Bypass

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Stage 2 Submission

Addendums to Geotechnical Reports

Portsmouth Bypass, Phase 1

SCI-823-6.81

PID 19415

July 31, 2009

PREPARED FOR:
Ohio Department of Transportation
District 9
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Introduction

The purpose of these addendums is to document the changes or modifications to the Phase 1 geotechnical reports and addendums prepared by DLZ Ohio, Inc. as a result of the vertical profile changes to the SR 823 Mainline, as well as the reconfiguration of the Lucasville-Minford Road (CR 28) Interchange. The modified vertical profile was approved by the Ohio Department of Transportation (ODOT) on March 26, 2009. The new horizontal and vertical alignments for Ramps A, B, C and D at the CR 28 interchange were approved by ODOT on April 23, 2009. Each geotechnical report for Phase I of the Portsmouth Bypass Project affected by the geometry changes is listed under the appropriate design section.

1. Embankment Evaluations

1. Report of Subsurface Investigation: Shumway Hollow Road Interchange, Project SCI-823-6.81, Phase I – Stage 1, Scioto County, Ohio (DLZ Ohio Inc., 11/29/2006)
2. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road Interchange (DLZ Ohio Inc., 3/7/2008)
3. Report of Subsurface Investigation: Lucasville-Minford Road Interchange, Project SCI-823-6.81, Phase I – Stage 1, Scioto County, Ohio (DLZ Ohio Inc., 11/29/2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Lucasville-Minford Road Interchange (DLZ Ohio Inc., 3/7/2008)

Slope Stability Analyses

As a result of the vertical profile change, stability of the embankment slopes were reanalyzed at three critical design sections, Sta. 408+50 and Sta. 410+50 at the Shumway Hollow Road Interchange and Sta. 526+50 at the Lucasville-Minford Road Interchange. The planned height of the embankment at Sta. 408+50, is approximately 78 feet, with the design stratigraphy of the underlying foundation soils consisting of approximately 37 feet of soft to medium stiff clays overlying roughly 10 feet of stiff silts and clays based on borings R-341, R-342 and R-343. At Sta. 410+50, the embankment height is approximately 80 feet, with the existing overburden consisting of roughly 41 feet of soft to medium stiff clays overlying approximately 4 feet of stiff silts and clays based on borings R-345, R-346 and R-348. At Sta. 536+50, the planned height of the embankment is approximately 45 feet. The design stratigraphy at Sta. 536+50 is based on borings B-1223, C-22, C-23 and TR-14, and consists of 14 feet of stiff silts and clays overlying 28 feet of soft to medium stiff clays and 5 feet of very stiff silts and clays.

Stability analyses for the planned embankment slopes were conducted in accordance with the guidelines and criteria established by ODOT using a minimum target factor of safety of 1.3 for both long and short term conditions. Staged construction of the embankment is necessary due to the low undrained shear strength of the overburden soils. The gain in shear strength due to the consolidation of the foundation soils after each load application was determined by the QRS method as outlined in "Stability Evaluation During Staged Construction" (Ladd, 1991) per the original DLZ analysis. Shear strength parameters (c, Φ_{CU}) for the foundation soils at the Shumway Hollow Interchange were determined from review of the table "Summary of Shear Strength Test Data: Shumway Hollow Interchange" as found in Appendix B of the Shumway Hollow Road Interchange geotechnical report. Shear strength parameters (c, Φ_{CU}) for the foundation soils at the Lucasville-Minford Road Interchange were determined from review of the table "Summary of Shear Strength Testing: Lucasville-Minford Road Interchange" as found in Appendix B of the Lucasville-Minford Road Interchange geotechnical report, as well as review of the Standard Penetration Test (SPT) N-values and Pocket Penetrometer Readings (PPR) from borings B-1223, C-22, C-23 and TR-14.

The stability analyses were performed using the software package SLOPE/W to analyze failure surfaces as determined by general limit equilibrium (GLE) formulation. As shown in Appendix A, the analyses indicate that embankment side slopes of 3H:1V are necessary to achieve the target factor of safety of 1.3 during construction of the embankments. A summary of the computed factor of safety for the various stages and loading cases is provided in Table 1.

TABLE 1: SUMMARY OF SLOPE STABILITY ANALYSES

Station	Stage	Stage Height (ft)	Calculated Factor of Safety (3H:1V Slopes)			Degree of Consolidation (U)
			Undrained	Excess Pore Pressure (Pressure Head = 18 feet)	Long Term	
408+50	1	26	1.64	1.32*	-	90%
	2	25	1.55	1.61	-	90%
	3	27	1.46	1.63	2.03	-
410+50	1	26	1.32	1.47	-	90%
	2	25	1.32	1.54	-	90%
	3	29	1.27*	1.63	1.98	-
536+50	1	27	1.29	1.36	-	90%
	2	18	1.27*	1.72	1.35	-

* Controlling case

A waiting or quarantine period will be required after construction of each stage to allow the foundation soils to consolidate under the applied embankment load. At least ninety percent of the consolidation (U = 90%) must occur prior to placing any additional fill to allow for the necessary gain in shear strength within the foundations soils.

The maximum pore water pressure head should not be allowed to exceed 18 feet above the existing ground surface during construction of the embankments. If the pore pressure head rises above this level, the placement of the fill should be immediately suspended to allow the excess pore pressures to dissipate, and the measured pressure head to decrease below 18 feet.

Settlement Analyses

Settlement analyses were performed to estimate the magnitude and time rate of settlement due to compression of the foundation soils under the weight of the embankment loads. Estimated settlements are provided in Table 2 for the full embankment height at Sta. 408+50 (H = 78 feet), Sta. 410+50 (H = 80 feet) and Sta. 536+50 (H= 45 feet), as well as after completion of each embankment stage. As shown in Table 2, the total settlement as a result of primary consolidation varies from approximately 30 to 41 inches depending upon the height of the embankment and the consolidation characteristics of the underlying silts and clays. The calculations for settlement at the three design sections are provided in Appendix B.

TABLE 2: ESTIMATED SETTLEMENT

Station	Settlement at Full Embankment Height (in)	Staged Construction				Difference
		Stage 1 Settlement (in)	Stage 2 Settlement (in)	Stage 3 Settlement (in)	Total	
408+50	41	18	11	9	38	8%
410+50	30	15	10	7	32	7%
536+50	34	25	8	-	33	3%

Wick Drains

The time to reach 90 percent consolidation for the full embankment height is estimated at over 40 years for the three design sections using the coefficient of consolidation (c_v) data available from test borings B-1 and B-2. As the current project schedule has the earthwork completed within two construction seasons, wick drains will be used to accelerate the time of consolidation for the foundation soils.

A conceptualized earthwork construction schedule was developed to assist in determining the optimal wick drain spacing at the two interchange locations as a result of the geometric changes. This schedule was modified from the conceptualized earthwork schedules previously developed by HDR to determine the wick drain spacing required for the various construction scenarios being considered by the District. These previous schedules and associated wick drain spacing were reviewed and approved by ODOT's Office of Geotechnical Engineering (OGE) on June 23, 2008. Per the selected construction scenario, additional time will be available for consolidation of the embankment fills south of Shumway Hollow Road (Mainline Station 384+00) as well as for the mainline embankment north of Station 529+00 as these areas will not be opened to traffic until construction of the adjacent roadway sections is complete.

The conceptualized construction schedule is based on a 50-hour work week, with a 13-week hiatus for winter each construction season. A productivity rate of 700 cubic yards per hour of embankment/waste material moved was assumed for each construction crew based on conversations with several earthwork contractors with experience on similar sized projects. Each construction crew is assumed to operate a minimum of two excavators. The schedule also assumes that the wick drains will be installed at a rate of 60,000 linear feet per day (6 rigs at a rate of 10,000 feet per day per rig). A copy of the conceptualized construction schedule is located in Appendix C.

The wick drain spacing was determined by the estimated time to achieve 90 percent primary consolidation of the foundation soils, while still completing the earthwork operations within the two construction seasons. The optimal wick drain spacing and estimated time for 90 percent of the primary consolidation to occur are presented in Table 3.

TABLE 3: ESTIMATED TIME RATE OF SETTLEMENT

SR 823 Interchange	Roadway Section	Wick Drain Spacing	Estimated Time To 90% Consolidation		
			Stage 1	Stage 2	Stage 3
Shumway Hollow Road	Area 1 & Area 2	6 Ft	265 Days	215 Days	-
	Area 3 & Area 4	4 Ft	145 Days	120 Days	95 Days
Lucasville-Minford Road	SR 823 Mainline	7 Ft	420 Days	360 Days	-
	Ramps A, B, C & D	5 Ft	215 Days	185 Days	-

The revised wick drain and instrumentation plan sheets as a result of the changes in the wick drain spacing are presented in Appendix C.

2. Rock Cuts

1. Report of Rock Cut Slopes: Portsmouth Bypass Project SCI-823-6.81, Phase I – Stage 1, Scioto County, Ohio (DLZ Ohio Inc., 11/29/2006)
2. Report of Rock Cut Slopes Addendum: Portsmouth Bypass Project SCI-823-6.81, Phase I – Stage 1, Scioto County, Ohio (DLZ Ohio Inc., 3/7/2008)

Rock Cut Slope Design

The cross-sections for Rock Cut No. 11 through Rock Cut No. 15 were modified to reflect the changes in the vertical alignment from Sta. 387+00 to Sta. 536+50. The cross-sections for both CR 28 Ramp A and CR 28 Ramp D located within Rock Cut No. 15 were also modified to reflect their new alignment as a result of the reconfiguration of the Lucasville-Minford Road (CR 28) Interchange. The proposed modifications were reviewed by OGE during the design process and any comments incorporated prior to drafting the cut slopes. The modified cross-sections for Rock Cut No. 11 through Rock Cut No. 15 are shown in Appendix D.

Colorado Rockfall Simulation Program Analyses

Type D barrier was recommended from Sta. 479+50 LT to Sta. 483+00 LT as less than 95 percent rockfall catchment was achieved for the project-standard catchment ditch. Although not documented in the geotechnical reports, Type D barrier was also shown from Sta. 512+00 LT to Sta. 520+00 LT on the Stage 1 plans. As the vertical alignment for the SR 823 Mainline was held constant or raised, these sections were reanalyzed using the Colorado Rockfall Simulation Program (CRSP) in accordance with GB 3 "Rock Cut Slope and Catchment Design" to determine if a barrier would still be required. Both the end of construction and long-term conditions as presented in Section 8 of the Report of Rock Cut Slopes were utilized in these analyses.

As shown in the CRSP output files presented in Appendix E, barrier will be required from Sta. 510+50 (LT) to Sta. 519+00 (LT) as less than 95 percent catchment is achieved. Please note that the limits of the barrier were determined based on the original report's assertion that a minimum slope height of 70 feet is necessary for any falling rock to reach beyond the catchment ditch. The rockfall analyses also indicate that barrier will not be required at Rock Cut No. 13 from Sta.479+50 LT to Sta. 483+00 LT.

In addition to reanalyzing those sections where barrier was recommended or shown, CRSP analyses were also performed at Sta. 523+45 RT (CR 28 Ramp A) and Sta. 524+50 LT (CR 28 Ramp D) as a result of the reconfigured intersection, as well as at Sta. 11+50 RT (TR 234) as the project-standard catchment ditch was modified from Sta. 10+24 RT to Sta. 13+50 RT due to design and safety issues related to the placement of the guardrail at the tie-in with the existing TR 234 alignment. The input data used in these analyses was that as presented by DLZ in their earlier report. As shown in the output presented in Appendix E, these sections achieve the 95 percent rockfall catchment at the edge of pavement.

3. Pavement Undercuts

1. Report of Subsurface Investigation: Shumway Hollow Road Interchange, Project SCI-823-6.81, Phase I – Stage 1, Scioto County, Ohio (DLZ Ohio Inc., 11/29/2006)
2. Report of Subsurface Investigation: Embankments (Station 416+00 to 509+50), Project SCI-823-6.81, Phase I – Stage 1, Scioto County, Ohio (DLZ Ohio Inc., 11/29/2006)

3. Report of Subsurface Investigation: Lucasville-Minford Road Interchange, Project SCI-823-6.81, Phase I – Stage 1, Scioto County, Ohio (DLZ Ohio Inc., 11/29/2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Lucasville-Minford Road Interchange (DLZ Ohio Inc., 3/7/2008)
5. Report of Subsurface Investigation: Pavement Design information Phase 1 – Mainline and Side Road CBR Values, Project SCI-823-6.81, Phase I – Stage 1, Scioto County, Ohio (DLZ Ohio Inc., 11/29/2006)
6. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Pavement Design Information - Phase 1, Mainline and Side Road CBR Values (DLZ Ohio Inc., 3/7/2008)

Subgrade Treatment Recommendations

The limits of the previously recommended undercuts were modified for the SR 823 Mainline, CR 28 Ramps A, B, C and D, and SR 335 as a result of the geometric changes. In addition, 24-inch undercuts are recommended for TR 234 Ramps C and D based on the subsurface conditions encountered at the interchange. Table 4 and Table 5 present the modified subgrade treatment recommendations.

TABLE 4: UNDERCUT AND REPLACE – SUBGRADE IN SOIL

Alignment	Beginning Station	Ending Station	Depth of Undercut
SR 823 Mainline	527+50	529+00	36 inches
TR 234 Ramp C	368+00	373+00	24 inches
TR 234 Ramp C	382+00	383+50	24 inches
TR 234 Ramp D	387+50	395+00	24 inches
CR 28 Ramp A	528+50	530+00	36 inches
CR 28 Ramp B	527+00	530+00	36 inches
CR 28 Ramp C	522+00	522+50	36 inches
CR 28 Ramp C	523+50	525+00	36 inches
CR 28 Ramp C	526+00	530+00	36 inches
CR 28 Ramp D	528+50	530+00	36 inches
CR 28 Ramp D	531+00	532+50	36 inches
CR 28 Ramp D	535+00	537+50	36 inches
SR 335	9+50	23+00	36 inches

It should be noted that as test borings were not located beyond SR 335 Sta. 14+30, the recommended 36 inch undercut was extended to Sta. 23+00 as similar soil conditions can be expected based on review of the soil survey information.

TABLE 5: UNDERCUT AND REPLACE – SUBGRADE IN ROCK

Alignment	Beginning Station	Ending Station	Depth of Undercut
Mainline SR 823	355+50	362+00	24 inches
Mainline SR 823	416+00	433+50	24 inches
Mainline SR 823	436+00	438+00	24 inches
Mainline SR 823	450+50	456+50	24 inches
Mainline SR 823	480+00	482+50	24 inches
Mainline SR 823	498+50	503+00	24 inches
Mainline SR 823	508+50	527+00	24 inches
CR 28 Ramp A	525+00	528+00	24 inches
CR 28 Ramp D	524+50	528+00	24 inches

Limitations

These addendums document the analyses and conclusions of HDR Engineering, Inc. for the geotechnical aspects related to the design of the SCI-823-6.81 Portsmouth Bypass Project. These addendums have been prepared for the use of the Ohio Department of Transportation for specific application to the project, in accordance with generally accepted engineering practice and in a manner consistent with the level of care and skill for this type of project within this geographical area. The geotechnical analyses presented herein are based on the parameters, findings and conclusions established by others from previous project geotechnical studies within the study area. No warranty, expressed or implied, is made.

These addendums and analyses do not reflect variations that can occur between borings or at other points in time. Variations in conditions, if any, may become evident during the construction period, at which time, a re-evaluation of the recommendations may become necessary. In such an event, the recommendations and changes should be reviewed by HDR's geotechnical staff.

Appendix A
Slope Stability Analyses

Job No. 000000000045878 | PID No. 19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed JSA	Date 7/17/2009
Subject	Roadway Embankments	Checked DMV	Date 7/18/09
Task	Summarize Slope Stability	Sheet 1	Of 1

	Stage 1		Stage 2		Stage 3		Full Height
	Undrained	Drained	Undrained	Drained	Undrained	Drained	Drained
Sta 408+50	1.64	1.32(1)	1.55	1.61	1.46	1.63	2.03
Sta 410+50	1.32(2)	1.47	1.32(3)	1.54	1.27(4)	1.63	1.98
Sta 536+50	1.29	1.36	1.27	1.72	-	-	1.35

Notes:

1. Controls excess pore pressure.
2. Controls stage lift height.
3. Controls stage lift height.
4. Controls stage lift height.

Shear Strength Test Data - Shumway Hollow Interchange (DLZ - 2006)

Soil Classification	Boring No.	Unconfined Compression	Unconsolidated Undrained	Consolidated Undrained		Pocket Penetrometer
		C (psf)	C (psf)	C (psf)	Φ°	C (psf)
A-7-6	B-1	2051				3250
	B-1	2365				2750
	B-2	2005				4000
	B-2	2572				2750
	B-2	2198				2500
	B-3	1658				1750
	B-3	2204				2250
	B-1314			646	19.9	
	B-1318			228	14.2	
	B-1320		1438			1500
	B-1320			860	11.2	
	B-1322	969				2500
	B-1323		1578			2250
	B-1326			592	15.2	
	B-1328			282	10.8	
	C-19	1143				2250
	R-329	1999				2500
	R-343		1590			2000
	R-351		2025			750
A-6a	R-335		1680			
A-6b	R-346		1720			500

Average	1824.7 psf	14.3	2233.3 psf
Mean	1859.5 psf	14.2	2250.0 psf
Std Dev	432.8 psf	3.7	883.7 psf
within 1 Std Dev	1426.7 psf	10.5	1366.3 psf
Low	969.0 psf	10.8	500.0 psf

use	**C**
Soft to Medium Stiff Clays (A-7-6, A-6)	**969 psf**
Stiff Clays (A-7-6, A-6)	**1427 psf**
	Φ
	14 °

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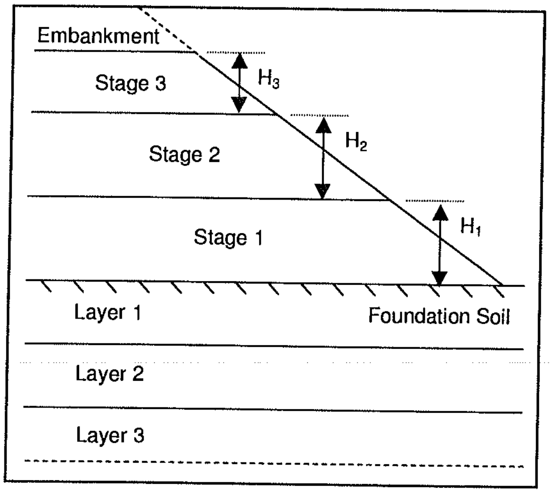
Project:	SCI-823 Portsmouth Bypass	Computed: JSA	Date: 17-Jul-09
Subject:	Roadway Embankments - Sta 408+50	Checked: DMV ✓	Date: 7/18/09
Task:	Undrained Strength Analyses - Staged Construction	Page: 1 of 1	
Job #:	45878 (Dept. 212)	No:	

Reference: Ladd, Charles C. (1991). "Stability Evaluation During Staged Construction." *The Twenty-Second Karl Terzaghi* Lecture, Journal of Geotechical Engineering, ASCE, 114(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, psf

Φ_{cu} =

$\Delta\sigma'$ = 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 = 26 ft Average Percent Consolidation, U= 90%

Layer	Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	Δc_u (psf), After Consolidation	Percent Increase
1	0-37	A-7-6	969	2925	14.0	729	1698	75%
2	37-47	A-6a	1427	2925	14.0	729	2156	51%
3								

Stage 2 Embankment Second Stage Embankment Height, H_2 = 25 ft Average Percent Consolidation, U= 90%

Layer	Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	Δc_u (psf), After Consolidation	Percent Increase
1	0-37	A-7-6	1698	2813	14.0	701	2400	41%
2	37-47	A-6a	2156	2813	14.0	701	2858	33%
3								

Stage 3 Embankment Third Stage Embankment Height, H_3 = ft Average Percent Consolidation, U= 0%

Layer	Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	Δc_u (psf), After Consolidation	Percent Increase
1	0-37	A-7-6	2400	0	0.0	0	2400	0%
2	37-47	A-6a	2858	0	0.0	0	2858	0%
3								

Project:	SCI-823 Portsmouth Bypass	Computed:	DMV	Date:	7-17-09
Subject:	Roadway Embankments	Checked:		Date:	
Task:	Stress Distribution	Page:		of:	
Job #:	45878	No:			

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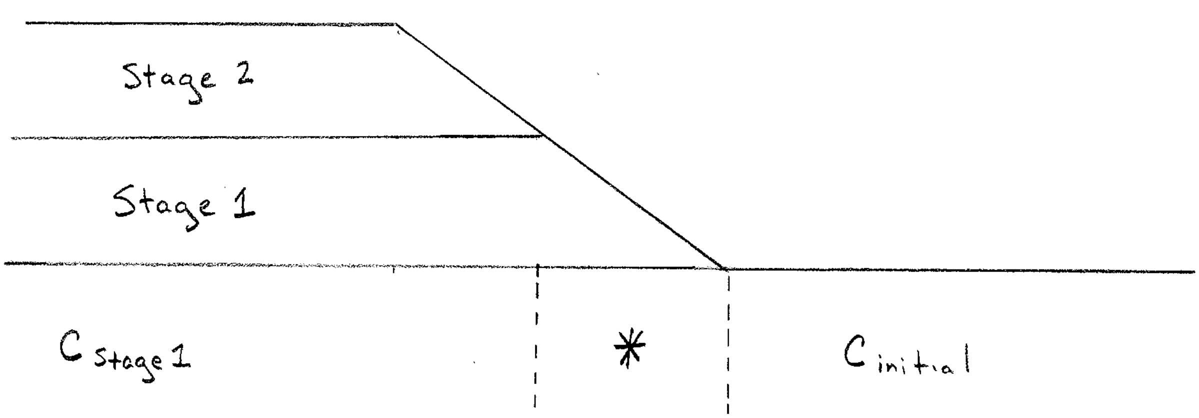
Review of the original slope stability analyses indicates that the gain in strength (due to consolidation of the foundation soils as a result of staged embankment construction) was applied to the entire soil layer. This gain in shear strength should only have been applied to those soils located beneath the embankment itself. For the revised stability analyses, the strength gain was only applied to those soils directly underneath the embankment. In addition, the average shear strength was applied to those areas beneath the embankment side slopes. See below.



$$* = (C_{initial} + C_{Stage 1})/2$$

Sta 4 50 - Stage 1 Undrained

SCI-823, Shumway Interchange, Stability Analyses

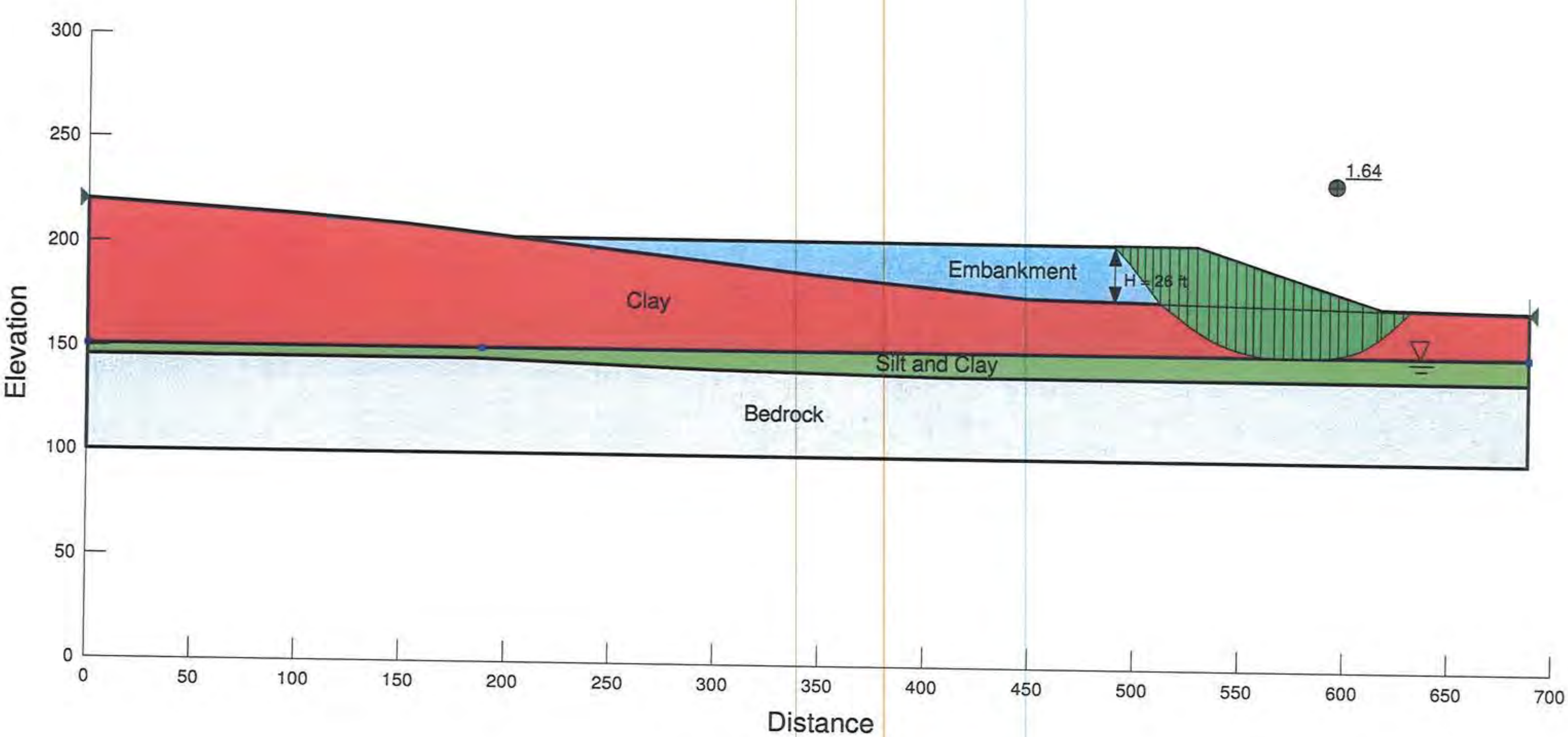
Project Name: SCI-823
Description: STA 408+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1427 psf
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 969 psf
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1427 psf
Piezometric Line: 1
Add Weight: No



Sta 4 .50 - Stage 1 Drained

SCI-823, Shumway Interchange, Stability Analyses

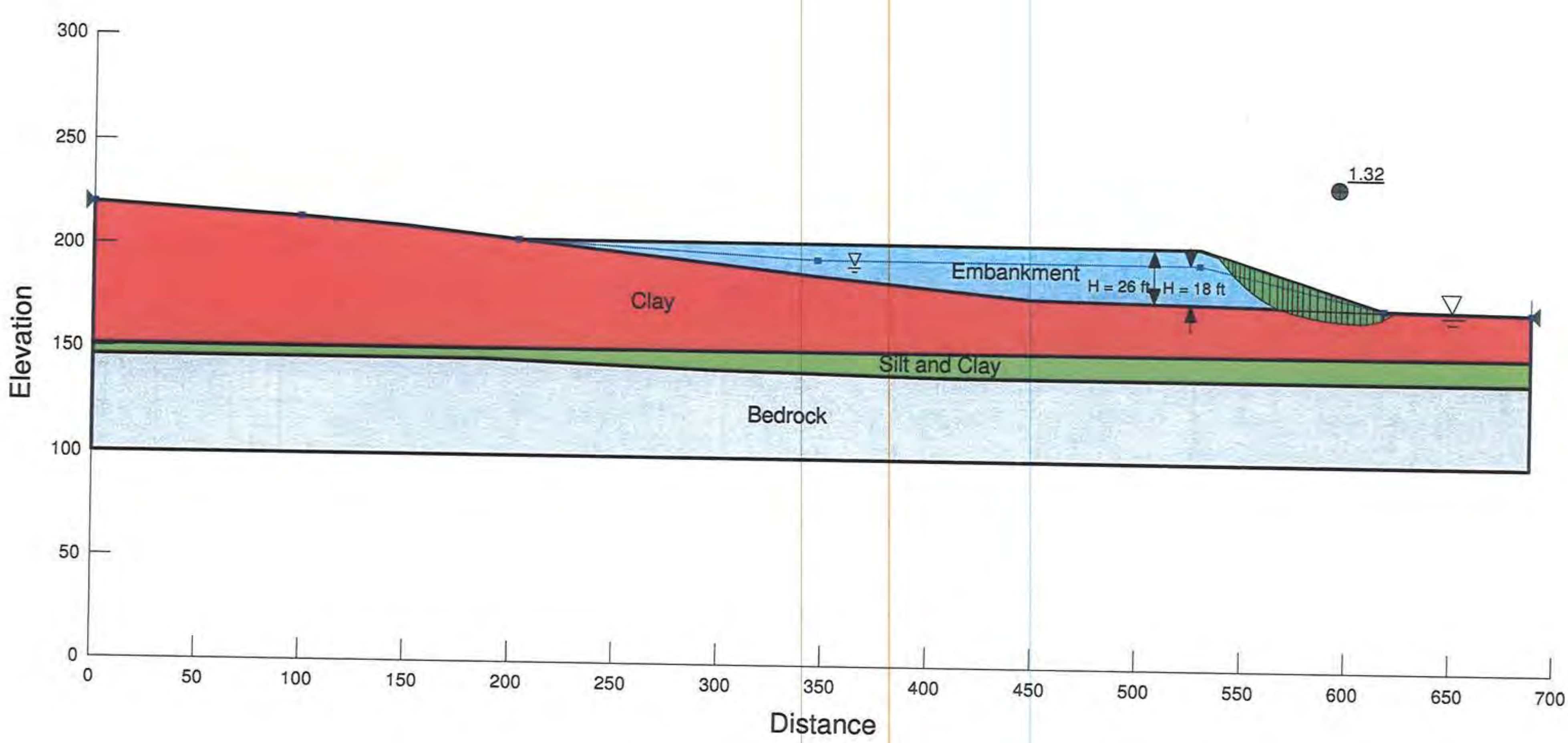
Project Name: SCI-823
Description: STA 408+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No



Sta 4 50 - Stage 2 Undrained

SCI-823, Shumway Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 408+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

$$*_1 = \frac{969 + 1698}{2} = 1334 \text{ psf}$$

$$*_2 = \frac{1427 + 2156}{2} = 1792 \text{ psf}$$

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1698 psf
Piezometric Line: 1
Add Weight: No

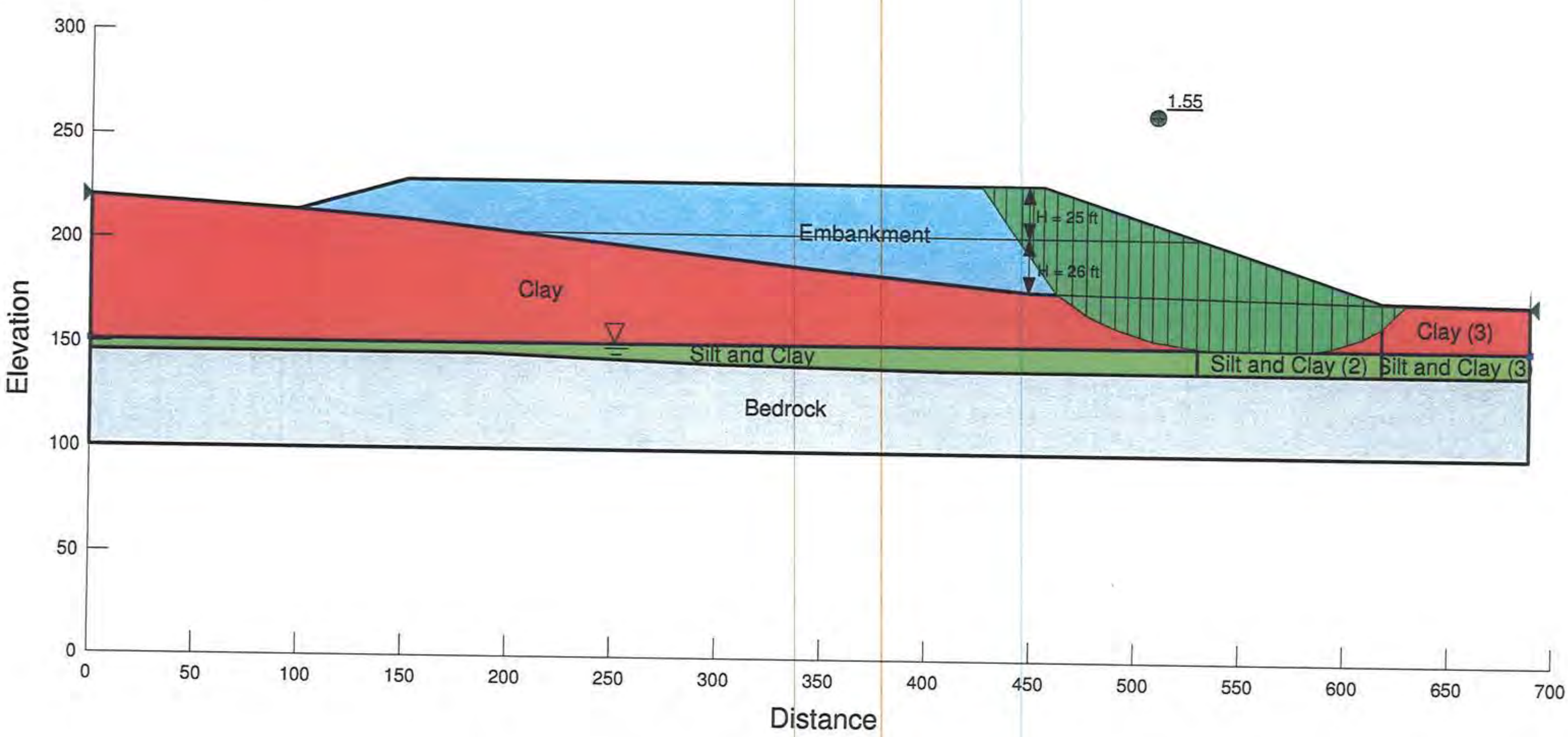
Name: Clay (2)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1334 psf $*_1$
Piezometric Line: 1
Add Weight: No

Name: Clay (3)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 969 psf
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2156 psf
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay (2)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1792 psf $*_2$
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay (3)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1427 psf
Piezometric Line: 1
Add Weight: No



Sta 4 50 - Stage 2 Drained

SCI-823, Shumway Interchange, Stability Analyses

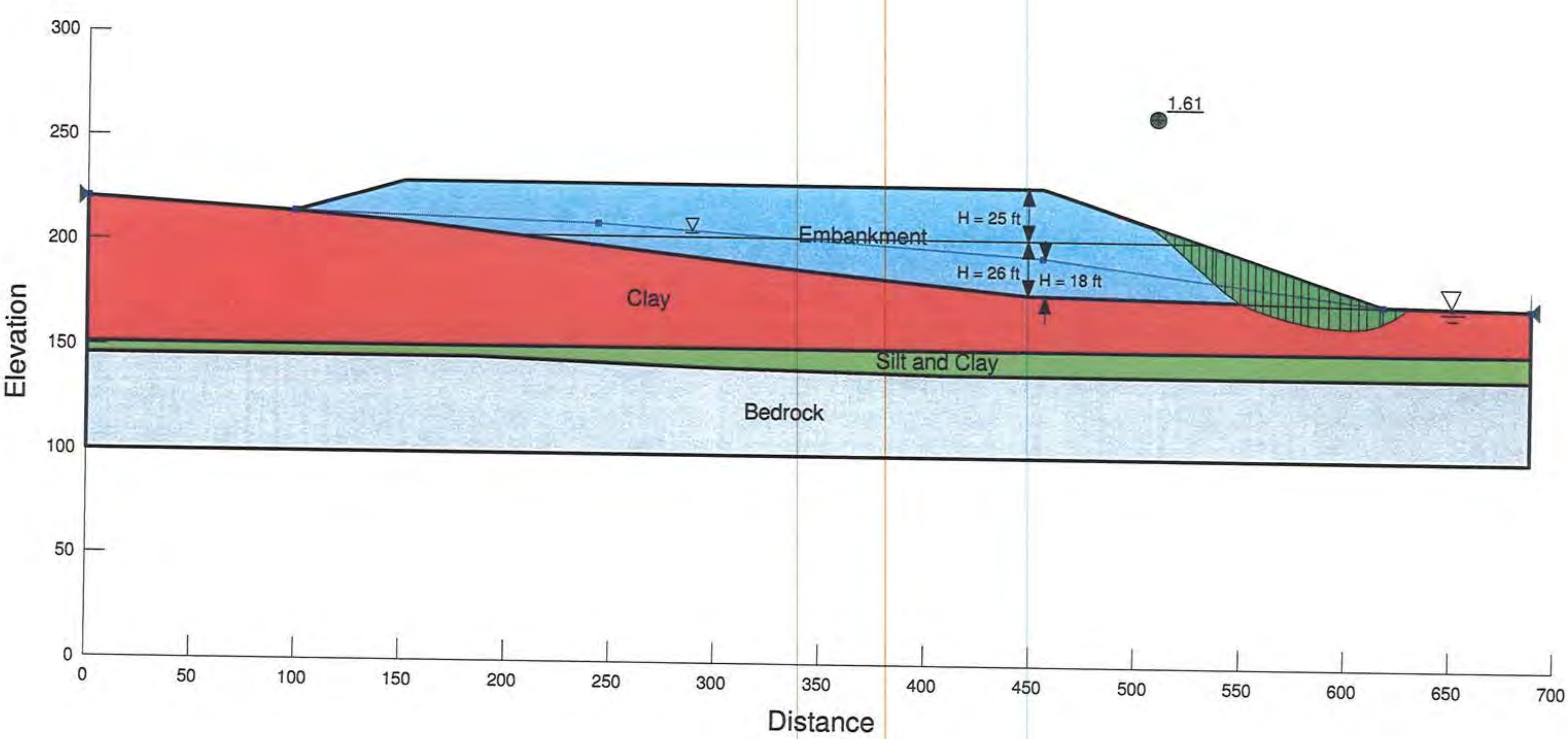
Project Name: SCI-823
Description: STA 408+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No



Sta 4 50 - Stage 3 Undrained

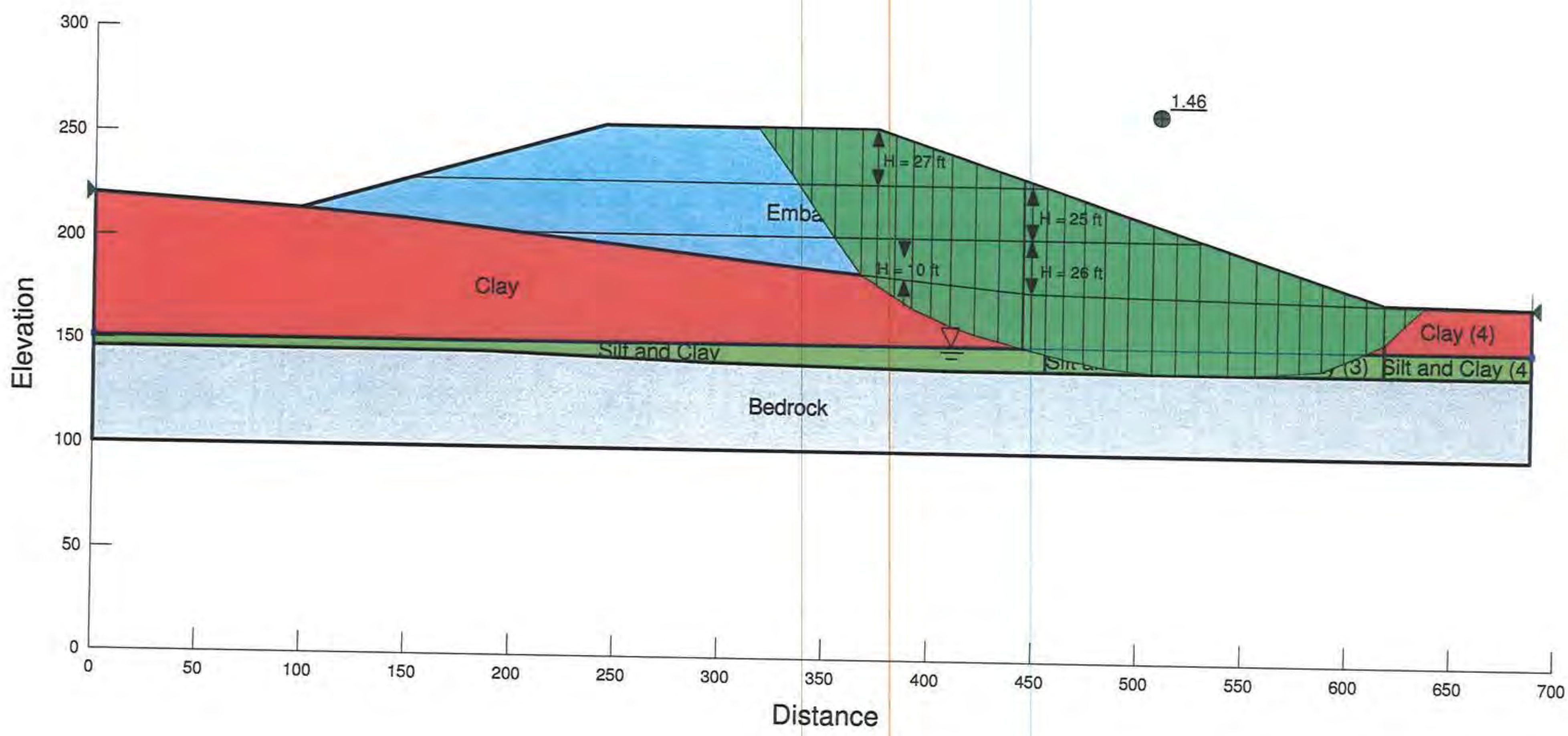
SCI-823, Shumway Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 408+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

$*_1 = \frac{2400 + 1698}{2} = 2049$ psf

$*_2 = \frac{2858 + 2156}{2} = 2507$ psf

Name	Model	Unit Weight	Cohesion	Phi	Piezometric Line	Add Weight
Bedrock	Mohr-Coulomb	120 pcf	3500 psf	45 °	1	No
Embankment	Mohr-Coulomb	125 pcf	0 psf	35 °	1	No
Clay	Undrained (Phi=0)	125 pcf	2400 psf		1	No
Clay (2)	Undrained (Phi=0)	125 pcf	2049 psf $*_1$		1	No
Clay (3)	Undrained (Phi=0)	125 pcf	1334 psf		1	No
Clay (4)	Undrained (Phi=0)	125 pcf	969 psf		1	No
Silt and Clay	Undrained (Phi=0)	125 pcf	2858 psf		1	No
Silt and Clay (2)	Undrained (Phi=0)	125 pcf	2507 psf $*_2$		1	No
Silt and Clay (3)	Undrained (Phi=0)	125 pcf	1792 psf		1	No
Silt and Clay (4)	Undrained (Phi=0)	125 pcf	1427 psf		1	No



Sta 4 ;0 - Stage 3 Drained

SCI-823, Shumway Interchange, Stability Analyses

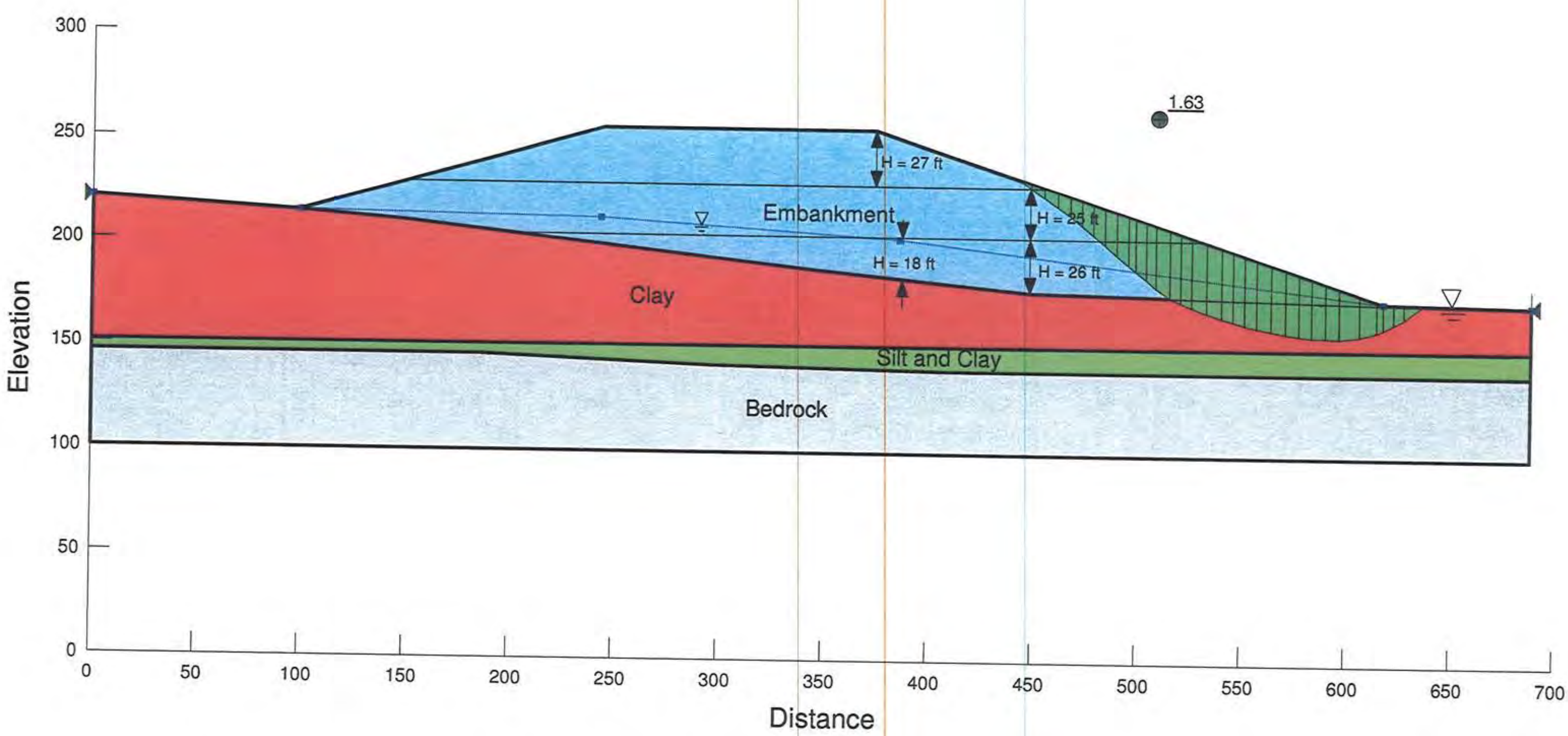
Project Name: SCI-823
Description: STA 408+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No



Sta 4 50 - Full Height Drained

SCI-823, Shumway Interchange, Stability Analyses

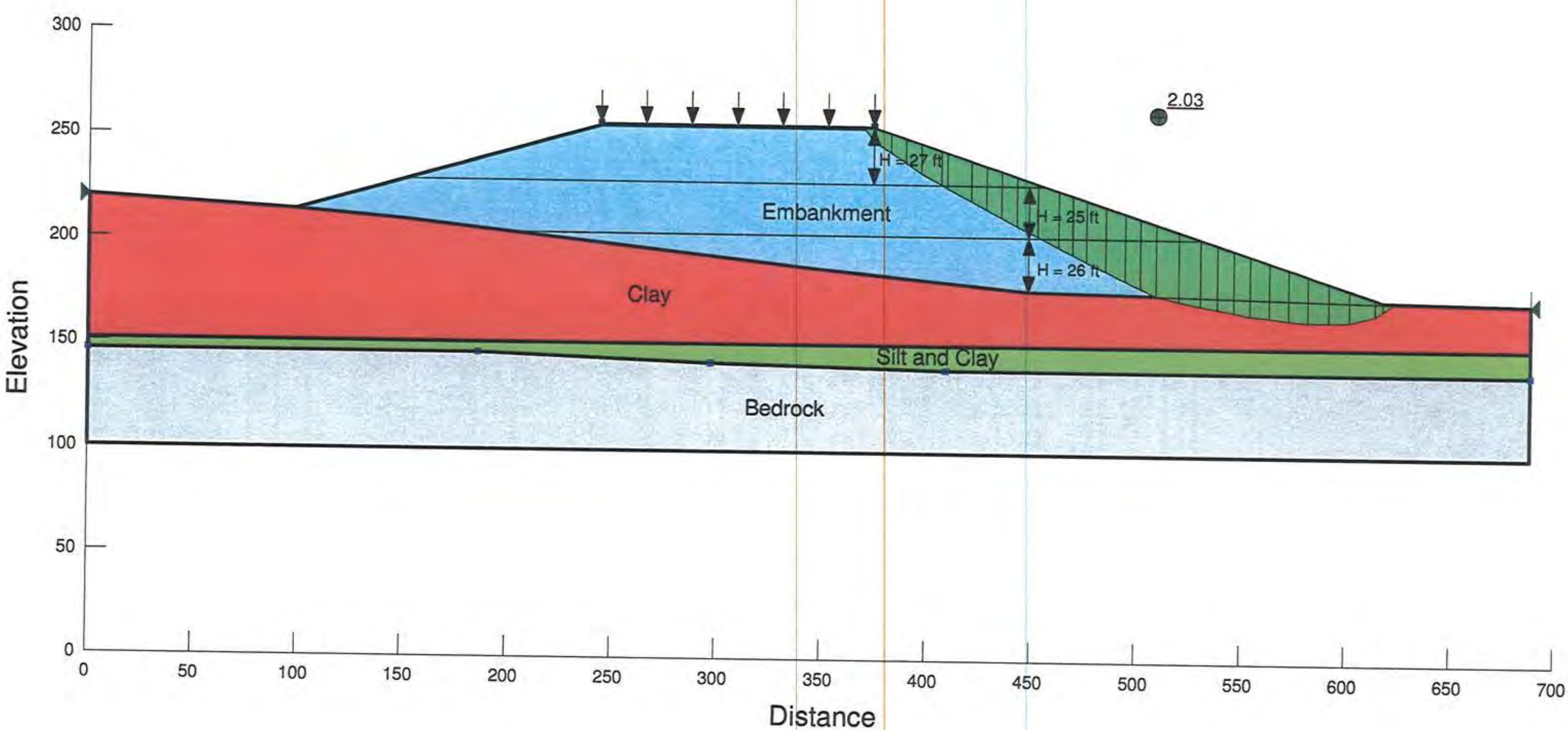
Project Name: SCI-823
Description: STA 408+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No



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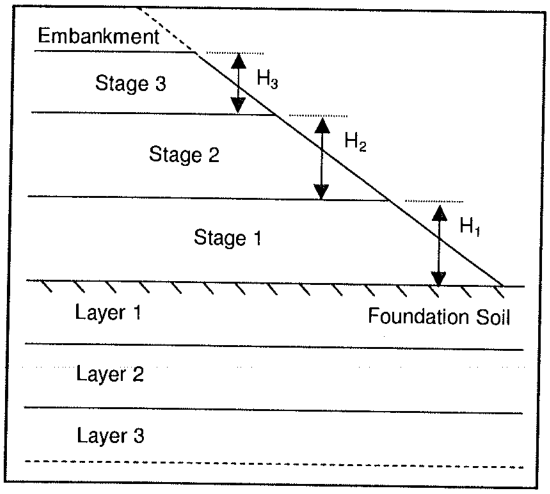
Project:	SCI-823 Portsmouth Bypass	Computed: JSA	Date: 17-Jul-09
Subject:	Roadway Embankments - Sta 410+50	Checked: DMV	Date: 7/18/09
Task:	Undrained Strength Analyses - Staged Construction	Page: 1 of 1	
Job #:	45878 (Dept. 212)	No:	

Reference: Ladd, Charles C. (1991). "Stability Evaluation During Staged Construction." *The Twenty-Second Karl Terzaghi* Lecture, Journal of Geotechical Engineering, ASCE, 114(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, psf

Φ_{cu} =

$\Delta\sigma'$ = 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 = 26 ft Average Percent Consolidation, U= 90%

Layer	Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	Δc_u (psf), After Consolidation	Percent Increase
1	0-41	A-7-6	969	2925	14.0	729	1698	75%
2	41-45	A-6a	1427	2925	14.0	729	2156	51%
3								

Stage 2 Embankment Second Stage Embankment Height, H_2 = 25 ft Average Percent Consolidation, U= 90%

Layer	Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	Δc_u (psf), After Consolidation	Percent Increase
1	0-41	A-7-6	1698	2813	14.0	701	2400	41%
2	41-45	A-6a	2156	2813	14.0	701	2858	33%
3								

Stage 3 Embankment Third Stage Embankment Height, H_3 = ft Average Percent Consolidation, U= 0%

Layer	Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	Δc_u (psf), After Consolidation	Percent Increase
1	0-41	A-7-6	2400	0	0.0	0	2400	0%
2	41-45	A-6a	2858	0	0.0	0	2858	0%
3								

Sta 410-. - Stage 1 Undrained

SCI-823, Shumway Interchange, Stability Analyses

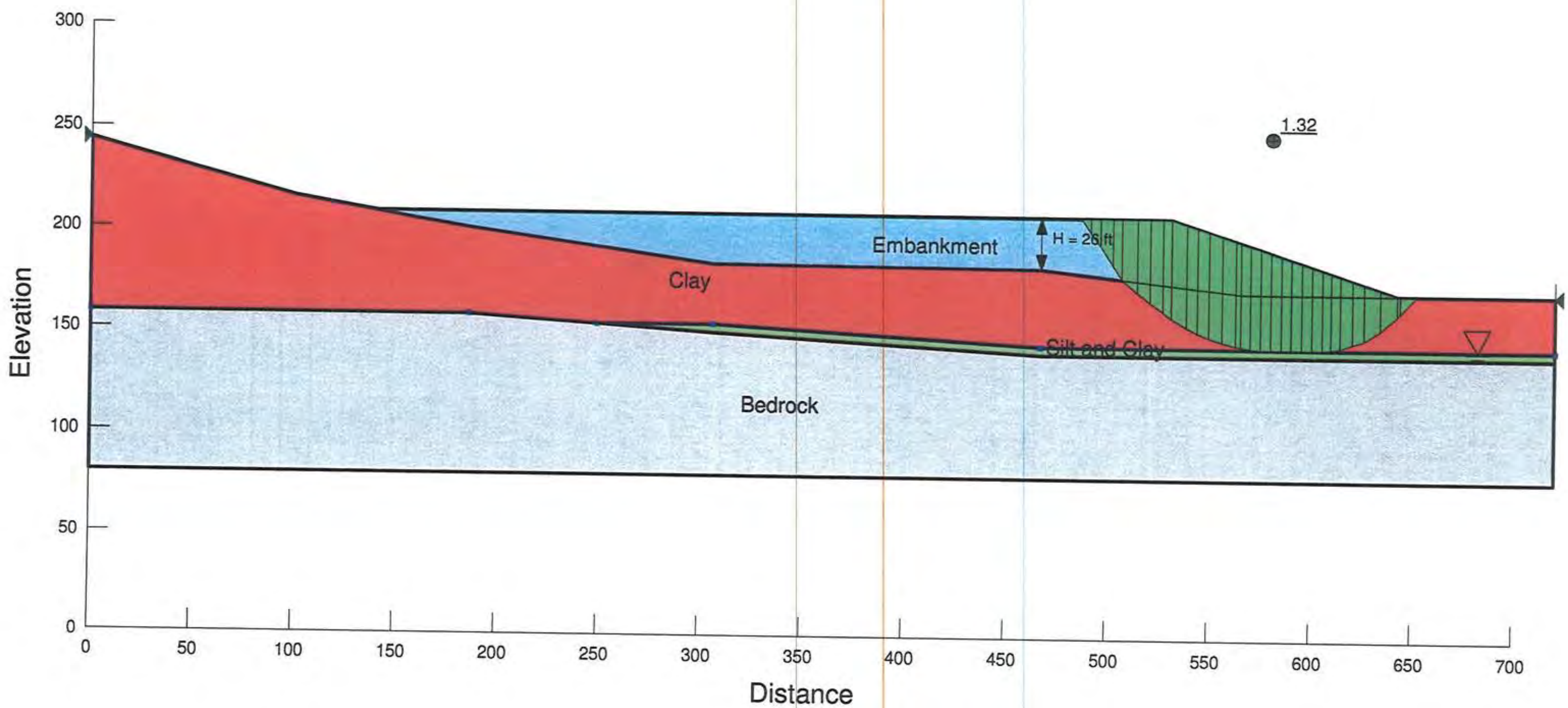
Project Name: SCI-823
Description: STA 410+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 969 psf
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1427 psf
Piezometric Line: 1
Add Weight: No



Sta 410 · Stage 1 Drained

SCI-823, Shumway Interchange, Stability Analyses

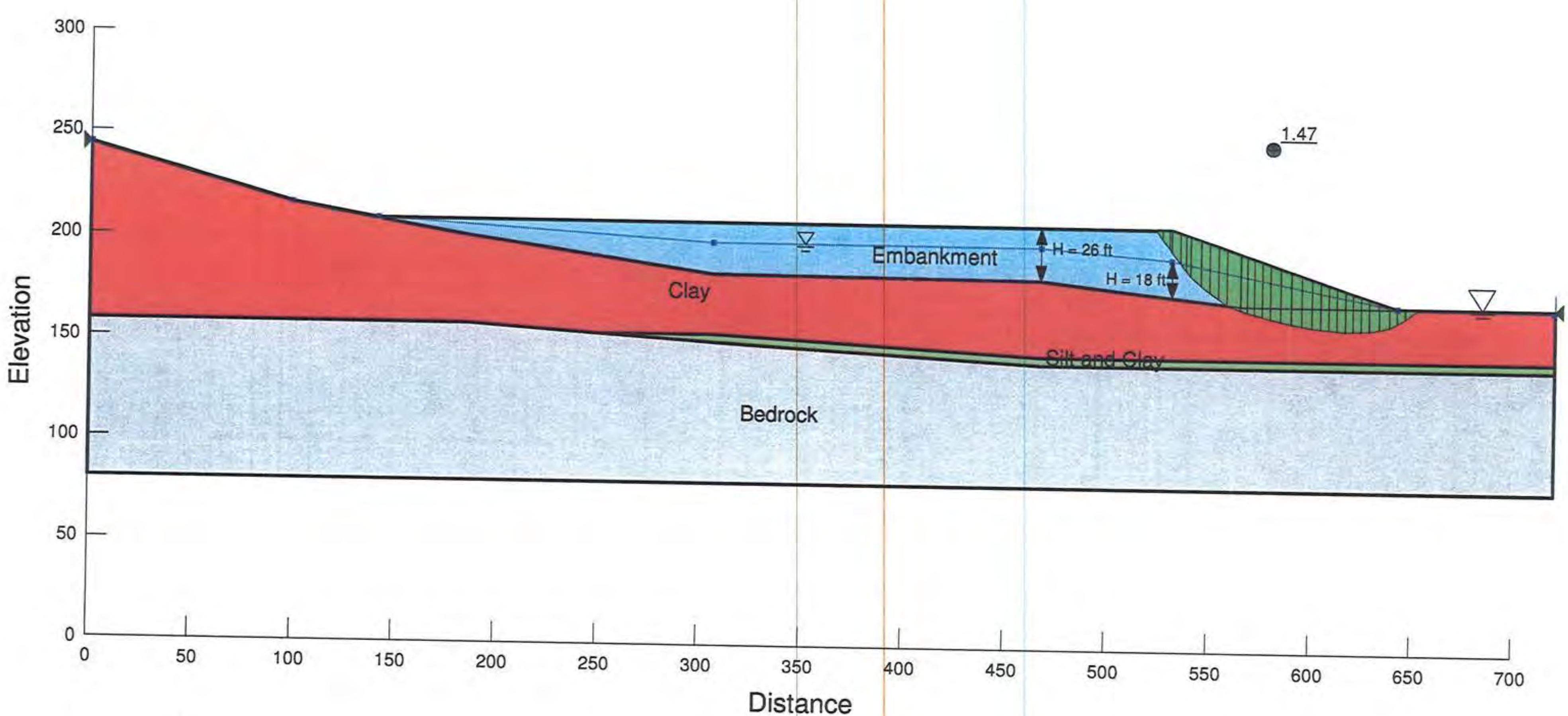
Project Name: SCI-823
Description: STA 410+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No



Sta 410 Stage 2 Undrained

SCI-823, Shumway Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 410+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

$*_1 = \frac{1698 + 969}{2} = 1334$ psf

$*_2 = \frac{2156 + 1427}{2} = 1792$ psf

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1698 psf
Piezometric Line: 1
Add Weight: No

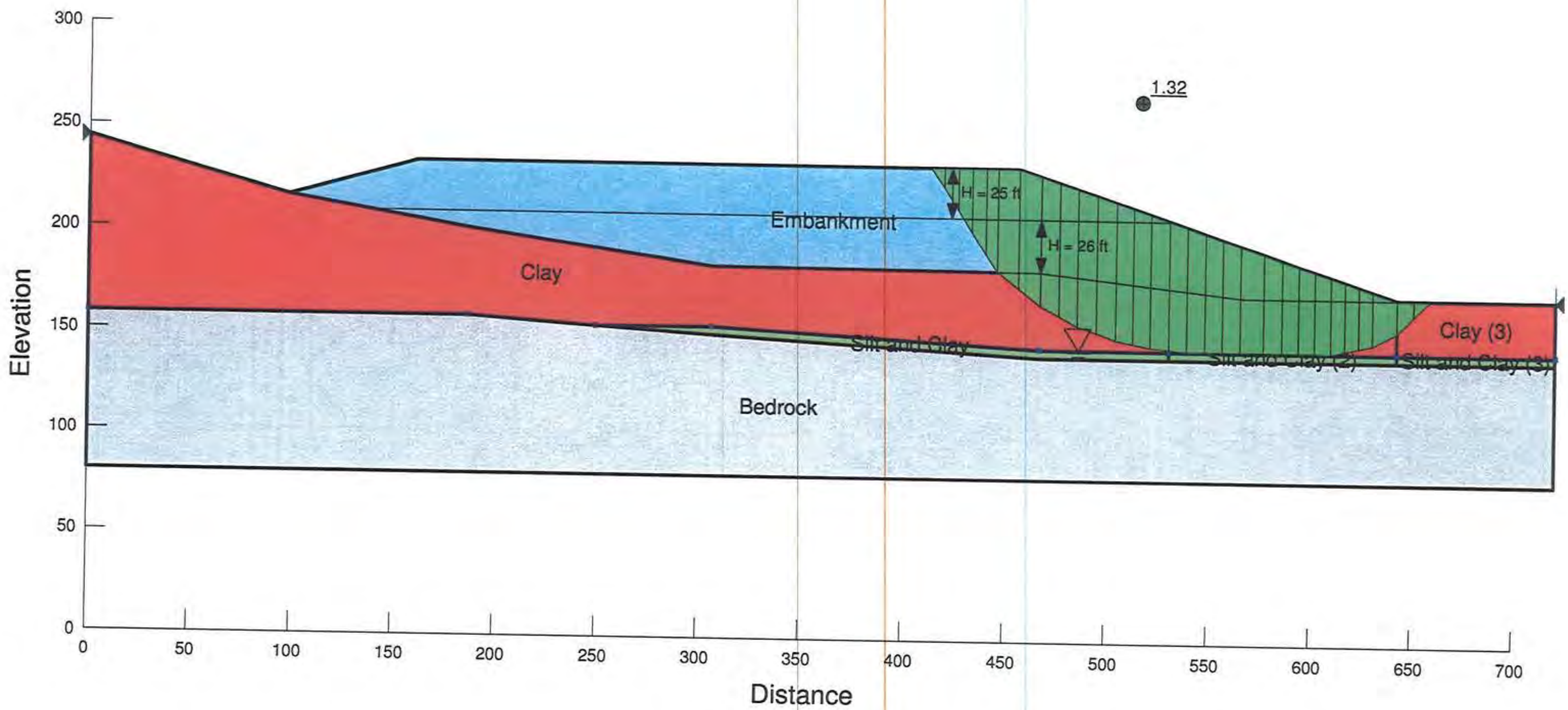
Name: Clay (2)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1334 psf $*_1$
Piezometric Line: 1
Add Weight: No

Name: Clay (3)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 969 psf
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2156 psf
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay (2)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1792 psf $*_2$
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay (3)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1427 psf
Piezometric Line: 1
Add Weight: No

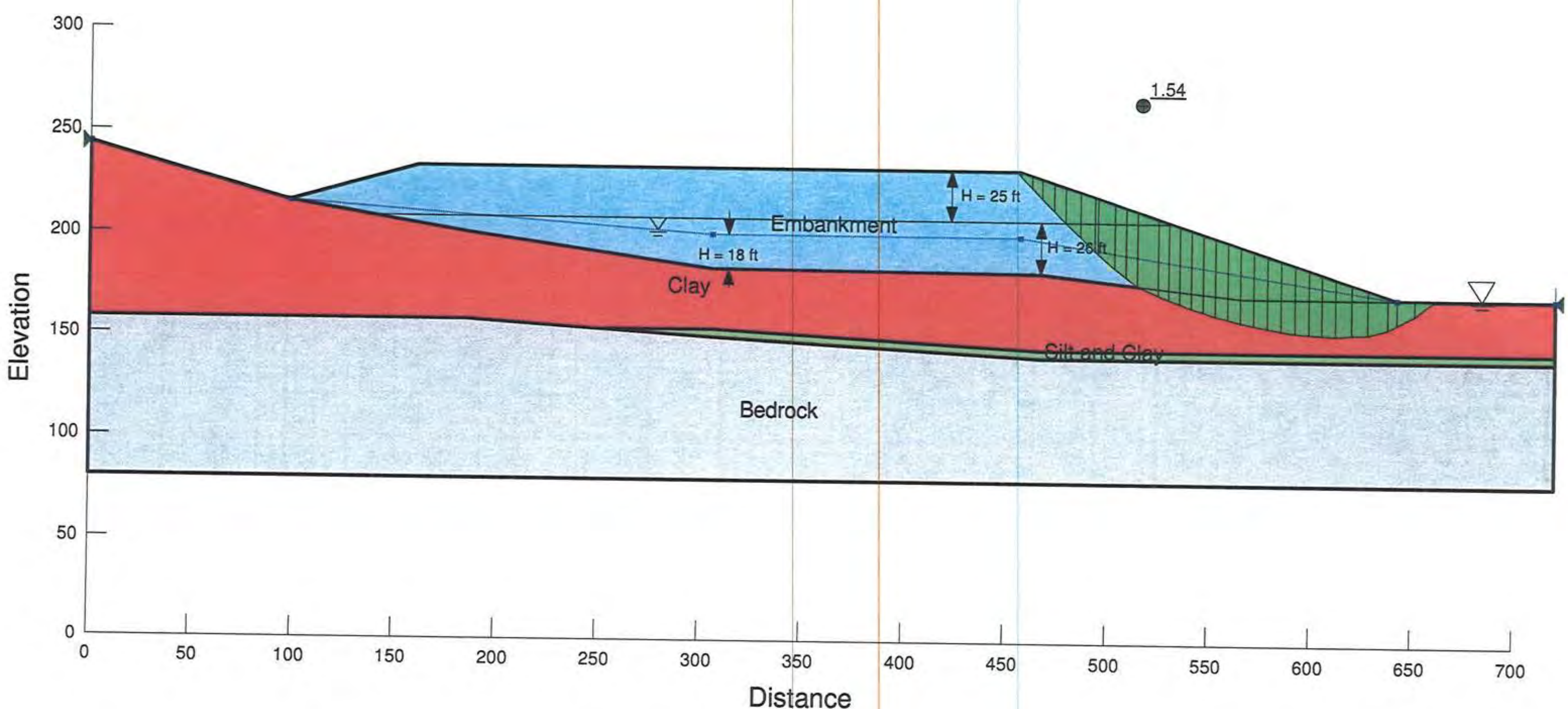


Sta 410+ Stage 2 Drained

SCI-823, Shumway Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 410+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Bedrock	Embankment	Clay	Silt and Clay
Name: Bedrock	Name: Embankment	Name: Clay	Name: Silt and Clay
Model: Mohr-Coulomb	Model: Mohr-Coulomb	Model: Mohr-Coulomb	Model: Mohr-Coulomb
Unit Weight: 120 pcf	Unit Weight: 125 pcf	Unit Weight: 125 pcf	Unit Weight: 125 pcf
Cohesion: 3500 psf	Cohesion: 0 psf	Cohesion: 0 psf	Cohesion: 0 psf
Phi: 45 °	Phi: 35 °	Phi: 28 °	Phi: 28 °
Piezometric Line: 1	Piezometric Line: 1	Piezometric Line: 1	Piezometric Line: 1
Add Weight: No	Add Weight: No	Add Weight: No	Add Weight: No



Sta 410 Stage 3 Undrained

SCI-823, Shumway Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 410+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

$*_1 = \frac{2400 + 1698}{2} = 2049$ psf

$*_2 = \frac{2858 + 2156}{2} = 2507$ psf

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2400 psf
Piezometric Line: 1
Add Weight: No

Name: Clay (2)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2049 psf $*_1$
Piezometric Line: 1
Add Weight: No

Name: Clay (3)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1334 psf
Piezometric Line: 1
Add Weight: No

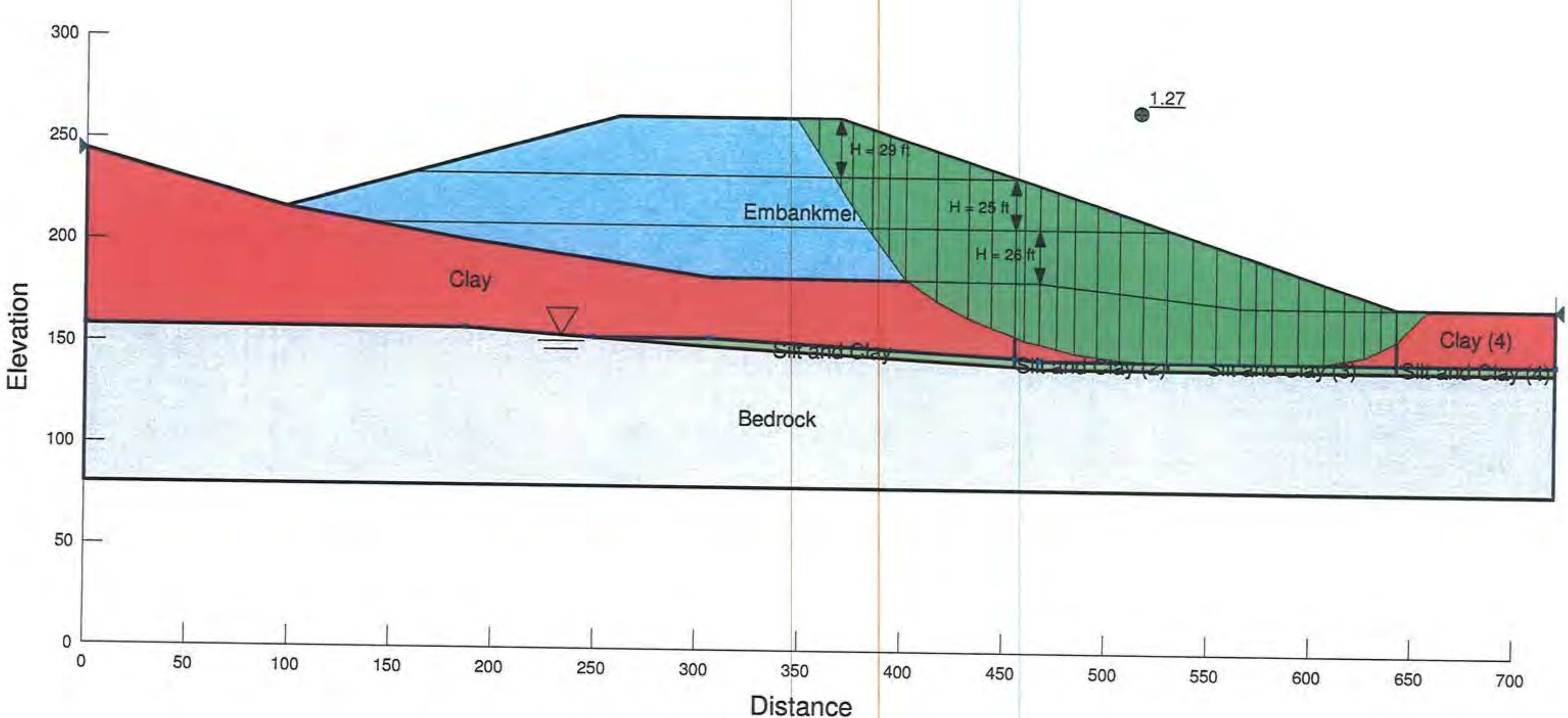
Name: Clay (4)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 969 psf
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2858 psf
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay (2)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2507 psf $*_2$
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay (3)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1792 psf
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay (4)
Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1427 psf
Piezometric Line: 1
Add Weight: No



Sta 410+ Stage 3 Drained

SCI-823, Shumway Interchange, Stability Analyses

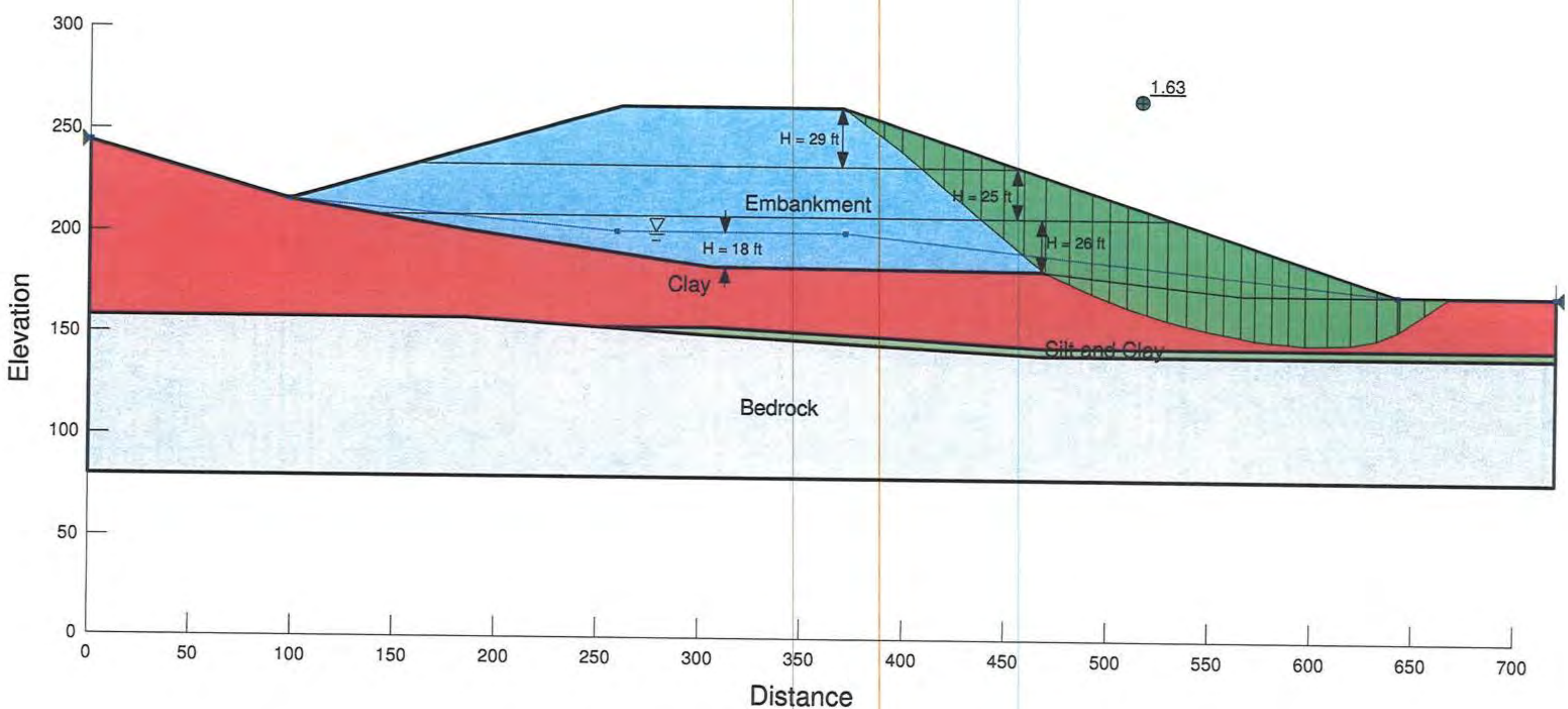
Project Name: SCI-823
Description: STA 410+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No



Sta 410+50 - Full Height Drained

SCI-823, Shumway Interchange, Stability Analyses

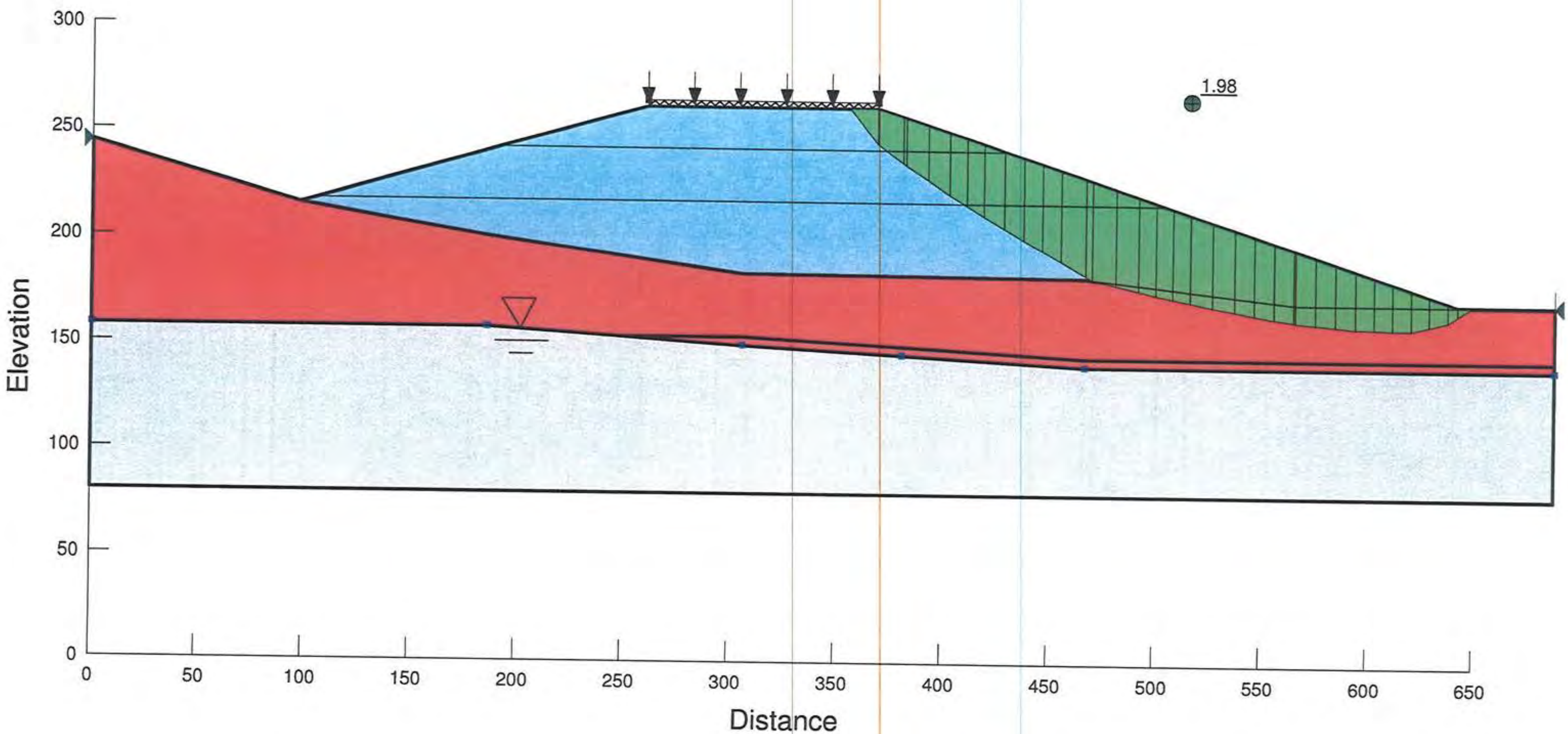
Project Name: SCI-823
Description: STA 410+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Silt and Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No



Shear Strength Test Data - Portsmouth Minford Road Interchange (DLZ - 2006)

Soil Classification	Boring No.	Unconfined Compression	Unconsolidated Undrained	Consolidated Undrained		Pocket Penetrometer
		C (psf)	C (psf)	C (psf)	Φ°	C (psf)
A-7-6	B-1223	1206				2500
	B-1223			546	11	1250
	R-464	1354				1250
	R-465	2147				1000
	R-466	744				500
	TR-14	1911				1000

	Unconfined Compression	Φ°	Pocket Penetrometer
Average	1472.4 psf	11.0	1250.0 psf
Mean	1354.0 psf	11.0	1125.0 psf
Std Dev	561.9 psf		670.8 psf
within 1 Std Dev	792.1 psf		454.2 psf
Low	744.0 psf	11.0	500.0 psf

use	C	
Stiff Clays (A-7-6, A-6)	**1500 psf**	(Layer 1)
Soft to Medium Stiff Clays (A-7-6)	**792 psf**	(Layer 2)
Very Stiff Clays (A-7-6, A-6)	**2000 psf**	(Layer 3)
	Φ	
	11 °	

Layer 1		
Boring No.	SPT N-value	PPR
C-22	3	1500
	23	4500
	15	1250
	10	2250
	14	
	20	2500
	17	4000
C-23	5	2250
	2	1250
	15	4500
	10	3750
B-1223	6	2750
	10	4500
TR-14	8	2250
	6	3750
	10	2750

Average	10.9	2916.7
Mean	10.0	2750.0
Std Dev	6.0	1171.3
within 1 Std Dev	4.0	1578.7
Low	2.0	1250.0
c (psf)	1359.4	1578.7
say	1500 psf	

Layer 3		
Boring No.	SPT N-value	PPR
C-22	18	1250
	32	
B-1223	12	500
	27	2000

Average	22.3	1250.0
Mean	22.5	1250.0
Std Dev	9.0	750.0
within 1 Std Dev	13.5	500.0
Low	12.0	500.0
c (psf)	2781.3	1250
say	2000 psf	

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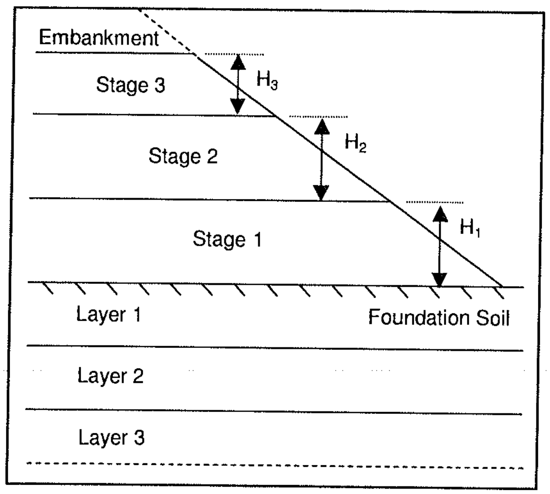
Project:	SCI-823 Portsmouth Bypass	Computed: JSA	Date: 17-Jul-09
Subject:	Roadway Embankments - Sta 536+50	Checked: DMV	Date: 7/18/09
Task:	Undrained Strength Analyses - Staged Construction	Page: 1 of 1	
Job #:	45878 (Dept. 212)	No:	

Reference: Ladd, Charles C. (1991). "Stability Evaluation During Staged Construction." *The Twenty-Second Karl Terzaghi* Lecture, Journal of Geotechical Engineering, ASCE, 114(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, psf

Φ_{cu} =

$\Delta\sigma'$ = 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 = 27 ft Average Percent Consolidation, U= 90%

Layer	Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	Δc_u (psf), After Consolidation	Percent Increase
1	0-14	A-7-6, A-6	1500	3038	11.0	590	2090	39%
2	14-42	A-7-6	792	3038	11.0	590	1382	75%
3	42-47	A-7-6, A-6	2000	3038	11.0	590	2590	30%

Stage 2 Embankment Second Stage Embankment Height, H_2 = 0 ft Average Percent Consolidation, U= 0%

Layer	Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	Δc_u (psf), After Consolidation	Percent Increase
1	0-14	A-7-6, A-6	2090	0	11.0	0	2090	0%
2	14-42	A-7-6	1382	0	11.0	0	1382	0%
3	42-47	A-7-6, A-6	2590	0	11.0	0	2590	0%

Stage 3 Embankment Third Stage Embankment Height, H_3 = ft Average Percent Consolidation, U= 0%

Layer	Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	Δc_u (psf), After Consolidation	Percent Increase
1	0-14	A-7-6, A-6	2090	0	0.0	0	2090	0%
2	14-42	A-7-6	1382	0	0.0	0	1382	0%
3	42-47	A-7-6, A-6	2590	0	0.0	0	2590	0%

Sta 536+50 - Stage 1 Undrained

SCI-823, CR 28 Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 536+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Right to Left

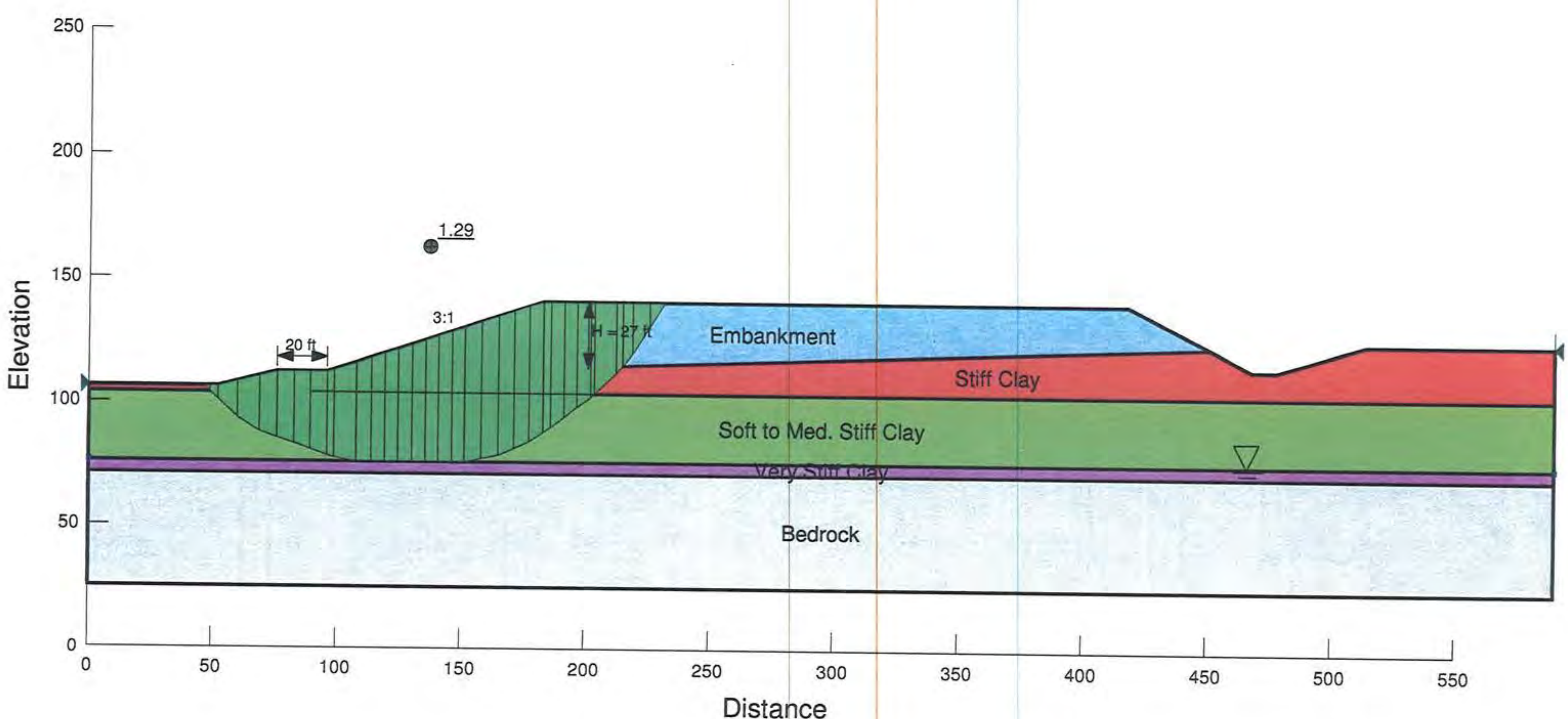
Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Stiff Clay
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 1500 psf
Piezometric Line: 1
Add Weight: No

Name: Very Stiff Clay
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 2000 psf
Piezometric Line: 1
Add Weight: No

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Soft to Med. Stiff Clay
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 792 psf
Piezometric Line: 1
Add Weight: No



Sta 536+50 - Stage 1 Drained

SCI-823, CR 28 Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 536+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Right to Left

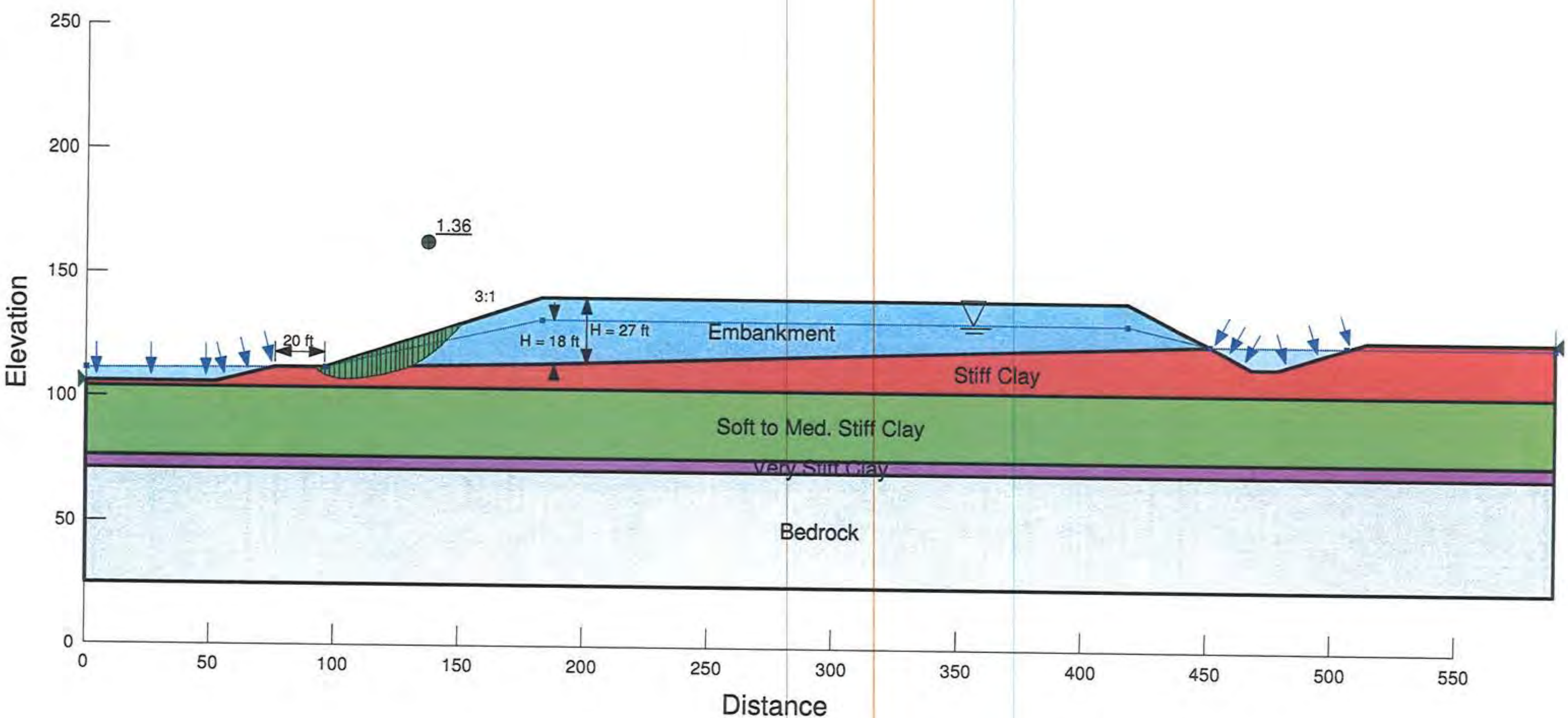
Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Soft to Med. Stiff Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 600 psf
Phi: 17 °
Piezometric Line: 1
Add Weight: No

Name: Stiff Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 29 °
Piezometric Line: 1
Add Weight: No

Name: Very Stiff Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °
Piezometric Line: 1
Add Weight: No



Sta 536+50 - Stage 2 Undrained

SCI-823, CR 28 Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 536+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Right to Left

$*_1 = \frac{2090 + 1500}{2} = 1795$ psf

$*_2 = \frac{1382 + 792}{2} = 1087$ psf

$*_3 = \frac{2590 + 2000}{2} = 2295$ psf

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Stiff Clay
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 2090 psf
Piezometric Line: 1
Add Weight: No

Name: Stiff Clay (2)
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 1795 psf $*_1$
Piezometric Line: 1
Add Weight: No

Name: Stiff Clay (3)
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 1500 psf
Piezometric Line: 1
Add Weight: No

Name: Soft to Med. Stiff Clay
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 1382 psf
Piezometric Line: 1
Add Weight: No

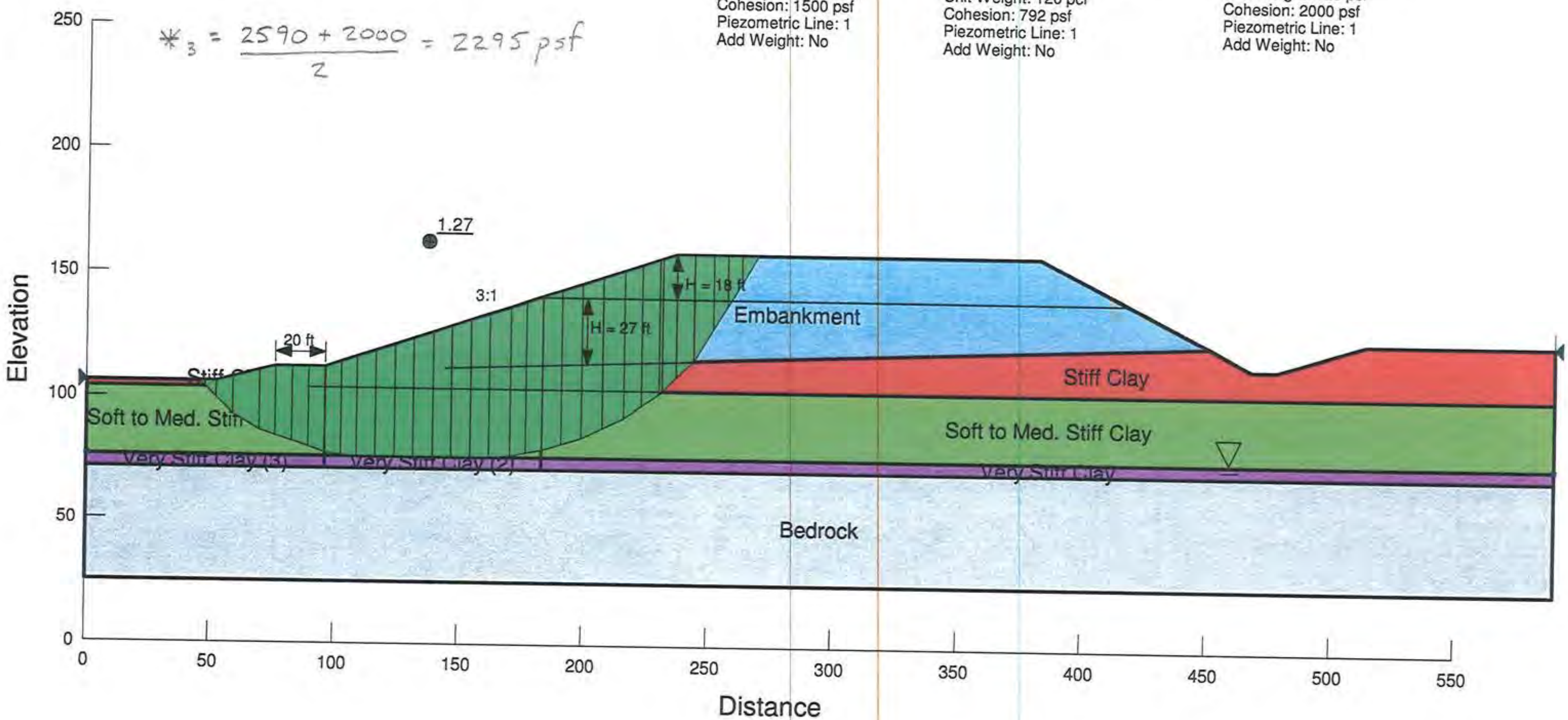
Name: Soft to Med. Stiff Clay (2)
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 1087 psf $*_2$
Piezometric Line: 1
Add Weight: No

Name: Soft to Med. Stiff Clay (3)
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 792 psf
Piezometric Line: 1
Add Weight: No

Name: Very Stiff Clay
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 2590 psf
Piezometric Line: 1
Add Weight: No

Name: Very Stiff Clay (2)
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 2295 psf $*_3$
Piezometric Line: 1
Add Weight: No

Name: Very Stiff Clay (3)
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 2000 psf
Piezometric Line: 1
Add Weight: No



Sta 536+50 - Stage 2 Drained

SCI-823, CR 28 Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 536+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Right to Left

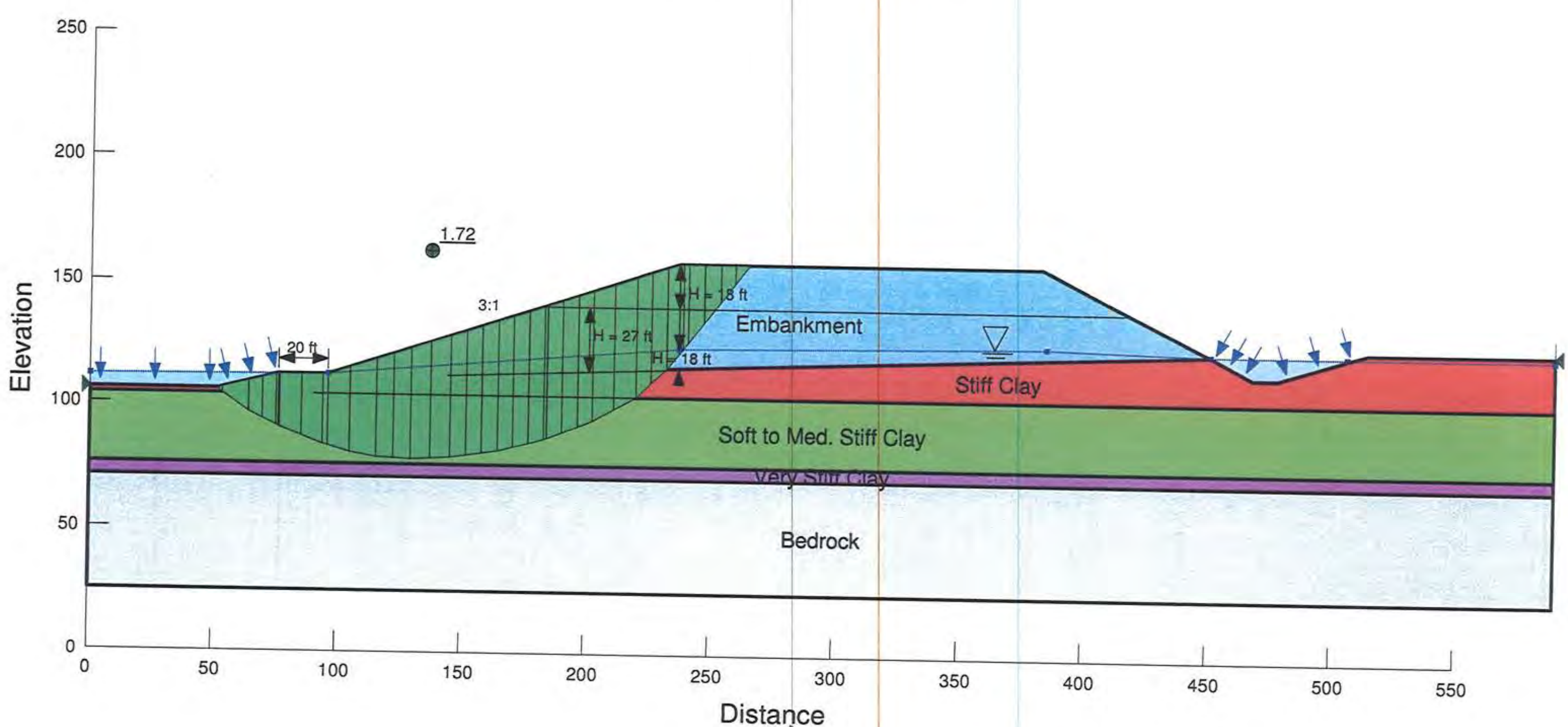
Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Soft to Med. Stiff Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 600 psf
Phi: 17 °
Piezometric Line: 1
Add Weight: No

Name: Stiff Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 29 °
Piezometric Line: 1
Add Weight: No

Name: Very Stiff Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °
Piezometric Line: 1
Add Weight: No



Sta 536+50 - Full Hieght Drained

SCI-823, CR 28 Interchange, Stability Analyses

Project Name: SCI-823
Description: STA 536+50
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Right to Left

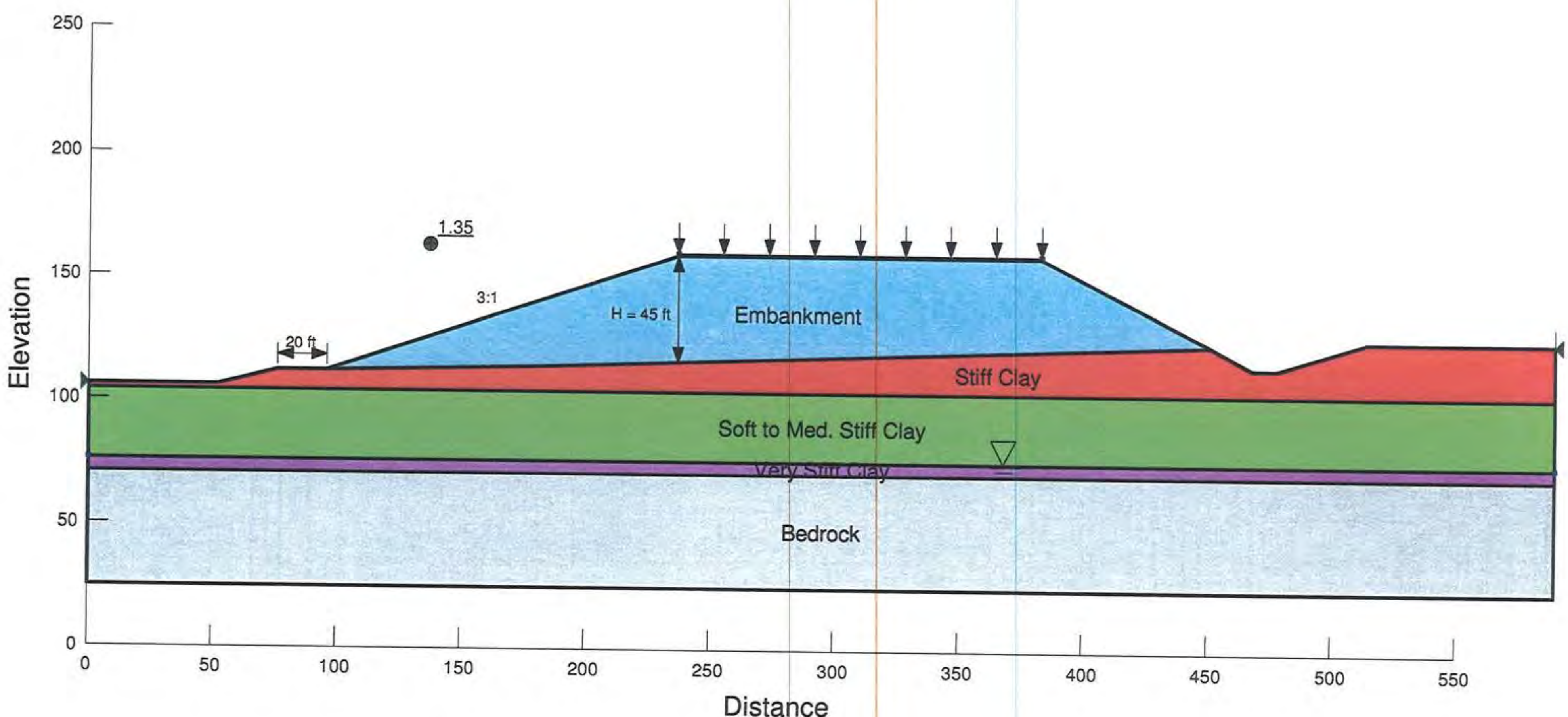
Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Soft to Med. Stiff Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 600 psf
Phi: 17 °
Piezometric Line: 1
Add Weight: No

Name: Stiff Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 29 °
Piezometric Line: 1
Add Weight: No

Name: Very Stiff Clay
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °
Piezometric Line: 1
Add Weight: No



Project:	SCI-823 Portsmouth Bypass	Computed:	JSA	Date:	17-Jul-09
Subject:	Roadway Embankments	Checked:	DMV	Date:	7/18/09
Task:	Infinite Slope Analyses	Page:	1 of 3		
Job #:	45878 (Dept. 212)	No:			

HDR | ONE COMPANY *Many Solutions*℠

References:

1.) EM 1110-2-1902 "Slope Stability", prepared by the US Army Corps of Engineers, 2003.

2.) Principles of Geotechnical Engineering, by Braja M. Das, 2002.

Assumptions:

1.) Groundwater level coincides with the existing ground surface.

Governing Equation:

$$F.S. = \frac{c'}{\gamma_{sat} H \cos^2\beta \tan\beta} + \frac{\gamma'}{\gamma_{sat}} \frac{\tan\phi'}{\tan\beta}$$

Ref. #2, Eq. 14.28

where,

F.S. = factor of safety with respect to strength

γ_{sat} = saturated unit weight of soil, pcf

γ' = effective unit weight of soil, pcf

Φ' = effective angle of internal friction, deg

c' = effective cohesion of soil, psf

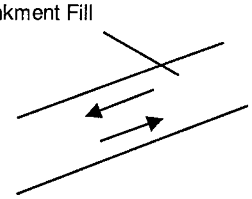
H = height of slope, ft

β = angle of slope, deg

Note: Derivation of equation 14.28 included on pages 2 and 3 (Based on Reference #2).

Factor of Safety Along New Embankment Fill.

New Embankment Fill



Case	Embankment Fill						
	γ_{sat} (pcf)	γ' (pcf)	Φ' (deg.)	c' (psf)	H (ft)	β (deg)	F.S.
2:1 Post Construction (No Seepage)	125	125	35	0	-	26.6	1.40
2.5:1 Post Construction (No Seepage)	125	125	35	0	-	21.8	1.75
3.0:1 Post Construction (No Seepage)	125	125	35	0	-	18.4	2.10

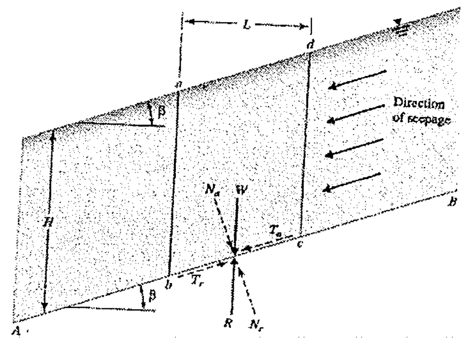
<u>The background theory for the infinite slope analyses with seepage pressures are provided below.</u>

Step 1: The shear strength of soil can be given by,

$$\tau_f = c' + \sigma' \tan\phi$$ *(eq 14.17)*

where,

c' = effective cohesion of soil
σ' = effective normal stress
Φ' = effective angle of internal friction



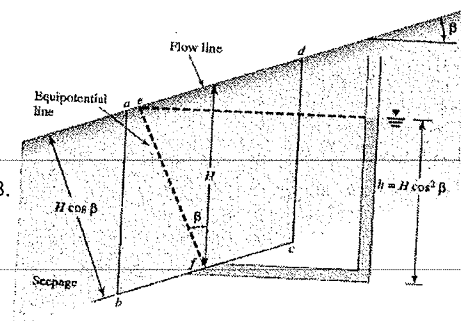
(a)

Step 2: Estimate total weight of the slope element.

$$W = \gamma_{sat} L H$$ *(Ref. #2, Eq 14.18)*

where,

W = total weight of slope element, lb/ft
γ_{sat} = saturated unit weight of soil, pcf
L = length of slope, ft
H = height of slope, ft



(b)

Step 3: Calculate the components of W in the directions normal and parallel to plane AB.

$$N_a = R\cos\beta = \gamma_{sat} L H \cos\beta$$ *(Ref. #2, Eq 14.19)*

and,

$$T_a = W\sin\beta = \gamma_{sat} L H \sin\beta$$ *(Ref. #2, Eq 14.20)*

Step 4: The reaction to the weight W is equal to R. Thus,

$$N_r = R\cos\beta = W\cos\beta = \gamma_{sat} L H \cos\beta$$ *(Ref. #2, Eq 14.21)*

and,

$$T_r = R\sin\beta = W\sin\beta = \gamma_{sat} L H \sin\beta$$ *(Ref. #2, Eq 14.22)*

Step 5: The total normal stress and the shear stress at the base of the element are, respectively,

$$\sigma = \frac{N_r}{\left(\dfrac{L}{\cos\beta}\right)} = \gamma_{sat} H \cos^2\beta$$ *(Ref. #2, Eq 14.23)*

and,

$$\tau = \frac{T_r}{\left(\dfrac{L}{\cos\beta}\right)} = \gamma_{sat} H \cos\beta \sin\beta$$ *(Ref. #2, Eq 14.24)*

Step 6: The resistive shear stress developed at the base of the element can also be given by,

$$\tau_d = c'_d + \sigma' \tan\phi_d = c'_d + (\sigma - u)\tan\phi'_d$$ *(Ref. #2, Eq 14.25)*

where,

u = pore water pressure, psf

Step 7: Pore water pressure can be defined as,

$$u = (Height\_of\_water\_in\_piezometer\_placed\_at\_f)(\gamma_w) = h\gamma_w$$

and,

$$h = \overline{ef}\cos\beta = (H\cos\beta)(\cos\beta) = H\cos^2\beta$$

so,

$$u = \gamma_w H\cos^2\beta$$

Step 8: Substituting values of σ (Eq. 14.23) and u into Eq. 14.25), we get

$$\tau_d = c'_d + (\gamma_{sat} H\cos^2\beta - \gamma_w H\cos^2\beta)\tan\phi'_d = c'_d + \gamma' H\cos^2\beta\tan\phi'_d$$ *(Ref. #2, Eq 14.26)*

Step 9: Now, setting the right-hand sides of Eqs. 14.24 and 14.26 equal to each other gives,

$$\gamma_{sat} H\cos\beta\sin\beta = c'_d + \gamma' H\cos^2\beta\tan\phi'_d$$

or,

$$\frac{c'_d}{\gamma_{sat}H} = \cos^2\beta(\tan\beta - \frac{\gamma'}{\gamma_{sat}}\tan\phi'_d)$$ *(Ref. #2, Eq 14.27)*

where,

$\gamma' = \gamma_{sat} - \gamma_w$ effective unit weight of soil, pcf.

