Geotechnical Recommendations Reports
SH 92 Stengel's Hill
Project No: STA 092A-024
Project Code: 17772

The geotechnical recommendations for this project consist of the following four Memorandums.

1. Memorandum Date, March 12, 2012 – Geotechnical Recommendations for State Highway 92 & Union Pacific Railroad Intersection and Big Gulch, (26 pages)

2. Memorandum Date, October 23, 2013 – Geotechnical Addendum for State Highway 92 & Union Pacific Railroad Intersection and Big Gulch, (14 pages)

3. Memorandum Date, April 10, 2013 – Geotechnical Recommendations for State Highway 92 Retaining Wall at MM 15.1 Stengel's Hill, (11 Pages)

4. Memorandum Date, September 14, 2013 – Embankment Review for State Highway 92 & Union Pacific Railroad Intersection, (67 pages)

MEMORANDUM

MATERIALS AND GEOTECHNICAL BRANCH
GEOTECHNICAL PROGRAM
4670 HOLLY STREET, UNIT A, DENVER, COLORADO 80216 303-398-6604 FAX 303-398-6504

HB 092A-020
SH-92 & UPRR
SA 14934

TO: Behrooz Far, CDOT Staff Bridge

FROM: David Thomas, Geotechnical Program

DATE: March 12, 2012

SUBJECT: **GEOTECHNICAL RECOMMENDATIONS FOR STATE HIGHWAY 92 & UNION PACIFIC RAIL ROAD INTERSECTION AND BIG GULCH**

1.0 INTRODUCTION

This report presents geotechnical exploration observations and recommendations for planned improvements along SH-92 near the intersection of the Union Pacific Railroad (UPRR). The intersection is located at mile marker 14.4 along SH-92 between Delta and Hotchkiss. Currently, the UPRR is an at-grade crossing with SH-92. To increase safety, a bridge raising SH-92 is proposed allowing UPRR to cross underneath SH-92. The proposed bridge is a three span precast, prestressed girder bridge founded on driven piles and drilled shafts. Retaining walls will also be required to contain the approximately 45 feet of embankment fill required to construct the bridge approaches. In addition, a concrete box culvert (CBC) located at Big Gulch (mile marker 14.8) will be extended to the north approximately 92 feet allowing for realignment of the highway as it approaches the bridge.

The purpose of the geotechnical exploration is to characterize physical properties of foundation materials at the proposed structure locations. Foundation recommendations are provided for design and construction of the proposed structures. The scope of work was based on conversations with Mike Perez with URS Corporation, Inc. and Hans Egghart, CDOT Region 3.

2.0 GEOTECHNICAL INVESTIGATION

Geotechnical field activities were completed between December 19 and 20, 2011. Thirteen borings (TH1 through TH13) were advanced using a CME 55 all terrain drill rig and a CME 75 truck mounted drill rig with hollow stem auger techniques. The borings were advanced along SH-92 and the UPRR for the proposed bridge and wall locations as determined by rig access and utility clearances. Only one boring, TH10, was advanced at the Big Gulch CBC extension because entry agreements were not obtained from local land owners. Standard penetration tests using split spoon samplers and California samplers were performed in the borings at select intervals in general accordance with ASTM D-l586 and D-3550, respectively. Traffic control was provided by CDOT Maintenance Patrol 33 along with a Flagman from UPRR. Survey data was provided by CDOT Region 3.

2.1 GEOLOGY

The geology is similar across the site. The geology consists of loose sand and gravel and stiff to very stiff clay and silt underlain by medium hard to very hard shale bedrock. Bedrock was encountered in 12 of the 13 borings ranging from elevations of 5,352 feet above mean sea level (amsl) to 5,381 feet amsl (surface to 8 feet below ground surface [bgs]). Bedrock encountered at the surface was saturated with snow melt and was highly weathered. Groundwater was only encountered during drilling at Big Gulch at an elevation of 5,368 feet amsl. Piezometers PZ1, PZ2, and PZ3 were installed in borings TH3, TH5, and TH8 to allow for future measurement of groundwater. Groundwater was recorded at 5,357.8 feet amsl (9.6 feet bgs) in PZ1, dry in PZ2, and 5,370.5 feet amsl (7.1 feet bgs) in PZ3 on February 1, 2012 and 5,357.9 feet amsl (9.5 feet bgs) in PZ1, dry in PZ2, and 5,371.5 feet amsl (6.1 feet bgs) in PZ3 on March 5, 2012. Groundwater elevations may fluctuate with seasonal changes including precipitation and surface runoff. The engineering geology sheets and boring logs are presented in Attachments 1 and 2, respectively.

2.2 PHYSICAL PROPERTIES

AASHTO classifications for the gravel was A-2-6 (1), the clay ranged from A-6 (9) to A-7-6 (28), and bedrock ranged from A-7-6 (20) to A-7-6 (32). Shale samples from TH4, TH8, TH9, and TH10 were found to be highly plastic with liquid limits up to 51 and plasticity indices up to 30. Swell testing of the clay and shale resulted in swells ranging from 0% to 1.9% under a surcharge pressure of 1.0 ksf. The liquid limit, plastic limit, and swell results indicate a marginal to high potential for swell per AASHTO LRFD Bridge Design Table 10.4.6.3-1. Unconfined compressive strength testing of bedrock samples ranged from 8.7 kips per square foot (ksf) to 32.4 ksf. These values are believed to be low since samples were collected using a California sampler causing disturbance in the sample. Detailed material properties are presented on the engineering geology sheets in Attachment 1.

2.3 GEOCHEMICAL PROPERTIES

Bedrock was analyzed for percent sulfate, pH, percent chlorides, and resistivity. Based on the results of water soluble sulfate testing obtained from CP 2103, the potential for sulfate attack on Portland cement concrete in direct contact with the bedrock is classified as a Class 3 exposure per Table 601-2 of the CDOT 2011 Standard Specifications for Road and Bridge Construction Section 601. The result for resistivity suggests a strong corrosion towards metal based on values per Table C.1 of FHWA report FHWAO-IF-3-017, Geotechnical Engineering Circular No. 7 - Soil Nail Walls. Detailed material properties are presented on the engineering geology sheets in Attachment 1.

3.0 RECOMMENDATIONS

The subsurface conditions are favorable for a bridge on drilled shaft or driven pile foundations, MSE walls, and extension of the Big Gulch CBC.

3.1 DRILLED SHAFTS

For drilled shafts embedded into the bedrock, the allowable unit tip resistance (q_a) and the allowable unit side resistance (f_a) for the Allowable Stress Design (ASD) method, as determined using local practice, are presented in Table 1 along with the nominal unit tip resistance (q_p) and the nominal unit side resistance (q_s) required for the Load Resistance Factor Design (LRFD). The LRFD capacities are converted from ASD values. Table 1 presents the resistance values along with the estimated bedrock elevation.

TABLE 1. DRILLED SHAFT RESISTANCE VALUES BY ELEVATION

Location	Estimated Bedrock Elevation (feet)	ASD		LRFD	
		q_a (ksf)	f_a (ksf)	q_p (ksf)	q_s (ksf)
West Abutment (Abutment 1)	5,363	27	2.7	80	8
West Pier (Pier 2)	5,368				
East Pier (Pier 3)	5,379				
East Abutment (Abutment 4)	5,381				

Shafts should be completed into the bedrock to obtain tip and side resistance. The recommended minimum bedrock penetration is l0 feet. Side resistance in the overburden soil should be ignored due to the difference in strain limits between the soil and bedrock. Also, the top 5 feet of bedrock penetration should be ignored for side resistance due to material weathering and potential disturbance from temporary casing. The side resistance values are applicable in both vertical directions without reduction. The nominal capacities assume a weighted load factor of 1.5. When using the LRFD method, we recommend a resistance factor of 0.5 be used for both unit tip and side resistance. Should a different load factor be applied for shafts, the resistance factor should be adjusted by dividing the new load factor by 3 to obtain the corresponding resistance factor. Material properties for lateral load analysis are presented in Table 2.

The recommended unit tip and side resistance values assume a minimum spacing of 3 shaft diameters, center-to center, between adjacent drilled shafts. Drilled shafts spaced at 2 diameters will require a reduction factor of 0.9. Reduction factors for spacing less than 2 diameters will require additional analysis and iteration with the structural engineer.

Caving soil may occur above the bedrock elevation. Slurry and/or casing may be needed to support the soils overlying the bedrock during drilled shaft excavation if caving occurs. Dewatering of the drilled holes also may be required prior to placement of the concrete. The potential for dewatering may increase with the amount of time the drill holes remain open. Alternatively, the concrete may be placed by tremie as described in CDOT 2011 *Standard Specifications for Road and Bridge Construction* Section 503 – Drilled Caissons.

3.2 DRIVEN PILES

For driven H-piles with Grade 36 steel, a combined nominal unit side and tip resistance of 27 kips per square inch (ksi) times the cross sectional area of the pile is recommended. For Grade 50 steel, the nominal capacity would be increased to 36 ksi. Per CDOT 2011 *Standard Specifications for Road and Bridge Construction* Section 502 – Piling, a pile driving analyzer will be used to establish the driving criteria. A resistance factor of 0.65 may be used in accordance with AASHTO LRFD bridge design specifications. Driven piles will function as end bearing piles at this site with generally less than 10 feet of penetration into bedrock for Grade 36 steel and 15 feet of penetration into the bedrock for Grade 50 steel. Predrilling of the piles may be required in some areas to reach the minimum penetration depth of 10 feet into natural ground per CDOT Standard Specifications due to the hard bedrock encountered. Battered piles no steeper than 1:4 (H:V) may be used to provide lateral capacity. Additionally, pile tips may be required to penetrate the bedrock. If used, the tips should be Associated Pile & Fitting Corp. (APF) HARD-BITE HP-77600 for hard rock, or equivalent. Material properties for lateral load analyses of the piles using LPILE or similar software are presented in Table 2.

TABLE 2. MATERIAL PROPERTIES FOR LATERAL LOAD ANALYSIS USING LPILE

Material	**Internal Friction Angle ϕ (degrees)**	**Cohesion C (lb/ft^2)**	**Soil-Modulus k (lb/in^3)**	**Strain at ½ maximum principal stress ε_{50} (in/in)**	**Total Unit Weight (lb/ft^3)**	**Saturated Unit Weight γ_T (lb/ft^3)**
New Class 1 Structure Backfill*	34	0	225	–	125	135
Native Sand/Gravel	32	0	90	–	125	135
Native Silt/Clay	0	1,000	500	0.005	120	130
Bedrock	0	8,000	2,000	0.004	130	140

* – If proper compaction as described in Section 3.3 cannot be achieved, Native Sand/Gravel values should be used.

3.3 RETAINING WALLS AND TEMPORARY EXCAVATIONS

Retaining walls will be required to contain the approximately 45 feet of embankment fill required to construct the bridge approaches. MSE walls are the proposed wall type. For retaining walls, it is assumed new fill will consist of Class 1 Structure Backfill. Class 1 Structure Backfill should be compacted to at least 95 percent of the maximum dry density and within 2 percent of optimum moisture content as determined by AASHTO T180 (ASTM D 1557) and as described in Section 206 of the 2011 CDOT *Standard Specification for Road and Bridge*

Construction. Retaining wall parameters for design are presented in Table 3. Lateral pressures must be reevaluated when a surcharge loads exist. Temporary excavation support may be required where slopes above the groundwater table are steeper than 1:1 (H:V). Parameters presented in Table 3 also are suitable for temporary excavation support design.

TABLE 3. MATERIAL PARAMETERS FOR RETAINING WALLS AND TEMPORARY EXCAVATIONS

Material	Typical Total Unit Weight γ_T (pcf)	Internal Friction Angle φ (degrees)	Cohesion C (psf)	Earth Pressure Coefficients		
				Active (Ka)	At Rest (Ko)	Passive (Kp)
New Class 1 Structure Backfill	125	34	0	0.28[a]/0.42[b]	0.44[a]/0.64[b]	3.5
Sand	125	32	0	0.30[a]/0.47[b]	0.47[a]/0.68[b]	3.2
Clay/Silt	120	20	100	0.49[a]	0.65[a]/0.95[b]	2.0

[a] – Values calculated for horizontal backfill.
[b] – Values calculated for a sloping backfill at 2:1 (H:V).

The bearing material will vary from the silt, clay, sand, gravel, and shale bedrock. The nominal bearing capacity value was calculated based on current groundwater conditions, an assumed maximum wall height of approximately 45 feet and reinforcement lengths up to 30 feet. A minimum 3 feet of embedment for frost protection is recommended. Nominal bearing capacities are listed in Table 4 based on the possible foundation material. The bearing capacity will decrease with decreasing reinforcement lengths in the sand and gravel. A bearing resistance factor of 0.65 for MSE walls may be applied when using the LRFD method. Table 4 also presents the coefficient of sliding resistance (μ) that may be used between concrete or MSE and undisturbed foundation material.

It will be important to maintain a good drainage at the base of the MSE wall in order to prevent the shale bedrock in contact with the MSE from becoming wet. If this shale bedrock at the surface becomes wet, the μ can be reduced to near zero resulting in a sliding failure. It is unlikely that the CDOT standard MSE wall drain design will prevent the interface between the granular MSE backfill and the shale bedrock foundation from getting wet. Additional drainage design is recommended to ensure that this interface remains dry. A potential for sliding failure along the shale bedrock surface may also be prevented by using other foundation elements such as caissons or piles to increase the sliding resistance. Properties in Sections 3.1 and 3.2 can be used for design of a drilled shaft or driven pile elements for the MSE walls. The global stability of the walls should be verified after final design is completed.

3.4 EMBANKMENTS

It is currently planned to raise the roadway approximately 45 feet above current grade at the bridge to allow UPRR to pass underneath SH-92. Embankment fill and construction shall be as described in Section 203 of the 2011 CDOT *Standard Specification for Road and Bridge Construction*. Due to the height of the embankment, settlement may be encountered depending on the construction quality of the fill (type, placement, and compaction). Construction oversight and field testing of the embankment construction will be fundamental to try and minimize settlement over the life of the embankment. Settlement of the foundation materials may also occur due to the embankment construction. We estimate settlements on the order of 1½-inches in the foundation materials. Most of this settlement is anticipated to occur during construction.

TABLE 4. RETAINING WALL BEARING CAPACITY AND SLIDING RESISTANCE

Material	Nominal Bearing Capacity (q_n)	Coefficient of Sliding Resistance (μ)
Sand/Gravel[1]	25 ksf	0.45
Sand/Gravel[2]	5 ksf	0.45
Silt/Clay	5.1 ksf	0.35
Bedrock	31 ksf	0.35[3]

[1] – Reinforcement length of 30 feet.
[2] – Reinforcement length of 6 feet.
[3] – Under dry conditions.

3.5 BIG GULCH CBC EXTENSION

The CBC foundation will likely be supported on the medium dense cobbly sand and gravels. It is assumed the new extensions will be the same height (10 feet) and width (8 feet) as the existing CBC. Nominal bearing capacity is 12 ksf for CBC sections that are supported on undisturbed soil. Additionally, the final CBC will be an extension to the current CBC and differential movement should be expected at the union of the two structures. This movement may be up to a quarter of an inch during initial placement of the extensions.

It is assumed that the wing wall bearing material will be the medium dense cobbly sand and gravels encountered from ground surface to 5,363 feet amsl. Fill quality, fill placement, and material properties from Section 3.3 should be applied to the wing wall design. The nominal bearing capacity value for the wing walls was calculated to be 12 ksf based on an assumed maximum wall height of approximately 10 feet, footing width of 6.66 feet per CDOT Standard Plan M-601-20, and a 1 foot minimum embedment. Bearing capacity will be decreased with decreased footing widths. A bearing resistance factor of 0.55 for gravity walls may be applied when using the LRFD method. A coefficient of sliding resistance (μ) of 0.45 may be used between concrete and undisturbed foundation soil. The global stability of the walls should be verified after final design is completed.

4.0 SEISMIC DESIGN PARAMETERS

The AASHTO Specifications for LRFD Seismic Bridge Design classify the site as “C" and the seismic zone as “1" using Tables 3.10.3.1-1 and 3.10.6-1, respectively. Using the USGS AASHTO Earthquake Motion Parameters program, a seismic design spectrum plot was created for Spectral Acceleration vs. Time and is presented in Figure 1. Additional data from the program is included in Attachment 3.

Please contact the Geotechnical Program at 303-398-6604 with questions.

REVIEW: Conroy

COPY: Eller – Region 3 RTD
Mertes – Region 3 West Engineering Program Engineer
Alexander – Region 3 North Engineering RE
Egghart – Region 3 West Engineering
Goodrich – Region 3 Materials Engineer
Perez – URS Corporation
Zufall/Hernandez – Staff Materials and Geotechnical
Liu – Geotechnical Program

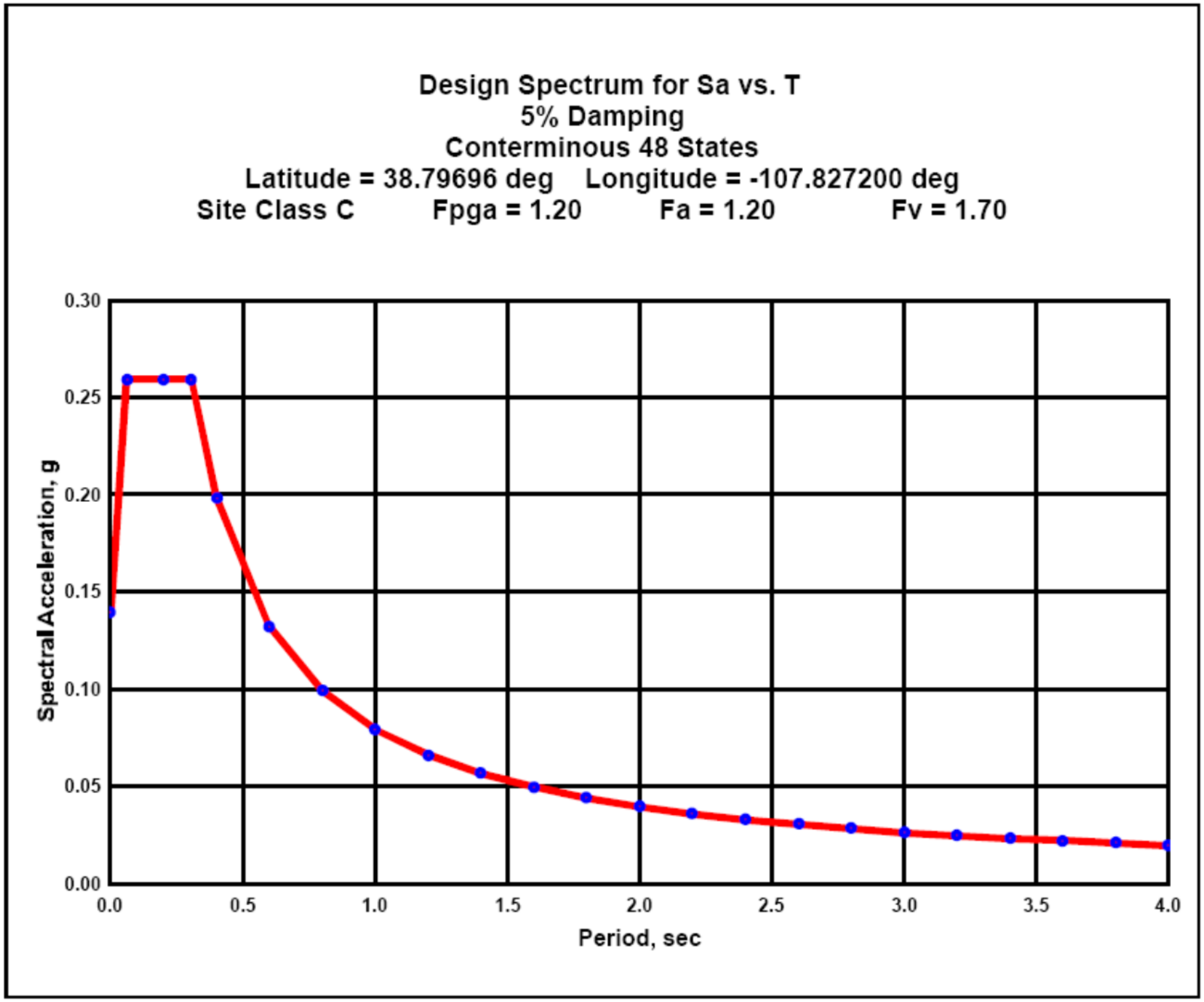
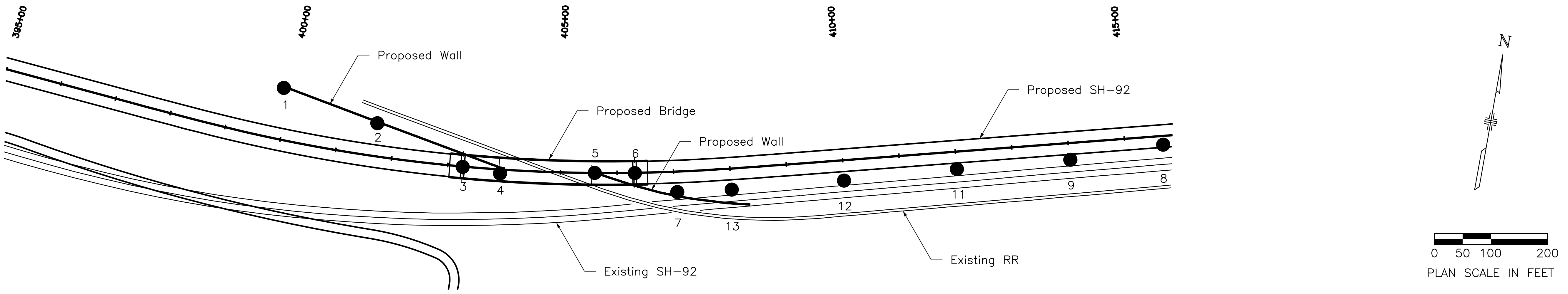


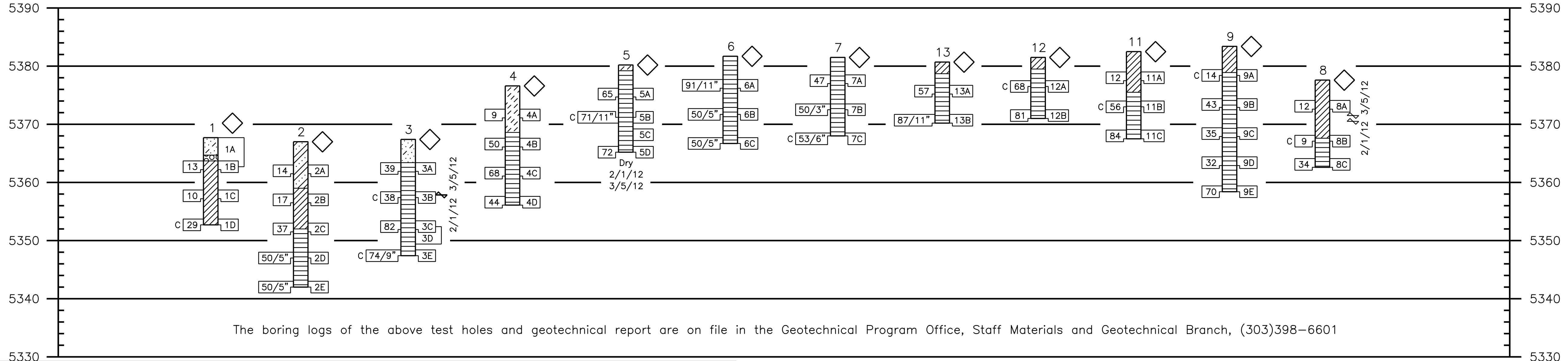
FIGURE 1. DESIGN SPECTRAL ACCELERATION VS. TIME

ATTACHMENT 1

GEOLOGY SHEETS

HB 092A-020
SH-92 & UPRR
SA 14934





The boring logs of the above test holes and geotechnical report are on file in the Geotechnical Program Office, Staff Materials and Geotechnical Branch, (303)398–6601

SUMMARY OF TEST RESULTS

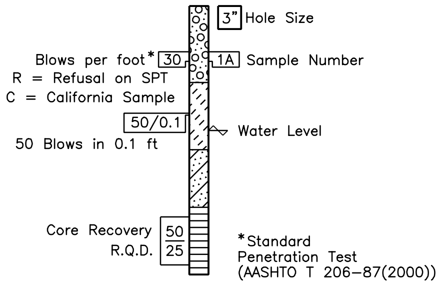
Sample Number	Depth (feet)	Classification			Grading Analysis (AASHTO) Percent				Atterberg Limits			Water Content W %	Dry Density (lb/ft³)	Uniaxial Compressive Strength (psf)	Swell/ Surcharge Pressure (%/ksf)	Chlorides (%)	Water Soluble Sulfates (%)	Soil pH ($H_2O/CaCl_2$)	Resistivity ohm–cm Saturated
		Corps of Engrs. or Visual	USCS	AASHTO	Gravel	Coarse Sand	Fine Sand	Silt and Clay	L.L. L_W	P.L. P_W	P.I. I_W								
1C	10	Clay	CL	A–7–6(16)	13.5	5.7	7.8	73.0	43	20	23	16.3	–	–	–	–	–	–	–
1D	14	Clay	CL	A–7–6(23)	0.0	0.4	1.2	98.4	43	22	21	15.3	106.8	–	–	–	–	–	–
2A	4	Sandy Clay	CL	A–6(9)	20.5	9.0	9.6	60.9	39	21	18	8.2	–	–	–	–	–	–	–
2E	24	Shale	CL	A–7–6(24)	0.3	1.1	1.5	97.1	44	21	23	9.9	–	–	–	–	–	–	–
3A	4	Shale	CL	A–7–6(20)	2.8	6.0	4.5	86.7	44	22	22	10.5	–	–	–	–	–	–	–
3B	9	Shale	CL	A–7–6(25)	1.7	1.1	1.1	96.2	44	20	24	14.2	118.0	–	1.9/1.0	–	–	–	–
3D	16	Shale	–	–	–	–	–	–	–	–	–	–	–	–	–	0.014	3.08	5.80	400
3E	19	Shale	CL	A–7–6(28)	0.3	1.0	1.0	97.6	46	20	26	13.0	117.6	16,520	–	–	–	–	–
4C	15	Shale	CH	A–7–6(29)	1.7	2.5	1.8	93.9	50	22	28	11.8	–	–	–	–	–	–	–
5B	9	Shale	CL	A–7–6(31)	0.4	0.4	0.4	98.9	47	18	29	11.6	123.9	32,417	–	–	–	–	–
5C	12	Shale	–	–	–	–	–	–	–	–	–	–	–	–	–	0.014	3.04	5.64	300
7C	13	Shale	CL	A–7–6(25)	2.2	1.0	0.6	96.2	45	21	24	11.5	114.4	8,701	–	–	–	–	–
8B	9	Clay	CL	A–7–6(28)	0.1	0.3	3.0	96.7	45	18	27	30.5	92.0	–	0.0/1.0	–	–	–	–
8C	14	Shale	CH	A–7–6(27)	1.0	3.2	3.6	92.2	51	25	26	21.3	–	–	–	–	–	–	–
9A	4	Shale	CH	A–7–6(32)	0.1	0.5	1.9	97.5	50	20	30	21.0	107.0	–	0.5/1.0	–	–	–	–
11A	4	Clay	CL	A–7–6(21)	6.3	4.4	6.0	83.4	45	20	25	14.6	–	–	–	–	–	–	–
11B	9	Shale	CL	A–7–6(25)	0.4	0.2	0.4	99.0	43	20	23	11.8	123.0	–	–	–	–	–	–
12A	4	Shale	CL	A–7–6(28)	0.1	0.4	1.0	98.5	45	19	26	13.5	118.6	21,677	1.1/1.0	–	–	–	–
13B	10	Shale	CL	A–7–6(25)	0.3	0.7	0.9	98.1	44	21	23	12.3	–	–	–	–	–	–	–

TYPE OF MATERIAL

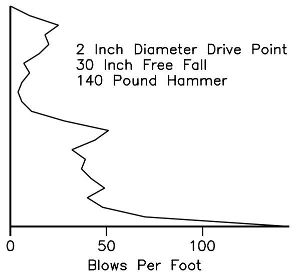
▨	Clay	▨	Silty Sand
▨	Sandy Clay	▨	Gravel
▨	Silt	▤	Shale

LEGEND

TEST BORING



CONTINUOUS PENETRATION TEST



● Location of Test Boring
○ Location of Continuous Penetration Test
W 3 Inch Wireline Boring
☐ Rotary Boring
◇ Auger Boring

Print Date: 3/7/2012
Drawing File Name: 14934geosheet01.dgn
Horiz. Scale: 1:200 Vert. Scale: As Noted
Staff Geotechnical Program HCL

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Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
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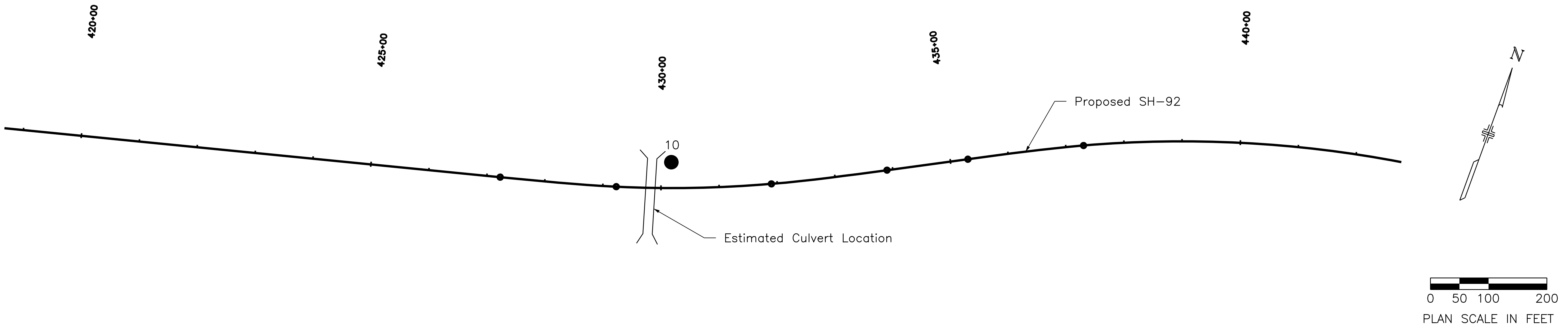
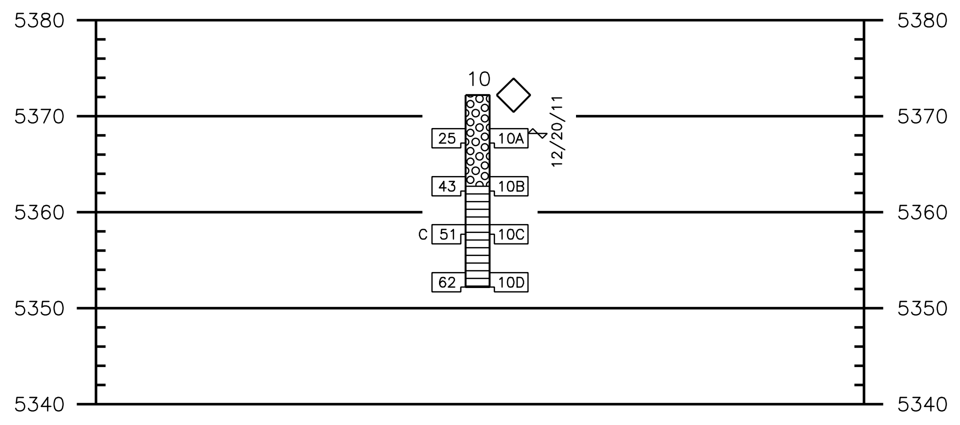
DEPARTMENT OF TRANSPORTATION
Staff Geotechnical Program HCL

As Constructed
No Revisions:
Revised:
Void:

ENGINEERING GEOLOGY
Designer: D. Thomas
Detailer: T. McNulty
Structure Numbers
Sheet Subset: Geology
Subset Sheets: XXX of XXX

Project No./Code
14934
Sheet Number XXX





The boring log of the above test hole and geotechnical report are on file in the Geotechnical Program Office, Staff Materials and Geotechnical Branch, (303)398-6601

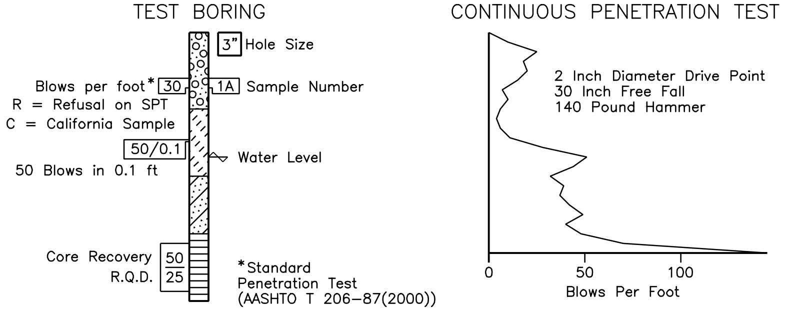
SUMMARY OF TEST RESULTS

Sample Number	Depth (feet)	Classification			Grading Analysis (AASHTO)				Atterberg Limits			Water Content W %	Dry Density (lb/ft^3)	Uniaxial Compressive Strength (psf)	Swell/ Surcharge Pressure (%/ksf)	Water Soluble Sulfates (%)	Soil pH (H$_2$O/CaCl$_2$)	Resistivity ohm-cm Saturated
					Percent													
		Corps of Engrs. or Visual	USCS	AASHTO	Gravel	Coarse Sand	Fine Sand	Silt and Clay	L.L. L_W	P.L. P_W	P.I. I_W							
10B	9	Clayey Gravel	GC	A-2-6(1)	67.6	5.7	4.3	22.4	37	18	19	11.7	–	–	–	–	–	–
10C	14	Shale	CH	A-7-6(31)	0.3	1.1	1.2	97.4	50	21	29	24.6	104.0	12,340	0.1/1.0	–	–	–

TYPE OF MATERIAL

▨	Gravel
▤	Shale

LEGEND



●	Location of Test Boring
○	Location of Continuous Penetration Test
W	3 Inch Wireline Boring
☐	Rotary Boring
◇	Auger Boring

Print Date: 2/8/2012
Drawing File Name: 14934geosheet02.dgn
Horiz. Scale: 1:200 Vert. Scale: As Noted
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Sheet Revisions

Date:	Comments	Init.

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As Constructed
No Revisions:
Revised:
Void:

ENGINEERING GEOLOGY

Designer: D. Thomas
Detailer: T. McNulty
Sheet Subset: Geology
Structure Numbers
Subset Sheets: XXX of XXX

Project No./Code
14934
Sheet Number XXX

ATTACHMENT 2

BORING LOGS

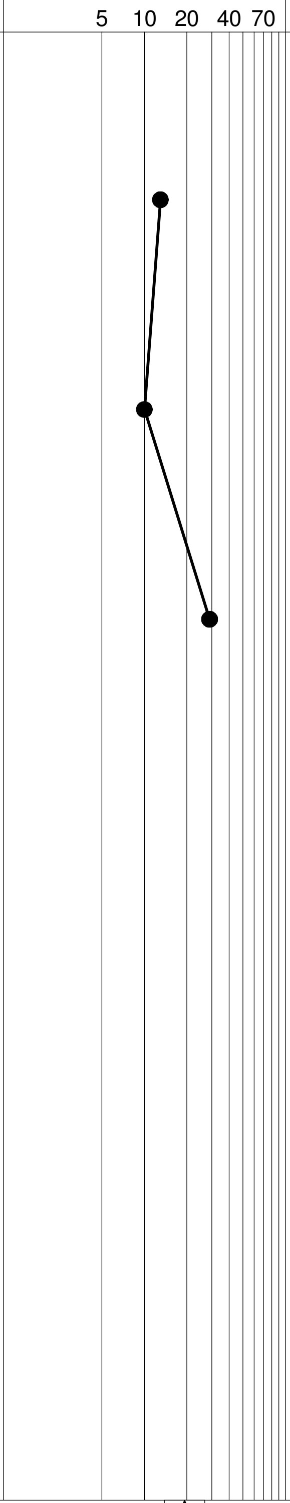
HB 092A-020
SH-92 & UPRR
SA 14934

DOT
DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

PROJECT ID	SA 14934	PROJECT NAME SH 92, RR	BORING # 1
ROUTE SH 92	COUNTY Delta	STRUCTURE/BENT /	DATE DRILLED 12/19/11
			LOCATION
TOP HOLE ELEV 5,367.7ft	TOTAL DEPTH 15.0ft	SURVEY INFO N: 359,540 E: 336,137	GEOLOGIST/FOREMAN D. Thomas/R. Brown/P. Spahr

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA	WELL DIAGRAM
			Silty Sand, yellowish orange		0.0	1A (0' - 5')			
5365				◈					
	3.0		**Gravel,** well graded, subrounded						
	4.0		**Clay,** mottled light brown & light gray, veins of white mineralization, blocky texture, stiff	☒	4.0	1B 5-5-8	13		
5360									
				☒	9.0	1C 5-5-5	10		
5355									
	14.0		very stiff	▲	14.0	1D 5-24	29		
	15.0		Total Boring Depth 15.0ft						
5350									
5345									
5340									
5335									



☒ SPT	▮ CON'T	◈ GRAB	■ SHELBY	⋈ CORE	▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Auger

DOT
DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

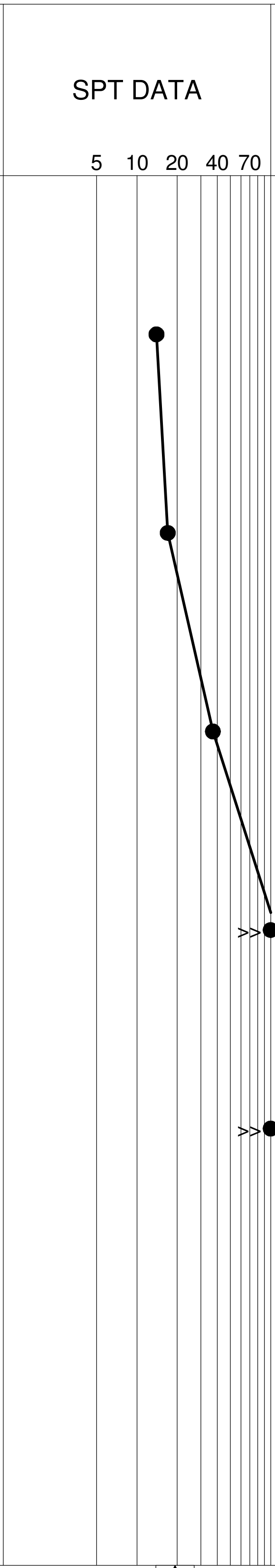
BORING # 2

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
	14934	SH 92, RR	12/19/11

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/	

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,367.0ft	25.0ft	N: 359,507 E: 336,311	D. Thomas/R. Brown/P. Spahr

ELEV (ft)	DEPTH (ft)	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%
		Sandy Clay, with gravel & cobbles, olive gray, stiff, subrounded gravel				
5365						
			☒	4.0	2A 5-8-6	14
5360						
	8.0	**Clay,** olive gray, white vein mineralization, blocky, very stiff				
			☒	9.0	2B 3-7-10	17
5355						
			☒	14.0	2C 3-12-25	37
	15.0	*drills harder* **Shale Bedrock,** medium hard, dark gray, red iron oxide weathering				
5350						
	19.0	very hard	☒	19.0	2D 13-50/5"	50/5"
5345						
	24.0	very hard	☒	24.0	2E 27-50/5"	50/5"
	25.0	Total Boring Depth 25.0ft				
5340						
5335						



WELL DIAGRAM

☒ SPT | CON'T | GRAB | SHELBY | CORE | CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Auger

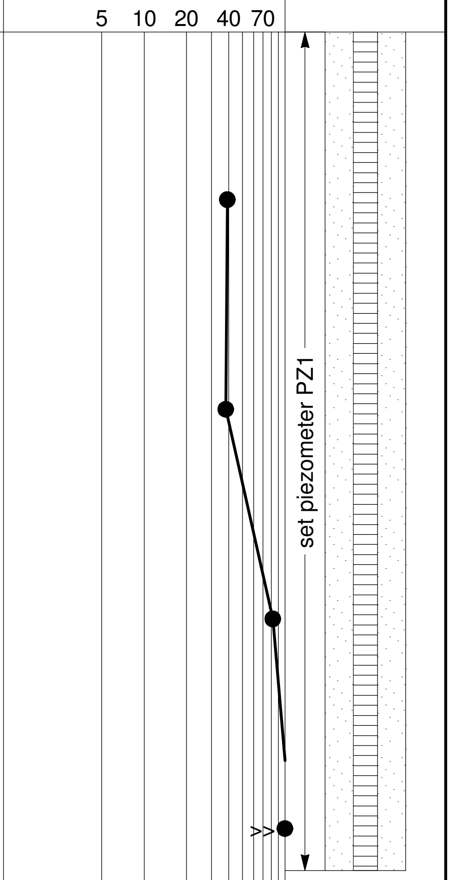
GEOLOGIC BORING LOG SH92 RR.GPJ CO_DOT.GDT 3/7/12

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # 3	PROJECT ID	SA 14934	PROJECT NAME SH 92, RR	DATE DRILLED 12/19/11
ROUTE SH 92	COUNTY Delta	STRUCTURE/BENT /Abutment 1	LOCATION	
TOP HOLE ELEV 5,367.4ft	TOTAL DEPTH 20.0ft	SURVEY INFO N: 359,457 E: 336,473	GEOLOGIST/FOREMAN D. Thomas/R. Brown/P. Spahr	

ELEV (ft)	DEPTH (ft)	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%
		Silty Sand, with gravel, light gray, subrounded gravel				
5365						
	4.0	**Shale Bedrock,** dark gray, medium hard, red iron oxide weathering	☒	4.0	3A 12-18-21	39
5360						
	8.0	*drills harder*				
▼	9.0	medium hard	▲	9.0	3B 13-25	38
5355						
	14.0	very hard	☒	14.0	3C 11-32-50	82
			◈	15.0	3D (15'-18')	
5350						
	19.0	very hard	▲	19.0	3E 24-50/3"	74+
	20.0	Total Boring Depth 20.0ft				
5345						
5340						
5335						



☒ SPT ▌ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)	▼ 9.6	▽ 9.5			
DATE	2/1/12	3/5/12			
TIME					

NOTES: CME 55, Auger

DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

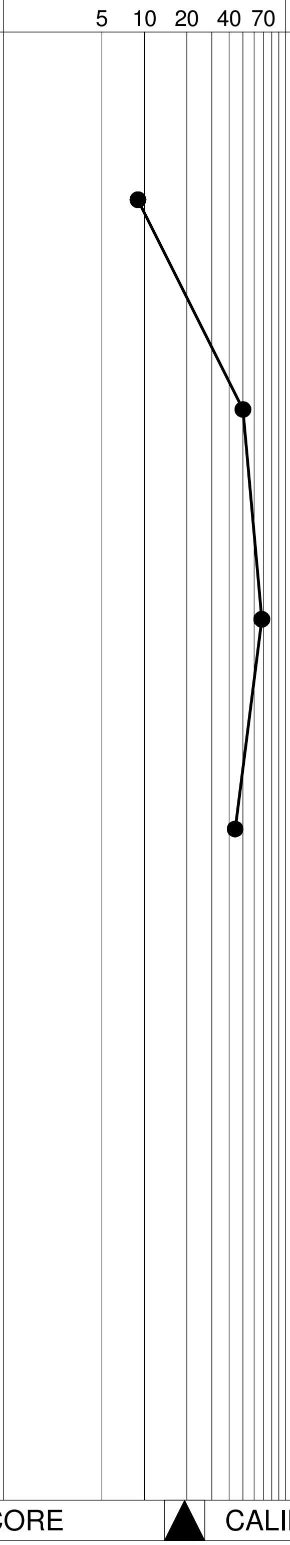
BORING # 4

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
	14934	SH 92, RR	12/19/11

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/Pier 2	

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,376.6ft	20.5ft	N: 359,457 E: 336,540	D. Thomas/R. Brown/P. Spahr

