BURNHAM BRIDGE OVER COBBOSSEECONTEE STREAM

West Gardiner - Litchfield, Kennebec County, Maine

Geotechnical Design Report

NOVEMBER 10, 2017

PREPARED FOR

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16 State House Station
Augusta, ME 04333

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HNTB

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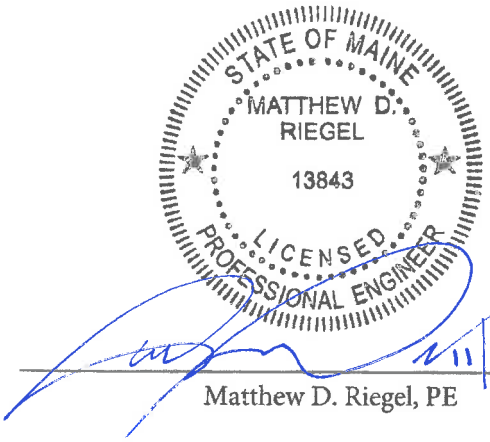

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WEST GARDINER - LITCHFIELD, MAINE

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1.0 PROJECT DESCRIPTION AND SCOPE

1.1 Introduction

The following represents the results of the geotechnical assessment prepared by HNTB for the replacement of the existing Burnham Bridge structure over the Cobbosseecontee Stream in Kennebec County, Maine (**Figure 1** Project Location Map). The existing two-span structure carries Pond Road / Plains Road with two travel lanes and a span length of approximately 90 feet. The existing bridge will be replaced within its current horizontal alignment with a new structure consisting of a 105 foot single span supported on integral abutments. Approach embankments will be widened and raised approximately 3.0 feet to meet the proposed alignment. A phased subsurface investigation was executed by HNTB and included three borings behind each proposed abutment, one boring performed along the south approach embankment and one boring through the existing bridge deck at the approximate location of the proposed pier in the Cobbosseecontee Stream. This geotechnical assessment was prepared to determine the soil profile and design parameters for foundation and embankment analysis and to develop final design recommendations contained herein.

1.2 Scope of Services

In completing this study, HNTB has performed the following scope of services:

- Reviewed available geotechnical data for the project site.
- Implemented a subsurface investigation including a geotechnical boring and laboratory testing program to gather additional information where needed.
- Analyzed the resulting data collected to identify subsurface conditions that impact the design and construction of the project.
- Prepared a geologic subsurface profile summarizing geotechnical data from the borings and laboratory testing.
- Established geotechnical engineering design parameters based on the available borings.
- Conducted geotechnical analyses and provided recommendations and design parameters for the support of the proposed bridge and approach embankments.
- Prepared and submitted this Final Geotechnical Engineering Report

1.3 Existing Structure and Proposed Improvements

The project site is located at the intersection of Pond Road / Plains Road and the Cobbosseecontee Stream in West Gardiner, Maine. The Burnham Bridge serves as a connection between Plains Road in the town of Litchfield to the south and Pond Road in the town of West Gardiner to the north, and travels in a northeasterly alignment parallel to the Maine Turnpike. The roadway crosses the east-west flowing Cobbosseecontee Stream on a two-span bridge supported on timber pile abutments and a center pier constructed on timber cribbing. The south approach embankment bisects the stream's

floodway which extends approximately 200 feet behind the existing abutment. The embankment rises from the natural topography with a maximum height of approximately 8.0 feet above existing grade with slopes as steep as 1.75H:1.0V. The north approach embankment bisects the stream's floodway which extends approximately 100 feet behind the existing abutment. The north approach is situated on a fill embankment with a maximum height of approximately 9.0 feet above existing grade with slopes as steep as 1.5H:1.0V.

1.4 Survey Control

The project elevation datum and elevations referenced are in feet and reference the North American Vertical Datum of 1988 (NAVD 88). Boring locations were field located with elevations estimated based on topographic survey data.

2.0 Geology And Site Conditions

2.1 Site Geology

Existing geologic mapping utilized for this assessment includes Web Soil Survey data provided by the USDA Natural Resource Conservation Service (NRCS) and bedrock and surficial geology mapping prepared by the Maine Geological Survey (MGS) for the Gardiner quadrangle. Excerpts from the surficial and bedrock geology mapping are included in **Figure 2** and **Figure 3**, respectively. NRCS web soil survey results are included in **Attachment 3**.

NRCS mapping indicates that both approaches and abutments are underlain by Buxton Silt loam, 3% to 8% slopes and Saco soils (flood plain deposits). Surficial geologic maps from the MGS show both abutments and approaches underlain by artificial fill that is located above deposits associated with the Presumpscot Formation including glaciomarine silts, clays and sands. Bedrock geologic maps from the MGS show the site is underlain by Ordovician aged Vassalboro Formation containing biotite, granofels and metasiltstone.

3.0 Subsurface Explorations

3.1 General

The subsurface investigation for the project was performed in two distinct phases. A preliminary subsurface investigation was performed by Schonewald Engineering Associates, Inc. of Cumberland Maine, under the direction of HNTB, which included borings BB-WGLC-101, BB-WGLC-102, BB-WGLC-103, and BB-WGLC-104. The final design subsurface investigation consisted of geophysical testing and borings. Geophysical testing was performed by Hager-Richter Geoscience, Inc. under the direction of HNTB. Final design phase borings were again performed by Schonewald Engineering Associates, Inc. under the direction of HNTB and included borings BB-WGLC-201, BB-WGLC-202, BB-WGLC-203, and BB-WGLC-204.

The preliminary and final subsurface investigation borings were advanced using cased wash boring methods from a Mobile drill rig using 4.0 inch (HW-size) and 3.0 inch (NW-size) inside diameter steel casing. Standard Penetration Testing (SPT) was performed by driving a 1-3/8 inch ID split spoon sampler with a 140-lb hammer dropped 30 inch to obtain samples at approximately 5 foot intervals. Each sample was removed from the sampler in the field, examined, and classified in accordance with Maine DOT standards. The number of hammer blows required to advance the sampler through each six inch interval using an automatic hydraulic hammer was recorded and is provided on each boring log. The uncorrected SPT N-value is defined as the total number of blows required to advance the sampler through the second and third six inch interval of any given 24 inch sampling interval.

In-situ vane shear testing was completed in both phases in accordance with the requirements outlined in ASTM D 2573 and are outlined below. In situ vane shear testing involves using a simple rotated blade of specified dimensions to evaluate undrained shear strengths (Su) and remolded shear strengths (Sr) in soft to stiff clays (FHWA-IF-02-034 G.E.C. No. 5). The vane is advanced into the test soil and the blade is rotated at a maximum rate of six degrees per minute until failure of the soil occurs while the resulting torque measurement is recorded. This first test is used to approximate the undrained shear strength of the soil. Following the initial test the remolded strength of the soil is measured after 10 rapid turns of the vane (FHWA-IF-02-034 G.E.C. No. 5).

3.2 Preliminary Design Phase Geotechnical Subsurface Exploration

For preliminary design of the proposed bridge foundations and approach embankments, four soil borings were advanced between March 26th and March 31st in 2016 by New England Boring Contractors, with boring inspection carried out by HNTB's subconsultant, Schonewald Engineering Associates, Inc. Borings BB-WGLC-101 and BB-WGLC-102 were performed from existing grade a distance of 87 and 15 feet, respectively, behind the existing south abutment. Boring BB-WGLC-103 was performed 10 feet north of the center of existing bridge and boring BB-WGLC-104 was performed from existing grade approximately 25 feet behind the north abutment. A summary of the preliminary borings indicating locations and depths of exploration are included in **Table 3-1**.

Table 3-1: Summary of Preliminary Phase Subsurface Exploration

Boring No.	Station	Offset (feet)	Ground Elevation (feet)	Depth of Boring (feet)	Bottom of Exploration Elevation (feet)
BB-WGLC-101	17+75	7.0 LT	140.5	30.5	110.0
BB-WGLC-102	18+47	6.0 RT	140.0	50.0	90.0
BB-WGLC-103	19+10	7.0 LT	121.3	12.4	108.9

Boring No.	Station	Offset (feet)	Ground Elevation (feet)	Depth of Boring (feet)	Bottom of Exploration Elevation (feet)
BB-WGLC-104	19+91.69	6.0 RT	139.5	38.9	100.6

SPT energy testing (hammer calibration) was completed on January 19, 2016 using a Pile Driving Analyzer in accordance with ASTM D4633-10 using the force velocity method. Four SPT energy test series were run to determine the measured hammer efficiency. The test report indicated that the measured energy transfer efficiency of the Diedrich Auto Hammer ranged from 50% to 62% efficiency, with an average of 57%. All SPT N-values discussed in this report have been corrected to reflect the 60 percent hammer efficiency (N_{60}) unless noted otherwise.

In-situ vane shear testing was completed in accordance with the requirements outlined in ASTM D 2573 and the results of the tests performed during the preliminary investigation are reported in **Table 3-2**.

Table 3-2: Summary of Preliminary Phase In-Situ Vane Shear Tests

Boring No.	Test No.	Test Depth (feet)	Test Elevation (feet)	Undrained Shear Strength (psf)	Remolded Shear Strength (psf)
BB-WGLC-101	V1	16.4	124.1	> 1045	-
BB-WGLC-102	V1	24.8	115.2	402	45
BB-WGLC-102	V2	25.8	114.2	380	45
BB-WGLC-104	V1	20.8	118.7	848	179
BB-WGLC-104	V2	21.8	117.7	670	179

Approximately 10 feet of bedrock was cored in each of the borings using a 2.0 inch inner diameter NQ-2 size core barrel. The recovery and rock quality designation (RQD) of each core was calculated and is included on the borings logs. The final boring location plan and boring logs are included in **Attachment 1**.

3.3 Final Design Phase Geotechnical Subsurface Investigation

For final design of the proposed bridge foundations and approach embankments, four soil borings were advanced between July 25th and July 27st in 2017 by New England Boring Contractors, with boring inspection carried out by HNTB's subconsultant, Schonewald Engineering Associates, Inc. Borings BB-WGLC-201 and BB-WGLC-202 were performed from existing grade a distance of 24.6 and 4.8 feet, respectively, behind the existing south

abutment. Borings BB-WGLC-203 and BB-WGLC-204 were performed from existing grade approximately 5.6 and 14.8 feet, respectively, behind the north abutment. A summary of the preliminary borings indicating locations and depths of exploration are included in **Table 3-3**.

Table 3-3: Summary of Final Design Phase Subsurface Exploration

Boring No.	Location	Offset (feet)	Ground Elevation (feet)	Depth of Boring (feet)	Bottom of Exploration Elevation (feet)
BB-WGLC-201	18+37	7.6 RT	140.0	39.3	100.7
BB-WGLC-202	18+57	5.8 LT	140.0	39.0	101.0
BB-WGLC-203	19+72	6.0 LT	140.0	28.7	111.3
BB-WGLC-204	19+81	6.1 RT	140.0	30.2	109.8

SPT-N values obtained with a rope and cathead system are already assumed to have 60 percent hammer efficiency so the uncorrected blow count and corrected blow count are the same. All SPT N-values discussed in this report have been corrected to reflect the 60 percent hammer efficiency (N60) unless noted otherwise.

In-situ vane shear testing was completed in accordance with the requirements outlined in ASTM D 2573 and the results of the tests performed during the preliminary investigation are reported in **Table 3-4**.

Table 3-4: Summary of Final Phase In-Situ Vane Shear Tests

Boring No.	Test No.	Test Depth (feet)	Test Elevation (feet)	Undrained Shear Strength (psf)	Remolded Shear Strength (psf)
BB-WGLC-201	V1	22.8	117.2	604	55
BB-WGLC-201	V2	23.8	116.2	467	41
BB-WGLC-201	V3	25.8	114.2	467	55
BB-WGLC-201	V4	26.8	113.2	577	55
BB-WGLC-202	V1	25.8	114.2	591	69
BB-WGLC-202	V2	26.6	113.4	563	41
BB-WGLC-204	V1	20.8	119.2	577	82
BB-WGLC-204	V2	21.8	118.2	618	82
BB-WGLC-204	V3	23.8	116.2	426	55

Approximately 5 feet of bedrock was cored in borings BB-WGLC-202 and BB-WGLC-203 using a 2.0 inch inner diameter NQ-2 size core barrel. The recovery and RQD of each core was calculated and is included on the borings logs. The final boring location plan and boring logs are included in **Attachment 1**.

3.4 Geophysical Testing & Investigation

Anomalies in the form of apparent subsurface voids behind the south abutment were identified during the preliminary design phase geotechnical subsurface investigation. While performing boring BB-WGLC-102, behind the south abutment, Schonewald Engineering Associates, Inc. noted that a potential void had been encountered which may extend up to five feet thick at approximately 18 feet in depth from the ground surface. To further investigate the potential for subsurface voids a geophysical survey was performed using ground penetrating radar (GPR). GPR data was acquired on the accessible portions of the north and south bridge approaches and traverses were spaced 1-foot apart parallel to the long axis of the roadway and 5 feet apart perpendicular to the long axis of the roadway.

For additional details, refer to Section 7.2.11 of this report and the Geophysical Survey Report for Burnham Bridge in West Gardiner, Maine by Hager-Richter Geoscience, Inc. included in **Attachment 4**.

4.0 LABORATORY TEST RESULTS

Upon completion of the subsurface investigation program, a laboratory testing program was performed to verify the visual-manual field classifications and to aid in determination of the engineering soil properties. Laboratory testing was performed by R.W Gillespie & Associates, Inc. of Saco Maine.

Laboratory soil testing consisted of fourteen (14) standard grain size analyses with natural water content, five (5) hydrometer with natural water content, (15) Atterberg limit tests and two (2) one dimensional consolidation tests. Laboratory rock testing consisted of two (2) unconfined compression tests.

Corrosion testing was initially performed by the Maine Environmental Laboratory in Yarmouth Maine to determine the pH, sulfate content and chloride content of select soil samples. Corrosion testing was performed in accordance with USEPA standards and indicated high levels of sulfates in boring BB-WGLC-104 behind the existing north abutment. Upon discussion with the MaineDOT, additional soil testing was performed on two (2) samples in accordance with AASHTO standards to determine the pH, sulfate content and chloride content to aid in the determination of corrosion potential at each of the proposed abutments. This testing was performed by GeoTesting Express of Acton Massachusetts. The supplemental testing of the additional samples did not show levels of

chloride or sulfates above established thresholds levels that would indicate aggressive soil conditions.

A summary of the laboratory tests to determine index properties, consolidation and corrosion potential are presented in the following sections. The complete laboratory results are presented in **Attachment 2**.

4.1 Soil Tests

The soil testing was performed in general accordance with the following ASTM Standards:

Natural Moisture Content	ASTM D2216
Atterberg Limits	ASTM D4318
Grain Size Analysis	ASTM D422
Percent Passing No. 200 Sieve	ASTM D1140
Unit Weight Determination	ASTM D2937
One Dimensional Consolidation Using Incremental Loading	ASTM D2435-M

The laboratory soil testing results are included in **Attachment 2** and are summarized below in **Table 4-1 and Table 4-2**. Additionally, laboratory test results have been summarized and presented on the final phase boring logs provided in **Attachment 1**.

Table 4-1: Summary of Identification Tests Results

Boring No.	Sample No.	Depth (feet)	Water Content (%)	Passing # 200 (%)	Atterberg Limits			Particle Distribution (%)		
					LL	PL	PI	Gravel	Sand	Fines
BB-WGLC-101	2D	5-7	7.9	19.8	-	-	-	51.2	29	19.8
BB-WGLC-101	3D	13-15	33.8	99.0	39.6	21.6	18	-	-	-
BB-WGLC-101	4D	15.4 -17.4	29.0	97.8	34.9	17.8	17.1	-	-	-
BB-WGLC-102	1D	2-4	4.4	9.2	-	-	-	30.1	60.7	9.2
BB-WGLC-102	5D	22-24	47.7	99.3	33.7	18.0	15.7	-	-	-
BB-WGLC-103	1D	0-1.7	20.3	14.7	-	-	-	36.5	48.8	14.7
BB-WGLC-104	2D	5-7	4.5	7.3	-	-	-	24.3	68.4	7.3
BB-WGLC-104	4D	15-17	32.6	97.6	19.0	33.0	14.0	-	2.4	97.6
BB-WGLC-104	5D	20-22	41.4	99.3	17.9	29.4	11.5	-	0.7	99.3
BB-WGLC-201	2D	5-7	6.3	9.8	-	-	-	23.7	66.5	9.8
BB-WGLC-201	4D	15-17	32.2	95.6	-	-	-	-	4.4	95.6

Boring No.	Sample No.	Depth (feet)	Water Content (%)	Passing # 200 (%)	Atterberg Limits			Particle Distribution (%)		
					LL	PL	PI	Gravel	Sand	Fines
BB-WGLC-201	5D	17-19	140.2	85.5	146.7	102.5	44.2	-	14.5	85.5
BB-WGLC-201	7D	22-24	43.5	-	39.1	21.8	17.3	-	-	-
BB-WGLC-201	8D	25-27	46.4	-	43.4	21.6	21.8	-	-	-
BB-WGLC-201	10D	35-37	8.2	22.1	-	-	-	26.2	51.7	22.1
BB-WGLC-202	3D	10-12	9.5	9.5	-	-	-	47.8	42.7	9.5
BB-WGLC-202	6D	22-24	101	74	NP	NV	NP	0	26	74
BB-WGLC-202	7D	25-26.8	42.7	-	48.3	21.8	26.5	-	-	-
BB-WGLC-202	8D	30-32	8.7	6.2	-	-	-	55.8	38	6.2
BB-WGLC-203	2D	5-7	5.2	7.5	-	-	-	27	65.5	7.5
BB-WGLC-203	5D	20-22	42.6	-	45.3	21.7	23.6	-	-	-
BB-WGLC-204	2D	5-7	5.1	5.3	-	-	-	24.3	70.4	5.3
BB-WGLC-204	3D	10-12	229.5	68.6	-	-	-	0	31.4	68.8
BB-WGLC-204	4D	15-17	34.6	-	42.7	24	18.7	-	-	-
BB-WGLC-204	6D	23-25	42	-	42.5	20.7	21.8	-	-	-

Table 4-2: Summary of Consolidation Tests Results

Boring No.	Sample No.	Depth (feet)	Atterberg Limits			Compression Indices	
			LL	PL	PI	C_C	C_r
BB-WGLC-104	U-1	18.75	45.2	24.2	21.0	0.42	0.05
BB-WGLC-104	U-2	25.7	42.0	21.6	20.4	0.90	0.04

4.2 Rock Tests

Intact rock core specimens were tested for compressive strength and elastic moduli in accordance with ASTM D-7012. A summary of the laboratory tests is presented in **Table 4-3**, and the complete laboratory results are presented in **Attachment 2**.

Table 4-3: Summary of Rock Test Results

Boring No.	Sample No.	Depth (ft)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compressive Strength (psi)	Axial Strain at Failure (%)	Estimated Elastic Modulus (psi)
BB-BPR-103	R1	7.4 - 7.8	-	169.2	11,833	0.17	5.87×10^6
BB-BPR-104	R1	30.2 – 30.6	-	167.5	18,316	0.25	6.57×10^6

4.3 Corrosion Tests

Select soil samples were tested for pH, Sulfate content, and chloride content.

The corrosively testing was performed in accordance with the following Standards:

pH	EPA 9045D and AASHTO T289
Sulfates	EPA 9056 and AASHTO T290
Chlorides	EPA9056 and AASHTO T291

A summary of the laboratory corrosion tests is presented in **Table 4-4**, the complete laboratory results are presented in **Attachment 2**.

Table 4-4: Summary of Corrosion Test Results

Boring No.	Sample No.	Depth (ft)	pH	Sulfate (ppm)	Chloride (ppm)	Standard
BB-WGLC-104	3D	10 - 12	7.75	1335	157	USEPA
BB-WGLC-104	1D	2 - 4	6.31	< 30	162	AASHTO
BB-WGLC-102	2D/3D/4D	5 - 17	6.73	161	63	AASHTO

5.0 SUBSURFACE CONDITIONS

5.1 Generalized Subsurface Stratification

The interpretation of soil and groundwater conditions at the project site are based on information obtained at the boring locations only. This information has been used as the basis for the conclusions and recommendations contained in this report. Significant variations at areas not explored by the project borings may require reevaluation of the findings and conclusions contained herein if found during construction.

A generalized interpretive subsurface profile is included as **Figure 5** and is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed through interpretations of widely spaced borings and samples. Actual soil transitions included in the subsurface profile may vary and may be more erratic than indicated.

Subsurface conditions encountered in the test borings at Abutment 1 generally consist of granular fill overlaying organic silt which is underlain by a soft to medium stiff clay. Soft to stiff clay layers above the till were encountered as the final stratum before encountering bedrock.

Subsurface conditions encountered in the test borings at Abutment 2 generally consist of granular fill overlaying soft to medium stiff clay. The soft to stiff clay is underlain by thin layer of till, which resides immediately above the bedrock.

The soil encountered in boring BB-WGLC-103, near the center of the creek, generally consisted of recent alluvium deposits underlain by bedrock. All other stratum which may have been present in the stream bed, at this location, were likely scoured away over time.

Stratum 1: Fill

Each boring performed behind the existing abutments shows a 15 foot to 17 foot thick layer of fill beneath the existing ground surface. Further away from the abutment, at boring BB-WGLC-101, the fill layer was approximately 10 feet thick. The fill layer was present in all borings except for boring BB-WGLC-103, which was performed near the middle of Cobbosseecontee Stream.

The surficial fill layer at Abutment 1 (south abutment) extends from the existing grade to approximately 15 feet below ground surface (BGS) and generally consists of a fine to coarse sand with gravel and trace to little silt. Pieces of old timbers are present from the existing timber cribbing behind the abutments. A boulder was encountered in boring BB-WGLC-102 from 9.2 feet to 10.9 feet BGS. The corrected (for overburden stress and hammer efficiency) SPT blow count $N1_{60}$ average value for this portion of the fill was 13 blows per foot (bpf).

The surficial fill layer at Abutment 2 (north abutment) extends from existing grade to approximately 15 feet to 17 feet BGS. Abutment 2 has approximately 4 feet of fine to coarse sand with little to some gravel and trace to little silt with a $N1_{60}$ average value of 24 bpf. This upper fill layer overlays a clayey silt with trace to some sand and trace to some gravel fill layer with a $N1_{60}$ average value of 9 bpf.

Stratum 2: Alluvium

Recent undisturbed alluvial deposits exist primarily within the channel of Cobbosseecontee Stream as identified in boring BB-WGLC-103. This layer exists within the stream bed as the upper most stratum lying directly over bedrock. Only one SPT was collected within the

stream bed with a $N1_{60}$ value of 15. The upper 18 inches of the strata consists of fine to coarse sand with little silt while the lower 2 inches was primarily gravel with some fine to coarse sand and silt.

One hydrometer was performed on sample A-1-b which indicated that approximately 14.7% of the sample was finer than the #200 sieve, with a water content of 20.3%, and had a USCS classification of SM.

Stratum 3: Organic Silt

The organic silt layer was only encountered in the borings behind Abutment 1 and was encountered immediately below the fill strata. This stratum consists of very loose silt with little fine sand containing various quantities of wood, peat, roots, and reeds with an average $N1_{60}$ value of 5 bpf. The two Atterberg limit tests performed on samples collected had a wide range of results from non-plastic to plastic with a liquid limit of 146.7 and plasticity index of 44.2.

Stratum 4: Soft to Medium Stiff Clay

The soft to medium stiff clay layer was encountered in all borings behind the abutments. The stratum is, on average, thicker at Abutment 2 than at Abutment 1.

The soft to medium stiff clay layer primarily consists of saturated silty clay to silt and clay. This stratum at Abutment 1 underlies the organic silt layer and was encountered between 20 feet and 28 feet BGS with an average $N1_{60}$ of 5 bpf. The average liquid limit and plasticity index of the samples tested beneath Abutment 1 was 41.1 and 20.3, respectively.

At Abutment 2, the soft to medium stiff clay is beneath the fill layer and primarily consists of saturated silty clay to silt and clay. The stratum as it exists beneath Abutment 2 is between 15 feet and 28 feet BGS with an average $N1_{60}$ of 11 bpf. The average liquid limit and plasticity index of the samples tested beneath Abutment 2 was 36.4 and 18.7, respectively.

Stratum 5: Till

The till stratum was identified in most borings at each abutment through SPT sampling and coring. The thickness of the layer varied based on each boring but was consistently the layer nearest to the granofels bedrock. The average $N1_{60}$ of 47 bpf is reflective of the gravelly nature of the till. The till consisted of fine to coarse sandy gravel with little to some silt. Borings behind Abutment 1 showed that nested boulders were present in the till, especially in boring BB-WGLC-102 which showed nested boulders from elevation 112.5 ft to 101 ft. The thickness of the till at BB-WCLG-102, BB-WCLG-202, and BB-WCLG-202 near Abutment 1 was approximately 10 feet. Till near Abutment 2 was not collected in a splitspoon sample, but was identified through drill cuttings and noted drilling action from the rig and operator. The average thickness of the till near Abutment 2 is approximately 2 feet.

Stratum 6: Granofels Bedrock

Bedrock was sampled at four preliminary phase borings and two final design phase borings. The top of bedrock elevation ranged from 119.5 ft to 100.7 ft. The shallowest bedrock was encountered in BB-WGLC-103 at the center of the creek channel. Bedrock encountered at the site generally consists of hard, typically fresh, aphanitic to fine grained, greenish grey Granofels bedrock with quartzite intrusions and high angle relic bedding.

Rock quality designation (RQD) is a common parameter that is used to help assess the competency of the sampled bedrock. RQD is defined as the sum of the pieces of recovered bedrock greater than 4 inches in length divided by the total length of recovered bedrock. RQD values of the bedrock that were encountered on site ranged from 0 to 82 percent. **Table 5-1** summarizes the results of the RQD and recovery for all recovered bedrock samples.

Table 5-1: Summary of Recovery and RQD of Bedrock Samples

Boring No.	Sample No.	Elevation (ft)	Recovery (%)	RQD (%)
BB-WGLC-101	R1	118.5 - 113.5	97	72
BB-WGLC-101	R2	113.5 - 109.5	94	77
BB-WGLC-102	R3	100.0 - 94.5	75	12
BB-WGLC-102	R4	95.0 - 93.1	100	0
BB-WGLC-102	R5	93.1 – 90.0	78	11
BB-WGLC-103	R1	118.0 – 113.0	100	35
BB-WGLC-103	R2	113.0 - 108.9	100	10
BB-WGLC-104	R1	110.5 - 105.5	100	50
BB-WGLC-104	R2	105.5 - 101.6	96	81
BB-WGLC-202	R1	106.0 – 101.0	95	68
BB-WGLC-203	R1	116 – 111.3	98	82

Note: RQD – Rock Quality Designation

5.2 Groundwater

The Ordinary High Water elevation associated with the 1.1 year flood (Q1.1) at the Cobbosseecontee Stream at the Burnham Bridge is elevation 137.14 as per the Preliminary Hydrologic and Hydraulic Report prepared by HNTB and dated July 2016. The Design water surface elevation associated with the 50 year flood event (Q50) is elevation 138.83 feet and the water surface elevation associated with the 100 year flood event (Q100) is elevation 139.03 feet. The average mean low water level is located at approximate elevation 133.0 and has been used for design purposes when it presents a more conservative design

assessment (particularly in regards to global stability). The Q50 water level has been assessed for all other design component.

6.0 FOUNDATION ALTERNATIVES

Integral abutments and semi-integral cantilever abutments supported on H-piles were considered for this crossing. Preference was given to integral abutments based on their lower construction cost and lower future maintenance requirements.

Various alternatives for the superstructure including steel plate girders and pre-stressed concrete NEPT girders were considered for one and two span configurations. The Preliminary Engineering Report (2016) recommended a two span bridge with a central river pier consisting of a reinforced concrete pile cap supported on 48 inch diameter drilled shafts with 42 inch diameter rock sockets. Subsequent to that recommendation it was determined that a one span bridge would be preferred so the center pier was removed,

7.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

7.1 General

Geotechnical design recommendations for the abutment foundations and approach embankments associated with the Burnham Bridge Replacement project are discussed in the following sections. Recommendations have been developed in accordance with the 2014 AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, Seventh Edition and the 2003 MaineDOT Bridge Design Guide (BDG) with 2014 updates.

7.2 Integral Abutment Design Considerations

7.2.1 Foundation Type Selection

Pile supported integral abutments were chosen as the preferred superstructure /substructure combination due to advantages associated with fast construction, low maintenance costs, and a long service life associated with the joint-less construction. HP 14x102 piles were chosen as the preferred foundation type to resist the relatively high bending moments at the pile head associated with thermal displacement and large axial demand given a single span bridge selection with a span length of 105 feet. H-piles are well suited for use as end bearing piles, and as combination shaft resistance and end bearing piles associated with the soils present at the project location. H-piles generally displace a minimum amount of soil, and can be driven more easily through dense granular layers present at the site locations than displacement piles. A total of five (5) HP 14x102 piles are proposed at each abutment to resist the structural axial demands.

7.2.2 Design Methodology

Integral abutment sections have been designed for relevant service, strength and extreme limit state load combinations in accordance with AASHTO LRFD Articles 3.4.1 and 11.5.5. The abutment foundations have been designed to resist dead loads, live loads, lateral earth loads, longitudinal braking forces, and thermal deformations.

Under service limit state conditions, a resistance factor of 1.0 has been used to assess vertical settlement and lateral displacement in the longitudinal direction along the bridge alignment (baseline). Additionally, the overall stability of each abutment has been assessed under service limit state conditions with a resistance factor of 0.65 (which equates to a factor of safety using limit equilibrium stability analyses of approximately 1.5) in accordance with AASHTO Article 11.6.2.3.

The design of H-Pile foundations under strength and extreme limit state conditions has been developed in consideration of the compressive axial geotechnical resistance of individual piles; drivability resistance; structural resistance in axial compression and combined axial and flexure loading.

An axial resistance factor (φ_c) of 0.5 has been used to assess the structural resistance of the H-Pile in compression (when not subjected to bending) in accordance with AASHTO LRFD Article 6.5.4.2 given the pile may be subjected to damage due to severe driving conditions and where use of a pile tip is necessary. The structural resistance of each H-Pile has also been checked against combined axial and flexure in accordance with AASHTO LRFD Articles 6.9.2.2 and 6.15.2. As per Article 6.5.4.2 an axial resistance factor of 0.7 has been used when piles are subjected to both axial compression and flexure and the corresponding flexure resistance factor (φ_f) of 1.0 has been used in the interaction equation specified in AASHTO LRFD Article 6.9.2.2 to determine structural resistance.

Geotechnical resistance factors under the strength limit state conditions have been determined in accordance with AASHTO LRFD Table 10.5.5.2.3-1. A geotechnical resistance factor (φ_{dyn}) of 0.65 has been selected assuming that driving criteria will be established by dynamic testing of at least one pile at each abutment during construction. For piles driven to point bearing on hard rock AASHTO LRFD Article 10.7.3.2.1 states that the geotechnical resistance shall not exceed the structural pile resistance determined from AASHTO LRFD Article 6.9.4.1 with an axial resistance factor (φ_c) of 0.5 when severe driving conditions are encountered. The factored geotechnical resistance using a factor of 0.65 was assessed relative to the factored structural resistance using a factor of 0.5 to determine the limiting resistance.

7.2.3 Subsurface Material Properties

Geotechnical design parameters for soil and rock were developed for each stratum based on material descriptions, standard published correlations, results from laboratory testing, and engineering judgment. A summary of soil design properties at the north and south approaches and abutments are included below as **Tables 7-1** and **7-2**.

Table 7-1: Final Engineering Properties of Soil at South Approach / Abutment

Soil Properties	Strata					
	Selected Structural Fill	Sand and Gravel Layer (Fill)	Organic Silt (Organics)	Soft to Medium Stiff Clay (OC Clay)	Gravel & Sand (TILL)	Granofels Bedrock
$N_{60,}$ (bpf)	NA	10	4	4	48	-
$N1_{60,}$ (bpf)	NA	13.4	5	5	47	-
γ (pcf)	NA	113	103	106	126	-
φ', (deg)	32	33	25 (drained)	28 (drained)	38	-
k, AGW (pci)	77	102	NA	NA	244	-
k, BGW (pci)	51	64	NA	NA	140	-
c', (psf)	NA	NA	320	506	NA	-
ε_{50}	-	-	-	0.01	-	-
E_s (ksi)	NA	268	NA	NA	1123	-
Compression Index, C_c	NA	NA	1.39	0.42	NA	-
Recompression Index, C_r	NA	NA	0.32	0.05	NA	-
Initial Void Ratio, e_o	NA	NA	1.04	1.04	NA	-
OCR	NA	NA	1.5	4.9	NA	-
Secondary Compression Index, C_a	NA	NA	0.15	0.07	NA	-

Table 7-2: Final Engineering Properties of Soil at North Approach / Abutment

Soil Properties	Soil Strata						
	Selected Structural Fill	Sand and Gravel Layer (Upper Fill)	Sand and Gravel Layer (Lower Fill)	Soft to Medium Stiff Clay (OC Clay)	Very Soft to Soft Clay & Silt	Gravel & Sand (TILL)	Granofels Bedrock
$N_{60,}$ (bpf)	NA	14	6	9	1	48	-
$N1_{60,}$ (bpf)	NA	24	9	11	1	47	-
γ (pcf)	NA	120	111	113	91	126	-
φ', (deg)	32	36	32	30(drained)	27 (drained)	38	-
k, AGW (pci)	77	161	77	NA	NA	244	-

k, BGW (pci)	51	94	51	NA	NA	140	-
c', (psf)	NA	NA	NA	642	350	NA	-
ε_{50}	-	-	-	0.01	0.02	-	-
E_s (ksi)	NA	83	70	NA	NA	1123	-
Compression Index, C_c	NA	NA	NA	0.42	0.90	NA	-
Recompression Index, C_r	NA	NA	NA	0.05	0.04	NA	-
Initial Void Ratio, e_o	NA	NA	NA	1.04	1.04	NA	-
OCR	NA	NA	NA	4.9	1.4	NA	-
Secondary Compression Index, C_a	NA	NA	NA	0.07	0.07	NA	-

Where: $\overline{N_{60}}$= Average SPT-N value of stratum, corrected for hammer efficiency, in blows per foot.
$\overline{N1_{60}}$= Average SPT-N value of stratum, corrected for hammer efficiency and effective overburden pressure, in blows per foot.
γ = Total unit weight of soil - correlated.
φ' = Internal friction angle of drained soil, per multiple SPT-N value correlations.
k= Subgrade modulus – correlated (above WT / below WT)..
c'= Undrained shear strength based on in-situ vain shear testing.
ε_{50}= Strain at 50% - correlated.
E_s= Modulus of elasticity – correlated.
C_c= Compression Index – correlated with lab testing.
C_r= Recompression Index – correlated with lab testing.
e_o= Initial void ratio – correlated with lab testing.
OCR= Overconsolidation ratio – correlated with lab testing.
C_a= Secondary compression index – correlated.

Drained strength parameters for slope stability analysess were developed using established correlations between Liquid Limit, clay fraction and effective stress published by Stark and Hussain, 2013. Effective stress was calculated using estimated unit weights of each of the soil layer and Q50 water level of elevation 139.0 feet. Liquid limits and clay fractions were obtained from Atterberg Limit and hydrometer test results from samples obtained during the subsurface investigation.

7.2.4 Lateral Earth Pressure

As per the MaineDOT Bridge Design Guide (BDG), integral abutment and wingwall reinforcement should be designed for the full passive earth pressure acting on the back face of the abutment or wingwall as the bridge expands. Passive pressure acts as a triangular pressure distribution on the full height of the abutment backwall from the bottom of the approach slab to the bottom of the abutment/pile cap. Calculation of passive earth pressure

should assume a Coulomb passive earth pressure coefficient in accordance with the BDG Section 3.6.6 using the material properties defined in BDG Table 3-3 for a granular borrow.

Developing full passive earth pressure requires that wall rotation, i.e. the ratio of lateral abutment movement to abutment height (y/H), exceeds 0.005 as per the BDG Section 5.4.2.11. If the calculated rotation is significantly less than that required to develop full passive pressure, Rankine passive earth pressure coefficients may be considered in accordance with BDG Section 5.4.2.11. A load factor for passive earth pressure is not specified in AASHTO LRFD, however a load factor for passive earth pressure (γ_{EH}) equal to 1.50 should be applied in accordance with BDG Section 5.4.2.11.

Active earth pressure coefficients using either Coulomb or Rankine theory can be used for the design of yielding walls that include: gravity walls and abutments, semi gravity walls, prefabricated modular walls with steep backfaces and cantilever walls and abutments with short heels as defined by AASHTO LRFD Figure C3.11.5.3-1. **Table 7-3** summarizes Coulomb and Rankine Active and Passive earth pressure coefficients for a granular borrow material with a friction angle (ϕ) of 32 degrees and an interface friction angle (δ) between soil and concrete of 19.2 degrees in accordance with AASHTO (2002) Table 5.5.2B assuming a vertical backface and horizontal backfill.

Table 7-3: Earth Pressure Coefficients

Earth Pressure Theory	Friction Angle of Soil (deg)	Interface Friction Angle of Soil and Concrete (deg)	Angle of Backface of Wall to Horizontal (deg)	Angle of Backfill to Horizontal (deg)	Passive Earth Pressure Coefficient (dim)	Active Earth Pressure Coefficient (dim)
Coulomb Theory	32	19.2	90	0	6.638	0.276
Rankine Theory	32	19.2	90	0	3.255	0.307

A live load surcharge should be applied when traffic loads are located within a horizontal distance equal to one-half of the wall height, H, behind the back of the wall. The additional lateral earth pressure due to live load should be modeled by a surcharge load equal to that applied by a height of soil defined in Table 3-3 of the BDG. The surcharge will result in the application of an additional uniform, constant horizontal pressure on the back of the wall. When a structural approach slab is specified, a reduction of the live load surcharge is permitted in accordance with AASHTO LRFD Article 3.11.6.5.

7.2.5 Pile Demands

Design pile loading information at each abutment was developed by evaluating each of the applicable limit states in accordance with BDG Section 5.4.1.2. The limit states evaluated include: Strength I, Strength IV, Service I, and Extreme Event II. Pile demands include anticipated downdrag at Abutment 1 and Abutment 2. **Table 7-4** summarizes the maximum factored pile head axial demands and maximum thermal displacements that were assessed for design.

Table 7-4: Summary of Maximum Factored Pile Head Demands per Pile

Limit State Condition	Abutment 1		Abutment 2	
	Max Factored Axial Compressive Force (kips)	Max Thermal Displacement - Procedure A (in)	Max Factored Axial Compressive Force (kips)	Max Thermal Displacement - Procedure A (in)
Service I	257	0.45	245	0.45
Strength I	357	0.45	345	0.45
Extreme II	252	0.45	240	0.45

7.2.6 Axial Pile Resistance and Design Considerations

The maximum factored axial compressive demand from **Table 7-4** is 357 kips per pile at Abutment 1 and 345 kips per pile at Abutment 2 corresponding to the Strength I limit state. Using a geotechnical resistance factor of 0.65 associated with dynamic testing of at least one pile at each abutment during construction yields a required nominal geotechnical resistance of 550 kips per pile at Abutment 1 and 531 kips per pile at Abutment 2 under strength limit state conditions. Using a geotechnical resistance factor of 1.0 under the Service and Extreme limit states yields a required nominal geotechnical resistance of 257 kips and 252 kips respectively at Abutment 1. The required nominal geotechnical resistance for Service and Extreme limit states at Abutment 2 is 245 kips and 240 kips, respectively. Therefore, the governing required nominal geotechnical resistance occurs under the Strength limit state and is 550 kips at Abutment 1 and 531 kips at Abutment 2.

The minimum required nominal driving resistance of the abutment piles has been checked against the lesser of the factored structural resistance, the factored geotechnical resistance, or the factored resistance that piles can be driven to without exceeding the allowable stresses as per AASHTO LRFD Article 10.7.8 using an axial resistance factor of 1.0 for resistance during driving as per AASHTO LRFD Article 6.5.4.2.

The factored axial compressive structural resistances for piles loaded in compression without flexure have been calculated using a resistance factor of 0.5 associated with severe driving conditions and are summarized in **Table 7-5.** Calculations of factored axial compressive structural resistance that account for combined compression and flexure have been performed by the structural engineer using the associated values for unbraced length and effective length factors from the results of LPILE analyses performed to assess the lateral performance of the piles. HNTB anticipates that H-piles will be driven to refusal conditions, and therefore pile axial design will be structurally controlled, either by stresses in the pile during driving or the structural resistance of the pile under static loading.

In order to determine whether piles can be installed to the minimum tip elevations, preliminary drivability evaluations were conducted using the software program GRL WEAP 2010 distributed by GRL Engineers, Inc. Additionally, drivability analyses were performed to develop a relationship between nominal axial geotechnical compressive resistance and the corresponding stresses in the pile assuming the piles are driven to those resistances. Drivability analyses were performed assuming a Delmag 36-32 diesel hammer for this assessment using a Fuel Setting of 4 However, the contractor will be required to reassess using their proposed pile driving equipment prior to installation.

Nominal axial geotechnical resistance was determined from the drivability assessment at the specific resistance where stresses in the pile exceeded 45 ksi (the structural limit as per AASHTO LRFD Article 10.7.8) assuming the H-Piles have yield strengths of 50 ksi. Factored axial geotechnical resistance was developed using a resistance factor of 0.65 associated with dynamic testing during construction in accordance with AASHTO LRFD Table 10.5.5.2.3-1.

Table 7-5 summarizes the maximum factored load imposed onto a single pile compared to the factored geotechnical resistance based on structural limitations and drivability of a single pile under the governing strength limit state. It should be noted that the minimum required nominal driving resistance as indicated in **Table 7-6** is less than the governing axial compressive resistance indicated in **Table 7-5**.

Table 7-5: Limiting Factored Axial Resistance of an HP 14x102 at the Strength Limit State

HP 14x102	Factored Load (kips)	Limiting Factored Structural Resistance[1] (kips)	Limiting Factored Geotechnical Resistance[2] (kips)	Estimated Factored Drivability Resistance[3] (kips)	Governing Factored Axial Compressive Resistance (kips)
Abutment 1	357	750	750	650	650
Abutment 2	345	750	750	575	575

Note: 1. Based on severe driving conditions and a resistance factor of 0.5. Structural resistance is equivalent to geotechnical resistance when piles are driven to hard rock of refusal.
2. Assumes piles are driven to hard rock or refusal conditions.
3. Based on a resistance factor of 0.65 for piles driven with dynamic testing using a Delmag 36-32 with a Fuel Setting of 4.

Controlling factored axial compressive resistance is governed by drivability at Abutment 1 and Abutment 2. The governing factored axial compressive resistance is greater than the maximum factored demand and satisfies design requirements.

HNTB anticipates that the piles will be driven to refusal conditions and will have negligible settlement at the pile tip. Therefore, we believe majority of the settlement at the bridge abutments will be a result of the elastic compression of the H-Pile itself. This compression is estimated to be less than 0.15 inches at each abutment.

7.2.7 Lateral Pile Resistance and Design Considerations

Design of integral abutments was conducted in accordance with Section 5.4.2.4 of the MaineDOT BDG and the recommendations included in the "Integral Abutment Bridge Design Guidelines" by the Vermont Department of Transportation (VTrans). HP 14x102 piles selected for the analysis conform to ASTM A572 Grade 50, and are aligned for weak-axis bending parallel to the bridge centerline. The number of H-Piles at each abutment was governed by axial considerations.

Single pile lateral analysis was conducted using the LPILE version 2016.9.06 computer program from Ensoft, Inc. The ground surface was assumed at the top of abutment for analysis of pile reaction to thermal expansion, and at bottom of abutment for thermal contraction. For design of abutments, the project structural engineer estimated a maximum thermal deflection per abutment of 0.45 inches. The maximum estimated factored axial compression load per pile was 357 kips at Abutment 1 and 345 kips at Abutment 2.

Lateral analyses were first performed with defined pile head deflections corresponding to the thermal expansion at each abutment, assuming a fixed-head condition (zero slope condition). The plastic moment resistance of the pile was calculated using unbraced lengths and effective length factors as a result of the first LPILE analysis. The structural capacity of the pile was checked to determine if a plastic hinge formed for the specified displacement and specified axial thrust load based on the provisions of Article 6 of AASHTO and as per the recommendations of Section 5.4.2.4 of the MaineDOT BDG.

If the resulting moment from the first LPILE iteration exceeded the calculated plastic moment, a second LPILE analysis was performed using a specified pile head displacement and moment. The pile head displacement in the second iteration remained unchanged while the specified pile head moment was equivalent to the plastic moment calculated from the results of the first LPILE iteration. The results of the second LPILE iteration were used to revise the unbraced length of the piles and recalculate the pile axial structural resistance.

The design indicates that plastic hinges will form at the base of pile cap for the proposed configuration. The hinge allows the pile head to rotate with a constant moment, i.e. the plastic moment. The pile head transforms from a fixed connection to a pinned connection, thereby changing the effective length of the top segment for stability checks. The capacity of the top segment of the pile is enhanced if the plastic moment forms as described.

Piles have been designed to accommodate additional shear forces to increase the global stability factors of safety to design minimums in the slope stability analysis. These shear forces, as well as longitudinal braking forces, were accounted for in the lateral design of the piles. After verifying that the pile did not form a second plastic hinge in the analysis, an additional scenario was evaluated to develop a representative "maximum displacement" that incorporates the additional lateral forces.

7.2.8 Recommended Pile Tip Elevations and Nominal Driving Resistances

The nominal static axial geotechnical resistance was assessed using the software program APILE version 2014.6.2 distributed by Ensoft Inc. using the Nordlund/Thurman (FHWA) Method.

Downdrag was considered for analysis due to the quantity of fill being placed and the identification of compressible soils beneath Abutment 1 and 2. The skin friction applied to the length of pile which is anticipated to undergo 0.4 inches or more was calculated for Abutment 1 and 2. Using the downdrag load factor of 1.4, from AASHTO LRFD Table 3.4.1–2, the factored downdrag load for the HP14x102 piles at Abutment 1 and 2 was 52 and 40 kips respectively. This factored downdrag load was applied to all load cases for Abutments 1 and 2.

HNTB anticipates that piles will reach refusal when the top of bedrock is encountered. Estimated pile tip elevations have been based on top of rock elevations and lateral requirements and are indicated in **Table 7-6**. Additionally, minimum nominal driving resistances have also been included in **Table 7-6**. All pile should be driven to at least the minimum pile tip elevations and to a suitable penetration depth so that the minimum required nominal driving resistance is achieved.

Table 7-6: Pile Tip Elevations and Nominal Driving Resistances

Location	Minimum Pile Tip Elevation (ft)	Estimated Pile Tip Elevation (ft)	Factored Axial Load (kips)	Minimum Required Nominal Driving Resistance (kips)
Abutment 1	110.0	100.0	357	550
Abutment 2	116.0	110.0	345	531

HNTB recommends ordering lengths of piles that reflect a minimum of 5 additional feet per pile to accommodate variations in pile penetration, dynamic pile test instrumentation and pile head damage during driving.

7.2.9 Wingwalls

Wingwalls shall be designed for all relevant service, strength and extreme limit state load combinations as specified in the MaineDOT BDG and AASHTO LRFD. Wingwalls should generally not exceed 10 feet in length and should be straight cantilevered extension wings where possible. As per BDG Section 5.4.2.11, piles should not be placed under wingwalls that are integral with the abutment stem. Because of the high bending moments due to passive pressure in wingwalls 10 feet or longer, it may be necessary to support longer wingwalls on their own independent foundations that are isolated from the abutment. If this is the case, a flexible joint must be provided between the wingwalls and the backwall.

The passive earth pressure which acts on the back face of the wall when the bridge expands, developed using the Coulomb passive earth pressure coefficients defined in **Table 7-3** and a passive earth pressure load factor (γ_{EH}) of 1.5 should be applied to design wingwall reinforcement. Rankine passive earth pressure coefficients may be considered in accordance with BDG Section 5.4.2.11 when the ratio of lateral abutment movement to abutment height (y/H), exceeds 0.005.

7.2.10 Global Stability at Bridge Abutments Longitudinal to Bridge Alignment

AASHTO LRFD Bridge Design Specifications (AASHTO) requires that the embankments be analyzed for global stability in the Service-I loading condition using limit equilibrium methods. A global stability resistance factor of 0.75 is required when embankments are not supporting or do not contain structural elements. This resistance factor results in a minimum required factor of safety of approximately 1.3 in accordance with AASHTO Section 11.6.2.3. When global stability analysis is performed and the geotechnical parameters are based on limited information, or when the slope contains or supports a structural element, AASHTO requires that a resistance factor of 0.65 be utilized. This resistance factor results in a minimum required factor of safety of approximately 1.5 in accordance with AASHTO Section 11.6.2.3.

In analyzing global stability, limit equilibrium analyses were performed at Abutment 1 and Abutment 2 using the Slope/W module of GeoStudio 2016, version 8.16 distributed by Geo-Slope International Ltd. Subsurface conditions for global stability analysis at each approach were selected based on review and interpretation of the available borings and stability was evaluated along the approximate centerline of a section cut along the Pond / Plains Road baseline. Spencer's method of analysis has been used to perform all global stability analyses which satisfies both force and moment equilibrium and meets the requirements prescribed by AASHTO LRFD Article C11.6.2.2 for slope stability analysis. Results of the analysis were assessed using non-optimized failure surfaces, the results of which have been provided herein.

Global stability analysis was performed for long term loading conditions using drained soil strength design parameters and short term loading conditions using undrained soil strength design parameters are specified in **Table 7-1** and **Table 7-2**. Analysis was performed at Station 18+50 near Abutment 1 and Station 20+00 near Abutment 2. Stability was assessed at ground water levels corresponding to the Q50 design flood elevation of approximately 139.0 feet and elevation 133 feet, the approximate average mean low water level at the base of the approach embankments. A surcharge load of 250 psf was applied to the approach embankments to simulate the vehicular live load.

Subsurface stratigraphy for stability analysis performed at the abutments was based on the subsurface exploration completed at the project site. Stratigraphy used to model the north abutment was derived from borings BB-WGLC-103, BB-WGLC-104, BB-WGLC-203, and BB-WGLC-204. Stratigraphy for the south abutment were derived from borings BB-WGLC-101, BB-WGLC-102, BB-WGLC-103, BB-WGLC-201, and BB-WGLC-202. Additional information was gathered through interpretation of the geologic maps in **Figures 2** and **3**. The alluvium encountered in boring BB-WGLC-103 was extended up both the north and south river banks to simulate the occurrence of these deposits along the stream channel. The voids/timber encountered in BB-WGLC-102 were not explicitly modeled. Additional investigation did not indicate systemic voids beneath either the north or south abutments.

Preliminary results from the abutment stability analysis are summarized in **Table 7-7**. In order to meet the AASHTO requirements for global stability, abutment piles have been designed to provide additional shear reinforcement in the longitudinal direction of the bridge alignment. To achieve a non-optimized factor of safety of 1.5 at both abutments a mobilized shear resistance of 2.75 kips per linear foot of abutment is required. The stability results in **Table 7-7** include a shear resistance of 16.5 kips per pile distributed linearly across the embankment.

Additionally, the reported factors of safety include the contribution from geogrid reinforcing placed directly behind each abutment. Although the factors of safety against global stability remain above 1.0 when the reinforcing elements are excluded, the slopes do not meet minimum design requirements. With the inclusion of the reinforcing elements the global stability factors of safety of both abutments satisfy AASHTO requirements of 1.5 when non-optimized (circular) slip surfaces are assessed.

Table 7-7: Summary of Stability Results for Proposed Bridge Abutments

Location	Loading Condition	Water Elevation	Factor of Safety	
			Optimized	Non-Optimized
North Abutment	Undrained	133.0	1.42	1.64
		139.0	1.51	1.66
	Drained	133.0	1.47	1.56
		139.0	1.46	1.53
South Abutment	Undrained	133.0	1.43	1.52

Location	Loading Condition	Water Elevation	Factor of Safety	
			Optimized	Non-Optimized
		139.0	1.59	1.67
	Drained	133.0	1.46	1.56
		139.0	1.41	1.53

In some instances the factors of safety drop below a 1.5 if optimized surfaces are assessed, but typically remain at or above a factor of safety of 1.4. The primary failure mechanisms are typically deep seated global stability failures that originate behind the abutment and propagate through the existing fill and underneath the abutment stem wall, exiting approximately 15 feet below the proposed ground surface in the alluvium/river bank deposits.

7.2.11 Assessment of Potential Subsurface Voids

The 1949 Burnham Bridge Construction Plans included as **Figure 6** indicate that timber pile anchors are present approximately 20 feet behind each existing abutment and are attached to the existing abutments with tie rods. Boring BB-WGLC-102 was drilled approximately 14 feet behind the south abutment within the limits of the existing anchors and tie-rods and may have encountered these subsurface elements. Furthermore, boring BB-WGLC-104 was drilled approximately 24 feet behind the existing north abutment, outside the limits of the existing anchors and did not indicate the presence of subsurface voids.

Final design phase borings were performed behind both north and south abutments, which provided more information on the subsurface conditions. BB-WGLC-201 was performed 24.6 feet south of Abutment 1 and did encounter wood within the fill layer at approximately 8 feet BGS, but there were no indications of a void being present. BB-WGLC-202 was only 4.8 feet behind the existing Abutment 1. A possible 0.2 ft void was noted at 15.3 ft in depth, directly above where drill cuttings consisting of wood and wood pulp were encountered. This gives support to the theory that the cribbing itself is present beneath the embankment and that it is in a deteriorated state.

On the north abutment side of the bridge, BB-WGLC-203, located 5.6 feet north of the existing north abutment, shows some minor irregularities while drilling. After drilling through nested cobbles, a 0.3 foot drop in the drill string was noted at 10.7 feet BGS. Drilling continued through the granular fill with another possible 0.3 foot drop in the drill string at 11.5 feet BGS. These irregularities were all noted prior to encountering cribbing between 17 feet and 20 feet BGS. In this case, it may have been more related to the drops associated with breaking through and moving large granular material while drilling as opposed to actual voids being present. BB-WCLG-204 was drilled at 14.8 feet north of the north abutment and had no noted irregularities. Wood was still encountered, likely from the timber cribbing, at 10 feet BGS.

Geophysical testing was proposed during preliminary design as an alternative means of investigating the subsurface conditions behind each of the abutments. Geophysical testing in the form of ground penetrating radar (GPR) was performed by Hager-Richter Geoscience, Inc in the approaches leading up to and immediately behind the existing abutments to assess the potential for voids.

GPR reflections typical of voids or slumping soil are not evident in the data for the approaches within the effective depth of penetration of the GPR signal. Whether a void occurs at a depth greater than the effective depth of penetration of the GPR signal (approximately 8-10 feet for much of the survey area, or less than 3 feet in the area of limited signal penetration) or in areas inaccessible to the geophysical survey cannot be determined from the geophysical data. However, GPR reflections consistent with the limits of excavation for the structural cribbing are evident for both approaches, reflections consistent with possible structural cribbing are evident for the north approach, and reflections consistent with a flat topped structure are evident at 4 to5 feet in depth for the south approach.

The possible void that was identified in BB-WGLC-102 appears to be isolated to where the boring was performed. Deteriorated timber cribbing may have given the appearance of an annulus being present. Additional subsurface investigation performed at each abutment during the final design phase indicated irregularities may exist but are mostly function of the interactions between the roller bit and the cobbles, boulders, granular fill, and timber cribbing near the existing abutment. GPR geophysical testing showed no indication of voids or collapsing soils within the limits of the investigation, but did identify the presence of the old timber cribbing.

7.2.12 Assessment of Corrosion Potential

Corrosion testing of fill material performed at the east abutment in accordance with USEPA standards indicated aggressive corrosion conditions as noted in **Table 4.3**, which could result in higher corrosion rates and a considerable reduction of pile design life if not accounted for. Subsequent testing which was performed in accordance with AASHTO standards at both proposed abutments indicated non-aggressive corrosion conditions and is summarized in **Table 4.3**.

Given the results of the subsequent corrosion testing performed at each abutment location and the necessity to remove a significant portion of the existing fill above the water table in order to demolish the existing concrete abutments and construct the proposed abutments, the potential for aggressive corrosion is expected to be small.

The corrosion risk to the abutment piles will be substantially mitigated through the predrilling of oversized holes at each pile location to a minimum of 10 feet below the bottom of concrete jacket elevation. After predrilling, placement of HDPE casings will be installed to provide a barrier isolating the piles from the aggressive soils. H-piles would be installed through the casing and driven to the required resistances. Upon completion of

driving, the void space between casing and H-pile would be backfilled with loose, clean sand, defined on the plans as cushion sand.

Granular borrow will be replacing fill to elevation 132.47 at Abutment 1 and elevation 133.6 at Abutment 2. The concrete jacket which encases the upper portion of the pile extends to 3 feet below the bottom of cap. At this point, the piles will be encased by the HDPE isolation casing with clean cushion sand for 10 feet. Given the corrosion mitigation efforts being implemented on this project and extend of fill removal in the footprint of the abutment, corrosion is anticipated to be negligible in the piles.

7.2.13 Frost Protection

The minimum depth of embedment for walls or other subgrade structures was evaluated in accordance with Section 5.2.1 of the BDG and AASHTO LRFD Articles 10.6.1.2 and 11.10.2.2. Based on a design freezing index equal to 1.500 freezing degree days, it is recommended that the footings and walls bear a minimum of 6.85 feet below the lowest adjacent ground surface exposed to freezing.