Step 10: The factor of safety with respect to strength can be found by substituting $\tan\Phi'_d = (\tan\Phi')/F_s$ and $c'_d = c'/F_s$ into Eq. 14.27

$$\boxed{F.S. = \frac{c'}{\gamma_{sat}H\cos^2\beta\tan\beta} + \frac{\gamma'}{\gamma_{sat}}\frac{\tan\phi'}{\tan\beta}}$$ *(Ref. #2, Eq 14.28)*

Sta ...+00 - Undrained

SCI-823, Stability Analyses

Project Name: SCI-823
Description: STA 459+00
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right

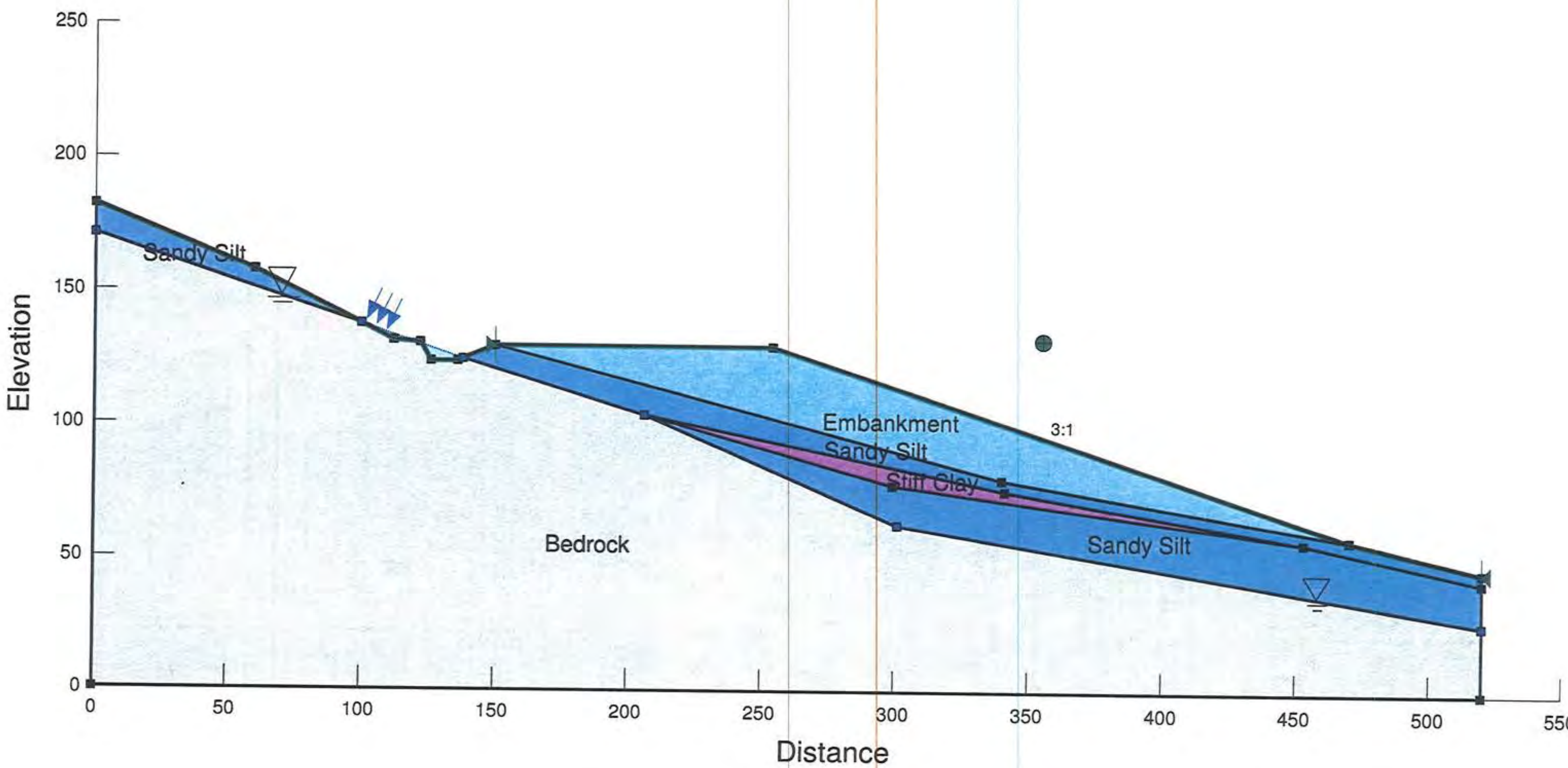
INPUT

Name: Bedrock
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 3500 psf
Phi: 45 °
Piezometric Line: 1
Add Weight: No

Name: Embankment
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Piezometric Line: 1
Add Weight: No

Name: Stiff Clay
Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 1500 psf
Piezometric Line: 1
Add Weight: No

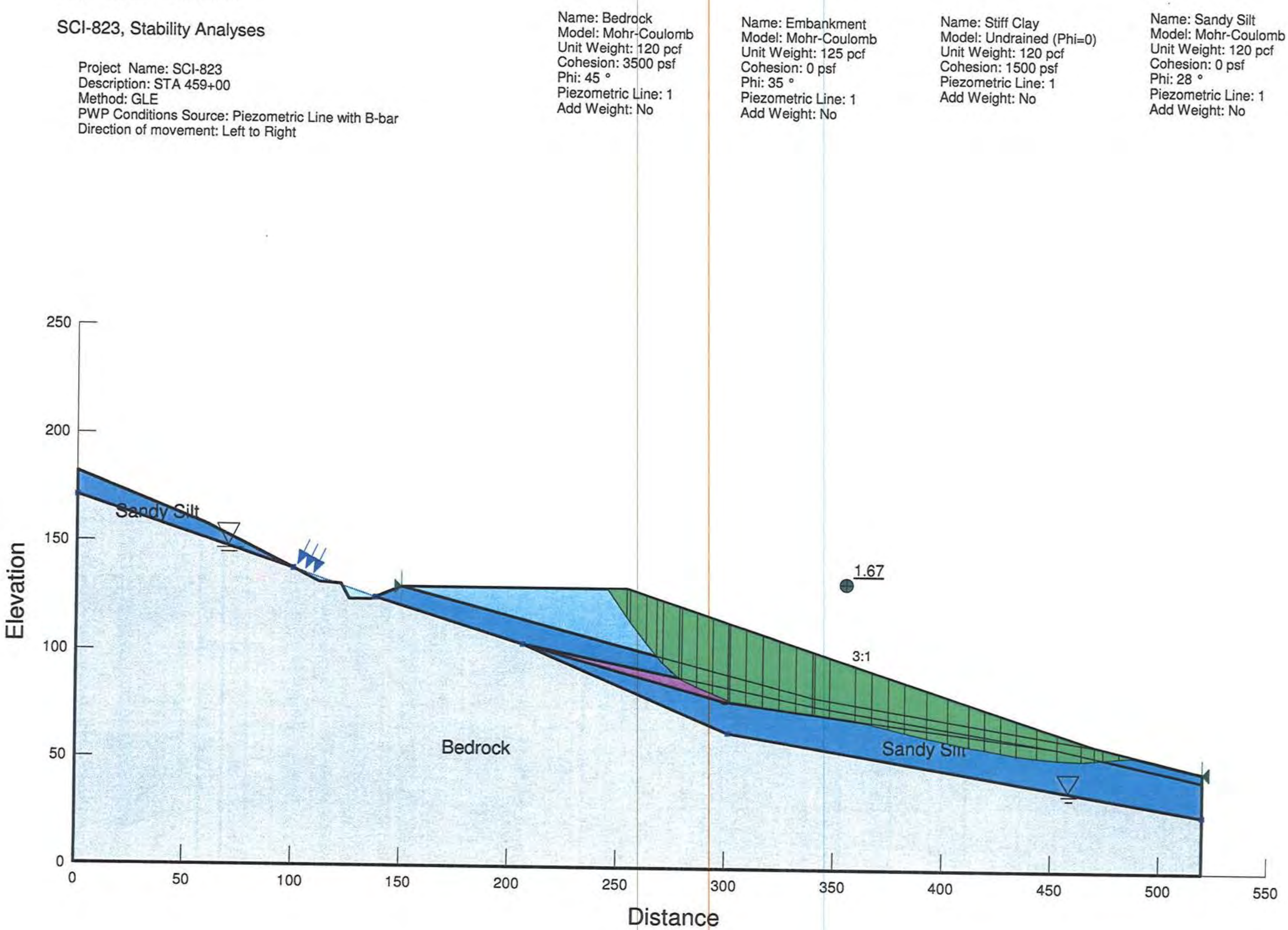
Name: Sandy Silt
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 28 °
Piezometric Line: 1
Add Weight: No



Sta ȷ+00 - Undrained

SCI-823, Stability Analyses

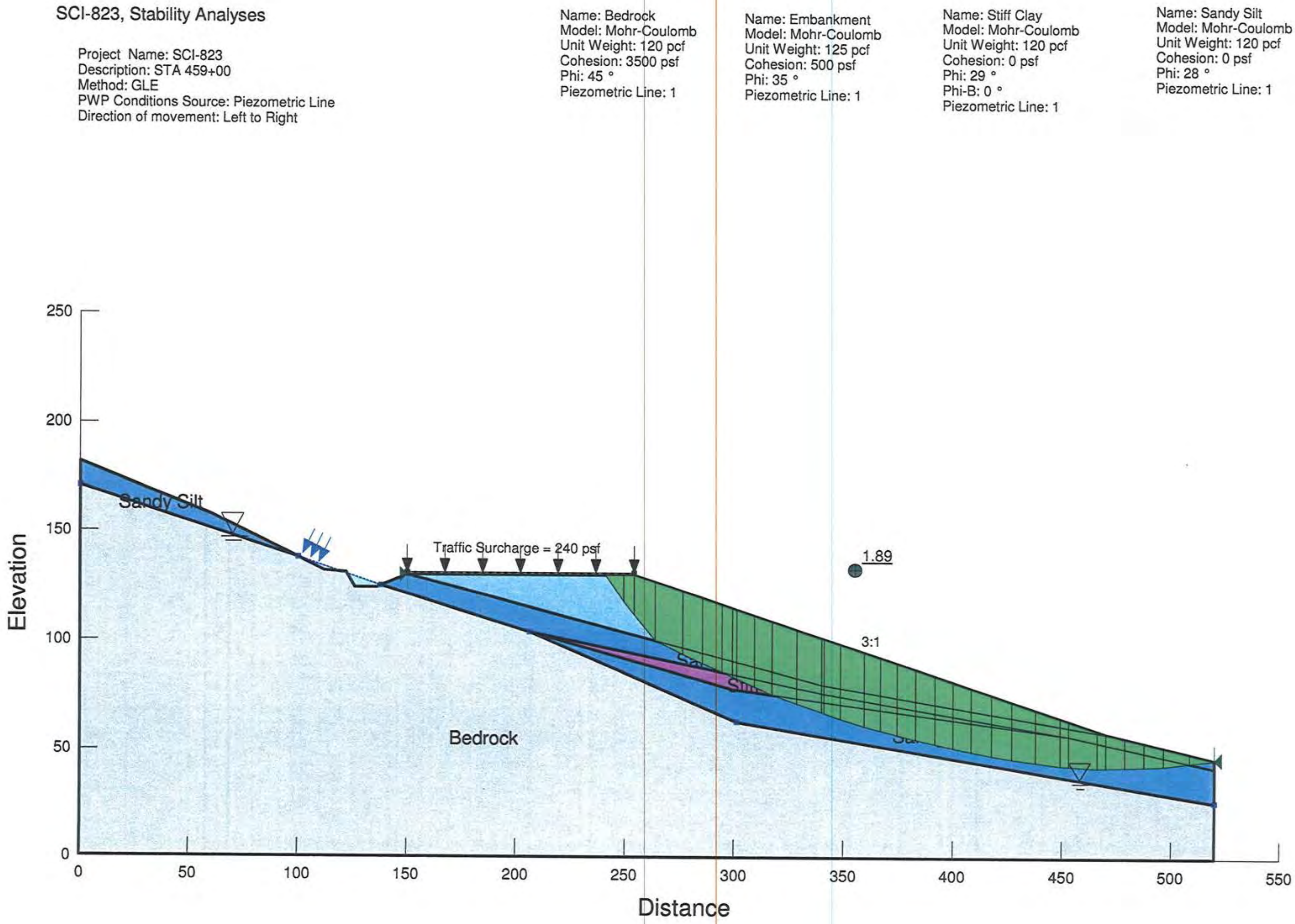
Project Name: SCI-823
Description: STA 459+00
Method: GLE
PWP Conditions Source: Piezometric Line with B-bar
Direction of movement: Left to Right



Sta ,+00 - Drained

SCI-823, Stability Analyses

Project Name: SCI-823
Description: STA 459+00
Method: GLE
PWP Conditions Source: Piezometric Line
Direction of movement: Left to Right



Appendix B
Embankment Settlement

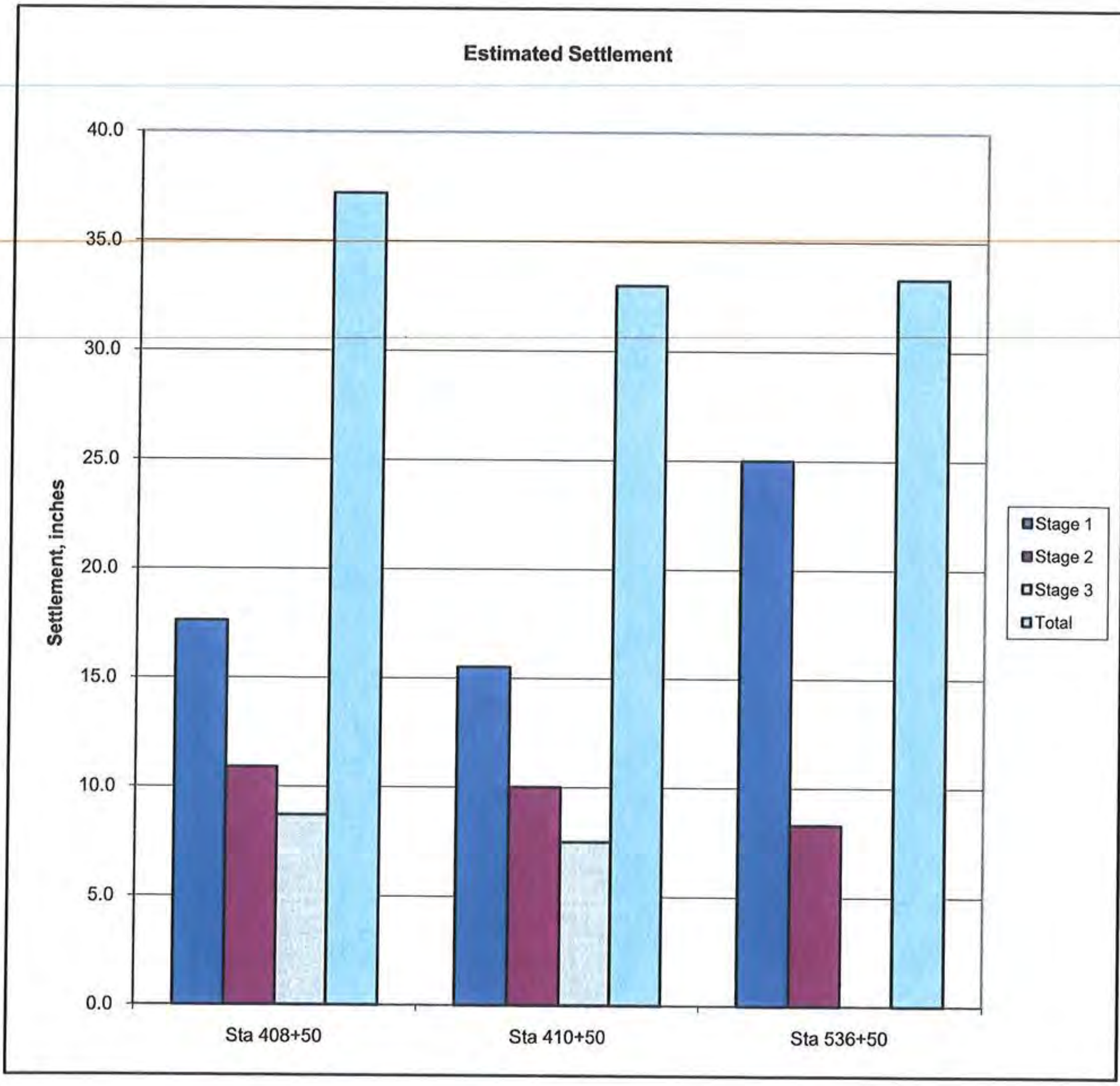
Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Roadway Embankments	Checked	DMV	Date	7/18/09
Task	Summary of Estimated Primary Consolidation Settlement	Sheet	1	Of	1

	Full Height	Stage 1	Stage 2	Stage 3	Total	Difference
Sta 408+50	40.8	17.6	10.9	8.7	37.2	-9%
Sta 410+50	30.1	15.5	10.0	7.5	33.0	10%
Sta 536+50	34.5	25.0	8.3	-	33.3	-3%

Note: All values in inches.



Job No. 000000000045878 | PID No. 19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed JSA	Date 7/17/2009
Subject	Sta 408+50	Checked DMV	Date 7/18/09
Task	Estimate Full Height Consolidation Settlement	Sheet 1	Of 2

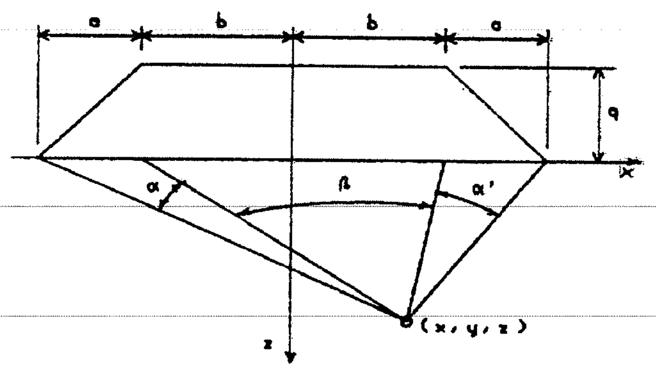
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	37	ft	
Embankment Height:	H =	78	ft	
Fill Unit Weight:	γ_{emb} =	125	pcf	*q* = 9750 psf
Surcharge:	P =	240	psf	
Width of Slope:	a =	234	ft	*3:1 Slope*
Top half-width of Emb.:	b =	65	ft	
Distance from CL:	x =	0	ft	
Output Range:	z =	0	to	47 ft
Drainage:		Single		

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot \left(\alpha(z) + \alpha'(z)\right) + x \cdot \left(\left(\alpha(z) - \alpha'(z)\right)\right)$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Clay	12	6	0.1	0.1	3.0	9634.8	240	9874.8
2	Clay	24	18	0.2	0.2	2.6	9404.1	240	9644.1
3	Clay	37	30.5	0.3	0.3	2.3	9162.8	240	9402.8
4	Silt & Clay	47	42	0.4	0.4	2.0	8940.2	240	9180.2
5									
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 408+50	Checked	DMV	Date	7/18/09
Task	Estimate Full Height Consolidation Settlement	Sheet	2	Of	2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c < \sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_c'}{\sigma_0'} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_c'} \right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c[1]	C_r[1]	e_o[1]	S
1	Clay	12	125	750	9875	10625	3600	0.350	0.120	1.060	1.434
2	Clay	24	125	2250	9644	11894	10800	0.350	0.120	1.060	0.562
3	Clay	37	125	3813	9403	13215	18300	0.350	0.120	1.060	0.409
4	Silt & Clay	47	62.6	4938	9180	14118	4938	0.470	0.170	1.157	0.994
5											
6											
7											
8											
9											
10											

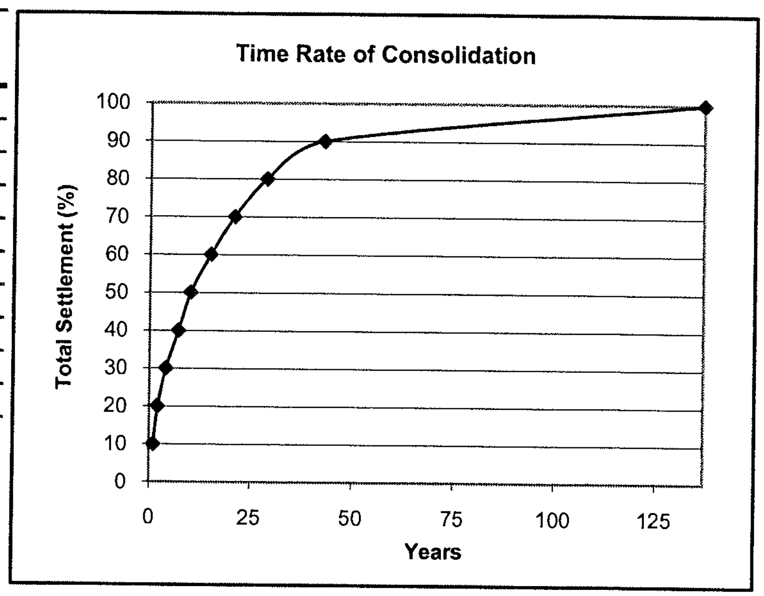
1. Parameters based on DLZ Interchange Report & Addendum.
2. Stratigraphy and Water Table Elev. based on boring R-341
3. σ'_c is based on average (from lab testing) OCR = 4.8 for Clay and 1.0 for Silt & Clay, respectively.

	3.399	ft
Total Settlement	**40.8**	in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft²/day)	Time (Years)
10	0.01	47	0.12	1
20	0.03	47	0.12	2
30	0.07	47	0.12	4
40	0.13	47	0.12	7
50	0.20	47	0.12	10
60	0.29	47	0.12	15
70	0.40	47	0.12	21
80	0.57	47	0.12	29
90	0.85	47	0.12	43
99.9	2.71	47	0.12	137

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 408+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 1 Consolidation Settlement	Sheet	1	Of	2

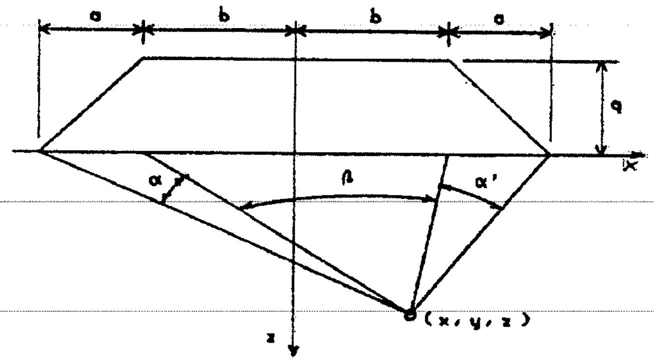
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	37	ft		
Embankment Height:	H =	26	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	3250 psf
Surcharge:	P =	0	psf		
Width of Slope:	a =	78	ft	*3:1 Slope*	
Top half-width of Emb.:	b =	216	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	47	ft
Drainage:	Single				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Clay	12	6	0.0	0.0	3.1	3211.0	0	3211.0
2	Clay	24	18	0.0	0.0	3.0	3133.0	0	3133.0
3	Clay	37	30.5	0.0	0.0	2.9	3052.1	0	3052.1
4	Silt & Clay	47	42	0.1	0.1	2.8	2978.1	0	2978.1
5									
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 408+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 1 Consolidation Settlement	Sheet	2	Of	2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma_0'}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c < \sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_c}{\sigma_0'}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'}\right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c[(1)]	C_r[(1)]	e_o[(1)]	S
1	Clay	12	125	750	3211	3961	3600	0.350	0.120	1.060	0.561
2	Clay	24	125	2250	3133	5383	10800	0.350	0.120	1.060	0.265
3	Clay	37	125	3813	3052	6865	18300	0.350	0.120	1.060	0.193
4	Silt & Clay	47	62.6	4938	2978	7916	4938	0.470	0.170	1.157	0.447
5											
6											
7											
8											
9											
10											

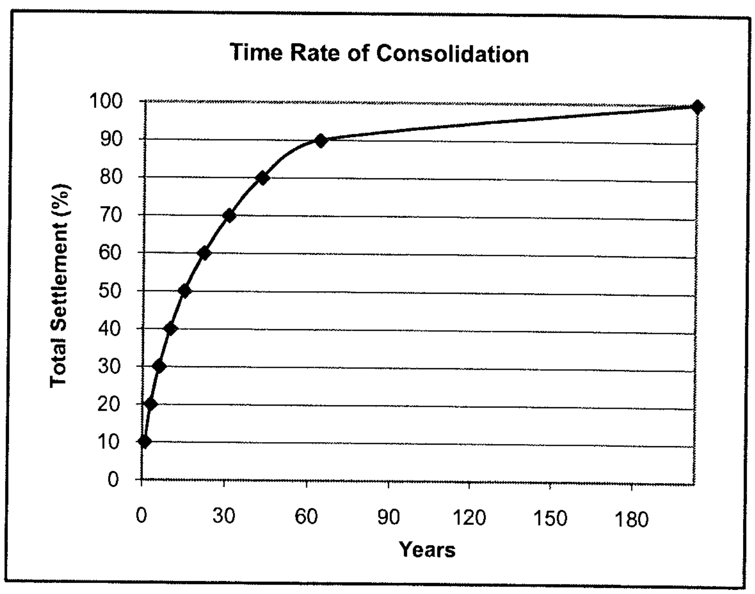
1. Parameters based on DLZ Interchange Report & Addendum.
2. Stratigraphy and Water Table Elev. based on boring R-341
3. σ'_c is based on average (from lab testing) OCR = 4.8 for Clay and 1.0 for Silt & Clay, respectively.

Total Stage 1 Settlement **1.466** ft **17.6** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (Years)
10	0.01	47	0.081	1
20	0.03	47	0.081	3
30	0.07	47	0.081	6
40	0.13	47	0.081	10
50	0.20	47	0.081	15
60	0.29	47	0.081	22
70	0.40	47	0.081	31
80	0.57	47	0.081	43
90	0.85	47	0.081	64
99.9	2.71	47	0.081	203

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 408+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 2 Consolidation Settlement	Sheet	1	Of	2

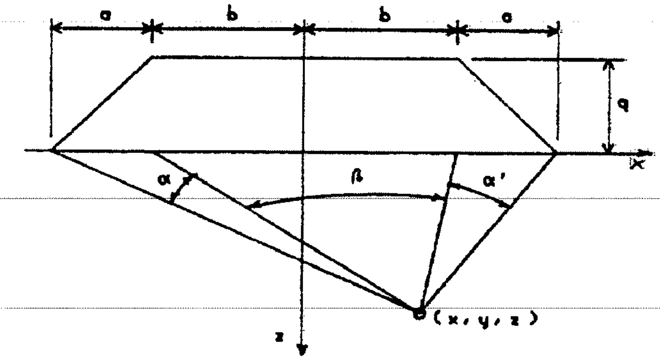
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	0	ft	
Embankment Height:	H =	25	ft	
Fill Unit Weight:	γ_{emb} =	125	pcf	q = 3125 psf
Surcharge:	P =	0	psf	
Width of Slope:	a =	75	ft	*3:1 Slope*
Top half-width of Emb.:	b =	141	ft	
Distance from CL:	x =	0	ft	
Output Range:	z =	0	to	47 ft
Drainage:		Single		

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Clay	12	32	0.1	0.1	2.7	2853.9	0	2853.9
2	Clay	24	44	0.1	0.1	2.5	2753.8	0	2753.8
3	Clay	37	56.5	0.1	0.1	2.4	2651.3	0	2651.3
4	Silt & Clay	47	68	0.1	0.1	2.2	2558.9	0	2558.9
5									
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 408+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 2 Consolidation Settlement	Sheet	2	Of	2

Normally Consolidated Soil

$$S = \sum\left[\frac{C_c}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c$)

$$S = \sum\left[\frac{C_r}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_f}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f$)

$$S = \sum\left[\frac{C_r}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_c}{\sigma_0'}\right)+\frac{C_c}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma_f'}{\sigma_c'}\right)\right]$$

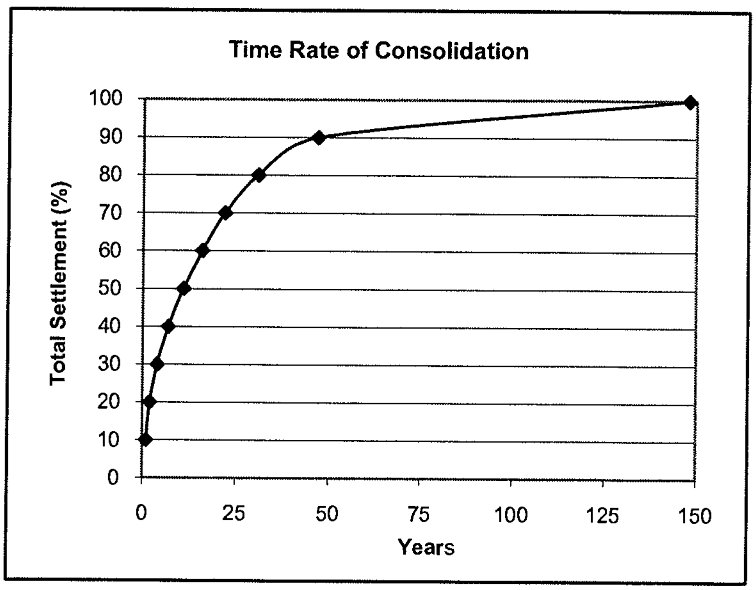
Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	Clay	12	62.6	3626	2854	6479	3961	0.350	0.120	1.060	0.463
2	Clay	24	62.6	4377	2754	7131	10800	0.350	0.120	1.060	0.148
3	Clay	37	62.6	5159	2651	7811	18300	0.350	0.120	1.060	0.136
4	Silt & Clay	47	62.6	5879	2559	8438	7916	0.470	0.170	1.157	0.162
5											
6											
7											
8											
9											
10											

1. Parameters based on DLZ Interchange Report & Addendum. — **0.909** ft
2. Water Table Elev. assumed at ground surface (excess pore pressure) — **Total Stage 2 Settlement** **10.9** in
3. σ'_c is based on greater of max past pressure prior to embankment construction (see Stage 1) & initial stress after placing previous lift(s). — **Total Cumulative Settlement** **28.5** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (Years)
10	0.01	47	0.111	1
20	0.03	47	0.111	2
30	0.07	47	0.111	4
40	0.13	47	0.111	7
50	0.20	47	0.111	11
60	0.29	47	0.111	16
70	0.40	47	0.111	22
80	0.57	47	0.111	31
90	0.85	47	0.111	47
99.9	2.71	47	0.111	148

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Job No. 000000000045878 | PID No. 19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 408+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 3 Consolidation Settlement	Sheet	1	Of	2

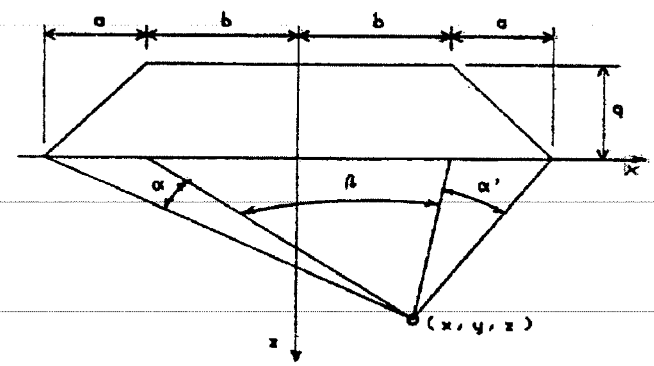
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	0	ft		
Embankment Height:	H =	27	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	3375 psf
Surcharge:	P =	240	psf		
Width of Slope:	a =	81	ft	*3:1 Slope*	
Top half-width of Emb.:	b =	65	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	47	ft
Drainage:	Single				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Clay	12	57	0.3	0.3	1.7	2620.5	240	2860.5
2	Clay	24	69	0.4	0.4	1.5	2475.0	240	2715.0
3	Clay	37	81.5	0.4	0.4	1.3	2331.6	240	2571.6
4	Silt & Clay	47	93	0.4	0.4	1.2	2207.5	240	2447.5
5									
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 408+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 3 Consolidation Settlement	Sheet	2	Of	2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_c}{\sigma_0'}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'}\right)\right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	Clay	12	62.6	6751	2860	9611	6479	0.350	0.120	1.060	0.313
2	Clay	24	62.6	7502	2715	10217	10800	0.350	0.120	1.060	0.094
3	Clay	37	62.6	8284	2572	10856	18300	0.350	0.120	1.060	0.089
4	Silt & Clay	47	62.6	9004	2448	11452	8438	0.470	0.170	1.157	0.228
5											
6											
7											
8											
9											
10											

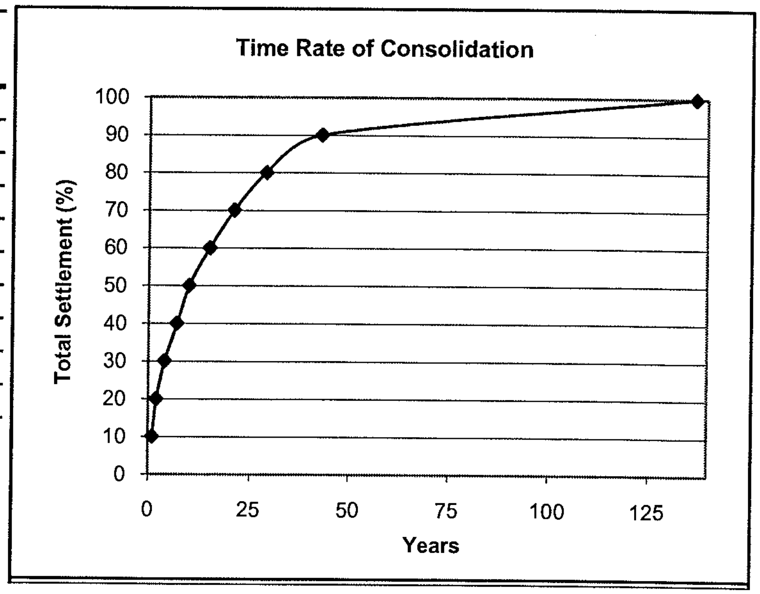
1. Parameters based on DLZ Interchange Report & Addendum.
2. Water Table Elev. assumed above ground surface (excess pore pressure)
3. σ'_c is based on greater of max past pressure prior to embankment construction (see Stage 1) & initial stress after placing previous lift(s).

	0.723	ft
Total Stage 3 Settlement	**8.7**	in
Total Cumulative Settlement	**37.2**	in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (Years)
10	0.01	47	0.12	1
20	0.03	47	0.12	2
30	0.07	47	0.12	4
40	0.13	47	0.12	7
50	0.20	47	0.12	10
60	0.29	47	0.12	15
70	0.40	47	0.12	21
80	0.57	47	0.12	29
90	0.85	47	0.12	43
99.9	2.71	47	0.12	137

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 410+50	Checked	DMV	Date	7/18/09
Task	Estimate Full Height Consolidation Settlement	Sheet	1	Of	2

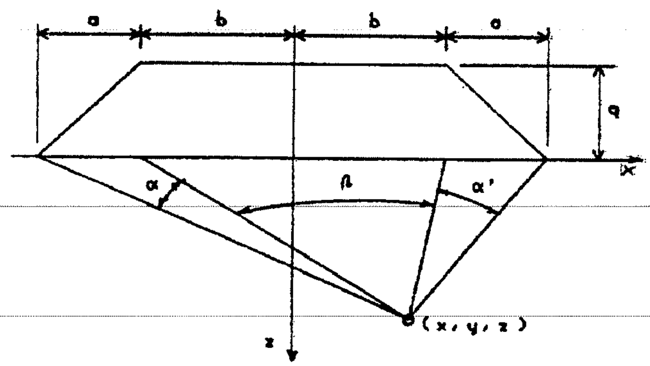
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	35	ft		
Embankment Height:	H =	80	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	10000 psf
Surcharge:	P =	240	psf		
Width of Slope:	a =	240	ft	*3:1 Slope*	
Top half-width of Emb.:	b =	52	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	45	ft
Drainage:		Single			

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Clay	11	5.5	0.1	0.1	2.9	9889.1	240	10129.1
2	Clay	23	17	0.3	0.3	2.5	9656.6	240	9896.6
3	Clay	35	29	0.4	0.4	2.1	9412.4	240	9652.4
4	Clay	41	38	0.5	0.5	1.9	9228.3	240	9468.3
5	Silt & Clay	45	43	0.5	0.5	1.8	9125.9	240	9365.9
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 410+50	Checked	DMV	Date	7/18/09
Task	Estimate Full Height Consolidation Settlement	Sheet	2	Of	2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_c'}{\sigma_0'}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'}\right)\right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (3) (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	Clay	11	125	688	10129	10817	3300	0.350	0.120	1.060	1.400
2	Clay	23	125	2125	9897	12022	10200	0.350	0.120	1.060	0.622
3	Clay	35	125	3625	9652	13277	17400	0.350	0.120	1.060	0.197
4	Clay	41	62.6	4563	9468	14031	21901	0.350	0.120	1.060	0.085
5	Silt & Clay	45	62.6	4876	9366	14242	4876	0.470	0.170	1.157	0.203
6											
7											
8											
9											
10											

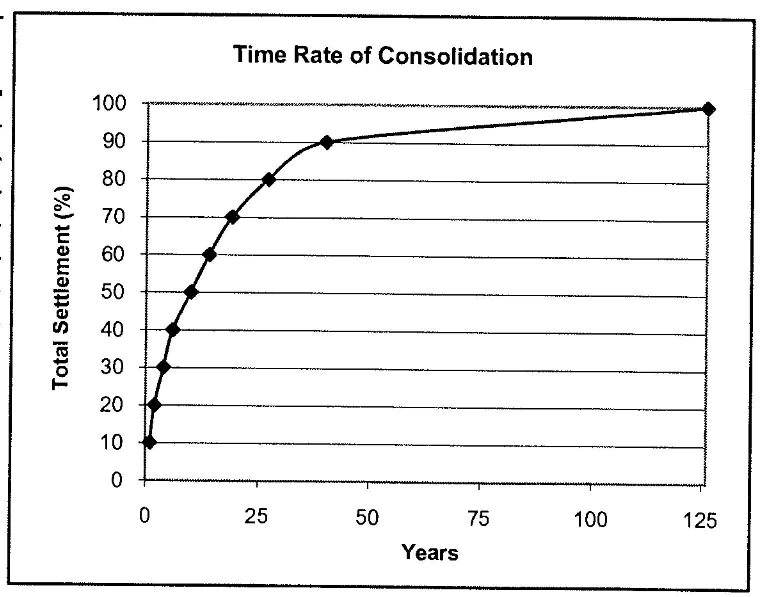
1. Parameters based on DLZ Interchange Report & Addendum.
2. Stratigraphy and Water Table Elev. based on borings R-345 & R-346.
3. σ'_c is based on average (from lab testing) OCR = 4.8 for Clay and 1.0 for Silt & Clay, respectively.

Total Settlement **2.507** ft / **30.1** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (Years)
10	0.01	45	0.12	1
20	0.03	45	0.12	2
30	0.07	45	0.12	4
40	0.13	45	0.12	6
50	0.20	45	0.12	10
60	0.29	45	0.12	14
70	0.40	45	0.12	19
80	0.57	45	0.12	27
90	0.85	45	0.12	40
99.9	2.71	45	0.12	126

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



HDR Computation

Project: SCI-823-0.00/6.81 Portsmouth Bypass	Computed: JSA	Date: 7/17/2009	
Subject: Sta 410+50	Checked: DMV	Date: 7/18/09	
Task: Estimate Stage 1 Consolidation Settlement	Sheet: 1	Of: 2	

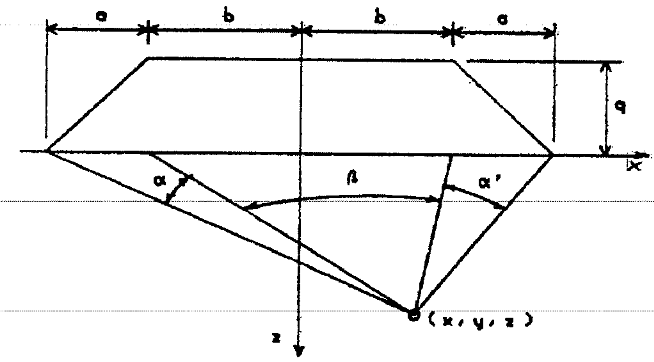
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table: D = 35 ft
Embankment Height: H = 26 ft
Fill Unit Weight: γ_{emb} = 125 pcf q = 3250 psf
Surcharge: P = 0 psf
Width of Slope: a = 78 ft   *3:1 Slope*
Top half-width of Emb.: b = 216 ft
Distance from CL: x = 0 ft
Output Range: z = 0 to 45 ft
Drainage: Single

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Clay	11	5.5	0.0	0.0	3.1	3214.2	0	3214.2
2	Clay	23	17	0.0	0.0	3.0	3139.5	0	3139.5
3	Clay	35	29	0.0	0.0	2.9	3061.8	0	3061.8
4	Clay	41	38	0.0	0.0	2.8	3003.8	0	3003.8
5	Silt & Clay	45	43	0.1	0.1	2.7	2971.7	0	2971.7
6									
7									
8									
9									
10									

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed JSA	Date 7/17/2009
Subject	Sta 410+50	Checked DMV	Date 7/18/09
Task	Estimate Stage 1 Consolidation Settlement	Sheet 2	Of 2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c < \sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_c'}{\sigma_0'} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_c'} \right) \right]$$

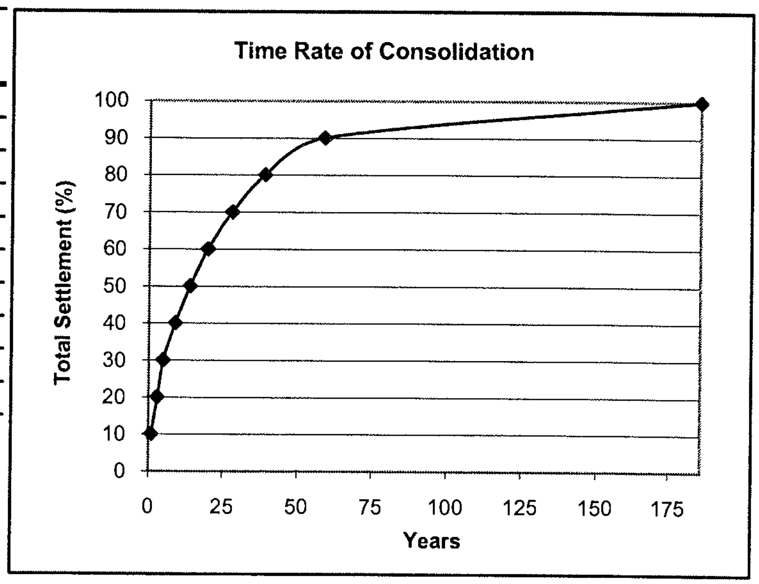
Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (3) (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	Clay	11	125	688	3214	3902	3300	0.350	0.120	1.060	0.572
2	Clay	23	125	2125	3139	5264	10200	0.350	0.120	1.060	0.275
3	Clay	35	125	3625	3062	6687	17400	0.350	0.120	1.060	0.186
4	Clay	41	62.6	4563	3004	7567	21901	0.350	0.120	1.060	0.077
5	Silt & Clay	45	62.6	4876	2972	7847	4876	0.470	0.170	1.157	0.180
6											
7											
8											
9											
10											

1. Parameters based on DLZ Interchange Report & Addendum. **1.291** ft
2. Stratigraphy and Water Table Elev. based on borings R-345 & R-346. **Total Stage 1 Settlement** **15.5** in
3. σ'_c is based on average (from lab testing) OCR = 4.8 for Clay and 1.0 for Silt & Clay, respectively.

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft²/day)	Time (Years)
10	0.01	45	0.081	1
20	0.03	45	0.081	3
30	0.07	45	0.081	5
40	0.13	45	0.081	9
50	0.20	45	0.081	14
60	0.29	45	0.081	20
70	0.40	45	0.081	28
80	0.57	45	0.081	39
90	0.85	45	0.081	59
99.9	2.71	45	0.081	186

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Job No. 000000000045878 | PID No. 19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed JSA	Date 7/17/2009
Subject	Sta 410+50	Checked DMV	Date 7/18/09
Task	Estimate Stage 2 Consolidation Settlement	Sheet 1	Of 2

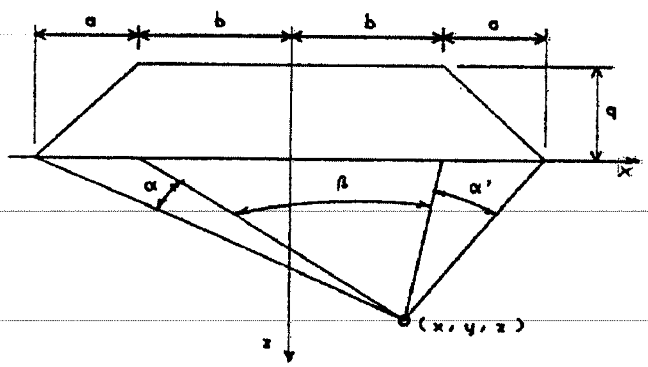
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	0	ft	
Embankment Height:	H =	25	ft	
Fill Unit Weight:	γ_{emb} =	125	pcf	q = 3125 psf
Surcharge:	P =	0	psf	
Width of Slope:	a =	75	ft	*3:1 Slope*
Top half-width of Emb.:	b =	141	ft	
Distance from CL:	x =	0	ft	
Output Range:	z =	0	to	45 ft
Drainage:	Single			

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Clay	11	31.5	0.1	0.1	2.7	2858.0	0	2858.0
2	Clay	23	43	0.1	0.1	2.5	2762.1	0	2762.1
3	Clay	35	55	0.1	0.1	2.4	2663.5	0	2663.5
4	Clay	41	64	0.1	0.1	2.3	2590.9	0	2590.9
5	Silt & Clay	45	69	0.1	0.1	2.2	2551.0	0	2551.0
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 410+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 2 Consolidation Settlement	Sheet	2	Of	2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_c}{\sigma_0'} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'} \right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (3) (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	Clay	11	62.6	3594	2858	6452	3902	0.350	0.120	1.060	0.431
2	Clay	23	62.6	4314	2762	7076	10200	0.350	0.120	1.060	0.150
3	Clay	35	62.6	5065	2664	7729	17400	0.350	0.120	1.060	0.128
4	Clay	41	62.6	5629	2591	8220	21901	0.350	0.120	1.060	0.057
5	Silt & Clay	45	62.6	5942	2551	8493	7847	0.470	0.170	1.157	0.068
6											
7											
8											
9											
10											

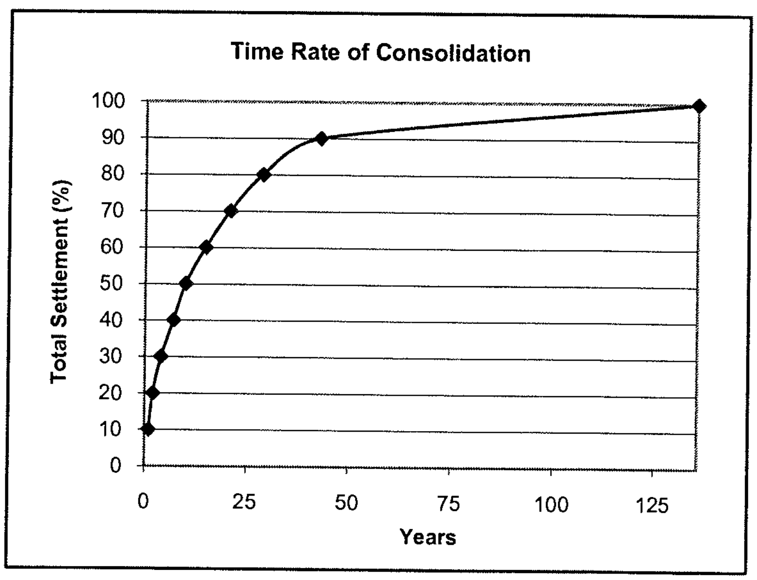
1. Parameters based on DLZ Interchange Report & Addendum.
2. Water Table Elev. assumed at ground surface (excess pore pressure)
3. σ'_c is based on greater of max past pressure prior to embankment construction (see Stage 1) & initial stress after placing previous lift(s).

	0.835	ft
Total Stage 2 Settlement	**10.0**	in
Total Cumulative Settlement	**25.5**	in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft²/day)	Time (Years)
10	0.01	45	0.111	1
20	0.03	45	0.111	2
30	0.07	45	0.111	4
40	0.13	45	0.111	7
50	0.20	45	0.111	10
60	0.29	45	0.111	15
70	0.40	45	0.111	21
80	0.57	45	0.111	29
90	0.85	45	0.111	43
99.9	2.71	45	0.111	136

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 410+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 3 Consolidation Settlement	Sheet	1	Of	2

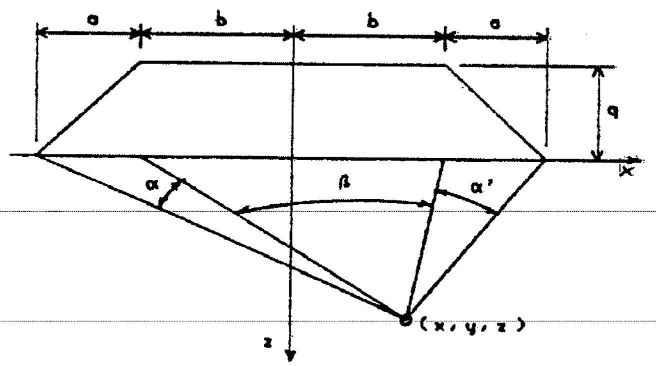
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	0	ft		
Embankment Height:	H =	29	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	3625 psf
Surcharge:	P =	240	psf		
Width of Slope:	a =	87	ft	*3:1 Slope*	
Top half-width of Emb.:	b =	52	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	45	ft
Drainage:	Single				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Clay	11	56.5	0.4	0.4	1.5	2779.9	240	3019.9
2	Clay	23	68	0.5	0.5	1.3	2623.2	240	2863.2
3	Clay	35	80	0.5	0.5	1.2	2468.9	240	2708.9
4	Clay	41	89	0.5	0.5	1.1	2359.8	240	2599.8
5	Silt & Clay	45	94	0.5	0.5	1.0	2301.8	240	2541.8
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 410+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 3 Consolidation Settlement	Sheet	2	Of	2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_c'}{\sigma_0'}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'}\right)\right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (3) (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	Clay	11	62.6	6719	3020	9739	6452	0.350	0.120	1.060	0.301
2	Clay	23	62.6	7439	2863	10302	10200	0.350	0.120	1.060	0.105
3	Clay	35	62.6	8190	2709	10899	17400	0.350	0.120	1.060	0.087
4	Clay	41	62.6	8754	2600	11354	21901	0.350	0.120	1.060	0.039
5	Silt & Clay	45	62.6	9067	2542	11609	8493	0.470	0.170	1.157	0.094
6											
7											
8											
9											
10											

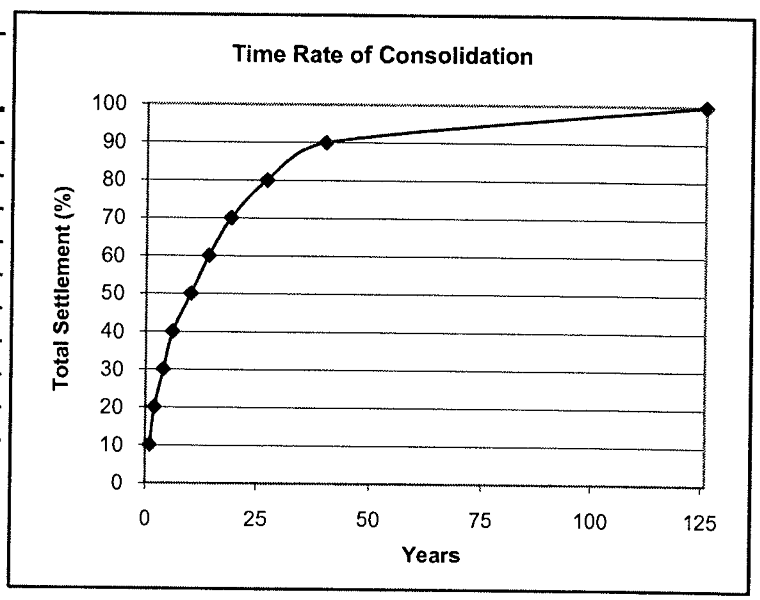
1. Parameters based on DLZ Interchange Report & Addendum.
2. Water Table Elev. assumed at ground surface (excess pore pressure)
3. σ'_c is based on greater of max past pressure prior to embankment construction (see Stage 1) & initial stress after placing previous lift(s).

	0.626	ft
Total Stage 3 Settlement	**7.5**	in
Total Cumulative Settlement	**33.0**	in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft²/day)	Time (Years)
10	0.01	45	0.12	1
20	0.03	45	0.12	2
30	0.07	45	0.12	4
40	0.13	45	0.12	6
50	0.20	45	0.12	10
60	0.29	45	0.12	14
70	0.40	45	0.12	19
80	0.57	45	0.12	27
90	0.85	45	0.12	40
99.9	2.71	45	0.12	126

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Job No. 000000000045878	PID No. 19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed JSA	Date 7/17/2009
Subject	Sta 536+50	Checked DMV	Date 7/18/09
Task	Estimate Full Height Consolidation Settlement	Sheet 1	Of 2

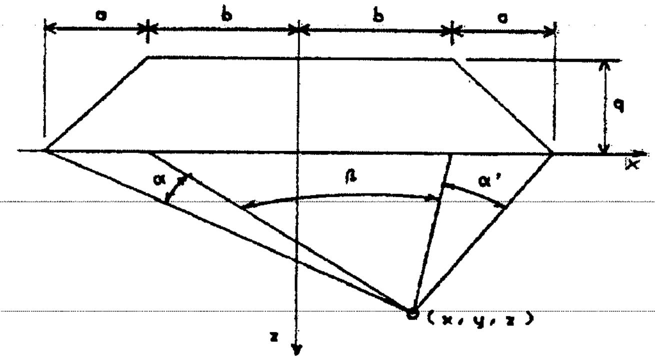
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	42	ft		
Embankment Height:	H =	45	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	5625 psf
Surcharge:	P =	240	psf		
Width of Slope:	a =	135	ft	*3:1 Slope*	
Top half-width of Emb.:	b =	74	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	47	ft
Drainage:	Single				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Stiff Clay	14	7	0.1	0.1	3.0	5514.1	240	5754.1
2	Soft to Med. Stiff Clay	28	21	0.2	0.2	2.6	5292.5	240	5532.5
3	Soft to Med. Stiff Clay	42	35	0.3	0.3	2.3	5071.7	240	5311.7
4	Very Stiff Clay	47	44.5	0.3	0.3	2.1	4922.8	240	5162.8
5									
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 536+50	Checked	DMV	Date	7/18/09
Task	Estimate Full Height Consolidation Settlement	Sheet	2	Of	2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_c}{\sigma_0'}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'}\right)\right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	Stiff Clay	14	120	840	5754	6594	1092	0.270	0.100	0.790	1.738
2	Soft to Med. Stiff Clay	28	120	2520	5532	8052	12096	0.370	0.160	1.124	0.532
3	Soft to Med. Stiff Clay	42	120	4200	5312	9512	20160	0.370	0.160	1.124	0.374
4	Very Stiff Clay	47	57.6	5184	5163	10347	5184	0.270	0.100	0.790	0.226
5											
6											
7											
8											
9											
10											

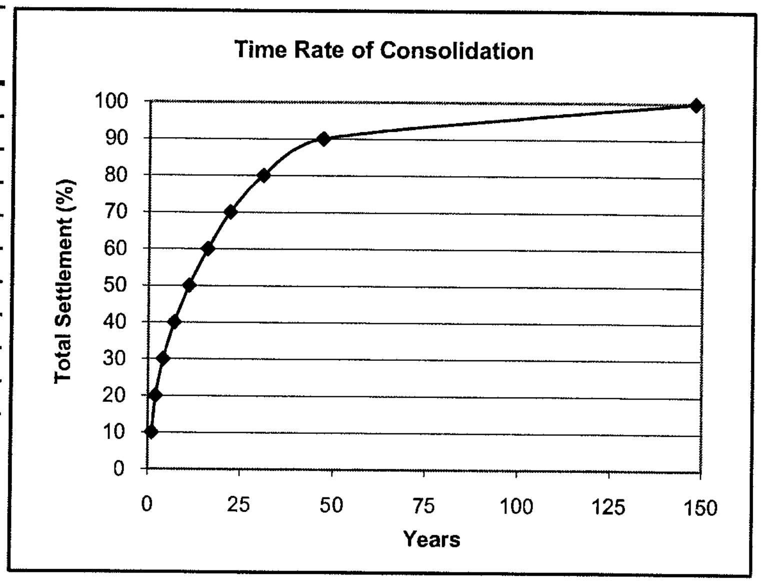
1. Parameters based on DLZ Interchange Report & Addendum.
2. Stratigraphy and Water Table Elev. based on borings C-22, C-23 and B-1223
3. σ'_c is based on average (from lab testing) OCR = 1.3 for Stiff Clay, 4.8 for Soft to Med. Stiff Clay and 1.0 for Very Stiff Clay.

Total Settlement **2.871** ft / **34.5** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (Years)
10	0.01	47	0.111	1
20	0.03	47	0.111	2
30	0.07	47	0.111	4
40	0.13	47	0.111	7
50	0.20	47	0.111	11
60	0.29	47	0.111	16
70	0.40	47	0.111	22
80	0.57	47	0.111	31
90	0.85	47	0.111	47
99.9	2.71	47	0.111	148

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 536+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 1 Consolidation Settlement	Sheet	1	Of	2

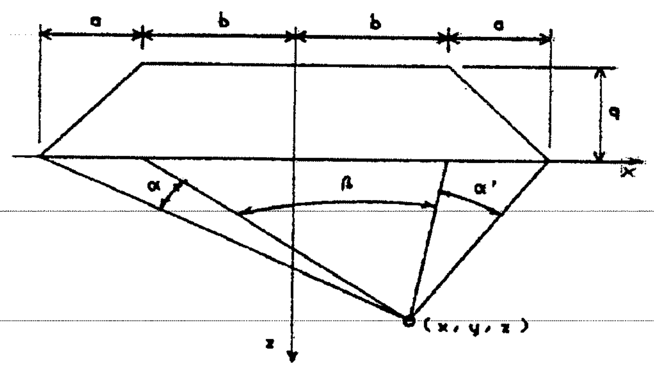
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	42	ft		
Embankment Height:	H =	27	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	3375 psf
Surcharge:	P =	0	psf		
Width of Slope:	a =	81	ft	*3:1 Slope*	
Top half-width of Emb.:	b =	114	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	47	ft
Drainage:	Single				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Stiff Clay	14	7	0.0	0.0	3.0	3303.7	0	3303.7
2	Soft to Med. Stiff Clay	28	21	0.1	0.1	2.8	3161.6	0	3161.6
3	Soft to Med. Stiff Clay	42	35	0.1	0.1	2.5	3020.8	0	3020.8
4	Very Stiff Clay	47	44.5	0.1	0.1	2.4	2926.6	0	2926.6
5									
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed JSA	Date 7/17/2009
Subject	Sta 536+50	Checked DMV	Date 7/18/09
Task	Estimate Stage 1 Consolidation Settlement	Sheet 2	Of 2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_c}{\sigma_0'}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'}\right)\right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	Stiff Clay	14	120	840	3304	4144	1092	0.270	0.100	0.790	1.312
2	Soft to Med. Stiff Clay	28	120	2520	3162	5682	12096	0.370	0.160	1.124	0.372
3	Soft to Med. Stiff Clay	42	120	4200	3021	7221	20160	0.370	0.160	1.124	0.248
4	Very Stiff Clay	47	57.6	5184	2927	8111	5184	0.270	0.100	0.790	0.147
5											
6											
7											
8											
9											
10											

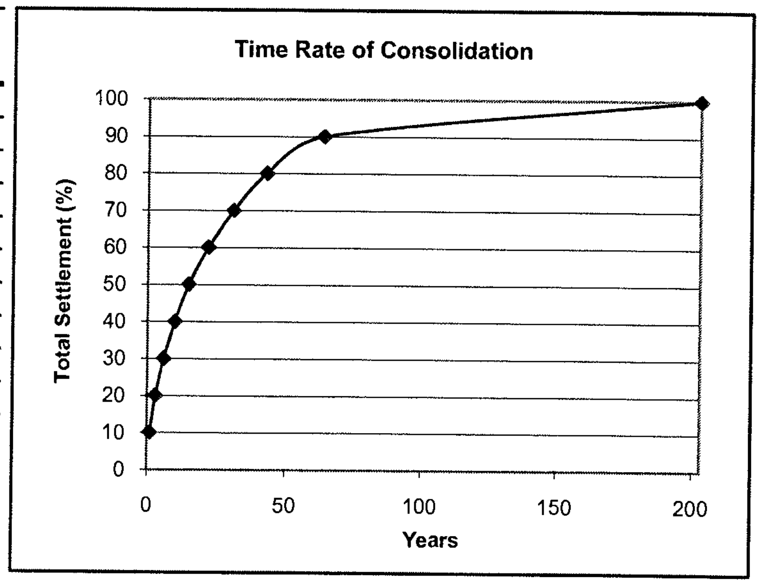
1. Parameters based on DLZ Interchange Report & Addendum.
2. Stratigraphy and Water Table Elev. based on borings C-22, C-23 and B-1223
3. σ'_c is based on average (from lab testing) OCR = 1.3 for Stiff Clay, 4.8 for Soft to Med. Stiff Clay and 1.0 for Very Stiff Clay.

Total Stage 1 Settlement **2.079** ft **25.0** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft²/day)	Time (Years)
10	0.01	47	0.081	1
20	0.03	47	0.081	3
30	0.07	47	0.081	6
40	0.13	47	0.081	10
50	0.20	47	0.081	15
60	0.29	47	0.081	22
70	0.40	47	0.081	31
80	0.57	47	0.081	43
90	0.85	47	0.081	64
99.9	2.71	47	0.081	203

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 536+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 2 Consolidation Settlement	Sheet	1	Of	2

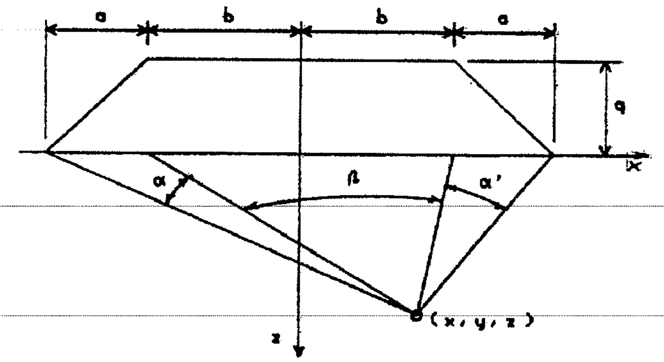
References:

1. EM 1110-1-1904 "Settlement Analyses"
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimmensional consolidation theory applies.

Stress Due to Additional Fill (Embankment)



Groundwater Table:	D =	0	ft		
Embankment Height:	H =	18	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	2250 psf
Surcharge:	P =	240	psf		
Width of Slope:	a =	54	ft	*3:1 Slope*	
Top half-width of Emb.:	b =	74	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	47	ft
Drainage:	Single				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot (\alpha(z) + \beta(z) + \alpha'(z))\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	Stiff Clay	14	34	0.2	0.2	2.3	1903.4	240	2143.4
2	Soft to Med. Stiff Clay	28	48	0.2	0.2	2.0	1768.2	240	2008.2
3	Soft to Med. Stiff Clay	42	62	0.2	0.2	1.7	1640.3	240	1880.3
4	Very Stiff Clay	47	71.5	0.3	0.3	1.6	1558.6	240	1798.6
5									
6									
7									
8									
9									
10									

Job No.	000000000045878	PID No.	19415

HDR Computation

Project	SCI-823-0.00/6.81 Portsmouth Bypass	Computed	JSA	Date	7/17/2009
Subject	Sta 536+50	Checked	DMV	Date	7/18/09
Task	Estimate Stage 2 Consolidation Settlement	Sheet	2	Of	2

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_c'}{\sigma_0'} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'} \right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c(1)	C_r(1)	e_o(1)	S
1	Stiff Clay	14	57.6	3778	2143	5922	4144	0.270	0.100	0.790	0.359
2	Soft to Med. Stiff Clay	28	57.6	4585	2008	6593	12096	0.370	0.160	1.124	0.166
3	Soft to Med. Stiff Clay	42	57.6	5391	1880	7271	20160	0.370	0.160	1.124	0.137
4	Very Stiff Clay	47	57.6	5938	1799	7737	8111	0.270	0.100	0.790	0.032
5											
6											
7											
8											
9											
10											

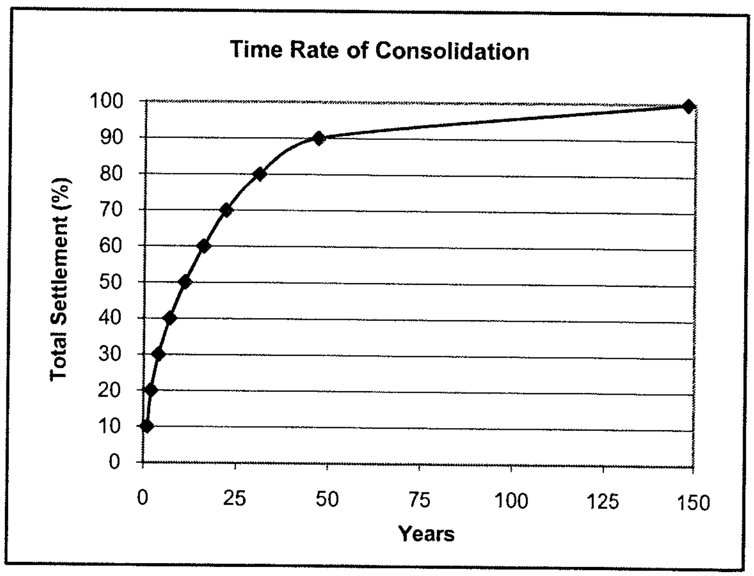
1. Parameters based on DLZ Interchange Report & Addendum.
2. Water Table Elev. assumed at ground surface (excess pore pressure)
3. σ'_c is based on greater of max past pressure prior to embankment construction (see Stage 1) & initial stress after placing previous lift.

	0.694	ft
Total Stage 2 Settlement	**8.3**	in
Total Cumulative Settlement	**33.3**	in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft²/day)	Time (Years)
10	0.01	47	0.111	1
20	0.03	47	0.111	2
30	0.07	47	0.111	4
40	0.13	47	0.111	7
50	0.20	47	0.111	11
60	0.29	47	0.111	16
70	0.40	47	0.111	22
80	0.57	47	0.111	31
90	0.85	47	0.111	47
99.9	2.71	47	0.111	148

1. Assume Single Drainage
2. C_v based on laboratory testing at Borings B-1 & B-2.



Determination of Overconsolidation Ratio

Boring	Depth (ft)	Classification	Unit Weight (pcf)	σv (psf)	Pc (tsf)	Pc (psf)	OCR
B-1220	19	A-6b	128	2432	1.66	3320	1.365132
B-1221	11	A-7-6	125.5	1380.5	1.15	2300	1.666063
B-1223	9	A-7-6	122.2	1099.8	0.89	1780	1.618476
B-1223	19	A-7-6	115.7	2198.3	5.4	10800	4.912887
R-464	22	A-7-6	118.7	2611.4	20.22	40440	15.48595
R-465	19	A-7-6	118	2242	6.18	12360	5.512935
R-466	19.5	A-7-6	118.7	2314.65	7.95	15900	6.869289
R-466	24	A-7-6	124	2976	1.94	3880	1.303763
TR-14	14	A-7-6	116.9	1636.6	7.28	14560	8.896493
B-1	18.55	A-7-6	120.8555556	2241.871	0.74	1480	0.660163
B-2	7	A-7-6	120.8555556	845.9889	0.7	1400	1.654868
B-2	12.5	A-7-6	120.8555556	1510.694	3.18	6360	4.209984
B-1318	19.5	A-7-6	120.8555556	2356.683	5.46	10920	4.633631
B-1322	29.5	A-7-6	120.8555556	3565.239	1.79	3580	1.00414
C-19	17.5	A-7-6	120.8555556	2114.972	4.15	8300	3.924401
C-21	22.35	A-6a	120.8555556	2701.122	0.8	1600	0.592347
R-329	12	A-7-6	120.8555556	1450.267	0.8	1600	1.103245
R-335	14	A-6a	120.8555556	1691.978	2	4000	2.364097
R-343	14	A-7-6	120.8555556	1691.978	1	2000	1.182049
R-351	23	A-7-6	120.8555556	2779.678	5.41	10820	3.892538

120.8555556 Average of soil unit weight

(light blue) unit weight as determined by laboratory testing
(yellow) OCR > 3
(blue) OCR < 3

	OCR
Average	3.64
Mean	2.02
Std Dev	3.60

	OCR > 3	Removing OCR = 15.49
Average	6.48	5.36
Mean	4.91	4.77
Std Dev	3.75	1.74

	OCR < 3
Average	1.32
Mean	1.30
Std Dev	0.50

Recommendations:		OCR
	Clay (Sta. 408+50 & Sta. 410+50)	4.8
	Silt & Clay (Sta. 408+50 & Sta. 410+50)	1
	Stiff Clay (Sta. 536+50)	1.3
	Soft to Medium Stiff Clay (Sta. 536+50)	4.8
	Very Stiff Clay (Sta. 536+50)	1

} apply to initial stress σ_o prior to placement of embankment fill

Appendix C
Wick Drains

HDR Computation

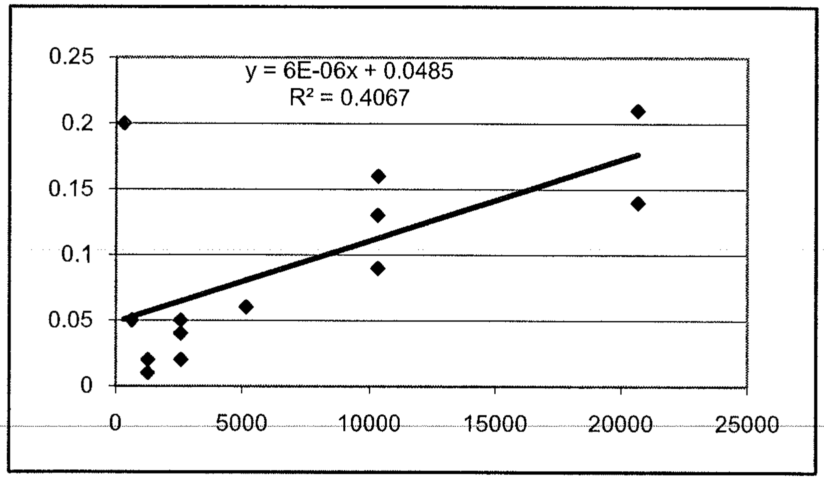
Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Mainline Embankment	Checked	JSA	Date	7/29/09
Task	Determine Coefficient Consolidation for Vertical Drainage (Cv)	Sheet	1	Of	1

References:

1. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

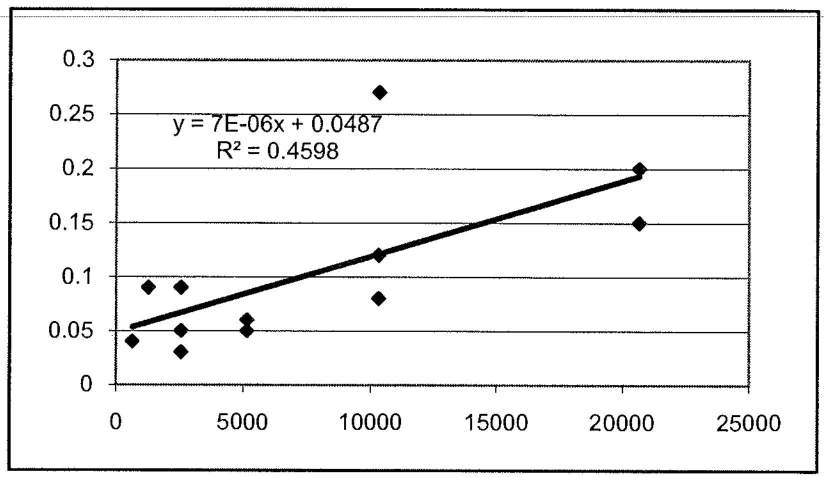
B-1

	Load (psf)	Cv
1	324	0.2
2	646	0.05
3	1292	0.02
4	2584	0.05
5	10336	0.13
6	20672	0.21
7	10336	0.16
8	2584	0.04
9	1292	0.01
10	2584	0.02
11	5168	0.06
12	10336	0.09
13	20672	0.14



B-2

	Load (psf)	Cv
1	324	1.38
2	646	0.04
4	2584	0.09
6	10336	0.12
7	20672	0.2
8	10336	0.27
9	5168	0.05
10	2584	0.03
12	1292	0.09
13	2584	0.05
14	5168	0.06
15	10336	0.08
16	20672	0.15



From Undrained Shear Strength Analysis - Staged Construction SR 823 Mainline Embankment (DLZ, 2008)

H_{comp}	=	40	ft	*Height Compressible Layer*
γ_{soil}	=	120	pcf	*Unit Weight of Compressible Soil*
γ_{fill}	=	125	pcf	*Unit Weight of Fill*
H_1	=	26	ft	*Stage 1 Fill Lift Height*
H_2	=	25	ft	*Stage 2 Fill Lift Height*
H_3	=	29	ft	*Stage 3 Fill Lift Height*

σ_{v0}	=	$\gamma*(H_{comp}/2)$ =	2400	psf	*Initial Stress at Midpoint of Compressible Layer*
σ_{F1}	=	$\sigma_{v0} + H_1*\gamma_{fill}$ =	5650	psf	*Stress at Midpoint of Compressible Layer after placement of Stage 1 Fill.*
σ_{F2}	=	$\sigma_{F1} + H_2*\gamma_{fill}$ =	8775	psf	*Stress at Midpoint of Compressible Layer after placement of Stage 2 Fill.*
σ_{F3}	=	$\sigma_{F2} + H_3*\gamma_{fill}$ =	12400	psf	*Stress at Midpoint of Compressible Layer after placement of Stage 3 Fill.*

Based on Consolidation Testing on B-1 & B-2 and the estimated load due to additional Stage 1, Stage 2 & Stage 3 fill

c_v = 0.0853 ft^2/day *after placing Stage 1 Fill*

c_v = 0.1056 ft^2/day *after placing Stage 2 Fill*

c_v = 0.1202 ft^2/day *after placing Stage 3 Fill*

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 1 - South of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	108,315	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	257	day	available time to achieve desired degree of consolidation U_h
H =	13	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.085	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.102	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: $c_h = 1.2$ to $1.5*c_v$
-If layering of silt and sand in discontinuous lenses is evident: $c_h = 2$ to $4*c_v$
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to $10*c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
$U = U_v$ = 90 %
T_v = 0.848

t = 1686 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 257 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.13
U_v = 0.41

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.83

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 1 - South of TR 234	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet 2	Of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

t = 257 day — available time to achieve desired degree of consolidation U_h

$\bar{U}_h$ = 0.83 — average degree of consolidation due to horizontal drainage

c_h = 0.102 ft^2/day — coefficient of consolidation for horizontal drainage

$F(n)$ = 2.65321 — drain spacing factor

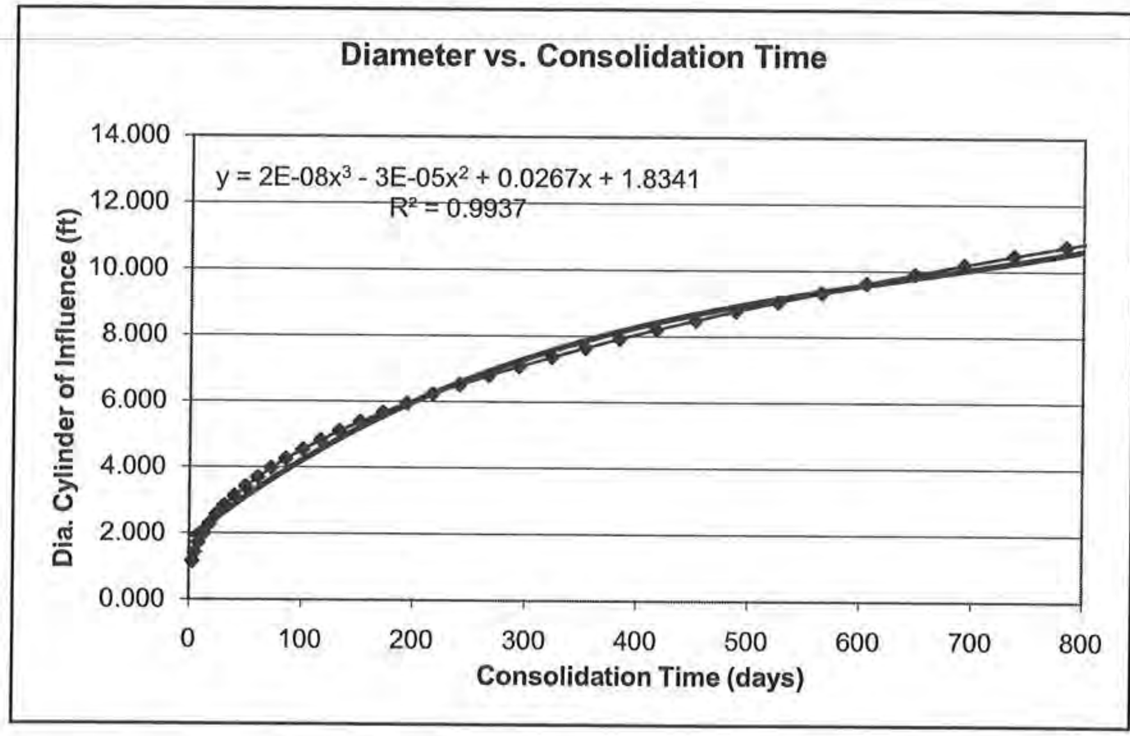
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.781086 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.00 ft**

Length Outer Edge of Equilateral Triangle (or square) = 500.14 ft

Number Drain Spaces Along Outer Edge = 83.34 ea

Total number wick drains = 3600 ea

Total linear feet wick drain = 54000 lf

Estimated total cost = **$27,000.00**

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 1 - South of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	108,315	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	208	day	available time to achieve desired degree of consolidation U_h
H =	13	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.105	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.126	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: c_h = 1.2 to 1.5*c_v
-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
U = U_v = 90 %
T_v = 0.848

t = 1365 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 208 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.13
U_v = 0.41

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.83

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 1 - South of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t = 208 day — available time to achieve desired degree of consolidation U_h

$\overline{U}_h$ = 0.83 — average degree of consolidation due to horizontal drainage

c_h = 0.126 ft^2/day — coefficient of consolidation for horizontal drainage

F(n) = 2.653016 — drain spacing factor

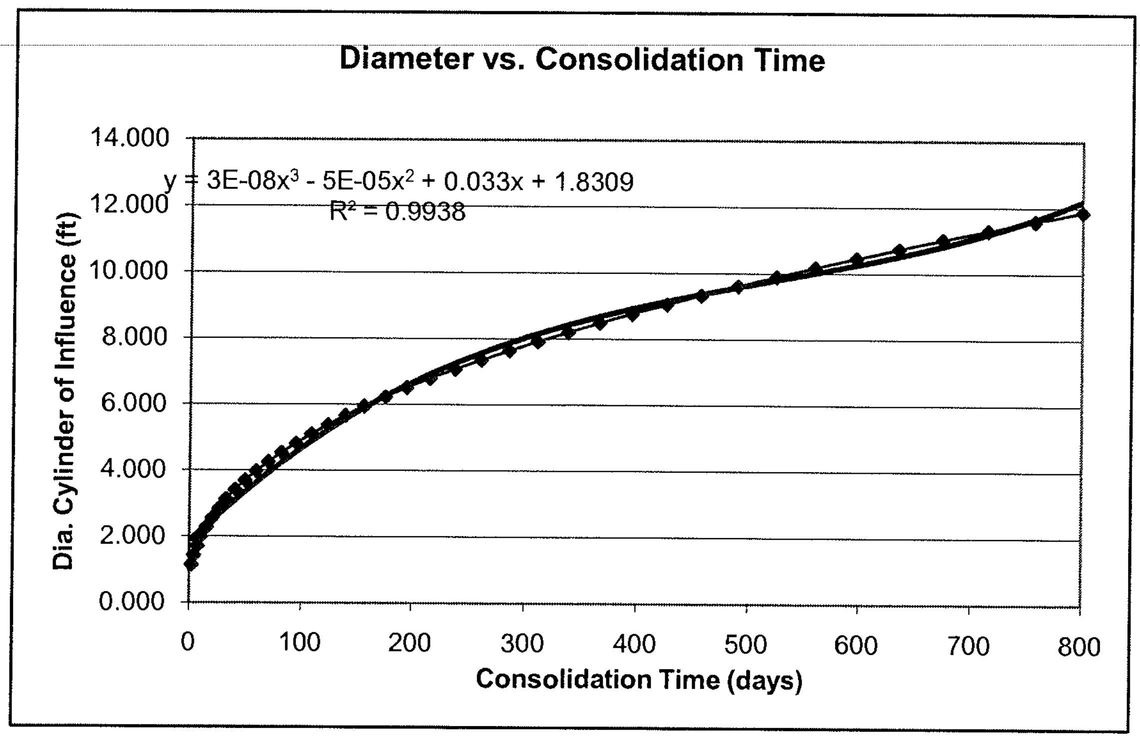
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.779768 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	500.14 ft
Number Drain Spaces Along Outer Edge =	83.36 ea
Total number wick drains =	3601 ea
Total linear feet wick drain =	54015 lf
Estimated total cost =	**$27,007.50**

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 2 - South of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	232,843	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	263	day	available time to achieve desired degree of consolidation U_h
H =	14	ft	height of compressible layer
~~a =~~	~~0.33333~~	~~ft~~	~~width of drain (Assume 4" wide x 1/4" thick)~~
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.085	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.102	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: c_h = 1.2 to 1.5*c_v
-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v) \quad \text{(See FHWA eq. 1)}$$

where,
U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.
U_h = 0 %
Uv = 90 %
U = U_v = 90 %
T_v = 0.848

t = 1955 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.
t = 263 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.11
U_v = 0.38

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v) \quad \text{(See FHWA eq. 1)}$$

U_h = 0.84

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 2 - South of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

$t =$ 263 day — available time to achieve desired degree of consolidation U_h

$\bar{U}_h =$ 0.84 — average degree of consolidation due to horizontal drainage

$c_h =$ 0.102 ft^2/day — coefficient of consolidation for horizontal drainage

$F(n) =$ 2.653606 — drain spacing factor

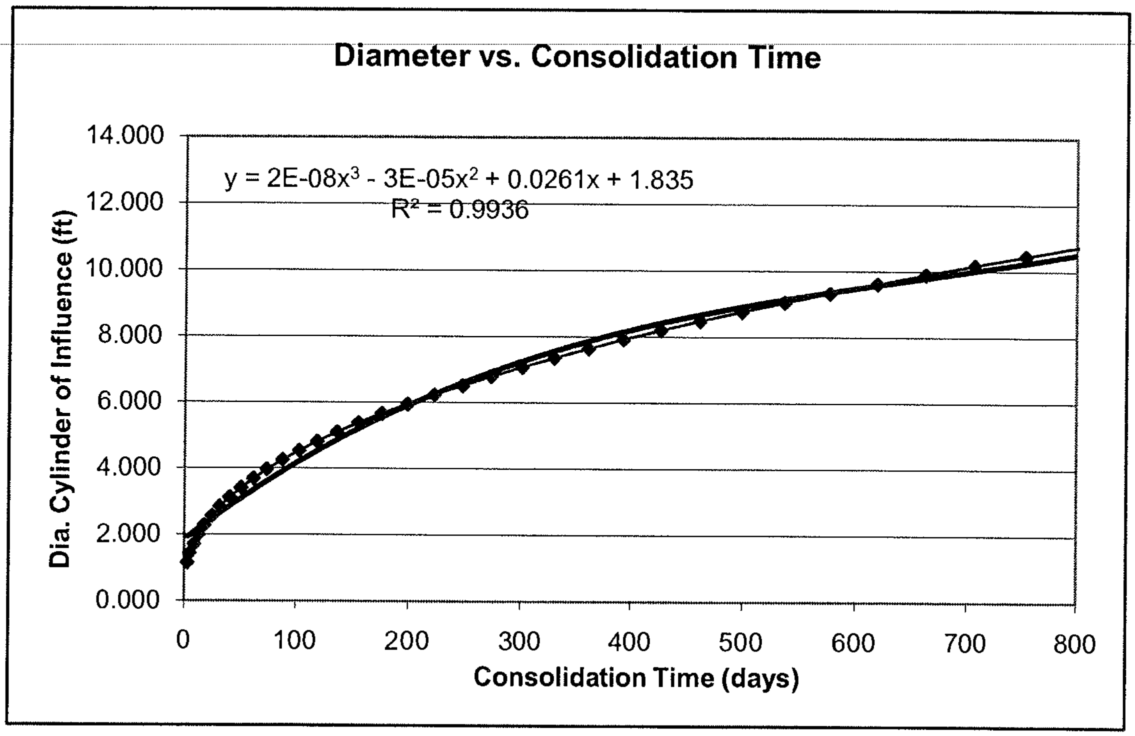
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ — diameter of an equivalent circular drain (See FHWA eq. 9)

$d_w =$ 0.23 ft

$D =$ 6.783771 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	733.30 ft
Number Drain Spaces Along Outer Edge =	122.15 ea
Total number wick drains =	7645 ea
Total linear feet wick drain =	122320 lf
Estimated total cost =	**$61,160.00**

Job No. 79784 | PID No. 19415

HDR Computation

Project: SCI-823 Portsmouth Bypass		Computed: DMV	Date: 7/12/09
Subject: Shumway Hollow Road (TR 234) Interchange: Area 2 - South of TR 234		Checked: JSA	Date: 7/29/09
Task: Wick Drain Analyses - Revised Profile: Stage 2		Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	232,843	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	213	day	available time to achieve desired degree of consolidation U_h
H =	14	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.105	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.126	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: $c_h = 1.2$ to $1.5*c_v$
-If layering of silt and sand in discontinuous lenses is evident: $c_h = 2$ to $4*c_v$
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to $10*c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

where,
U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.
U_h = 0 %
Uv = 90 % t = 1583 days **Need to Consider Other Options.**
$U = U_v$ = 90 %
T_v = 0.848

Calculate U_v that will occur in design period of t.
t = 213 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.11
U_v = 0.38

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.84

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 2 - South of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	213 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.84	average degree of consolidation due to horizontal drainage
c_h =	0.126 ft²/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.653556	drain spacing factor

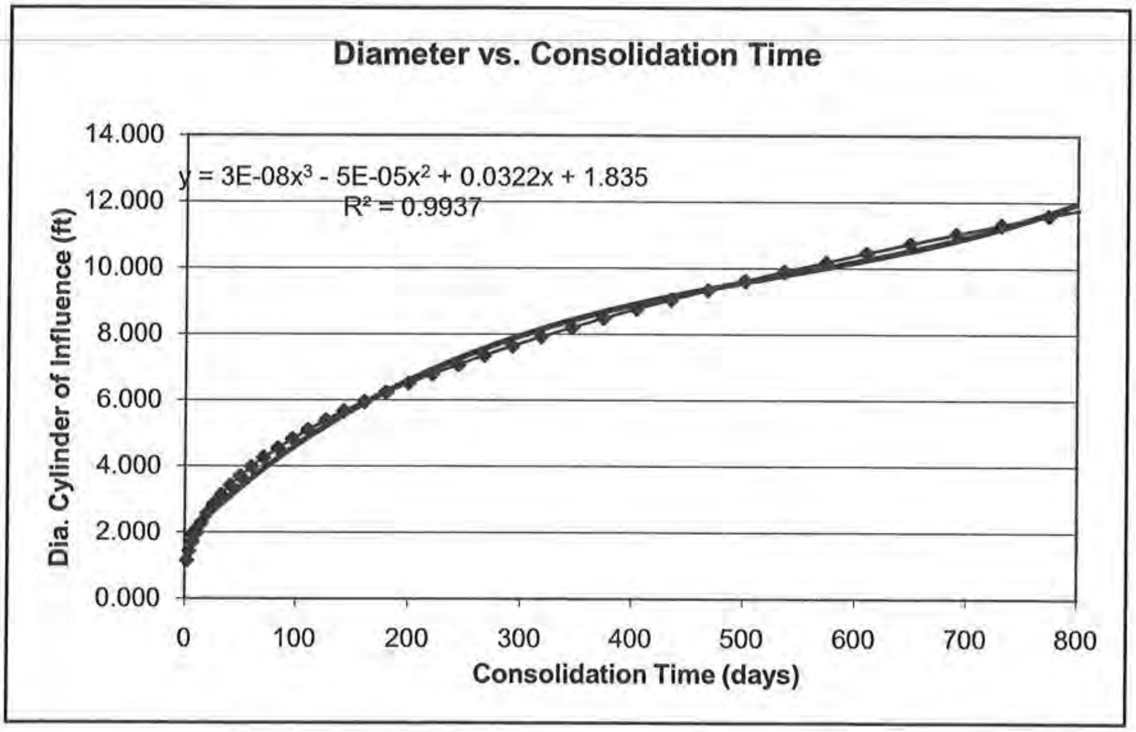
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.783433 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	733.30 ft
Number Drain Spaces Along Outer Edge =	122.15 ea
Total number wick drains =	7646 ea
Total linear feet wick drain =	122336 lf
Estimated total cost =	**$61,168.00**

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 3 - North of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	923,588	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	144	day	available time to achieve desired degree of consolidation U_h
H =	43	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.085	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.102	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: c_h = 1.2 to 1.5*c_v
-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
U = U_v = 90 %
T_v = 0.848

t = 18446 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 144 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01
U_v = 0.09

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.89

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HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 3 - North of TR 234	Checked	JSA	Date	7/29/09
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$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	144 day	available time to achieve desired degree of consolidation U_h
$\bar{U}_h$ =	0.89	average degree of consolidation due to horizontal drainage
c_h =	0.102 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.247559	drain spacing factor

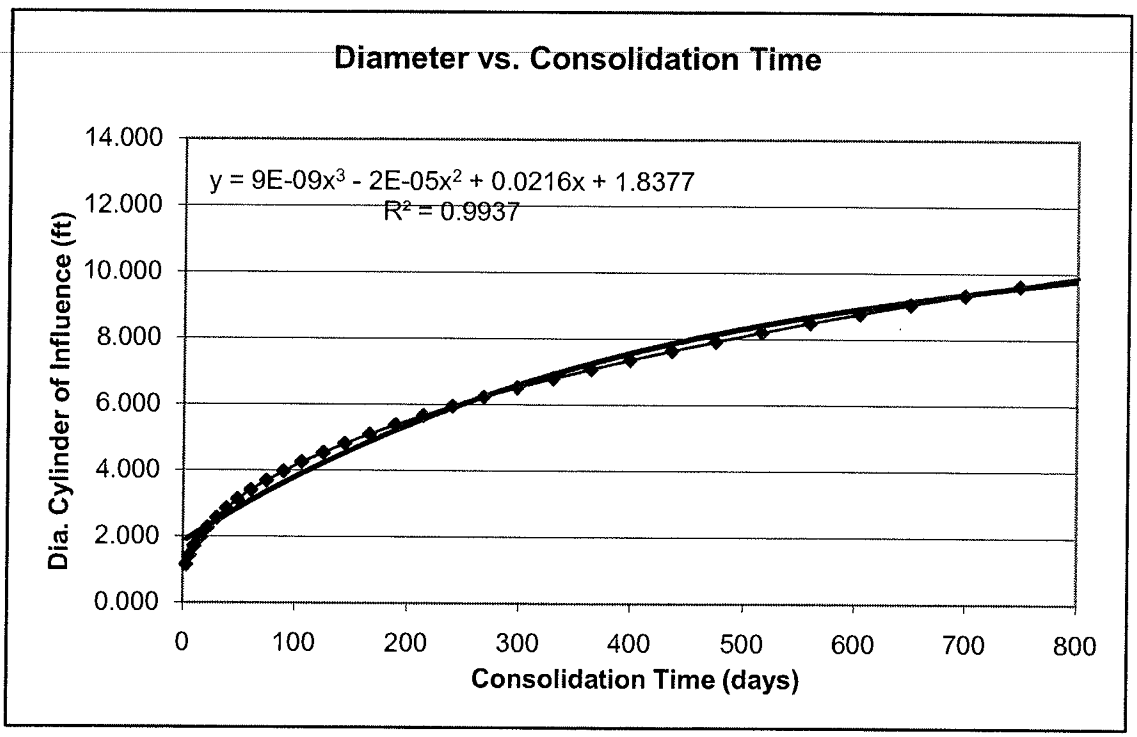
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 4.519884 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **4.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1460.46 ft
Number Drain Spaces Along Outer Edge =	365.12 ea
Total number wick drains =	67207 ea
Total linear feet wick drain =	3024315 lf
Estimated total cost =	**$1,512,157.50**

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HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 3 - North of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	923,588	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	117	day	available time to achieve desired degree of consolidation U_h
H =	43	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.105	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.126	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: c_h = 1.2 to 1.5*c_v
-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
U = U_v = 90 %
T_v = 0.848

t = 14933 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 117 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01
U_v = 0.09

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.89

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HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 3 - North of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	117 day	available time to achieve desired degree of consolidation U_h
$\bar{U}_h$ =	0.89	average degree of consolidation due to horizontal drainage
c_h =	0.126 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.248672	drain spacing factor

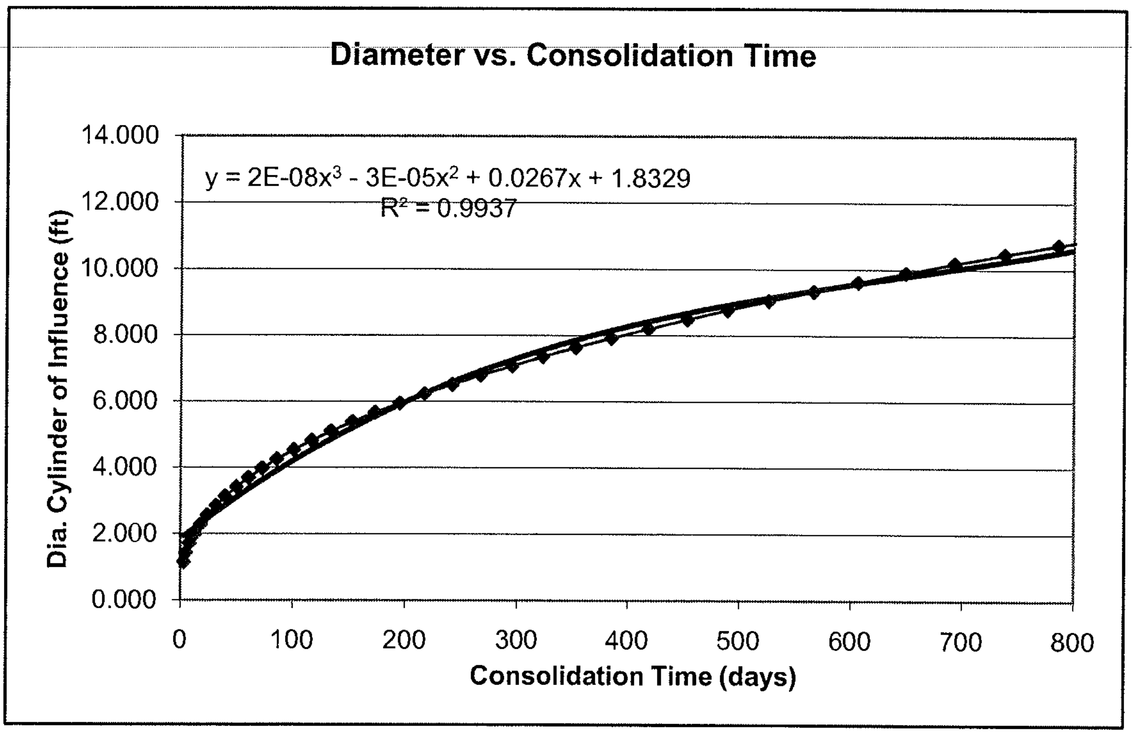
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 4.524916 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **4.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1460.46 ft
Number Drain Spaces Along Outer Edge =	364.72 ea
Total number wick drains =	67058 ea
Total linear feet wick drain =	3017610 lf
Estimated total cost =	**$1,508,805.00**

Job No. 79784	PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 3 - North of TR 234	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 3	Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	923,588	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	95	day	available time to achieve desired degree of consolidation U_h
H =	43	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.129	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.1548	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: $c_h = 1.2$ to $1.5*c_v$
-If layering of silt and sand in discontinuous lenses is evident: $c_h = 2$ to $4*c_v$
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to $10*c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
$U = U_v$ = 90 %
T_v = 0.848

t = 12155 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 95 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01
U_v = 0.09

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.89

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 3 - North of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 3	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

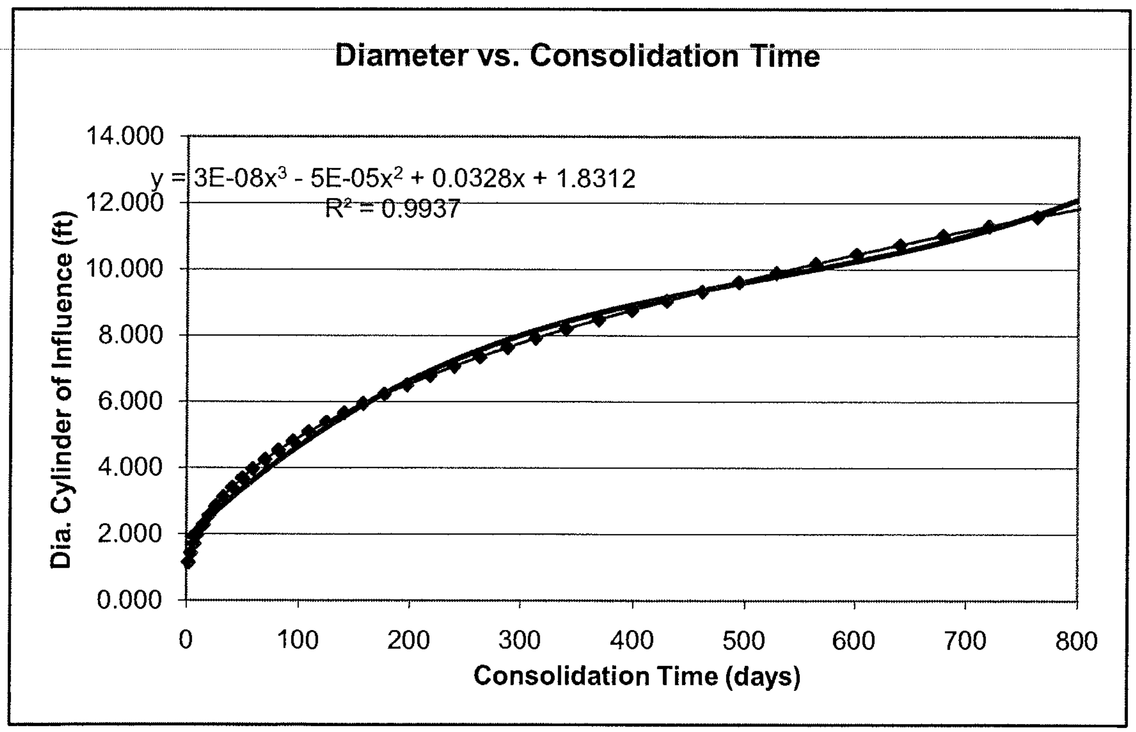
where,

t =	95 day	available time to achieve desired degree of consolidation U_h
$\bar{U}_h$ =	0.89	average degree of consolidation due to horizontal drainage
c_h =	0.1548 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.247176	drain spacing factor

where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w =	$2(a+b)/\pi$	diameter of an equivalent circular drain (See FHWA eq. 9)
d_w =	0.23 ft	
D =	4.518154 ft	required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **4.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1460.46 ft
Number Drain Spaces Along Outer Edge =	365.26 ea
Total number wick drains =	67258 ea
Total linear feet wick drain =	3026610 lf
Estimated total cost =	**$1,513,305.00**

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 4 - North of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	497,192	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	130	day	available time to achieve desired degree of consolidation U_h
H =	14	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.085	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.102	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: $c_h = 1.2 \text{ to } 1.5*c_v$
-If layering of silt and sand in discontinuous lenses is evident: $c_h = 2 \text{ to } 4*c_v$
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to $10*c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
U = U_v = 90 %
T_v = 0.848

t = 1955 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 130 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.06
U_v = 0.27

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.86

Job No. 79784	PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 4 - North of TR 234	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet 2	of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	130 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.86	average degree of consolidation due to horizontal drainage
c_h =	0.102 ft^2/day	coefficient of consolidation for horizontal drainage
F(n) =	2.247179	drain spacing factor

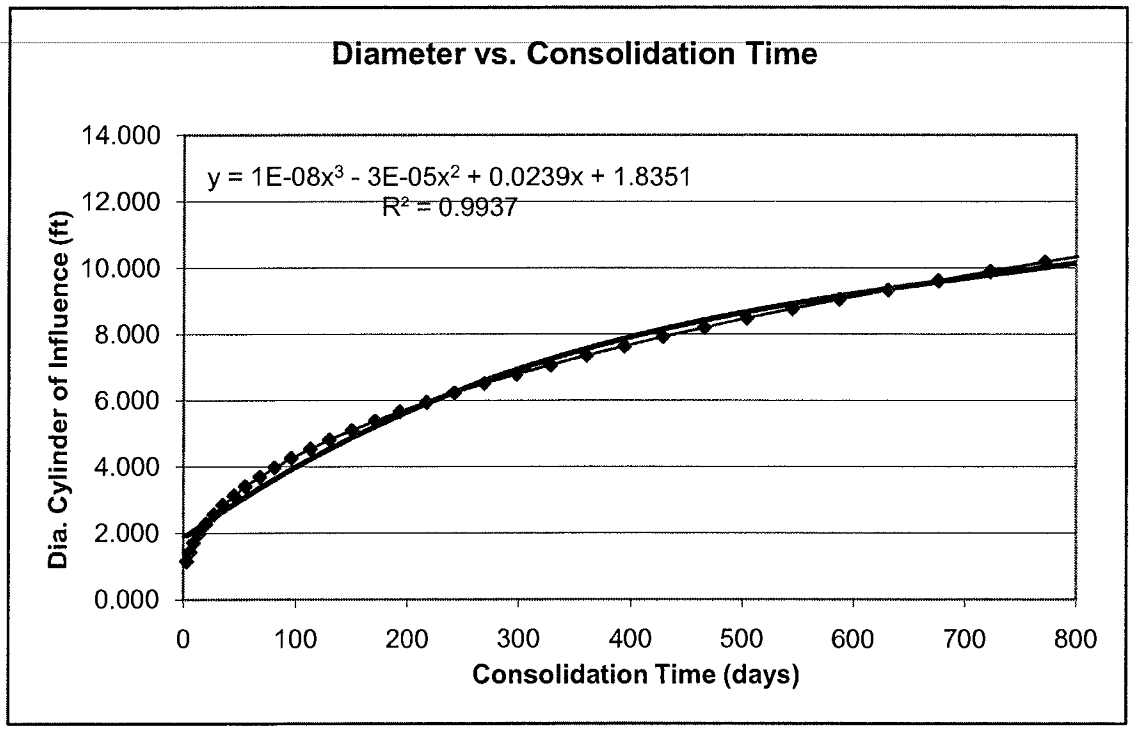
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 4.518166 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **4.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1071.55 ft
Number Drain Spaces Along Outer Edge =	268.00 ea
Total number wick drains =	36314 ea
Total linear feet wick drain =	581024 lf
Estimated total cost =	**$290,512.00**

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 4 - North of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	497,192	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	105	day	available time to achieve desired degree of consolidation U_h
H =	14	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.105	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.126	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: c_h = 1.2 to 1.5*c_v
-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
U = U_v = 90 %
T_v = 0.848

t = 1583 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 105 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.06
U_v = 0.27

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.86

Job No. 79784	PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 4 - North of TR 234	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet 2	Of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

$t =$ 105 day — available time to achieve desired degree of consolidation U_h

$\bar{U}_h =$ 0.86 — average degree of consolidation due to horizontal drainage

$c_h =$ 0.126 ft^2/day — coefficient of consolidation for horizontal drainage

$F(n) =$ 2.24546 — drain spacing factor

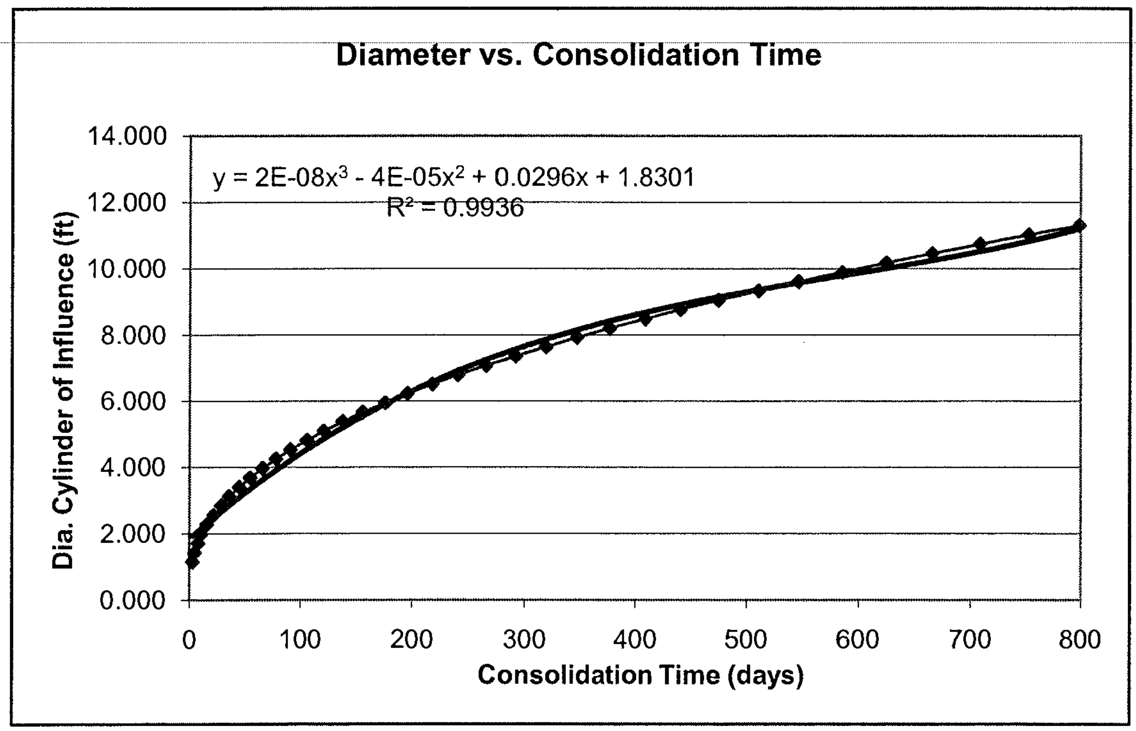
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ — diameter of an equivalent circular drain (See FHWA eq. 9)

$d_w =$ 0.23 ft

$D =$ 4.510408 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **3.99 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1071.55 ft
Number Drain Spaces Along Outer Edge =	268.46 ea
Total number wick drains =	36439 ea
Total linear feet wick drain =	583024 lf
Estimated total cost =	**$291,512.00**

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 4 - North of TR 234	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 3	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	497,192	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	86	day	available time to achieve desired degree of consolidation U_h
H =	14	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.129	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.1548	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: c_h = 1.2 to 1.5*c_v
-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,
U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 % t = 1288 days **Need to Consider Other Options.**
U = U_v = 90 %
T_v = 0.848

Calculate U_v that will occur in design period of t.

t = 86 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.06
U_v = 0.27

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.86

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Shumway Hollow Road (TR 234) Interchange: Area 4 - North of TR 234	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 3	Sheet 2	Of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t = 86 day — available time to achieve desired degree of consolidation U_h

$\overline{U}_h$ = 0.86 — average degree of consolidation due to horizontal drainage

c_h = 0.1548 ft^2/day — coefficient of consolidation for horizontal drainage

$F(n)$ = 2.248562 — drain spacing factor

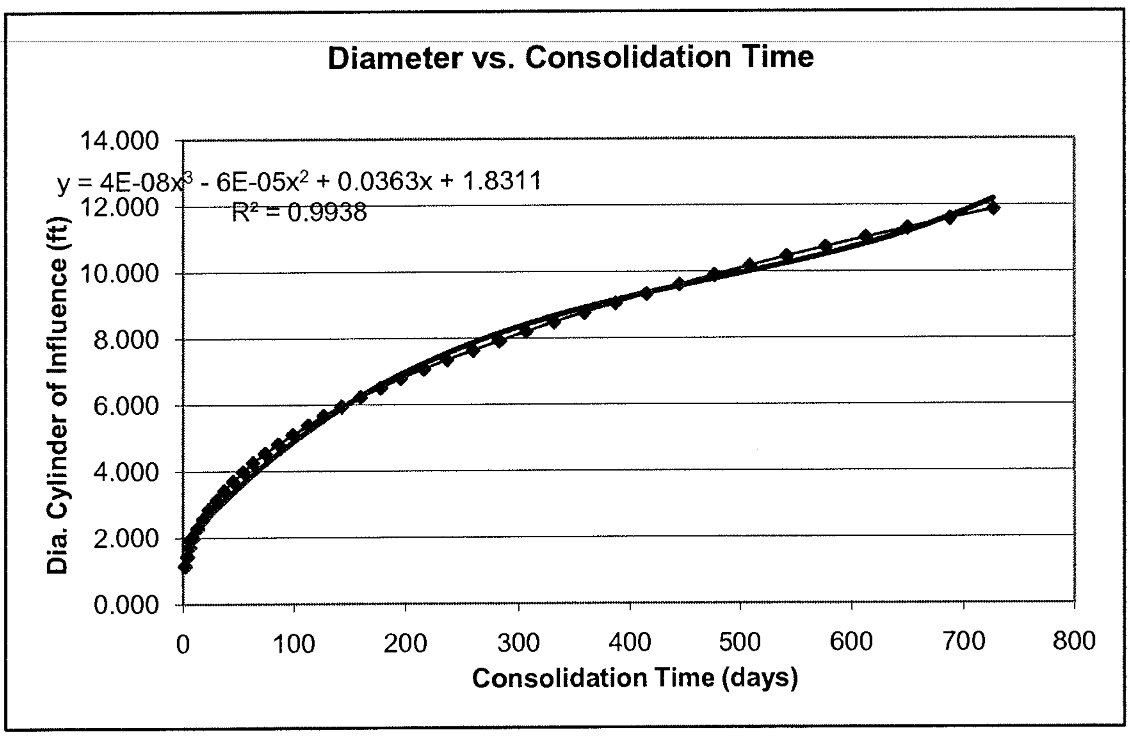
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 4.524419 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **4.00 ft**

Length Outer Edge of Equilateral Triangle (or square) = 1071.55 ft

Number Drain Spaces Along Outer Edge = 267.63 ea

Total number wick drains = 36215 ea

Total linear feet wick drain = 579440 lf

Estimated total cost = **$289,720.00**

Job No. 79784 | PID No. 19415

HDR Computation

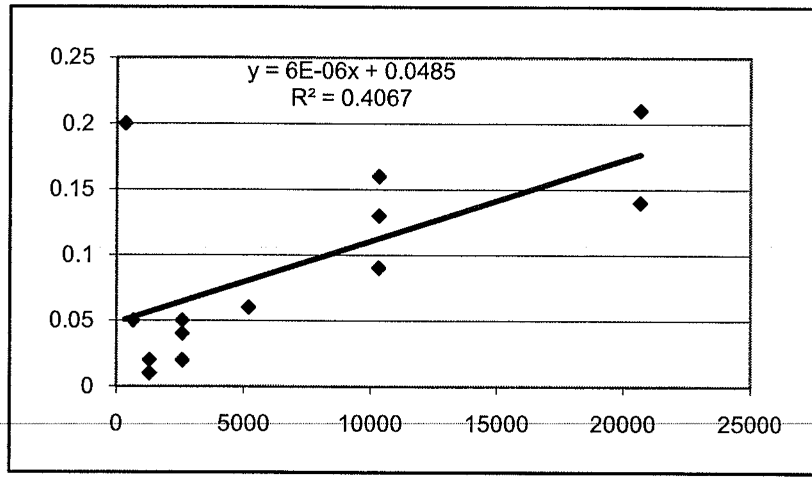
Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Lucasville-Minford Road (CR 28) Interchange: Mainline Embankment	Checked	JSA	Date	7/29/09
Task	Determine Coefficient Consolidation for Vertical Drainage (Cv)	Sheet	1	Of	1

References:

1. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

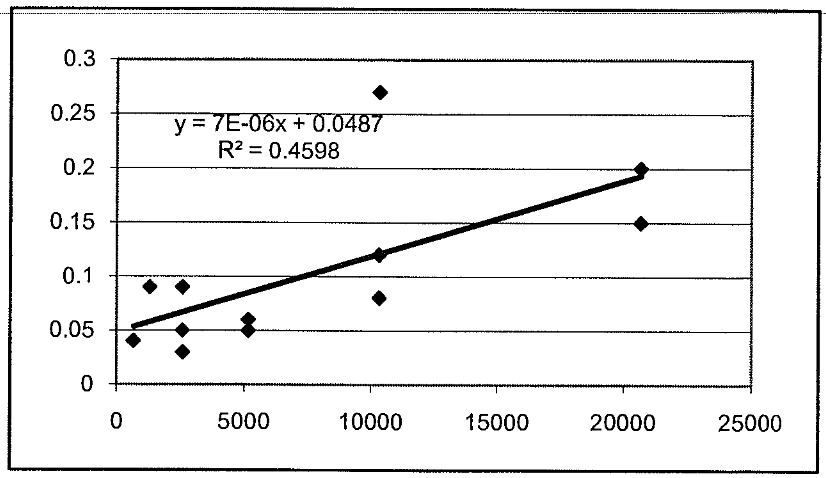
B-1

	Load (psf)	Cv
1	324	0.2
2	646	0.05
3	1292	0.02
4	2584	0.05
5	10336	0.13
6	20672	0.21
7	10336	0.16
8	2584	0.04
9	1292	0.01
10	2584	0.02
11	5168	0.06
12	10336	0.09
13	20672	0.14



B-2

	Load (psf)	Cv
1	324	1.38
2	646	0.04
4	2584	0.09
6	10336	0.12
7	20672	0.2
8	10336	0.27
9	5168	0.05
10	2584	0.03
12	1292	0.09
13	2584	0.05
14	5168	0.06
15	10336	0.08
16	20672	0.15



From Undrained Shear Strength Analysis - Staged Construction SR 823 Mainline Embankment (DLZ, 2008)

H_{comp}	=	43.5	ft	*Height Compressible Layer*
γ_{soil}	=	120	pcf	*Unit Weight of Compressible Soil*
γ_{fill}	=	125	pcf	*Unit Weight of Fill*
H_1	=	27	ft	*Stage 1 Fill Lift Height*
H_2	=	18	ft	*Stage 2 Fill Lift Height*

σ_{v0}	=	$\gamma*(H_{comp}/2)$ =	2610	psf	*Initial Stress at Midpoint of Compressible Layer*
σ_{F1}	=	$\sigma_{v0} + H_1*\gamma_{fill}$ =	5985	psf	*Stress at Midpoint of Compressible Layer after placement of Stage 1 Fill.*
σ_{F2}	=	$\sigma_{F1} + H_2*\gamma_{fill}$ =	8235	psf	*Stress at Midpoint of Compressible Layer after placement of Stage 2 Fill.*

Based on Consolidation Testing on B-1 & B-2 and the estimated load due to additional Stage 1 & Stage 2 fill

c_v = 0.875 ft^2/day *after placing Stage 1 Fill*

c_v = 0.1021 ft^2/day *after placing Stage 2 Fill*

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HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	329,029	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	420	day	available time to achieve desired degree of consolidation U_h
H =	45	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.087	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.1044	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: $c_h = 1.2$ to $1.5*c_v$
-If layering of silt and sand in discontinuous lenses is evident: $c_h = 2$ to $4*c_v$
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to $10*c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,
U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.
U_h = 0 %
Uv = 90 %
U = U_v = 90 %
T_v = 0.848

t = 19738 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.
t = 420 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.02
U_v = 0.15

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t = 420 day — available time to achieve desired degree of consolidation U_h

$\overline{U}_h$ = 0.88 — average degree of consolidation due to horizontal drainage

c_h = 0.1044 ft^2/day — coefficient of consolidation for horizontal drainage

$F(n)$ = 2.806606 — drain spacing factor

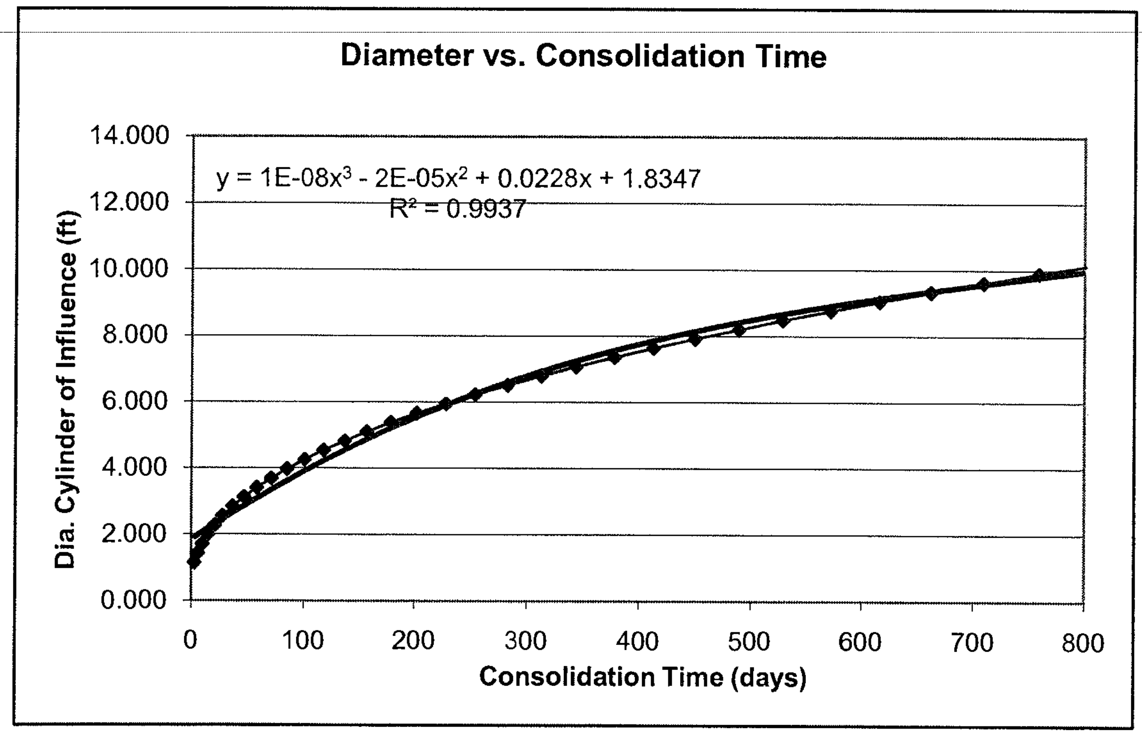
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 7.905297 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **7.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	871.70 ft
Number Drain Spaces Along Outer Edge =	124.60 ea
Total number wick drains =	7951 ea
Total linear feet wick drain =	373697 lf
Estimated total cost =	**$186,848.50**