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA	WELL DIAGRAM
		▨	**Silt,** yellowish orange, stiff						
5375									
				☒	4.0	4A 2-2-7	9		
5370									
	8.0	☰	**Shale Bedrock,** dark gray, hard, red oxidation weathering						
				☒	9.0	4B 12-24-26	50		
5365									
	14.0		hard	☒	14.0	4C 15-30-38	68		
5360									
	19.0		medium hard	☒	19.0	4D 11-16-28	44		
	20.5		Total Boring Depth 20.5ft						
5355									
5350									
5345									



☒ SPT ▮ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Auger

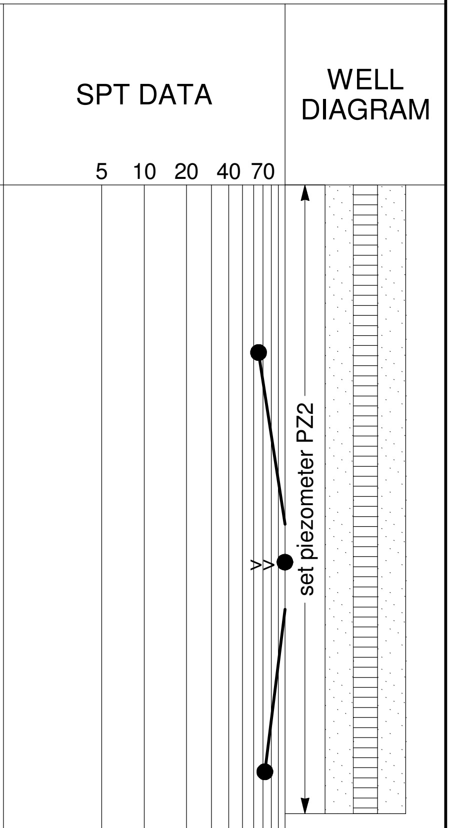
C DOT
DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

BORING #	5
PROJECT ID	
SA	14934
PROJECT NAME	SH 92, RR
DATE DRILLED	12/19/11
ROUTE	SH 92
COUNTY	Delta
STRUCTURE/BENT	/Pier 3
LOCATION	
TOP HOLE ELEV	5,380.2ft
TOTAL DEPTH	15.0ft
SURVEY INFO	N: 359,487 E: 336,705
GEOLOGIST/FOREMAN	D. Thomas/D. Novak/A. Moreno

ELEV (ft)	DEPTH (ft)	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%
		Silt, yellowish orange				
	1.0	*drills harder*				
		Shale Bedrock, dark gray, hard				
			☒	4.0	5A 28-28-37	65
5375						
	9.0	hard	▲	9.0	5B 21-50/5"	71+
5370						
			◈	11.0	5C (11'-13')	
	14.0	hard	☒	14.0	5D 22-50	72
5365	15.0	Total Boring Depth 15.0ft				
5360						
5355						
5350						

SPT DATA | WELL DIAGRAM



☒ SPT	▮ CON'T	◈ GRAB	■ SHELBY	⧓ CORE	▲ CALIFORNIA

H_2O DEPTH (ft)	dry	dry			
DATE	2/1/12	3/5/12			
TIME					

NOTES: CME 75, Auger

DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

BORING # 6

PROJECT ID

SA 14934

PROJECT NAME SH 92, RR

DATE DRILLED 12/19/11

ROUTE SH 92

COUNTY Delta

STRUCTURE/BENT /Abutment 4

LOCATION

TOP HOLE ELEV 5,381.7ft

TOTAL DEPTH 15.0ft

SURVEY INFO N: 359,499 E: 336,775

GEOLOGIST/FOREMAN D. Thomas/D. Novak/A. Moreno

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA 5 10 20 40 70	WELL DIAGRAM
			Shale, light gray, very hard, white mineralization						
5380									
				☒	4.0	6A 30-41- 50/5"	91/11"	>>●	
5375									
	9.0		white mineralization	☒	9.0	6B 37-50/5"	50/5"	>>●	
5370									
				☒	14.0	6C 48-50/5"	50/5"	>>●	
	15.0		Total Boring Depth 15.0ft						
5365									
5360									
5355									
5350									

☒ SPT ▮ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

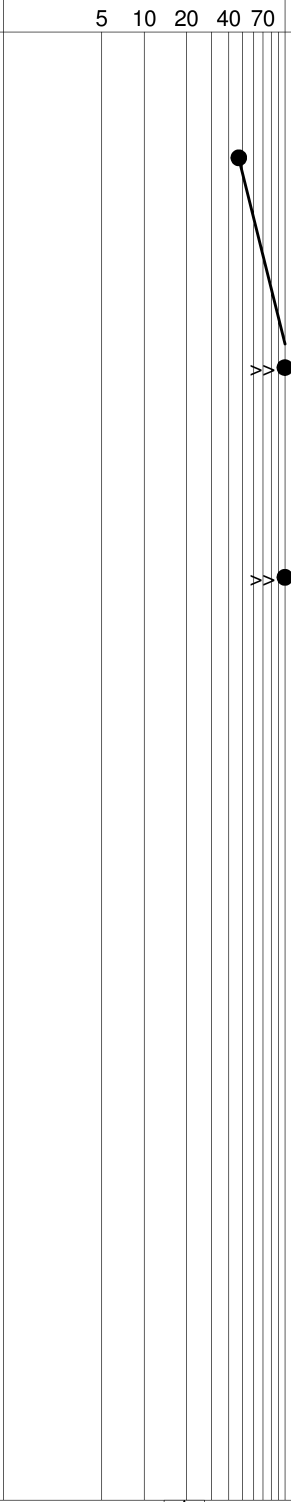
NOTES: CME 75, Auger

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING #	7		
PROJECT ID	SA 14934	PROJECT NAME SH 92, RR	DATE DRILLED 12/19/11
ROUTE SH 92	COUNTY Delta	STRUCTURE/BENT /	LOCATION
TOP HOLE ELEV 5,381.5ft	TOTAL DEPTH 13.5ft	SURVEY INFO N: 359,479 E: 336,855	GEOLOGIST/FOREMAN D. Thomas/R. Brown/P. Spahr

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA	WELL DIAGRAM
5380			**Shale,** light gray, red oxidation weathering, medium hard						
				☒	3.0	7A 5-20-27	47		
5375									
	8.0		very hard	☒	8.0	7B 20-50/3"	50/3"		
5370									
	13.0 13.5		very hard Total Boring Depth 13.5ft	▲	13.0	7C 53/6"	53+		
5365									
5360									
5355									
5350									



☒ SPT ▮ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Auger

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

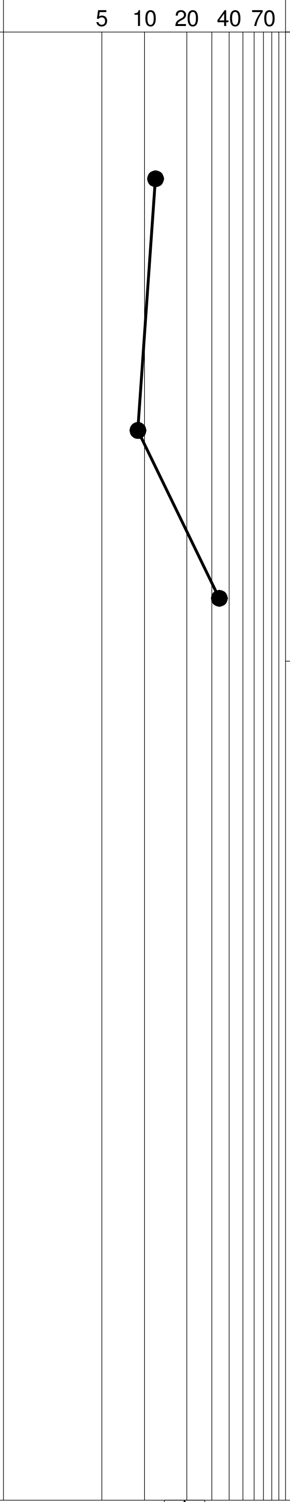
BORING #	PROJECT ID	SA	PROJECT NAME	DATE DRILLED
8		14934	SH 92, RR	12/20/11

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/	

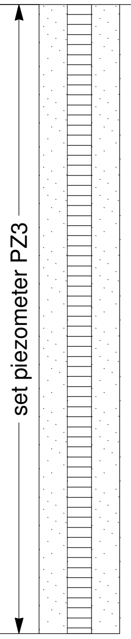
TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,377.6ft	15.0ft	N: 359,711 E: 337,687	D. Thomas/D. Novak/A. Moreno

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%
			Clay, light brown, stiff				
5375							
				☒	3.5	8A 15-7-5	12
▽ ▼							
5370							
				▲	9.5	8B 4-5	9
	10.0		*drills harder*				
			Shale, mottled light gray & yellowish orange, medium hard, blocky				
5365							
				☒	13.5	8C 11-14-20	34
	15.0		Total Boring Depth 15.0ft				
5360							
5355							
5350							
5345							

SPT DATA



WELL DIAGRAM



☒ SPT	▌ CON'T	◈ GRAB	■ SHELBY	⧓ CORE	▲ CALIFORNIA

H_2O DEPTH (ft)	▼ 7.1	▽ 6.1			
DATE	2/1/12	3/5/12			
TIME					

NOTES: CME 75, Auger

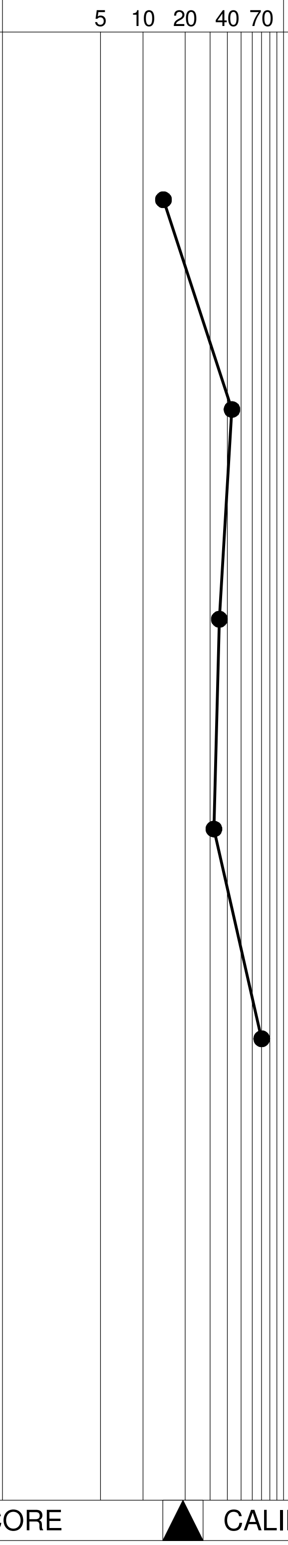
DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

BORING # 9				
PROJECT ID	SA 14934	PROJECT NAME SH 92, RR	DATE DRILLED 12/20/11	
ROUTE SH 92	COUNTY Delta	STRUCTURE/BENT /	LOCATION	
TOP HOLE ELEV 5,383.4ft	TOTAL DEPTH 25.0ft	SURVEY INFO N: 359,656 E: 337,530	GEOLOGIST/FOREMAN D. Thomas/A. Moreno/D. Thomas	

ELEV (ft)	DEPTH (ft)	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%
		Clay, dark gray, stiff, blocky				
5380						
	4.5	**Shale,** dark gray, medium hard, trace white mineralization, blocky	▲	4.0	9A 5-9	14
5375						
			☒	9.0	9B 6-16-27	43
5370						
			☒	14.0	9C 7-15-20	35
5365						
			☒	19.0	9D 13-15-17	32
5360						
	24.0	hard	☒	24.0	9E 20-50	70
	25.0	Total Boring Depth 25.0ft				
5355						
5350						

SPT DATA



WELL DIAGRAM

☒ SPT ▮ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 75, Auger

GEOLOGIC BORING LOG SH92 RR.GPJ CO_DOT.GDT 3/7/12

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # 10

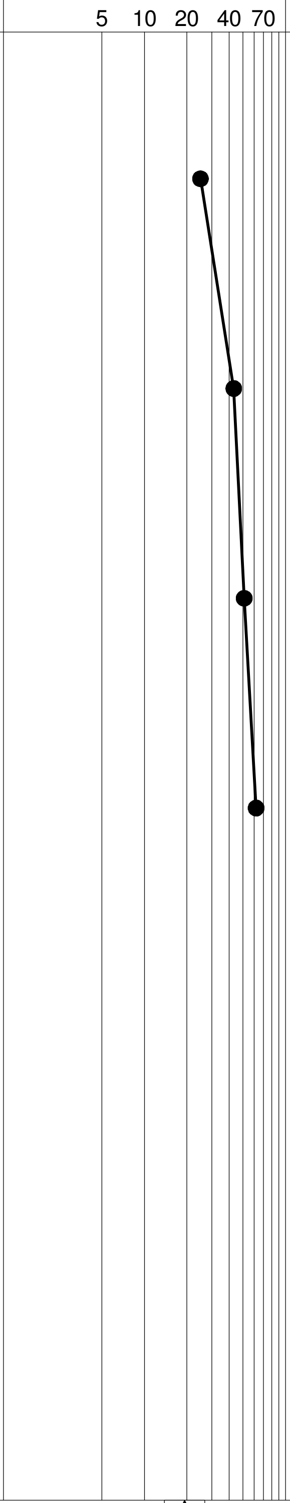
PROJECT ID	SA	PROJECT NAME	DATE DRILLED
	14934	SH 92, RR	12/20/11

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/	

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,372.2ft	20.0ft	N: 360,137 E: 339,070	D. Thomas/R. Brown/P. Spahr

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%
			Gravel, well graded, with clay, sand and cobbles, light brown, medium dense				
5370							
▼				☒	3.5	10A 10-15-10	25
5365							
				☒	8.5	10B 35-32-11	43
	9.5		**Shale,** dark gray, medium hard				
5360							
	13.5		hard	▲	13.5	10C 17-34	51
5355							
				☒	18.5	10D 14-25-37	62
	20.0		Total Boring Depth 20.0ft				
5350							
5345							
5340							

SPT DATA



WELL DIAGRAM

☒ SPT ▮ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)	▼ 4.0				
DATE	12/20/11				
TIME					

NOTES: CME 55, Auger

DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

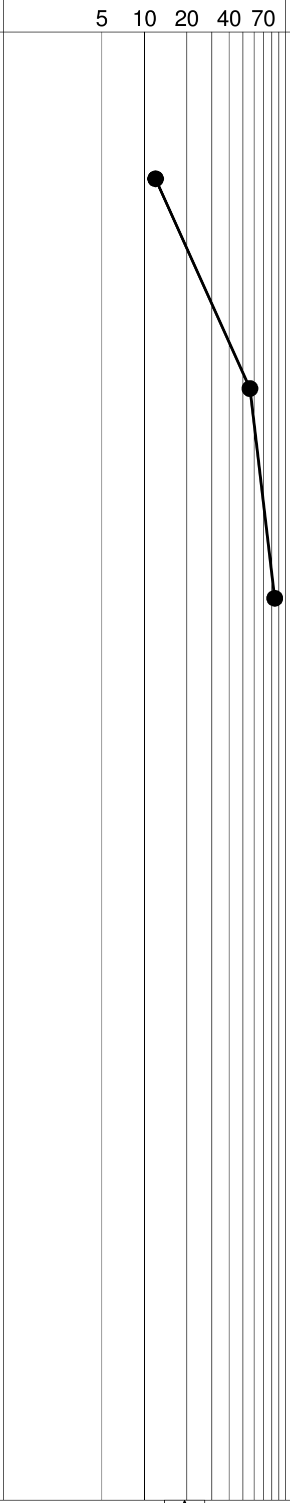
BORING # 11

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
	14934	SH 92, RR	12/20/11

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/	

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,382.5ft	15.0ft	N: 359,605 E: 337,335	D. Thomas/D. Novak/A. Moreno

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA	WELL DIAGRAM
		▨	**Clay,** dark gray, stiff						
5380									
				⊠	3.5	11A 5-5-7	12		
5375	7.0	▤	**Shale,** dark gray, hard, blocky						
				▲	8.5	11B 22-34	56		
5370									
	13.5		very hard	⊠	13.5	11C 21-34-50	84		
	15.0		Total Boring Depth 15.0ft						
5365									
5360									
5355									
5350									



⊠ SPT	▌ CON'T	◈ GRAB	■ SHELBY	⧓ CORE	▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 75, Auger

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

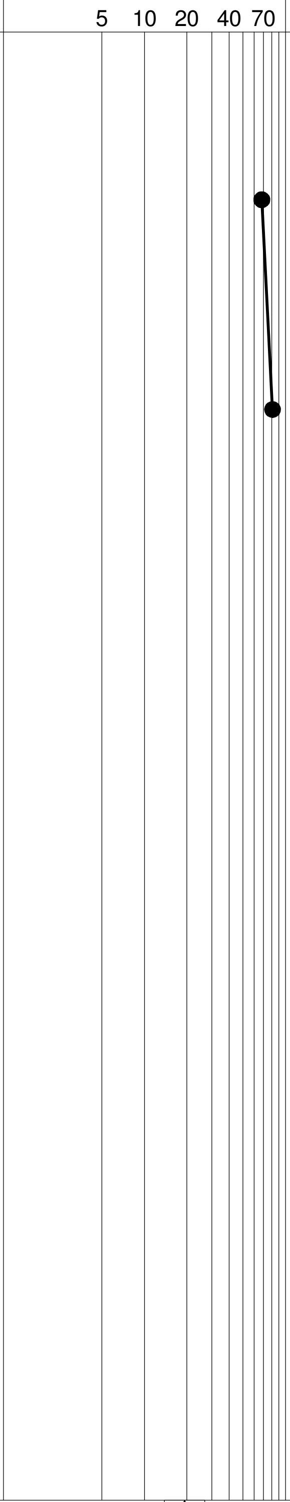
BORING #	PROJECT ID	SA	PROJECT NAME	DATE DRILLED
12		14934	SH 92, RR	12/20/11

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/	

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,381.5ft	10.5ft	N: 359,550 E: 337,142	D. Thomas/D. Novak/A. Moreno

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%
5380		▨	**Clay,** dark gray				
	2.0	▤	*drills harder* **Shale,** dark gray, hard, red iron oxide weathering				
				▲	4.0	11A 19-49	68
5375							
	9.0		very hard	☒	9.0	11B 20-31-50	81
5370	10.5		Total Boring Depth 10.5ft				
5365							
5360							
5355							
5350							

SPT DATA



WELL DIAGRAM

☒	SPT	▮	CON'T	◈	GRAB	■	SHELBY	⧓	CORE	▲	CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

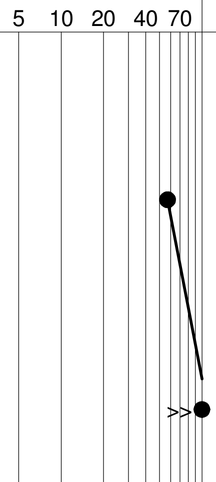
NOTES: CME 75, Auger

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING #	13
PROJECT ID	
SA	14934
PROJECT NAME	SH 92, RR
DATE DRILLED	12/20/11
ROUTE	SH 92
COUNTY	Delta
STRUCTURE/BENT	/
LOCATION	
TOP HOLE ELEV	5,380.7ft
TOTAL DEPTH	10.5ft
SURVEY INFO	N: 359,500 E: 336,949
GEOLOGIST/FOREMAN	D. Thomas/D. Novak/A. Moreno

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA	WELL DIAGRAM
5380		▨	**Clay,** dark gray						
	2.0	☰	*drills harder* **Shale,** dark gray, hard, trace white mineralization						
		☰		☒	4.0	13A 16-23-34	57		
5375		☰							
	9.0	☰	very hard	☒	9.0	13B 20-37-50/5"	87/11"		
5370	10.5		Total Boring Depth 10.5ft						
5365									
5360									
5355									
5350									



☒ SPT ▮ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 75, Auger

ATTACHMENT 3
HB 092A-020, SH-92 & UPRR, SA 14934
2007 AASHTO Bridge Design Guidelines

AASHTO Spectrum for 7% PE in 75 years

Latitude = 38.796959

Longitude = -107.827158

Site Class B

Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.116	PGA - Site Class B
0.2	0.216	Ss - Site Class B
1.0	0.047	S1 - Site Class B

Map Response Spectra for Site Class B

Ss and S1 = Mapped Spectral Acceleration Values

Site Class B

Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	Sd in.	
0.000	0.116	0.000	T = 0.0, Sa = PGA
0.043	0.216	0.004	T = To, Sa = Ss
0.200	0.216	0.084	T = 0.2, Sa = Ss
0.216	0.216	0.099	T = Ts, Sa = Ss
0.300	0.156	0.137	
0.400	0.117	0.182	
0.600	0.078	0.274	
0.800	0.058	0.365	
1.000	0.047	0.456	T = 1.0, Sa = S1
1.200	0.039	0.547	
1.400	0.033	0.638	
1.600	0.029	0.729	
1.800	0.026	0.821	
2.000	0.023	0.912	
2.200	0.021	1.003	
2.400	0.019	1.094	
2.600	0.018	1.185	
2.800	0.017	1.277	
3.000	0.016	1.368	
3.200	0.015	1.459	
3.400	0.014	1.550	
3.600	0.013	1.641	
3.800	0.012	1.732	
4.000	0.012	1.824	

Spectral Response Accelerations SDs and SD1

Latitude = 38.796959

Longitude = -107.827158

As = FpgaPGA, SDs = FaSs, and SD1 = FvS1

Site Class C - Fpga = 1.20, Fa = 1.20, Fv = 1.70

Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.139	As - Site Class C
0.2	0.259	SDs - Site Class C
1.0	0.079	SD1 - Site Class C

As = FpgaPGA, SDs = FaSs, SD1 = FvS1

Site Class C - Fpga = 1.20, Fa = 1.20, Fv = 1.70

Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	Sd in.	
0.000	0.139	0.000	T = 0.0, Sa = As
0.061	0.259	0.009	
0.200	0.259	0.101	T = 0.2, Sa = SDs
0.306	0.259	0.237	T = Ts, Sa = SDs
0.400	0.198	0.310	
0.600	0.132	0.465	
0.800	0.099	0.620	
1.000	0.079	0.775	T = 1.0, Sa = SD1
1.200	0.066	0.930	
1.400	0.057	1.085	
1.600	0.050	1.240	
1.800	0.044	1.395	
2.000	0.040	1.550	
2.200	0.036	1.705	
2.400	0.033	1.860	
2.600	0.031	2.015	
2.800	0.028	2.170	
3.000	0.026	2.325	
3.200	0.025	2.480	
3.400	0.023	2.635	
3.600	0.022	2.790	
3.800	0.021	2.945	
4.000	0.020	3.100	

MEMORANDUM

MATERIALS AND GEOTECHNICAL BRANCH
GEOTECHNICAL PROGRAM
4670 HOLLY STREET, UNIT A, DENVER, COLORADO 80216 303-398-6604 FAX 303-398-6504

HB 092A-020
SH-92 & UPRR
SA 14934

TO: Behrooz Far, CDOT Staff Bridge

FROM: David Thomas, Geotechnical Program

DATE: October 23, 2013

SUBJECT: **GEOTECHNICAL ADDENDUM TO STATE HIGHWAY 92 & UNION PACIFIC RAIL ROAD INTERSECTION AND BIG GULCH**

1.0 INTRODUCTION

This report is an addendum to the March 12, 2012 geotechnical report. Only the additional exploration activities are discussed in this addendum. Details pertaining to the original field exploration including foundation recommendations are covered in the March 2012 report. The scope of work was based on conversations with Colin Young with URS Corporation, Inc. and Hans Egghart, CDOT Region 3.

2.0 GEOTECHNICAL INVESTIGATION

Geotechnical field activities were completed between August 19 and 21, 2013. Four borings (TH21 through TH24) were advanced using a CME 55 all-terrain drill rig using wireline coring techniques. The borings were advanced along SH-92 and the UPRR for the proposed bridge and wall locations as determined by rig access and utility clearances. The additional borings were to determine bedrock characteristics along the full design depth of the deep foundation elements.

2.1 GEOLOGY

The geology is similar across the site. The geology consists of 4 to 15 feet of clay underlain by shale bedrock. Bedrock was encountered in the borings ranging from elevations of 5,356 feet above mean sea level (amsl) to 5,377 feet amsl. The updated engineering geology sheets and boring logs for TH21 through TH24 are presented in Attachments 1 and 2, respectively.

2.2 PHYSICAL PROPERTIES

AASHTO classifications for the bedrock ranged from A-4 (9) to A-7-6 (32). A shale sample from TH22 was found to be highly plastic with a liquid limit of 55 and plasticity index of 29. Unconfined compressive strength testing of bedrock samples ranged from 27.3 kips per square foot (ksf) to 613.4 ksf. Detailed material properties are presented on the engineering geology sheets in Attachment 1.

Please contact the Geotechnical Program at 303-398-6604 with questions.

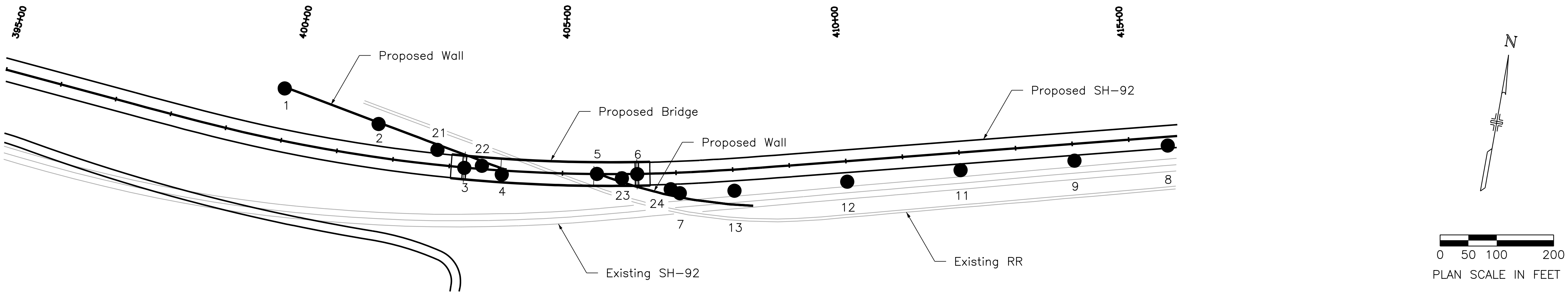
REVIEW: Thomas

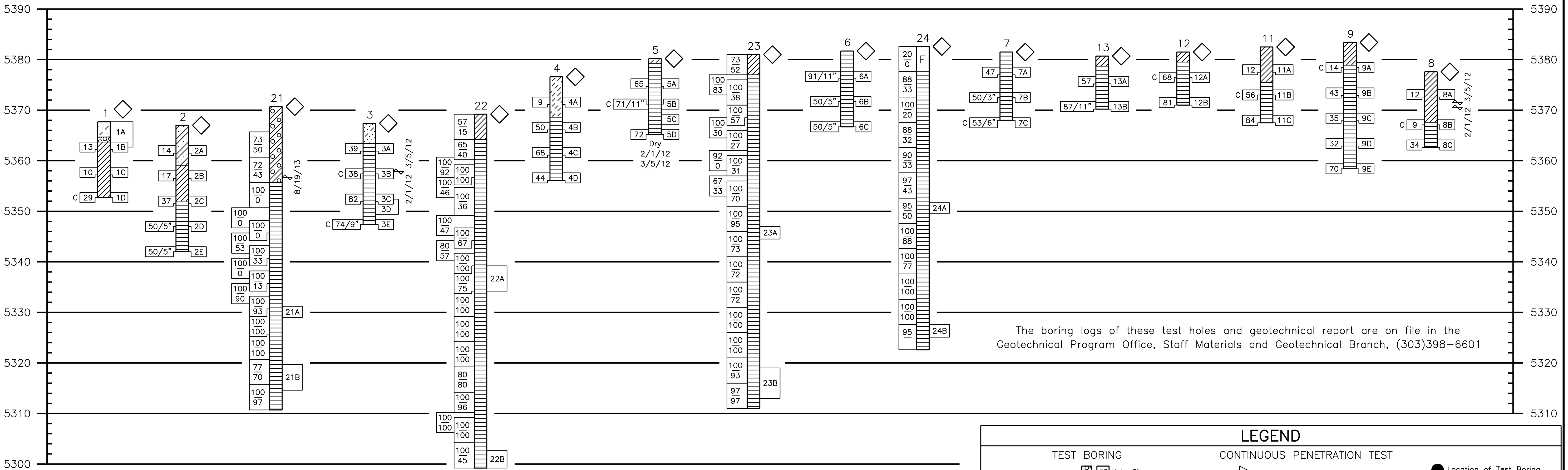
COPY: Eller – Region 3 RTD
Smith – Region 3 West Engineering Program Engineer
Alexander – Region 3 North Engineering RE
Egghart – Region 3 West Engineering
Goodrich – Region 3 Materials Engineer
Chomsrimake – Staff Bridge
Young – URS Corporation
Schiebel/Hernandez – Staff Materials and Geotechnical
Ortiz – Geotechnical Program

ATTACHMENT 1

GEOLOGY SHEET

HB 092A-020
SH-92 & UPRR
SA 14934





The boring logs of these test holes and geotechnical report are on file in the Geotechnical Program Office, Staff Materials and Geotechnical Branch, (303)398-6601

Sample Number	Depth (feet)	Classification			Grading Analysis (AASHTO)				Atterberg Limits			Water Content W %	Dry Density (lb/ft³)	Uniaxial Compressive Strength (psf)	Swell/ Surcharge Pressure (%/ksf)	Chlorides (%)	Water Soluble Sulfates (%)	Soil pH ($H_2O/CaCl_2$)	Resistivity ohm-cm Saturated
		Corps of Engrs. or Visual	USCS	AASHTO	Percent				L.L. L_W	P.L. P_W	P.I. I_W								
					Gravel	Coarse Sand	Fine Sand	Silt and Clay											

Test Results are on Sheet: 14934geosheet04

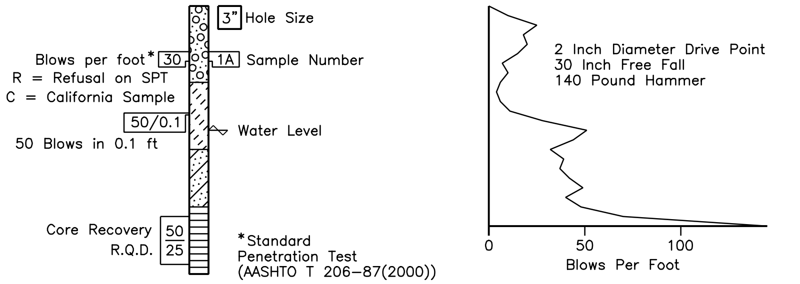
TYPE OF MATERIAL

F Fill	▨ Silt
▨ Clay	▨ Silty Sand
▨ Sandy Clay	▨ Gravel
▨ Gravelly Clay	▤ Shale

LEGEND

TEST BORING

CONTINUOUS PENETRATION TEST



● Location of Test Boring

○ Location of Continuous Penetration Test

W 3 Inch Wireline Boring

☐ Rotary Boring

◇ Auger Boring

Print Date: 10/21/2013
Drawing File Name: 14934geosheet01.dgn
Horiz. Scale: 1:200 Vert. Scale: As Noted
Staff Geotechnical Program HCL

R-X

Sheet Revisions

Date:	Comments	Init.

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As Constructed
No Revisions:
Revised:
Void:

ENGINEERING GEOLOGY

Designer: D. Thomas
Detailer: T. McNulty
Sheet Subset: Geology
Structure Numbers
Subset Sheets: XXX of XXX

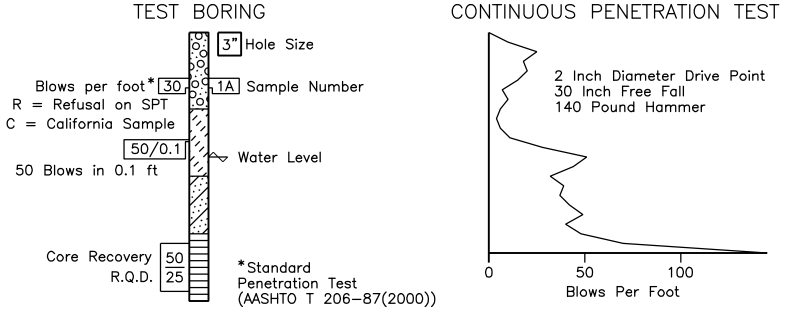
Project No./Code
14934
Sheet Number XXX

SUMMARY OF TEST RESULTS

Sample Number	Depth (feet)	Classification			Grading Analysis (AASHTO)				Atterberg Limits			Water Content W %	Dry Density (lb/ft³)	Uniaxial Compressive Strength (psf)	Swell/ Surcharge Pressure (%/ksf)	Chlorides (%)	Water Soluble Sulfates (%)	Soil pH ($H_2O/CaCl_2$)	Resistivity ohm-cm Saturated
					Percent														
		Corps of Engrs. or Visual	USCS	AASHTO	Gravel	Coarse Sand	Fine Sand	Silt and Clay	L.L. L_W	P.L. P_W	P.I. I_W								
1C	10	Clay	CL	A–7–6(16)	13.5	5.7	7.8	73.0	43	20	23	16.3	–	–	–	–	–	–	–
1D	14	Clay	CL	A–7–6(23)	0.0	0.4	1.2	98.4	43	22	21	15.3	106.8	–	–	–	–	–	–
2A	4	Sandy Clay	CL	A–6(9)	20.5	9.0	9.6	60.9	39	21	18	8.2	–	–	–	–	–	–	–
2E	24	Shale	CL	A–7–6(24)	0.3	1.1	1.5	97.1	44	21	23	9.9	–	–	–	–	–	–	–
3A	4	Shale	CL	A–7–6(20)	2.8	6.0	4.5	86.7	44	22	22	10.5	–	–	–	–	–	–	–
3B	9	Shale	CL	A–7–6(25)	1.7	1.1	1.1	96.2	44	20	24	14.2	118.0	–	1.9/1.0	–	–	–	–
3D	16	Shale	–	–	–	–	–	–	–	–	–	–	–	–	–	0.014	3.08	5.80	400
3E	19	Shale	CL	A–7–6(28)	0.3	1.0	1.0	97.6	46	20	26	13.0	117.6	16,520	–	–	–	–	–
4C	15	Shale	CH	A–7–6(29)	1.7	2.5	1.8	93.9	50	22	28	11.8	–	–	–	–	–	–	–
5B	9	Shale	CL	A–7–6(31)	0.4	0.4	0.4	98.9	47	18	29	11.6	123.9	32,417	–	–	–	–	–
5C	12	Shale	–	–	–	–	–	–	–	–	–	–	–	–	–	0.014	3.04	5.64	300
7C	13	Shale	CL	A–7–6(25)	2.2	1.0	0.6	96.2	45	21	24	11.5	114.4	8,701	–	–	–	–	–
8B	9	Clay	CL	A–7–6(28)	0.1	0.3	3.0	96.7	45	18	27	30.5	92.0	–	0.0/1.0	–	–	–	–
8C	14	Shale	CH	A–7–6(27)	1.0	3.2	3.6	92.2	51	25	26	21.3	–	–	–	–	–	–	–
9A	4	Shale	CH	A–7–6(32)	0.1	0.5	1.9	97.5	50	20	30	21.0	107.0	–	0.5/1.0	–	–	–	–
11A	4	Clay	CL	A–7–6(21)	6.3	4.4	6.0	83.4	45	20	25	14.6	–	–	–	–	–	–	–
11B	9	Shale	CL	A–7–6(25)	0.4	0.2	0.4	99.0	43	20	23	11.8	123.0	–	–	–	–	–	–
12A	4	Shale	CL	A–7–6(28)	0.1	0.4	1.0	98.5	45	19	26	13.5	118.6	21,677	1.1/1.0	–	–	–	–
13B	10	Shale	CL	A–7–6(25)	0.3	0.7	0.9	98.1	44	21	23	12.3	–	–	–	–	–	–	–
21A	39.5–41.7	Shale	CL	A–4(9)	0.0	0.2	1.0	98.7	27	17	10	9.4	–	613,440	–	–	–	–	–
21B	51.0–56.1	Shale	CL	A–6(17)	1.2	0.3	1.7	96.8	35	18	17	4.5	–	384,480	–	–	–	–	–
22A	30.0–35.0	Shale	CH	A–7–6(32)	0.1	1.6	3.2	95.2	55	26	29	9.6	–	–	–	–	–	–	–
22B	66.5–70.0	Shale	CL	A–6(12)	0.0	0.2	1.2	98.6	30	17	13	3.5	–	319,680	–	–	–	–	–
23A	34.0–36.5	Shale	CL	A–7–6(21)	0.0	0.2	0.8	99.0	42	23	19	5.9	–	–	–	–	–	–	–
23B	62.0–68.0	Shale	CL	A–6(11)	0.0	0.0	1.3	98.6	30	18	12	3.5	–	161,280	–	–	–	–	–
24A	30.9–33.0	Shale	CL	A–6(20)	0.0	0.1	1.0	98.9	40	22	18	4.9	–	27,360	–	–	–	–	–
24B	55.0–57.5	Shale	CL	A–6(15)	0.0	0.4	1.8	97.8	33	18	15	2.5	–	410,400	–	–	–	–	–

TYPE OF MATERIAL

LEGEND



● Location of Test Boring

○ Location of Continuous Penetration Test

W 3 Inch Wireline Boring

☐ Rotary Boring

◇ Auger Boring

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Horiz. Scale: 1:200 Vert. Scale: As Noted
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Sheet Revisions		
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No Revisions:
Revised:
Void:

ENGINEERING GEOLOGY

Designer: D. Thomas
Detailer: T. McNulty
Sheet Subset: Geology
Structure Numbers
Subset Sheets: XXX of XXX

Project No./Code
14934
Sheet Number XXX

ATTACHMENT 2

BORING LOGS

HB 092A-020
SH-92 & UPRR
SA 14934

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # 21	PROJECT ID HB 092A-020	SA 14934	PROJECT NAME Stingel's Hill	DATE DRILLED 8/19/13
ROUTE SH 92	COUNTY Delta	STRUCTURE/BENT /	LOCATION MM 14.4, E. of Hotchkiss	
TOP HOLE ELEV 5,370.7ft	TOTAL DEPTH 60.0ft	SURVEY INFO N: 359,480 E: 336,421	GEOLOGIST/FOREMAN B. Taylor/D. Novak	

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA 5 10 20 40 70	WELL DIAGRAM
5370			no recovery						
5365	5.0		2' blow out into sand, brownish-gray gravelly clay, fill (same as surface material - basalt cobbles, etc.)		5.0		73% 50%		
5360	10.0		dark brown-gray gravelly clay to clay-shale (~13" of fill)		10.0		72% 43%		
	▼								
5355	15.0 15.0		dark gray shale - difficult to remove from pipe		15.0		100% 0%		
5350	20.0		dark gray shale		20.0		100% 0%		
	22.5		dark gray shale		22.5		100% 0%		
5345	25.0		dark gray shale with clay layer		25.0		100% 53%		
	27.5		dark gray shale interbedded with clay layer		27.5		100% 33%		
5340	30.0		dark gray shale interbedded with clay layers, sample wrapped		30.0		100% 0%		
	32.5		dark gray shale interbedded with clay layers, sample wrapped		32.5		100% 13%		
5335	35.0		dark gray shale interbedded with clay layers		35.0		100% 90%		
	37.5		dark gray shale interbedded with clay layers - rotten odor		37.5		100% 93%		

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H_2O DEPTH (ft)	▼ 14.0				
DATE	8/19/13				
TIME					

NOTES: CME 55, Wireline

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DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

BORING # 21

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
HB 092A-020	14934	Stingel's Hill	8/19/13

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/	MM 14.4, E. of Hotchkiss

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,370.7ft	60.0ft	N: 359,480 E: 336,421	B. Taylor/D. Novak

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA 5 10 20 40 70	WELL DIAGRAM
5330	40.0	▤	dark gray shale, 1 natural break in core after 4", remaining was unbroken to 45', fossil shell present	⧓	40.0		100% 100%		
5325	45.0	▤	black shale - no breaks	⧓	45.0		100% 100%		
5320	50.0	▤	black to dark gray shale with last 12", light gray clayey-shale	⧓	50.0		77% 70%		
5315	55.0	▤	~2" of light gray shale - 58" dark gray thinly bedded shale (sample wrapped)	⧓	55.0		100% 97%		
5310	60.0		Total Boring Depth 60.0ft						
5305									
5300									
5295									

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H_2O DEPTH (ft)	▼ 14.0				
DATE	8/19/13				
TIME					

NOTES: CME 55, Wireline

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # 22				
PROJECT ID HB 092A-020	SA 14934	PROJECT NAME Stingel's Hill		DATE DRILLED 8/20/13
ROUTE SH 92	COUNTY Delta	STRUCTURE/BENT /	LOCATION MM 14.4, E. of Hotchkiss	
TOP HOLE ELEV 5,369.2ft	TOTAL DEPTH 70.0ft	SURVEY INFO N: 359,466 E: 336,503	GEOLOGIST/FOREMAN B. Taylor/D. Novak	

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA 5 10 20 40 70	WELL DIAGRAM
		▨	brownish gray clay, highly weathered shale, little to no fill	⧓	0.0		57% 15%		
5365									
	5.0 5.0	≡	brownish gray thinly bedded shale	⧓	5.0		65% 40%		
5360	9.0	≡	brownish gray shale with clay layers	⧓	9.0		100% 92%		
	10.0	≡	gray/red mix shale, calcite layers	⧓	10.0		100% 100%		
	12.5	≡	gray shale with brownish red staining nodules (siderite?)	⧓	12.5		100% 46%		
5355									
	15.0	≡	top ~8" - light grayish brown into dark gray clay/shale, color transition likely represents lowest water table @ ~16' depth	⧓	14.5		100% 36%		
5350									
	20.0	≡	dark gray shale, thinly bedded	⧓	20.0		100% 47%		
	22.5	≡	very dark gray shale, thinly bedded, little clay layers	⧓	22.5		100% 67%		
5345									
	25.0	≡	very dark gray shale, thinly bedded, layer of light gray clay (washed mostly out), with pyrite?, metallic minerals	⧓	25.0		80% 57%		
	27.5	≡	very dark gray shale, with clay layer	⧓	27.5		100% 100%		
5340									
	30.0	≡	very dark gray shale, clay layer ~ 2" thick, wrapped sample	⧓	30.0		100% 75%		
5335									
	35.0	≡	very dark gray shale, thin bedding to massive silt/mudstone, shell fossils present, pyrite, clay layers in upper ~12"	⧓	35.0		100% 100%		
5330									

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H_2O DEPTH (ft)						NOTES: CME 55, Wireline
DATE						
TIME						

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # 22

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
HB 092A-020	14934	Stingel's Hill	8/20/13

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/	MM 14.4, E. of Hotchkiss

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,369.2ft	70.0ft	N: 359,466 E: 336,503	B. Taylor/D. Novak

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA 5 10 20 40 70	WELL DIAGRAM
	40.0		very dark gray black shale to silt/mudstone, no clay, fossil shells & pyrite present, no natural breaks	⧓	40.0		100% 100%		
5325									
	45.0		very dark gray/black shale to silt/mudstone, fossil shells & pyrite present	⧓	45.0		100% 100%		
5320									
	50.0		very dark gray/black shale/siltstone/mudstone, 25" light gray layer with clay part washed out, fossils present	⧓	50.0		80% 80%		
5315									
	55.0		very dark gray/black shale/silt/mudstone, with 3" clay layer	⧓	55.0		100% 96%		
5310	59.0		very dark gray/black shale/siltstone/mudstone	⧓	59.0		100% 100%		
	60.0		very dark gray/black shale/siltstone/mudstone, no clay, small amount of pyrite	⧓	60.0		100% 100%		
5305									
	65.0		dark gray/black shale (siltstone/mudstone), no clay, wrapped sample	⧓	65.0		100% 45%		
5300									
	70.0		Total Boring Depth 70.0ft						
5295									
5290									