7.3 Approach Embankment Design Considerations

7.3.1 Design Methodology

The existing approach embankments along Pond Road/Plains Road have a maximum height of approximately 8 to 9 feet at Abutment 1 (south approach) and Abutment 2 (north approach), respectively. The maximum existing embankment slopes are approximately 1.7H:1.0V along the south approach embankment and 1.5H:1.0V along the north approach embankment. The proposed construction requires raising of the approach embankments by as much as 3 feet and widening of the embankments to accommodate the raised grade and proposed re-grading of the embankment slopes to 2.0H:1.0V

In analyzing the approach embankments, HNTB performed limit equilibrium analysis of the maximum-height embankment cross-section, located at Station 18+50 near Abutment 1 and Station 20+00 near Abutment 2, using the Slope/W module of GeoStudio 2016, version 8.16 distributed by Geo-Slope International Ltd. Stations 18+50 and 20+00 were selected as the most critical section based on the high relief from roadway to base of embankment (approximately 10 feet) and grading of slope 1.75H:1V. The maximum of both of these parameters were present at stations 18+50 and 20+00 and represent the controlling section as it relates to slope instability.

Subsurface conditions for global stability analysis at each approach were selected based on conditions at the nearest abutment borings. Spencer's method of analysis has been used to perform all global stability analyses which satisfies both force and moment equilibrium and meets the requirements prescribed by AASHTO LRFD Article C11.6.2.2. Results of the analysis were assessed using non-optimized failure surfaces, the preliminary results of which have been provided herein.

Global stability analysis was performed for long term loading conditions using drained soil strength design parameters and short term loading conditions using undrained soil strength design parameters as specified in **Table 7-1** and **Table 7-2.** Stability was assessed at ground water levels corresponding to the Q50 design flood elevation of approximately 139.0 feet and elevation 133 feet, the approximate average mean low water level at the base of the approach embankments. Additionally, a surcharge load of 250 psf was applied to the approach embankment to simulate the vehicular live load.

7.3.2 Stability Assessment

Subsurface stratigraphy for stability analysis performed at the approach embankments was based on the subsurface exploration completed to date. The stratigraphy for the analysis performed along the south approach embankment was based on information from borings BB-WGLC-102, BB-WGLC-201, and BB-WGLC-202. The stratigraphy for the analysis performed along the north approach embankment was based on information from boring BB-WGLC-104, BB-WGLC-203, and BB-WGLC-204.

Results of the embankment analysis are summarized in **Table 7-8.** Global stability analysis of both the north and south approach embankments returned factors of safety that satisfy AASHTO requirements of approximately 1.3 when non-optimized (circular) slip surfaces were used. While the embankments don't exhibit deep seated global stability failure through the foundation soils, there are instances where the proposed slopes have a factor of safety that is marginally less than 1.3 when slip surfaces less than 4 feet deep are assessed.

Table 7-8: Summary of Stability Results for Approach Embankments

Location	Station	Water level	Condition	East - Factor of Safety		West - Factor of Safety	
				Optimized	Non-Optimized	Optimized	Non-Optimized
South Approach	18+50	133.0	Undrained	1.30	1.39	1.39	1.48
		139.0	Undrained	1.49	1.56	1.72	1.83
		133.0	Drained	1.51	1.56	1.50	1.57
		139.0	Drained	1.50	1.64	1.51	1.62
North Approach	20+00	133.0	Undrained	1.35	1.53	1.49	1.62
		139.0	Undrained	1.73	1.73	1.69	1.73
		133.0	Drained	1.62	1.68	1.74	1.80
		139.0	Drained	1.66	1.69	1.26	1.3

7.3.3 Settlement Assessment

Settlement was assessed for both abutments and the approach embankments due to the proposed fill being placed over the existing embankment and the widening of the existing embankment. Consideration was necessary due to the identification of an organic silt stratum during the final design phase borings which was not present in the preliminary

engineering phase borings. This organic silt stratum was only encountered beneath Abutment 1 and heavily influences the anticipated settlement where present. Settlement analysis was performed at Station 18+50 for Abutment 1 and corresponding approach and Station 20+00 for Abutment 2 and the corresponding approach.

The stratigraphy for the settlement analysis performed at Station 18+50 along the south approach embankment was based on information from borings BB-WGLC-102, BB-WGLC-201, and BB-WGLC-202. The stratigraphy for the analysis performed at Station 20+00 along the north approach embankment was based on information from boring BB-WGLC-104, BB-WGLC-203, and BB-WGLC-204.

Settlement was analyzed at the abutments and embankments in the Settle3D computer software version 4.012. Primary and secondary consolidation for cohesive materials and elastic settlement for cohesionless materials were accounted for when assessing settlement using Settle3D. Settlement inputs for the model coincide with the values in **Table 7.1** for Abutment 1 and **Table 7.2** for Abutment 2.

Settlement for Abutment 1 and the south approach was evaluated for the short term condition at 0.1 years after loading and 100 years after loading. The short term maximum settlement within the footprint of the 30-foot-wide roadway was 0.3 inches, which also corresponds to the maximum settlement experienced by the embankment in the short-term analysis. The 100-year analysis indicates that a maximum total settlement of approximately 3.6 inches at Station18+50 occurs at 33 feet to the right of the baseline under the embankment slope, which is 18 feet to the right of the edge of roadway. The highest magnitude of settlement within the footprint of the 30-foot-wide roadway is 1.7 inches at 100 years at 15 feet to the right of the baseline, but the magnitude of settlement at the center of the roadway is estimated at 1.3 inches.

Settlement for Abutment 2 and the north approach was evaluated for short term settlement at 0.1 years after loading and 100 years after loading. The short term maximum settlement within the footprint of the 30-foot-wide roadway was 0.84 inches, which also corresponds to the maximum settlement experienced by the embankment in the short-term analysis. The 100-year analysis indicates that a maximum total settlement of approximately 1.3 inches at Station 20+00 occurs at 33 feet to the right of the baseline, which is 18 feet to the right of the edge of roadway. The highest magnitude of settlement within the footprint of the 30-foot-wide roadway is 1.02 inches at 100 years at 15 feet to the right of the baseline, while at the center of the roadway, the magnitude of settlement is anticipated to be 1.0 inches.

8.0 Seismic Design Recommendations

8.1 Site Evaluation

Based on the corrected SPT blow count for granular soils obtained from the test borings, the site is considered a Site Class "E" in accordance with AASHTO LRFD Table 3.10.3.1-1.

Table 8-1 provides the seismic design parameters developed in accordance with AASHTO LRFD and the United States Geologic Survey software Seismic Design Parameters.

Table 8-1: Seismic Design Parameters

Parameter	Design Value	AASHTO LRFD Reference
Site Class	E	Table 3.10.3.1-1
Peak Ground Acceleration (PGA)	0.075	Figure 3.10.2.1-1
F_{PGA} (0.0 second period)	2.5	Table 3.10.3.2-1
F_a	2.5	Table 3.10.3.2-2
F_v	3.5	Table 3.10.3.2-3
Acceleration Coefficient (As)	0.875	Figure 3.10.4.1-1
S_{DS} (0.2 second period)	0.413	Figure 3.10.4.1-1
S_{D1} (1.0 second period)	0.147	Figure 3.10.4.1-1
Seismic Zone	1	Table 3.10.6-1

Bridges in Seismic Zone 1 need not be analyzed for seismic loads, regardless of their operational classification and geometry as specified in AASHTO LRFD Article 4.7.4. However, the minimum requirements, as specified in AASHTO LRFD Articles 4.7.4.4 and 3.10.9 regarding superstructure connections and minimum support length requirements shall still apply.

8.2 Liquefaction Screening

As part of the seismic assessment, a determination of the liquefaction hazards present at the project site was conducted. Liquefaction is a phenomenon whereby a soil substantially loses strength in response to an applied cyclic stress, typically associated with earthquake loading. This temporary loss of soil strength causes the soil to behave like a liquid, impacting bearing capacity and lateral stiffness. Liquefaction induced ground movement can cause serious damage to structures. Damage may occur during the earthquake itself, or continue to occur or be initiated subsequent to the earthquake in situations where the static factor of safety against lateral movement is reduced to less than unity. Two types of post-liquefaction deformations are possible:

1. Horizontal shear deformation arising from the large shearing strains occurring in zones where the earthquake has induced initial liquefaction.

2. Settlements arising from volume changes that occur on reconsolidation accompanying dissipation of the large excess pore pressures in liquefied zones.

In general, strata meeting the following criteria are typically not susceptible to liquefaction and can be eliminated from the screening:

- Soil with fines content (percent passing through No. 200 sieve) more than 35 percent
- Soils classified as Marine and Lacustrine Silt and Clay
- Layers with SPT-N values greater than 30 blows per foot
- Unsaturated soils above the groundwater table

The conditions at the project site satisfy the above screening criteria, and are not susceptible to liquefaction.

9.0 CONSTRUCTION CONSIDERATIONS

9.1 Existing Structures

The proposed abutment foundations will be driven behind the existing timber cribbing abutments. The as-built footing dimensions are not known with certainty and it will be the responsibility of the contractor to remove any portions of the existing abutments and footings so that they do not obstruct or conflict with the pile driving operations. The 1949 Burnham Bridge Construction Plans included as **Figure 6 and Figure 7** indicate that timber pile anchors are present approximately 20 feet behind each existing abutment and are attached to the existing abutments with tie rods. Boring BB-WGLC-102 was drilled approximately 14 feet behind the south abutment within the limits of the existing anchors and tie-rods and may have encountered these subsurface elements.

Additionally, other man made or natural obstructions (such as cobbles and boulders) may be encountered at either of the proposed abutment locations and have the potential to impede pile driving operations. If obstructions are encountered prior to reaching the minimum required pile tip they may be addressed by pre-augering, using pile toe reinforcement or by conventional excavation methods for the near surface obstructions. Other methods may be used by the contractor with the approval of the Engineer.

Pile toe reinforcement using commercially manufactured cast pile shoes is recommended for H-piles driven through or into very dense soil or soil containing boulders or other obstructions. Shoes that are attached to the H-piles with fillet welds along the outside of each flange are recommended. Additionally, pile shoes fabricated from cast steel (ASTM A 27) are recommended because of their strength and durability.

9.2 Dynamic Pile Load Testing Program

Wave equation analysis should be performed by the contractor to verify that the proposed pile hammer is adequate to drive the piles to the required nominal resistances without subjecting the pile to stresses greater than 45 ksi. The first pile driven at each abutment should be dynamically tested to confirm nominal pile resistance and develop a driving criterion for the remainder of the piles. The pile driving acceptance criteria should prevent pile damage and be structured so that the end of initial drive penetration resistance is

between 3 and 15 blows per inch over the final 6 inches of driving. If the pile penetration is less than 0.5 inches over 10 consecutive blows, the driving may be terminated.

10.0 LIMITATIONS OF REPORT

The conclusions and recommendations contained in this report are based upon the subsurface data obtained during this investigation and on details stated in this report. The validity of the conclusions and recommendations contained in this report are necessarily limited by, among other things, the scope of field investigation and by the number of borings. Therefore, given the nature of this subsurface study, there is a possibility that actual conditions encountered will differ from those discussed in this report. Should conditions arise which differ from those described in this report, HNTB should be notified immediately and provided with all information when available regarding subsurface conditions.

As part of the geotechnical recommendations presented in this report, HNTB makes no warranty as to the absence or presence of any environmental hazard or waste present on any property evaluated hereunder and all reports generated hereto are qualified as being based upon existing data reasonably available to HNTB and not subject to independent verification. HNTB is not responsible for any latent defects that could not be reasonably discovered during the performance of its services and makes no legal representations whatsoever concerning any matter, including but not limited to, the ownership of any property or the interpretation of any law. These limitations form a material part of this report and are considered incorporated by reference therein. No warranty for the contents of this report, neither expressed nor implied, is made except that professional services were performed in accordance with generally accepted principles and practices.

11.0 REFERENCES

1. AASHTO. "LRFD Bridge Design Specifications" 7th Edition, 2014

2. AASHTO. "Standard Specifications for Highway Bridges" 17th Edition, 2002.

3. FHWA, "Evaluation of Soil and Rock Properties," Geotechnical Engineering Circular No. 5, FHWA-IF-02-034, 2002.

4. FHWA, "Design and Construction of Driven Pile Foundations", Volume I, FHWA-NHI-05-042, 2006.

5. FHWA, "Design and Construction of Driven Pile Foundations", Volume II, FHWA-NHI-05-042, 2006..

6. MaineDOT, "Bridge Design Guide", Maine Department of Transportation, Prepared by Guertin Elkerton & Associates, August 2003 with 2014 updates.

7. VTrans Structures Section, "Integral Abutment Bridge Design Guidelines, Second Edition", SD0002, 2008

FIGURES

FIGURE 1

PROJECT LOCATION MAP

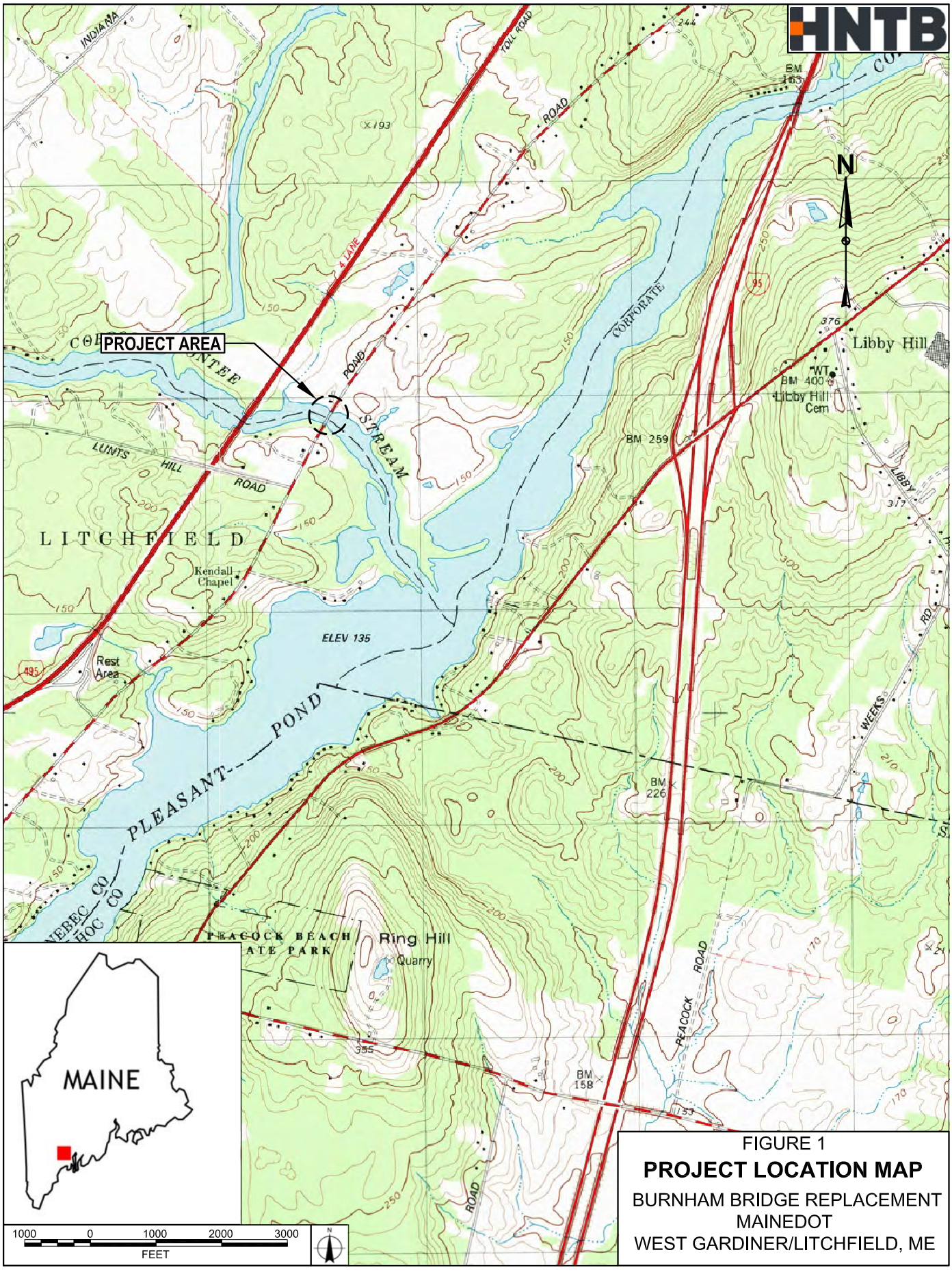


FIGURE 1

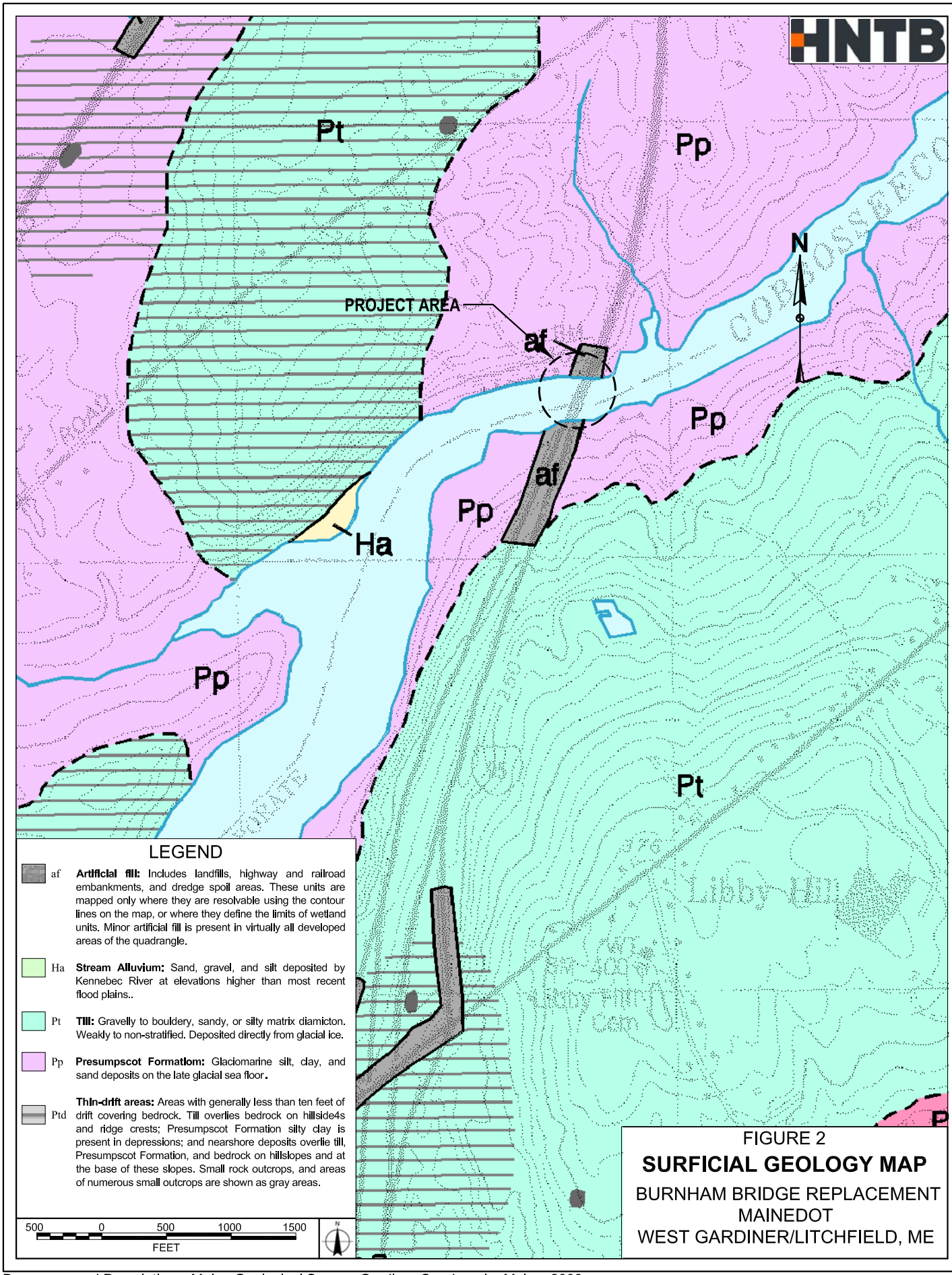
PROJECT LOCATION MAP

BURNHAM BRIDGE REPLACEMENT
MAINEDOT
WEST GARDINER/LITCHFIELD, ME

Basemap: U.S.G.S. Gardiner, Maine 1991

FIGURE 2

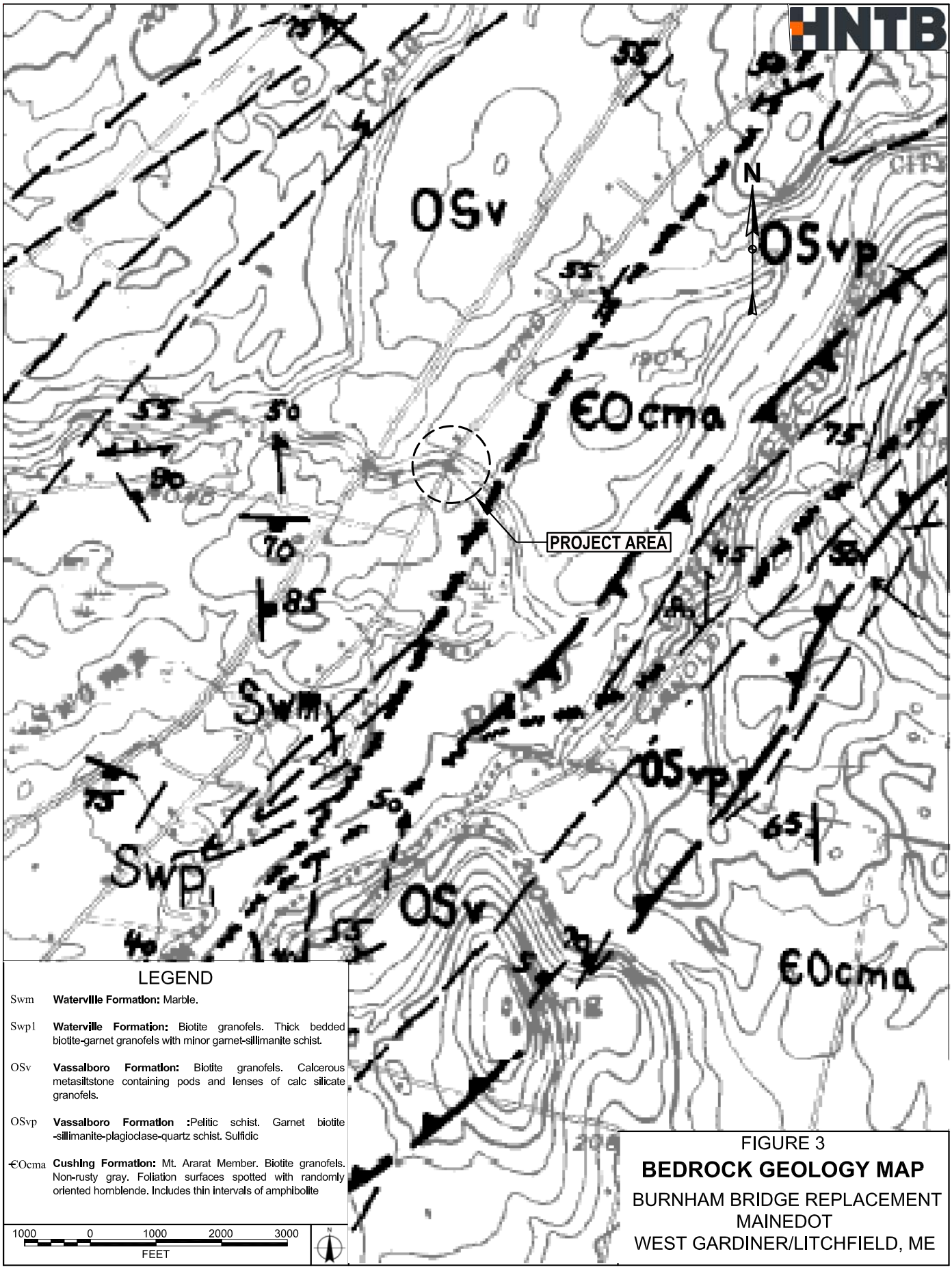
SURFICIAL GEOLOGY MAP



Basemaps and Descriptions: Maine Geological Survey, Gardiner Quadrangle, Maine, 2008

FIGURE 3

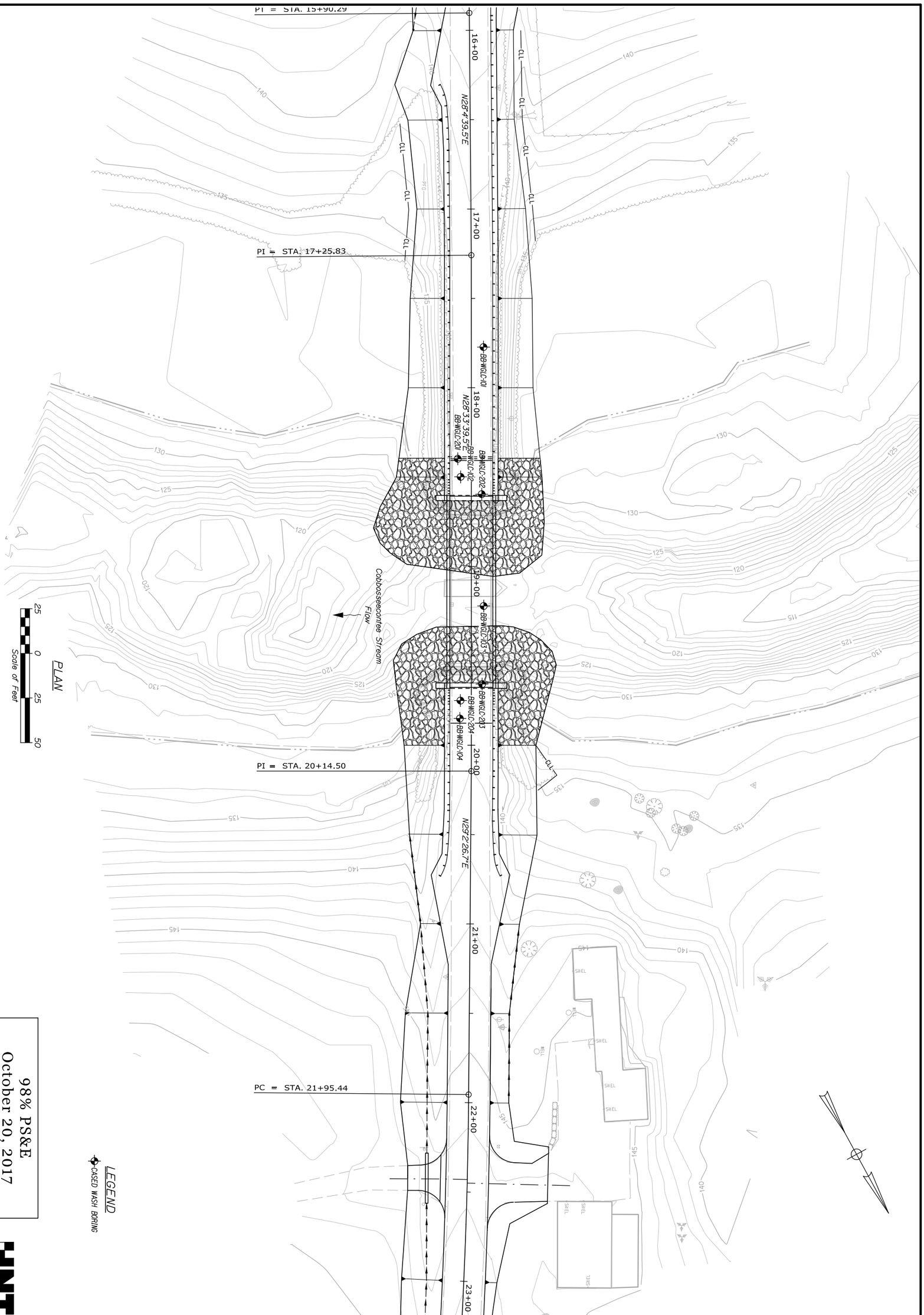
BEDROCK GEOLOGY MAP



Basemaps and Descriptions: Maine Geological Survey, "Bedrock Geology of the Gardiner 15' Quadrangle, maine", by Donald W. Newbergl, 1984.

FIGURE 4

BORING LOCATION PLAN



98% PS&E
October 20, 2017

HNTB

SHEET NUMBER 8 OF 34

BURNHAM BRIDGE
COBBOSSEECONTEE STREAM
W. GARDINER-LITCHFIELD KENNEBEC

BORING LOCATION PLAN

	PROJ. MANAGER	L. Timberlake	BY	DATE
	DESIGN-DETAILED	K. Reidy	P. Bishop	10\17
	CHECKED-REVIEWED	B. Materek	C. Morin	10\17
	DESIGN2-DETAILED2	_	_	_
	DESIGN3-DETAILED3	_	_	_
	REVISIONS 1	_		_
	REVISIONS 2	_		_
	REVISIONS 3	_		_
	REVISIONS 4	_		_
	FIELD CHANGES	_		_

SIGNATURE

P.E. NUMBER

DATE

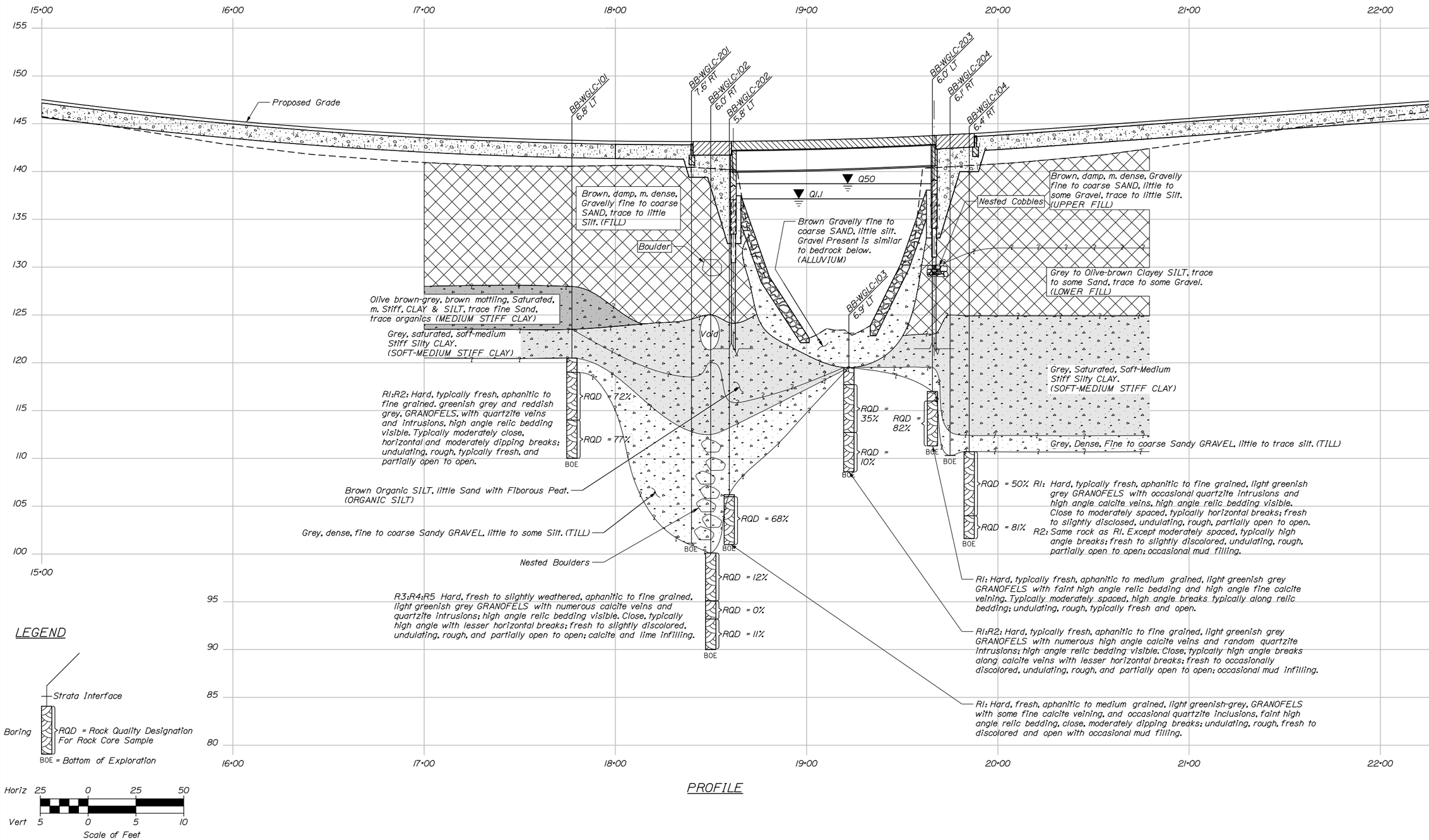
STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

WIN 018954.00

BRIDGE NO. 2112 BRIDGE PLANS

FIGURE 5

INTERPRETIVE SUBSURFACE PROFILE



NOTE:

This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

98% PS&E
October 20, 2017

HNTB

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

WIN 018954.00

BRIDGE PLANS

BRIDGE NO. 2112

	BY	DATE
PROJ. MANAGER	L. Timmerske	
DESIGN-DETAILED	P. Bishop	10\17
CHECKED-REVIEWED	K. Reidy	10\17
DESIGN2-DETAILED2	B. Materek	- -
DESIGN3-DETAILED3	C. Morin	- -
REVISIONS 1	-	- -
REVISIONS 2	-	- -
REVISIONS 3	-	- -
REVISIONS 4	-	- -
FIELD CHANGES	-	- -

SIGNATURE

P.E. NUMBER

DATE

BURNHAM BRIDGE
COBBOSSEECONTEE STREAM
W. GARDINER-LITCHFIELD KENNEBEC

INTERPRETIVE
SUBSURFACE PROFILE

SHEET NUMBER

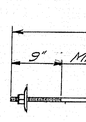
9

OF 34

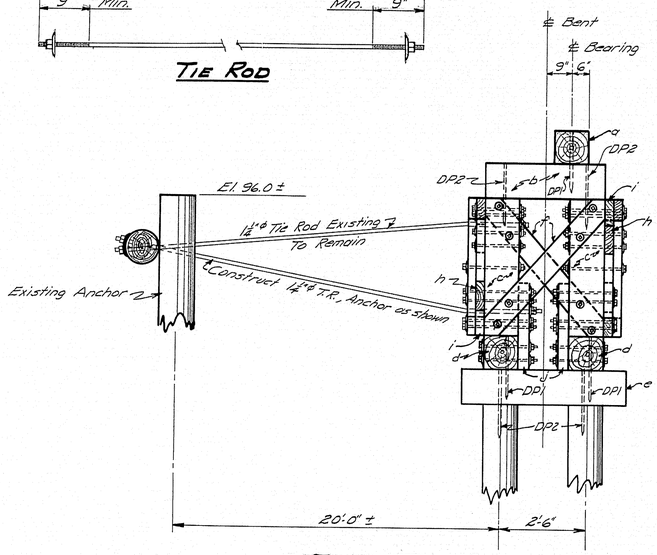
Filename: 009_Interpretive Subsurface Profile.dgn Division: Username: Date:10/19/2017

FIGURE 6

1949 DESIGN PLANS - ABUTMENTS

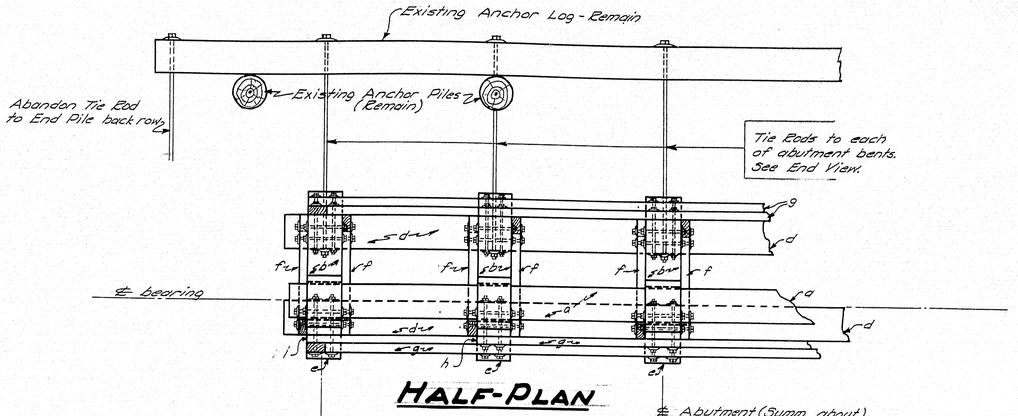


TIE ROD

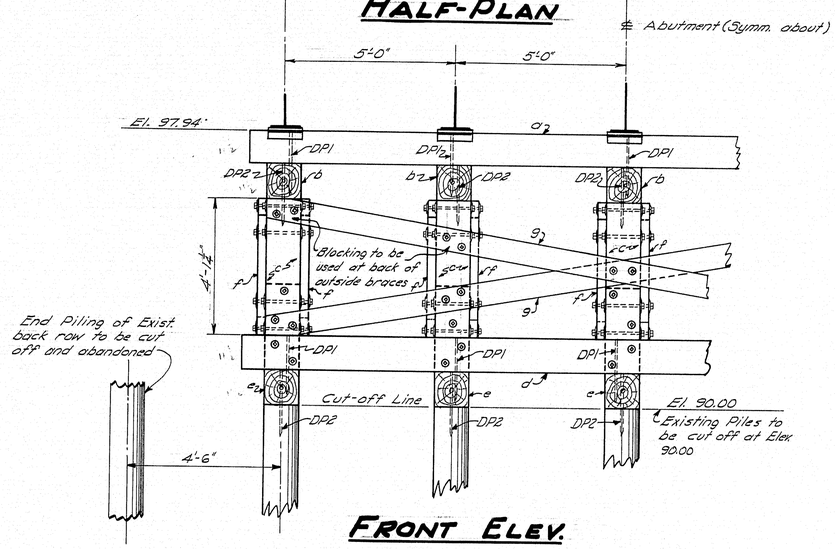


END VIEW

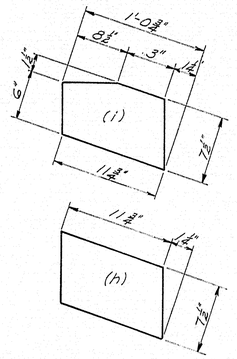
NOTE: Abut. #1 as shown - Abut. #2 Opp. hand



HALF-PLAN



FRONT ELEV.



BLOCKING PIECES

HARDWARE LIST - ABUTMENTS

No.	Size	Length	Washer	Description	Location
10	1"ø	1'-10"	——	Drift Pins (1)	Bridge Seat to Bent Caps
20	1"ø	1'-10"	——	" " (1)	Bent Sills to Pile Caps
20	1"ø	2'-0"	——	" " (2)	Bent Caps to Posts
20	1"ø	2'-0"	——	" " (2)	Pile Caps to Piles
80	⅝"ø	1'-6"	Cast-160	Mach. Bolts	Bent Bracing
80	⅝"ø	1'-6"	" -160	" "	Abutment Bracing
40	⅝"ø	1'-8"	" -80	" "	" "
16	¾"ø	2'-0"	" -32	" "	" "
10	1¼"ø	24'-0"±	" - 20	Tie Rods	Anchorages

All hardware to be galvanized

TIMBER SCHEDULE - ABUTMENTS

Mark	Fin. Size	Length	Treatment	No.	Location
a	11⅝" × 11⅝"	22'-0"	Creosote Full Length Process	2	Abutments - Bridge Seat
b		3'-6"		10	Bent Caps
c		4'-1½"		20	" Posts
d		22'-4"		4	" Sills
e	11⅝" × 11⅝"	4'-10"		10	Pile Caps
f	2⅝" × 7½"	5'-5"		20	Bent Bracing
g		21'-8"		8	Abutment Bracing
h		1'-1"		8	Blocking Piece - Interior Bents
i	2⅝" × 7½"	1'-1"		8	" " - Exterior "
j	3⅝" × 11⅝"	2'-6"		20	Scabbing; Bent Posts to Sills

DESIGN — MAGDONALD
TRACE — CLARK
CHECK — [illegible]

BRIDGE — 2112

STATE HIGHWAY COMMISSION
BRIDGE DIVISION

BURNHAM BRIDGE
OVER
COBBOSSEECONTEE STREAM
BETWEEN THE TOWNS OF
W. GARDINER & LITCHFIELD
KENNEBEC COUNTY

ABUTMENTS

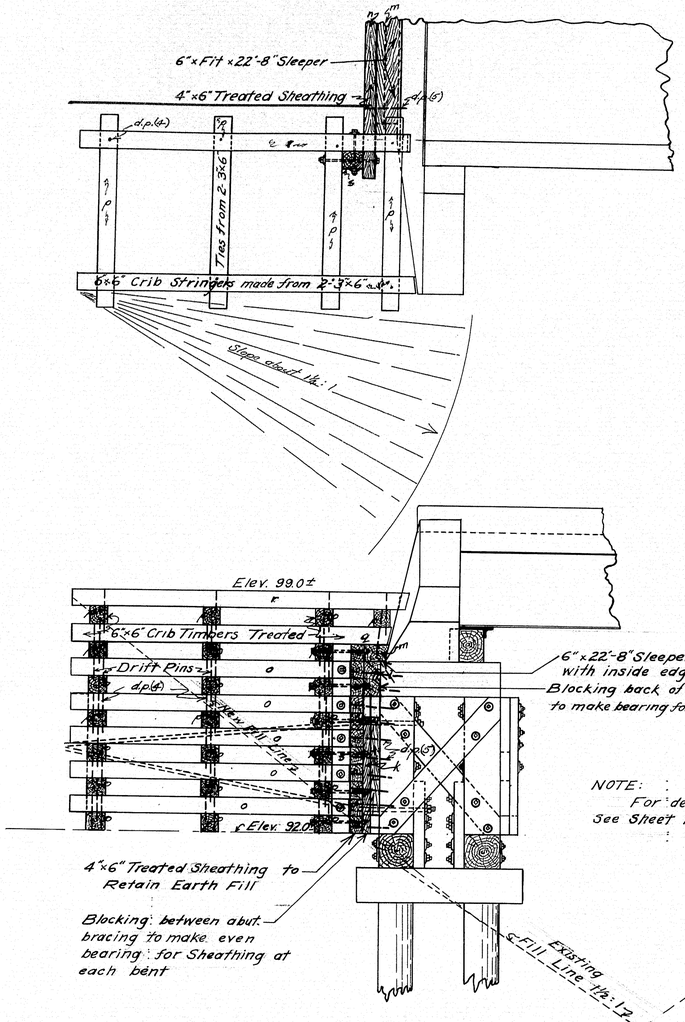
SHEET 5 OF 4 AUGUSTA, MAINE SEPT. 1949

47-17

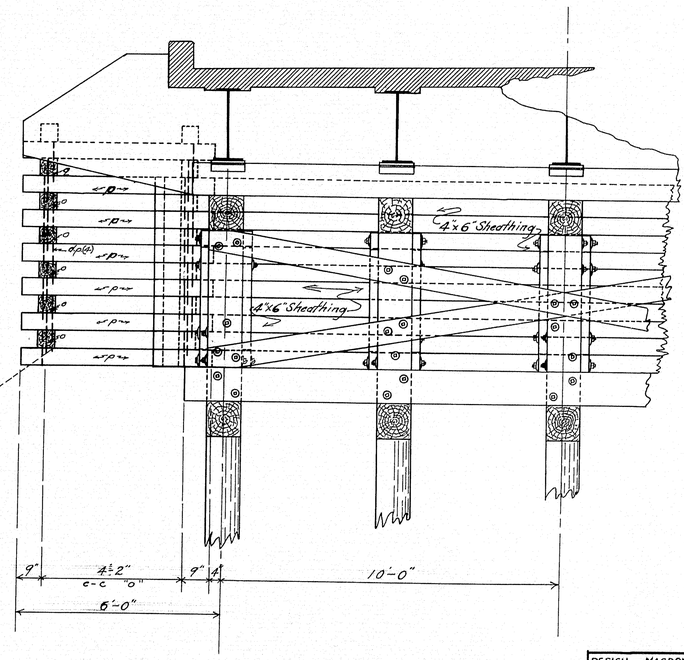
0 1 2 3 4 5 INCHES

FIGURE 7

1949 DESIGN PLANS – TIMBER CRIBBING



NOTE:
For details of abutment
See Sheet No. 3



NOTE:
Timbers shown as 6"x6" to be made of two pieces of 3"x6"
Pieces d,p, q, and r to be on flat

Timber - Salvage from Sheepscott River Br. Wiscasset - Edgecomb

HARDWARE LIST - ABUTMENTS

No.	Size	Length	Washer	Description	Location
20	¾"ø	1'-2"	Cast 2.	Mach. Bolts	Bolting Piece to Crib
24	¾"ø	1'-6"	Cast 2.	Mach. Bolts	Sheathing to Crib
328	⅝"ø	1'-4"	—	Drift Pins (4)	Crib
120	¾"ø	1'-6"	—	Drift Pins (5)	Sheathing

TIMBER SCHEDULE - ABUTMENTS

Mark	Size	Length	Treatment	No.	Location
s	6"x6"	5'-6"		4	Bolting Piece-Crib
k	2⅝"x 7½"	As Needed			Blocking under Ref. Sheathing
l	5½"x 11½"	1'-6"		10	Blocking under Ref. Sheathing (Center on Bent Cap)
m	6"x10"	22'-8"±	Creosote	2	Retaining Sheathing (Cut to fit)
n	4"x6"	24'-3"		22	Retaining Sheathing
o	6"x6"	10'-0"±		40	Crib Stringers
p	6"x6"	5'-8		88	Crib Ties
q	6"x6"	11'-6"±		8	Crib Stringers
r	6"x6	12'-0"±		8	Crib Stringers

DESIGN - MACDONALD
TRACE - MACDONALD
CHECK PJ.

BRIDGE - 2112

STATE HIGHWAY COMMISSION
BRIDGE DIVISION

BURNHAM BRIDGE
OVER
COBBOSSEECONTEE STREAM
BETWEEN THE TOWNS OF
W. GARDINER & LITCHFIELD
KENNEBEC COUNTY

ABUTMENTS

SHEET 3A OF 4 AUGUSTA, MAINE JAN. 1950

47-17A

0 1 2 3 4 5 INCHES

ATTACHMENTS

ATTACHMENT 1
BORING LOGS & ROCK CORE PHOTOS

SCHONEWALD
ENGINEERING
ASSOCIATES, INC.
■ www.SchonewaldEngineering.com ■

100-SERIES SUBSURFACE EXPLORATION LOGS

SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-101
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.5 (est'd)	**Core Barrel:**	NQ2
Operator:	Dupuis / Maynard	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	3/28/16; 0930-1610	**Drilling Method:**	cased wash boring	**Hammer Type:**	Diedrich Auto Hammer (1)
Boring Location:	87.1 ft behind S abutment; 6.8 ft LT	**Casing ID/OD:**	NW (3") telescoped inside HW (4")	**Hammer Efficiency:**	0.572
		Auger ID/OD:	SSA to 5 ft	**Water Level*:**	

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
.
.
.
-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
0							SSA	140.1		5 inches HMA	
										0.4	
	1D	14/9	2.0 - 3.2	9-11-50/2"	61	58				1D: Reddish-brown, damp, fine to coarse SAND, some Gravel, little Silt. FILL	
										3.2 ft - obstruction; relocate boring for second attempt; two additional relocations needed to advance to 10 feet.	
5	2D	24/8	5.0 - 7.0	3-11-13-12	24	23	RC			2D: Brown, damp, fine to coarse Sandy GRAVEL, little to some Silt. FILL	A-1-b, GM WC=7.9% -#200=19.8%
10	MD	24/0	10.5 - 12.5	15-19-17-14	36	34		130.0		Boney material (FILL) encountered above 10.5 ft	
										10.5	
										MD: No recovery. Likely pushed something from fill ahead of split-spoon.	
	3D	24/19	13.0 - 15.0	1-3-4-4	7	7				3D: Olive brown - grey, brown mottling, saturated, m. stiff, SILT & CLAY, trace organics, trace fine Sand. OC CLAY	A-6(20), CL WC=33.8% -#200=99.0% LL=39.6 PL=21.6 PI=18.0
15	V1 4D	1/-- 24/24	15.2 - 15.3 15.4 - 17.4	Su over 1045 psf WR-WH/12"-1	-- 0	0				V1: raw torque rdg: over 26.6 in-lbs (25.4 x 50.8 mm vane for stiff soil) 4D: Olive brown grading to grey, minor mottling, saturated, v. soft, CLAY & SILT, trace fine Sand. OC CLAY	A-6(17), CL WC=29.0% -#200=97.8% LL=34.9 PL=17.8 PI=17.1
								123.5		17.0	
										Apparent transition to NC CLAY	
20	MU 5D	0/0 8/2	20.0 - 20.0 20.0 - 20.7	-- 12-50/2"	-- --			120.5		20.0 MU: Fixed piston sampler unable to fully extend. 5D: One large piece and several chips of granitic rock.	
	R1	60/58	21.5 - 26.5	RQD: 43"=72%				119.1		21.4 21.4 ft casing refusal - roller cone to 21.5 ft and seat casing R1: Hard, typically fresh, aphanitic to fine grained, greenish grey and reddish grey, GRANOFELS, with quartzite veins and intrusions; high angle relic bedding visible. Typically moderately close, horizontal and moderately dipping breaks; undulating, rough, typically fresh, and partially open to open. Highly fractured zone (quartzite intrusion) from 24.7 to 25.5 ft. Core	
25											

Remarks:

(1) SPT energy testing (hammer calibration) was completed on January 19, 2016 using a Pile Driving Analyzer in accordance with ASTM D4633-10 using the force velocity method (EFV). Four SPT energy test series were run. The test report indicates that the measured energy transfer efficiency of the Diedrich Auto Hammer ranged from 50% to 62%, with an average of 57.2%.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

SCHONEWALD ENGINEERING ASSOCIATES, INC.	**PROJECT:** Burnham Bridge Replacement Pond Rd over Cobbosseecontee Stream **LOCATION:** West Gardiner-Litchfield, Maine	**Boring No.:**	BB-WGLC-101
		WIN:	18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.5 (est'd)	**Core Barrel:**	NQ2
Operator:	Dupuis / Maynard	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	3/28/16; 0930-1610	**Drilling Method:**	cased wash boring	**Hammer Type:**	Diedrich Auto Hammer (1)
Boring Location:	87.1 ft behind S abutment; 6.8 ft LT	**Casing ID/OD:**	NW (3") telescoped inside HW (4")	**Hammer Efficiency:**	0.572
		Auger ID/OD:	SSA to 5 ft	**Water Level*:**	

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RQD = Rock Quality Designation (%)

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WOR = weight of rods
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SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
25										times: 4:25 / 2:40 / 1:50 / 1:45 / 2:10 min:sec/ft.	
	R2	48/45	26.5 - 30.5	RQD: 37"=77%						R2: Same as R1. Fractured zone from 28. 8 to 29.0 ft. Core times: 2:30 / 2:00 / 2:20 / 2:05 min:sec/ft.	
30								110.0		30.5 **Bottom of Exploration at 30.5 feet below ground surface.**	
35											
40											
45											
50											

Remarks:

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SCHONEWALD ENGINEERING ASSOCIATES, INC.	**PROJECT:** Burnham Bridge Replacement Pond Rd over Cobbosseecontee Stream **LOCATION:** West Gardiner-Litchfield, Maine	**Boring No.:** BB-WGLC-102 **WIN:** 18954.00	

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 (est'd)	**Core Barrel:**	NQ2
Operator:	Dupuis / Maynard	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	3/29/16; 0755-3/30/16; 1320	**Drilling Method:**	cased wash boring	**Hammer Type:**	Diedrich Auto Hammer (1)
Boring Location:	14.5 ft behind S abutment; 6.0 ft RT	**Casing ID/OD:**	NW (3") telescoped inside HW (4")	**Hammer Efficiency:**	0.572
		Auger ID/OD:	SSA to 5 ft	**Water Level*:**	

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WOH = weight of 140lb. hammer
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LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
0							SSA	139.7		4" HMA 0.3	
	1D	24/10	2.0 - 4.0	7-6-5-5	11	10				1D: Brown, damp, m. dense, Gravelly fine to coarse SAND, trace to little Silt. FILL	A-1-b, SW-SM WC=4.4% -#200=9.2%
5	2D	24/2	5.0 - 7.0	8-5-6-5	11	10	RC			2D: Brown, damp, m. dense, fine to coarse SAND, little to some Gravel, little Silt. FILL	
								130.8		9.2 9.2 to 10.9 ft BGS - boulder	
10	3D	24/5	10.9 - 12.9	39-9-21-29	30	29				3D: Light grey, m. dense, GRAVEL, with mix of Clayey SILT and Sand. FILL	corrosivity series by AASHTO methods - composited samples 2D, 3D and 4D
								125.5		Cobbles / boney material above 14.5 ft 14.5 Timber / wood encountered at 14.5 ft; break through at 15.0 ft.	
15	4D	24/1	15.0 - 17.0	1-1-1-2	2	2				4D: Brown wood pulp (possibly wash). Drove as if through voids; possibly corduroy road. Attempt to wash out debris.	
	MD	24/0	17.4 - 19.4	1-1-2-1	3	3				MD: No recovery. Drove as if no resistance, unlike even a v. soft silt clay.	
20	MU	24/0	20.0 - 22.0	PUSH				120.0		20.0 MU: Push with difficulty. Wood pulp / Organic SILT and Clayey SILT on outside of tube. 20 to 22 ft Wash to 22 ft; wood pulp predominates wash water. Rinse with clean water at 22 ft.	
	5D	24/19	22.0 - 24.0	2-1-1-1	2	2				5D: Grey, saturated, soft, Silty CLAY. Chunk of wood at 12 inches above bottom of sample suggests had been pushing wood ahead of borehole; appears to be cleared.	A-6(16), CL WC=47.7% -#200=99.3% LL=33.7 PL=18.0 PI=15.7
25	V1		24.6 - 25.0	Su= 402 / 45 psf						V1: raw torque rdgs: Tu=9/Tr=1 ft-lbs (55 x 110 mm vane)	

Remarks:

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SCHONEWALD ENGINEERING ASSOCIATES, INC.	**PROJECT:** Burnham Bridge Replacement Pond Rd over Cobbosseecontee Stream **LOCATION:** West Gardiner-Litchfield, Maine	**Boring No.:** BB-WGLC-102 **WIN:** 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 (est'd)	**Core Barrel:**	NQ2
Operator:	Dupuis / Maynard	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	3/29/16; 0755-3/30/16; 1320	**Drilling Method:**	cased wash boring	**Hammer Type:**	Diedrich Auto Hammer (1)
Boring Location:	14.5 ft behind S abutment; 6.0 ft RT	**Casing ID/OD:**	NW (3") telescoped inside HW (4")	**Hammer Efficiency:**	0.572
		Auger ID/OD:	SSA to 5 ft	**Water Level*:**	

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Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
25	V2		25.6 - 26.0	Su= 380 / 45 psf						V2: raw torque rdgs: Tu=8.5/Tr=1 ft-lbs (55 x 110 mm vane)	
	MU	0/0	26.0 - 26.0	--						MU: Fixed piston sampler unable to fully extend. Eliminated vane at 26.6 to 27.0 ft due to possible disturbance from tube attempt.	
	MV			--				112.5		MV: Unable to push vane past 27.5 ft.	
	R1	60/--	28.5 - 33.5							27.5 28.3 ft Roller cone on something solid; telescope 3-inch casing. R1: Nested boulders; some significantly large. Possibly competent rock at bottom of core run.	
30											
	R2	60/--	33.5 - 38.5							R2: Continue in nested boulders.	
35											
										38.5 ft Pull 3-inch drive shoe; switch to spin shoe. Spin 3-inch casing to 39.0 ft.	
	MD	2/0	40.0 - 40.2	50/2"	--			101.0		39.0 39.0 ft Possible competent rock at 39.0 ft; break through with roller cone at 39.9 ft. MD: No recovery. Possible open fracture.	
40	R3	60/45	40.0 - 45.0	RQD: 7"=12%						R3: Hard, fresh to slightly weathered, aphanitic to fine grained, light greenish grey GRANOFELS with numerous calcite veins and quartzite intrusions; high angle relic bedding visible. Close, typically high angle with lesser horizontal breaks; fresh to slightly discolored, undulating, rough, and partially open to open; calcite and lime infilling. Upper 0.9 feet appears to be soil / open fracture based on wash water; fractured from 42.1 to 42.3 ft. Core times: 1:00 / 2:15 / 3:35 / 3:25 / 3:50 min:sec/ft.	
45	R4	23/23	45.0 - 46.9	RQD: 0"=0%						R4: Same as R3. Highly fractured and partially decomposed from 46.4 to 46.9 ft, with lime infilling. Core times: 4:10 / -- min:sec/ft.	
	R5	37/29	46.9 - 50.0	RQD: 4"=11%						R5: Same as R3. Core times: -- / 5:00 / 4:05 / 5:40 min:sec/ft.	
50											

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PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-102
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 (est'd)	**Core Barrel:**	NQ2
Operator:	Dupuis / Maynard	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	3/29/16; 0755-3/30/16; 1320	**Drilling Method:**	cased wash boring	**Hammer Type:**	Diedrich Auto Hammer (1)
Boring Location:	14.5 ft behind S abutment; 6.0 ft RT	**Casing ID/OD:**	NW (3") telescoped inside HW (4")	**Hammer Efficiency:**	0.572
		Auger ID/OD:	SSA to 5 ft	**Water Level*:**	

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Depth (ft.)	Sample Information: Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
50								90.0		50.0 **Bottom of Exploration at 50.0 feet below ground surface.**	
										Bottom of Exploration at 50.0 feet below ground surface.	
55											
60											
65											
70											
75											

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PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-103
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	121.3 (est'd)	**Core Barrel:**	NQ2
Operator:	Dupuis / Maynard	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	3/31/16; 1040-1700	**Drilling Method:**	cased wash boring	**Hammer Type:**	Diedrich Auto Hammer (1)
Boring Location:	9.8 ft N of ctr joint; 6.9 ft LT	**Casing ID/OD:**	NW (3") telescoped inside HW (4")	**Hammer Efficiency:**	0.572
		Auger ID/OD:		**Water Level*:**	

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-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
0	1D	20/7	0.0 - 1.7	2-3-13-50/2"	16	15	RC	119.5		1D: Brown, Gravelly fine to coarse SAND, little Silt; changing at approx. 1.6 ft to grey, GRAVEL, some Silt, some fine to coarse Sand; gravel appears to be broken bedrock. [Note sample jar broke; second "redo" surficial sample obtained due to broken glass in sample by angling rods through deck; similar material description.]	A-1-b, SM WC=20.3% -#200=14.7% hydrometer
										1.8 ft Refusal of 4-inch casing. Telescope 3-inch casing and spin to 3.3 ft.; no notable drops. 3.3 ft Refusal of 3-inch casing.	
	R1	60/60	3.3 - 8.3	RQD: 21"=35%						R1: Hard, typically fresh, aphanitic to fine grained, light greenish grey GRANOFELS with numerous high-angle calcite veins and random quartzite intrusions; high angle relic bedding visible. Close, typically high angle breaks along calcite veins with lesser horizontal breaks; fresh to occasionally discolored, undulating, rough, and partially open to open; occasional mud infilling. Core times: 3:35 / 3:10 / 3:00 / 4:10 / 4:35 min:sec/ft.	
5			7.4 - 7.8								UCT qp = 11.83 ksi
	R2	49/49	8.3 - 12.4	RQD: 5"=10%						R2: Same as R1. Core times: 4:30 / 4:05 / 4:30 / 4:05 / -- min:sec/ft	
10								108.9		12.4	
										Bottom of Exploration at 12.4 feet below ground surface.	
15											
20											
25											

Remarks:

Concrete deck 7 inch thick. Measured 18.7 feet from top of deck to mudline; depths recorded are below mudline.
(1) SPT energy testing (hammer calibration) was completed on January 19, 2016 using a Pile Driving Analyzer in accordance with ASTM D4633-10 using the force velocity method (EFV). Four SPT energy test series were run. The test report indicates that the measured energy transfer efficiency of the Diedrich Auto Hammer ranged from 50% to 62%, with an average of 57.2%.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-104
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.5 (est'd)	**Core Barrel:**	NQ2
Operator:	Dupuis / Maynard	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	3/30/16; 1335-3/31/16; 0920	**Drilling Method:**	cased wash boring	**Hammer Type:**	Diedrich Auto Hammer (1)
Boring Location:	24.8 ft behind N abutment; 6.4 ft RT	**Casing ID/OD:**	NW (3") telescoped inside HW (4")	**Hammer Efficiency:**	0.572
		Auger ID/OD:	SSA to 5 ft	**Water Level*:**	

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
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-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
0							SSA	140.1		5 in. HMA	
										0.4	
	1D	24/5	2.0 - 4.0	8-9-9-7	18	17				1D: Brown, damp, m. dense, fine to coarse SAND, little to some Gravel, trace to little Silt. FILL	corrosivity series by AASHTO methods
5	2D	24/7	5.0 - 7.0	6-6-6-4	12	11	30			2D: Brown, damp, m. dense, fine to coarse SAND, some Gravel, trace to little Silt. FILL	A-1-b, SW-SM WC=4.5% -#200=7.3%
							23				
							14				
							16	132.0		8.5	
							22				
10	3D	24/16	10.0 - 12.0	7-5-7-8	12	11	42			3D: Olive-brown, mottled, stiff, Clayey SILT, trace fine Sand, trace Gravel; appears reworked. FILL	corrosivity series by ASTM and EPA methods
							53				
							56				
							57				
							56				
15	4D	24/19	15.0 - 17.0	8-5-4-4	9	9	RC	124.9		Olive-brown, mottled, Clayey SILT, trace fine Sand, trace Gravel. FILL	
										15.6	A-6(14), CL WC=32.6% -#200=97.6% LL=33.0 PL=19.0 PI=14.0
										Changing at 15.6 ft to 4D: Olive-brown, mottled, stiff, CLAY & SILT, trace fine Sand. OC CLAY (Native)	
	U1	24/24	18.0 - 20.0	PUSH						U1: Olive-brown, CLAY & SILT.	1D consol LL=45.2 PL=24.2 PI=21.0
20	5D	24/24	20.0 - 22.0	VANE INTERVAL	--					5D: Grey, Silty CLAY.	A-6(10), CL WC=41.4% -#200=99.3% LL=29.4 PL=17.9 PI=11.5
	V1		20.6 - 21.0	Su= 848/ 179 psf						V1: raw torque rdgs: Tu=19/Tr=4 ft-lbs (55 x 110 mm vane)	
	V2		21.6 - 22.0	Su= 670/ 179 psf						V2: raw torque rdgs: Tu=15/Tr=4 ft-lbs (55 x 110 mm vane)	
								117.0		23.5	
25											

Remarks:

(1) SPT energy testing (hammer calibration) was completed on January 19, 2016 using a Pile Driving Analyzer in accordance with ASTM D4633-10 using the force velocity method (EFV). Four SPT energy test series were run. The test report indicates that the measured energy transfer efficiency of the Diedrich Auto Hammer ranged from 50% to 62%, with an average of 57.2%.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-104
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.5 (est'd)	**Core Barrel:**	NQ2
Operator:	Dupuis / Maynard	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	3/30/16; 1335-3/31/16; 0920	**Drilling Method:**	cased wash boring	**Hammer Type:**	Diedrich Auto Hammer (1)
Boring Location:	24.8 ft behind N abutment; 6.4 ft RT	**Casing ID/OD:**	NW (3") telescoped inside HW (4")	**Hammer Efficiency:**	0.572
		Auger ID/OD:	SSA to 5 ft	**Water Level*:**	

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
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-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
25	U2	24/24	25.0 - 27.0	HYD PUSH						U2: Grey, Silty CLAY.	1D consol LL=42.0 PL=21.6 PI=20.4
	V3		27.6 - 28.0	Su= 714/ 164 psf						V3: raw torque rdgs: Tu=26/Tr=6 ft-lbs (65 x 130 mm vane)	
								112.4		28.1	
	MV			--						MV: Unable to push past 28.1 ft. 28.5 ft BGS Solid grind with roller cone; possible weathered rock. 29.2 ft BGS Roller cone refusal.	
								110.7		29.8	
30	R1	60/60	30.0 - 35.0 30.2 - 30.6	RQD: 30"=50%						29.8 ft BGS Refusal of 3-inch (spin) casing. R1: Hard, typically fresh, aphanitic to fine grained, light greenish grey GRANOFELS with occasional quartzite intrusions and high angle calcite veins; high angle relic bedding visible. Close to moderately spaced, typically horizontal breaks; fresh to slightly discolored, undulating, rough, partially open to open. Possible open fracture at 35.0 ft. Core times: 5:05 / 3:55 / 3:55 / 3:55 / 3:30 min:sec/ft.	UCT qp = 18.32 ksi
35	R2	47/45	35.0 - 38.9	RQD: 38"=81%						R2: Same rock as R1. Moderately spaced, typically high angle breaks; fresh to slightly discolored, undulating, rough, partially open to open; occasional mud infilling. Core times: 4:00 / 8:00 / 4:45 / -- min:sec/ft.	
								101.6		38.9	
40										**Bottom of Exploration at 38.9 feet below ground surface.**	
45											
50											

Remarks:

(1) SPT energy testing (hammer calibration) was completed on January 19, 2016 using a Pile Driving Analyzer in accordance with ASTM D4633-10 using the force velocity method (EFV). Four SPT energy test series were run. The test report indicates that the measured energy transfer efficiency of the Diedrich Auto Hammer ranged from 50% to 62%, with an average of 57.2%.