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	329,029	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	359	day	available time to achieve desired degree of consolidation U_h
H =	45	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.102	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.1224	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: $c_h = 1.2$ to $1.5*c_v$

-If layering of silt and sand in discontinuous lenses is evident: $c_h = 2$ to $4*c_v$

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to $10*c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h =	0	%	t =	16835	days	**Need to Consider Other Options.**
Uv =	90	%				
$U = U_v$ =	90	%				
T_v =	0.848					

Calculate U_v that will occur in design period of t.

t = 359 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.02

U_v = 0.15

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

Job No. 79784	PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet 2	Of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

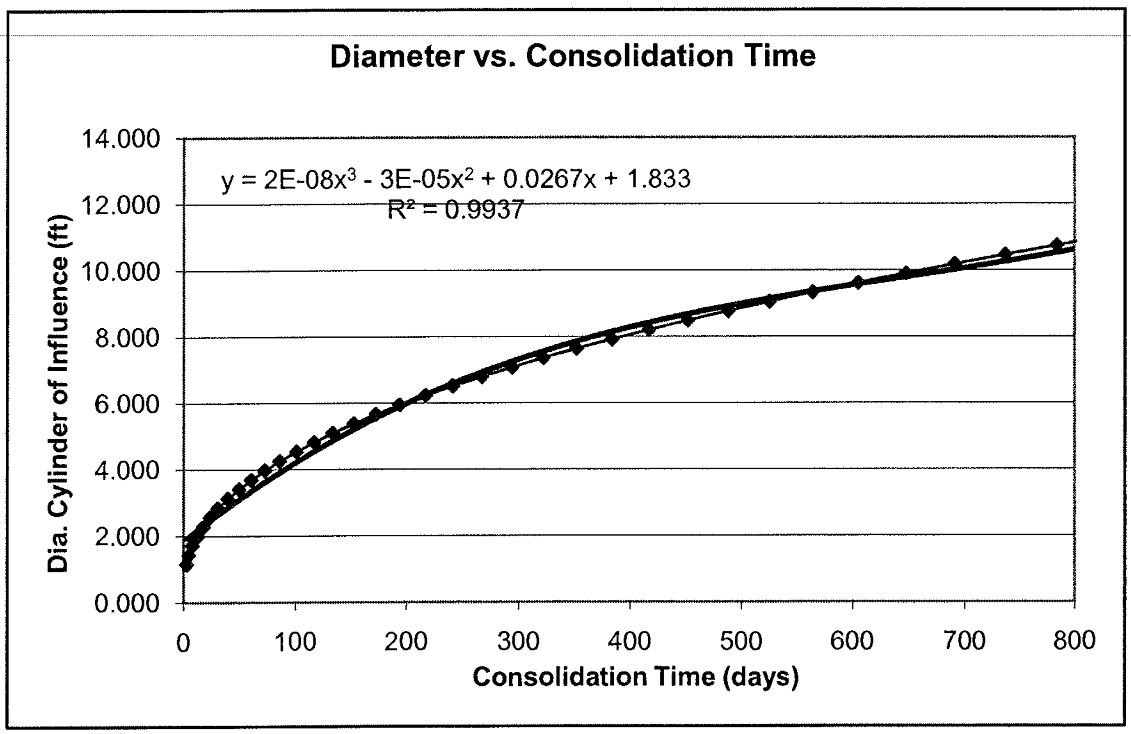
where,

t =	359 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.88	average degree of consolidation due to horizontal drainage
c_h =	0.1224 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.807366	drain spacing factor

where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w =	$2(a+b)/\pi$	diameter of an equivalent circular drain (See FHWA eq. 9)
d_w =	0.23 ft	
D =	7.911313 ft	required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **7.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	871.70 ft
Number Drain Spaces Along Outer Edge =	124.51 ea
Total number wick drains =	7939 ea
Total linear feet wick drain =	373133 lf
Estimated total cost =	**$186,566.50**

Job No. 79784	PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange - Ramp A & B	Checked JSA	Date 7/27/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	94,847	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	215	day	available time to achieve desired degree of consolidation U_h
H =	46	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.087	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.1044	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: c_h = 1.2 to 1.5*c_v
-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %   t = 20625 days   **Need to Consider Other Options.**
U = U_v = 90 %
T_v = 0.848

Calculate U_v that will occur in design period of t.

t = 215 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01
U_v = 0.11

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.89

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange - Ramp A & B	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	215 day	available time to achieve desired degree of consolidation U_h
$\bar{U}_h$ =	0.89	average degree of consolidation due to horizontal drainage
c_h =	0.1044 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.470072	drain spacing factor

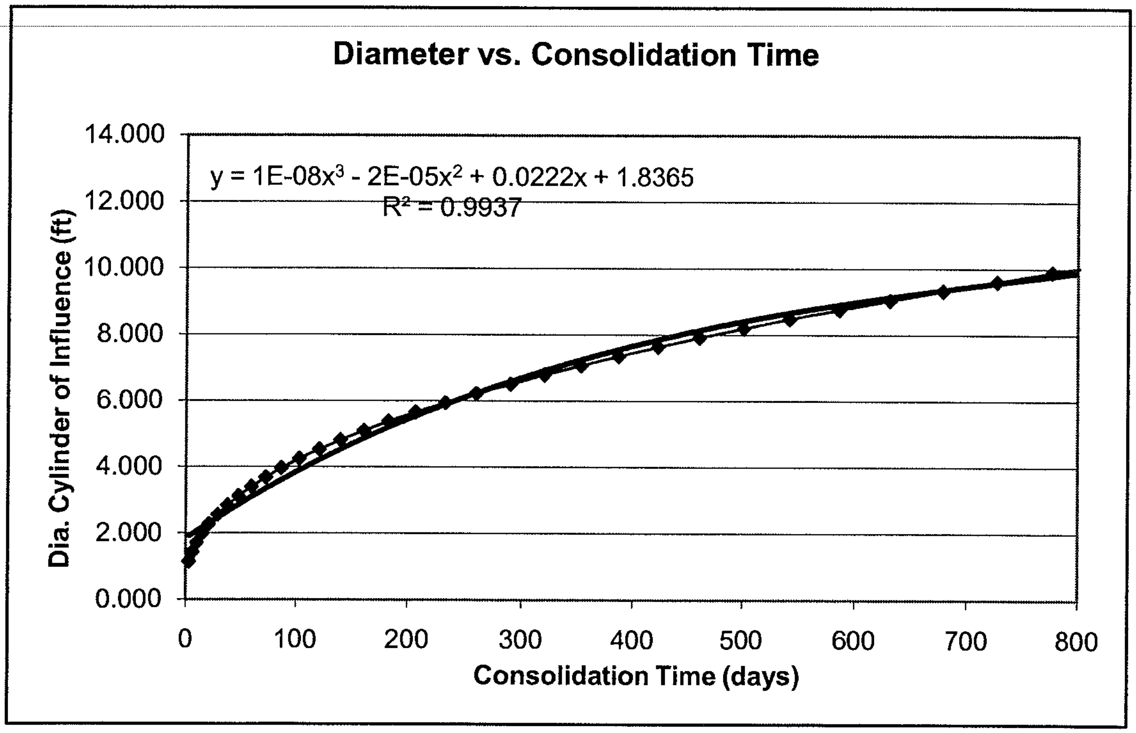
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = $2(a+b)/\pi$ diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 5.646295 ft required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **5.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	468.02 ft
Number Drain Spaces Along Outer Edge =	93.66 ea
Total number wick drains =	4529 ea
Total linear feet wick drain =	217392 lf
Estimated total cost =	**$108,696.00**

Job No. 79784	PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange - Ramp A & B	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	94,847	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	184	day	available time to achieve desired degree of consolidation U_h
H =	46	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.102	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.1224	ft²/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 90 %

U = U_v = 90 %

T_v = 0.848

t = 17592 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 184 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01

U_v = 0.11

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.89

Job No. 79784	PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange - Ramp A & B	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet 2	Of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

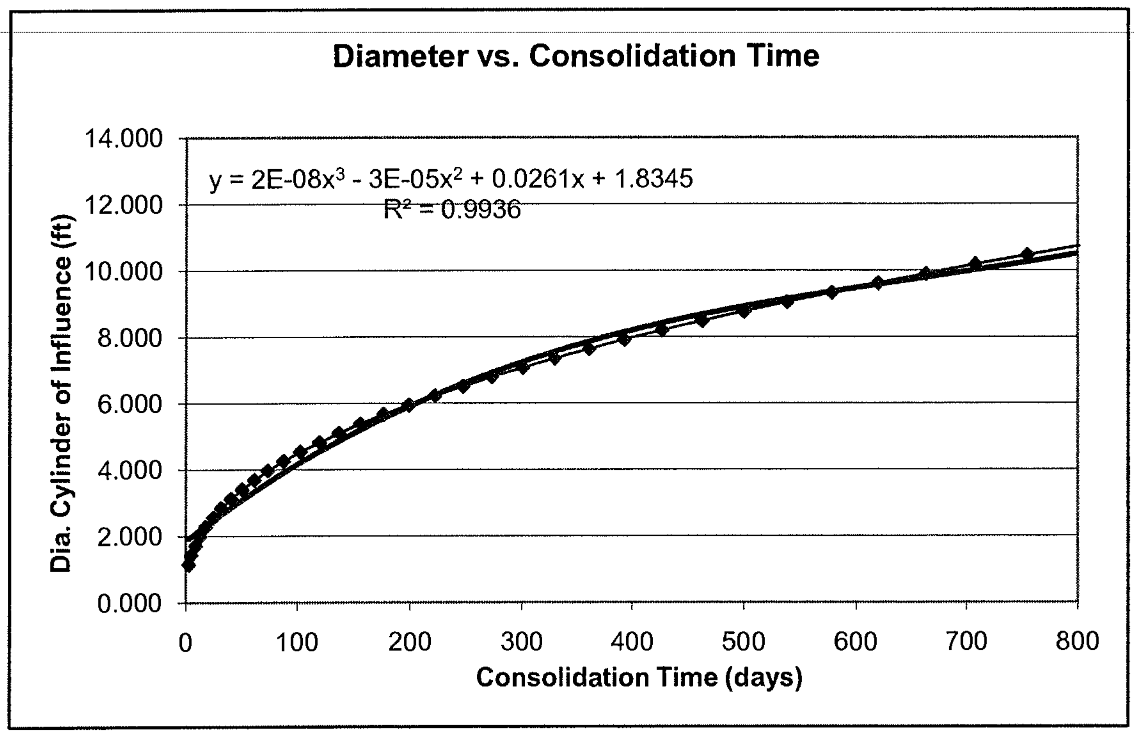
where,

t =	184 day	available time to achieve desired degree of consolidation U_h
$\bar{U}_h$ =	0.89	average degree of consolidation due to horizontal drainage
c_h =	0.1224 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.471779	drain spacing factor

where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w =	$2(a+b)/\pi$	diameter of an equivalent circular drain (See FHWA eq. 9)
d_w =	0.23 ft	
D =	5.655938 ft	required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **5.01 ft**

Length Outer Edge of Equilateral Triangle (or square) =	468.02 ft
Number Drain Spaces Along Outer Edge =	93.51 ea
Total number wick drains =	4513 ea
Total linear feet wick drain =	216624 lf
Estimated total cost =	**$108,312.00**

Job No. 79784	PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	DMV	Date	7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange - Ramp C & D	Checked	JSA	Date	7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	107,519	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	213	day	available time to achieve desired degree of consolidation U_h
H =	38	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.087	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.1044	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: c_h = 1.2 to 1.5*c_v
-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h =	0	%				
Uv =	90	%	t =	14075	days	**Need to Consider Other Options.**
U = U_v =	90	%				
T_v =	0.848					

Calculate U_v that will occur in design period of t.

t = 213 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01
U_v = 0.13

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.89

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange - Ramp C & D	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 1	Sheet 2	Of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

$t =$ 213 day — available time to achieve desired degree of consolidation U_h

$\overline{U}_h =$ 0.89 — average degree of consolidation due to horizontal drainage

$c_h =$ 0.1044 ft^2/day — coefficient of consolidation for horizontal drainage

$F(n) =$ 2.47089 — drain spacing factor

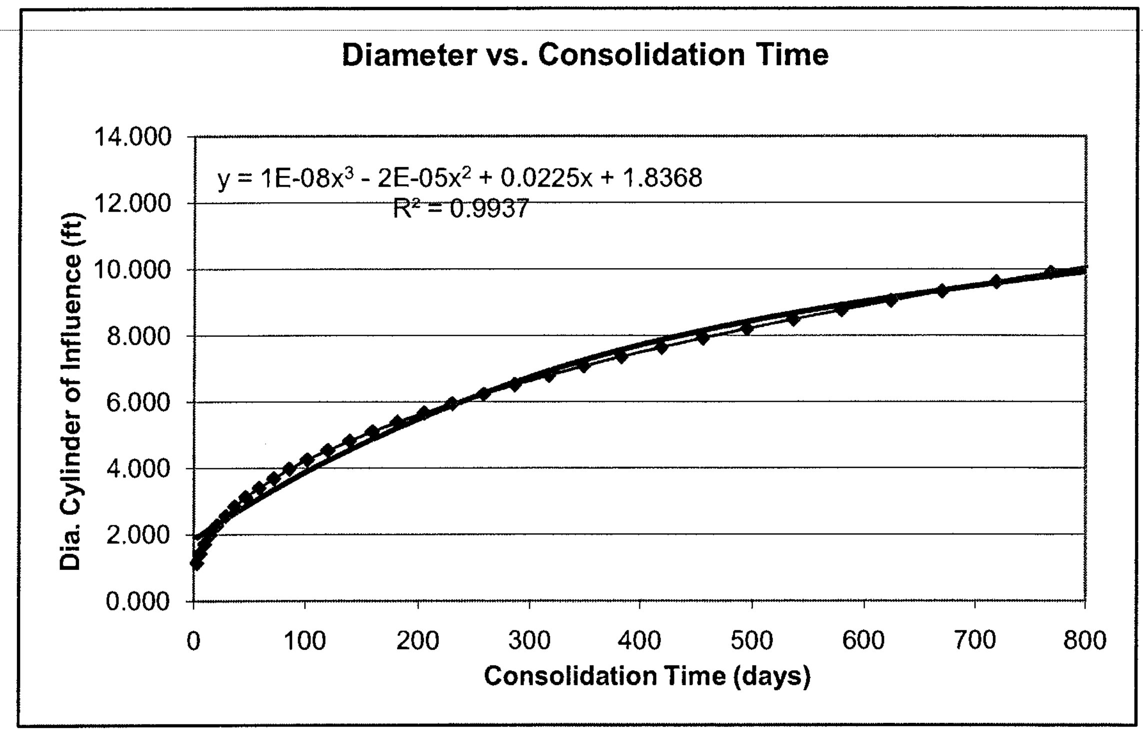
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ — diameter of an equivalent circular drain (See FHWA eq. 9)

$d_w =$ 0.23 ft

$D =$ 5.650916 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **5.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	498.30 ft
Number Drain Spaces Along Outer Edge =	99.64 ea
Total number wick drains =	5115 ea
Total linear feet wick drain =	204600 lf
Estimated total cost =	**$102,300.00**

Job No. 79784	PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange - Ramp C & D	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	107,519	sf	Total area to be drained
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	182	day	available time to achieve desired degree of consolidation U_h
H =	38	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.102	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.1224	ft^2/day	coefficient consolidation for horizontal drainage

Note:
-General Case: c_h = 1.2 to 1.5*c_v
-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v
-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %   t = 12005 days   **Need to Consider Other Options.**
U = U_v = 90 %
T_v = 0.848

Calculate U_v that will occur in design period of t.

t = 182 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01
U_v = 0.13

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.89

Job No. 79784 | PID No. 19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed DMV	Date 7/12/09
Subject	Lucasville Minford Road (CR 28) Interchange - Ramp C & D	Checked JSA	Date 7/29/09
Task	Wick Drain Analyses - Revised Profile: Stage 2	Sheet 2	Of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	182 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.89	average degree of consolidation due to horizontal drainage
c_h =	0.1224 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.47148	drain spacing factor

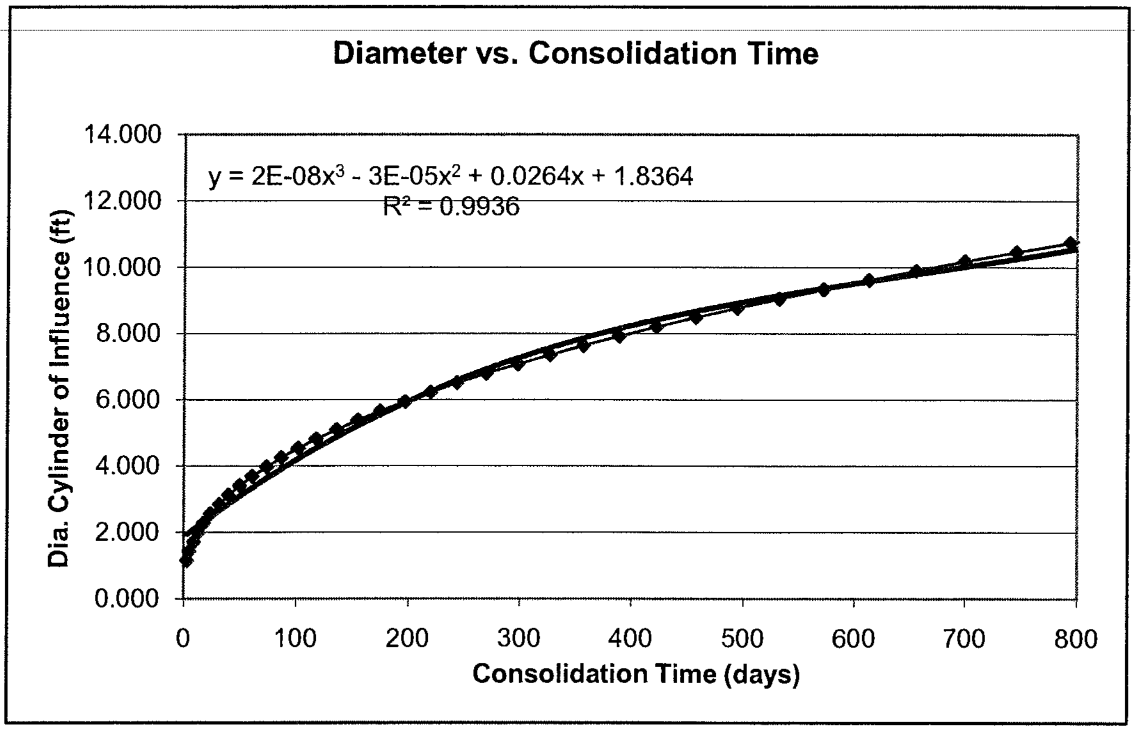
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = $2(a+b)/\pi$ diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 5.654249 ft required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **5.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	498.30 ft
Number Drain Spaces Along Outer Edge =	99.59 ea
Total number wick drains =	5110 ea
Total linear feet wick drain =	204400 lf
Estimated total cost =	**$102,200.00**

Productivity Rate to move/place embankment fill: 700 cy/hr

Street	Earthwork Cut Vol.	Earthwork Cut Vol. (w/Swell)	Earthwork Fill Vol.	Total Fill Volume Stage 1	Total Fill Volume Stage 2	Total Fill Volume Stage 3
Mainline Emb. Sta 352+00 to 384+00	3,381,507	3,888,733	352,687	258,264	94,424	0
Mainline Emb. Sta 384+00 to 417+00			1,358,208	704,804	421,255	232,149
Mainline Emb. Sta 417+00 to 528+00			1,762,373	1,762,373	0	0
Mainline Emb. Sta 528+00 to 536+50			192,287	138,447	53,840	0
TR234 Ramp A	4,828	5,552	146,947	66,126	48,493	32,328
TR234 Ramp B	1,477	1,699	110,349	70,623	39,726	0
TR234 Ramp C	33,825	38,899	61,735	39,510	22,225	0
TR234 Ramp D	233,874	268,955	63,616	28,627	20,993	13,996
CR28 Ramp A	92,574	106,460	16,387	11,799	4,588	0
CR28 Ramp B	3,733	4,293	1,685	1,213	472	0
CR28 Ramp C	26,770	30,786	7,274	5,237	2,037	0
CR28 Ramp D	200,704	230,810	25,740	18,533	7,207	0
TR234	446,301	513,246	29,156	29,156	0	0
SR335	4,349	5,001	3,005	3,005	0	0
CR28	17,361	19,965	47,479	47,479	0	0
Total	**4,447,303**	**5,114,398**	**4,178,928**			
	CUT (CY)	**CUT (CY)**	**FILL (CY)**			

Street	Time to Complete (hours) Stage 1	Time to Complete (hours) Stage 2	Time to Complete (hours) Stage 3	Time to Complete (weeks) Stage 1	Time to Complete (weeks) Stage 2	Time to Complete (weeks) Stage 3
Mainline Emb. Sta 352+00 to 384+00	368.9	134.9	0.0	7.4	2.7	0.0
Mainline Emb. Sta 384+00 to 417+00	1,006.9	601.8	331.6	20.1	12.0	6.6
Mainline Emb. Sta 417+00 to 528+00	2,517.7	0.0	0.0	50.4	0.0	0.0
Mainline Emb. Sta 528+00 to 536+50	197.8	76.9	0.0	4.0	1.5	0.0
TR234 Ramp A	94.5	69.3	46.2	1.9	1.4	0.9
TR234 Ramp B	100.9	56.8	0.0	2.0	1.1	0.0
TR234 Ramp C	56.4	31.7	0.0	1.1	0.6	0.0
TR234 Ramp D	40.9	30.0	20.0	0.8	0.6	0.4
CR28 Ramp A	16.9	6.6	0.0	0.3	0.1	0.0
CR28 Ramp B	1.7	0.7	0.0	0.0	0.0	0.0
CR28 Ramp C	7.5	2.9	0.0	0.1	0.1	0.0
CR28 Ramp D	26.5	10.3	0.0	0.5	0.2	0.0
TR234	41.7	0.0	0.0	0.8	0.0	0.0
SR335	4.3	0.0	0.0	0.1	0.0	0.0
CR28	67.8	0.0	0.0	1.4	0.0	0.0
	4,550	1,022	398	hours	=	5,970 hours
	456	103	40	days	=	599 days
	92	21	8	weeks	=	121 weeks
						Total

Waste = ***935,470*** ***CY***

Time to Move Waste = 1,336 hour
134 day
27 weeks

Total Project Time = ***148*** ***weeks***

Note: 10 hour work days assumed

Project: SCI-823-6.81		Computed: DMV	Date: 7-14-09
Subject: Wick Drain - Schedule		Checked:	Date:
Task: Approximate Earthwork		Page: 1	of:
Job #: 45878		No:	

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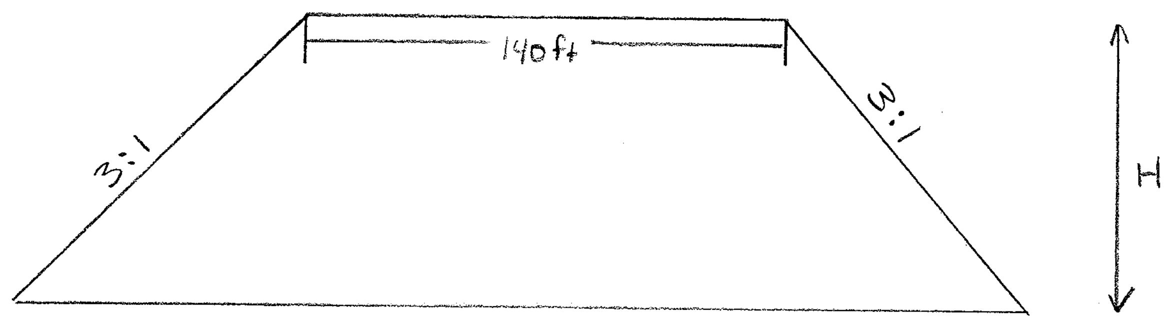
Generalized Embankment



Shumway Hollow Interchange (TR 234)

Stage 1 = 26 ft
Stage 2 = 25 ft
Stage 3 = 29 ft

1.) $H \leq 26$ ft : Stage 1 = 100%

2.) $26 \text{ ft} < H \leq 51 \text{ ft}$: Stage 1 = 64%
: Stage 2 = 36%

$S2 = (140 \times 25) + 2(\frac{1}{2} \times 25 \times 75) = 5375 \text{ ft}^2$
$S1 = ((140+150) \times 26) + 2(\frac{1}{2} \times 26 \times 78) = 9568 \text{ ft}^2$

3.) $51 \text{ ft} < H \leq 80 \text{ ft}$: Stage 1 = 45%
Stage 2 = 33%
Stage 3 = 22%

$S3 = (140 \times 29) + 2(\frac{1}{2} \times 29 \times 87) = 6583 \text{ ft}^2$
$S2 \quad ((140+174) \times 26) + 2(\frac{1}{2} \times 25 \times 75) = 10039 \text{ ft}^2$
$S1 \quad ((140+174+150) \times 25) + 2(\frac{1}{2} \times 26 \times 78) = 13628 \text{ ft}^2$

Project: SCI-823-6.81		Computed: DMV	Date: 7-14-09
Subject: Wick Drain - Schedule		Checked:	Date:
Task: Approximate Earthwork		Page: 2	of:
Job #: 45878		No:	

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Lucasville - Minford Road Interchange (CR 28)

Stage 1 = 27 ft
Stage 2 = 18 ft

1.) $H \leq 27$ ft : Stage 1 = 100%

2.) $27 \text{ ft} < H \leq 45$ ft : Stage 1 = 72%
Stage 2 = 28%

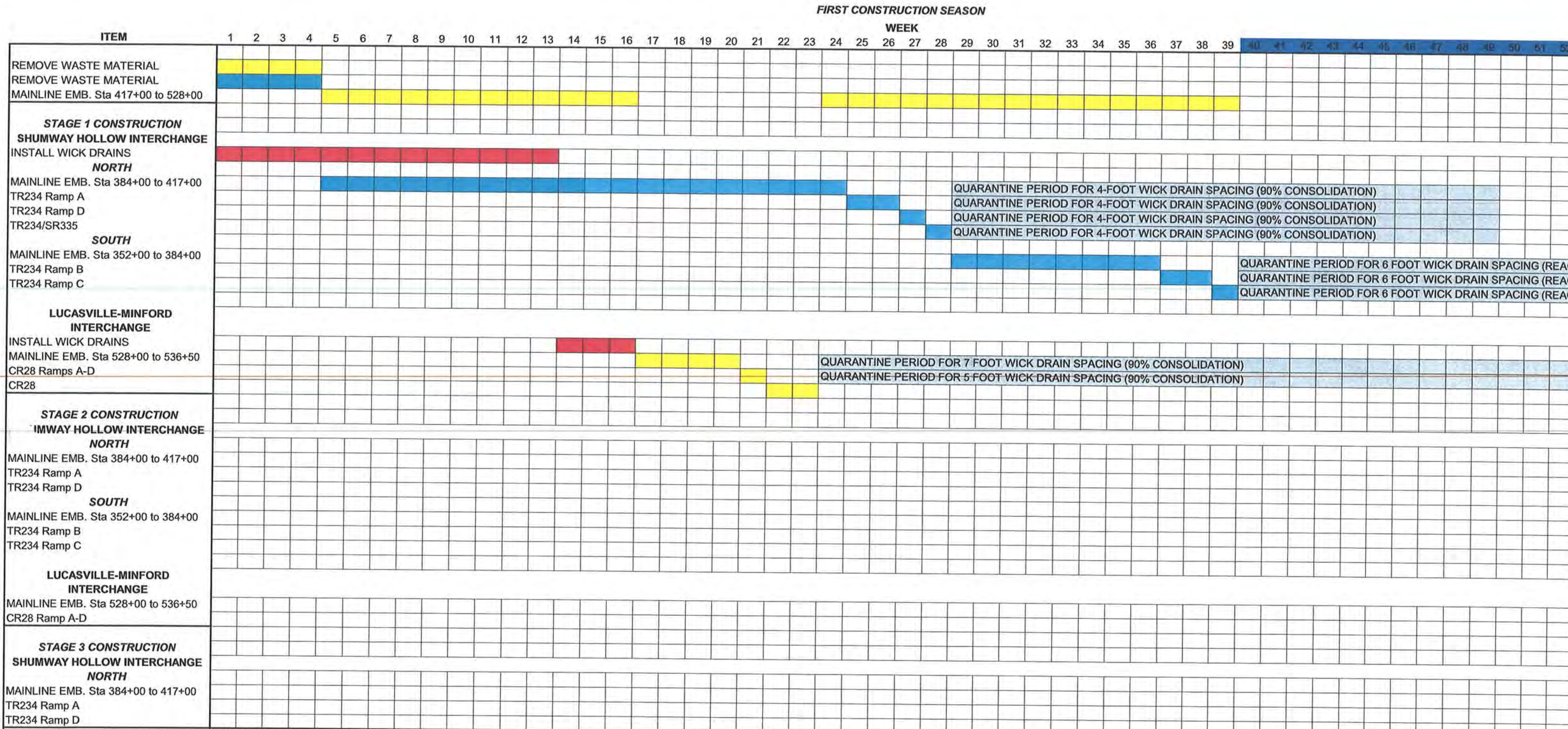
$S_2 = (140 \times 18) + 2(\frac{1}{2} \times 18 \times 54) = 3492 \text{ ft}^2$

~~$S_1 = ((140 + 108) \times 27) + 2(\frac{1}{2} \times 27 \times 81) = 8883 \text{ ft}^2$~~

Stage 2: Revised Vertical Profile

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 1



NOTES:

1. Schedule based on 10 hour work days and a 5 day week.
2. Productivity rate of 700 CY / HR was used for time estimates based on conversations with contractors.
3. Quantities used in analyses:
   - CUT = 4,447,303 CY
   - FILL = 4,178,928 CY
   - WASTE = 935,470 CY (based on 15% swell)
4. Wick drain spacing at TR234 Interchange: North of TR 234 at 4 feet, South of TR 234 at 6 feet. Wick drain spacing at CR 28 Interchange: SR 823 Mainline at 7 feet, Ramps A, B, C & D at 5 feet.
5. Assume 6 rigs for installation of wick drains at an installation rate of 10,000 ft/day per rig.
6. Estimated Wick Drain Installation Cost ($0.50/ft. Installed) = $186,850 (CR 28 Mainline: 7 ft. spacing) + $211,000 (CR 28 Ramps: 5 ft. spacing) + $27,010 (TR 234 - Area 1: 6 ft. spacing) + $61,170 (TR 234 - Area 2: 6 ft. spacing) + $1,513,305 (TR 234 - Area 3: 4 ft. spacing) + $291,515 (TR 234 - Area 4: 4 ft. spacing) + $2,887,910 (2 ft. sand blanket @ $17/CY) =

$ 5,178,760 (Total)

Legend

- Crew Number 1 (2 Excavators)
- Crew Number 2 (2 Excavators)
- Wick Drain Installation
- Quarantine Period
- Earthwork Contingency

Stage 2: Revised Vertical Profile

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 2

SECOND CONSTRUCTION SEASON

WEEK: 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104

ITEM	Schedule notes
REMOVE WASTE MATERIAL	
REMOVE WASTE MATERIAL	
MAINLINE EMB. Sta 417+00 to 528+00	
STAGE 1 CONSTRUCTION	
SHUMWAY HOLLOW INTERCHANGE	
INSTALL WICK DRAINS	
NORTH	
MAINLINE EMB. Sta 384+00 to 417+00	
TR234 Ramp A	
TR234 Ramp D	
TR234/SR335	
SOUTH	
MAINLINE EMB. Sta 352+00 to 384+00	H 90% CONSOLIDATION)
TR234 Ramp B	H 90% CONSOLIDATION)
TR234 Ramp C	H 90% CONSOLIDATION)
LUCASVILLE-MINFORD INTERCHANGE	
INSTALL WICK DRAINS	
MAINLINE EMB. Sta 528+00 to 536+50	
CR28 Ramps A-D	
CR28	
STAGE 2 CONSTRUCTION	
`MWAY HOLLOW INTERCHANGE	
NORTH	
MAINLINE EMB. Sta 384+00 to 417+00	QUARANTINE PERIOD FOR 4 FOOT WICK DRAIN SPACING (90% CONSOLIDATION)
TR234 Ramp A	QUARANTINE PERIOD FOR 4 FOOT WICK DRAIN SPACING (90% CONSOLIDATION)
TR234 Ramp D	QUARANTINE PERIOD FOR 4 FOOT WICK DRAIN SPACING (90% CONSOLIDATION)
SOUTH	
MAINLINE EMB. Sta 352+00 to 384+00	QUARANTINE PERIOD FOR 6 FOOT WICK DRAIN SPACING (90% CONSOLIDATION)
TR234 Ramp B	QUARANTINE PERIOD FOR 6 FOOT WICK DRAIN SPACING (90% CONSOLIDATION)
TR234 Ramp C	QUARANTINE PERIOD FOR 6 FOOT WICK DRAIN SPACING (90% CONSOLIDATION)
LUCASVILLE-MINFORD INTERCHANGE	
MAINLINE EMB. Sta 528+00 to 536+50	QUARANTINE PERIOD FOR 7 FOOT WICK DRAIN SPACING (90% CONSOLIDATION)
CR28 Ramp A-D	QUARANTINE PERIOD FOR 5 FOOT WICK DRAIN SPACING (90% CONSOLIDATION)
STAGE 3 CONSTRUCTION	
SHUMWAY HOLLOW INTERCHANGE	
NORTH	
MAINLINE EMB. Sta 384+00 to 417+00	QUARANTINE PERIOD FOR 4 FOOT WICK DRAIN SPACING (90% CONSOLIDATION
TR234 Ramp A	QUARANTINE PERIOD FOR 4 FOOT WICK DRAIN SPACING (90% CONSOLIDATION
TR234 Ramp D	QUARANTINE PERIOD FOR 4 FOOT WICK DRAIN SPACING (90% CONSOLIDATION

CONCEPTUALIZED CONSTRUCTION SCHEDULE

THIRD CONSTRUCTION SEASON

WEEK

ITEM	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
REMOVE WASTE MATERIAL																																																				
REMOVE WASTE MATERIAL																																																				
MAINLINE EMB. Sta 417+00 to 528+00																																																				
STAGE 1 CONSTRUCTION																																																				
SHUMWAY HOLLOW INTERCHANGE																																																				
INSTALL WICK DRAINS																																																				
NORTH																																																				
MAINLINE EMB. Sta 384+00 to 417+00																																																				
TR234 Ramp A																																																				
TR234 Ramp D																																																				
TR234/SR335																																																				
SOUTH																																																				
MAINLINE EMB. Sta 352+00 to 384+00																																																				
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MAINLINE EMB. Sta 528+00 to 536+50																																																				
CR28 Ramps A-D																																																				
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MAINLINE EMB. Sta 352+00 to 384+00																																																				
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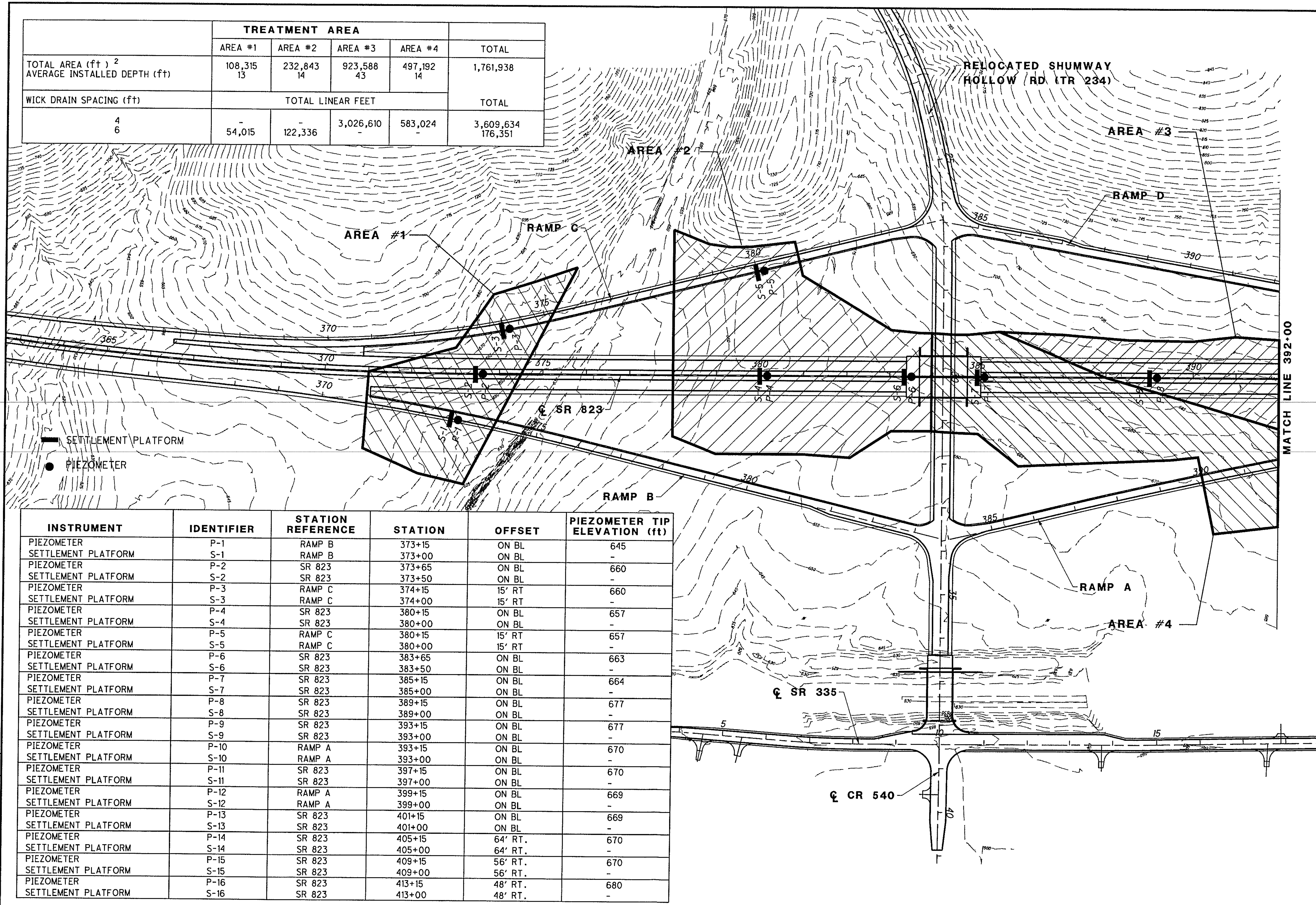
MAINLINE EMB. Sta 384+00 to 417+00	I)																																																			
TR234 Ramp A	I)																																																			
TR234 Ramp D																																																				

	TREATMENT AREA				
	AREA #1	AREA #2	AREA #3	AREA #4	TOTAL
TOTAL AREA (ft²) AVERAGE INSTALLED DEPTH (ft)	108,315 13	232,843 14	923,588 43	497,192 14	1,761,938
WICK DRAIN SPACING (ft)	TOTAL LINEAR FEET				TOTAL
4 6	- 54,015	- 122,336	3,026,610 -	583,024 -	3,609,634 176,351



INSTRUMENT	IDENTIFIER	STATION REFERENCE	STATION	OFFSET	PIEZOMETER TIP ELEVATION (ft)
PIEZOMETER	P-1	RAMP B	373+15	ON BL	645
SETTLEMENT PLATFORM	S-1	RAMP B	373+00	ON BL	-
PIEZOMETER	P-2	SR 823	373+65	ON BL	660
SETTLEMENT PLATFORM	S-2	SR 823	373+50	ON BL	-
PIEZOMETER	P-3	RAMP C	374+15	15' RT	660
SETTLEMENT PLATFORM	S-3	RAMP C	374+00	15' RT	-
PIEZOMETER	P-4	SR 823	380+15	ON BL	657
SETTLEMENT PLATFORM	S-4	SR 823	380+00	ON BL	-
PIEZOMETER	P-5	RAMP C	380+15	15' RT	657
SETTLEMENT PLATFORM	S-5	RAMP C	380+00	15' RT	-
PIEZOMETER	P-6	SR 823	383+65	ON BL	663
SETTLEMENT PLATFORM	S-6	SR 823	383+50	ON BL	-
PIEZOMETER	P-7	SR 823	385+15	ON BL	664
SETTLEMENT PLATFORM	S-7	SR 823	385+00	ON BL	-
PIEZOMETER	P-8	SR 823	389+15	ON BL	677
SETTLEMENT PLATFORM	S-8	SR 823	389+00	ON BL	-
PIEZOMETER	P-9	SR 823	393+15	ON BL	677
SETTLEMENT PLATFORM	S-9	SR 823	393+00	ON BL	-
PIEZOMETER	P-10	RAMP A	393+15	ON BL	670
SETTLEMENT PLATFORM	S-10	RAMP A	393+00	ON BL	-
PIEZOMETER	P-11	SR 823	397+15	ON BL	670
SETTLEMENT PLATFORM	S-11	SR 823	397+00	ON BL	-
PIEZOMETER	P-12	RAMP A	399+15	ON BL	669
SETTLEMENT PLATFORM	S-12	RAMP A	399+00	ON BL	-
PIEZOMETER	P-13	SR 823	401+15	ON BL	669
SETTLEMENT PLATFORM	S-13	SR 823	401+00	ON BL	-
PIEZOMETER	P-14	SR 823	405+15	64' RT.	670
SETTLEMENT PLATFORM	S-14	SR 823	405+00	64' RT.	-
PIEZOMETER	P-15	SR 823	409+15	56' RT.	670
SETTLEMENT PLATFORM	S-15	SR 823	409+00	56' RT.	-
PIEZOMETER	P-16	SR 823	413+15	48' RT.	680
SETTLEMENT PLATFORM	S-16	SR 823	413+00	48' RT.	-

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CALCULATED BEE CHECKED DMV

WICK DRAIN AND INSTRUMENTATION PLAN
SHUMWAY HOLLOW RD (TR 234) INTERCHANGE

SCI-823-6.81

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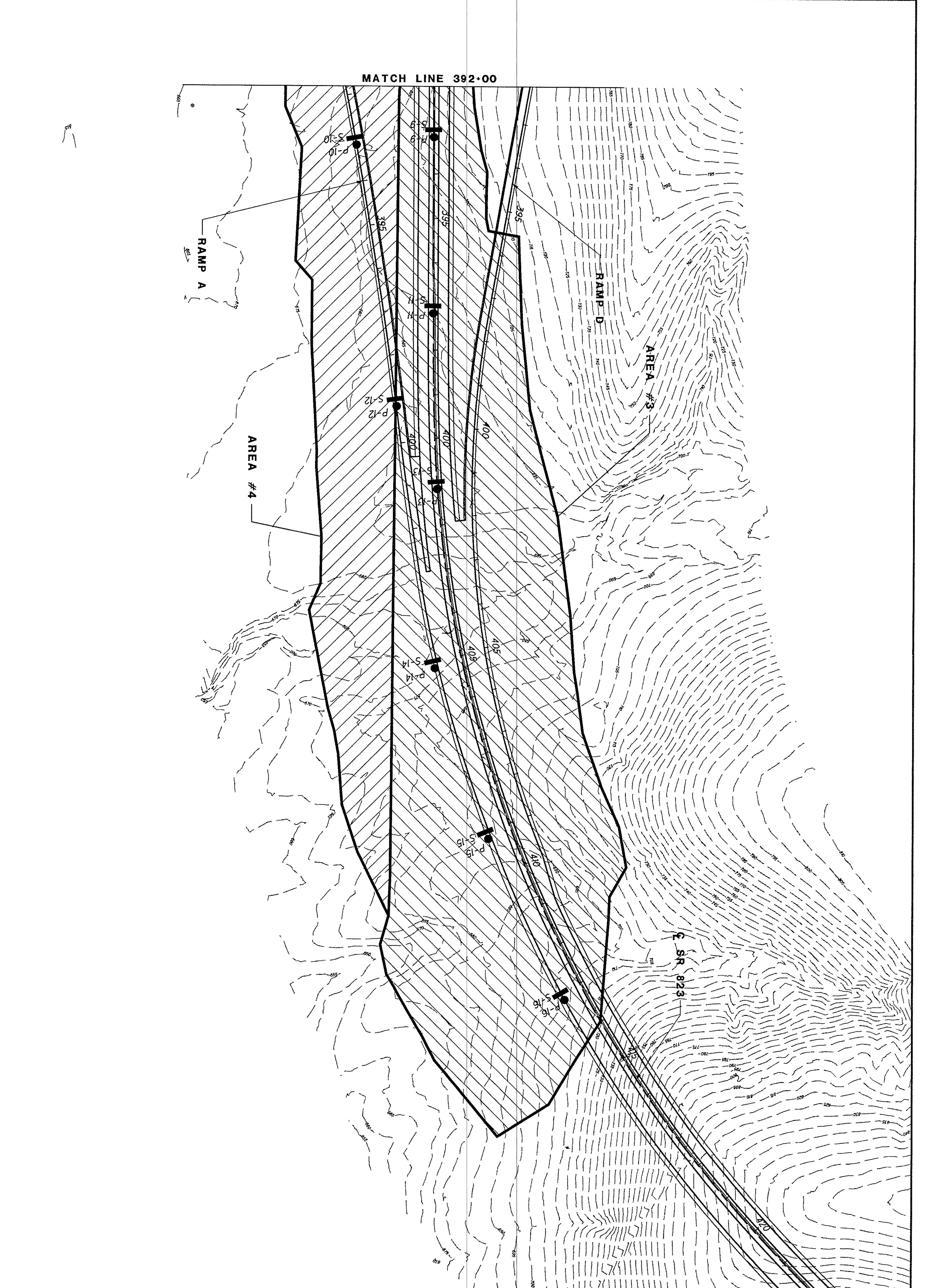
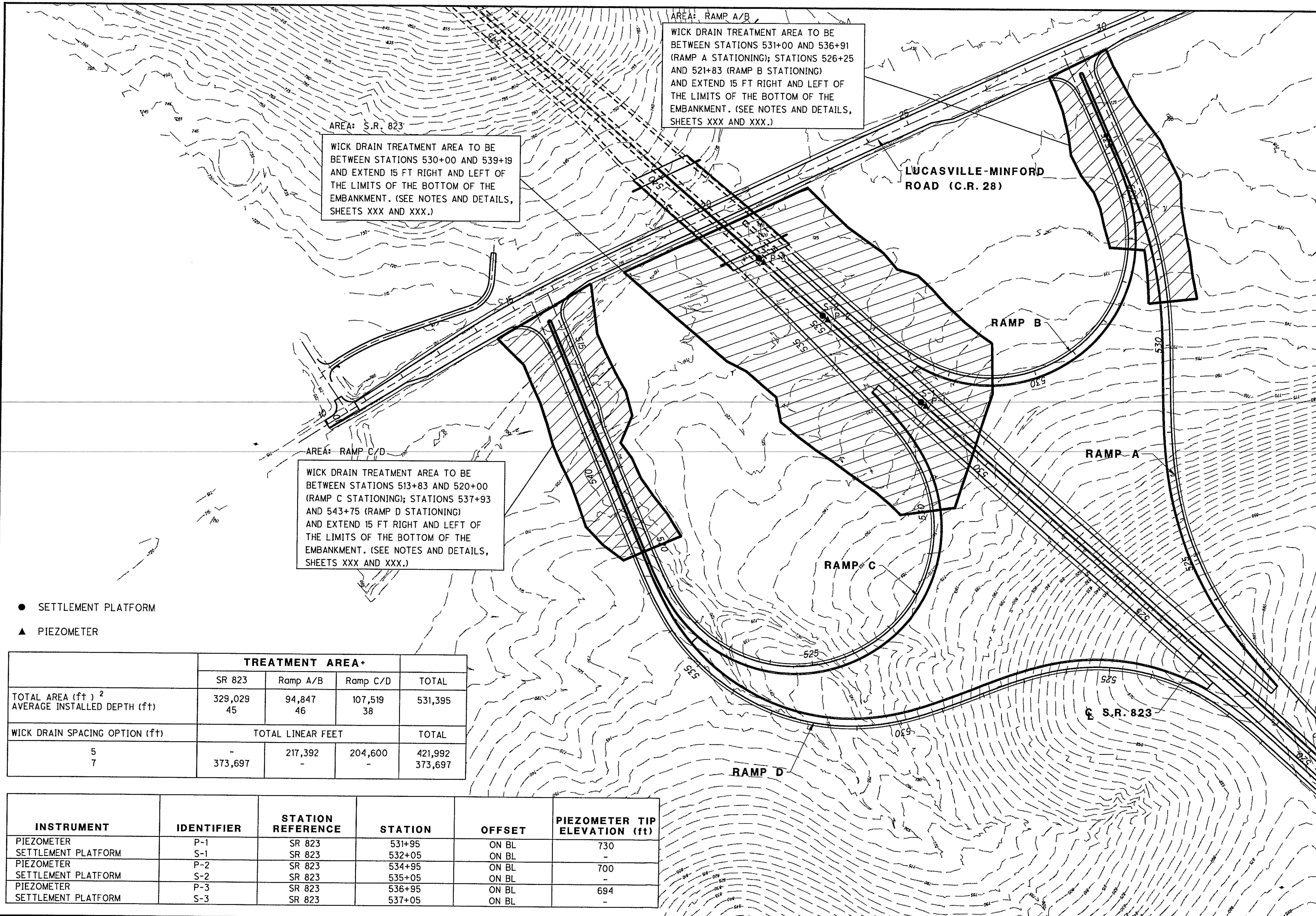


542 / 752	SCI-823-6.81	WICK DRAIN AND INSTRUMENTATION PLAN SHUMWAY HOLLOW RD (TR 234) INTERCHANGE	CALCULATED BEE CHECKED DMV	0 50 100 200 HORIZONTAL SCALE IN FEET	N



● SETTLEMENT PLATFORM

▲ PIEZOMETER

	TREATMENT AREA+			
	SR 823	Ramp A/B	Ramp C/D	TOTAL
TOTAL AREA (ft)² AVERAGE INSTALLED DEPTH (ft)	329,029 45	94,847 46	107,519 38	531,395
WICK DRAIN SPACING OPTION (ft)	TOTAL LINEAR FEET			TOTAL
5 7	- 373,697	217,392 -	204,600 -	421,992 373,697

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	-

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CALCULATED BEE
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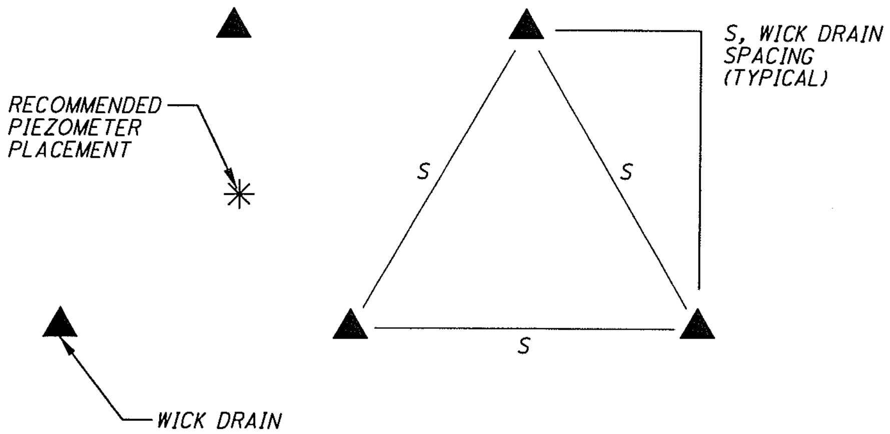
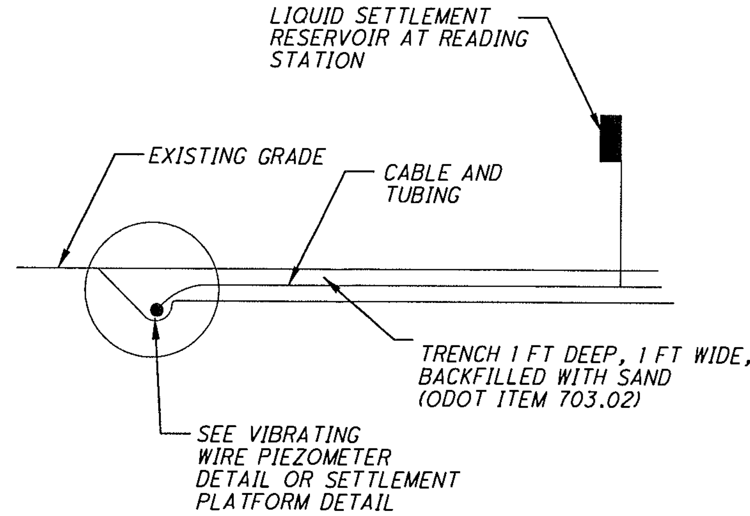
WICK DRAIN AND INSTRUMENTATION PLAN
CR 28/SR 823 INTERCHANGE

SCI-823-6.81



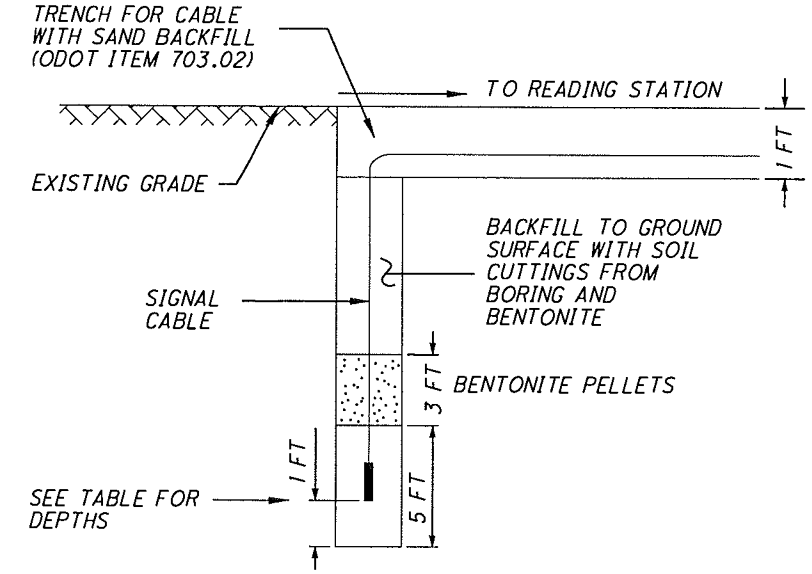
DETAIL "A"

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



DETAIL "B"

INSTRUMENTATION DETAILS
(NOT TO SCALE)



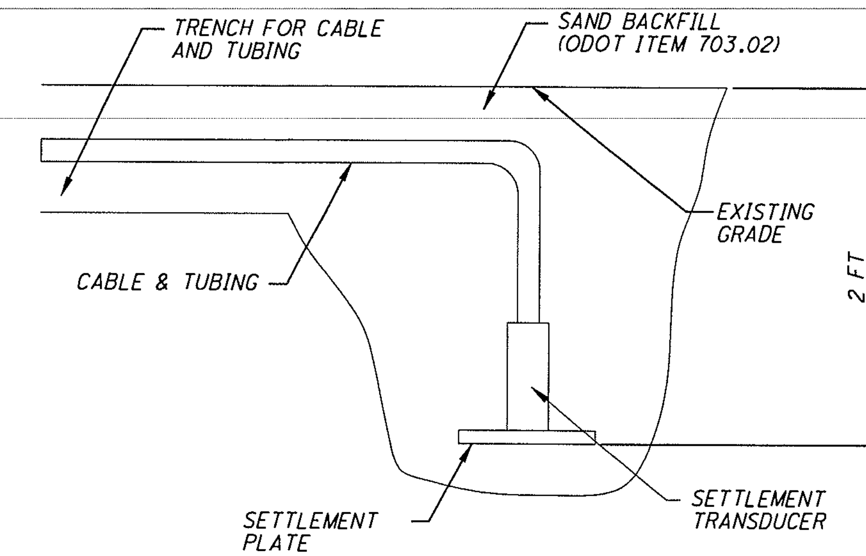
VIBRATING WIRE PIEZOMETER, AS PER PLAN

(NOT TO SCALE)

TABLE 1 - EMBANKMENT STAGED CONSTRUCTION

ROADWAY SECTION	TOTAL EMBANKMENT HEIGHT		REQUIRED DEGREE OF CONSOLIDATION PRIOR TO PLACING SUBSEQUENT STAGES	MAXIMUM EXCESS PORE PRESSURE HEAD[1]
TR 234 INTERCHANGE[2]	STAGE 1	26 FT	90%	18 FT
	STAGE 2	51 FT	90%	18 FT
	STAGE 3	80 FT	-	18 FT
CR 28 INTERCHANGE[3]	STAGE 1	27 FT	90%	18 FT
	STAGE 2	45 FT	-	18 FT

1. EXCESS PORE PRESSURES SHOULD NOT BE ALLOWED TO RISE ABOVE SPECIFIED LEVEL AT ANY TIME. LEVEL MEASURED RELATIVE TO EXISTING GROUND SURFACE
2. APPROXIMATE MAXIMUM EMBANKMENT HEIGHT IS 80 FT
3. APPROXIMATE MAXIMUM EMBANKMENT HEIGHT IS 45 FT



SETTLEMENT PLATFORM DETAIL

(NOT TO SCALE)

TABLE 2 - ESTIMATED WAITING PERIOD

ROADWAY SECTION	WICK DRAIN SPACING	ESTIMATED TIME TO 90% CONSOLIDATION[1]		
		STAGE 1	STAGE 2	STAGE 3
TR 234 INTERCHANGE				
AREA 1 & AREA 2	6 FT	265 DAYS	215 DAYS	-
AREA 3 & AREA 4	4 FT	145 DAYS	120 DAYS	95 DAYS
CR 28 INTERCHANGE				
SR 823 MAINLINE	7 FT	420 DAYS	360 DAYS	-
RAMPS A, B, C & D	5 FT	215 DAYS	185 DAYS	-

1. PROVIDED WAITING PERIODS ARE ESTIMATES ONLY. VERIFY THAT CONSOLIDATION REQUIREMENTS ARE ACHIEVED BY ANALYSIS OF PIEZOMETER AND SETTLEMENT READINGS

CALCULATED MAB CHECKED DMV

INSTRUMENTATION AND SPECIAL CONSTRUCTION NOTES AND DETAILS

SCI-823-6.81

USER: ebstdorf PLOT DATE: 7/29/2009 12:46:00 PM REVISION DATE: 7/29/2009 FILE: ...006594/000000045878 /7945gn006.dgn MODEL: Sheet

NOTES:

1. WICK DRAINS TO BE INSTALLED PRIOR TO EMBANKMENT CONSTRUCTION.

2. ITEM 203, EMBANKMENT AS PER PLAN: PLACE 2 FEET OF ODOT ITEM 703.02A BEFORE THE INSTALLATION OF THE WICK DRAINS. THE FINE AGGREGATE SHALL CONSIST OF CLEAN, FREE-DRAINING, COARSE, NATURAL SAND OR SAND MANUFACTURED FROM STONE; 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 703.02A. THE SAND SHALL NOT CONTAIN ANY ORGANIC OR OTHER DELETERIOUS MATERIALS AND SHALL NOT BE FROZEN WHEN PLACED.

3. WICK DRAINS SHALL BE INSTALLED FROM THE WORKING SURFACE TO THE DEPTH SHOWN IN THE PLANS, OR SHALL COMPLETELY PENETRATE THE COMPRESSIBLE FOUNDATION SOILS AT SUCH A DEPTH EITHER SHALLOWER OR DEEPER THAN THE PLAN DEPTH.

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. 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.

6. 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" (SHEET XXX). THE ODOT CONSTRUCTION REPRESENTATIVE MAY MODIFY THE INSTRUMENTATION PLAN BASED UPON FIELD CONDITIONS.

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

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

9. MAINLINE SR823 ROADWAY EMBANKMENTS MUST BE BUILT USING STAGED CONSTRUCTION. THE FOUNDATION PORE WATER PRESSURES AND SETTLEMENTS SHALL BE MONITORED. THE STAGE HEIGHTS, REQUIRED DEGREE OF CONSOLIDATION AND THE MAXIMUM ALLOWABLE PORE PRESSURE ARE PRESENTED IN TABLE 1 (SHEET XXX). A WAITING OR QUARANTINE PERIOD WILL BE REQUIRED BETWEEN STAGES TO ALLOW EXCESS PORE PRESSURES TO DISSIPATE PRIOR TO PLACING SUBSEQUENT STAGES. THE ESTIMATED TIME TO ACHIEVE 90 PERCENT CONSOLIDATION (U=90%) ARE PRESENTED IN TABLE 2 (SHEET XXX). ESTIMATES FOR WICK DRAIN QUANTITIES ARE PRESENTED IN TABULAR FORM ON SHEETS XXX AND XXX.

10. DURING CONSTRUCTION, THE VIBRATING WIRE PIEZOMETERS SHALL BE READ A MINIMUM OF TWO TIMES EACH DAY DURING FILL PLACEMENT. MORE FREQUENT READINGS SHALL BE TAKEN IF THE EXCESS PORE PRESSURE HEAD IS ABOVE THE LEVEL OF THE EXISTING GROUND SURFACE. THE SETTLEMENT PLATFORMS SHALL ALSO BE READ A MINIMUM OF TWO TIMES EACH DAY. DURING THE WAITING OR CONSOLIDATION PERIOD, READINGS OF THE VIBRATING WIRE PIEZOMETERS AND SETTLEMENT PLATFORMS CAN BE REDUCED TO A MINIMUM OF ONE TIME EACH DAY.

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CALCULATED MAB
CHECKED DMV

INSTRUMENTATION AND SPECIAL CONSTRUCTION
NOTES AND DETAILS

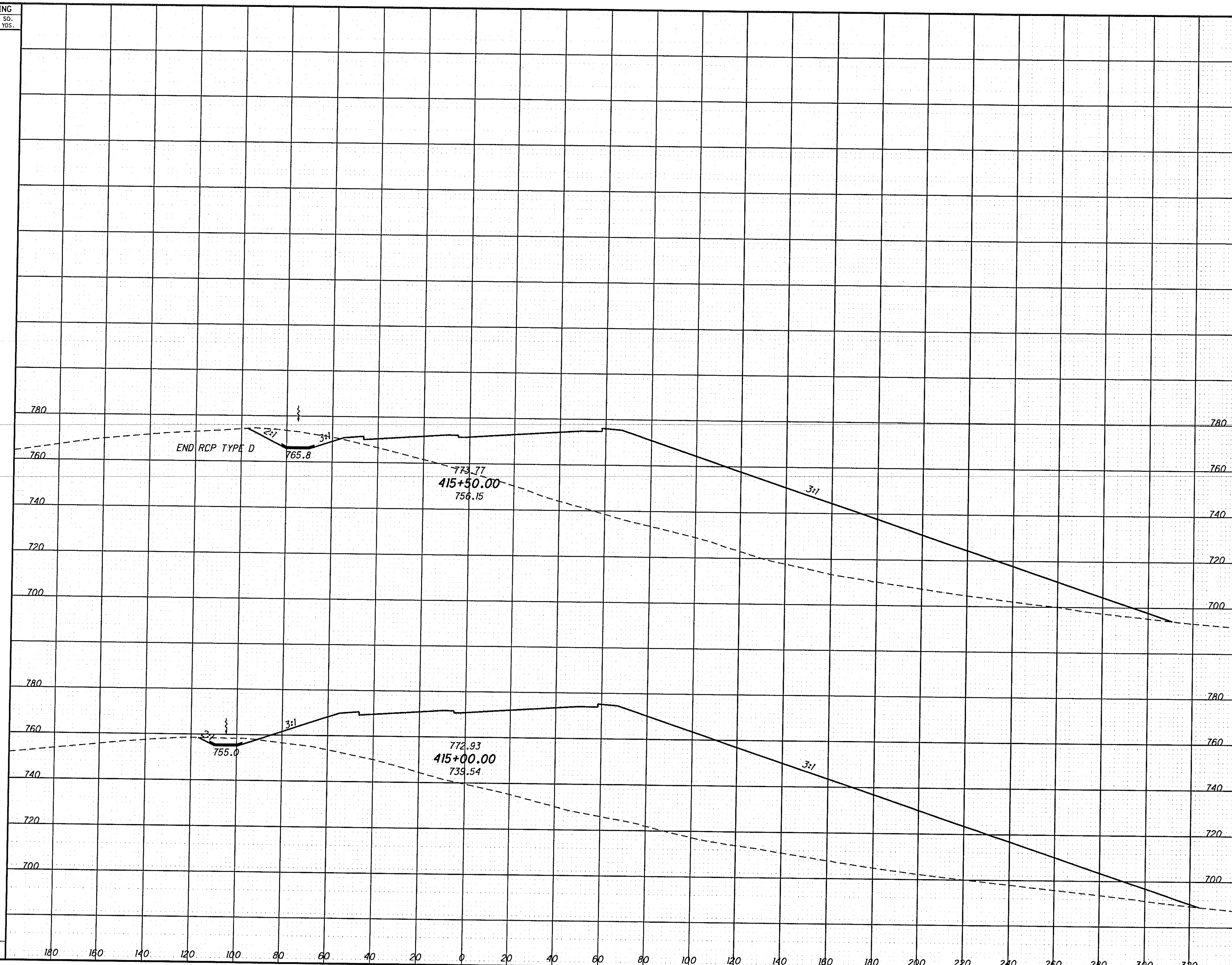
SCI-823-6.81

Appendix D
Rock Cuts

Rock Cut No. 11
Rock Cut No. 12
Rock Cut No. 13
Rock Cut No. 14
Rock Cut No. 15

Rock Cut No. 11
Sta. 416+00 to Sta. 434+50

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

CHECKED

CROSS SECTIONS - SR823

STA. 415+00.00 TO STA. 415+50.00

SCI-823-6.81

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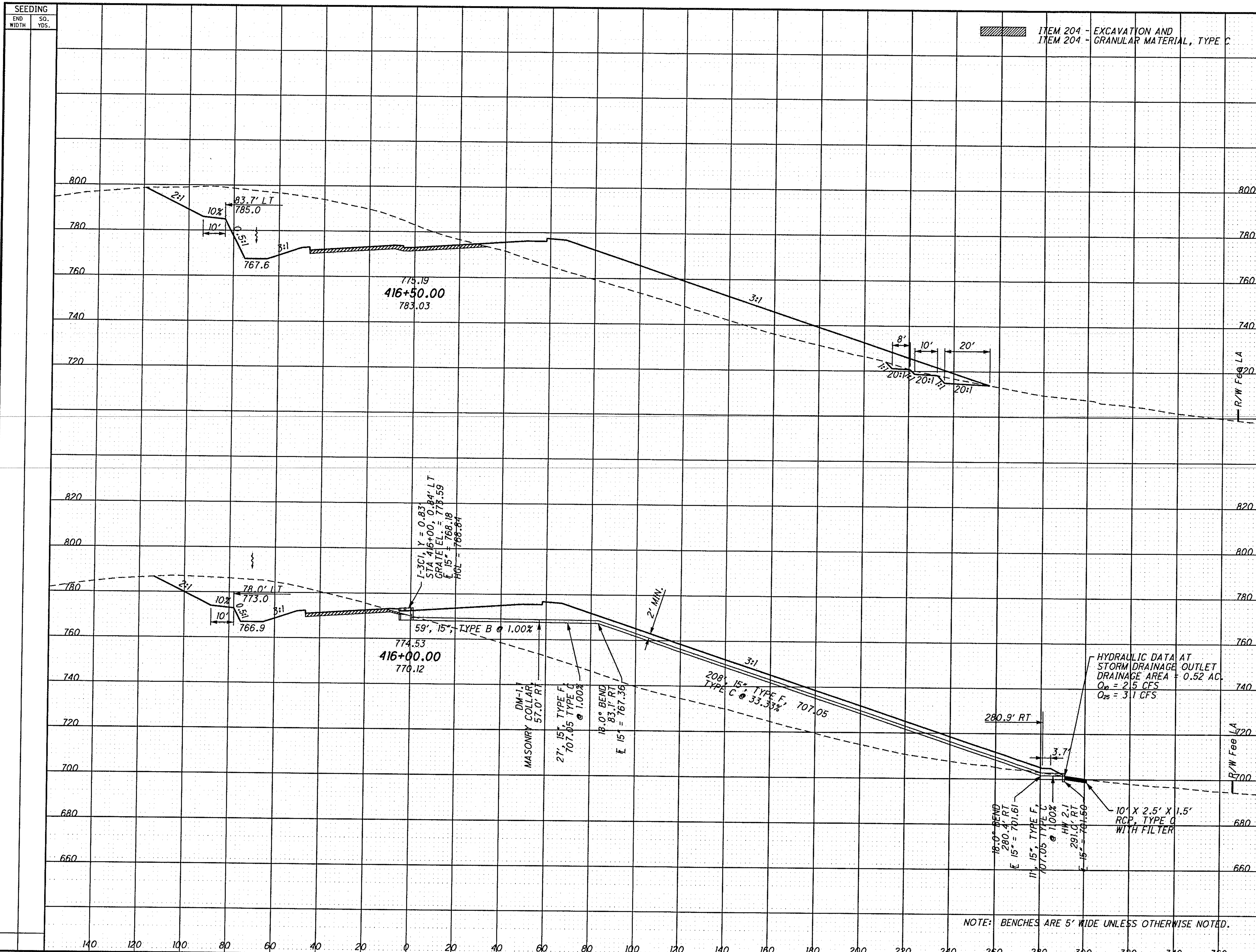

CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 416+00.00 TO STA. 416+50.00

SCI-823-6.81

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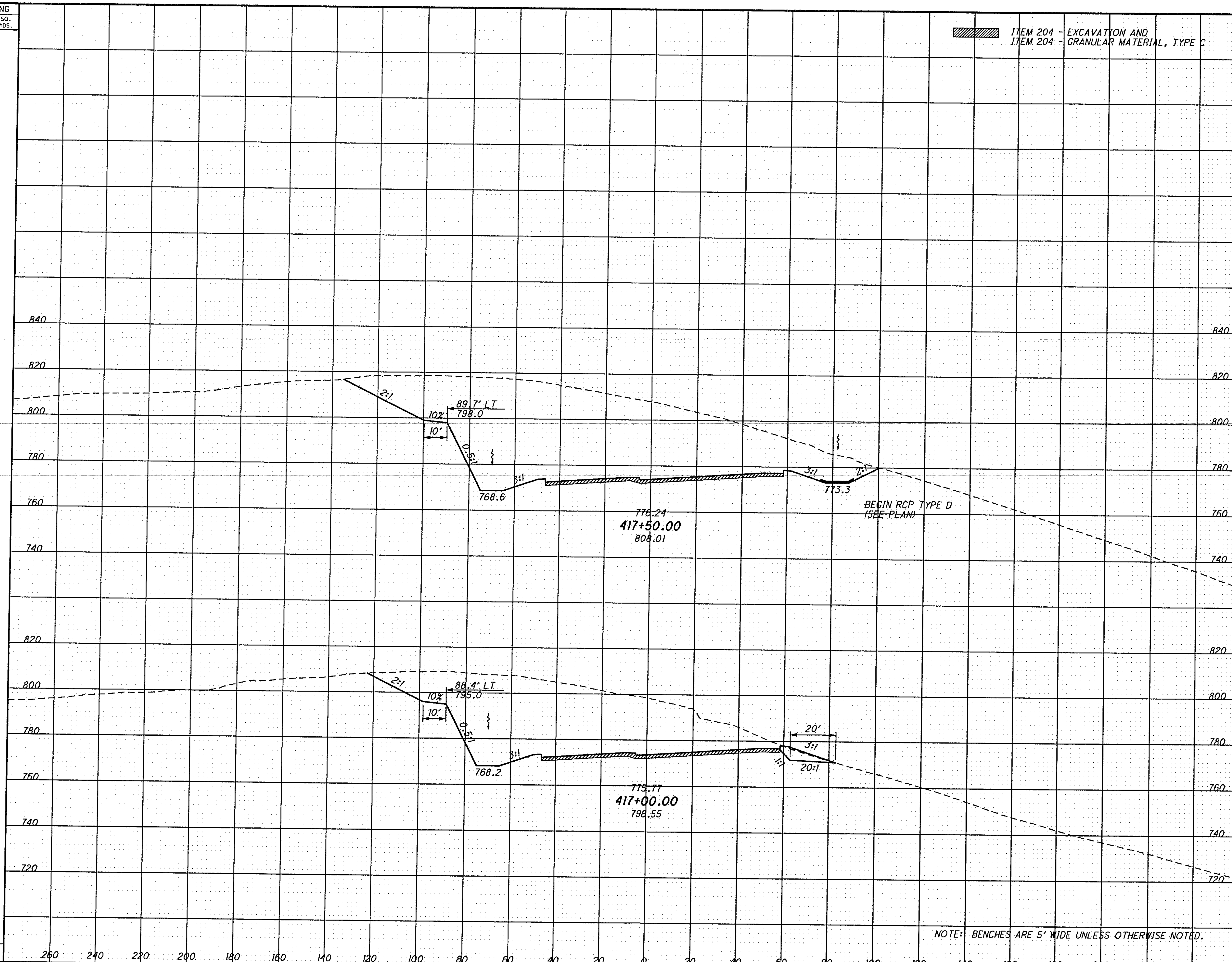
SEEDING	
END WIDTH	SQ. YDS.

END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

CHECKED



CROSS SECTIONS - SR823
STA. 417+00.00 TO STA. 417+50.00

SCI-823-6.81

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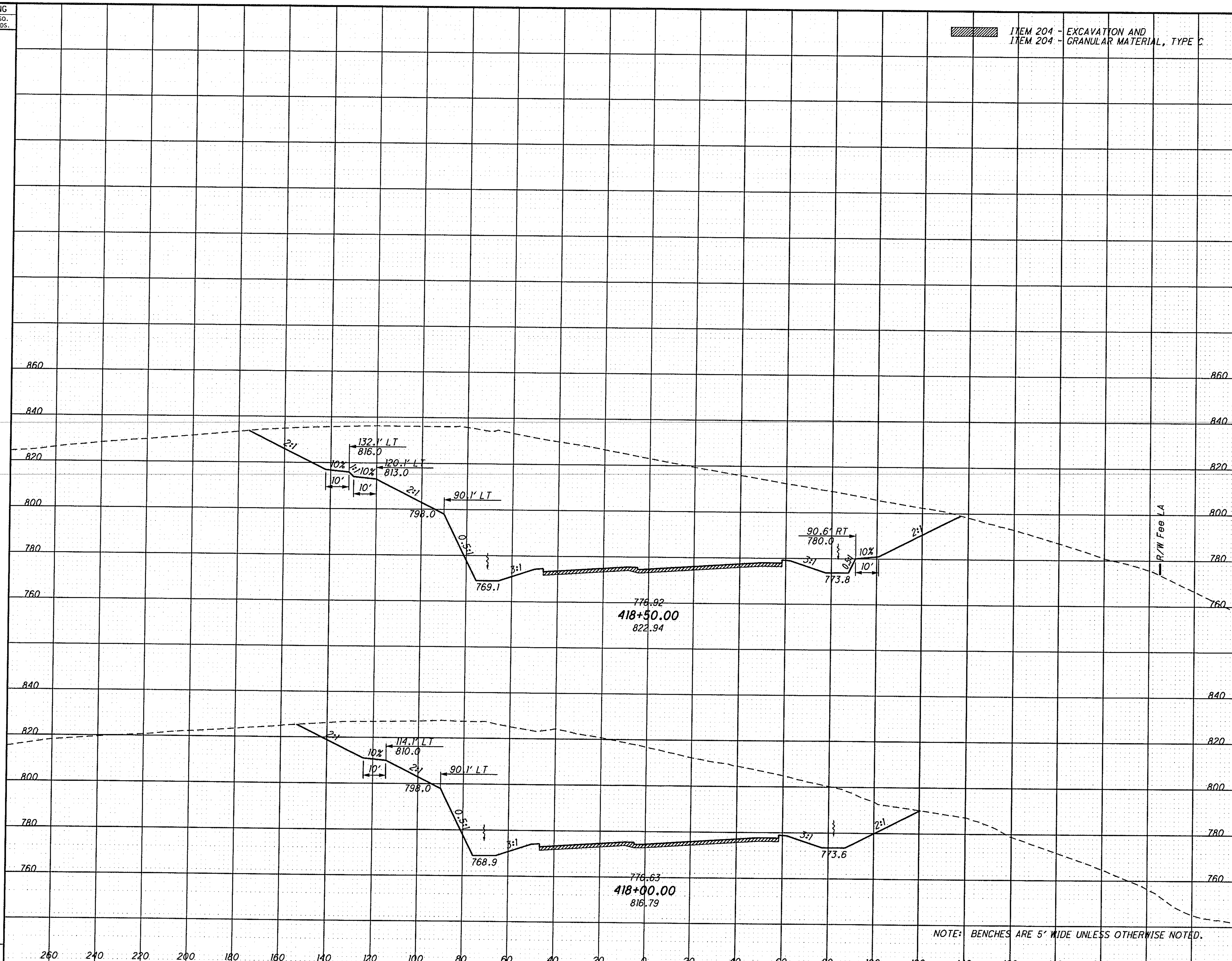
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 418+00.00 TO STA. 418+50.00

SCI-823-6.81

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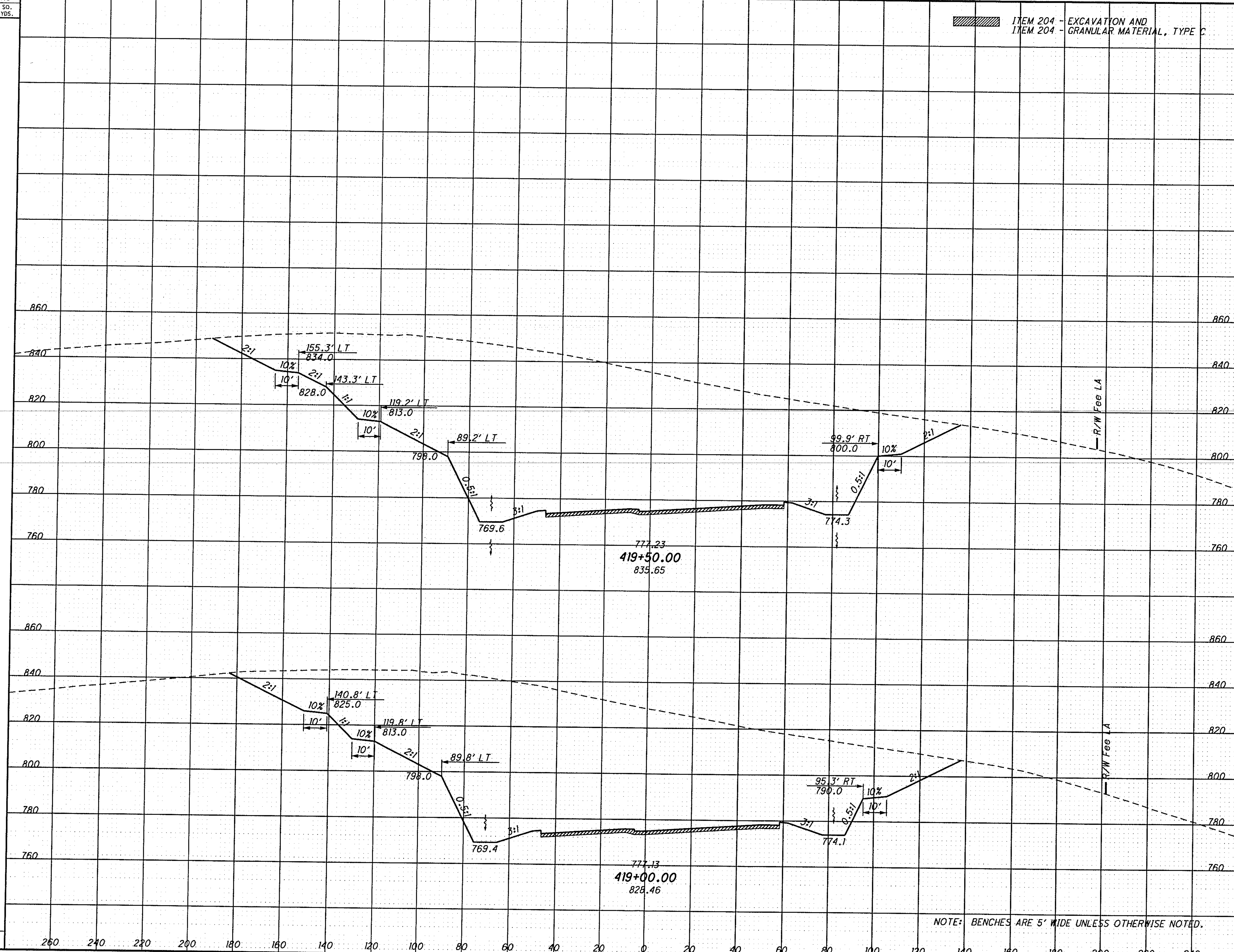

END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - SR823
STA. 419+00.00 TO STA. 419+50.00

SCI-823-6.81

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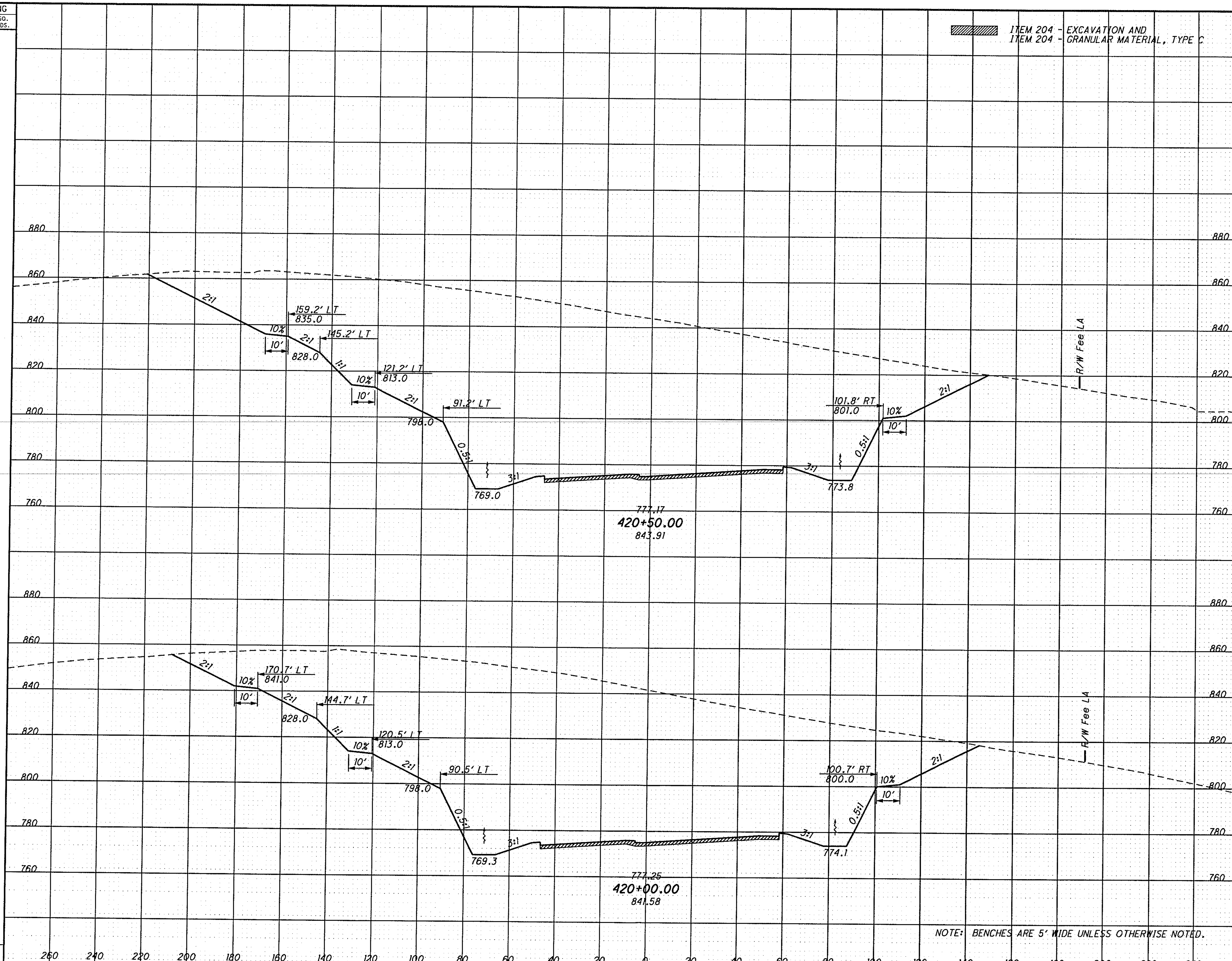

END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 420+00.00 TO STA. 420+50.00

SCI-823-6.81

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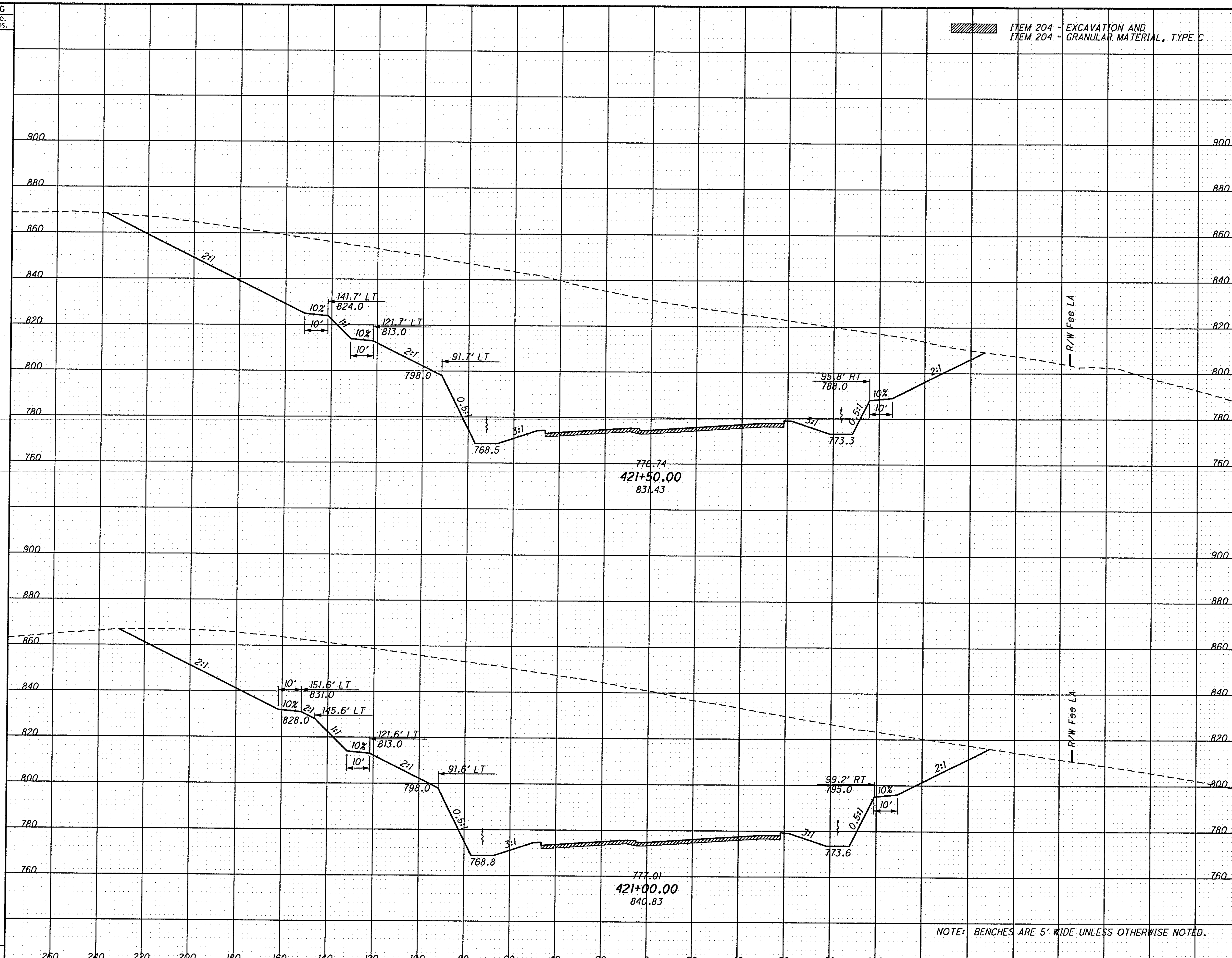
SEEDING		END AREA		VOLUME	
END WIDTH	SQ. YDS.	CUT	FILL	CUT	FILL



CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 421+00.00 TO STA. 421+50.00

SCI-823-6.81

194/752

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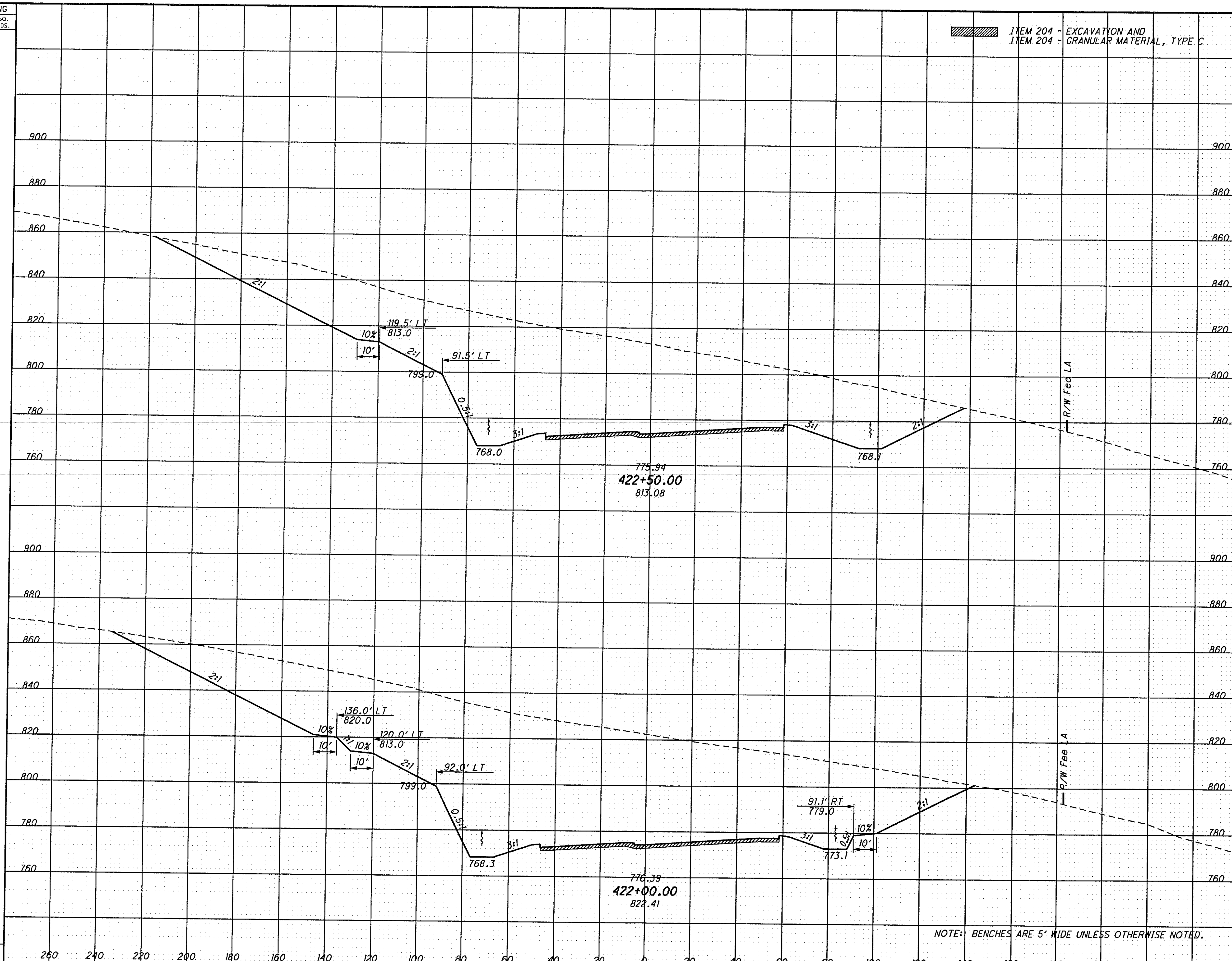
SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 422+00.00 TO STA. 422+50.00

SCI-823-6.81

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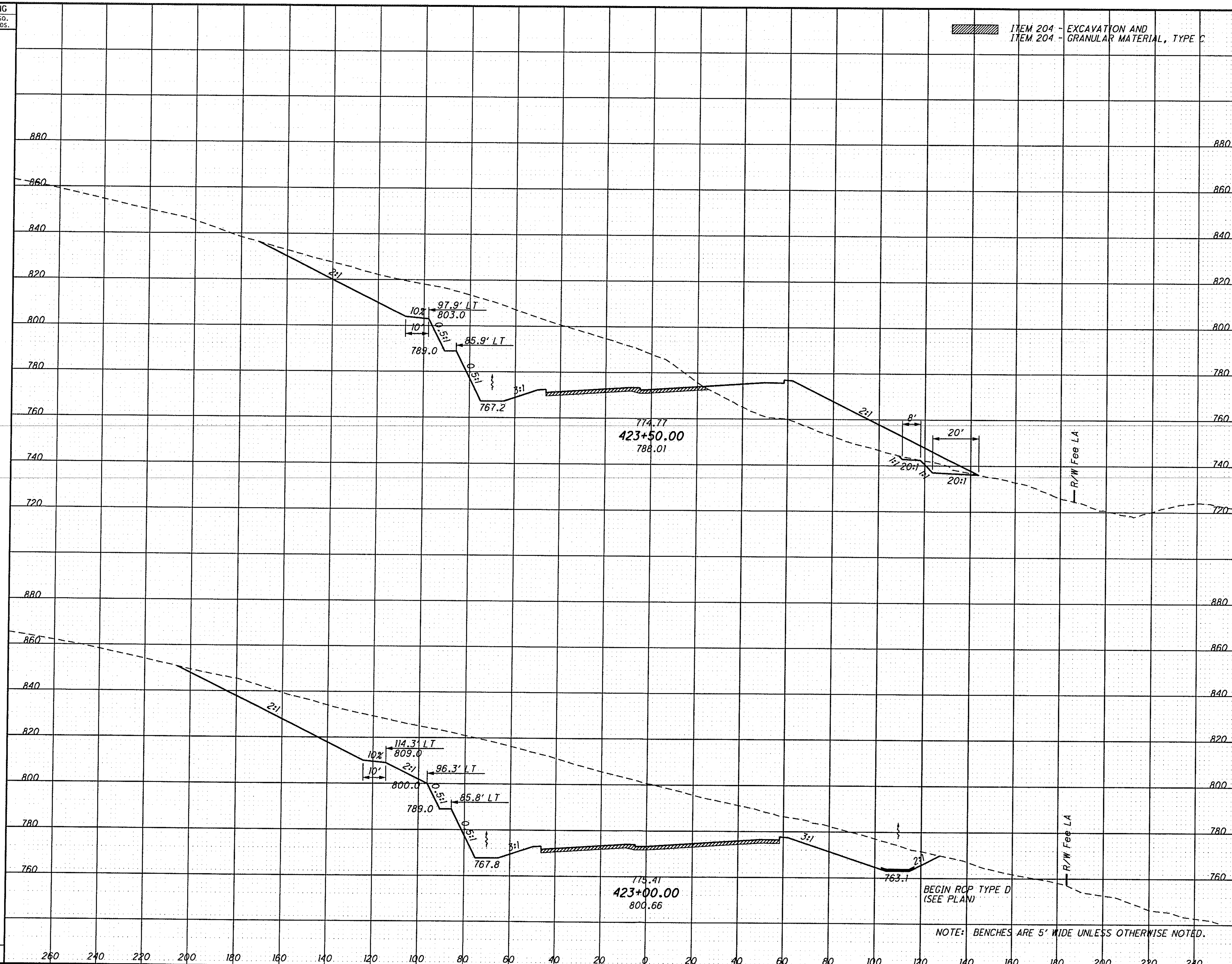
SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 423+00.00 TO STA. 423+50.00

SCI-823-6.81

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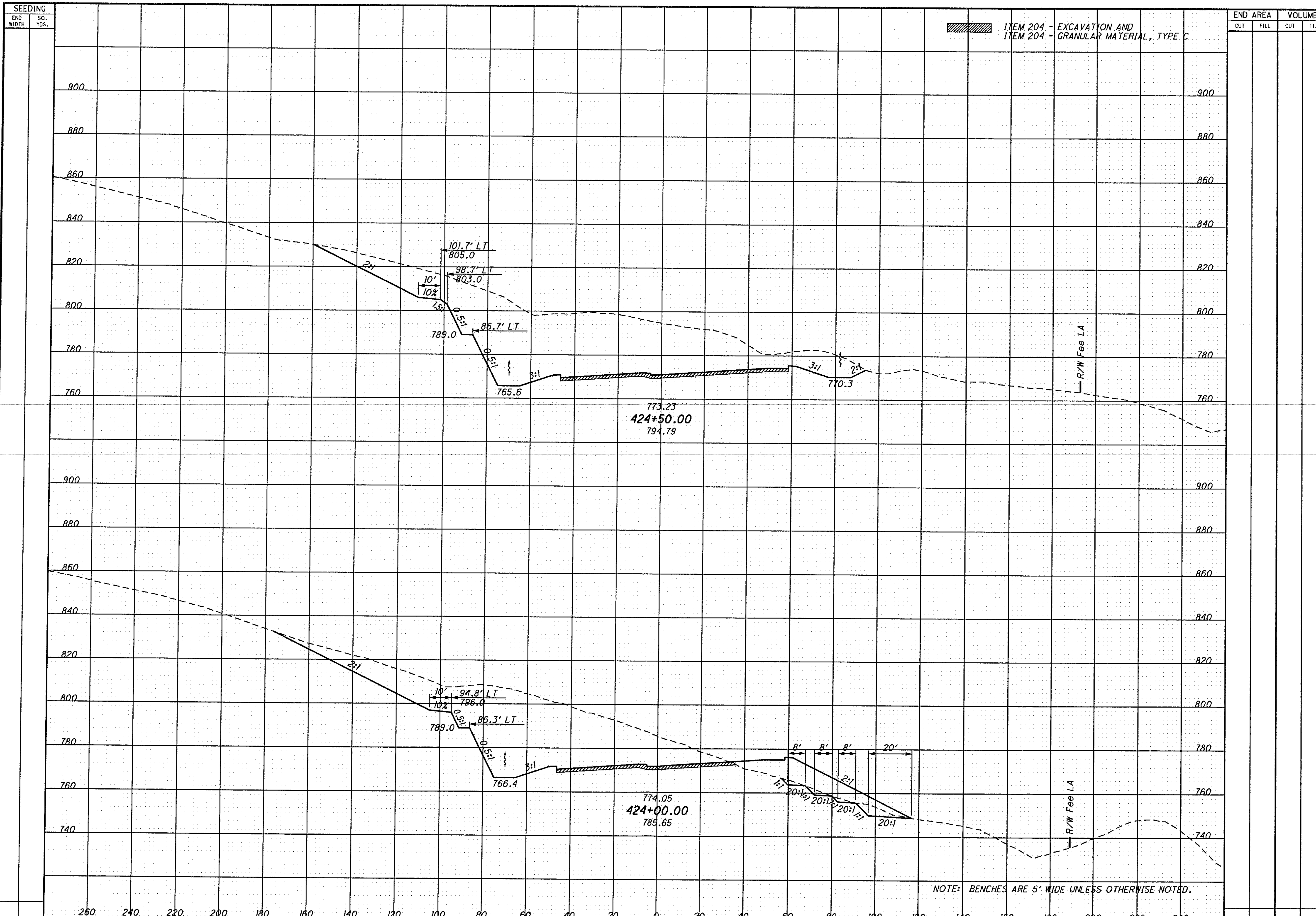


CALCULATED

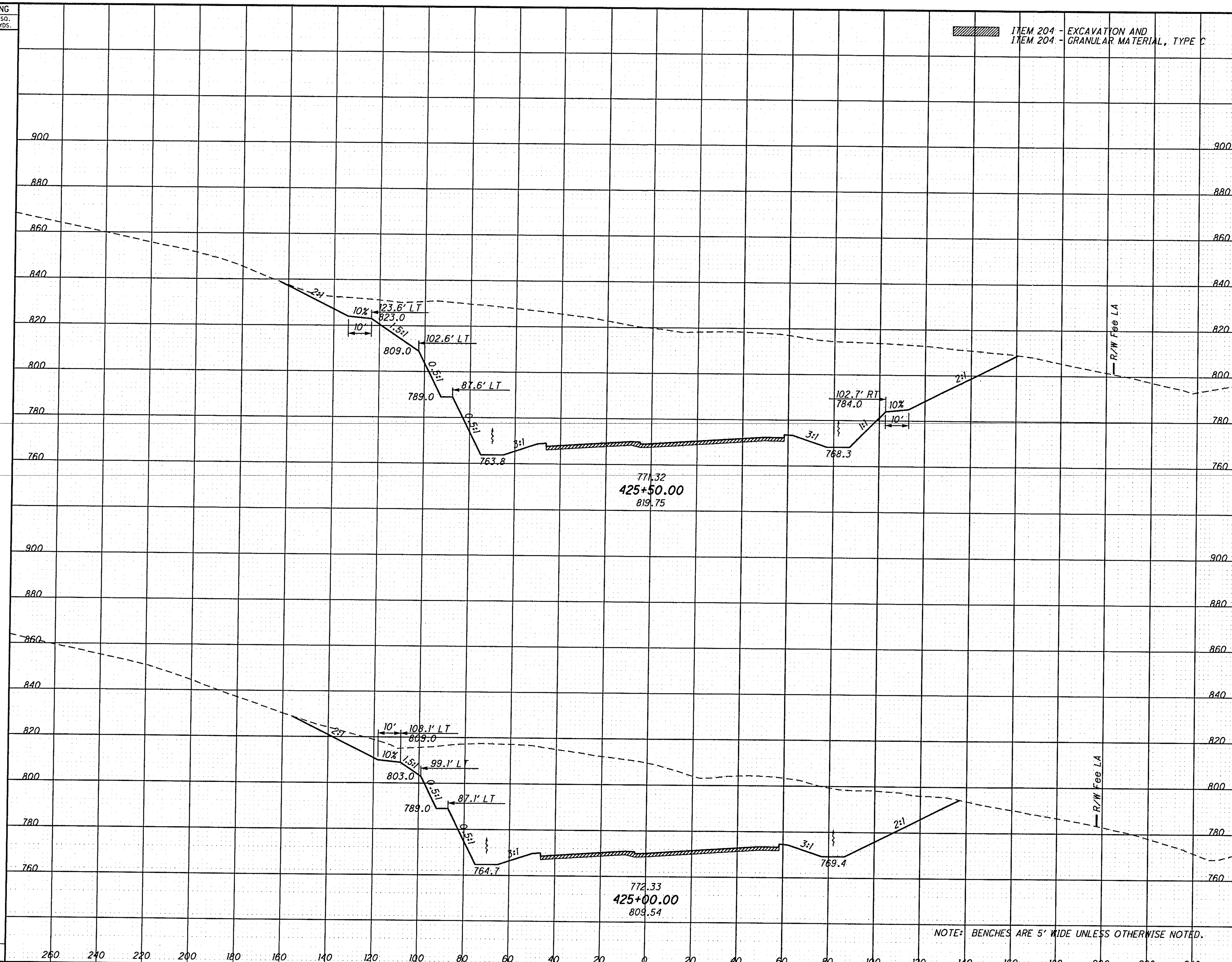
CHECKED

CROSS SECTIONS - SR823

STA. 424+00.00 TO STA. 424+50.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

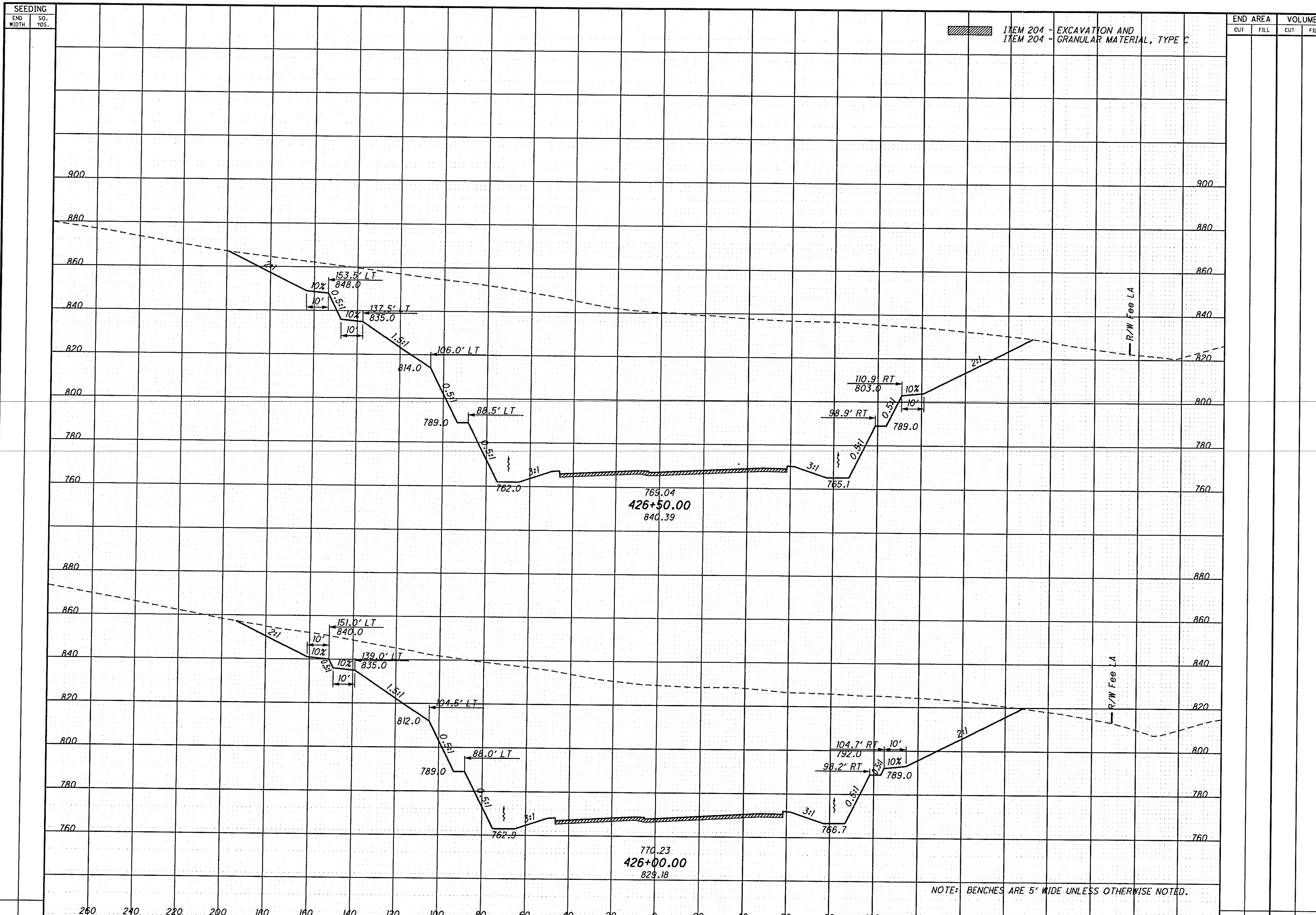
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 425+00.00 TO STA. 425+50.00

SCI-823-6.81

198
752

USER: mbotdorf PLOT DATE: 7/26/2009 6:09:25 PM REVISION DATE: 7/26/2009
FILE:...006594/000000000045878 /19415xs005.dgn MODEL: XS_SHEET_temporary_model_name_11



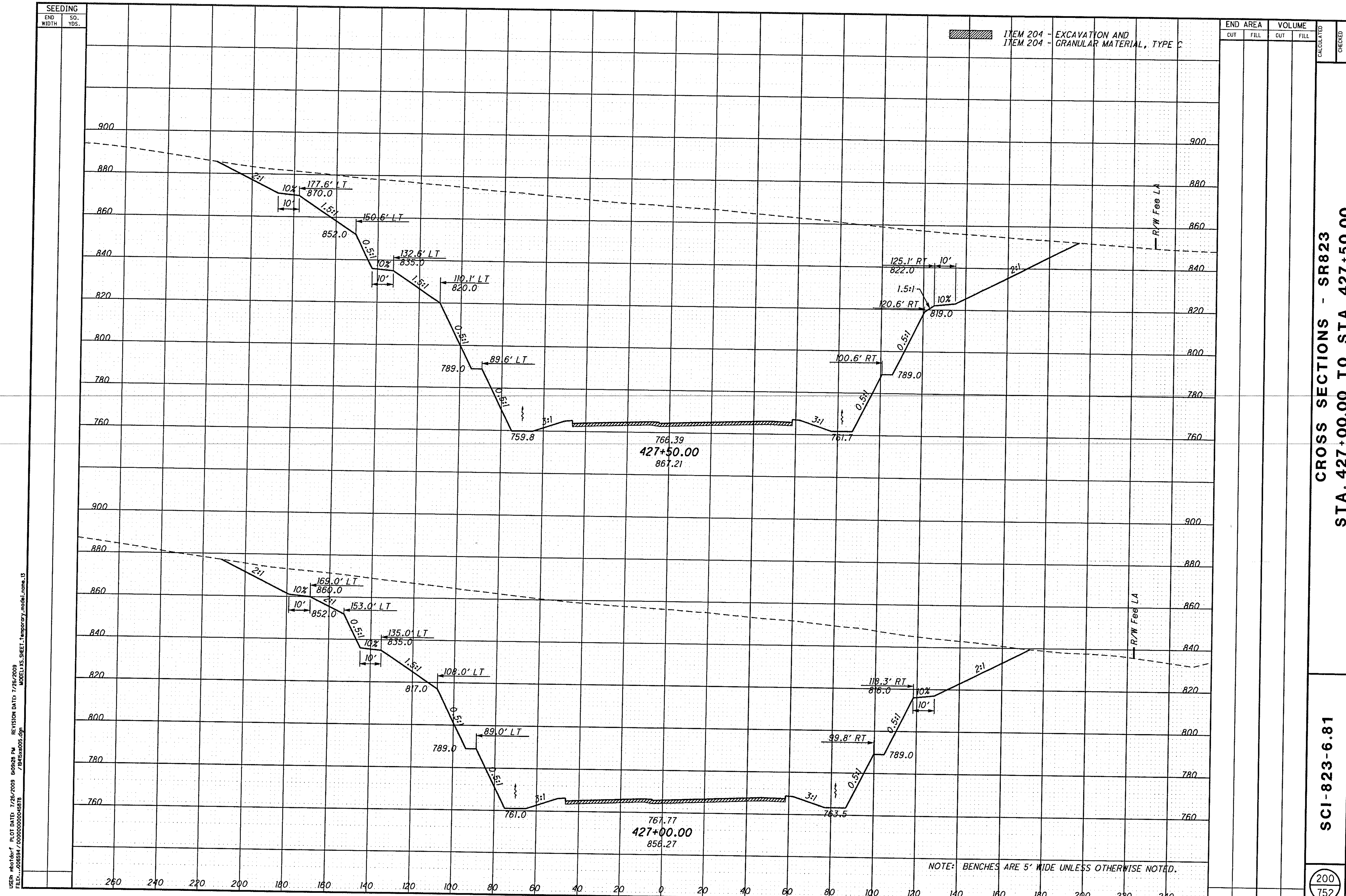
CALCULATED

CHECKED

CROSS SECTIONS - SR823

STA. 426+00.00 TO STA. 426+50.00

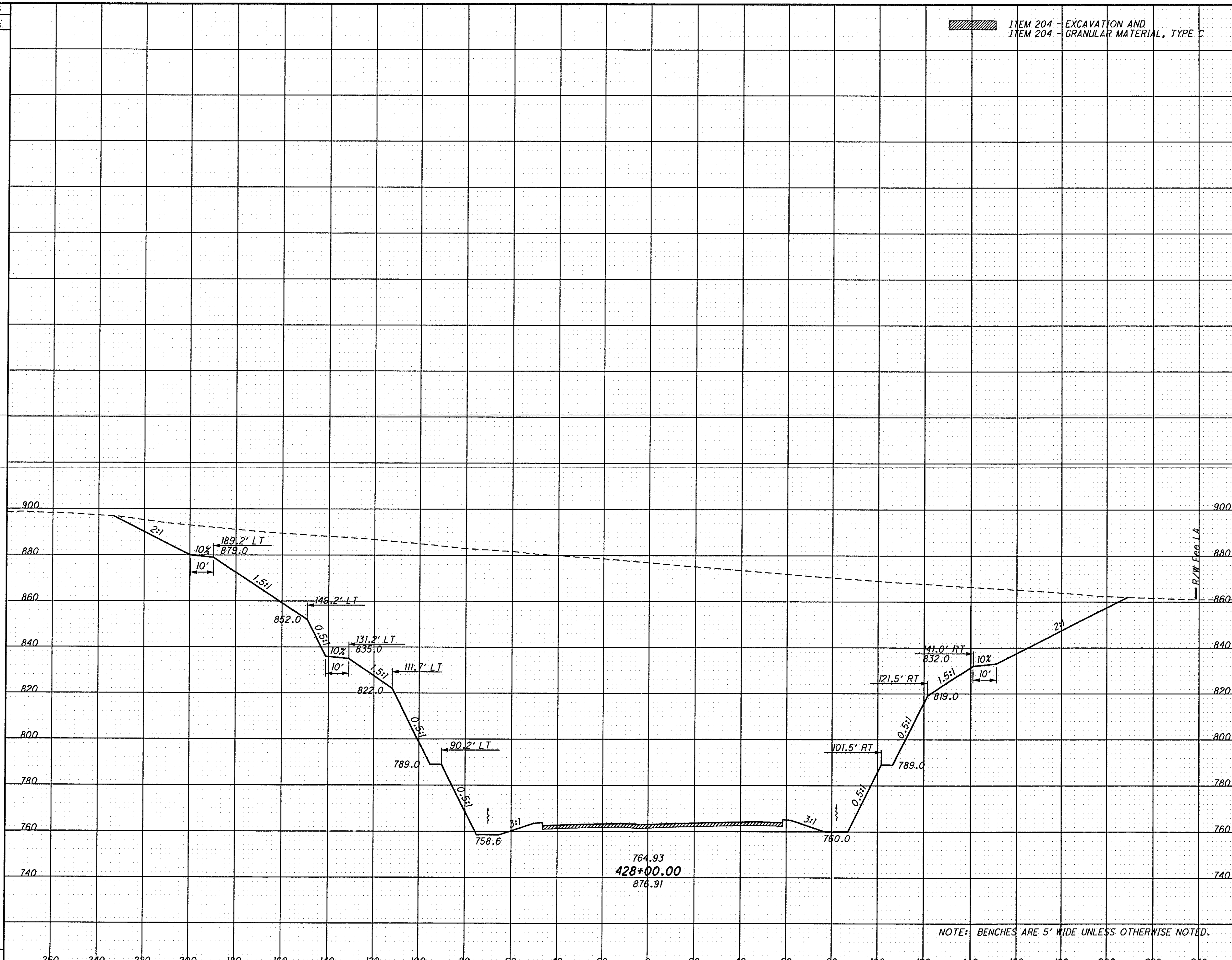
SCI-823-6.81



CROSS SECTIONS - SR823
STA. 427+00.00 TO STA. 427+50.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

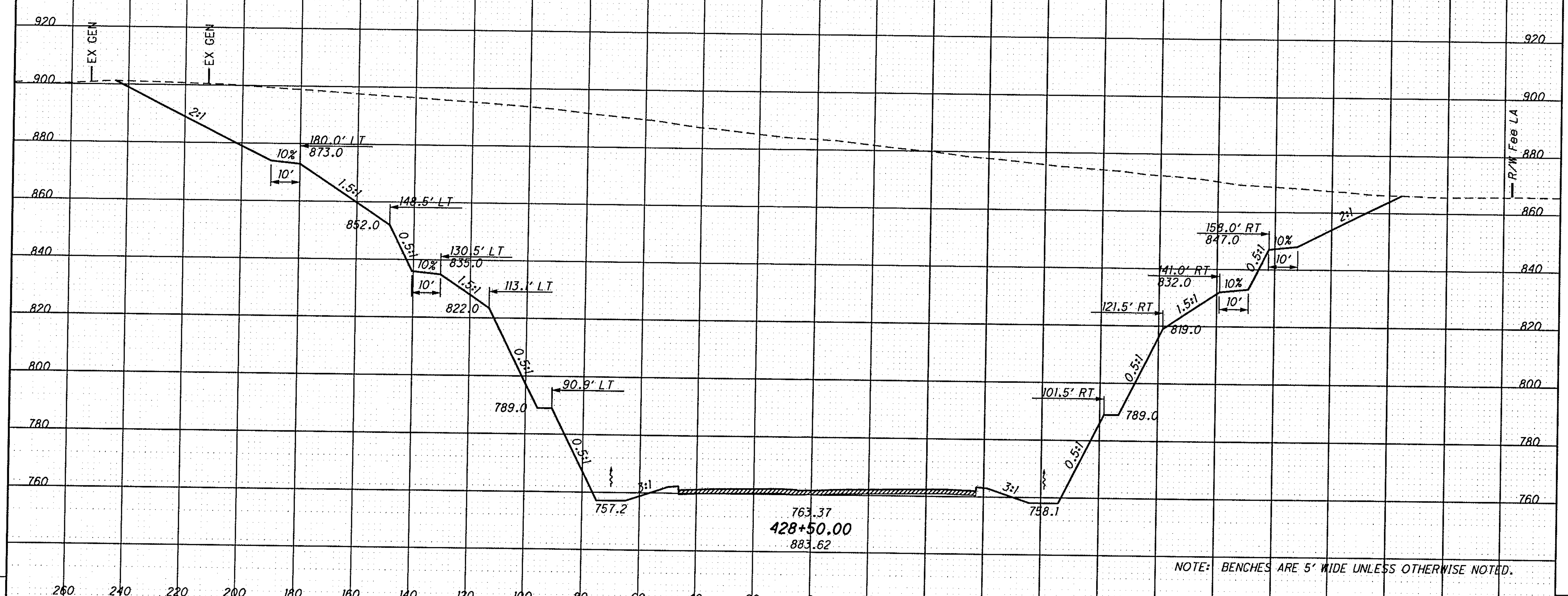
CHECKED

CROSS SECTIONS - SR823
STA. 428+00.00 TO STA. 428+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 5:09:28 PM REVISION DATE: 7/26/2009
FILE: ...008594/000000000045878 /79415xs005.dgn MODEL: XS_SHEET_temporary_model_name_14

SEEDING	
END WIDTH	SQ. YDS.