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H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Wireline

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING # 23

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
HB 092A-020	14934	Stingel's Hill	8/20/13

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/	MM 14.4, E. of Hotchkiss

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,381.0ft	70.0ft	N: 359,487 E: 336,750	B. Taylor/D. Novak

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA 5 10 20 40 70	WELL DIAGRAM
5380			light brown clay & mud	⧗	0.0		73% 52%		
	4.0 4.0		light brown clay & shale	⧗	4.0		100% 83%		
5375	5.0		dark brown/gray shale & clay, with mineral (gypsum?) filled fractures	⧗	5.0		100% 38%		
5370	10.0		gray shale with interbedded clay, mineral filled fractures	⧗	10.0		100% 57%		
	12.5		gray shale with mineral filled fractures	⧗	12.5		100% 30%		
5365	15.0		gray shale, reddish brown staining & mineral filled fractures	⧗	15.0		100% 27%		
	19.0		gray shale with clay, mineral filled fractures	⧗	19.0		92% 0%		
5360	20.0		gray shale interbedded with thin mud layers, mineralized fractures	⧗	20.0		100% 31%		
	24.0		gray shale, mineralized fracture	⧗	24.0		67% 33%		
5355	25.0		dark gray shale interbedded with clay	⧗	25.0		100% 70%		
5350	30.0		dark gray shale, thinly bedded	⧗	30.0		100% 95%		
5345	35.0		very dark gray shale, thinly bedded, ~7" very light gray muddy clay, wrapped sample	⧗	35.0		100% 73%		

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H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Wireline

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GEOLOGICAL BORING LOG

BORING # 23				
PROJECT ID HB 092A-020	SA 14934	PROJECT NAME Stingel's Hill		DATE DRILLED 8/20/13
ROUTE SH 92	COUNTY Delta	STRUCTURE/BENT /	LOCATION MM 14.4, E. of Hotchkiss	
TOP HOLE ELEV 5,381.0ft	TOTAL DEPTH 70.0ft	SURVEY INFO N: 359,487 E: 336,750	GEOLOGIST/FOREMAN B. Taylor/D. Novak	

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA 5 10 20 40 70	WELL DIAGRAM
5340	40.0		very dark gray shale, thinly bedded, ~3" very light gray muddy clay, fossils present (shells)	⋈	40.0		100% 72%		
5335	45.0		very dark gray shale, thinly bedded, fossils present into very dark gray/black massive pyrite shale/siltstone/mudstone	⋈	45.0		100% 72%		
5330	50.0		very dark gray/black massive shale (siltstone/mudstone), fossil shells	⋈	50.0		100% 100%		
5325	55.0		very dark gray/black massive shale (siltstone/mudstone), fossil shells, core was unbroken	⋈	55.0		100% 100%		
5320	60.0		very dark gray/black massive shale (siltstone/mudstone), with ~4" section of light gray shale & clay layer, fossil shells & pyrite	⋈	60.0		100% 93%		
5315	65.0		very dark gray/black massive shale (siltstone/mudstone), few small fossil shells & pyrite, wrapped sample	⋈	65.0		97% 97%		
5310	70.0		Total Boring Depth 70.0ft						
5305									

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H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Wireline

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DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

BORING # 24

PROJECT ID	SA	PROJECT NAME	DATE DRILLED
HB 092A-020	14934	Stingel's Hill	8/21/13

ROUTE	COUNTY	STRUCTURE/BENT	LOCATION
SH 92	Delta	/	MM 14.4, E. of Hotchkiss

TOP HOLE ELEV	TOTAL DEPTH	SURVEY INFO	GEOLOGIST/FOREMAN
5,382.6ft	60.0ft	N: 359,483 E: 336,838	B. Taylor/D. Novak

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA 5 10 20 40 70	WELL DIAGRAM
5380		F	fill		0.0		20% 0%		
5375	5.0 5.0		brown shale & clay, thinly bedded, some reddish-brown staining in fractures		5.0		88% 33%		
5370	10.0		dark brown shale & clay, thinly bedded, reddish-brown staining in fractures & mineralization		10.0		100% 20%		
5365	15.0		dark brown-gray shale, thinly bedded, reddish-brown staining & mineralization in fractures		15.0		88% 32%		
5360	20.0		gray shale, thinly bedded, reddish-brown staining & mineralization in fractures		20.0		90% 33%		
5355	25.0		gray shale, thinly bedded, reddish-brown staining in fractures, some clay layers		25.0		97% 43%		
5350	30.0		dark gray shale, thinly bedded, some gypsum in fractures, wrapped core		30.0		95% 50%		
5345	35.0		dark gray shale, thinly bedded, interbedded clay, light gray clay ~3", fossil shells present		35.0		100% 88%		

☒ SPT ▮ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Wireline

DEPARTMENT OF TRANSPORTATION

GEOLOGICAL BORING LOG

BORING # 24				
PROJECT ID HB 092A-020	SA 14934	PROJECT NAME Stingel's Hill		DATE DRILLED 8/21/13
ROUTE SH 92	COUNTY Delta	STRUCTURE/BENT /	LOCATION MM 14.4, E. of Hotchkiss	
TOP HOLE ELEV 5,382.6ft	TOTAL DEPTH 60.0ft	SURVEY INFO N: 359,483 E: 336,838	GEOLOGIST/FOREMAN B. Taylor/D. Novak	

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA 5 10 20 40 70	WELL DIAGRAM
	40.0		dark gray shale, thinly bedded, into very dark gray/black shale (siltstone/mudstone), shell fossils	⧓	40.0		100% 77%		
5340									
	45.0		very dark gray/black shale/siltstone/mudstone shell fossils, ~1" clay layer - only natural break	⧓	45.0		100% 100%		
5335									
	50.0		very dark gray/black shale (siltstone/mudstone), shell fossils, no clay	⧓	50.0		100% 100%		
5330									
	55.0		very dark gray/black shale (siltstone/mudstone), shell fossils, few clay layers ~1" thick, wrapped sample	⧓	55.0		95%		
5325									
	60.0		Total Boring Depth 60.0ft						
5320									
5315									
5310									
5305									

☒ SPT ▮ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Wireline

MEMORANDUM

MATERIALS AND GEOTECHNICAL BRANCH
GEOTECHNICAL PROGRAM
4670 HOLLY STREET, UNIT A, DENVER, COLORADO 80216 303-398-6604 FAX 303-398-6504

STA 092A-024
SH-92 Stengel's Hill
SA 17772

TO: Behrooz Far, CDOT Staff Bridge

FROM: David Thomas, Geotechnical Program

DATE: April 10, 2013

SUBJECT: **GEOTECHNICAL RECOMMENDATIONS FOR STATE HIGHWAY 92 RETAINING WALL AT MM 15.1 (STENGEL'S HILL)**

1.0 INTRODUCTION

This report presents geotechnical exploration observations and recommendations for a planned retaining wall as part of planned improvements along SH-92 near the intersection of the Union Pacific Railroad (UPRR). The wall is to be located at mile marker 15.1 along SH-92 between Delta and Hotchkiss. Currently, the UPRR is an at-grade crossing with SH-92. To increase safety, a bridge raising SH-92 is proposed allowing UPRR to cross underneath SH-92. To improve the line of sight and the approach alignment to the bridge, SH-92 is being shifted to the south requiring excavation and a retaining wall. It is proposed that the retaining wall be a cast in place (CIP) wall that will extend 372 feet from approximately STA 442+00 to STA 445+72 with a maximum height of 10 feet. The wall will be placed on top of a cut slope ranging from 2:1 to 4:1 (horizontal to vertical) with a maximum height of approximately 7 feet.

The purpose of the geotechnical exploration is to characterize physical properties of foundation materials at the proposed structure location. Foundation recommendations are provided for design and construction of the proposed structures. The scope of work was based on conversations with Mike Perez with URS Corporation, Inc. and Hans Egghart, CDOT Region 3.

2.0 GEOTECHNICAL INVESTIGATION

Geotechnical field activities were completed between March 5 and 6, 2012. Two borings (TH1 and TH2) were advanced using a CME 55 all-terrain drill rig with hollow stem auger techniques. The borings were advanced along SH-92 for the proposed wall location as determined by rig access and utility clearances. TH1 was advanced on top of the slope along the right of way fence and TH2 was advanced along the grade of SH-92 due to utility constraints. Standard penetration tests using split spoon samplers and California samplers were performed in the borings at select intervals in general accordance with ASTM D-l586 and D-3550, respectively. Traffic control was provided by CDOT Maintenance Patrol 33.

2.1 GEOLOGY

The geology of the soils to be excavated consists of interbedded medium dense to very dense clayey sand with gravel and stiff clay with sand. Cobbles up to 4 inches in diameter were encountered in TH1 at approximately 20 feet bgs. Claystone bedrock was encountered at a depth of 24 feet below ground surface (bgs) in TH1 and 5 feet bgs in TH2. Groundwater was only encountered during drilling at TH1 at a depth of 18.5 feet bgs. The geology sheet and boring logs are presented in Attachment 1 and Attachment 2, respectively.

2.2 PHYSICAL PROPERTIES

AASHTO classifications for the clayey sand was A-2-6 (0) to A-7-6 (7) and the clay ranged from A-6 (8) to A-7-6 (32), and bedrock ranged from A-7-6 (27) to A-7-6 (32). Clay and bedrock samples from TH2 were found to be highly plastic with liquid limits up to 56 and plasticity indices up to 33 indicating a marginal potential for swell per AASHTO LRFD Bridge Design Table 10.4.6.3-1. Unconfined compressive strength testing of bedrock samples resulted in 8.1 kips per square foot (ksf). These values are believed to be low since samples were collected using a California sampler causing disturbance in the sample. Detailed material properties are presented on the engineering geology sheet in Attachment 1.

3.0 RECOMMENDATIONS

The subsurface conditions are favorable for a CIP retaining wall at the road cut. For retaining walls, it is assumed new fill will consist of Class 1 Structure Backfill. Class 1 Structure Backfill should be compacted to at least 95 percent of the maximum dry density and within 2 percent of optimum moisture content as determined by AASHTO T180 (ASTM D 1557) and as described in Section 206 of the 2011 CDOT *Standard Specification for Road and Bridge Construction*. Retaining wall parameters for design are presented in Table 1. Lateral pressures must be reevaluated when sloping backfill or surcharge loads exist. Temporary excavation support may be required where slopes above the groundwater table are steeper than 1:1 (H:V). Parameters presented in Table 1 also are suitable for temporary excavation support design.

The bearing material will be the clayey sand or clay. Nominal bearing capacity values were calculated based on wall design options provided by Craig Parent with URS (Attachment 3), including current groundwater conditions, footer widths from 6 to 12 feet, a 2:1 slope in front of the wall toe, varying distances between the footer and the slope, and a minimum 3 feet of embedment for frost protection is recommended. Table 2 summarizes the bearing capacities for the different wall configurations.

The coefficient of sliding resistance (μ) that may be used between concrete and undisturbed foundation material is 0.32 for clay and 0.40 for clayey sand. It will be important to maintain a good drainage at the base of the retaining wall in order to prevent the clay from becoming saturated. A bearing resistance factor of 0.55 for gravity walls may be applied when using the Load Resistance Factor Design (LRFD) method. The global stability of the walls should be verified after final design is completed.

TABLE 1. MATERIAL PARAMETERS FOR RETAINING WALLS AND TEMPORARY EXCAVATIONS

Material	Typical Total Unit Weight γ_T (pcf)	Internal Friction Angle ϕ (degrees)	Cohesion C (psf)	Earth Pressure Coefficients		
				Active (Ka)	At Rest (Ko)	Passive (Kp)
New Class 1 Structure Backfill	125	34	0	0.28	0.44	3.5
Clayey Sand	125	30	0	0.33	0.50	3.0
Clay	120	20	100	0.49	0.65	2.0

TABLE 2. WALL NOMINAL BEARING CAPACITIES

Station	Footer Width (ft)	Footer Placement	Nominal Bearing Capacities (ksf)	
			Sand	Clay
443	6	A	10.5	5.3
443	7	B	9.7	6.2
444	9	A	10.6	4.7
444	12	B	7.2	6.2

Note: See Attachment 3 for additional information.

Please contact the Geotechnical Program at 303-398-6604 with questions.

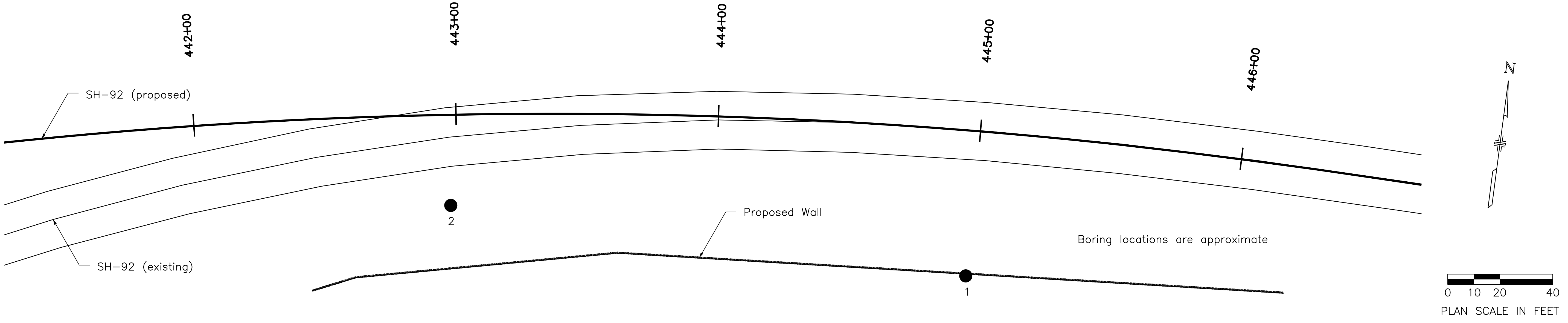
REVIEW: Conroy

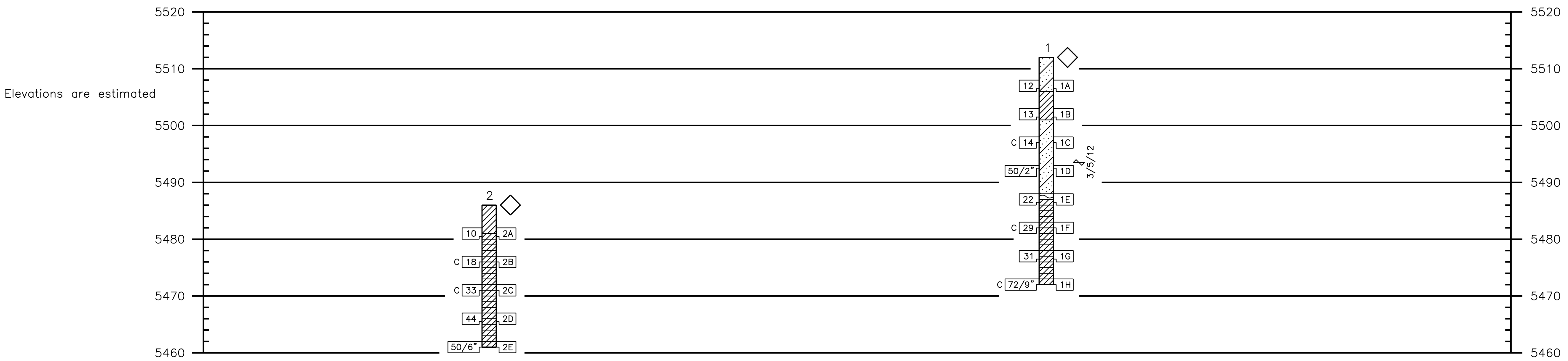
COPY:
Eller – Region 3 RTD
Znamenacek – Region 3 West Engineering Program Engineer
Alexander – Region 3 West Engineering RE
Egghart – Region 3 West Engineering
Goodrich – Region 3 Materials Engineer
Perez – URS Corporation
Schiebel/Hernandez – Staff Materials and Geotechnical
Conroy – Geotechnical Program

ATTACHMENT 1

GEOLOGY SHEET

STA 092A-024
SH-92 STENGEL'S HILL
SA 17772





The boring logs of the above test holes and geotechnical report are on file in the Geotechnical Program Office, Staff Materials and Geotechnical Branch, (303)398–6601

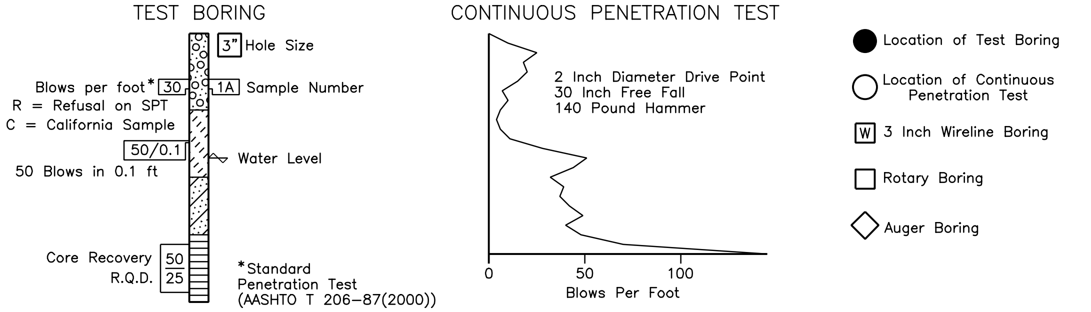
SUMMARY OF TEST RESULTS

Sample Number	Depth (feet)	Classification			Grading Analysis (AASHTO) Percent				Atterberg Limits			Water Content W %	Dry Density (lb/ft³)	Uniaxial Compressive Strength (psf)	Swell (%)	Water Soluble Sulfates (%)	Soil pH (H₂O/CaCl₂)	Resistivity ohm–cm Saturated
		Corps of Engrs. or Visual	USCS	AASHTO	Gravel	Coarse Sand	Fine Sand	Silt and Clay	L.L. L_W	P.L. P_W	P.I. I_W							
1A	4	Clayey Sand	SC	A–7–6(7)	28.4	14	10.5	47.1	45	22	23	11.0	–	–	–	–	–	–
1B	9	Clay	CL	A–6(8)	4.5	10.7	29.7	55.1	36	16	20	11.7	–	–	–	–	–	–
1C	14	Clayey Sand	SC	A–2–6(0)	1.7	22.8	44.6	31.0	25	14	11	13.9	110.4	–	–	–	–	–
2A	4	Clay	CH	A–7–6(32)	5.7	2.9	2.2	89.1	56	23	33	21.1	–	–	–	–	–	–
2B	9	Claystone	CH	A–7–6(32)	1.7	1.7	2.3	94.3	50	18	32	16.1	110.8	8,087	–	–	–	–
2C	14	Claystone	CH	A–7–6(27)	11.7	2.5	3.1	82.6	54	23	31	17.4	106.4	–	–	–	–	–

TYPE OF MATERIAL

- ▨ Clay
- ▨ Clayey Sand
- ▨ Weathered Claystone
- ▨ Claystone

LEGEND



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Staff Geotechnical Program HCL

R–X

Sheet Revisions		
Date:	Comments	Init.

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Denver, CO 80216
Phone: 303-398-6601 FAX: 303-398-6504
Staff Geotechnical Program HCL

As Constructed
No Revisions:
Revised:
Void:

ENGINEERING GEOLOGY
Designer: D. Thomas
Detailer: T. McNulty
Sheet Subset: Geology
Structure Numbers
Subset Sheets: XXX of XXX

Project No./Code
STA 092A-024
17772
Sheet Number XXX

ATTACHMENT 2

BORING LOGS

STA 092A-024
SH-92 STENGEL'S HILL
SA 17772

C DOT
DEPARTMENT OF TRANSPORTATION

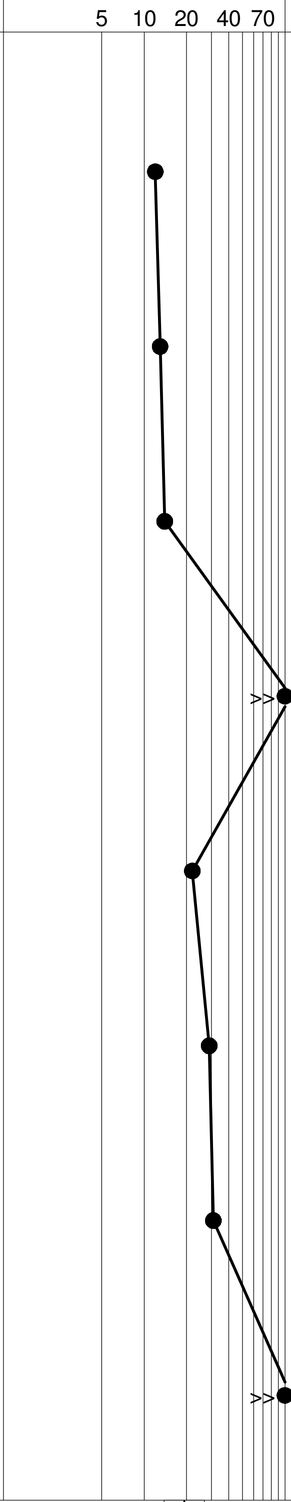
GEOLOGICAL BORING LOG

BORING # 1

PROJECT ID STA 092A-024	SA 17772	PROJECT NAME SH 92, Stengel's Hill		DATE DRILLED 3/5/12
ROUTE SH 92	COUNTY Delta	STRUCTURE/BENT Wall 442/	LOCATION MP 15.1	
TOP HOLE ELEV 5,512.0ft	TOTAL DEPTH 40.0ft	SURVEY INFO N: 360,534 E: 340,470 (approx)	GEOLOGIST/FOREMAN D. Thomas/D. Novak	

ELEV (ft)	DEPTH (ft)	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%
		Clayey Sand, with gravel, yellowish orange, medium dense, subangular				
5510						
			☒	4.0	1A 4-5-7	12
	6.0	*drills hard* **Clay,** with sand, light brown, stiff				
5505						
			☒	9.0	1B 6-6-7	13
	11.0	*drills harder* **Clayey Sand,** light brown, medium dense, subangular, gravels - very angular				
5500						
			▲	14.0	1C 5-9	14
5495						
	▼					
	19.0	very dense, 4" cobbles in cuttings	☒	19.0	1D 50/2"	50/2"
5490						
	24.0	**Weathered Claystone,** mottled light gray & reddish orange & yellowish orange, very stiff	☒	24.0	1E 6-11-11	22
	25.0	**Claystone,** firm, dark gray				
5485						
			▲	29.0	1F 12-17	29
5480						
	34.0	medium hard	☒	34.0	1G 9-14-17	31
5475						
	39.0	very hard	▲	39.0	1H 22-50/3"	72/9"
	40.0	Total Boring Depth 40.0ft				
5470						

SPT DATA



WELL DIAGRAM

☒ SPT	▌ CON'T	◆ GRAB	■ SHELBY	⧓ CORE	▲ CALIFORNIA

H_2O DEPTH (ft)	▼ 18.5				
DATE	3/5/12				
TIME					

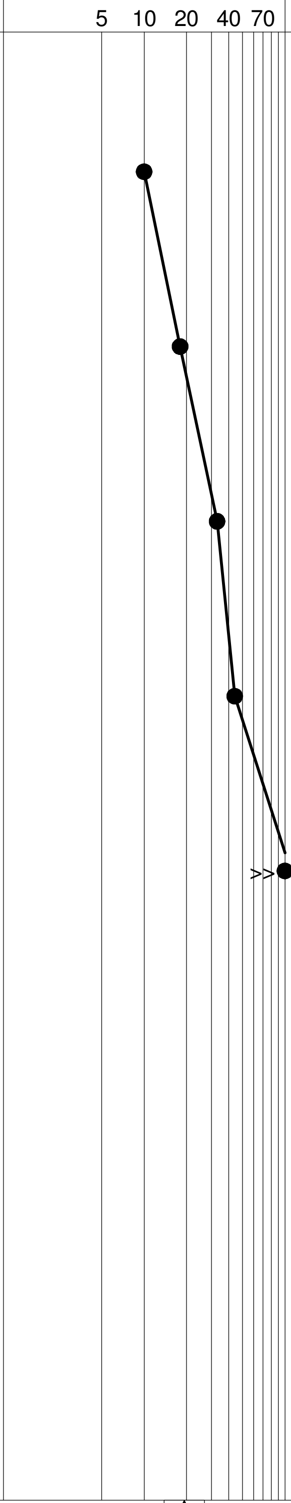
NOTES: CME 55, Auger
Top Hole Elevation is Approximate

GEOLOGICAL BORING LOG

DEPARTMENT OF TRANSPORTATION

BORING #	2
PROJECT ID	STA 092A-024
SA	17772
PROJECT NAME	SH 92, Stengel's Hill
DATE DRILLED	3/5/12
ROUTE	SH 92
COUNTY	Delta
STRUCTURE/BENT	Wall 442/
LOCATION	MP 15.1
TOP HOLE ELEV	5,486.0ft
TOTAL DEPTH	25.0ft
SURVEY INFO	N: 360,535 E: 340,272 (approx)
GEOLOGIST/FOREMAN	D. Thomas/D. Novak

ELEV (ft)	DEPTH (ft)	LOG	DESCRIPTION	SAMPLE TYPE	DEPTH (ft)	SAMPLE ID BLOWS	N-VALUE REC%/RQD%	SPT DATA	WELL DIAGRAM
5485			**Clay,** light brown to yellowish orange, stiff						
				☒	4.0	2A 3-5-5	10		
	5.0		*drills harder* **Claystone,** weathered, mottled light brown & dark gray, blocky texture						
5480									
				▲	9.0	2B 8-10	18		
5475									
	14.0		medium hard	▲	14.0	2C 12-21	33		
5470									
	19.0		medium hard, dark gray	☒	19.0	2D 11-16-28	44		
5465									
	24.0		very hard, dark gray	☒	24.0	2E 18-50/6"	50/6"		
	25.0		Total Boring Depth 25.0ft						
5460									
5455									
5450									
5445									



☒ SPT ▮ CON'T ◈ GRAB ■ SHELBY ⧓ CORE ▲ CALIFORNIA

H_2O DEPTH (ft)					
DATE					
TIME					

NOTES: CME 55, Auger
Top Hole Elevation is Approximate

ATTACHMENT 3

PROPOSED WALL DESIGNS

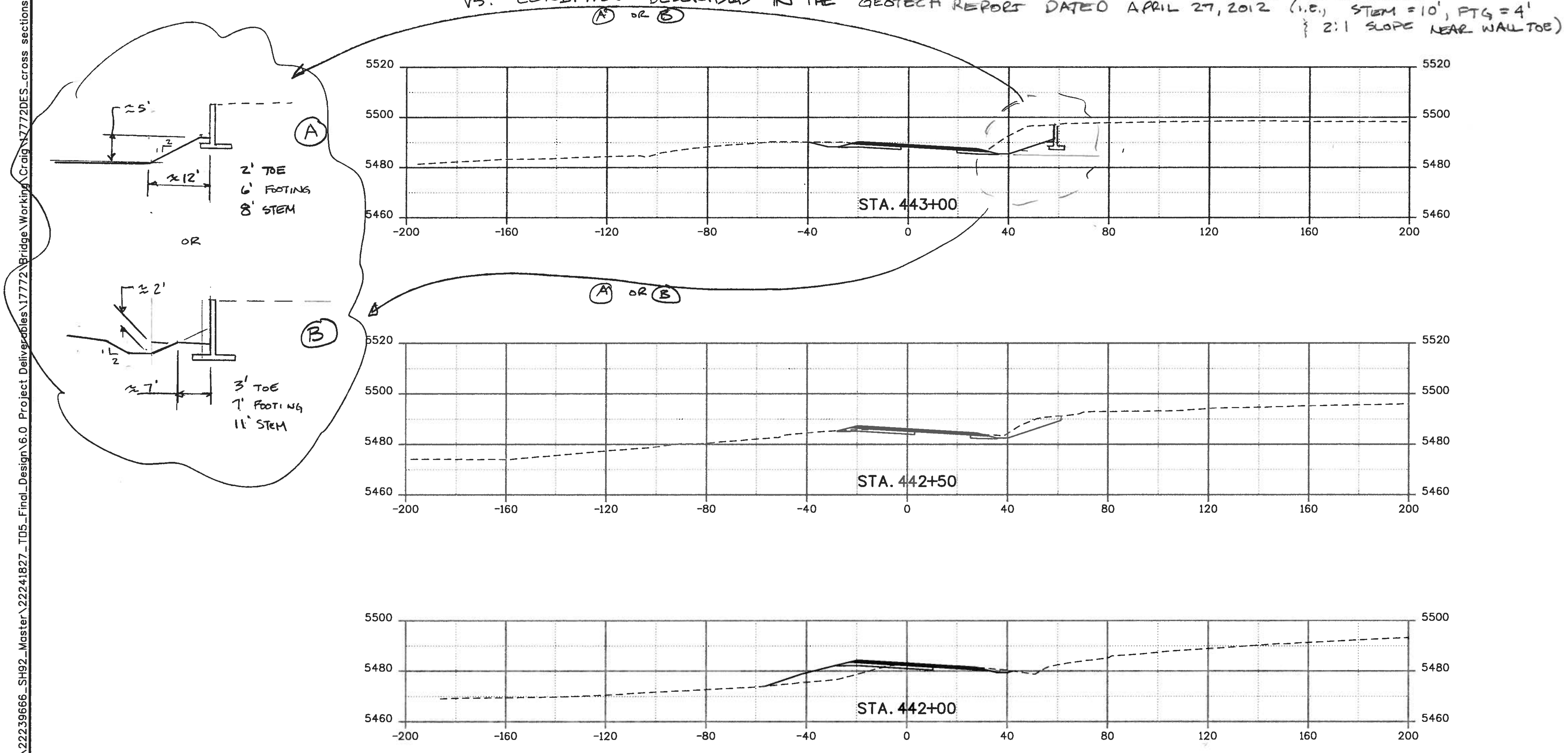
STA 092A-024
SH-92 STENGEL'S HILL
SA 17772

Ⓐ HIGHER BOTTOM OF FTG. ELEV.

Ⓑ LOWER " " " ELEV.

NOTE: FTG EL COULD BE SOMEWHERE BETWEEN Ⓐ & Ⓑ DEPENDING ON IF THERE IS A DIFFERENCE IN BRG. PRESSURE FOR THESE CONDITIONS VS. CONDITION DESCRIBED IN THE GEOTECH REPORT DATED APRIL 27, 2012 (I.E., STEM = 10', FTG = 4' & 2:1 SLOPE NEAR WALL TOE)

CIP WALL 442



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Print Date: 3/20/2012
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Unit Information Unit Leader Initials
URS

Sheet Revisions		
Date:	Comments	Init.

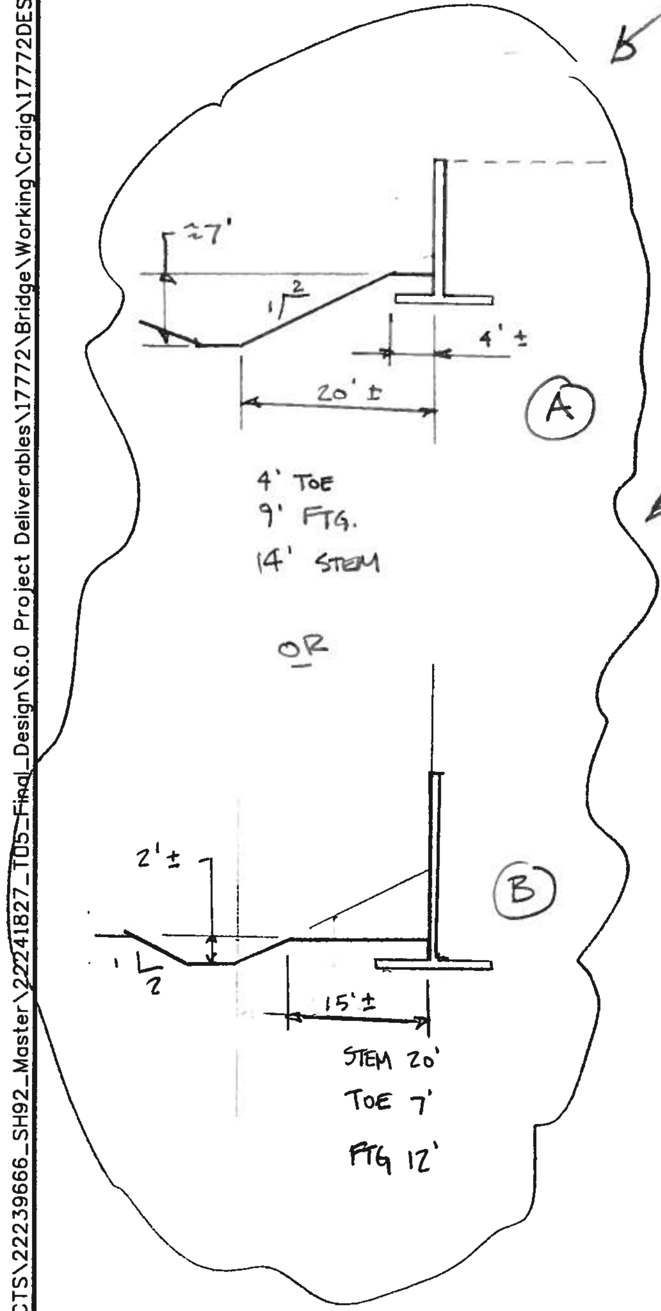
Colorado Department of Transportation
2424 North Townsend Avenue
Montrose, CO 81401
Phone: 972-249-5285 FAX: 970-249-6018
Region 3 RA

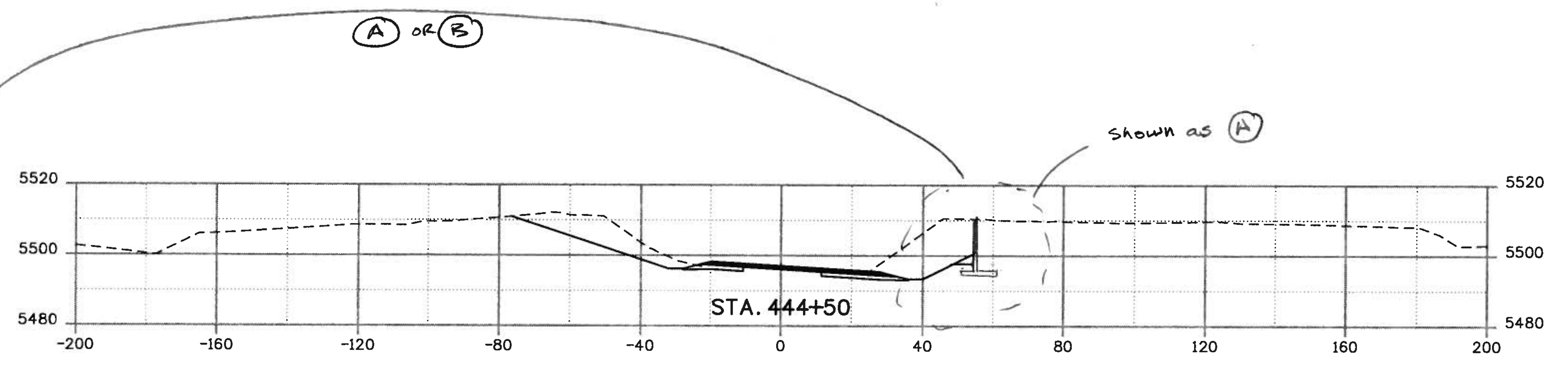
As Constructed
No Revisions:
Revised:
Void:

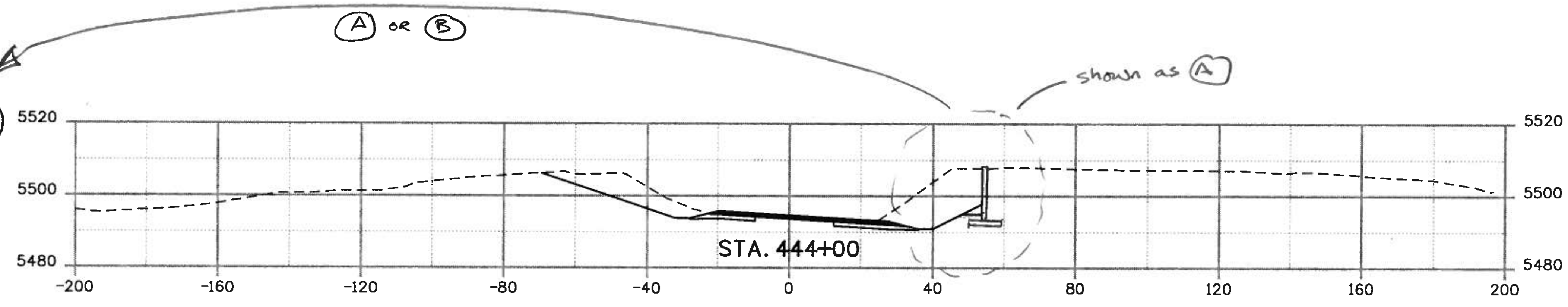
SH92
CROSS SECTIONS
Designer: M. PEREZ
Detailer: B.TENNANT
Sheet Subset: SH92 XS
Structure Numbers
Subset Sheets: of

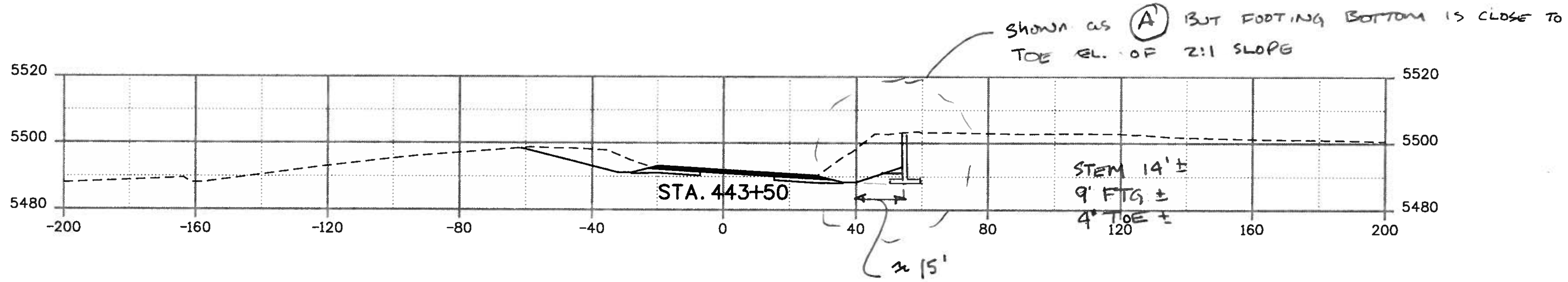
Project No./Code
HB 092A-024
17772
Sheet Number .

CIP WALL 442









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Unit Information Unit Leader Initials
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No Revisions:
Revised:
Void:

SH92
CROSS SECTIONS
Designer: M. PEREZ
Detailer: B.TENNANT
Sheet Subset: SH92 XS
Structure Numbers
Subset Sheets: of

Project No./Code
HB 092A-024
17772
Sheet Number

MEMORANDUM

MATERIALS AND GEOTECHNICAL BRANCH
GEOTECHNICAL PROGRAM
4670 HOLLY STREET, UNIT A, DENVER, COLORADO 80216 303-398-6604 FAX 303-398-6504

HB 092A-020
SH-92 & UPRR
SA 14934

TO: Ronald Alexander, Region 3 North Engineering RE

FROM: David Thomas, Geotechnical Program

DATE: September 14, 2012

SUBJECT: **EMBANKMENT REVIEW FOR STATE HIGHWAY 92 & UNION PACIFIC RAIL ROAD INTERSECTION**

1.0 INTRODUCTION

This report presents geotechnical observations and recommendations concerning embankment construction for planned improvements along SH-92 near the intersection of the Union Pacific Railroad (UPRR). The intersection is located at mile marker 14.4 along SH-92 between Delta and Hotchkiss. Currently, the UPRR is an at-grade crossing with SH-92. To increase safety, a bridge raising SH-92 is proposed allowing UPRR to cross underneath SH-92.

Retaining walls along the railroad will be required to contain the approximately 45 feet high embankment fill required to construct the bridge approaches. The embankment will be sloped on the opposite side into native soil. The embankment for each bridge approach is planned to be constructed using A-6/A-7-6 material due to its availability in Region 3 and the high cost to import better material. The embankment is planned to be 45 feet high with slopes of 2:1 to 3:1 (H:V) depending on right of way restrictions. The embankment will take approximately 271,000 cubic yards (cu. yds.) to construct.

2.0 MATERIAL PROPERTIES

Concerns were raised by Staff Bridge and Region 3 on potential stability and settlement issues of the embankment after construction and if increasing the construction compaction from 95% to 97% would help reduce settlement. To help answer these questions, Donald Green with Region 3 collected four samples from the Buckwheat Way Stockpile. The stockpile consists of approximately 60,000 to 70,000 cu. yds. of soil that is similar to the soil planned to be used in the embankments and is also planned to be used in the embankment construction as well.

2.1 SAMPLE ANALYSIS

We received the four samples consisting of about 2 square feet per sample of clayey soils. Each sample was analyzed for classification, proctor testing, sulfate content, chlorides, pH, and resistivity. The samples were dried to a temperature of 140 degrees per Colorado Procedure 20-08 due to the gypsum content previously seen in the Region. Based on the classification and proctor tests, select samples were further tested at 95% or 97% density at a range up to -2% optimum moisture per CDOT Standard Specification 203.07 to simulate conditions after construction. These additional tests included direct shear, 1-D consolidation, and swell testing

2.2 PHYSICAL PROPERTIES

AASHTO classifications for the clay ranged from A-6 (16) to A-7-6 (26). Swell testing of the clay resulted in swells ranging from 2% to 7% under a surcharge pressure of 200 pounds per square feet (psf). Detailed material properties including direct shear testing results are presented in Attachments 1 and 2.

2.3 GEOCHEMICAL PROPERTIES

The samples were analyzed for percent sulfate, pH, percent chlorides, and resistivity. Based on the results of water soluble sulfate testing obtained from CP 2103, the potential for sulfate attack on Portland cement concrete in direct contact with the bedrock is classified as a Class 3 exposure per Table 601-2 of the CDOT 2011 *Standard Specifications for Road and Bridge Construction* Section 601. The result for resistivity, sulfates, and chlorides suggests a strong corrosion towards metal based on values per Table C.1 of FHWA report FHWAO-IF-3-017, *Geotechnical Engineering Circular No. 7 - Soil Nail Walls*. Detailed material properties are presented in Attachments 1 and 2.

3.0 DISCUSSION & RECOMMENDATIONS

It should be understood that the laboratory results and the calculations based on these results represent a trace fraction of the total 271,000 cu. yds. of soil to be placed during the embankment construction. It is not feasible or practical to test large sections of the embankments. Because of this, the results discussed should be taken as guidelines for design and construction of the embankment.

3.1 SWELLING

Swelling will be a concern under the pavement and along the slopes of the embankment. Results show a swelling potential of up to 7% which represents a high probability of damage risk according to Table 2.7 of the CDOT *2013 Pavement Design Manual*. Subgrade treatment or an alternative subgrade material should be considered under the pavement to minimize pavement impacts and damage due to swell. The proposed slopes of the embankment are mostly 2:1 (H:V). This slope along with the high swell potential will likely cause localized slope failures such as soil creep, slumping, “popcorn” texture, and other maintenance issues when the soils become saturated from precipitation or snow melt. Alternatives are to shallow the slopes (3:1 or better), promote and accelerate vegetation growth, or armor the slopes with stone or other material that also promotes drainage away from the slope.