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SCHONEWALD
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■ www.SchonewaldEngineering.com ■

200-SERIES SUBSURFACE EXPLORATION LOGS

SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-201
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 ft. (est'd)	**Core Barrel:**	--
Operator:	Schaefer/ Royal	**Datum:**		**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-51	**Hammer Wt./Fall:**	140 lbs. / 30 inches
Date Start/Finish:	7/26/17; 1410-7/27/17; 1225	**Drilling Method:**	cased wash boring	**Hammer Type:**	rope and cathead
Boring Location:	24.6' south of south abutment, 7.6' RT	**Casing ID/OD:**	HW (4") to 39.3 ft.	**Hammer Efficiency:**	0.60
		Auger ID/OD:	SSA to 5 ft.	**Water Level*:**	--

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
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-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
0							SSA	139.5		6 inches HMA (0.5)	
	1D	24/13	1.0 - 3.0	10-10-7-8	17	17				1D: Brown, damp, m. dense, Gravelly fine to coarse SAND, trace to little Silt. FILL	
5	2D	24/6	5.0 - 7.0	3-4-4-2	8	8	19			2D: Brown, damp to moist, loose, Gravelly fine to coarse SAND, trace to little Silt. FILL	A-1-b, SW-SM WC=6.3% -#200=9.8%
							17				
							15				
							18				
							13	131.0		(9.0)	
10	3D	24/4	10.0 - 12.0	2-5-3-3	8	8	8			3D: Black-brown, WOOD. Disturbed grey silt in tip of spoon.	
							11	128.1		(11.9)	
							16				
							33				
	MV						30			MV: Unable to push vane at 15.0 ft.	
15	4D	24/22	15.0 - 17.0	2-1-2-2	3	3	RC	124.3		4D: Grey, SILT, little v. fine Sand, with one piece rounded Gravel at top of sample RECENT ALLUVIUM; grading at 15.7 ft to: (15.7)	A-4(0), ML WC=32.2% -#200=95.6% hydrometer
										4D-A: Brown, FIBROUS PEAT and ORGANIC SILT, little fine Sand, with wood and reeds.	
	5D	24/22	17.0 - 19.0	2/12"-2-2	3	3	RC			5D: Brown, v. loose, ORGANIC SILT, little fine Sand with wood, peat, and roots.	A-7-5(62), MH WC=140.2% -#200=85.5% LL=146.7 PL=102.5 PI=44.2
							24				
20	6D	24/24	20.0 - 22.0	1/18"-2	1	1	PUSH			6D: Brown, v. loose, fine Sandy ORGANIC SILT, with fibrous peat and wood; changing at 21.5 ft to:	
								118.5		(21.5)	
	7D V1	24/24	22.0 - 24.0 22.6 - 23.0	VANE INTERVAL Su= 604 / 55 psf						6D-A: Grey, CLAY & SILT. 7D: Grey, Silty CLAY. V1: Tu=22/Tr=2 ft-lbs (65 mm x 130 mm vane)	CL WC=43.5% LL=39.1 PL=21.8 PI=17.3
	V2		23.6 - 24.0	Su= 467 / 41 psf						V2: Tu=17/Tr=1.5 ft-lbs (65 mm x 130 mm vane)	
25											

Remarks:

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SCHONEWALD ENGINEERING ASSOCIATES, INC.	**PROJECT:** Burnham Bridge Replacement Pond Rd over Cobbosseecontee Stream **LOCATION:** West Gardiner-Litchfield, Maine	**Boring No.:** BB-WGLC-201 **WIN:** 18954.00	

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 ft. (est'd)	**Core Barrel:**	--
Operator:	Schaefer/ Royal	**Datum:**		**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-51	**Hammer Wt./Fall:**	140 lbs. / 30 inches
Date Start/Finish:	7/26/17; 1410-7/27/17; 1225	**Drilling Method:**	cased wash boring	**Hammer Type:**	rope and cathead
Boring Location:	24.6' south of south abutment, 7.6' RT	**Casing ID/OD:**	HW (4") to 39.3 ft.	**Hammer Efficiency:**	0.60
		Auger ID/OD:	SSA to 5 ft.	**Water Level*:**	--

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
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-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
25	8D V3	24/24	25.0 - 27.0 25.6 - 26.0	VANE INTERVAL Su= 467 / 55 psf						8D: Grey, Silty CLAY. V3: Tu=17/Tr=2 ft-lbs (65 mm x 130 mm vane)	CL WC=46.4% LL=43.4 PL=21.6 PI=21.8
	V4		26.6 - 27.0	Su= 577 / 55 psf						V3: Tu=21/Tr=2 ft-lbs (65 mm x 130 mm vane)	
							62	112.8		27.2 27.2 ft: Bottom of soft stratum.	
							70				
							68				
30	9D	24/11	30.0 - 32.0	15-26-20-15	46	46	56			9D: Grey, dense, fine to coarse Sandy GRAVEL, little to some Silt. TILL	
							70				
							66				
							50				
							45				
35	10D	24/12	35.0 - 37.0	22-27-24-25	51	51	88			10D: Grey, v. dense, fine to coarse Sandy GRAVEL, some Silt. TILL	A-1-b, SM WC=8.2% -#200=22.1%
							78				
							115				
							110				
							90/3"	100.7		39.3 ft: Casing refusal. 39.3 **Bottom of Exploration at 39.3 feet below ground surface.** at casing refusal.	
40											
45											
50											

Remarks:

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SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-202
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 ft. (est'd)	**Core Barrel:**	NQ2
Operator:	Schaefer/ Royal	**Datum:**		**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-51	**Hammer Wt./Fall:**	140 lbs. / 30 inches
Date Start/Finish:	7/25/17; 0805-1705	**Drilling Method:**	cased wash boring	**Hammer Type:**	rope and cathead
Boring Location:	4.8' south of south abutment, 5.8' LT	**Casing ID/OD:**	HW (4") and NW (3") to 34.0'	**Hammer Efficiency:**	0.60
		Auger ID/OD:	SSA to 5 ft.	**Water Level*:**	--

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
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-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
0							SSA	139.3		9" HMA 0.8	
	1D	24/10	1.0 - 3.0	8-7-12-25	19	19				1D: Brown, damp, m. dense, fine to coarse Sandy GRAVEL, trace to little Silt. FILL	
5	2D	24/12	5.0 - 7.0	4-5-5-3	10	10	29			2D: Reddish brown, moist, loose, Gravelly fine to coarse SAND, trace Silt. FILL	
							42				
							44				
							34				
							37				
10	3D	24/5	10.0 - 12.0	14-24-15-5	39	39	20			3D: Grey, dense, GRAVEL, some fine to coarse Sand, little Silt. FILL	A-1-a, GW-GM WC=9.5% -#200=9.5%
							32				
							29				
							13				
							162				
15	4D	24/6	15.0 - 17.0	6-3-12-14	15	15	18	124.7		4D: Grey, m. dense, GRAVEL, some Silt, little fine to coarse Sand. (0.2 ft void (drop) at 15.3 ft) 15.3	
							25				
							33				
							RC	121.5		18.5 18.5 ft: Wood encountered at 18.5 ft, below a 6-in cobble. Grab sample of drill cuttings mostly wood/wood pulp. Occasional small voids based on drilling behavior.	
20	5D	24/7	20.0 - 22.0	4-5-5-5	10	10	RC	120.0		20.0 ft: Bottom of wood; organic silt in wash water. 20.0 5D: Dark brown, stiff, ORGANIC SILT, little fine Sand.	
										22.0 ft: Wash out with clean water before SPT/sample.	
	6D	24/16	22.0 - 24.0	3-3-5-5	8	8	RC			6D: Dark brown, m. stiff, ORGANIC SILT, some fine Sand, with pockets of fibrous peat.	A-4(0), ML WC=101.0% -#200=74.0% LL=NV PL=NP PI=NP
								116.0		24.0	
25											

Remarks:

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SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-202
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 ft. (est'd)	**Core Barrel:**	NQ2
Operator:	Schaefer/ Royal	**Datum:**		**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-51	**Hammer Wt./Fall:**	140 lbs. / 30 inches
Date Start/Finish:	7/25/17; 0805-1705	**Drilling Method:**	cased wash boring	**Hammer Type:**	rope and cathead
Boring Location:	4.8' south of south abutment, 5.8' LT	**Casing ID/OD:**	HW (4") and NW (3") to 34.0'	**Hammer Efficiency:**	0.60
		Auger ID/OD:	SSA to 5 ft.	**Water Level*:**	--

IN-SITU SAMPLING AND TESTING:
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MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
.
.
.
-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
25	7D V1	22/22	25.0 - 26.8 25.6 - 26.0	VANE INTERVAL Su= 591 / 69 psf			RC			7D: Grey, Silty CLAY. V1: Tu=21.5/Tr=2.5 ft-lbs (65 mm x 130 mm vane)	CL WC=42.7% LL=48.3 PL=21.8 PI=26.5
	V2		26.4 - 26.8	Su= 563 / 41 psf				113.2		V2: Tu=20.5/Tr=1.5 ft-lbs (65 mm x 130 mm vane). Unable to push past 26.8 ft. 26.8	
30	8D	24/3	30.0 - 32.0	11-34-2-10	36	36	32 45 70 110			8D: Grey, dense, GRAVEL, little to some fine to coarse Sand, trace to little Silt. TILL	A-1-a, GP-GM WC=8.7% -#200=6.2%
	R1	60/57	34.0 - 39.0	RQD: 41"=68%				106.0		34.0 R1: Hard, typically fresh, aphanitic to medium grained, light greenish grey GRANOFELS with faint high-angle relic bedding, some high-angle fine calcite veining, and occasional quartzite inclusions. Typically close, moderately dipping breaks; undulating, rough, fresh to discolored, and open with occasional mud infilling. One weathered quartzite vein from 37.2 to 37.5 feet. Core times: 2:50 / 2:30 / 2:40 / 2:00 / 2:55 min:sec/ft. FAIR ROCK QUALITY.	
35								101.0		39.0 **Bottom of Exploration at 39.0 feet below ground surface.**	
40											
45											
50											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-203
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 ft. (est'd)	**Core Barrel:**	NQ2
Operator:	Schaefer/ Royal	**Datum:**		**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-51	**Hammer Wt./Fall:**	140 lbs. / 30 inches
Date Start/Finish:	7/26/17; 0800-1350	**Drilling Method:**	cased wash boring	**Hammer Type:**	rope and cathead
Boring Location:	5.6' north of north abutment, 6.0' LT	**Casing ID/OD:**	HW (4") to 20'; NW (3") to 24.0'	**Hammer Efficiency:**	0.60
		Auger ID/OD:	SSA to 5 ft.	**Water Level*:**	--

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
.
.
-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
0							SSA	139.6		5 inches HMA	
										0.4	
	1D	24/13	1.0 - 3.0	8-10-8-10	18	18				1D: Brown, damp, m dense, fine to medium SAND, some Gravel, little Silt, trace coarse Sand. FILL	
5	2D	24/12	5.0 - 7.0	5-5-3-3	8	8	32			2D: Brown, damp to moist, loose, Gravelly fine to coarse SAND, trace to little Silt. FILL	A-1-b, SW-SM WC=5.2% -#200=7.5%
							27				
							28				
							35				
							55				
10							RC	130.2		9.8	
	3D	24/5	11.0 - 13.0	5-2-14-9	16	16	38			9.8 ft: Nested cobbles; no water return. Drop through void at 10.7 ft; fetch up at 11.0 ft. 3D: Dark grey, m. dense, coarse Sandy GRAVEL, trace Silt, trace fine to medium Sand, with one 2-inch layer grey SILT & CLAY (mixture of granular fill and disturbed marine silt-clay). MISC FILL (void 11.5 to 11.8 ft)	
							32				
							30				
							48				
15	4D	24/7	15.0 - 17.0	7-7-8-10	15	15	35			4D: Dark grey, m. dense, mixture of granular fill and disturbed marine silt-clay. MISC FILL	
							35				
							52	123.0		17.0	
							115			17 to 20 ft: Minor amounts of wood observed in wash water.	
							78				
20	5D	24/12	20.0 - 22.0	3-WOH/12"-7	0	0	RC	120.0		20.0	
										5D: Dark grey, v. soft, Silty CLAY; appears undisturbed. Possible sand on sample in tip of spoon,	CL WC=42.6% LL=45.3 PL=21.7 PI=23.6
								118.0		22.0	
										22 ft: Dense sand and gravel at 22.0 ft based on drilling behavior.	
								117.0		23.0	
										23 ft: Weathered rock at 23.0 ft based on drilling behavior. 24 ft: Casing refusal at 24.0 ft.	
								116.0		24.0	
25	R1	56/55	24.0 - 28.7	RQD: 46"=82%						R1: Hard, typically fresh, aphanitic to medium grained, light	

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-203
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 ft. (est'd)	**Core Barrel:**	NQ2
Operator:	Schaefer/ Royal	**Datum:**		**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-51	**Hammer Wt./Fall:**	140 lbs. / 30 inches
Date Start/Finish:	7/26/17; 0800-1350	**Drilling Method:**	cased wash boring	**Hammer Type:**	rope and cathead
Boring Location:	5.6' north of north abutment, 6.0' LT	**Casing ID/OD:**	HW (4") to 20'; NW (3") to 24.0'	**Hammer Efficiency:**	0.60
		Auger ID/OD:	SSA to 5 ft.	**Water Level*:**	--

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
.
.
.
-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample Information: Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
25										greenish grey GRANOFELS, with faint high-angle relic bedding and high-angle fine calcite veining. Typically moderately spaced, high-angle breaks typically along relic bedding; undulating, rough, typically fresh and open. Core times: 4:00 / 3:05 / 2:30 / 2:30 / -- min:sec/ft. GOOD ROCK QUALITY	
								111.3		28.7	
										Bottom of Exploration at 28.7 feet below ground surface.	
30											
35											
40											
45											
50											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-204
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 ft. (est'd)	**Core Barrel:**	--
Operator:	Schaefer/ Royal	**Datum:**		**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-51	**Hammer Wt./Fall:**	140 lbs. / 30 inches
Date Start/Finish:	7/27/17; 1250-1710	**Drilling Method:**	cased wash boring	**Hammer Type:**	rope and cathead
Boring Location:	14.8' north of north abutment, 6.1' RT	**Casing ID/OD:**	HW (4") to 25 ft.	**Hammer Efficiency:**	0.60
		Auger ID/OD:	SSA to 5 ft.	**Water Level*:**	--

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
.
.
.
-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
0							SSA	139.6		5 inches HMA	
										0.4	
	1D	24/7	1.0 - 3.0	8-12-12-14	24	24				1D: Light brown, damp, m. dense, fine to medium SAND, some Gravel, trace to little Silt, trace coarse Sand. FILL	
5	2D	24/12	5.0 - 7.0	6-4-2-4	6	6	24			2D: Brown, moist, loose, fine to coarse SAND, some Gravel, trace Silt. FILL	A-1-b, SW-SM WC=5.1% -#200=5.3%
							27				
							19				
							17	131.5		8.5	
							22				
10	3D	24/15	10.0 - 12.0	3-3-3-2	6	6	8			3D: Dark brown, WOOD, with some sand and gravel; changing at 11.4 ft to:	A-4(0), ML WC=229.5% -#200=68.6% hydrometer
							12	128.6		11.4	
							15			3D-A: Blue-grey to grey, SILT, some fine Sand, trace coarse Sand. RECENT ALLUVIUM	
							25				
							39				
15	4D	24/0	15.0 - 17.0	3-3-4-4	7	7	36	125.0		15.0	
							45			Standard split-spoon empty; appears to have pushed something ahead of spoon. Re-sampled using 3-inch diameter spoon; large rounded gravel 0.6 ft from top of spoon. 4D: Olive brown and grey, mottled, SILT & CLAY, little fine Sand. OC MARINE SILT- CLAY	CL WC=34.6% LL=42.7 PL=24.0 PI=18.7
							50				
							62	121.5		18.5	
							62				
20	5D V1	24/24	20.0 - 22.0 20.6 - 21.0	VANE INTERVAL Su= 577 / 82 psf			38			5D: Grey, CLAY & SILT. V1: Tu=21/Tr=3 ft-lbs (65 mm x 130 mm vane)	
	V2		21.6 - 22.0	Su= 618 / 82 psf			40			V2: Tu=22.5/Tr=3 ft-lbs (65 mm x 130 mm vane)	
							40				
	6D V3	24/24	23.0 - 25.0 23.6 - 24.0	VANE INTERVAL Su= 426 / 55 psf			45			6D: Grey, Silty CLAY; concretion noted at 24.2 ft. V3: Tu=15.5/Tr=2 ft-lbs (65 mm x 130 mm vane)	CL WC=42.0% LL=42.5 PL=20.7 PI=21.8
25	MV		24.2 - 24.2				52			MV: Unable to push 65 mm x 130 mm vane past 24.2 ft.	

Remarks:

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* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

PROJECT: Burnham Bridge Replacement
Pond Rd over Cobbosseecontee Stream
LOCATION: West Gardiner-Litchfield, Maine

Boring No.: BB-WGLC-204
WIN: 18954.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	140.0 ft. (est'd)	**Core Barrel:**	--
Operator:	Schaefer/ Royal	**Datum:**		**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-51	**Hammer Wt./Fall:**	140 lbs. / 30 inches
Date Start/Finish:	7/27/17; 1250-1710	**Drilling Method:**	cased wash boring	**Hammer Type:**	rope and cathead
Boring Location:	14.8' north of north abutment, 6.1' RT	**Casing ID/OD:**	HW (4") to 25 ft.	**Hammer Efficiency:**	0.60
		Auger ID/OD:	SSA to 5 ft.	**Water Level*:**	--

IN-SITU SAMPLING AND TESTING:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt

ADDITIONAL DEFINITIONS:
N-uncorrected = N value
N_{60} = N value corrected for hammer efficiency
hammer efficiency = calculated hammer efficiency
S_u = Insitu Field Vane Shear Strength (psf)
R = Rock Core Sample
RQD = Rock Quality Designation (%)

ADDITIONAL DEFINITIONS:
WOH = weight of 140lb. hammer
WOR = weight of rods
.
.
.
-- = not recorded

BOREHOLE ADVANCEMENT METHOD:
SSA=solid stem auger/HSA=hollow stem auger/RC=roller cone

LABORATORY TEST RESULTS:
LL=Liquid Limit / PL=Plastic Limit / PI=Plasticity Index
WC = water content, percent
-#200 = percent fines from grain size analysis
UCT qp = peak compressive strength of rock

Depth (ft.)	Sample Information: Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N-60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Lab. Testing Results
25	7D	24/15	25.5 - 27.5	WOR/12"-9-15	9	9	RC			7D: Grey, Silty CLAY. Piece of gravel in tip of spoon.	
								113.3		26.7 ft: Dense sand and gravel based on drilling behavior. (26.7)	
30								109.8		(30.2) **Bottom of Exploration at 30.2 feet below ground surface.** at roller cone refusal	
35											
40											
45											
50											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

SCHONEWALD
ENGINEERING
ASSOCIATES, INC.
■ www.SchonewaldEngineering.com ■

ROCK CORE PHOTOGRAPHS
(100- AND 200-SERIES)

Photo 1: Core box containing dried rock core from test boring BB-WGLC-101 left side of core box (top portion of cores).
Slots from top to bottom 1) BB-WGLC-101, R1; 2) BB-WGLC-101, R2.

Photo 2: Core box containing dried rock core from test boring BB-WGLC-101 – right side of core box (bottom portion of cores).
Slots from top to bottom 1) BB-WGLC-101, R1; 2) BB-WGLC-101, R2.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

ROCK CORE PHOTOGRAPHS
TEST BORING BB-WGLC-101
BURNHAM BRIDGE REPLACEMENT
POND ROAD OVER COBBOSSEECONTEE STREAM
WEST GARDINER-LITCHFIELD, MAINE

Sheet No.:

1 of 5

Photo 3: Core box containing dried rock core from test boring BB-WGLC-102 left side of core box (top portion of cores).
Slots from top to bottom 1) BB-WGLC-102, R1 & R2 (nested boulders and cobbles);
2) BB-WGLC-102, R3; 3) BB-WGLC-102, R4; 4) BB-WGLC-102, R5.

Photo 4: Core box containing dried rock core from test boring BB-WGLC-102 – right side of core box (bottom portion of cores).
Slots from top to bottom 1) empty; 2) BB-WGLC-102, R3; 3) empty; 4) empty.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

ROCK CORE PHOTOGRAPHS
TEST BORING BB-WGLC-102
BURNHAM BRIDGE REPLACEMENT
POND ROAD OVER COBBOSSEECONTEE STREAM
WEST GARDINER-LITCHFIELD, MAINE

Sheet No.:

2 of 5

Photo 5: Core box containing dried rock core from test boring BB-WGLC-103 left side of core box (top portion of cores).
Slots from top to bottom 1) BB-WGLC-103, R1; 2) BB-WGLC-103, R2.

Photo 6: Core box containing dried rock core from test boring BB-WGLC-103 – right side of core box (bottom portion of cores).
Slots from top to bottom 1) BB-WGLC-103, R1; 2) BB-WGLC-103, R2.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

ROCK CORE PHOTOGRAPHS
TEST BORING BB-WGLC-103
BURNHAM BRIDGE REPLACEMENT
POND ROAD OVER COBBOSSEECONTEE STREAM
WEST GARDINER-LITCHFIELD, MAINE

Sheet No.:

3 of 5

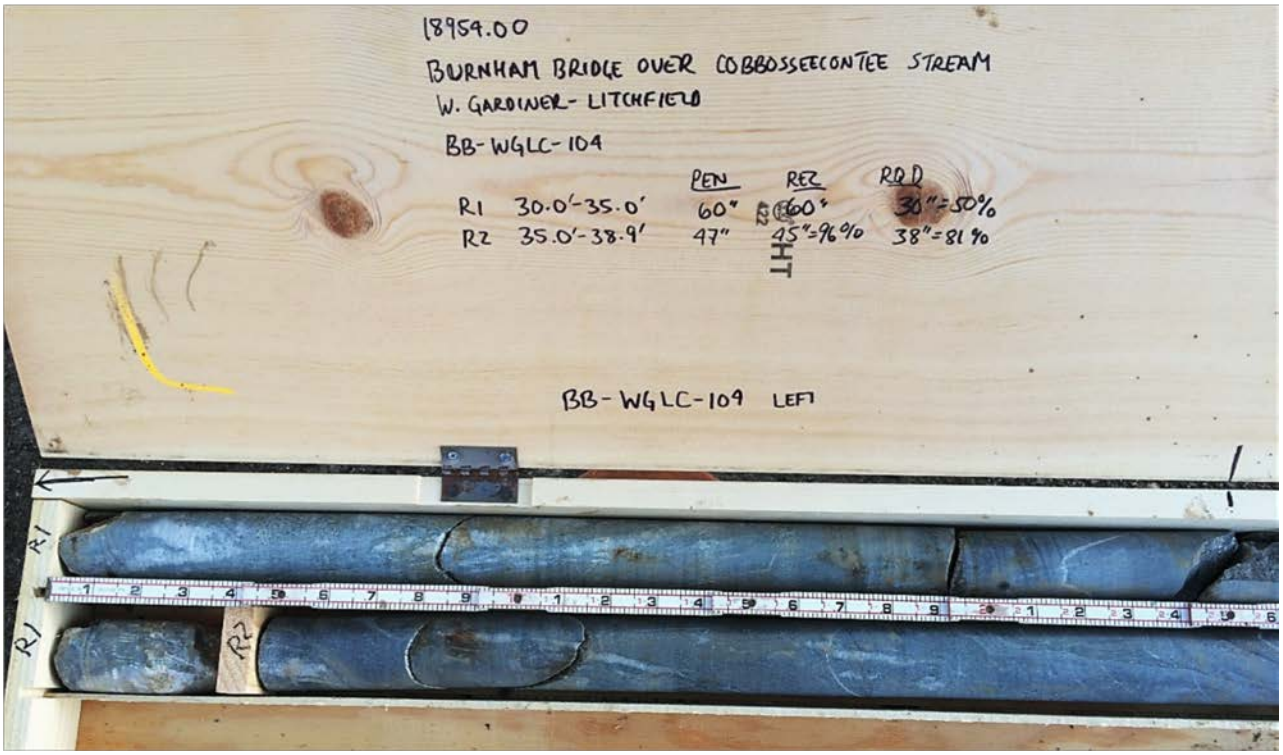

Photo 7: Core box containing dried rock core from test boring BB-WGLC-104 left side of core box (top portion of cores).
Slots from top to bottom 1) BB-WGLC-104, R1; 2) BB-WGLC-104, R1 (bottom) and R2.

Photo 8: Core box containing dried rock core from test boring BB-WGLC-104 – right side of core box (bottom portion of cores).
Slots from top to bottom 1) BB-WGLC-104, R1; 2) BB-WGLC-104, R2.

SCHNEWALD ENGINEERING ASSOCIATES, INC.

ROCK CORE PHOTOGRAPHS
TEST BORING BB-WGLC-104
BURNHAM BRIDGE REPLACEMENT
POND ROAD OVER COBBOSSEECONTEE STREAM
WEST GARDINER-LITCHFIELD, MAINE

Sheet No.:

4 of 5

Photo 9: Core box containing dried rock core from test borings BB-WGLC-202 and BB-WGLC-203 - left side of core box (top portion of cores).
Slots from top to bottom 1) BB-WGLC-202, R1; 2) BB-WGLC-203, R1.

Photo 10: Core box containing dried rock core from test borings BB-WGLC-202 and BB-WGLC-203 – right side of core box (bottom portion of cores).
Slots from top to bottom 1) BB-WGLC-202, R1; 2) BB-WGLC-203, R1.

SCHONEWALD ENGINEERING ASSOCIATES, INC.

ROCK CORE PHOTOGRAPHS
TEST BORINGS BB-WGLC-202 AND BB-WGLC-203
BURNHAM BRIDGE REPLACEMENT
POND ROAD OVER COBBOSSEECONTEE STREAM
WEST GARDINER-LITCHFIELD, MAINE

Sheet No.:

5 of 5

ATTACHMENT 2
LAB TESTING RESULTS

SCHONEWALD
ENGINEERING
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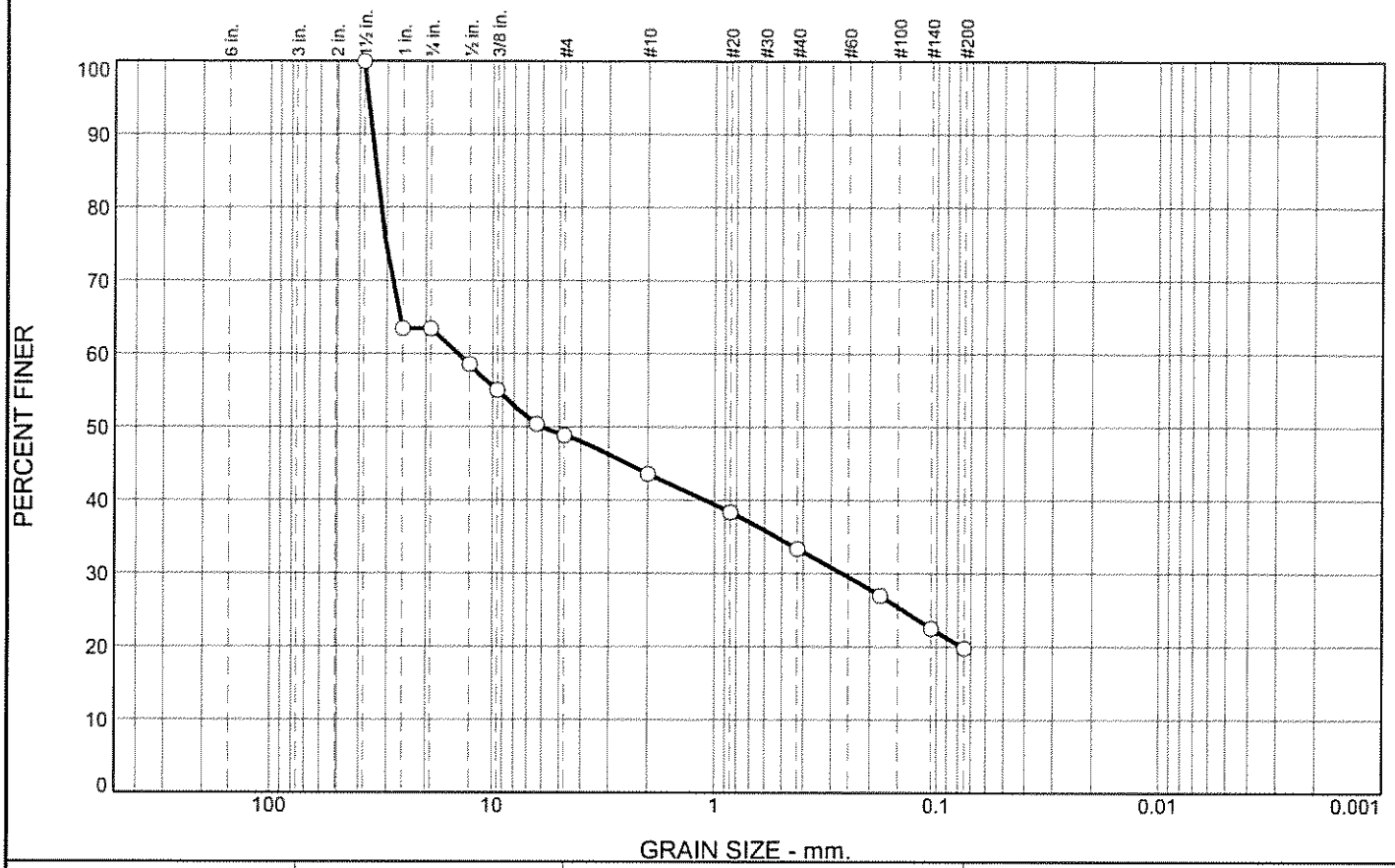
100-SERIES SOILS LABORATORY TEST RESULTS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	36.6	14.6	5.2	10.2	13.6	19.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 1/2"	100.0		
1"	63.4		
3/4"	63.4		
1/2"	58.5		
3/8"	55.0		
1/4"	50.4		
#4	48.8		
#10	43.6		
#20	38.3		
#40	33.4		
#80	27.0		
#140	22.5		
#200	19.8		

* (no specification provided)

Soil Description

Fill - silty gravel with sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 33.4704 D_{60}= 14.3081 D_{50}= 6.0506
D_{30}= 0.2667 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GM AASHTO= A-1-b

Remarks

Moisture Content: 7.9%

Sample No.: 2D **Source of Sample:** BB-WGLC-101 **Date:** 04/29/2016
Location: W. Gardiner-Litchfield **Elev./Depth:** 5'-7'

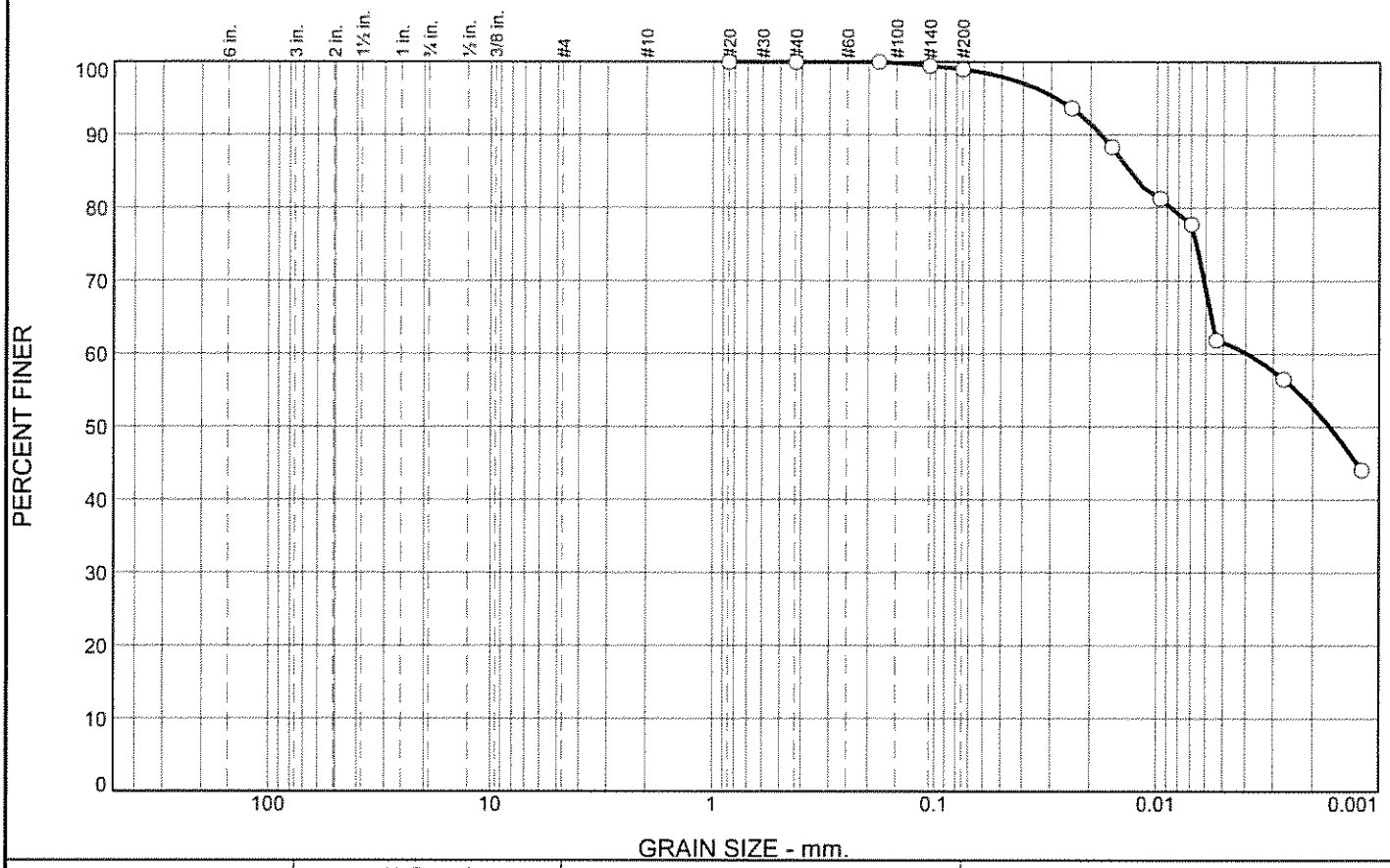
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc.
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)
Project No: 1368-003 **Lab No.** 14006a

Tested By: JEL **Checked By:** MTG

MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	1.0	37.5	61.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	100.0		
#80	100.0		
#140	99.5		
#200	99.0		
0.0243 mm.	93.7		
0.0160 mm.	88.3		
0.0097 mm.	81.3		
0.0070 mm.	77.8		
0.0054 mm.	61.8		
0.0027 mm.	56.5		
0.0012 mm.	44.1		

* (no specification provided)

Soil Description

lean clay

Atterberg Limits

PL= 21.6 LL= 39.6 PI= 18.0

Coefficients

D_{85}= 0.0133 D_{60}= 0.0039 D_{50}= 0.0017
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO= A-6(20)

Remarks

Moisture Content: 33.8%

Sample No.: 3D **Source of Sample:** BB-WGLC-101 **Date:** 5/9/16
Location: W. Gardiner-Litchfield **Elev./Depth:** 13'-15'

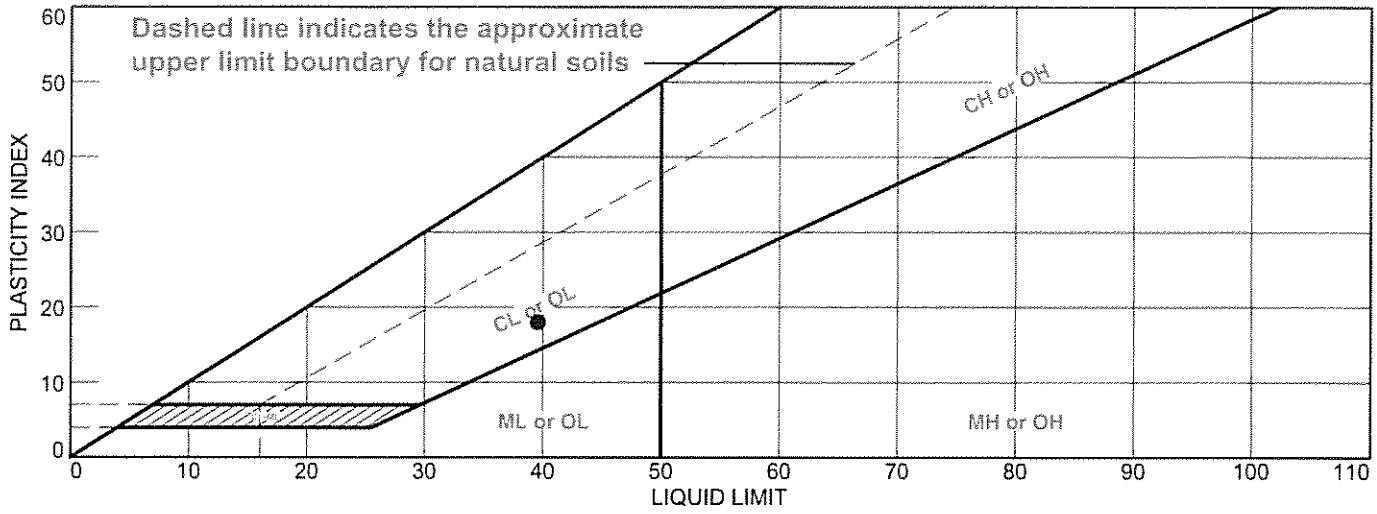
R.W. Gillespie & Associates, Inc.
Saco, Maine

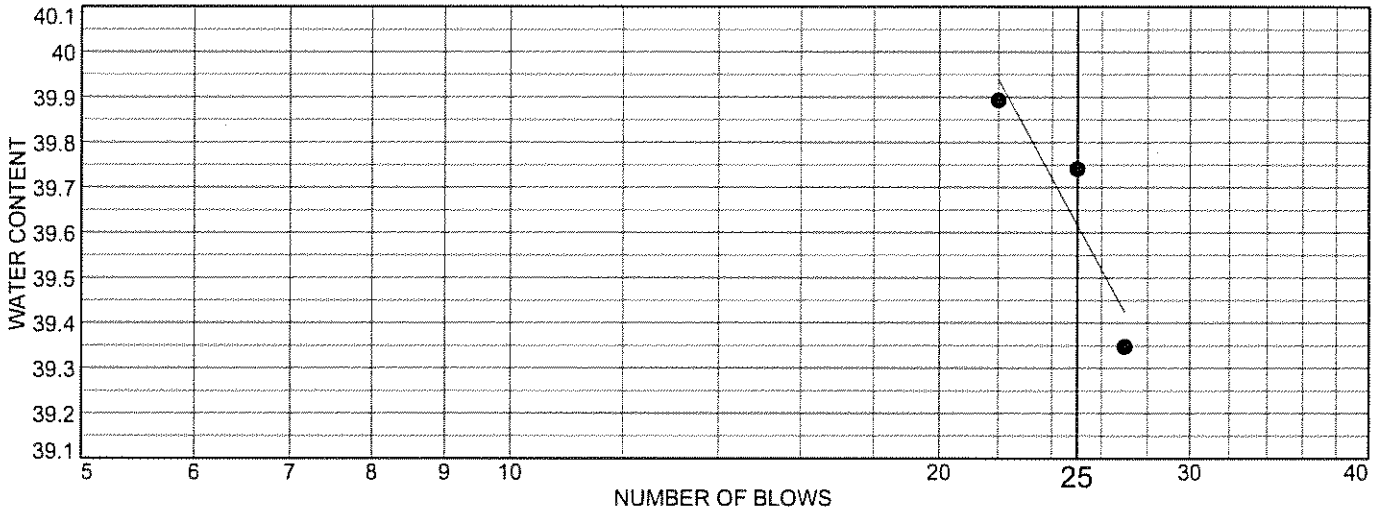
Client: Schonewald Engineering Associates, Inc.
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Project No: 1368-003 **Lab No.** 14007a

Tested By: JEL **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	lean clay	39.6	21.6	18.0	100.0	99.0	CL

Project No. 1368-003 **Client:** Schonewald Engineering Associates, Inc.

Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

● **Location:** W. Gardiner-Litchfield **Depth:** 13'-15' **Sample Number:** 3D

Remarks:

● Moisture: 33.8%
Source BB-WGLC-101

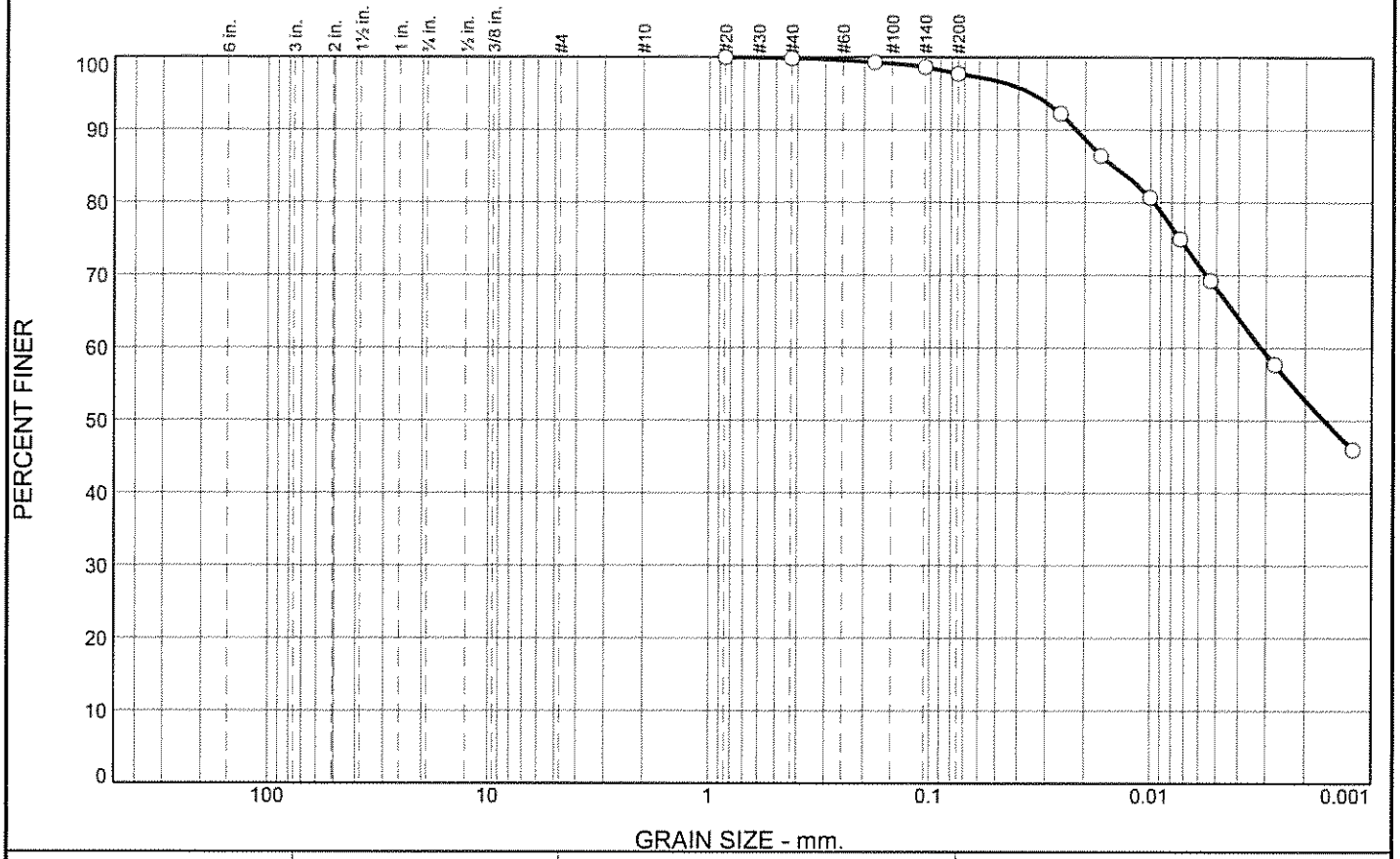
R.W. Gillespie & Associates, Inc.

Saco, Maine

Lab No. 14007a

Tested By: JEL **Checked By:** MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	2.1	29.6	68.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	99.9		
#80	99.3		
#140	98.7		
#200	97.8		
0.0259 mm.	92.2		
0.0169 mm.	86.5		
0.0101 mm.	80.7		
0.0073 mm.	75.0		
0.0053 mm.	69.3		
0.0028 mm.	57.7		
0.0012 mm.	46.0		

* (no specification provided)

Soil Description

lean clay

Atterberg Limits

PL= 17.8 LL= 34.9 PI= 17.1

Coefficients

D_{85}= 0.0148 D_{60}= 0.0032 D_{50}= 0.0016
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO= A-6(17)

Remarks

Moisture Content: 29.0%

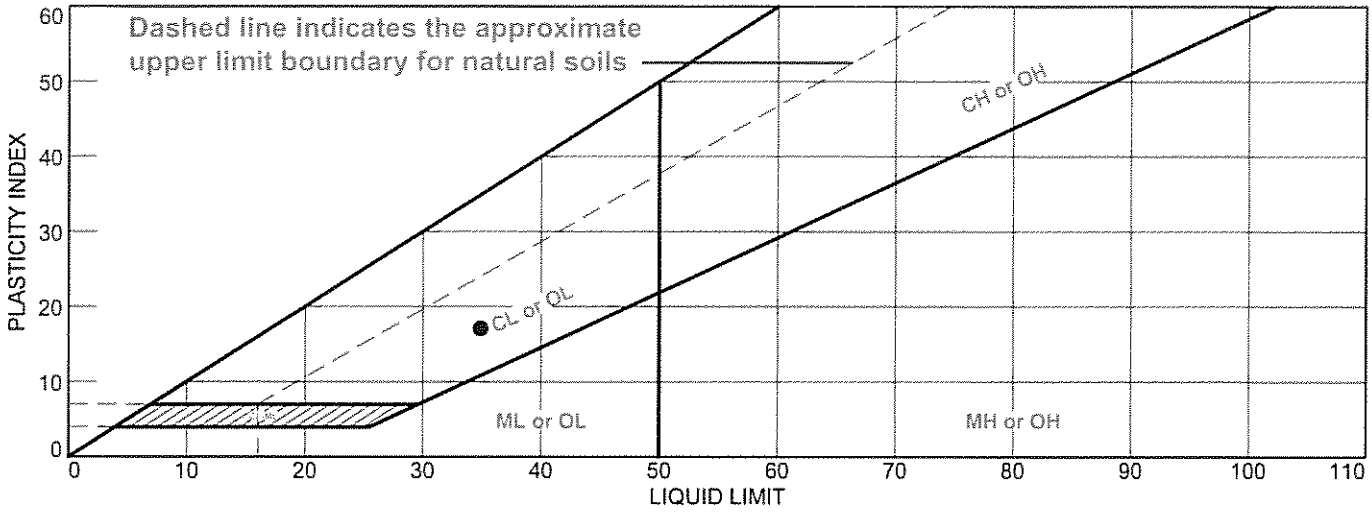
Sample No.: 4D **Source of Sample:** BB-WGLC-101 **Date:** 5/9/16
Location: W. Gardiner-Litchfield **Elev./Depth:** 15.4'-17.4'

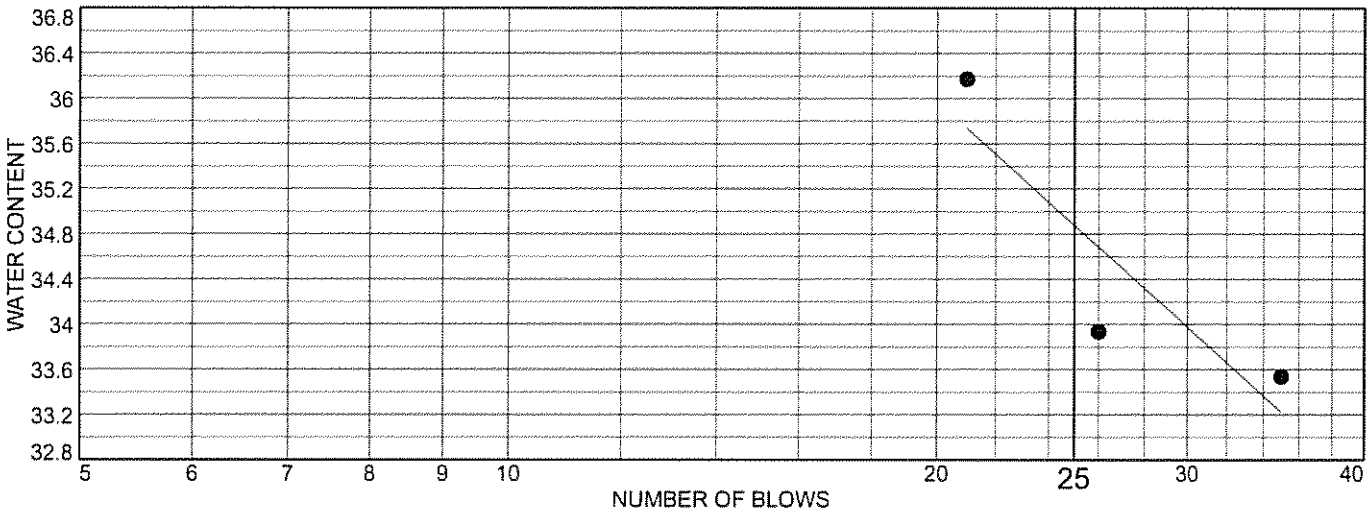
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc.
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)
Project No: 1368-003 **Lab No.** 14007b

Tested By: JEL **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	lean clay	34.9	17.8	17.1	99.9	97.8	CL

Project No. 1368-003 **Client:** Schonewald Engineering Associates, Inc.

Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

● **Loc.:** W. Gardiner-Litchfield **Depth:** 15.4'-17.4' **Sample No.:** 4D

Remarks:

● Moisture Content: 29.0%
Source: BB-WGLC-101

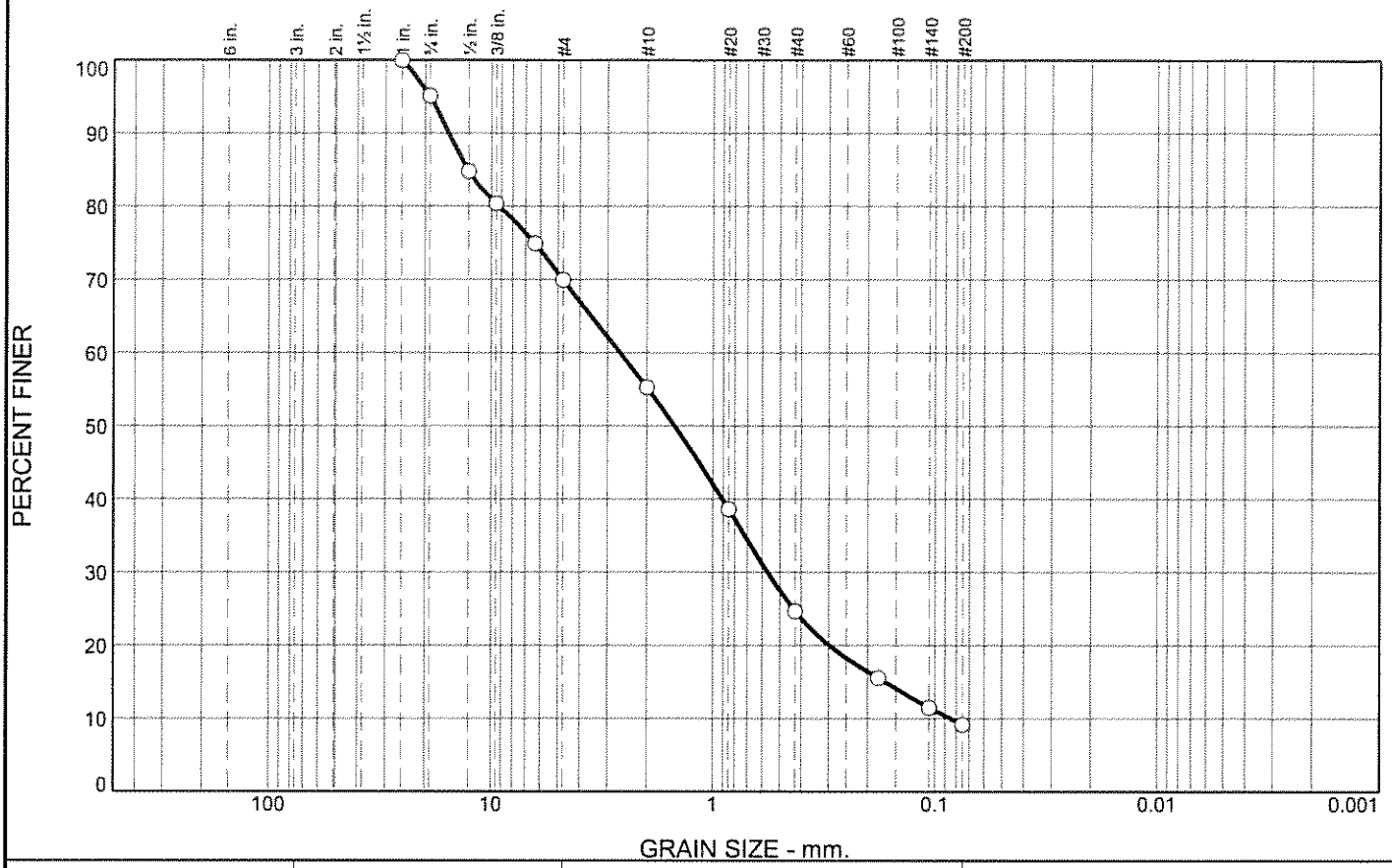
R.W. Gillespie & Associates, Inc.

Saco, Maine

Lab No. 14007b

Tested By: JEL **Checked By:** MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	4.9	25.2	14.7	30.5	15.5	9.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	95.1		
1/2"	84.8		
3/8"	80.4		
1/4"	74.9		
#4	69.9		
#10	55.2		
#20	38.6		
#40	24.7		
#80	15.6		
#140	11.5		
#200	9.2		

* (no specification provided)

Soil Description

Fill - well-graded sand with silt and gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 12.8275 D_{60}= 2.6410 D_{50}= 1.4987
D_{30}= 0.5671 D_{15}= 0.1679 D_{10}= 0.0849
C_u= 31.09 C_c= 1.43

Classification

USCS= SW-SM AASHTO= A-1-b

Remarks

Moisture Content: 4.4%

Sample No.: 1D **Source of Sample:** BB-WGLC-102 **Date:** 04/29/2016
Location: W. Gardiner-Litchfield **Elev./Depth:** 2'-4'

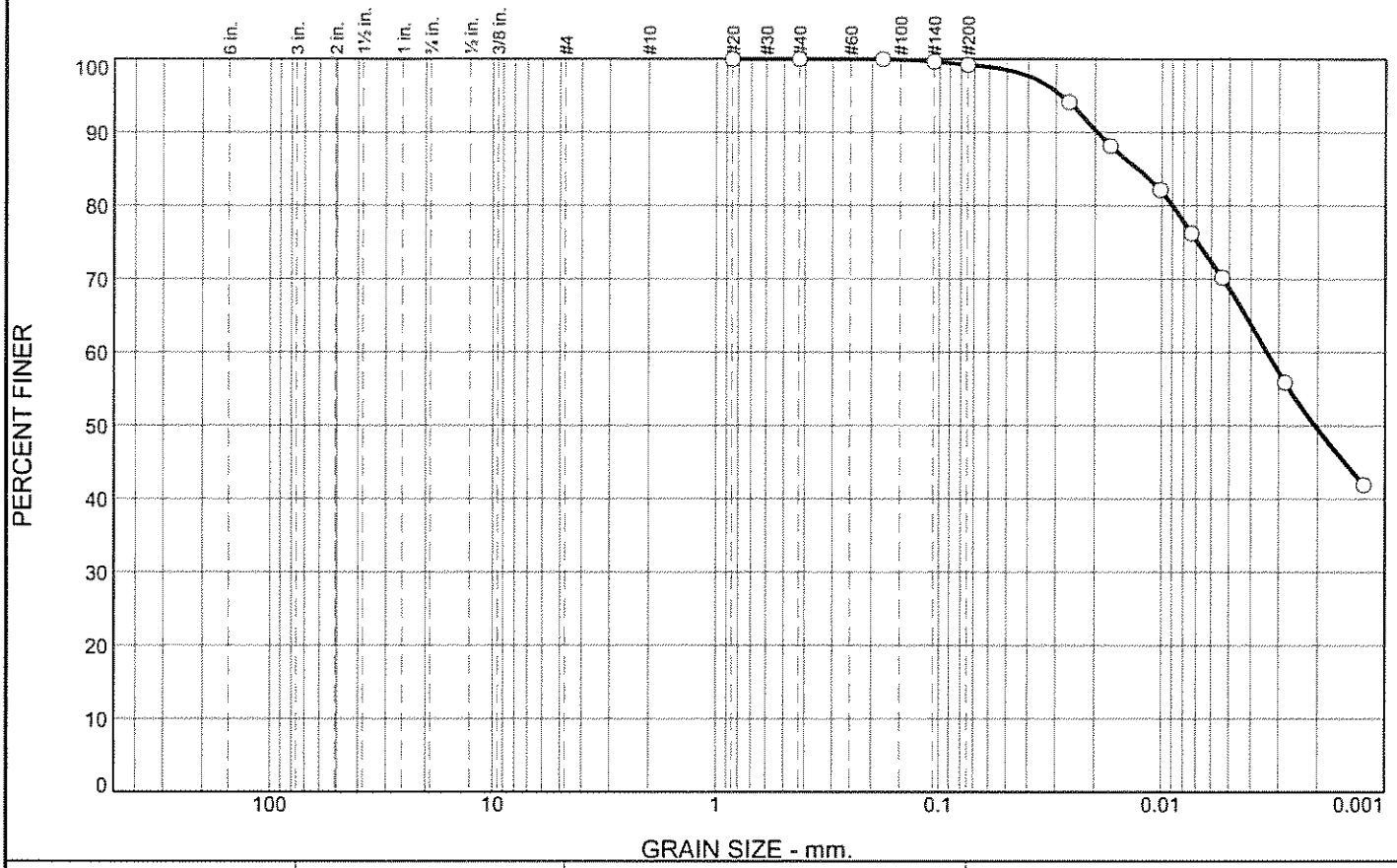
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc.
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)
Project No: 1368-003 **Lab No.** 14006b

Tested By: JEL **Checked By:** MTG

MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	0.7	30.6	68.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	100.0		
#80	100.0		
#140	99.7		
#200	99.3		
0.0262 mm.	94.2		
0.0171 mm.	88.2		
0.0102 mm.	82.2		
0.0074 mm.	76.2		
0.0054 mm.	70.2		
0.0028 mm.	55.9		
0.0012 mm.	41.9		

* (no specification provided)

Soil Description

lean clay

Atterberg Limits

PL= 18.0 LL= 33.7 PI= 15.7

Coefficients

D_{85}= 0.0127 D_{60}= 0.0034 D_{50}= 0.0021
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO= A-6(16)

Remarks

Moisture Content: 47.7%

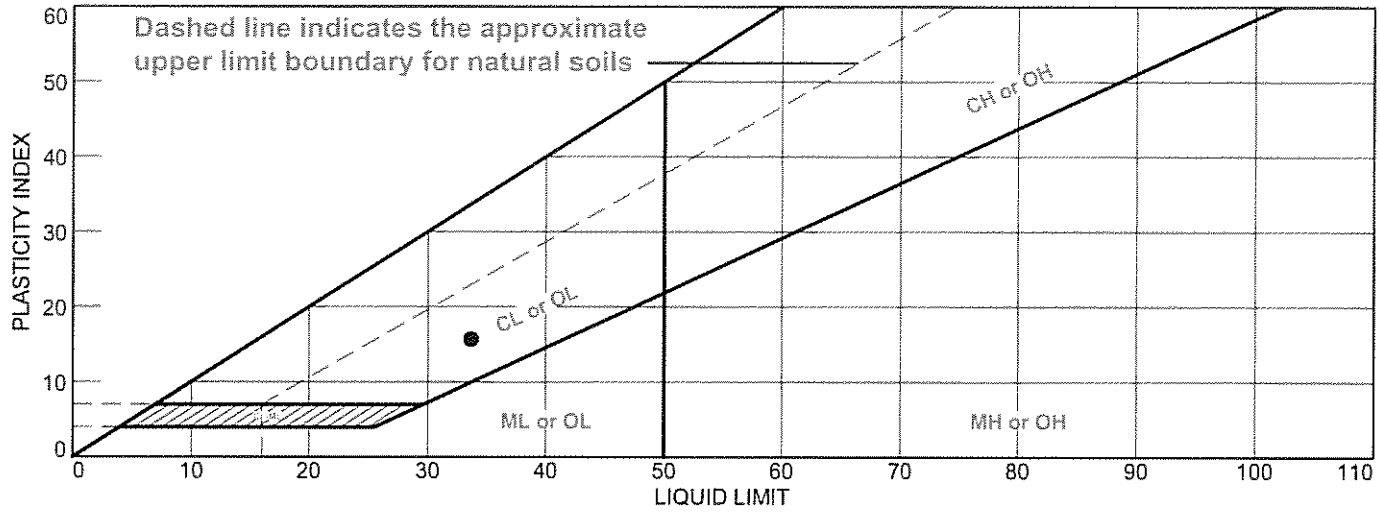
Sample No.: 5D **Source of Sample:** BB-WGLC-102 **Date:** 5/9/16
Location: W. Gardiner-Litchfield **Elev./Depth:** 22'-24'

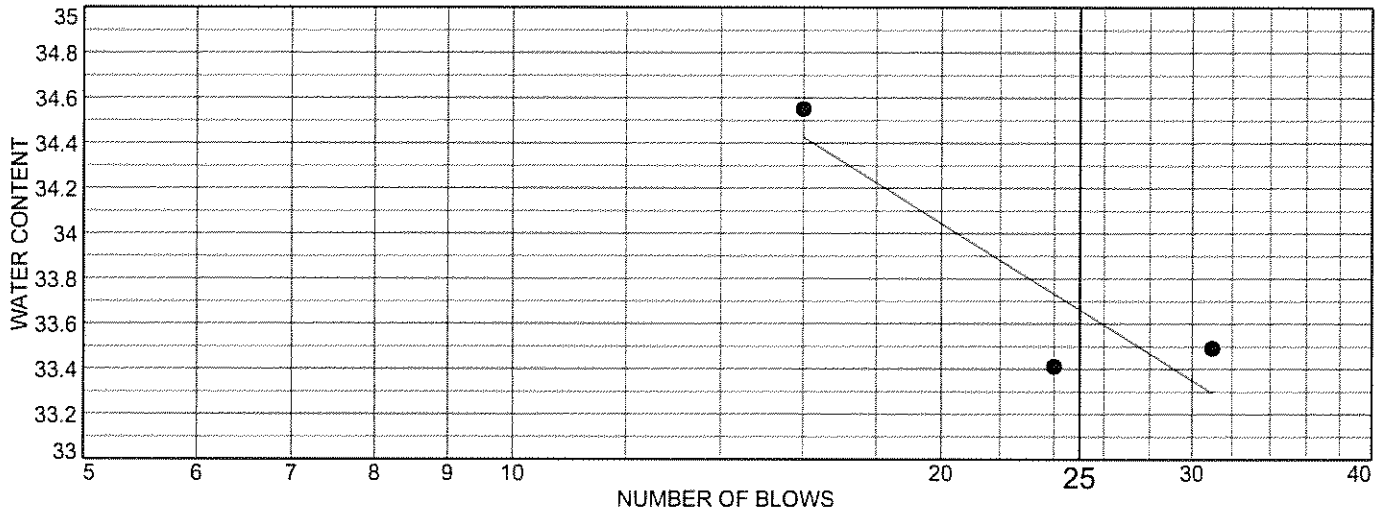
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc.
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)
Project No: 1368-003 **Lab No.** 14007c

Tested By: JEL **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	lean clay	33.7	18.0	15.7	100.0	99.3	CL

Project No. 1368-003 **Client:** Schonewald Engineering Associates, Inc.

Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

● **Location:** W. Gardiner-Litchfield **Depth:** 22'-24' **Sample Number:** 5D

Remarks:

● Moisture Content: 47.7%
Source: BB-WGLC-102

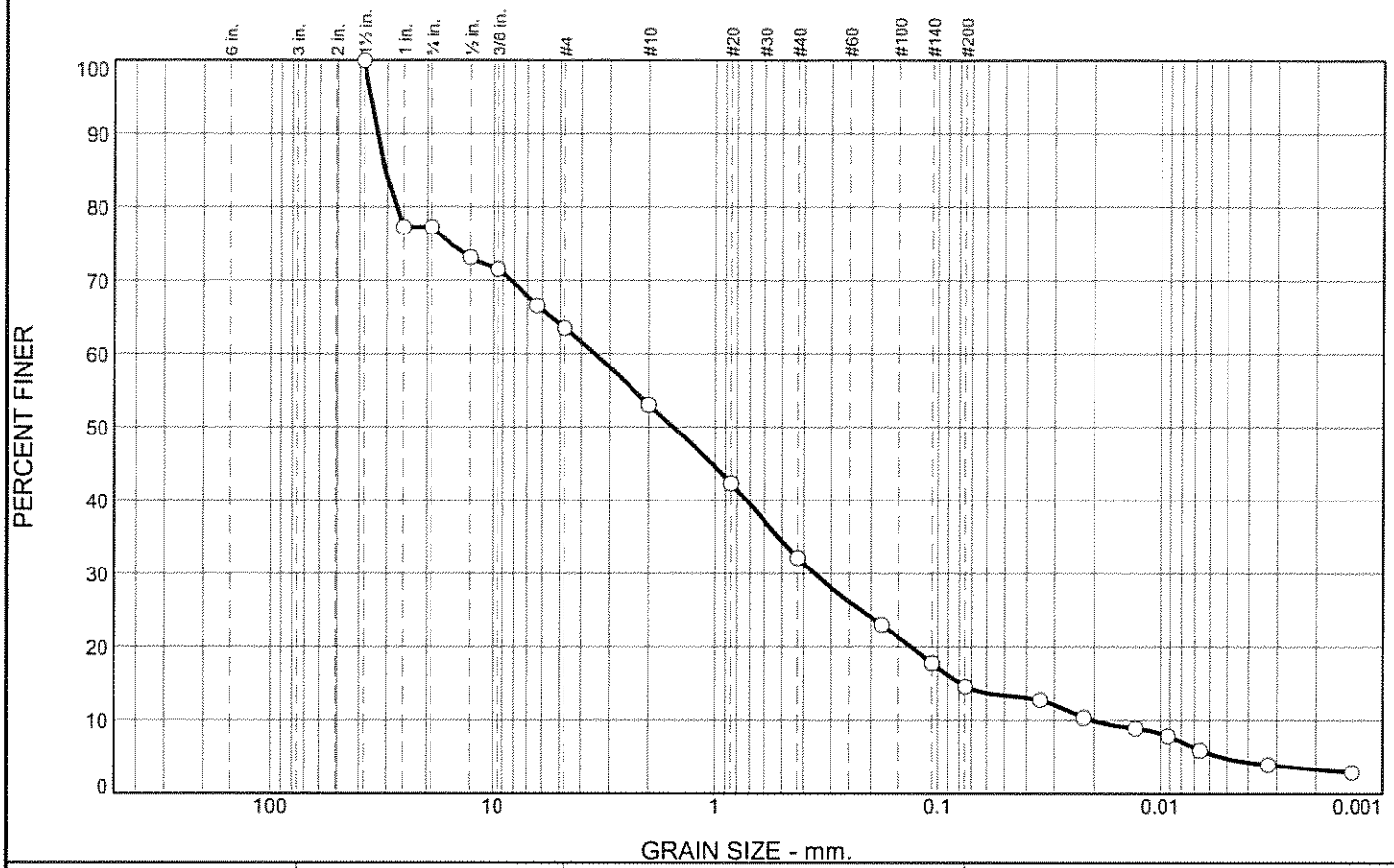
R.W. Gillespie & Associates, Inc.

Saco, Maine

Lab No. 14007c

Tested By: JEL **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	22.7	13.8	10.5	20.8	17.5	9.9	4.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 1/2"	100.0		
1"	77.3		
3/4"	77.3		
1/2"	73.1		
3/8"	71.5		
1/4"	66.5		
#4	63.5		
#10	53.0		
#20	42.3		
#40	32.2		
#80	23.0		
#140	17.8		
#200	14.7		
0.0346 mm.	12.8		
0.0222 mm.	10.4		
0.0130 mm.	8.9		
0.0092 mm.	7.9		
0.0066 mm.	6.0		
0.0033 mm.	4.0		
0.0014 mm.	2.9		

* (no specification provided)

Soil Description

Alluvium - silty sand with gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 30.6455 D_{60}= 3.4908 D_{50}= 1.5580
D_{30}= 0.3574 D_{15}= 0.0787 D_{10}= 0.0204
C_u= 170.71 C_c= 1.79

Classification

USCS= SM AASHTO= A-1-b

Remarks

Moisture Content: 20.3%

Sample No.: 1D **Source of Sample:** BB-WGLC-103 **Date:** 4/9/16
Location: W. Gardiner-Litchfield **Elev./Depth:** 0'-1.7'

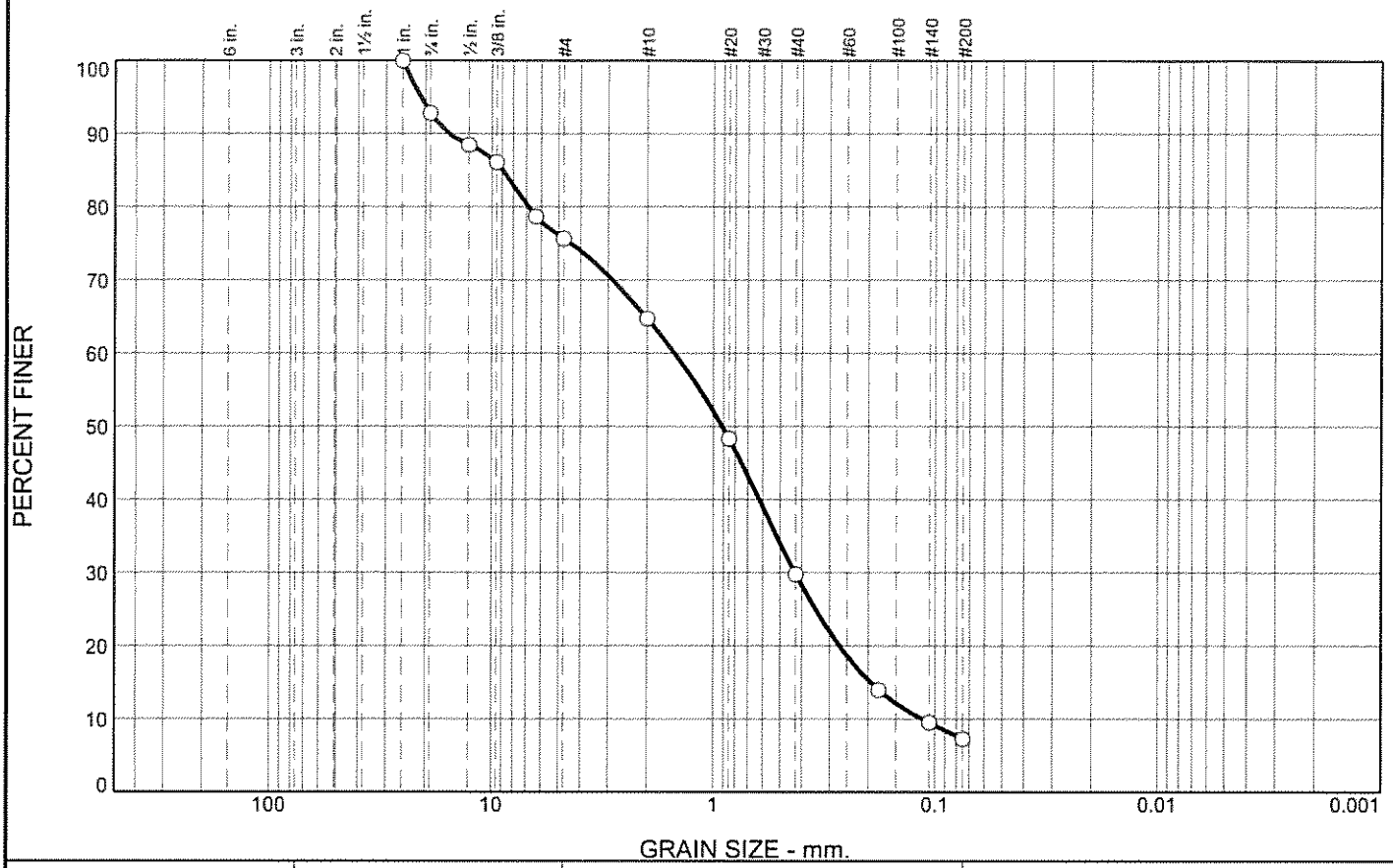
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc.
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)
Project No: 1368-003 **Lab No.** 14007d

Tested By: JEL **Checked By:** MTG MTG

MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	7.2	17.1	11.0	34.9	22.5	7.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	92.8		
1/2"	88.5		
3/8"	86.1		
1/4"	78.7		
#4	75.7		
#10	64.7		
#20	48.3		
#40	29.8		
#80	14.0		
#140	9.5		
#200	7.3		

* (no specification provided)

Soil Description

Fill - well-graded sand with silt and gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 8.8841 D_{60}= 1.4984 D_{50}= 0.9127
D_{30}= 0.4285 D_{15}= 0.1962 D_{10}= 0.1137
C_u= 13.18 C_c= 1.08

Classification

USCS= SW-SM AASHTO= A-1-b

Remarks

Moisture Content: 4.5%

Sample No.: 2D **Source of Sample:** BB-WGLC-104 **Date:** 04/29/2016
Location: W. Gardiner-Litchfield **Elev./Depth:** 5'-7'

R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc.
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)
Project No: 1368-003 **Lab No.** 14006c

Tested By: JEL **Checked By:** MTG

MTG

1368-003
14009

Maine Environmental Laboratory

Report of Analyses

One Main Street Yarmouth, Maine 04096 Tel.: (207) 846-6569 Fax: (207) 846-9066 Email: melab@mel-lab.com

Matthew Grady
R.W. Gillespie & Associates, Inc.
86 Industrial Park Road, Suite 4
Saco, ME 04072

May 5, 2016

Report No.: RWG005-16

Enclosed are the results of the analyses requested for your samples as received by the laboratory. Samples were received in acceptable condition and analyzed within method holding times. All quality control data was within laboratory acceptance limits unless noted. Parameters requiring thermal preservation were received outside of required temperature range (above freezing to 6 °C).
The Limit of Quantitation (LOQ) is the minimum level for reporting quantitative data. The Limit of Detection (LOD) is the minimum level for reporting estimated data. Data reported between the Limit of Quantitation and Limit of Detection are J flagged as estimated.
Maine Environmental Laboratory is certified by Maine (cert. #2015007) and New Hampshire NELAP (NH ELAP) (cert. #2031).
A list of certified parameters is available on request. The results reported herein conform to the most current NELAP standards where applicable unless otherwise narrated in this report. This report shall not be reproduced except in full without the written consent of the laboratory.

The complete report consists of the following sections:

Maine Environmental Laboratory report
Chain of Custody form

References

EPA - EPA600/4-79-020, Methods for Chemical Analysis of Water and Wastes, USEPA, Cincinnati, Ohio, March 1983.
EPA1 - EPA/600/R-93/100 Methods for the Determination of Inorganic Substances in Environmental Samples, Aug. 1993.
EPA2 - EPA/600R-94/111, Methods for the Determination of Metals in Environmental Samples, Supplement 1, May, 1994.
EPA3-EPA/600/R-06/115,Determination of Trace Elements in DW by Axially Viewed ICP-Atomic Emission Spectrometry,Rev 4.2 Oct. 2003
STM - Standard Methods for the Examination of Water and Wastewater, 18th edition, APHA,AWWA,WPCF, 1992.
SW8- SW846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, USEPA, third edition. Updates I-IV, 2007.
CLP - USEPA CLP Statement of Work for Inorganic Superfund Methods, ISM01.2, Exh. D, Sec. 1.6, Jan. 2010.
HACH - Chemical Oxygen Demand, Method 8000, Hach Handbook of Water Analysis, Hach Chemical Company, 1979.
HEX - EPA-821-R-98-002, Method 1664, Rev. A: N-Hexane Extractable Material by Extraction and Gravimetry, Feb. 1999.
AOA - Official Methods of Analysis of the Association of Official Analytical Chemists, 14th edition, 1984.
STM1 - Standard Methods for the Examination of Water and Wastewater, 20th edition, APHA,AWWA,WPCF, 1998.

Authorized signature Jacquelyn R. Villinski

Jacquelyn R. Villinski, Laboratory Director

Maine Environmental Laboratory

Report of Analyses

One Main Street Yarmouth, Maine 04096 Tel.: (207) 846-6569 Fax: (207) 846-9066 Email: melab@mel-lab.com

Matthew Grady
R.W. Gillespie & Associates, Inc.
86 Industrial Park Road, Suite 4
Saco, ME 04072

May 5, 2016

1368-003

Report No:	RWG005-16	Sampler:	I. Schonewald
Date received:	04/25/16	Sampling date:	04/19/16
Project ID:	Burnham Bridge #1368-003/15-031	Sample matrix:	Clay
Laboratory ID:	RWG00516-01	Sample ID:	#14009, 18954.00 1313-WGLC-104, 3D, 10'-12'

Data reported on a dry-weight basis.

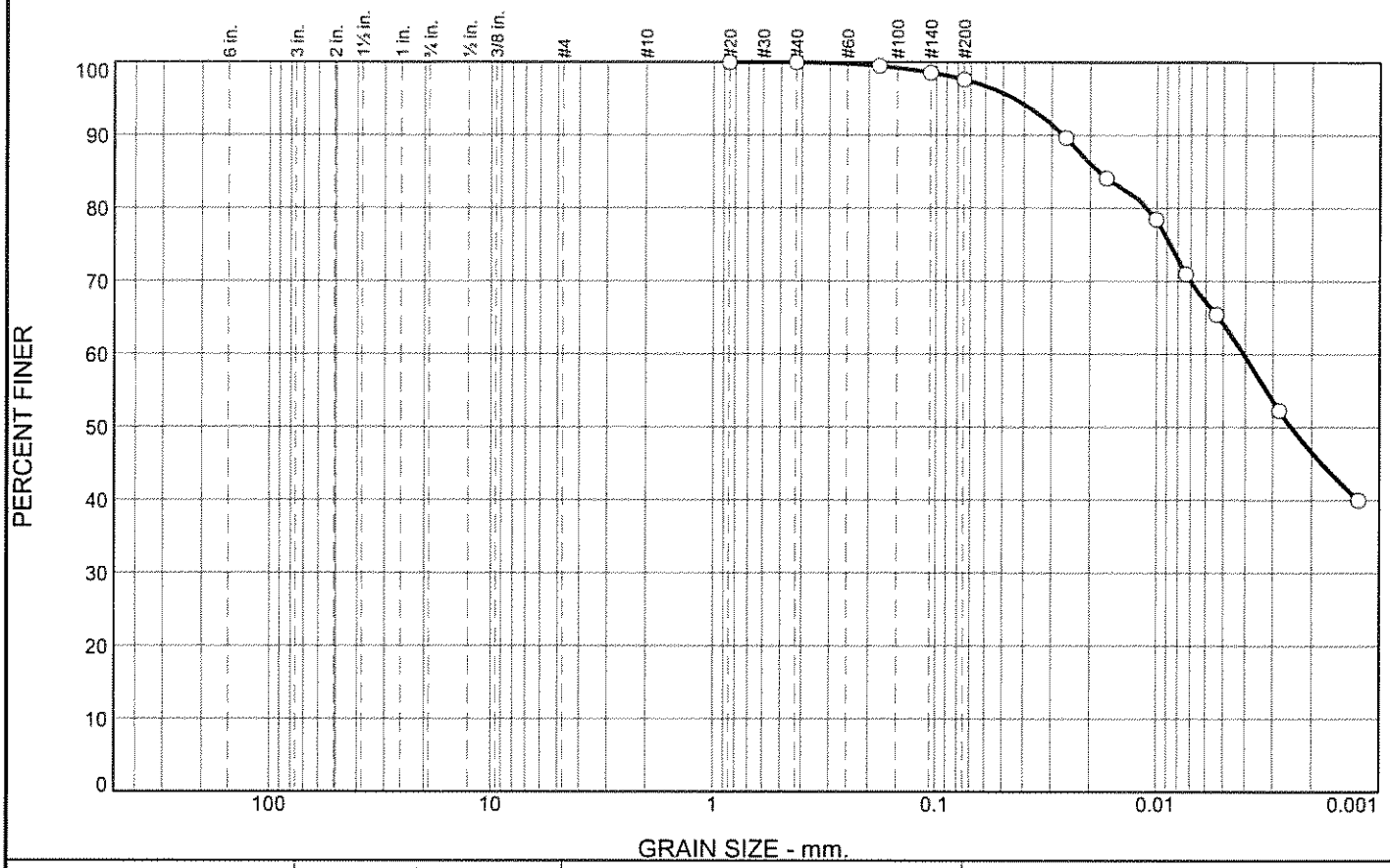
Parameter	Results	units	Date Analyzed	LOD	LOQ	Method	Reference
Chloride	157	mg/kg	05/04/16	10	31	9056	SW8
pH*	7.75	pH units	04/26/16		0.01	9045D	SW8
Sulfate	1350	mg/kg	05/04/16	7	21	9056	SW8
Total Solids	80.55	%	04/25/16		0.01	2540G	STM1

*Data reported on an as-received basis.

ND = not detected J = estimated B = detected in blank S = DLs increased due to sample matrix

MTC

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	2.4	33.5	64.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	100.0		
#80	99.5		
#140	98.6		
#200	97.6		
0.0258 mm.	89.7		
0.0169 mm.	84.1		
0.0101 mm.	78.5		
0.0074 mm.	71.0		
0.0054 mm.	65.4		
0.0028 mm.	52.3		
0.0012 mm.	40.0		

* (no specification provided)

Soil Description

lean clay

Atterberg Limits

PL= 19.0 LL= 33.0 PI= 14.0

Coefficients

D_{85}= 0.0183 D_{60}= 0.0041 D_{50}= 0.0025
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO= A-6(14)

Remarks

Moisture content: 32.6%

Sample No.: 4D **Source of Sample:** BB-WGLC-104 **Date:** 5/9/16
Location: W. Gardiner-Litchfield **Elev./Depth:** 15'-17'

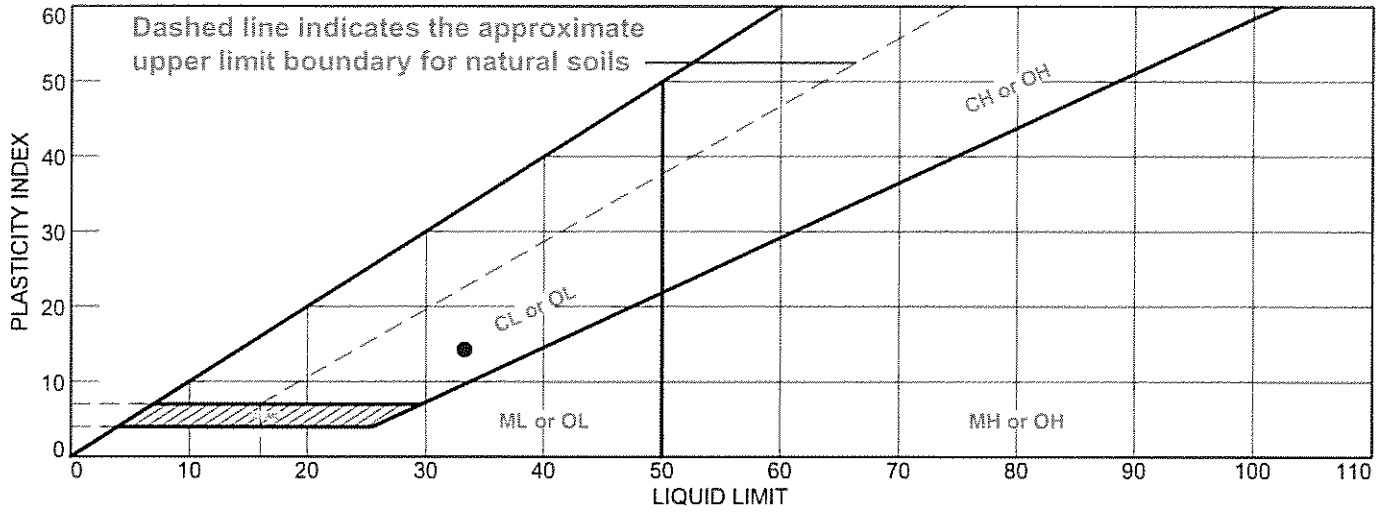
R.W. Gillespie & Associates, Inc.
Saco, Maine

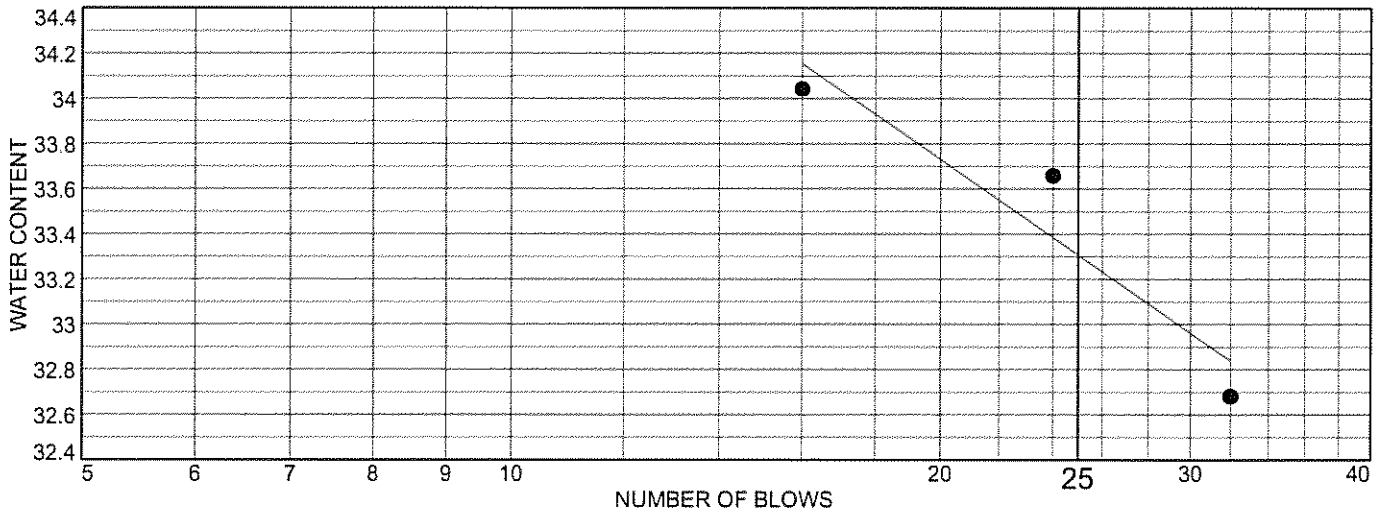
Client: Schonewald Engineering Associates, Inc.
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Project No: 1368-003 **Lab No.** 14007e

Tested By: JEL **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	lean clay	33.3	19.0	14.3	100.0	97.6	CL

Project No. 1368-003 **Client:** Schonewald Engineering Associates, Inc.

Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

● **Location:** W. Gardiner-Litchfield **Depth:** 15'-17' **Sample Number:** 4D

Remarks:

● Moisture Content: 32.6%
Source: BB-WGLC-104

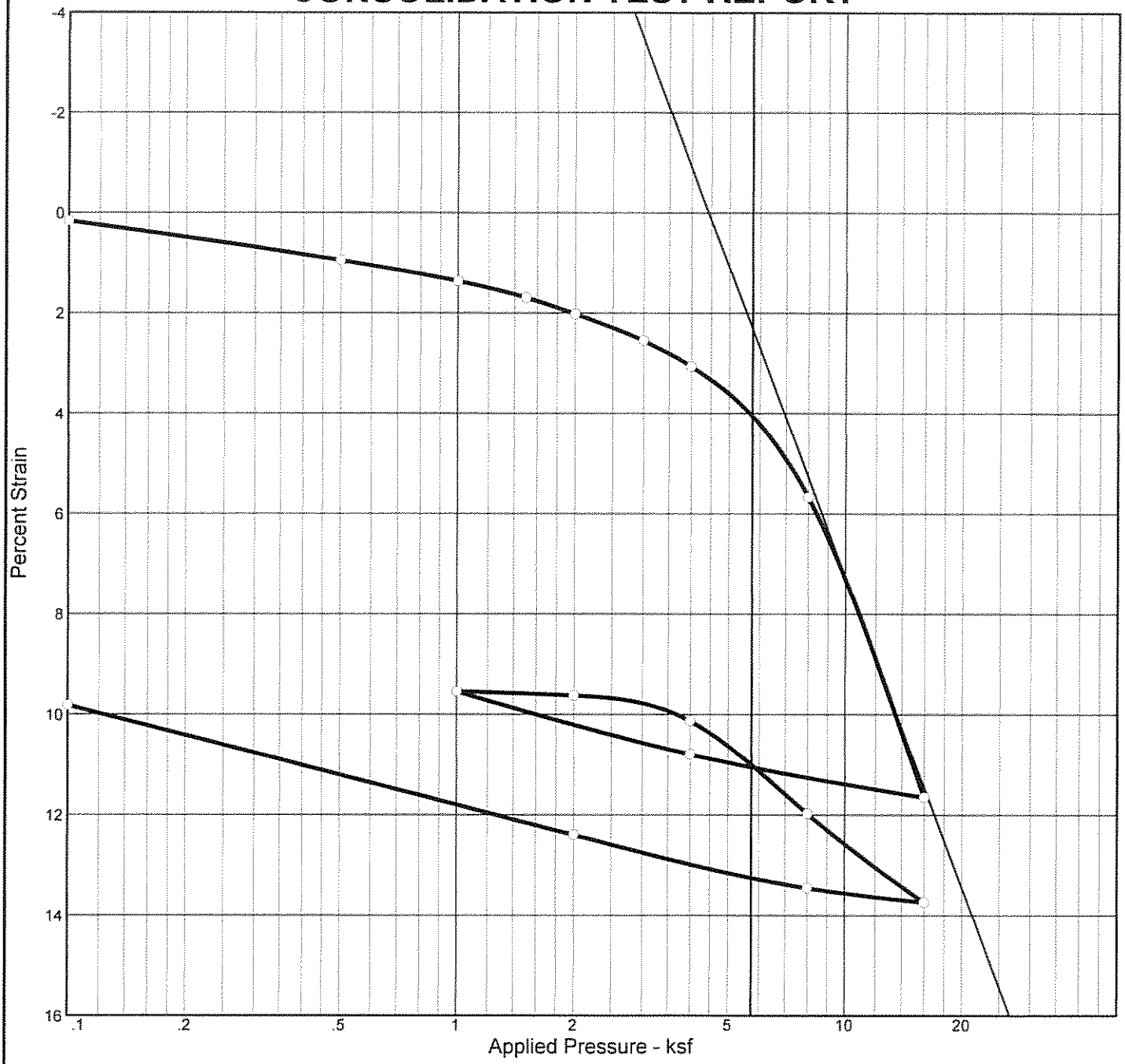
R.W. Gillespie & Associates, Inc.

Saco, Maine

Lab No. 14007e

Tested By: JEL **Checked By:** MTG

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	P_c (ksf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
94.0 %	35.4 %	84.5	45.2	21.0	2.76		7.34	0.42	0.05	1.039

MATERIAL DESCRIPTION	USCS	AASHTO
Silty Clay - Stiff, gray-green		

Project No. 1368-003 **Client:** Schonewald Engineering Associates, Inc.

Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 **Sample No.:** U-1 **Elev./Depth:** 18.75'

R.W. Gillespie & Associates, Inc.

Saco, Maine

Remarks:

Tested by: MTG/JEL

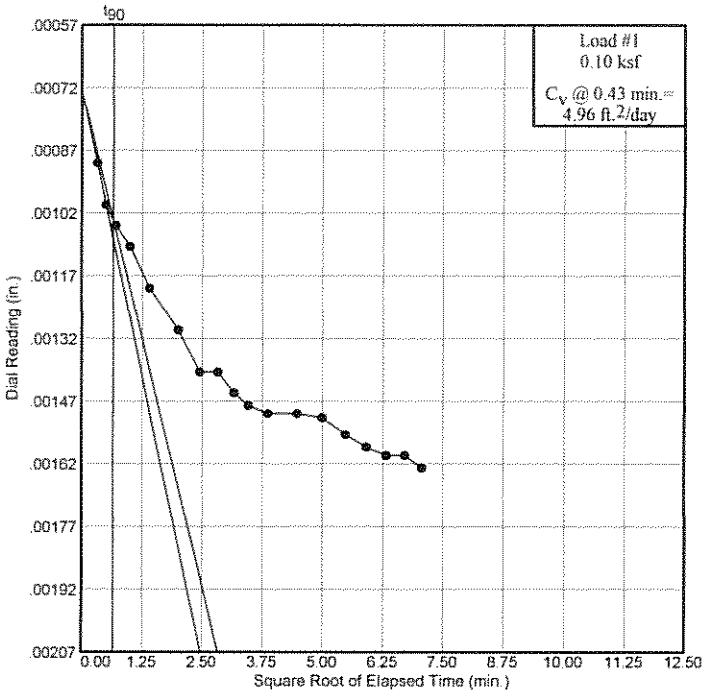
MTG

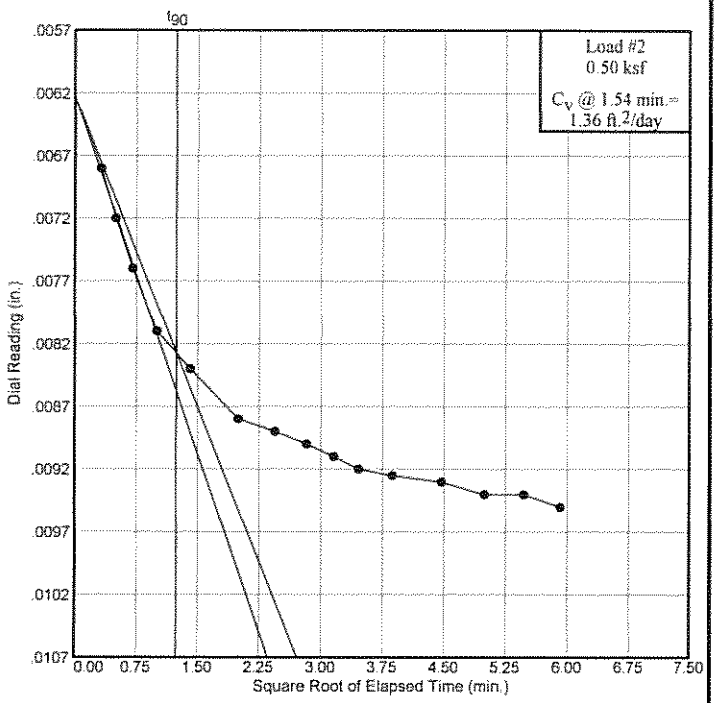
Lab No. 14008a

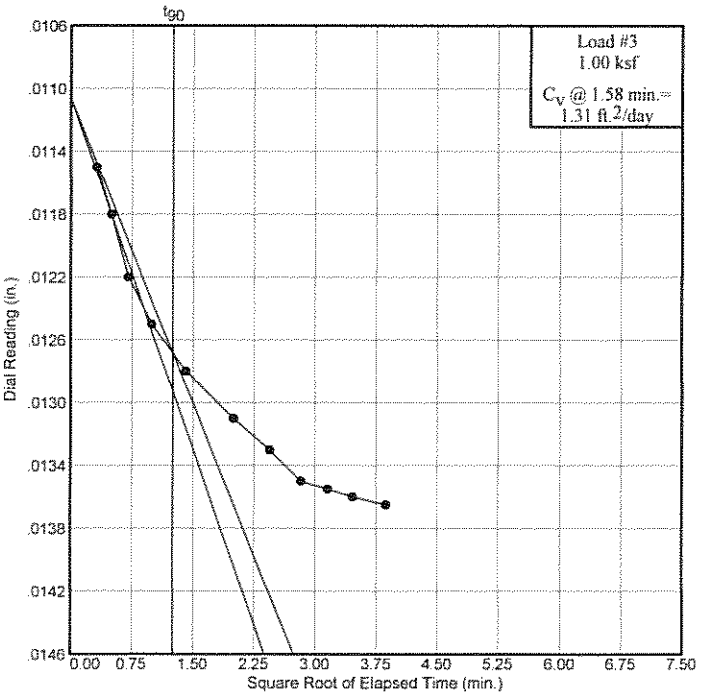
Dial Reading vs. Time

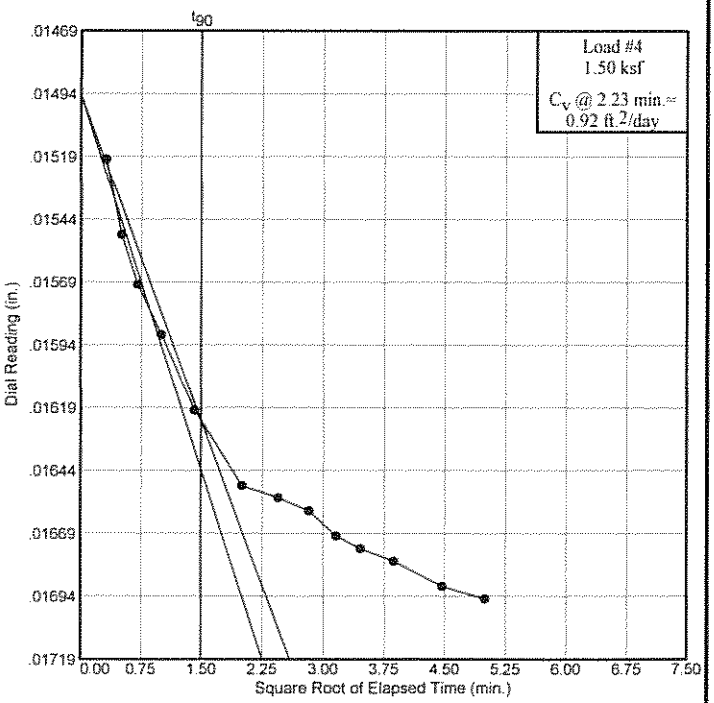
Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-1 Elev./Depth: 18.75'









R.W. Gillespie & Associates, Inc.

Saco, Maine

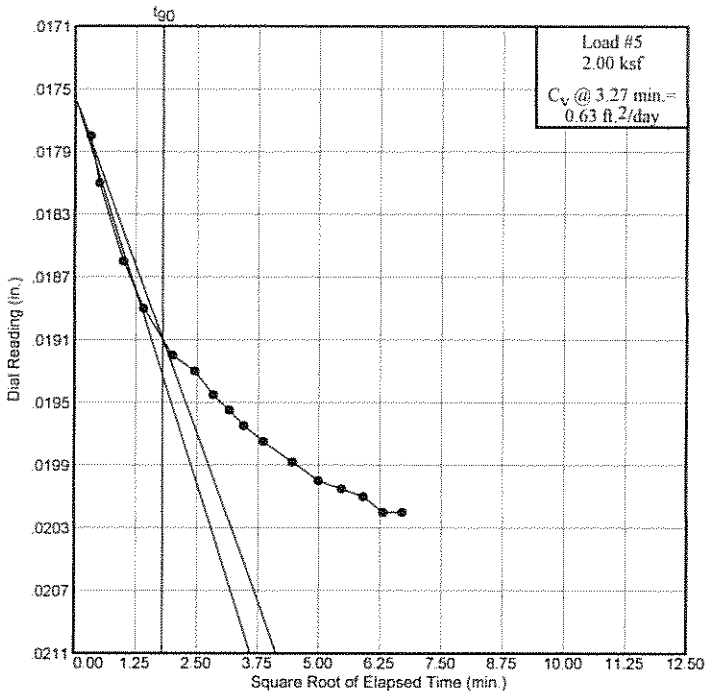
MTP

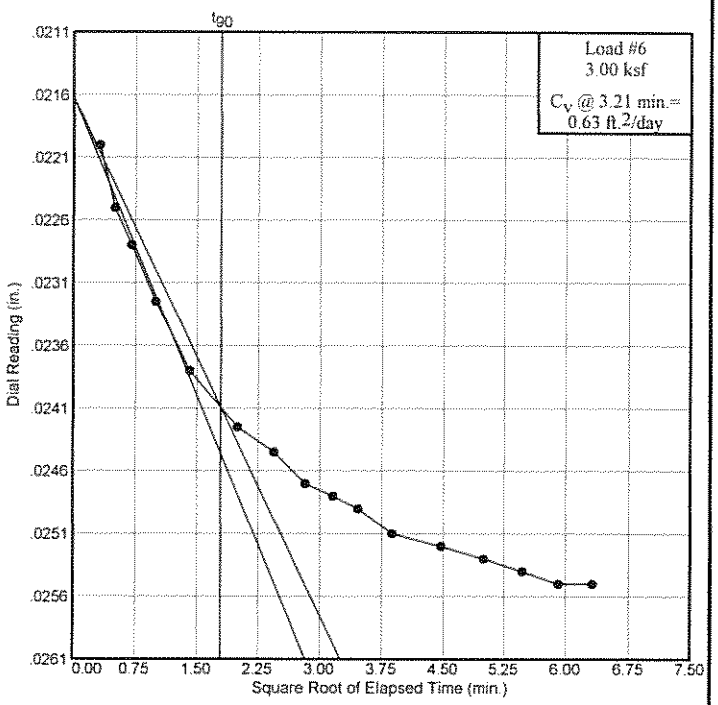
Lab No. 14008a

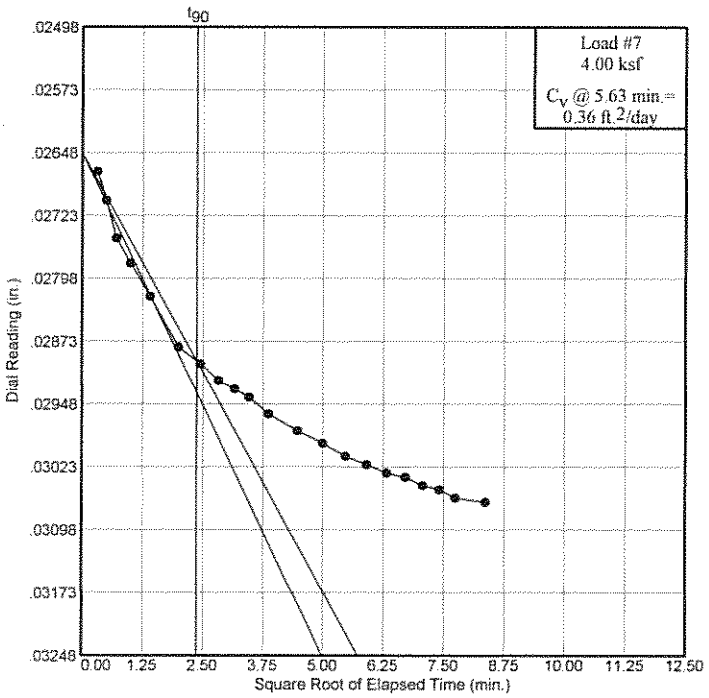
Dial Reading vs. Time

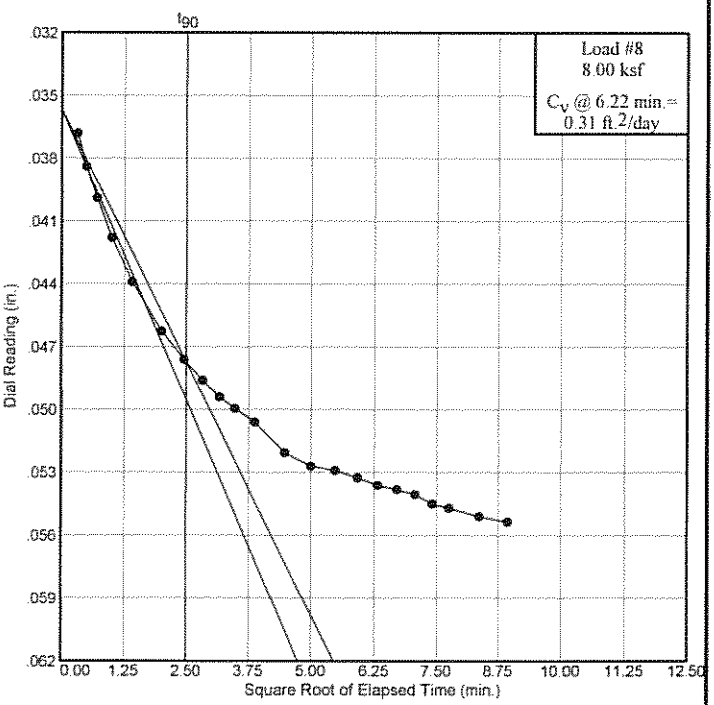
Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-1 Elev./Depth: 18.75'









R.W. Gillespie & Associates, Inc.