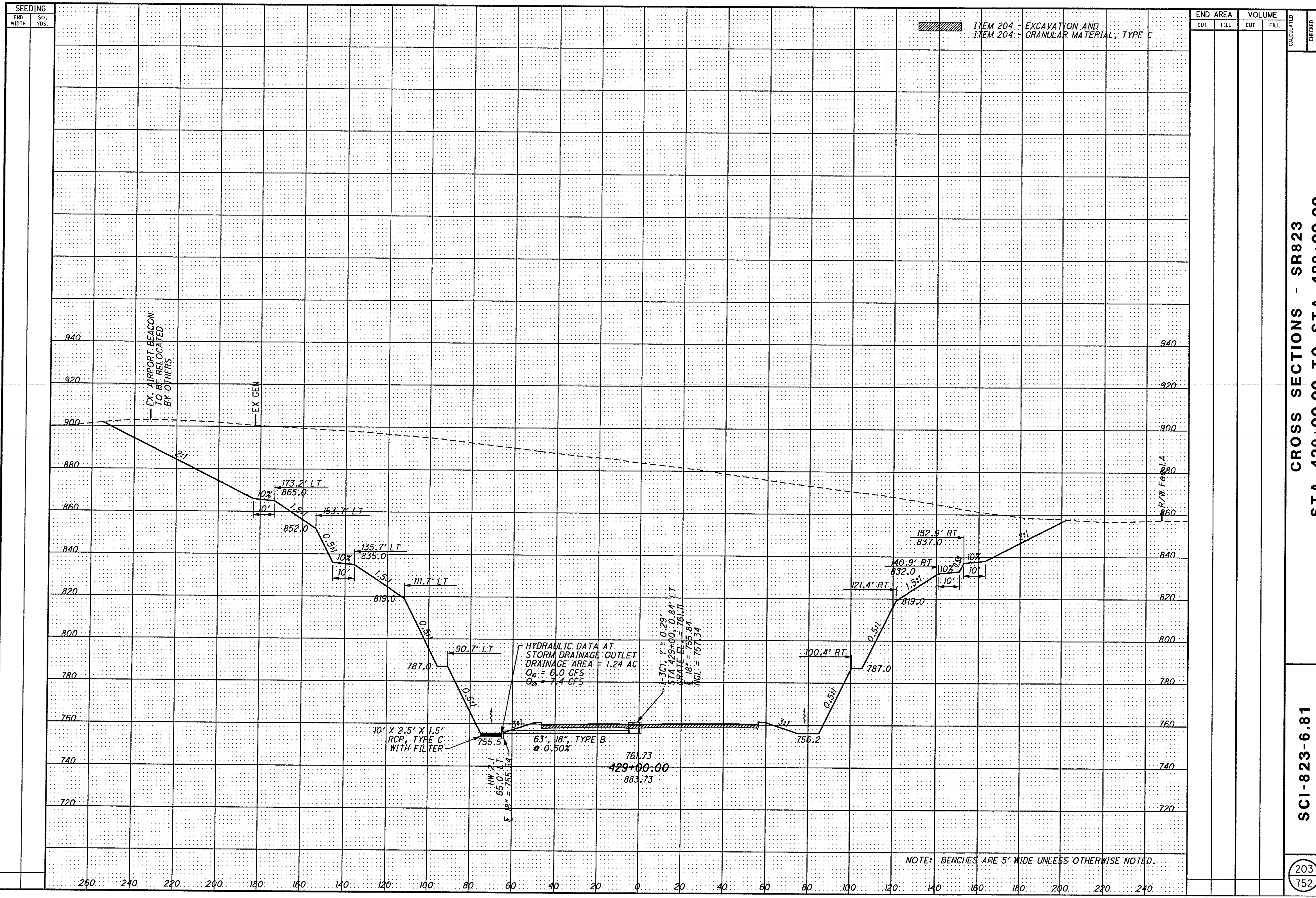
END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 428+50.00 TO STA. 428+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 60929 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000004587 /19415xs005.dgn MODEL: XS_SHEET_temporary_model_name_15



CALCULATED

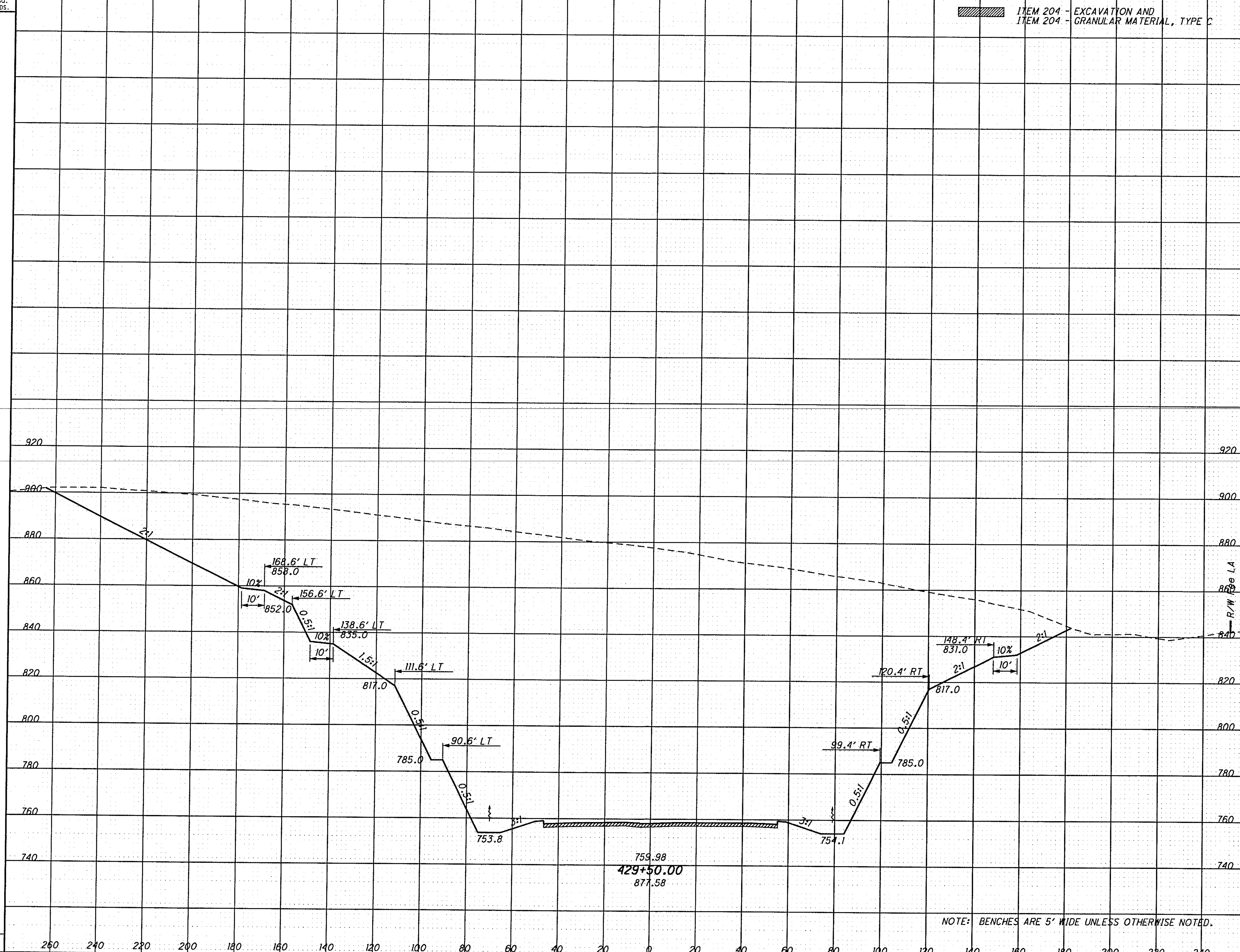
CHECKED

CROSS SECTIONS - SR823
STA. 429+00.00 TO STA. 429+00.00

SCI-823-6.81

USER: ballcm PLOT DATE: 7/29/2009 3:13:46 PM REVISION DATE: 7/29/2009
FILE: ...006594/00000000045878 /18415xs005.dgn MODEL: XS_SHEET_temporary_model_name_16

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

CHECKED

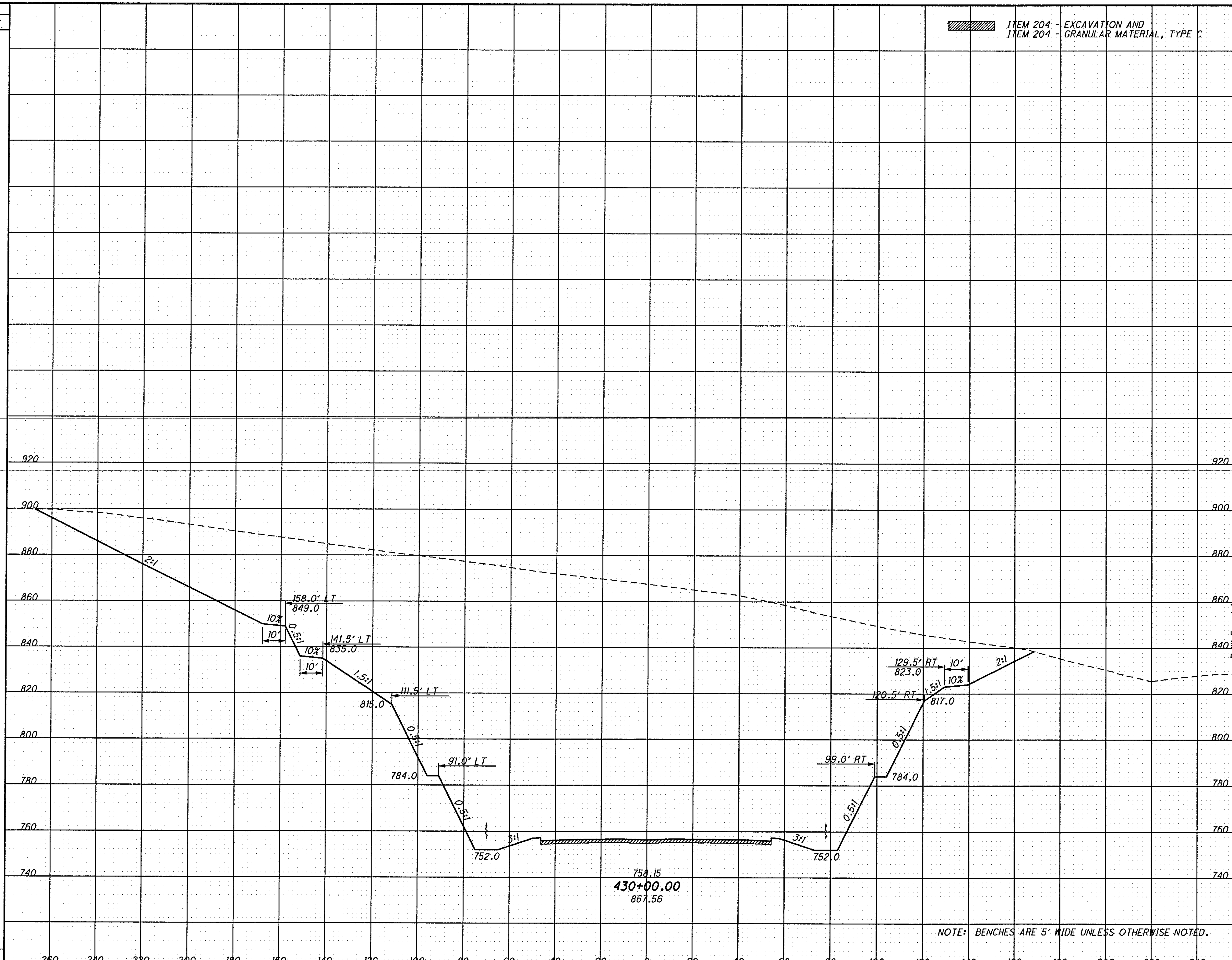
CROSS SECTIONS - SR823

STA. 429+50.00 TO STA. 429+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:09:31 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045878/19415xs005.dgn MODEL: XS_SHEET_temporary_model_name_17

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

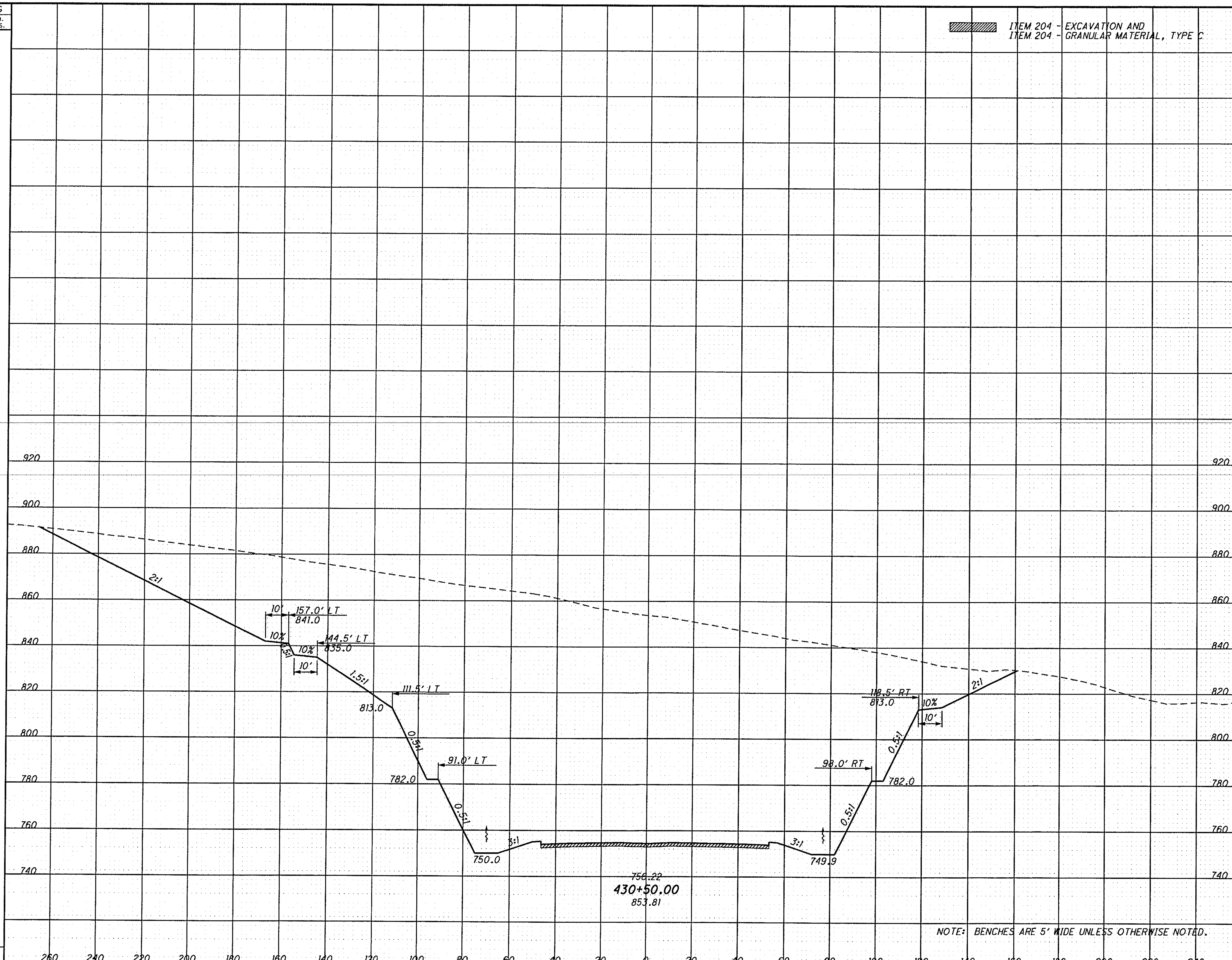
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 430+00.00 TO STA. 430+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:09:32 PM REVISION DATE: 7/26/2009
FILE: ...006594/0000000004587B /1941xs005.dgn MODEL: XS_SHEET_Temporary_model_name_18

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

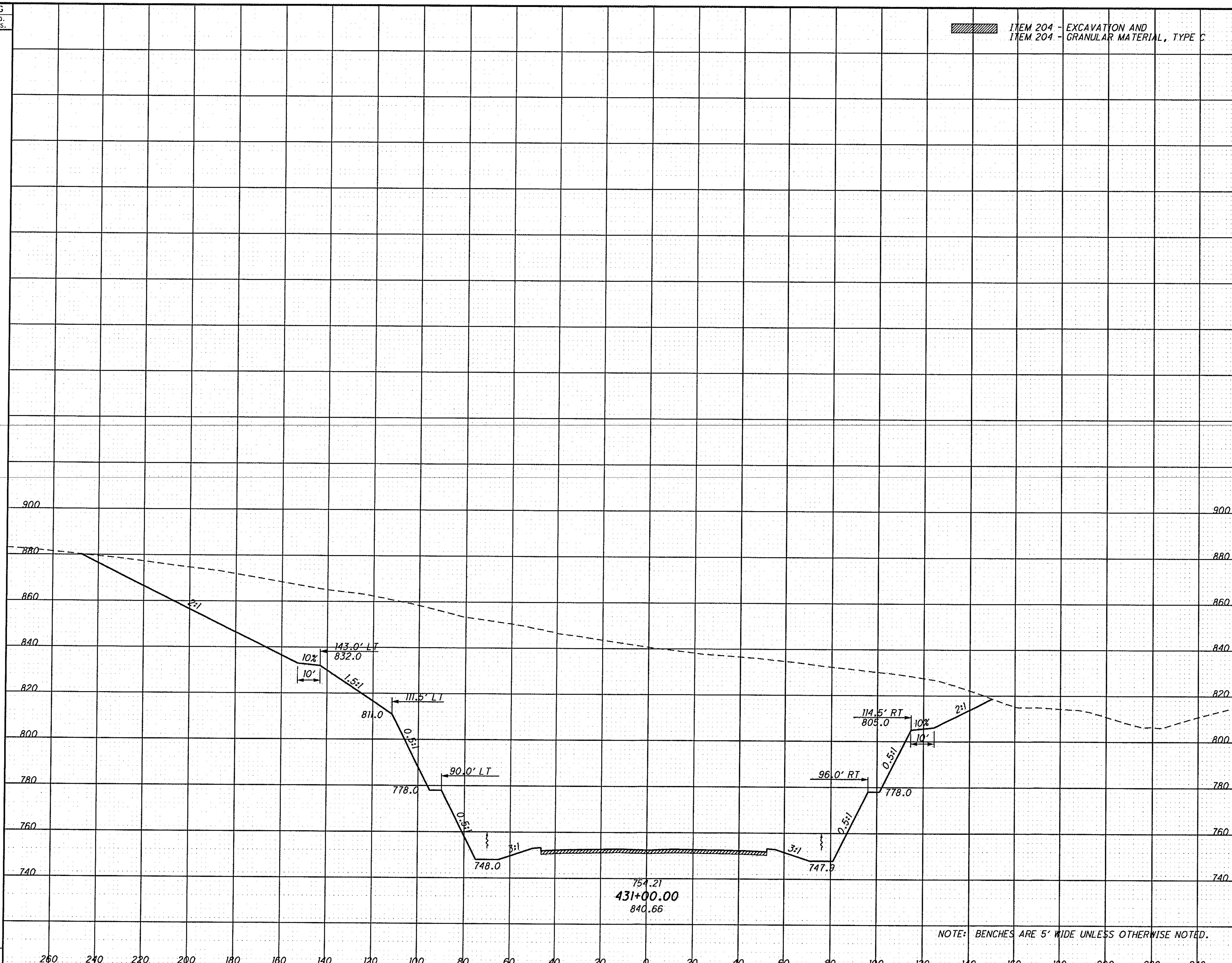
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 430+50.00 TO STA. 430+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/28/2009 6:09:33 PM REVISION DATE: 7/28/2009
FILE: ...008594/000000000045878 78415x005.dgn MODEL: XS_SHEET_temporary_model_name_19

SEEDING	
END WIDTH	SQ. YDS.



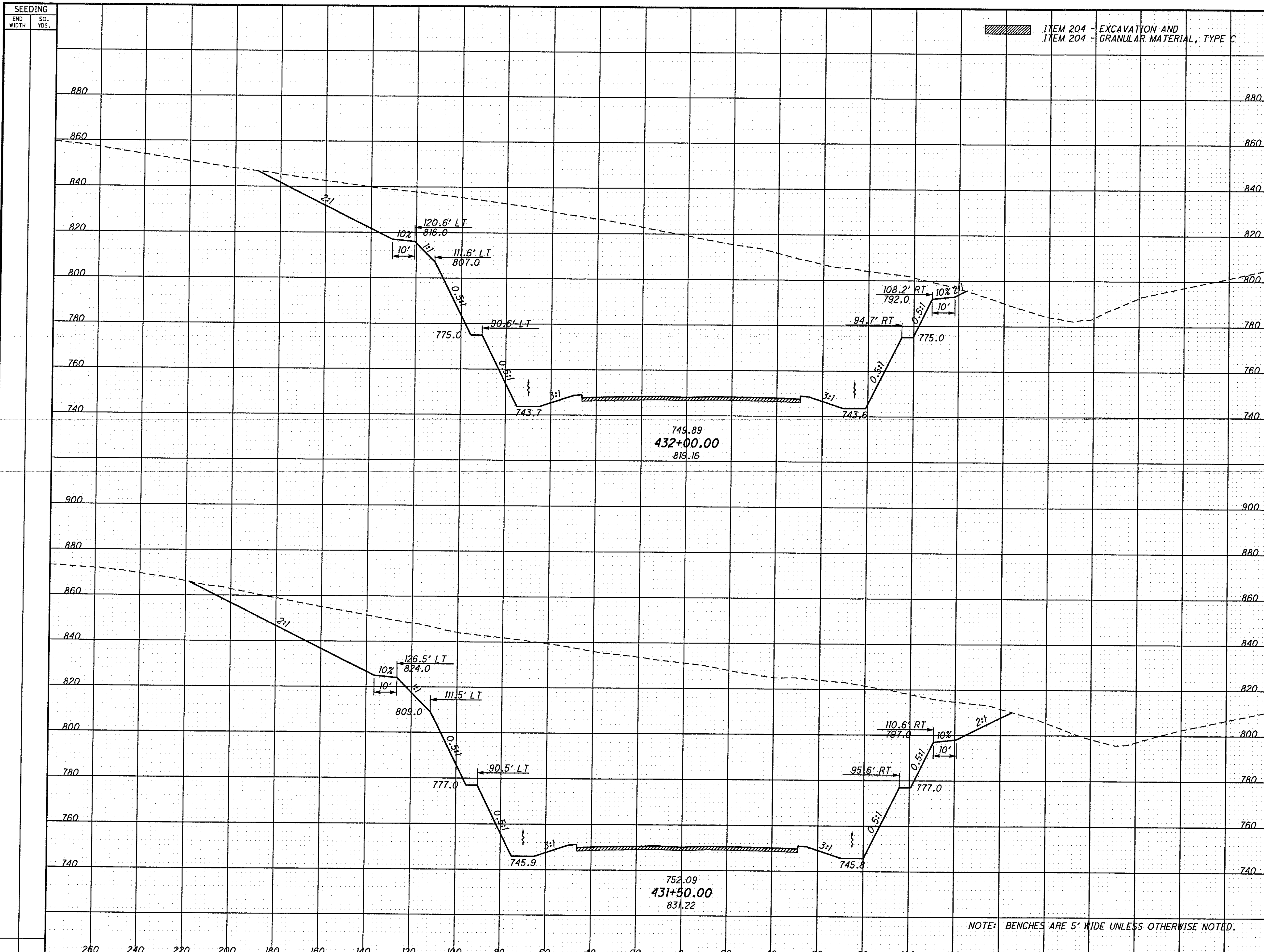
END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 431+00.00 TO STA. 431+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:09:34 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045878 /19415xs005.dgn MODEL: XS_SHEET_temporary_model_name_20



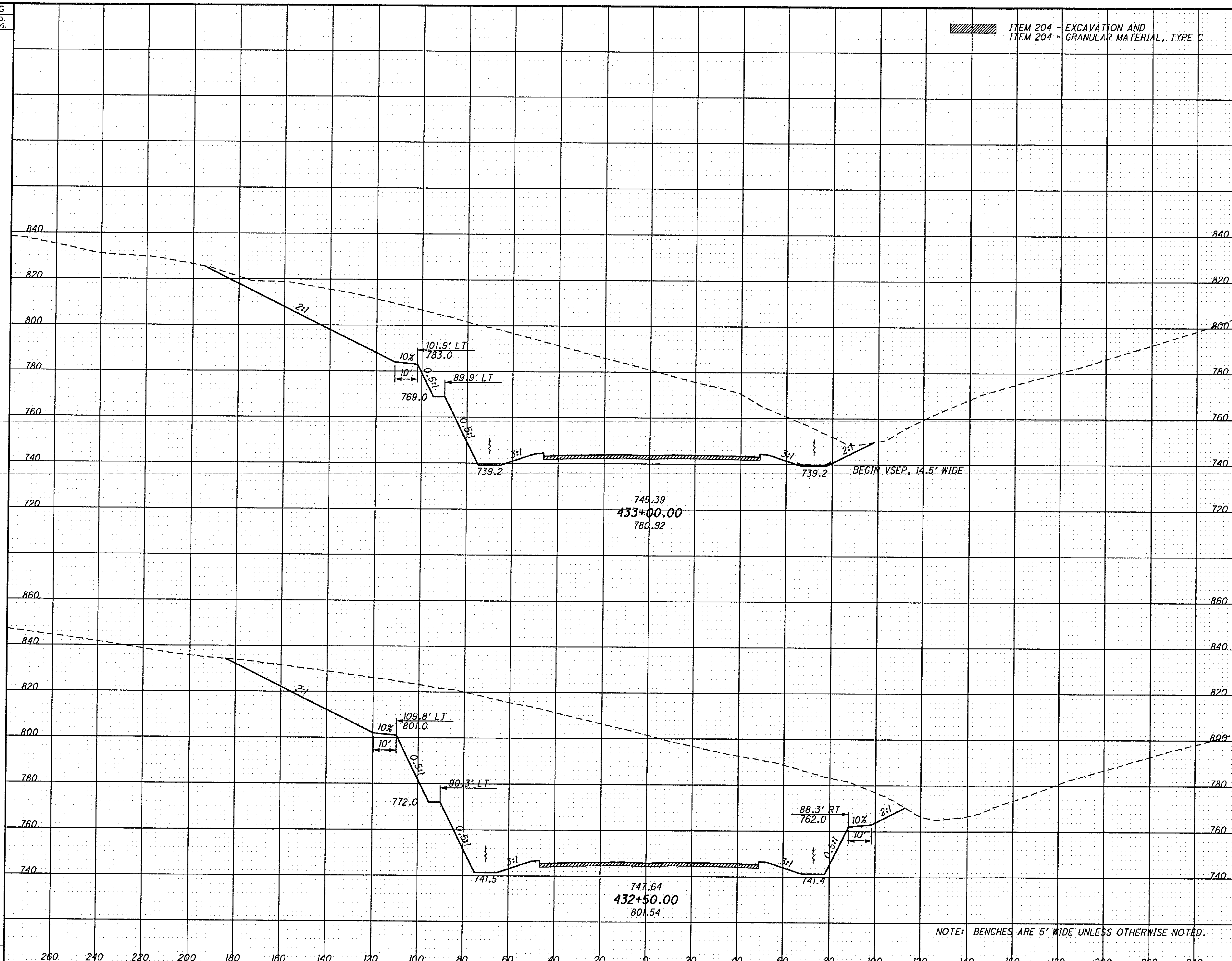
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 431+50.00 TO STA. 432+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:09:35 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045878 /7845xs005.dgn MODEL: XS_SHEET_temporary_model_name_21

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

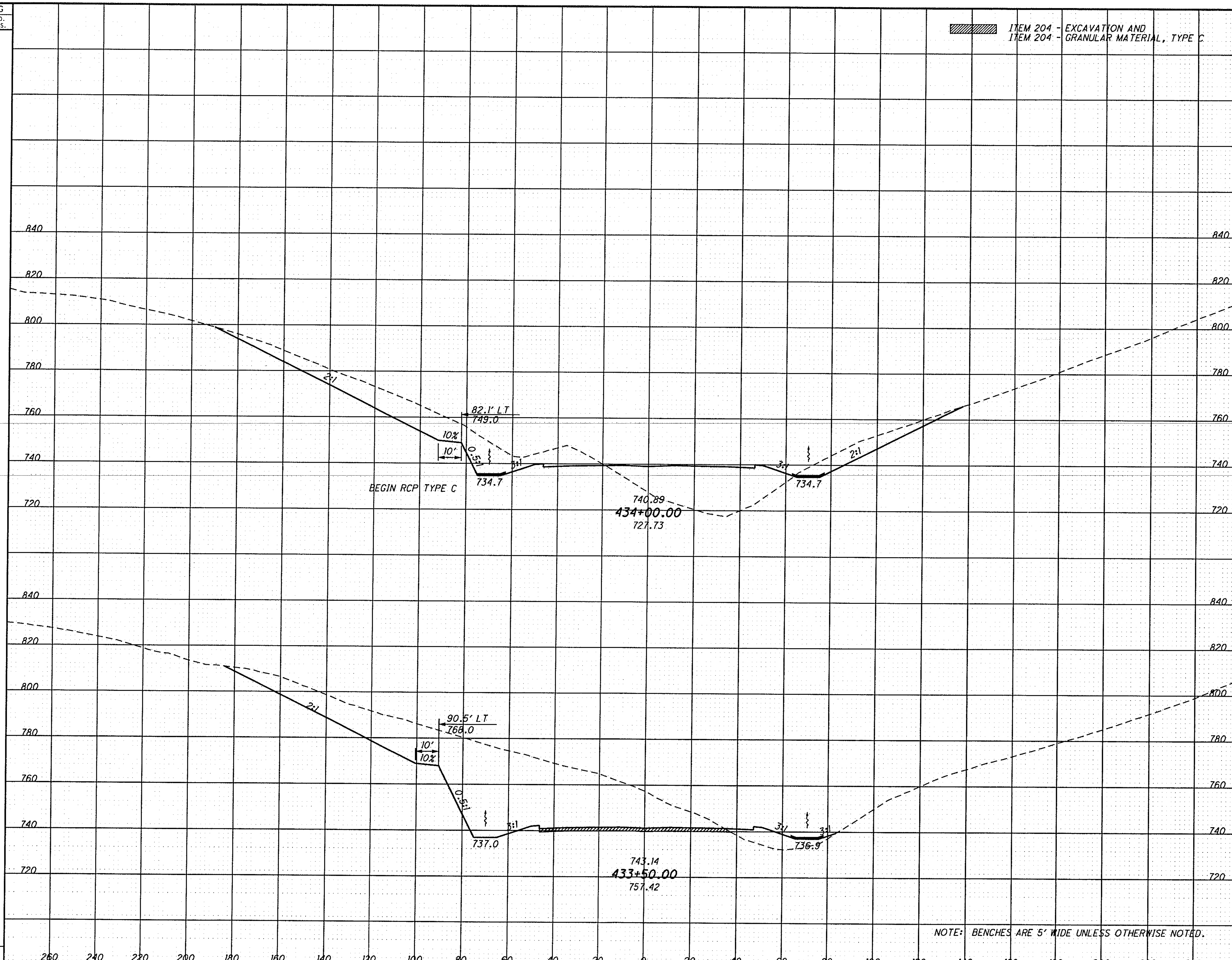
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 432+50.00 TO STA. 433+00.00

SCI-823-6.81

USER: mbetdorf PLOT DATE: 7/26/2009 6:09:35 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045876 /7945xs005.dgn MODEL: XS_SHEET_temporary_model_name_22

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

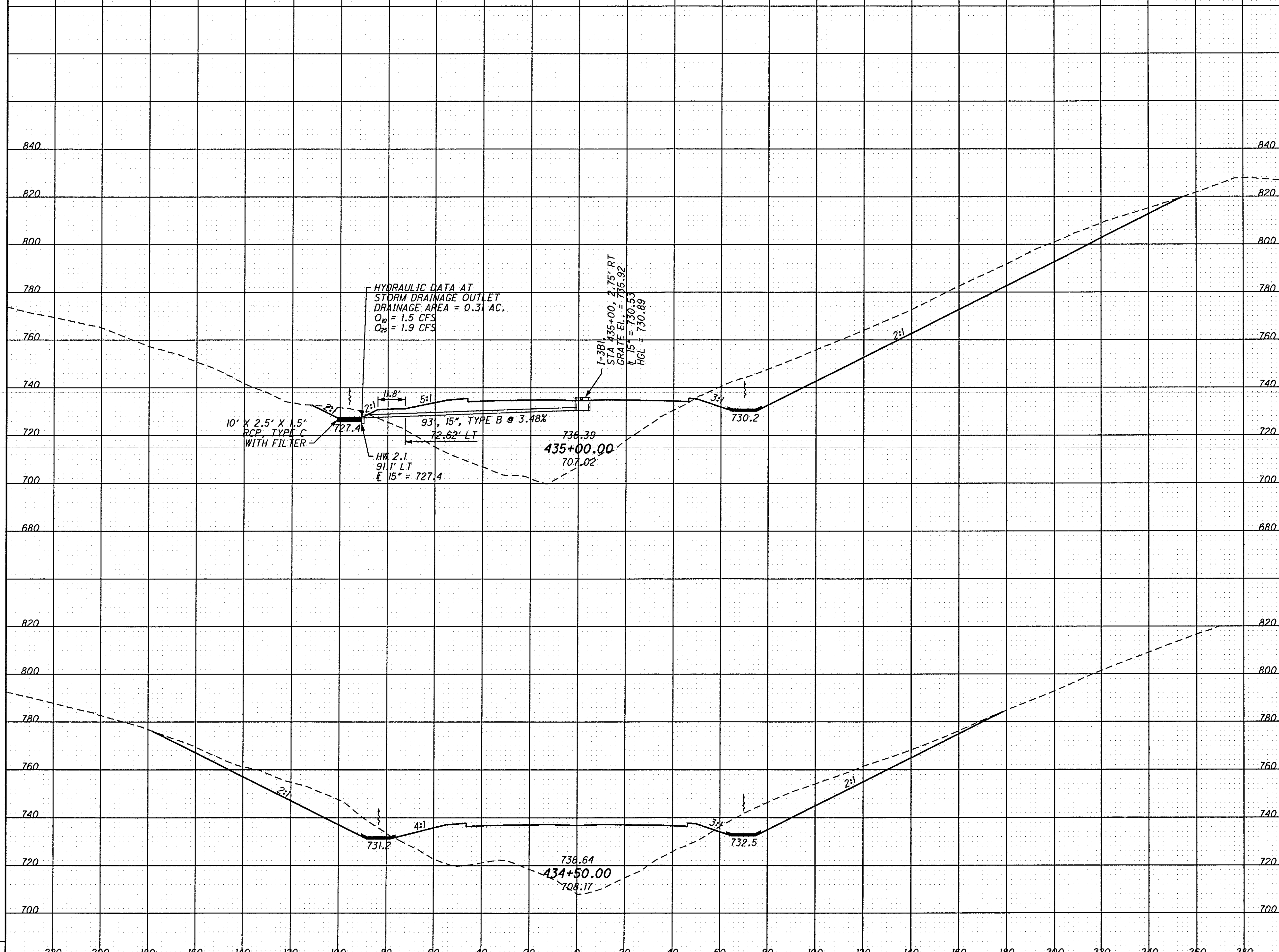
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 433+50.00 TO STA. 434+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:09:35 PM REVISION DATE: 7/26/2009
FILE: ...005594/000000000045878 /79415xs005.dgn MODEL: XS_SHEET_temporary_model_name_23

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

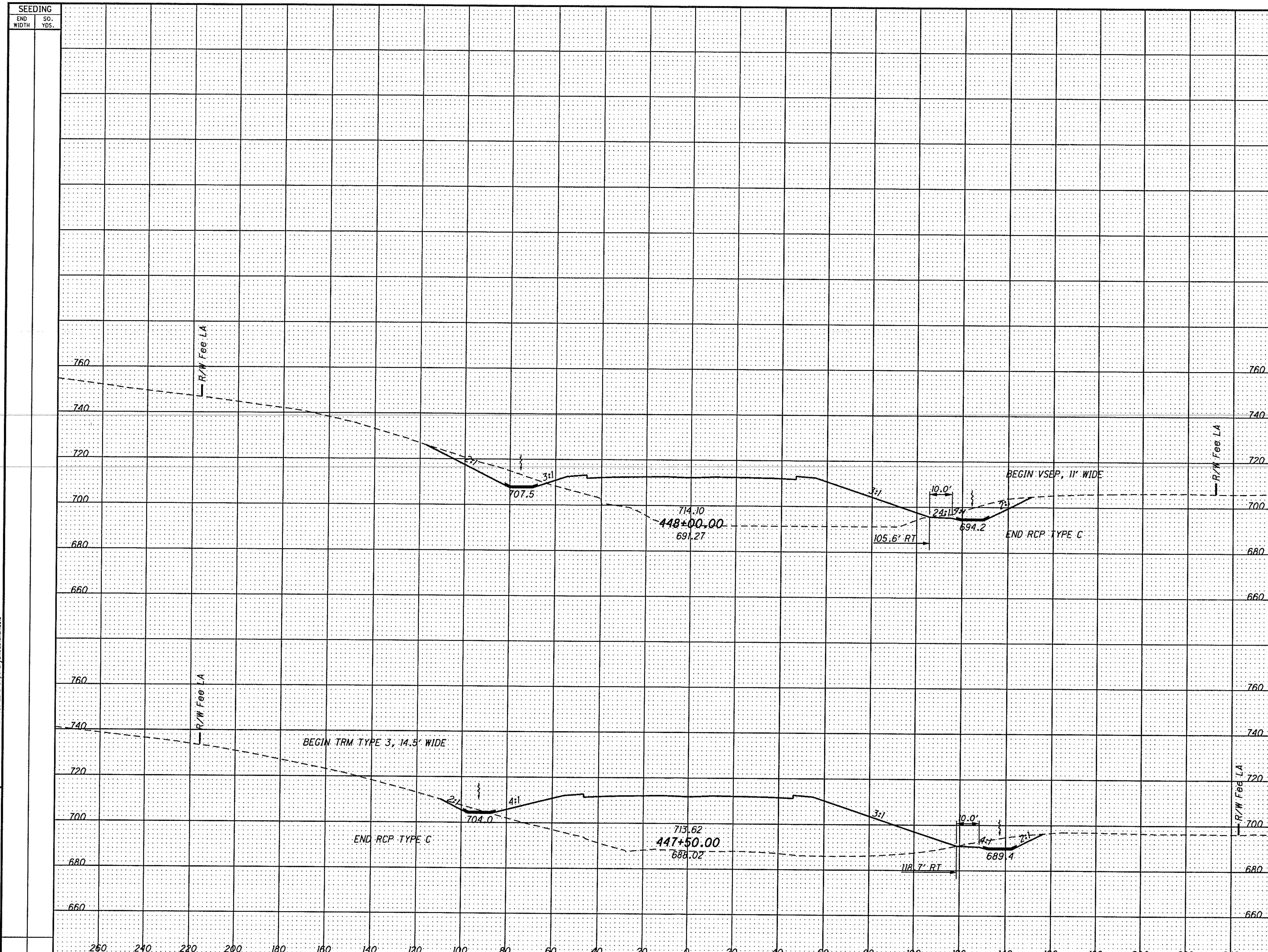
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 434+50.00 TO STA. 435+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:09:43 PM REVISION DATE: 7/26/2009
FILE:...006594/0000000000045878 /19415xs006.dgn MODEL: XS_SHEET_temporary_model_name_1

Rock Cut No. 12
Sta. 448+00 to Sta. 460+00



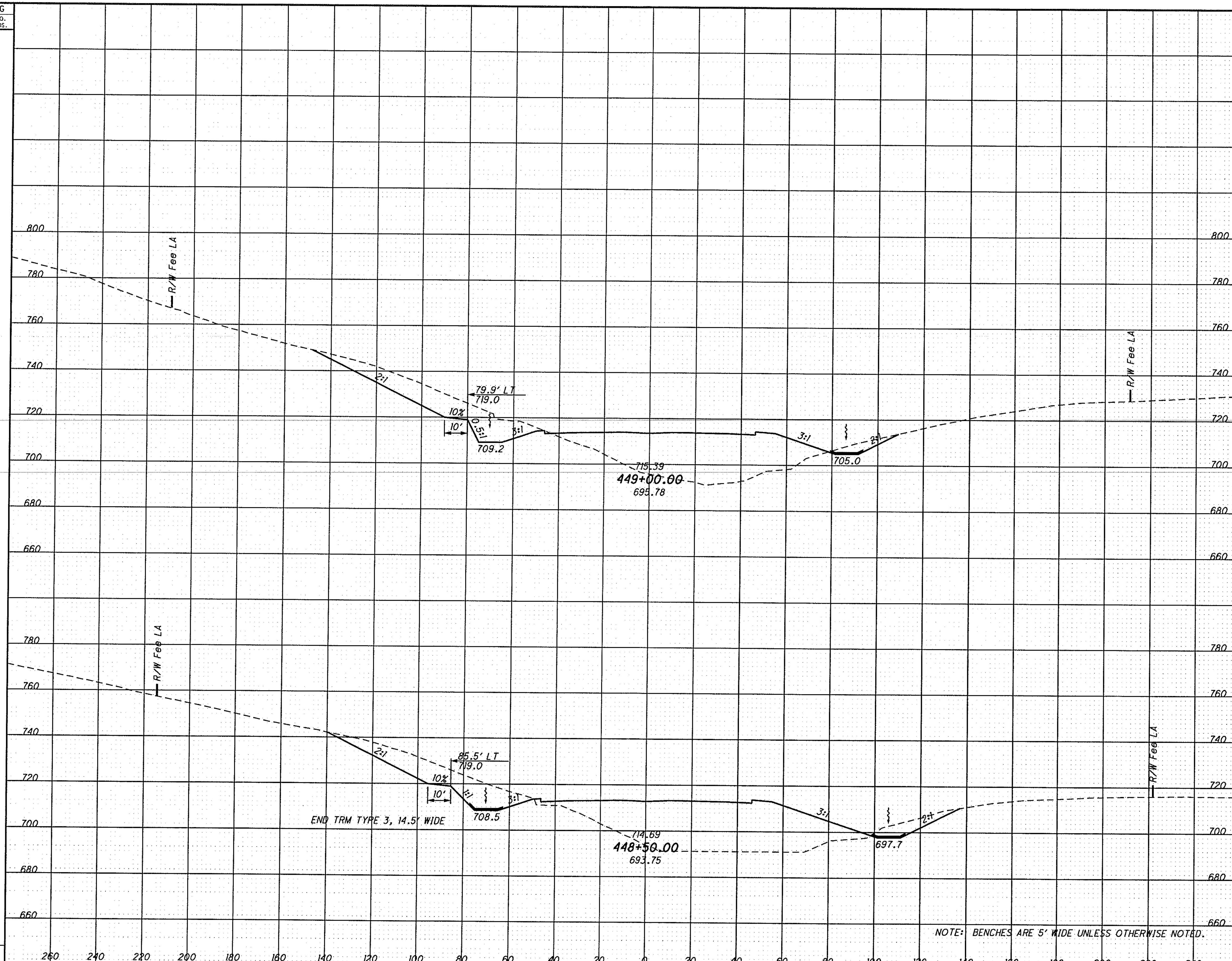
END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - SR823
STA. 447+50.00 TO STA. 448+00.00

SCI-823-6.81

USER: belkan PLOT DATE: 7/29/2009 3:14:54 PM REVISION DATE: 7/29/2009
FILE: ...\00000000045878 \78415xs006.dgn MODEL: XS_SHEET_temporary_model_name_10

SEEDING	
END WIDTH	SQ. YDS.



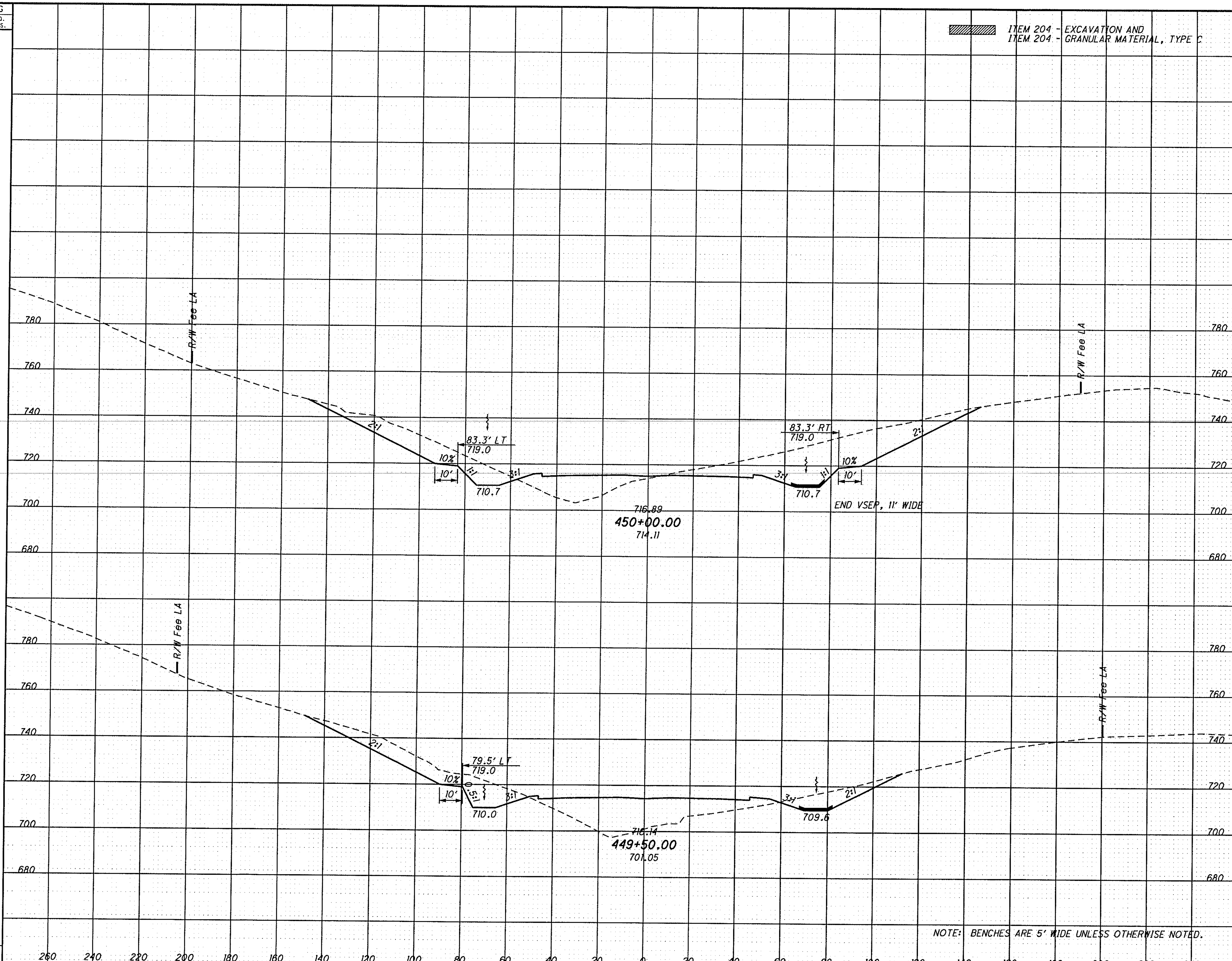
END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - SR823
STA. 448+50.00 TO STA. 449+00.00

SCI-823-6.81

USER: mbatdorf PLOT DATE: 7/28/2009 6:09:53 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045878 /7945xs006.dgn MODEL: XS_SHEET_temporary_model_name_11

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

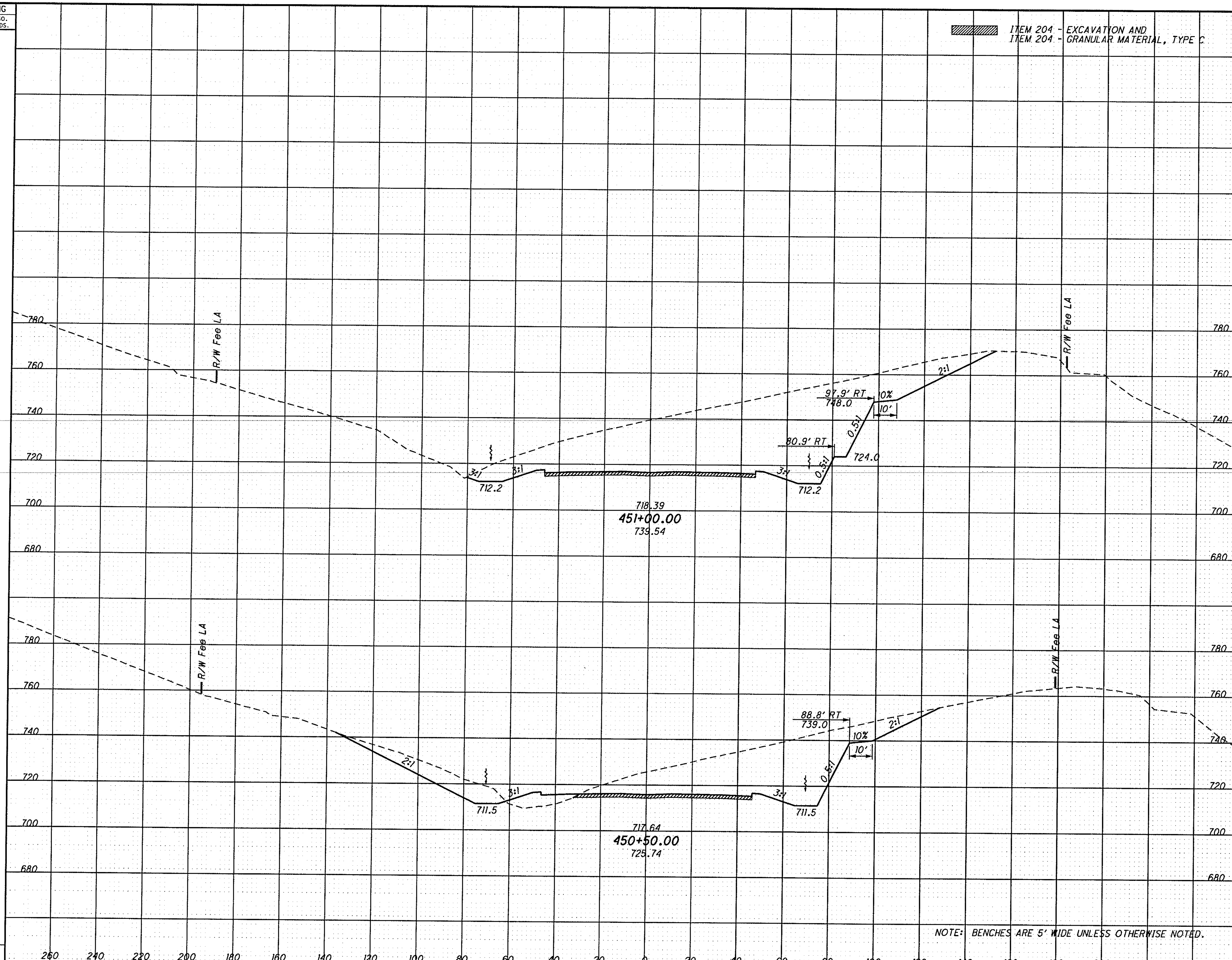
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 449+50.00 TO STA. 450+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:09:59 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045878 /8485xs007.dgn MODEL: XS_SHEET_temporary_model_name_1

SEEDING	
END WIDTH	SQ. YDS.



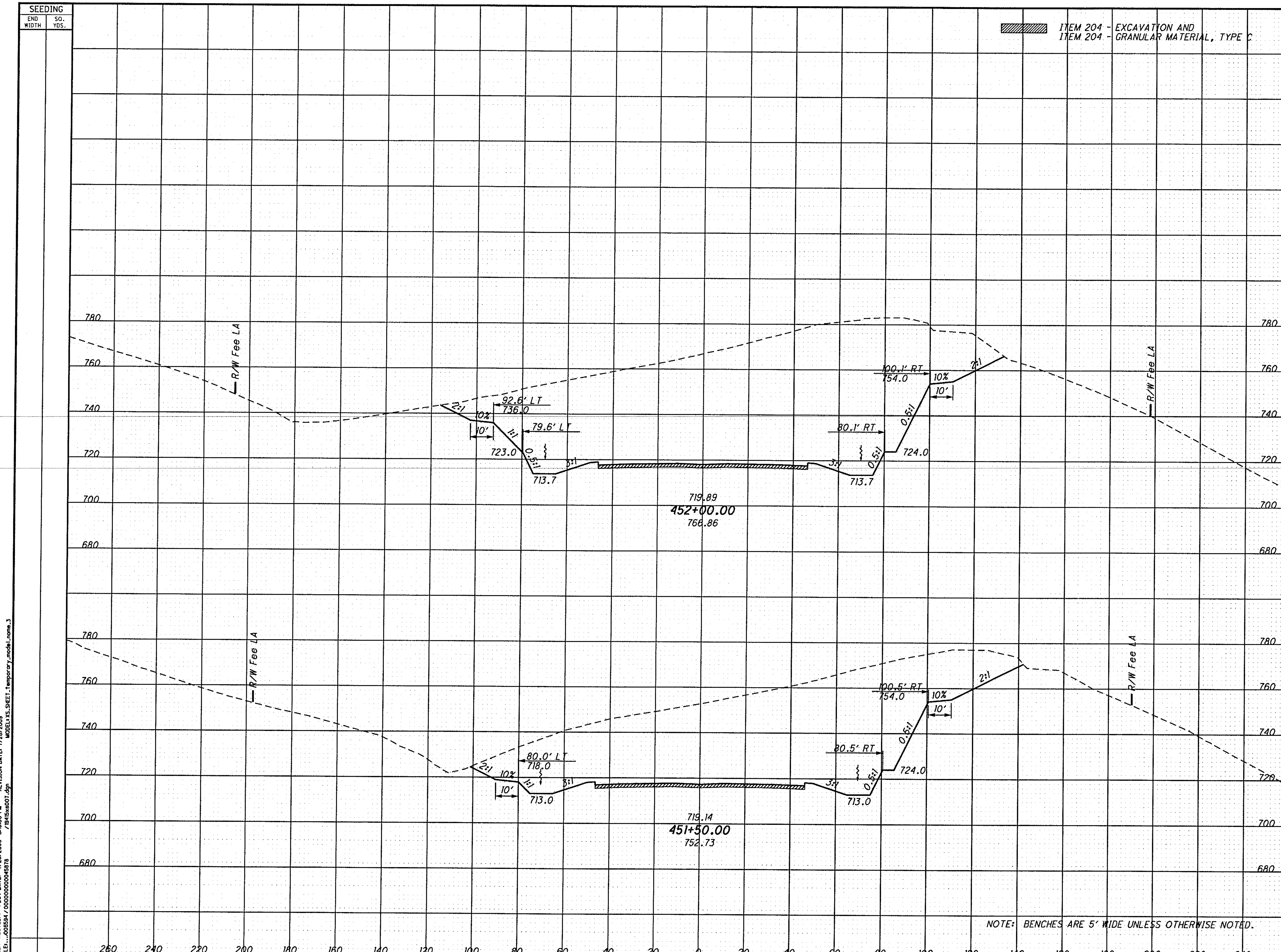
END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 450+50.00 TO STA. 451+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATED 7/26/2009 6:03:59 PM REVISION DATE: 7/26/2009
FILE: ...005594/000000000045878 /7845xs007.dgn MODEL: XS_SHEET_temporary_model_name_2



END AREA		VOLUME	
CUT	FILL	CUT	FILL

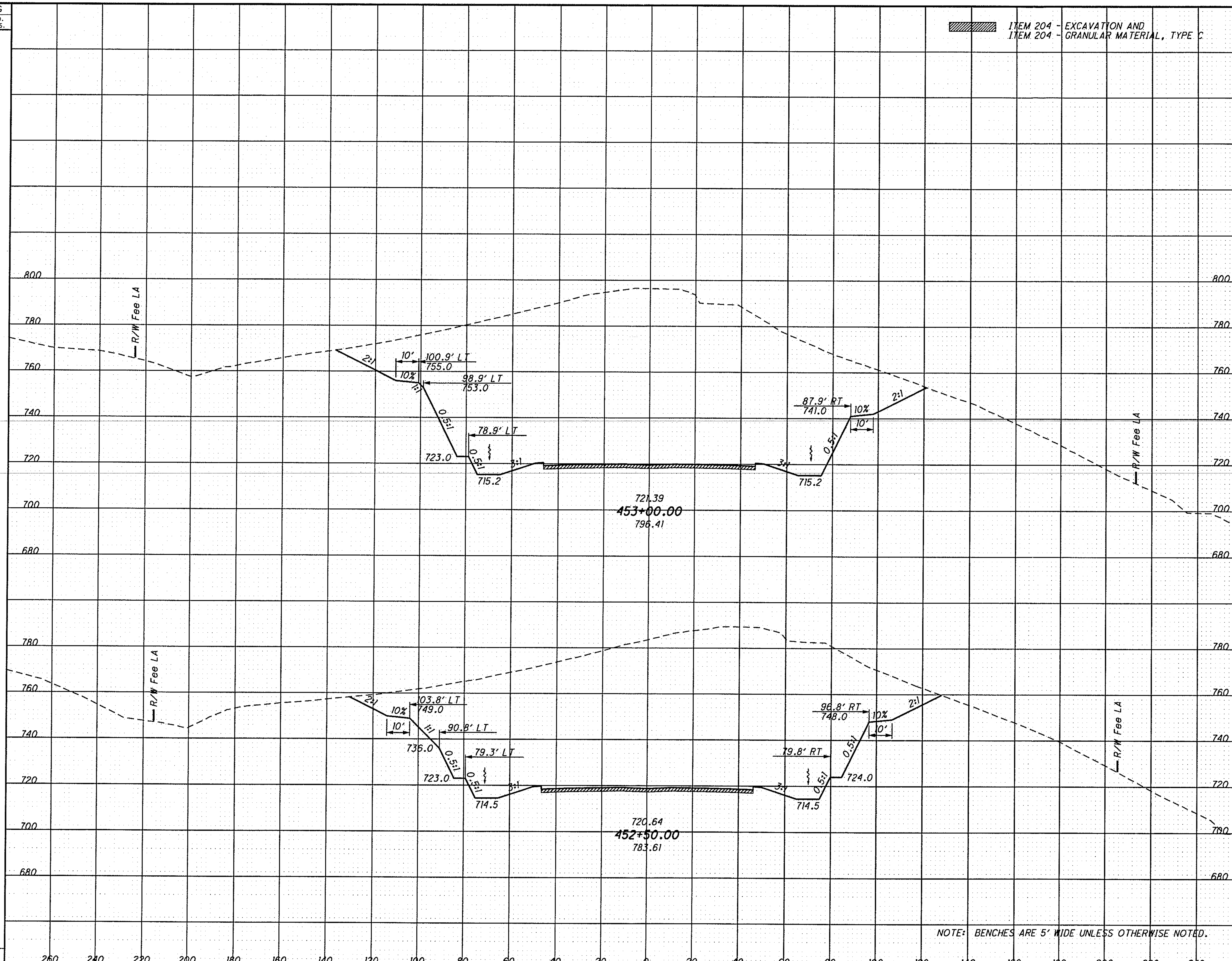
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 451+50.00 TO STA. 452+00.00

SCI-823-6.81

USER: mbstdorf PLOT DATE: 7/26/2009 6:00:00 PM REVISION DATE 7/26/2009
FILE: ...006594/000000000045878 /78415xs007.dgn MODEL: XS_SHEET_temporary_model_name_3

SEEDING		END AREA		VOLUME		CALCULATED	CHECKED
END WIDTH	SQ. YDS.	CUT	FILL	CUT	FILL		

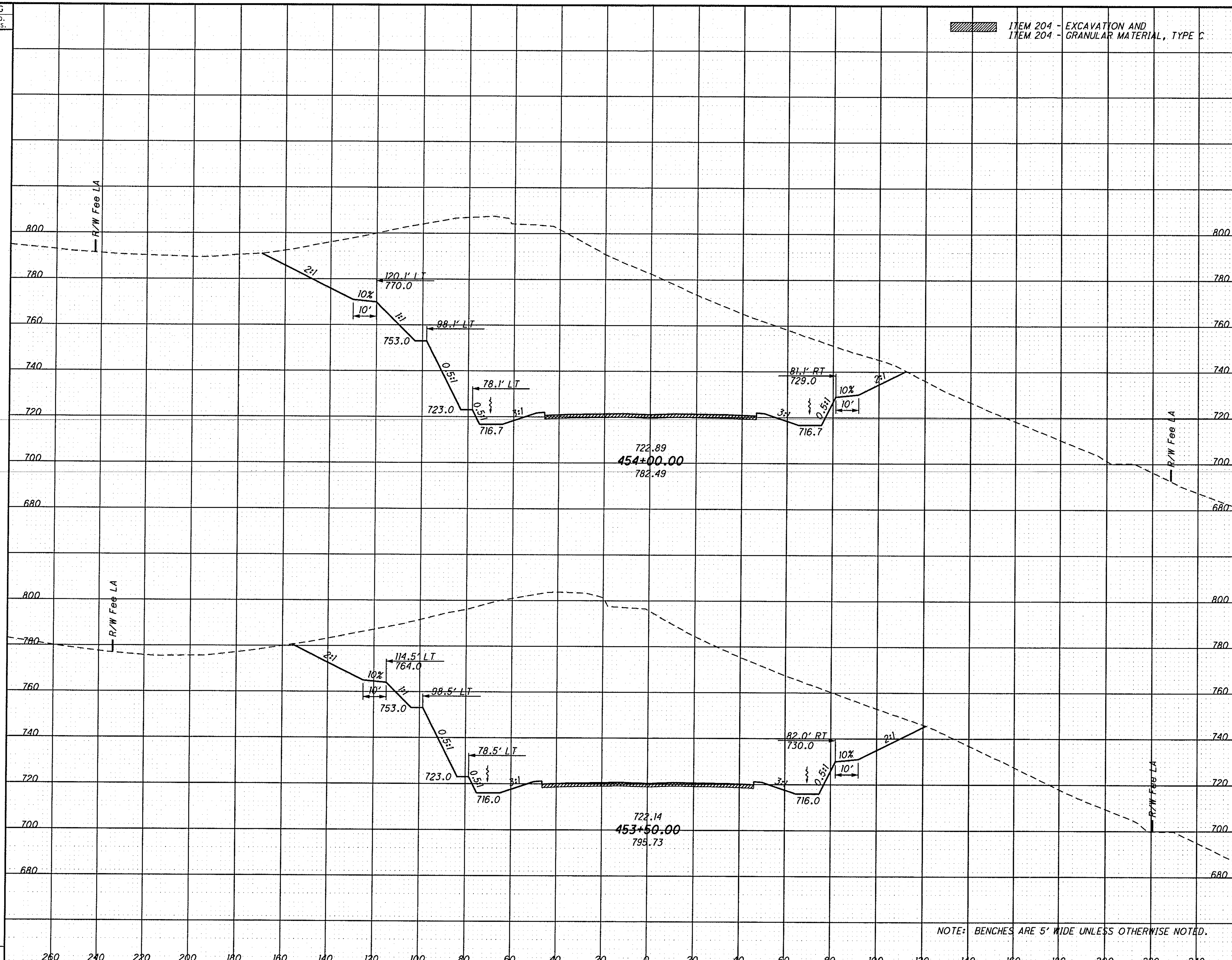


CROSS SECTIONS - SR823
STA. 452+50.00 TO STA. 453+00.00

SCI-823-6.81

USER: mbstdorf PLOT DATE: 7/28/2009 6:00:01 PM REVISION DATE: 7/26/2009
FILE: ...008594/0000000000045878 /78415xs007.dgn MODEL: XS_SHEET_temporary_model_name_4

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

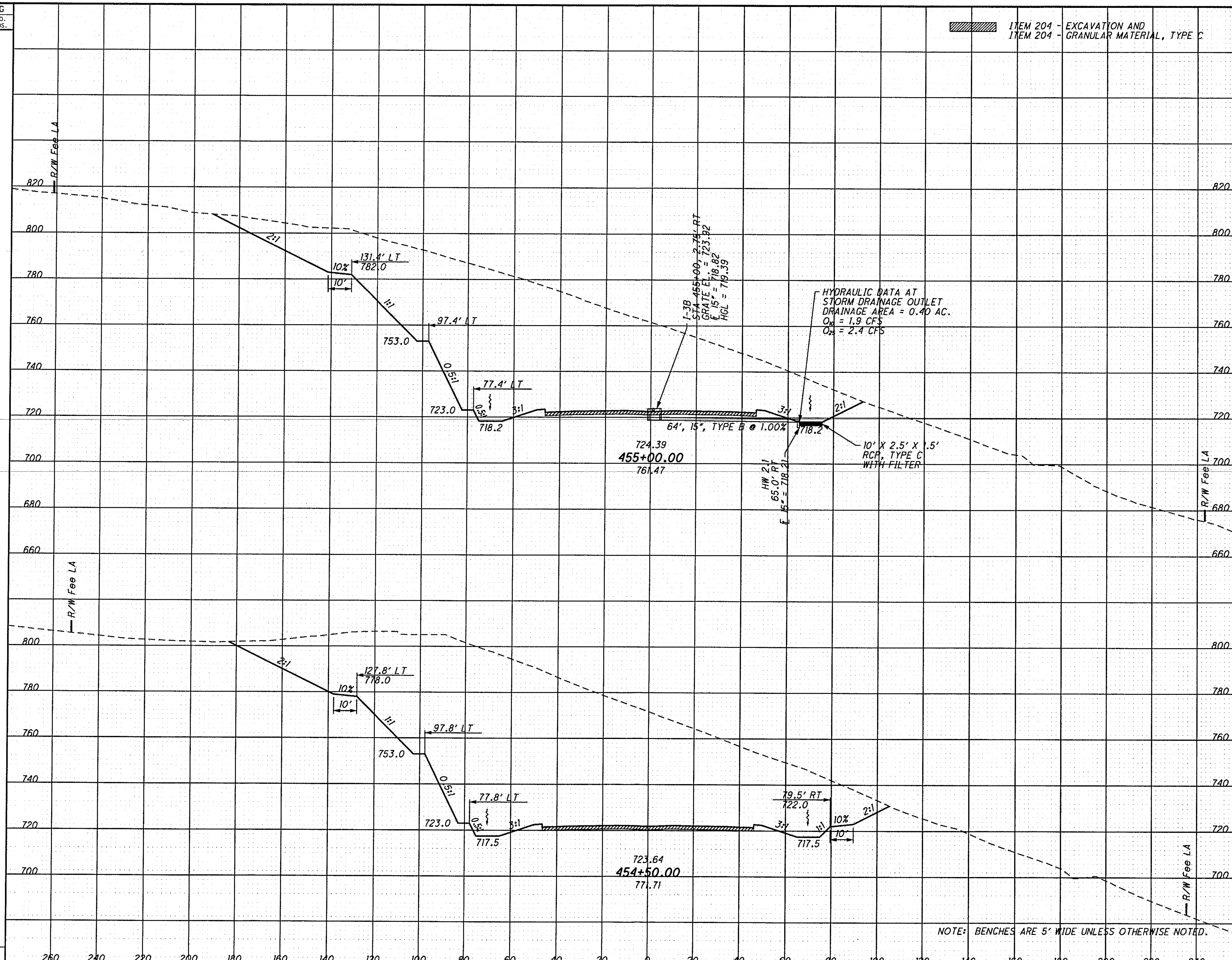
CALCULATED | CHECKED

CROSS SECTIONS - SR823
STA. 453+50.00 TO STA. 454+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:10:02 PM REVISION DATE: 7/26/2009
FILE:...\006594\000000000045878 \79415xs007.dgn MODEL: XS_SHEET_temporary_model_name_5

SEEDING	
END WIDTH	SQ. YDS.



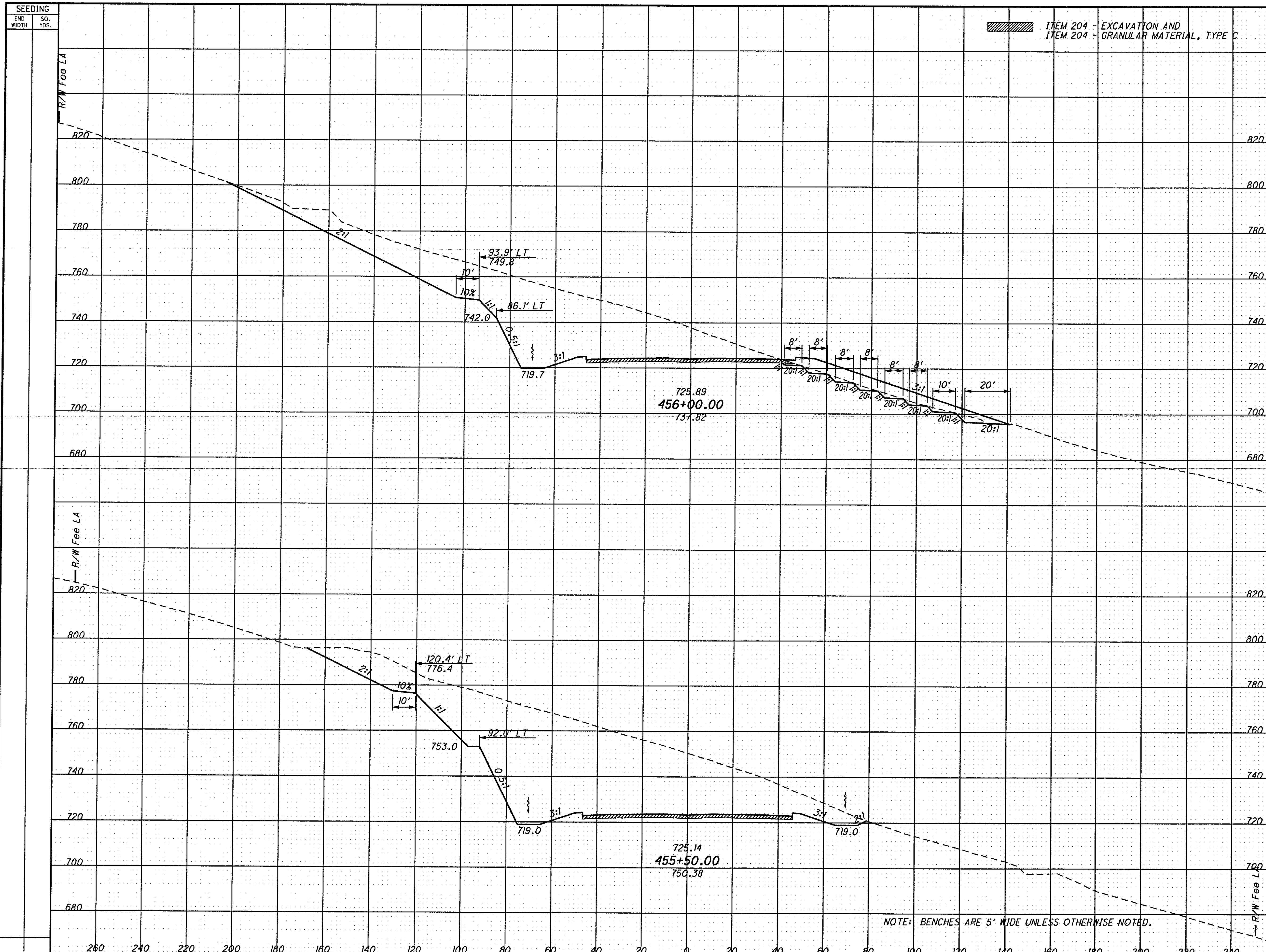
END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED | CHECKED

CROSS SECTIONS - SR823
STA. 454+50.00 TO STA. 455+00.00

SCI-823-6.81

USER: mbstdorf PLOT DATE: 7/28/2009 6:00:03 PM REVISION DATE: 7/28/2009
FILE: ...008594/00000000004587B 78945xs007.dgn MODEL: XS_SHEET_temporary_model_name_6

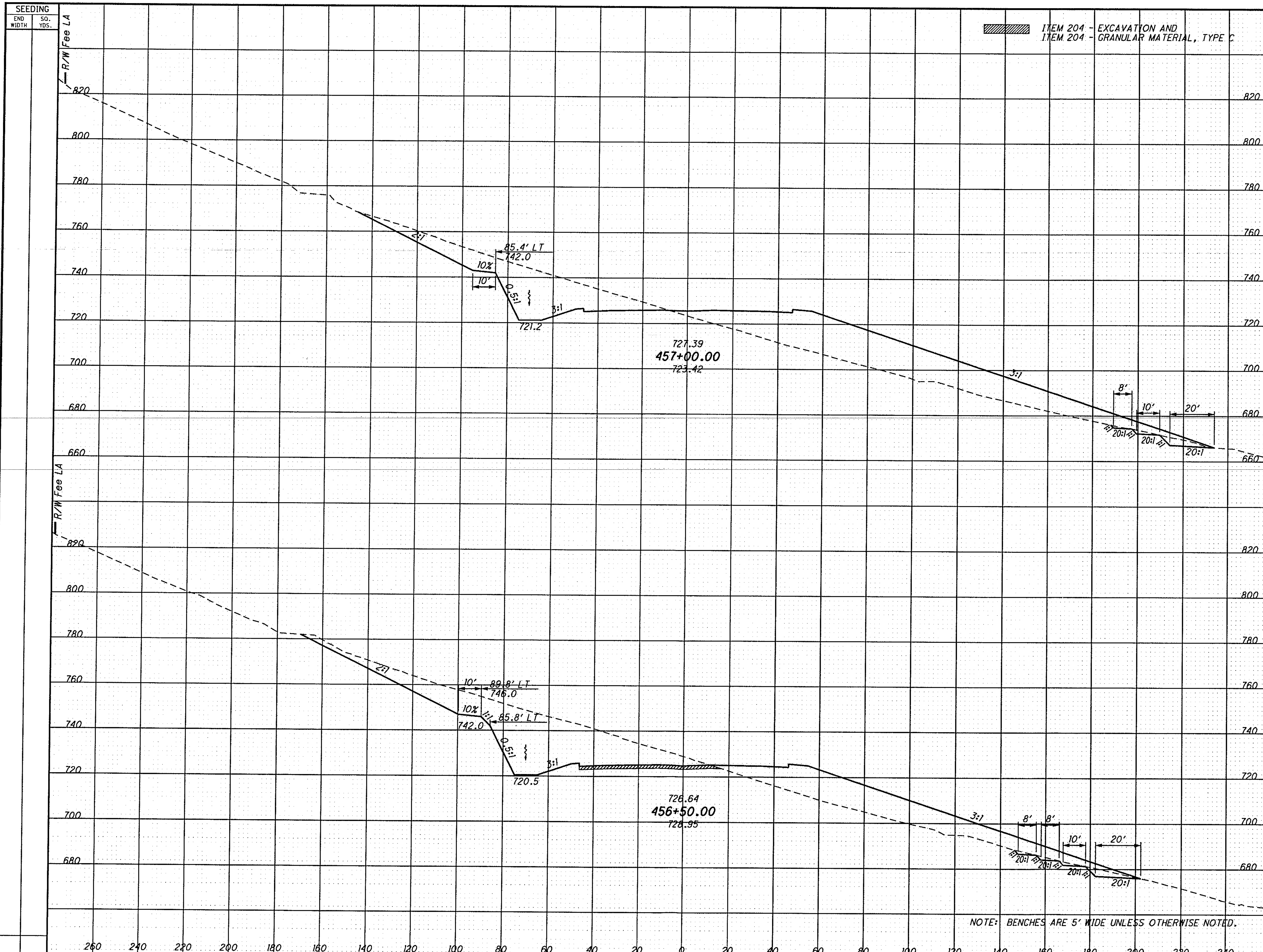


END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 455+50.00 TO STA. 456+00.00

SCI-823-6.81



CALCULATED

CHECKED

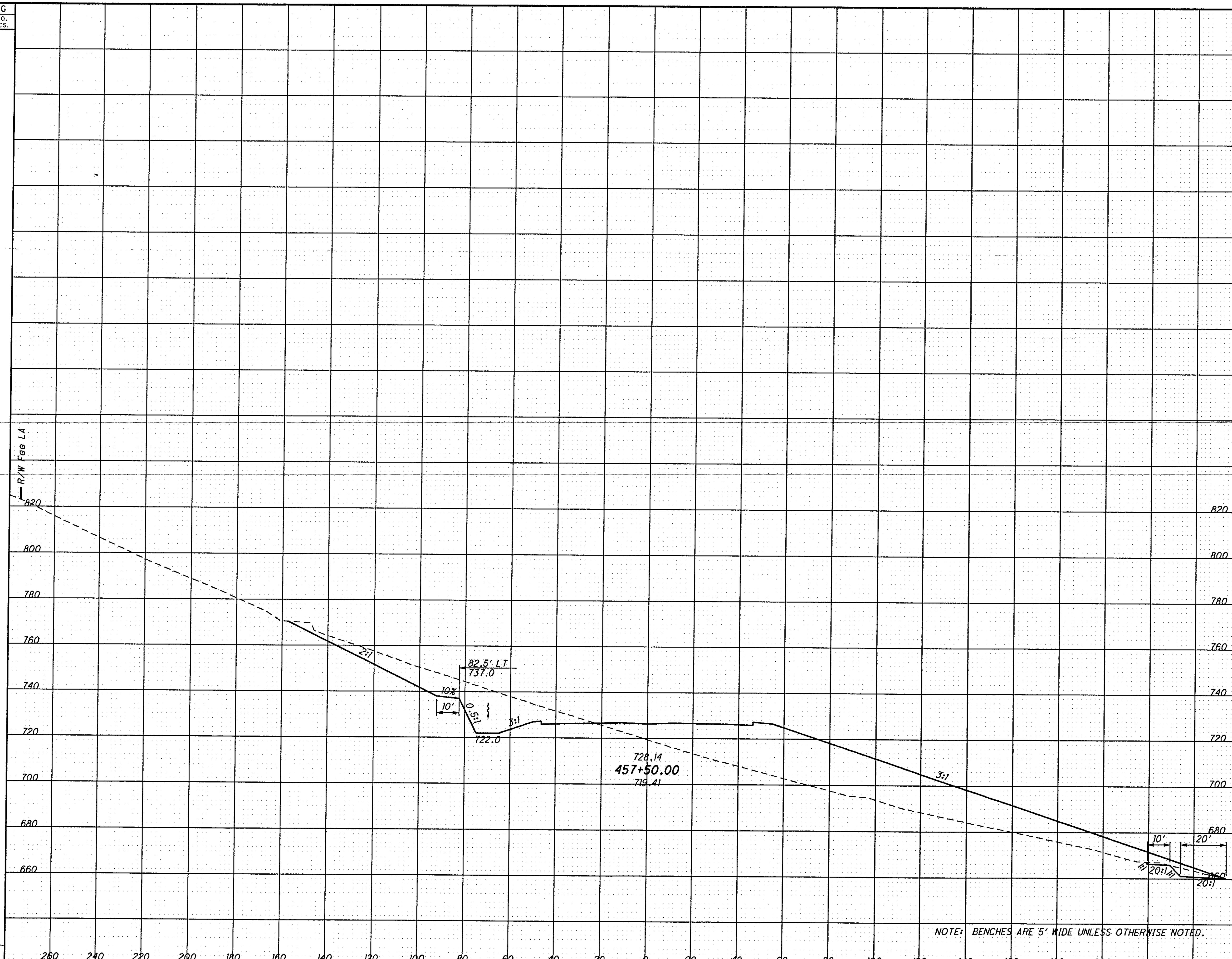
CROSS SECTIONS - SR823

STA. 456+50.00 TO STA. 457+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/28/2009 6:10:04 PM REVISION DATE: 7/28/2009
FILE: ...006594/000000000045878 /79415xs001.dgn MODEL: XS_SHEET_temporary_model_name_8

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

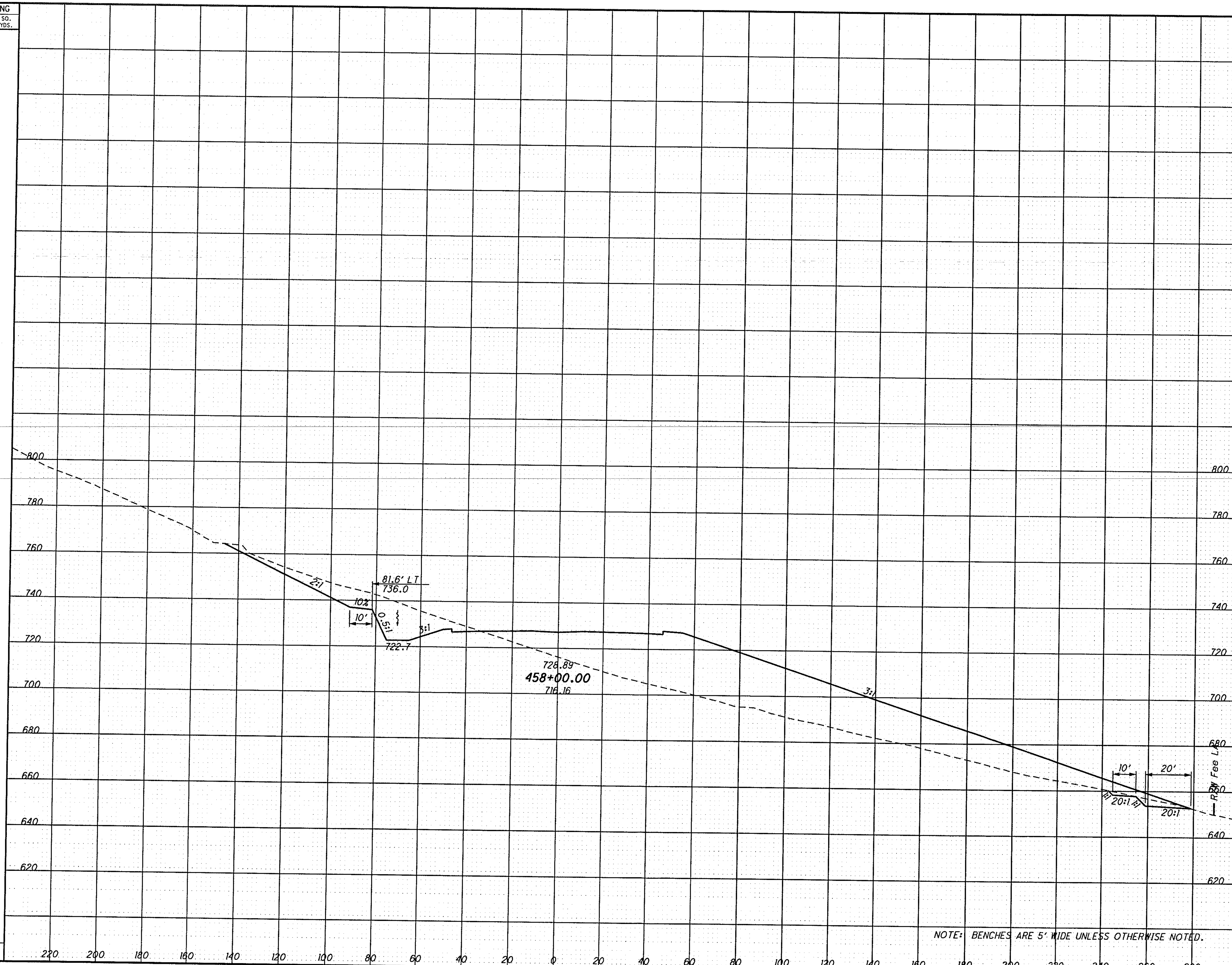
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 457+50.00 TO STA. 457+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:10:05 PM REVISION DATE: 7/26/2009
FILE:...008594/000000000045878 /1945xs007.dgn MODEL: XS_SHEET_temporary_model_name_9

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

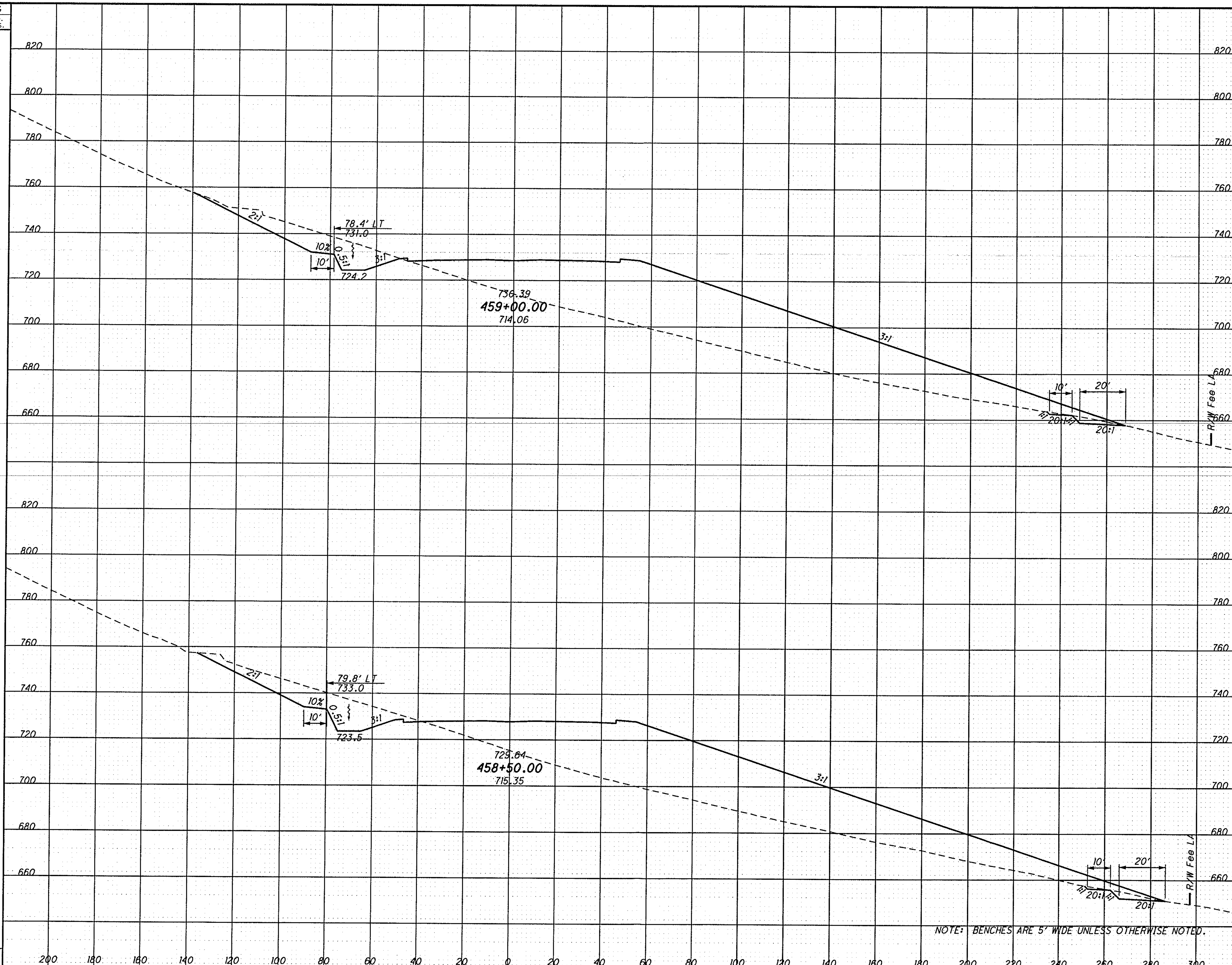
CROSS SECTIONS - SR823
STA. 458+00.00 TO STA. 458+00.00

SCI-823-6.81

231
752

USER: mbotdorf PLOT DATE: 7/26/2009 6:10:06 PM REVISION DATE: 7/26/2009
FILE: ...006594/0000000004587 8 /19415xs00T.dgn MODEL: XS_SHEET_temporary_model_name_10

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

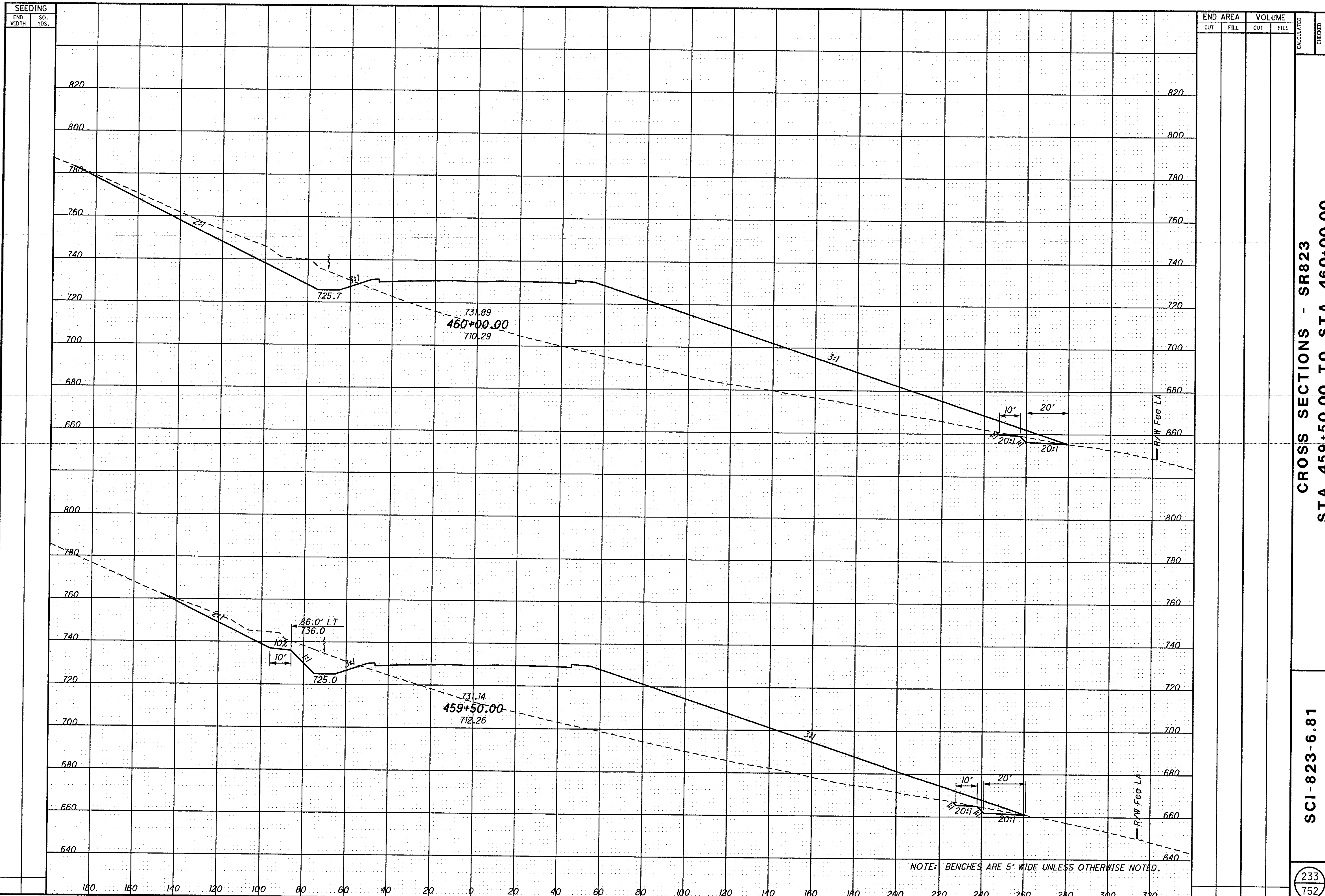
CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 458+50.00 TO STA. 459+00.00

SCI-823-6.81

USER: mbatdorf PLOT DATE: 7/28/2009 6:40:12 PM REVISION DATE: 7/28/2009 FILE: ...006594/00000000045878/19415xs008.dgn MODEL: XS_SHEET_temporary_model_name_1



CALCULATED
CHECKED

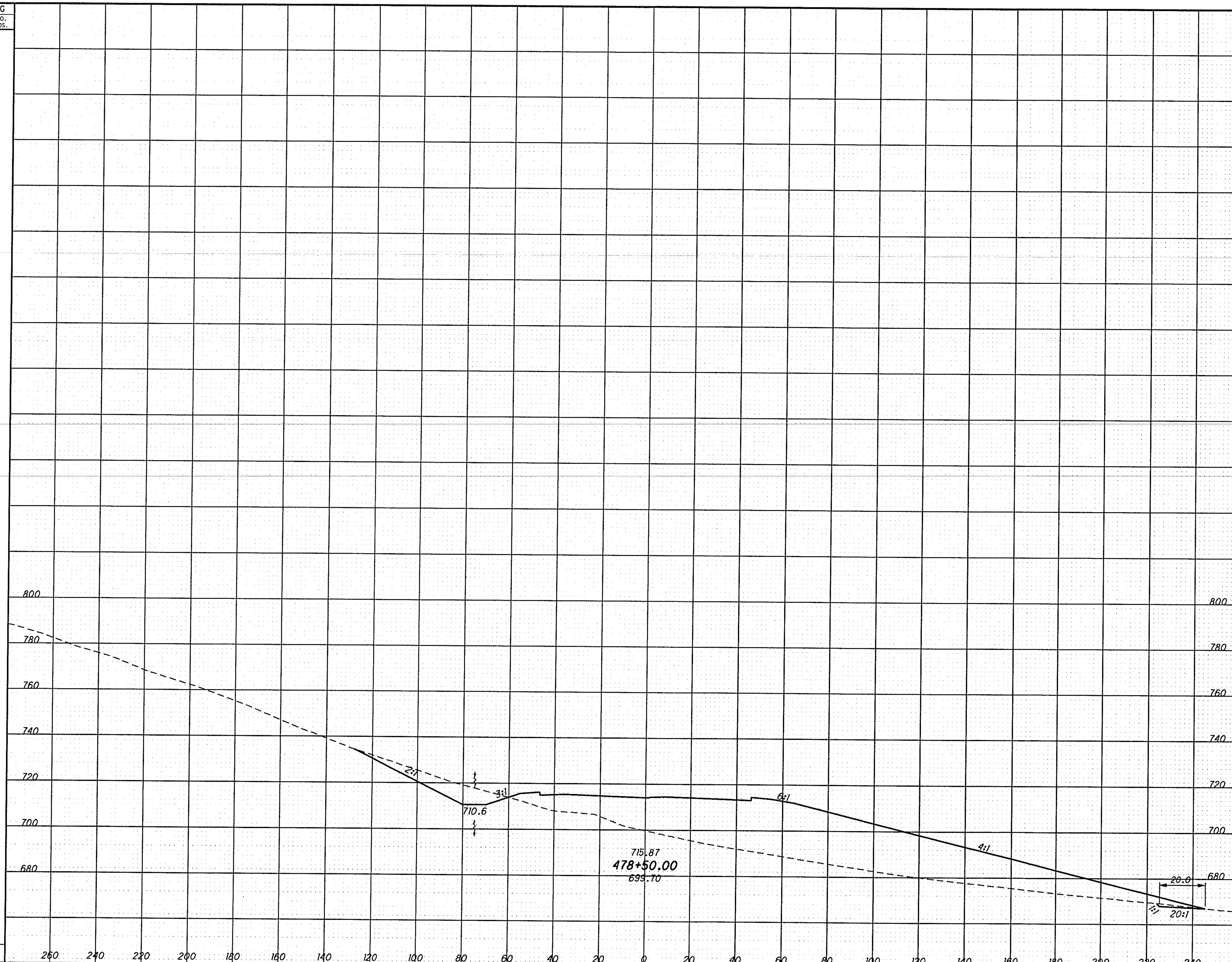
CROSS SECTIONS - SR823
STA. 459+50.00 TO STA. 460+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:01:13 PM REVISION DATE: 7/26/2009 MODEL: XS_SHEET_temporary_model_name_2
FILE: ...006594/000000000045876/19415xs008.dgn

Rock Cut No. 13
Sta. 478+50 to Sta. 482+81

SEEDING	
END WIDTH	SQ. YDS.