3.2 CONSOLIDATION

It was assumed that the worse settlement and area of highest concern would be at the full height of the embankment where it approached the bridge structure. Therefore, consolidation and time rate of consolidation calculations assumed the total height of the embankment was 45 feet, consisted of 4 layers (three at 10 feet thick and the upper at 15 feet thick) placed one at a time, and drainage paths would be along the layer interfaces. Using the 1-D consolidation sample laboratory results, consolidation of the constructed soils may be on the order of 10 inches near the bridge. It was calculated that in the first year, up to 4 inches of settlement may occur with the remaining 6 inches over 9 years. Additional minor consolidation may take place after the 9 years. The consolidation would be less the farther from the bridge one got. No significant improvement was observed between samples that were compacted at 95% vs. 97%. Consolidation will likely be worse if proper construction oversight is not performed. There are multiple options that could be considered that should reduce the risk of consolidation:

- Use an alternate material for the embankment fill that is less susceptible to consolidation such as material with lower fines content. One way would be to construct a MSE wall on the other side (opposite of the planned MSE along the railroad) since the required reinforcement for the tall MSE wall would nearly span the width of the roadway.
- Use light weigh fill within the core or thickest areas of the embankment.
- Surcharge the embankment along the bridge approaches.

If any of these options are selected, the global stability of the embankment should be verified once the final design has been completed.

3.3 GLOBAL STABILITY

For the current design, the global stability was verified using sections provided by Region 3. A slope stability model was created using Slope/W at the highest embankment heights with and without MSE walls. The soil values inputted into the model were based on the laboratory data results and field data collected during drilling. The models resulted in a global stability factor of safety greater than 1.3 which is the industry standard and in Federal Highway Administration publications. This does not mean that localized slope failures will not occur in the embankment as discussed in Section 3.1.

Please contact the Geotechnical Program at 303-398-6604 with any questions.

REVIEW: Conroy

COPY: Eller – Region 3 RTD
Mertes – Region 3 West Engineering Program Engineer
Egghart – Region 3 West Engineering
Goodrich – Region 3 Materials Engineer
Far – Staff Bridge
Henry/Hernandez – Staff Materials and Geotechnical
Conroy – Geotechnical Program

ATTACHMENT 1

LABORATORY TESTING SUMMARY

HB 092A-020
SH-92 & UPRR
SA 14934

LABORATORY TEST SUMMARY
SH-92 West of Hotchkiss

				AASHTO Gradation									Direct Shear								
Sample No.	Visual Description	USCS	AASHTO	Gravel (%)	Coarse Sand (%)	Fine Sand (%)	Silt & Clay (%)	Liquid Limit	Plastic Limit	Plasticity Index	Water Content* (%)	Dry Density (lb/ft³)	Peak Friction Angle (º)	Peak Cohesion (psf)	Residual Friction Angle (º)	Residual Cohesion (psf)	Swell (%/ksf)	Chlorides (% mass)	Water Soluble Sulfates (% mass)	Soil pH ($H_2O/CaCl_2$)	Resistivity Ω-cm Saturated
1	Clay	CL	A-6 (16)	0.7	5.4	9.4	84.5	35	15	20	14.1	107[†]	26.7	2,134	32.9	1,305	2.0	0.0187	0.90	7.01	400
2	Clay	CL	A-6 (18)	0.9	6.1	7.2	85.7	39	18	21	15.3	103[‡]	30.9	1,984	37.7	994	2.7	0.0190	1.30	7.84	300
3	Clay	CL	A-7-6 (25)	0.4	3.0	5.5	91.9	44	18	26	16.4	99[‡]	35.5	1,781	33.0	1,337	7.0	0.0088	0.80	6.95	260
4	Clay	CL	A-7-6 (26)	0.6	2.0	4.3	93.1	44	17	27	16.3	102[†]	18.1	3,288	33.0	1,337	5.0	0.0164	2.10	7.78	190

* - Value is optimum moisture up to -2% based on T99 standard proctor test.

[†] - Value is 97% density based on T99 standard proctor test.

[‡] - Value is 95% density based on T99 standard proctor test.

All samples were dried at 140º F due to high gypsum content per CP 20-08.

ATTACHMENT 2

LABORATORY TESTING RESULTS

HB 092A-020
SH-92 & UPRR
SA 14934

Project: CTL # DN46162-300

Reported to: CDOT Materials Laboratory
4670 Holly Street, Unit A
Denver, Colorado 80216
Attn: David Thomas

Date: 07/17/12

Reported by: PSH

Sample Information

Sample Number: 1
Field Sheet Number: 208108
Project Number: STA092-024

Depth:

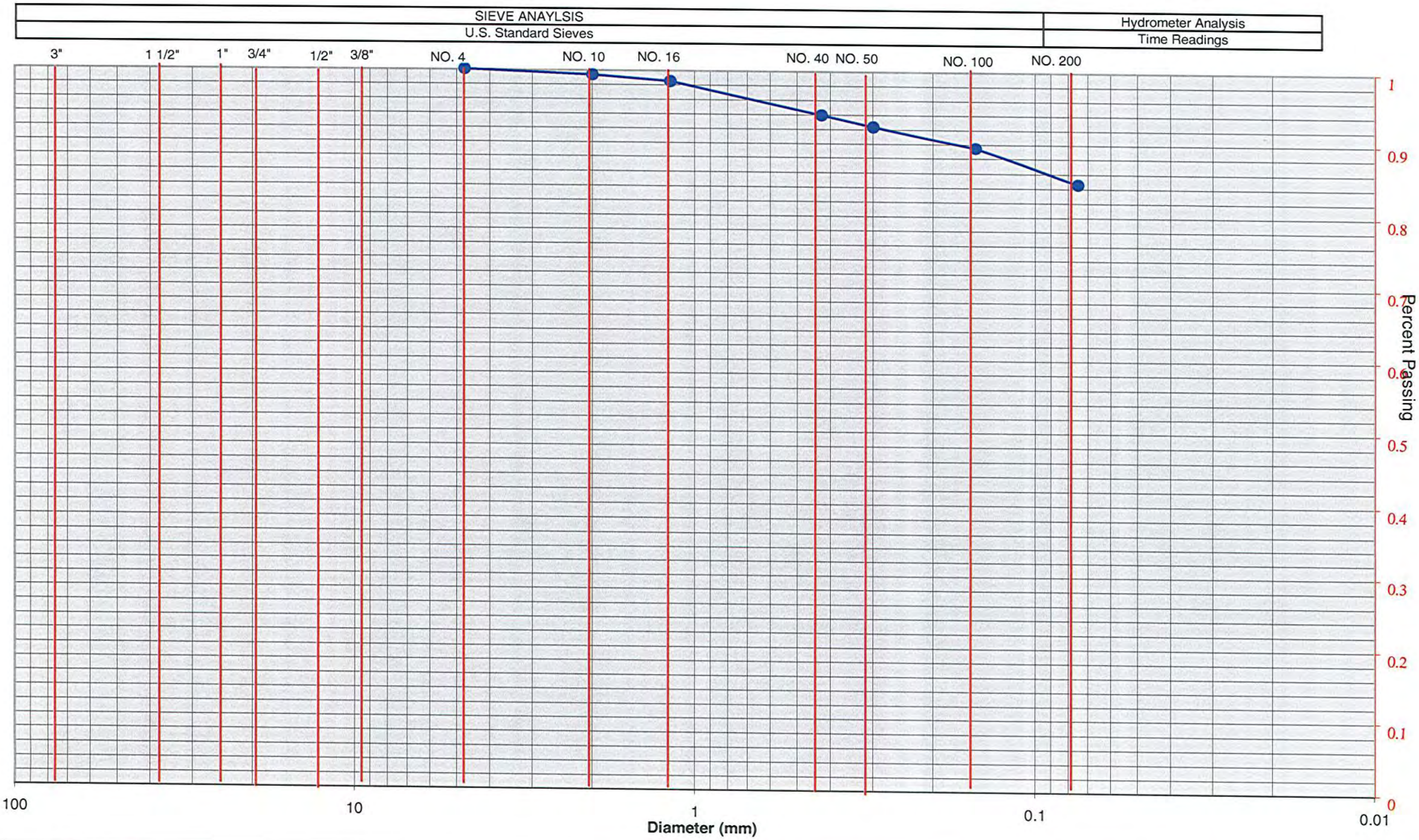
Sieve Analysis (T 11, T 27)

Sieve Size	Wt. Retained	Percent Retained	Percent Passing
3"		0.0	
1 1/2"		0.0	
1"		0.0	
3/4"		0.0	
1/2"		0.0	
3/8"		0.0	
#4	0.0	0.0	100
#10	1.9	0.7	99
#16	2.3	0.8	98
#40	12.4	4.6	94
#50	4.3	1.6	92
#100	7.9	2.9	89
#200	13.3	4.9	84.5
Dry Soil Weight	272.3		

Moisture Content (%) (AASHTO T 265)	
Dry Density (pcf)	
Percent Gravel	0.7
Percent Sand	14.8
Percent Coarse Sand	5.4
Percent Fine Sand	9.4
Percent Silt and Clay	84.5
Liquid Limit (AASHTO T 89)	35
Plasticity Index (AASHTO T 90)	20
AASHTO Classification (AASHTO M 145)	A-6 (16)
USCS Classification (ASTM D 2487)	CL
Sulfate Content (SO_4)	0.900
Chloride Ion In Water (ASTM D 512-89)	0.0187
PH of Soil for Corrosion Testing (ASTM G 51-95)	7.010
Wenner Four-Electrode (ASTM G 57-95a) *	
(As received)	1300 @ 13.3%
(Saturated)	400 @ 28.5%

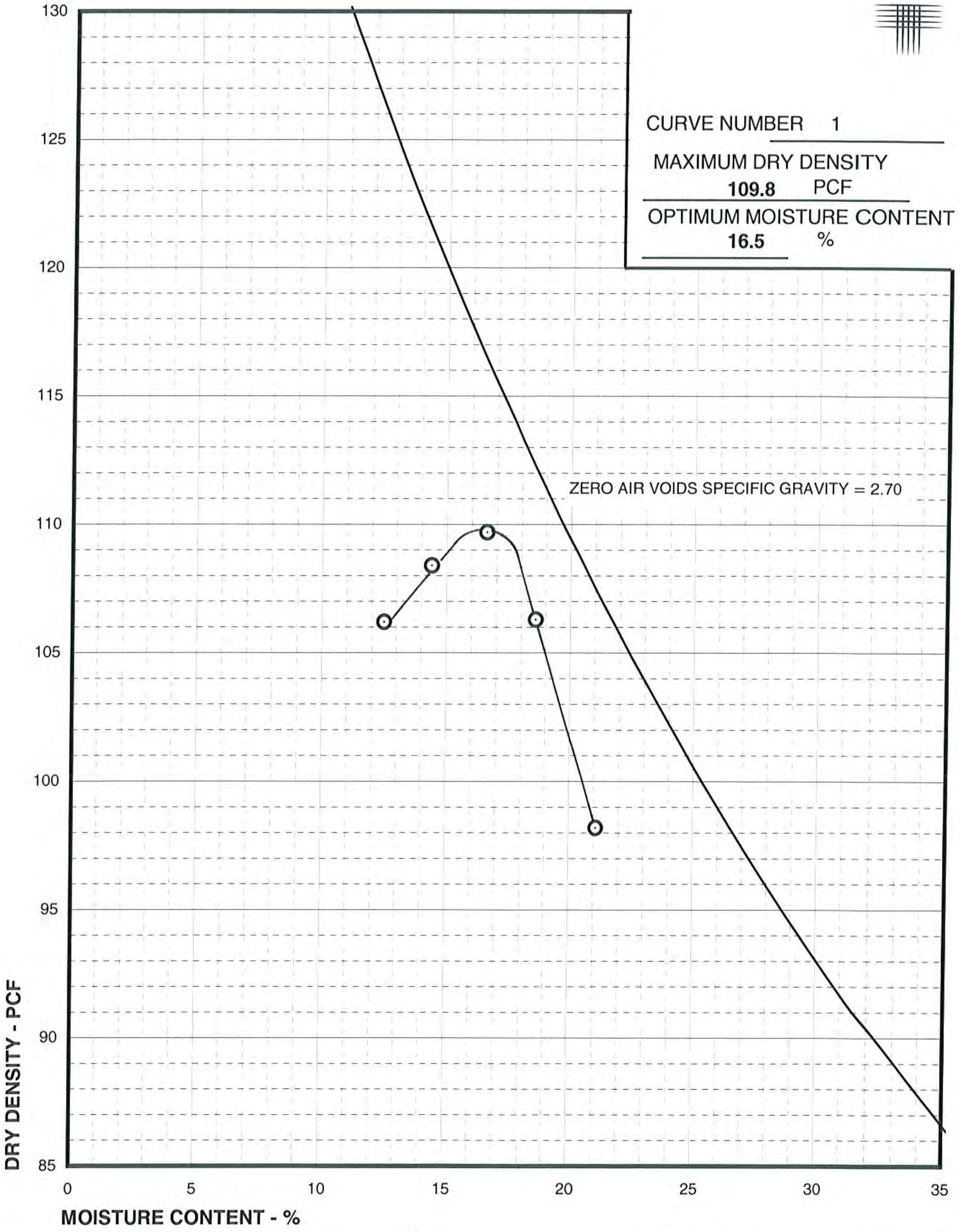
*Measured in ohm-centimeters

SIEVE ANALYSIS AASHTO T 27



Gravel	0.7	Sand	14.8	Silt and Clay	84.5
		Coarse 5.4	Fine 9.4		

Sample ID 1
Lab ID STA092-024



CURVE NUMBER 1

MAXIMUM DRY DENSITY
109.8 PCF

OPTIMUM MOISTURE CONTENT
16.5 %

Sample Description Clay, Sandy A-6 (16)

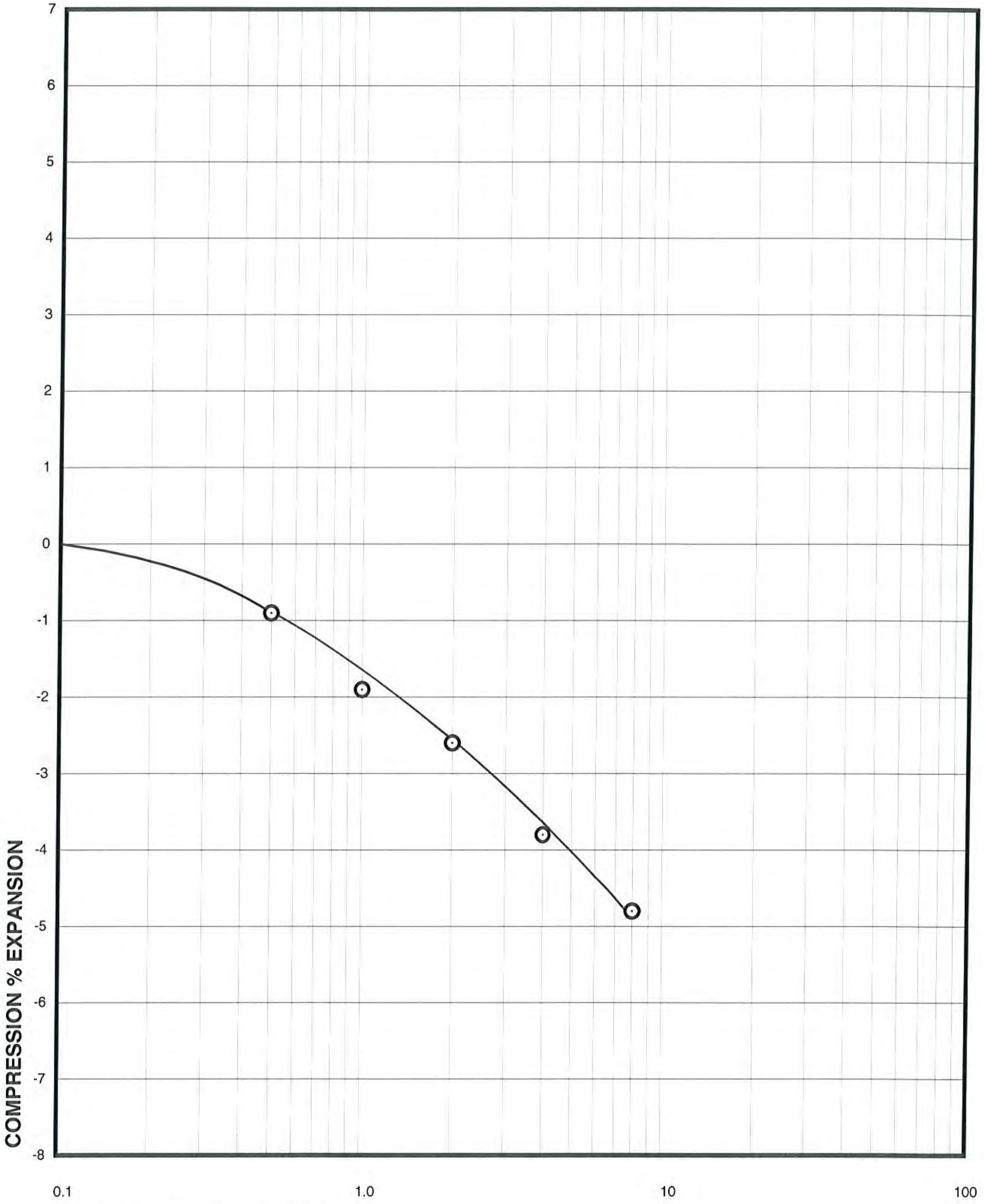
Location Sample No. 1 Field Sheet 208108

Compaction Test Procedure AASHTO T99
METHOD "A"

LIQUID LIMIT	35	%
PLASTICITY INDEX	20	%
GRAVEL	0.7	%
SAND	14.8	%
SILT AND CLAY	84.5	%

COLORADO DEPARTMENT OF TRANSPORTATION

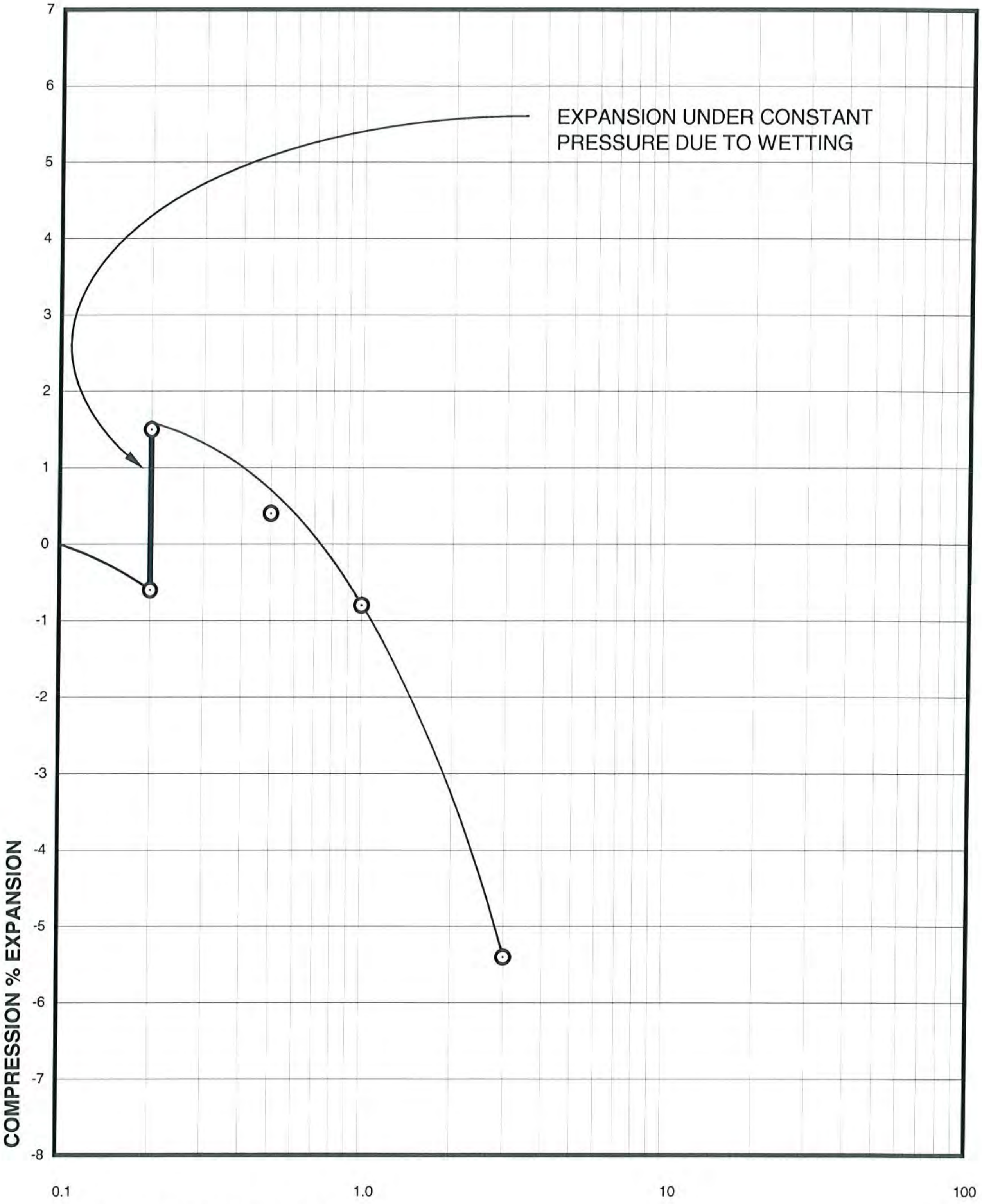
Compaction Test Results



Sample of	Clay, Sandy A-6 (16)	DRY UNIT WEIGHT=	107	PCF
From	S-1, FS208108	MOISTURE CONTENT=	14.1	%

Swell Consolidation Test Results

CDOT
LABORATORY TESTING
PROJECT NO. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\Swell data



Sample of Clay, Sandy A-6 (16)

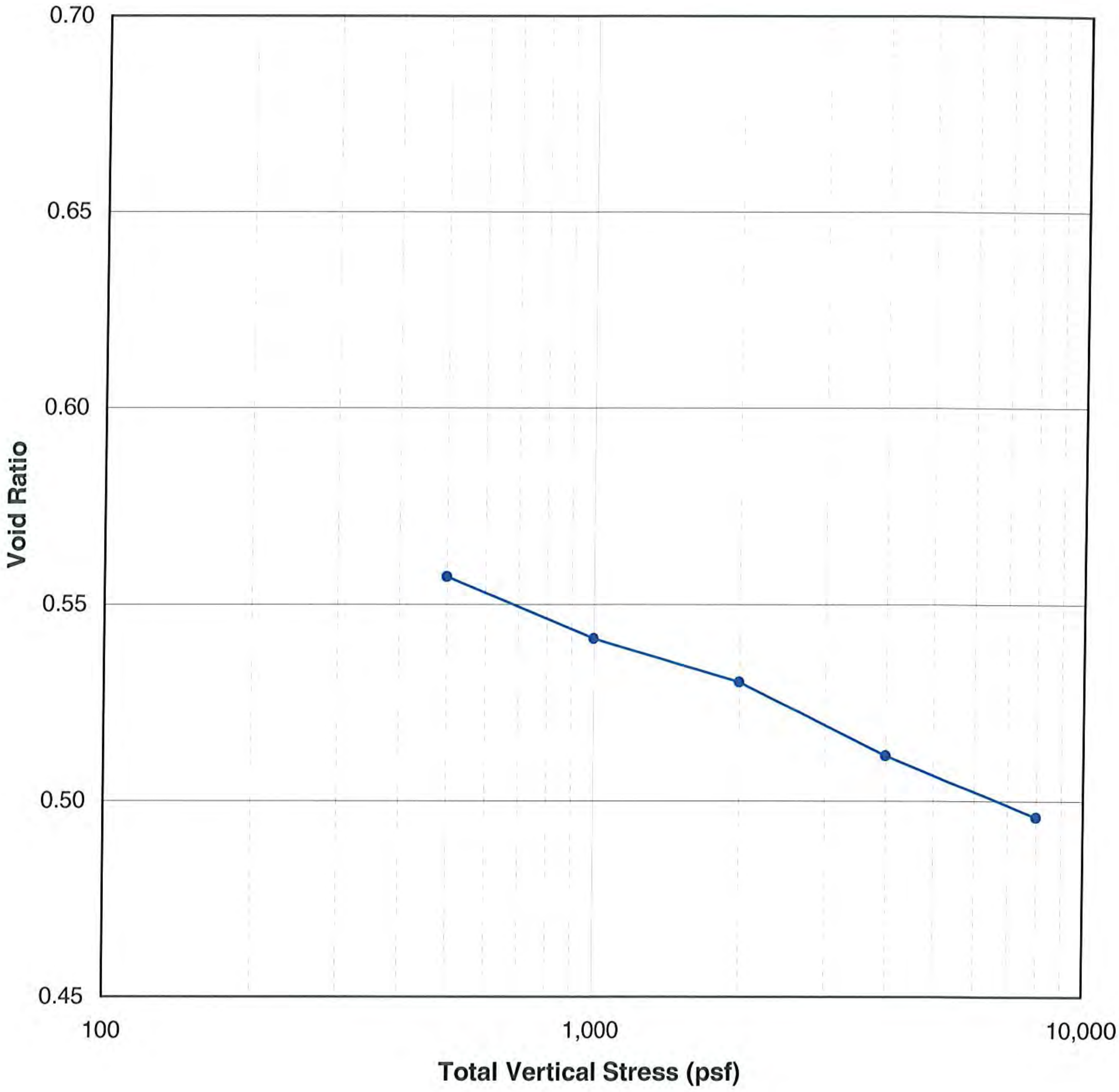
From S-1, FS208108

DRY UNIT WEIGHT= 107 PCF

MOISTURE CONTENT= 14.1 %

CDOT
LABORATORY TESTING
PROJECT NO. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\Swell data

Swell Consolidation Test Results

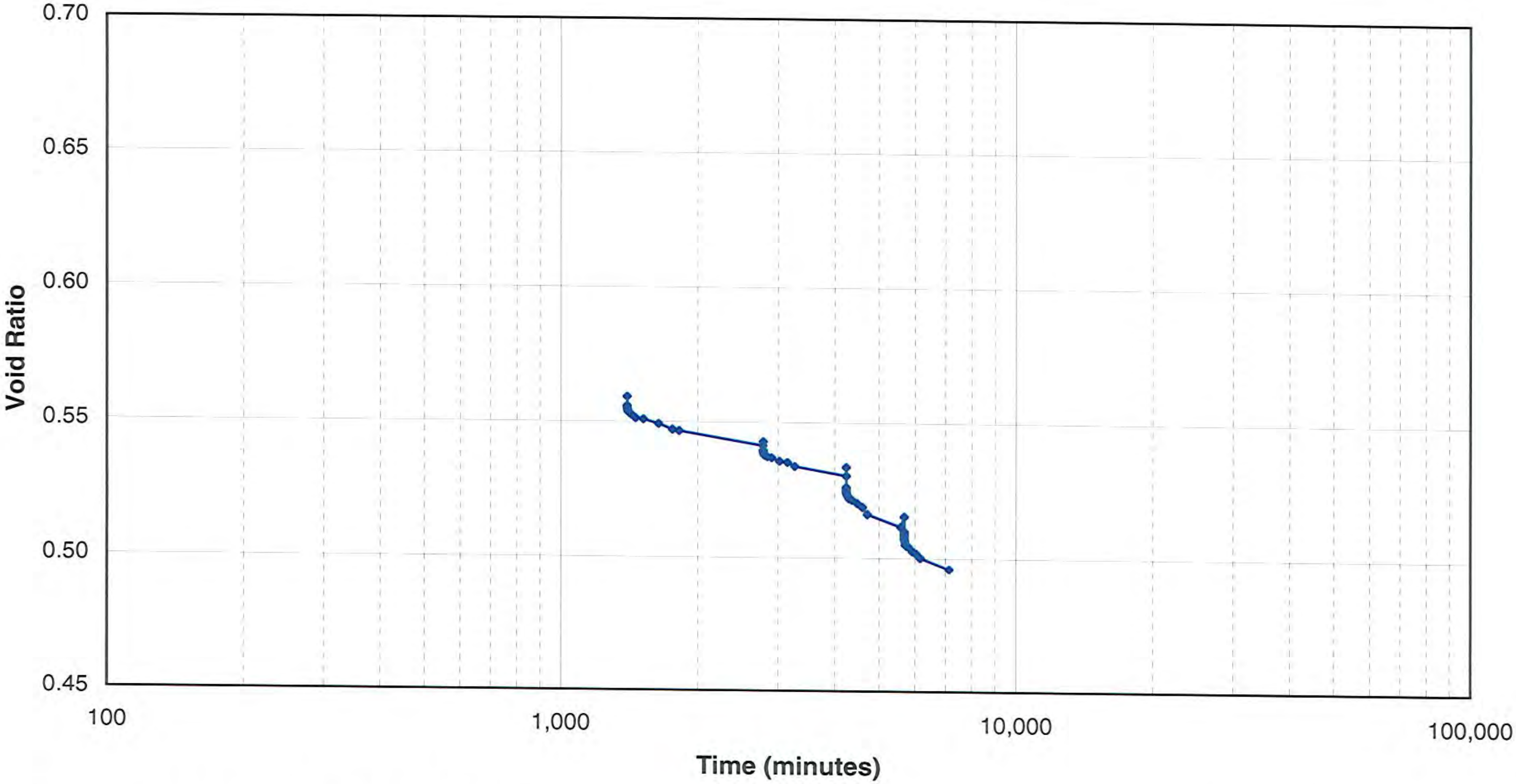


SAMPLE DESCRIPTION: Clay, Sandy A-6 (16)
LOCATION: S-1 FS208108
MOISTURE CONTENT: 14.1 % (Before Test)
11.9 % (After Test)
DRY DENSITY: 107 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 35 %
PLASTICITY INDEX: 20 %
GRAVEL: 1 %
SAND: 15 %
SILT AND CLAY: 85 %

One Dimensional Consolidation Test Results

FIG. 1



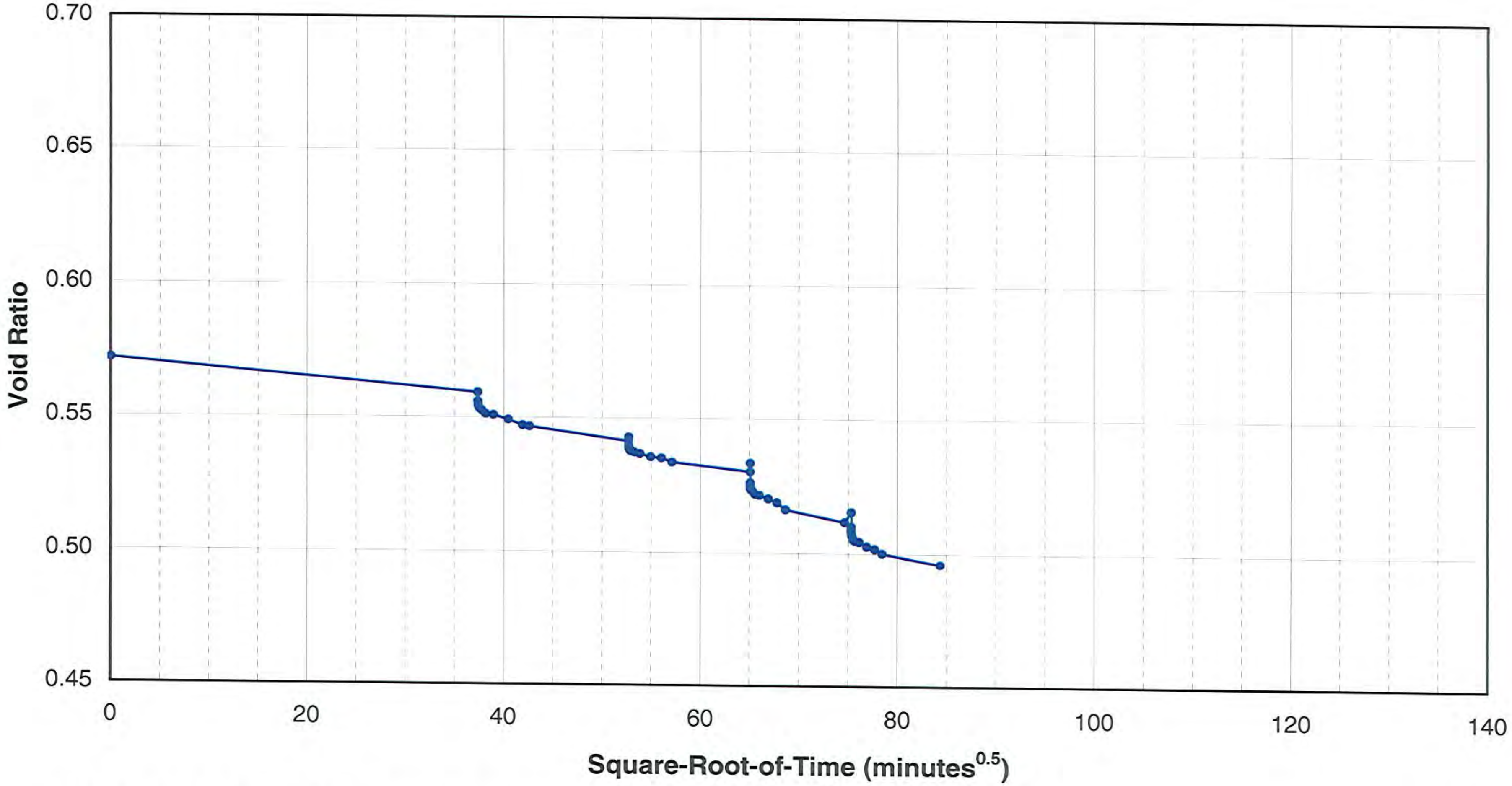
SAMPLE DESCRIPTION: Clay, Sandy A-6 (16)
LOCATION: S-1 FS208108
MOISTURE CONTENT: 14.1 % (Before Test)
11.9 % (After Test)
DRY DENSITY: 107 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 35 %
PLASTICITY INDEX: 20 %
GRAVEL: 1 %
SAND: 15 %
SILT AND CLAY: 85 %

CDOT
Laboratory Testing
Project No. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-1-Consolidation test

One Dimensional Consolidation Test Results

FIG. 2



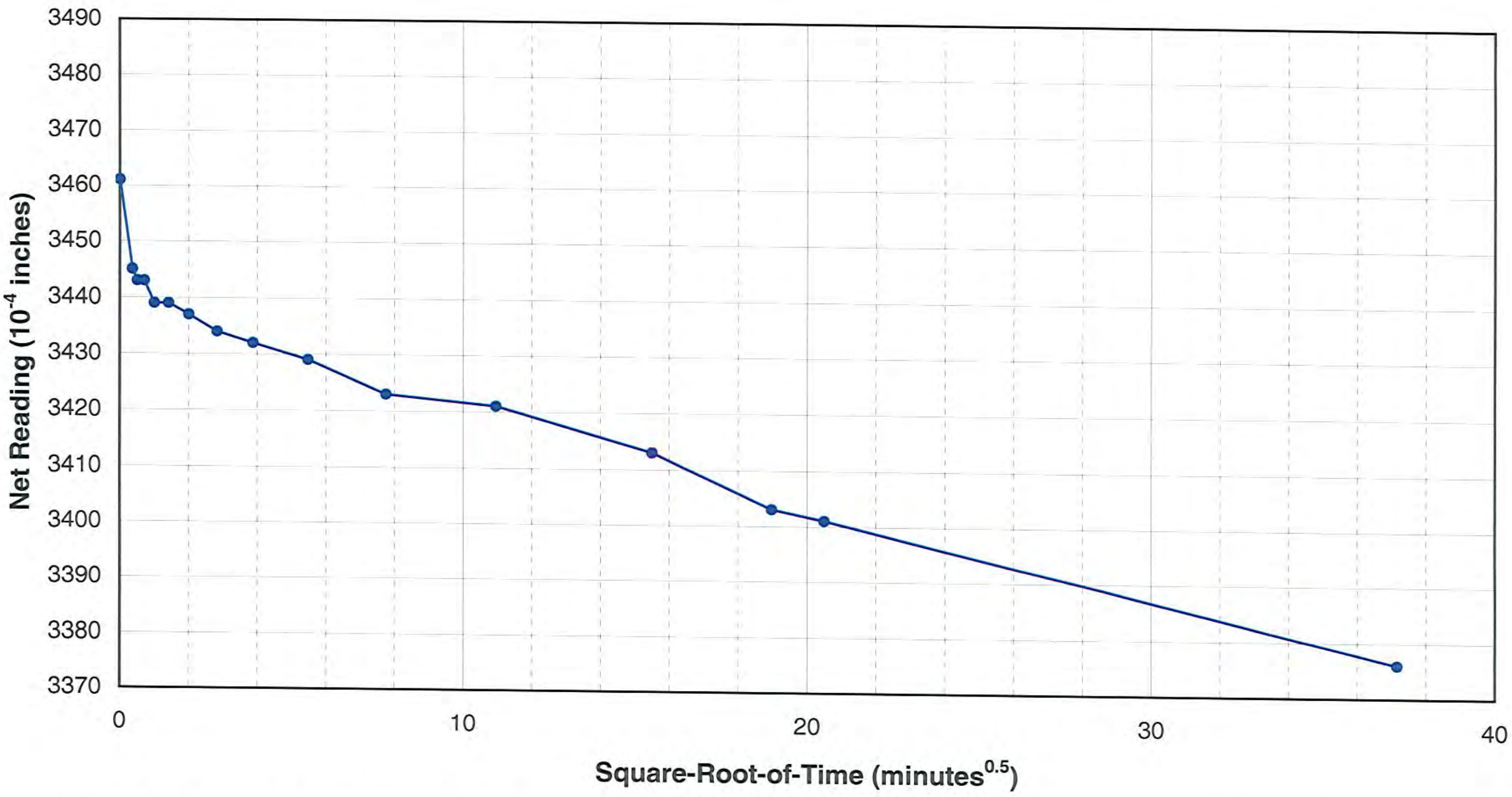
SAMPLE DESCRIPTION: Clay, Sandy A-6 (16)
LOCATION: S-1 FS208108
MOISTURE CONTENT: 14.1 % (Before Test)
11.9 % (After Test)
DRY DENSITY: 107 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 35 %
PLASTICITY INDEX: 20 %
GRAVEL: 1 %
SAND: 15 %
SILT AND CLAY: 85 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-1-Consolidation test

One Dimensional Consolidation Test Results

FIG. 3



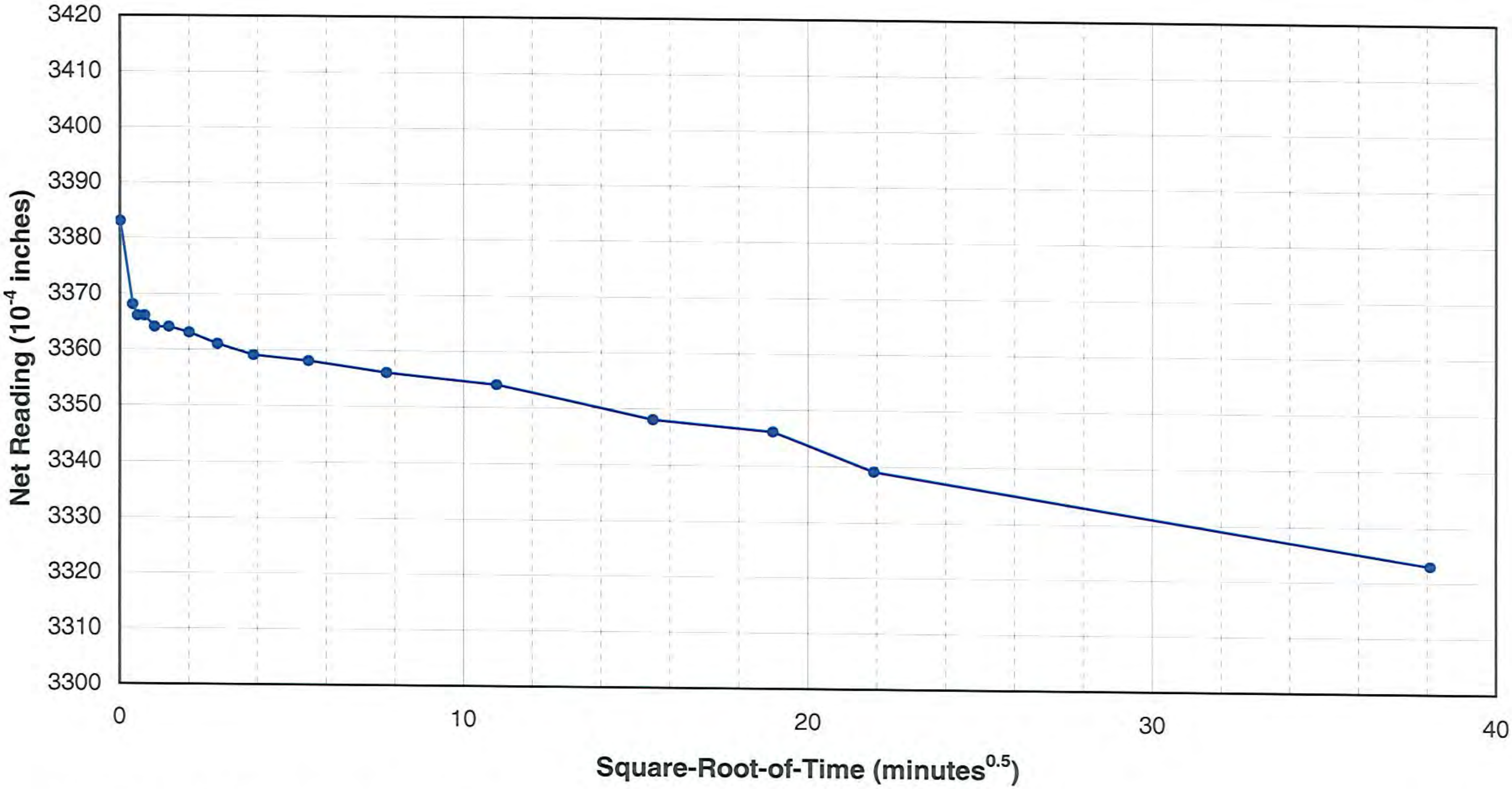
SAMPLE DESCRIPTION: Clay, Sandy A-6 (16)
LOCATION: S-1 FS208108
LOAD NO. 2
PRESSURE 1000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 35 %
PLASTICITY INDEX: 20 %
GRAVEL: 1 %
SAND: 15 %
SILT AND CLAY: 85 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-1-Consolidation test