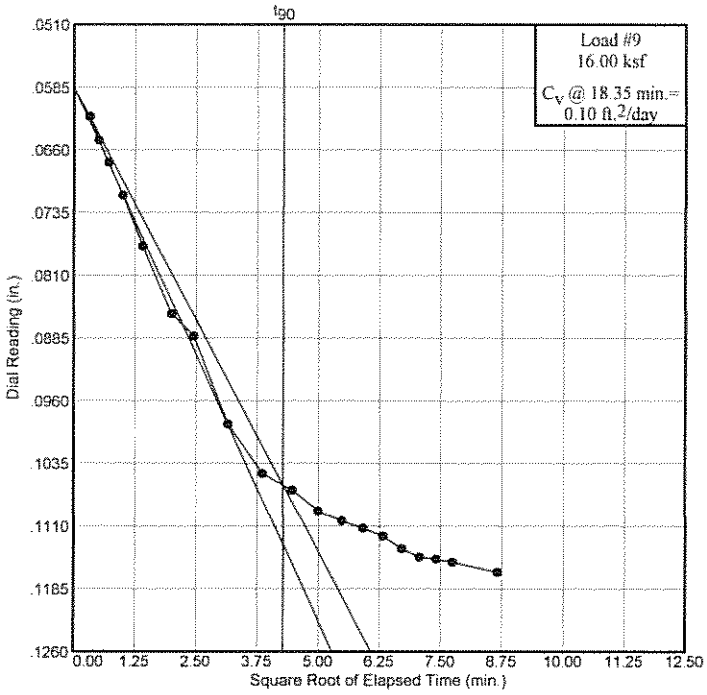
Saco, Maine

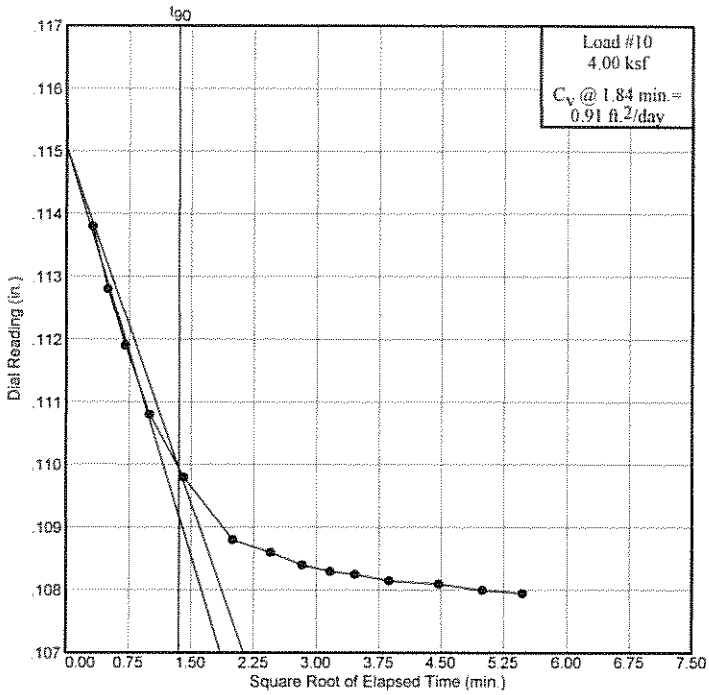
Lab No. 14008a

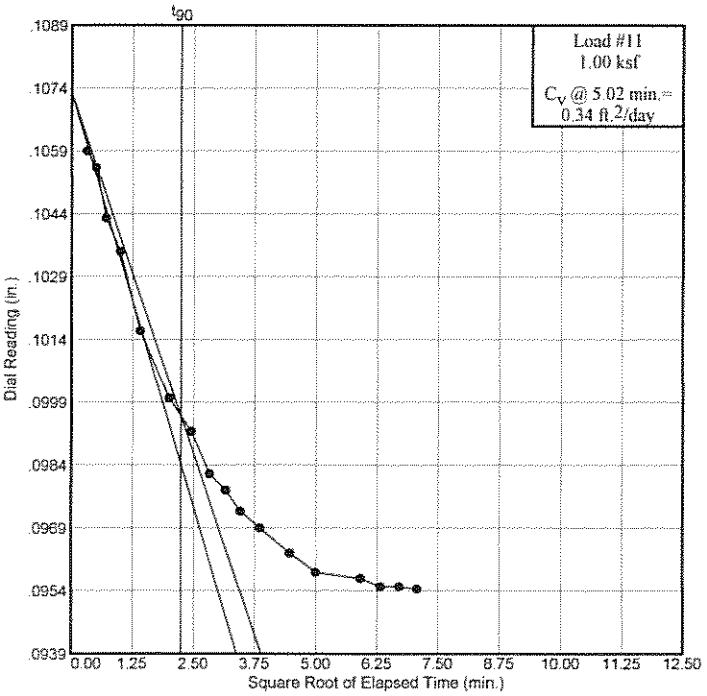
Dial Reading vs. Time

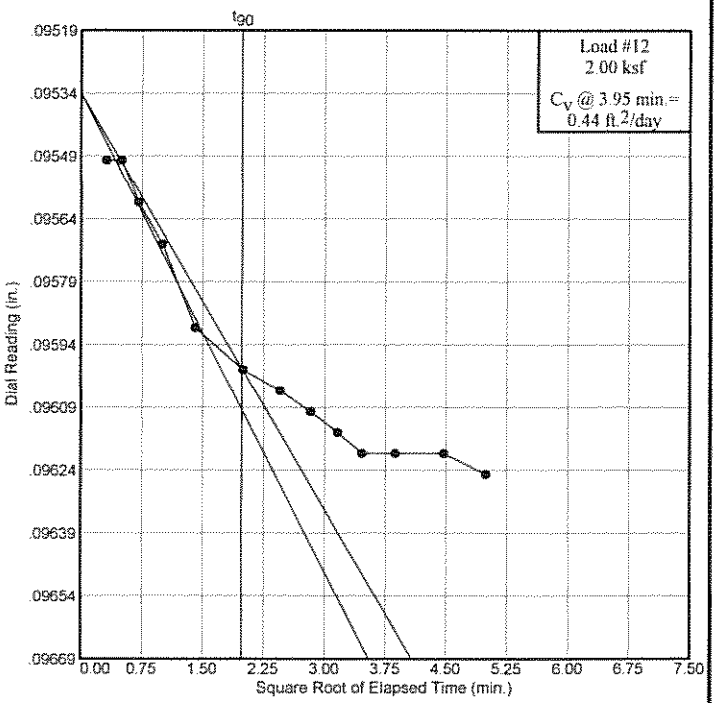
Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-1 Elev./Depth: 18.75'









R.W. Gillespie & Associates, Inc.

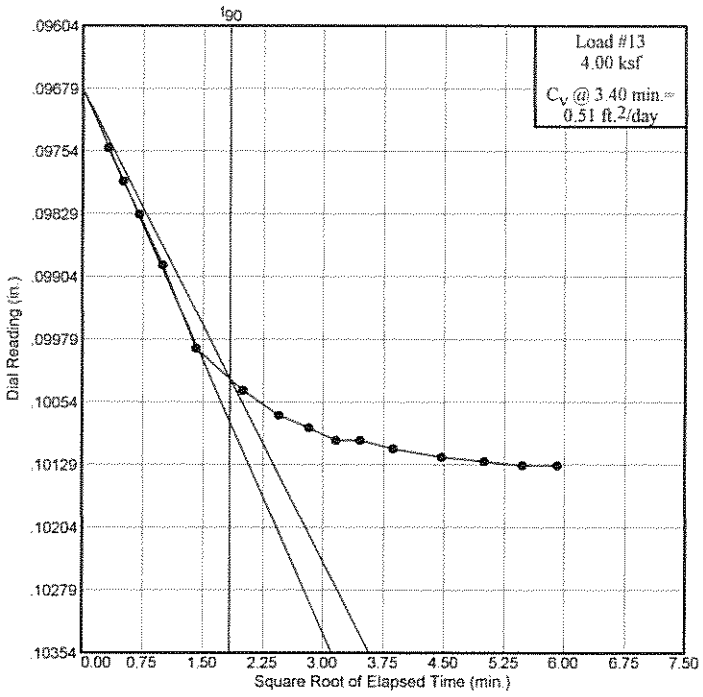
Saco, Maine

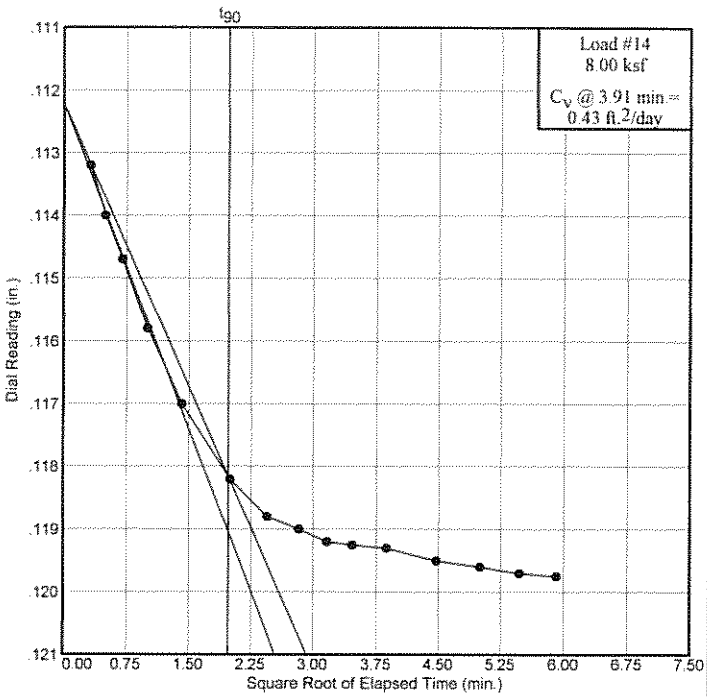
Lab No. 14008a

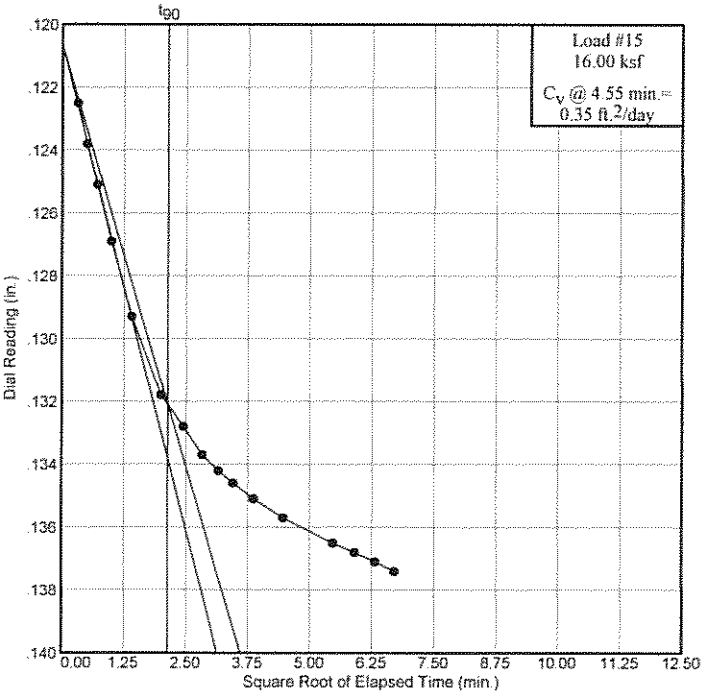
Dial Reading vs. Time

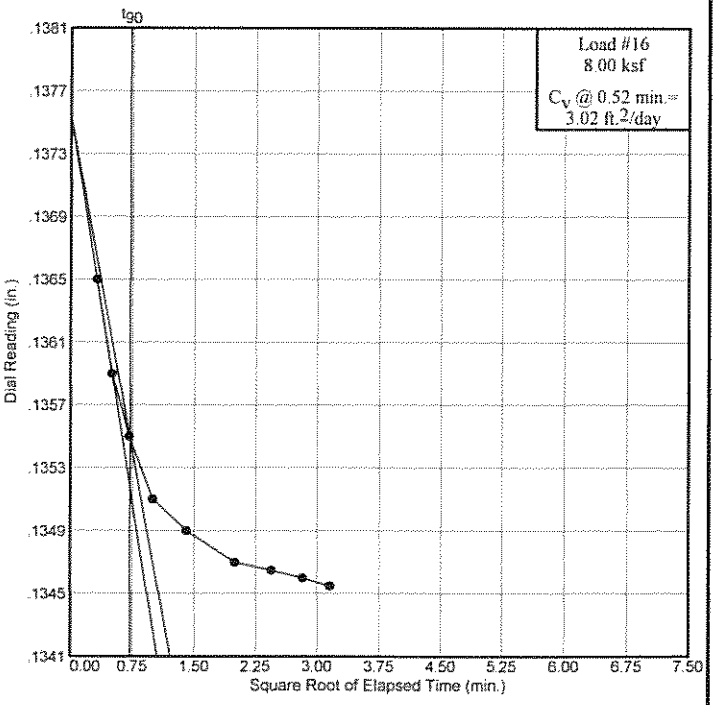
Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-1 Elev./Depth: 18.75'









R.W. Gillespie & Associates, Inc.

Saco, Maine

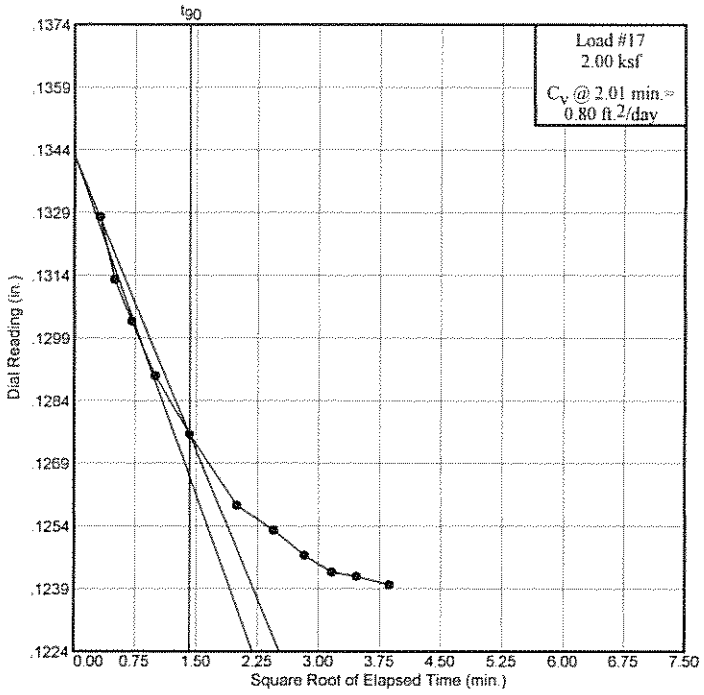
MTC

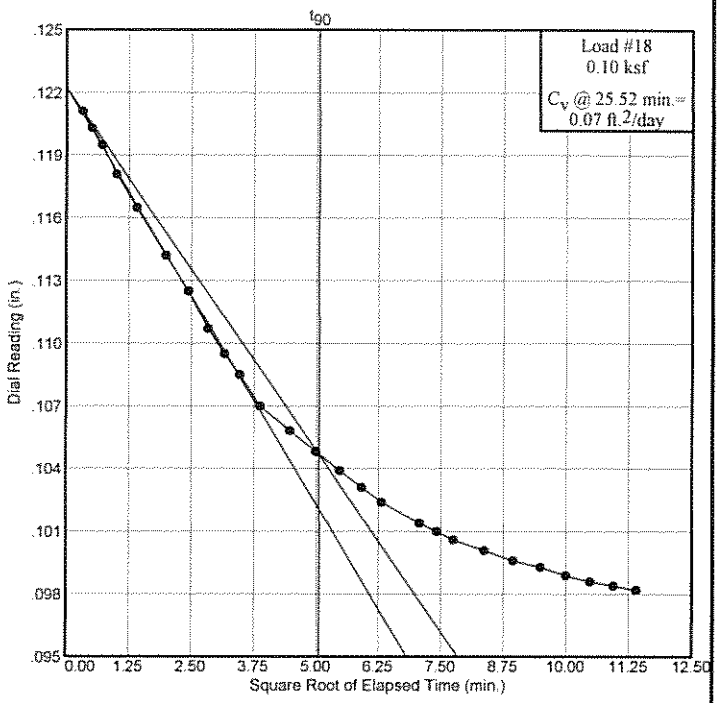
Lab No. 14008a

Dial Reading vs. Time

Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-1 Elev./Depth: 18.75'

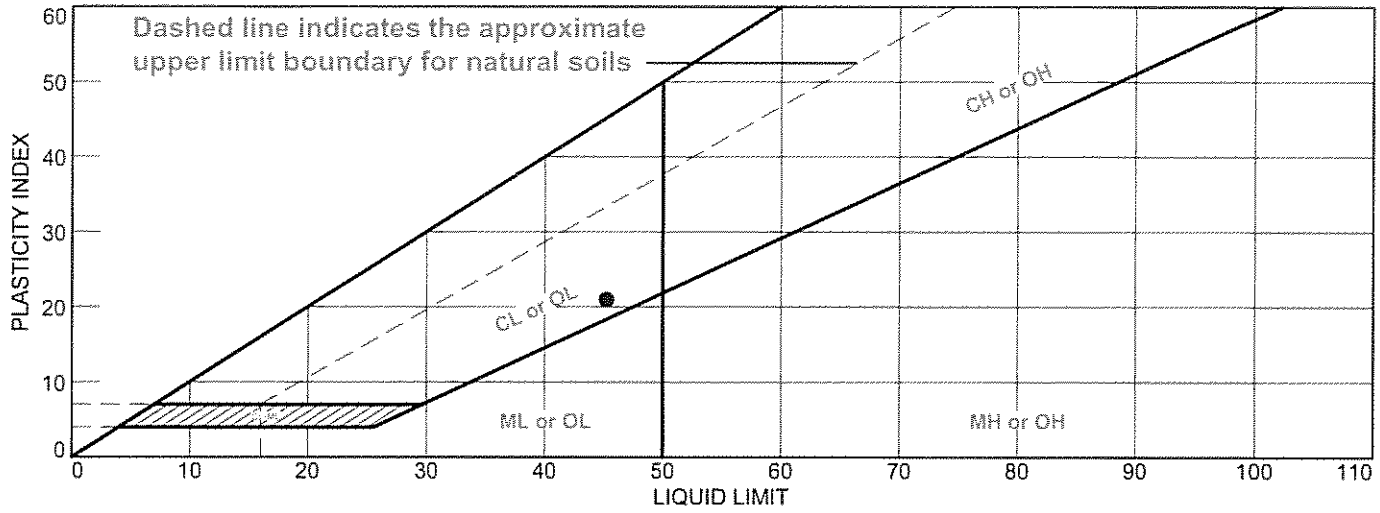


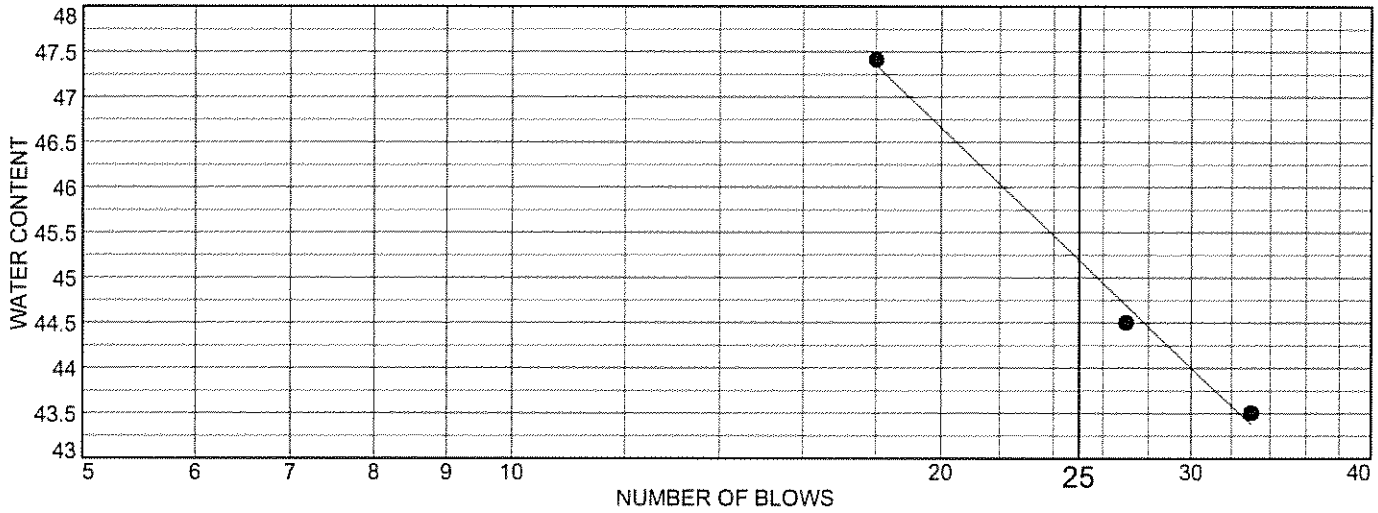


R.W. Gillespie & Associates, Inc.
Saco, Maine

Lab No. 14008a

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Silty Clay - Stiff, gray-green	45.2	24.2	21.0			

Project No. 1368-003 **Client:** Schonewald Engineering Associates, Inc.

Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

● **Location:** W. Gardiner-Litchfield **Depth:** 18'-20' **Sample Number:** U-1

Remarks:

● Moisture Content: 35.4% at 18.5'
Source BB-WGLC-104

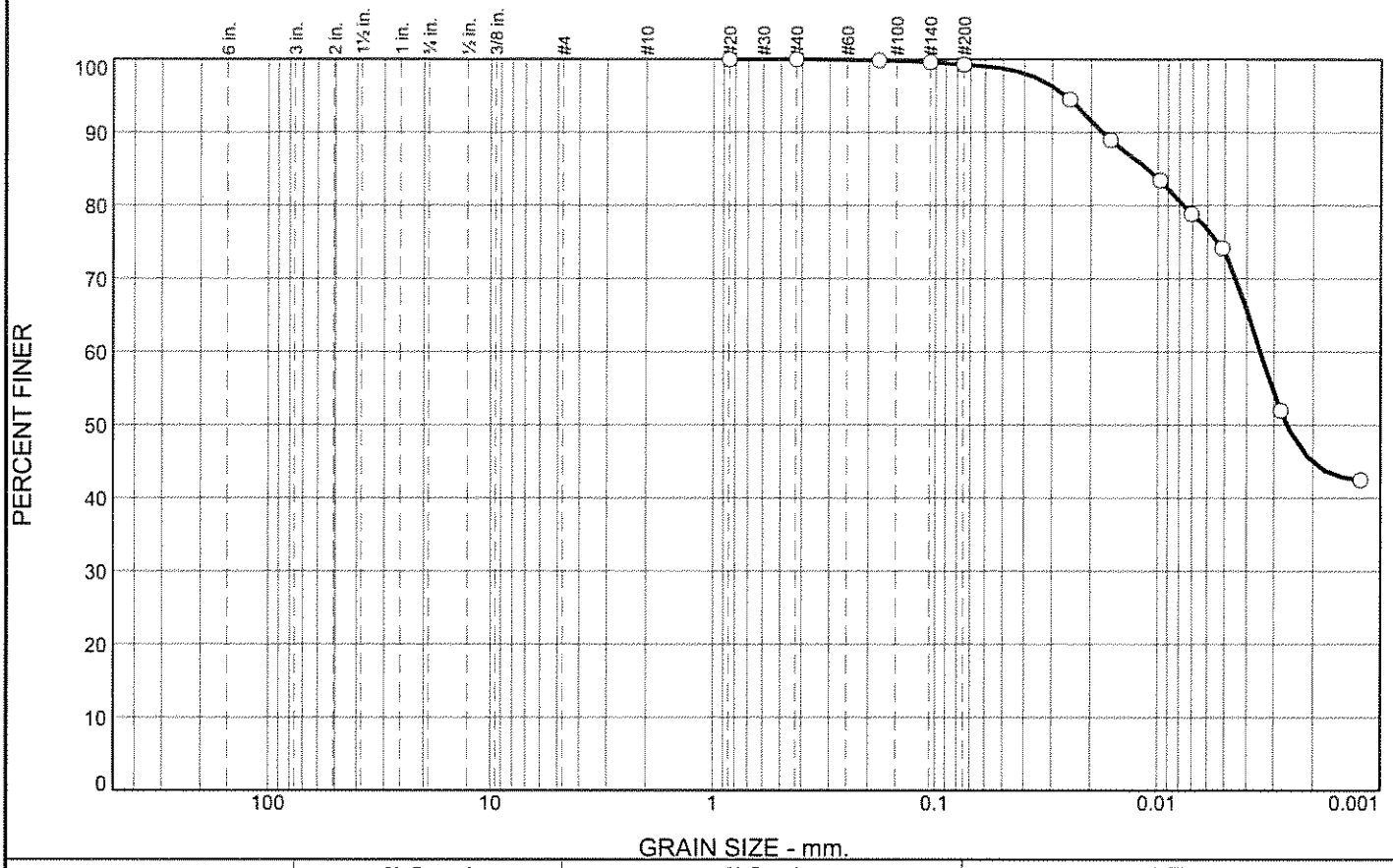
R.W. Gillespie & Associates, Inc.

Saco, Maine

Lab No. 14008A

Tested By: JEL **Checked By:** MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	0.7	25.8	73.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	100.0		
#80	99.9		
#140	99.7		
#200	99.3		
0.0250 mm.	94.5		
0.0164 mm.	89.0		
0.0098 mm.	83.5		
0.0071 mm.	78.8		
0.0051 mm.	74.2		
0.0028 mm.	52.0		
0.0012 mm.	42.5		

* (no specification provided)

Soil Description

lean clay

Atterberg Limits

PL= 17.9 LL= 29.4 PI= 11.5

Coefficients

D_{85}= 0.0111 D_{60}= 0.0035 D_{50}= 0.0026
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO= A-6(10)

Remarks

Moisture Content: 41.4%

Sample No.: 5D **Source of Sample:** BB-WGLC-104 **Date:** 4/9/16
Location: W. Gardiner-Litchfield **Elev./Depth:** 20'-22'

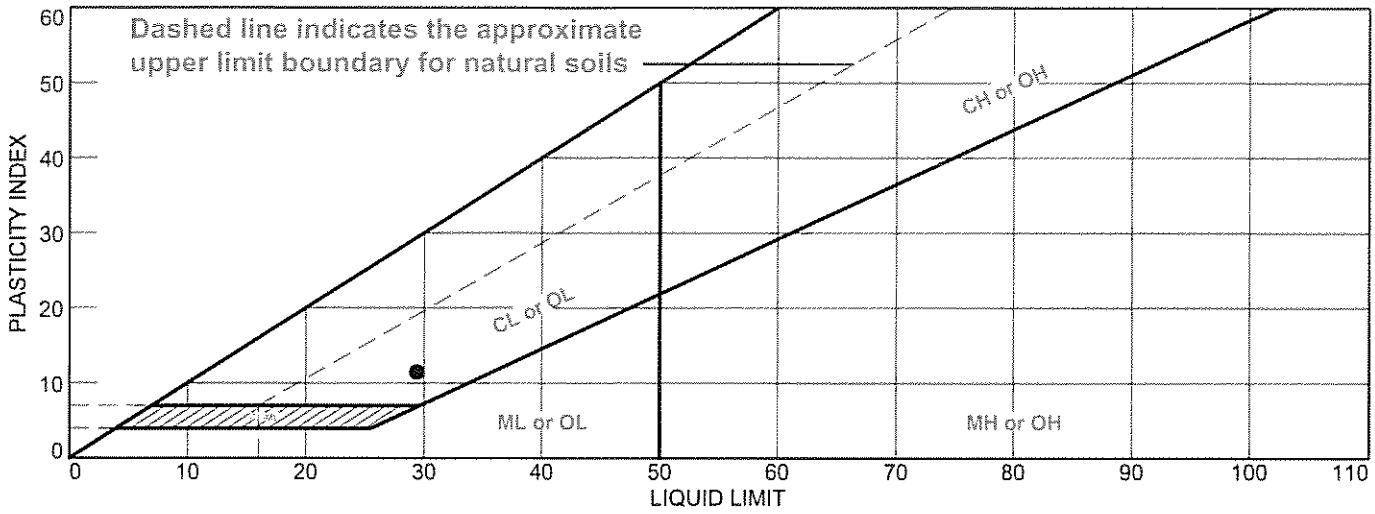
R.W. Gillespie & Associates, Inc.
Saco, Maine

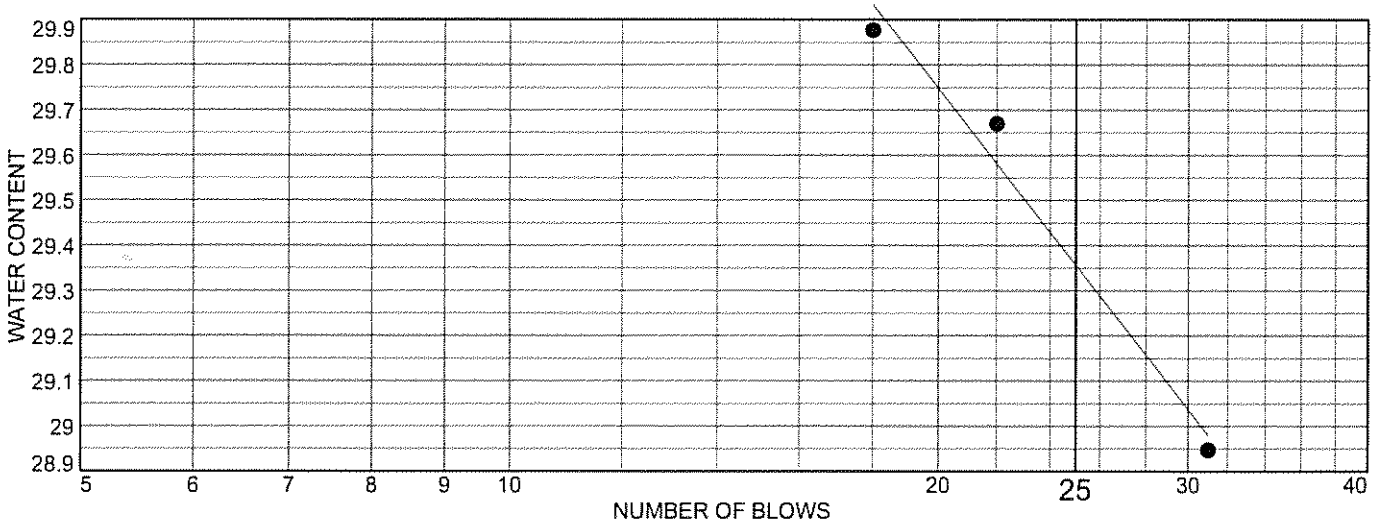
Client: Schonewald Engineering Associates, Inc.
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Project No: 1368-003 **Lab No.** 14007f

Tested By: JEL **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	lean clay	29.4	17.9	11.5	100.0	99.3	CL

Project No. 1368-003 **Client:** Schonewald Engineering Associates, Inc.

Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

● **Location:** W. Gardiner-Litchfield **Depth:** 20'-22' **Sample Number:** 5D

Remarks:

● Moisture Content: 41.4%
Source: BB-WGLC-104

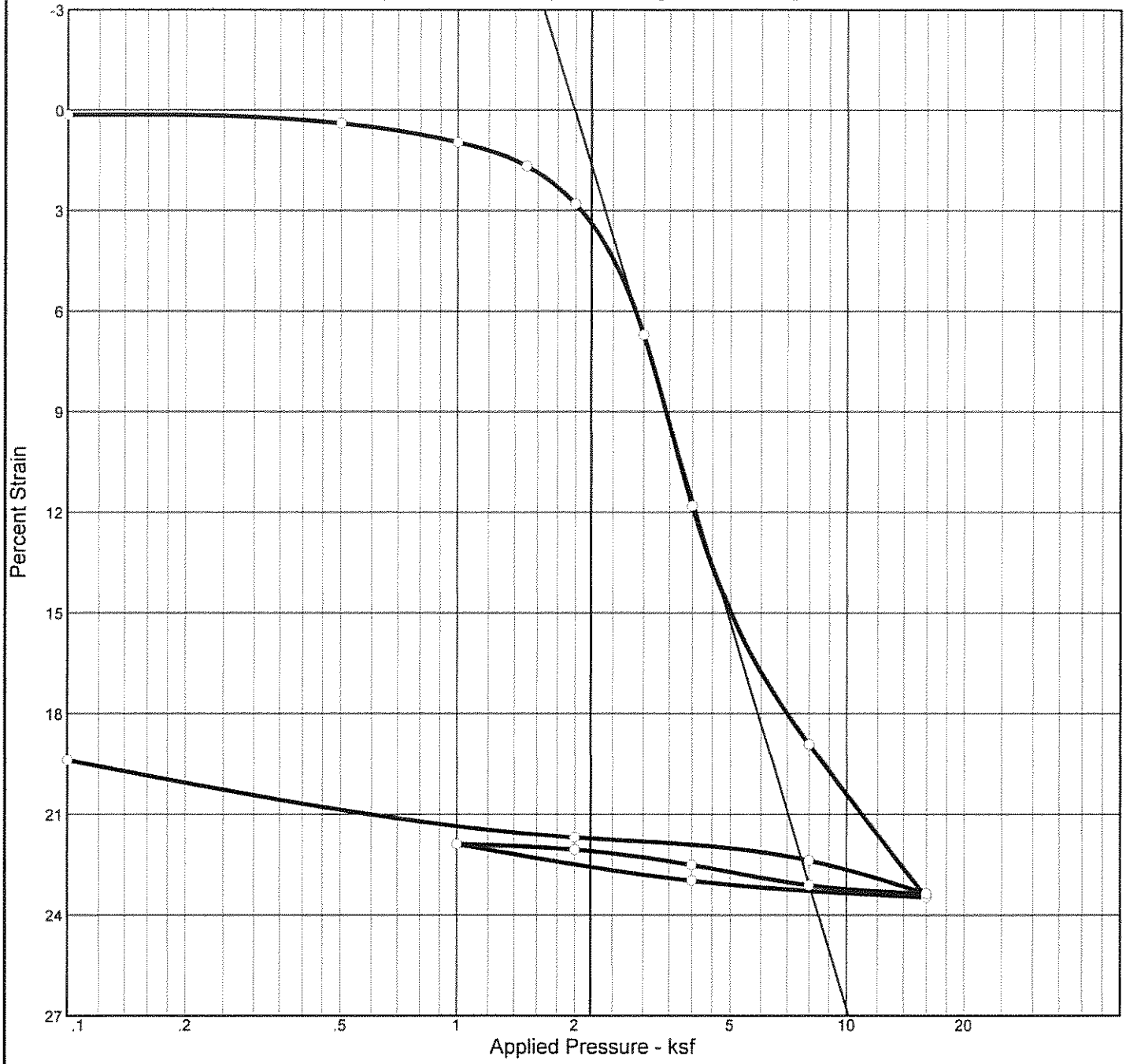
R.W. Gillespie & Associates, Inc.

Saco, Maine

Lab No. 14007f

Tested By: JEL **Checked By:** MTG MTG

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	P_c (ksf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
96.9 %	47.9 %	72.9	42.0	20.4	2.76		2.51	0.90	0.04	1.363

MATERIAL DESCRIPTION	USCS	AASHTO
Silty Clay - Soft, gray-blue		

Project No. 1368-003 **Client:** Schonewald Engineering Associates, Inc.

Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 **Sample No.:** U-2 **Elev./Depth:** 25.7'

R.W. Gillespie & Associates, Inc.

Saco, Maine

Remarks:

Tested by: MTG/JEL

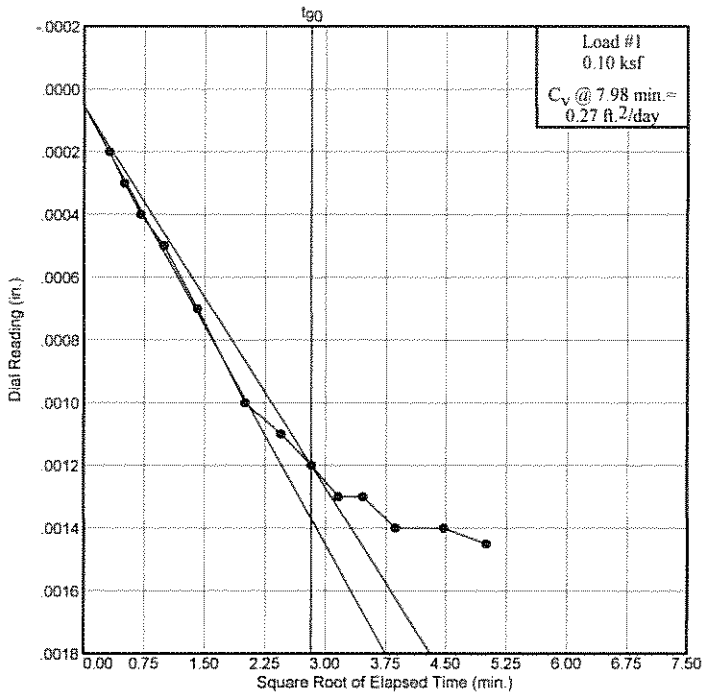
MTG

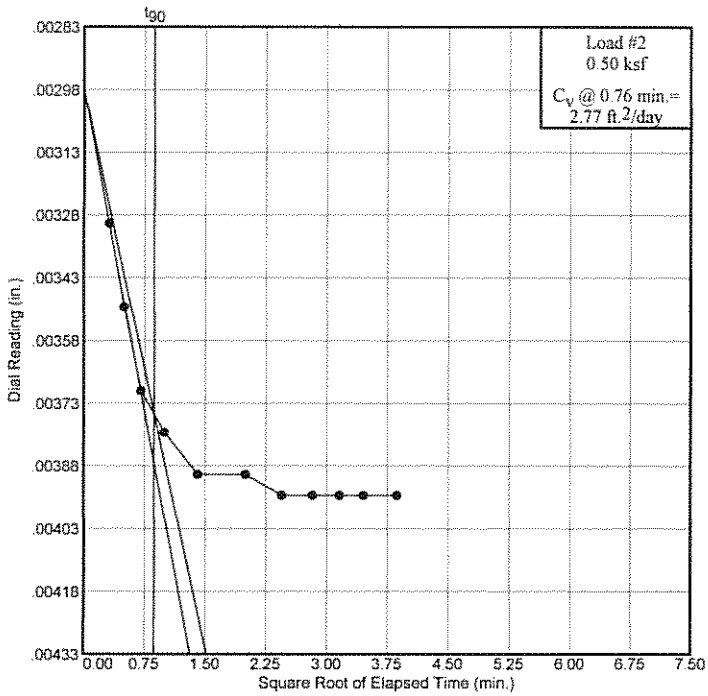
Lab No. 14008b

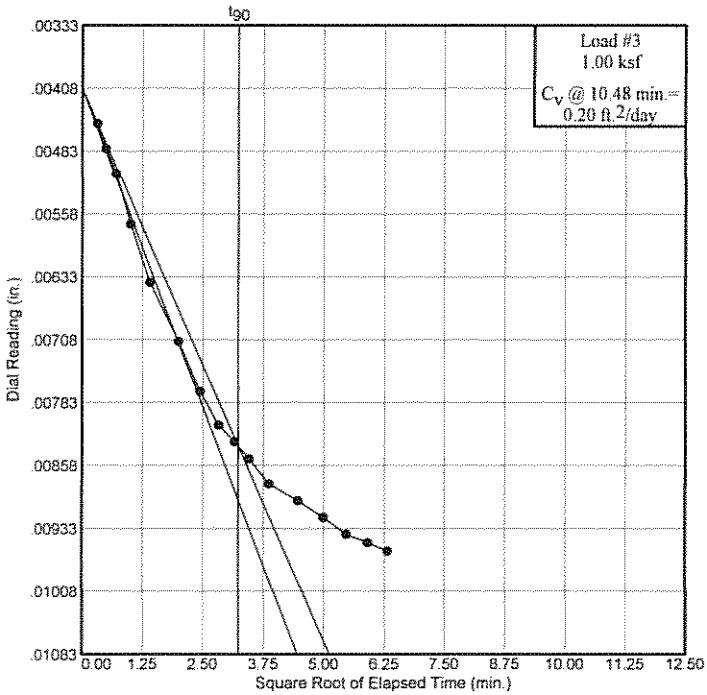
Dial Reading vs. Time

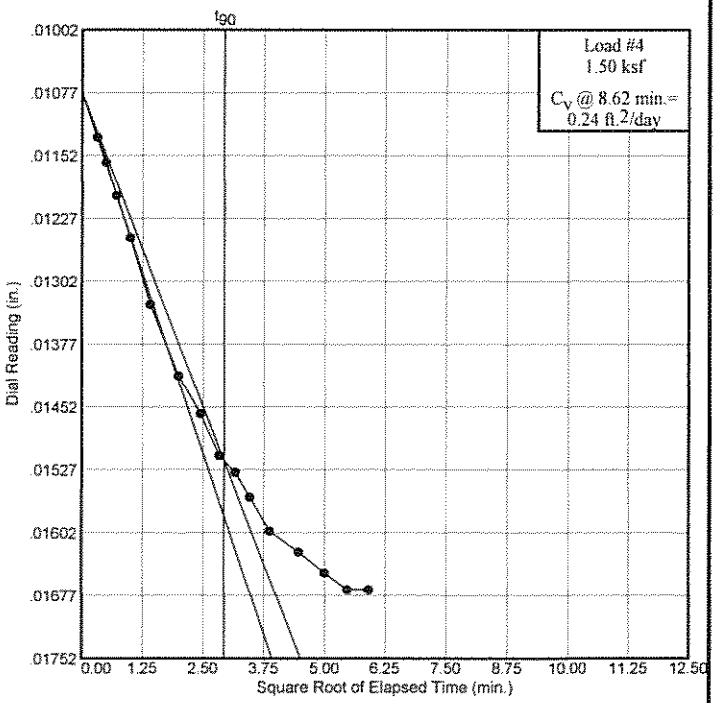
Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-2 Elev./Depth: 25.7'









R.W. Gillespie & Associates, Inc.

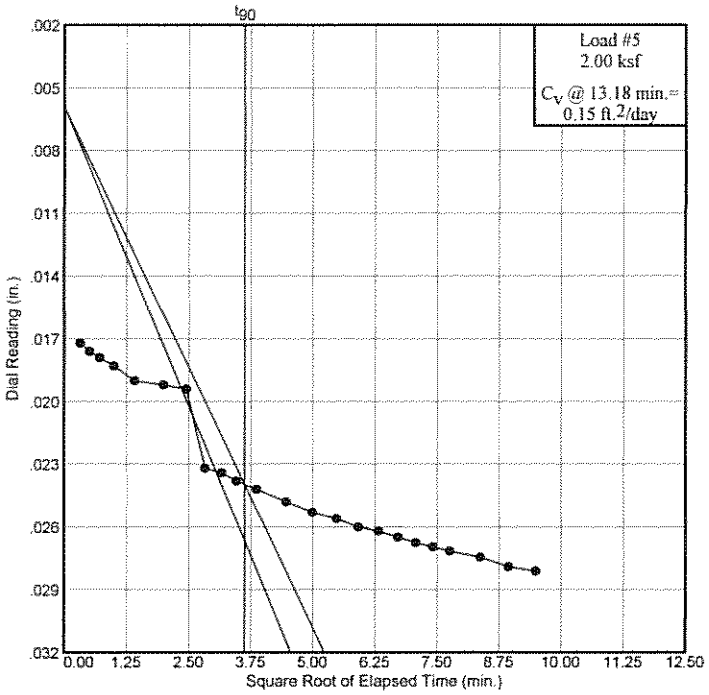
Saco, Maine

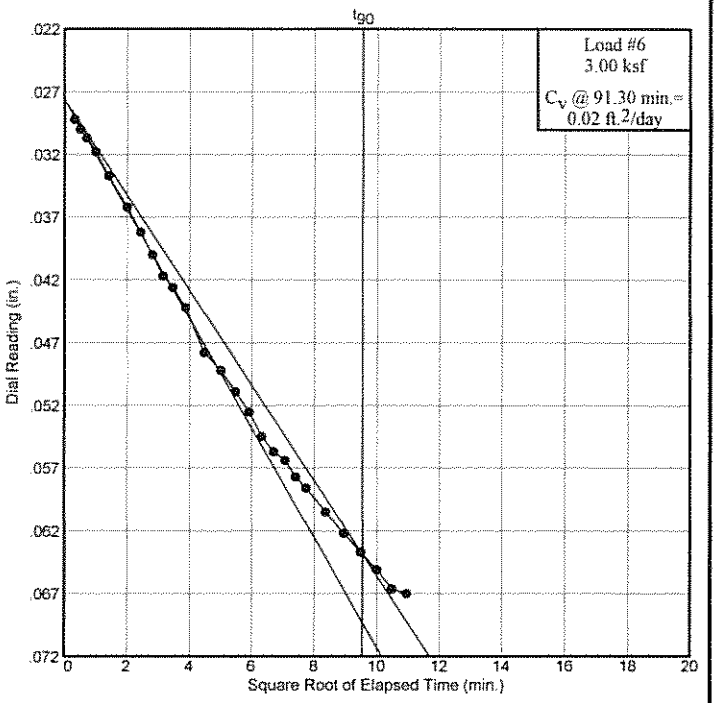
Lab No. 14008b

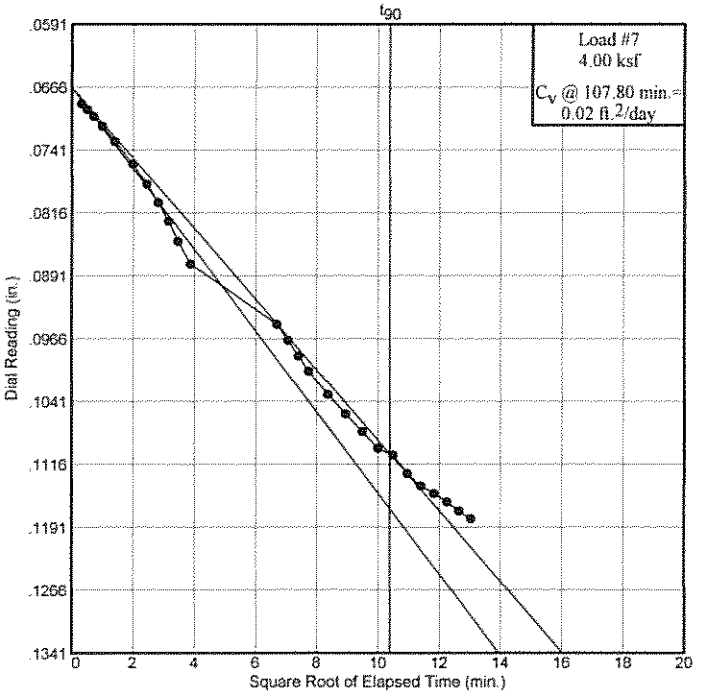
Dial Reading vs. Time

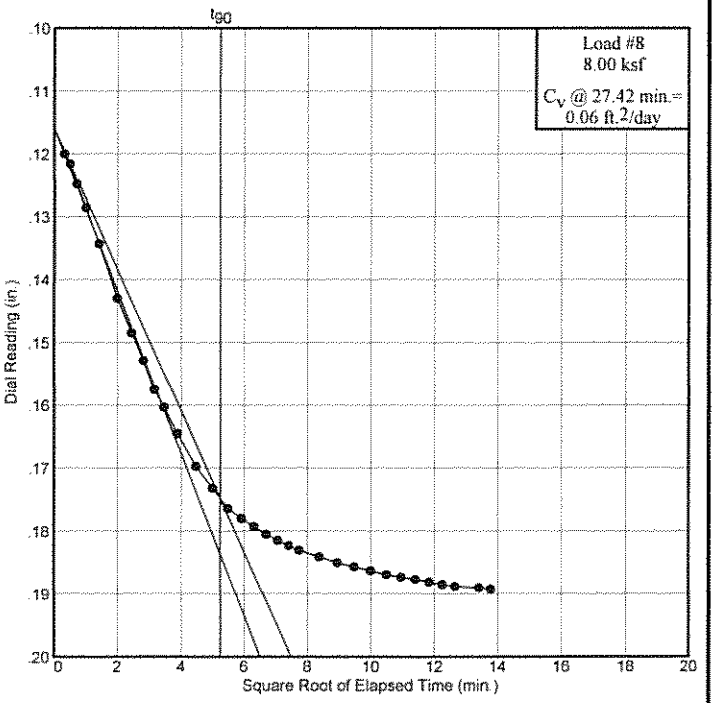
Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-2 Elev./Depth: 25.7'









R.W. Gillespie & Associates, Inc.

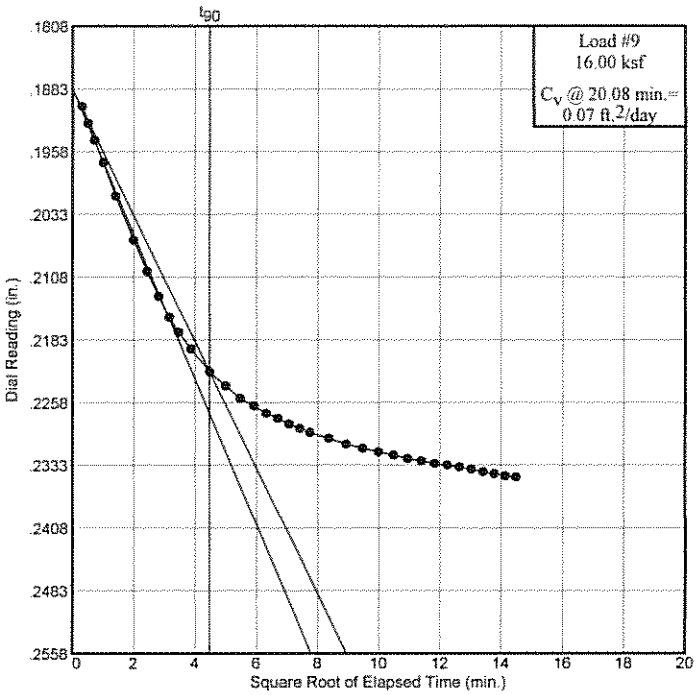
Saco, Maine

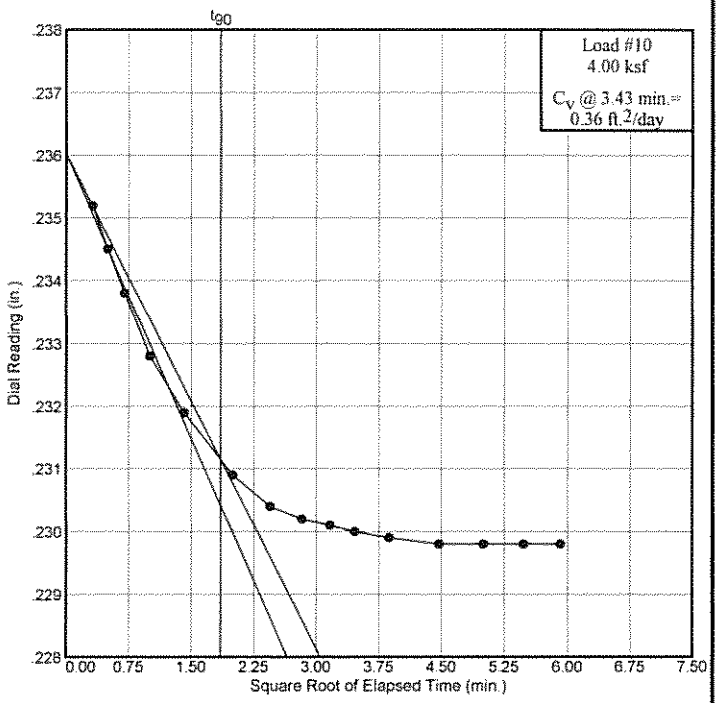
Lab No. 14008b

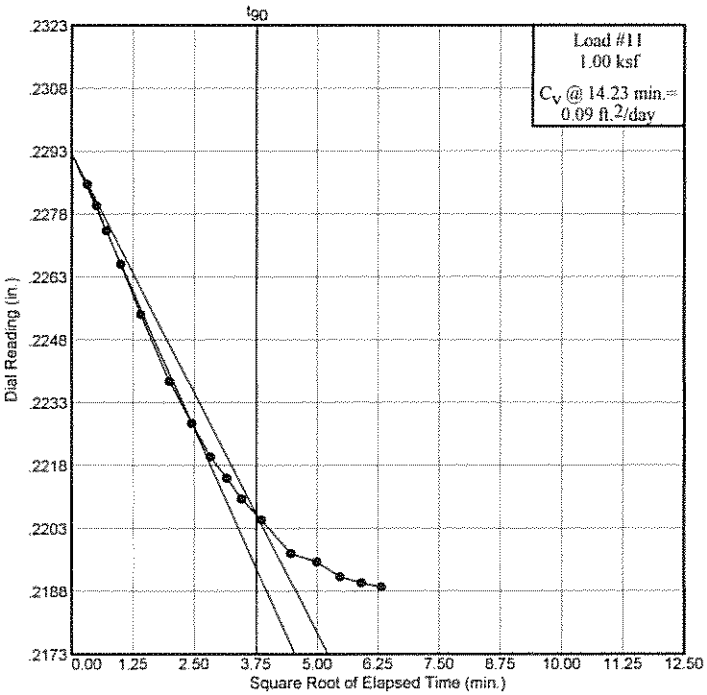
Dial Reading vs. Time

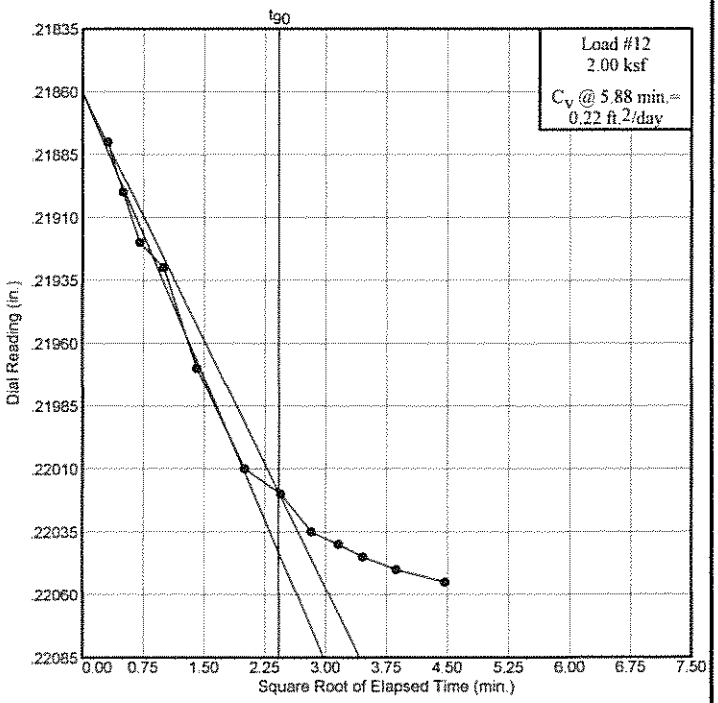
Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-2 Elev./Depth: 25.7'









R.W. Gillespie & Associates, Inc.

Saco, Maine

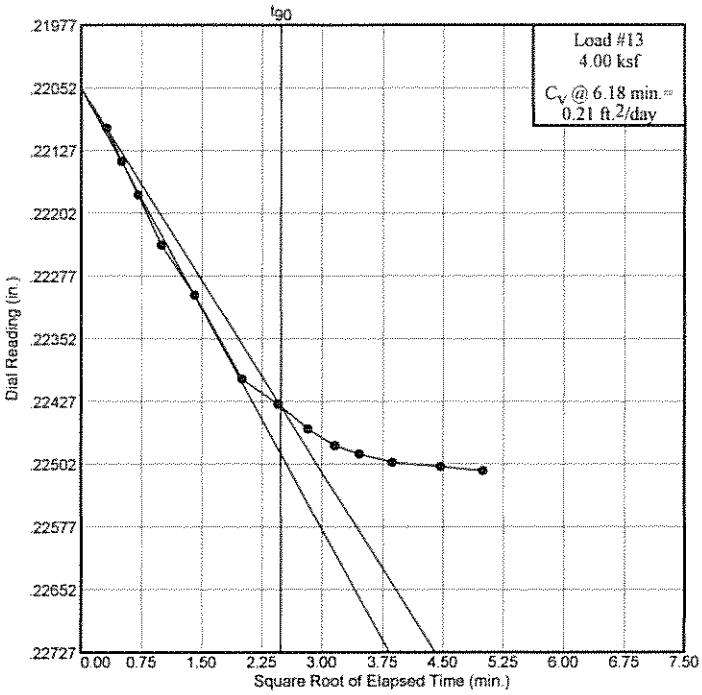
MTC

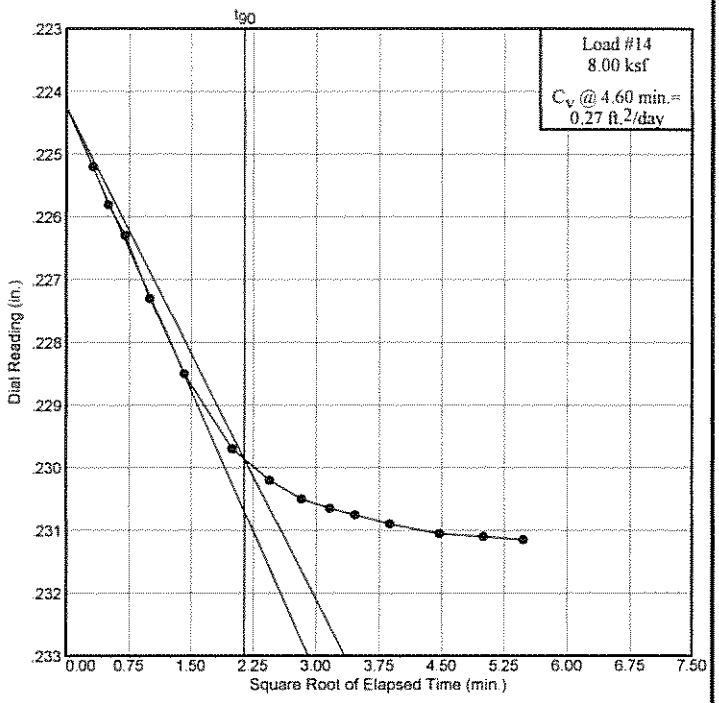
Lab No. 14008b

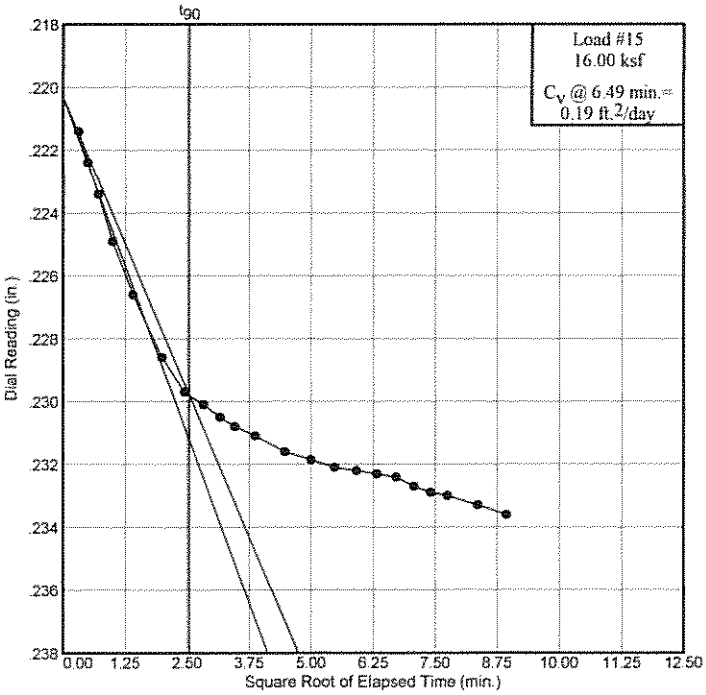
Dial Reading vs. Time

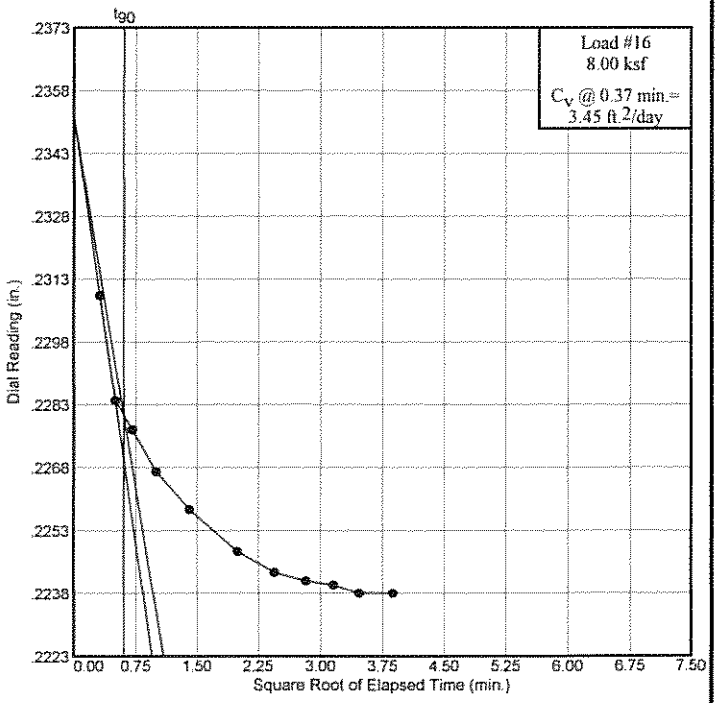
Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-2 Elev./Depth: 25.7'









R.W. Gillespie & Associates, Inc.