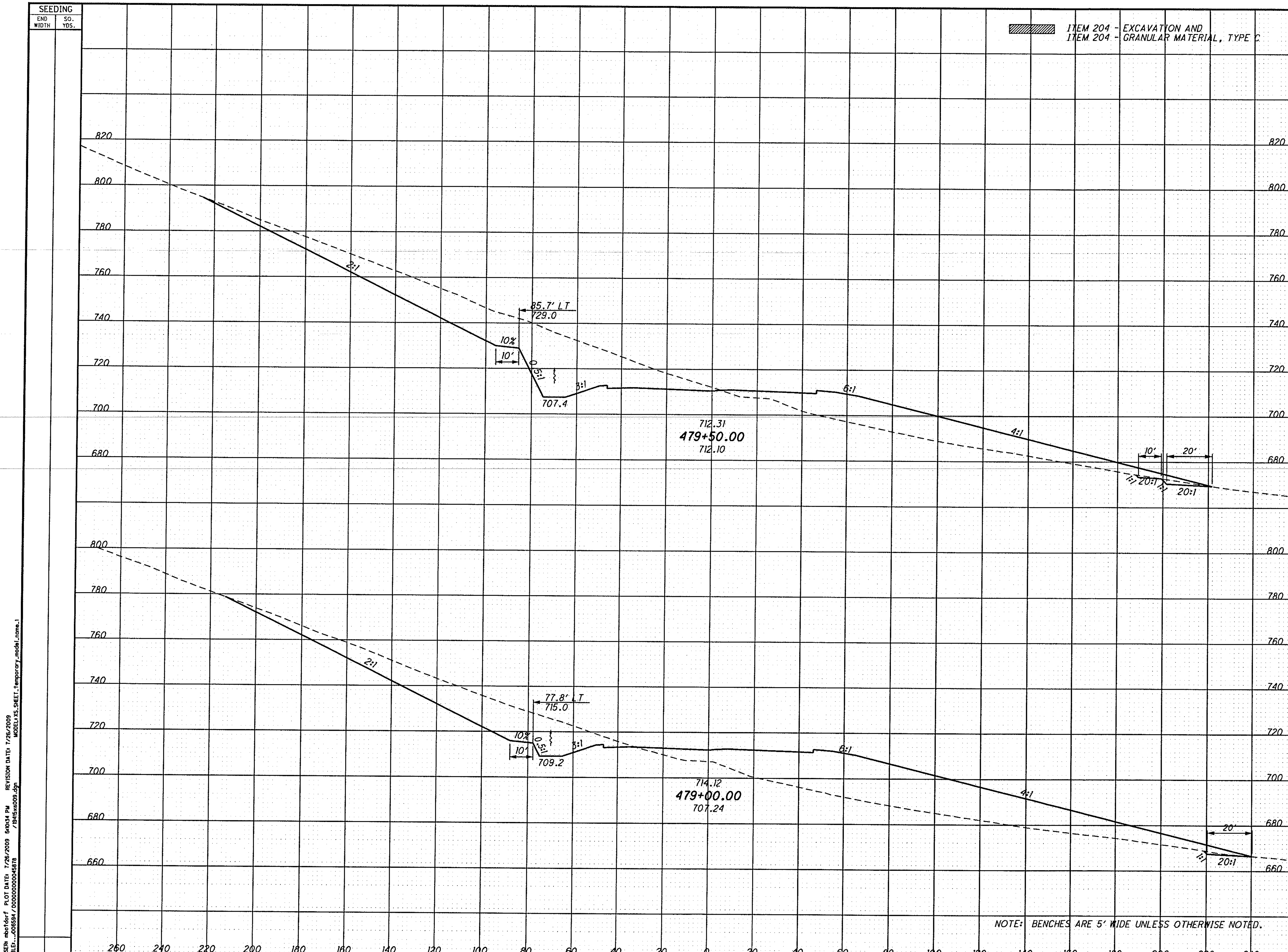
END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 478+50.00 TO STA. 478+50.00

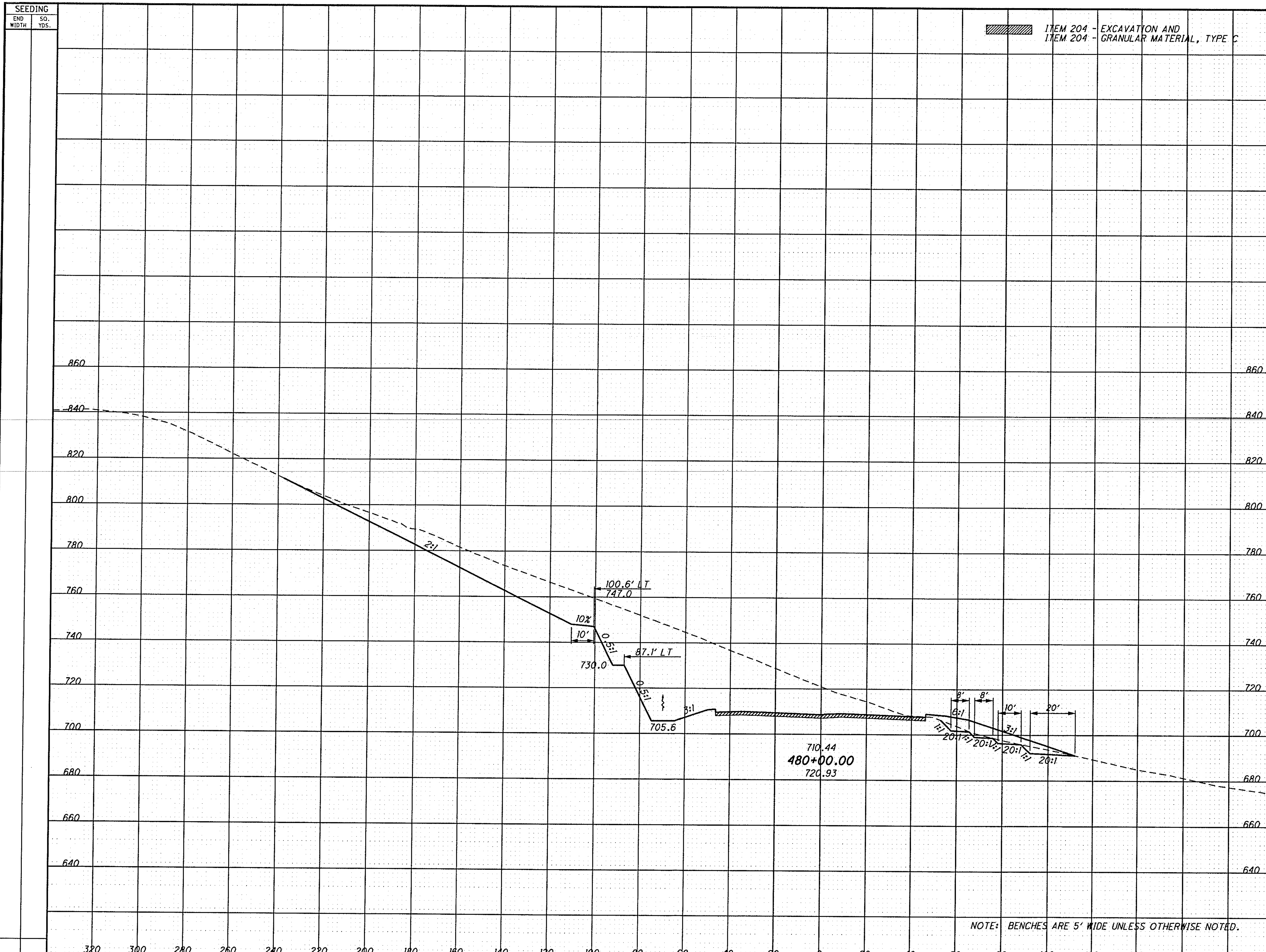
SCI-823-6.81



CROSS SECTIONS - SR823

STA. 479+00.00 TO STA. 479+50.00

SCI-823-6.81



END AREA		VOLUME	
CUT	FILL	CUT	FILL

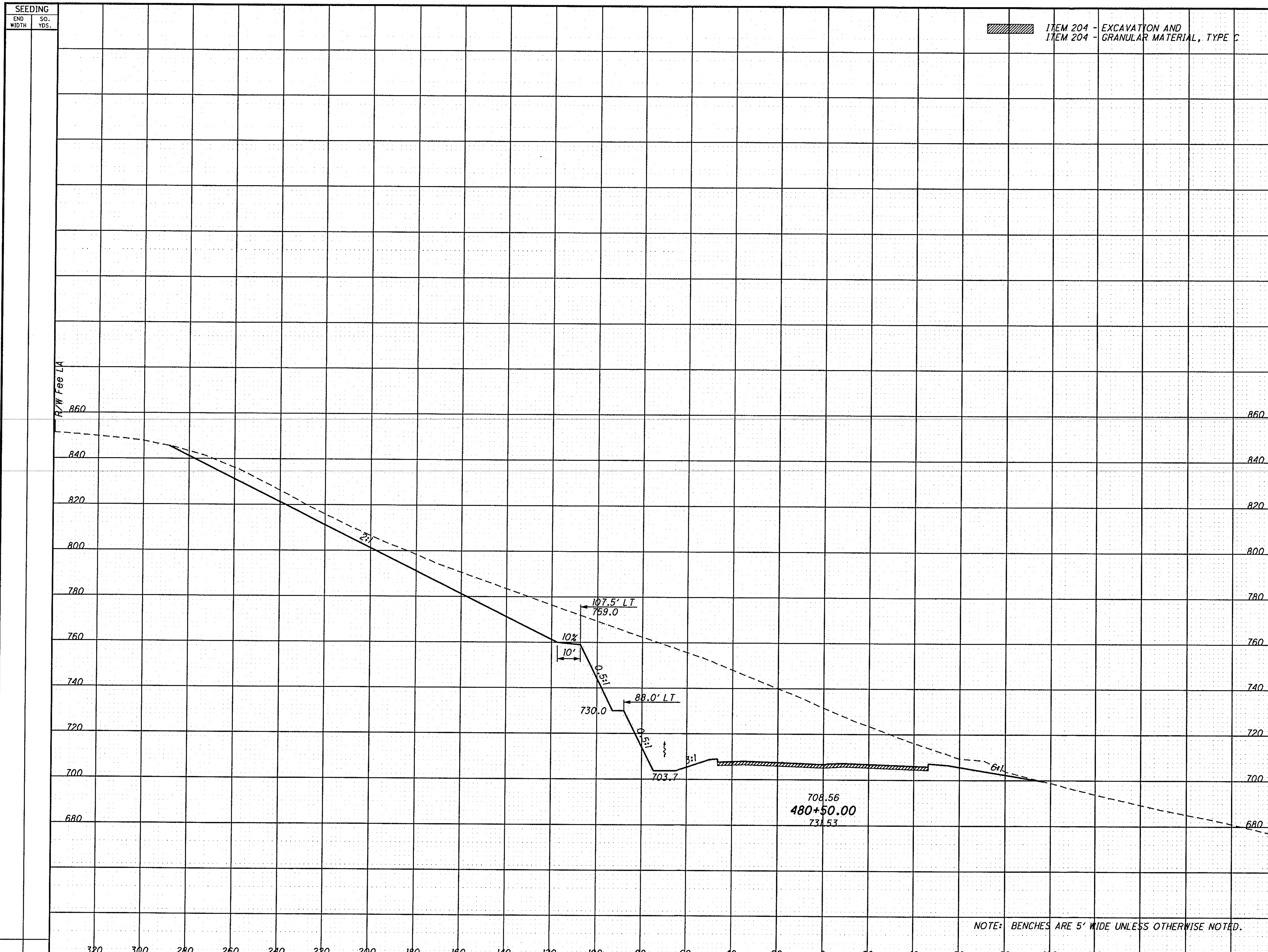
CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 480+00.00 TO STA. 480+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:00:34 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045878 /1945xs009.dgn MODEL: XS_SHEET_temporary_model_name_2

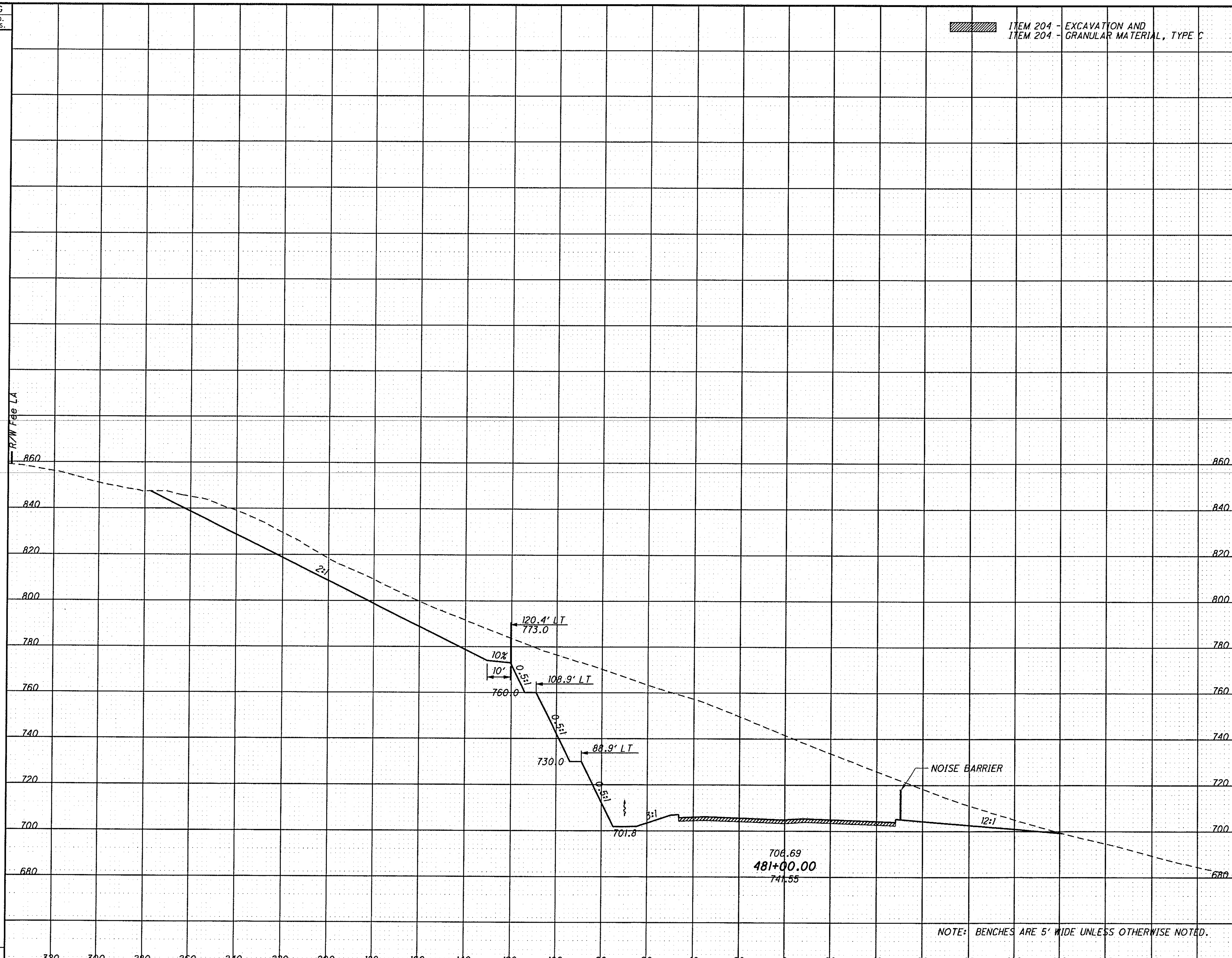


CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 480+50.00 TO STA. 480+50.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

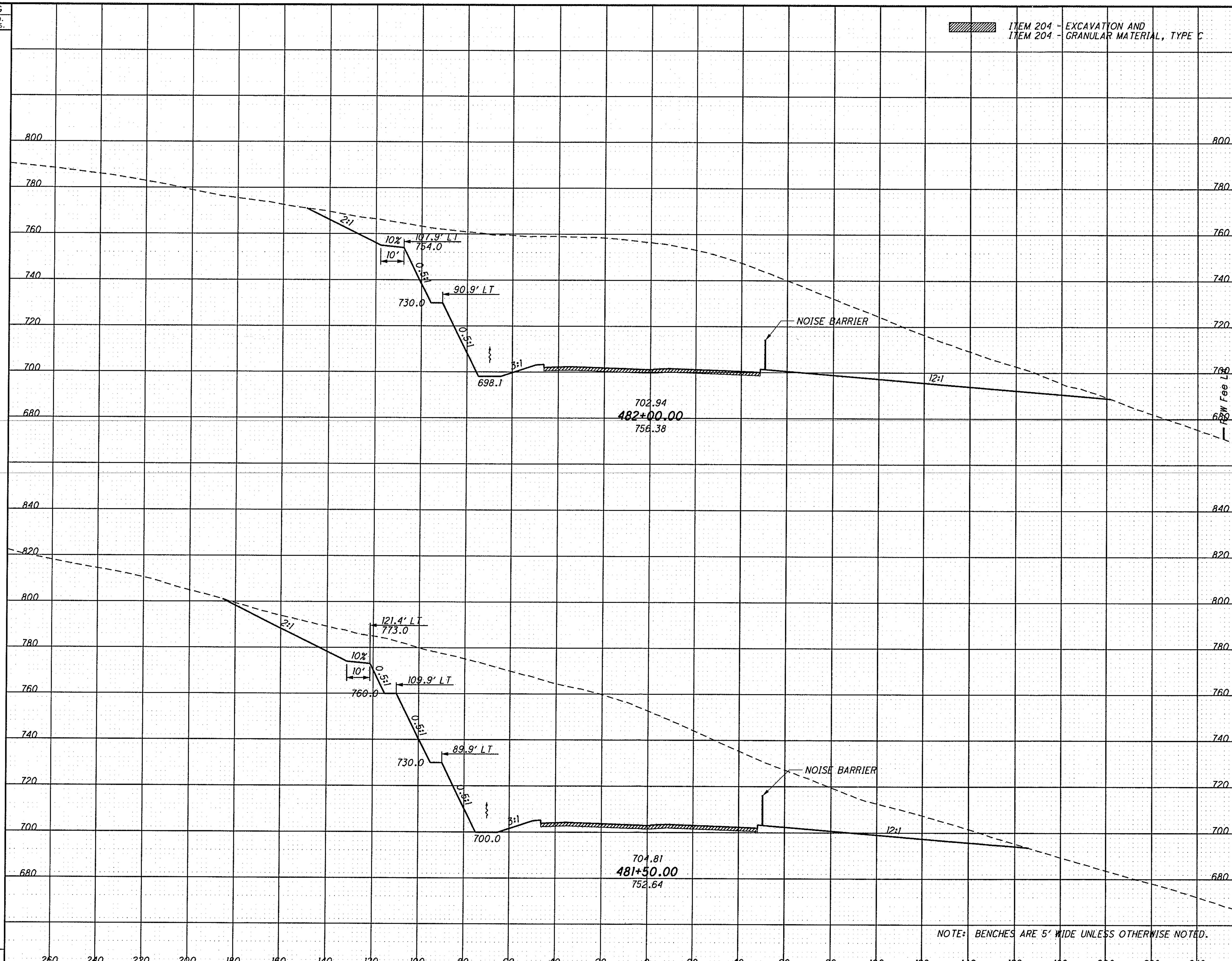
CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 481+00.00 TO STA. 481+00.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



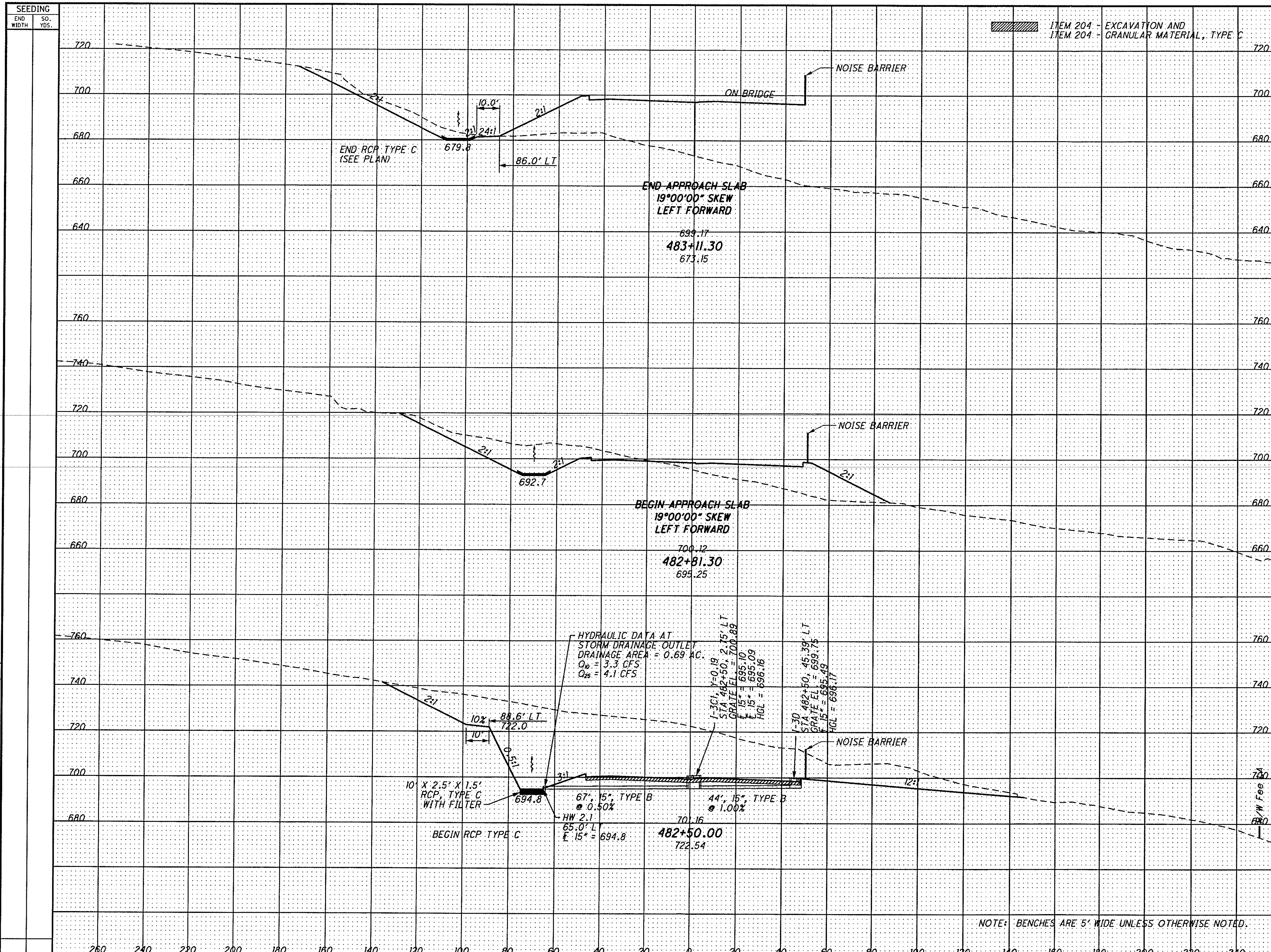
END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 481+50.00 TO STA. 482+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:10:37 PM REVISION DATE: 7/26/2009
FILE: ...005594/000000000045878 79415xs009.dgn MODEL: XS_SHEET_temporary_model_name_5



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

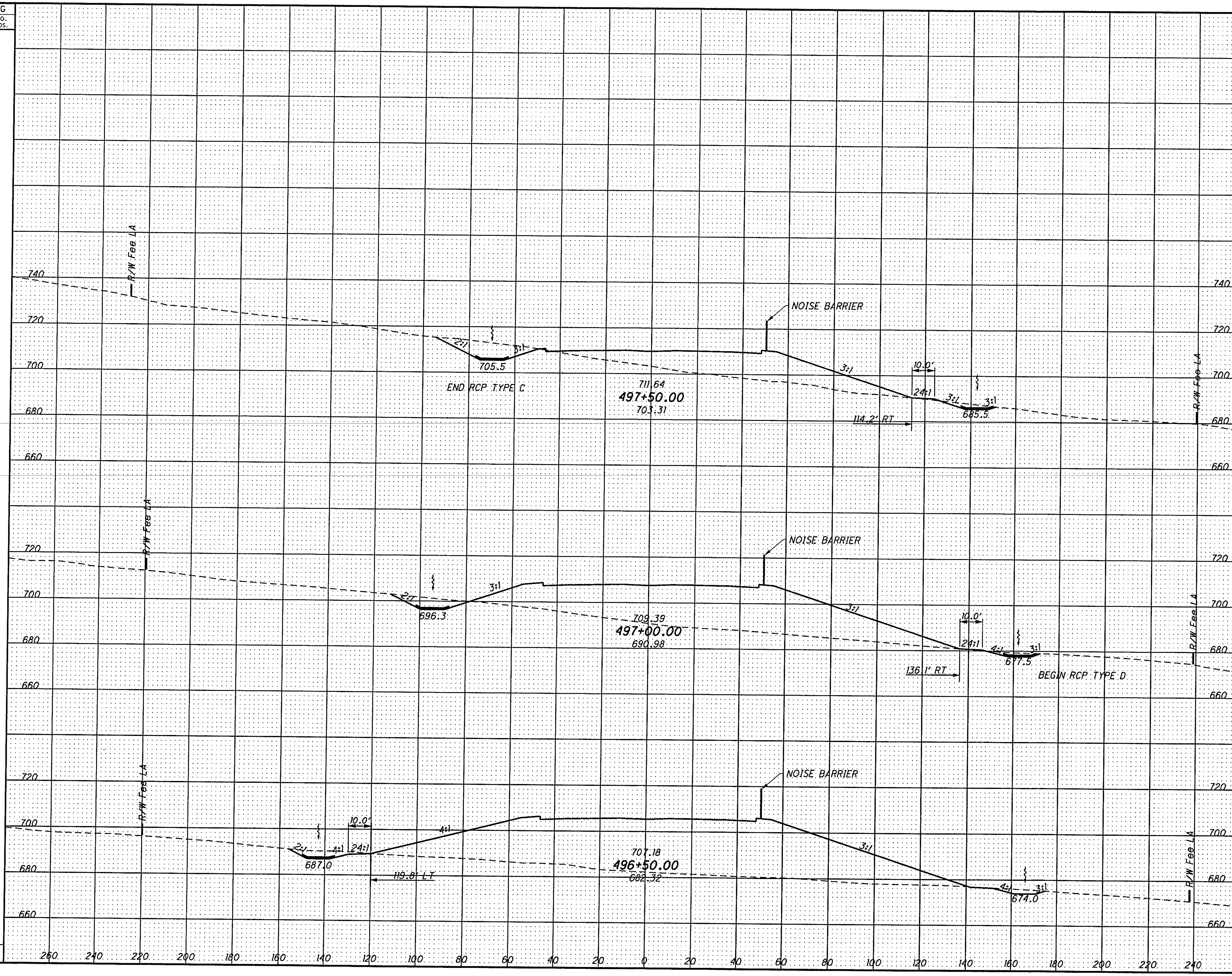
CROSS SECTIONS - SR823
STA. 482+50.00 TO STA. 483+11.30

SCI-823-6.81

USER: belkam PLOT DATE: 7/29/2009 3:15:00 PM REVISION DATE: 7/29/2009 MODEL: XS_SHEET_temporary_model_name_6
FILE: ...\00000000004578\79415xs009.dgn

Rock Cut No. 14
Sta. 497+50 to Sta. 503+50

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

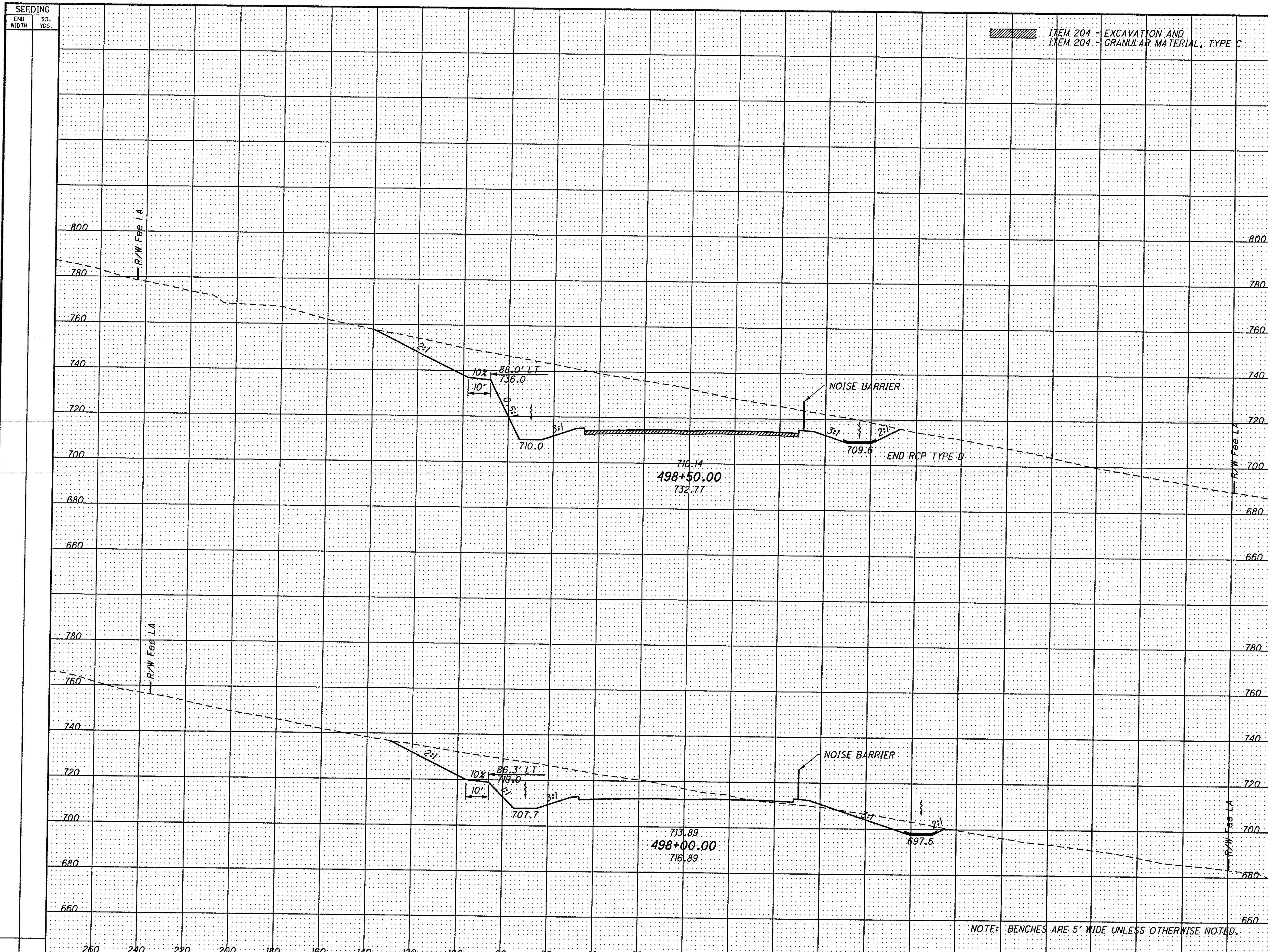
CHECKED

CROSS SECTIONS - SR823
STA. 496+50.00 TO STA. 497+50.00

SCI-823-6.81

262
752

USER: belkon PLOT DATE: 7/29/2009 3:17:17 PM REVISION DATE: 7/29/2009
FILE: ...006594/000000000045878 /19415xs010.dgn MODEL: XS_SHEET_temporary_model_name_1

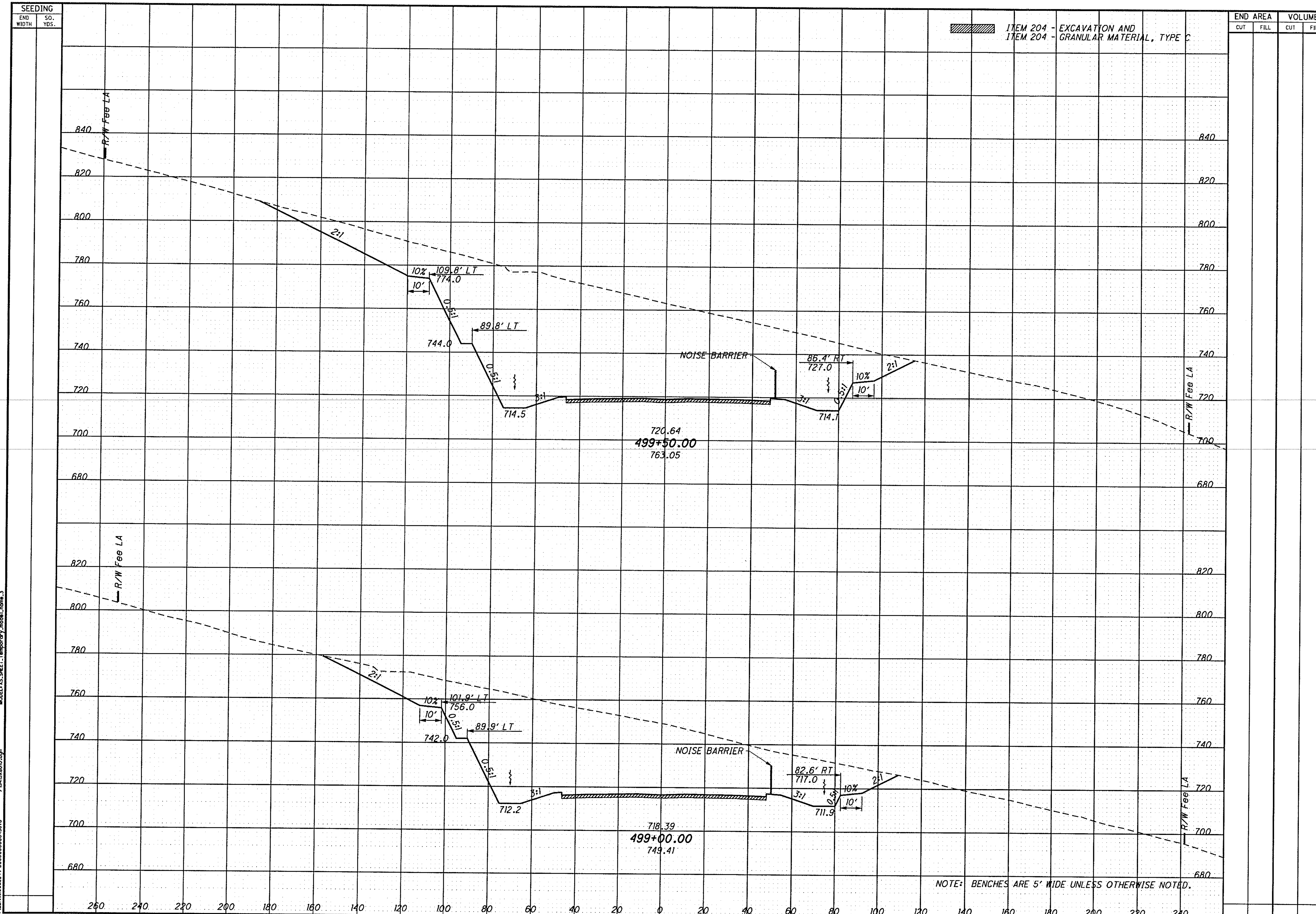


END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 498+00.00 TO STA. 498+50.00

SCI-823-6.81

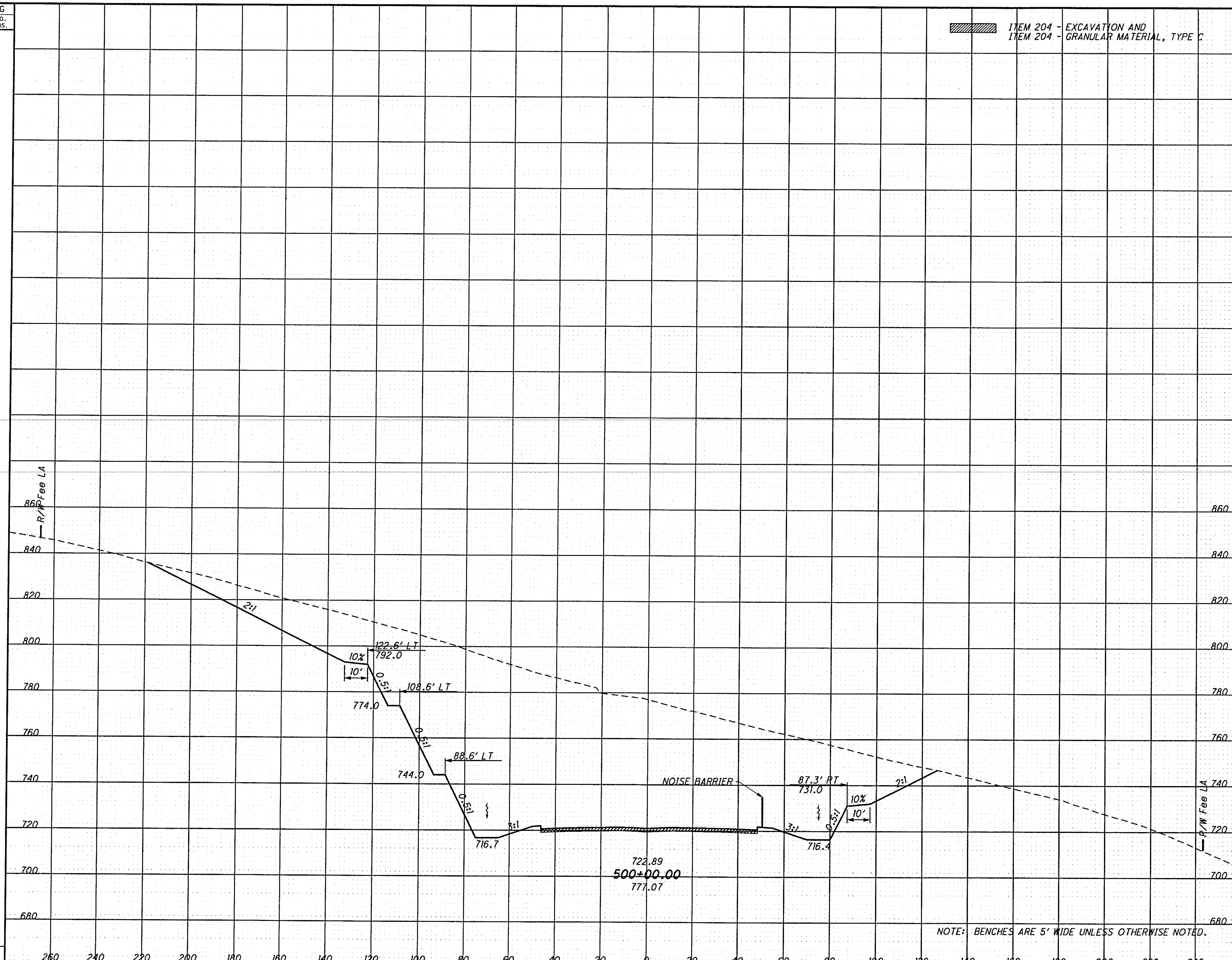


CROSS SECTIONS - SR823
STA. 499+00.00 TO STA. 499+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:10:52 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045878 /19415xs010.dgn MODEL: XS_SHEET_temporary_model_name_3

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

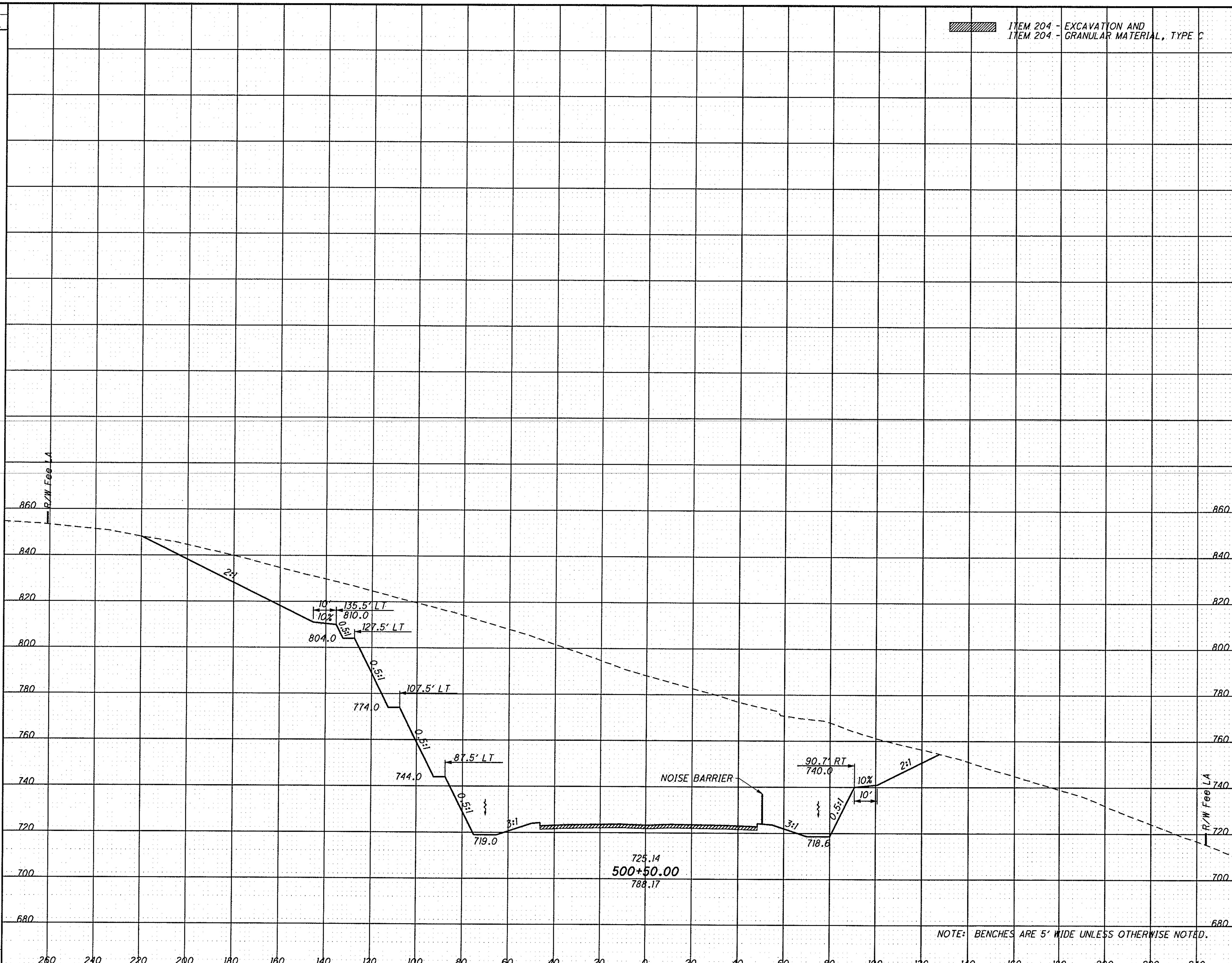
CHECKED

CROSS SECTIONS - SR823
STA. 500+00.00 TO STA. 500+00.00

SCI-823-6.81

USER: mbutdorf PLOT DATE: 7/26/2009 6:10:53 PM REVISION DATE: 7/26/2009
FILE: ...08594/000000000045876 ...x010.dgn MODEL: XS_SHEET_temporary_model_name_4

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

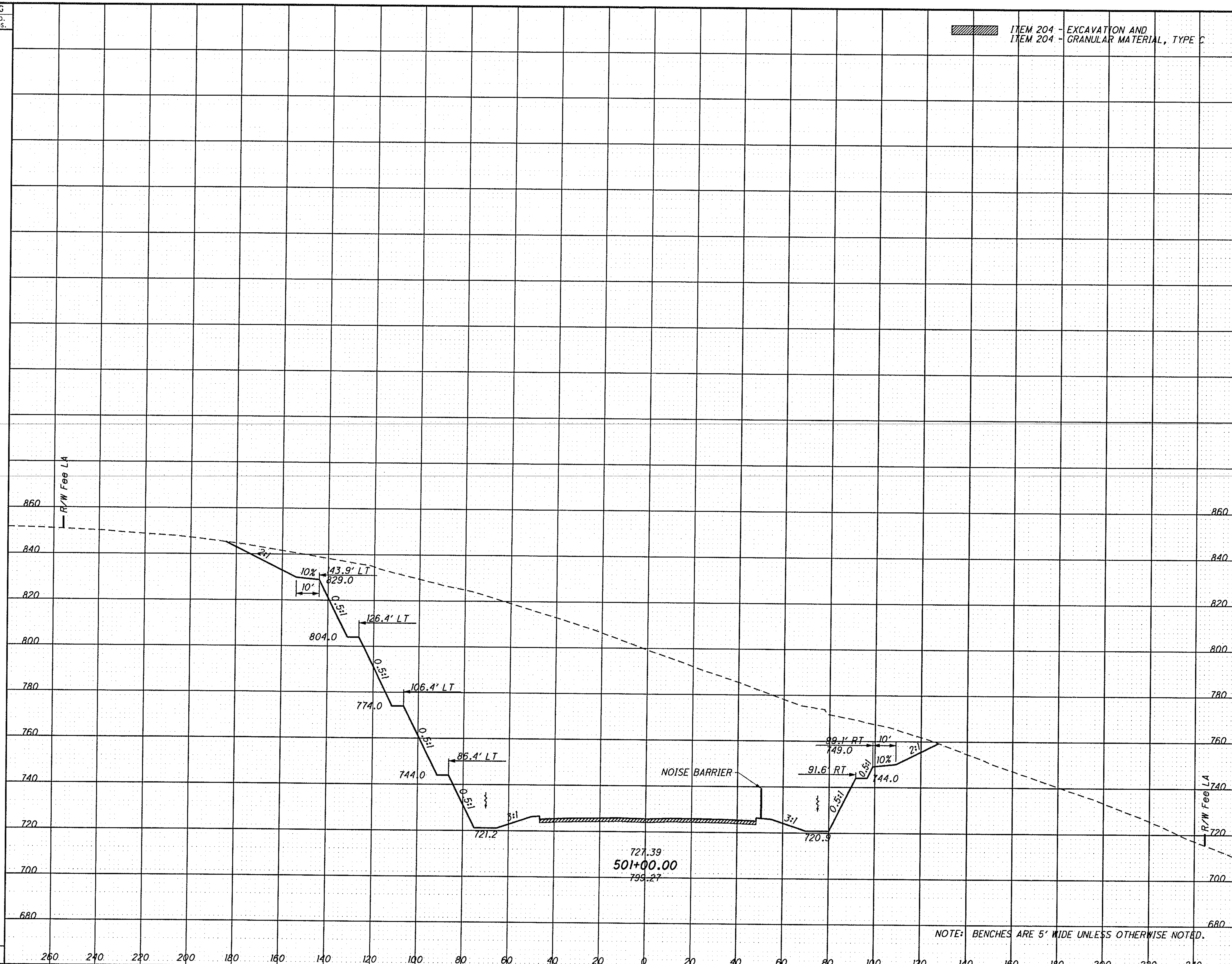
CALCULATED | CHECKED

CROSS SECTIONS - SR823
STA. 500+50.00 TO STA. 500+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:10:53 PM REVISION DATE: 7/26/2009
FILE:...006594/000000000045878 /19415xs010.dgn MODEL: XS_SHEET_temporary_model_name_5

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

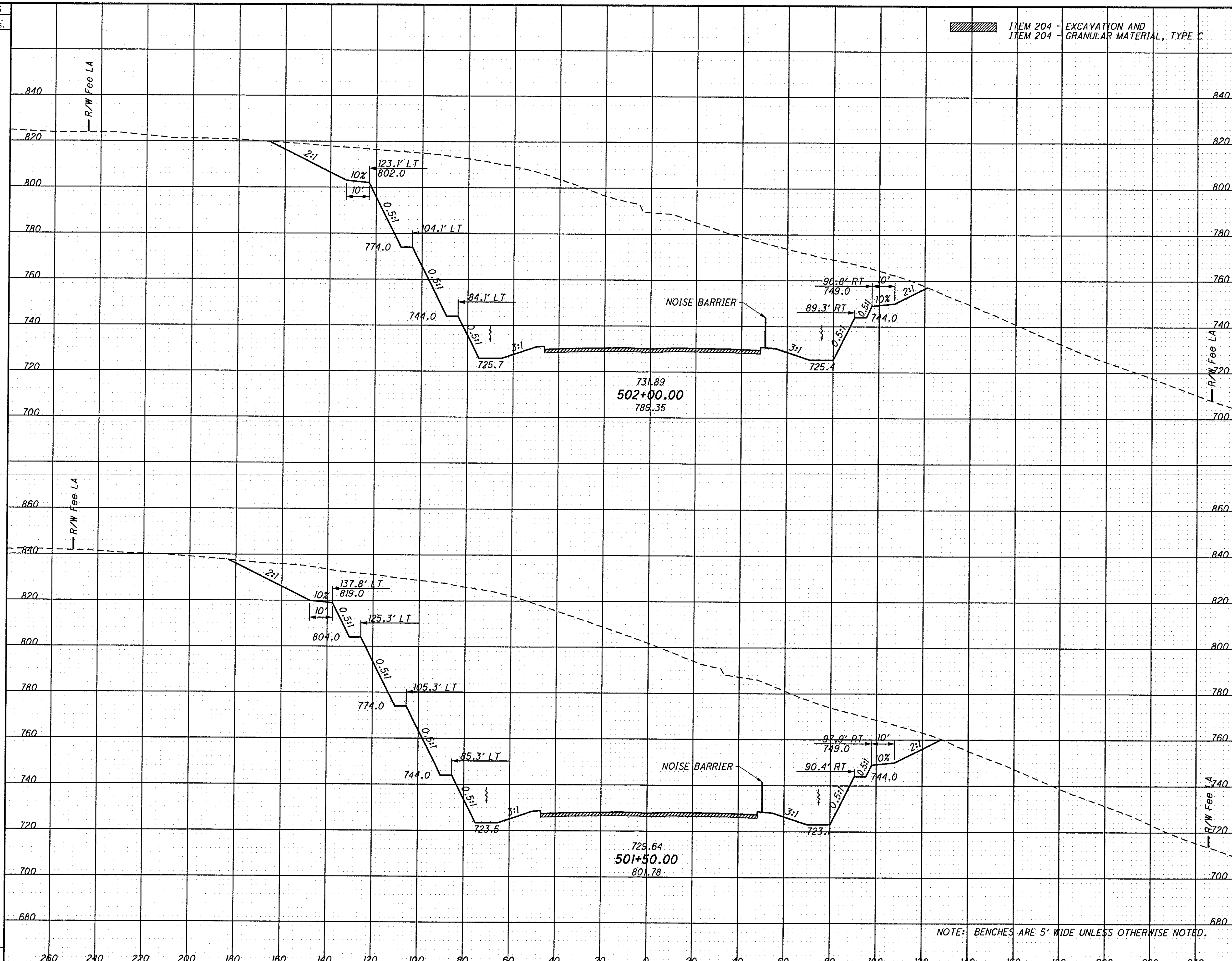
CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 501+00.00 TO STA. 501+00.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



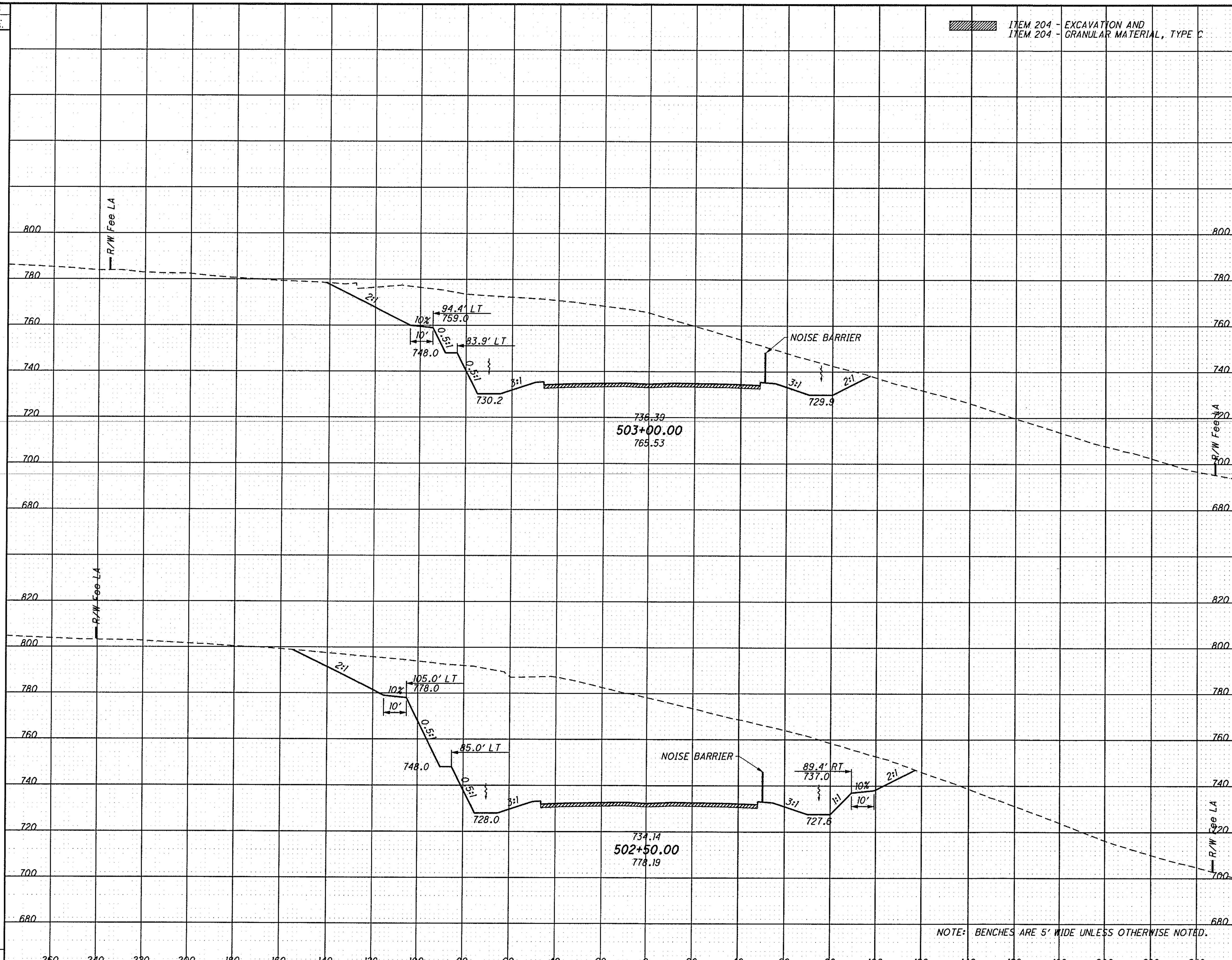
END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED | CHECKED

CROSS SECTIONS - SR823
STA. 501+50.00 TO STA. 502+00.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



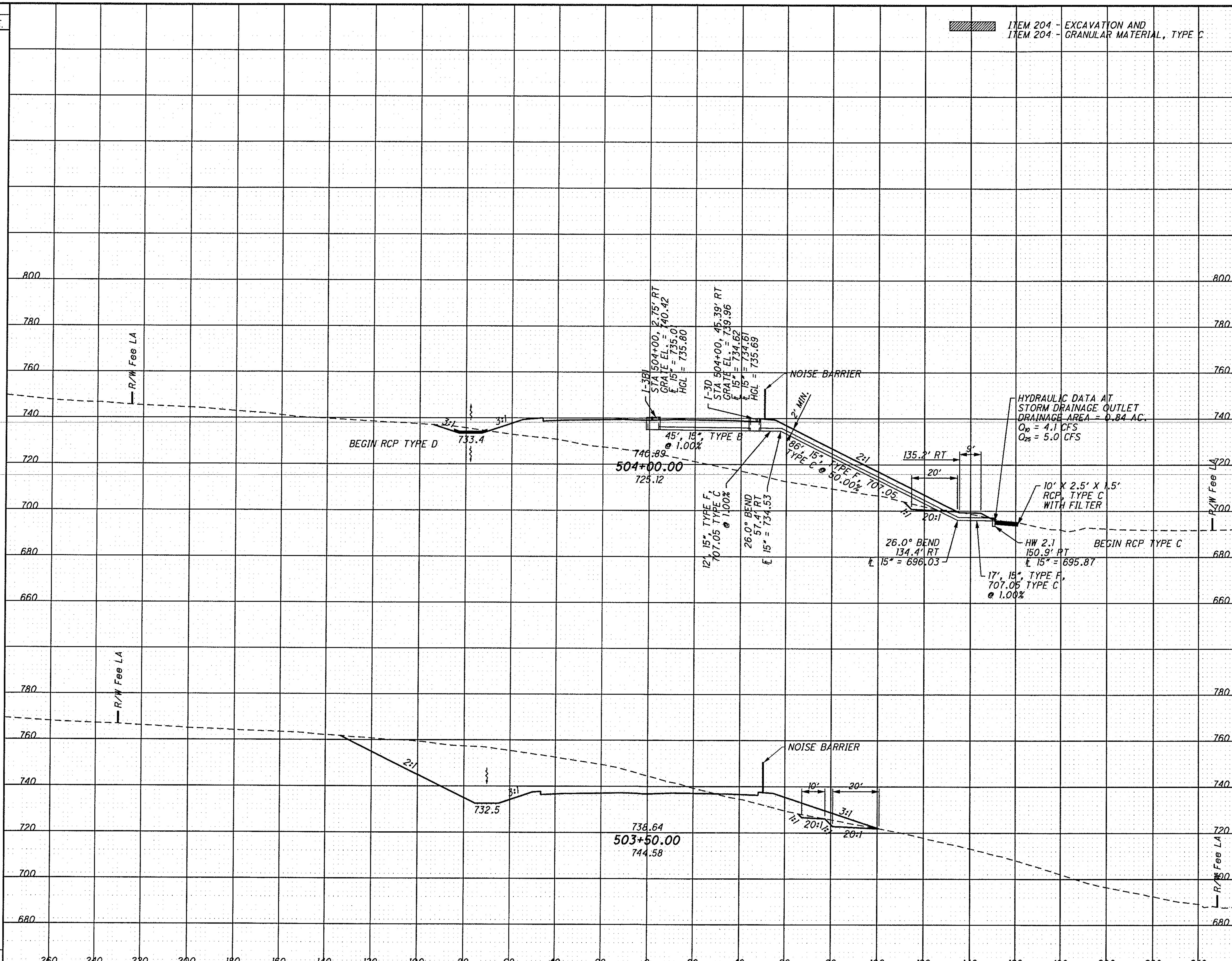
END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - SR823
STA. 502+50.00 TO STA. 503+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:10:56 PM REVISION DATE: 7/26/2009
FILE: ...006934/00000000004878 78415xs010.dgn MODEL: XS_SHEET_temporary_model_name_8

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

CHECKED

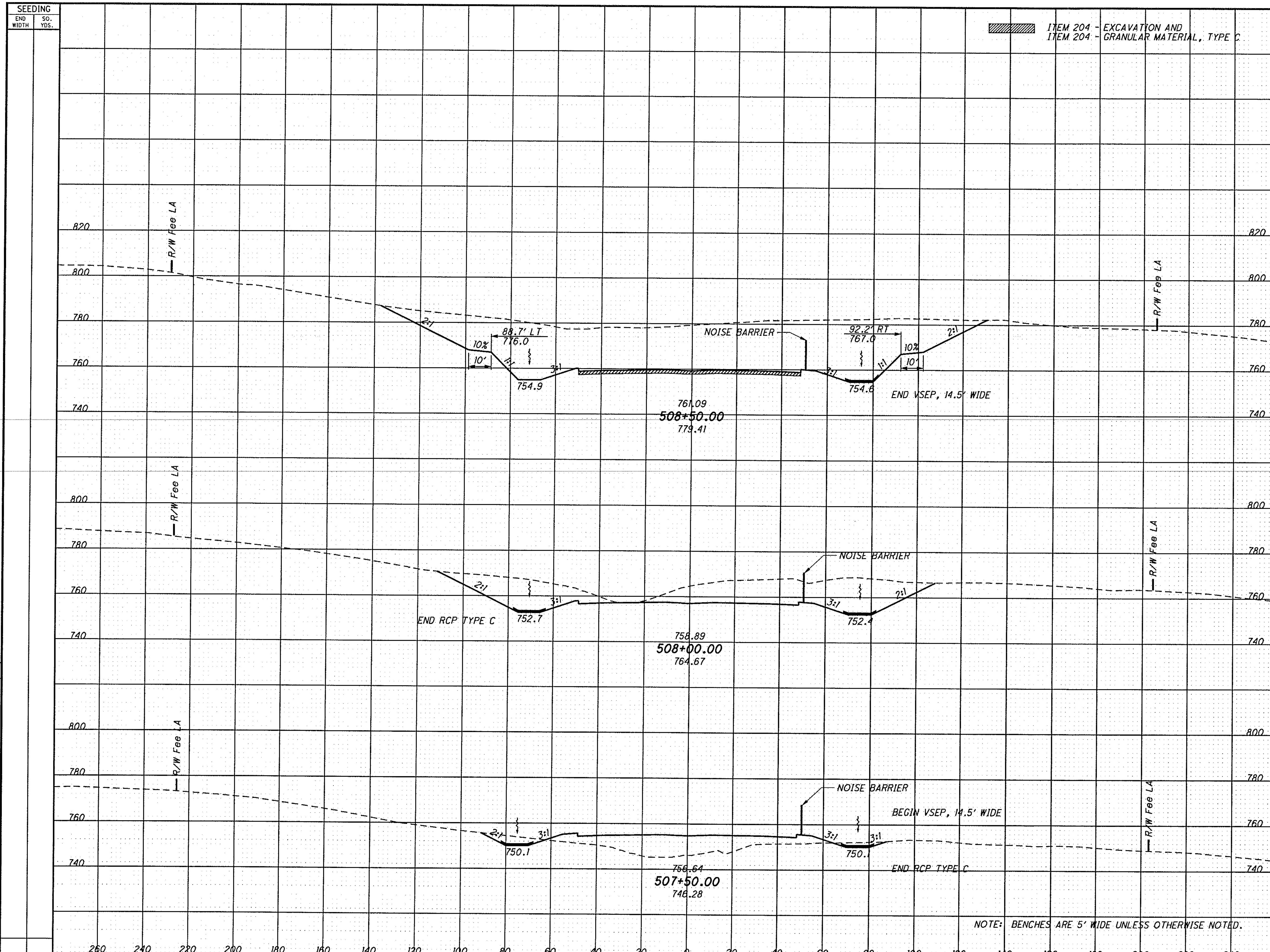
CROSS SECTIONS - SR823
STA. 503+50.00 TO STA. 504+00.00

SCI-823-6.81

270
752

USER: mbotdorf PLOT DATE: 7/26/2009 6:10:57 PM REVISION DATE: 7/26/2009
FILE: ...006594/0000000004587B /7945xs010.dgn MODEL: XS_SHEET_temporary_model_name_9

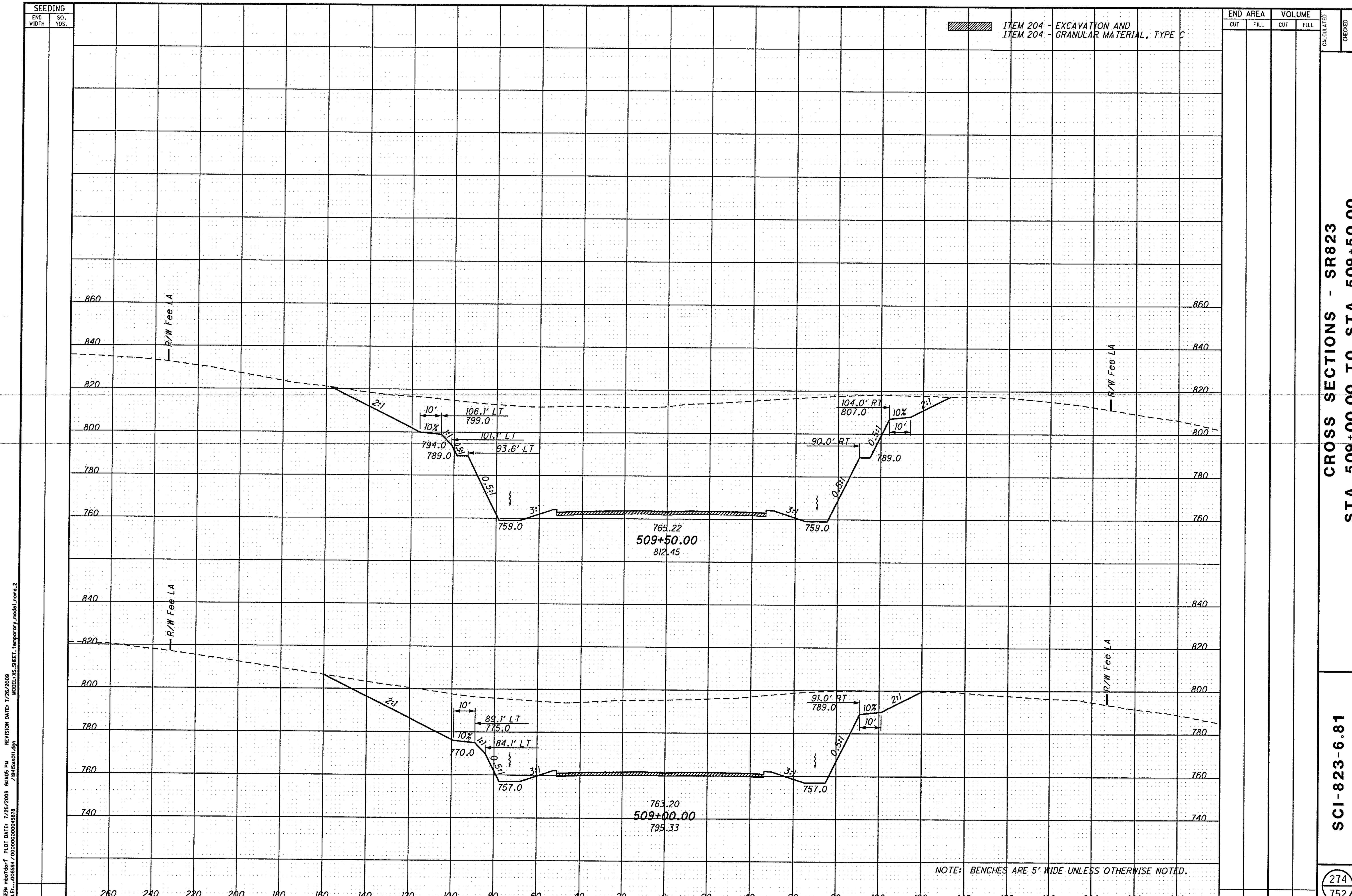
Rock Cut No. 15
Sta. 508+00 to Sta. 528+00



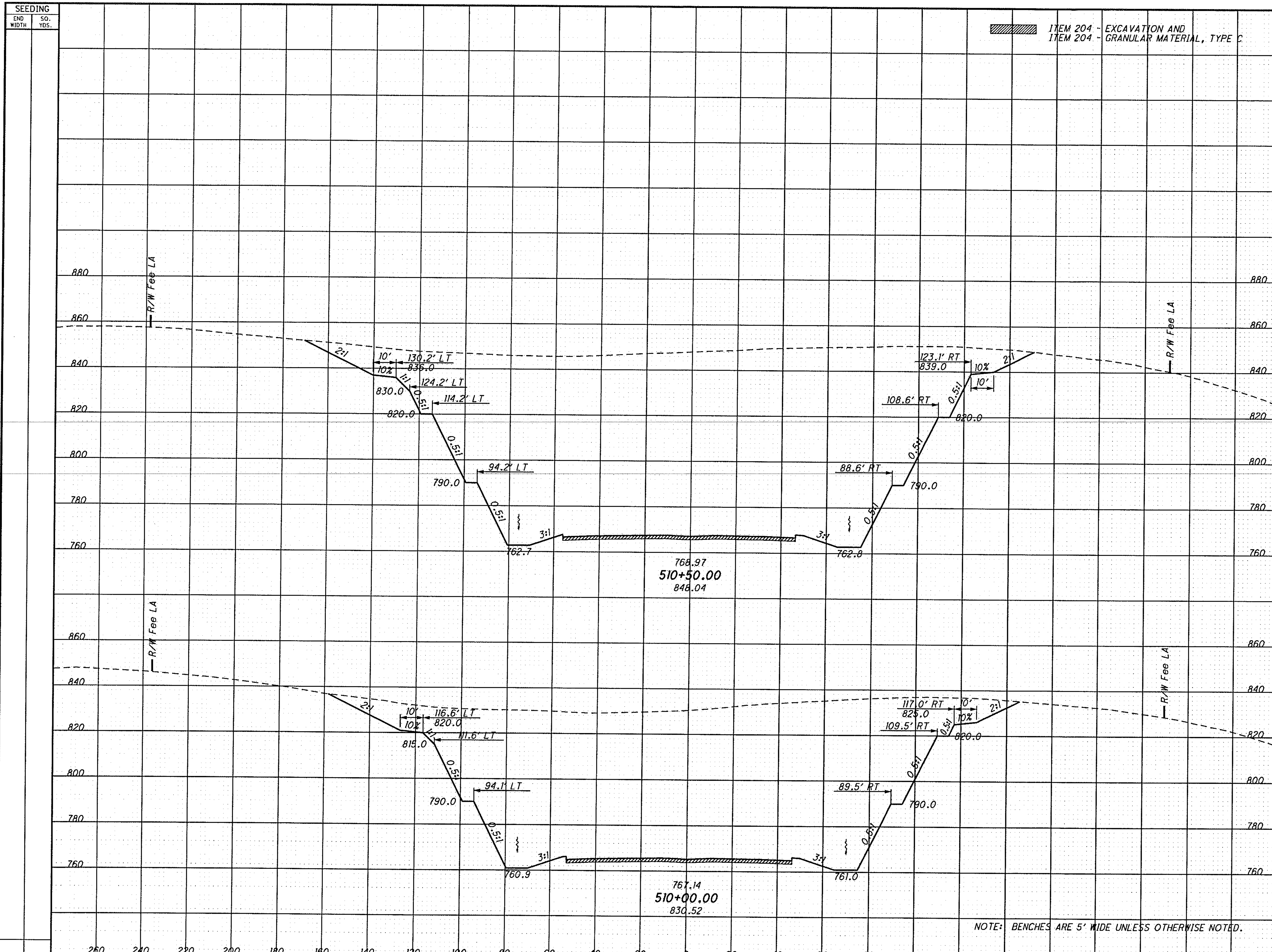
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 507+50.00 TO STA. 508+50.00

SCI-823-6.81



SEEDING
END WIDTH
SQ. YDS.
ITEM 204 - EXCAVATION AND
ITEM 204 - GRANULAR MATERIAL, TYPE C
END AREA
CUT
FILL
VOLUME
CUT
FILL
CALCULATED
CHECKED
R/W Fee LA
2:1
10'
10%
106.1' LT
799.0
101.1' LT
93.6' LT
794.0
789.0
1:1
0.5:1
3:1
759.0
765.22
509+50.00
812.45
104.0' RT
807.0
10%
10'
2:1
90.0' RT
789.0
759.0
89.1' LT
775.0
84.1' LT
770.0
757.0
763.20
509+00.00
795.33
91.0' RT
789.0
NOTE: BENCHES ARE 5' WIDE UNLESS OTHERWISE NOTED.
860
840
820
800
780
760
740
260
240
220
200
180
160
140
120
100
80
60
40
20
0
CROSS SECTIONS - SR823
STA. 509+00.00 TO STA. 509+50.00
SCI-823-6.81
274
752



CALCULATED

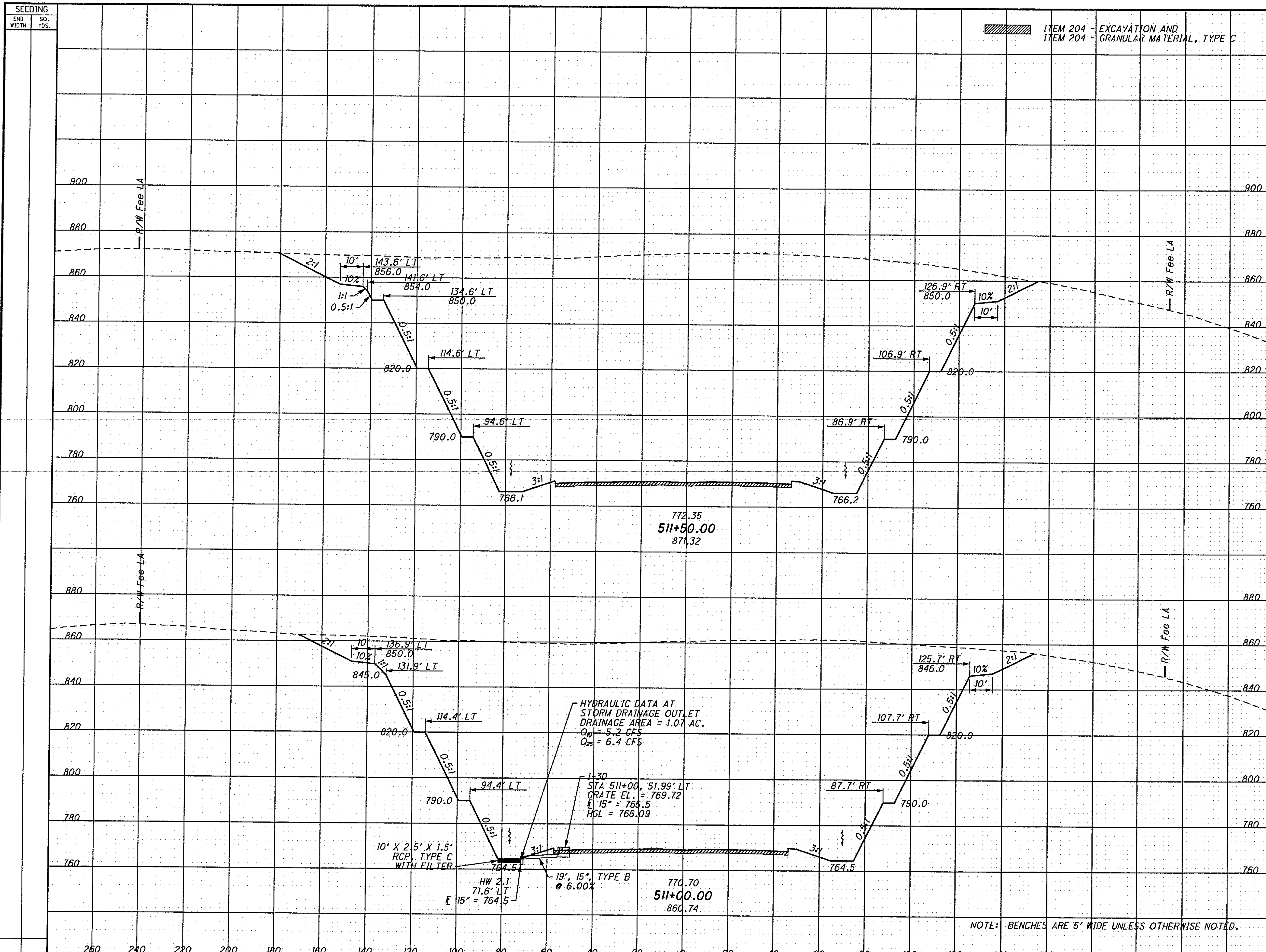
CHECKED

CROSS SECTIONS - SR823

STA. 510+00.00 TO STA. 510+50.00

SCI-823-6.81

275/752

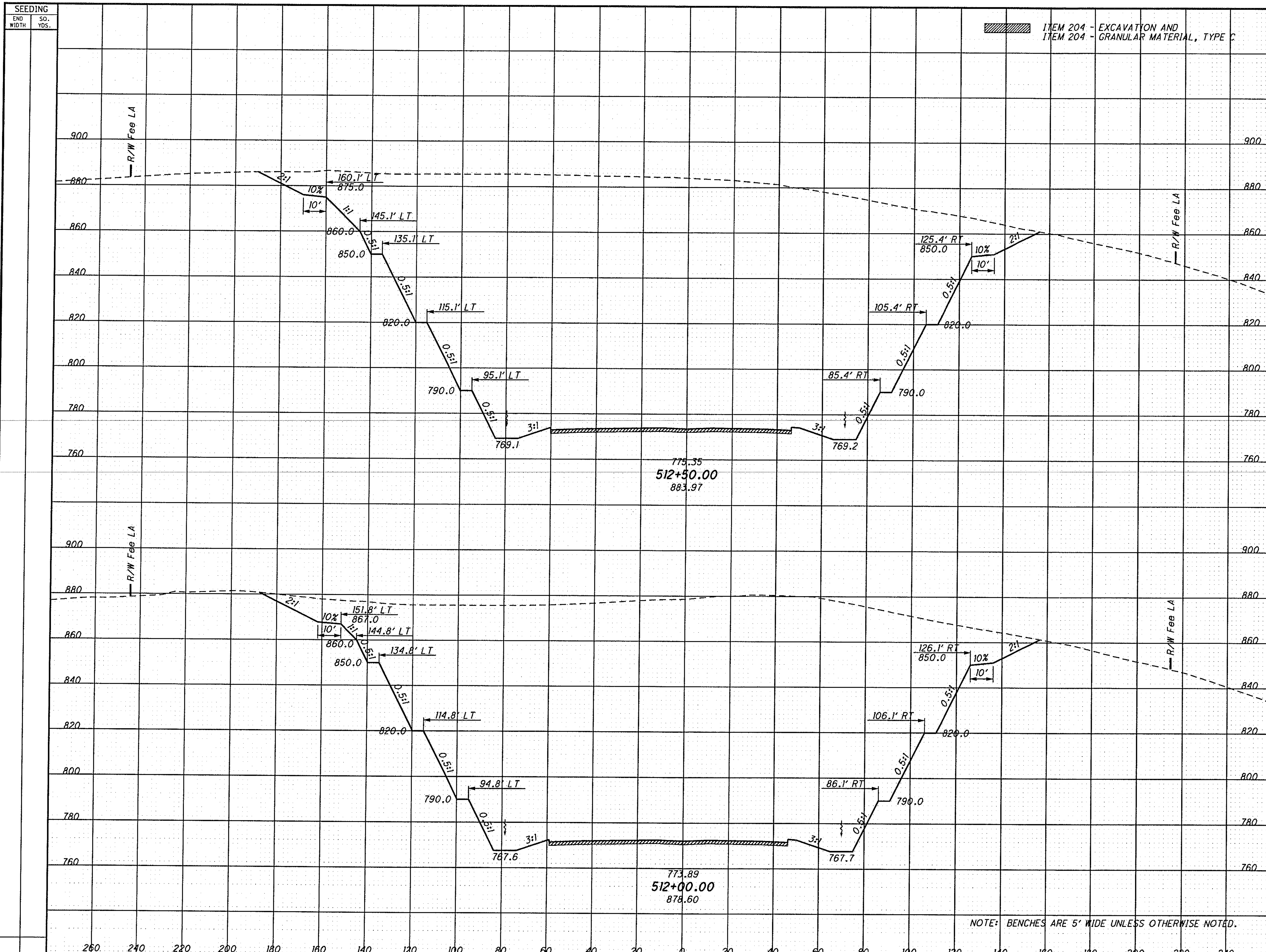


CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 511+00.00 TO STA. 511+50.00

SCI-823-6.81

276
752

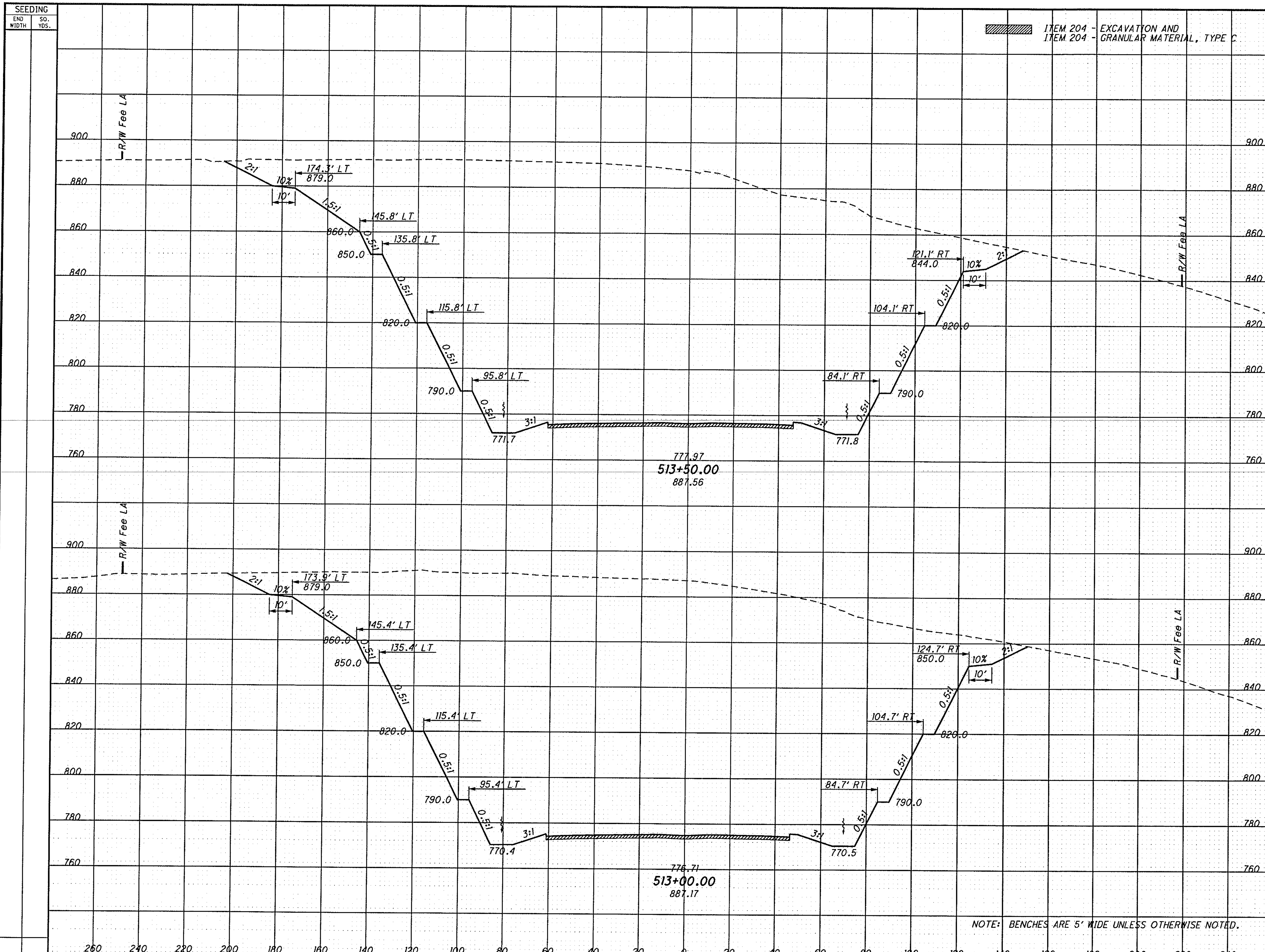


END AREA | VOLUME
CUT | FILL | CUT | FILL

CALCULATED | CHECKED

CROSS SECTIONS - SR823
STA. 512+00.00 TO STA. 512+50.00

SCI-823-6.81



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

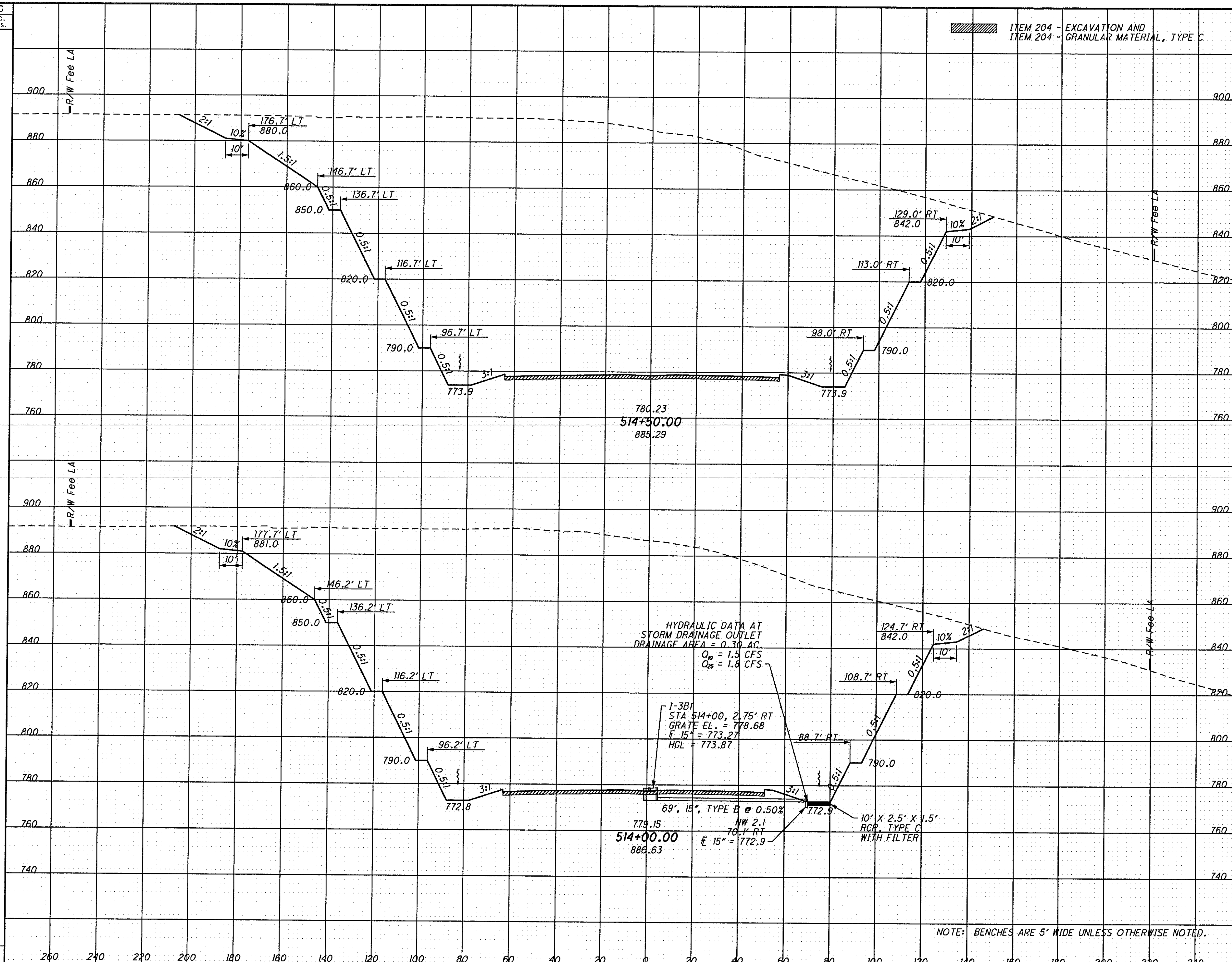
CHECKED

CROSS SECTIONS - SR823
STA. 513+00.00 TO STA. 513+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:11:09 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045878 /79465xs011.dgn MODEL: XS_SHEET_temporary_model_name_6

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

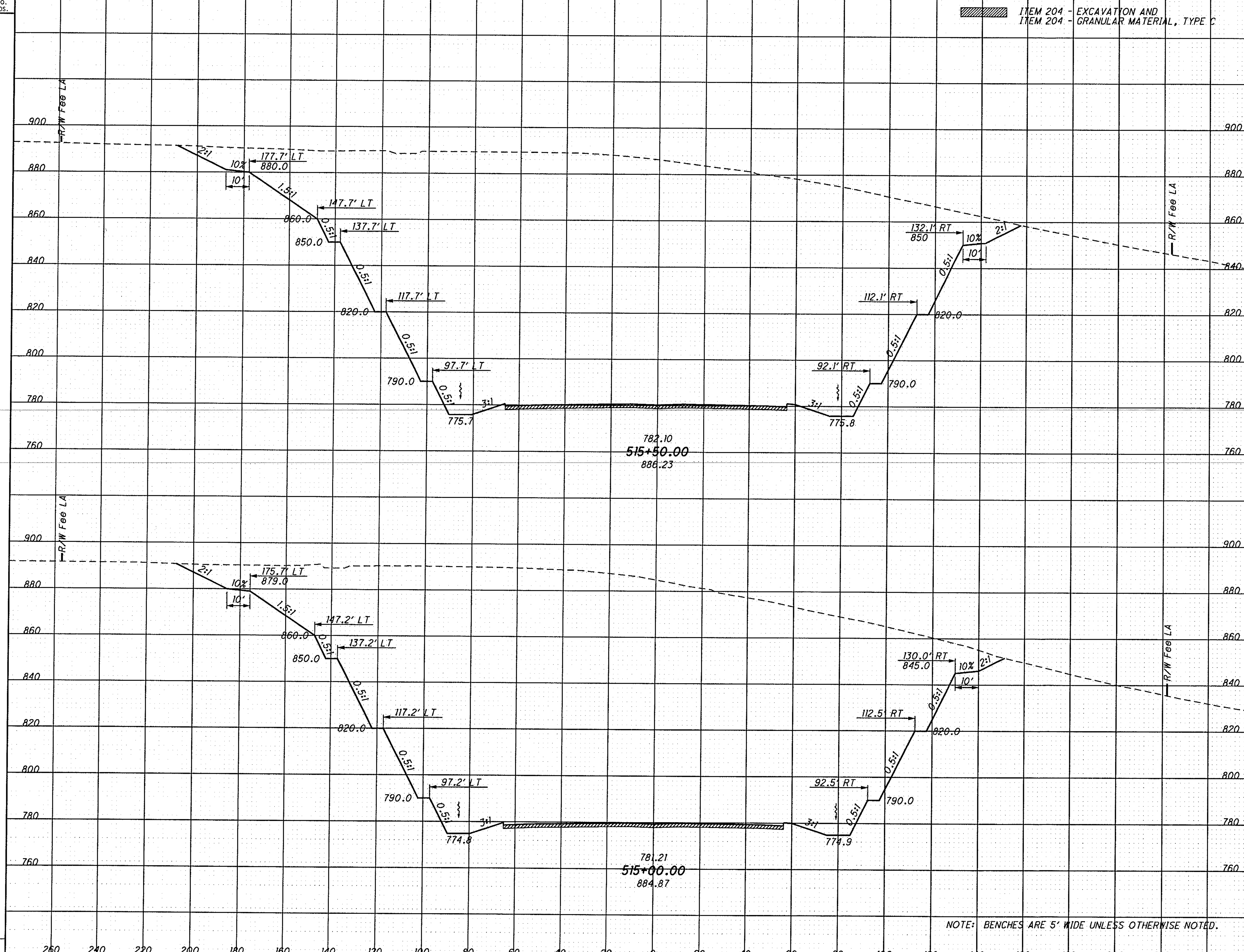
CALCULATED | CHECKED

CROSS SECTIONS - SR823
STA. 514+00.00 TO STA. 514+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:11:09 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045878 /19415xs011.dgn MODEL: XS_SHEET_temporary_model_name_7

SEEDING		END AREA		VOLUME		CALCULATED	CHECKED
END WIDTH	SQ. YDS.	CUT	FILL	CUT	FILL		

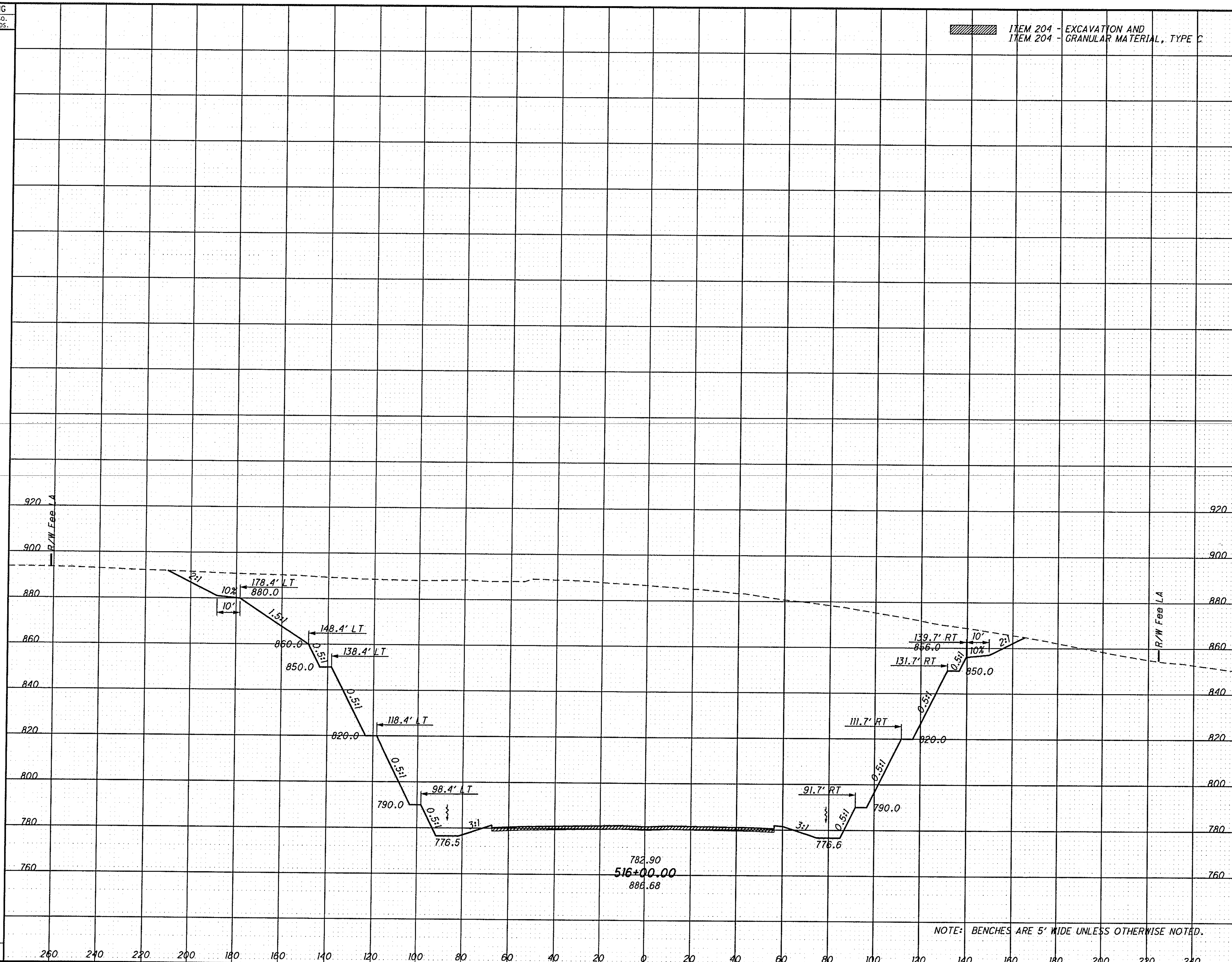


USER: mbotdorf PLOT DATE: 7/26/2009 REVISION DATE: 7/26/2009 MODEL: XS_SHEET_temporary_model_name_8
FILE: ...006594/000000000045878 /1945xs011.dgn

CROSS SECTIONS - SR823
STA. 515+00.00 TO STA. 515+50.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

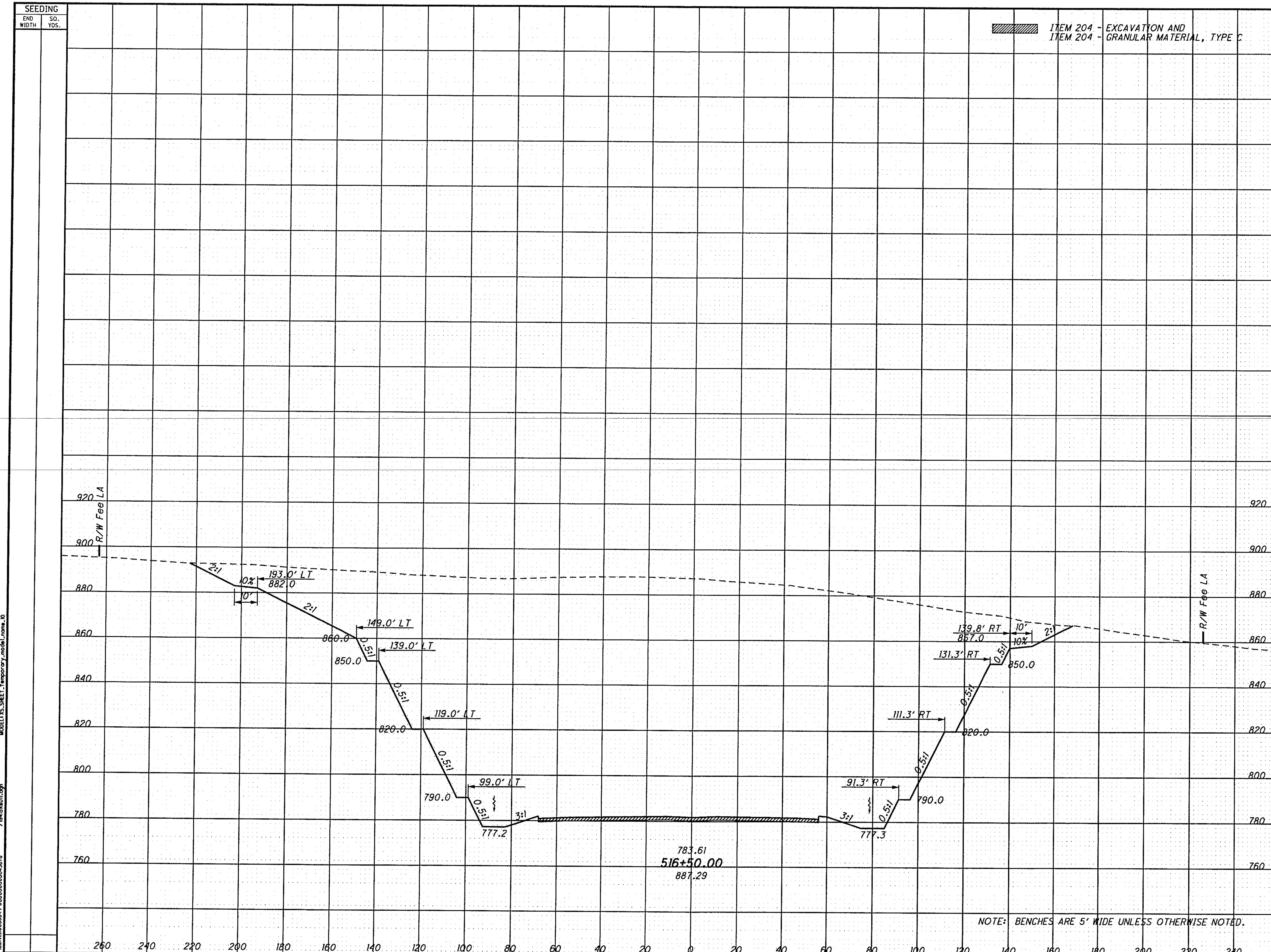
CHECKED

CROSS SECTIONS - SR823

STA. 516+00.00 TO STA. 516+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:11:11 PM REVISION DATE: 7/26/2009
FILE:...006594/00000000045878 /19415xs011.dgn MODEL: XS_SHEET_temporary_model_name_9



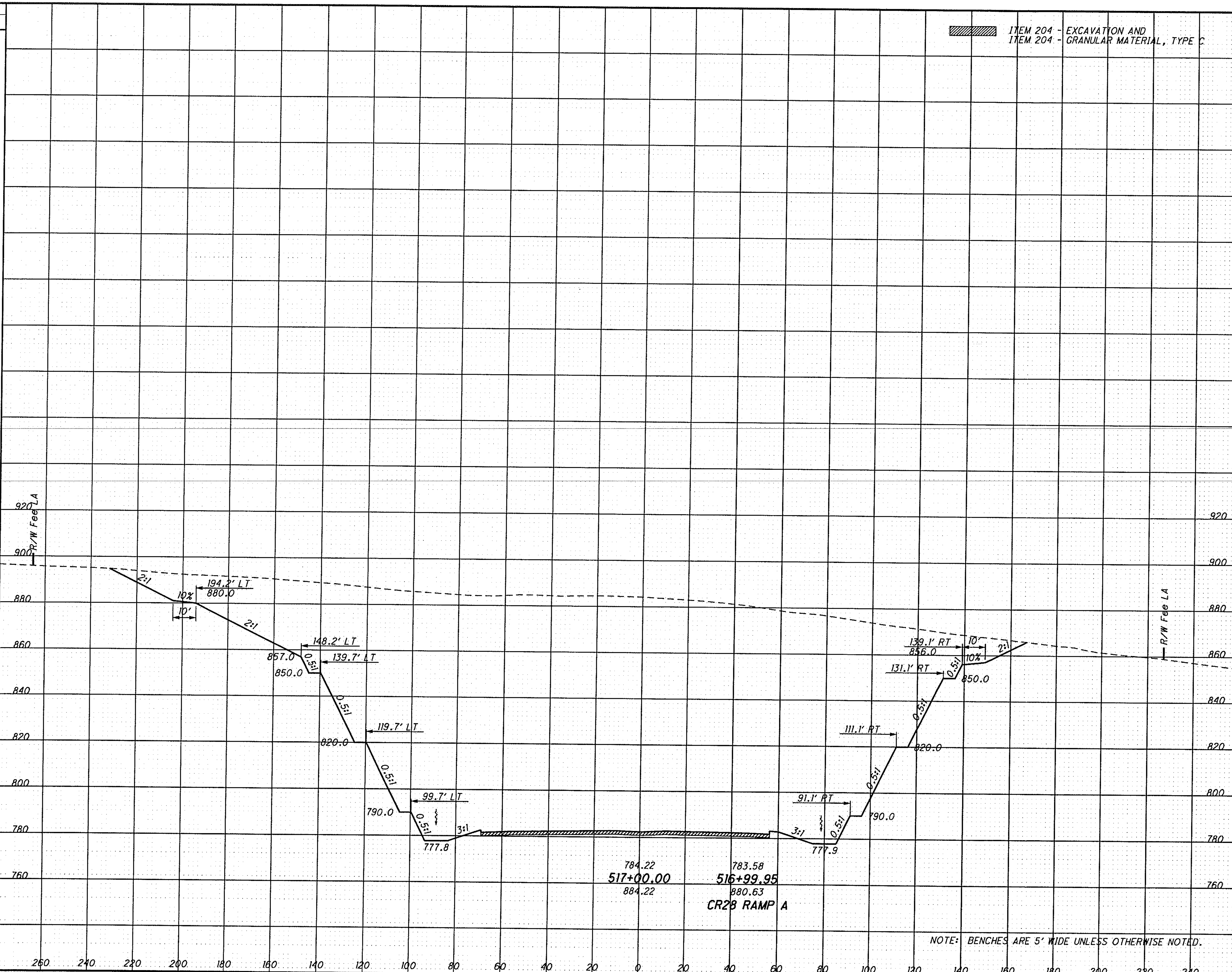
USER: mbotdorf PLOT DATE: 7/26/2009 6:11:12 PM REVISION DATE: 7/26/2009
FILE: ...006594/0000000000045878 /79415xs011.dgn MODEL: XS_SHEET_temporary_model_name_10

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 516+50.00 TO STA. 516+50.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

CHECKED

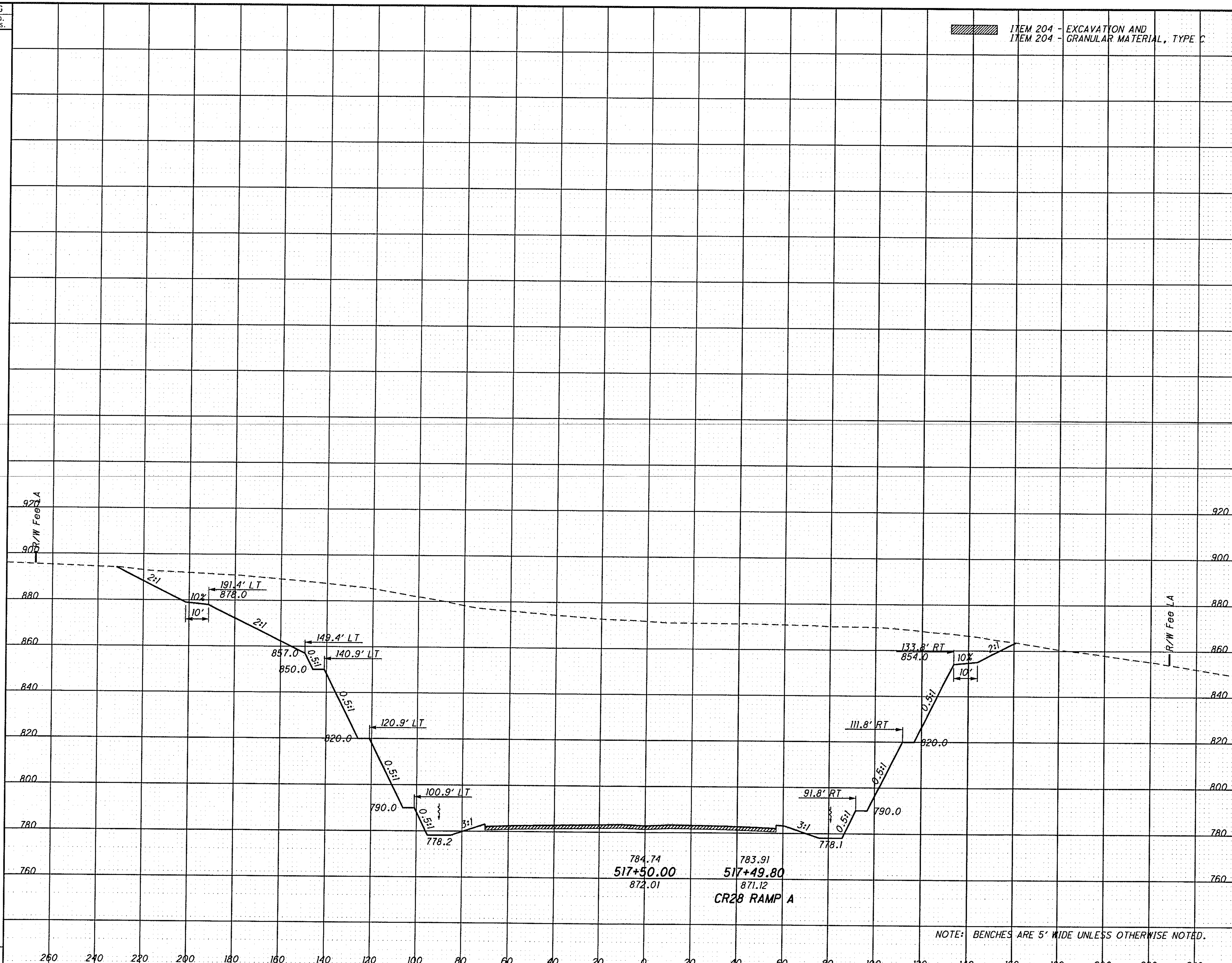
CROSS SECTIONS - SR823

STA. 517+00.00 TO STA. 517+00.00

SCI-823-6.81

USER: mboldorf PLOT DATE: 7/26/2009 6:11:13 PM REVISION DATE: 7/26/2009
FILE: ...008594/000000000045978 / 71945xs011.dgn MODEL: XS_SHEET_temporary_model_none_11

SEEDING	
END WIDTH	SQ. YDS.



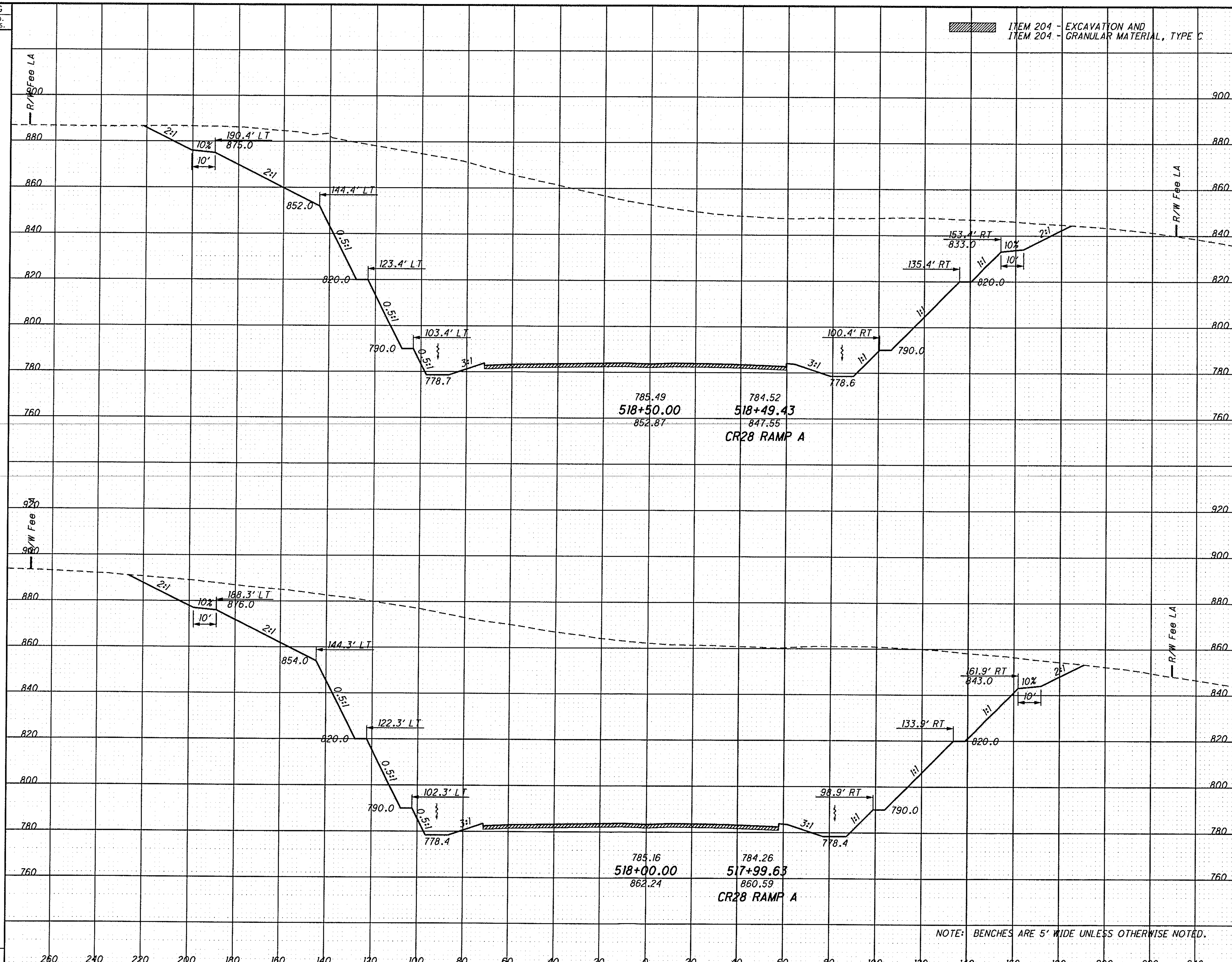
END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 517+50.00 TO STA. 517+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/28/2009 6:11:13 PM REVISION DATE: 7/26/2009
FILE: ...\005594\000000000045878 7194\xs011.dgn MODEL: XS_SHEET_temporary_model_name_12



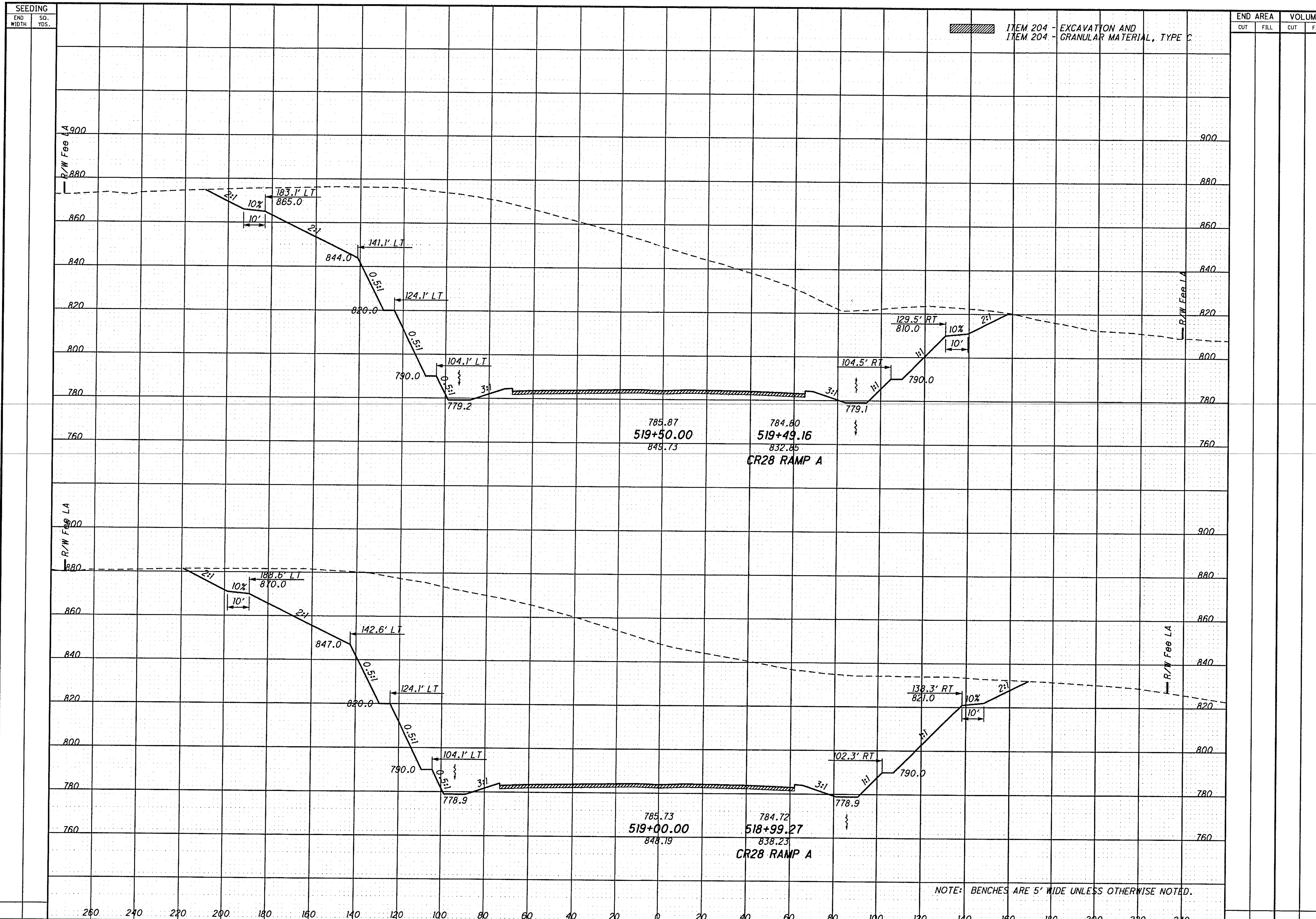
SEEDING	
END WIDTH	SQ. YDS.

END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 518+00.00 TO STA. 518+50.00

SCI-823-6.81

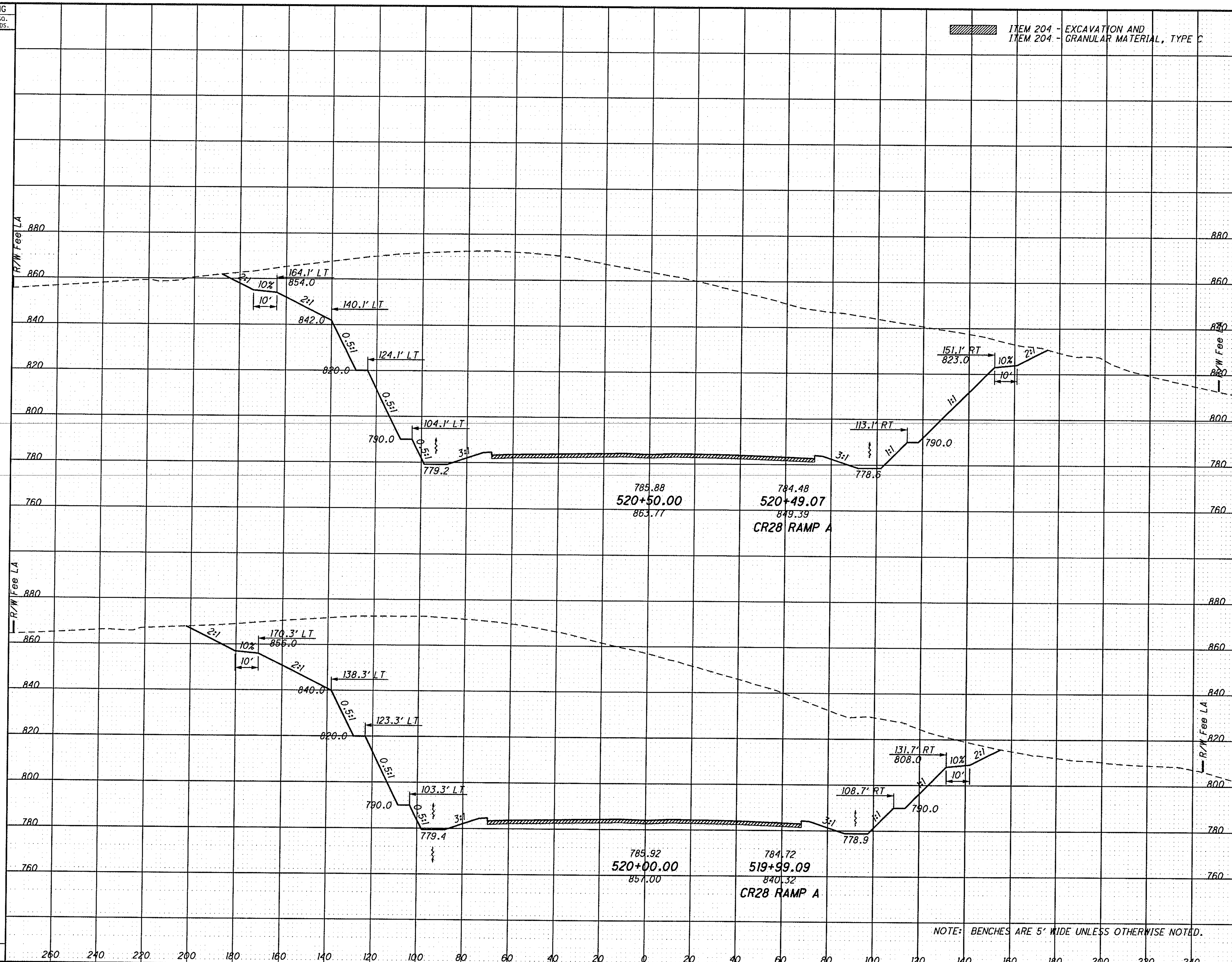


CROSS SECTIONS - SR823

STA. 519+00.00 TO STA. 519+50.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

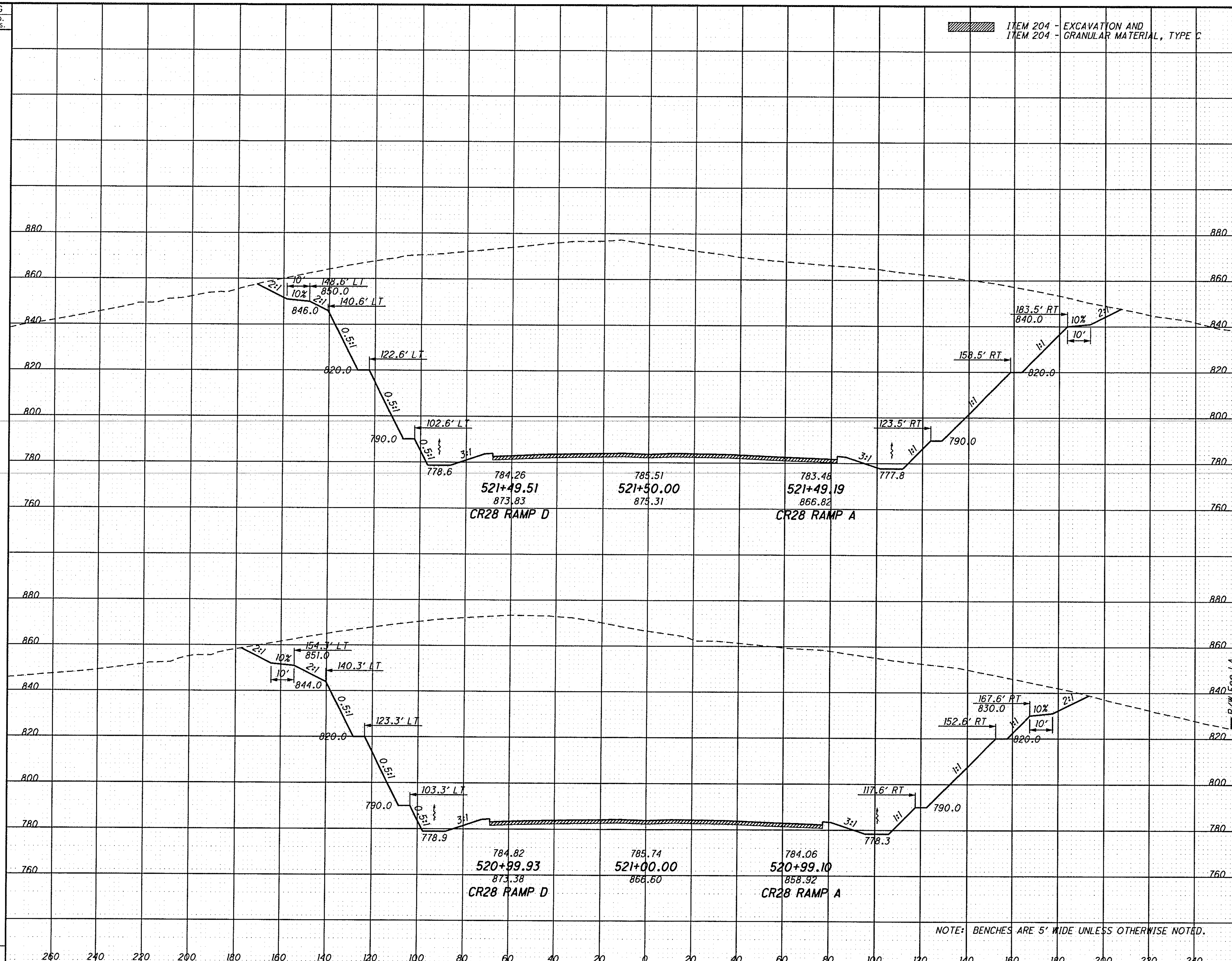
CHECKED

CROSS SECTIONS - SR823

STA. 520+00.00 TO STA. 520+50.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.



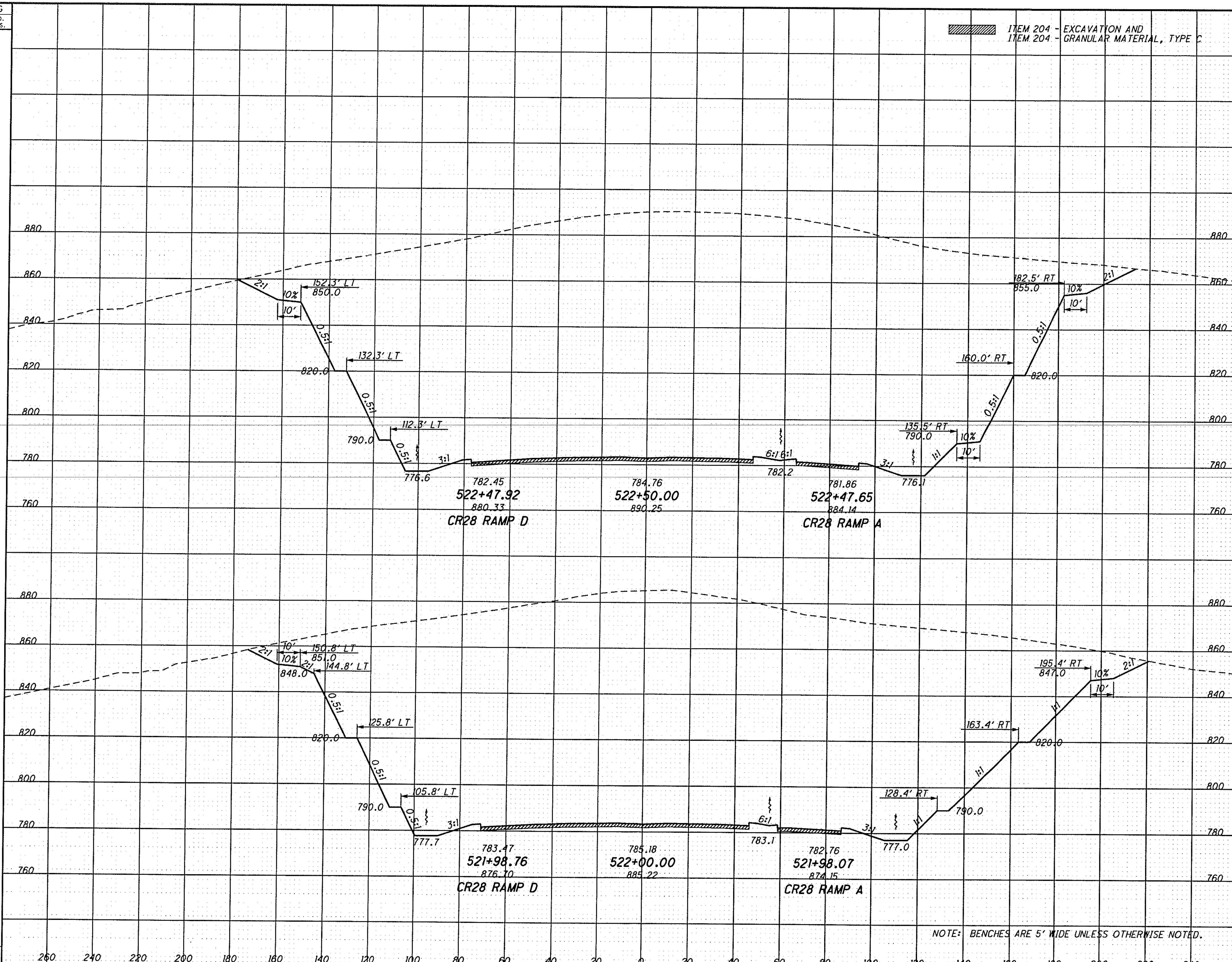
END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - SR823
STA. 521+00.00 TO STA. 521+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:11:17 PM REVISION DATE: 7/26/2009
FILE: ...\06934\0000000004587\8 78415xs011.dgn MODEL: XS_SHEET_temporary_model_name_15

SEEDING	
END WIDTH	SQ. YDS.