One Dimensional Consolidation Test Results

FIG. 4



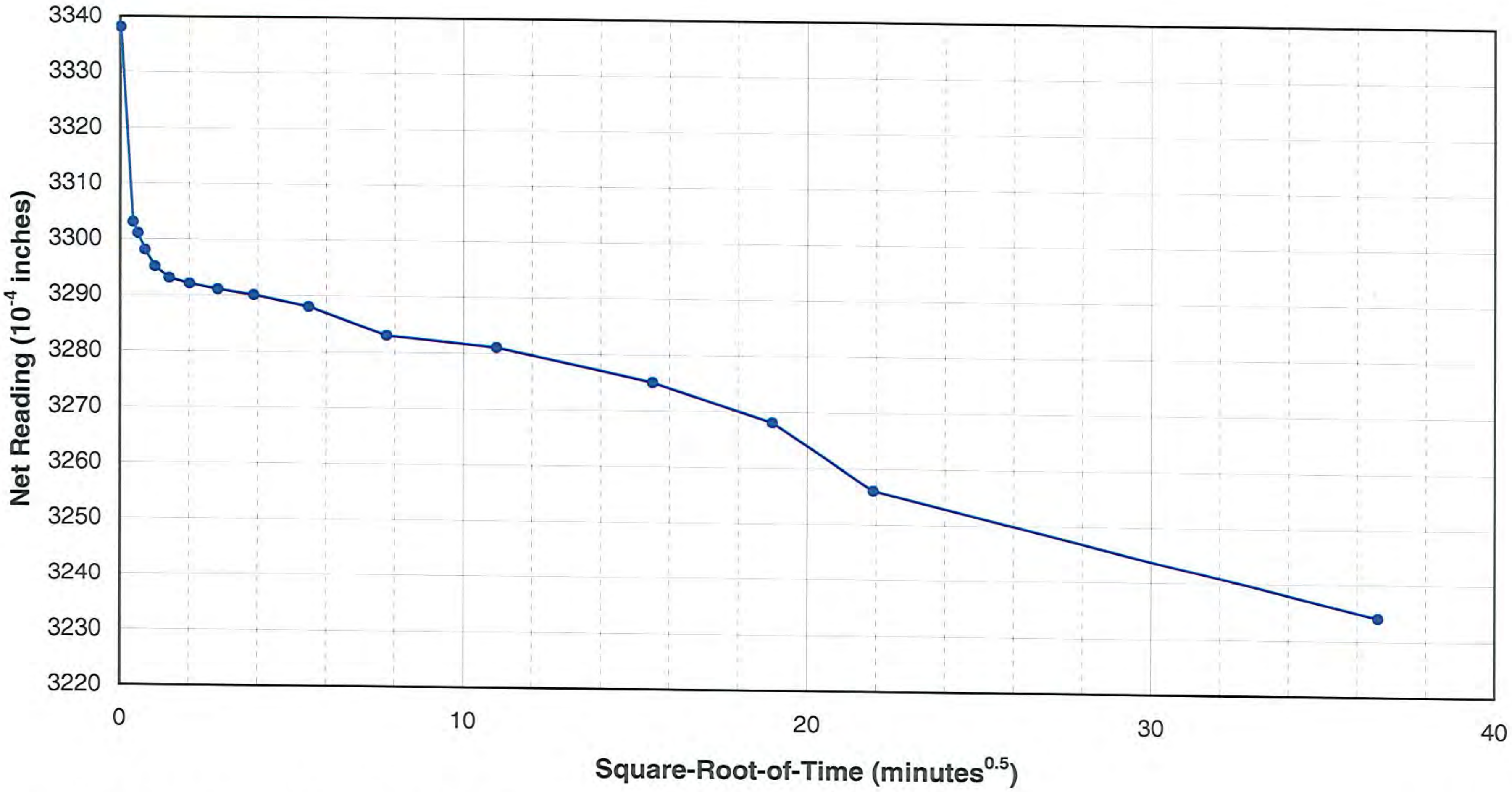
SAMPLE DESCRIPTION: Clay, Sandy A-6 (16)
LOCATION: S-1 FS208108
LOAD NO. 3
PRESSURE 2000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 35 %
PLASTICITY INDEX: 20 %
GRAVEL: 1 %
SAND: 15 %
SILT AND CLAY: 85 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-1-Consolidation test

One Dimensional Consolidation Test Results

FIG. 5



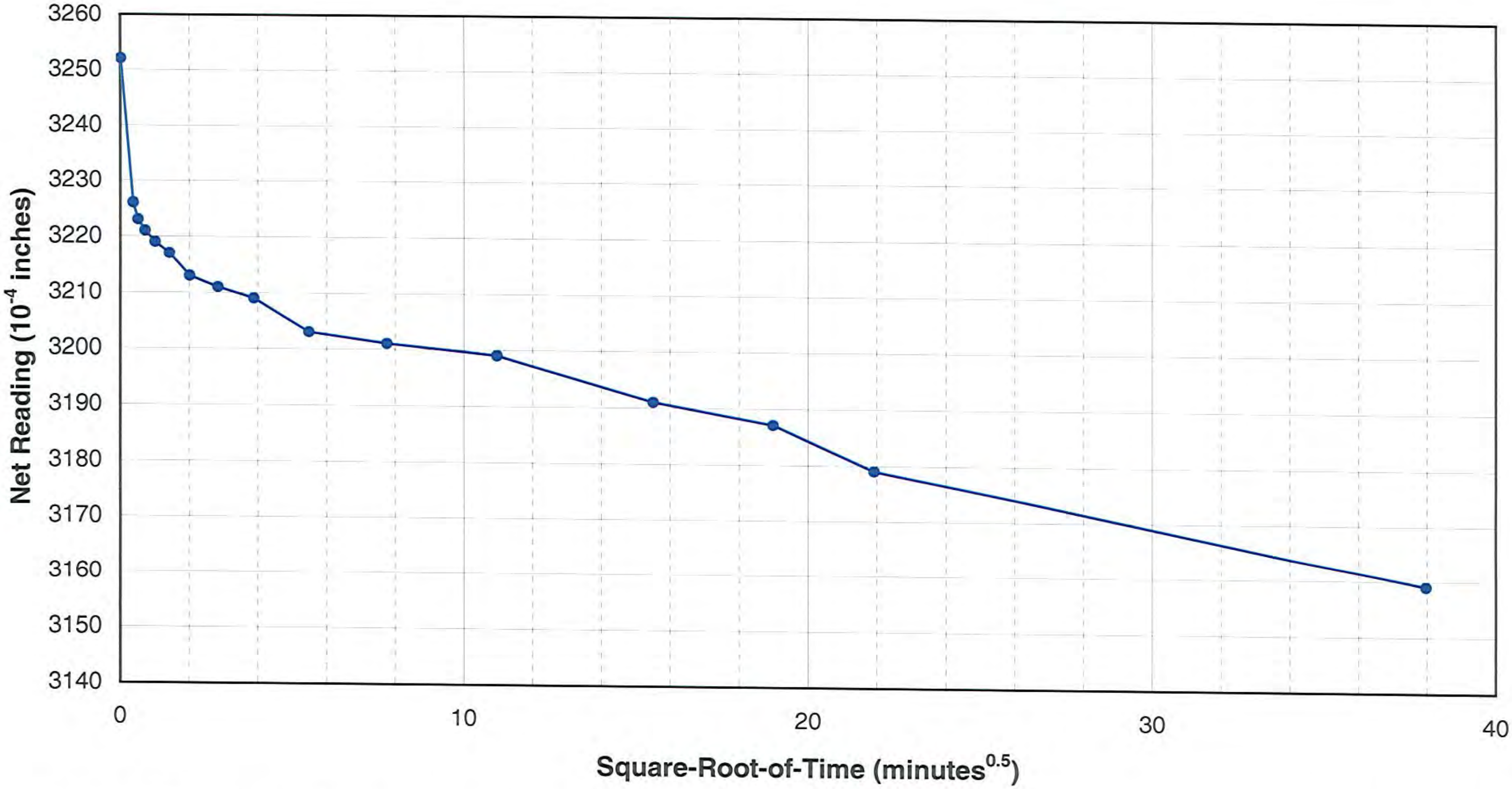
SAMPLE DESCRIPTION: Clay, Sandy A-6 (16)
LOCATION: S-1 FS208108
LOAD NO. 4
PRESSURE 4000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 35 %
PLASTICITY INDEX: 20 %
GRAVEL: 1 %
SAND: 15 %
SILT AND CLAY: 85 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-1-Consolidation test

One Dimensional Consolidation Test Results

FIG. 6



SAMPLE DESCRIPTION: Clay, Sandy A-6 (16)
LOCATION: S-1 FS208108
LOAD NO. 5
PRESSURE 8000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 35 %
PLASTICITY INDEX: 20 %
GRAVEL: 1 %
SAND: 15 %
SILT AND CLAY: 85 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-1-Consolidation test

One Dimensional Consolidation Test Results

FIG. 7

ONE-DIMENSIONAL CONSOLIDATION CALCULATION SHEET

PROJECT NO: DN46162-300
PROJECT NAME: CDOT
Sample Description: Clay, Sandy A-6 (16)
Sample Location: S-1 FS208108
Date: 7/30/2012

SAMPLE INFORMATION

Density

Diameter (in.):	1.935
Length, H (in.):	0.750
Volume (in^3):	2.21
Total volume, V_0 (cm^3):	36.14
Wet soil/ring wt (g):	310.60
Ring wt (g):	239.90
Wet wt, $W_{t,0}$ (g):	70.70
Wet unit wt (g/cc):	1.96
Wet unit wt (pcf):	122.1
Dry density (pcf):	107.0

Moisture

	Before (Trimmings)	After (Total Sample)
Dish No.:	50	24
Dish/wet soil (g):	342.70	298.70
Dish/dry soil (g):	328.80	291.30
Dish wt (g):	230.30	229.20
Water wt (g):	13.90	7.40
Soil wt (g):	98.50	62.10
Moisture (%):	14.1	11.9

🟩 Input Data

SAMPLE CALCULATIONS

Initial volume (cm^3):	36.14
Unit weight of water, γ_w (g/cc):	1.00
Specific Gravity, G_s:	2.70
Initial volume of solids, $V_s=W_s/\gamma_w G_s$ (cm^3):	23.00
Initial volume of voids, $V_{v,0}=V_0-V_s$ (cm^3):	13.14
Initial volume of water, $V_{w,0}=(W_{t,0}-W_s)/\gamma_w$ (cm^3):	8.60
Initial degree of saturation, $S_0=V_{w,0}/V_{v,0}$ (%):	65.44
Initial void ratio, $e_{0=}V_{v,0}/V_s$:	0.57
Final void ratio, e_f:	0.00
Final volume of water, $V_{w,f}=(W_{t,f}-W_s)/\gamma_w$ (cm^3):	7.4
Final volume of voids, $V_{v,f}=e_f{}^*V_s$ (cm^3):	0.00
Final degree of saturation, $S_f=V_{w,f}/V_{v,f}$ (%):	#DIV/0!
G_s assumed or from lab data?	**ASSUMED**

$W_{t,0}$=Initial total sample weight
$W_{t,f}$=Final total sample weight
V_0=Total sample volume
W_s=Soil weight

Liquid Limit:	35
Plasticity Index:	20
Percent Gravel:	0.7
Percent Sand:	14.8
Percent Silt and Clay:	84.5

CALCULATION OF % EXPANSION/COMPRESSION AND VOID RATIOS

Cell filled with water (yes/no)?: **NO**

Machine No.: 109

Final Readings:

Load No.	Start Date and Time	Pressure (psf)	Final Reading (10^{-4} in.)	Machine Deflection (10^{-4} in.)	Net Reading (10^{-4} in.)	ΔH (in.)	Expansion/ Compression, +/- (%)	Δe	Void Ratio, e
Initial	7/30/2012 8:56	0	3520	0	3520	0.0000	0.00	0.000	0.571
1	7/30/2012 8:11	500	3440	11	3451	-0.0069	-0.92	-0.014	0.557
2	7/31/2012 8:12	1000	3355	21	3376	-0.0144	-1.92	-0.030	0.541
3	8/1/2012 7:15	2000	3295	28	3323	-0.0197	-2.63	-0.041	0.530
4	8/2/2012 7:27	4000	3191	43	3234	-0.0286	-3.81	-0.060	0.511
5	8/3/2012 7:27	8000	3098	61	3159	-0.0361	-4.81	-0.076	0.496

C=-Δe/Δ log σ
0.0522
0.0369
0.0619
0.0522

Expansion/Compression (%)=ΔH/H

$\Delta e=(\Delta H/H)*(1+e_0)$

Colorado Department of Transportation
DIRECT SHEAR TEST REPORT (AASHTO T 236)

Field Sheet No. : **208110 (#1)**
Date Received : 7/23/2012
Item Number : 203
Lab Test No. : 2012-077

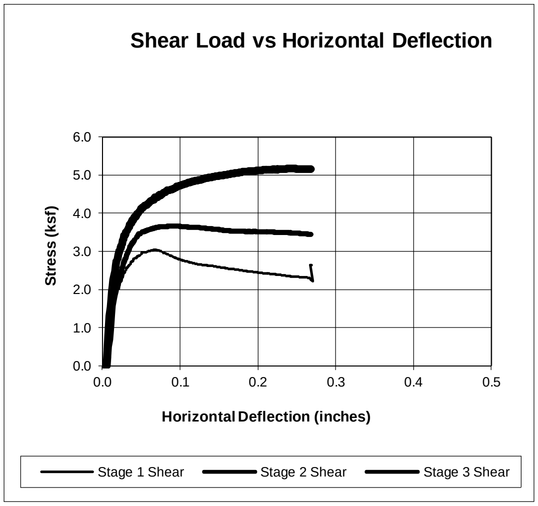
Project ID : **14934**
Project : HB 092A-020
Location : SH 92 and UPRR
Test Date : 07/31/2012
Source : Stockpile
Region : 3

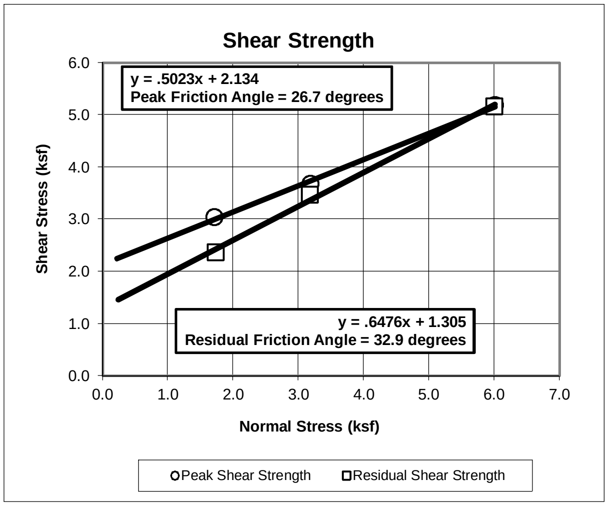
Classification : N/A
Liquid Limit : N/A
Plastic Limit : N/A
Plastic Index : N/A

Compaction Method : T 99 (A)
Max. Dry Dens. (pcf) : 109.8
Optimum Moisture : 16.5%

Specimens were compacted to 95% of AASHTO T 180 Method A at optimum moisture content.

Specimen Preparation	Stage 1	Stage 2	Stage 3
Surcharge Pressure (ksf)	1.73	3.19	6.01
Compacted Dry Density (pcf)	105.8	105.8	105.9
Moisture Content	16.2%	16.2%	16.1%
Percent of Maximum Dry Density	96.4%	96.4%	96.5%





Project Specifications:
Peak Friction Angle: **26.7 degrees**
Residual Friction Angle: **32.9 degrees**

Distribution:
Central Laboratory
Region Materials Engineer

C.K. Su
Soils and Rockfall Program

Project: CTL # DN46162-300
Reported to: CDOT Materials Laboratory
4670 Holly Street, Unit A
Denver, Colorado 80216
Attn: David Thomas

Date: 07/17/12
Reported by: PSH

Sample Information

Sample Number: 2
Field Sheet Number: 208108
Project Number: STA092-024
Depth:

Sieve Analysis (T 11, T 27)

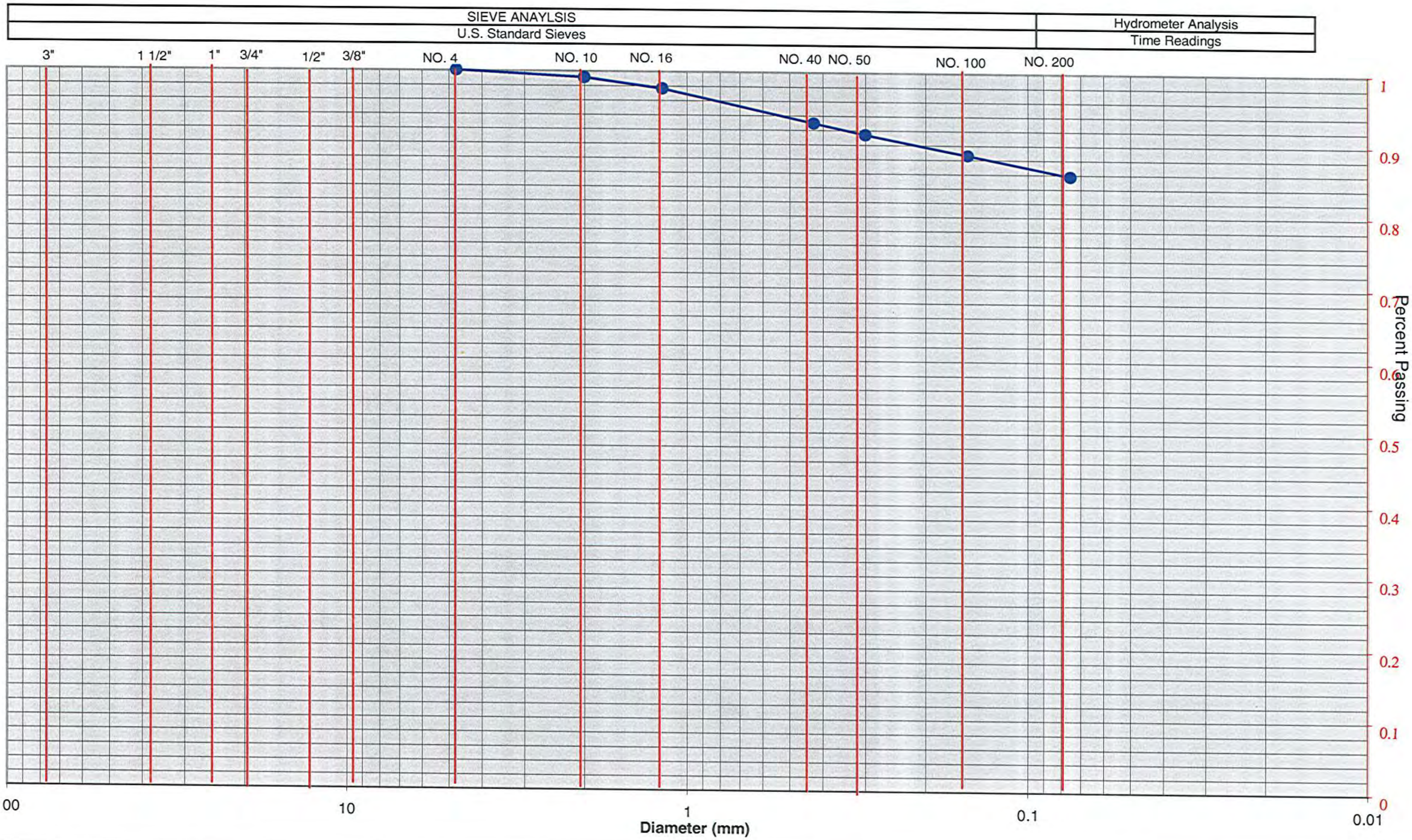
Sieve Size	Wt. Retained	Percent Retained	Percent Passing
3"		0.0	
1 1/2"		0.0	
1"		0.0	
3/4"		0.0	
1/2"		0.0	
3/8"		0.0	
#4	0.0	0.0	100
#10	1.8	0.9	99
#16	2.8	1.4	98
#40	9.1	4.7	93
#50	3.0	1.5	91
#100	5.4	2.8	89
#200	5.6	2.9	85.7

Dry Soil Weight 193.7

Moisture Content (%) (AASHTO T 265)	
Dry Density (pcf)	
Percent Gravel	0.9
Percent Sand	13.4
Percent Coarse Sand	6.1
Percent Fine Sand	7.2
Percent Silt and Clay	85.7
Liquid Limit (AASHTO T 89)	39
Plasticity Index (AASHTO T 90)	21
AASHTO Classification (AASHTO M 145)	A-6 (18)
USCS Classification (ASTM D 2487)	CL
Sulfate Content (SO_4)	1.300
Chloride Ion In Water (ASTM D 512-89)	0.019
PH of Soil for Corrosion Testing (ASTM G 51-95)	7.840
Wenner Four-Electrode (ASTM G 57-95a) *	
(As received)	1400 @ 12.8%
(Saturated)	300 @ 34.4%

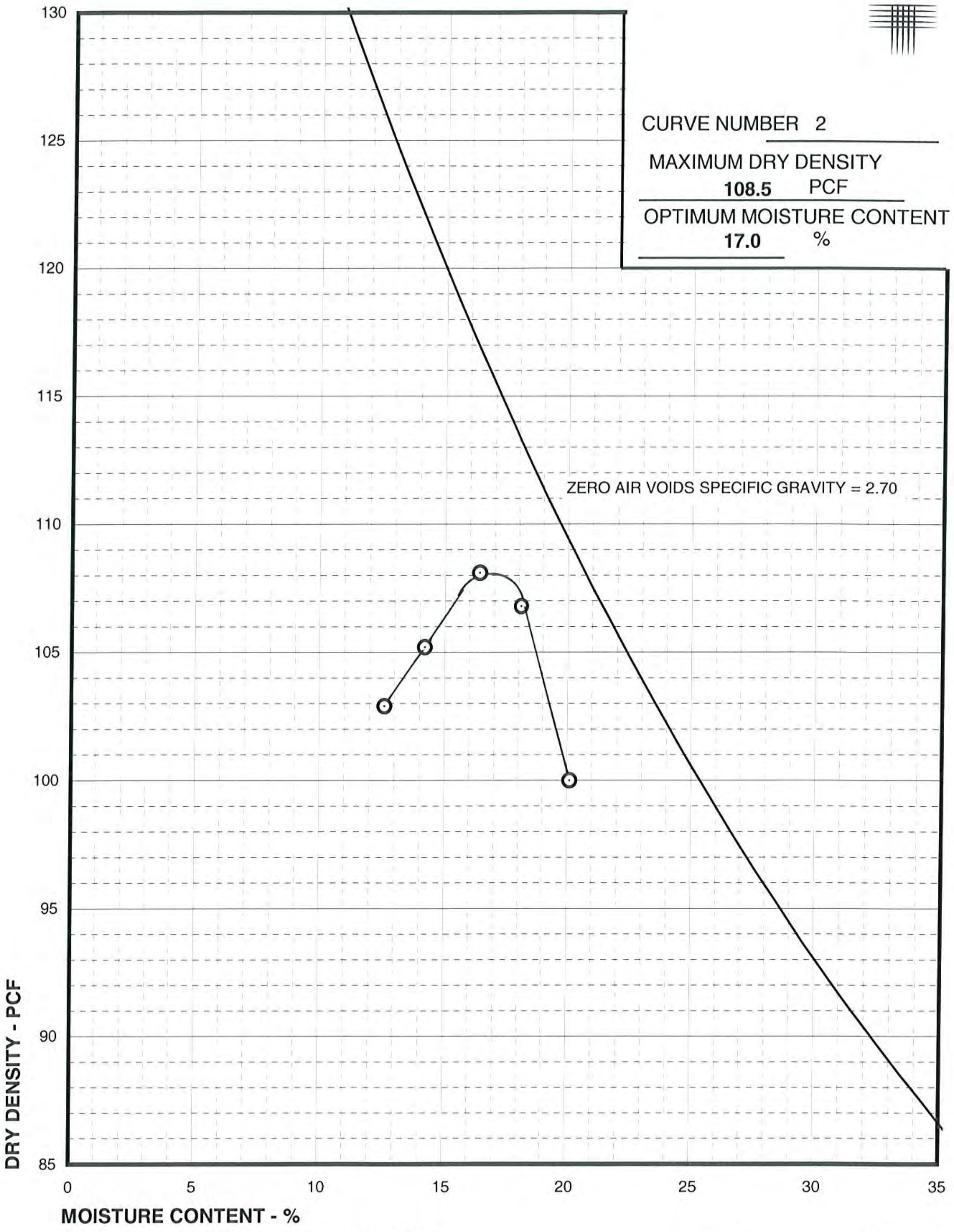
*Measured in ohm-centimeters

SIEVE ANALYSIS AASHTO T 27



Gravel	0.9	Sand	13.4	Silt and Clay	85.7
		Coarse 6.1	Fine 7.2		

Sample ID 2
Lab ID STA092-024



CURVE NUMBER 2

MAXIMUM DRY DENSITY
108.5 PCF

OPTIMUM MOISTURE CONTENT
17.0 %

Sample Description Clay, Sandy A-6 (18)

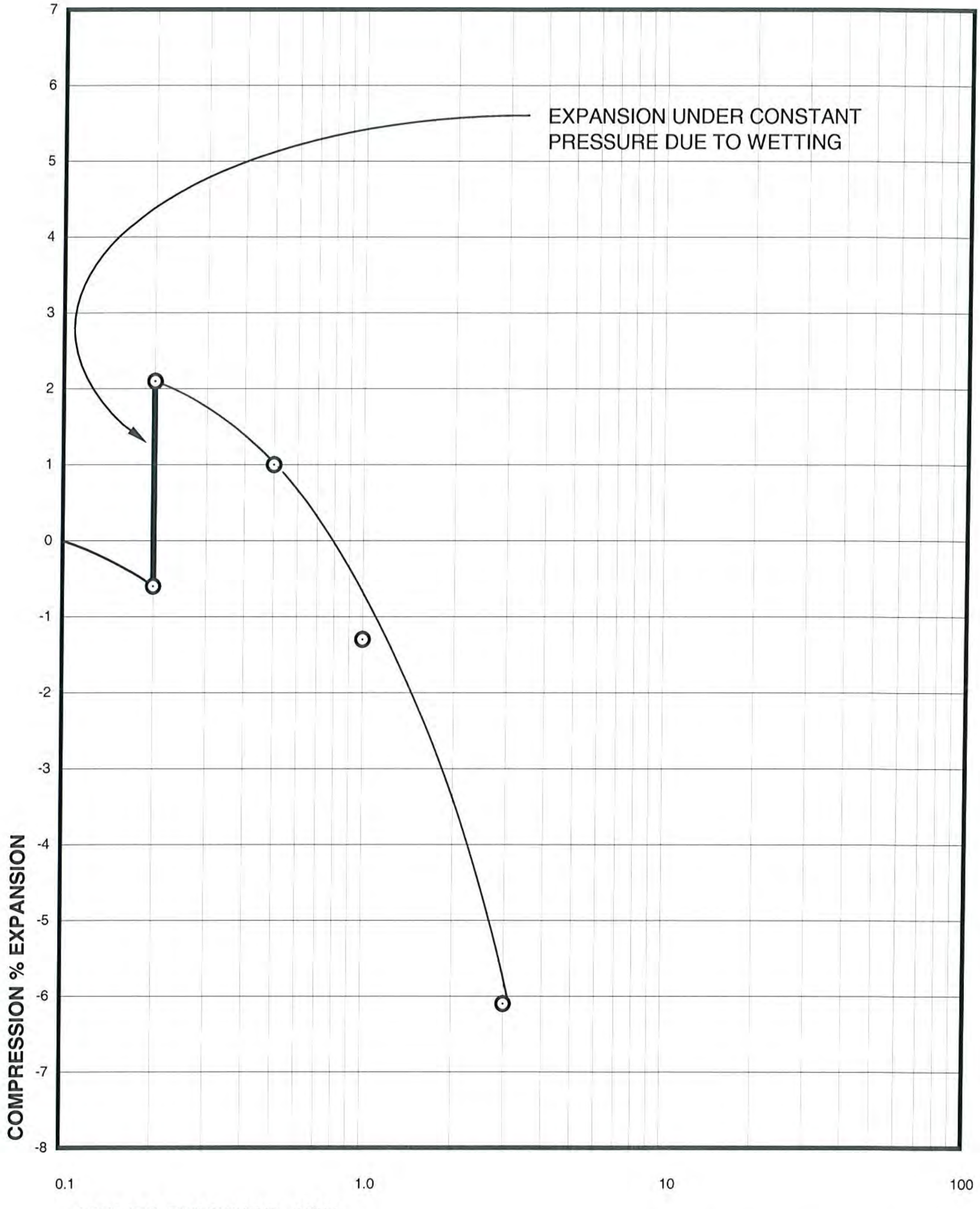
Location Sample No. 2, Field Sheet 208108

Compaction Test Procedure AASHTO T99
METHOD "A"

LIQUID LIMIT 39 %
PLASTICITY INDEX 21 %
GRAVEL 0.9 %
SAND 13.4 %
SILT AND CLAY 85.7 %

COLORADO DEPARTMENT OF TRANSPORTATION

Compaction Test Results



Sample of Clay, Sandy A-6 (16)

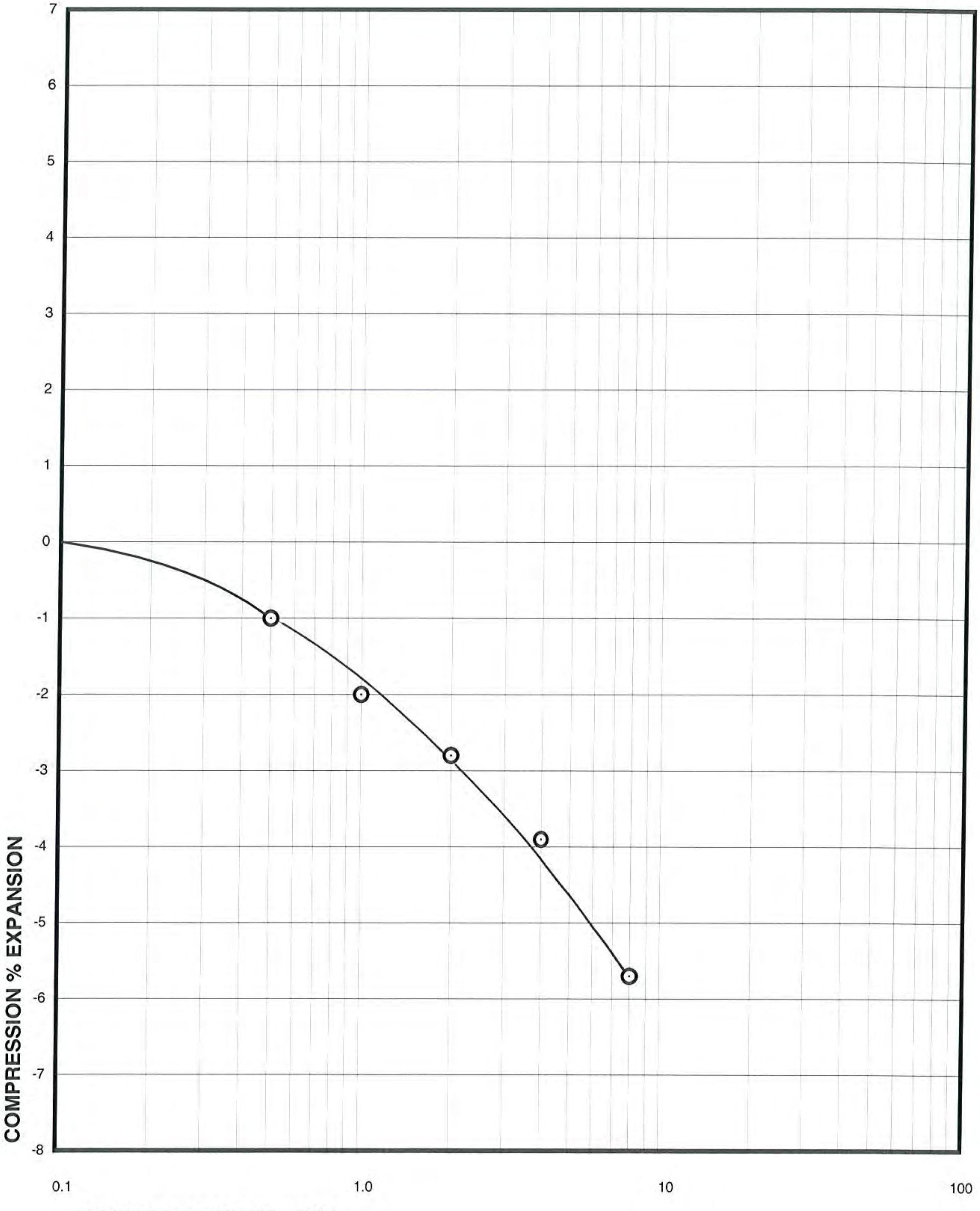
From S-2, FS208108

DRY UNIT WEIGHT= 103 PCF

MOISTURE CONTENT= 15.3 %

Swell Consolidation Test Results

CDOT
LABORATORY TESTING
PROJECT NO. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\Swell data



Sample of Clay, Sandy A-6 (16)

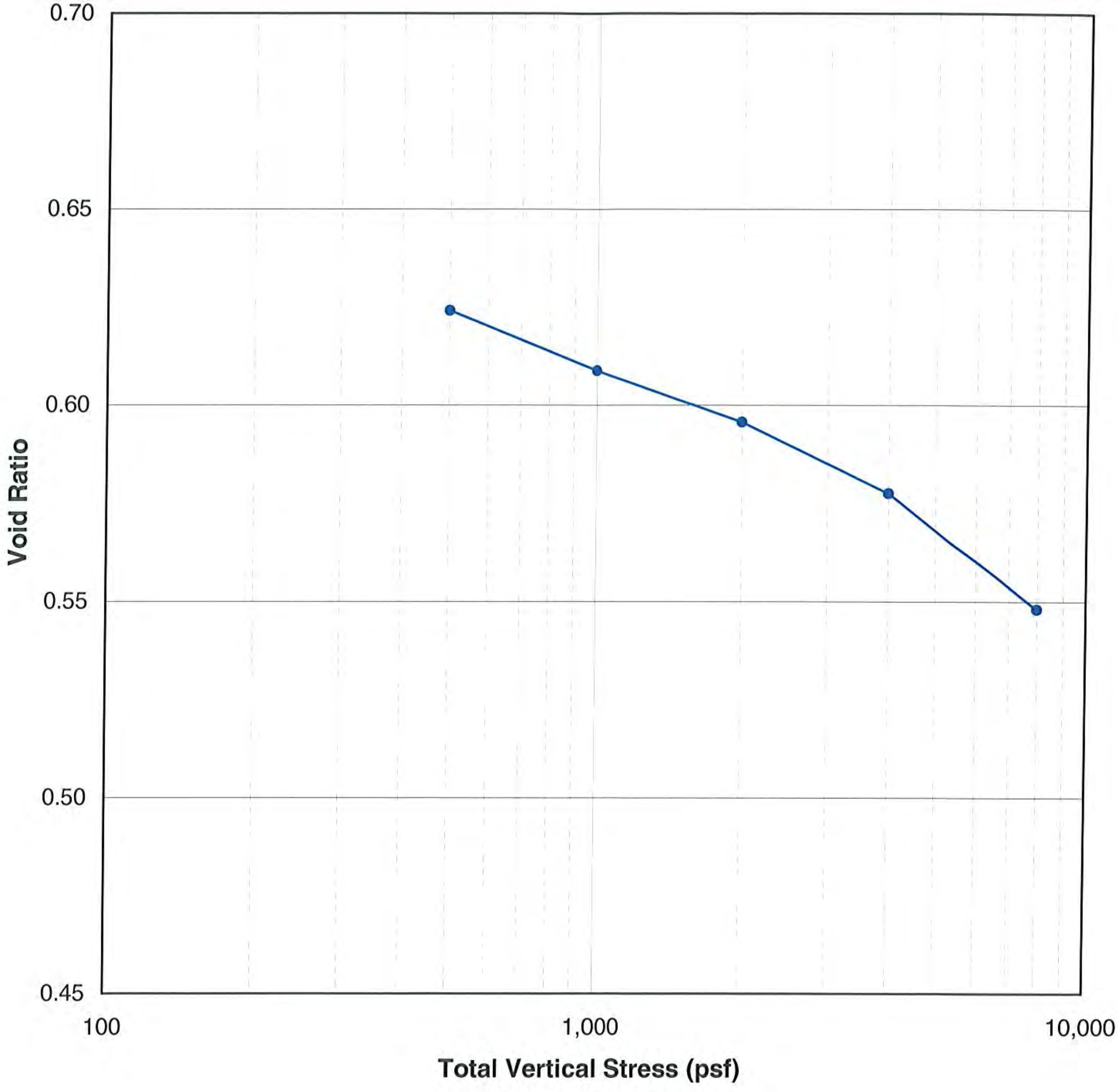
From S-2, FS208108

DRY UNIT WEIGHT= 103 PCF

MOISTURE CONTENT= 15.3 %

Swell Consolidation Test Results

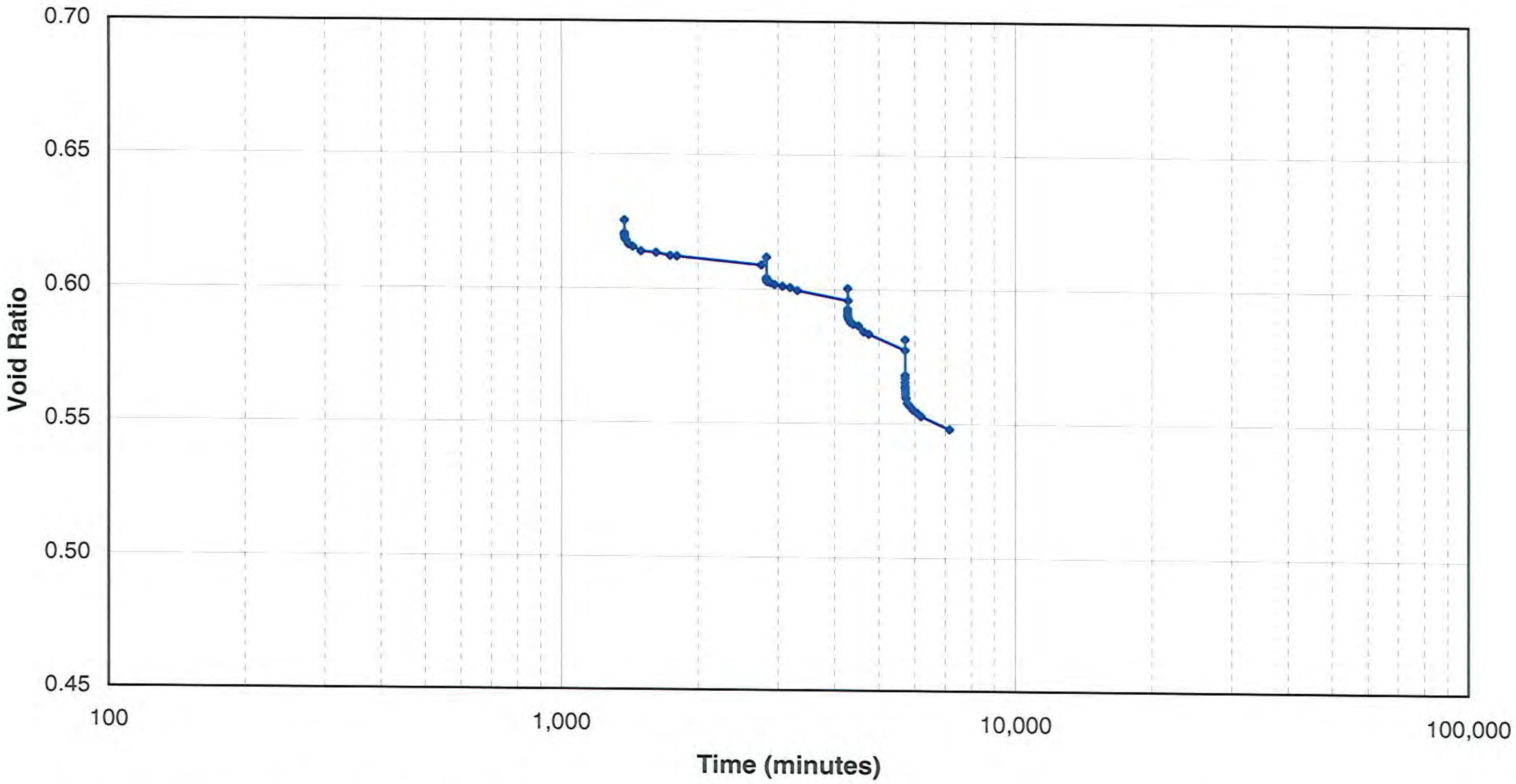
CDOT
LABORATORY TESTING
PROJECT NO. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\Swell data



SAMPLE DESCRIPTION:	Clay, Sandy A-6 (18)		LIQUID LIMIT:	39 %
LOCATION:	S-2 FS208108		PLASTICITY INDEX:	21 %
MOISTURE CONTENT:	15.3	% (Before Test)	GRAVEL:	1 %
		% (After Test)	SAND:	13 %
DRY DENSITY:	103	pcf (Before Test)	SILT AND CLAY:	86 %
TEST PROCEDURE:	ASTM D2435			

One Dimensional Consolidation Test Results

FIG. 1



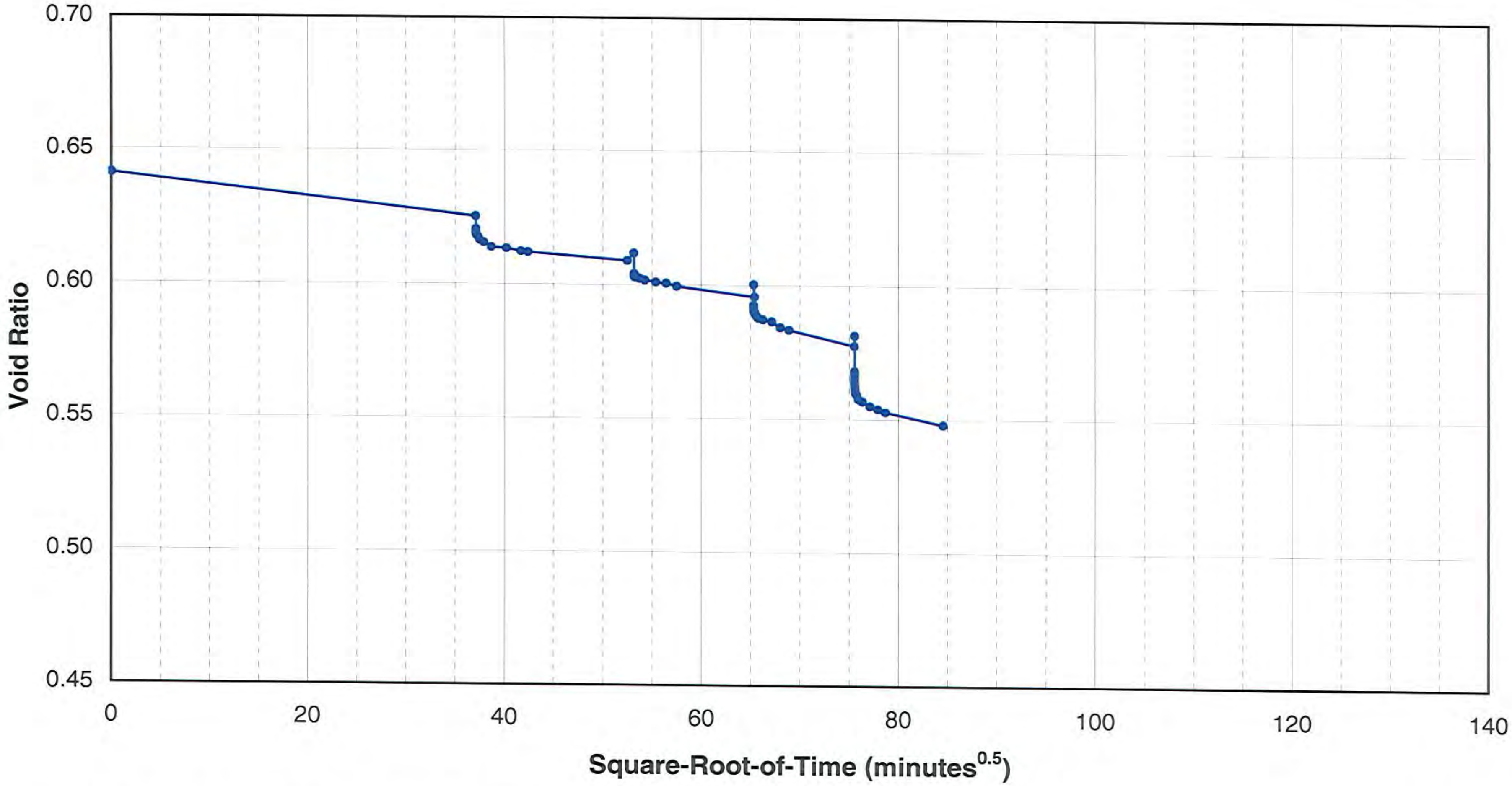
SAMPLE DESCRIPTION: Clay, Sandy A-6 (18)
LOCATION: S-2 FS208108
MOISTURE CONTENT: 15.3 % (Before Test)
% (After Test)
DRY DENSITY: 103 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 39 %
PLASTICITY INDEX: 21 %
GRAVEL: 1 %
SAND: 13 %
SILT AND CLAY: 86 %