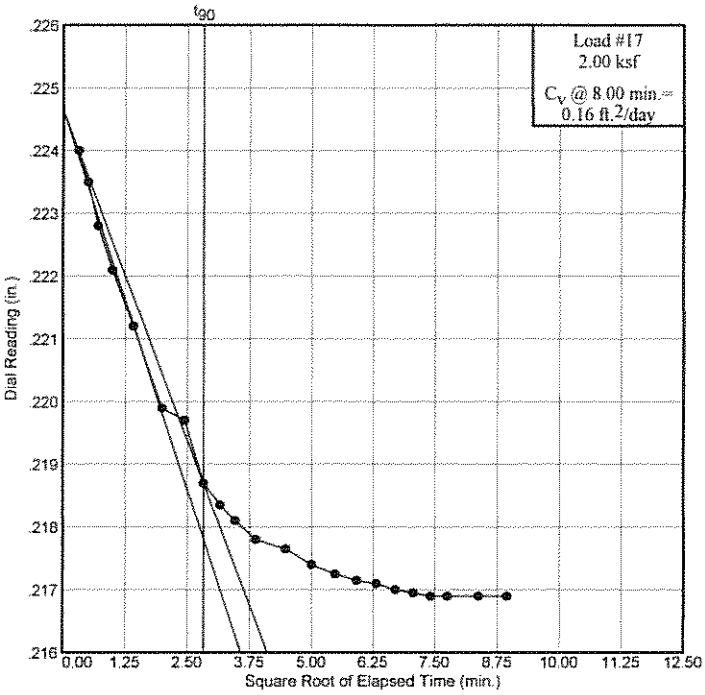
Saco, Maine

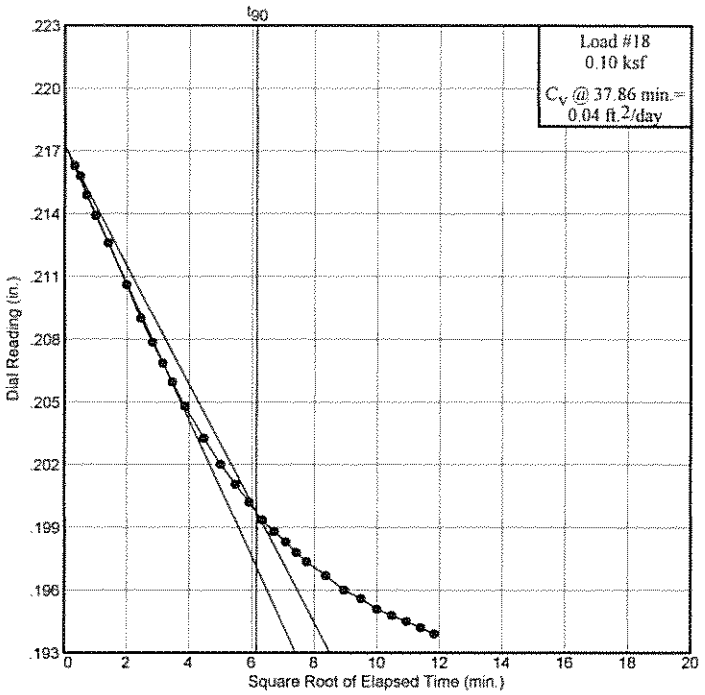
Lab No. 14008b

Dial Reading vs. Time

Project No.: 1368-003
Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

Source: BB-WGLC-104 Sample No.: U-2 Elev./Depth: 25.7'



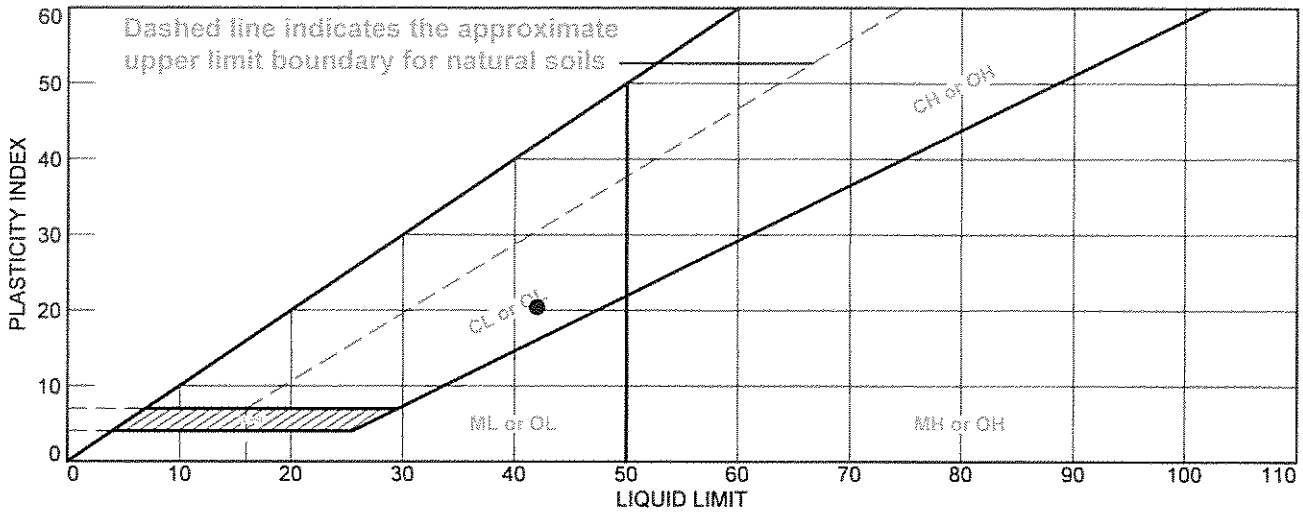


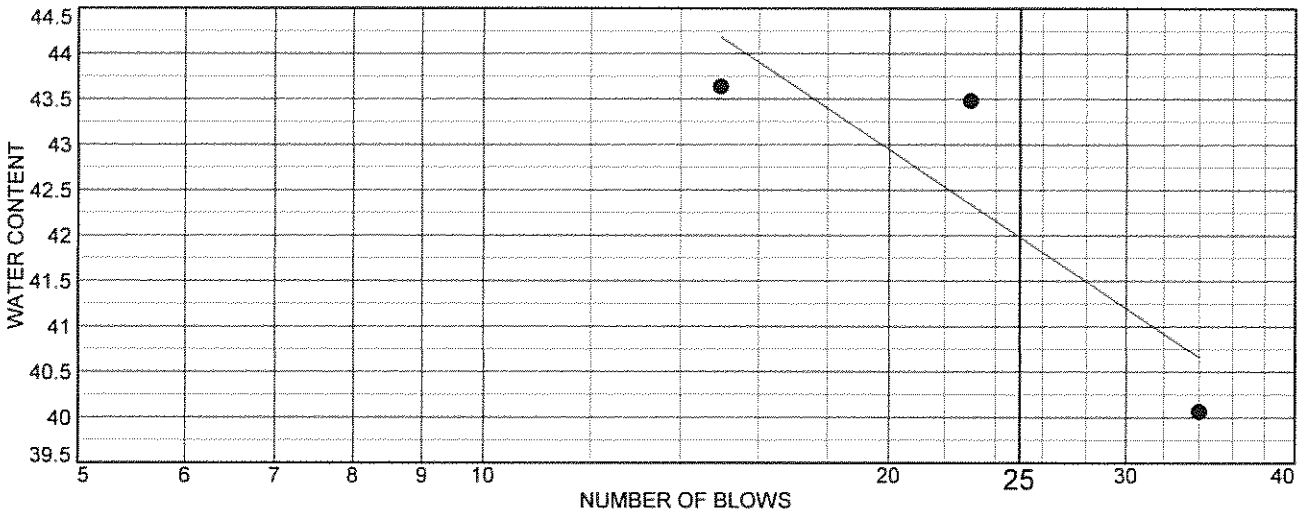
R.W. Gillespie & Associates, Inc.
Saco, Maine

MTC

Lab No. 14008b

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Silty Clay - Soft, gray-blue	42.0	21.6	20.4			

Project No. 1368-003 **Client:** Schonewald Engineering Associates, Inc.

Project: 15-031 Burnham Bridge (MaineDOT WIN 18954.00)

● **Loc.:** W. Gardiner-Litchfield **Depth:** 25'-27' **Sample No.:** U-2

Remarks:

● Moisture Content: 48.9% at 25.25'
Source: BB-WGLC-104

R.W. Gillespie & Associates, Inc.

Saco, Maine

MTG

Lab No. 14008B

Tested By: JEL **Checked By:** MTG

SCHONEWALD
ENGINEERING
ASSOCIATES, INC.
■ www.SchonewaldEngineering.com ■

SUPPLEMENTAL 100-SERIES SOILS LABORATORY TEST RESULTS
(pH, SULFATES, AND CHLORIDES BY AASHTO METHODS)

Client:	Schonewald Engineering Associates, Inc
Project Name:	Burnham Bridge (MaineDOT WIN 18954)
Project Location:	W. Gardiner-Litchfield
GTX #:	304946
Test Date:	06/28/16
Tested By:	jbr
Checked By:	jsc

pH by AASHTO T 289

Boring ID	Sample ID	Depth, ft	Description	pH
BB-WGLC-104	1D	2-4	Moist, brown silty sand	6.31
BB_WGLC-102	2D/3D/4D	5-17	Moist, brown clayey gravel	6.73

Notes:

FUGRO CONSULTANTS, INC.

6100 HILLCROFT
PHONE (713) 369-5400

HOUSTON, TEXAS 77081
FAX (713) 369-5518

RESULTS OF TESTS

PROJECT: BB-WGLC-102, 2D/3D/4D 5 -17' (GTX 304946)

FOR: GEOTESTING EXPRESS, INC.
125 NAGOG PARK ACTION, MA 01720

REPORTED TO: ETHAN MARRO

LAB NUMBER: 0706015

REPORT DATE: 07-11-16
CLIENT NUMBER:
JOB NUMBER: 04.1115-0003
REPORT NUMBER:
DATE SAMPLED:
TIME SAMPLED:
SAMPLED BY: CLIENT
DATE RECEIVED: 07-06-16
TIME RECEIVED: 1300
RECEIVED BY: SD

PARAMETER	RESULTS	UNITS	METHOD	TIME/DATE	ANALYST
Sulfate, Soluble	161 *	mg/kg	AASHTO T 290	0900/07-11-16	SD
Chloride, Soluble	63 *	mg/kg	AASHTO T 291	1000/07-11-16	SD

SO4CL 061-16

Respectfully submitted,

*** Dry weight basis**

Steve DeGregorio
Chemist

SD

THE RESULTS RELATE AS TO THE LOCATION TESTED AND NO OTHER REFERENCE SHALL BE MADE.
THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN APPROVAL OF THE LABORATORY.

END OF REPORT

FUGRO CONSULTANTS, INC.

6100 HILLCROFT
PHONE (713) 369-5400

HOUSTON, TEXAS 77081
FAX (713) 369-5518

RESULTS OF TESTS

PROJECT: BB-WGLC-104, 1D, 3 – 4' (GTX 304946)

FOR: GEOTESTING EXPRESS, INC.
125 NAGOG PARK ACTION, MA 01720

REPORTED TO: ETHAN MARRO

LAB NUMBER: 0706016

REPORT DATE: 07-11-16
CLIENT NUMBER:
JOB NUMBER: 04.1115-0003
REPORT NUMBER:
DATE SAMPLED:
TIME SAMPLED:
SAMPLED BY: CLIENT
DATE RECEIVED: 07-06-16
TIME RECEIVED: 1300
RECEIVED BY: SD

PARAMETER	RESULTS	UNITS	METHOD	TIME/DATE	ANALYST
Sulfate, Soluble	< 30 *	mg/kg	AASHTO T 290	0900/07-11-16	SD
Chloride, Soluble	162 *	mg/kg	AASHTO T 291	1000/07-11-16	SD

SO4CL 061-16

Respectfully submitted,

*** Dry weight basis**

Steve DeGregorio
Chemist

SD

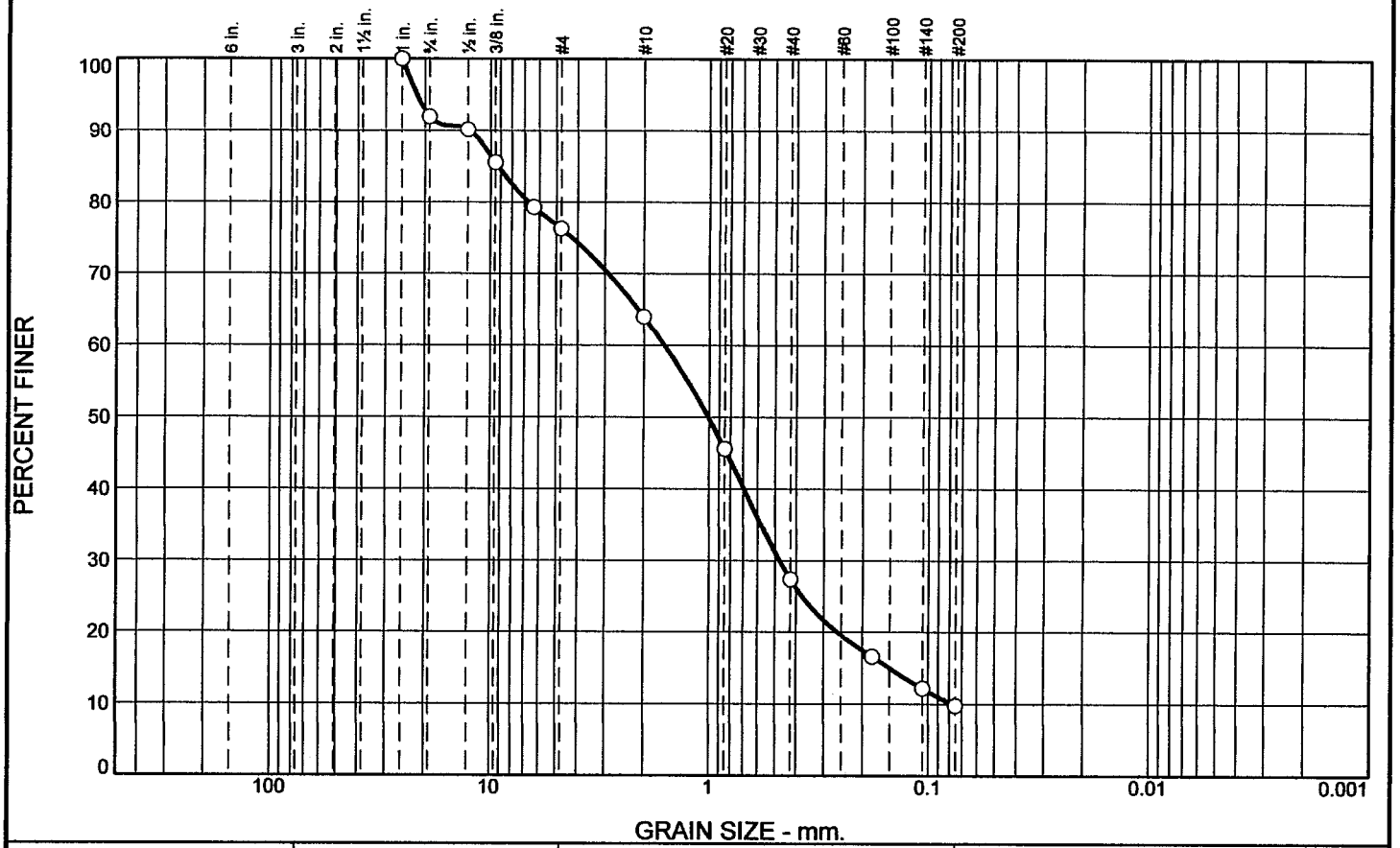
THE RESULTS RELATE AS TO THE LOCATION TESTED AND NO OTHER REFERENCE SHALL BE MADE.
THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN APPROVAL OF THE LABORATORY.

END OF REPORT

SCHONEWALD
ENGINEERING
ASSOCIATES, INC.
■ www.SchonewaldEngineering.com ■

200-SERIES SOILS LABORATORY TEST RESULTS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	8.1	15.6	12.3	36.6	17.6	9.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	91.9		
1/2"	90.1		
3/8"	85.5		
1/4"	79.3		
#4	76.3		
#10	64.0		
#20	45.6		
#40	27.4		
#80	16.6		
#140	12.2		
#200	9.8		

* (no specification provided)

Soil Description

Well-graded sand with silt and gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 12.5060 D_{85}= 9.2648 D_{60}= 1.6087
D_{50}= 1.0124 D_{30}= 0.4774 D_{15}= 0.1496
D_{10}= 0.0776 C_u= 20.72 C_c= 1.82

Classification

USCS= SW-SM AASHTO= A-1-b

Remarks

Moisture Content: 6.3%

Location: BB-WGLC-201 - W. Gardner-Litchfield, ME
Sample Number: 2D **Depth:** 5'-7'

Date: 9/9/2017

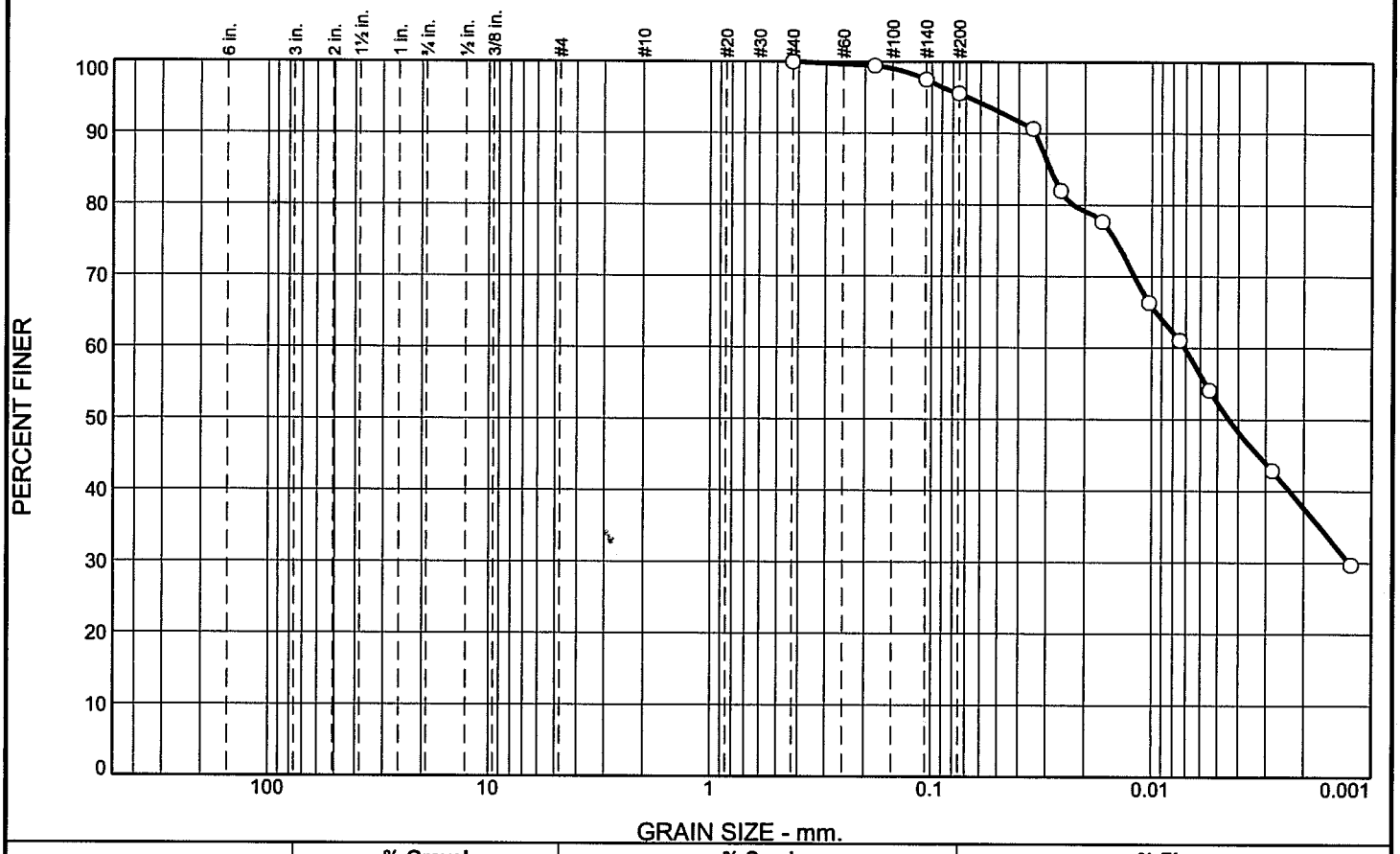
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Project No: 1368-006 **Lab No.** 14660a

Tested By: ZTG **Checked By:** MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	4.4	43.3	52.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#40	100.0		
#80	99.5		
#140	97.5		
#200	95.6		
0.0344 mm.	90.7		
0.0257 mm.	82.0		
0.0167 mm.	77.6		
0.0103 mm.	66.3		
0.0075 mm.	61.1		
0.0054 mm.	54.1		
0.0028 mm.	42.9		
0.0012 mm.	29.7		

* (no specification provided)

Soil Description

Silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.0336 D_{85}= 0.0287 D_{60}= 0.0071
D_{50}= 0.0044 D_{30}= 0.0012 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

Moisture Content - 32.2%

Location: BB-WGLC-201 - W. Gardner-Litchfield, ME
Sample Number: 4D **Depth:** 15'-17'

Date: 9/9/2017

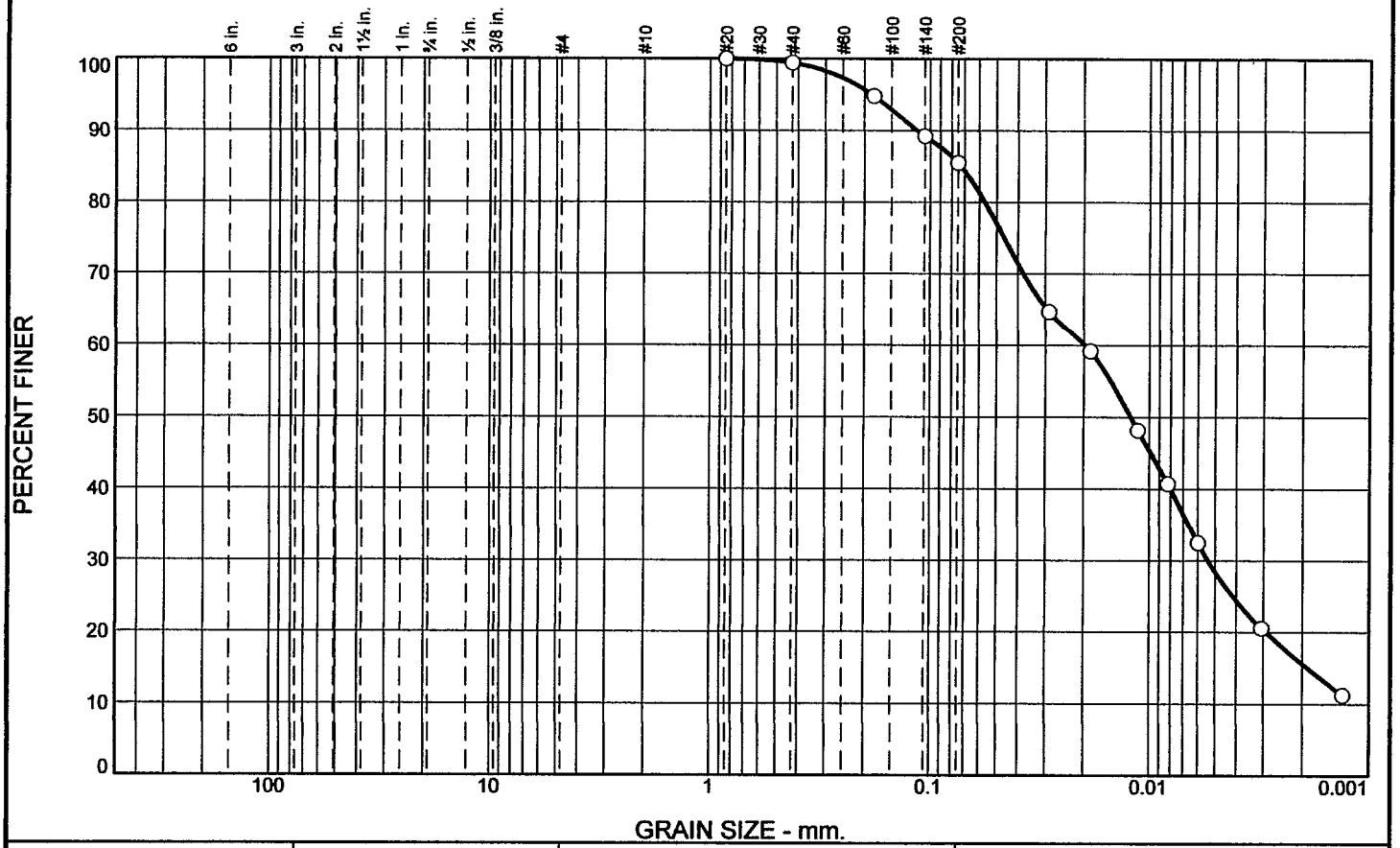
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Project No: 1368-006 **Lab No.** 14660b

Tested By: AGS **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.6	13.9	57.1	28.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	99.4		
#80	94.8		
#140	89.2		
#200	85.5		
0.0288 mm.	64.7		
0.0187 mm.	59.2		
0.0113 mm.	48.1		
0.0082 mm.	40.7		
0.0060 mm.	32.5		
0.0031 mm.	20.6		
0.0013 mm.	11.2		

* (no specification provided)

Soil Description

Elastic silt

Atterberg Limits

PL= 102.5 LL= 146.7 PI= 44.2

Coefficients

D_{90}= 0.1148 D_{85}= 0.0727 D_{60}= 0.0197
D_{50}= 0.0122 D_{30}= 0.0054 D_{15}= 0.0019
D_{10}= C_u= C_c=

Classification

USCS= MH AASHTO= A-7-5(62)

Remarks

Moisture Content - 140.2%

Location: BB-WGLC-201 - W. Gardner-Litchfield, ME
Sample Number: 5D **Depth:** 17'-19' **Date:**

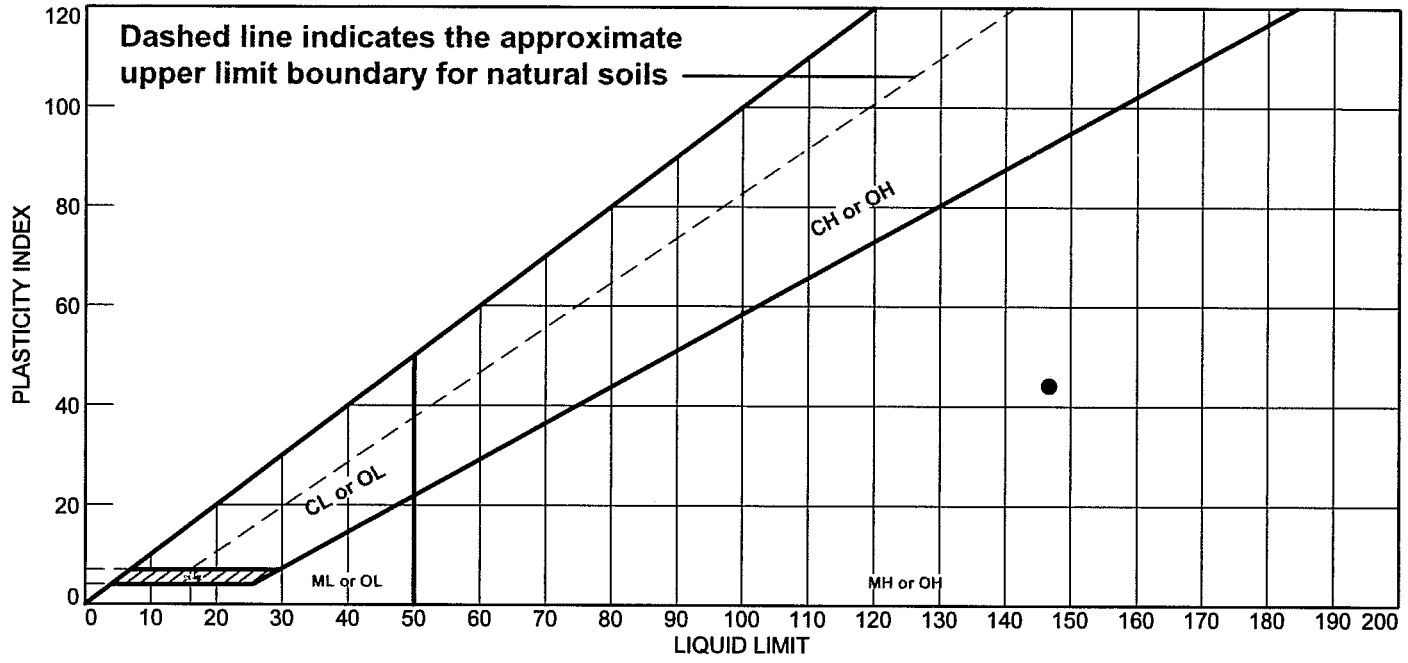
R.W. Gillespie & Associates, Inc.
Saco, Maine

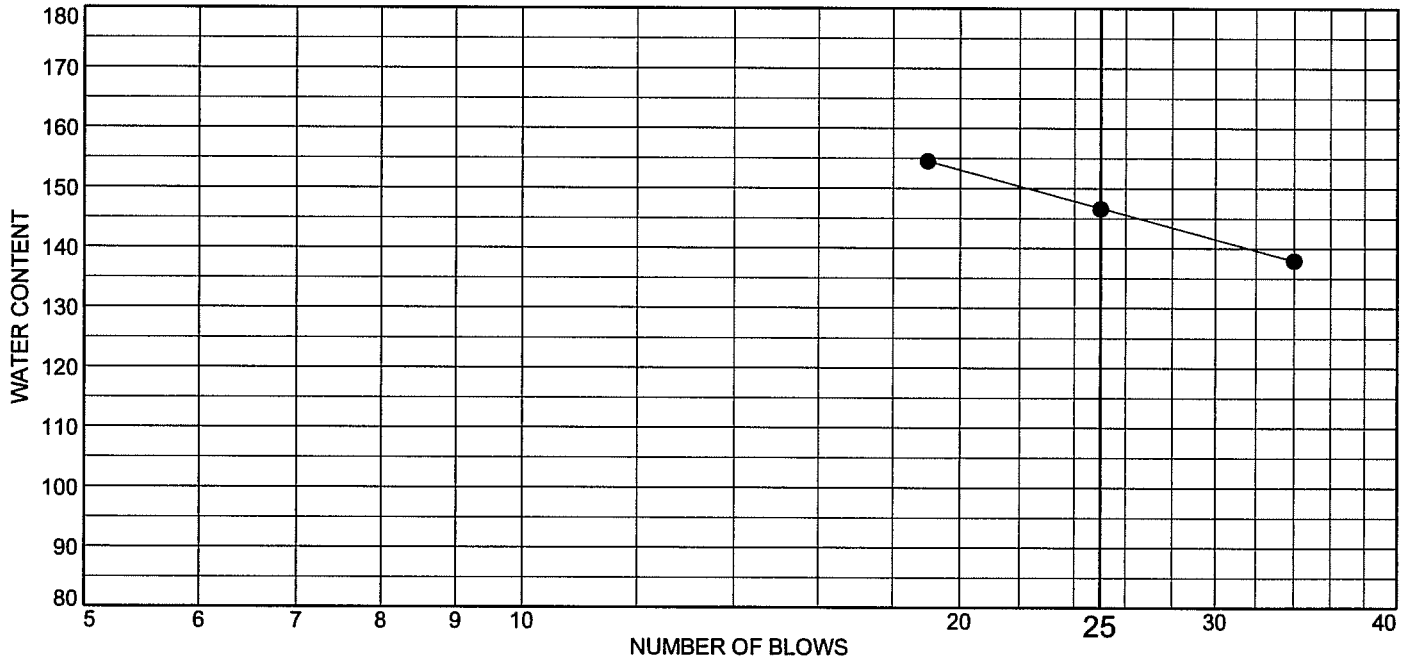
Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Project No: 1368-006 **Lab No.** 14660c

Tested By: JRF **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Elastic silt	146.7	102.5	44.2	99.4	85.5	MH

Project No. 1368-006 **Client:** Schonewald Engineering Associates, Inc

Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Location: BB-WGLC-201 - W. Gardner-Litchfield, ME
Sample Number: 5D **Depth:** 17'-19'

R.W. Gillespie & Associates, Inc.

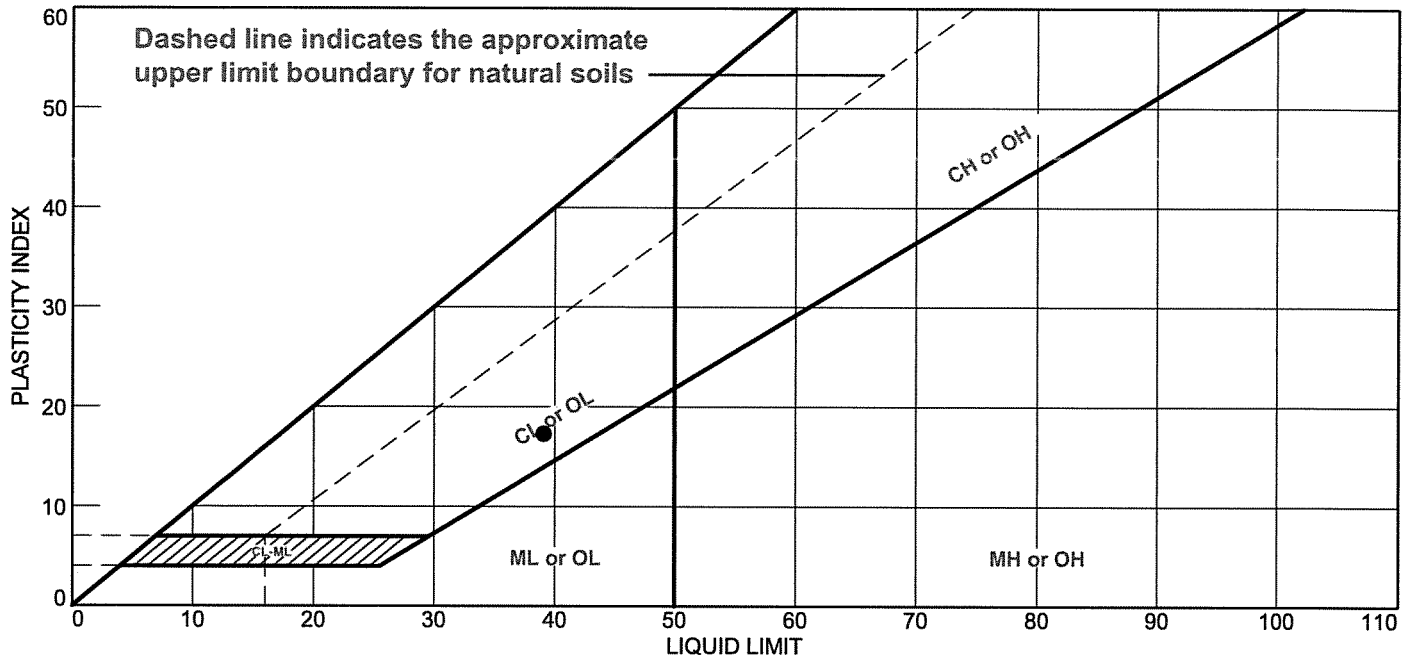
Saco, Maine

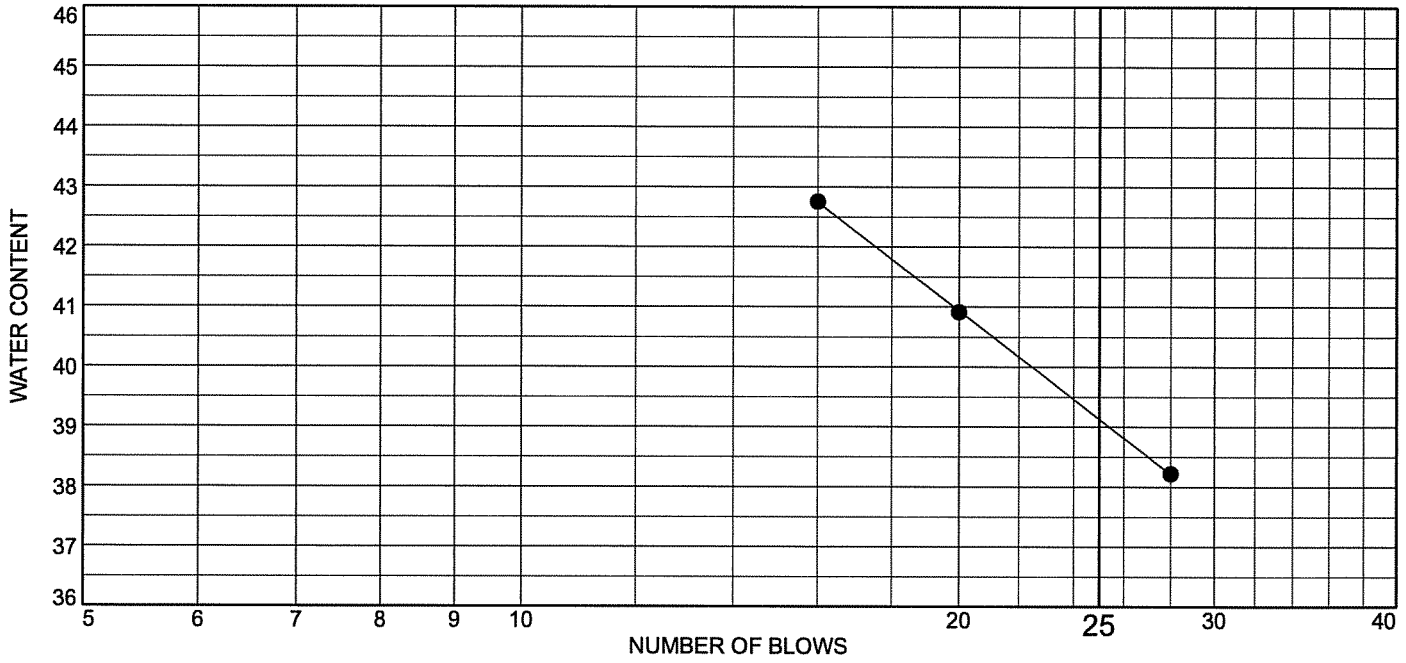
Remarks:
● Moisture Content - 140.2

Lab No. 14660c

Tested By: AGS **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Marine Clay	39.1	21.8	17.3			

Project No. 1368-006 **Client:** Schonewald Engineering Associates, Inc

Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Location: BB-WGLC-201 - W. Gardner-Litchfield, ME
Sample Number: 7D **Depth:** 22'-24'

R.W. Gillespie & Associates, Inc.

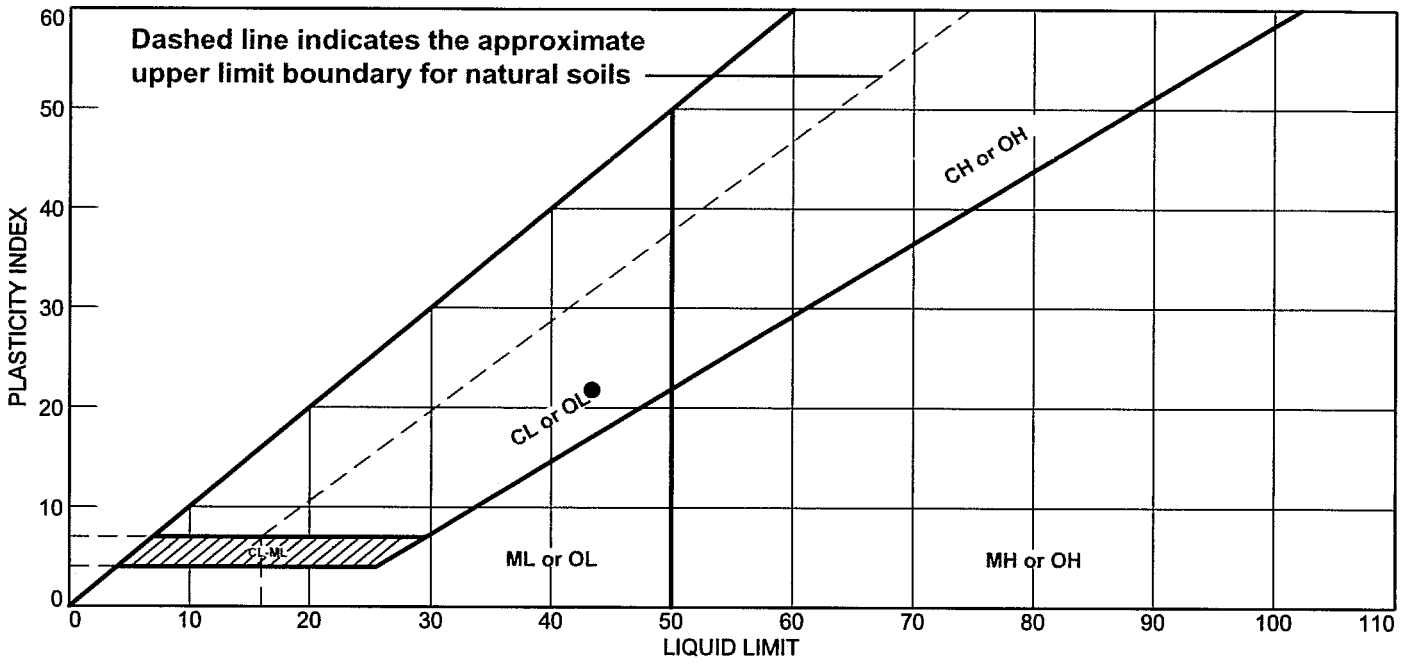
Saco, Maine

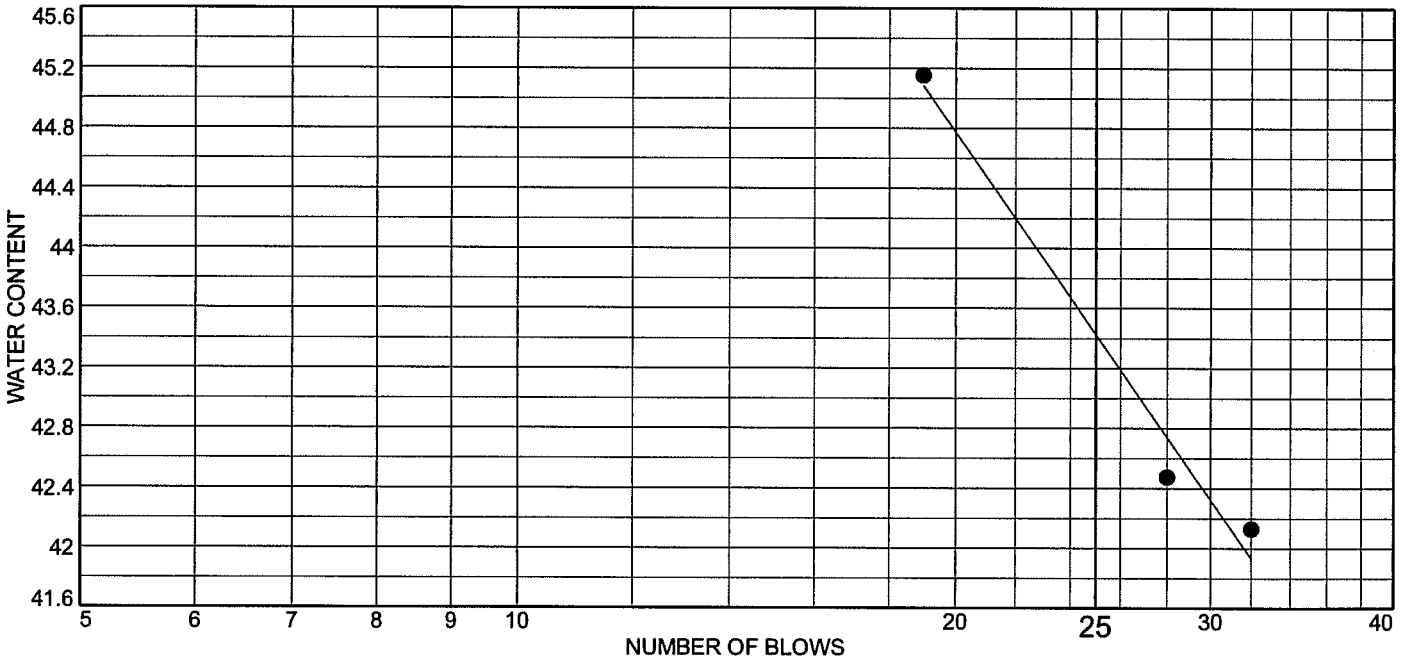
Remarks:
● Moisture Content - 43.5%

Lab No. 14660d

Tested By: AGS **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Marine Clay	43.4	21.6	21.8			

Project No. 1368-006 **Client:** Schonewald Engineering Associates, Inc

Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Location: BB-WGLC-201 - W. Gardner-Litchfield, ME
Sample Number: 8D **Depth:** 25'-27'

R.W. Gillespie & Associates, Inc.

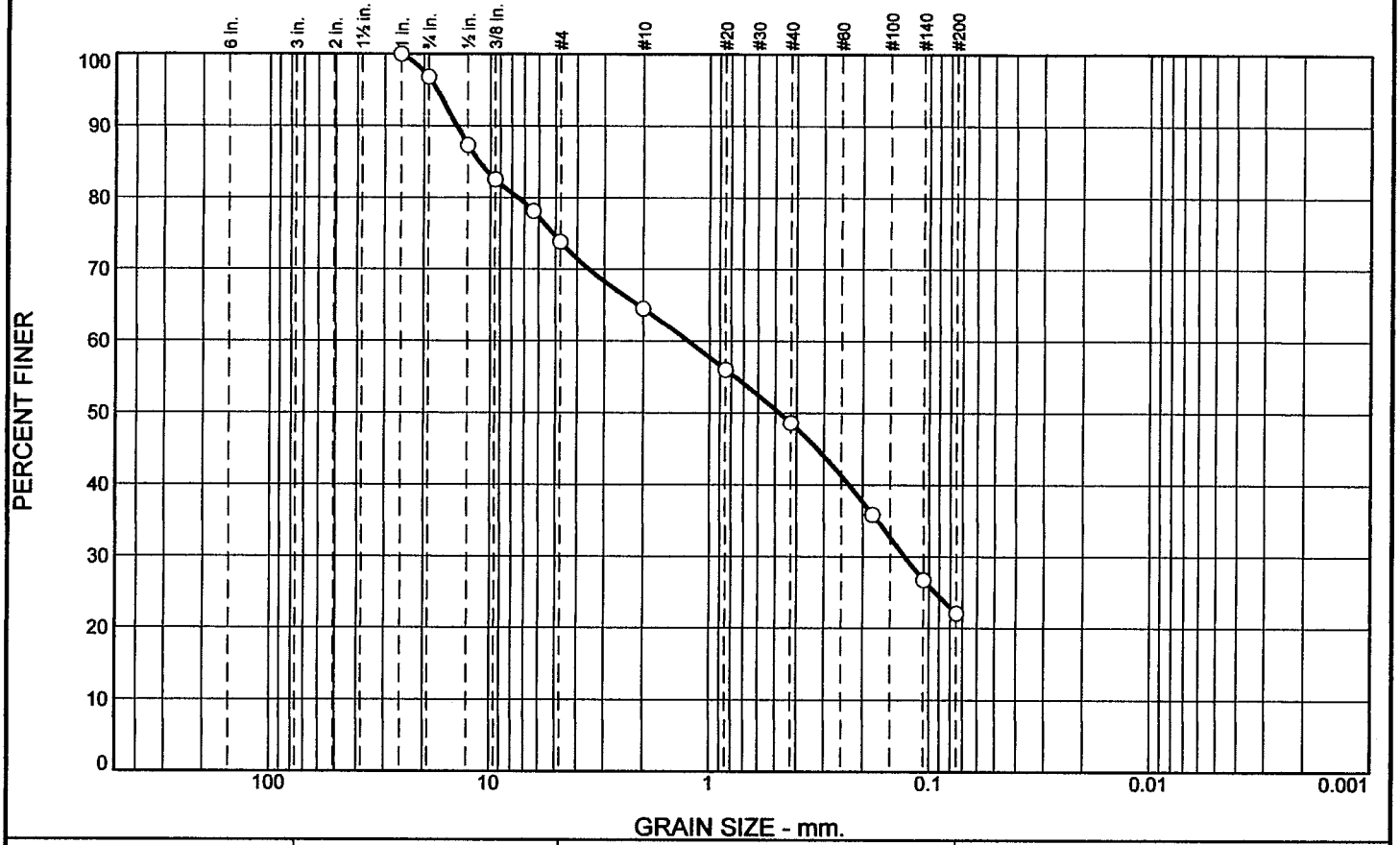
Saco, Maine

Remarks:
● Moisture Content - 46.4 %

Lab No. 14660e

Tested By: JRF **Checked By:** MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	3.2	23.0	9.3	15.9	26.5	22.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	96.8		
1/2"	87.3		
3/8"	82.5		
1/4"	78.1		
#4	73.8		
#10	64.5		
#20	56.0		
#40	48.6		
#80	35.9		
#140	26.8		
#200	22.1		

* (no specification provided)

Soil Description

Silty sand with gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 14.2263 D_{85}= 11.2991 D_{60}= 1.2559
D_{50}= 0.4779 D_{30}= 0.1293 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

Moisture Content - 8.2%

Location: BB-WGLC-201 - W. Gardner-Litchfield, ME
Sample Number: 10D **Depth:** 35'-37-

Date: 9/7/2017

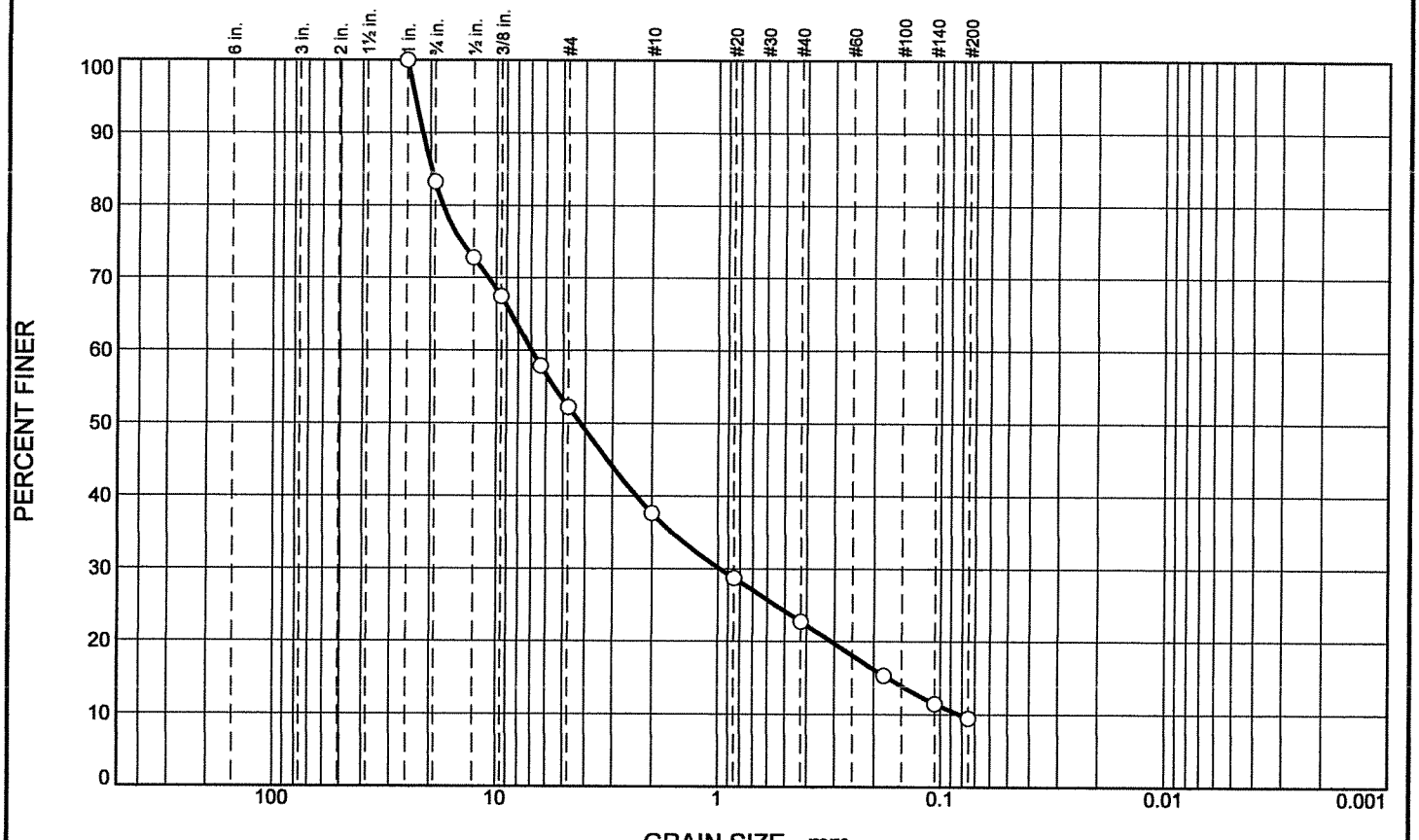
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Project No: 1368-006 **Lab No.** 14660f

Tested By: ZTG **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	16.8	31.0	14.6	14.8	13.3	9.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	83.2		
1/2"	72.8		
3/8"	67.5		
1/4"	57.9		
#4	52.2		
#10	37.6		
#20	28.7		
#40	22.8		
#80	15.3		
#140	11.5		
#200	9.5		

* (no specification provided)

Soil Description

Well-graded gravel with silt and sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 21.6722 D_{85}= 19.7764 D_{60}= 6.9566
D_{50}= 4.2000 D_{30}= 0.9851 D_{15}= 0.1728
D_{10}= 0.0822 C_u= 84.66 C_c= 1.70

Classification

USCS= GW-GM AASHTO= A-1-a

Remarks

Moisture Content - 9.5%

Location: BB-WGLC-202 - W. Gardner-Litchfield, ME
Sample Number: 3D **Depth:** 10'-12'

Date: 9/7/2017

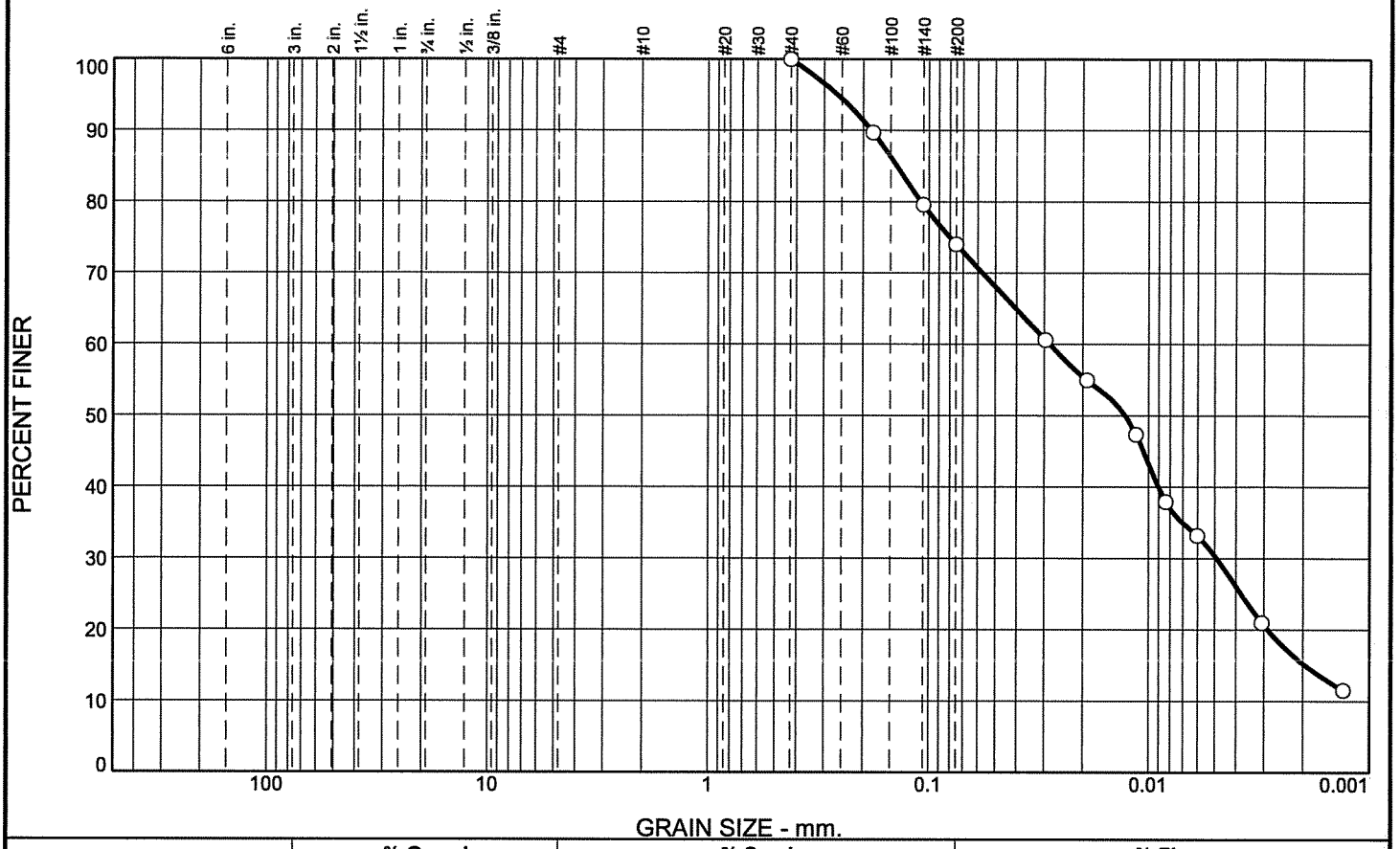
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Project No: 1368-006 **Lab No.** 14661a

Tested By: ZTG **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	26.0	43.6	30.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#40	100.0		
#80	89.7		
#140	79.6		
#200	74.0		
0.0296 mm.	60.6		
0.0192 mm.	55.0		
0.0114 mm.	47.4		
0.0084 mm.	37.9		
0.0060 mm.	33.2		
0.0031 mm.	21.0		
0.0013 mm.	11.5		

* (no specification provided)

Soil Description

Silt with sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.1832 D_{85}= 0.1404 D_{60}= 0.0283
D_{50}= 0.0128 D_{30}= 0.0049 D_{15}= 0.0019
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

Moisture Content - 101.0%
NP=Non-plastic, NV=Non-viscous, CNBD=Could not be determined.