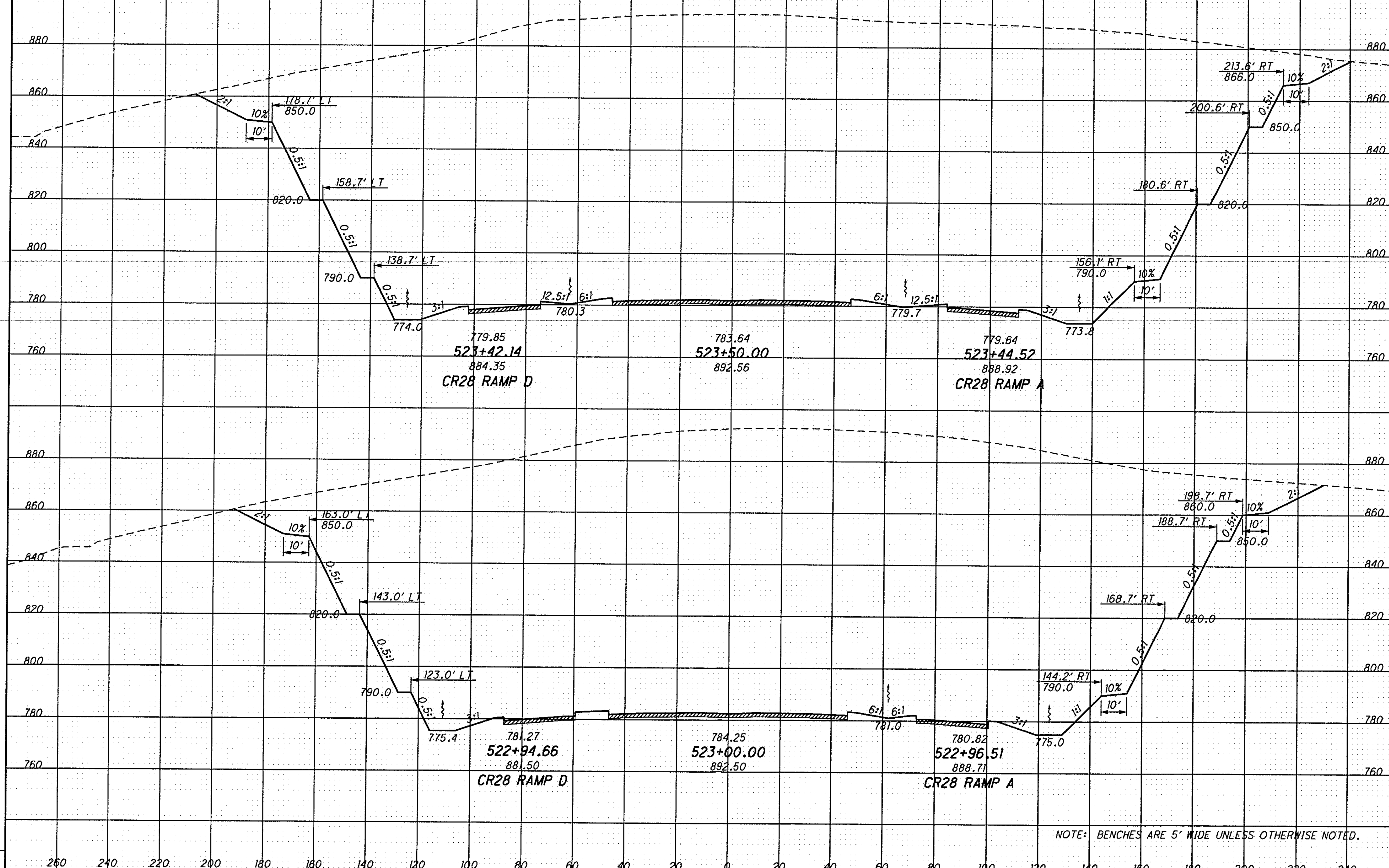
END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - SR823
STA. 522+00.00 TO STA. 522+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:19:17 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045678 /19415xs011.dgn MODEL: XS_SHEET_temporary_model_name_17

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

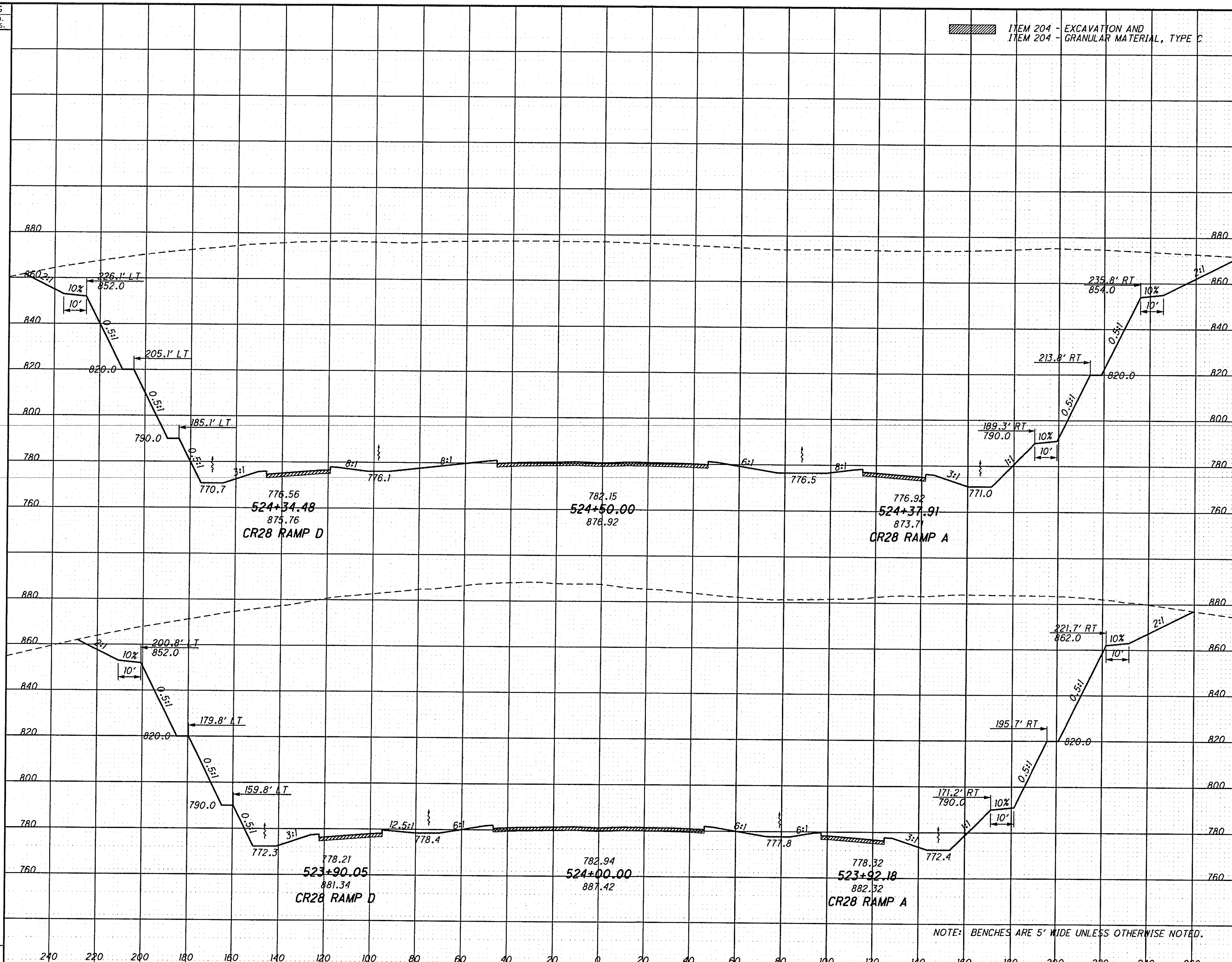
CHECKED

CROSS SECTIONS - SR823
STA. 523+00.00 TO STA. 523+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:11:18 PM REVISION DATE: 7/26/2009
FILE: ...\006594\0000000004S878 \79145xs011.dgn MODEL: XS_SHEET_Temporary_model_name_18

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

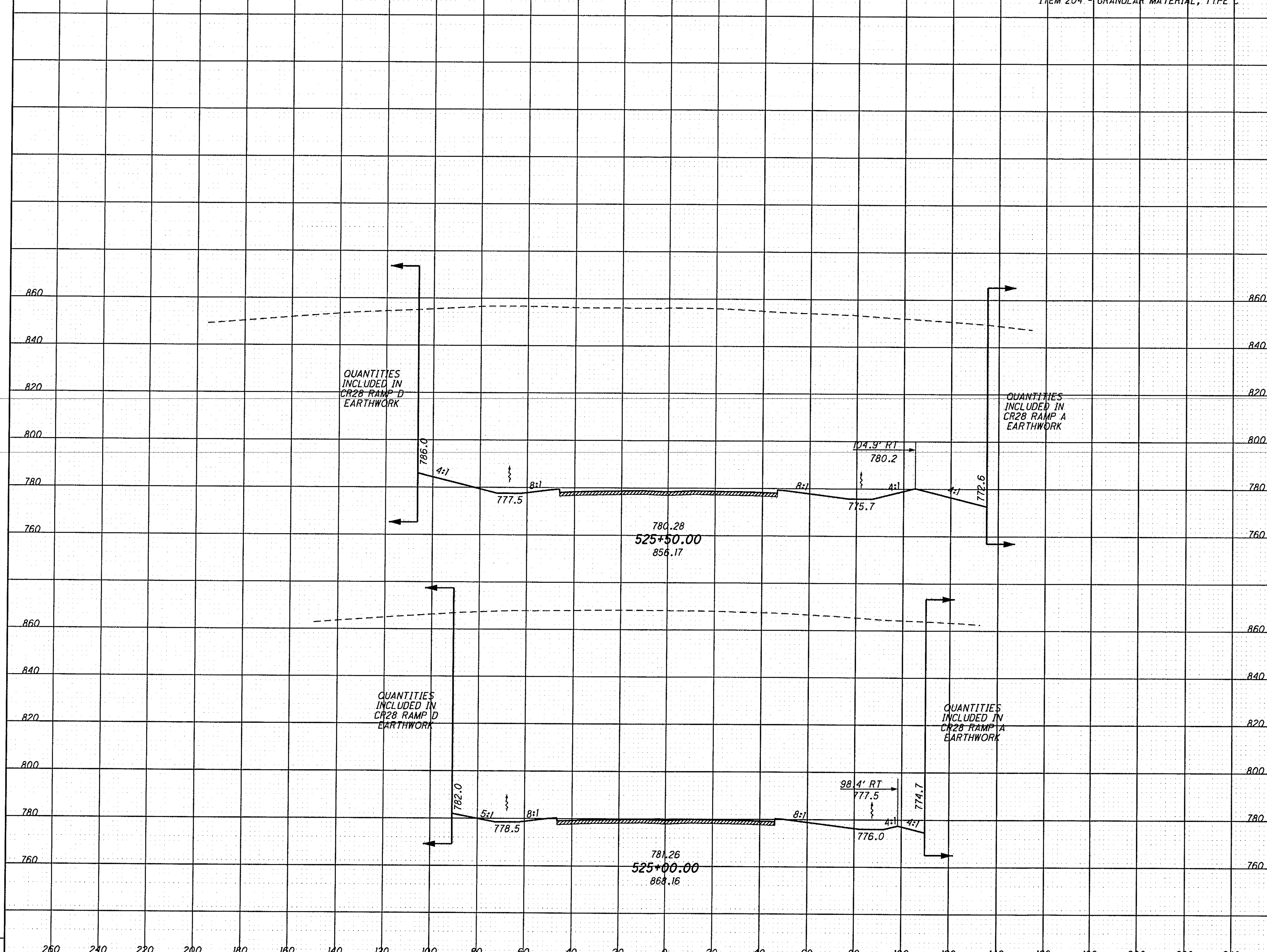
CALCULATED | CHECKED

CROSS SECTIONS - SR823
STA. 524+00.00 TO STA. 524+50.00

SCI-823-6.81

291 / 752

USER: mbotdorf PLOT DATE: 7/26/2009 6:11:19 PM REVISION DATE: 7/26/2009
FILE: ...006594/00000000045878/19415xs011.dgn MODEL: XS_SHEET_temporary_model_name_19



SEEDING	
END WIDTH	SQ. YDS.

END AREA		VOLUME	
CUT	FILL	CUT	FILL

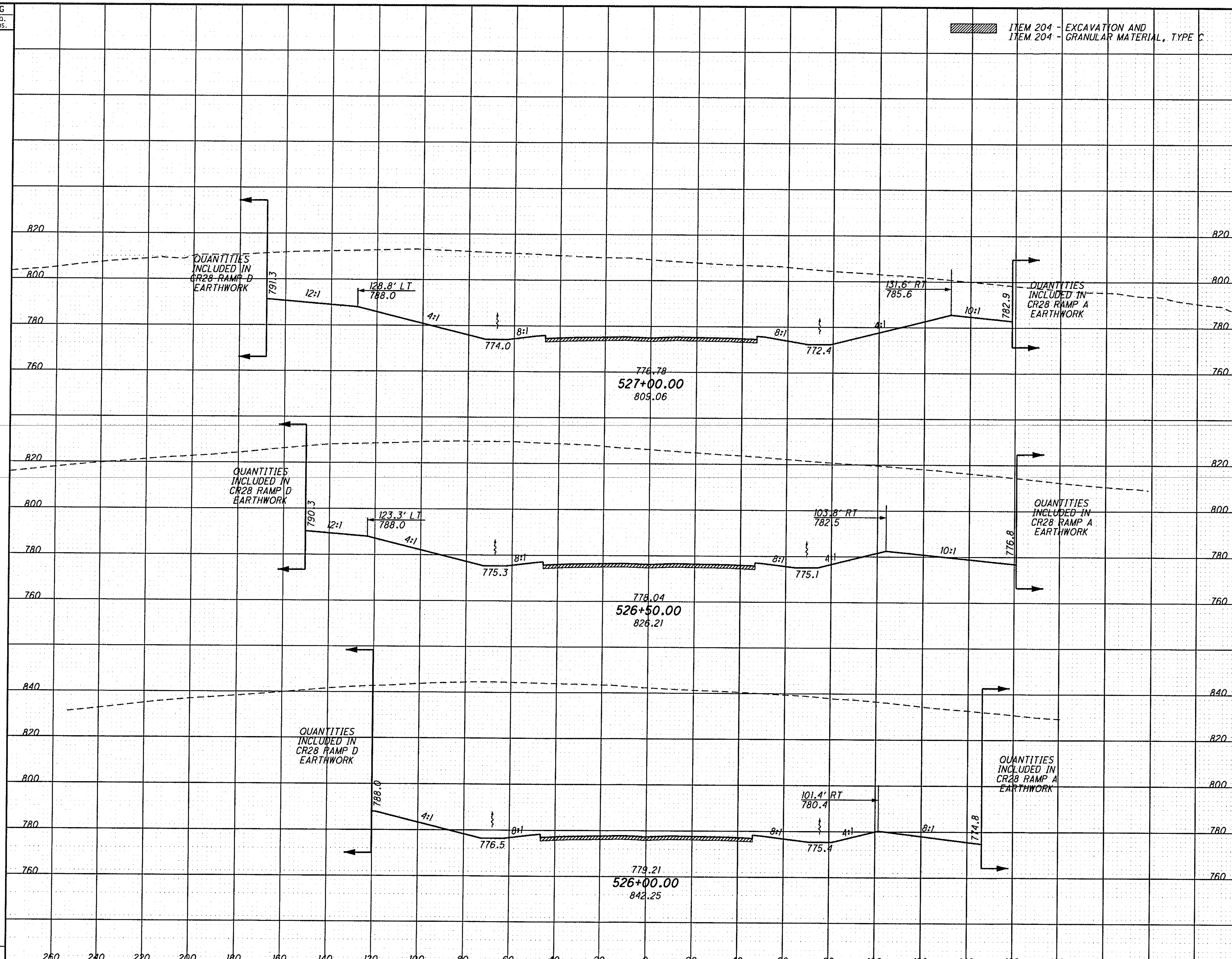
CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 525+00.00 TO STA. 525+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:11:20 PM REVISION DATE: 7/26/2009
FILE: ...006594/000000000045678 /1945xs011.dgn MODEL: XS_SHEET_temporary_model_name_20

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

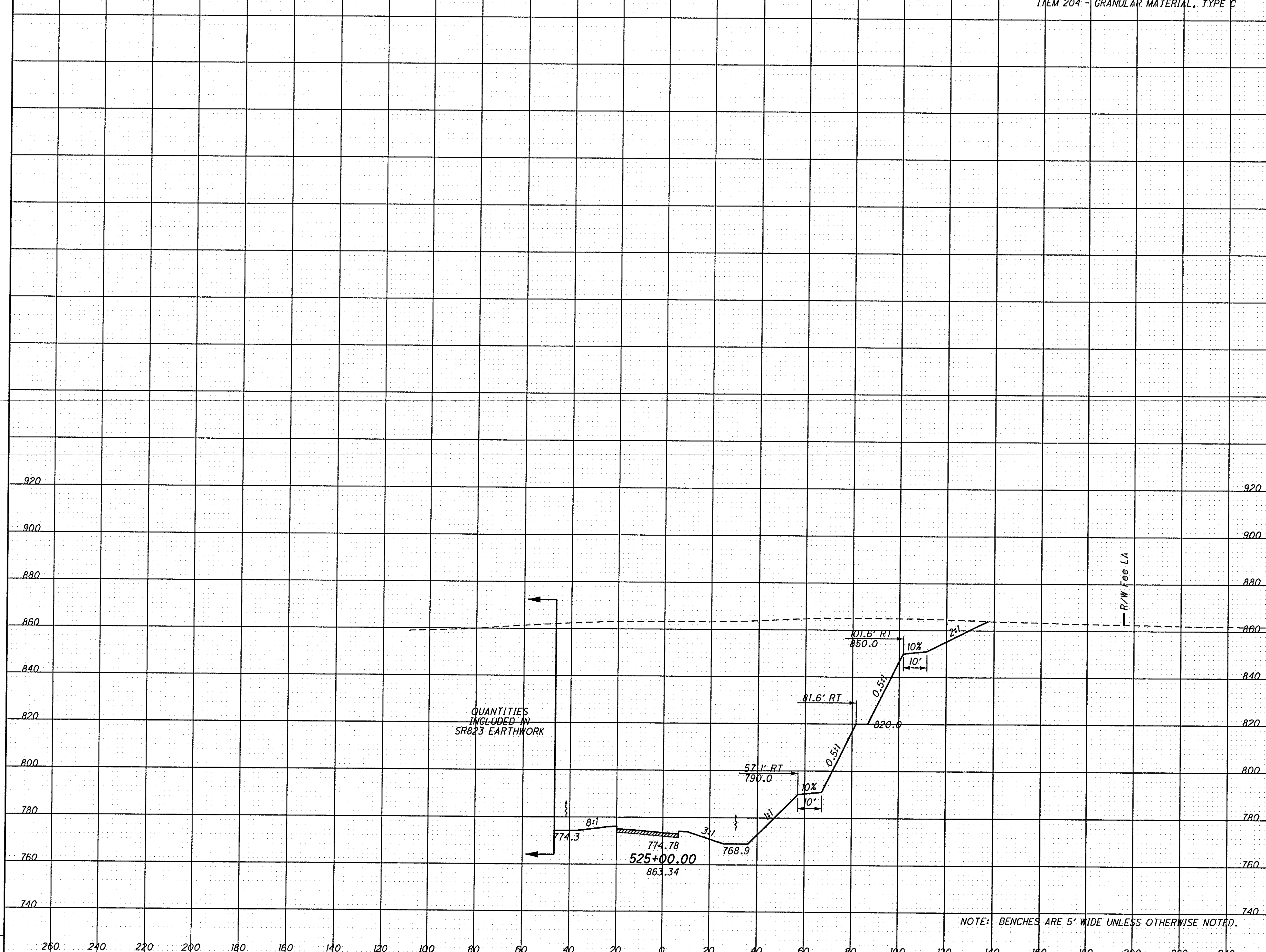
CROSS SECTIONS - SR823
STA. 526+00.00 TO STA. 527+00.00

SCI-823-6.81

SEEDING	
END WIDTH	SQ. YDS.

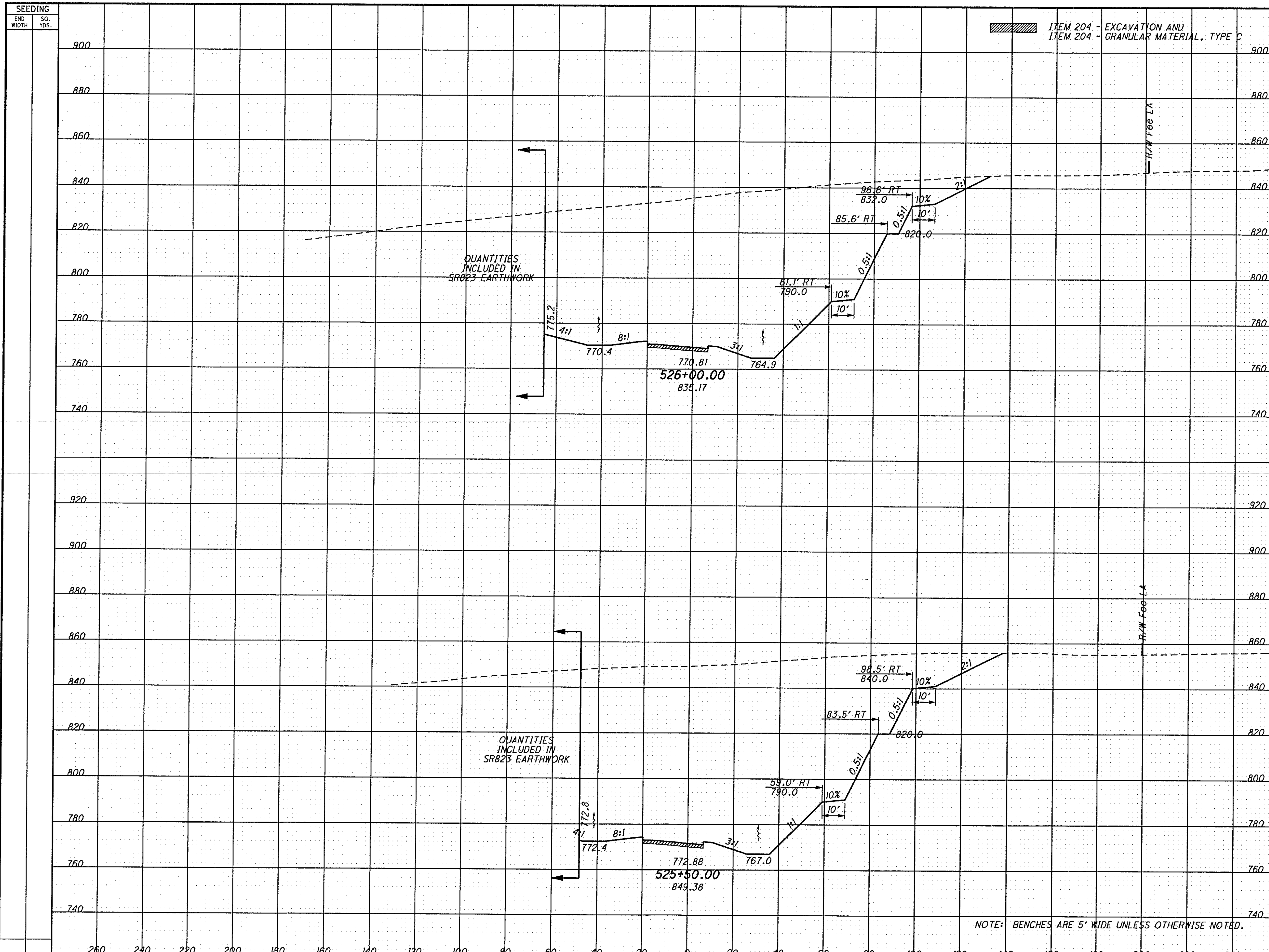
END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED | CHECKED



CROSS SECTIONS - CR28 RAMP A
STA. 525+00.00 TO STA. 525+00.00

SCI-823-6.81



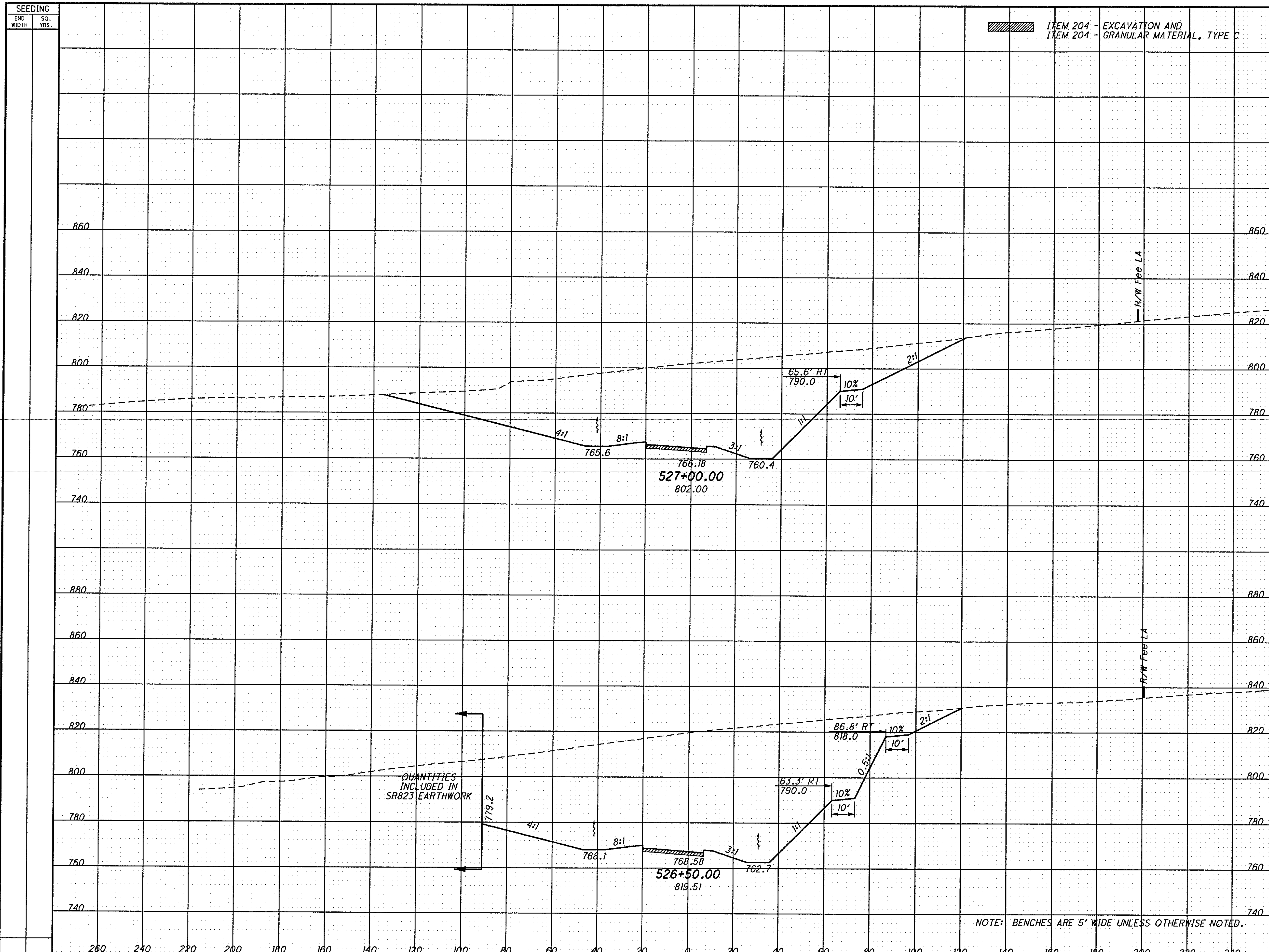
CALCULATED

CHECKED

CROSS SECTIONS - CR28 RAMP A
STA. 525+50.00 TO STA. 526+00.00

SCI-823-6.81

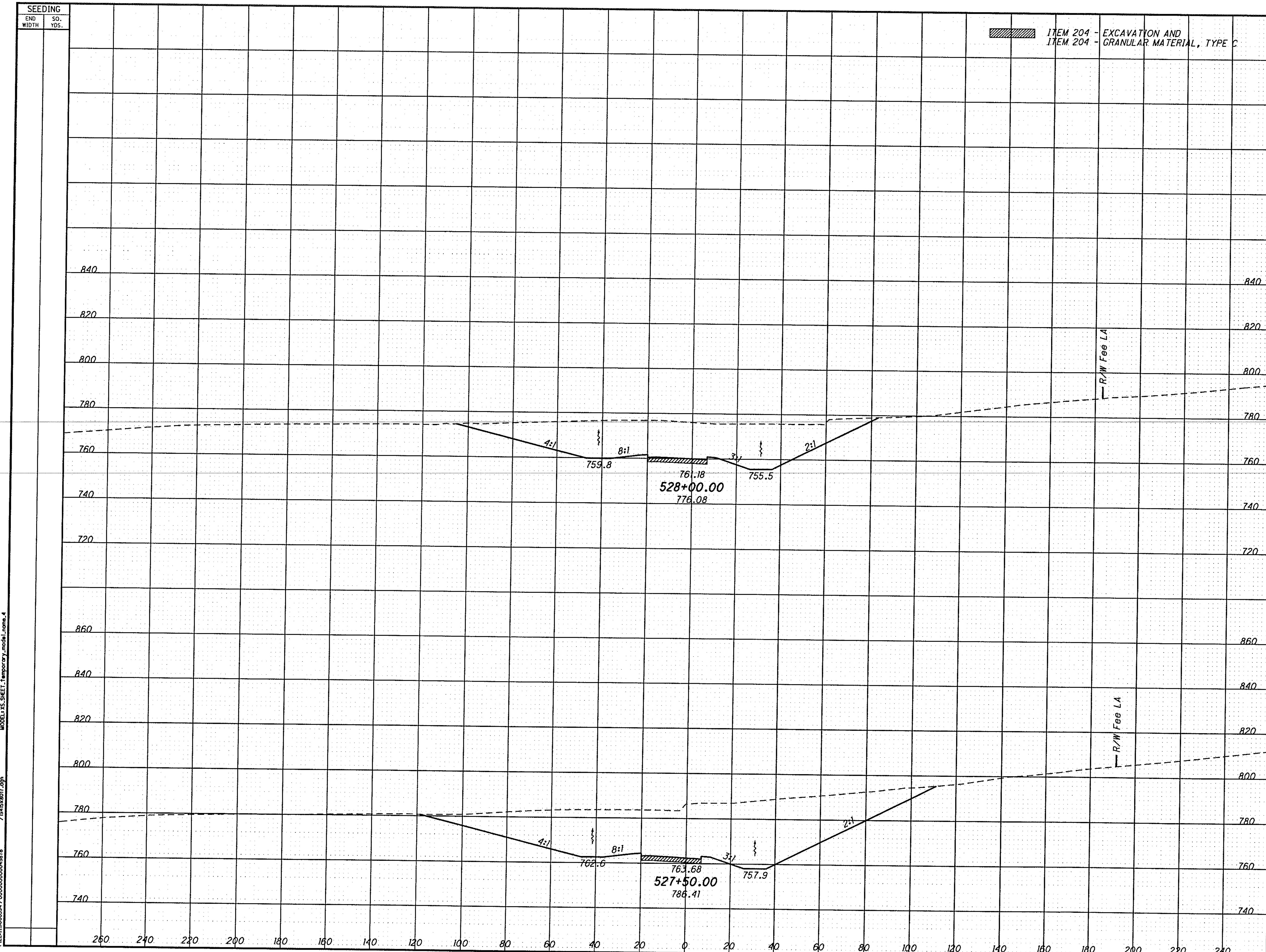
USER: mbotdorf PLOT DATE: 7/27/2009 2:40:00 PM REVISION DATE: 7/27/2009
FILE: ...\00000000045678 \ 719415xs017.dgn MODEL: XS_SHEET_temporary_model_name_2



CROSS SECTIONS - CR28 RAMP A
STA. 526+50.00 TO STA. 527+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/27/2009 2:40:01 PM REVISION DATE: 7/27/2009
FILE: ...000594/000000000045878 /7845xs017.dgn MODEL: XS_SHEET_temporary_model_name_3



END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - CR28 RAMP A
STA. 527+50.00 TO STA. 528+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/27/2009 2:40:02 PM REVISION DATE: 7/27/2009
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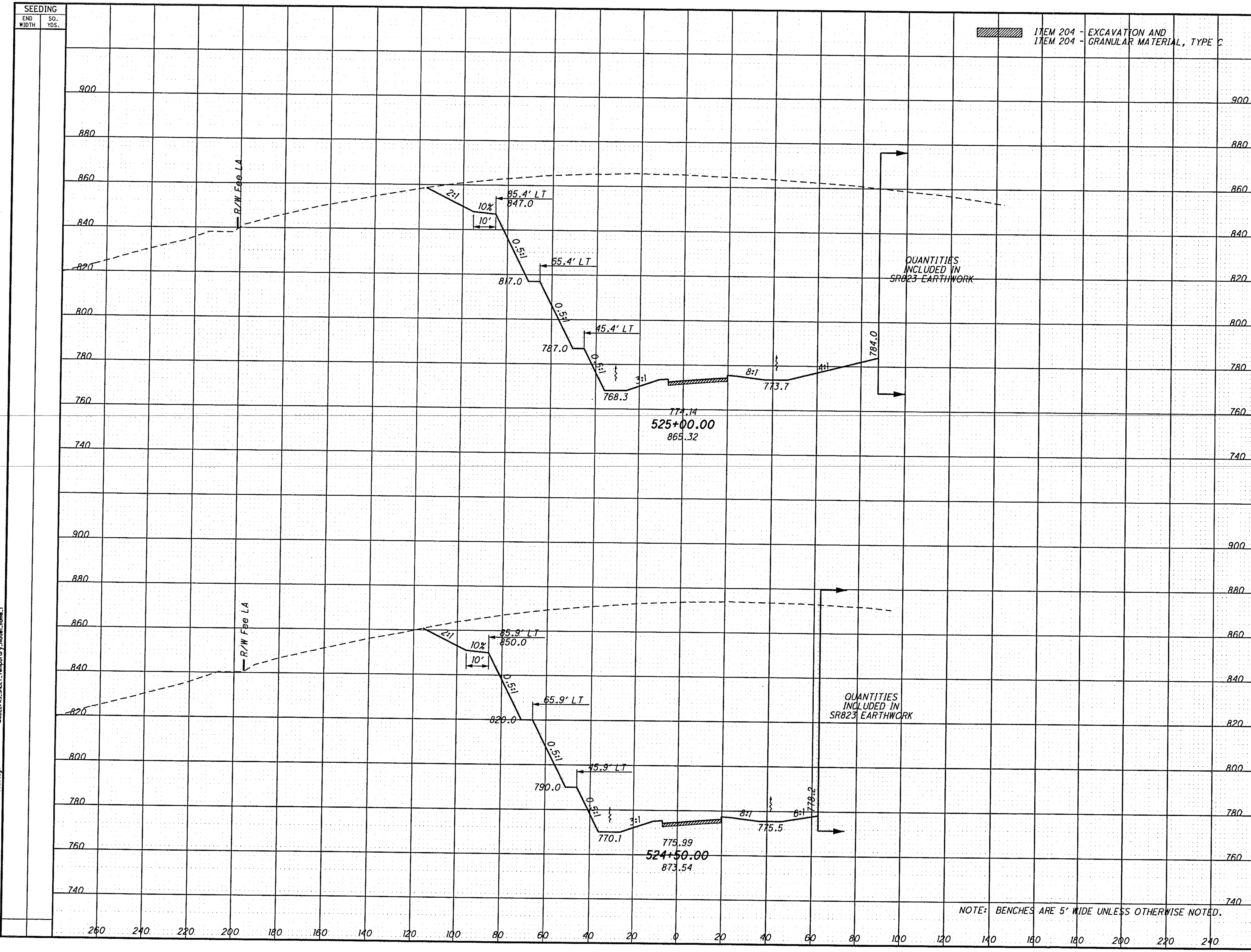

END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - CR28 RAMP D
STA. 524+50.00 TO STA. 525+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/27/2009 2:40:34 PM REVISION DATE: 7/27/2009
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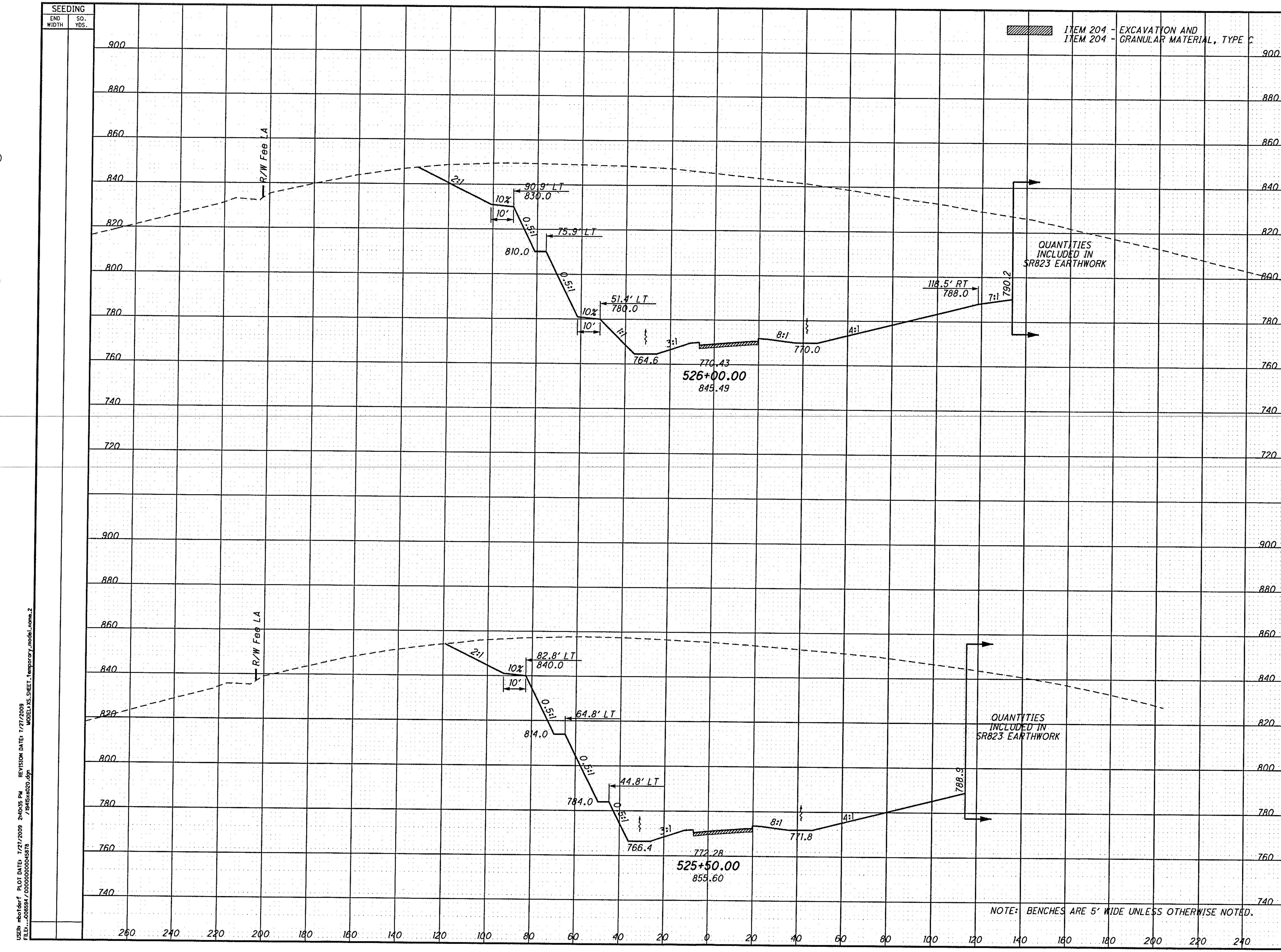
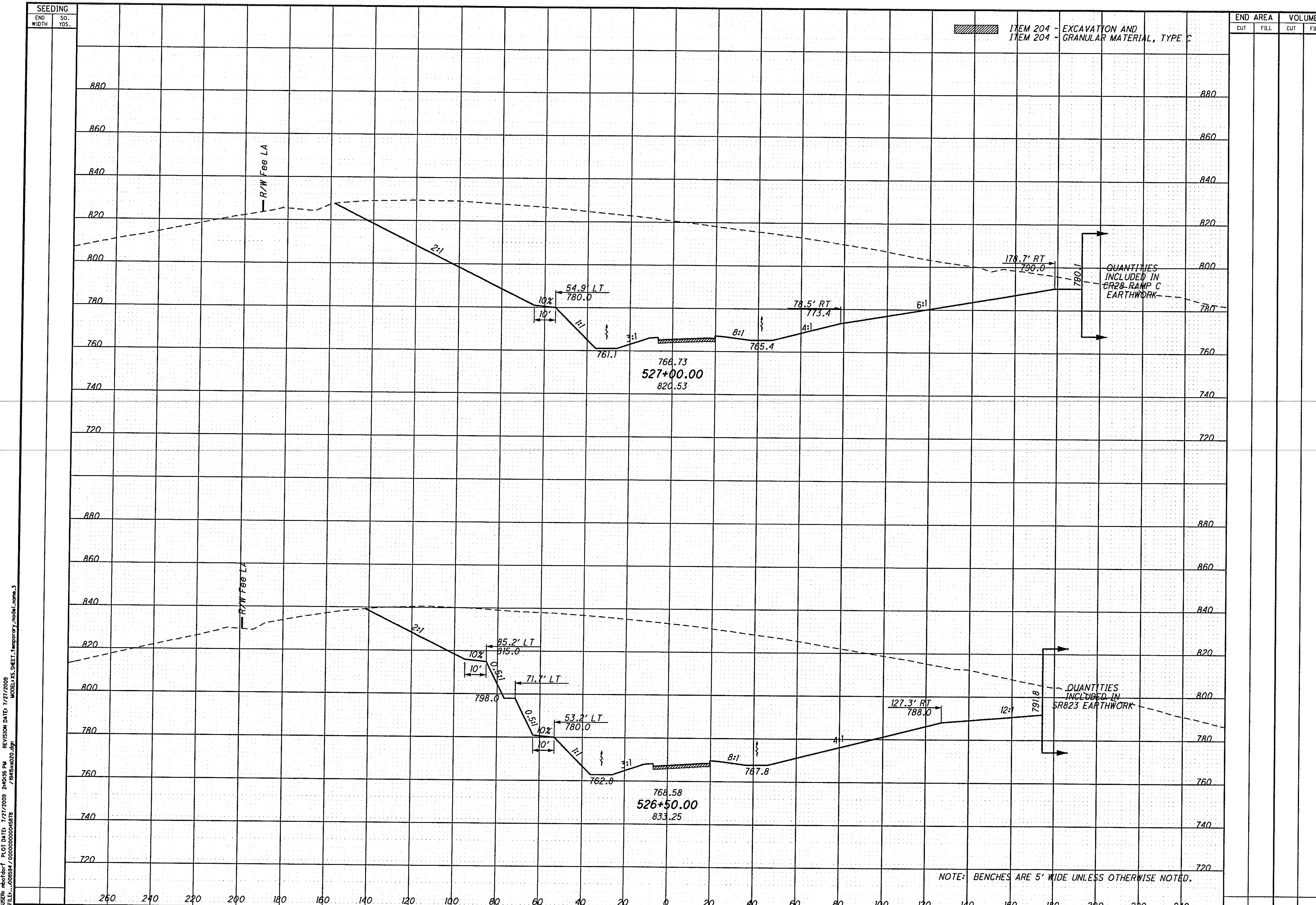


END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - CR28 RAMP D
STA. 525+50.00 TO STA. 526+00.00

SCI-823-6.81

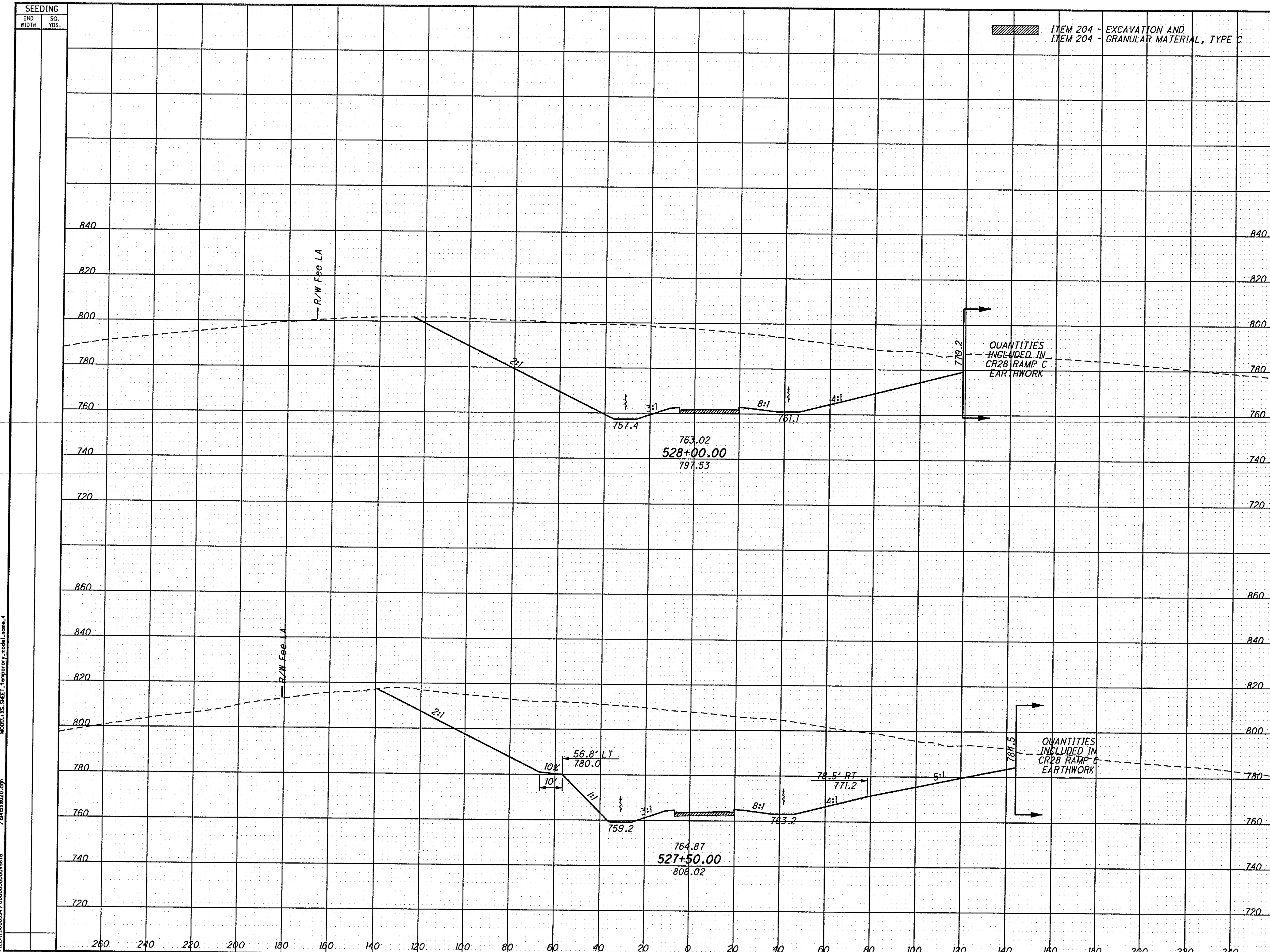


CALCULATED

CHECKED

CROSS SECTIONS - CR28 RAMP D
STA. 526+50.00 TO STA. 527+00.00

SCI-823-6.81



CROSS SECTIONS - CR28 RAMP D
STA. 527+50.00 TO STA. 528+00.00

SCI-823-6.81

Appendix E
CRSP Analyses

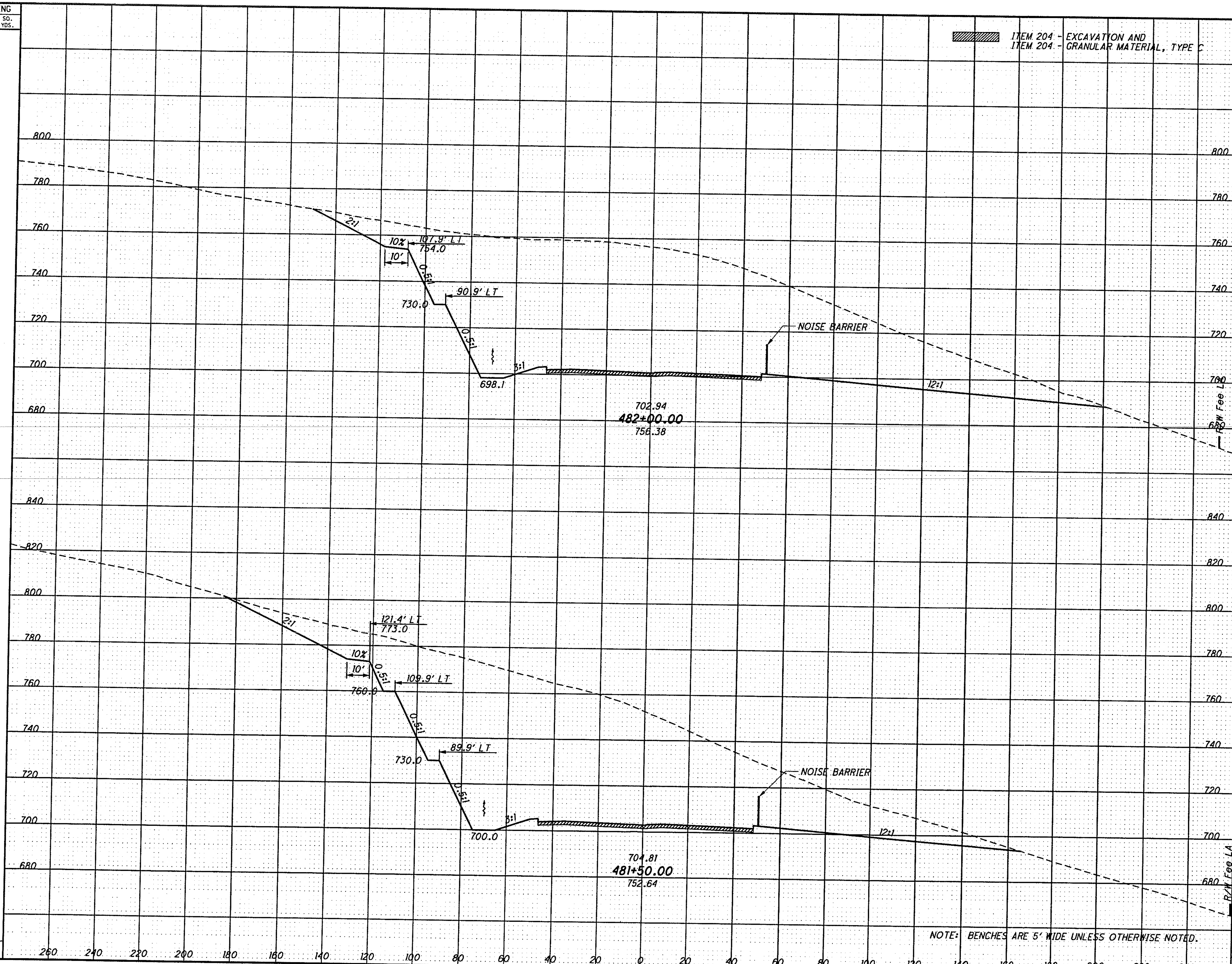
7/8/2009

Percentage of Rocks Contained within the Catchment Area

STA		End of Construction		Long Term	
		Avg. Rock Size	Max. Rock Size	Avg. Rock Size	Max. Rock Size
481+50		100%	100%	100%	100%
512+50		100%	99%	99%	94%
514+00		100%	100%	99%	93%
516+50		100%	100%	99%	94%
523+44.52	Ramp A	100%	100%	100%	100%
524+50	Ramp D	100%	100%	100%	100%
11+50	TR 234	100%	100%	100%	99%

SR 823 Mainline
Sta. 481+50 LT

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED
CHECKED

CROSS SECTIONS - SR823
STA. 481+50.00 TO STA. 482+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/26/2009 6:10:37 PM REVISION DATE: 7/26/2009
FILE: ...005594/000000000045878 /19415xs009.dgn MODEL: XS_SHEET_temporary_model_name_5

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 10
Analysis Point X-Coordinate 1: 81
Analysis Point X-Coordinate 2: 86
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 774
Initial Y-Base Starting Zone Coordinate: 705
Remarks: SCI-823-6.81 (End of Construction with Average Size Rock) STA 482+00

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.15	.85	.2	0	774	10	773
2	.15	.85	.2	10	773	16	760
3	.15	.85	.2	16	760	21	760
4	.15	.85	.2	21	760	36	730
5	.15	.85	.2	36	730	41	730
6	.15	.85	.2	41	730	56	700
7	.15	.85	.2	56	700	66	700
8	.15	.85	.2	66	700	81	705
9	.15	.85	.2	81	705	86	705
10	0.1	0.9	0.9	86	705	200	705

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2

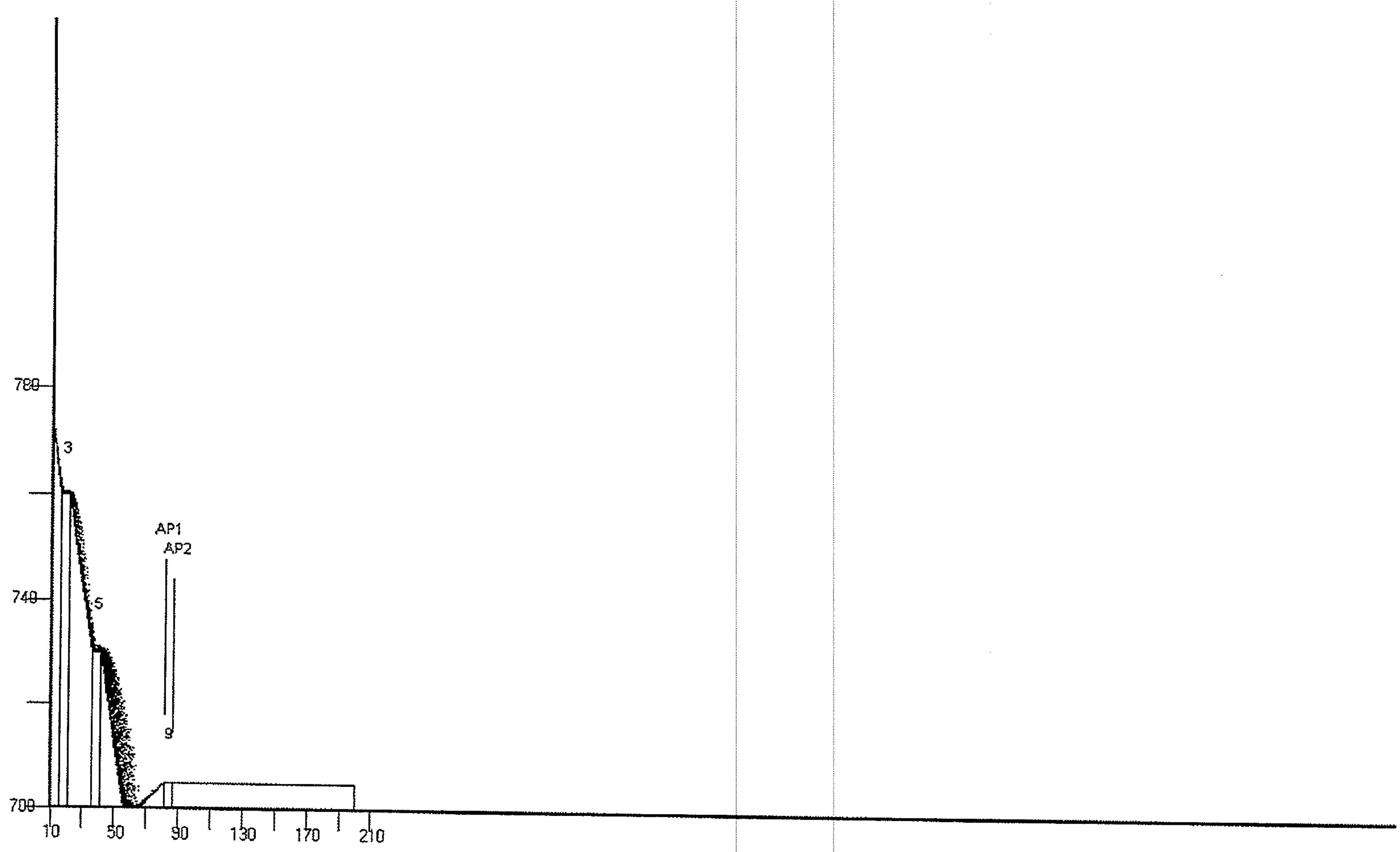
Ending Cell Number: 10

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft


780
740
700
10
50
90
130
170
210
3
5
AP1
AP2
9

Analysis Point 1

Analysis Point 1: X = 81, Y = 705

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: SCI-823-6.81 (End of Construction with Average Size Rock)

Analysis Point 2

Analysis Point 2: X = 86, Y = 705

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

NO ROCKS PAST ANALYSIS POINT 2

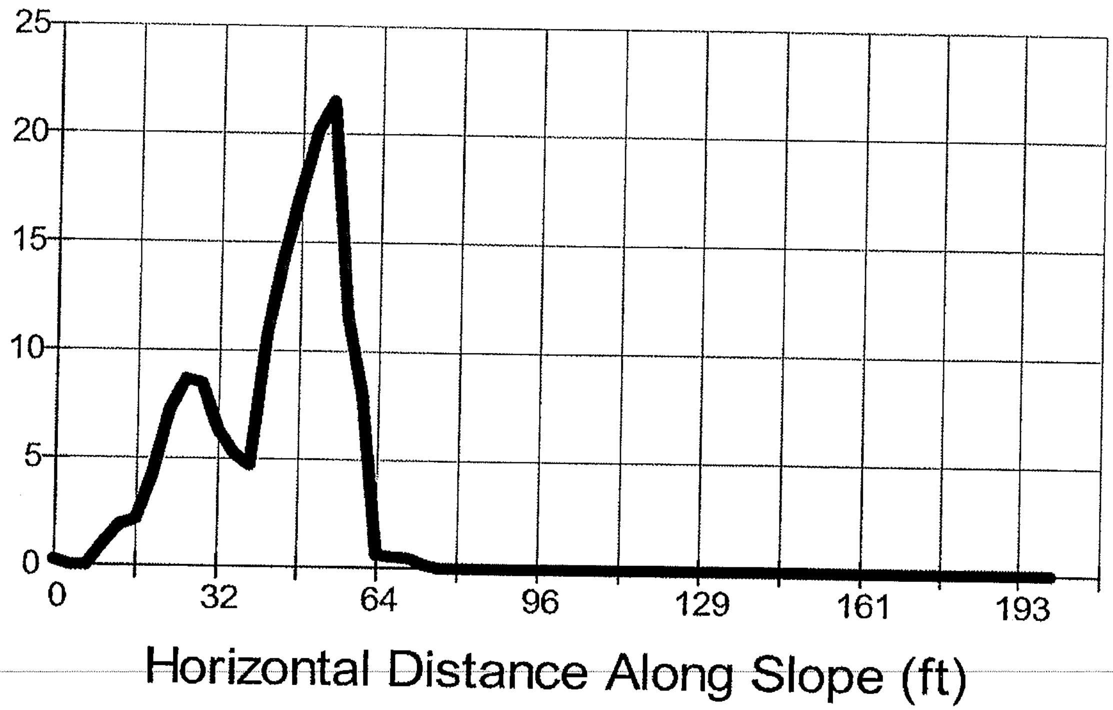
Remarks: SCI-823-6.81 (End of Construction with Average Size Rock)

Velocity Units: ft/sec Bounce Height Units: ft

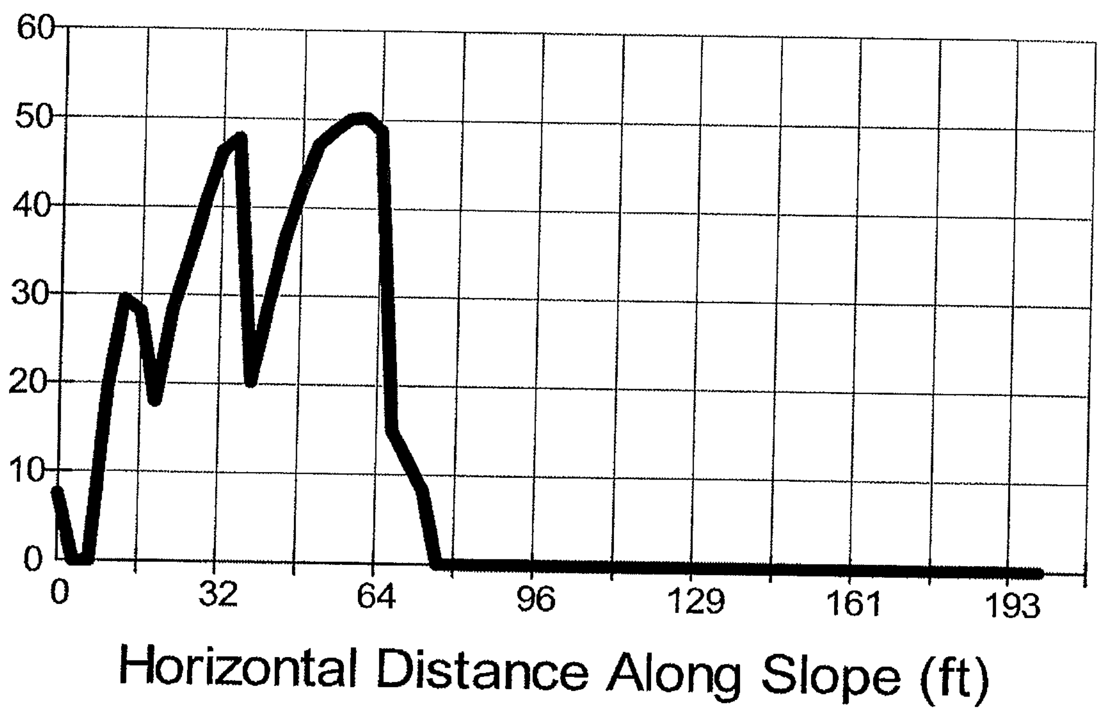
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	27	16	5.29	2	0
3	12	7	2.49	0	0
4	45	26	8.61	5	1
5	20	11	4.13	1	0
6	46	32	6.87	20	3
7	47	10	4.77	4	0
8	No rocks	past end of cell			
9	No rocks	past end of cell			
10	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	8
10 To 20 ft	35
20 To 30 ft	6
30 To 40 ft	31
40 To 50 ft	9
50 To 60 ft	17
60 To 70 ft	281
70 To 80 ft	113
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 10
Analysis Point X-Coordinate 1: 81
Analysis Point X-Coordinate 2: 86
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 774
Initial Y-Base Starting Zone Coordinate: 705
Remarks: SCI-823-6.81 (End of Construction with Max Size Rock) STA 482+00

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.15	.85	.2	0	774	10	773
2	.15	.85	.2	10	773	16	760
3	.15	.85	.2	16	760	21	760
4	.15	.85	.2	21	760	36	730
5	.15	.85	.2	36	730	41	730
6	.15	.85	.2	41	730	56	700
7	.15	.85	.2	56	700	66	700
8	.15	.85	.2	66	700	81	705
9	.15	.85	.2	81	705	86	705
10	0.1	0.9	0.9	86	705	200	705

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2

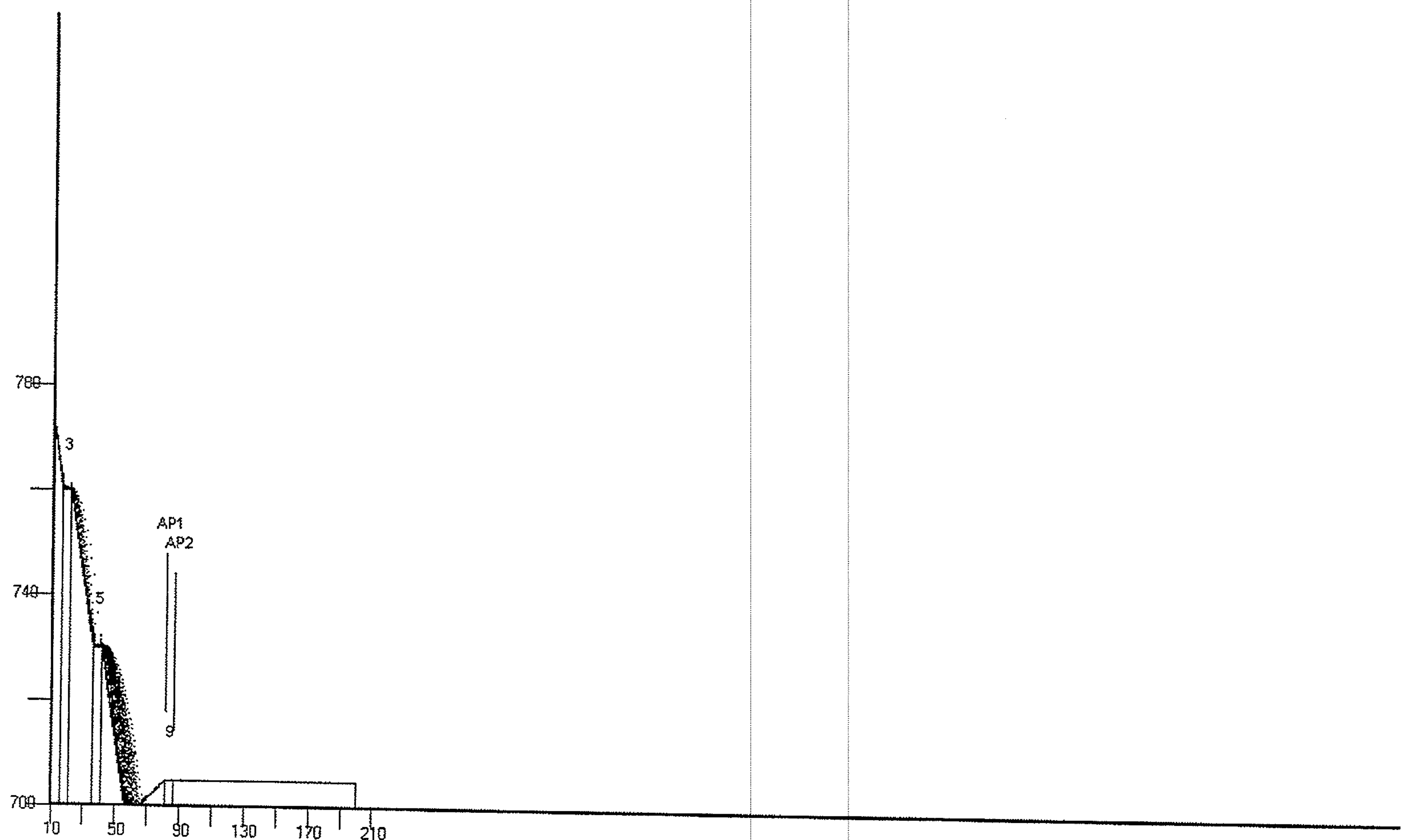
Ending Cell Number: 10

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft



780
740
700
3
5
AP1
AP2
9
10
50
90
130
170
210

Analysis Point 1

Analysis Point 1: X = 81, Y = 705

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: SCI-823-6.81 (End of Construction with Max Size Rock)

Analysis Point 2

Analysis Point 2: X = 86, Y = 705

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

NO ROCKS PAST ANALYSIS POINT 2

Remarks: SCI-823-6.81 (End of Construction with Max Size Rock)

Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	27	17	5.17	1	0
3	14	8	2.39	0	0
4	44	27	8.47	13	0
5	21	12	3.98	1	0
6	45	33	6.68	21	4
7	46	11	4.95	4	0
8	No rocks	past end of cell			
9	No rocks	past end of cell			
10	No rocks	past end of cell			

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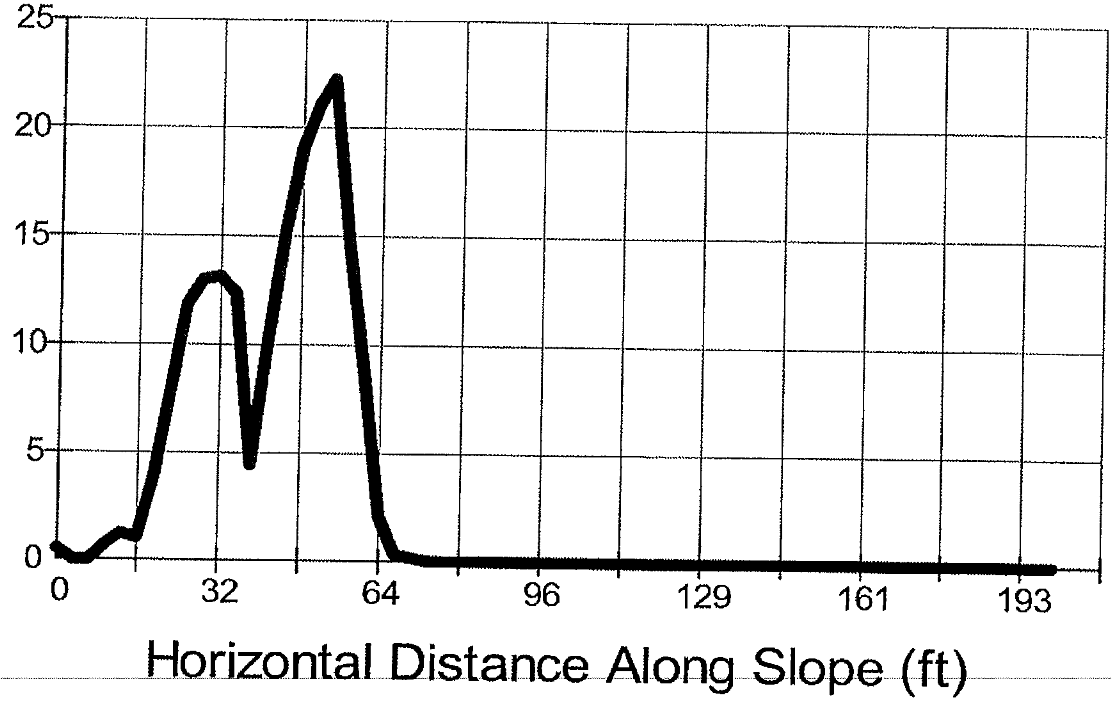
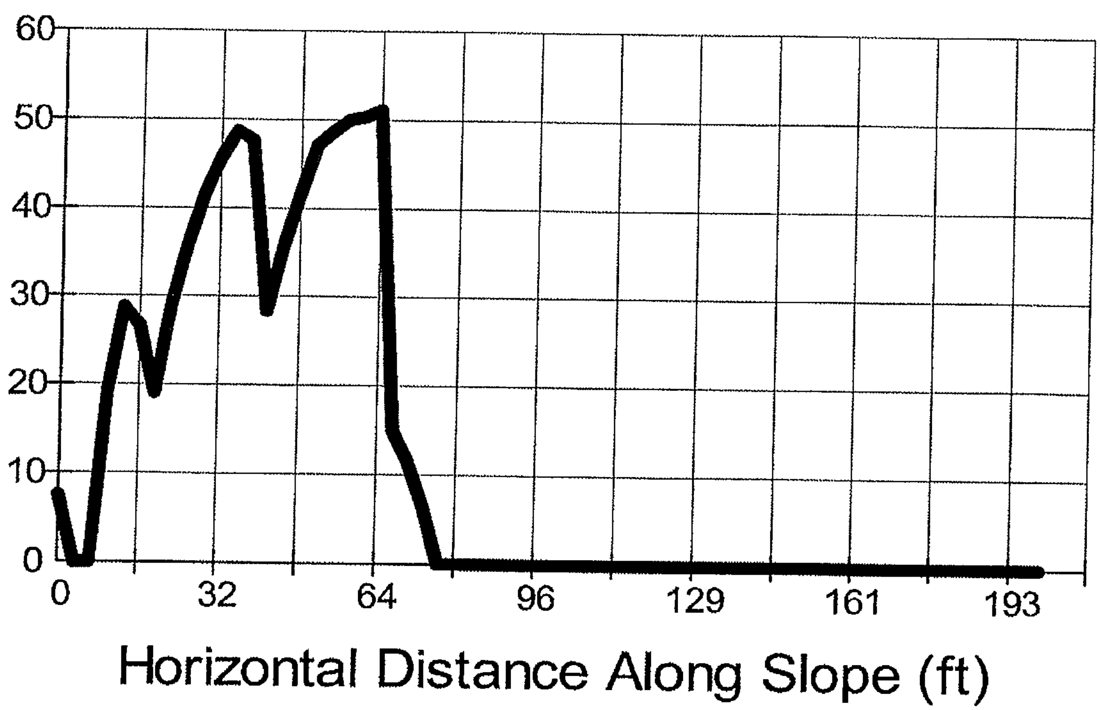
X Interval	Rocks Stopped
0 To 10 ft	8
10 To 20 ft	23
20 To 30 ft	4
30 To 40 ft	18
40 To 50 ft	2
50 To 60 ft	4
60 To 70 ft	263
70 To 80 ft	178
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 6
Analysis Point X-Coordinate 1: 81
Analysis Point X-Coordinate 2: 86
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 774
Initial Y-Base Starting Zone Coordinate: 705
Remarks: SCI-823-6.81 (482+00 Long Term with Average Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	0.3	0.8	.18	0	774	10	773
2	0.3	0.8	.18	10	773	56	700
3	0.3	0.8	.18	56	700	66	700
4	0.3	0.8	.18	66	700	81	705
5	0.3	0.8	.18	81	705	86	705
6	0.1	0.9	0.9	86	705	200	705

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2

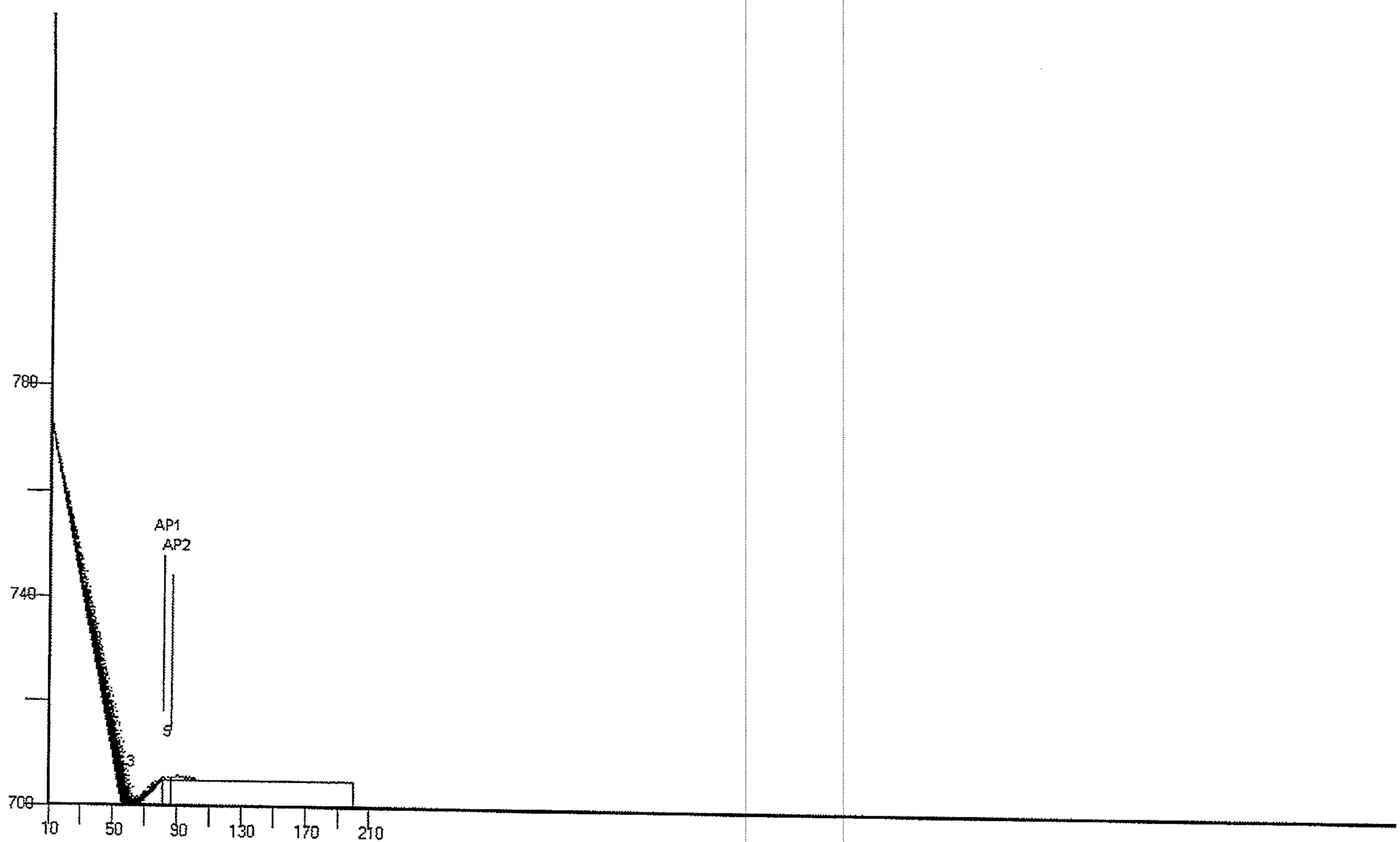
Ending Cell Number: 6

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft



780
740
700
AP1
AP2
3
5
10
50
90
130
170
210

Analysis Point 1

Analysis Point 1: X = 81, Y = 705

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 2

Velocity (ft/sec)

Maximum: 11.13
Average: 7.49
Minimum: 3.84
Std. Dev.: 0

Bounce Height (ft)

Maximum: .4
Average: .23
G. Mean: .15
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 419
Average: 238
Std. Dev.: 0

Remarks: SCI-823-6.81 (482+00 Long Term with Average Rock Size)

Analysis Point 2

Analysis Point 2: X = 86, Y = 705

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 1

Velocity (ft/sec)

Maximum: 9.74
Average: 9.74
Minimum: 9.74
Std. Dev.: 0

Bounce Height (ft)

Maximum: .15
Average: .15
G. Mean: .15
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 275
Average: 275
Std. Dev.: 0

Remarks: SCI-823-6.81 (482+00 Long Term with Average Rock Size)

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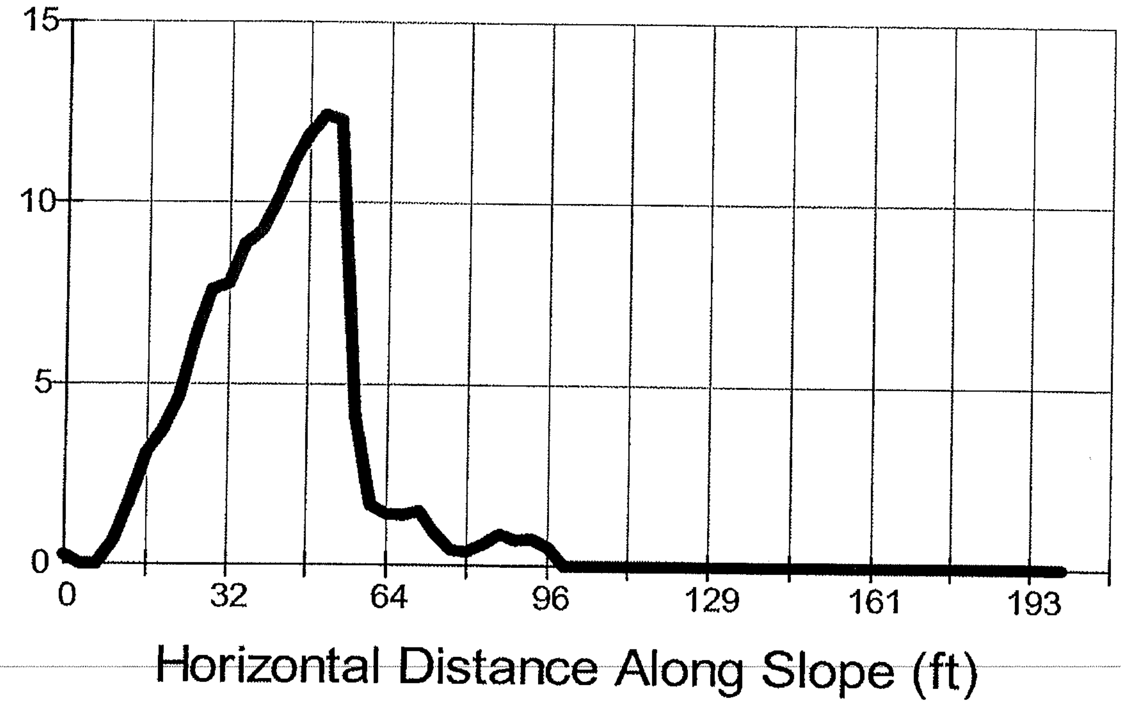
Velocity Units: ft/sec Bounce Height Units: ft

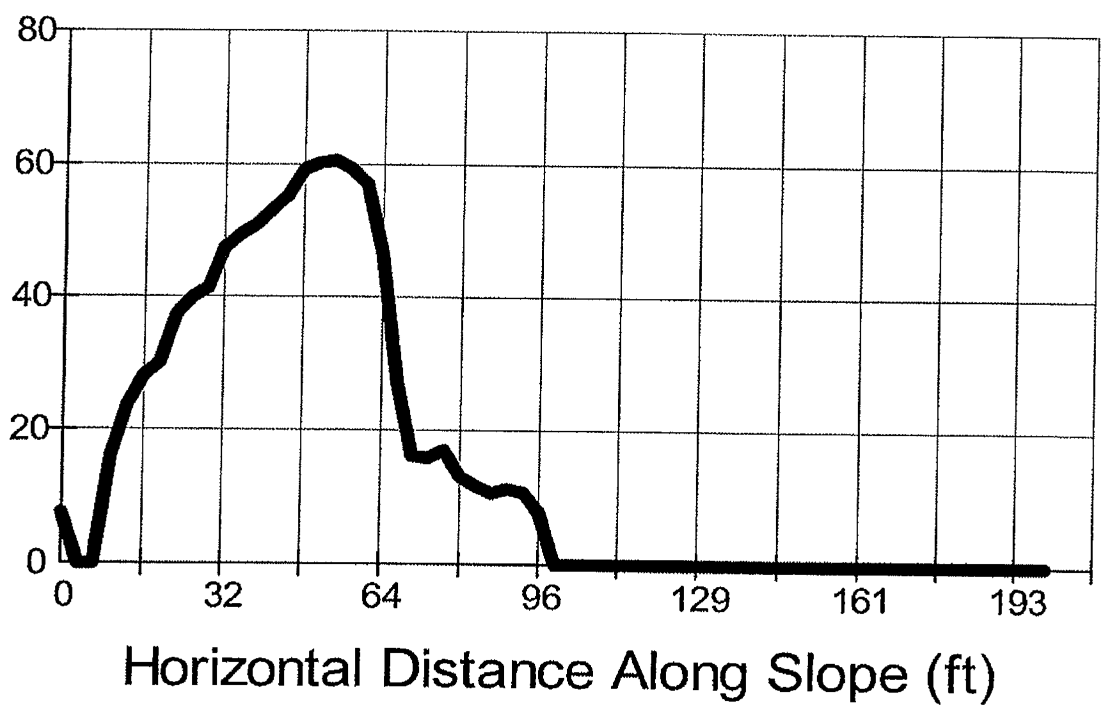
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	58	34	10.27	12	3
3	28	12	5.3	2	0
4	11	7	0	0	0
5	10	10	0	0	0
6	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	8
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	65
60 To 70 ft	305
70 To 80 ft	119
80 To 90 ft	2
90 To 100 ft	0
100 To 110 ft	1
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 6
Analysis Point X-Coordinate 1: 81
Analysis Point X-Coordinate 2: 86
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 774
Initial Y-Base Starting Zone Coordinate: 705
Remarks: SCI-823-6.81 (482+00 Long Term with Max Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	0.3	0.8	.18	0	774	10	773
2	0.3	0.8	.18	10	773	56	700
3	0.3	0.8	.18	56	700	66	700
4	0.3	0.8	.18	66	700	81	705
5	0.3	0.8	.18	81	705	86	705
6	0.1	0.9	0.9	86	705	200	705

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2

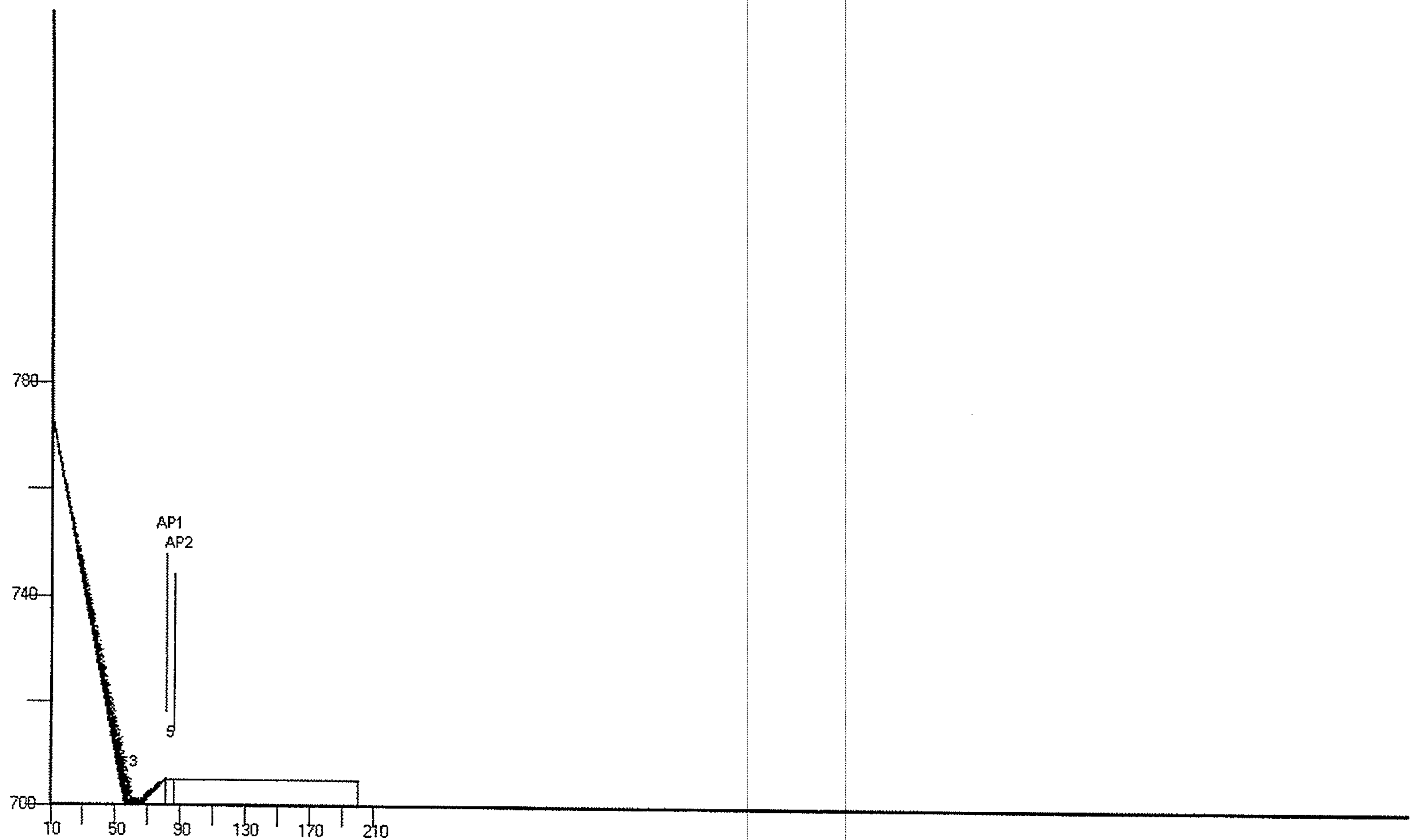
Ending Cell Number: 6

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft



780
740
700
10
50
90
130
170
210
AP1
AP2
3
5

Analysis Point 1

Analysis Point 1: X = 81, Y = 705

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 3

Velocity (ft/sec)

Maximum: 8.5
Average: 6.43
Minimum: 4.54
Std. Dev.: 0

Bounce Height (ft)

Maximum: .47
Average: .24
G. Mean: .15
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 867
Average: 531
Std. Dev.: 0

Remarks: SCI-823-6.81 (482+00 Long Term with Average Rock Size)

Analysis Point 2

Analysis Point 2: X = 86, Y = 705

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 1

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 7	Maximum: 0	Maximum: 447
Average: 7	Average: -.09	Average: 447
Minimum: 7	G. Mean: 0	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: SCI-823-6.81 (482+00 Long Term with Average Rock Size)

Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	58	36	9.94	10	2
3	28	13	5.2	1	0
4	9	6	0	0	0
5	7	7	0	0	-1
6	No rocks	past end of cell			

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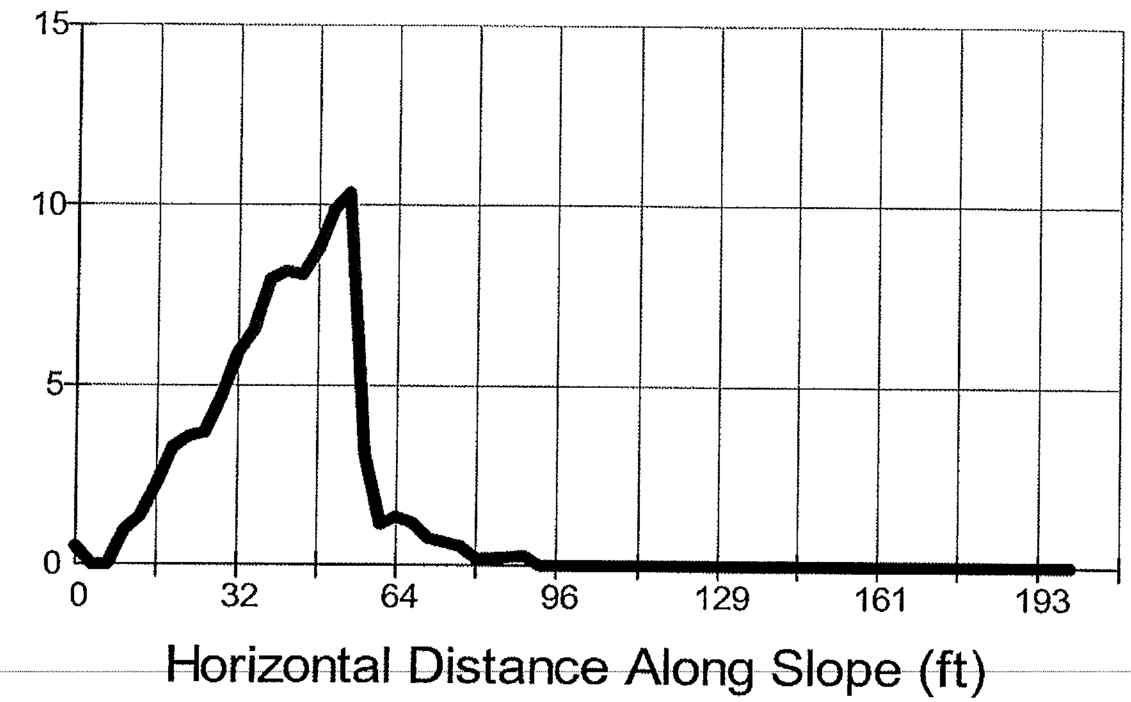
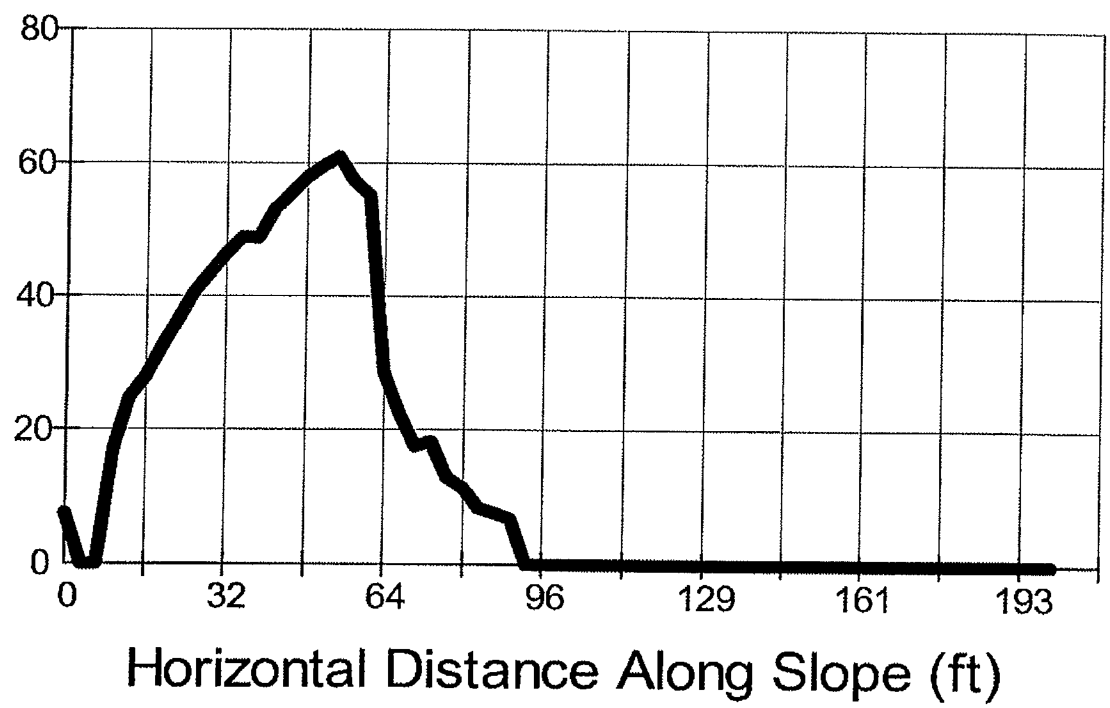
X Interval	Rocks Stopped
0 To 10 ft	8
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	10
60 To 70 ft	265
70 To 80 ft	209
80 To 90 ft	7
90 To 100 ft	1
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



SR 823 Mainline
Sta. 512+50 LT

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 14
Analysis Point X-Coordinate 1: 131
Analysis Point X-Coordinate 2: 136
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 883
Initial Y-Base Starting Zone Coordinate: 774
Remarks: SCI-823-6.81 STA 512+50 (End of Construction with Average Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.14	.75	.18	0	886	20	876
2	.14	.75	.18	20	876	30	875
3	.14	.75	.18	30	875	44	860
4	.14	.75	.18	44	860	50	850
5	.14	.75	.18	50	850	55	850
6	.12	.75	.18	55	850	70	820
7	.12	.85	.2	70	820	75	820
8	.12	.85	.2	75	820	90	790
9	.12	.85	.2	90	790	95	790
10	.12	.85	.2	95	790	106	769
11	.12	.85	.2	106	769	116	769
12	.12	.85	.2	116	769	131	774
13	.12	.85	.2	131	774	136	774
14	0.1	0.9	0.9	136	774	200	774

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

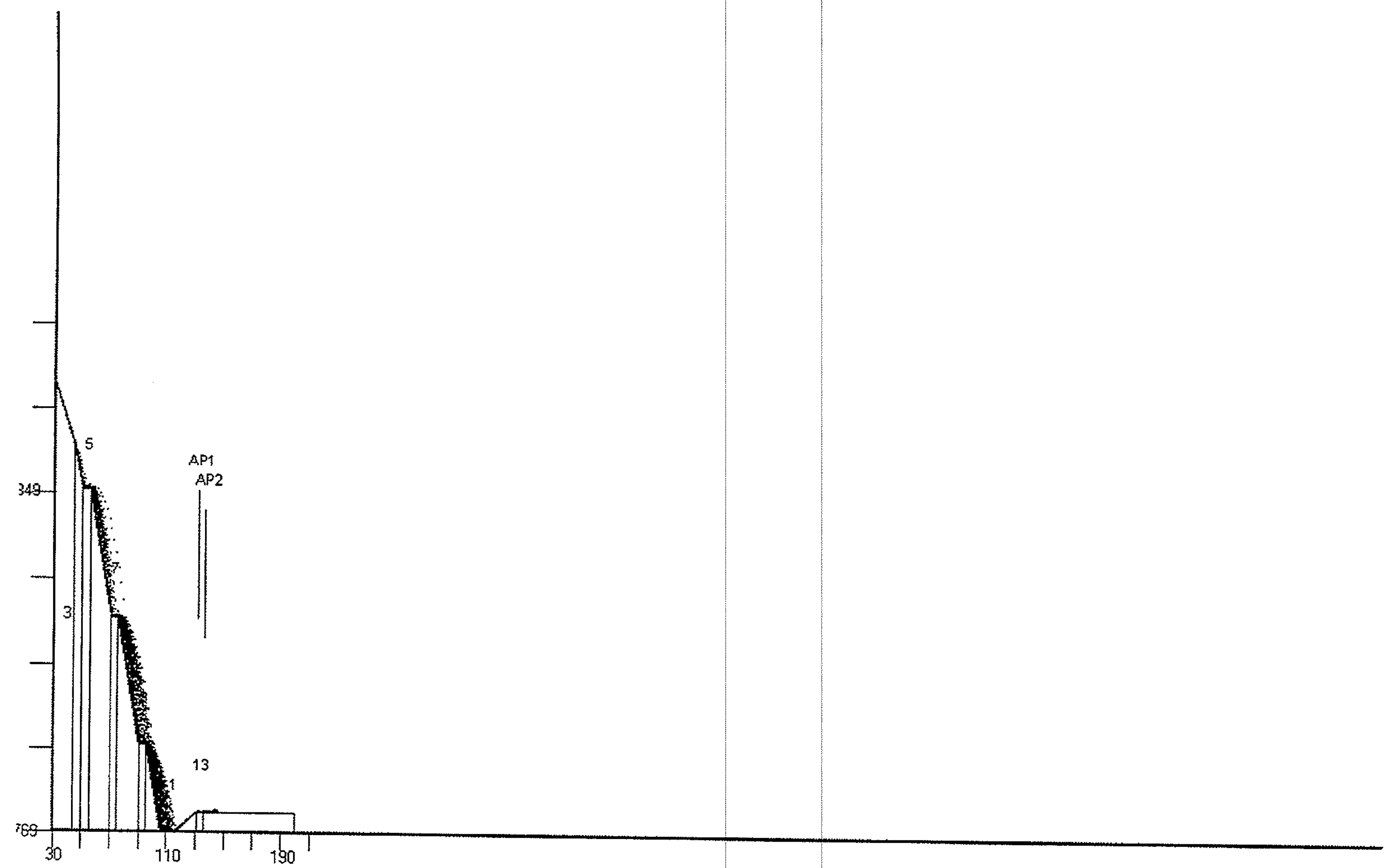
Ending Cell Number: 14

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.0 ft

Thickness: 1 ft



5
AP1
AP2
349
3
13
1
769
30
110
190

Analysis Point 1

Analysis Point 1: X = 131, Y = 774

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 3

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 8.68	Maximum: .05	Maximum: 241
Average: 6.76	Average: -.01	Average: 159
Minimum: 3.67	G. Mean: .01	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: SCI-823-6.81 STA 512+50 (End of Construction with Average Rock Size)

Analysis Point 2

Analysis Point 2: X = 136, Y = 774

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 2

Velocity (ft/sec)

Maximum: 7.41
Average: 6.21
Minimum: 5
Std. Dev.: 0

Bounce Height (ft)

Maximum: 0
Average: -.02
G. Mean: 0
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 153
Average: 111
Std. Dev.: 0

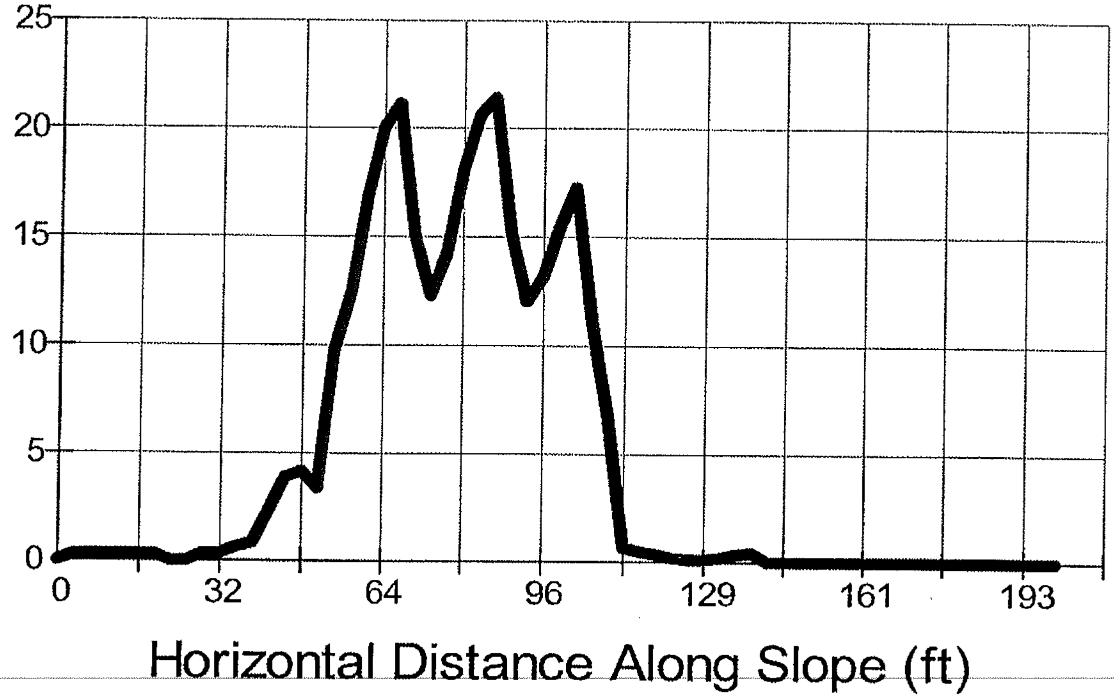
Remarks: SCI-823-6.81 STA 512+50 (End of Construction with Average Rock Size)

Velocity Units: ft/sec Bounce Height Units: ft

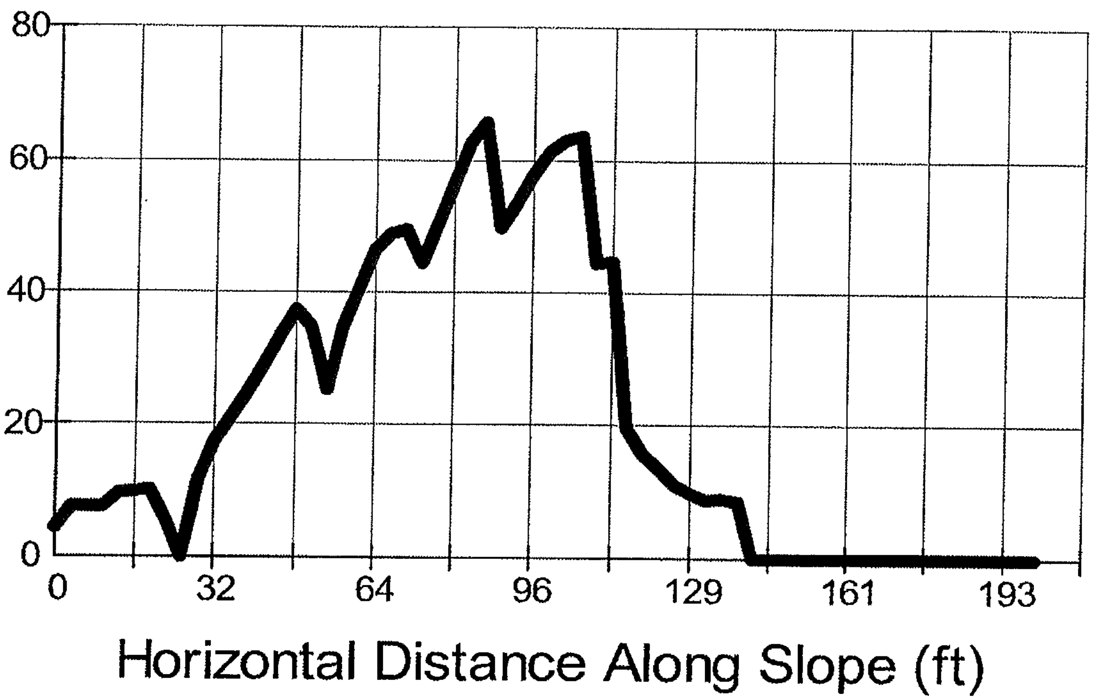
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	8	6	1.62	0	0
2	No rocks	past end of cell			
3	24	16	5.07	1	0
4	34	21	7.1	4	0
5	18	9	3.39	0	0
6	46	28	8.93	21	1
7	38	12	4.6	13	0
8	64	32	8.7	21	4
9	47	16	11.81	12	0
10	60	31	7.76	16	4
11	42	12	6.96	2	0
12	9	7	0	0	-1
13	7	6	0	0	-1
14	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	11
10 To 20 ft	11
20 To 30 ft	15
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	20
60 To 70 ft	1
70 To 80 ft	22
80 To 90 ft	0
90 To 100 ft	23
100 To 110 ft	9
110 To 120 ft	255
120 To 130 ft	129
130 To 140 ft	2
140 To 150 ft	2
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 14
Analysis Point X-Coordinate 1: 131
Analysis Point X-Coordinate 2: 136
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 883
Initial Y-Base Starting Zone Coordinate: 774
Remarks: SCI-823-6.81 STA 512+50 (End of Construction with Max Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.14	.75	.18	0	886	20	876
2	.14	.75	.18	20	876	30	875
3	.14	.75	.18	30	875	44	860
4	.14	.75	.18	44	860	50	850
5	.14	.75	.18	50	850	55	850
6	.12	.75	.18	55	850	70	820
7	.12	.85	.2	70	820	75	820
8	.12	.85	.2	75	820	90	790
9	.12	.85	.2	90	790	95	790
10	.12	.85	.2	95	790	106	769
11	.12	.85	.2	106	769	116	769
12	.12	.85	.2	116	769	131	774
13	.12	.85	.2	131	774	136	774
14	0.1	0.9	0.9	136	774	200	774

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

Ending Cell Number: 14

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft

AP1
AP2
1
3
5
7
13
349
769
0
80
160

Analysis Point 1

Analysis Point 1: X = 131, Y = 774

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 4

Velocity (ft/sec)

Maximum: 8.53
Average: 6.42
Minimum: 4.19
Std. Dev.: 0

Bounce Height (ft)

Maximum: .06
Average: .01
G. Mean: .02
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 706
Average: 432
Std. Dev.: 0

Remarks: SCI-823-6.81 STA 512+50 (End of Construction with Max Rock Size)

Analysis Point 2

Analysis Point 2: X = 136, Y = 774

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 3

Velocity (ft/sec)

Maximum: 6.01
Average: 4.42
Minimum: 3.11
Std. Dev.: 0

Bounce Height (ft)

Maximum: .01
Average: -.02
G. Mean: 0
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 347
Average: 196
Std. Dev.: 0

Remarks: SCI-823-6.81 STA 512+50 (End of Construction with Max Rock Size)

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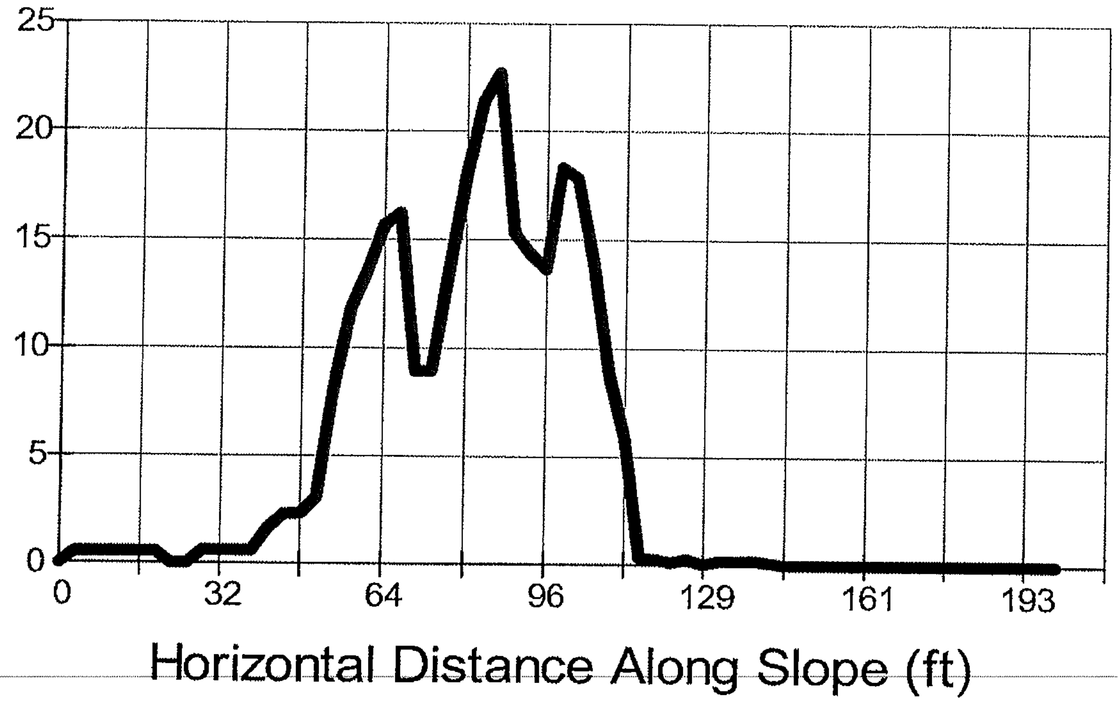
Velocity Units: ft/sec Bounce Height Units: ft

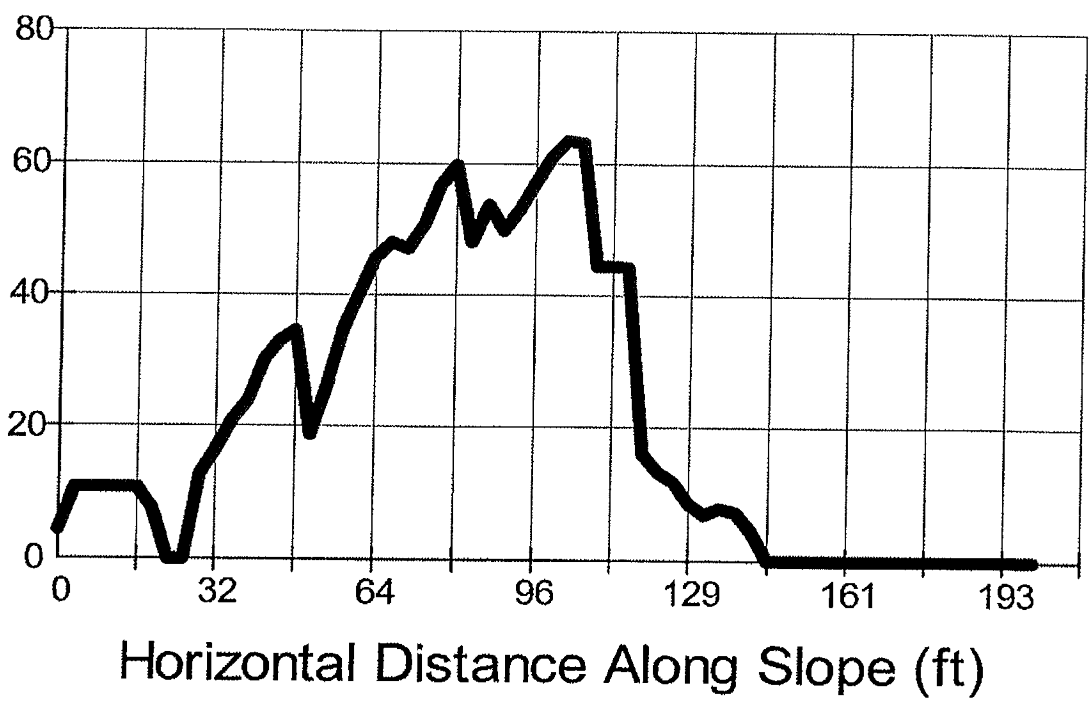
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	4	4	0	1	0
2	No rocks	past end of cell			
3	25	9	6.17	1	-1
4	33	15	7.5	2	0
5	19	9	2.98	0	0
6	44	27	8.64	16	0
7	44	13	5.13	6	0
8	51	31	8.6	22	4
9	47	17	12.35	14	0
10	60	31	7.95	18	4
11	40	12	6.35	7	0
12	9	6	0	0	0
13	6	4	0	0	-1
14	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	11
10 To 20 ft	23
20 To 30 ft	3
30 To 40 ft	6
40 To 50 ft	12
50 To 60 ft	39
60 To 70 ft	0
70 To 80 ft	17
80 To 90 ft	0
90 To 100 ft	15
100 To 110 ft	1
110 To 120 ft	204
120 To 130 ft	159
130 To 140 ft	9
140 To 150 ft	1
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 9
Analysis Point X-Coordinate 1: 131
Analysis Point X-Coordinate 2: 136
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 883
Initial Y-Base Starting Zone Coordinate: 774
Remarks: SCI-823-6.81 STA 512+50 (Long-Term with Average Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.3	.68	.15	0	886	20	876
2	0.28	.6	.15	20	876	30	876
3	.28	.6	.15	30	876	44	860
4	.28	.6	.15	44	860	54	850
5	.21	.8	.18	54	850	106	769
6	.21	.8	.18	106	769	116	769
7	.21	.8	.18	116	769	131	774
8	.21	.8	.18	131	774	136	774
9	.1	.9	.9	136	774	200	774

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

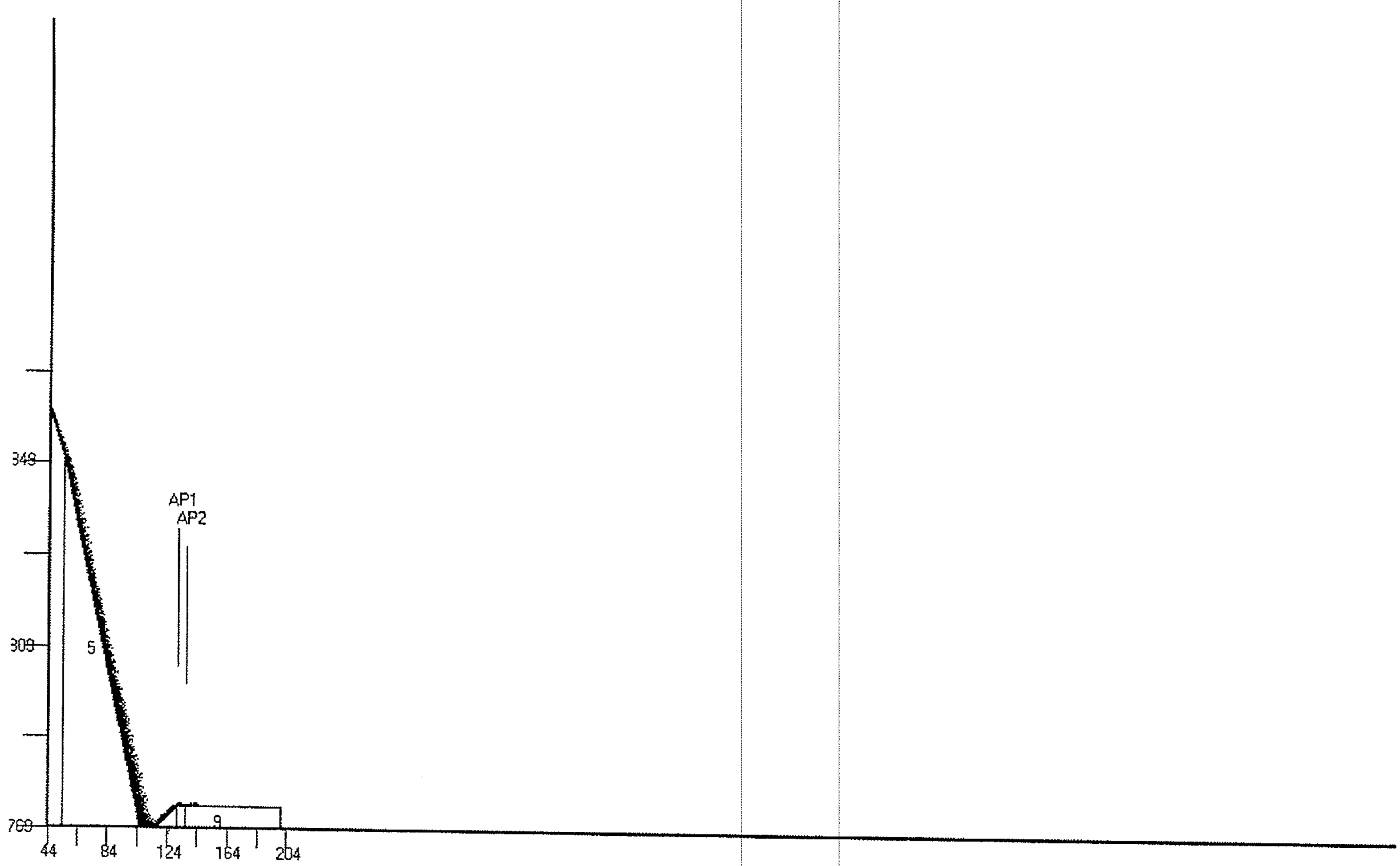
Ending Cell Number: 9

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft


AP1
AP2
5
9
349
309
769
44
84
124
164
204

Analysis Point 1

Analysis Point 1: X = 131, Y = 774

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 21

Velocity (ft/sec)

Maximum: 13.16
Average: 6.63
Minimum: 2.44
Std. Dev.: 3.44

Bounce Height (ft)

Maximum: .23
Average: .05
G. Mean: .02
Std. Dev.: 6.65

Kinetic Energy (ft-lb)

Maximum: 515
Average: 170
Std. Dev.: 161

Remarks: SCI-823-6.81 STA 512+50 (Long-Term with Average Rock Size)

Analysis Point 2

Analysis Point 2: X = 136, Y = 774

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 6

Velocity (ft/sec)

Maximum: 11.25
Average: 9.19
Minimum: 7.16
Std. Dev.: 1.62

Bounce Height (ft)

Maximum: .4
Average: .12
G. Mean: .03
Std. Dev.: 14.95

Kinetic Energy (ft-lb)

Maximum: 369
Average: 252
Std. Dev.: 90

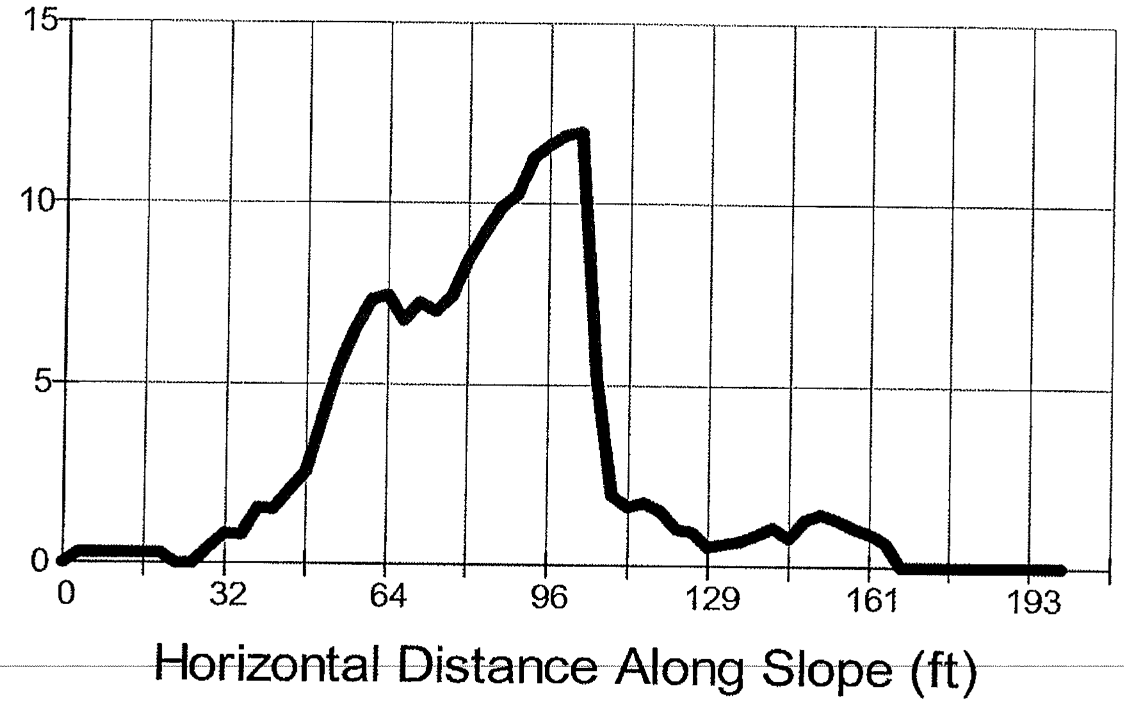
Remarks: SCI-823-6.81 STA 512+50 (Long-Term with Average Rock Size)