CDOT
Laboratory Testing
Project No. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-2-Consolidation test

One Dimensional Consolidation Test Results

FIG. 2



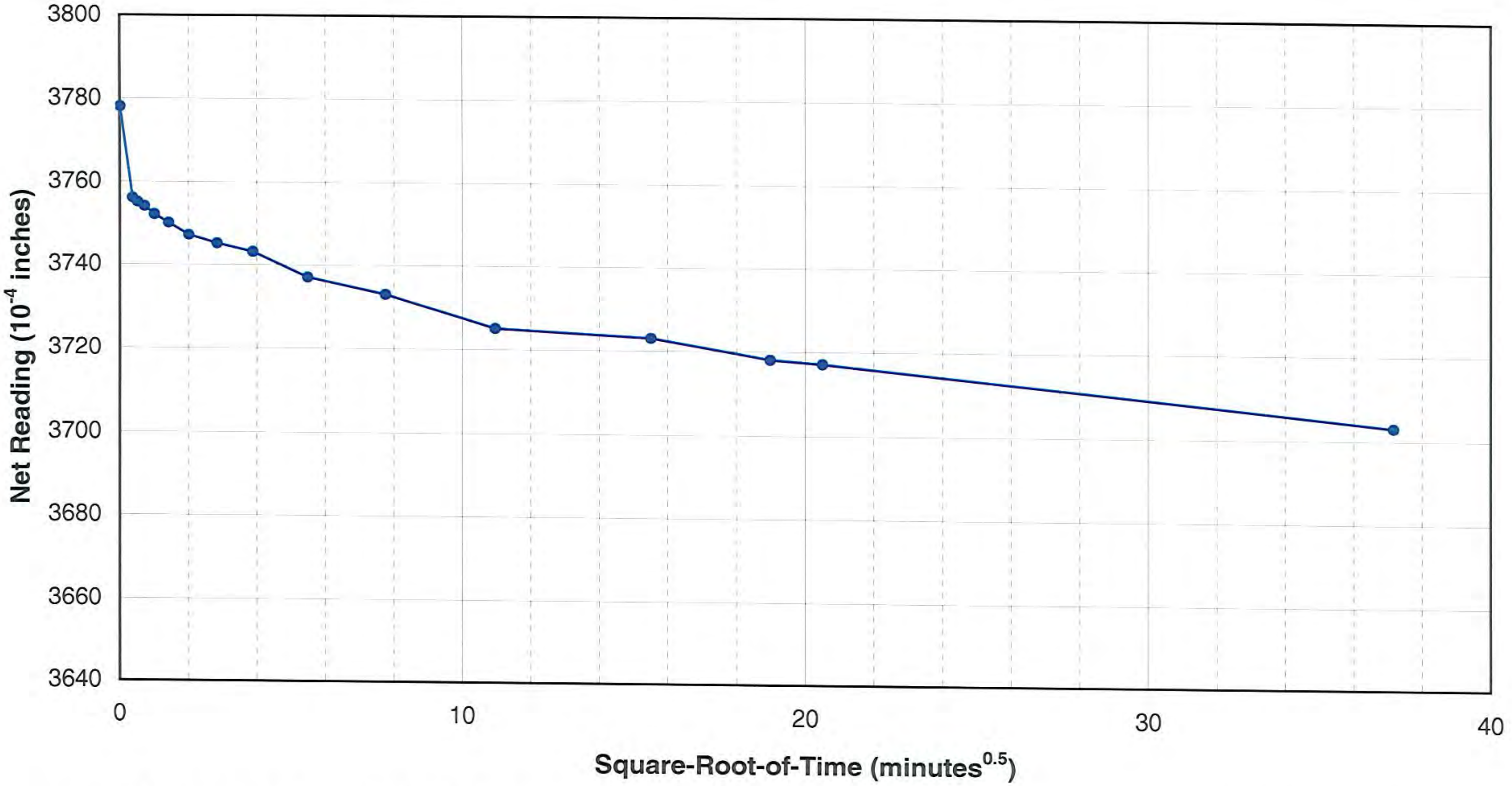
SAMPLE DESCRIPTION: Clay, Sandy A-6 (18)
LOCATION: S-2 FS208108
MOISTURE CONTENT: 15.3 % (Before Test)
% (After Test)
DRY DENSITY: 103 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 39 %
PLASTICITY INDEX: 21 %
GRAVEL: 1 %
SAND: 13 %
SILT AND CLAY: 86 %

CDOT
Laboratory Testing
Project No. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-2-Consolidation test

One Dimensional Consolidation Test Results

FIG. 3



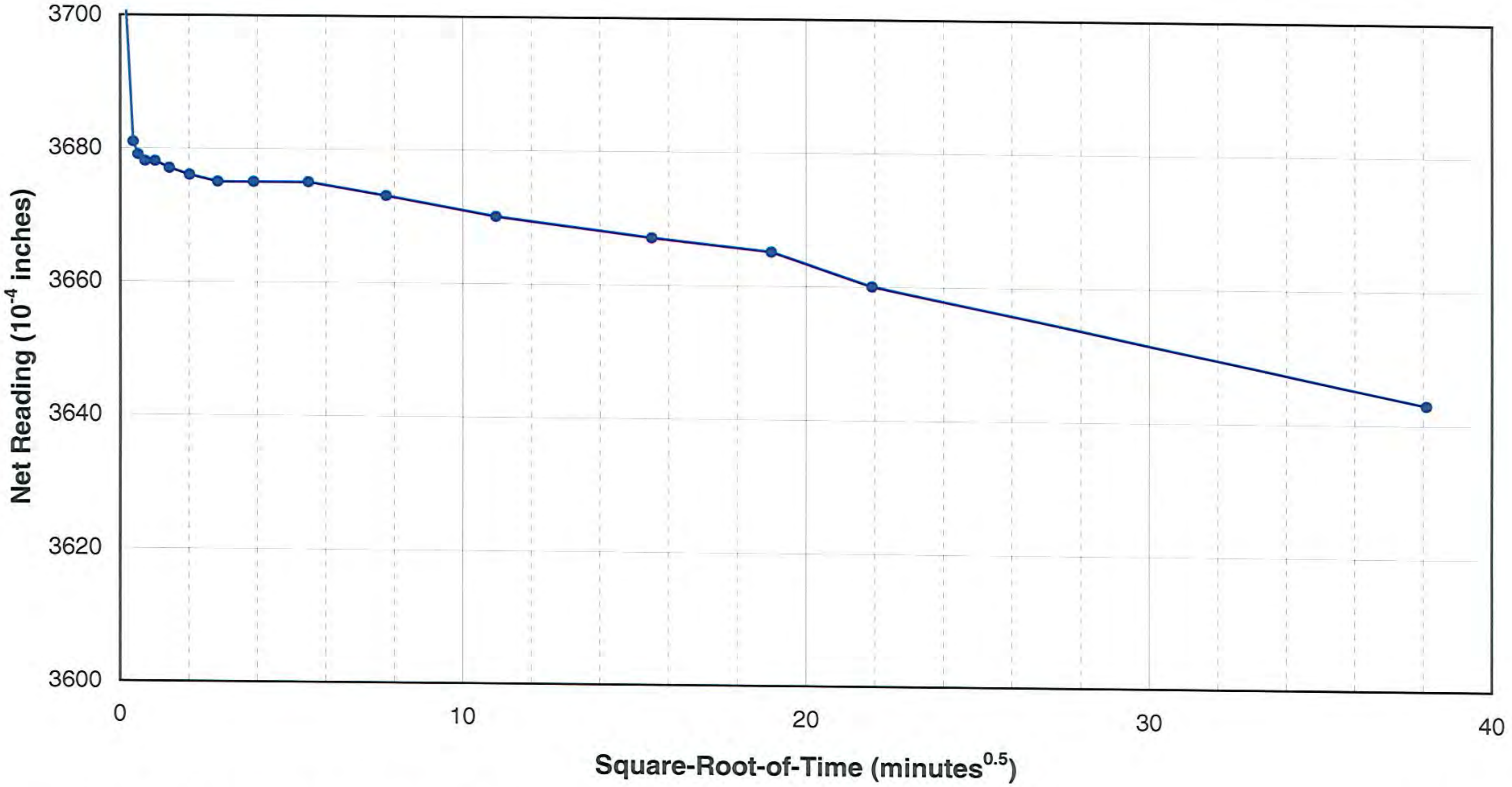
SAMPLE DESCRIPTION: Clay, Sandy A-6 (18)
LOCATION: S-2 FS208108
LOAD NO. 2
PRESSURE 1000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT:	39	%
PLASTICITY INDEX:	21	%
GRAVEL:	1	%
SAND:	13	%
SILT AND CLAY:	86	%

One Dimensional Consolidation Test Results

FIG. 4

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-2-Consolidation test



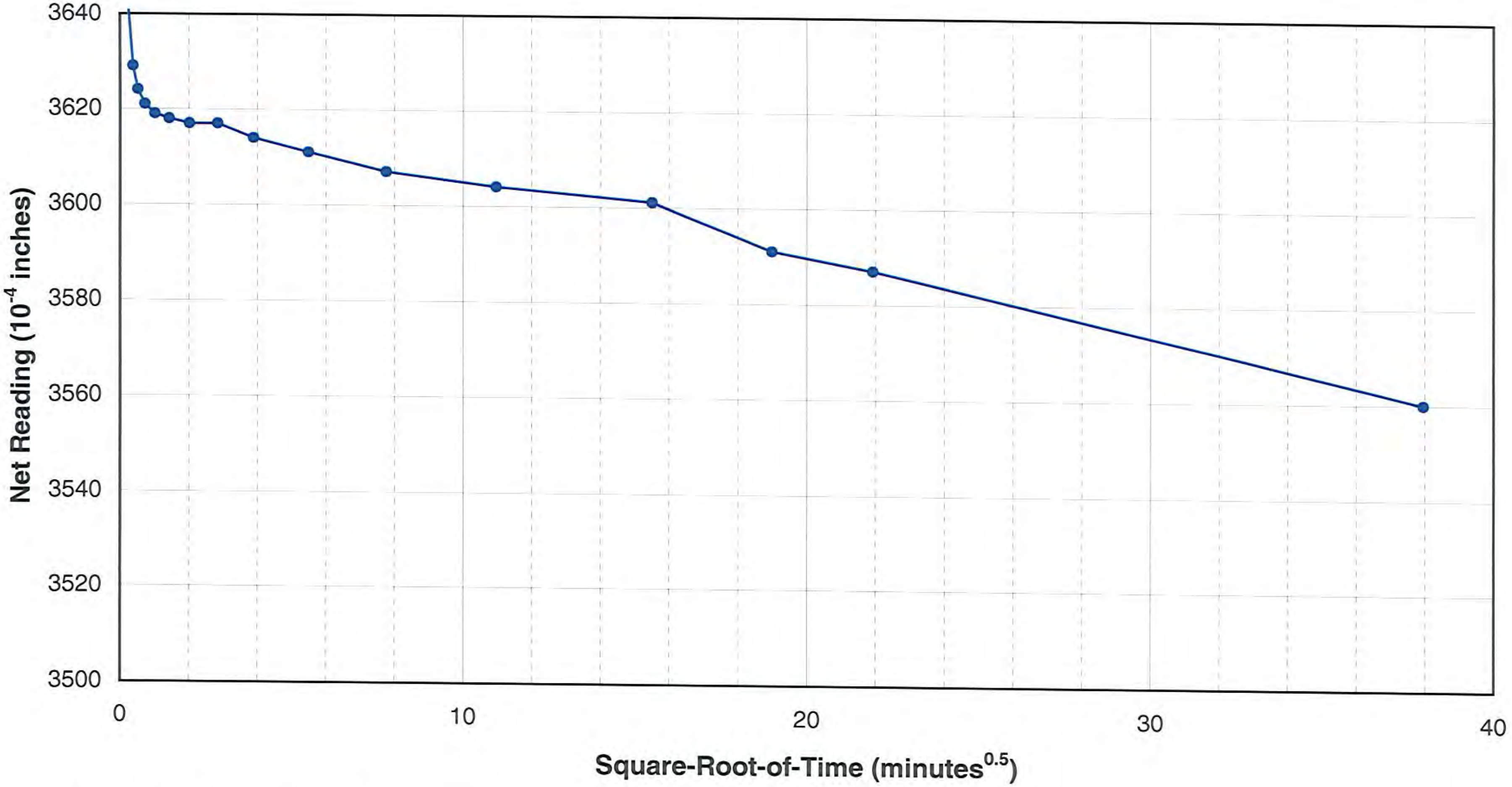
SAMPLE DESCRIPTION: Clay, Sandy A-6 (18)
LOCATION: S-2 FS208108
LOAD NO. 3
PRESSURE 2000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 39 %
PLASTICITY INDEX: 21 %
GRAVEL: 1 %
SAND: 13 %
SILT AND CLAY: 86 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-2-Consolidation test

One Dimensional Consolidation Test Results

FIG. 5



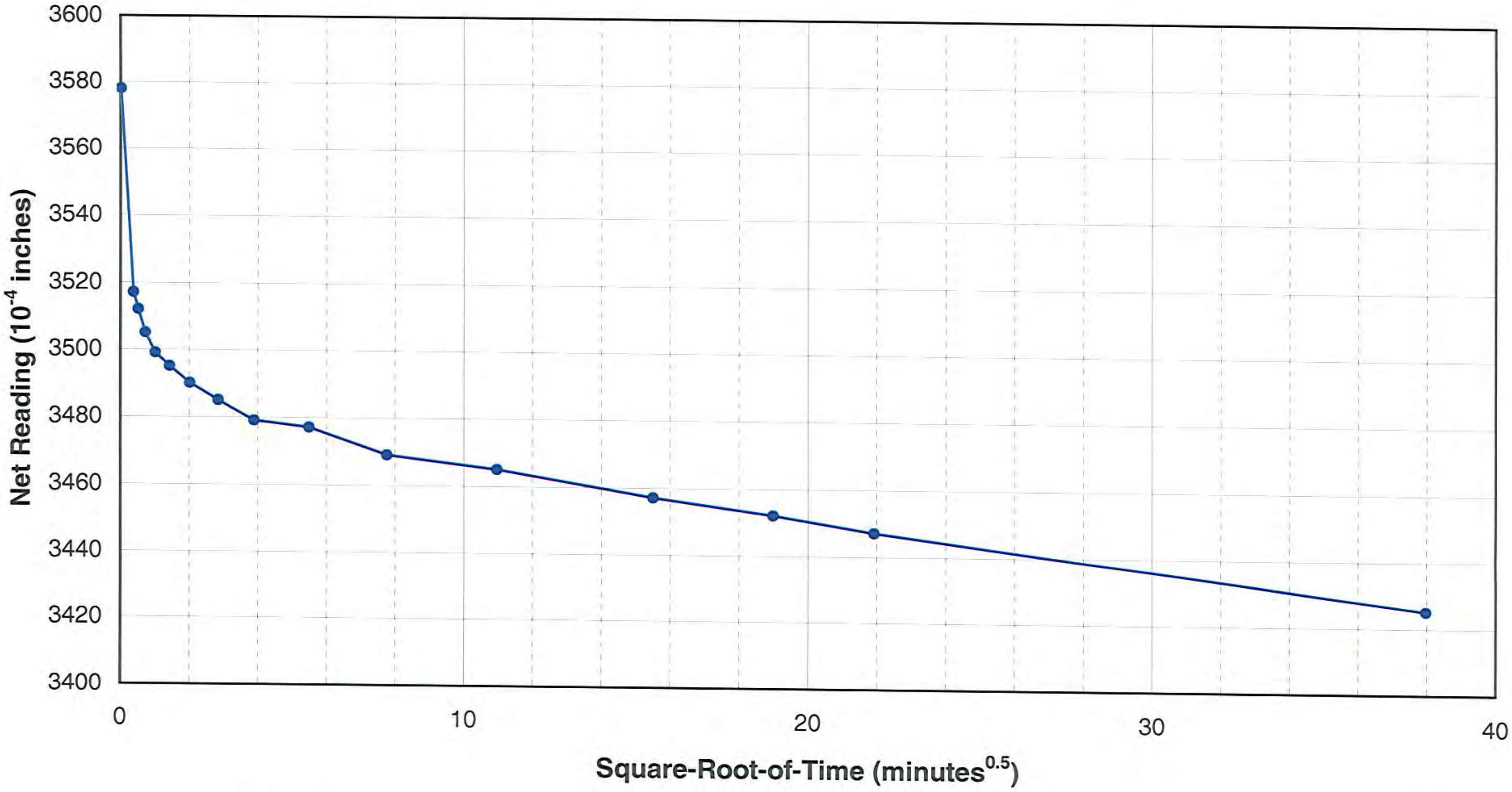
SAMPLE DESCRIPTION: Clay, Sandy A-6 (18)
LOCATION: S-2 FS208108
LOAD NO. 4
PRESSURE 4000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 39 %
PLASTICITY INDEX: 21 %
GRAVEL: 1 %
SAND: 13 %
SILT AND CLAY: 86 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-2-Consolidation test

One Dimensional Consolidation Test Results

FIG. 6



SAMPLE DESCRIPTION: Clay, Sandy A-6 (18)
LOCATION: S-2 FS208108
LOAD NO. 5
PRESSURE 8000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 39 %
PLASTICITY INDEX: 21 %
GRAVEL: 1 %
SAND: 13 %
SILT AND CLAY: 86 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-2-Consolidation test

One Dimensional Consolidation Test Resuts

FIG. 7

ONE-DIMENSIONAL CONSOLIDATION CALCULATION SHEET

PROJECT NO: DN46162-300
PROJECT NAME: CDOT
Sample Description: Clay, Sandy A-6 (18)
Sample Location: S-2 FS208108
Date: 7/30/2012

SAMPLE INFORMATION

Density

Diameter (in.):	1.935
Length, H (in.):	0.750
Volume (in^3):	2.21
Total volume, V_0 (cm^3):	36.14
Wet soil/ring wt (g):	271.20
Ring wt (g):	202.50
Wet wt, $W_{t,0}$ (g):	68.70
Wet unit wt (g/cc):	1.90
Wet unit wt (pcf):	118.7
Dry density (pcf):	102.9

Moisture

	Before (Trimmings)	After (Total Sample)
Dish No.:	146	249
Dish/wet soil (g):	347.20	247.70
Dish/dry soil (g):	331.50	289.37
Dish wt (g):	229.10	229.90
Water wt (g):	15.70	-41.67
Soil wt (g):	102.40	59.47
Moisture (%):	15.3	

🟩 Input Data

SAMPLE CALCULATIONS

Initial volume (cm^3):	36.14
Unit weight of water, γ_w (g/cc):	1.00
Specific Gravity, G_s:	2.70
Initial volume of solids, $V_s=W_s/\gamma_w G_s$ (cm^3):	22.03
Initial volume of voids, $V_{v,0}=V_0-V_s$ (cm^3):	14.12
Initial volume of water, $V_{w,0}=(W_{t,0}-W_s)/\gamma_w$ (cm^3):	9.23
Initial degree of saturation, $S_0=V_{w,0}/V_{v,0}$ (%):	65.39
Initial void ratio, $e_0=V_{v,0}/V_s$:	0.64
Final void ratio, e_f:	0.00
Final volume of water, $V_{w,f}=(W_{t,f}-W_s)/\gamma_w$ (cm^3):	-41.67
Final volume of voids, $V_{v,f}=e_f*V_s$ (cm^3):	0.00
Final degree of saturation, $S_f=V_{w,f}/V_{v,f}$ (%):	#DIV/0!
G_s assumed or from lab data?	**ASSUMED**

$W_{t,0}$=Initial total sample weight
$W_{t,f}$=Final total sample weight
V_0=Total sample volume
W_s=Soil weight

Liquid Limit:	39
Plasticity Index:	21
Percent Gravel:	0.9
Percent Sand:	13.4
Percent Silt and Clay:	85.7

CALCULATION OF % EXPANSION/COMPRESSION AND VOID RATIOS

Cell filled with water (yes/no)?: **NO**

Machine No.: 107

Final Readings:

Load No.	Start Date and Time	Pressure (psf)	Final Reading (10^{-4} in.)	Machine Deflection (10^{-4} in.)	Net Reading (10^{-4} in.)	ΔH (in.)	Expansion/ Compression, +/- (%)	Δe	Void Ratio, e	C=-Δe/Δ log σ
Initial	7/30/2012 8:23	0	3850	0	3850	0.0000	0.00	0.000	0.641	
1	7/30/2012 8:28	500	3763	10	3773	-0.0077	-1.03	-0.017	0.624	
2	7/31/2012 7:17	1000	3688	15	3703	-0.0147	-1.96	-0.032	0.609	0.0509
3	8/1/2012 7:27	2000	3615	28	3643	-0.0207	-2.76	-0.045	0.596	0.0436
4	8/2/2012 7:27	4000	3511	49	3560	-0.0290	-3.87	-0.063	0.577	0.0603
5	8/3/2012 7:28	8000	3358	67	3425	-0.0425	-5.67	-0.093	0.548	0.0981

Expansion/Compression (%)=ΔH/H

$\Delta e=(\Delta H/H)*(1+e_0)$

Colorado Department of Transportation
DIRECT SHEAR TEST REPORT (AASHTO T 236)

Field Sheet No. : **208110 (#2)**
Date Received : 7/23/2012
Item Number : 203
Lab Test No. : 2012-078

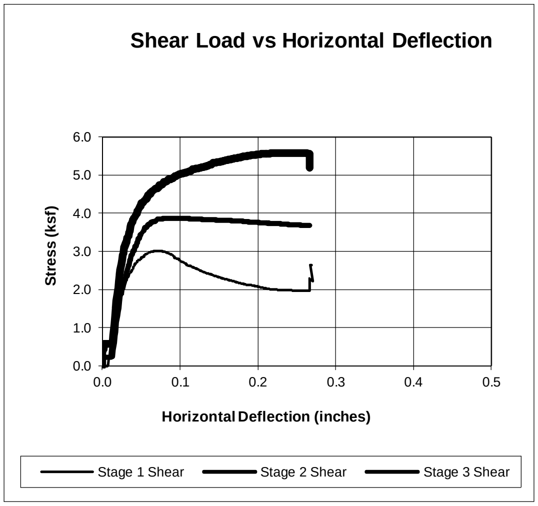
Project ID : **14934**
Project : HB 092A-020
Location : SH 92 and UPRR
Test Date : 08/1/2012
Source : Stockpile
Region : 3

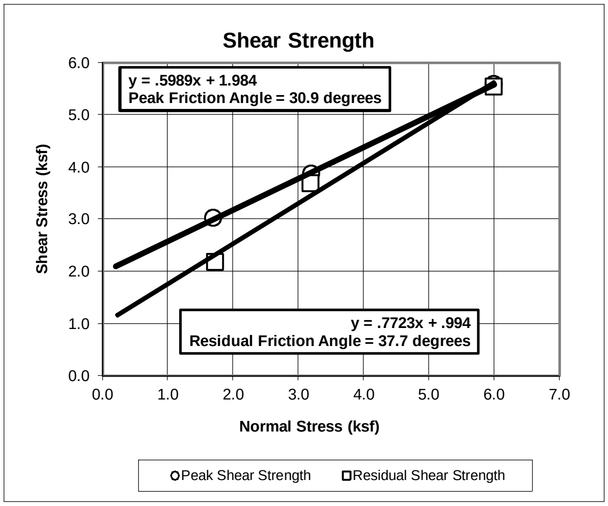
Classification : N/A
Liquid Limit : N/A
Plastic Limit : N/A
Plastic Index : N/A

Compaction Method : T 99 (A)
Max. Dry Dens. (pcf) : 108.5
Optimum Moisture : 17.0%

Specimens were compacted to 95% of AASHTO T 180 Method A at optimum moisture content.

Specimen Preparation	Stage 1	Stage 2	Stage 3
Surcharge Pressure (ksf)	1.72	3.19	5.99
Compacted Dry Density (pcf)	103.7	103.7	103.7
Moisture Content	16.8%	16.8%	16.8%
Percent of Maximum Dry Density	95.5%	95.6%	95.5%





Project Specifications:
Peak Friction Angle: **30.9 degrees**
Residual Friction Angle: **37.7 degrees**

Distribution:
Central Laboratory
Region Materials Engineer

C.K. Su
Soils and Rockfall Program

Project: CTL # DN46162-300

Reported to: CDOT Materials Laboratory
4670 Holly Street, Unit A
Denver, Colorado 80216
Attn: David Thomas

Date: 07/17/12
Reported by: PSH

Sample Information

Sample Number: 3
Field Sheet Number: 208108
Project Number: STA092-024
Depth:

Sieve Analysis (T 11, T 27)

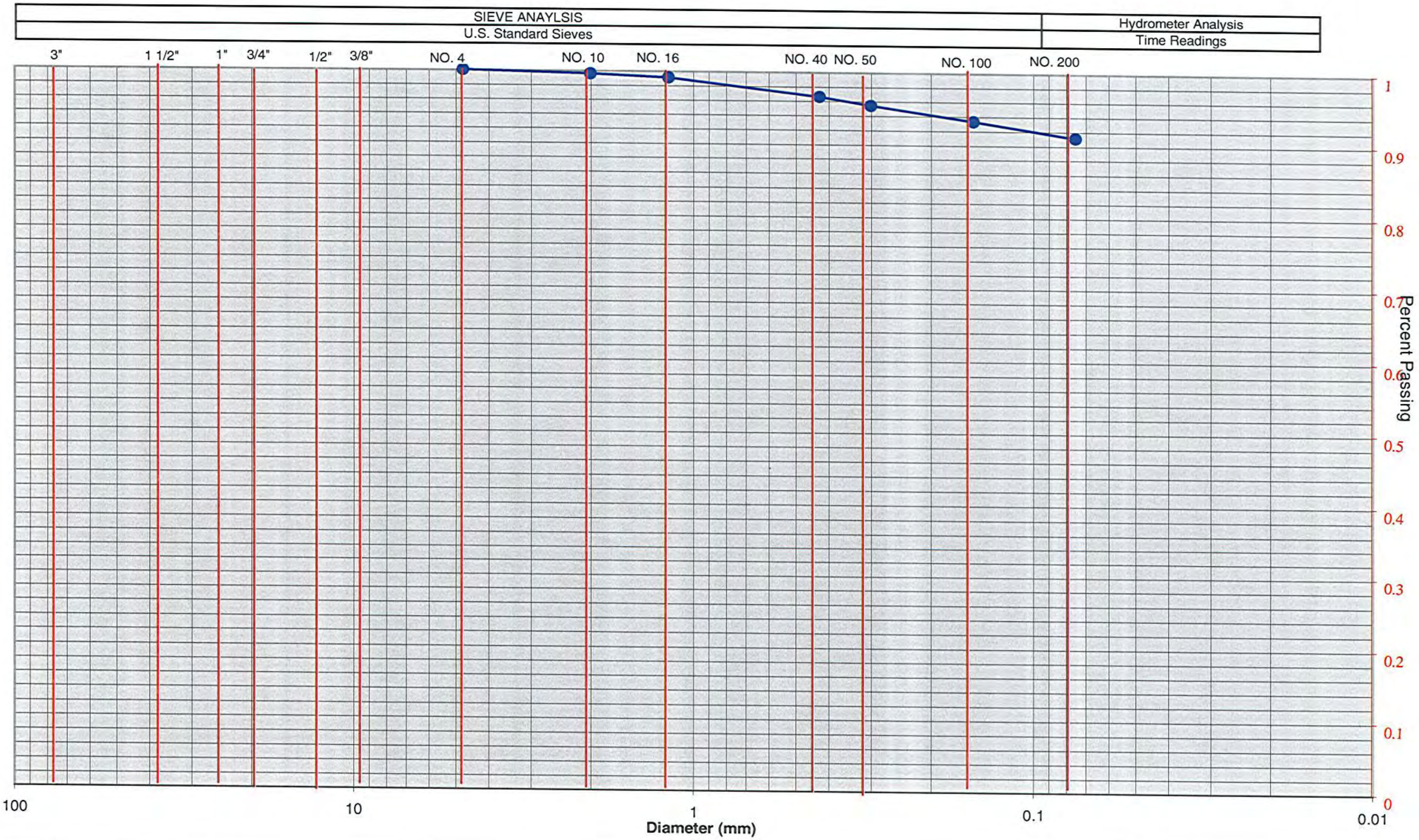
Sieve Size	Wt. Retained	Percent Retained	Percent Passing
3"		0.0	
1 1/2"		0.0	
1"		0.0	
3/4"		0.0	
1/2"		0.0	
3/8"		0.0	
#4	0.0	0.0	100
#10	1.0	0.4	100
#16	1.1	0.5	99
#40	5.6	2.5	97
#50	2.7	1.2	95
#100	4.7	2.1	93
#200	4.9	2.2	91.1

Dry Soil Weight 225.6

Moisture Content (%) (AASHTO T 265)	
Dry Density (pcf)	
Percent Gravel	0.4
Percent Sand	8.4
Percent Coarse Sand	3.0
Percent Fine Sand	5.5
Percent Silt and Clay	91.1
Liquid Limit (AASHTO T 89)	44
Plasticity Index (AASHTO T 90)	26
AASHTO Classification (AASHTO M 145)	A-7-6 (25)
USCS Classification (ASTM D 2487)	CL
Sulfate Content (SO_4)	0.8
Chloride Ion In Water (ASTM D 512-89)	0.0088
PH of Soil for Corrosion Testing (ASTM G 51-95)	6.950
Wenner Four-Electrode (ASTM G 57-95a) *	
(As received)	1100 @ 14.9%
(Saturated)	260 @ 42.6%

*Measured in ohm-centimeters

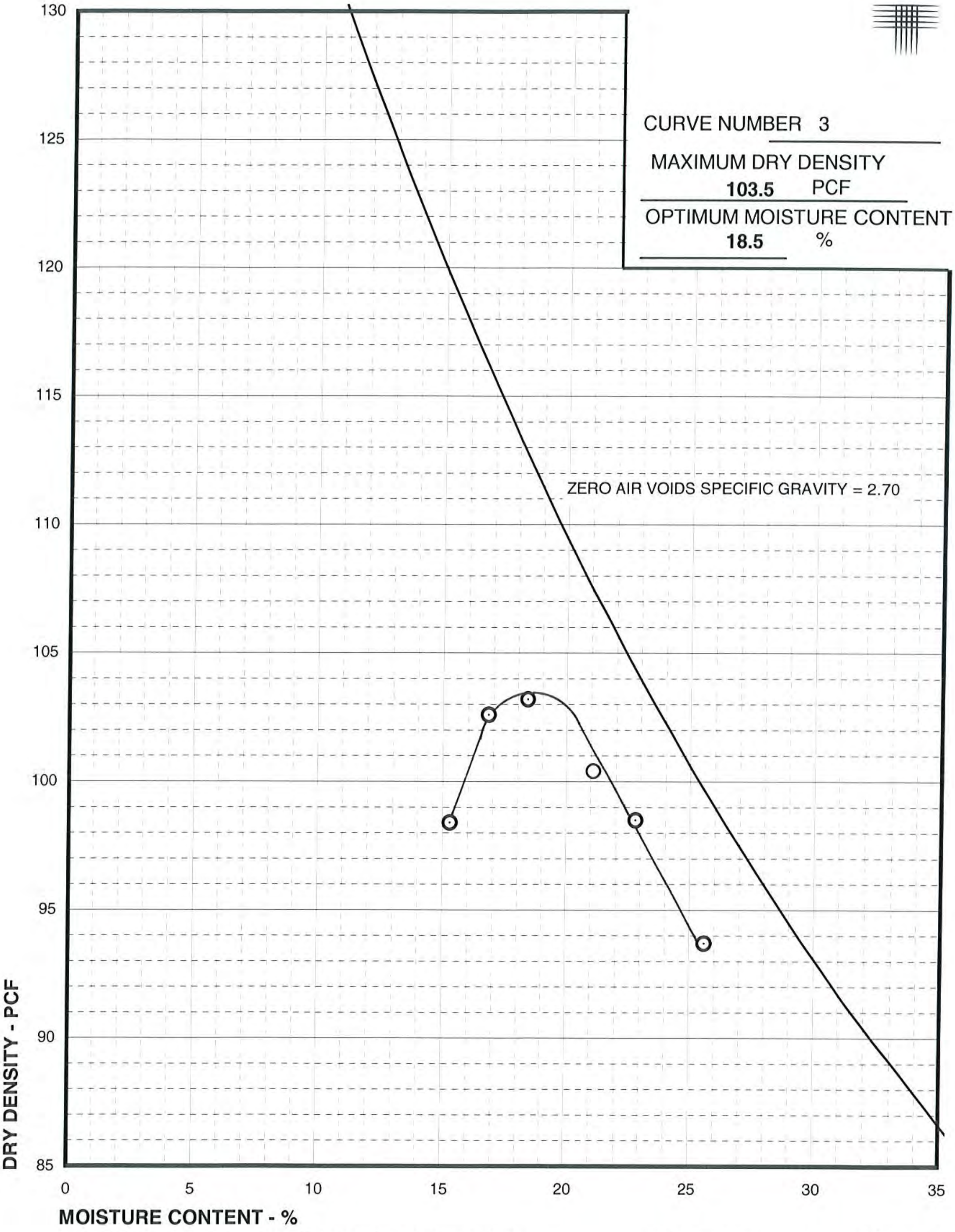
SIEVE ANALYSIS AASHTO T 27



Gravel	0.4	Sand	8.4	Silt and Clay	91.1

Coarse	3.0	Fine	5.5

Sample ID	3
Lab ID	STA092-024



CURVE NUMBER 3

MAXIMUM DRY DENSITY
103.5 PCF

OPTIMUM MOISTURE CONTENT
18.5 %

Sample Description Clay, Slightly Sandy A-7-6 (25)

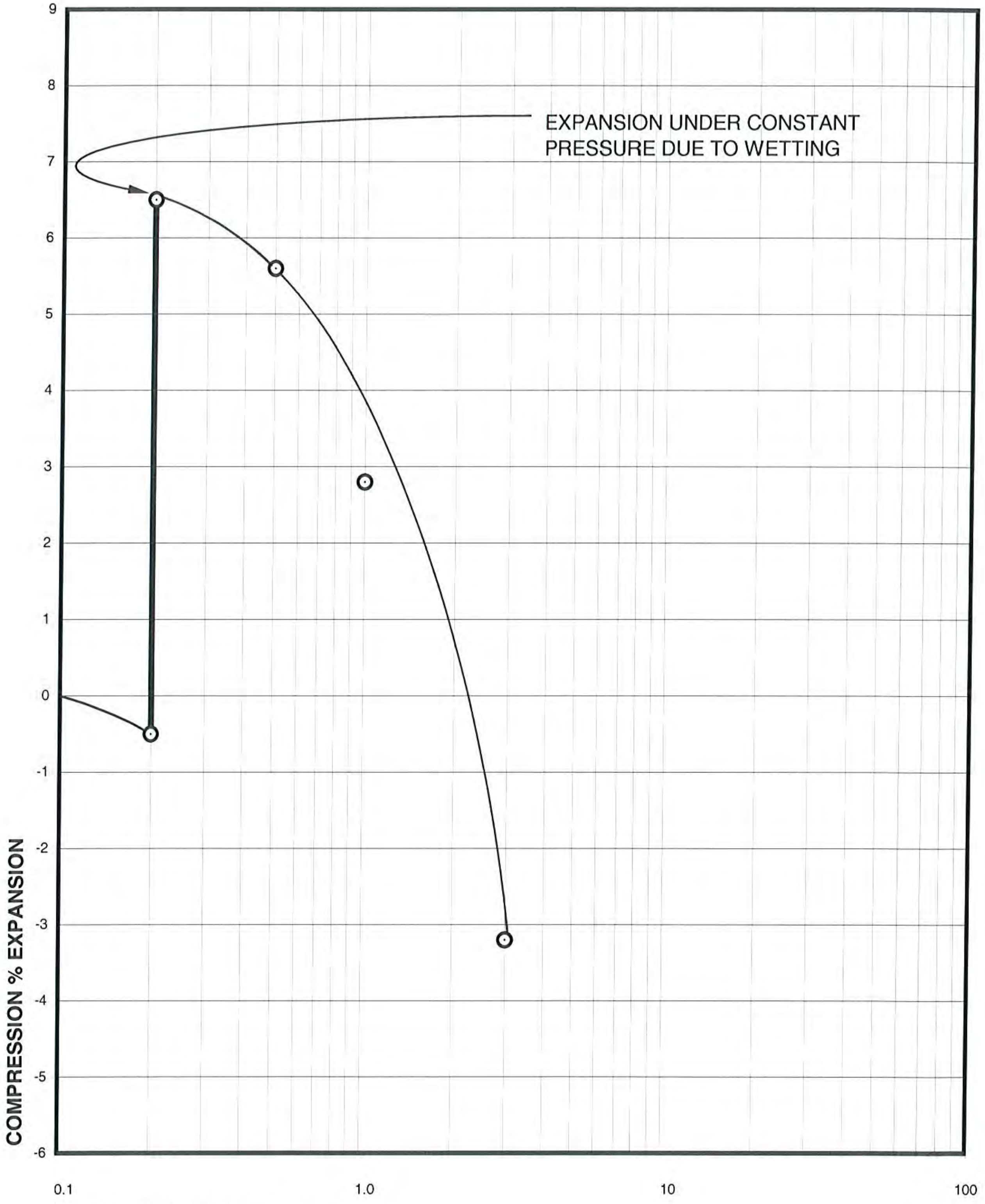
Location Sample No. 3, Field Sheet 208108

Compaction Test Procedure AASHTO T99
METHOD "A"

LIQUID LIMIT	44	%
PLASTICITY INDEX	26	%
GRAVEL	0.4	%
SAND	8.5	%
SILT AND CLAY	91.1	%

COLORADO DEPARTMENT OF TRANSPORTATION

Compaction Test Results

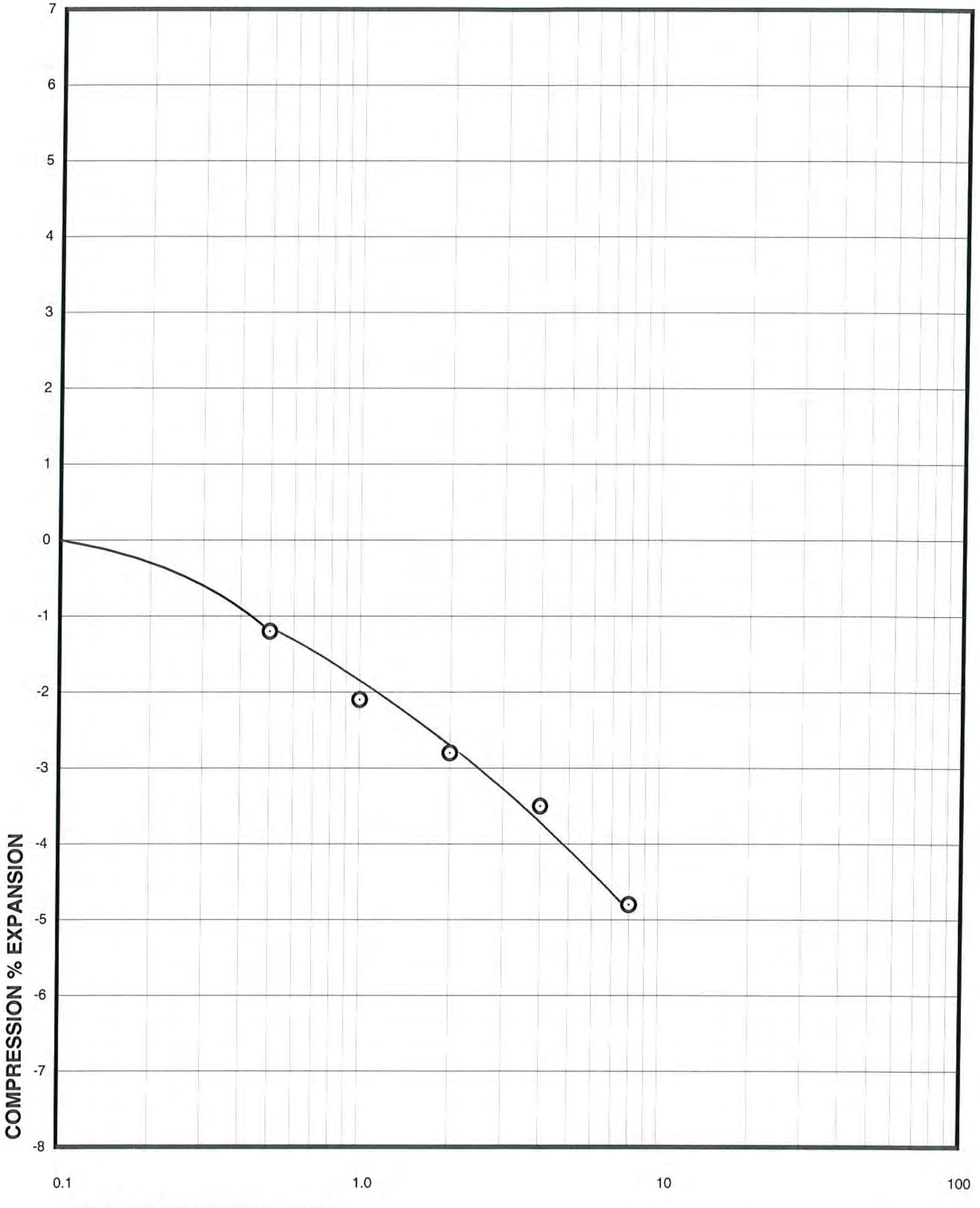


Sample of Clay, Sandy A-6 (16)
From S-3, FS208108

DRY UNIT WEIGHT= 99 PCF
MOISTURE CONTENT= 16.4 %

CDOT
LABORATORY TESTING
PROJECT NO. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\Swell data

Swell Consolidation Test Results



Sample of Clay, Sandy A-6 (16)

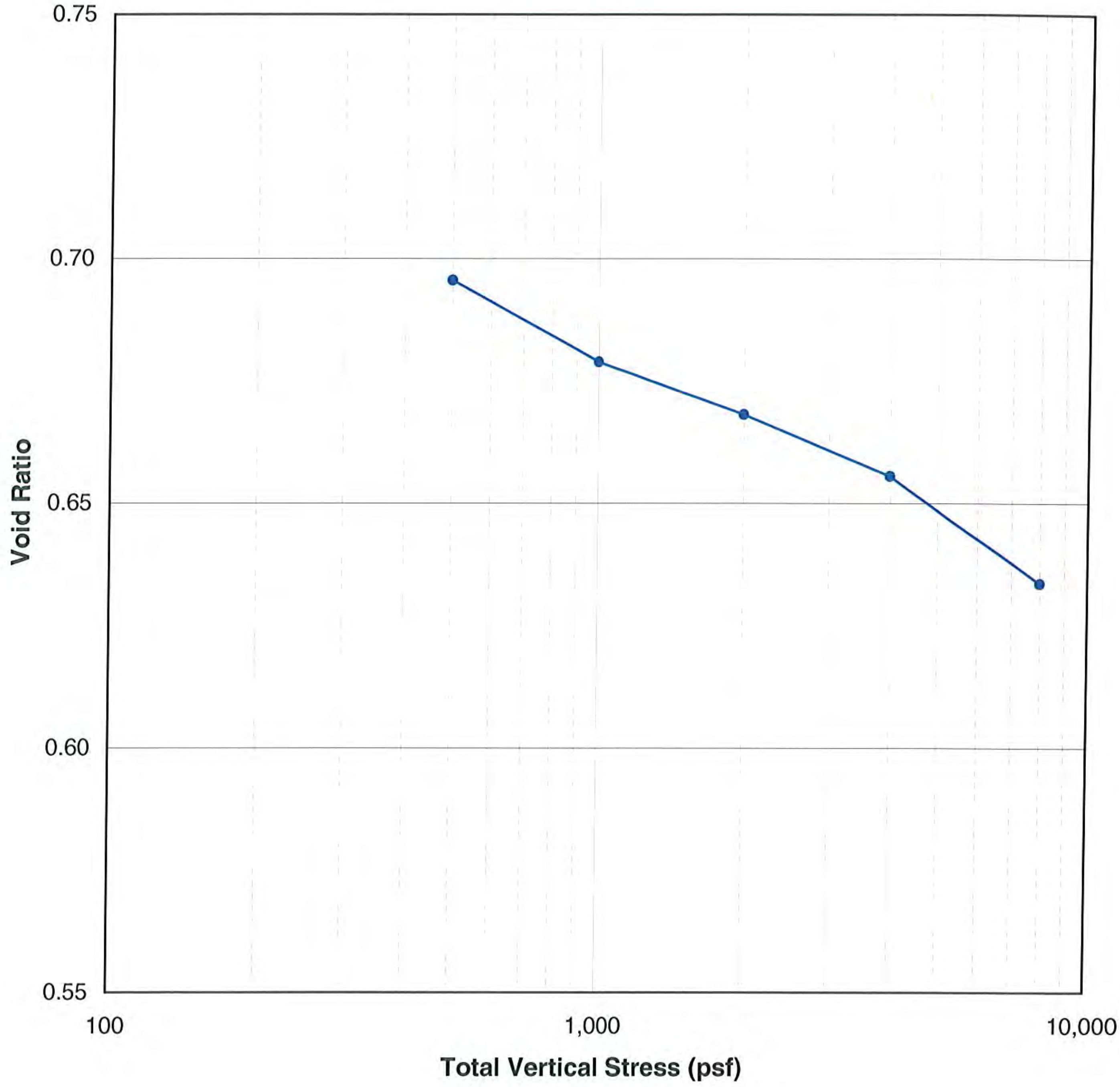
From S-3, FS208108

DRY UNIT WEIGHT= 98 PCF

MOISTURE CONTENT= 16.4 %

CDOT
LABORATORY TESTING
PROJECT NO. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\Swell data