Location: BB-WGLC-202 - W. Gardner-Litchfield, ME
Sample Number: 6D **Depth:** 22'-24'

Date: 9/7/2017

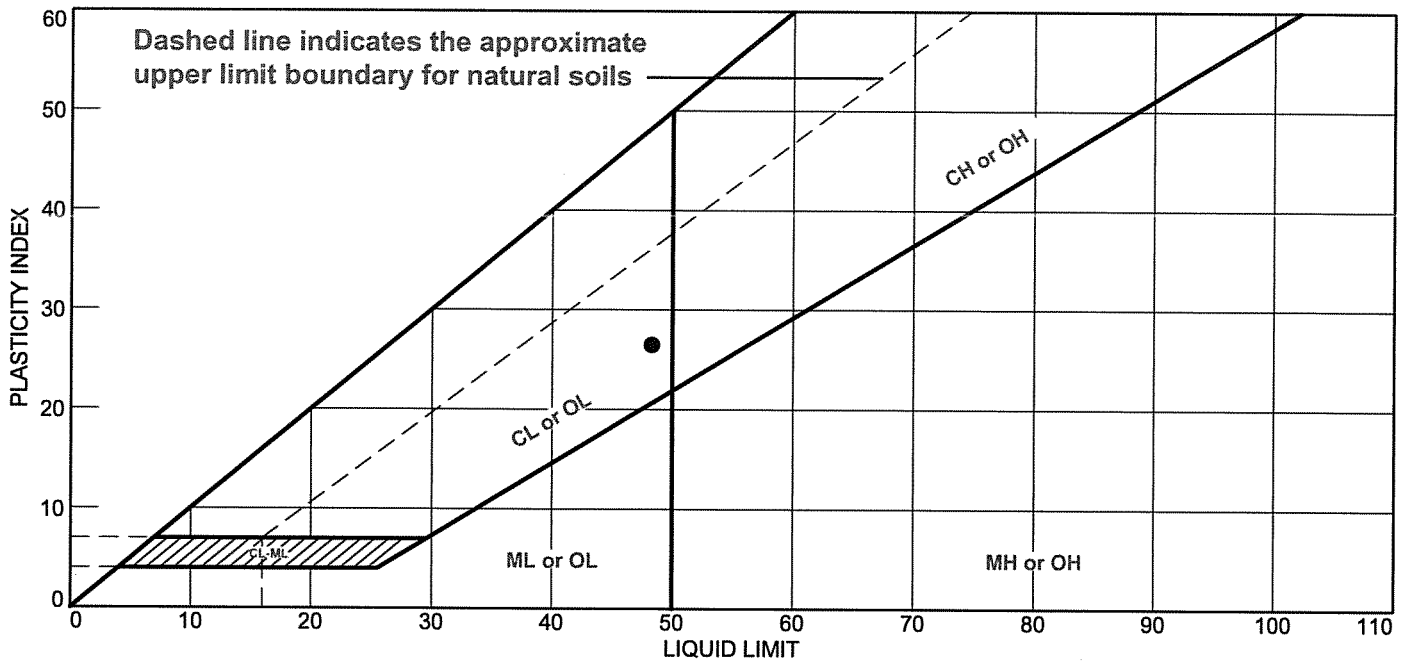
R.W. Gillespie & Associates, Inc.
Saco, Maine

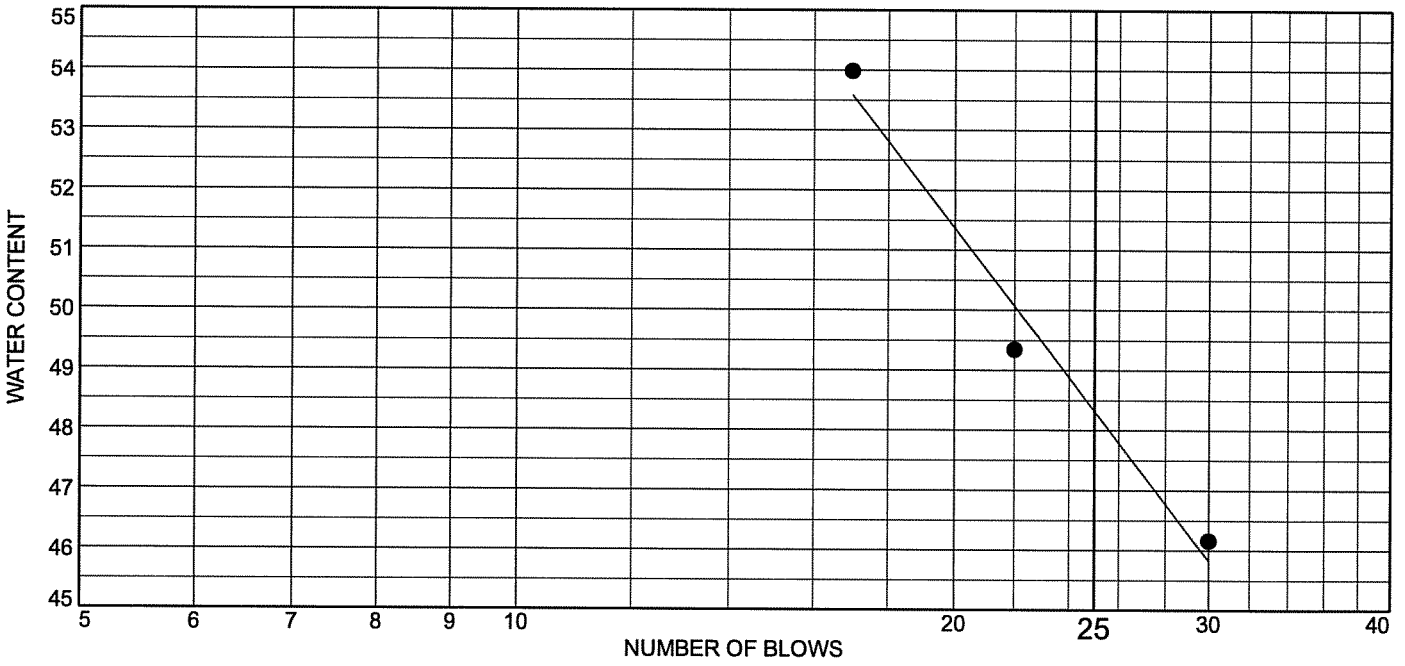
Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Project No: 1368-006 **Lab No.** 14661b

Tested By: AGS **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Marine Clay	48.3	21.8	26.5			

Project No. 1368-006 **Client:** Schonewald Engineering Associates, Inc

Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Location: BB-WGLC-202 - W. Gardner-Litchfield, ME
Sample Number: 7D **Depth:** 25'-26.8'

R.W. Gillespie & Associates, Inc.

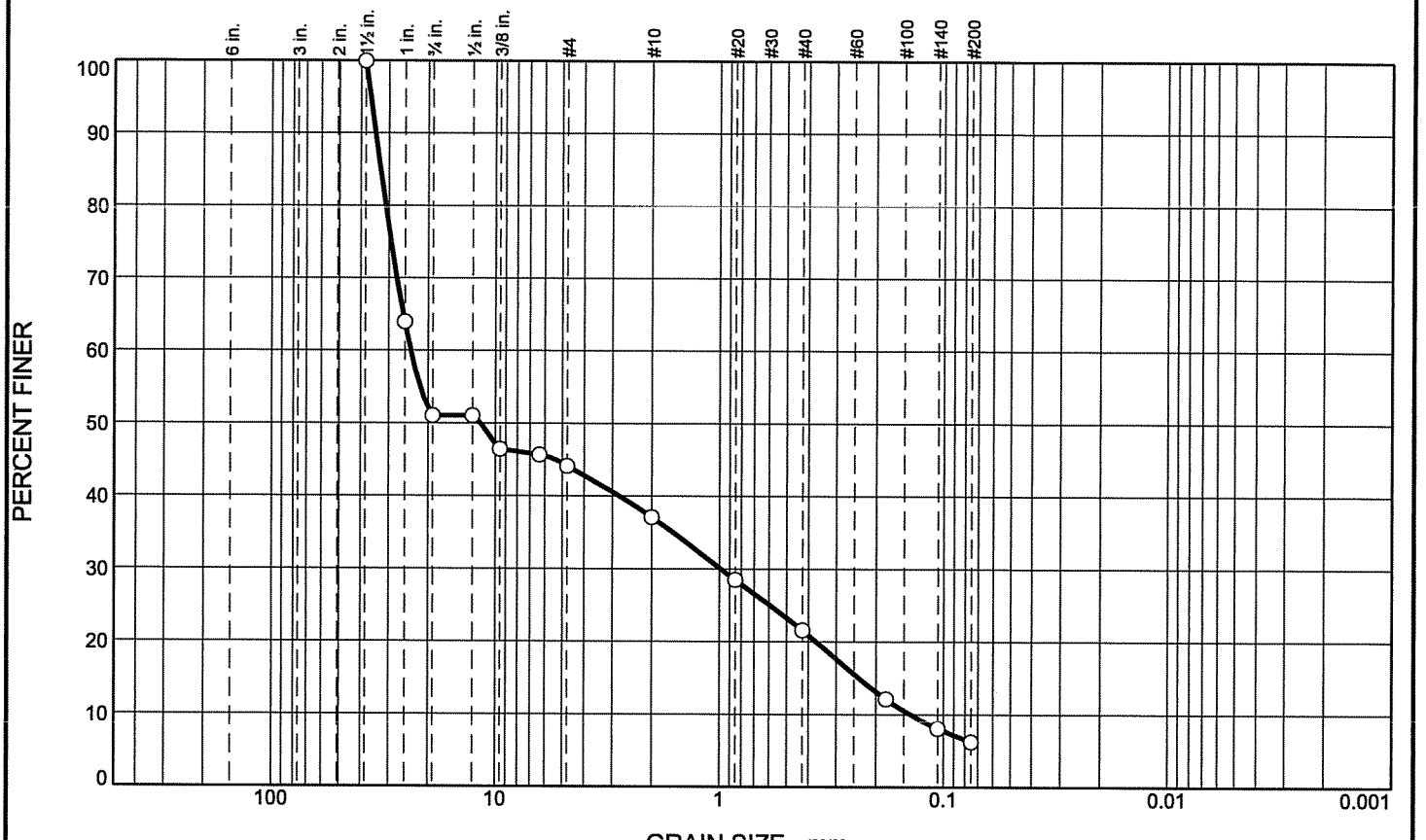
Saco, Maine

Remarks:
● Moisture Content - 42.7%

Lab No. 14661c

Tested By: AGS **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	48.9	6.9	7.1	15.5	15.4	6.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 1/2"	100.0		
1"	64.0		
3/4"	51.1		
1/2"	51.1		
3/8"	46.5		
1/4"	45.7		
#4	44.2		
#10	37.1		
#20	28.5		
#40	21.6		
#80	12.1		
#140	8.1		
#200	6.2		

* (no specification provided)

Soil Description

Poorly graded gravel with silt and sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 34.4119 D_{85}= 32.6625 D_{60}= 23.8810
D_{50}= 11.6257 D_{30}= 0.9835 D_{15}= 0.2376
D_{10}= 0.1401 C_u= 170.45 C_c= 0.29

Classification

USCS= GP-GM AASHTO= A-1-a

Remarks

Moisture Content - 8.7%

Location: BB-WGLC-202 - W. Gardner-Litchfield, ME
Sample Number: 8D **Depth:** 30'-32'

Date: 9/7/2017

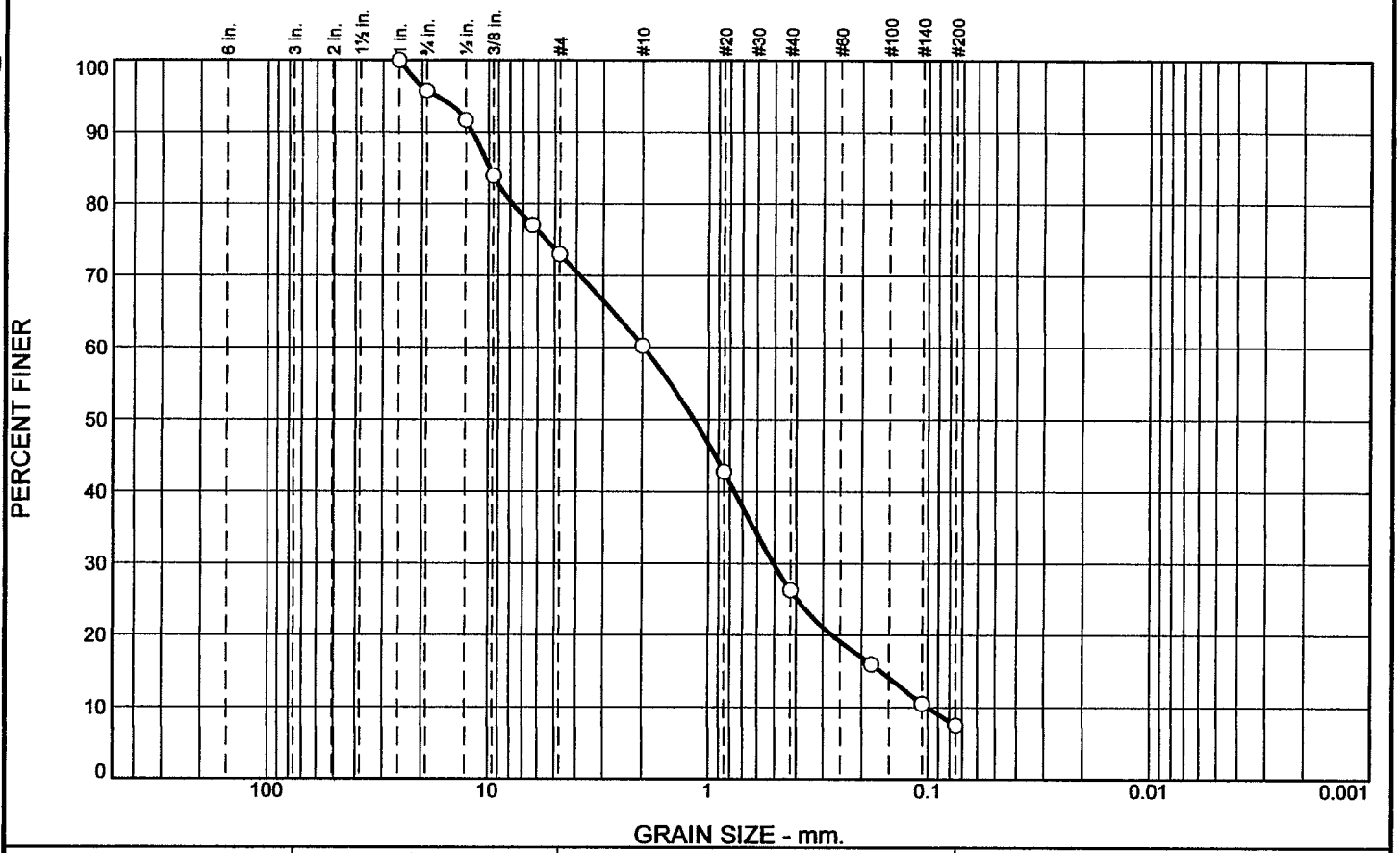
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Project No: 1368-006 **Lab No.** 14661d

Tested By: ZTG **Checked By:** MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	4.2	22.8	12.8	33.9	18.8	7.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	95.8		
1/2"	91.7		
3/8"	84.0		
1/4"	77.1		
#4	73.0		
#10	60.2		
#20	42.8		
#40	26.3		
#80	16.0		
#140	10.5		
#200	7.5		

* (no specification provided)

Soil Description

Well-graded sand with silt and gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 11.8300 D_{85}= 9.9092 D_{60}= 1.9710
D_{50}= 1.1659 D_{30}= 0.5081 D_{15}= 0.1634
D_{10}= 0.1002 C_u= 19.68 C_c= 1.31

Classification

USCS= SW-SM AASHTO= A-1-b

Remarks

Moisture Content - 5.2%

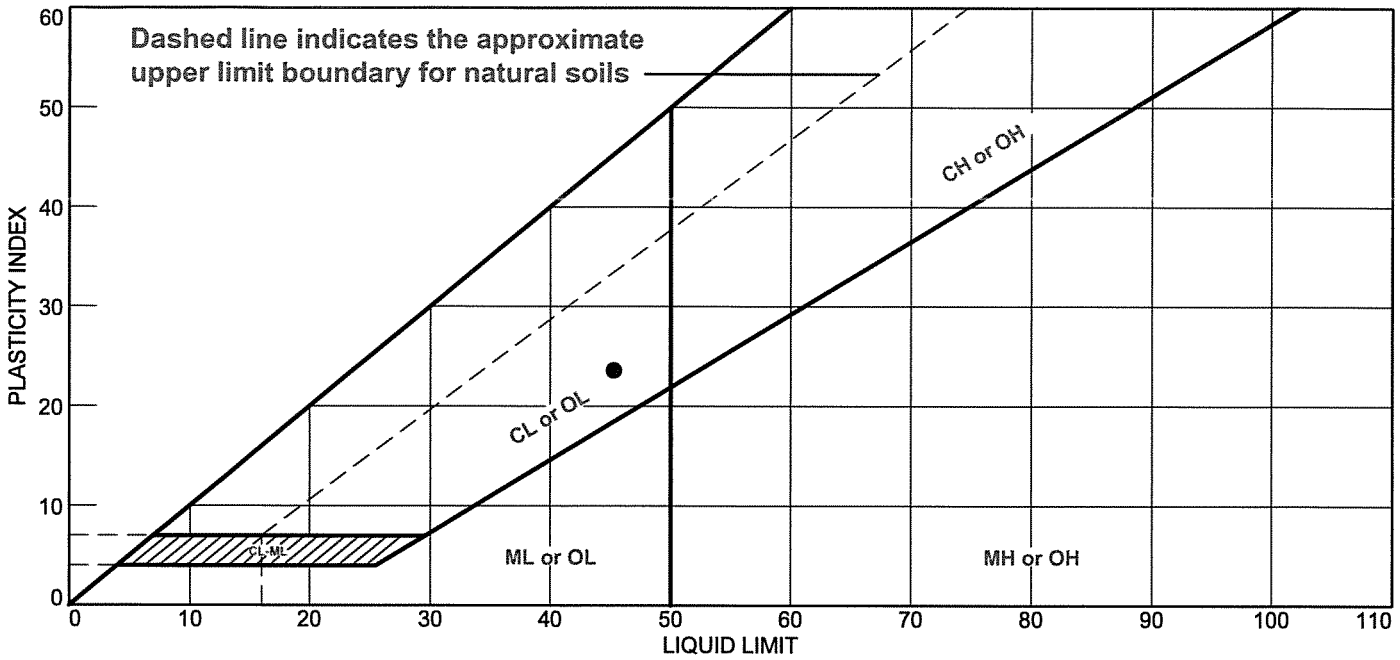
Location: BB-WGLC-203 - W. Gardner-Litchfield, ME
Sample Number: 2D **Depth:** 5'-7' **Date:** 9/7/2017

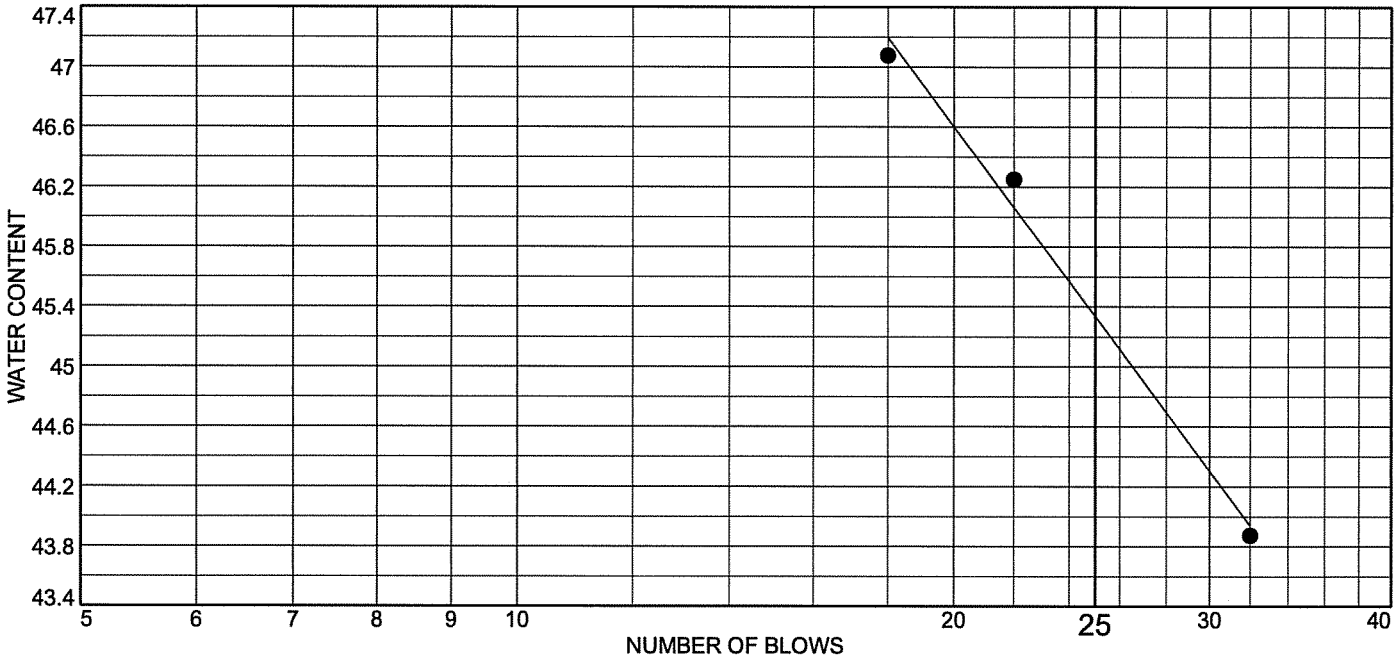
R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002
Project No: 1368-006 **Lab No.** 14662a

Tested By: AGS **Checked By:** MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Marine Clay	45.3	21.7	23.6			

Project No. 1368-006 **Client:** Schonewald Engineering Associates, Inc

Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Location: BB-WGLC-203 - W. Gardner-Litchfield, ME
Sample Number: 5D **Depth:** 20'-22'

R.W. Gillespie & Associates, Inc.

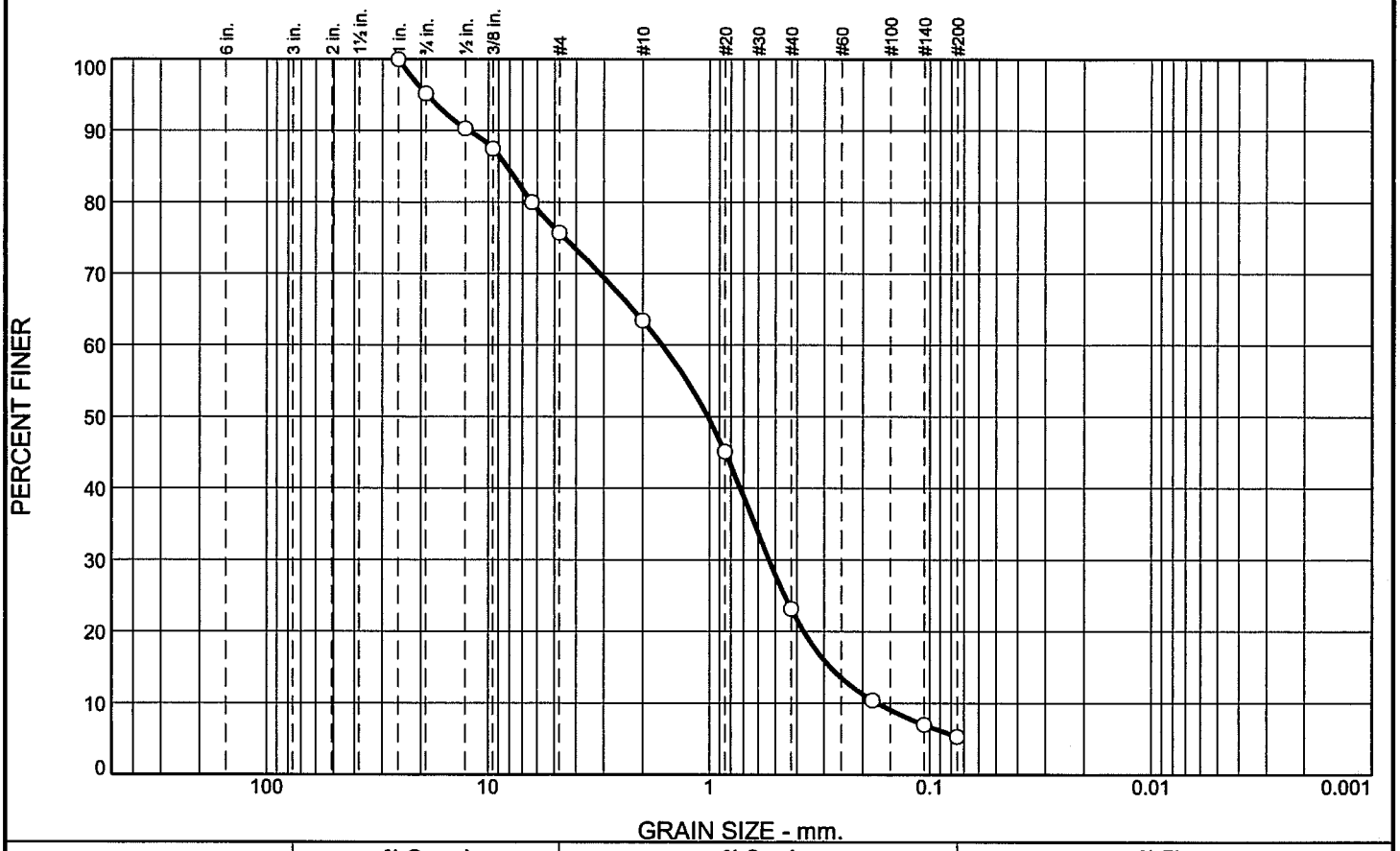
Saco, Maine

Remarks:
● Moisture Content - 42.6%

Lab No. 14662b

Tested By: JRF **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	4.8	19.5	12.2	40.3	17.9	5.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	95.2		
1/2"	90.3		
3/8"	87.5		
1/4"	80.0		
#4	75.7		
#10	63.5		
#20	45.1		
#40	23.2		
#80	10.4		
#140	7.0		
#200	5.3		

* (no specification provided)

Soil Description

Well-graded sand with silt and gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 12.2482 D_{85}= 8.2183 D_{60}= 1.6267
D_{50}= 1.0144 D_{30}= 0.5345 D_{15}= 0.2796
D_{10}= 0.1703 C_u= 9.55 C_c= 1.03

Classification

USCS= SW-SM AASHTO= A-1-b

Remarks

Moisture Content - 5.1%

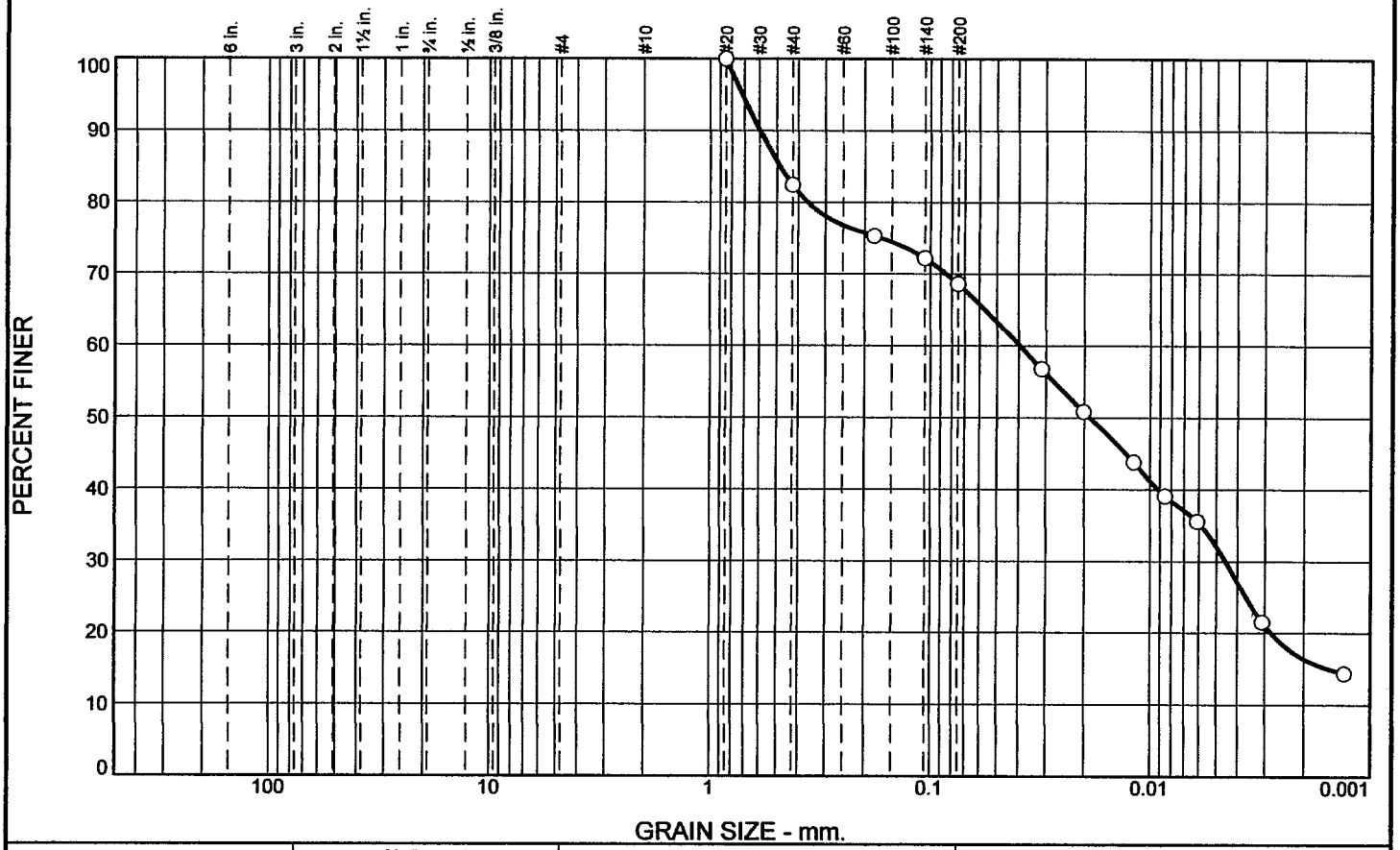
Location: BB-WGLC-204 - W. Gardner-Litchfield, ME
Sample Number: 2D **Depth:** 5'-7' **Date:** 9/7/2017

R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002
Project No: 1368-006 **Lab No.** 14663a

Tested By: ZTG **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	17.6	13.8	36.6	32.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	82.4		
#80	75.3		
#140	72.2		
#200	68.6		
0.0314 mm.	56.8		
0.0202 mm.	50.9		
0.0119 mm.	43.8		
0.0085 mm.	39.1		
0.0061 mm.	35.5		
0.0031 mm.	21.6		
0.0013 mm.	14.4		

* (no specification provided)

Soil Description

sandy silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.5965 D_{85}= 0.4847 D_{60}= 0.0394
D_{50}= 0.0189 D_{30}= 0.0046 D_{15}= 0.0015
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

Moisture Content - 229.5%
Highly organic material. Most of the sample was a piece of wood that crumbled to dust when tamped.

Location: BB-WGLC-204 - W. Gardner-Litchfield, ME
Sample Number: 3D **Depth:** 10'-12'

Date: 9/7/2017

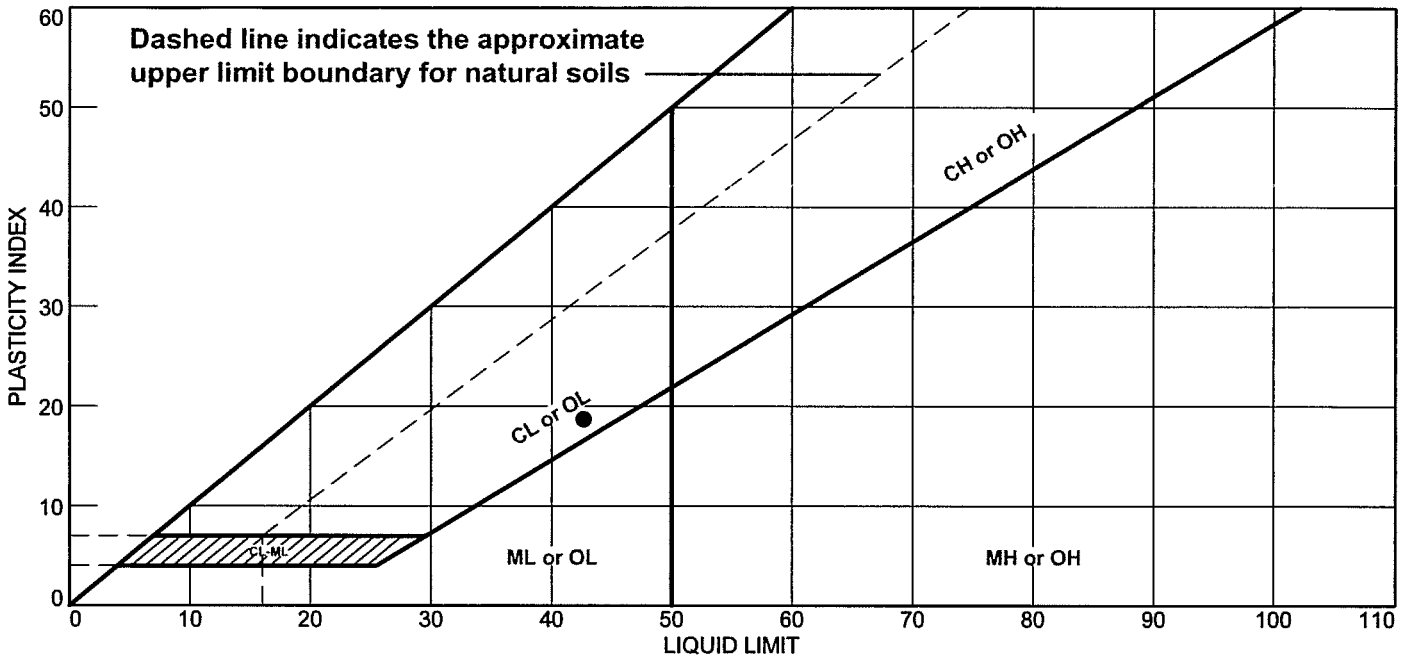
R.W. Gillespie & Associates, Inc.
Saco, Maine

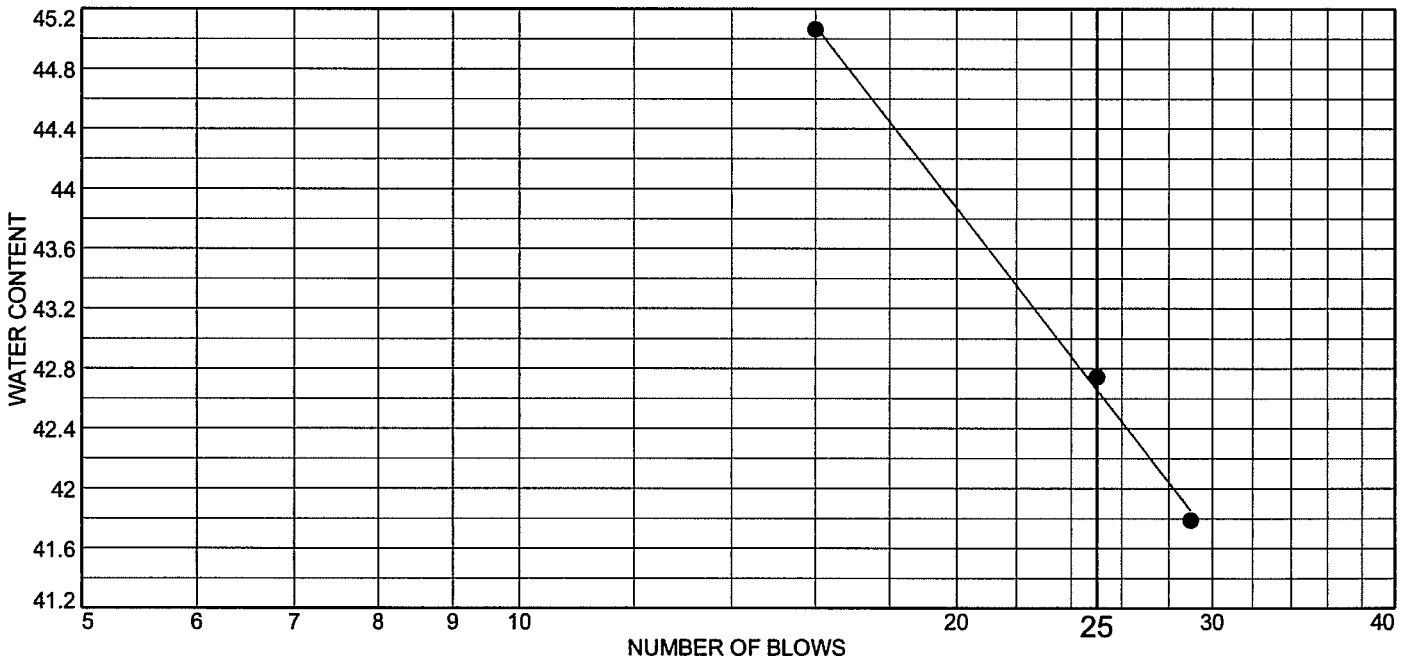
Client: Schonewald Engineering Associates, Inc
Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Project No: 1368-006 **Lab No.** 14663b

Tested By: AGS **Checked By:** MTG MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Marine Clay	42.7	24.0	18.7			

Project No. 1368-006 **Client:** Schonewald Engineering Associates, Inc

Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Location: BB-WGLC-204 - W. Gardner-Litchfield, ME
Sample Number: 4D **Depth:** 15'-17'

R.W. Gillespie & Associates, Inc.

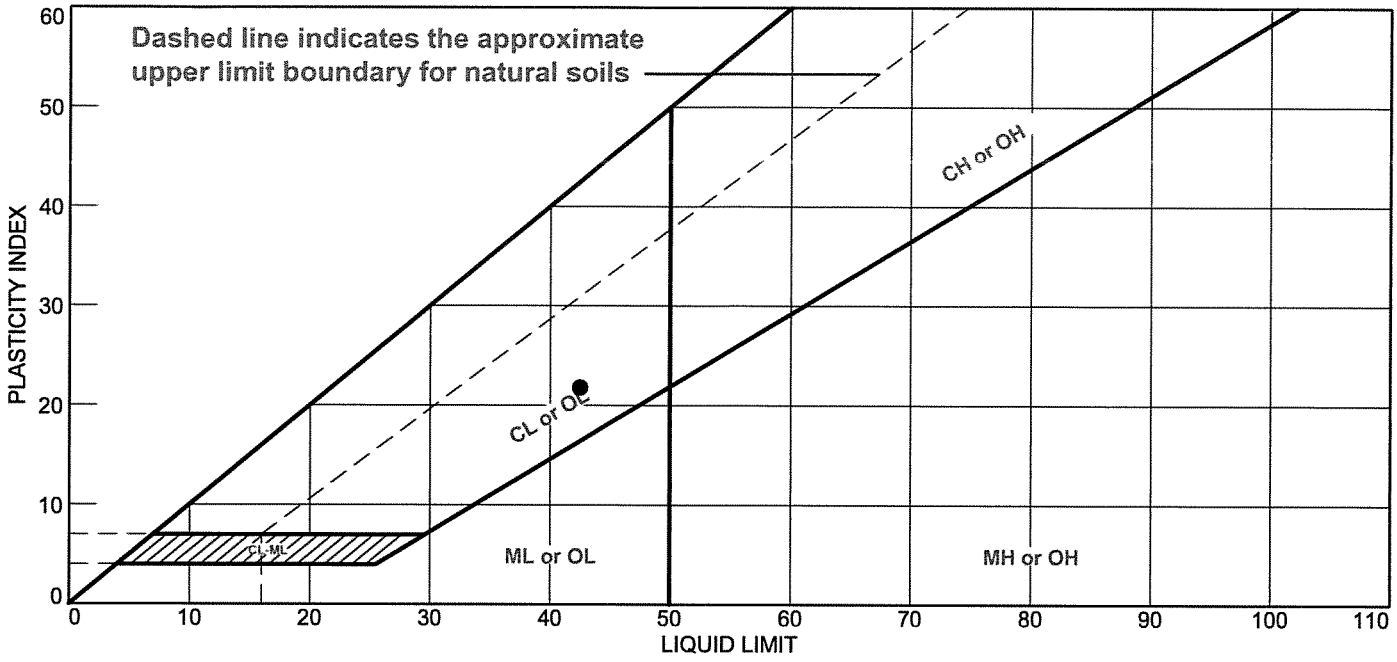
Saco, Maine

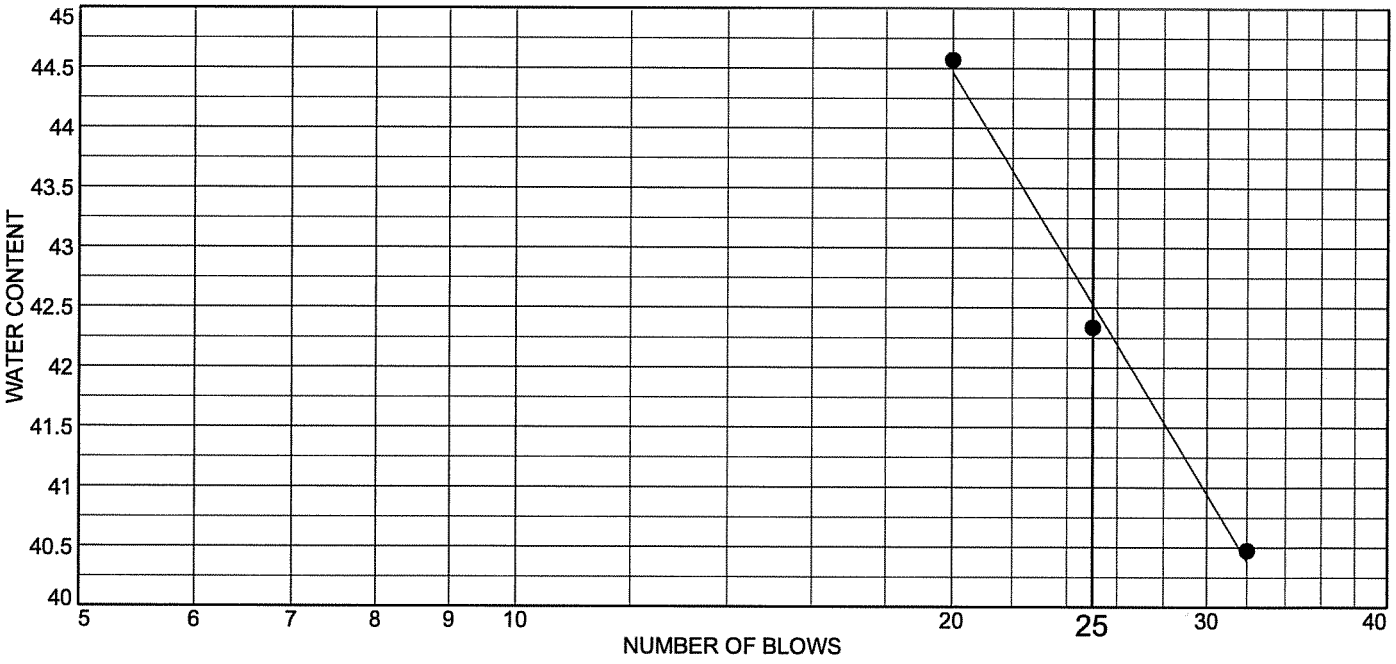
Remarks:
● Moisture Content: 34.6%

Lab No. 14663c

Tested By: JRF **Checked By:** MTG MTG

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Marine Clay	42.5	20.7	21.8			

Project No. 1368-006 **Client:** Schonewald Engineering Associates, Inc

Project: Maine DOT WIN 18954.00 Burnham Bridge - #17-002

Location: BB-WGLC-204 - W. Gardner-Litchfield, ME
Sample Number: 6D **Depth:** 23'-25'

R.W. Gillespie & Associates, Inc.

Saco, Maine

Remarks:
● Moisture Content: 42.0%

Lab No. 14663d

Tested By: AGS **Checked By:** MTG MTG

R. W. Gillespie & Associates, Inc.
86 Industrial Park Road, Suite 4, Saco, ME 04072 207-286-8008
200 Int'l Drive, Suite 170, Portsmouth, NH 03801 603-427-0244

LETTER OF TRANSMITTAL

Date:	Project No.:
09/11/2017	1368-006

Attention:
Isabel Schonewald

Re:
LaboratoryTesting
Maine DOT WIN 18954.00 BB #17-002
W. Gardner-Litchfield, ME

Schonewald Engineering Associates, Inc.

129 Middle Road

Cumberland, ME 04021

We are sending you attached laboratory test results.

Laboratory No. (s)	Test (s) Performed
14660a, b, c, d, e, f: BB-West Gardner-Litchfield, M	Washed Gradation with hydrometers, atterbergs and moisture

BB-WGLC-201

Remarks:

Copy to:

Signed: Matthew T. Grady

If enclosures are not as noted, kindly notify us at once.

R. W. Gillespie & Associates, Inc.
86 Industrial Park Road, Suite 4, Saco, ME 04072 207-286-8008
200 Int'l Drive, Suite 170, Portsmouth, NH 03801 603-427-0244

LETTER OF TRANSMITTAL

Date:	Project No.:
09/11/2017	1368-006

Attention:
Isabel Schonewald

Re:
LaboratoryTesting
Maine DOT WIN 18954.00 BB #17-002
W. Gardner-Litchfield, ME

Schonewald Engineering Associates, Inc.

129 Middle Road

Cumberland, ME 04021

We are sending you attached laboratory test results.

Laboratory No. (s)	Test (s) Performed
14661a, b, c, d: BB-West Gardner-Litchfield, ME.	Washed Gradation with hydrometers, atterbergs and moisture

BB-WGLC-202

Remarks:

Copy to:

Signed: Matthew T. Grady

If enclosures are not as noted, kindly notify us at once.

R. W. Gillespie & Associates, Inc.
86 Industrial Park Road, Suite 4, Saco, ME 04072 207-286-8008
200 Int'l Drive, Suite 170, Portsmouth, NH 03801 603-427-0244

LETTER OF TRANSMITTAL

Date:	Project No.:
09/11/2017	1368-001
Attention: Isabel Schonewald	
Re: LaboratoryTesting Maine DOT WIN 18954.00 BB #17-002 W. Gardner-Litchfield, ME	

Schonewald Engineering Associates, Inc.

129 Middle Road

Cumberland, ME 04021

We are sending you attached laboratory test results.

Laboratory No. (s)	Test (s) Performed
14662a, 14662b: BB-WGLC-203, W. Gardner-Litchf	Washed Gradation with hydrometers, atterbergs, moisture

BB-WGLC-203

Remarks:

Copy to:

Signed: Matthew T. Grady

If enclosures are not as noted, kindly notify us at once.

R. W. Gillespie & Associates, Inc.
86 Industrial Park Road, Suite 4, Saco, ME 04072 207-286-8008
200 Int'l Drive, Suite 170, Portsmouth, NH 03801 603-427-0244

LETTER OF TRANSMITTAL

Date:	Project No.:
09/11/2017	1368-006
Attention: Isabel Schonewald	
Re: LaboratoryTesting Maine DOT WIN 18954.00 BB #17-002 W. Gardner-Litchfield, ME	

Schonewald Engineering Associates, Inc.

129 Middle Road

Cumberland, ME 04021

We are sending you attached laboratory test results.

Laboratory No. (s)	Test (s) Performed
14663a, b, c, d: BB-WGLC-204, W. Gardner-Litchfi	Washed Gradation with hydrometers, atterbergs and moi

BB-WGLC-204

Remarks:

Copy to:

Signed: Matthew T. Grady

If enclosures are not as noted, kindly notify us at once.