Velocity Units: ft/sec   Bounce Height Units: ft

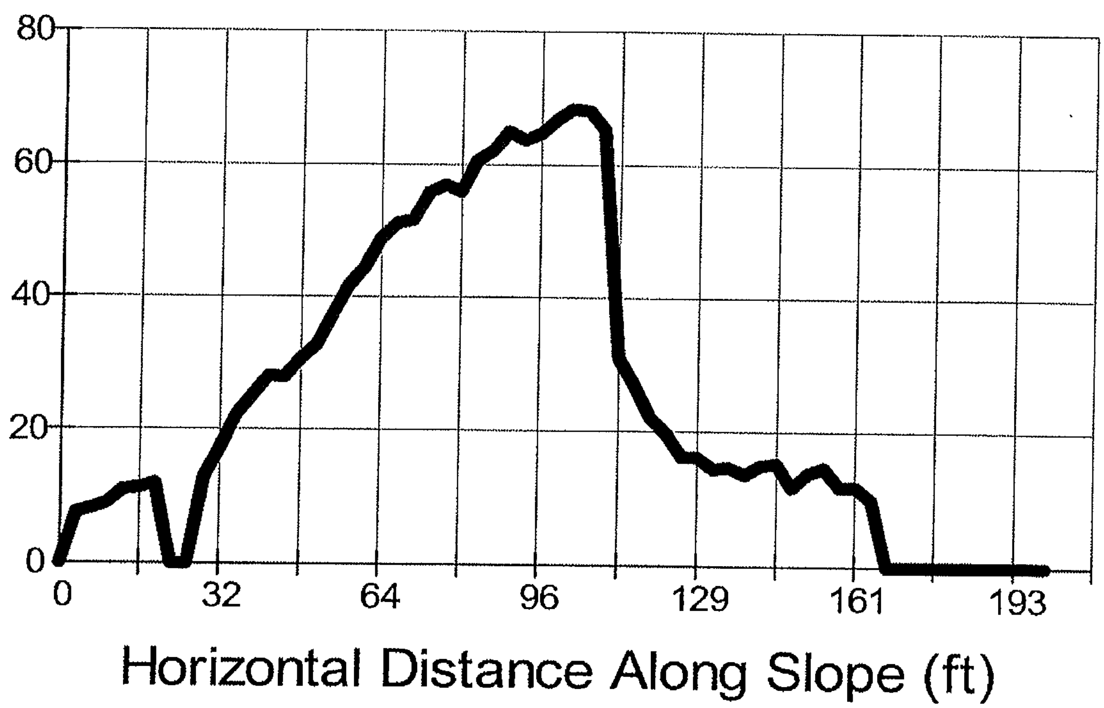
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	7	5	1.54	0	0
2	No rocks	past end of cell			
3	25	15	4.92	2	0
4	29	18	6.12	3	0
5	67	41	11.93	13	2
6	29	14	5.5	1	0
7	13	7	3.44	0	0
8	11	9	1.62	0	0
9	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	8
10 To 20 ft	16
20 To 30 ft	9
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	8
110 To 120 ft	217
120 To 130 ft	216
130 To 140 ft	20
140 To 150 ft	1
150 To 160 ft	3
160 To 170 ft	2
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 9
Analysis Point X-Coordinate 1: 131
Analysis Point X-Coordinate 2: 136
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 883
Initial Y-Base Starting Zone Coordinate: 774
Remarks: SCI-823-6.81 STA 512+50 (Long-Term with Max Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.3	.68	.15	0	886	20	876
2	0.28	.6	.15	20	876	30	876
3	.28	.6	.15	30	876	44	860
4	.28	.6	.15	44	860	54	850
5	.21	.8	.18	54	850	106	769
6	.21	.8	.18	106	769	116	769
7	.21	.8	.18	116	769	131	774
8	.21	.8	.18	131	774	136	774
9	.1	.9	.9	136	774	200	774

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

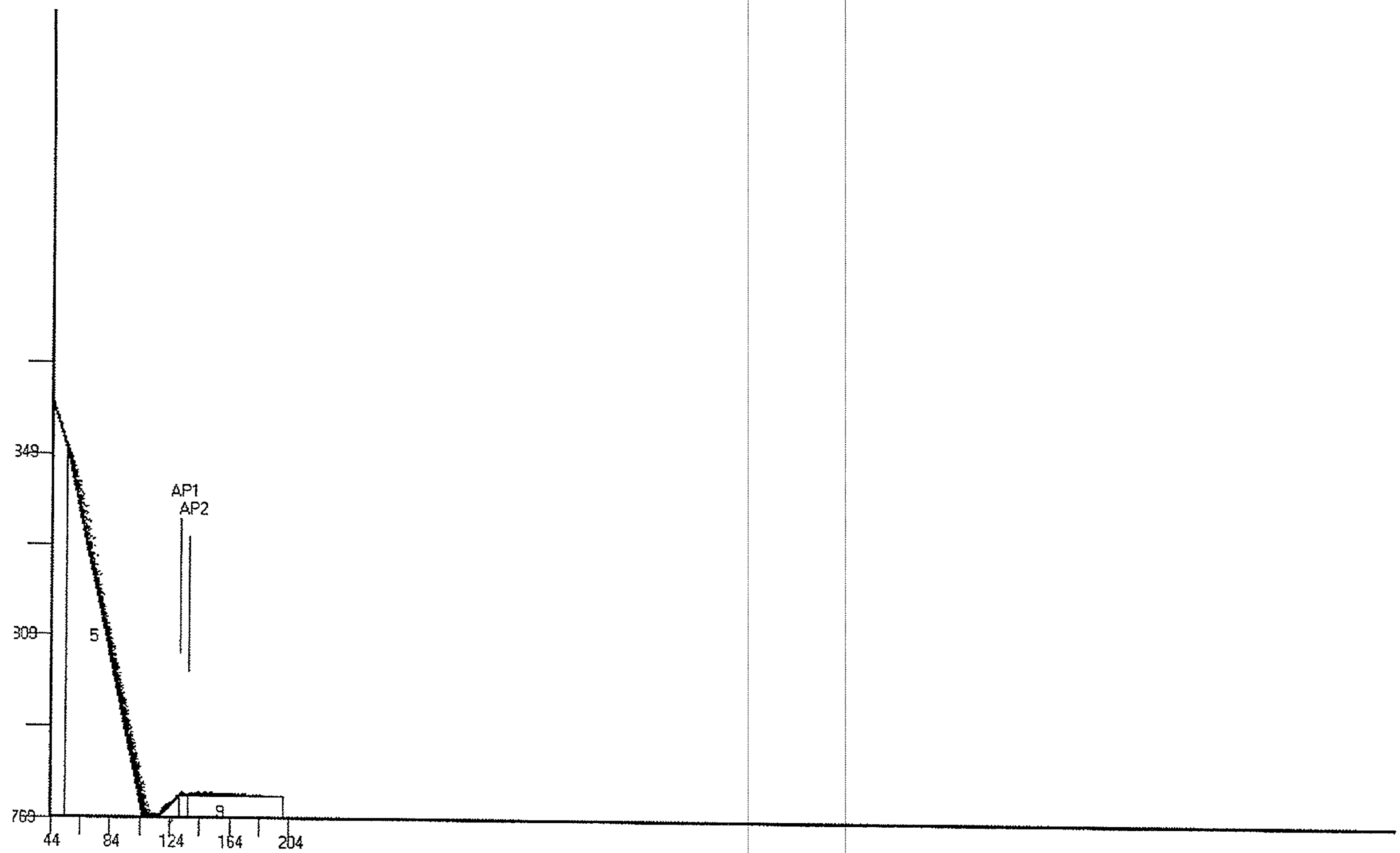
Ending Cell Number: 9

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft



349
309
769
44
84
124
164
204
5
9
AP1
AP2

Analysis Point 1

Analysis Point 1: X = 131, Y = 774

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 48

Velocity (ft/sec)

Maximum: 13.72
Average: 7.92
Minimum: 2.81
Std. Dev.: 3.15

Bounce Height (ft)

Maximum: .4
Average: .06
G. Mean: .02
Std. Dev.: 7.89

Kinetic Energy (ft-lb)

Maximum: 1814
Average: 761
Std. Dev.: 531

Remarks: SCI-823-6.81 STA 512+50 (Long-Term with Max Rock Size)

Analysis Point 2

Analysis Point 2: X = 136, Y = 774

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 28

Velocity (ft/sec)

Maximum: 12.83
Average: 7.93
Minimum: 2.79
Std. Dev.: 3.02

Bounce Height (ft)

Maximum: .2
Average: .03
G. Mean: .01
Std. Dev.: 7.05

Kinetic Energy (ft-lb)

Maximum: 1564
Average: 690
Std. Dev.: 456

Remarks: SCI-823-6.81 STA 512+50 (Long-Term with Max Rock Size)

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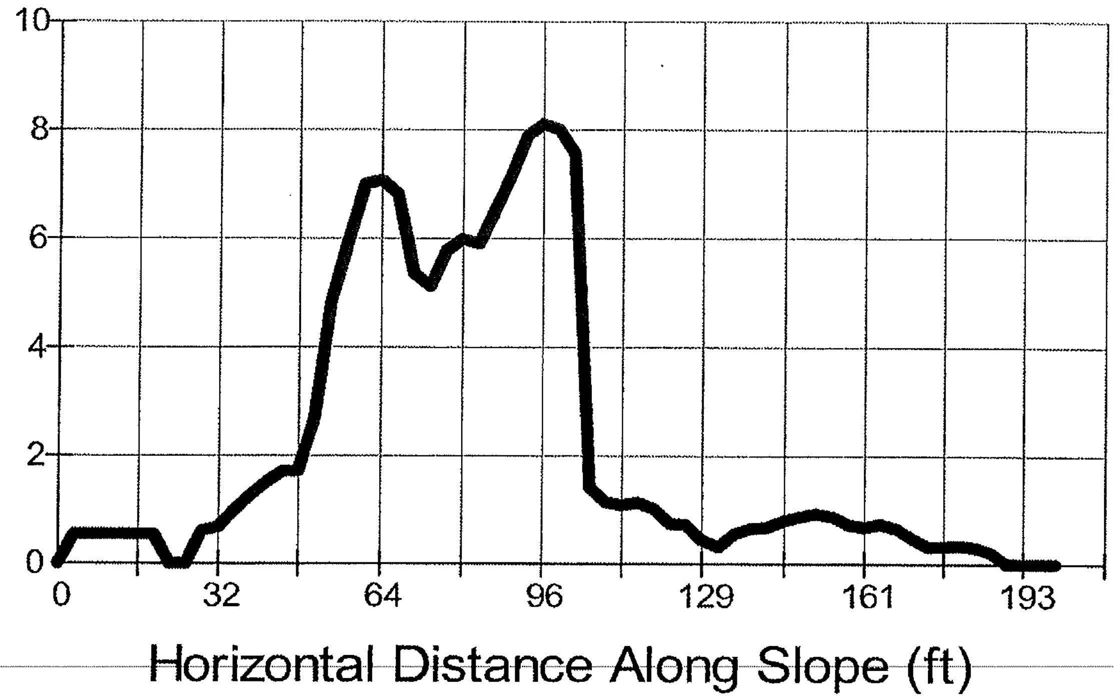
Velocity Units: ft/sec Bounce Height Units: ft

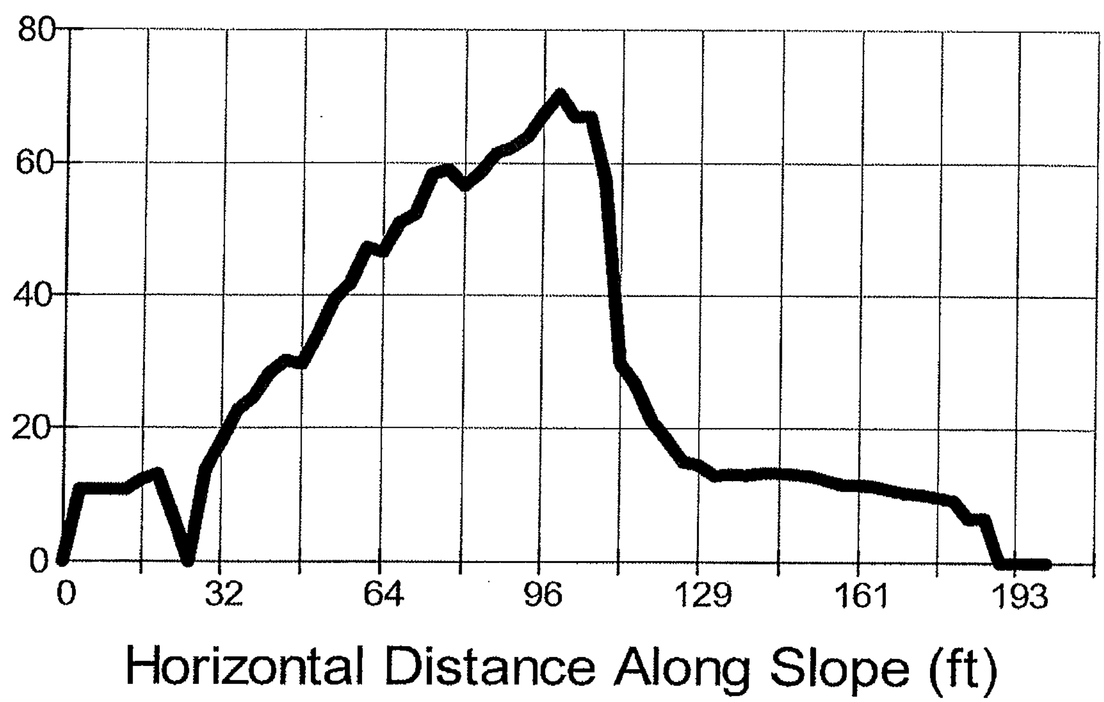
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	12	8	2.34	1	0
2	No rocks	past end of cell			
3	24	16	5.03	1	0
4	30	19	6.43	2	0
5	64	42	11.5	8	1
6	29	16	5.6	1	0
7	14	8	3.15	0	0
8	13	8	3.02	0	0
9	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	2
10 To 20 ft	12
20 To 30 ft	19
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	2
110 To 120 ft	100
120 To 130 ft	305
130 To 140 ft	37
140 To 150 ft	6
150 To 160 ft	4
160 To 170 ft	8
170 To 180 ft	3
180 To 190 ft	1
190 To 200 ft	1

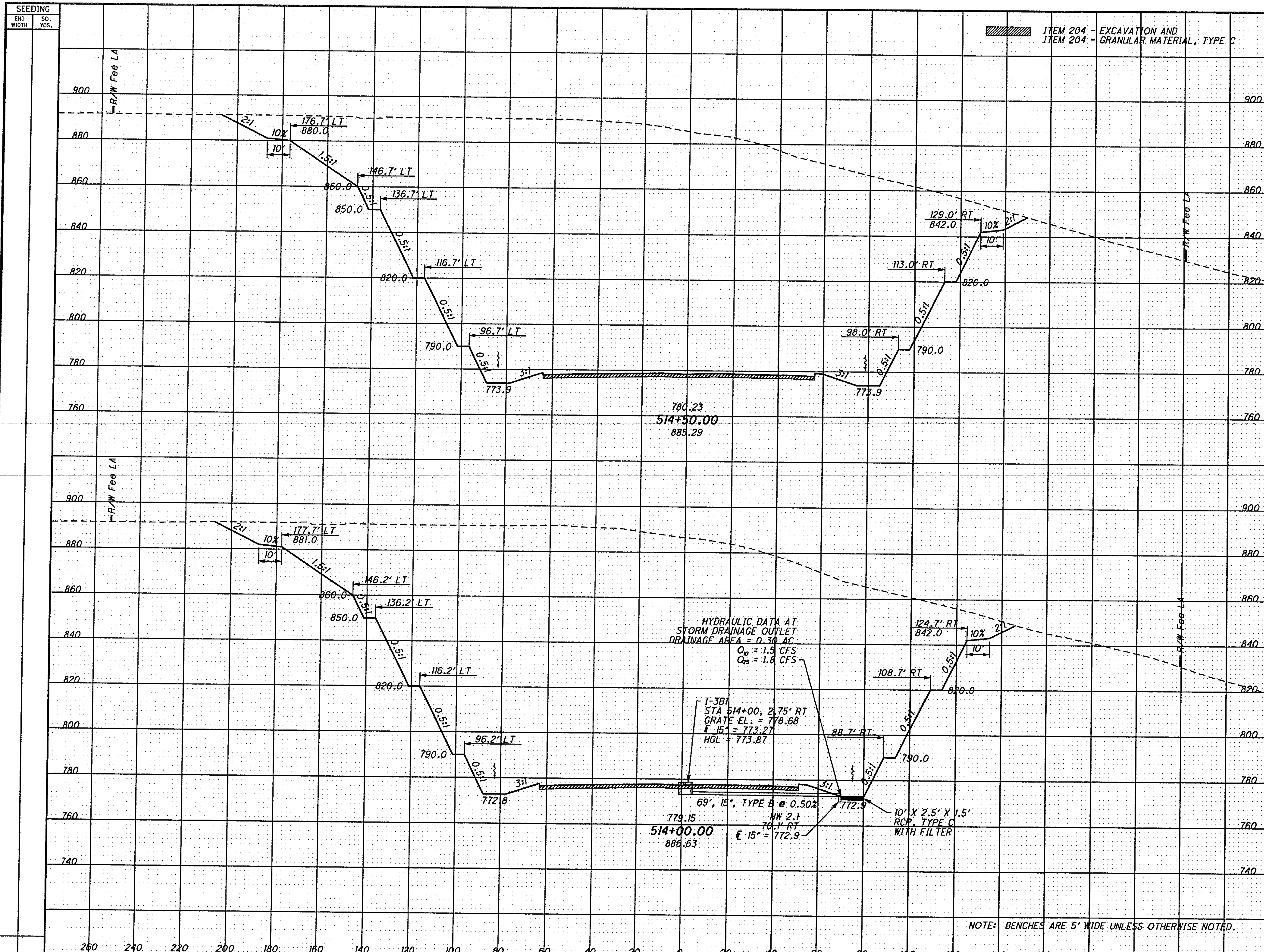
BOUNCE HEIGHT



VELOCITY GRAPH



SR 823 Mainline
Sta. 514+00 LT



CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 514+00.00 TO STA. 514+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/28/2009 6:11:09 PM REVISION DATE: 7/28/2009
FILE: ...008594/00000000045878 /19845xs011.dgn MODEL: XS_SHEET_temporary_model_name_7

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 13
Analysis Point X-Coordinate 1: 128
Analysis Point X-Coordinate 2: 133
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 882
Initial Y-Base Starting Zone Coordinate: 778
Remarks: SCI-823-6.81 STA 514+00 (End of Construction with Average Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	0.14	.75	.18	0	882	10	881
2	0.14	.75	.18	10	881	42	860
3	0.14	.75	.18	42	860	48	850
4	0.14	.75	.18	48	850	52	850
5	0.12	.75	.18	52	850	69	820
6	.12	.85	.2	69	820	74	820
7	.12	.85	.2	74	820	89	790
8	.12	.85	.2	89	790	94	790
9	.12	.85	.2	94	790	103	773
10	.12	.85	.2	103	773	113	773
11	.12	.85	.2	113	773	128	778
12	.12	.85	.2	128	778	133	778
13	0.1	0.9	0.9	133	778	200	778

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

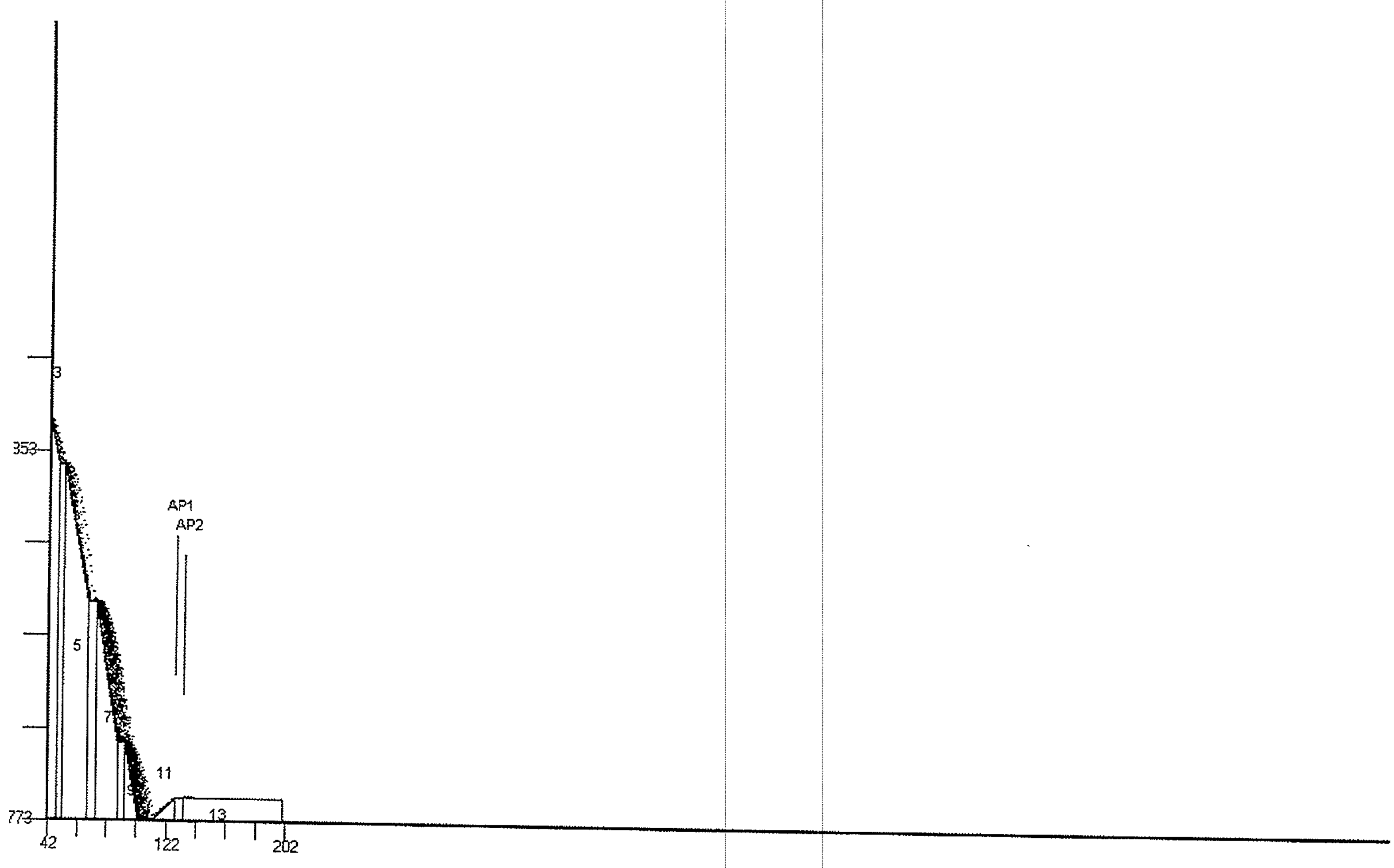
Ending Cell Number: 13

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft



3
353
773
5
7
9
11
13
AP1
AP2
42
122
202

Analysis Point 1

Analysis Point 1: X = 128, Y = 778

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 5

Velocity (ft/sec)

Maximum: 8.16
Average: 5.67
Minimum: 3.87
Std. Dev.: 1.64

Bounce Height (ft)

Maximum: .1
Average: .01
G. Mean: .01
Std. Dev.: 7.35

Kinetic Energy (ft-lb)

Maximum: 211
Average: 103
Std. Dev.: 64

Remarks: SCI-823-6.81 STA 514+00 (End of Construction with Average Rock Size)

Analysis Point 2

Analysis Point 2: X = 133, Y = 778

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 1

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 5.76	Maximum: .04	Maximum: 96
Average: 5.76	Average: .04	Average: 96
Minimum: 5.76	G. Mean: .04	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks: SCI-823-6.81 STA 514+00 (End of Construction with Average Rock Size)

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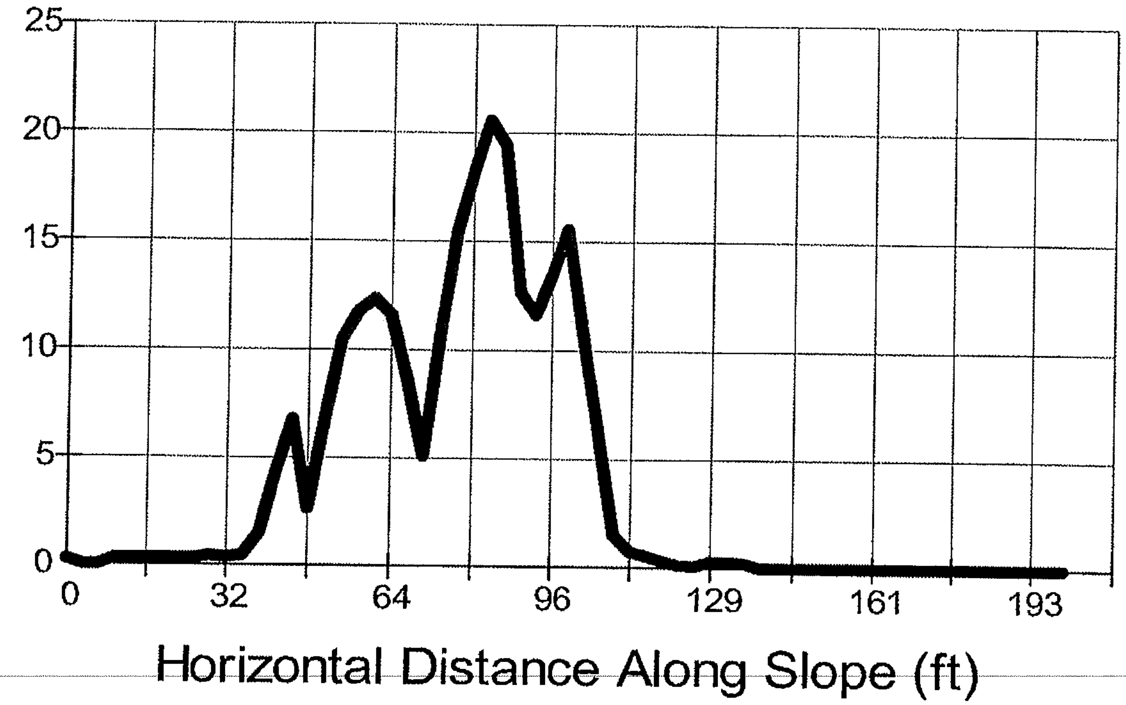
Velocity Units: ft/sec Bounce Height Units: ft

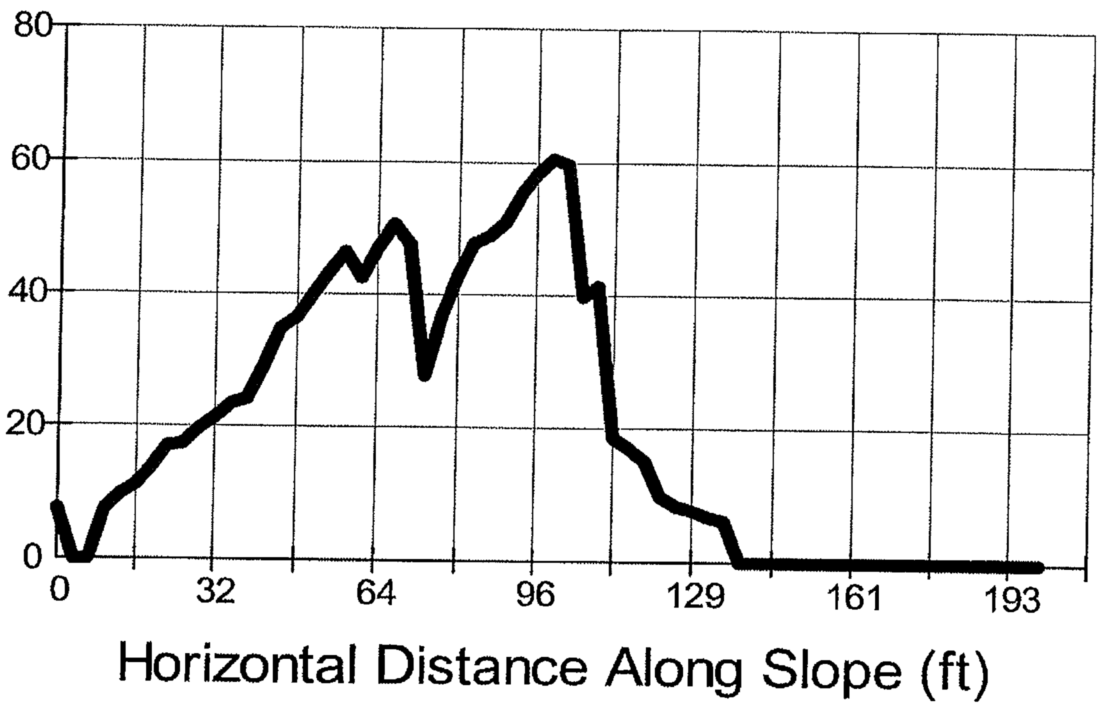
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	23	14	6.08	0	0
3	32	19	6.68	6	0
4	34	9	5	1	0
5	46	27	8.76	11	0
6	20	13	4.02	1	0
7	45	31	8.83	20	4
8	47	17	12.73	12	0
9	57	29	7.83	15	4
10	38	11	5.74	3	0
11	8	6	1.64	0	0
12	6	6	0	0	0
13	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	5
10 To 20 ft	18
20 To 30 ft	24
30 To 40 ft	19
40 To 50 ft	18
50 To 60 ft	10
60 To 70 ft	5
70 To 80 ft	14
80 To 90 ft	6
90 To 100 ft	20
100 To 110 ft	40
110 To 120 ft	276
120 To 130 ft	42
130 To 140 ft	2
140 To 150 ft	1
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 13
Analysis Point X-Coordinate 1: 128
Analysis Point X-Coordinate 2: 133
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 882
Initial Y-Base Starting Zone Coordinate: 778
Remarks: SCI-823-6.81 STA 514+00 (End of Construction with Max Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	0.14	.75	.18	0	882	10	881
2	0.14	.75	.18	10	881	42	860
3	0.14	.75	.18	42	860	48	850
4	0.14	.75	.18	48	850	52	850
5	0.12	.75	.18	52	850	69	820
6	.12	.85	.2	69	820	74	820
7	.12	.85	.2	74	820	89	790
8	.12	.85	.2	89	790	94	790
9	.12	.85	.2	94	790	103	773
10	.12	.85	.2	103	773	113	773
11	.12	.85	.2	113	773	128	778
12	.12	.85	.2	128	778	133	778
13	0.1	0.9	0.9	133	778	200	778

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

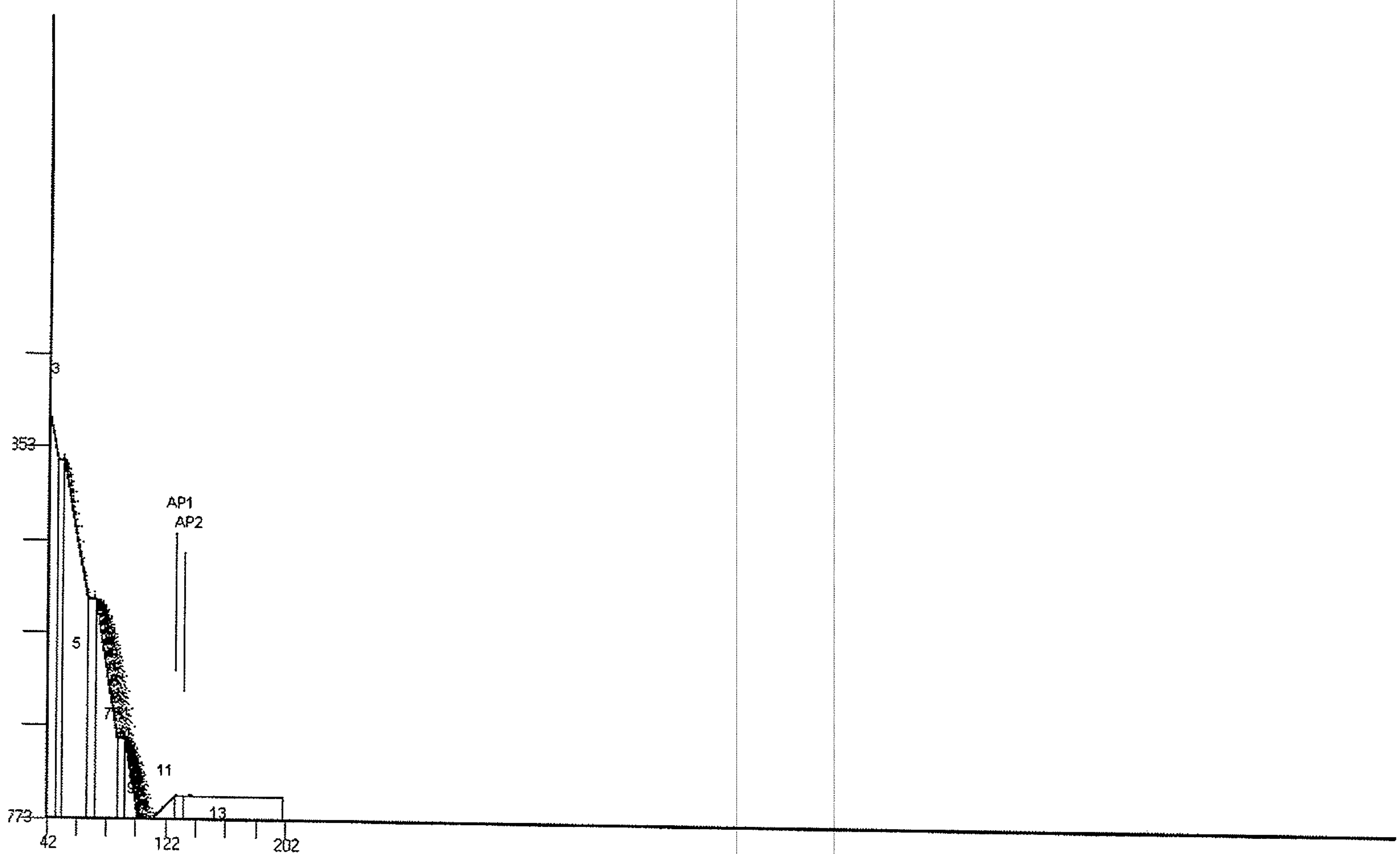
Ending Cell Number: 13

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft


3
353
5
7
AP1
AP2
11
13
773
42
122
202

Analysis Point 1

Analysis Point 1: X = 128, Y = 778

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 5

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 7.8	Maximum: .02	Maximum: 662
Average: 5.6	Average: .01	Average: 343
Minimum: 4.12	G. Mean: .01	Std. Dev.: 206
Std. Dev.: 1.59	Std. Dev.: 2.32	

Remarks: SCI-823-6.81 STA 514+00 (End of Construction with Max Rock Size)

Analysis Point 2

Analysis Point 2: X = 133, Y = 778

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 2

Velocity (ft/sec)

Maximum: 5.36
Average: 4.66
Minimum: 3.95
Std. Dev.: 0

Bounce Height (ft)

Maximum: 0
Average: -.04
G. Mean: 0
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 274
Average: 204
Std. Dev.: 0

Remarks: SCI-823-6.81 STA 514+00 (End of Construction with Max Rock Size)

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Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	6	5	.85	0	-1
3	22	15	4.3	1	0
4	12	8	2.22	0	-1
5	38	25	8.34	2	0
6	20	13	3.77	0	0
7	46	31	8.61	22	4
8	47	17	11.72	15	1
9	58	29	8.44	14	4
10	38	11	4.96	2	0
11	8	6	1.59	0	0
12	5	5	0	0	-1
13	No rocks	past end of cell			

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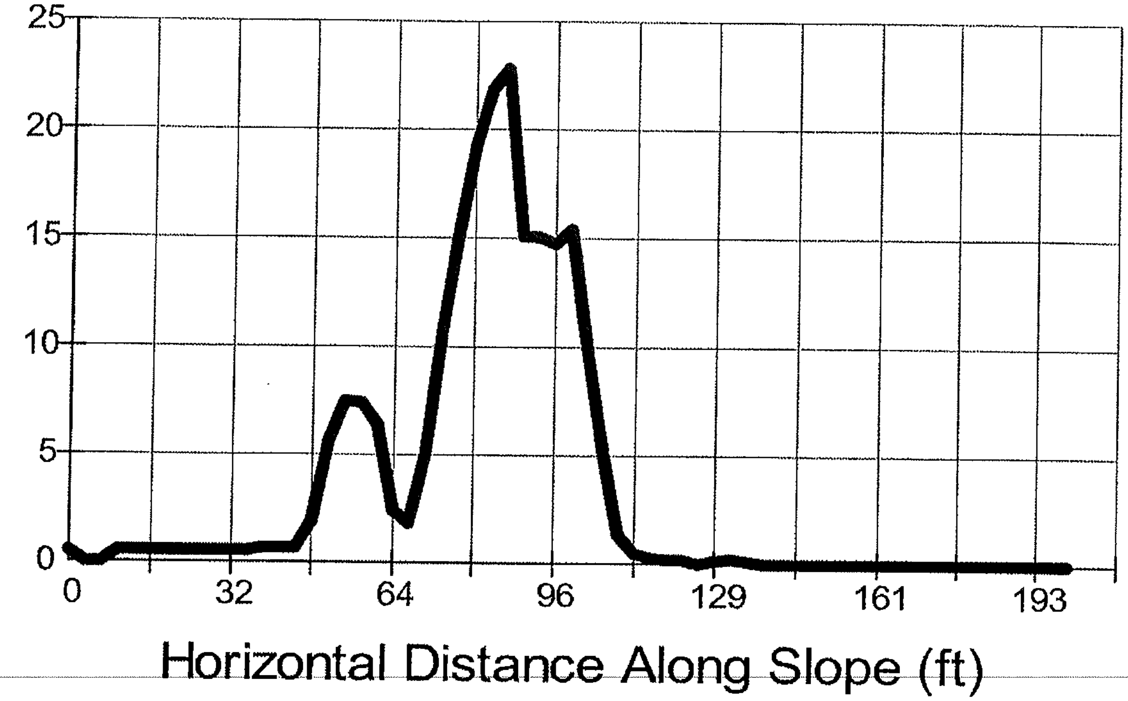
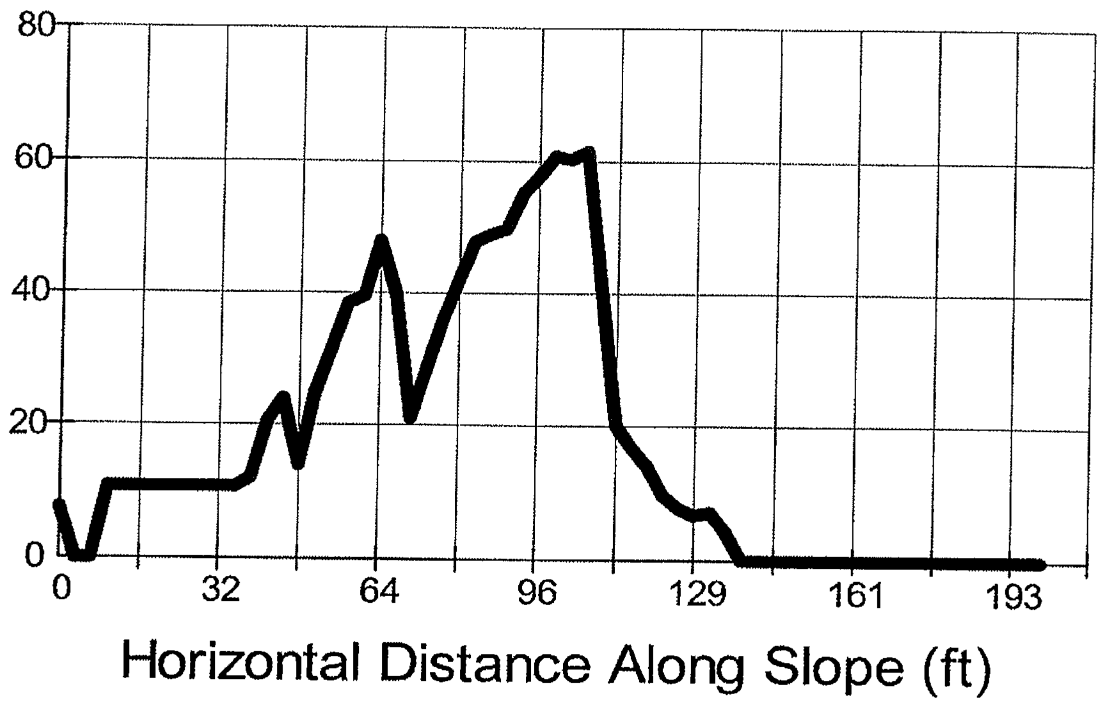
X Interval	Rocks Stopped
0 To 10 ft	5
10 To 20 ft	28
20 To 30 ft	32
30 To 40 ft	31
40 To 50 ft	14
50 To 60 ft	6
60 To 70 ft	5
70 To 80 ft	13
80 To 90 ft	3
90 To 100 ft	14
100 To 110 ft	18
110 To 120 ft	295
120 To 130 ft	33
130 To 140 ft	2
140 To 150 ft	1
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 9
Analysis Point X-Coordinate 1: 128
Analysis Point X-Coordinate 2: 133
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 882
Initial Y-Base Starting Zone Coordinate: 778
Remarks: SCI-823-6.81 STA 514+00 (Long Term with Average Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.28	.6	.15	0	882	10	881
2	.28	.6	.15	10	881	42	860
3	.28	.6	.15	42	860	50	850
4	.21	.8	.18	50	850	69	820
5	.21	.8	.18	69	820	103	773
6	.21	.8	.18	103	773	113	773
7	.21	.8	.18	113	773	128	778
8	.21	.8	.18	128	778	133	778
9	.1	.9	.9	133	778	200	778

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2

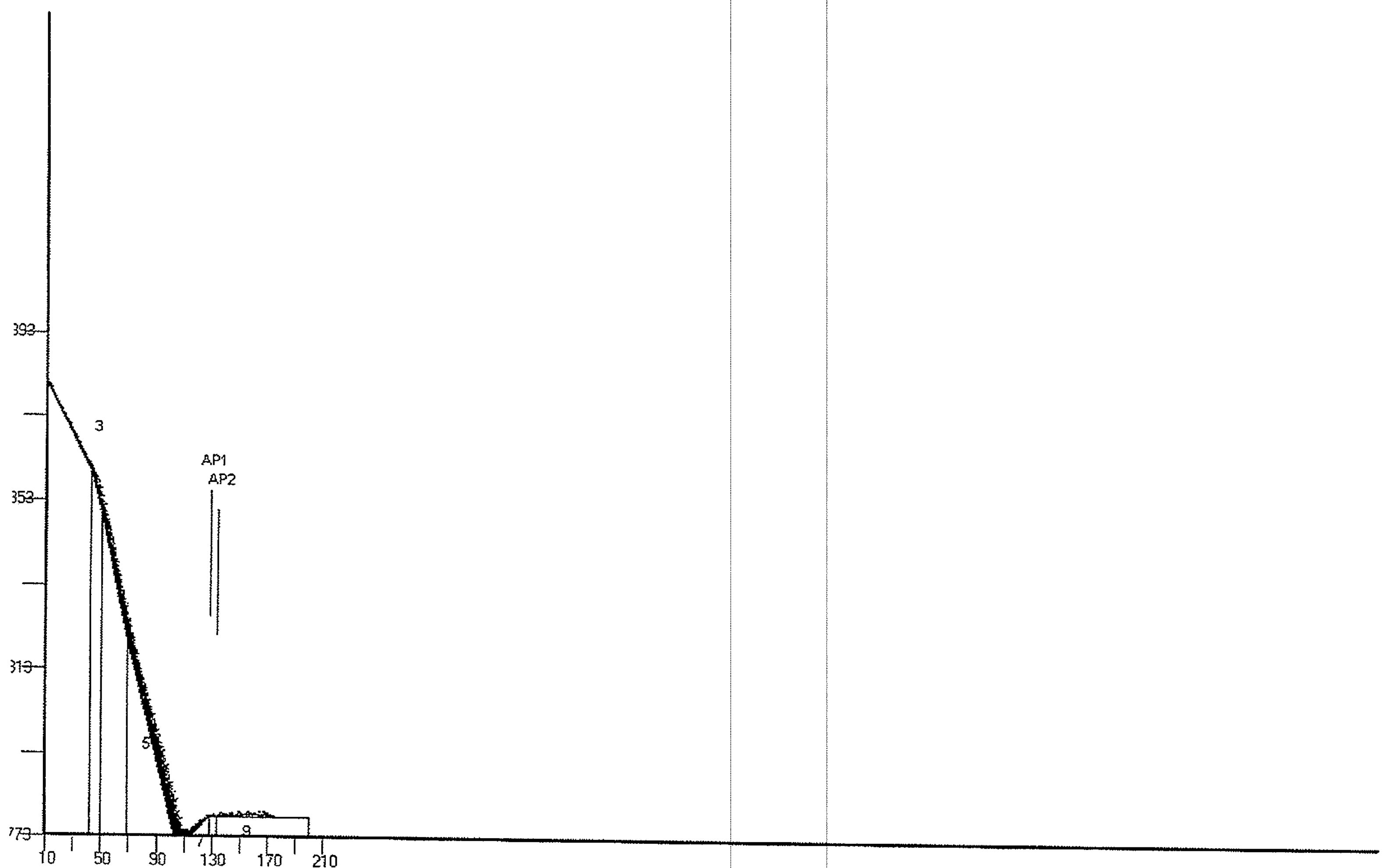
Ending Cell Number: 9

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft



393
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AP1
AP2

Analysis Point 1

Analysis Point 1: X = 128, Y = 778

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 18

Velocity (ft/sec)

Maximum: 15.34
Average: 7.06
Minimum: 2.96
Std. Dev.: 3.49

Bounce Height (ft)

Maximum: .28
Average: .05
G. Mean: .02
Std. Dev.: 7.68

Kinetic Energy (ft-lb)

Maximum: 667
Average: 197
Std. Dev.: 191

Remarks: SCI-823-6.81 STA 514+00 (Long Term with Average Rock Size)

Analysis Point 2

Analysis Point 2: X = 133, Y = 778

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 6

Velocity (ft/sec)

Maximum: 14.96
Average: 9.41
Minimum: 4.98
Std. Dev.: 3.99

Bounce Height (ft)

Maximum: .22
Average: .08
G. Mean: .04
Std. Dev.: 7.14

Kinetic Energy (ft-lb)

Maximum: 646
Average: 292
Std. Dev.: 231

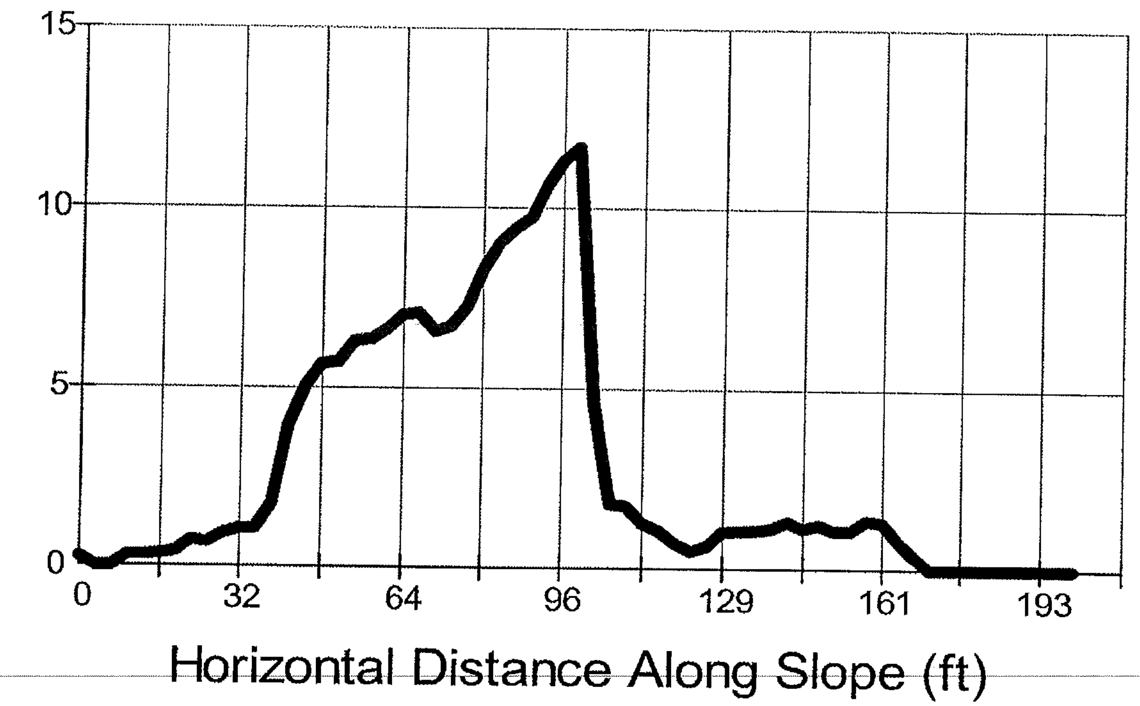
Remarks: SCI-823-6.81 STA 514+00 (Long Term with Average Rock Size)

Velocity Units: ft/sec Bounce Height Units: ft

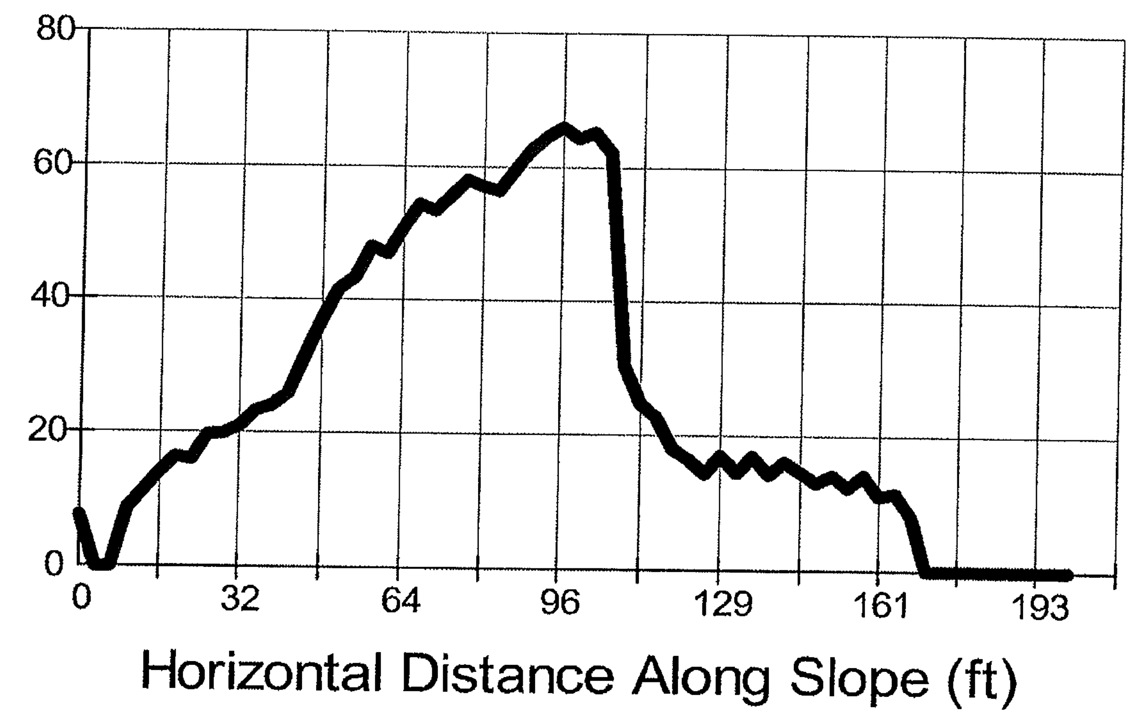
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	20	12	4.13	1	0
3	32	19	6.12	5	0
4	50	29	9.82	7	1
5	62	40	11.49	12	2
6	30	15	5.52	2	0
7	15	7	3.49	0	0
8	15	9	3.99	0	0
9	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	5
10 To 20 ft	8
20 To 30 ft	9
30 To 40 ft	4
40 To 50 ft	2
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	17
110 To 120 ft	276
120 To 130 ft	169
130 To 140 ft	5
140 To 150 ft	2
150 To 160 ft	1
160 To 170 ft	0
170 To 180 ft	2
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 9
Analysis Point X-Coordinate 1: 128
Analysis Point X-Coordinate 2: 133
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 882
Initial Y-Base Starting Zone Coordinate: 778
Remarks: SCI-823-6.81 STA 514+00 (Long Term with Max Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.28	.6	.15	0	882	10	881
2	.28	.6	.15	10	881	42	860
3	.28	.6	.15	42	860	50	850
4	.21	.8	.18	50	850	69	820
5	.21	.8	.18	69	820	103	773
6	.21	.8	.18	103	773	113	773
7	.21	.8	.18	113	773	128	778
8	.21	.8	.18	128	778	133	778
9	.1	.9	.9	133	778	200	778

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 2

Ending Cell Number: 9

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft

Analysis Point 1

Analysis Point 1: X = 128, Y = 778

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 60

Velocity (ft/sec)

Maximum: 15.5
Average: 8.06
Minimum: 2.52
Std. Dev.: 3.53

Bounce Height (ft)

Maximum: .36
Average: .08
G. Mean: .04
Std. Dev.: 4.64

Kinetic Energy (ft-lb)

Maximum: 2759
Average: 830
Std. Dev.: 711

Remarks: SCI-823-6.81 STA 514+00 (Long Term with Max Rock Size)

Analysis Point 2

Analysis Point 2: X = 133, Y = 778

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 35

Velocity (ft/sec)

Maximum: 16.49
Average: 8.53
Minimum: 3.64
Std. Dev.: 3.82

Bounce Height (ft)

Maximum: .42
Average: .02
G. Mean: .01
Std. Dev.: 7.86

Kinetic Energy (ft-lb)

Maximum: 2579
Average: 834
Std. Dev.: 738

Remarks: SCI-823-6.81 STA 514+00 (Long Term with Max Rock Size)

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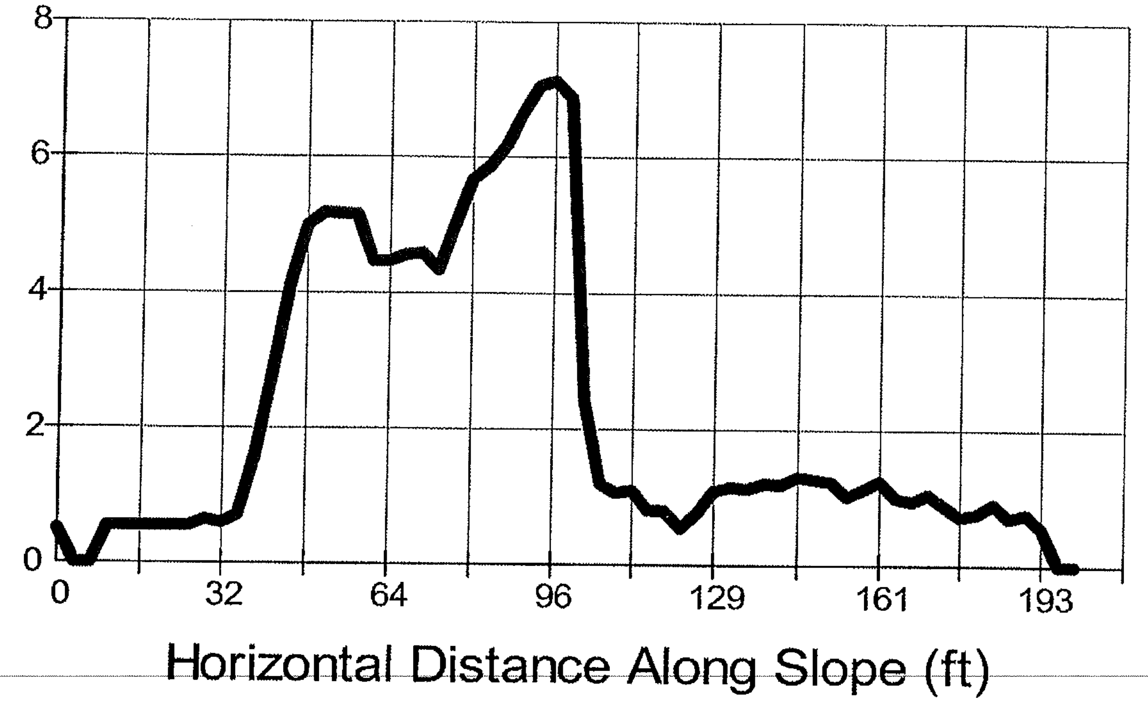
Velocity Units: ft/sec   Bounce Height Units: ft

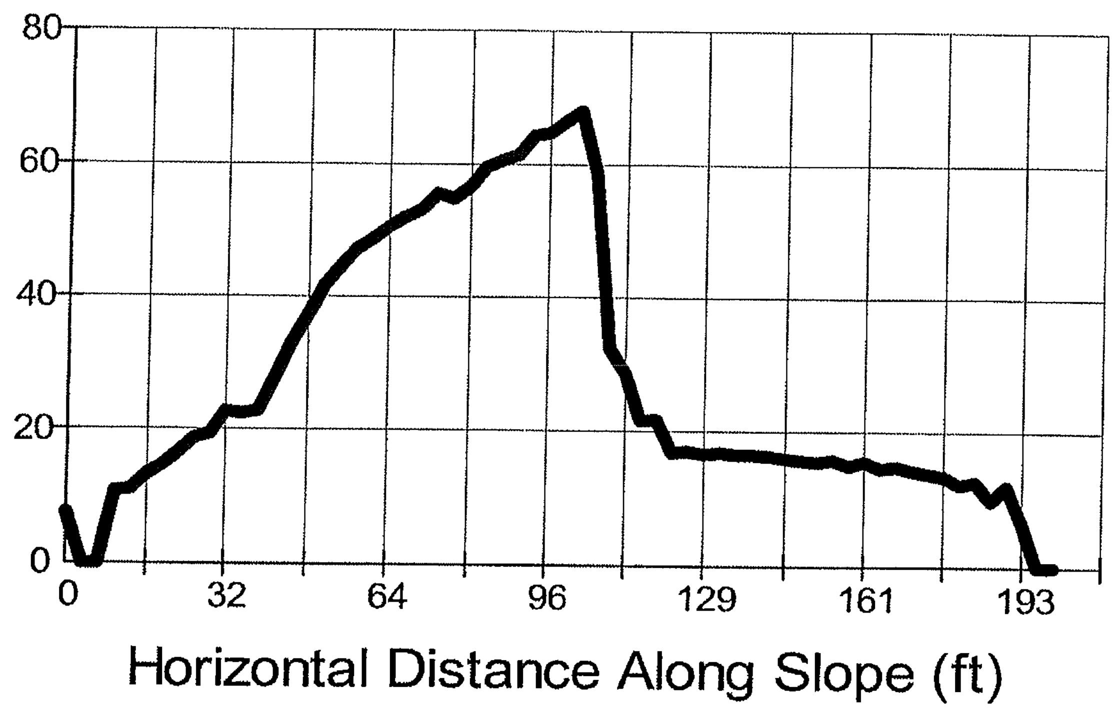
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	22	14	4.51	1	0
3	32	20	6.51	4	0
4	50	31	9.83	4	1
5	64	41	11.56	7	1
6	32	17	5.59	1	0
7	15	8	3.53	0	0
8	16	9	3.82	0	0
9	6	6	0	1	0

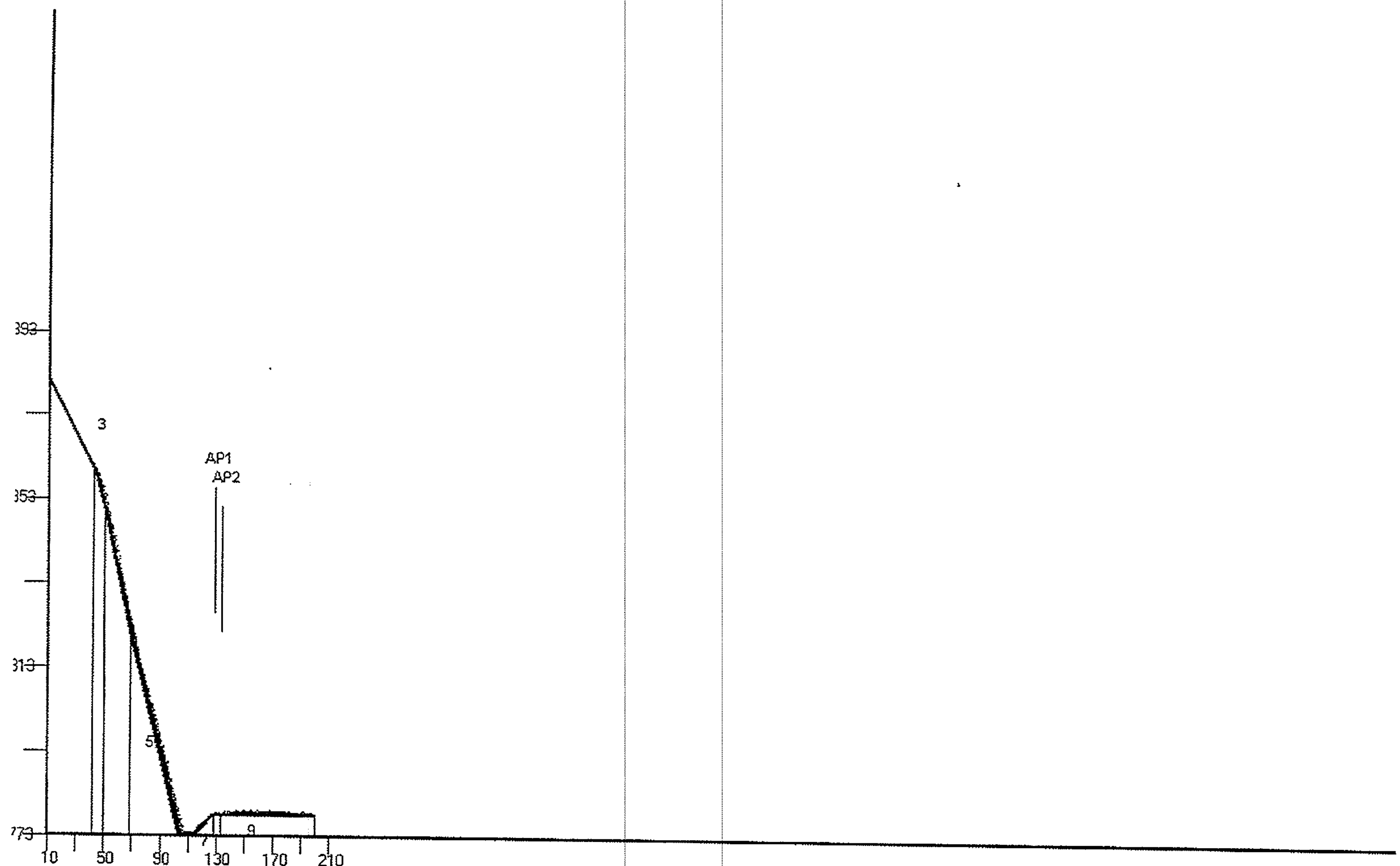
X Interval	Rocks Stopped
0 To 10 ft	5
10 To 20 ft	4
20 To 30 ft	3
30 To 40 ft	5
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	6
110 To 120 ft	176
120 To 130 ft	252
130 To 140 ft	21
140 To 150 ft	13
150 To 160 ft	5
160 To 170 ft	2
170 To 180 ft	1
180 To 190 ft	4
190 To 200 ft	1

BOUNCE HEIGHT



VELOCITY GRAPH





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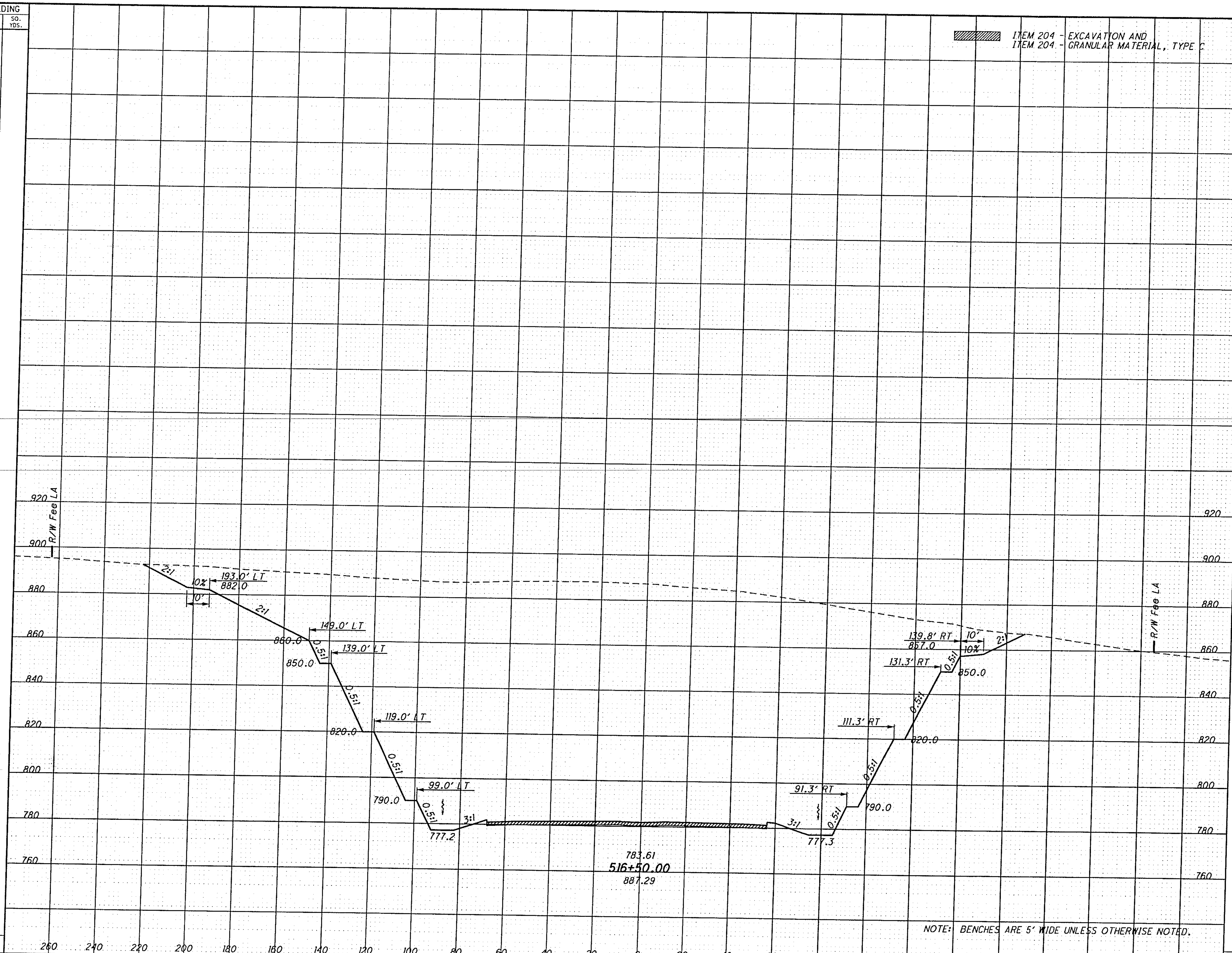
SR 823 Mainline
Sta. 516+50 LT

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME		CALCULATED	CHECKED
CUT	FILL	CUT	FILL		

CROSS SECTIONS - SR823

STA. 516+50.00 TO STA. 516+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/28/2009 6:11:12 PM REVISION DATE: 7/28/2009
FILE: ...008594/000000000045878 /1945xs011.dgn MODEL: XS_SHEET_temporary_model_name_10

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 13
Analysis Point X-Coordinate 1: 135
Analysis Point X-Coordinate 2: 140
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 883
Initial Y-Base Starting Zone Coordinate: 782
Remarks: SCI-823-6.81 STA 516+50 (End of Construction with Average Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	0.14	.75	.18	0	883	10	882
2	0.14	.75	.18	10	882	53	860
3	.12	.85	.2	53	860	58	850
4	.12	.85	.2	58	850	63	850
5	.12	.85	.2	63	850	78	820
6	.12	.85	.2	78	820	83	820
7	.12	.85	.2	83	820	98	790
8	.12	.85	.2	98	790	103	790
9	.12	.85	.2	103	790	110	777
10	.12	.85	.2	110	777	120	777
11	.12	.85	.2	120	777	135	782
12	.12	.85	.2	135	782	140	782
13	0.1	0.9	0.9	140	782	200	782

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

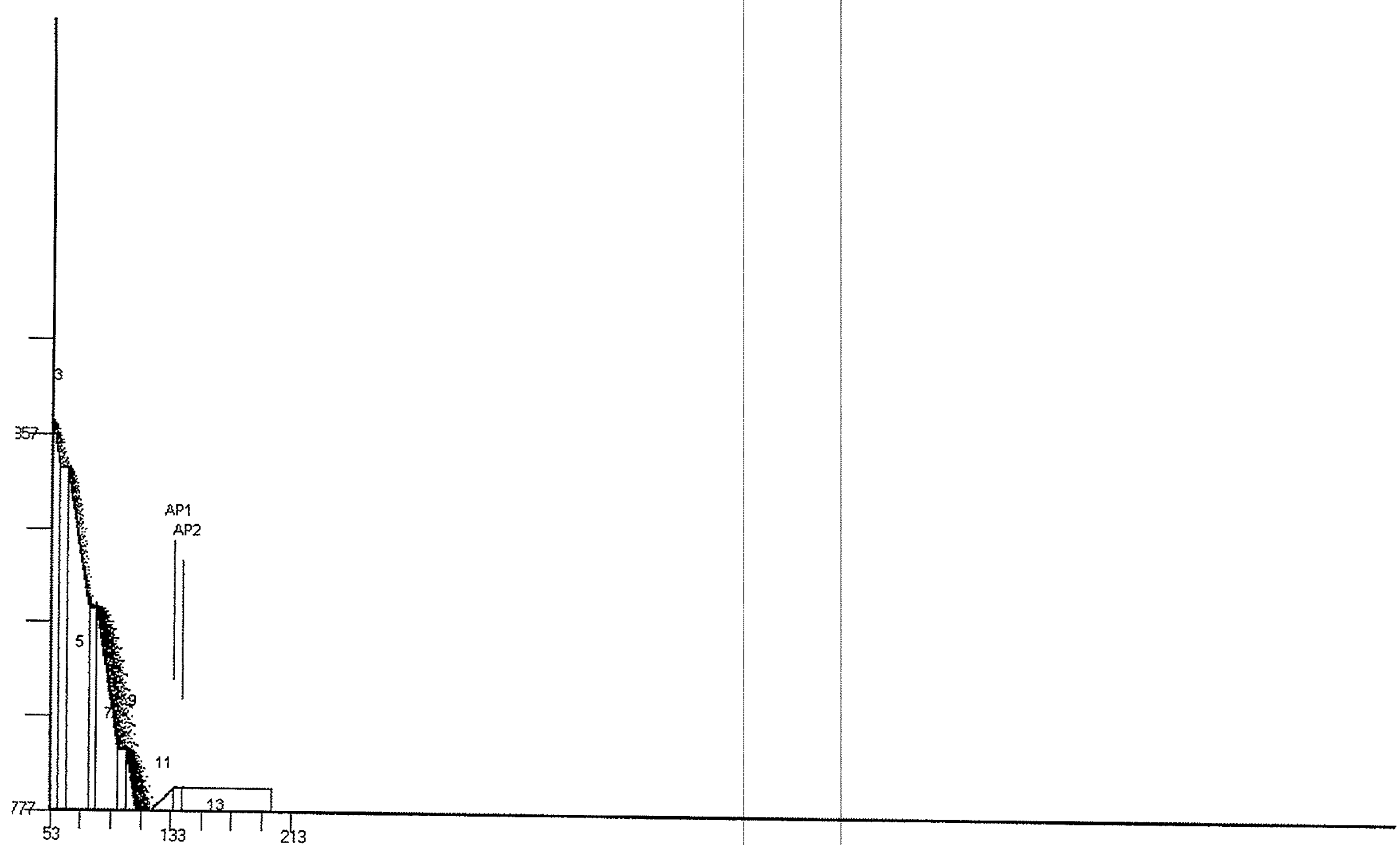
Ending Cell Number: 13

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft



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AP1
AP2

Analysis Point 1

Analysis Point 1: X = 135, Y = 782

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 2

Velocity (ft/sec)

Maximum: 6.9
Average: 5.08
Minimum: 3.26
Std. Dev.: 0

Bounce Height (ft)

Maximum: .06
Average: .05
G. Mean: .04
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 149
Average: 90
Std. Dev.: 0

Remarks: SCI-823-6.81 STA 516+50 (End of Construction with Average Rock Size)

Analysis Point 2

Analysis Point 2: X = 140, Y = 782

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 1

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 4.26	Maximum: 0	Maximum: 49
Average: 4.26	Average: -.02	Average: 49
Minimum: 4.26	G. Mean: 0	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

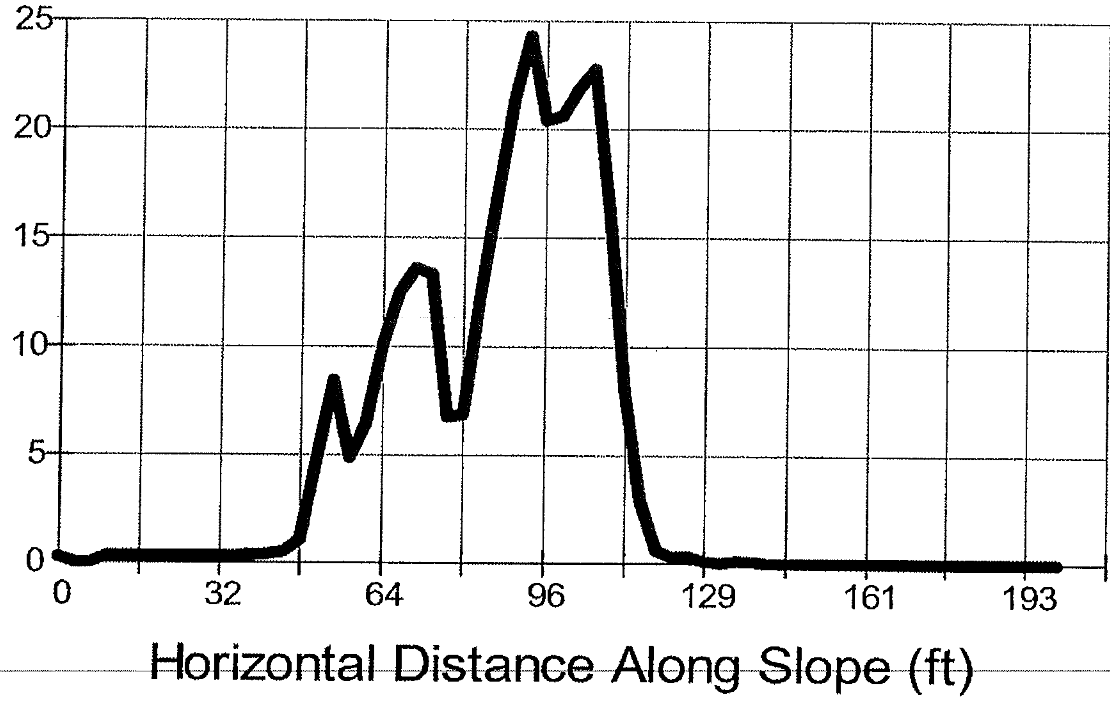
Remarks: SCI-823-6.81 STA 516+50 (End of Construction with Average Rock Size)

Velocity Units: ft/sec Bounce Height Units: ft

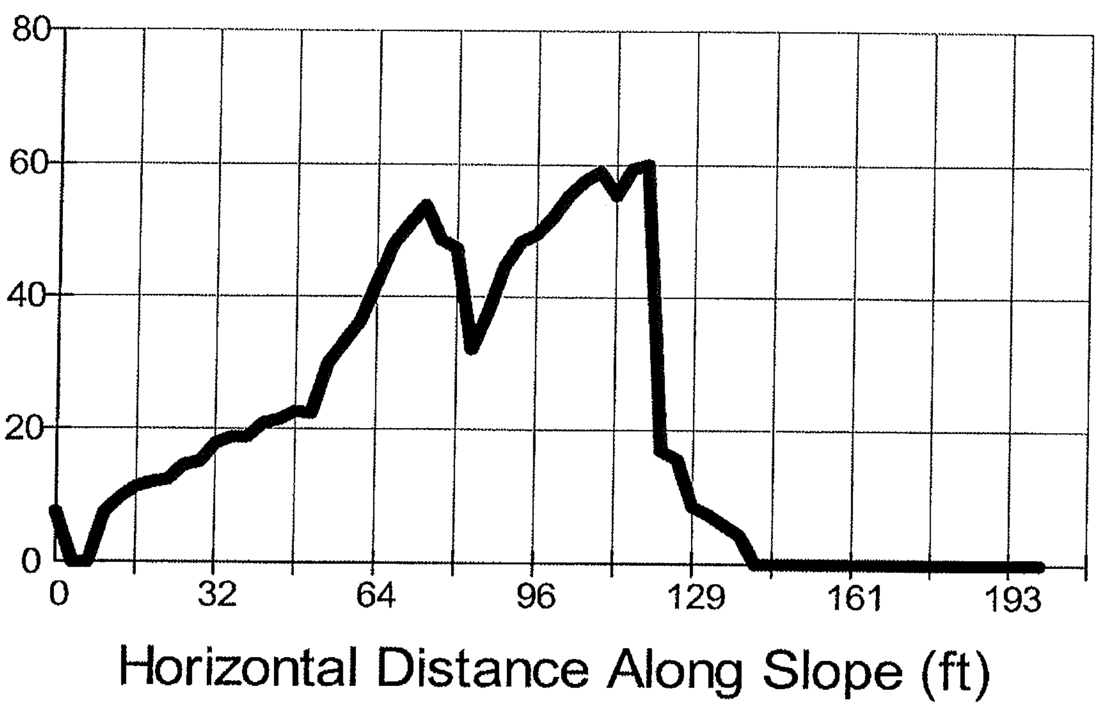
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	20	13	4.71	1	0
3	26	18	5.68	7	1
4	32	9	6.3	2	0
5	44	28	8.9	13	1
6	25	12	4.16	1	0
7	46	31	8.6	23	4
8	47	16	11.98	18	1
9	55	26	8.72	22	4
10	56	10	6.06	5	0
11	7	5	0	0	0
12	4	4	0	0	-1
13	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	5
10 To 20 ft	14
20 To 30 ft	16
30 To 40 ft	15
40 To 50 ft	19
50 To 60 ft	15
60 To 70 ft	10
70 To 80 ft	8
80 To 90 ft	20
90 To 100 ft	10
100 To 110 ft	15
110 To 120 ft	77
120 To 130 ft	258
130 To 140 ft	17
140 To 150 ft	1
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 13
Analysis Point X-Coordinate 1: 135
Analysis Point X-Coordinate 2: 140
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 883
Initial Y-Base Starting Zone Coordinate: 782
Remarks: SCI-823-6.81 STA 516+50 (End of Construction with Max Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.14	.75	.18	0	883	10	882
2	.14	.75	.18	10	882	53	860
3	.12	.85	.2	53	860	58	850
4	.12	.85	.2	58	850	63	850
5	.12	.85	.2	63	850	78	820
6	.12	.85	.2	78	820	83	820
7	.12	.85	.2	83	820	98	790
8	.12	.85	.2	98	790	103	790
9	.12	.85	.2	103	790	110	777
10	.12	.85	.2	110	777	120	777
11	.12	.85	.2	120	778	135	782
12	.12	.85	.2	135	782	140	782
13	0.1	0.9	0.9	140	782	200	782

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

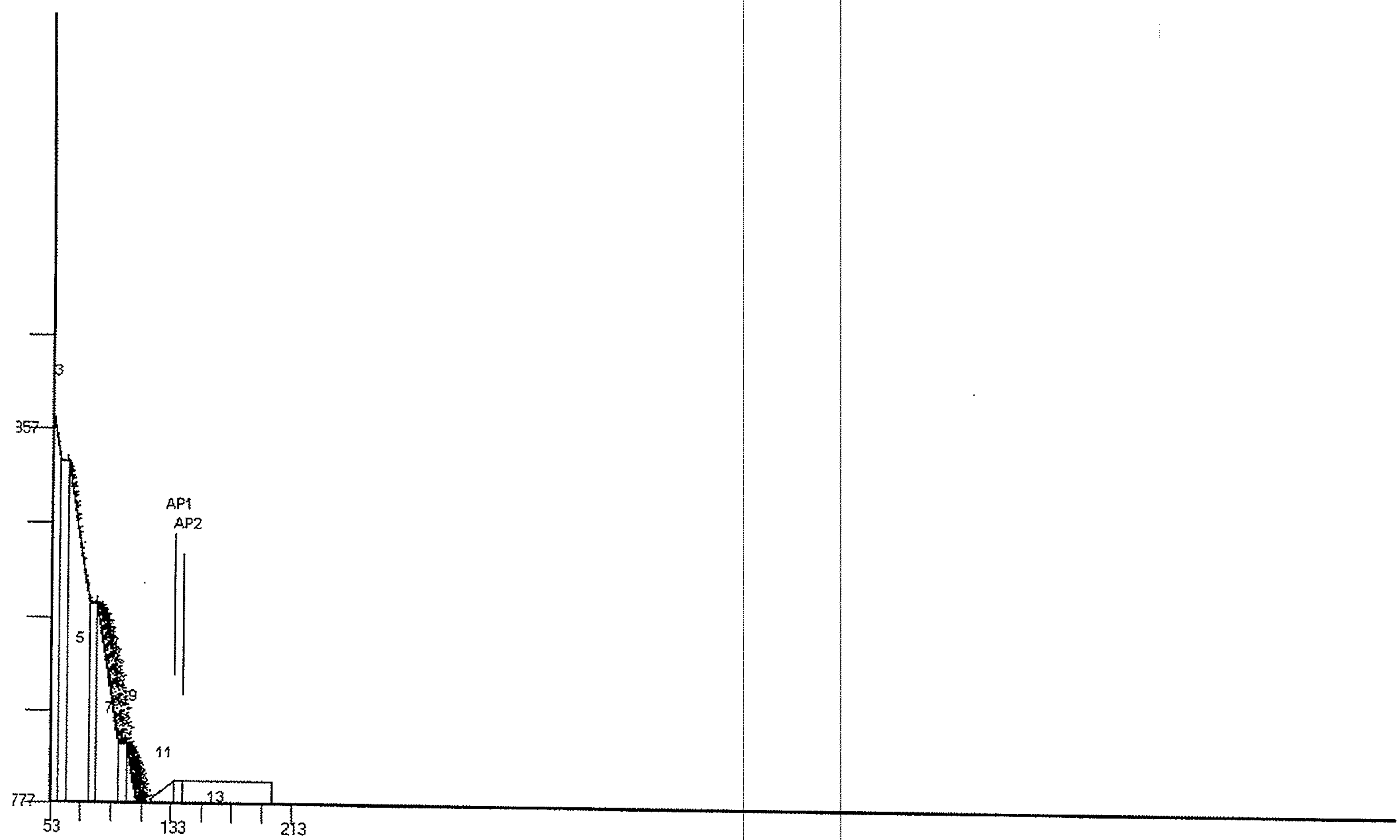
Ending Cell Number: 13

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft



357
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AP1
AP2

Analysis Point 1

Analysis Point 1: X = 135, Y = 782

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: SCI-823-6.81 STA 516+50 (End of Construction with Max Rock Size)

Analysis Point 2

Analysis Point 2: X = 140, Y = 782

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

NO ROCKS PAST ANALYSIS POINT 2

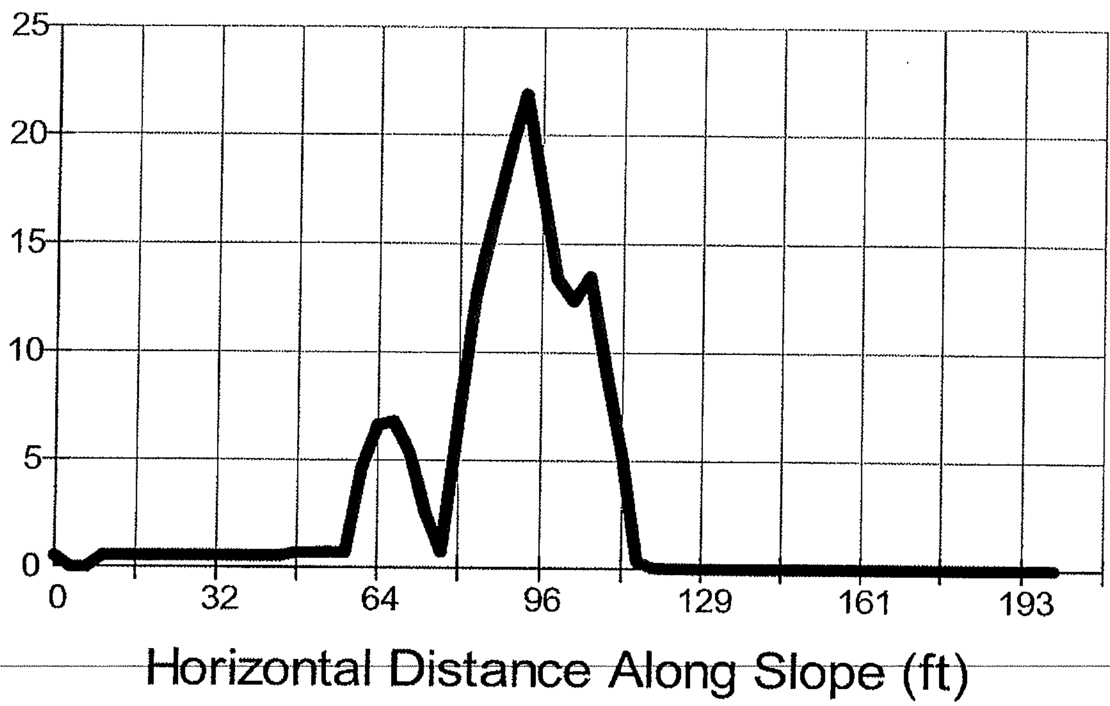
Remarks: SCI-823-6.81 STA 516+50 (End of Construction with Max Rock Size)

Velocity Units: ft/sec   Bounce Height Units: ft

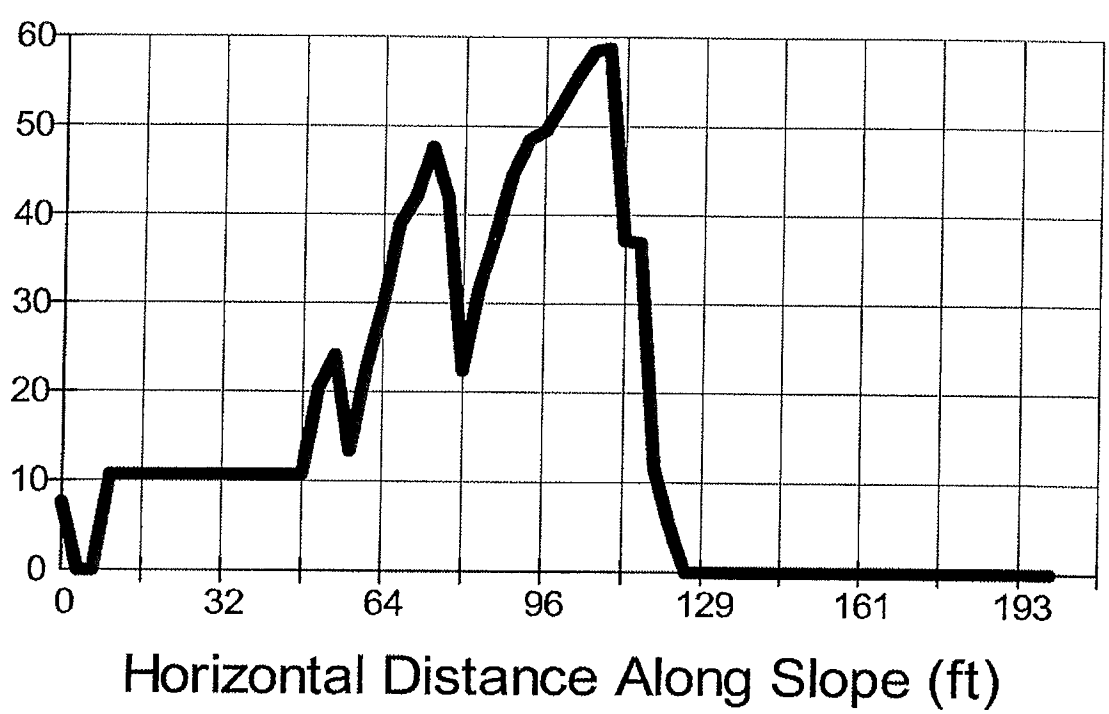
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	5	5	0	0	-1
3	22	15	4.6	1	0
4	12	8	1.88	0	-1
5	45	26	8.44	2	0
6	21	12	3.83	0	0
7	45	31	8.64	21	4
8	47	16	11.56	13	0
9	55	26	8.65	12	4
10	33	10	4.57	2	0
11	No rocks	past end of cell			
12	No rocks	past end of cell			
13	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	5
10 To 20 ft	24
20 To 30 ft	25
30 To 40 ft	26
40 To 50 ft	25
50 To 60 ft	11
60 To 70 ft	13
70 To 80 ft	6
80 To 90 ft	9
90 To 100 ft	3
100 To 110 ft	14
110 To 120 ft	51
120 To 130 ft	288
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 8
Analysis Point X-Coordinate 1: 135
Analysis Point X-Coordinate 2: 140
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 883
Initial Y-Base Starting Zone Coordinate: 782
Remarks: SCI-823-6.81 STA 516+50 (Long Term with Average Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.28	.6	.15	0	883	10	882
2	.28	.6	.15	10	882	53	860
3	.21	.8	.18	53	860	78	820
4	.21	.8	.18	78	820	110	777
5	.21	.8	.18	110	777	120	777
6	.21	.8	.18	120	777	135	782
7	.21	.8	.18	135	782	140	782
8	.1	.9	.9	140	782	200	782

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

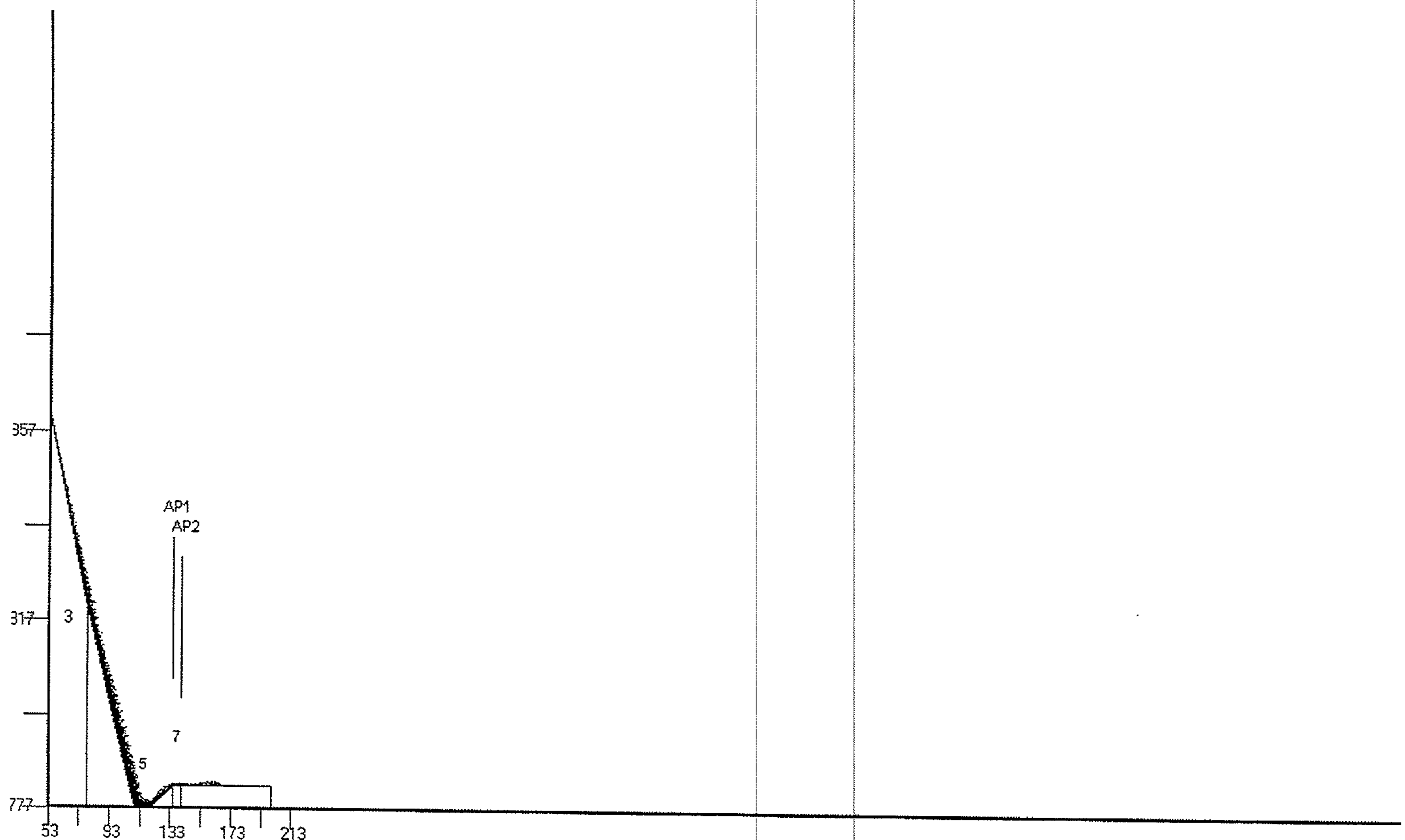
Ending Cell Number: 8

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft



357
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777
AP1
AP2
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7
53
93
133
173
213

Analysis Point 1

Analysis Point 1: X = 135, Y = 782

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 9

Velocity (ft/sec)

Maximum: 11.52
Average: 7.41
Minimum: 3.41
Std. Dev.: 2.75

Bounce Height (ft)

Maximum: .65
Average: .19
G. Mean: .04
Std. Dev.: 16.65

Kinetic Energy (ft-lb)

Maximum: 464
Average: 209
Std. Dev.: 145

Remarks: SCI-823-6.81 STA 516+50 (Long Term with Average Rock Size)

Analysis Point 2

Analysis Point 2: X = 140, Y = 782

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 4

Velocity (ft/sec)

Maximum: 10.27
Average: 6.72
Minimum: 3.59
Std. Dev.: 0

Bounce Height (ft)

Maximum: .26
Average: .14
G. Mean: .05
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 313
Average: 152
Std. Dev.: 0

Remarks: SCI-823-6.81 STA 516+50 (Long Term with Average Rock Size)

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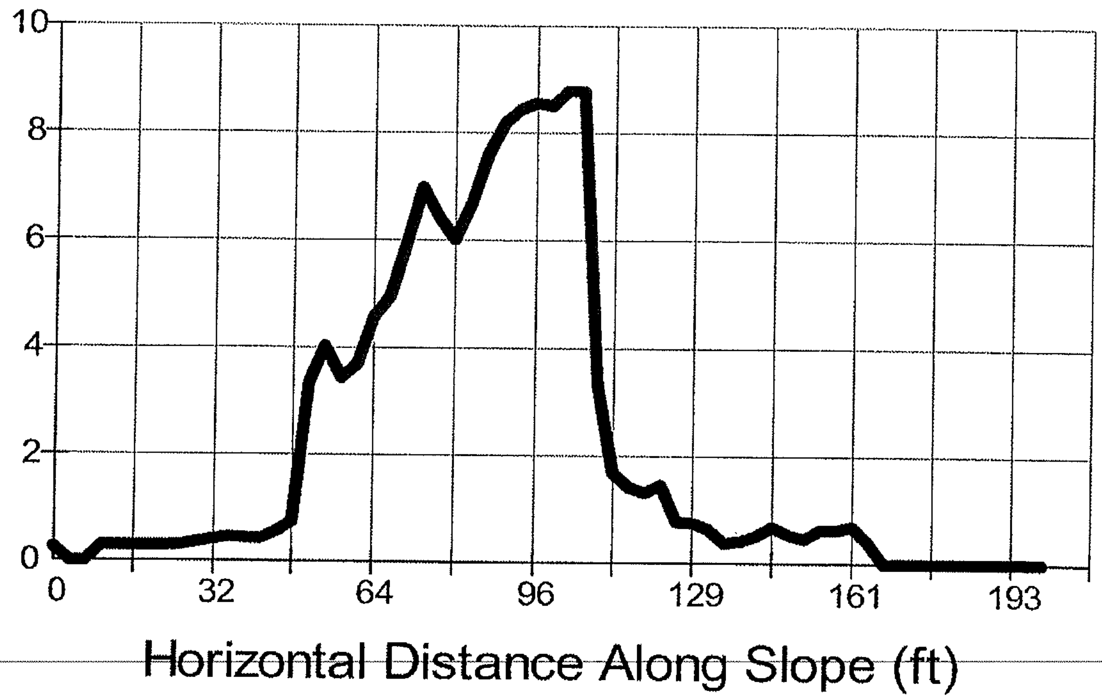
Velocity Units: ft/sec Bounce Height Units: ft

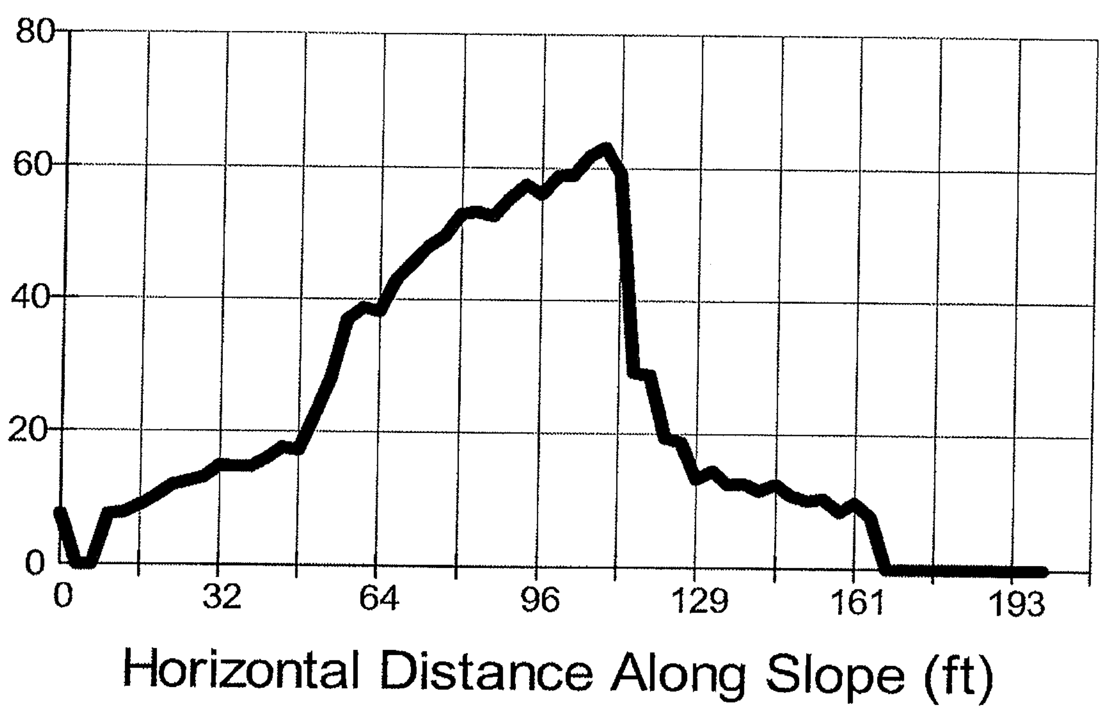
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	16	9	2.92	1	0
3	45	28	9.39	6	1
4	60	38	11.24	9	2
5	29	14	5.17	2	0
6	12	7	2.75	1	0
7	10	7	0	0	0
8	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	5
10 To 20 ft	21
20 To 30 ft	17
30 To 40 ft	15
40 To 50 ft	16
50 To 60 ft	6
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	41
120 To 130 ft	319
130 To 140 ft	57
140 To 150 ft	0
150 To 160 ft	2
160 To 170 ft	0
170 To 180 ft	1
180 To 190 ft	0
190 To 200 ft	0

BOUNCE HEIGHT



VELOCITY GRAPH



Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 8
Analysis Point X-Coordinate 1: 135
Analysis Point X-Coordinate 2: 140
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 883
Initial Y-Base Starting Zone Coordinate: 782
Remarks: SCI-823-6.81 STA 516+50 (Long Term with Max Rock Size)

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.28	.6	.15	0	883	10	882
2	.28	.6	.15	10	882	53	860
3	.21	.8	.18	53	860	78	820
4	.21	.8	.18	78	820	110	777
5	.21	.8	.18	110	777	120	777
6	.21	.8	.18	120	777	135	782
7	.21	.8	.18	135	782	140	782
8	.1	.9	.9	140	782	200	782

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

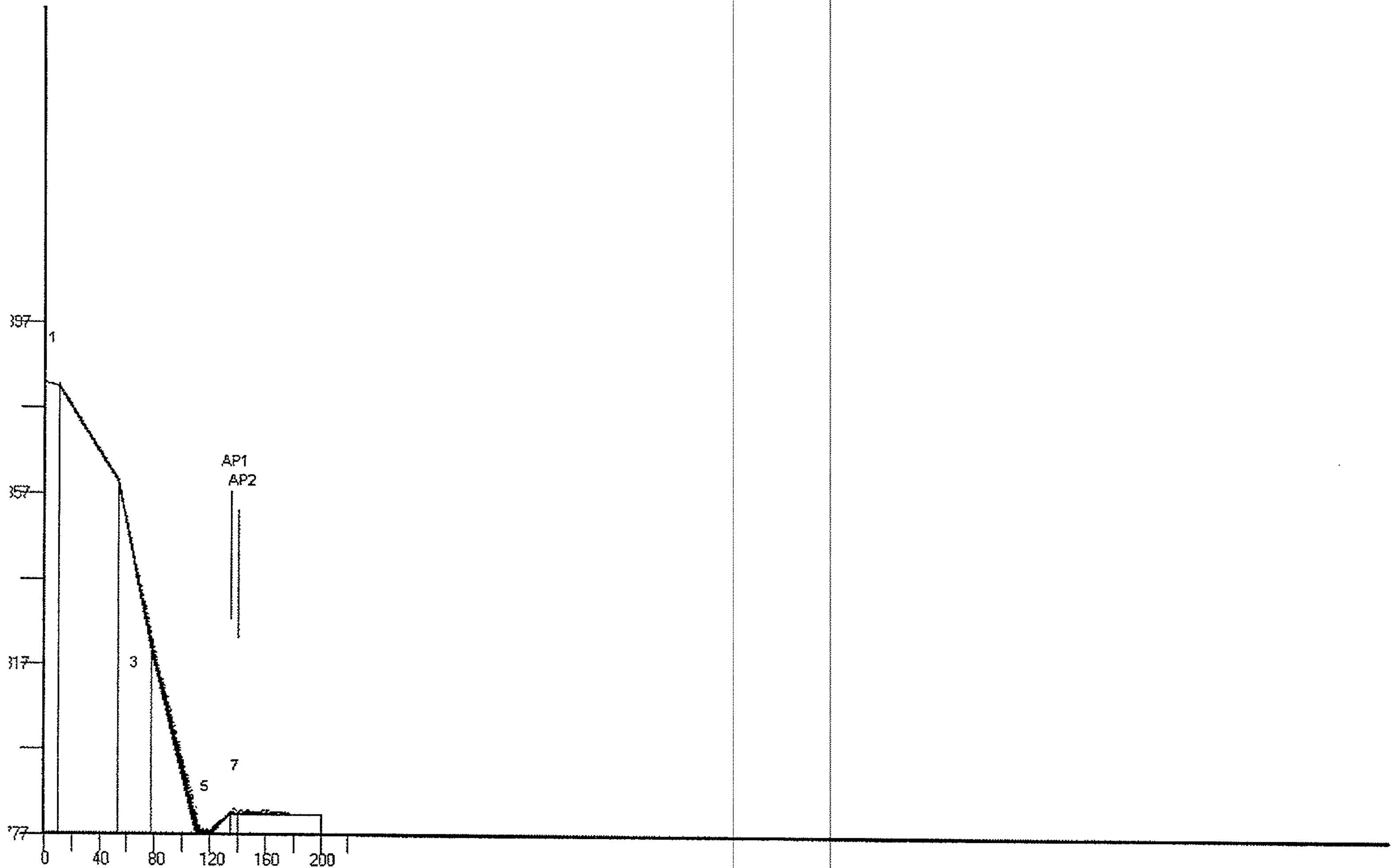
Ending Cell Number: 8

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft



397
357
317
277
0
40
80
120
160
200
1
3
5
7
AP1
AP2

Analysis Point 1

Analysis Point 1: X = 135, Y = 782

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 51

Velocity (ft/sec)

Maximum: 19.38
Average: 8.31
Minimum: 3.27
Std. Dev.: 4.11

Bounce Height (ft)

Maximum: .69
Average: .08
G. Mean: .02
Std. Dev.: 9.58

Kinetic Energy (ft-lb)

Maximum: 3852
Average: 897
Std. Dev.: 902

Remarks: SCI-823-6.81 STA 516+50 (Long Term with Max Rock Size)

Analysis Point 2

Analysis Point 2: X = 140, Y = 782

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 29

Velocity (ft/sec)

Maximum: 18.92
Average: 8.63
Minimum: 3.22
Std. Dev.: 4.66

Bounce Height (ft)

Maximum: 1.25
Average: .14
G. Mean: .02
Std. Dev.: 9.85

Kinetic Energy (ft-lb)

Maximum: 3741
Average: 951
Std. Dev.: 1032

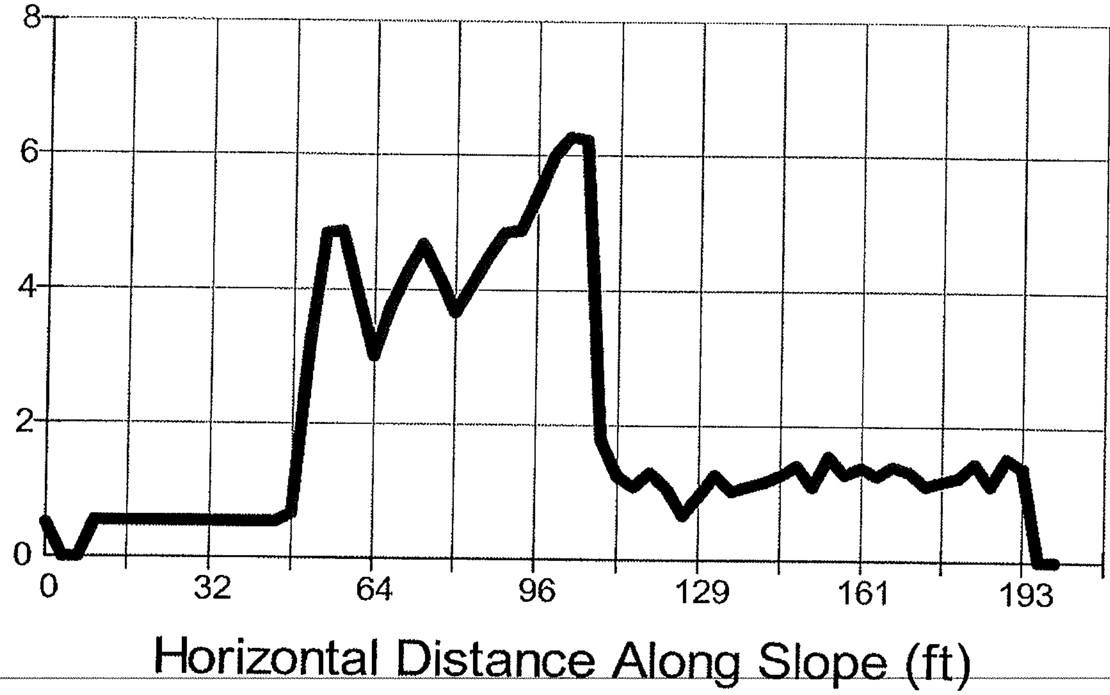
Remarks: SCI-823-6.81 STA 516+50 (Long Term with Max Rock Size)

Velocity Units: ft/sec   Bounce Height Units: ft

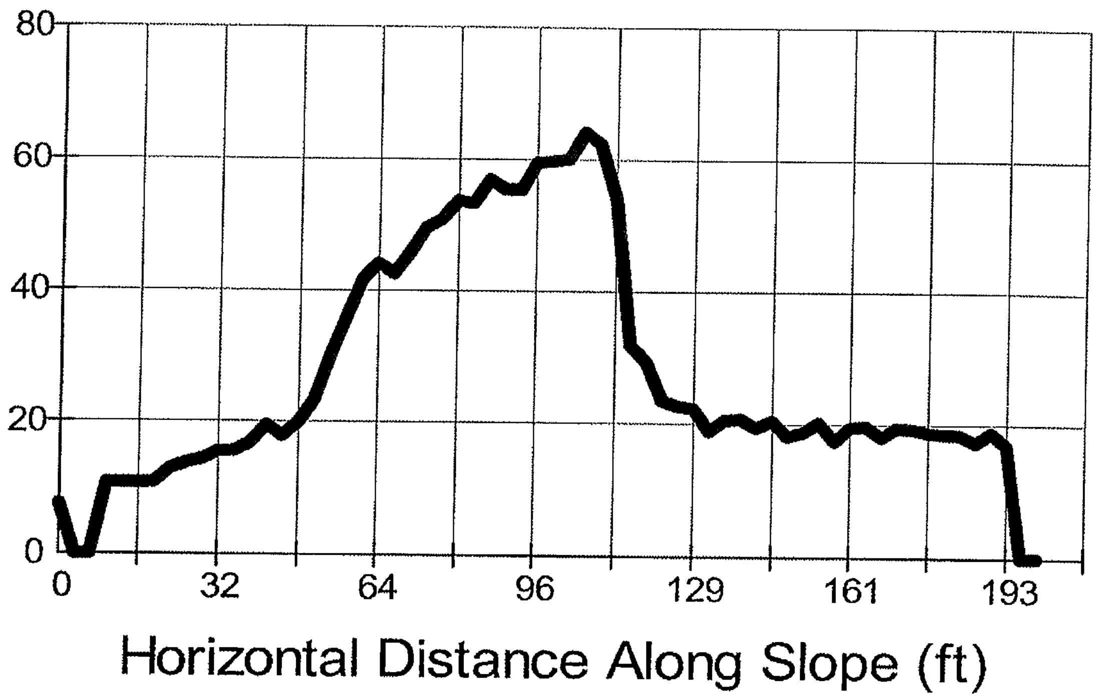
Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	18	11	3.86	0	0
3	46	29	9.62	5	1
4	61	39	10.99	6	1
5	31	17	5.7	1	0
6	19	8	4.11	1	0
7	19	9	4.66	1	0
8	16	9	0	2	0

X Interval	Rocks Stopped
0 To 10 ft	5
10 To 20 ft	11
20 To 30 ft	16
30 To 40 ft	12
40 To 50 ft	12
50 To 60 ft	6
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	13
120 To 130 ft	267
130 To 140 ft	129
140 To 150 ft	10
150 To 160 ft	6
160 To 170 ft	5
170 To 180 ft	0
180 To 190 ft	1
190 To 200 ft	3

BOUNCE HEIGHT

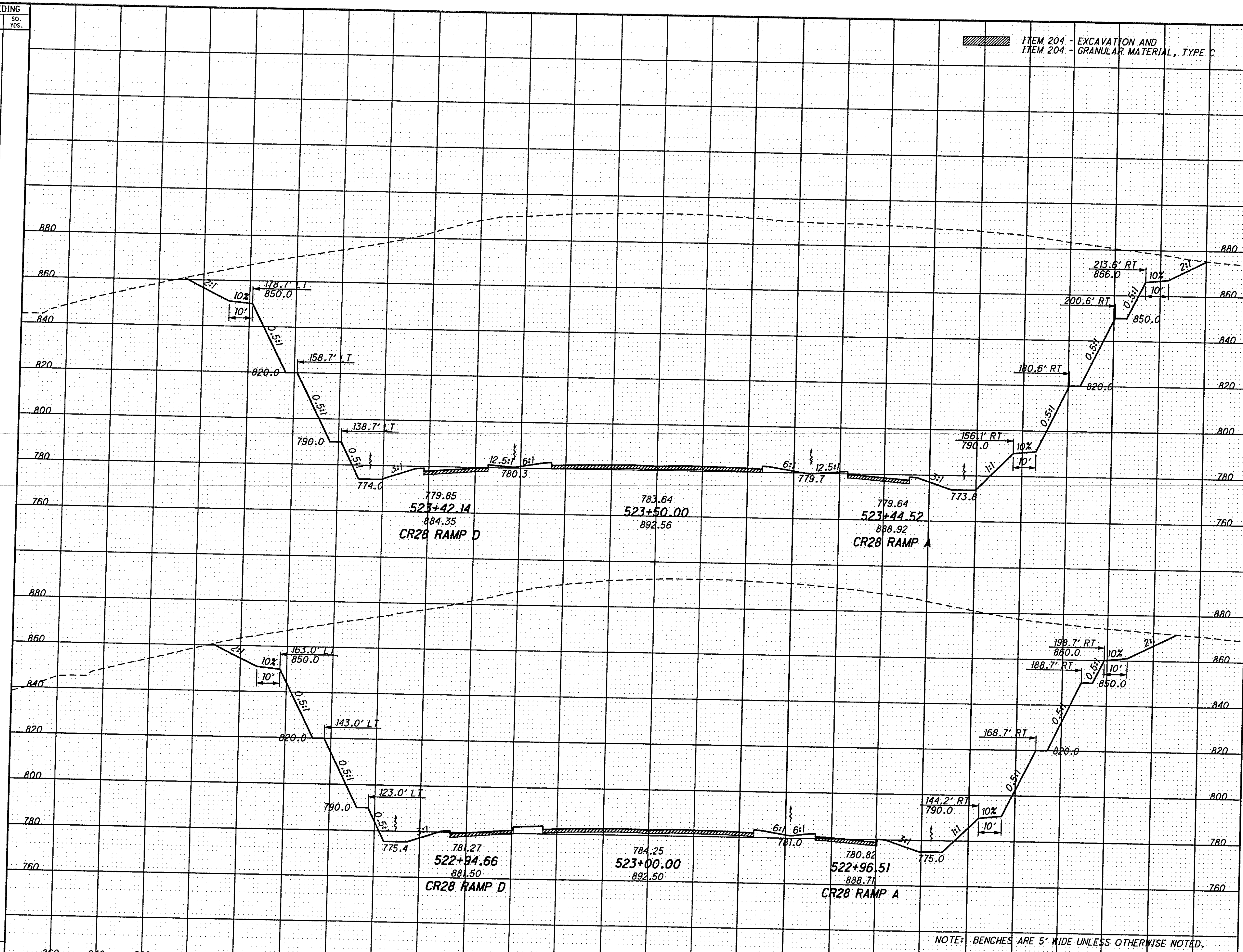


VELOCITY GRAPH



CR 28 Ramp A
Sta. 523+44.52 RT

SEEDING	
END WIDTH	SQ. YDS.