Swell Consolidation Test Results

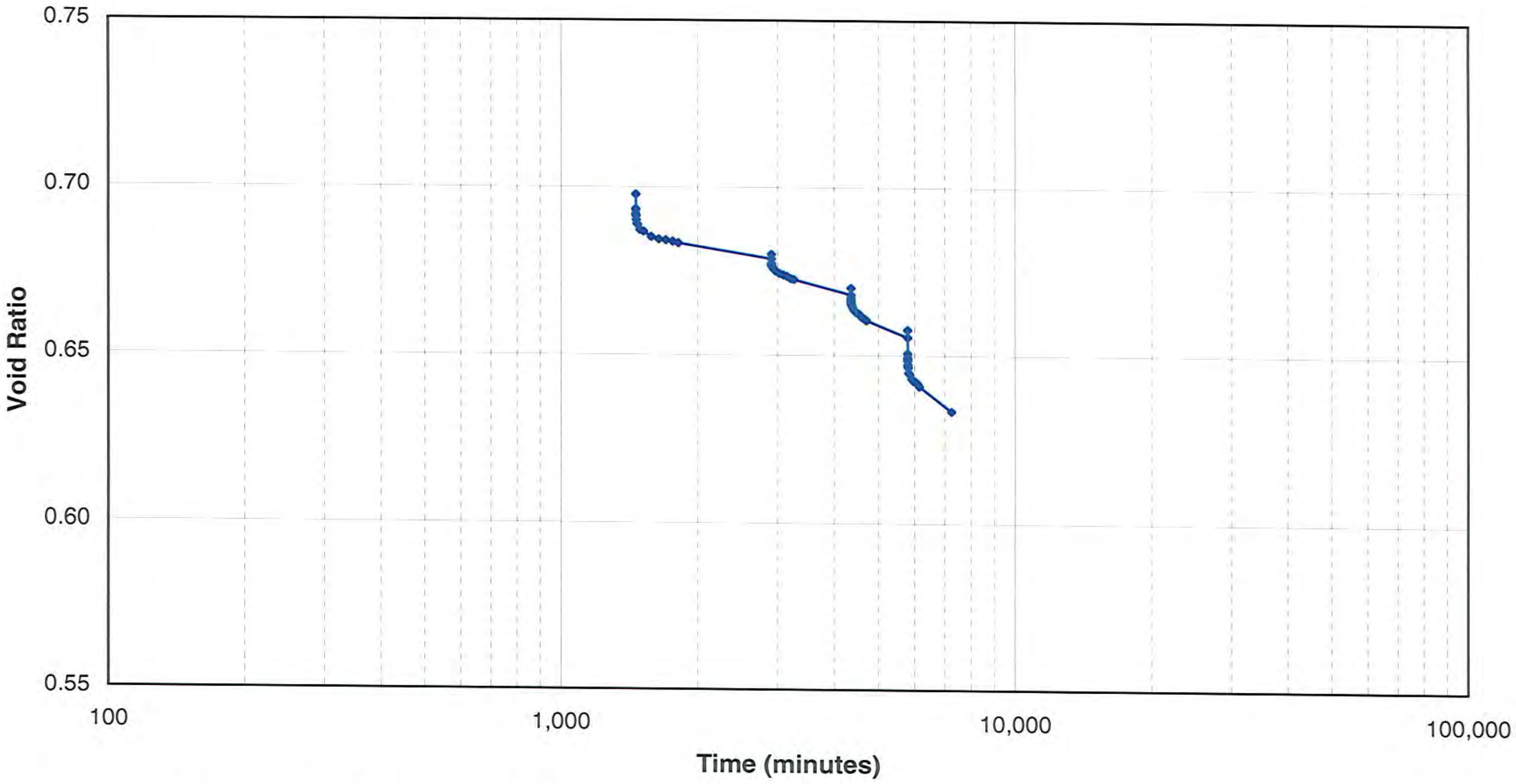


SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (25)
LOCATION: S-3 FS208108
MOISTURE CONTENT: 16.4 % (Before Test)
14.8 % (After Test)
DRY DENSITY: 98 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 26 %
GRAVEL: 0 %
SAND: 9 %
SILT AND CLAY: 91 %

One Dimensional Consolidation Test Results

FIG. 1



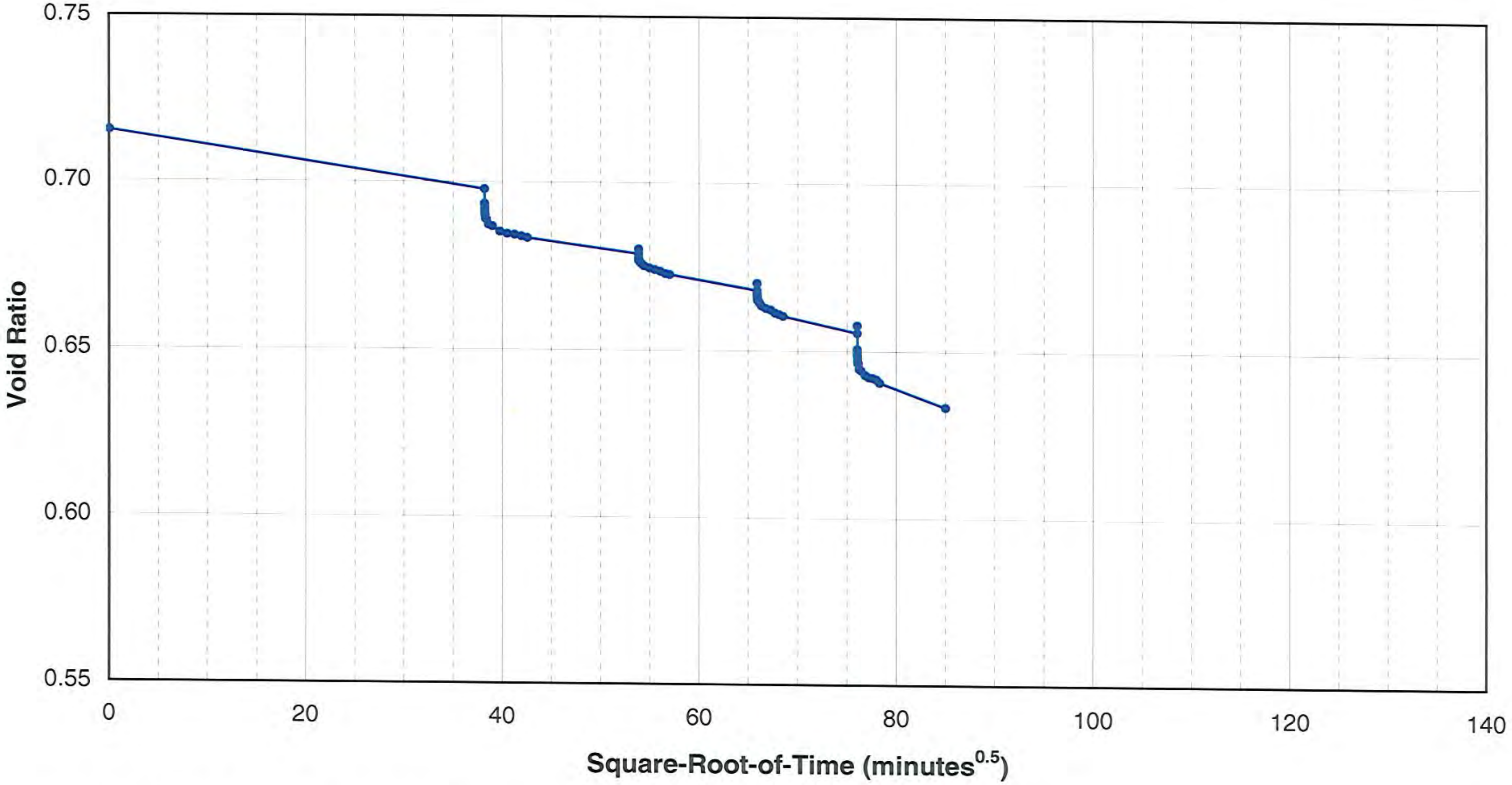
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (25)
LOCATION: S-3 FS208108
MOISTURE CONTENT: 16.4 % (Before Test)
14.8 % (After Test)
DRY DENSITY: 98 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 26 %
GRAVEL: 0 %
SAND: 9 %
SILT AND CLAY: 91 %

CDOT
Laboratory Testing
Project No. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-3-Consolidation test

One Dimensional Consolidation Test Results

FIG. 2



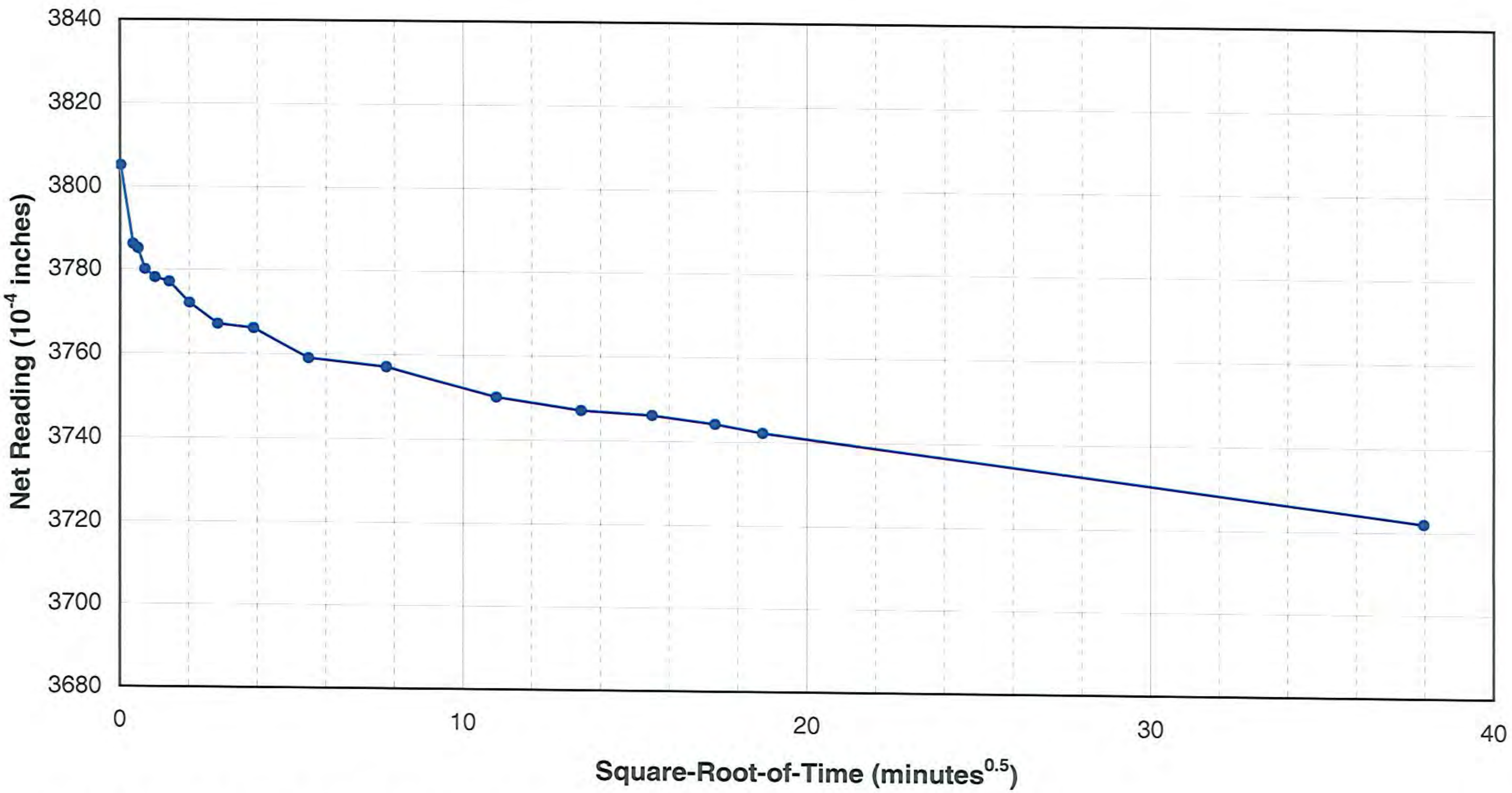
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (25)
LOCATION: S-3 FS208108
MOISTURE CONTENT: 16.4 % (Before Test)
14.8 % (After Test)
DRY DENSITY: 98 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 26 %
GRAVEL: 0 %
SAND: 9 %
SILT AND CLAY: 91 %

CDOT
Laboratory Testing
Project No. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-3-Consolidation test

One Dimensional Consolidation Test Results

FIG. 3



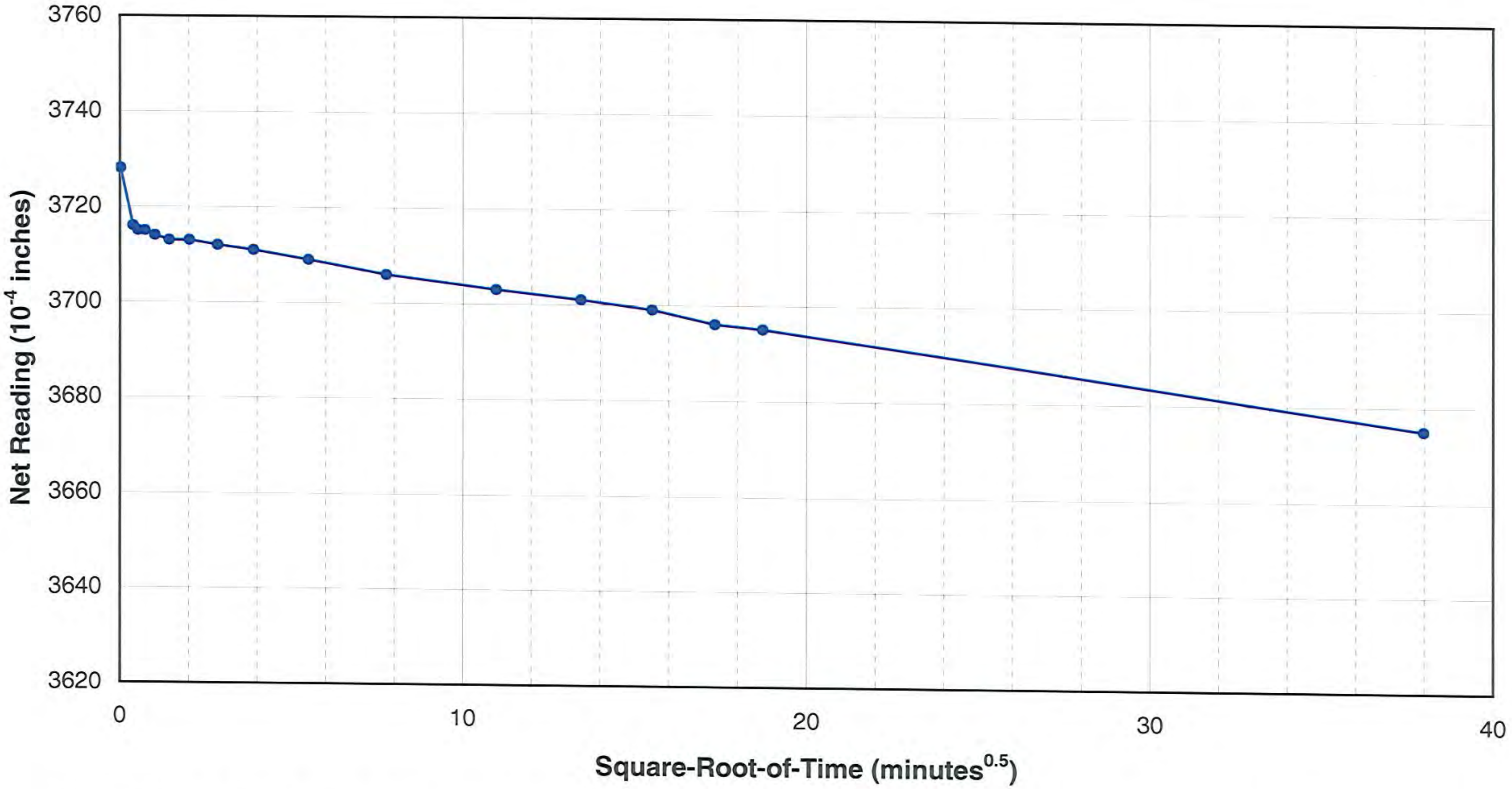
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (25)
LOCATION: S-3 FS208108
LOAD NO. 2
PRESSURE 1000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 26 %
GRAVEL: 0 %
SAND: 9 %
SILT AND CLAY: 91 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-3-Consolidation test

One Dimensional Consolidation Test Results

FIG. 4



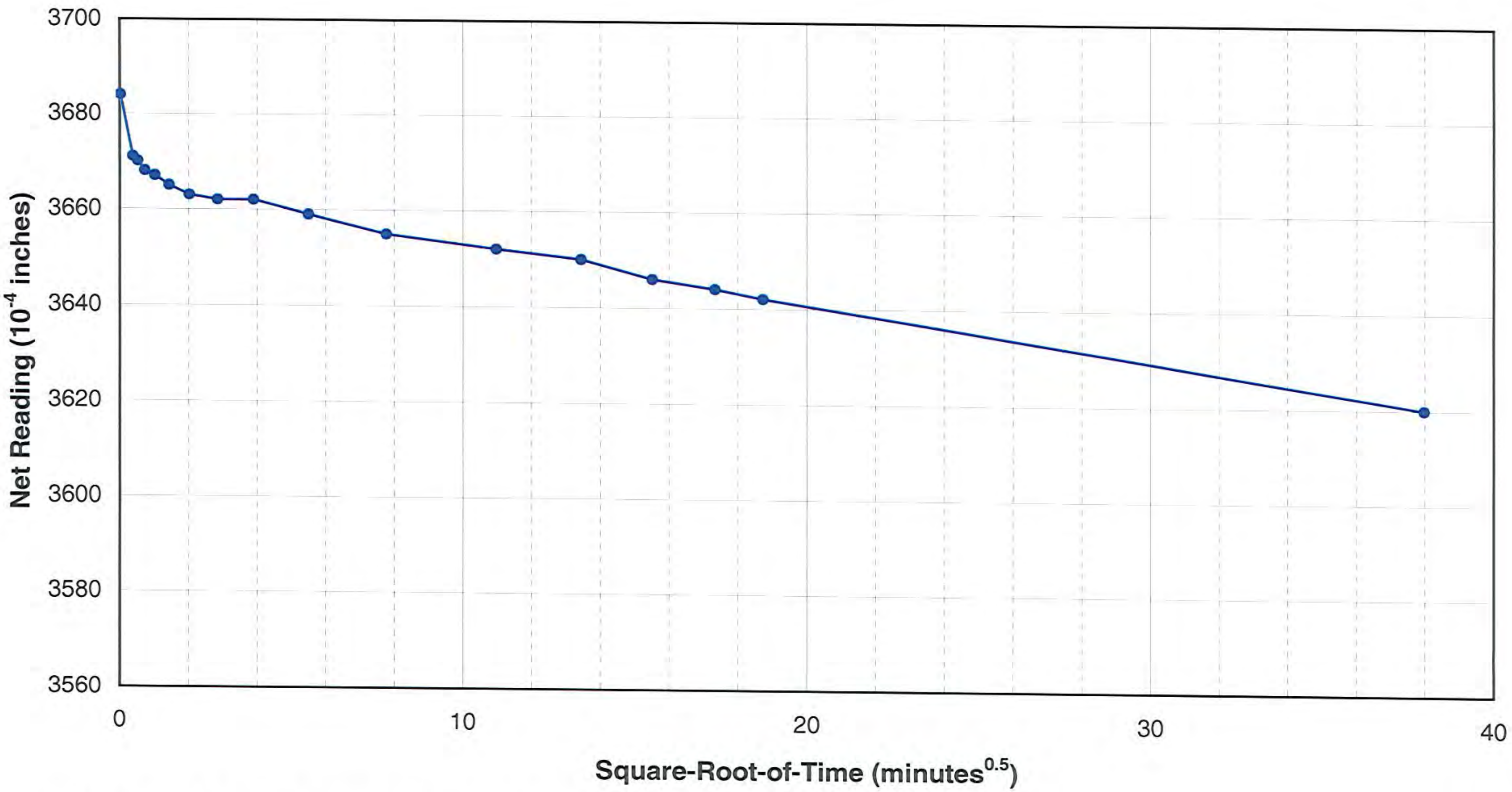
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (25)
LOCATION: S-3 FS208108
LOAD NO. 3
PRESSURE 2000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 26 %
GRAVEL: 0 %
SAND: 9 %
SILT AND CLAY: 91 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-3-Consolidation test

One Dimensional Consolidation Test Results

FIG. 5



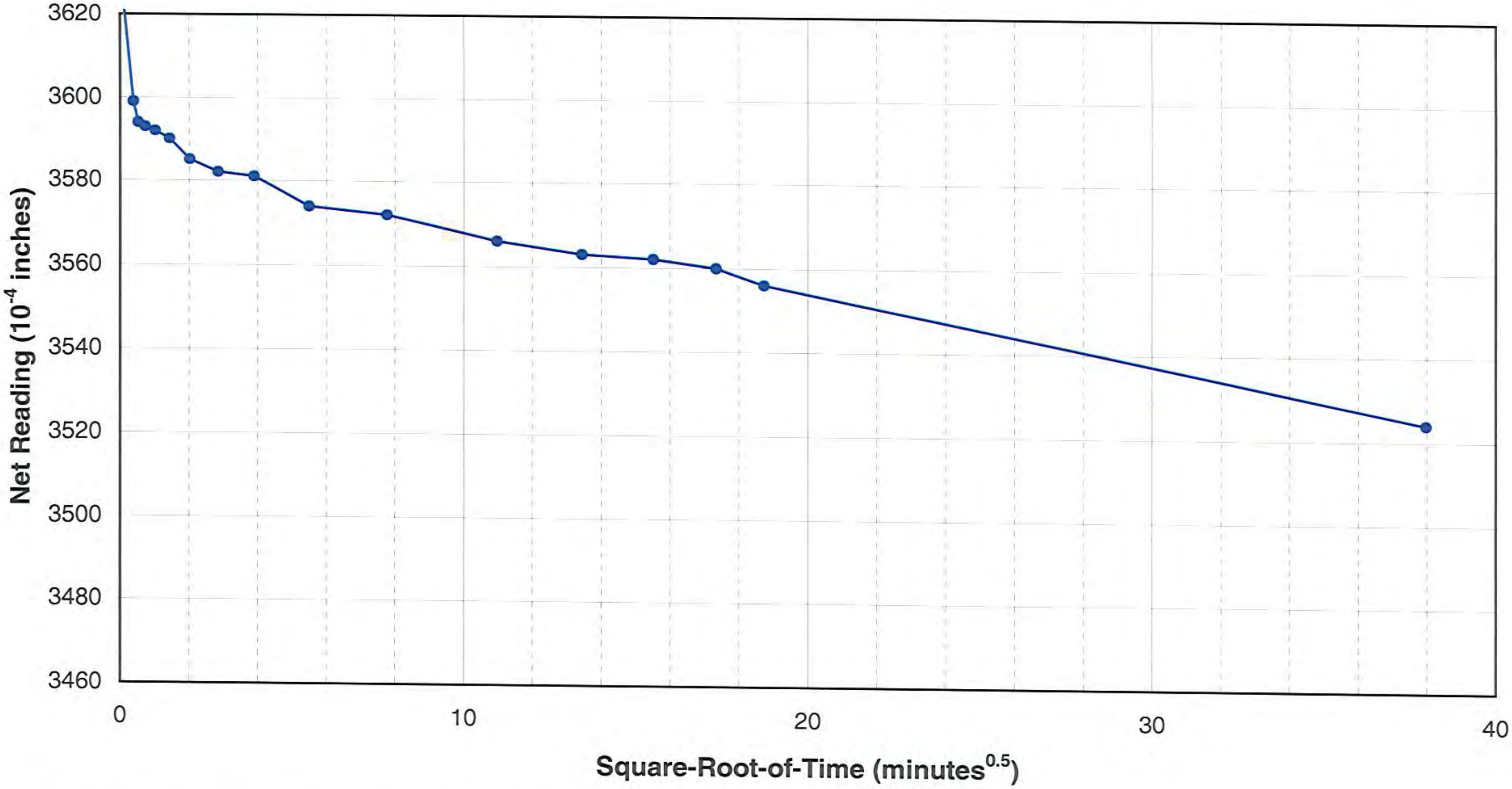
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (25)
LOCATION: S-3 FS208108
LOAD NO. 4
PRESSURE 4000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 26 %
GRAVEL: 0 %
SAND: 9 %
SILT AND CLAY: 91 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-3-Consolidation test

One Dimensional Consolidation Test Results

FIG. 6



SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (25)
LOCATION: S-3 FS208108
LOAD NO. 5
PRESSURE 8000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 26 %
GRAVEL: 0 %
SAND: 9 %
SILT AND CLAY: 91 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-3-Consolidation test

One Dimensional Consolidation Test Results

FIG. 7

ONE-DIMENSIONAL CONSOLIDATION CALCULATION SHEET

PROJECT NO: DN46162-300
PROJECT NAME: CDOT
Sample Description: Clay, Slightly Sandy A-7-6 (25)
Sample Location: S-3 FS208108
Date: 7/30/2012

SAMPLE INFORMATION

Density

Diameter (in.):	1.935
Length, H (in.):	0.750
Volume (in^3):	2.21
Total volume, V_0 (cm^3):	36.14
Wet soil/ring wt (g):	279.64
Ring wt (g):	213.45
Wet wt, $W_{t,0}$ (g):	66.19
Wet unit wt (g/cc):	1.83
Wet unit wt (pcf):	114.3
Dry density (pcf):	98.2

Moisture

	Before (Trimmings)	After (Total Sample)
Dish No.:	75	33
Dish/wet soil (g):	579.75	294.73
Dish/dry soil (g):	530.48	286.29
Dish wt (g):	229.70	229.40
Water wt (g):	49.27	8.44
Soil wt (g):	300.78	56.89
Moisture (%):	16.4	14.8

🟩 Input Data

SAMPLE CALCULATIONS

Initial volume (cm^3):	36.14
Unit weight of water, γ_w (g/cc):	1.00
Specific Gravity, G_s:	2.70
Initial volume of solids, $V_s=W_s/\gamma_w G_s$ (cm^3):	21.07
Initial volume of voids, $V_{v,0}=V_0-V_s$ (cm^3):	15.07
Initial volume of water, $V_{w,0}=(W_{t,0}-W_s)/\gamma_w$ (cm^3):	9.30
Initial degree of saturation, $S_0=V_{w,0}/V_{v,0}$ (%):	61.70
Initial void ratio, $e_{0=}V_{v,0}/V_s$:	0.72
Final void ratio, e_f:	0.00
Final volume of water, $V_{w,f}=(W_{t,f}-W_s)/\gamma_w$ (cm^3):	8.44
Final volume of voids, $V_{v,f}=e_f{*}V_s$ (cm^3):	0.00
Final degree of saturation, $S_f=V_{w,f}/V_{v,f}$ (%):	#DIV/0!
G_s assumed or from lab data?	**ASSUMED**

$W_{t,0}$=Initial total sample weight
$W_{t,f}$=Final total sample weight
V_0=Total sample volume
W_s=Soil weight

Liquid Limit:	44
Plasticity Index:	26
Percent Gravel:	0.4
Percent Sand:	8.5
Percent Silt and Clay:	91.1

CALCULATION OF % EXPANSION/COMPRESSION AND VOID RATIOS

Cell filled with water (yes/no)?: **NO**

Machine No.: 54

Final Readings:

Load No.	Start Date and Time	Pressure (psf)	Final Reading $(10^{-4}$ in.)	Machine Deflection $(10^{-4}$ in.)	Net Reading $(10^{-4}$ in.)	ΔH (in.)	Expansion/ Compression, +/- (%)	Δe	Void Ratio, e
Initial	7/30/2012 9:47	0	3882	0	3882	0.0000	0.00	0.000	0.715
1	7/30/2012 10:02	500	3778	17	3795	-0.0087	-1.16	-0.020	0.695
2	7/31/2012 10:03	1000	3695	27	3722	-0.0160	-2.13	-0.037	0.679
3	8/1/2012 10:03	2000	3642	33	3675	-0.0207	-2.76	-0.047	0.668
4	8/2/2012 10:03	4000	3578	42	3620	-0.0262	-3.49	-0.060	0.655
5	8/3/2012 10:03	8000	3472	52	3524	-0.0358	-4.77	-0.082	0.633

C=-Δe/Δ log σ
0.0555
0.0357
0.0418
0.0729

Expansion/Compression (%)=ΔH/H

$\Delta e=(\Delta H/H)*(1+e_0)$

Colorado Department of Transportation
DIRECT SHEAR TEST REPORT (AASHTO T 236)

Field Sheet No. : **208110 (#3)**
Date Received : 7/23/2012
Item Number : 203
Lab Test No. : 2012-079

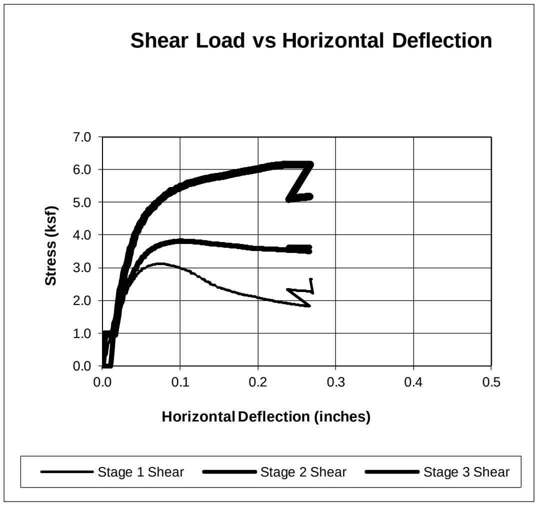
Project ID : **14934**
Project : HB 092A-020
Location : SH 92 and UPRR
Test Date : 08/2/2012
Source : Stockpile
Region : 3

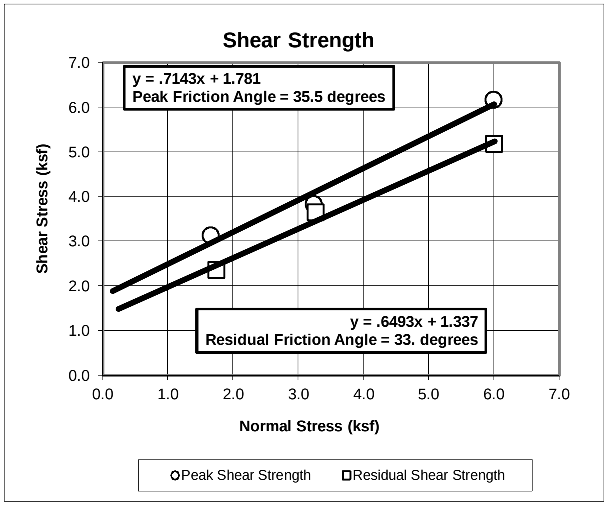
Classification : N/A
Liquid Limit : N/A
Plastic Limit : N/A
Plastic Index : N/A

Compaction Method : T 99 (A)
Max. Dry Dens. (pcf) : 103.5
Optimum Moisture : 18.5%

Specimens were compacted to 95% of AASHTO T 180 Method A at optimum moisture content.

Specimen Preparation	Stage 1	Stage 2	Stage 3
Surcharge Pressure (ksf)	1.70	3.25	6.00
Compacted Dry Density (pcf)	98.6	98.7	98.7
Moisture Content	18.3%	18.2%	18.3%
Percent of Maximum Dry Density	95.3%	95.4%	95.3%





Project Specifications:
Peak Friction Angle: **35.5 degrees**
Residual Friction Angle: **33.0 degrees**

Distribution:
Central Laboratory
Region Materials Engineer

C.K. Su
Soils and Rockfall Program

Project: CTL # DN46162-300

Reported to: CDOT Materials Laboratory
4670 Holly Street, Unit A
Denver, Colorado 80216
Attn: David Thomas

Date: 07/17/12

Reported by: PSH

Sample Information

Sample Number: 4

Field Sheet Number: 208108

Project Number: STA092-024

Depth: ____

Sieve Analysis (T 11, T 27)

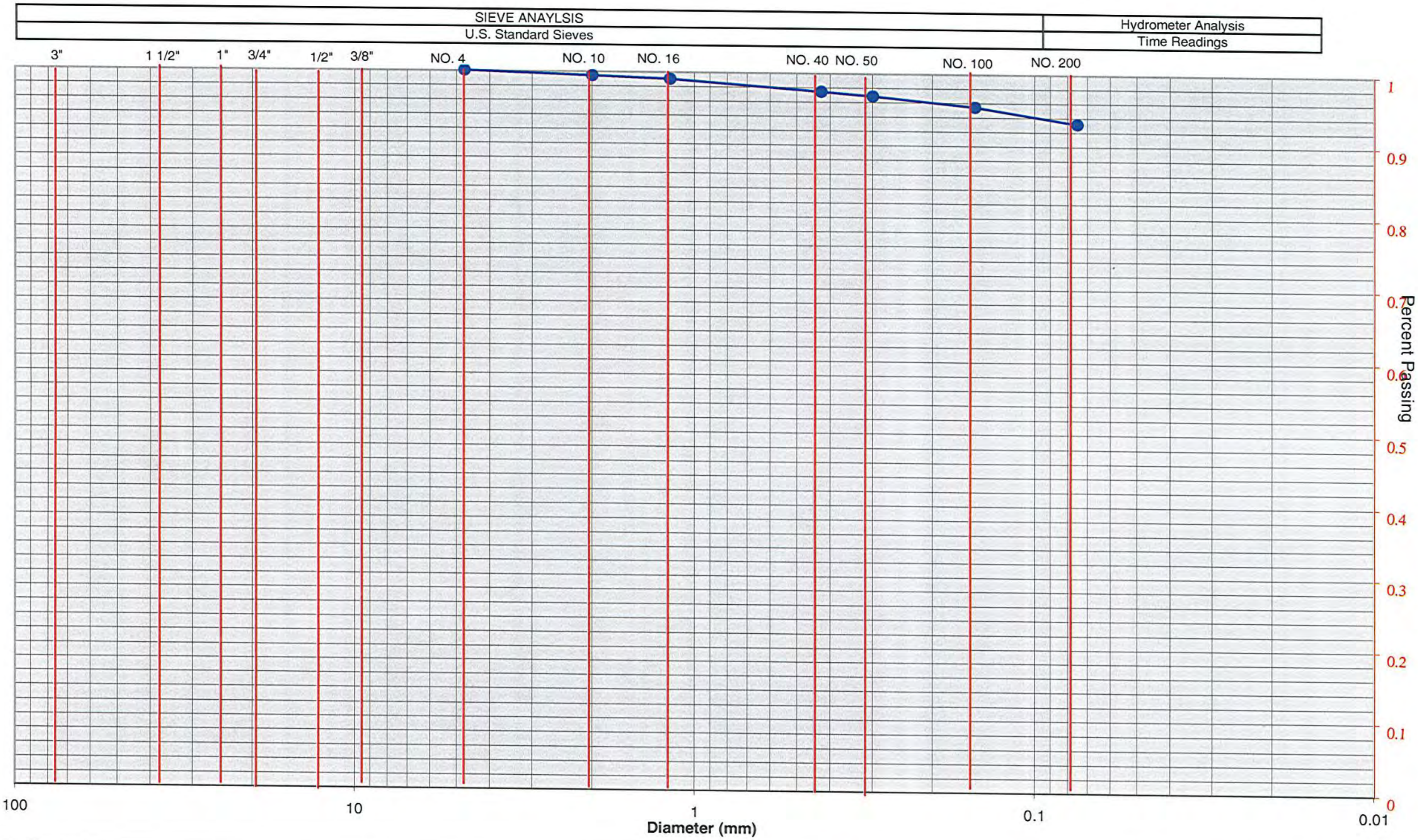
Sieve Size	Wt. Retained	Percent Retained	Percent Passing
3"		0.0	
1 1/2"		0.0	
1"		0.0	
3/4"		0.0	
1/2"		0.0	
3/8"		0.0	
#4	0.0	0.0	100
#10	1.4	0.6	99
#16	0.9	0.4	99
#40	3.7	1.6	97
#50	1.3	0.6	97
#100	3.3	1.4	95
#200	5.2	2.3	93.1

Dry Soil Weight 229.8

Moisture Content (%) (AASHTO T 265)	
Dry Density (pcf)	
Percent Gravel	0.6
Percent Sand	6.3
Percent Coarse Sand	2.0
Percent Fine Sand	4.3
Percent Silt and Clay	93.1
Liquid Limit (AASHTO T 89)	44
Plasticity Index (AASHTO T 90)	27
AASHTO Classification (AASHTO M 145)	A-7-6 (26)
USCS Classification (ASTM D 2487)	CL
Sulfate Content (SO_4)	2.1
Chloride Ion In Water (ASTM D 512-89)	0.0164
PH of Soil for Corrosion Testing (ASTM G 51-95)	7.78
Wenner Four-Electrode (ASTM G 57-95a) *	
(As received)	560 @ 17.9%
(Saturated)	190 @ 45.5%

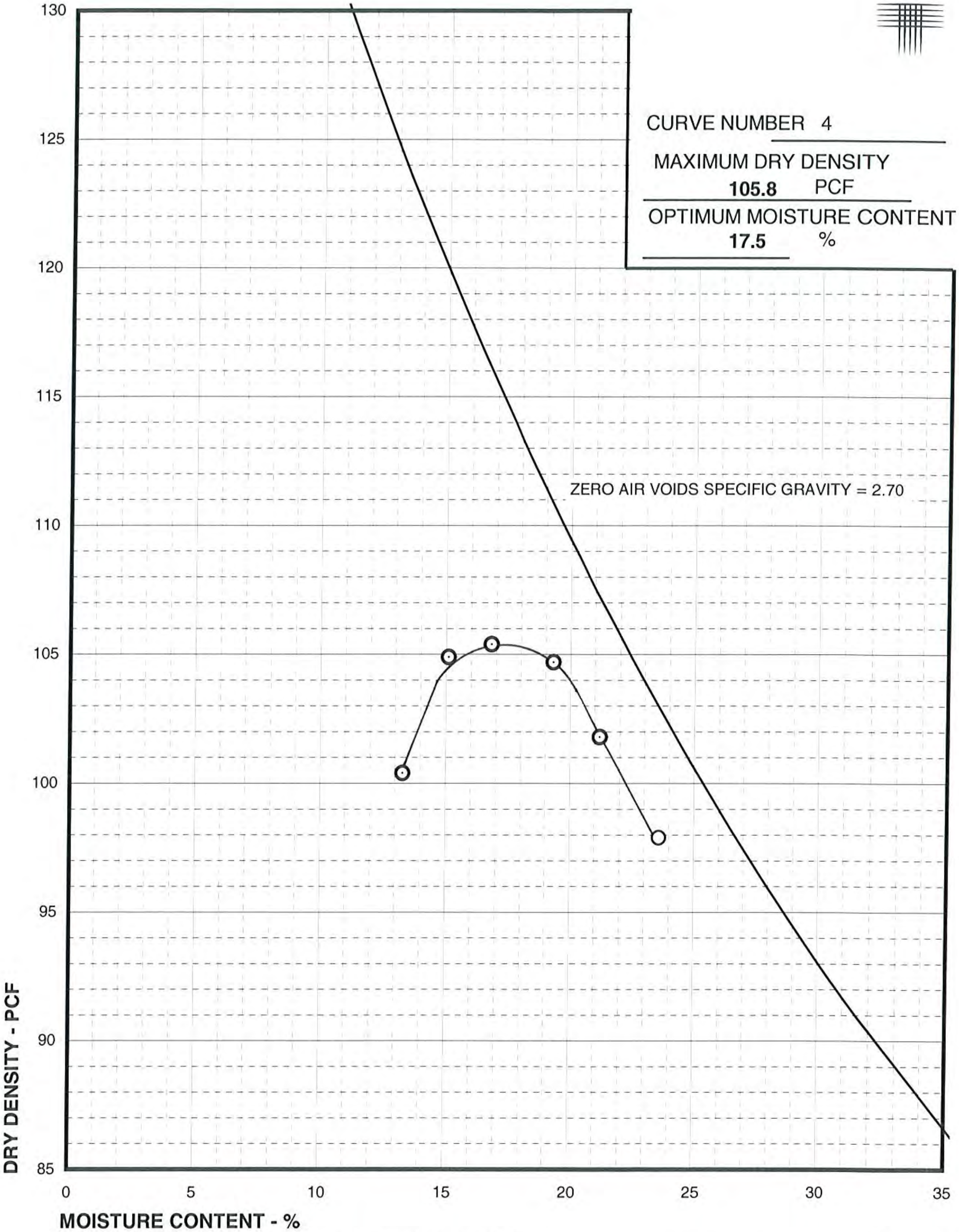
*Measured in ohm-centimeters

SIEVE ANALYSIS AASHTO T 27



Gravel	0.6	Sand	6.3	Silt and Clay	93.1
		Coarse	2.0	Fine	4.3

Sample ID 4
Lab ID STA092-024



CURVE NUMBER 4

MAXIMUM DRY DENSITY
105.8 PCF

OPTIMUM MOISTURE CONTENT
17.5 %

Sample Description Clay, Slightly Sandy A-7-6 (26)