END AREA		VOLUME	
CUT	FILL	CUT	FILL

CALCULATED

CHECKED

CROSS SECTIONS - SR823
STA. 523+00.00 TO STA. 523+50.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/28/2009 6:18 PM REVISION DATE: 7/28/2009
FILE: ...\08594\000000000045878\79415xe011.dgn MODEL: XS_SHEET_temporary_model_name_18

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 13
Analysis Point X-Coordinate 1: 130
Analysis Point X-Coordinate 2: 134
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 875
Initial Y-Base Starting Zone Coordinate: 779
Remarks: Sta. 523+44.52 (RT) - Ramp A: End of Construction with Average Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.12	.85	.2	0	875	15	867
2	.12	.85	.2	15	867	25	866
3	.12	.85	.2	25	866	34	850
4	.12	.85	.2	34	850	39	850
5	.12	.85	.2	39	850	54	820
6	.12	.85	.2	54	820	59	820
7	.12	.85	.2	59	820	79	791
8	.15	.75	.18	79	791	89	790
9	.15	.75	.18	89	790	105	774
10	.15	.75	.18	105	774	115	774
11	.15	.75	.18	115	774	130	779
12	.15	.75	.18	130	779	134	779
13	.1	.9	.9	134	779	200	779

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

Ending Cell Number: 13

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft


354
774
25
105
185
3
5
7
11
13
AP1
AP2

Analysis Point 1

Analysis Point 1: X = 130, Y = 779

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: Sta. 523+44.52 (RT) - Ramp A: End of Construction with Average Rock Size

Analysis Point 2

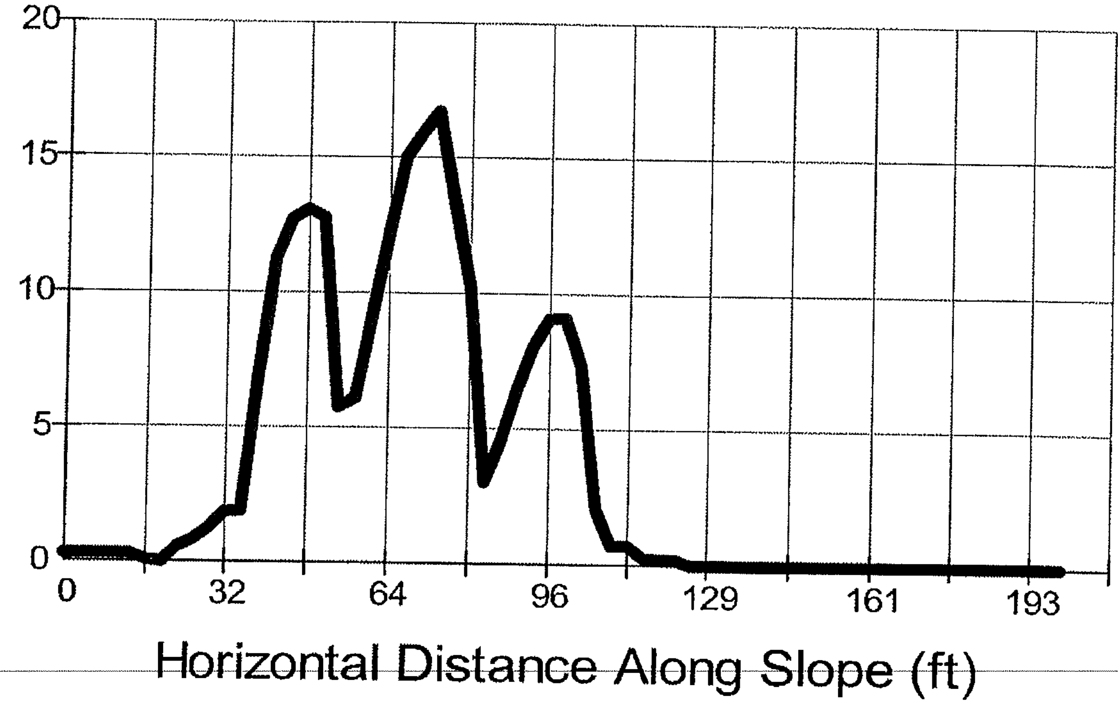
Analysis Point 2: X = 134, Y = 779

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

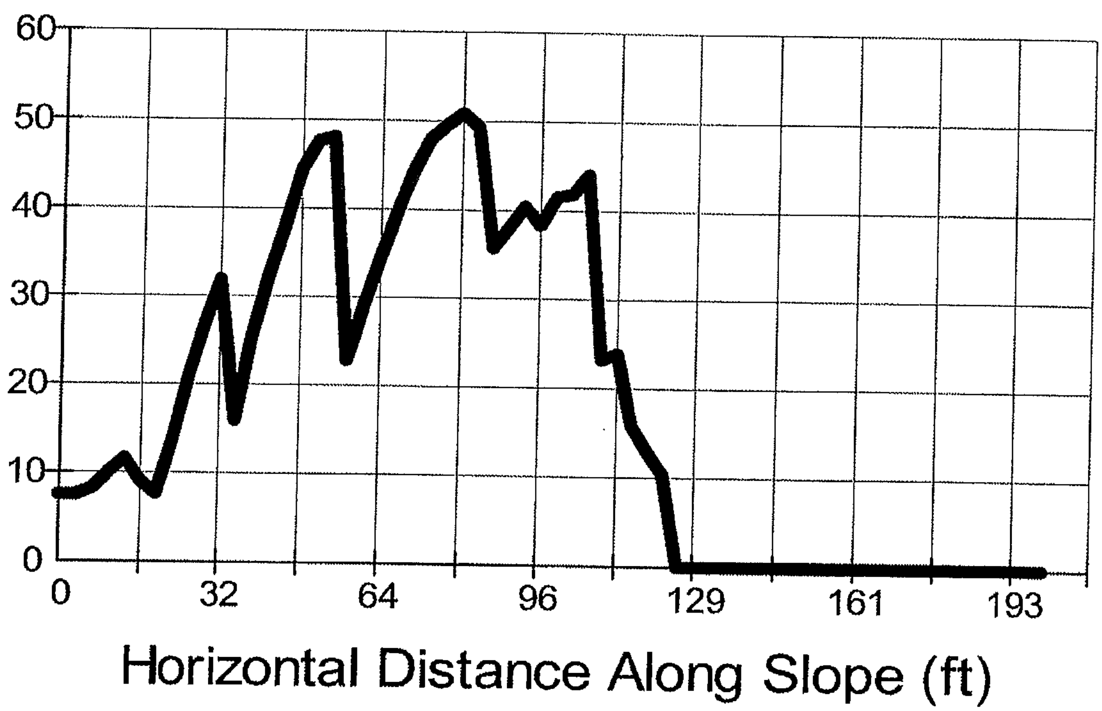
NO ROCKS PAST ANALYSIS POINT 2

Remarks: Sta. 523+44.52 (RT) - Ramp A: End of Construction with Average Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



'rojects\2009 Projects\212 - 000000000045878 - Portsmouth Bypass (Phase 2)\06.00 Proj_Engr\Design\CR

Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	10	5	1.75	0	-1
2	6	6	0	0	-1
3	29	18	5.82	2	0
4	15	8	2.97	0	0
5	45	28	8.94	13	1
6	21	12	4.15	1	0
7	46	30	8.65	17	1
8	49	15	4.77	1	0
9	40	27	5.63	9	1
10	23	12	3.73	1	0
11	No rocks	past end of cell			
12	No rocks	past end of cell			
13	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	27
10 To 20 ft	24
20 To 30 ft	0
30 To 40 ft	19
40 To 50 ft	0
50 To 60 ft	24
60 To 70 ft	0
70 To 80 ft	2
80 To 90 ft	26
90 To 100 ft	0
100 To 110 ft	2
110 To 120 ft	240
120 To 130 ft	136
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 13
Analysis Point X-Coordinate 1: 130
Analysis Point X-Coordinate 2: 134
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 875
Initial Y-Base Starting Zone Coordinate: 779
Remarks: Sta. 523+44.52 (RT) - Ramp A: End of Construction with Max Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.12	.85	.2	0	875	15	867
2	.12	.85	.2	15	867	25	866
3	.12	.85	.2	25	866	34	850
4	.12	.85	.2	34	850	39	850
5	.12	.85	.2	39	850	54	820
6	.12	.85	.2	54	820	59	820
7	.12	.85	.2	59	820	79	791
8	.15	.75	.18	79	791	89	790
9	.15	.75	.18	89	790	105	774
10	.15	.75	.18	105	774	115	774
11	.15	.75	.18	115	774	130	779
12	.15	.75	.18	130	779	134	779
13	.1	.9	.9	134	779	200	779

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

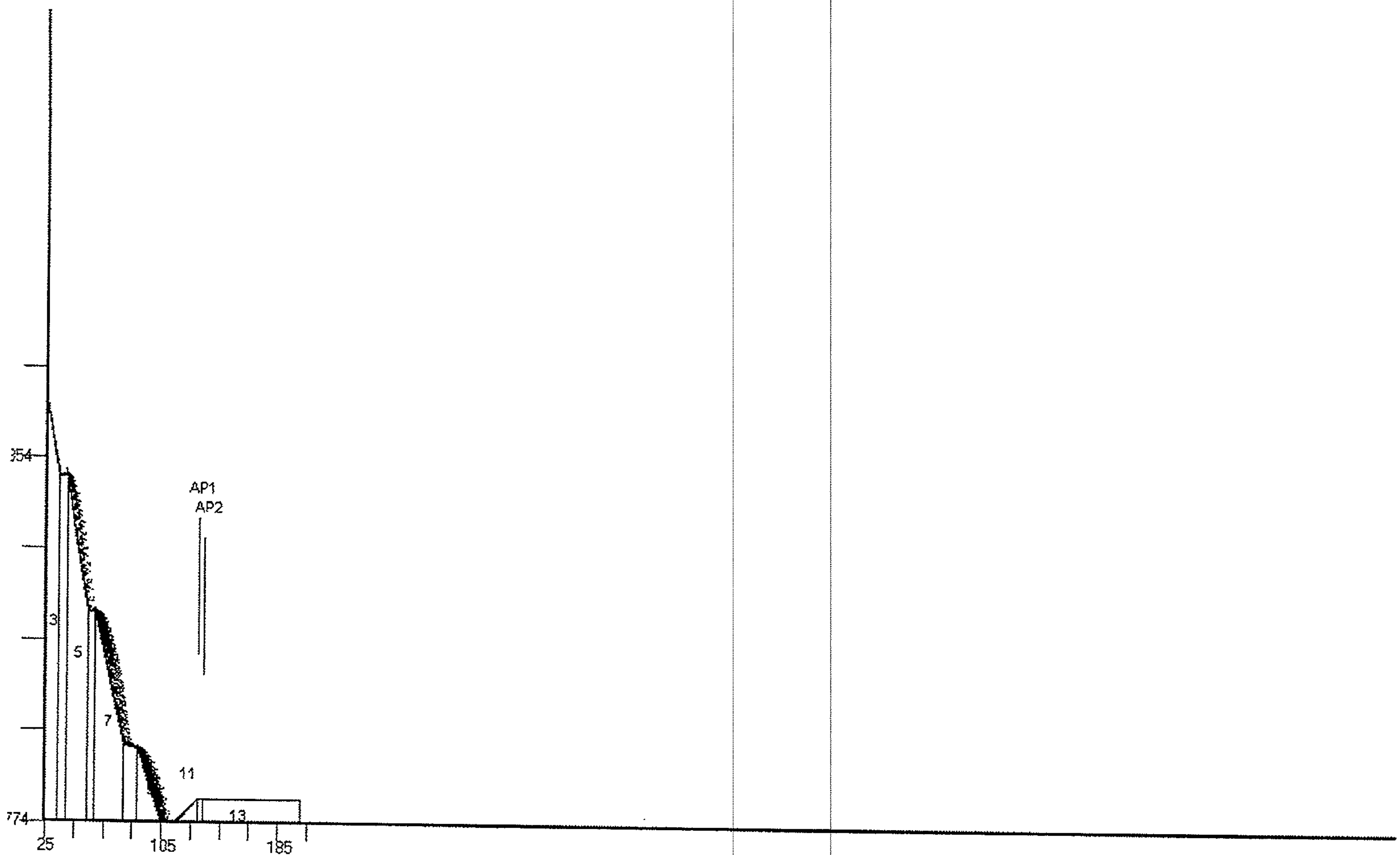
Ending Cell Number: 13

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft



AP1
AP2
3
5
7
11
13
354
774
25
105
185

Analysis Point 1

Analysis Point 1: X = 130, Y = 779

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: Sta. 523+44.52 (RT) - Ramp A: End of Construction with Max Rock Size

Analysis Point 2

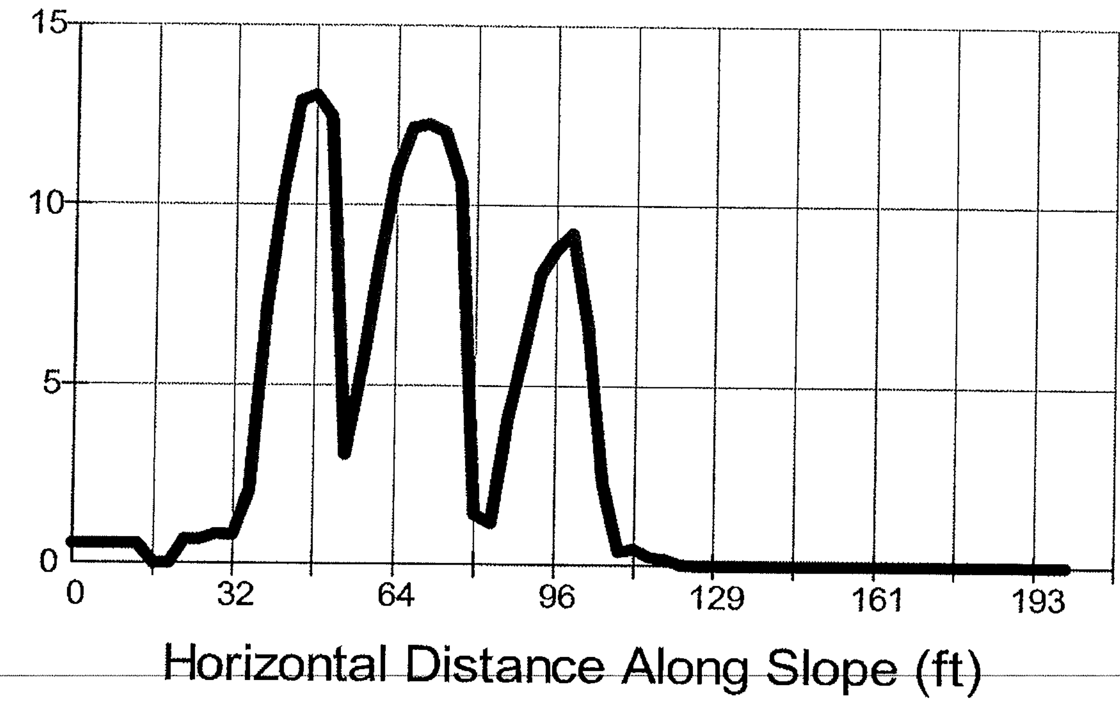
Analysis Point 2: X = 134, Y = 779

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

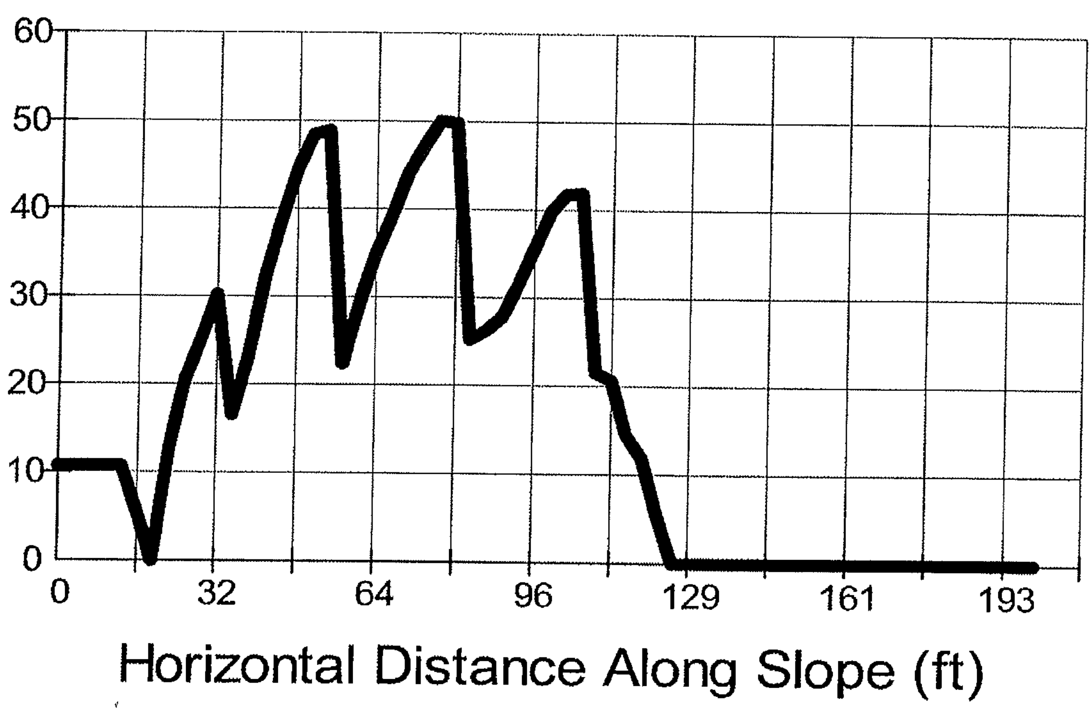
NO ROCKS PAST ANALYSIS POINT 2

Remarks: Sta. 523+44.52 (RT) - Ramp A: End of Construction with Max Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



Velocity Units: ft/sec Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	6	4	.62	0	-1
2	No rocks	past end of cell			
3	27	18	5.52	1	0
4	15	10	2.78	0	0
5	45	28	9.16	12	0
6	20	12	4.13	0	0
7	46	31	8.67	11	1
8	24	16	4.35	1	0
9	38	29	5.25	9	1
10	20	14	3.18	0	0
11	No rocks	past end of cell			
12	No rocks	past end of cell			
13	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	22
10 To 20 ft	30
20 To 30 ft	0
30 To 40 ft	15
40 To 50 ft	0
50 To 60 ft	16
60 To 70 ft	0
70 To 80 ft	2
80 To 90 ft	24
90 To 100 ft	40
100 To 110 ft	7
110 To 120 ft	154
120 To 130 ft	190
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 10
Analysis Point X-Coordinate 1: 130
Analysis Point X-Coordinate 2: 134
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 875
Initial Y-Base Starting Zone Coordinate: 779
Remarks: Sta. 523+44.52 (RT) - Ramp A: Long-Term with Avg. Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.21	.8	.18	0	875	15	867
2	.21	.8	.18	15	867	25	866
3	.21	.8	.18	25	866	79	791
4	.3	.68	.15	79	791	89	790
5	.3	.68	.15	89	790	105	774
6	.3	.68	.15	105	774	115	774
7	.3	.68	.15	115	774	130	779
8	.3	.68	.15	130	779	134	779
9	.1	.9	.9	134	779	160	779
10	.1	.9	.9	160	779	200	779

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 1

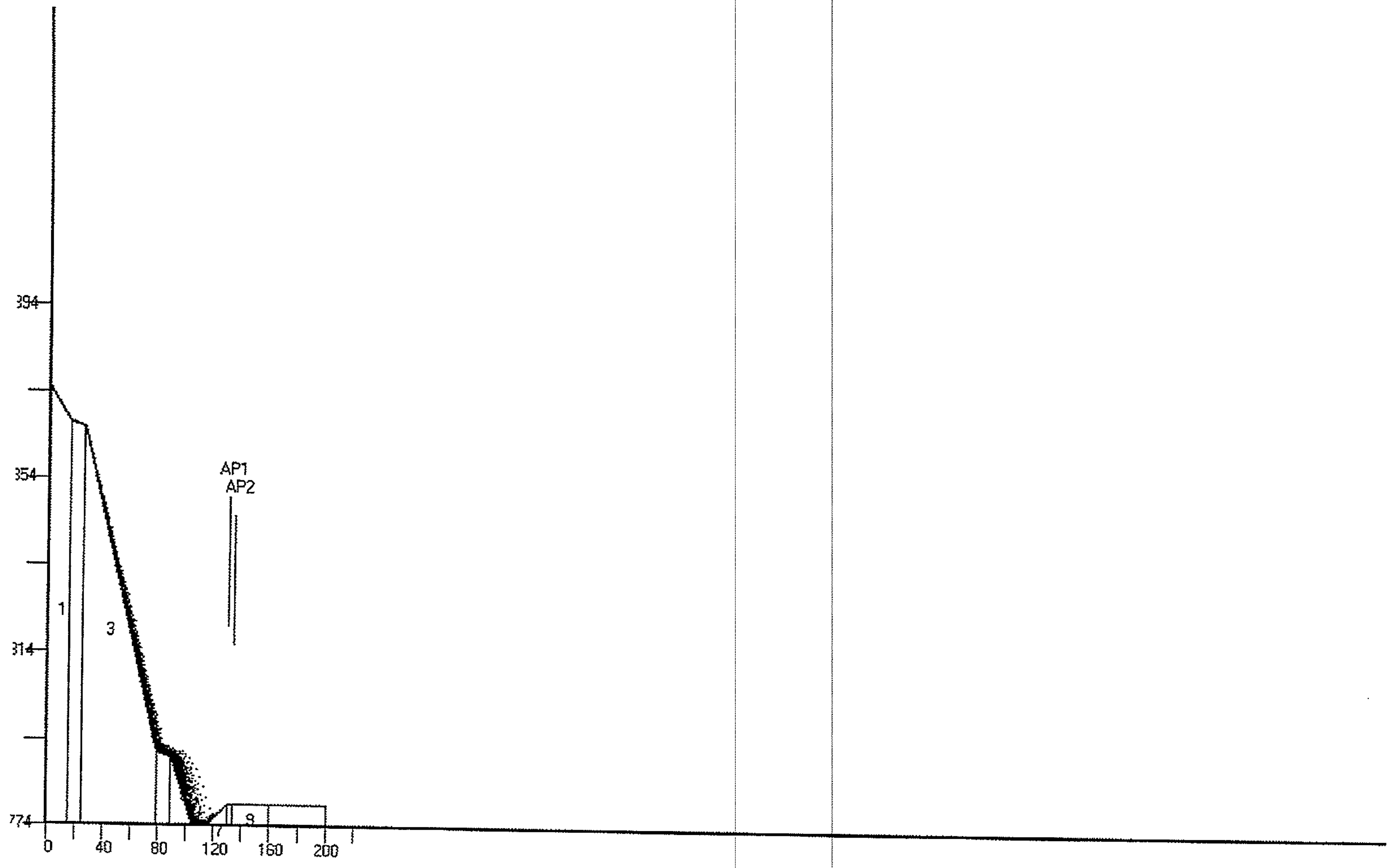
Ending Cell Number: 10

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft


394
354
314
774
0
40
80
120
160
200
1
3
7
9
AP1
AP2

Analysis Point 1

Analysis Point 1: X = 130, Y = 779

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: Sta. 523+44.52 (RT) - Ramp A: Long-Term with Avg. Rock Size

Analysis Point 2

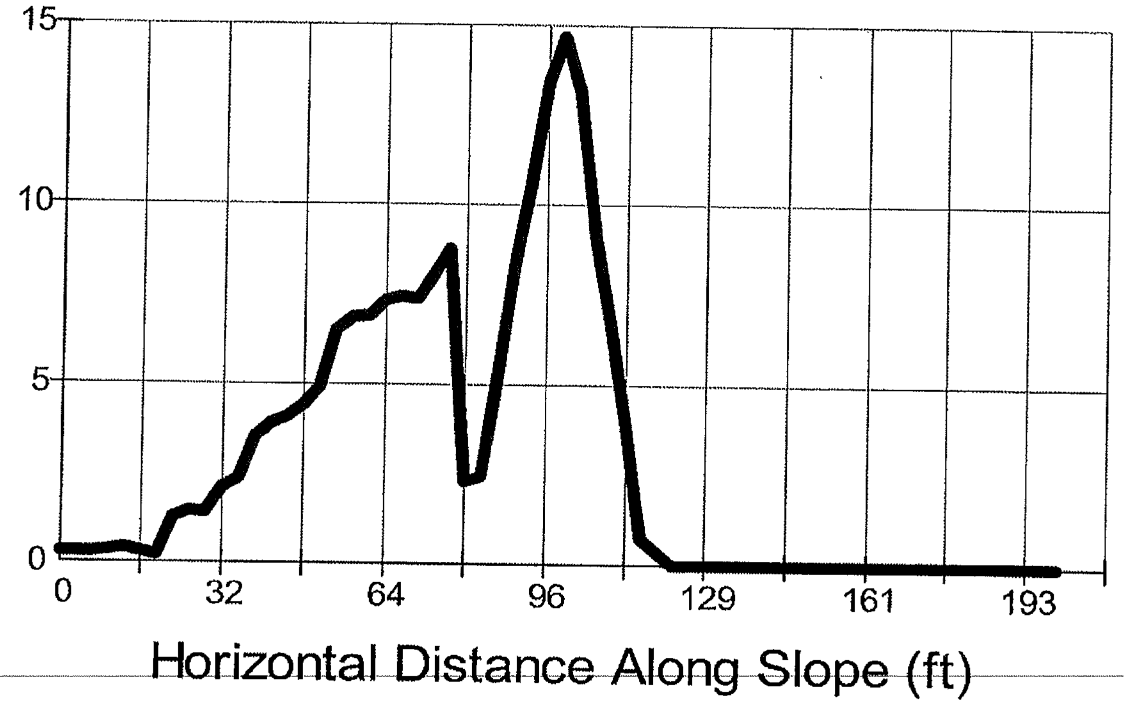
Analysis Point 2: X = 134, Y = 779

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

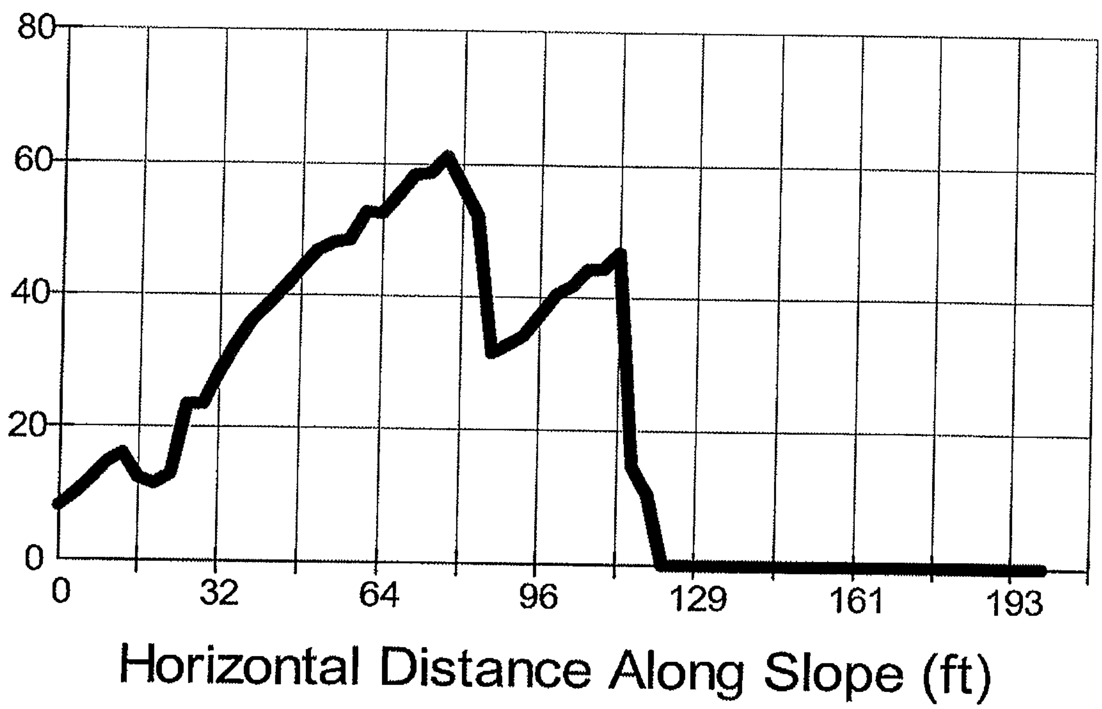
NO ROCKS PAST ANALYSIS POINT 2

Remarks: Sta. 523+44.52 (RT) - Ramp A: Long-Term with Avg. Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	14	9	3.1	0	0
2	7	5	1.38	0	0
3	60	34	11.41	8	1
4	30	14	5.89	2	0
5	39	25	6.44	15	1
6	39	10	5.07	7	0
7	No rocks	past end of cell			
8	No rocks	past end of cell			
9	No rocks	past end of cell			
10	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	18
10 To 20 ft	16
20 To 30 ft	8
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	6
80 To 90 ft	73
90 To 100 ft	0
100 To 110 ft	40
110 To 120 ft	322
120 To 130 ft	17
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 10
Analysis Point X-Coordinate 1: 130
Analysis Point X-Coordinate 2: 134
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 875
Initial Y-Base Starting Zone Coordinate: 779
Remarks: Sta. 523+44.52 (RT) - Ramp A: Long-Term with Max Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.21	.8	.18	0	875	15	867
2	.21	.8	.18	15	867	25	866
3	.21	.8	.18	25	866	79	791
4	.3	.68	.15	79	791	89	790
5	.3	.68	.15	89	790	105	774
6	.3	.68	.15	105	774	115	774
7	.3	.68	.15	115	774	130	779
8	.3	.68	.15	130	779	134	779
9	.1	.9	.9	134	779	160	779
10	.1	.9	.9	160	779	200	779

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 1

Ending Cell Number: 10

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft

394
354
314
274
0
40
80
120
160
200
1
3
7
9
AP1
AP2

Analysis Point 1

Analysis Point 1: X = 130, Y = 779

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: Sta. 523+44.52 (RT) - Ramp A: Long-Term with Max Rock Size

Analysis Point 2

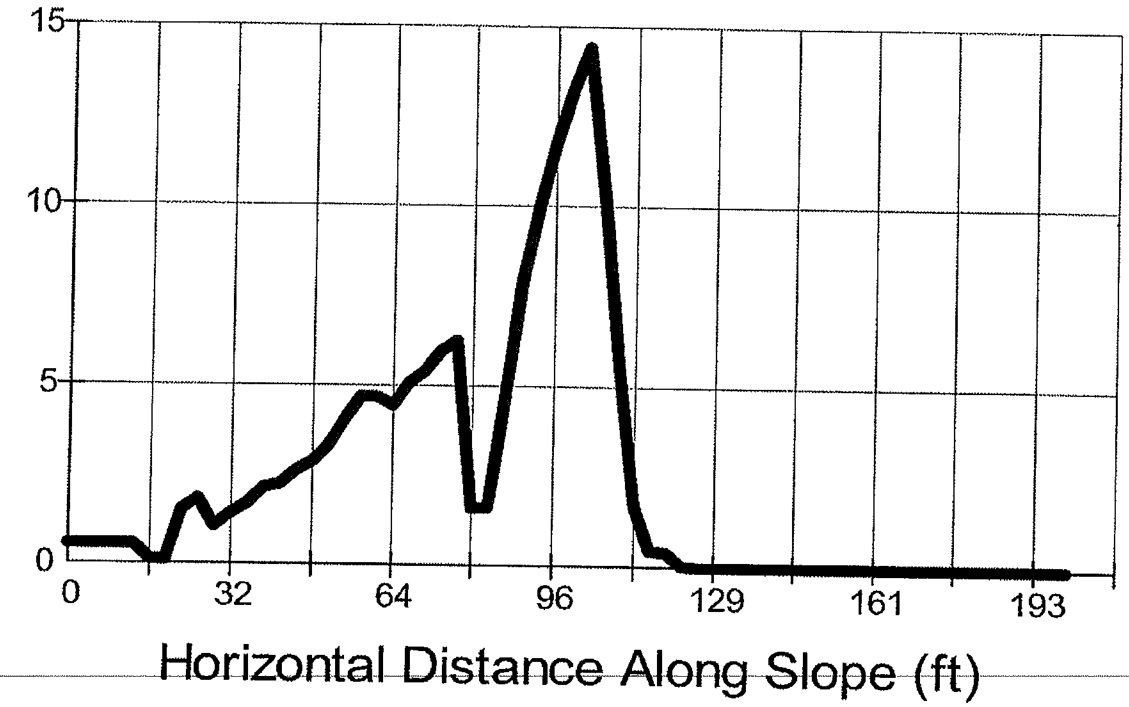
Analysis Point 2: X = 134, Y = 779

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

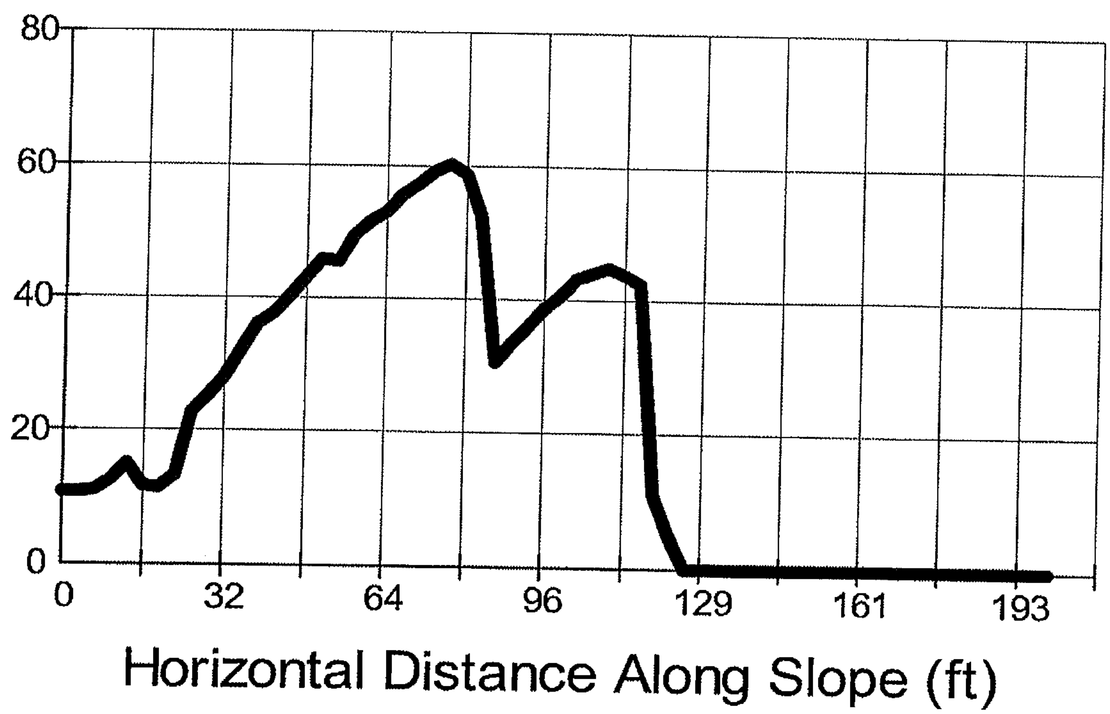
NO ROCKS PAST ANALYSIS POINT 2

Remarks: Sta. 523+44.52 (RT) - Ramp A: Long-Term with Max Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



Velocity Units: ft/sec Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	14	9	2.52	0	-1
2	9	6	1.32	0	-1
3	58	35	11.6	6	1
4	30	16	5.65	1	0
5	39	27	6.19	13	2
6	41	11	4.51	6	0
7	No rocks	past end of cell			
8	No rocks	past end of cell			
9	No rocks	past end of cell			
10	No rocks	past end of cell			

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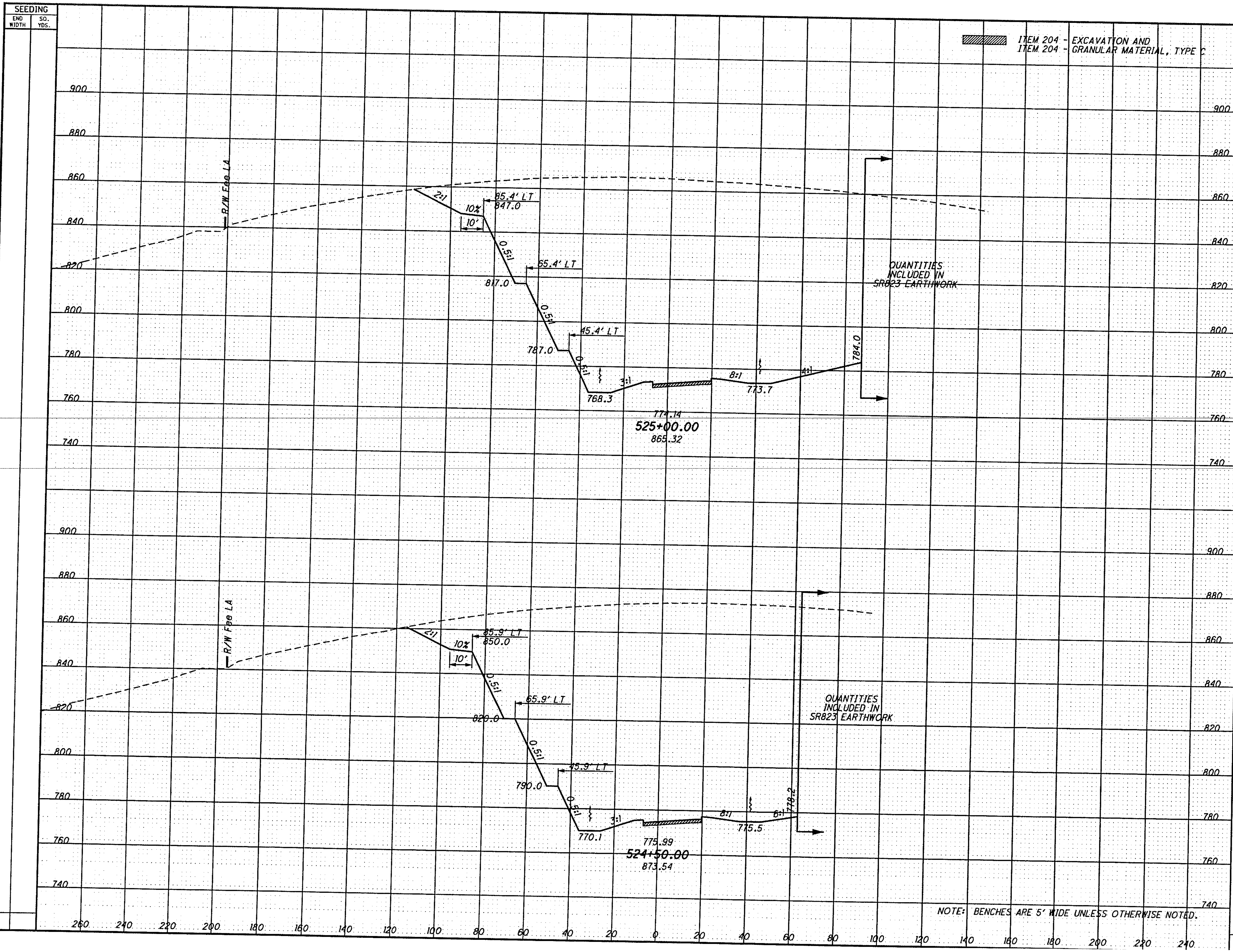
X Interval	Rocks Stopped
0 To 10 ft	11
10 To 20 ft	16
20 To 30 ft	10
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	3
80 To 90 ft	34
90 To 100 ft	0
100 To 110 ft	14
110 To 120 ft	346
120 To 130 ft	66
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

CR 28 Ramp D
Sta. 524+50 LT



CALCULATED

CHECKED

CROSS SECTIONS - CR28 RAMP D
STA. 524+50.00 TO STA. 525+00.00

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/27/2009 2:40:34 PM REVISION DATE: 7/27/2009
FILE: ...008594/00000000004587B /1945xs020.dgn MODEL: XS_SHEET_temporary_model_name_1

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 12
Analysis Point X-Coordinate 1: 98
Analysis Point X-Coordinate 2: 102
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 862
Initial Y-Base Starting Zone Coordinate: 776
Remarks: Sta. 524+50.0 - Ramp D: End of Construction with Avg. Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.14	.75	.18	0	862	18	853
2	.14	.75	.18	18	853	28	852
3	.14	.75	.18	28	852	34	840
4	.12	.85	.2	34	840	44	820
5	.12	.85	.2	44	820	49	820
6	.12	.85	.2	49	820	64	790
7	.12	.85	.2	64	790	69	790
8	.12	.85	.2	69	790	73	771
9	.12	.85	.2	73	771	83	771
10	.12	.85	.2	83	771	98	776
11	.12	.85	.2	98	776	102	776
12	.1	.9	.9	102	776	200	776

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

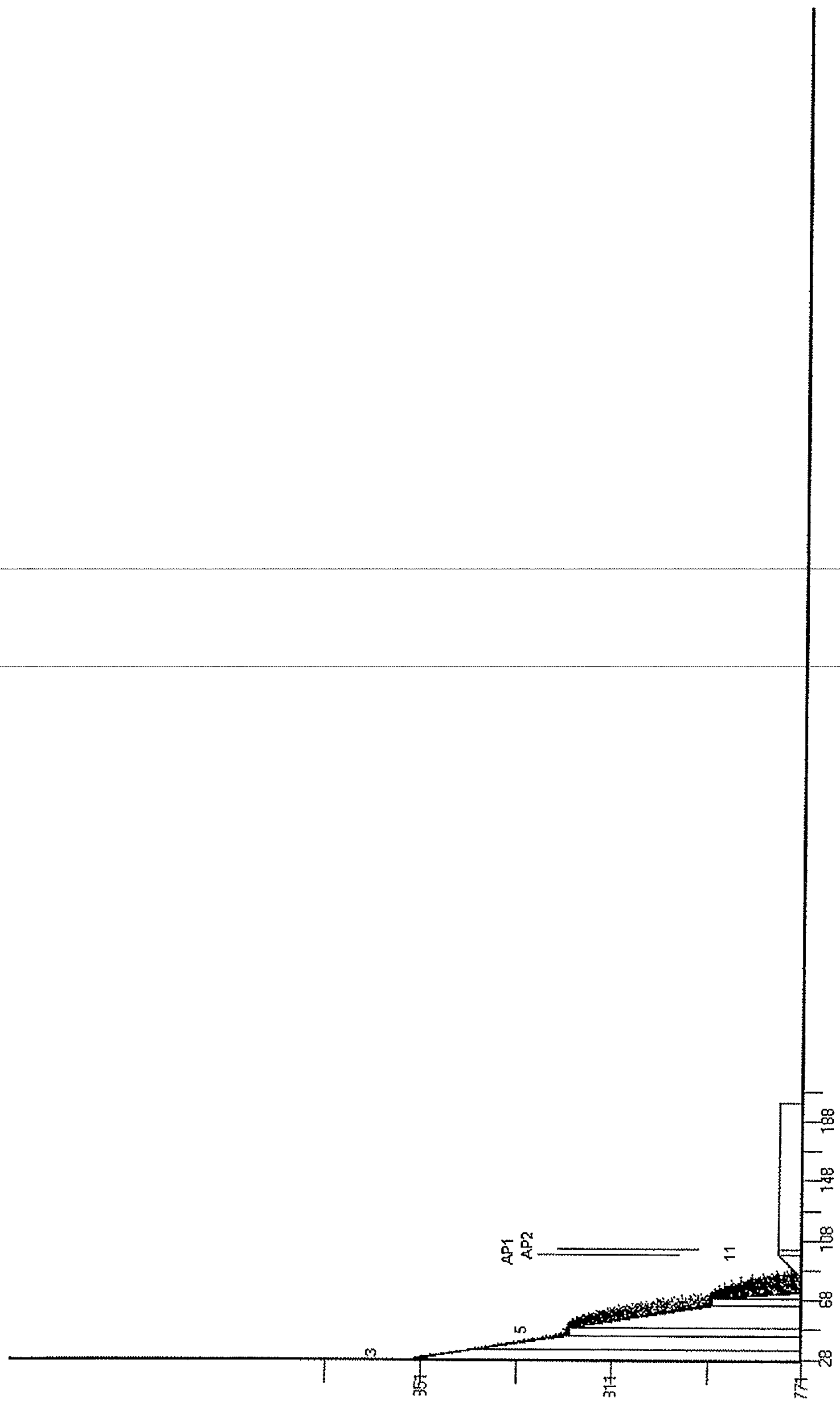
Ending Cell Number: 12

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft



AP1
AP2
3
5
11
28
68
108
148
188
771
314
351

Analysis Point 1

Analysis Point 1: X = 98, Y = 776

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: Sta. 524+50.0 - Ramp D: End of Construction with Avg. Rock Size

Analysis Point 2

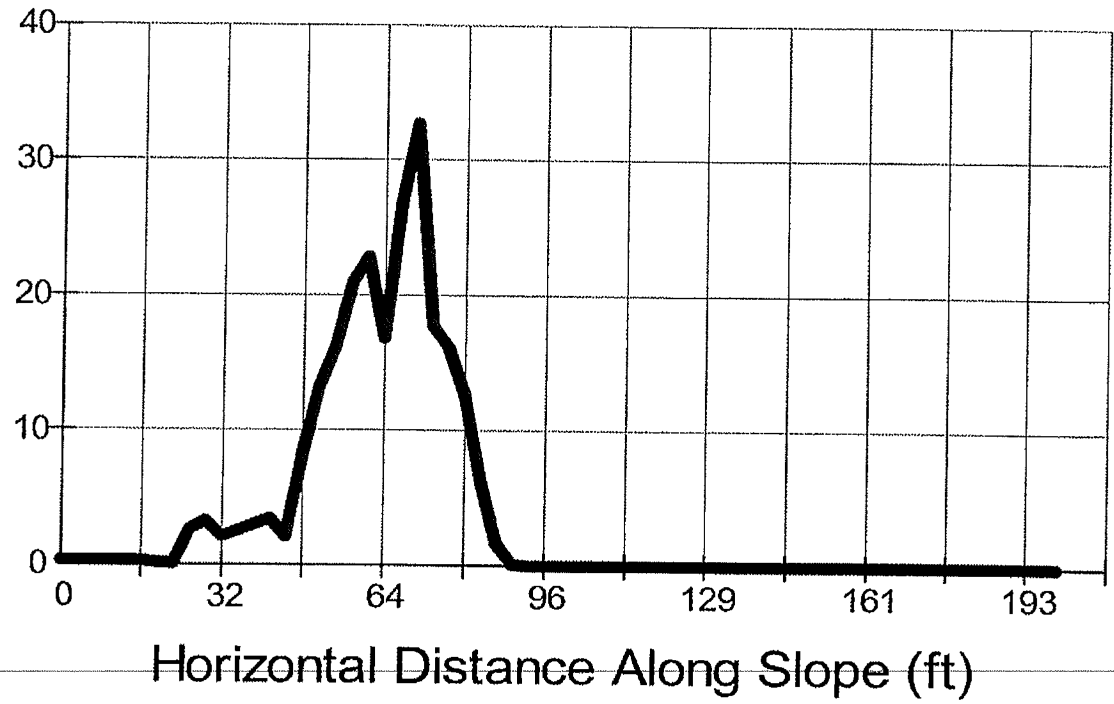
Analysis Point 2: X = 102, Y = 776

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

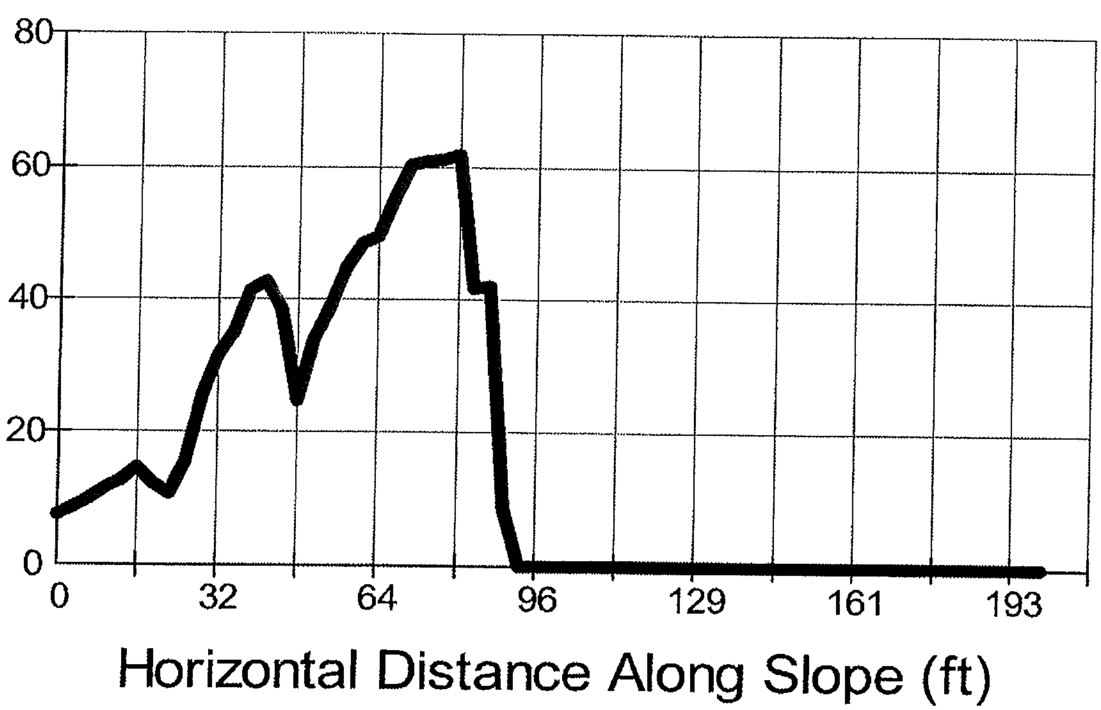
NO ROCKS PAST ANALYSIS POINT 2

Remarks: Sta. 524+50.0 - Ramp D: End of Construction with Avg. Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	11	8	2.61	0	0
2	8	6	1.65	0	-1
3	28	16	5.03	2	0
4	39	25	8.43	3	0
5	20	11	3.97	1	0
6	46	30	9.01	23	2
7	46	13	8.44	16	0
8	55	22	7.37	28	12
9	56	18	13.8	14	2
10	No rocks	past end of cell			
11	No rocks	past end of cell			
12	No rocks	past end of cell			

)9 Projects\212 - 000000000045878 - Portsmouth Bypass (Phase 2)\06.00 Proj_Engr\Design\CRSP\Sta 524

X Interval	Rocks Stopped
0 To 10 ft	22
10 To 20 ft	22
20 To 30 ft	10
30 To 40 ft	0
40 To 50 ft	25
50 To 60 ft	0
60 To 70 ft	29
70 To 80 ft	114
80 To 90 ft	262
90 To 100 ft	16
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 12
Analysis Point X-Coordinate 1: 98
Analysis Point X-Coordinate 2: 102
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 862
Initial Y-Base Starting Zone Coordinate: 776
Remarks: Sta. 524+50.0 - Ramp D: End of Construction with Max Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.14	.75	.18	0	862	18	853
2	.14	.75	.18	18	853	28	852
3	.14	.75	.18	28	852	34	840
4	.12	.85	.2	34	840	44	820
5	.12	.85	.2	44	820	49	820
6	.12	.85	.2	49	820	64	790
7	.12	.85	.2	64	790	69	790
8	.12	.85	.2	69	790	73	771
9	.12	.85	.2	73	771	83	771
10	.12	.85	.2	83	771	98	776
11	.12	.85	.2	98	776	102	776
12	.1	.9	.9	102	776	200	776

ects\2009 Projects\212 - 000000000045878 - Portsmouth Bypass (Phase 2)\06.00 Proj_Engr\Design\CRSP

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

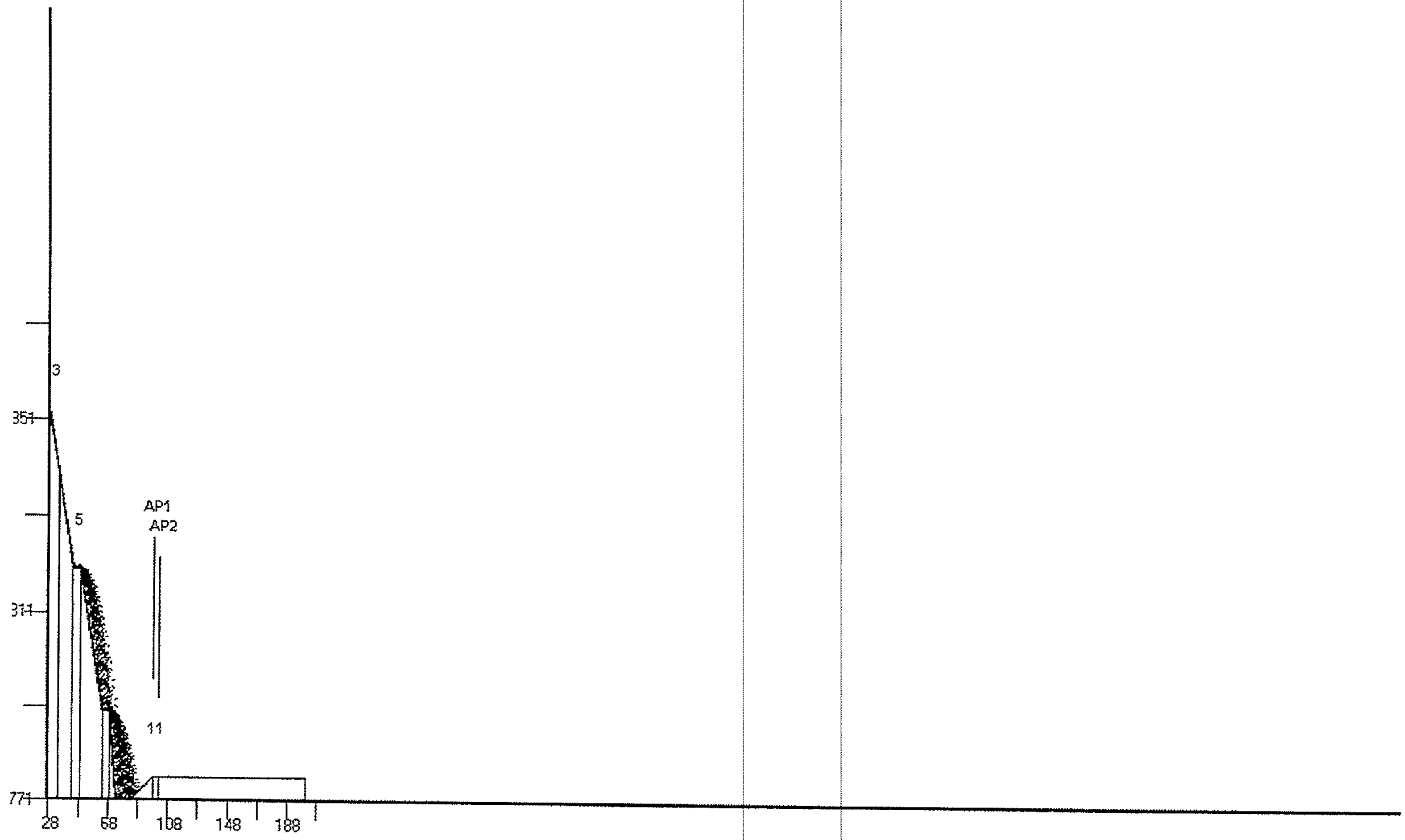
Ending Cell Number: 12

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft


3
5
AP1
AP2
11
351
311
771
28
68
108
148
188

Analysis Point 1

Analysis Point 1: X = 98, Y = 776

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: Sta. 524+50.0 - Ramp D: End of Construction with Max Rock Size

Analysis Point 2

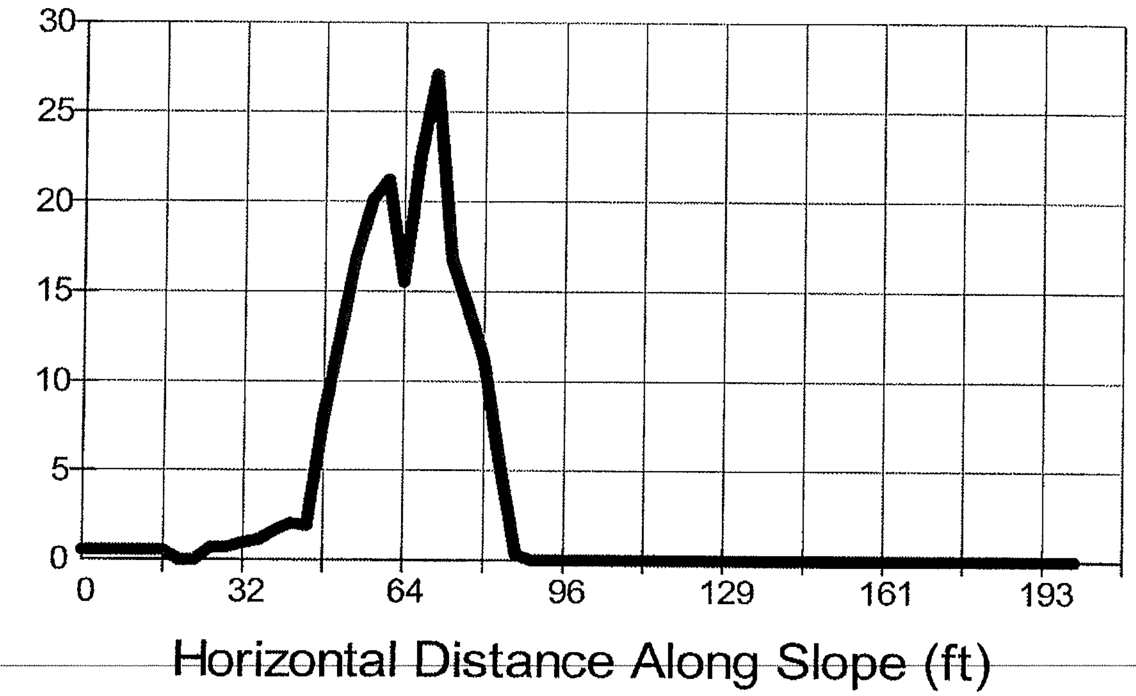
Analysis Point 2: X = 102, Y = 776

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

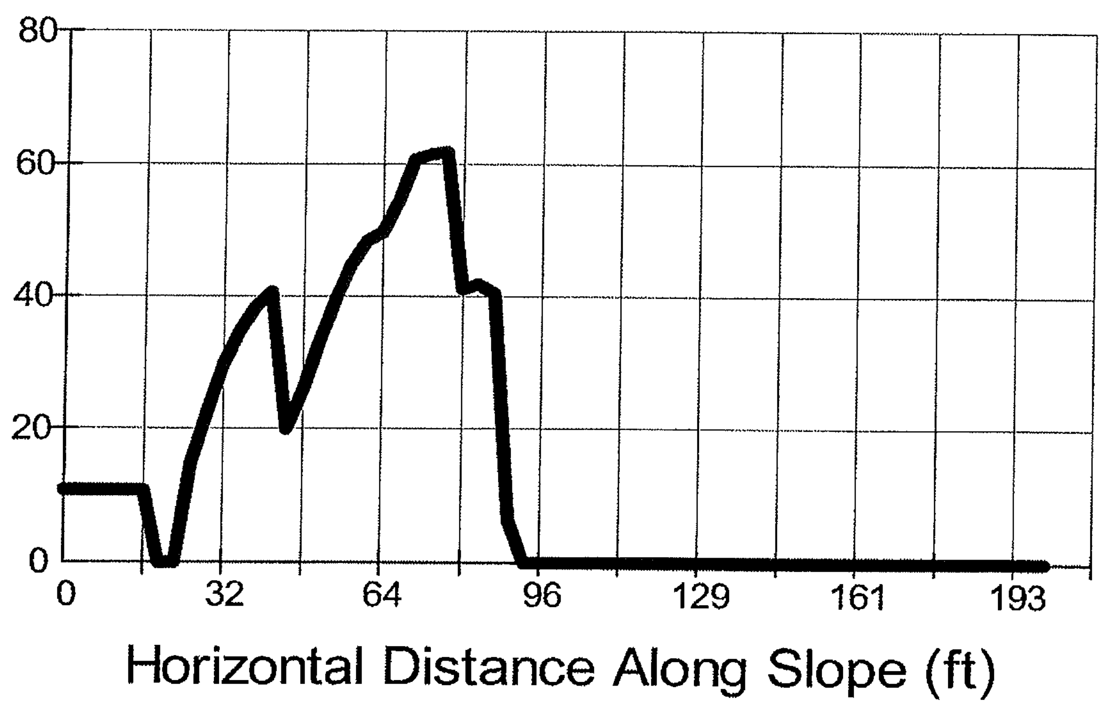
NO ROCKS PAST ANALYSIS POINT 2

Remarks: Sta. 524+50.0 - Ramp D: End of Construction with Max Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



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Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	5	4	0	0	0
2	No rocks	past end of cell			
3	25	16	4.72	1	0
4	38	25	8.06	2	0
5	20	12	3.81	0	0
6	45	30	8.81	21	3
7	47	16	11.06	13	0
8	54	23	9.89	23	12
9	38	18	13.36	12	2
10	No rocks	past end of cell			
11	No rocks	past end of cell			
12	No rocks	past end of cell			

s\2009 Projects\212 - 000000000045878 - Portsmouth Bypass (Phase 2)\06.00 Proj_Engr\Design\CRSP\St

X Interval	Rocks Stopped
0 To 10 ft	33
10 To 20 ft	26
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	18
50 To 60 ft	0
60 To 70 ft	22
70 To 80 ft	66
80 To 90 ft	311
90 To 100 ft	24
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 8
Analysis Point X-Coordinate 1: 98
Analysis Point X-Coordinate 2: 102
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 862
Initial Y-Base Starting Zone Coordinate: 776
Remarks: Sta. 524+50.0 - Ramp D: Long-Term with Average Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.28	.6	.15	0	862	18	853
2	.28	.6	.15	18	853	28	852
3	.28	.6	.15	28	852	36	840
4	.21	.8	.18	36	840	73	771
5	.21	.8	.18	73	771	83	771
6	.21	.8	.18	83	771	98	776
7	.21	.8	.18	98	776	102	776
8	.1	.9	.9	102	776	200	776

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

Ending Cell Number: 8

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft


3
351
311
771
AP1
AP2
7
5
28
68
108
148
188

Analysis Point 1

Analysis Point 1: X = 98, Y = 776

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 4

Velocity (ft/sec)

Maximum: 5.68
Average: 4.13
Minimum: 2.91
Std. Dev.: 0

Bounce Height (ft)

Maximum: .11
Average: .06
G. Mean: .04
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 115
Average: 63
Std. Dev.: 0

Remarks: Sta. 524+50.0 - Ramp D: Long-Term with Average Rock Size

Analysis Point 2

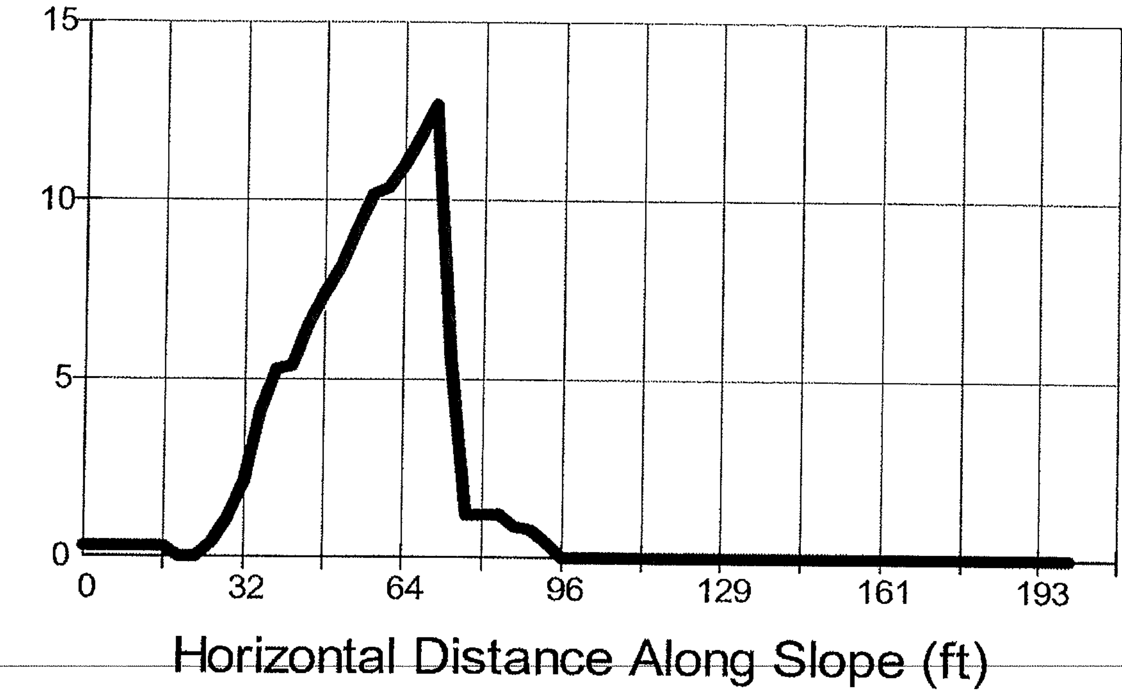
Analysis Point 2: X = 102, Y = 776

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

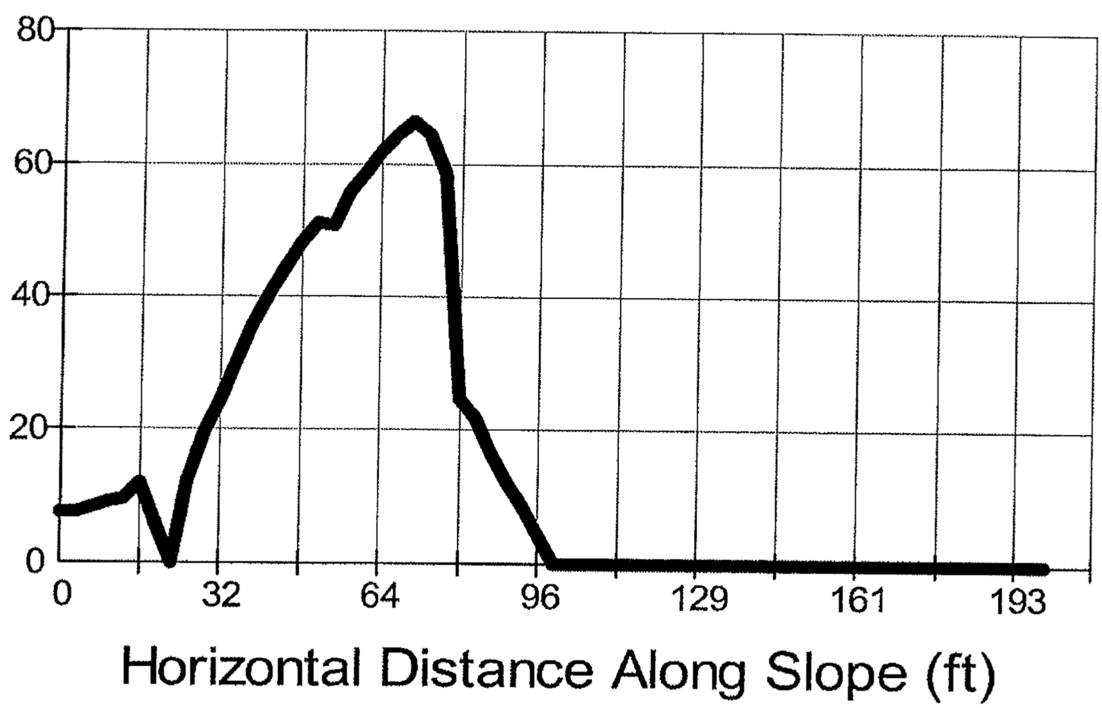
NO ROCKS PAST ANALYSIS POINT 2

Remarks: Sta. 524+50.0 - Ramp D: Long-Term with Average Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



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Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	9	6	1.53	0	0
2	No rocks	past end of cell			
3	23	14	4.47	2	0
4	64	38	10.97	12	3
5	24	12	4.82	1	0
6	5	5	0	0	0
7	No rocks	past end of cell			
8	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	31
10 To 20 ft	24
20 To 30 ft	4
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	47
80 To 90 ft	328
90 To 100 ft	65
100 To 110 ft	1
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 8
Analysis Point X-Coordinate 1: 98
Analysis Point X-Coordinate 2: 102
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 862
Initial Y-Base Starting Zone Coordinate: 776
Remarks: Sta. 524+50.0 - Ramp D: Long-Term with Max Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.28	.6	.15	0	862	18	853
2	.28	.6	.15	18	853	28	852
3	.28	.6	.15	28	852	36	840
4	.21	.8	.18	36	840	73	771
5	.21	.8	.18	73	771	83	771
6	.21	.8	.18	83	771	98	776
7	.21	.8	.18	98	776	102	776
8	.1	.9	.9	102	776	200	776

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

Ending Cell Number: 8

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft

3
351
AP1
AP2
311
7
5
771
28
68
108
148
188

Analysis Point 1

Analysis Point 1: X = 98, Y = 776

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 2

Velocity (ft/sec)

Maximum: 7.16
Average: 7.09
Minimum: 7.02
Std. Dev.: 0

Bounce Height (ft)

Maximum: .12
Average: .12
G. Mean: .12
Std. Dev.: 1

Kinetic Energy (ft-lb)

Maximum: 599
Average: 553
Std. Dev.: 0

Remarks: Sta. 524+50.0 - Ramp D: Long-Term with Max Rock Size

Analysis Point 2

Analysis Point 2: X = 102, Y = 776

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 2

Velocity (ft/sec)

Maximum: 5.7
Average: 4.88
Minimum: 4.07
Std. Dev.: 0

Bounce Height (ft)

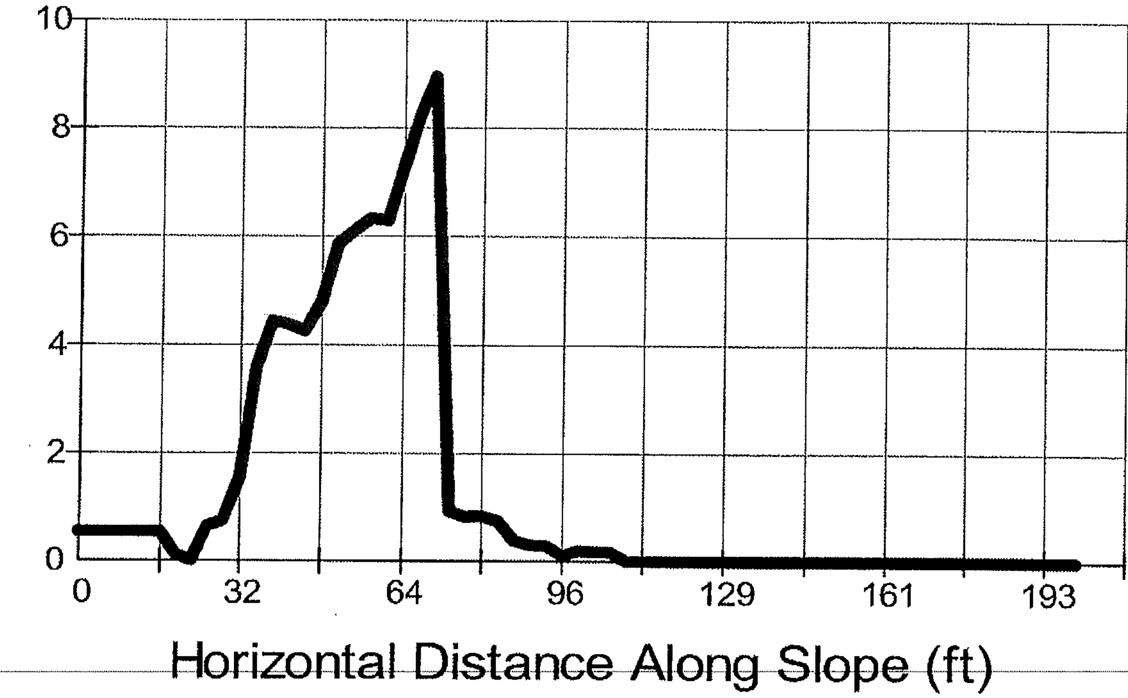
Maximum: .02
Average: .02
G. Mean: .02
Std. Dev.: 1

Kinetic Energy (ft-lb)

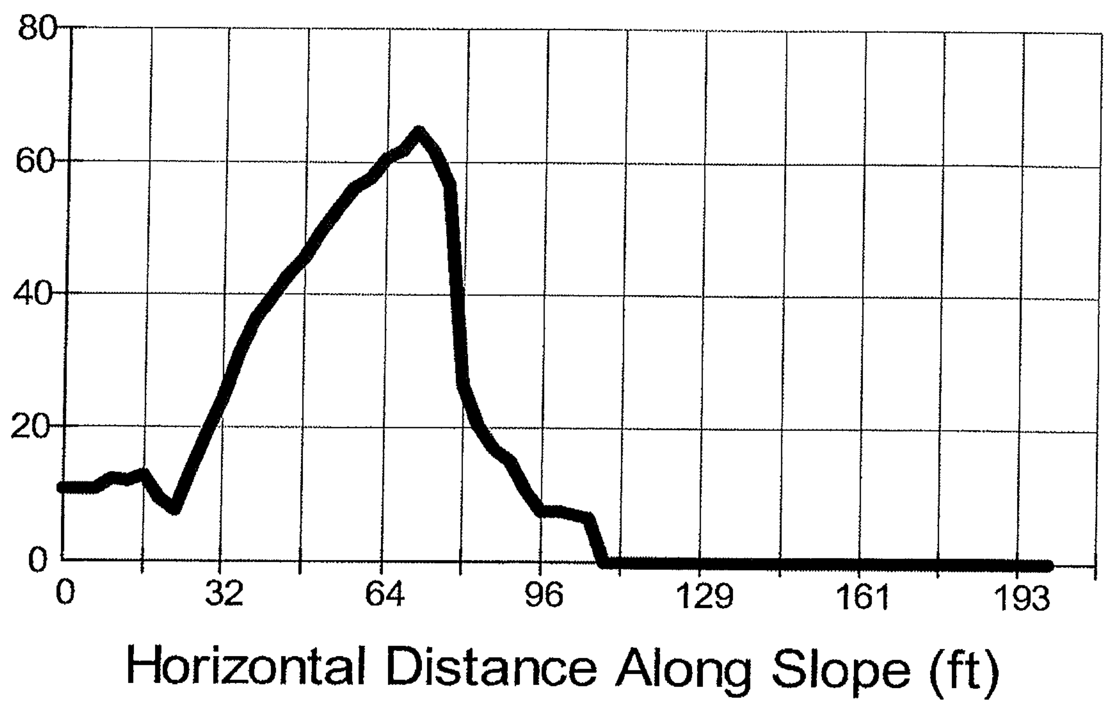
Maximum: 313
Average: 236
Std. Dev.: 0

Remarks: Sta. 524+50.0 - Ramp D: Long-Term with Max Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH

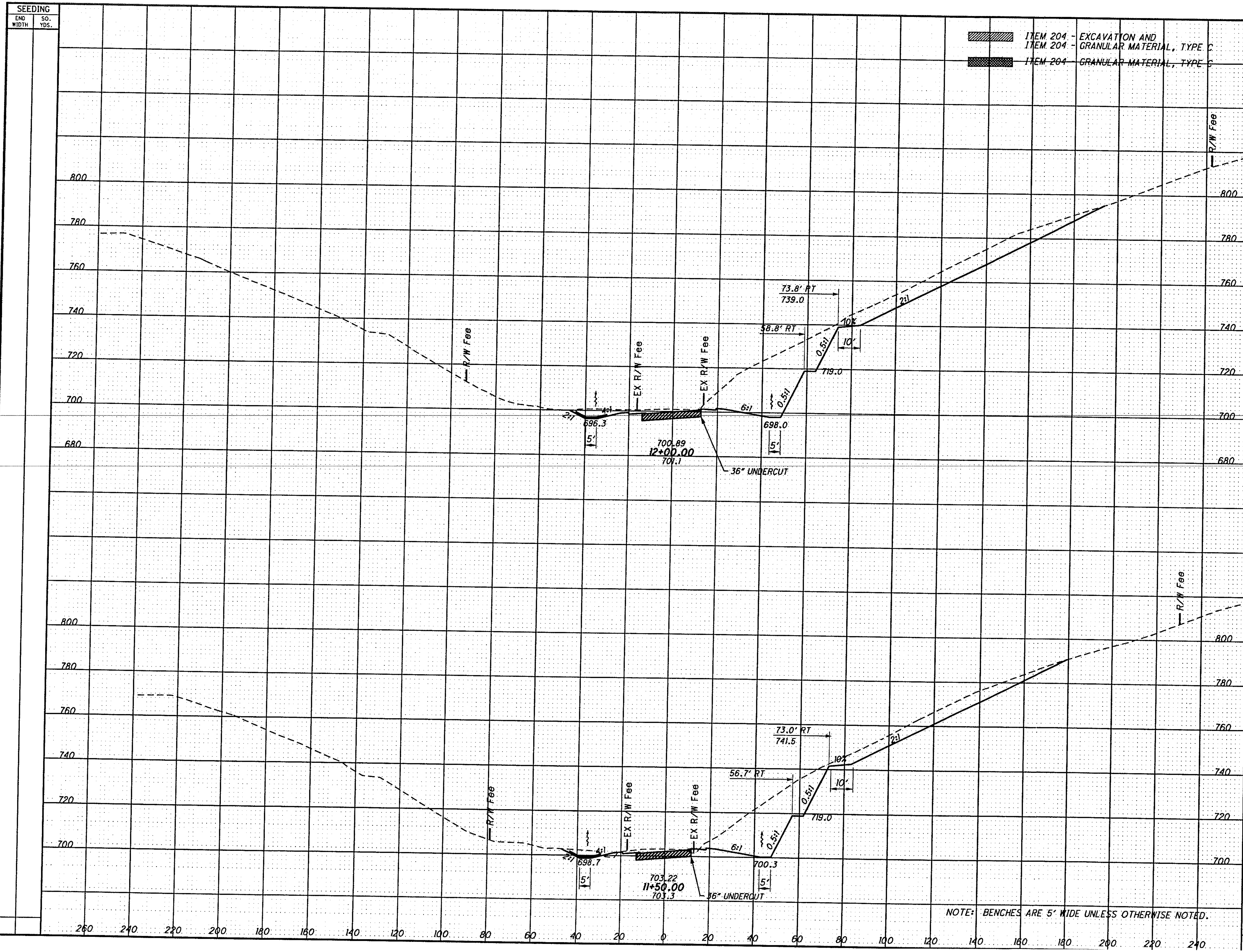


Velocity Units: ft/sec Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	11	7	1.97	0	0
2	No rocks	past end of cell			
3	22	15	4.24	1	0
4	61	39	10.74	8	1
5	25	13	4.47	1	0
6	7	7	0	0	0
7	6	5	0	0	0
8	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	22
10 To 20 ft	23
20 To 30 ft	14
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	21
80 To 90 ft	282
90 To 100 ft	136
100 To 110 ft	1
110 To 120 ft	1
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	0

TR 234
Sta. 11+50 RT



CROSS SECTIONS - TR 234
STA. 11+50.00 TO STA. 12+00.00

CALCULATED
CHECKED

SCI-823-6.81

USER: mbotdorf PLOT DATE: 7/27/2009 2:40:59 PM REVISION DATE: 7/27/2009

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 9
Analysis Point X-Coordinate 1: 173
Analysis Point X-Coordinate 2: 177
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 792
Initial Y-Base Starting Zone Coordinate: 704
Remarks: Sta ~~12+00~~.0 11+50 - TR 234: End of Construction with ~~Max~~ Avg. Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.12	.85	.2	0	792	115	742
2	.12	.85	.2	115	742	125	742
3	.12	.85	.2	125	742	137	719
4	.12	.85	.2	137	719	142	719
5	.12	.85	.2	142	719	152	700
6	.12	.85	.2	152	700	157	700
7	.12	.85	.2	157	700	178	704
8	.12	.85	.2	178	704	182	704
9	.1	.9	.9	182	704	220	704

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

Ending Cell Number: 9

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft


740
700
3
AP1
AP2
9
125
165
205

Analysis Point 1

Analysis Point 1: X = 173, Y = 703

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: Sta ~~12+00.0~~ 11+50 - TR 234: End of Construction with ~~Max~~ Avg Rock Size

Analysis Point 2

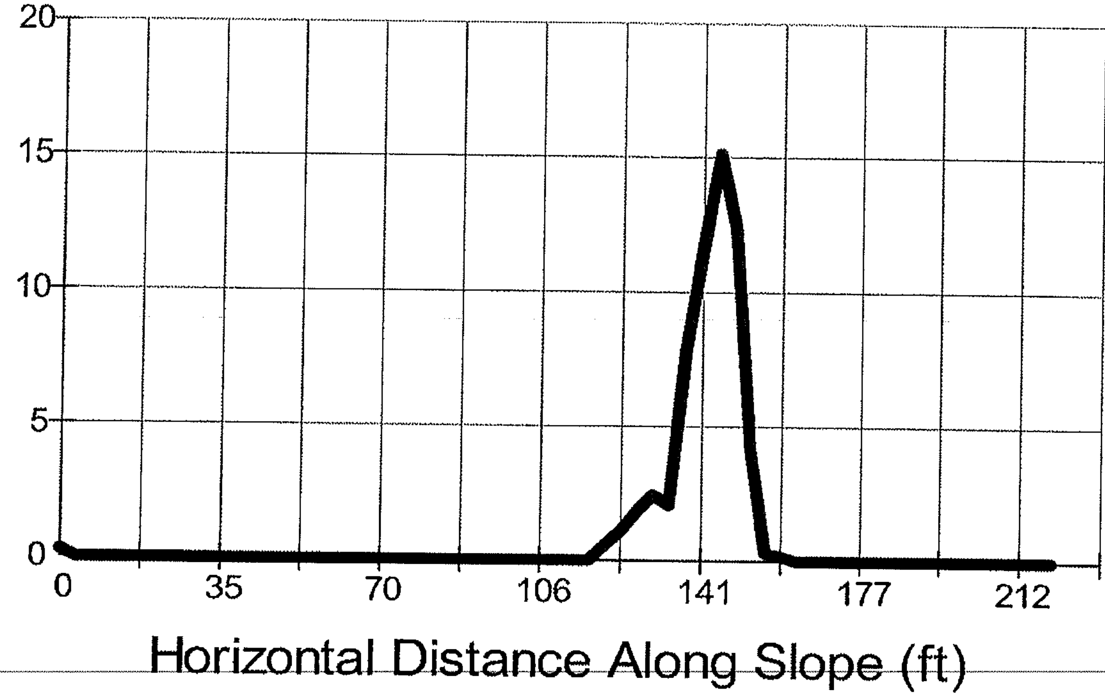
Analysis Point 2: X = 177, Y = 704

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

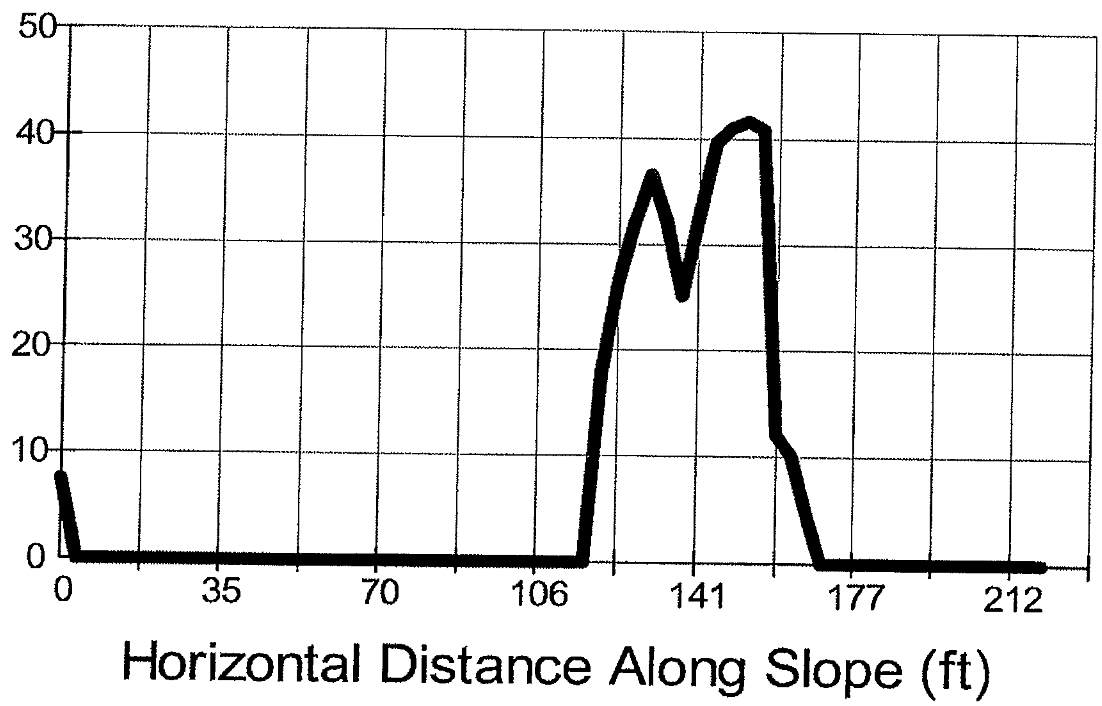
NO ROCKS PAST ANALYSIS POINT 2

Remarks: Sta ~~12+00.0~~ 11+50 - TR 234: End of Construction with ~~Max~~ Avg. Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	33	21	6.84	2	0
4	17	10	3.53	0	0
5	36	26	5.28	15	2
6	38	12	7.64	8	0
7	No rocks	past end of cell			
8	No rocks	past end of cell			
9	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	285
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	14
140 To 150 ft	10
150 To 160 ft	67
160 To 170 ft	123
170 To 180 ft	1
180 To 190 ft	0
190 To 200 ft	0
200 To 210 ft	0
210 To 220 ft	0

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 9
Analysis Point X-Coordinate 1: 173
Analysis Point X-Coordinate 2: 177
Analysis Point X-Coordinate 3: 0
Initial Y-Top Starting Zone Coordinate: 792
Initial Y-Base Starting Zone Coordinate: 704
Remarks: Sta ~~12+00.0~~ 114 50 - TR 234: End of Construction with Max Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.12	.85	.2	0	792	115	742
2	.12	.85	.2	115	742	125	742
3	.12	.85	.2	125	742	137	719
4	.12	.85	.2	137	719	142	719
5	.12	.85	.2	142	719	152	700
6	.12	.85	.2	152	700	157	700
7	.12	.85	.2	157	700	178	704
8	.12	.85	.2	178	704	182	704
9	.1	.9	.9	182	704	220	704

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

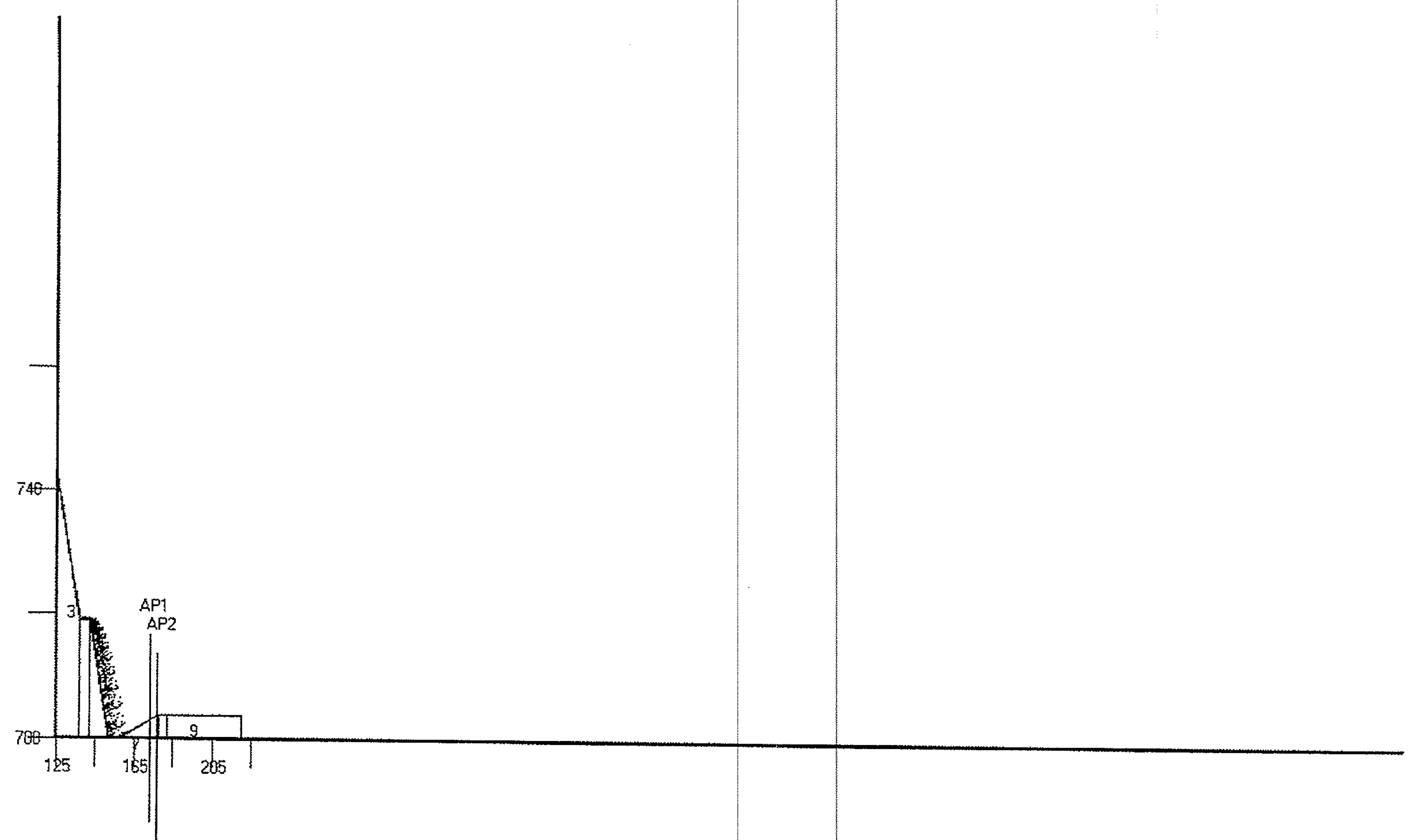
Ending Cell Number: 9

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft



740
700
3
AP1
AP2
9
125
165
205

Analysis Point 1

Analysis Point 1: X = 173, Y = 703

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

NO ROCKS PAST ANALYSIS POINT 1

Remarks: Sta 12+00.0 - TR 234: End of Construction with Max Rock Size
114.50

Analysis Point 2

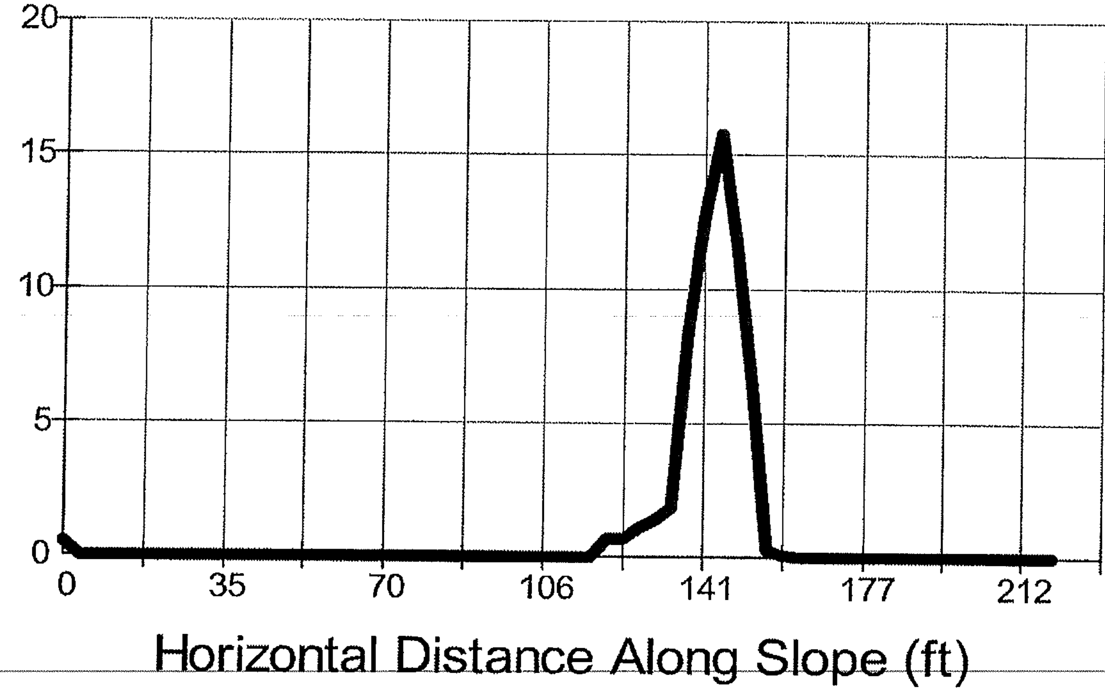
Analysis Point 2: X = 177, Y = 704

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

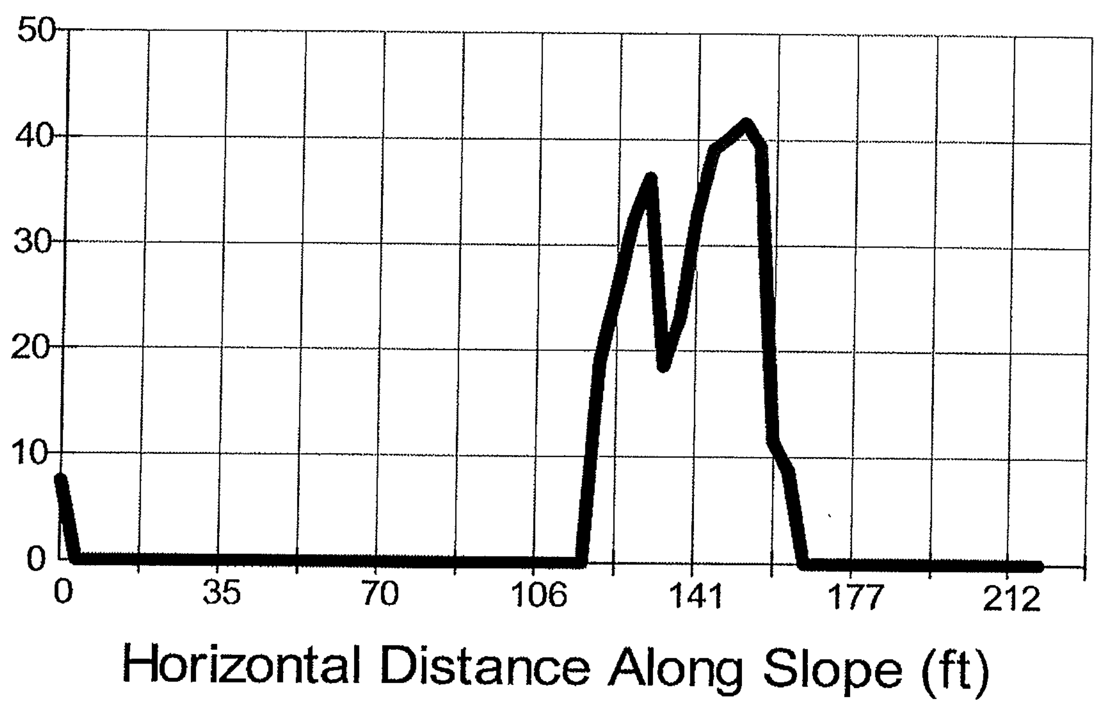
NO ROCKS PAST ANALYSIS POINT 2

Remarks: Sta ~~12+00.0~~ 11+50 - TR 234: End of Construction with Max Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



Velocity Units: ft/sec Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	34	21	6.68	1	0
4	18	11	3.4	0	0
5	36	26	5.11	15	3
6	38	13	8.2	8	0
7	No rocks	past end of cell			
8	No rocks	past end of cell			
9	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	285
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	10
140 To 150 ft	5
150 To 160 ft	48
160 To 170 ft	145
170 To 180 ft	7
180 To 190 ft	0
190 To 200 ft	0
200 To 210 ft	0
210 To 220 ft	0

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 7
Analysis Point X-Coordinate 1: 173
Analysis Point X-Coordinate 2: 177
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 792
Initial Y-Base Starting Zone Coordinate: 704
Remarks: Sta. 11+50.0 - TR 234: Long-Term with Average Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.21	.8	.18	0	792	115	743
2	.21	.8	.18	115	743	125	742
3	.21	.8	.18	125	742	152	700
4	.21	.8	.18	152	700	157	700
5	.21	.8	.18	157	700	178	704
6	.21	.8	.18	178	704	182	704
7	.21	.8	.18	182	704	220	704

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

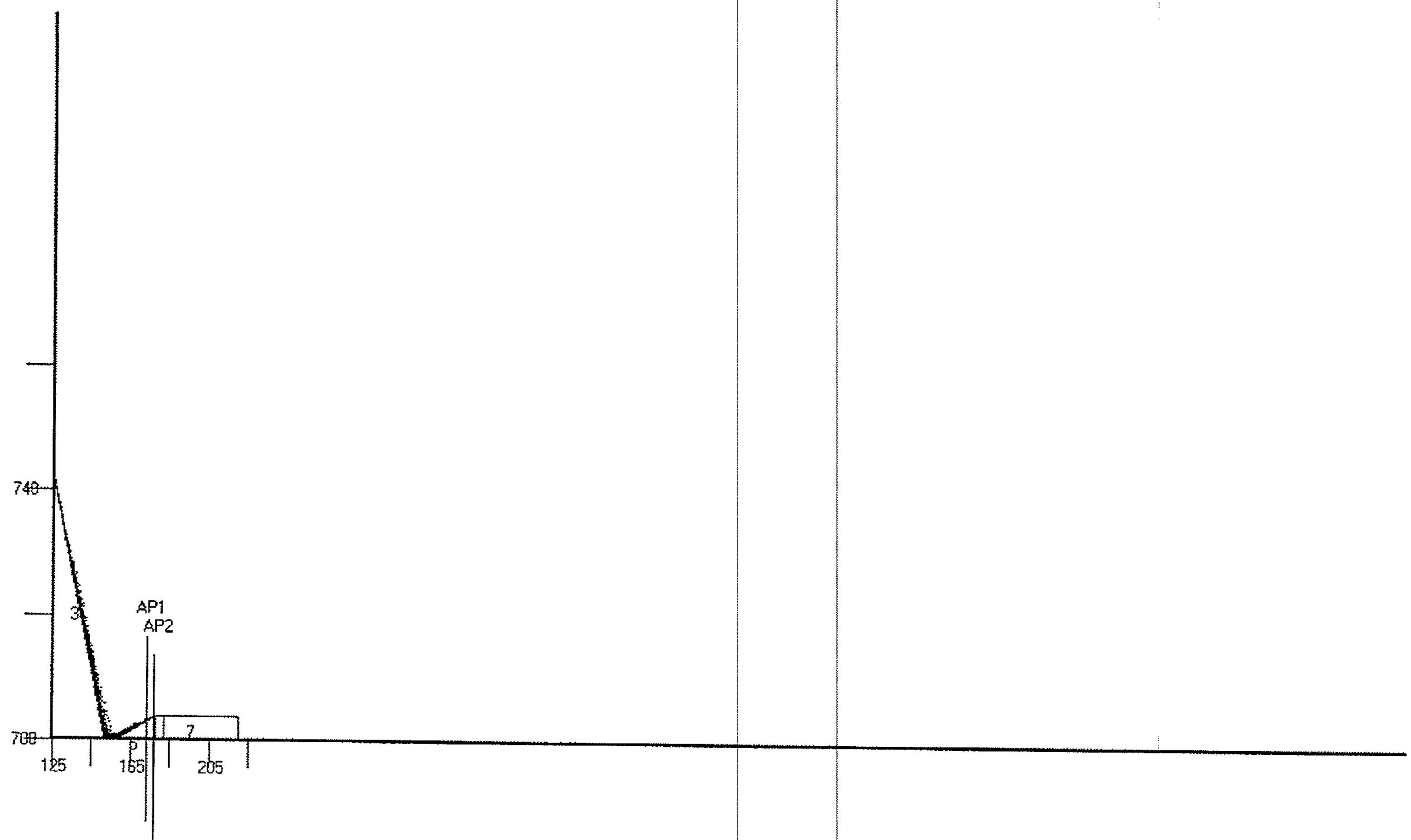
Ending Cell Number: 7

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1 ft

Thickness: 1 ft



740
700
125
165
205
AP1
AP2
3
7
P

Analysis Point 1

Analysis Point 1: X = 173, Y = 703

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 7

Velocity (ft/sec)

Maximum: 8.86
Average: 6.83
Minimum: 4.4
Std. Dev.: 1.66

Bounce Height (ft)

Maximum: .45
Average: .14
G. Mean: .08
Std. Dev.: 3.45

Kinetic Energy (ft-lb)

Maximum: 252
Average: 155
Std. Dev.: 73

Remarks: Sta. 11+50.0 - TR 234: Long-Term with Average Rock Size

Analysis Point 2

Analysis Point 2: X = 177, Y = 704

Discoidal Rock: 1-ft dia., 1-ft thick, 122-lb

Total Rocks Passing Analysis Point: 1

Velocity (ft/sec)

Maximum: 4.91
Average: 4.91
Minimum: 4.91
Std. Dev.: 0

Bounce Height (ft)

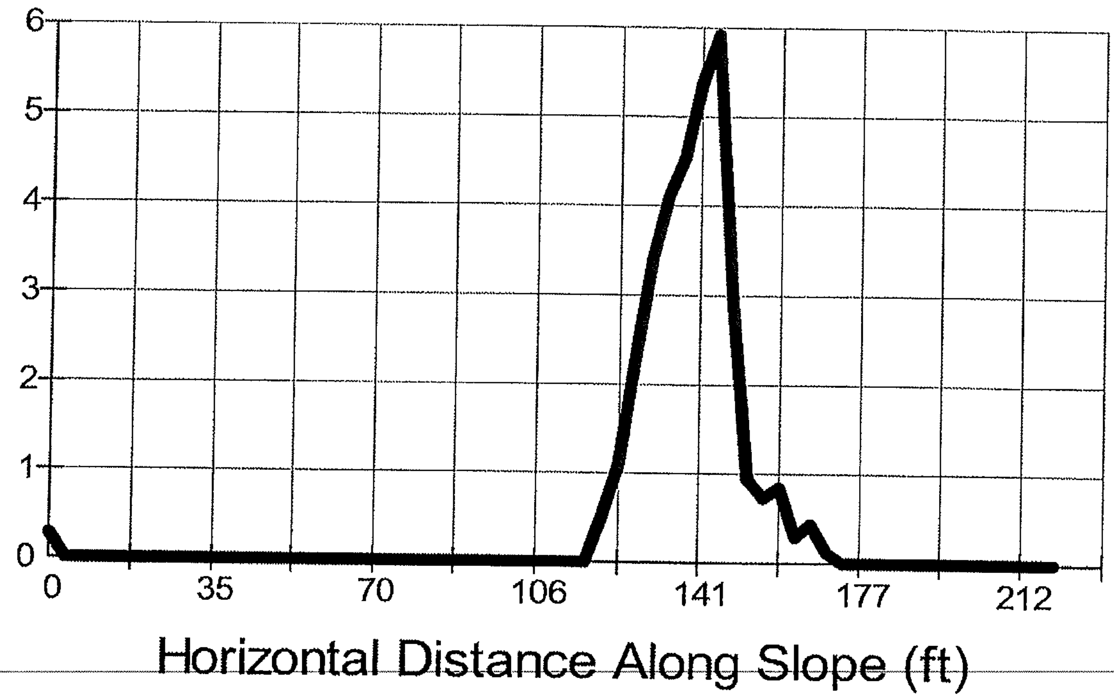
Maximum: .01
Average: .01
G. Mean: .01
Std. Dev.: 1

Kinetic Energy (ft-lb)

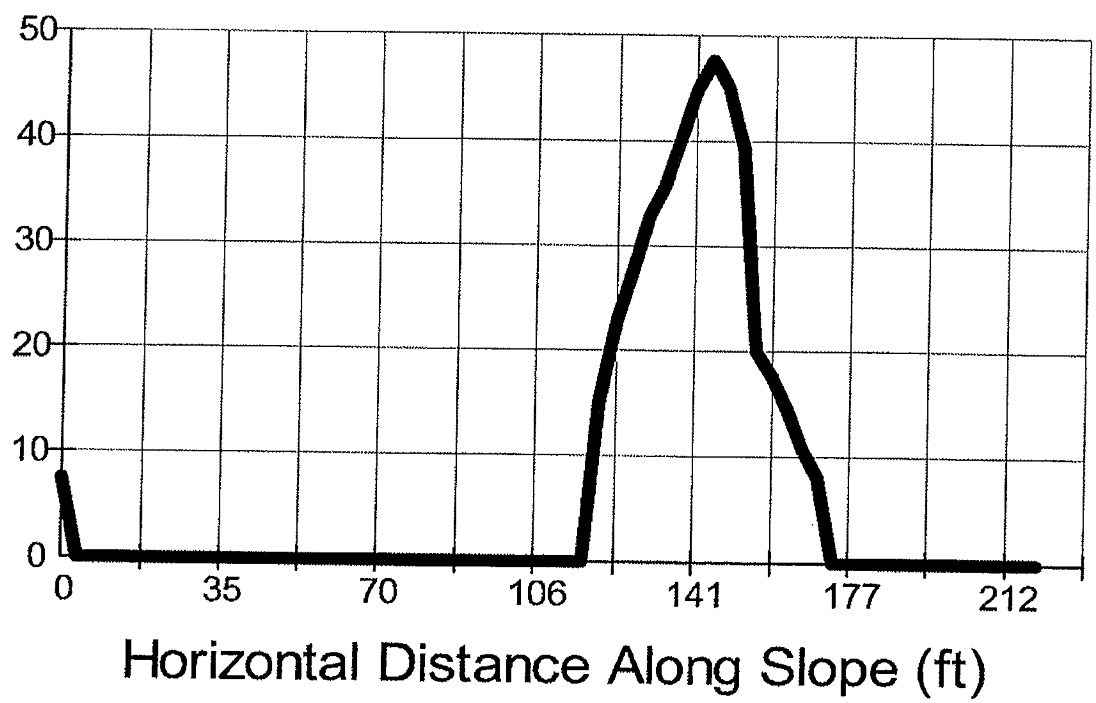
Maximum: 74
Average: 74
Std. Dev.: 0

Remarks: Sta. 11+50.0 - TR 234: Long-Term with Average Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



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Velocity Units: ft/sec   Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	46	28	7.21	6	1
4	23	12	4.16	1	0
5	No rocks	past end of cell			
6	No rocks	past end of cell			
7	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	285
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	72
160 To 170 ft	128
170 To 180 ft	15
180 To 190 ft	0
190 To 200 ft	0
200 To 210 ft	0
210 To 220 ft	0

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 7
Analysis Point X-Coordinate 1: 173
Analysis Point X-Coordinate 2: 177
Analysis Point X-Coordinate 3:
Initial Y-Top Starting Zone Coordinate: 792
Initial Y-Base Starting Zone Coordinate: 704
Remarks: Sta. 11+50.0 - TR 234: Long-Term with Max Rock Size

Cell Data

Cell No.	Surface R.	Tangent C.	Normal C.	Begin X	Begin Y	End X	End Y
1	.21	.8	.18	0	792	115	743
2	.21	.8	.18	115	743	125	742
3	.21	.8	.18	125	742	152	700
4	.21	.8	.18	152	700	157	700
5	.21	.8	.18	157	700	178	704
6	.21	.8	.18	178	704	182	704
7	.21	.8	.18	182	704	220	704

Total Number of Rocks Simulated: 500

Starting Velocity in X-Direction: 1 ft/sec

Starting Velocity in Y-Direction: -1 ft/sec

Starting Cell Number: 3

Ending Cell Number: 7

Rock Density: 155 lb/ft^3

Rock Shape: Discoidal

Diameter: 1.5 ft

Thickness: 1.5 ft

740
3
AP1
AP2
7
700
125
P
165
205

Analysis Point 1

Analysis Point 1: X = 173, Y = 703

Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 16

Velocity (ft/sec)

Maximum: 12.63
Average: 7.42
Minimum: 3.24
Std. Dev.: 2.96

Bounce Height (ft)

Maximum: .12
Average: .02
G. Mean: .01
Std. Dev.: 8.45

Kinetic Energy (ft-lb)

Maximum: 1639
Average: 638
Std. Dev.: 473

Remarks: Sta. 11+50.0 - TR 234: Long-Term with Max Rock Size

Analysis Point 2

Analysis Point 2: X = 177, Y = 704

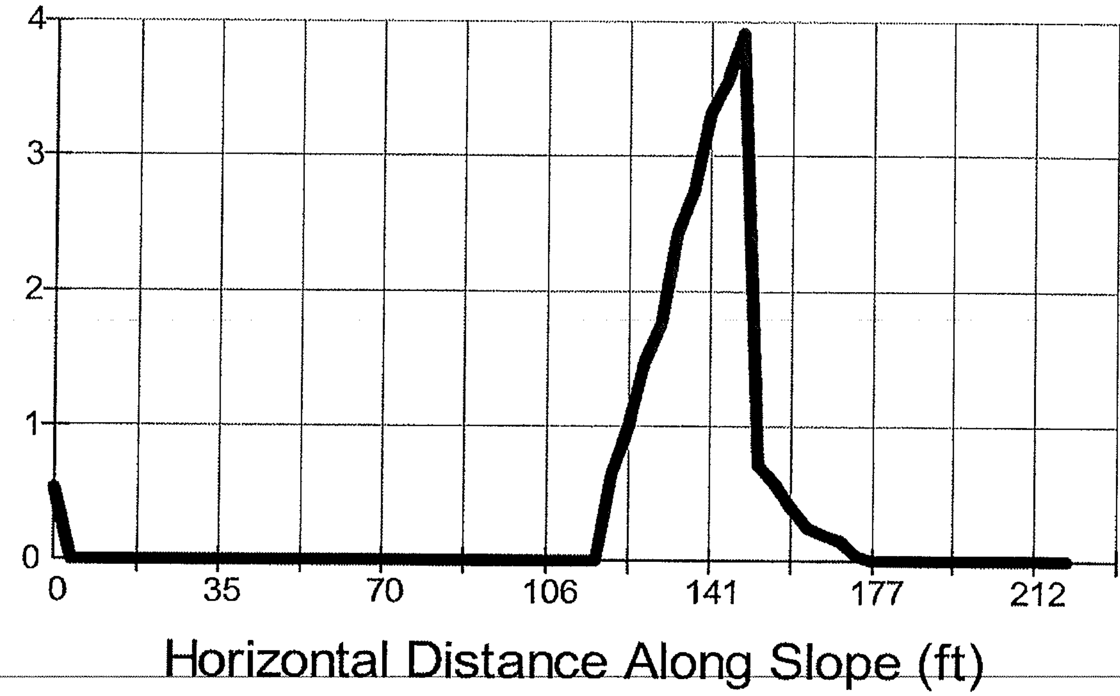
Discoidal Rock: 1.5-ft dia., 1.5-ft thick, 411-lb

Total Rocks Passing Analysis Point: 7

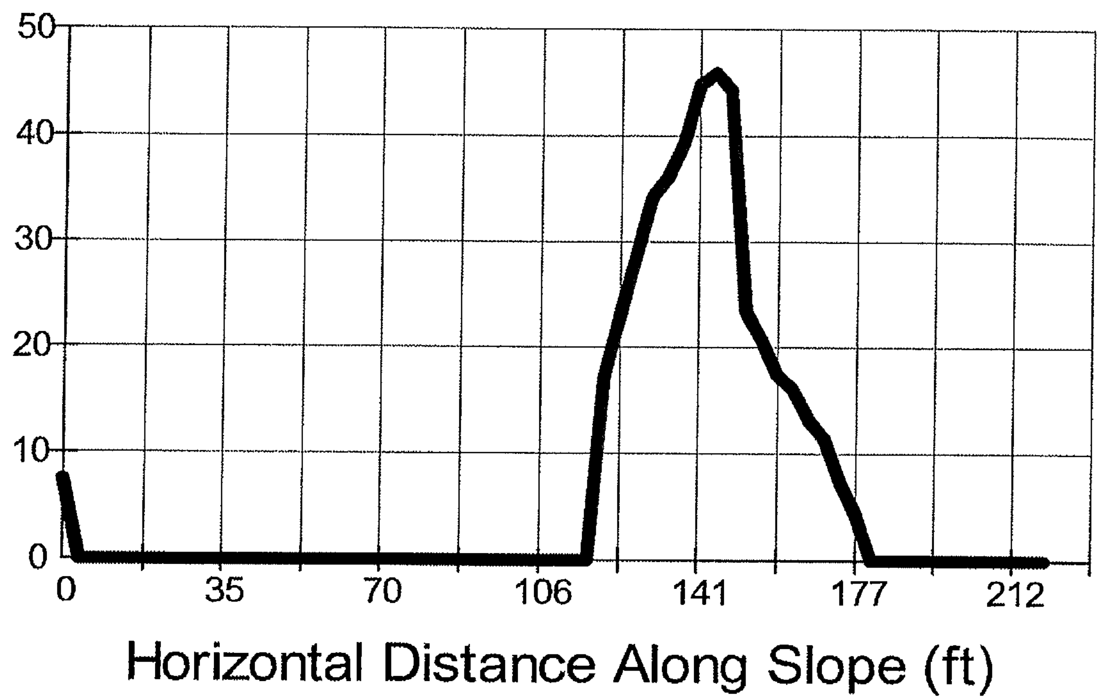
Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 9.1	Maximum: .06	Maximum: 850
Average: 5.55	Average: .01	Average: 344
Minimum: 3.19	G. Mean: .01	Std. Dev.: 247
Std. Dev.: 1.92	Std. Dev.: 5.6	

Remarks: Sta. 11+50.0 - TR 234: Long-Term with Max Rock Size

BOUNCE HEIGHT



VELOCITY GRAPH



Velocity Units: ft/sec Bounce Height Units: ft

Cell No.	Max. Velocity	Avg. Velocity	Std. Dev. Velocity	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	44	29	7.4	3	0
4	22	13	4.02	1	0
5	7	5	0	0	0
6	5	5	0	0	0
7	No rocks	past end of cell			

X Interval	Rocks Stopped
0 To 10 ft	285
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	30
160 To 170 ft	152
170 To 180 ft	32
180 To 190 ft	1
190 To 200 ft	0
200 To 210 ft	0
210 To 220 ft	0