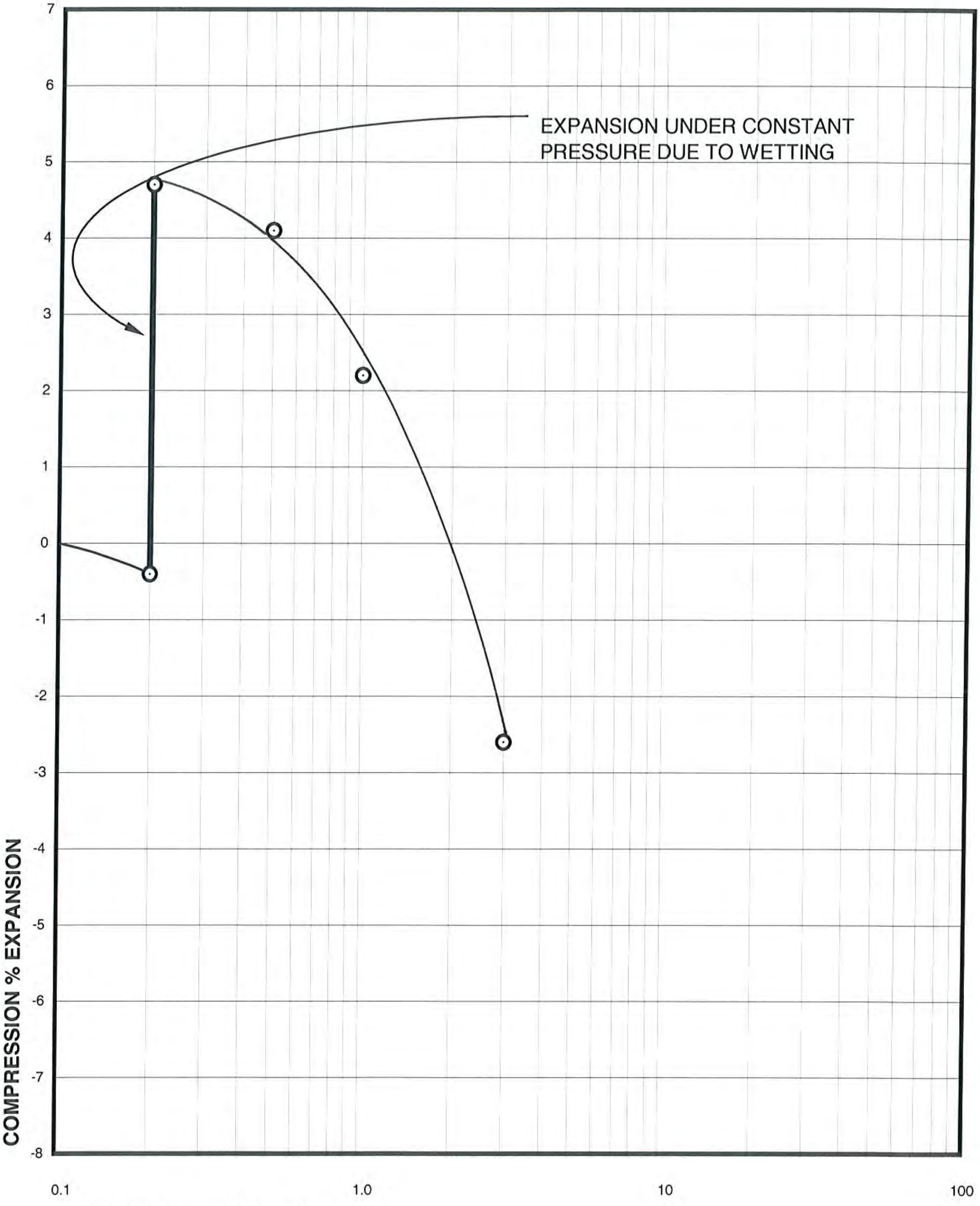
Location Sample No. 4, Field Sheet 208108

Compaction Test Procedure AASHTO T99
METHOD "A"

LIQUID LIMIT	44	%
PLASTICITY INDEX	27	%
GRAVEL	0.6	%
SAND	6.3	%
SILT AND CLAY	93.1	%

Compaction Test Results

COLORADO DEPARTMENT OF TRANSPORTATION

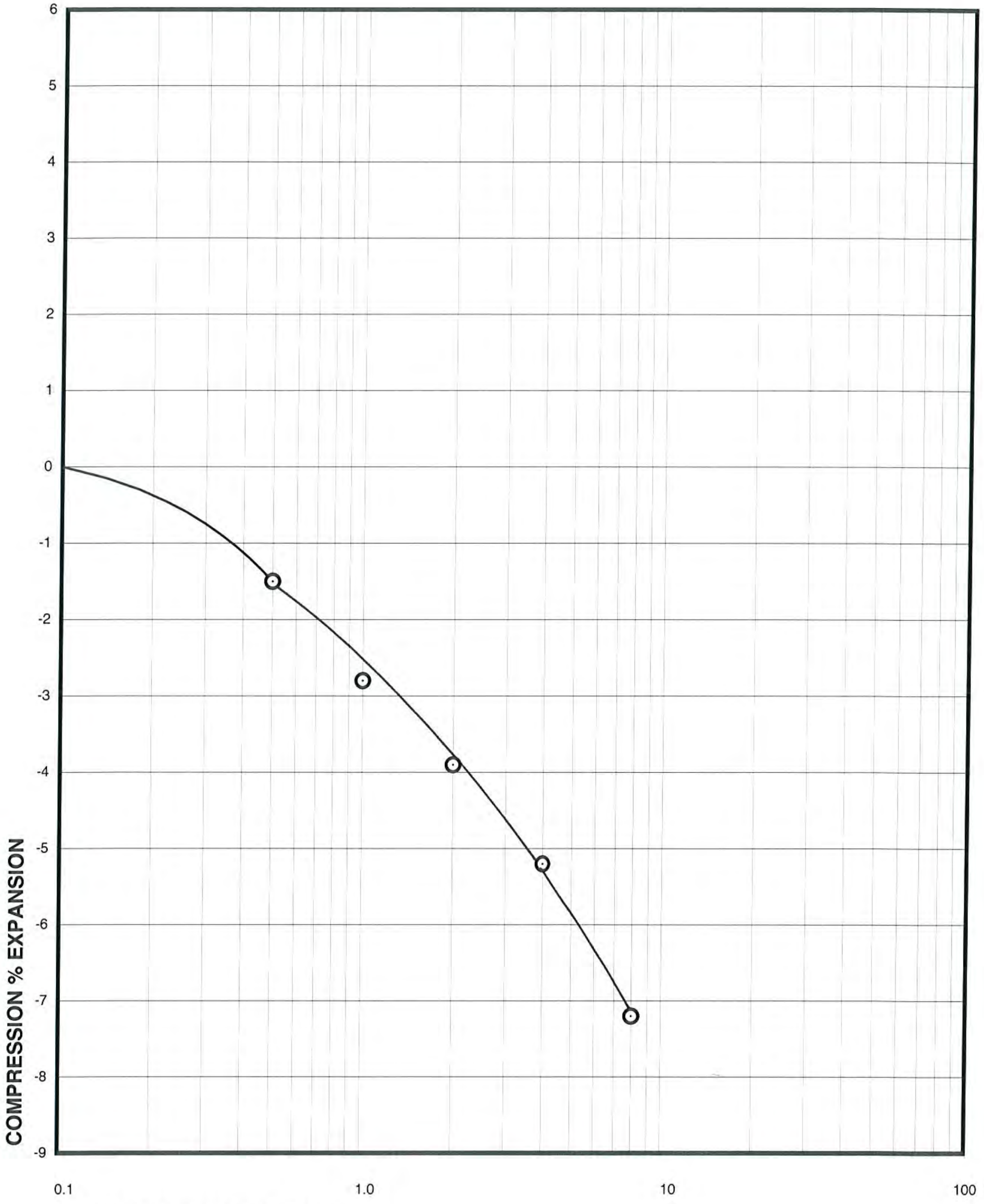


Sample of Clay, Sandy A-6 (16)
From S-4, FS208108

DRY UNIT WEIGHT= 102 PCF
MOISTURE CONTENT= 16.3 %

CDOT
LABORATORY TESTING
PROJECT NO. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\Swell data

Swell Consolidation Test Results



Sample of Clay, Sandy A-6 (16)

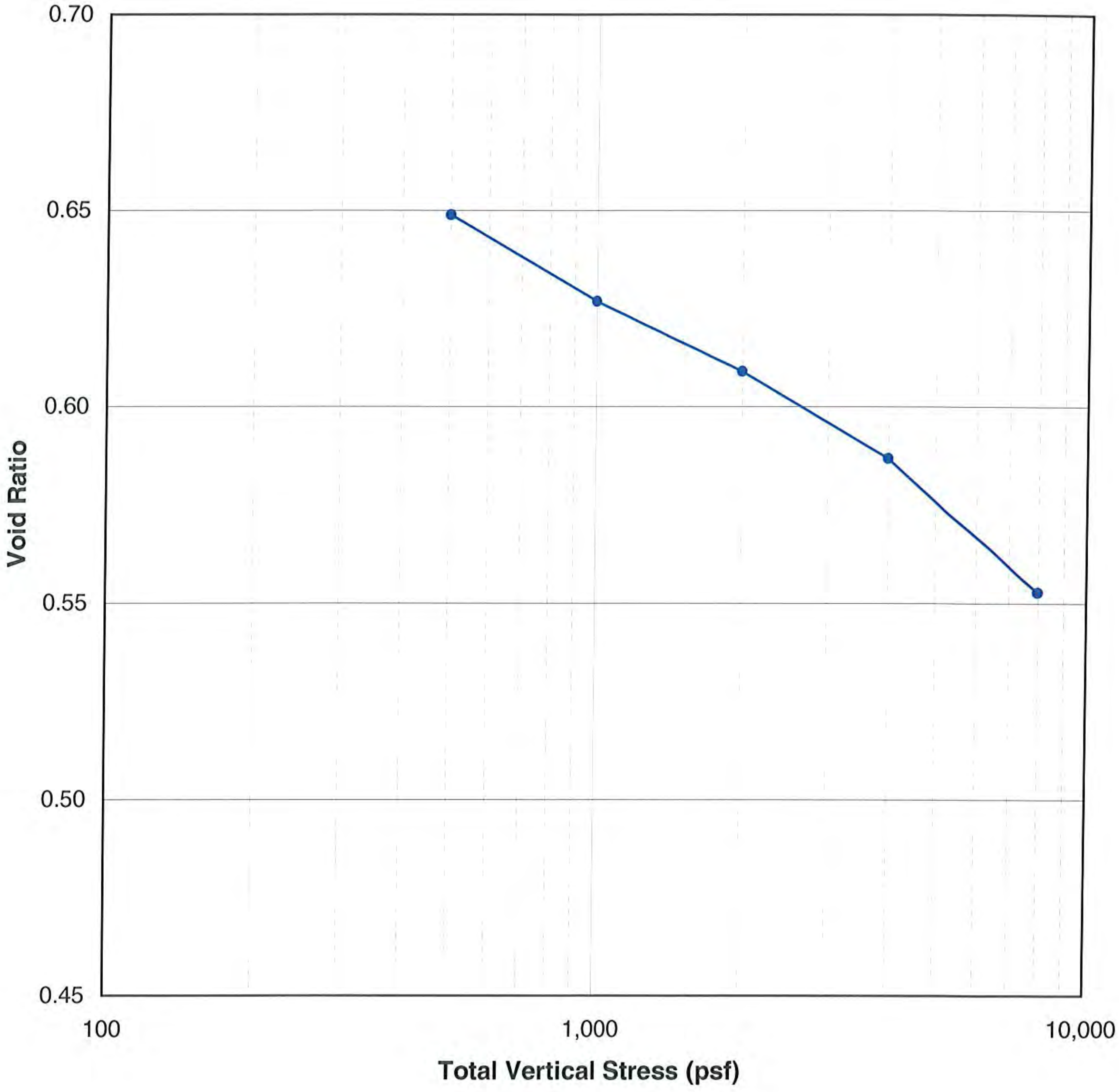
From S-4, FS208108

DRY UNIT WEIGHT= 102 PCF

MOISTURE CONTENT= 16.3 %

Swell Consolidation Test Results

CDOT
LABORATORY TESTING
PROJECT NO. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\Swell data



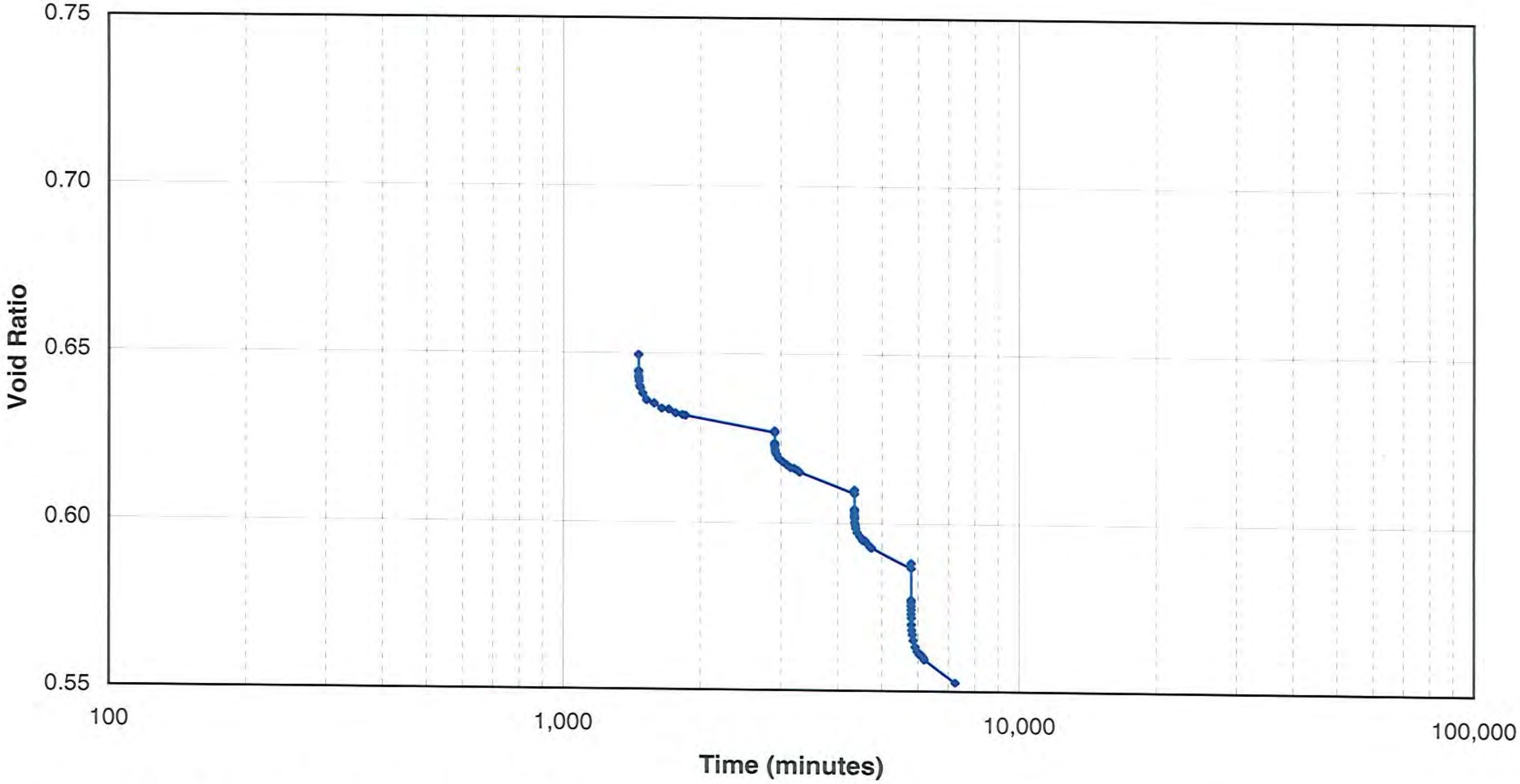
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (26)
LOCATION: S-4 FS208108
MOISTURE CONTENT: 16.3 % (Before Test)
15.9 % (After Test)
DRY DENSITY: 102 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 27 %
GRAVEL: 1 %
SAND: 6 %
SILT AND CLAY: 93 %

One Dimensional Consolidation Test Results

FIG. 1

CDOT
Laboratory Testing
Project No. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-4-Consolidation test



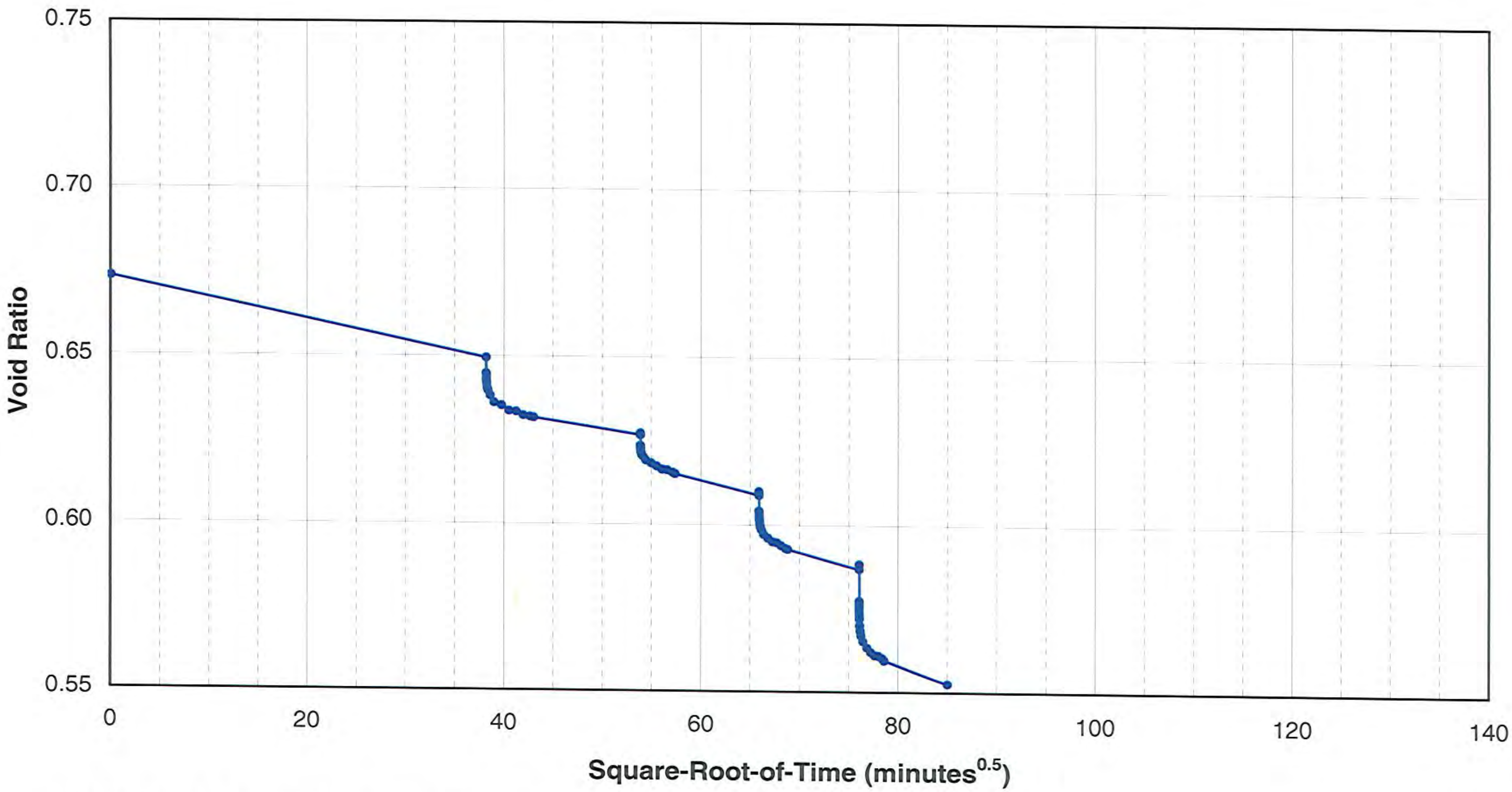
SAMPLE DESCRIPTION:	Clay, Slightly Sandy A-7-6 (26)
LOCATION:	S-4 FS208108
MOISTURE CONTENT:	16.3 % (Before Test)
	15.9 % (After Test)
DRY DENSITY:	102 pcf (Before Test)
TEST PROCEDURE:	ASTM D2435

LIQUID LIMIT:	44	%
PLASTICITY INDEX:	27	%
GRAVEL:	1	%
SAND:	6	%
SILT AND CLAY:	93	%

CDOT
Laboratory Testing
Project No. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-4-Consolidation test

One Dimensional Consolidation Test Results

FIG. 2



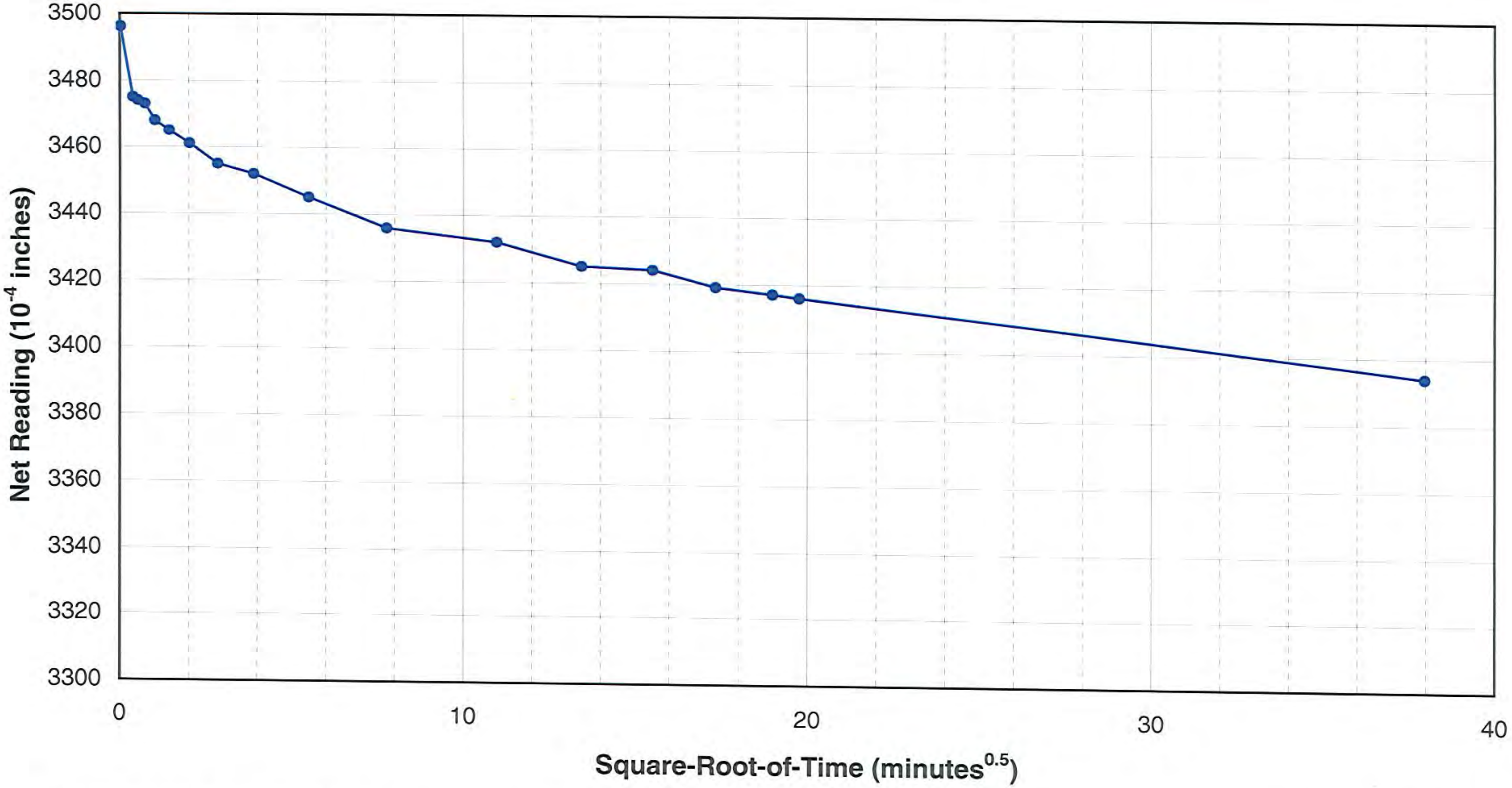
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (26)
LOCATION: S-4 FS208108
MOISTURE CONTENT: 16.3 % (Before Test)
15.9 % (After Test)
DRY DENSITY: 102 pcf (Before Test)
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 27 %
GRAVEL: 1 %
SAND: 6 %
SILT AND CLAY: 93 %

CDOT
Laboratory Testing
Project No. DN46,162-300
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-4-Consolidation test

One Dimensional Consolidation Test Results

FIG. 3



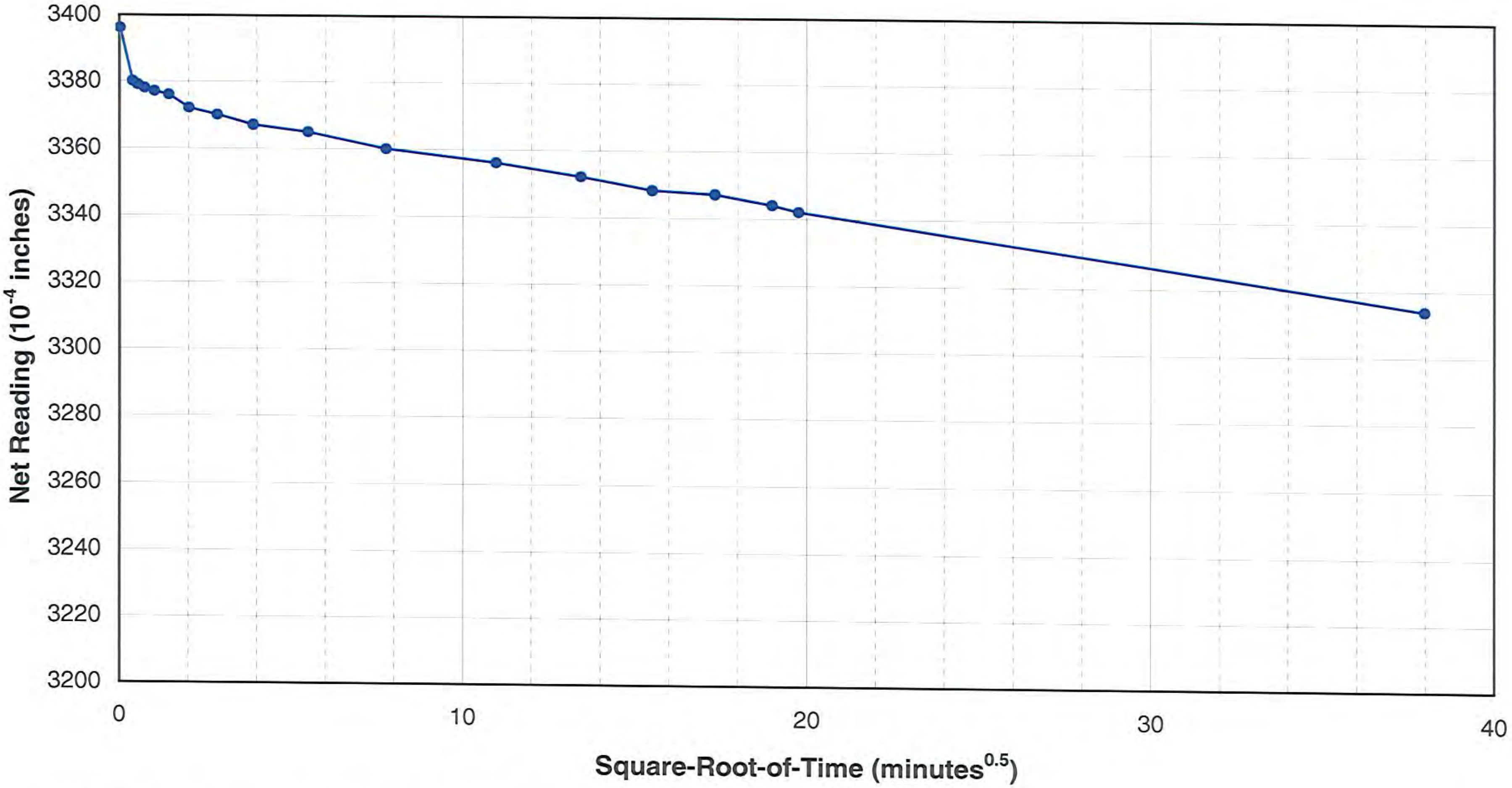
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (26)
LOCATION: S-4 FS208108
LOAD NO. 2
PRESSURE 1000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 27 %
GRAVEL: 1 %
SAND: 6 %
SILT AND CLAY: 93 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-4-Consolidation test

One Dimensional Consolidation Test Results

FIG. 4



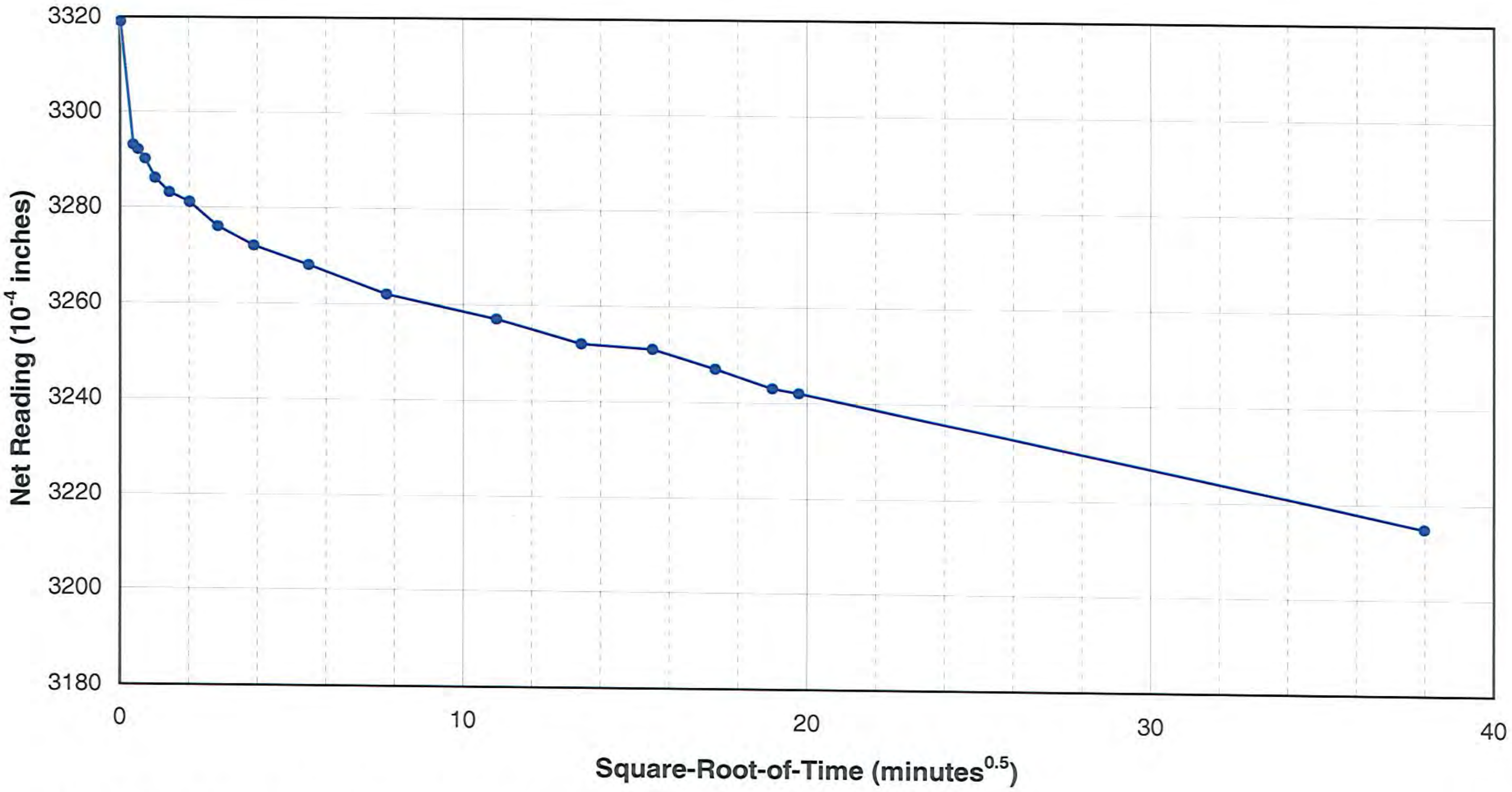
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (26)
LOCATION: S-4 FS208108
LOAD NO. 3
PRESSURE 2000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 27 %
GRAVEL: 1 %
SAND: 6 %
SILT AND CLAY: 93 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-4-Consolidation test

One Dimensional Consolidation Test Results

FIG. 5



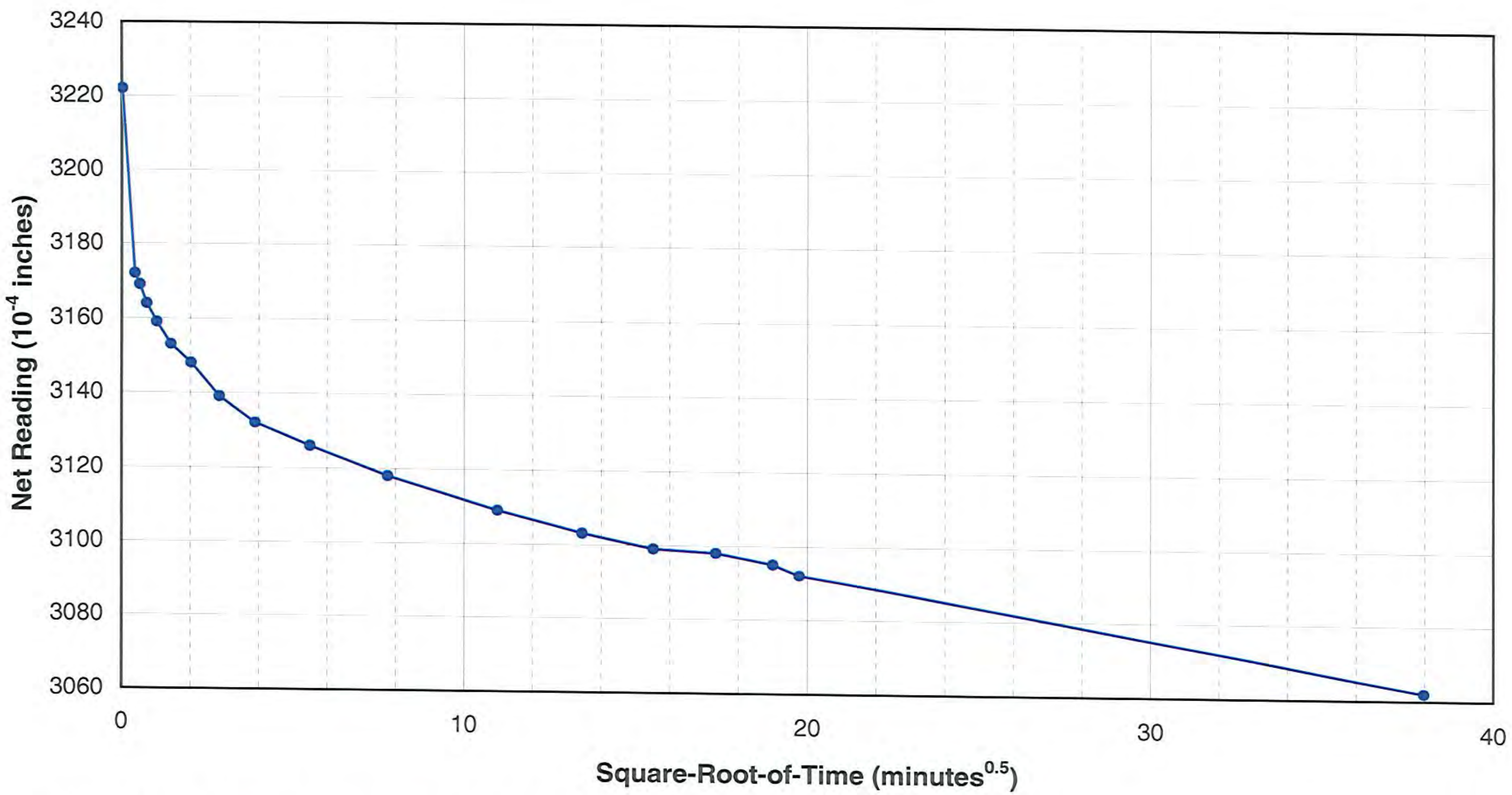
SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (26)
LOCATION: S-4 FS208108
LOAD NO. 4
PRESSURE 4000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 27 %
GRAVEL: 1 %
SAND: 6 %
SILT AND CLAY: 93 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-4-Consolidation test

One Dimensional Consolidation Test Results

FIG. 6



SAMPLE DESCRIPTION: Clay, Slightly Sandy A-7-6 (26)
LOCATION: S-4 FS208108
LOAD NO. 5
PRESSURE 8000 psf
TEST PROCEDURE: ASTM D2435

LIQUID LIMIT: 44 %
PLASTICITY INDEX: 27 %
GRAVEL: 1 %
SAND: 6 %
SILT AND CLAY: 93 %

MEEKER SCHOOL DISTRICT RE-1
C/O VANIR CONSTRUCTION MANAGEMENT, INC.
MEEKER ELEMENTARY SCHOOL
PROJECT NO. GS5617-125
S:\PROJECTS\46100\DN46162.000 CDOT\300\FS208108\S-4-Consolidation test

One Dimensional Consolidation Test Results

FIG. 7

ONE-DIMENSIONAL CONSOLIDATION CALCULATION SHEET

PROJECT NO: DN46162-300
PROJECT NAME: CDOT
Sample Description: Clay, Slightly Sandy A-7-6 (26)
Sample Location: S-4 FS208108
Date: 7/30/2012

SAMPLE INFORMATION

Density

Diameter (in.):	1.935
Length, H (in.):	0.750
Volume (in^3):	2.21
Total volume, V_0 (cm^3):	36.14
Wet soil/ring wt (g):	322.51
Ring wt (g):	253.89
Wet wt, $W_{t,0}$ (g):	68.62
Wet unit wt (g/cc):	1.90
Wet unit wt (pcf):	118.5
Dry density (pcf):	101.9

Moisture

	Before (Trimmings)	After (Total Sample)
Dish No.:	188	291
Dish/wet soil (g):	509.21	297.11
Dish/dry soil (g):	470.05	287.82
Dish wt (g):	229.50	229.50
Water wt (g):	39.16	9.29
Soil wt (g):	240.55	58.32
Moisture (%):	16.3	15.9

🟩 Input Data

SAMPLE CALCULATIONS

Initial volume (cm^3):	36.14
Unit weight of water, γ_w (g/cc):	1.00
Specific Gravity, G_s:	2.70
Initial volume of solids, $V_s=W_s/\gamma_w G_s$ (cm^3):	21.60
Initial volume of voids, $V_{v,0}=V_0-V_s$ (cm^3):	14.54
Initial volume of water, $V_{w,0}=(W_{t,0}-W_s)/\gamma_w$ (cm^3):	10.30
Initial degree of saturation, $S_0=V_{w,0}/V_{v,0}$ (%):	70.83
Initial void ratio, $e_{0=}V_{v,0}/V_s$:	0.67
Final void ratio, e_f:	0.00
Final volume of water, $V_{w,f}=(W_{t,f}-W_s)/\gamma_w$ (cm^3):	9.29
Final volume of voids, $V_{v,f}=e_f{*}V_s$ (cm^3):	0.00
Final degree of saturation, $S_f=V_{w,f}/V_{v,f}$ (%):	#DIV/0!
G_s assumed or from lab data?	**ASSUMED**

$W_{t,0}$=Initial total sample weight
$W_{t,f}$=Final total sample weight
V_0=Total sample volume
W_s=Soil weight

Liquid Limit:	44
Plasticity Index:	27
Percent Gravel:	0.6
Percent Sand:	6.3
Percent Silt and Clay:	93.1

CALCULATION OF % EXPANSION/COMPRESSION AND VOID RATIOS

Cell filled with water (yes/no)?: **NO**

Machine No.: 54

Final Readings:

Load No.	Start Date and Time	Pressure (psf)	Final Reading (10^{-4} in.)	Machine Deflection (10^{-4} in.)	Net Reading (10^{-4} in.)	ΔH (in.)	Expansion/ Compression, +/- (%)	Δe	Void Ratio, e
Initial	7/30/2012 9:11	0	3603	0	3603	0.0000	0.00	0.000	0.673
1	7/30/2012 9:26	500	3491	2	3493	-0.0110	-1.47	-0.025	0.649
2	7/31/2012 9:27	1000	3389	5	3394	-0.0209	-2.79	-0.047	0.627
3	8/1/2012 9:27	2000	3307	7	3314	-0.0289	-3.85	-0.064	0.609
4	8/2/2012 9:27	4000	3203	12	3215	-0.0388	-5.17	-0.087	0.587
5	8/3/2012 9:27	8000	3043	19	3062	-0.0541	-7.21	-0.121	0.553

C=-Δe/Δ log σ
0.0734
0.0593
0.0734
0.1134

Expansion/Compression (%)=ΔH/H

Δe=(ΔH/H)*(1+e_0)

Colorado Department of Transportation
DIRECT SHEAR TEST REPORT (AASHTO T 236)

Field Sheet No. : **208110 (#4)**
Date Received : 7/23/2012
Item Number : 203
Lab Test No. : 2012-080

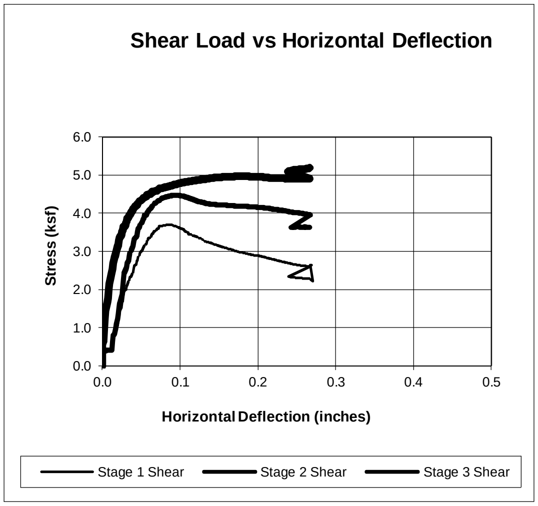
Project ID : **14934**
Project : HB 092A-020
Location : SH 92 and UPRR
Test Date : 08/3/2012
Source : Stockpile
Region : 3

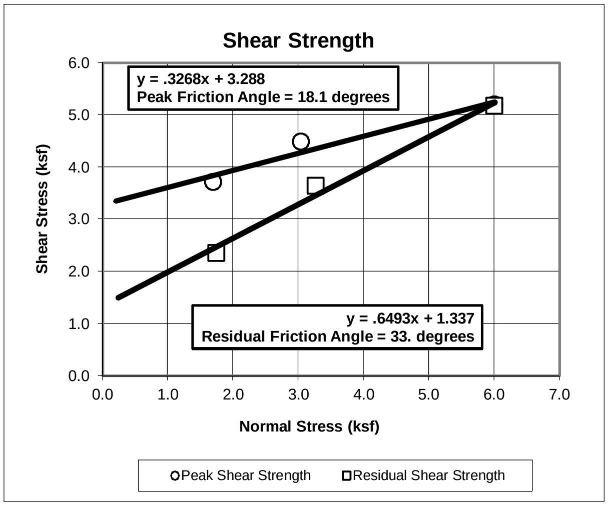
Classification : N/A
Liquid Limit : N/A
Plastic Limit : N/A
Plastic Index : N/A

Compaction Method : T 99 (A)
Max. Dry Dens. (pcf) : 105.8
Optimum Moisture : 17.5%

Specimens were compacted to 95% of AASHTO T 180 Method A at optimum moisture content.

Specimen Preparation	Stage 1	Stage 2	Stage 3
Surcharge Pressure (ksf)	1.72	3.15	6.01
Compacted Dry Density (pcf)	102.1	102.1	102.0
Moisture Content	17.4%	17.3%	17.4%
Percent of Maximum Dry Density	96.5%	96.5%	96.4%





Project Specifications:
Peak Friction Angle: **18.1 degrees**
Residual Friction Angle: **33.0 degrees**

Distribution:
Central Laboratory
Region Materials Engineer

C.K. Su
Soils and Rockfall Program