SCHONEWALD
ENGINEERING
ASSOCIATES, INC.
■ www.SchonewaldEngineering.com ■

100-SERIES ROCK LABORATORY TEST RESULTS

LABORATORY TESTING DATA SHEET

Schonewald Engineering
Associates No. 15-031 74-16-0003.18 Location W. Gardiner-Litchfield, ME Reviewed By
Project Name MaineDOT Burnham Bridge Assigned By Isabel Schonewald, P.E.
Project Engineer Isabel Schonewald, P.E. Report Date 4/29/2016 Date Reviewed 4/29/2016

Boring	Sample No.	Depth Ft.	Lab No.	Do in.	L in.	(1) Unit Wt. PCF	(2) Wet Density PCF	Bulk Gs.	Compression Tests (ASTM D7012 D) (3) Other Tests	(4) Strength PSI	(5) Strain %	(6) Conf. Stress	(7) E sec PSI EE+06	(8) Poisson's Ratio	στ KSI	Rock Formation or Description or Remarks
BB-WGLC-103	R1	7.4-7.8	16-R-479	1.985	4.575	169.2			U	11,833	0.17		5.87	0.10		Sample fractured along quartz vein
BB-WGLC-104	R-1	30.2-30.6	16-R-480	1.985	4.555	167.5			U	18,316	0.25		6.57	0.14		

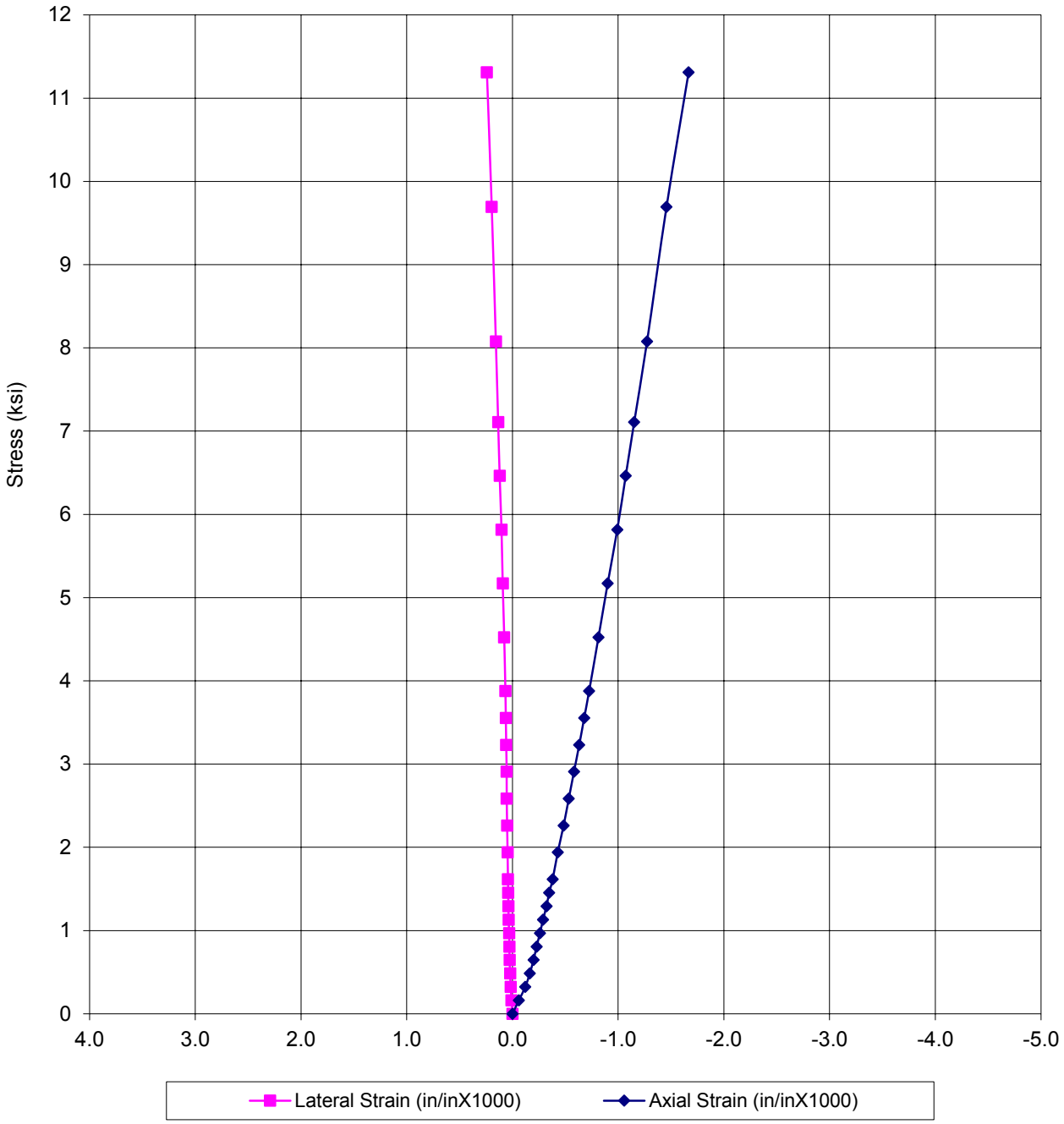
(1) Volume Determined By Measuring Dimensions
(2) Determined by Measuring Dimensions and Weight of Saturated Sample

(3) P=Petrographic PLD=Point Load (diametrical), PLA= Point Load (Axial) RST= Splitting Tensile U= Unconfined Compressive Strength
(4) Taken at Peak Deviator Stress

(5) Strain at Peak Deviator Stress
(6) Represents Confining Stress on Triaxial Tests
(7) Represents Secant Modulus at 50% of Total Failure Stress
(8) Represents Secant Poisson's Ratio at 50% of Total Failure Stress

THIELSCH ENGINEERING
195 Frances Avenue
Cranston, RI 02910 401-467-6454

MaineDOT Burnham Bridge
W. Gardiner-Litchfield, ME



Rock Testing

Schonewald EA	15-031	Test Method	ASTM D7012
Boring No.	BB-WGLC-103	File No.	CTS-74-16-0003.18
Sample No.	R1	Date:	03/30/16
Depth:	7.4-7.8'	Test No.	16-R-479

THIELSCH ENGINEERING

MaineDOT Burnham Bridge
W. Gardiner - Litchfield, ME

Schonewald EA Project # 15-031
CTS-74-16-0003.18

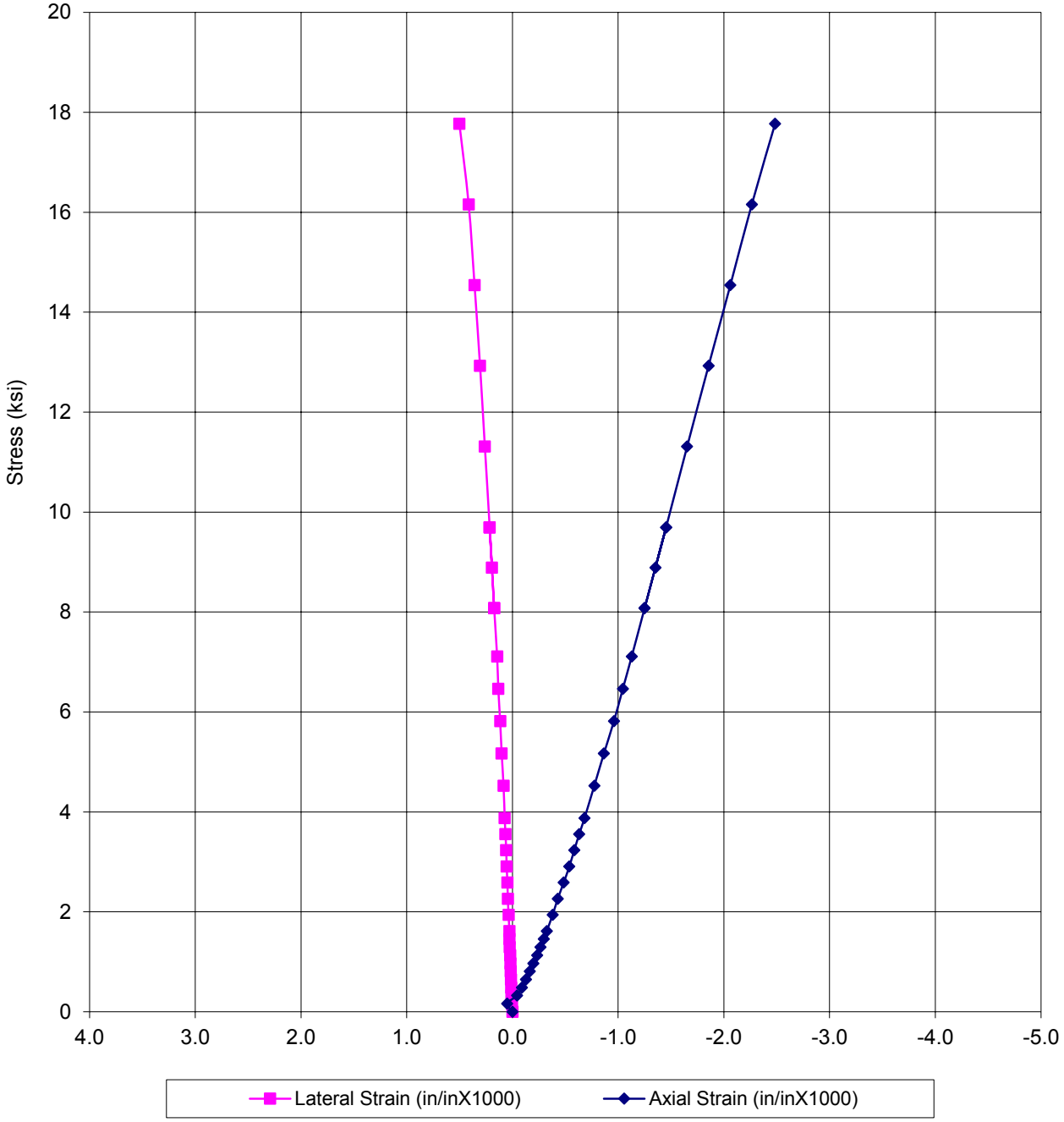
BORING NO.	SAMPLE NO.	DEPTH
BB-WGLC-103	R-1	7.4'– 7.8'

MaineDOT Burnham Bridge
W. Gardiner - Litchfield, ME

Schonewald EA Project # 15-031
CTS-74-16-0003.18

BORING NO.	SAMPLE NO.	DEPTH
BB-WGLC-103	R-1	7.4' – 7.8'

MaineDOT Burnham Bridge
W. Gardiner-Litchfield, ME



Rock Testing

Schonewald EA	15-031	Test Method	ASTM D7012
Boring No.	BB-WGLC-104	File No.	CTS-74-16-0003.18
Sample No.	R1	Date:	03/30/16
Depth:	30.2-30.6'	Test No.	16-R-480

THIELSCH ENGINEERING

MaineDOT Burnham Bridge
W. Gardiner - Litchfield, ME

Schonewald EA Project # 15-031
CTS-74-16-0003.18

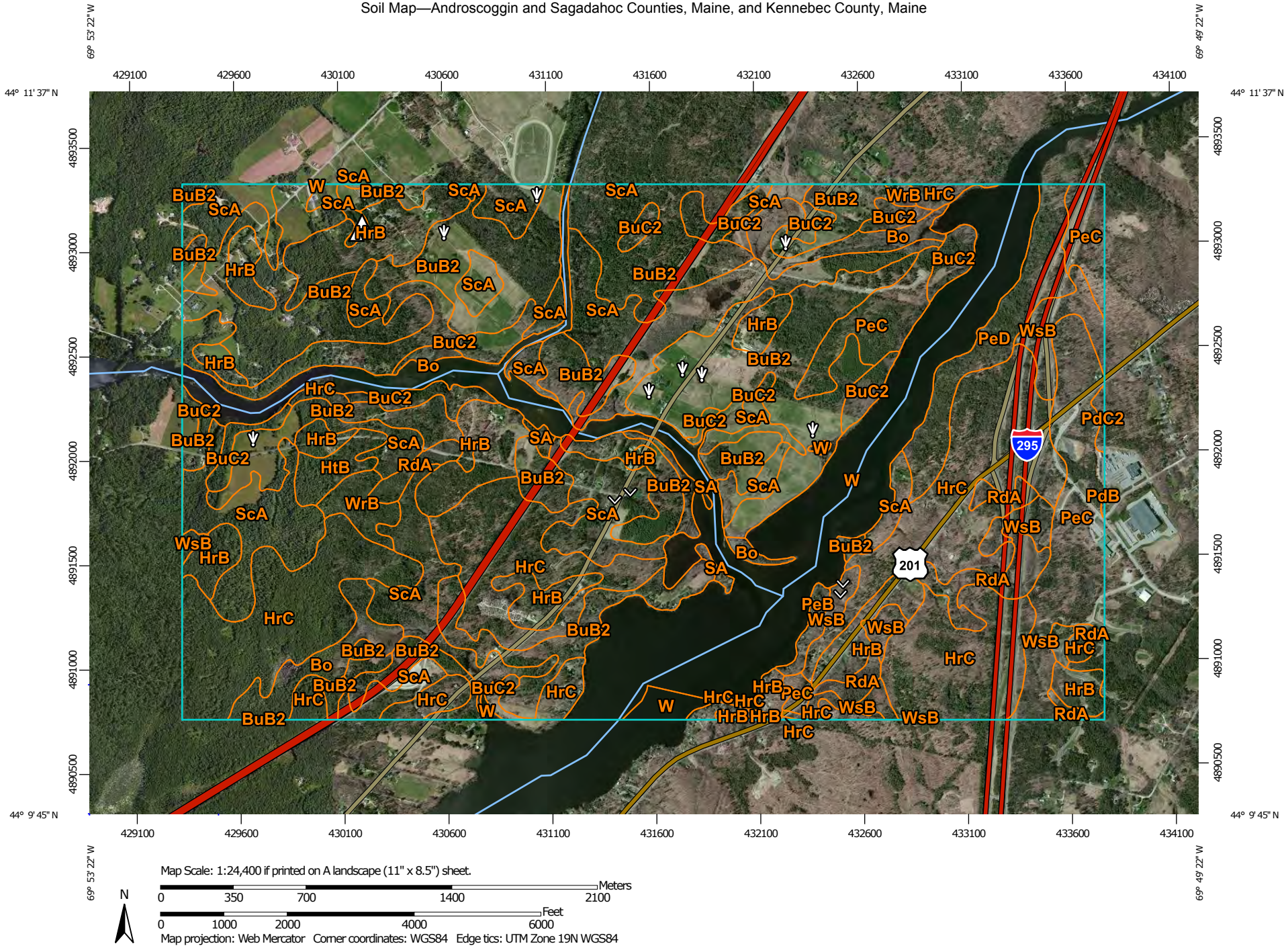
BORING NO.	SAMPLE NO.	DEPTH
BB-WGLC-104	R-1	30.2'– 30.6'

MaineDOT Burnham Bridge
W. Gardiner - Litchfield, ME

Schonewald EA Project # 15-031
CTS-74-16-0003.18

BORING NO.	SAMPLE NO.	DEPTH
BB-WGLC-104	R-1	30.2'– 30.6'

ATTACHMENT 3
USDA SOIL MAP



Map Scale: 1:24,400 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 350 700 1400 2100

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:15,800 to 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Androscoggin and Sagadahoc Counties, Maine
Survey Area Data: Version 16, Sep 14, 2015

Soil Survey Area: Kennebec County, Maine
Survey Area Data: Version 14, Sep 14, 2015

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 17, 2010—May 1, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Androscoggin and Sagadahoc Counties, Maine (ME606)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
HrB	Hollis fine sandy loam, 0 to 8 percent slopes	1.1	0.0%
HrC	Hollis fine sandy loam, 8 to 15 percent slopes	4.1	0.1%
SyB	Sutton very stony loam, 0 to 8 percent slopes	0.6	0.0%
W	Water	10.7	0.4%
Subtotals for Soil Survey Area		**16.5**	**0.6%**
Totals for Area of Interest		**2,825.4**	**100.0%**

Kennebec County, Maine (ME011)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Bo	Biddeford mucky peat, 0 to 3 percent slopes	71.2	2.5%
BuB2	Buxton silt loam, 3 to 8 percent slopes, eroded	647.0	22.9%
BuC2	Buxton silt loam, 8 to 15 percent slopes, eroded	154.5	5.5%
HrB	Hollis fine sandy loam, 3 to 8 percent slopes	199.9	7.1%
HrC	Hollis fine sandy loam, 8 to 15 percent slopes	499.7	17.7%
HtB	Hollis-Rock outcrop complex, 3 to 8 percent slopes	19.1	0.7%
PdB	Paxton-Charlton fine sandy loams, 3 to 8 percent slopes	0.4	0.0%
PdC2	Paxton-Charlton fine sandy loams, 8 to 15 percent slopes, eroded	2.9	0.1%
PeB	Paxton-Charlton very stony fine sandy loams, 3 to 8 percent slopes	3.6	0.1%
PeC	Paxton-Charlton very stony fine sandy loams, 8 to 15 percent slopes	170.5	6.0%
PeD	Paxton-Charlton very stony fine sandy loams, 15 to 30 percent slopes	64.6	2.3%
RdA	Ridgebury very stony fine sandy loam	58.4	2.1%
SA	Saco soils	14.0	0.5%
ScA	Scantic silt loam, 0 to 3 percent slopes	403.4	14.3%

Kennebec County, Maine (ME011)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
W	Water bodies	407.1	14.4%
WrB	Woodbridge fine sandy loam, 3 to 8 percent slopes	20.7	0.7%
WsB	Woodbridge very stony fine sandy loam, 3 to 8 percent slopes	72.0	2.5%
Subtotals for Soil Survey Area		**2,808.9**	**99.4%**
Totals for Area of Interest		**2,825.4**	**100.0%**

ATTACHMENT 4
GEOPHYSICAL TESTING REPORT

HAGER-RICHTER
GEOSCIENCE, INC.

GEOPHYSICAL SURVEY
BURNHAM BRIDGE
WEST GARDINER, MAINE

MAINE DOT WIN 018954.00

Prepared for:

HNTB Corporation
9 Entin Road, Suite 202
Parsippany, New Jersey 07054

Prepared by:

Hager-Richter Geoscience, Inc.
8 Industrial Way - D10
Salem, New Hampshire 03079

File 17J10
July, 2017

©2017 Hager-Richter Geoscience, Inc.

HAGER-RICHTER
GEOSCIENCE,INC.

GEOPHYSICISTS FOR THE ENGINEERING COMMUNITY
8 INDUSTRIAL WAY - D10
SALEM, NEW HAMPSHIRE 03079-5820
TELEPHONE (603) 893-9944
FAX (603) 893-8313

July 31, 2017
File 17J10

Britain Materek, P.E.
Geotechnical Engineer
HNTB Corporation
9 Entin Road, Suite 202
Parsippany, New Jersey 07054

Tel: (973) 434-3100
Dir: (973) 434-3128
Fax: (973) 434-3101
Email: bmaterek@HNTB.com

RE: Geophysical Survey
Burnham Bridge Replacement
West Gardiner, Maine
Maine DOT WIN 018954.00

Dear Mr. Materek:

In this letter, we report the results of a geophysical survey conducted by Hager-Richter Geoscience, Inc. (Hager-Richter) in support of a geotechnical investigation for the replacement of the Burnham Bridge in West Gardiner, Maine for HNTB Corporation (HNTB) and the Maine Department of Transportation (Maine DOT) in July, 2017. The scope of the project and areas of interest were specified by HNTB.

INTRODUCTION

The existing Burnham Bridge is located over Cobbosseecontee Stream on Plains/Pond Road at the West Gardiner-Litchfield town line. The general location of the Burnham Bridge is shown in Figure 1. The bridge is a 2-lane concrete structure and is approximately 97 feet long and 22 feet wide.

According to information provided by HNTB, voids were detected approximately 18 feet below the ground surface behind the existing south abutment during an initial subsurface investigation. Anchors, tie-rods, and timber cribbing reportedly extend approximately 20 to 25 feet behind the existing abutments, and the fine materials between the abutment and the anchors might be washing away.

As part of a geotechnical investigation for the replacement of the Burnham Bridge, HNTB requested costs for conducting a ground penetrating radar (GPR) survey of the bridge approaches to determine whether additional voids are present. Figure 2 is a site plan showing the limits of the geophysical survey.

OBJECTIVE

The objective of the geophysical survey was to detect and, if detected, determine the horizontal extent of voids behind the existing Burnham Bridge approaches.

THE SURVEY

Jeffrey Reid, P.G., and Sean Reid of Hager-Richter conducted the field operations on July 13, 2017. The project was coordinated with Mr. Britain Materek, P.E., of HNTB. The Maine DOT provided road lane closures and traffic protection for the geophysical survey. Photos 1 and 2 below show the north and south approaches, respectively.

Photo 1. View of the north approach from the bridge deck.

Photo 2. View of the south approach from the bridge deck.

The geophysical survey was conducted using the ground penetrating radar (GPR) method. GPR data were acquired on the accessible portions of the north and south bridge approaches. The GPR traverses were spaced 1-foot apart parallel to the long axis of the roadway and 5 feet apart perpendicular to the long axis of the roadway. The locations of the GPR traverses are shown in Figure 2. The positions of the GPR survey lines were recorded using a Trimble Geo 7XCM GPS receiver outfitted with a Zephyr 2 external antenna.

EQUIPMENT AND PROCEDURES

GPR. The GPR survey was conducted using a GSSI SIR 4000 subsurface imaging radar system. The system includes a survey wheel that triggers the recording of the data at fixed intervals, thereby increasing the accuracy of the locations of features detected along the survey lines. The system was used with a 350 MHz hyper-stacking antenna, and data were acquired using a 150 ns[1] time window.

GPR uses a high-frequency electromagnetic pulse (referred to herein as "radar signal") transmitted from a radar antenna to probe the subsurface. The transmitted radar signals are reflected from subsurface interfaces of materials with contrasting electrical properties. Travel times of the radar signal can be converted to approximate depth below the surface by correlation with targets of know depths. We monitor the acquisition of GPR data in the field and record the GPR data digitally for subsequent processing. Interpretation of the records is based on the nature and intensity of the reflected signals and on the resulting patterns.

Data from the GPR survey were processed using Radan 7.4, commercially licensed GPR processing software from Geophysical Survey Systems Inc.

LIMITATIONS OF THE METHOD

HAGER-RICHTER GEOSCIENCE, INC. MAKES NO GUARANTEE THAT ALL SUBSURFACE VOIDS, OR OTHER FEATURES OF INTEREST WERE DETECTED IN THIS SURVEY. HAGER-RICHTER GEOSCIENCE, INC. IS NOT RESPONSIBLE FOR DETECTING FEATURES OF INTEREST THAT CANNOT BE DETECTED DUE TO THE LIMITATIONS OF THE GPR METHOD OR BECAUSE OF SITE CONDITIONS.

[1]ns, abbreviation for nanosecond, 1/1,000,000,000 second. Light and the GPR signal require about 1 ns to travel 1 ft in air. The GPR signal requires about 3.5 ns to travel 1 ft in unsaturated sandy soil.

GPR detects and maps interfaces of contrasting electrical properties, and an air-filled void has electrical properties very different from soil and rock. The GPR method is useful for detecting voids and determining their footprint, but in general, GPR data cannot be used to determine the thickness of voids.

There are other limitations of the GPR technique: (1) surface conditions, (2) electrical conductivity and thickness of the subsurface layers, (3) electrical properties of the target(s), and (4) spacing of the traverses. Of these restrictions, only the last is controllable by us in most cases.

The condition of the survey surface can affect the quality of the GPR data and the depth of penetration of the GPR signal. For exterior sites, a surface covered with obstacles such as automobiles, dumpsters, thick leaf debris, materials piles, etc. limit the survey access. Similarly, for interior sites, a surface covered with obstacles such as desks, benches, laboratory equipment, etc. also limit access. Some floor coverings may limit the coupling of the GPR antenna with the subsurface.

The electrical conductivity of the subsurface determines the attenuation of the GPR signals, and thereby limits the maximum depth of exploration. The GPR signal does not penetrate clay-rich soils or soils contaminated with road salt. In some cases, the GPR signal may not penetrate below concrete pavement, and some asphalts are electrically conducting.

A strong contrast in the electrical conductivities of the ground and the target (for examples, UST, pipe, void, dry well, drum, contaminant plume) is required to obtain a reflection of the GPR signal. If the contrast is too small, then the reflection may be too weak to recognize, and the target can be missed.

Spacing of the traverses is limited by access at many sites, but where flexibility of traverse spacing is possible, the spacing is adjusted on the basis of the size of the target.

RESULTS

The geophysical survey was conducted using the ground penetrating radar (GPR) method on the south and north approach roadways for the Burnham Bridge in West Gardiner, Maine. The locations of the GPR traverses and interpretation of the data are shown in Figure 2.

The GPR survey was conducted utilizing a 350 MHz hyper-stacking antenna along a series of traverses spaced 1-foot apart oriented parallel to the roadway, and 5 feet apart oriented perpendicular to the roadway.

Apparent GPR signal penetration for both bridge approaches was generally good, with two-way traveltime reflections received from approximately 70-90 ns of the 150 ns time window. Based upon site-specific velocity calibrations, the maximum GPR signal penetration in the approach roadways is estimated to have been about 10 feet. GPR signal penetration was very limited (2-3 feet) in the center portion of the south approach. The area of limited signal penetration is shown in Figure 2 as a stippled area.

The typical signature of an air or water filled void space is a distinctive high-amplitude reflection present in the GPR record at the position of the top of the void. The high-amplitude GPR reflection is due to the large dielectric contrast between the soils and the air- or water-filled gap. Moderate amplitude GPR reflections draped downwards towards an open sinkhole or interpreted void, or areas that have moderate amplitude GPR reflections that are chaotic in character and differ significantly from surrounding area are interpreted to be caused by slumping soils or soils that have been modified by the presence of water.

GPR reflections typical of voids or slumping soil are not evident in the data for the Burnham Bridge within the effective depth of penetration of the GPR signal. GPR reflections typical of road base material are relatively uniform in depth and do not appear disturbed or interrupted indicating that voids, if present, have not worked their way to the road bed materials. *Whether a void occurs at a depth greater than the effective depth of penetration of the GPR signal (approximately 8-10 feet for much of the survey area, or less than 3 feet in the area of limited signal penetration) or in areas inaccessible to the geophysical survey cannot be determined from the geophysical data.*

The limits of excavation for the bridge cribbing structure are apparent in the GPR records for both the south and north approaches. The limit of excavation is approximately 30 feet south of the south edge of the bridge deck, and approximately 25 feet north of the north edge of the bridge deck. GPR reflections from possible cribbing oriented perpendicular to the roadway were detected at two locations on the north approach at 10 and 20 feet from the north edge of the bridge deck, and at about 8 feet, and 5 feet deep. The possible cribbing was detected at depths of approximately 8 feet and 5 feet for the cribs located at approximately 10 feet and 20 feet, respectively. Figure 3 is an example GPR record showing the lit f excavation, possible cribbing, and the base of the roadbed materials.

GPR reflections consistent with a flat topped structure occur in the GPR data for the southbound travel lane of the southern approach at a depth of about 4-5 feet. The structure may continue to the east under the northbound lane, but GPR signal penetration is not sufficient to detect its presence at this location.

CONCLUSIONS

Based on the geophysical survey performed by Hager-Richter Geoscience, Inc. for the HNTB Corporation and the Maine Department of Transportation at the Burnham Bridge in West Gardiner, Maine, we conclude:

- Near-surface possible voids, slumping soils, or soils modified by water are not evident in GPR records for the south and north approaches for the bridge within the effective depth of investigation. *Whether a void occurs at a depth greater than the effective depth of penetration of the GPR signal (approximately 8-10 feet for much of the survey area, or less than 3 feet in the area of limited signal penetration) or in areas inaccessible to the geophysical survey cannot be determined from the geophysical data.*

- GPR reflections consistent with the limits of excavation for the structural cribbing are evident in the GPR records for the south and north approaches.

- GPR reflections consistent with possible structural cribbing are evident in the GPR records for the north approach.

- GPR reflections consistent with a flat topped structure are evident in the GPR records at a depth of 4-5 feet for the south approach.

LIMITATIONS

This letter report was prepared for the exclusive use of the HNTB Corporation and the Maine Department of Transportation (collectively referred to as Client). No other party shall be entitled to rely on this Report or any information, documents, records, data, interpretations, advice or opinions given to Client by Hager-Richter Geoscience, Inc. (H-R) in the performance of its work. The Report relates solely to the specific project for which H-R has been retained and shall not be used or relied upon by Client or any third party for any variation or extension of this project, any other project or any other purpose without the express written permission of H-R. Any unpermitted use by Client or any third party shall be at Client's or such third party's own risk and without any liability to H-R.

H-R has used reasonable care, skill, competence and judgment in the performance of' its services for this project consistent with professional standards for those providing similar services at the same time, in the same locale, and under like circumstances. Unless otherwise stated, the work performed by H-R should be understood to be exploratory and interpretational in character and any results, findings or recommendations contained in this Report or resulting from

the work proposed may include decisions which are judgmental in nature and not necessarily based solely on pure science or engineering. It should be noted that our conclusions might be modified if subsurface conditions were better delineated with additional subsurface exploration including, but not limited to, test pits, soil borings with collection of soil and water samples, and laboratory testing.

Except as expressly provided in this limitations section, H-R makes no other representation or warranty of any kind whatsoever, oral or written, expressed or implied; and all implied warranties of merchantability and fitness for a particular purpose, are hereby disclaimed.

If you have any questions or comments on this letter report, please contact us at your convenience. It has been a pleasure to work with you on this project. We look forward to working with you again in the future.

Sincerely yours,
HAGER-RICHTER GEOSCIENCE, INC.

Jeffrey Reid, P.G.
Vice President & Senior Geophysicist

Dorothy Richter, P.G.
President

Attachments: Figures 1 - 3

N

APPROXIMATE SCALE (feet)

0 1000 2000

NOTE:

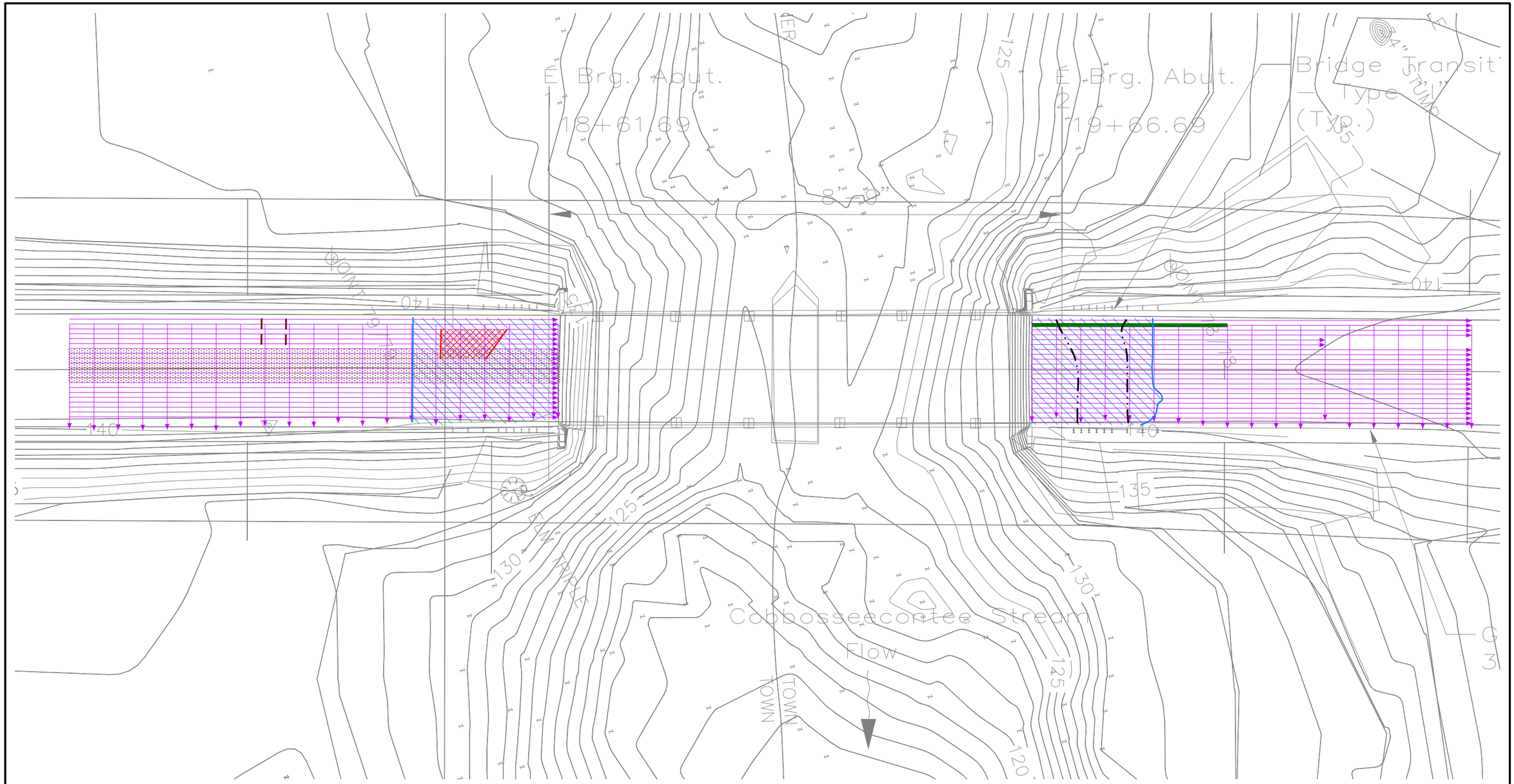
Modified from Google Earth Pro aerial photograph.

LOCATION

Figure 1
General Site Location
Burnham Bridge Replacement
West Gardiner, Maine
MaineDOT WIN 18954.00

File 17J10 | August, 2017

HAGER–RICHTER
Salem, NH | Fords, NJ



SCALE (feet)

0 20 40

LEGEND

- GPR TRAVERSE
- PORTION OF GPR TRAVERSE SHOWN IN FIGURE 3
- LIMIT OF EXCAVATION FOR BRIDGE STRUCTURE
- FLAT-TOPPED STRUCTURE
- POSSIBLE CRIB STRUCTURE
- POSSIBLE UTILITY
- AREA OF LIMITED GPR SIGNAL PENETRATION (SEE TEXT)

N

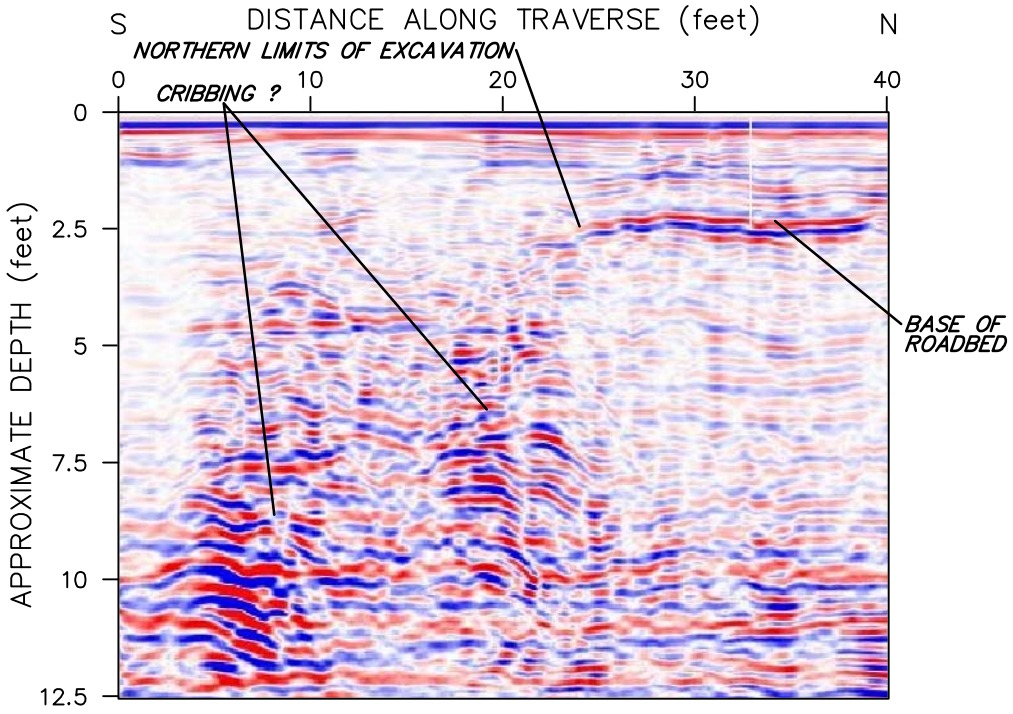
NOTE:

Modified from site plans provided by HNTB Corporation, identified as HAlignments.dgn, Bridge.dgn, Contours.dgn, Highway.dgn, RWPlan_-2d.dgn, Text.dgn, Topo.dgn, & Wetlands.dgn.

Figure 2
GPR Survey
Burnham Bridge Replacement
West Gardiner, Maine
MaineDOT WIN 18954.00

File 17J10 | August, 2017

HAGER-RICHTER
Salem, NH | Fords, NJ



HORIZONTAL SCALE (feet)

0 10 20

NOTES:

1. GPR data were acquired using a GSSI UtilityScan HS digital system using a 350 MHz hyper-stacking antenna with a 150 ns time window.
2. Location of GPR record shown in Figure 2.

Figure 3
Example GPR Record
Burnham Bridge Replacement
West Gardiner, Maine
MaineDOT WIN 18954.00

File 17J10 | August, 2017

HAGER-RICHTER
Salem, NH | Fords, NJ

ATTACHMENT 5
CALCULATIONS PACKAGE

Project: Final Design of Burnham Bridge Replacement	**Job No:59522**	**Design Criteria Document:**
Client: MaineDOT	**Discipline: Geotech**	**Calculation No: Station 20+00**

Name or Description of Calculation:

Calc. Rev. No.	Originator	Checker	Senior Technical Reviewer (if required)	Confirmation Required (Y/N)
01	M. Restrepo	B. Materek		

Calculation Objective:

The objective of this calculation is to examine the global stability in the transverse direction of the North Approach embankment for the replacement of the Burnham Bridge. Station 20+00 was examined because it is representative of the South Approach embankment. Multiple analyses were performed to ensure stability for slip surfaces developing on top of the embankment and extending beyond the toe of slope (global analysis) for the east and west sides of the embankment.

Calculation Methodology/List of Assumptions:

- Soil Parameters have been developed from borings performed by Schonewald Engineering Associates between March of 2016 and July of 2017.
- The stratigraphy of the following cross-section has been developed from borings BB-WGLC-104, BB-WGLC-203, and BB-WGLC-204.
- The groundwater was assumed to correspond to the average low water elevation and the 50 year flood event (Q50).
- Global stability analyses performed in accordance with AASHTO LRFD Bridge Design Specifications Section 11.6.2.3.
- A live load traffic surcharge of 250 psf was applied at the crest of the slope in accordance with AASHTO LRFD.
- Spenser's method was used to develop the critical slip surface.
- The retained structural backfill fill was assumed to have a unit weight of 115 psf and a friction angle of 32º.
- The reported factors of safety include the contribution from 3 layers of geogrid reinforcing placed directly behind each abutment.
- Analyses results using both optimized and non-optimized slip surfaces have been reported.

References/Inputs:

SLOPE/W version 8.16.2 by GeoStudio 2016
MaineDOT Boring logs performed by Schonewald Engineering Associates
Contract Document Drawing No. 8, 9, and 18.

Attachments:

- North Approach Embankment Analysis (Analysis @ East Side)
- North Approach Embankment Analysis (Analysis @ West Side)

Conclusions:

Table 1: Summary of Stability Results for Proposed Approach Embankment

Location	Station	Water level	Condition	East - Factor of Safety		West - Factor of Safety	
				Optimized	Non-Optimized	Optimized	Non-Optimized
North Approach	20+00	133.0	Undrained	1.35	1.53	1.49	1.62
		139.0	Undrained	1.73	1.73	1.69	1.73
		133.0	Drained	1.62	1.68	1.74	1.80
		139.0	Drained	1.66	1.69	1.26	1.3

Document Check:	Name	Signature	Date
Originator:	M. Restrepo		10/16/17
Checker:	B. Materek		10/18/17
BackChecker:	M. Restrepo		11/07/17
Updater:	B. Materek		11/07/17
Verifier:	M. Restrepo		11/09/17

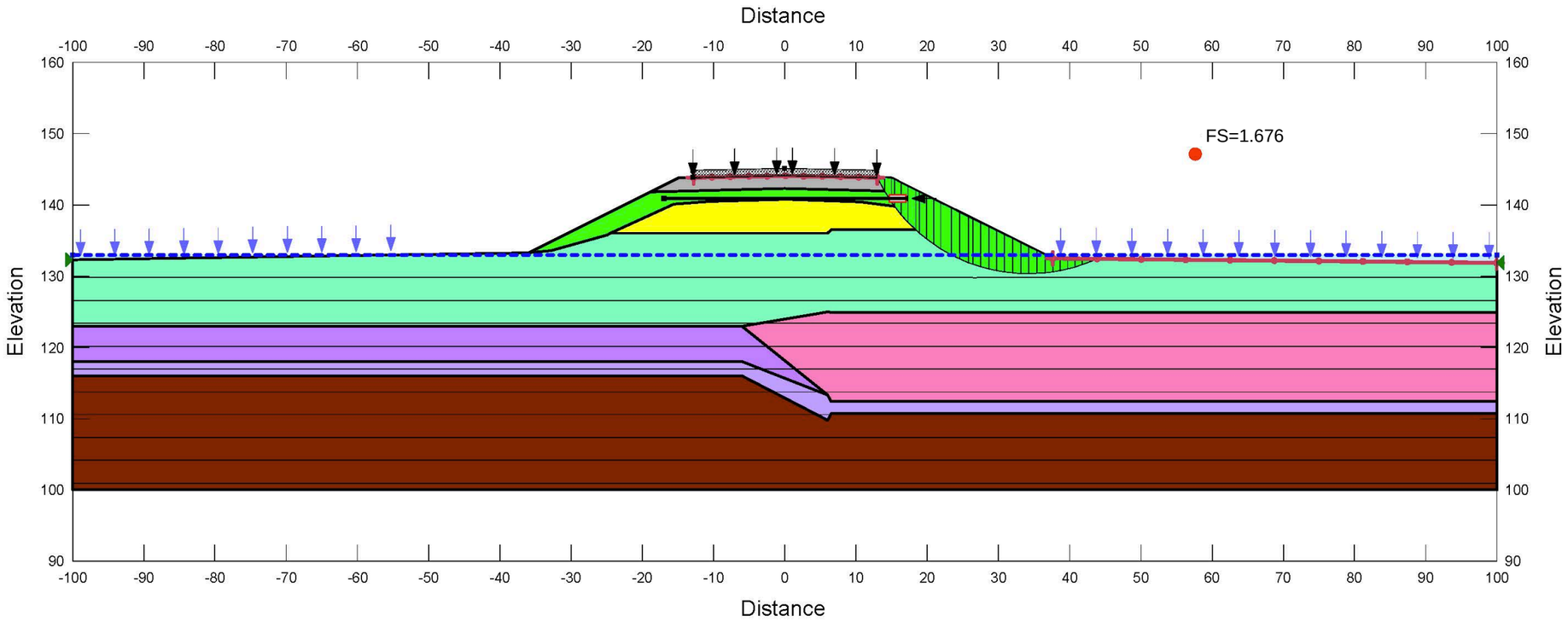
NORTH APPROACH EMBANKMENT

GLOBAL STABILITY ANALYSIS

EAST SIDE

WATER EL. 133 FEET

HNTB



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Lower Fill (North)	Mohr-Coulomb	1	111	0	32	0
	Med Stiff Clay (North)	Mohr-Coulomb	1	113	0	30	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft Clay (North)	Mohr-Coulomb	1	91	0	27	0
	Upper Fill (North)	Mohr-Coulomb	1	121	0	36	0

HNTB

HNTB PROJECT NUMBER 63738

NORTH ABUTMENT | DRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

EAST SIDE
STATION 20+00

East Side Slope Stability

Report generated using GeoStudio 2016. Copyright © 1991-2017 GEO-SLOPE International Ltd.

File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 114
Date: 10/18/2017
Time: 5:43:43 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_North_Abutment_Drained_LowGWT_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 20+00 Transverse w Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:56:10 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

East Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock
Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)
Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)
Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Med Stiff Clay (North)
Model: Mohr-Coulomb
Unit Weight: 113 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-12.8, 143.844) ft
Left-Zone Right Coordinate: (13, 143.84) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (37.6, 132.5) ft
Right-Zone Right Coordinate: (99.9, 131.90096) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 132.3) ft
Right Coordinate: (100, 131.9) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	100	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-12.9	143.9
	-12.9	144.9
	0	145.1
	12.9	144.9

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (17, 140.9) ft
Inside Point: (-17, 140.9) ft
Slip Surface Intersection: (14.660366, 140.9) ft
Length: 34 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 358.74384 lbs
Pullout Force per Length: 153.33333 lbs/ft
Available Length: 2.3396337 ft
Required Length: 2.3396337 ft
Governing Component: Pullout Resistance (Active Zone)

Points

	X (ft)	Y (ft)
Point 1	0	144.1
Point 2	-15	143.8
Point 3	15	143.8
Point 4	0	142.3

Point 5	-18.9	141.8
Point 6	18.9	141.8
Point 7	0.2	140.8
Point 8	-10.6	140.5
Point 9	10.6	140.4
Point 10	-15.6	140.1
Point 11	17.3	139.6
Point 12	6.5	136.5
Point 13	21.9	136.5
Point 14	-6	136
Point 15	-24.5	136
Point 16	6	136
Point 17	-24.9	135.8
Point 18	25.8	133.8
Point 19	-32.8	133.6
Point 20	26.4	133.5
Point 21	-36	133.3
Point 22	37.6	132.5
Point 23	-100	132.3
Point 24	100	131.9
Point 25	6	125
Point 26	6.5	124.9
Point 27	100	124.9
Point 28	-100	123
Point 29	-6	123
Point 30	-100	118
Point 31	-6	118
Point 32	-1	116
Point 33	-100	116
Point 34	-6	116
Point 35	6	113.3

Point 36	100	112.4
Point 37	6.5	112.4
Point 38	6.5	110.7
Point 39	100	110.7
Point 40	6	109.8
Point 41	-100	100
Point 42	-6	100
Point 43	100	100
Point 44	6	100
Point 45	6.5	100
Point 46	-12.9	143.8
Point 47	12.9	143.8

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	41,42,44,45,43,39,38,40,34,33	2,664.4
Region 2	Glacial Till	33,34,40,38,39,36,37,35,31,30	381.25
Region 3	Soft Clay (North)	30,31,35,29,28	500
Region 4	Med Stiff Clay (North)	29,35,37,36,27,26,25	1,245
Region 5	Lower Fill (North)	28,29,25,26,27,24,22,20,18,13,12,16,14,15,17,19,21,23	1,918.5
Region 6	Upper Fill (North)	15,14,16,12,13,11,9,7,8,10	166.21
Region 7	Embankment Fill	21,19,17,15,10,8,7,9,11,13,18,20,22,6,4,5	159.46
Region 8	Pavement Box	5,4,6,3,1,2	62.85

Current Slip Surface

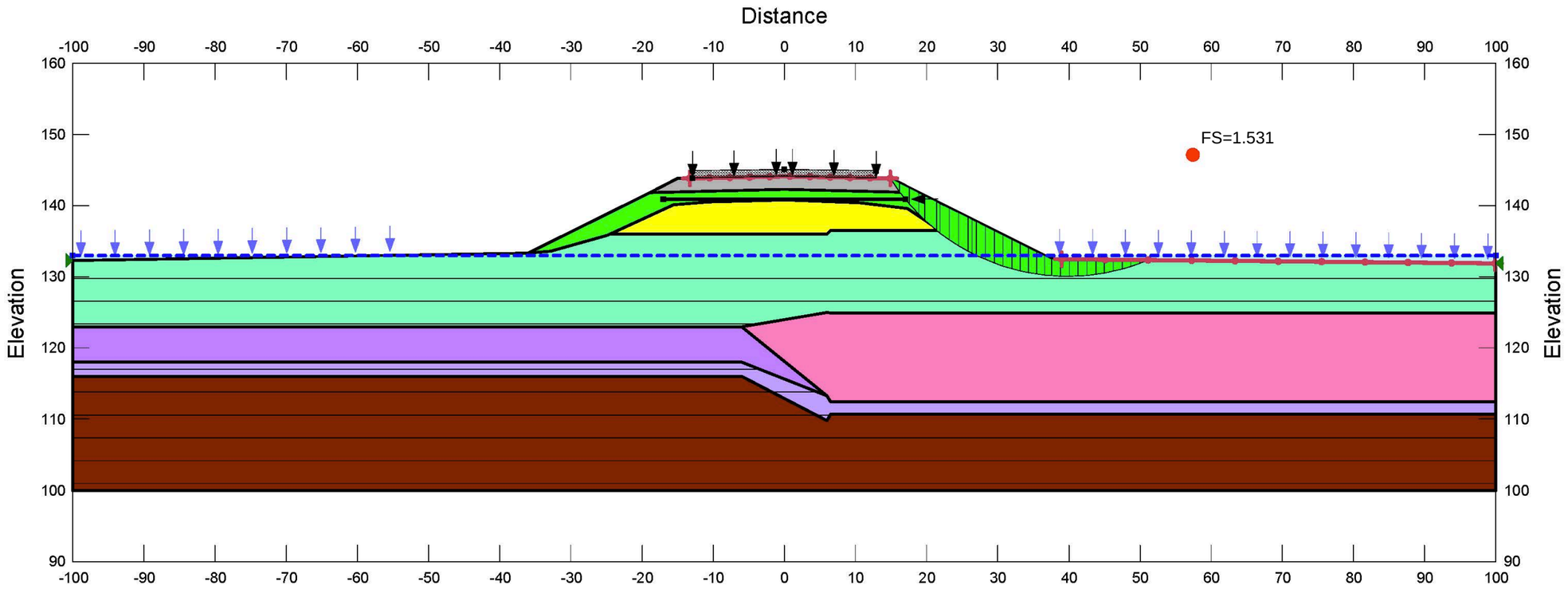
Slip Surface: 1,228
F of S: 1.676
Volume: 128.32384 ft³
Weight: 14,715.048 lbs
Resisting Moment: 184,532.24 lbs-ft
Activating Moment: 110,066.3 lbs-ft
Resisting Force: 6,761.005 lbs
Activating Force: 4,033.4675 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (43.83, 132.4401) ft

Entry: (13, 143.84) ft
Radius: 23.37625 ft
Center: (34.180266, 153.73168) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	13.501039	142.88479	-0	57.666187	41.896938	0
Slice 2	14.501039	141.14919	-0	197.82775	123.6165	0
Slice 3	15.194063	140.09855	-0	295.93599	184.92133	0
Slice 4	15.866094	139.22487	-0	307.90859	223.70869	0
Slice 5	16.822031	138.091	-0	371.60749	269.98864	0
Slice 6	17.842061	137.03027	-0	427.65072	310.70644	0
Slice 7	18.642061	136.27047	-0	499.38112	312.04796	0
Slice 8	19.4	135.63262	-0	511.89543	319.86776	0
Slice 9	20.4	134.85922	-0	528.83442	330.45242	0
Slice 10	21.4	134.1675	-0	558.90079	349.23998	0
Slice 11	22.639986	133.42044	-0	590.52818	369.00296	0
Slice 12	23.984979	132.70663	18.306584	620.79427	376.47609	0
Slice 13	25.194993	132.16123	52.339125	639.24348	366.73855	0
Slice 14	26.1	131.79869	74.96166	647.18536	357.56505	0
Slice 15	26.96	131.50624	93.210318	647.18615	346.16252	0
Slice 16	28.08	131.17289	114.01183	640.12831	328.75406	0
Slice 17	29.2	130.89931	131.08334	624.85247	308.5412	0
Slice 18	30.32	130.68336	144.55805	601.31049	285.4106	0
Slice 19	31.44	130.52345	154.53662	569.36268	259.21209	0
Slice 20	32.574328	130.41777	161.13121	528.15586	229.34246	0
Slice 21	33.722984	130.36697	164.30125	477.06521	195.43661	0
Slice 22	34.87164	130.37273	163.94193	416.0012	157.50411	0
Slice 23	36.020296	130.43509	160.05061	344.28153	115.12025	0
Slice 24	37.097312	130.54369	153.27396	287.01716	83.572028	0
Slice 25	38.119167	130.6957	143.78855	256.23245	70.262748	0
Slice 26	39.1575	130.89763	131.1877	235.59064	65.238197	0

Slice 27	40.195833	131.14909	115.49653	207.76209	57.653922	0
Slice 28	41.234167	131.45176	96.610176	171.90436	47.049028	0
Slice 29	42.2725	131.80776	74.395961	126.91269	32.816093	0
Slice 30	43.310833	132.21974	48.688215	71.305687	14.132965	0



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Lower Fill (North)	Mohr-Coulomb	1	111	0	32	0
	Med Stiff Clay (North)	Mohr-Coulomb		113	642	0	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft Clay (North)	Mohr-Coulomb		91	350	0	0
	Upper Fill (North)	Mohr-Coulomb	1	121	0	36	0

HNTB

HNTB PROJECT NUMBER 63738

NORTH ABUTMENT | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

EAST SIDE
STATION 20+00

East Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 109
Date: 10/18/2017
Time: 5:55:19 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_North_Abutment_Undrained_LowGWT_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 20+00 Transverse w Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:50:38 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

East Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)

Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 350 psf
Phi': 0 °
Phi-B: 0 °

Med Stiff Clay (North)

Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 642 psf
Phi': 0 °

Phi-B: 0 °

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-13.3, 143.834) ft
Left-Zone Right Coordinate: (14.9, 143.802) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (39, 132.48654) ft
Right-Zone Right Coordinate: (99.9, 131.90096) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 132.3) ft
Right Coordinate: (100, 131.9) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	100	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-12.9	143.9
	-12.9	144.9
	0	145.1
	12.9	144.9

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (17, 140.9) ft
Inside Point: (-17, 140.9) ft
Slip Surface Intersection: () ft
Length: 34 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	0	144.1
Point 2	-15	143.8
Point 3	15	143.8
Point 4	0	142.3
Point 5	-18.9	141.8
Point 6	18.9	141.8
Point 7	0.2	140.8

Point 8	-10.6	140.5
Point 9	10.6	140.4
Point 10	-15.6	140.1
Point 11	17.3	139.6
Point 12	6.5	136.5
Point 13	21.9	136.5
Point 14	-6	136
Point 15	-24.5	136
Point 16	6	136
Point 17	-24.9	135.8
Point 18	25.8	133.8
Point 19	-32.8	133.6
Point 20	26.4	133.5
Point 21	-36	133.3
Point 22	37.6	132.5
Point 23	-100	132.3
Point 24	100	131.9
Point 25	6	125
Point 26	6.5	124.9
Point 27	100	124.9
Point 28	-100	123
Point 29	-6	123
Point 30	-100	118
Point 31	-6	118
Point 32	-1	116
Point 33	-100	116
Point 34	-6	116
Point 35	6	113.3
Point 36	100	112.4
Point 37	6.5	112.4
Point 38	6.5	110.7

Point 39	100	110.7
Point 40	6	109.8
Point 41	-100	100
Point 42	-6	100
Point 43	100	100
Point 44	6	100
Point 45	6.5	100
Point 46	-12.9	143.8
Point 47	12.9	143.8

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	41,42,44,45,43,39,38,40,34,33	2,664.4
Region 2	Glacial Till	33,34,40,38,39,36,37,35,31,30	381.25
Region 3	Soft Clay (North)	30,31,35,29,28	500
Region 4	Med Stiff Clay (North)	29,35,37,36,27,26,25	1,245
Region 5	Lower Fill (North)	28,29,25,26,27,24,22,20,18,13,12,16,14,15,17,19,21,23	1,918.5
Region 6	Upper Fill (North)	15,14,16,12,13,11,9,7,8,10	166.21
Region 7	Embankment Fill	21,19,17,15,10,8,7,9,11,13,18,20,22,6,4,5	159.46
Region 8	Pavement Box	5,4,6,3,1,2	62.85

Current Slip Surface

Slip Surface: 1,238
F of S: 1.531
Volume: 105.98295 ft³
Weight: 12,055.086 lbs
Resisting Moment: 169,968.78 lbs-ft
Activating Moment: 111,017.22 lbs-ft
Resisting Force: 5,084.7713 lbs
Activating Force: 3,320.8119 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (51.18, 132.36942) ft
Entry: (14.9, 143.802) ft
Radius: 29.421692 ft
Center: (39.786692, 159.49558) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	14.95	143.72326	-0	4.8997313	3.5598632	0
Slice 2	15.61414	142.75761	-0	48.169956	34.997522	0
Slice 3	16.89621	141.04215	-0	126.0504	78.765034	0
Slice 4	18.23207	139.49383	-0	189.64902	118.50586	0
Slice 5	19.329175	138.35867	-0	238.63378	149.11493	0
Slice 6	20.595932	137.22164	-0	283.22054	205.77177	0
Slice 7	21.666757	136.31766	-0	331.2492	206.98748	0
Slice 8	22.55	135.66516	-0	357.39496	223.32516	0
Slice 9	23.85	134.77596	-0	393.06435	245.61386	0
Slice 10	25.15	133.98398	-0	421.5792	263.43192	0
Slice 11	26.1	133.45339	-0	438.46435	273.98294	0
Slice 12	26.697643	133.14786	-0	445.96242	278.66825	0
Slice 13	27.620874	132.7158	17.734061	454.19489	272.731	0
Slice 14	28.872053	132.18162	51.067187	459.86879	255.44759	0
Slice 15	30.123232	131.71403	80.244697	457.18552	235.53876	0
Slice 16	31.374411	131.30971	105.47396	446.14378	212.87413	0
Slice 17	32.574328	130.97775	126.18848	427.75009	188.43661	0
Slice 18	33.722984	130.71151	142.80189	402.62277	162.35411	0
Slice 19	34.87164	130.49319	156.42511	370.06847	133.49919	0
Slice 20	36.020296	130.32171	167.12536	329.83481	101.67215	0
Slice 21	37.097312	130.20141	174.63186	303.82397	80.728189	0
Slice 22	38.217273	130.12228	179.56962	301.95899	76.477364	0
Slice 23	39.451818	130.08227	182.06616	312.43096	81.460971	0
Slice 24	40.686364	130.09413	181.32606	317.30804	84.970974	0
Slice 25	41.920909	130.15793	177.34539	316.23247	86.786277	0
Slice 26	43.155455	130.27399	170.10289	308.75949	86.642259	0
Slice 27	44.39	130.44296	159.55938	294.33291	84.215847	0
Slice 28	45.624545	130.66576	145.65673	272.25056	79.104602	0
Slice 29	46.859091	130.94365	128.31614	241.61447	70.796656	0

Slice 30	48.093636	131.27827	107.43584	201.25749	58.626276	0
Slice 31	49.328182	131.67167	82.887819	149.63172	41.706219	0
Slice 32	50.562727	132.12639	54.513566	84.63395	18.821305	0

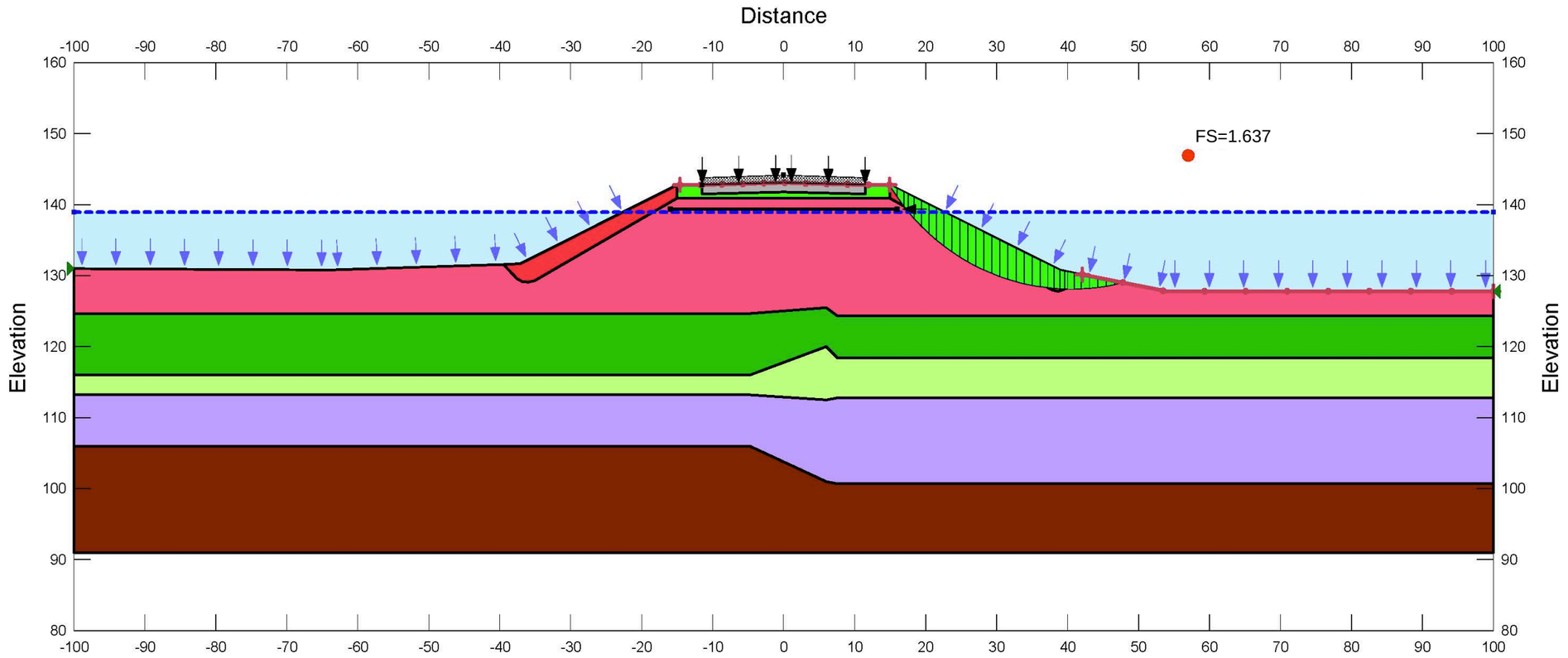
NORTH APPROACH EMBANKMENT

GLOBAL STABILITY ANALYSIS

EAST SIDE

WATER EL. 139 FEET

HNTB



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Fill (South)	Mohr-Coulomb	1	114	0	33	0
	Gabion Blanket	Mohr-Coulomb	1	130	0	45	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Organic Silt	Mohr-Coulomb	1	103	0	25	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	1	106	0	28	0

HNTB

HNTB PROJECT NUMBER 63738

NORTH ABUTMENT | DRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

EAST SIDE
STATION 20+00

East Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 118
Date: 10/18/2017
Time: 5:43:39 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_North_Abutment_Drained_HighGWT_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 20+00 Transverse w Geogrid\
Last Solved Date: 11/7/2017
Last Solved Time: 3:12:18 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

East Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock
Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)
Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)
Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Med Stiff Clay (North)
Model: Mohr-Coulomb
Unit Weight: 113 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-12.7, 143.846) ft
Left-Zone Right Coordinate: (13.1, 143.838) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (38.1, 132.49519) ft
Right-Zone Right Coordinate: (99.9, 131.90096) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 132.3) ft
Right Coordinate: (100, 131.9) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	100	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-12.9	143.9
	-12.9	144.9
	0	145.1
	12.9	144.9

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (17, 140.9) ft
Inside Point: (-17, 140.9) ft
Slip Surface Intersection: (9.6626273, 140.9) ft
Length: 34 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 1,125.0638 lbs
Pullout Force per Length: 153.33333 lbs/ft
Available Length: 7.3373727 ft
Required Length: 7.3373727 ft
Governing Component: Pullout Resistance (Active Zone)

Points

	X (ft)	Y (ft)
Point 1	0	144.1
Point 2	-15	143.8
Point 3	15	143.8
Point 4	0	142.3

Point 5	-18.9	141.8
Point 6	18.9	141.8
Point 7	0.2	140.8
Point 8	-10.6	140.5
Point 9	10.6	140.4
Point 10	-15.6	140.1
Point 11	17.3	139.6
Point 12	6.5	136.5
Point 13	21.9	136.5
Point 14	-6	136
Point 15	-24.5	136
Point 16	6	136
Point 17	-24.9	135.8
Point 18	25.8	133.8
Point 19	-32.8	133.6
Point 20	26.4	133.5
Point 21	-36	133.3
Point 22	37.6	132.5
Point 23	-100	132.3
Point 24	100	131.9
Point 25	6	125
Point 26	6.5	124.9
Point 27	100	124.9
Point 28	-100	123
Point 29	-6	123
Point 30	-100	118
Point 31	-6	118
Point 32	-1	116
Point 33	-100	116
Point 34	-6	116
Point 35	6	113.3

Point 36	100	112.4
Point 37	6.5	112.4
Point 38	6.5	110.7
Point 39	100	110.7
Point 40	6	109.8
Point 41	-100	100
Point 42	-6	100
Point 43	100	100
Point 44	6	100
Point 45	6.5	100
Point 46	-12.9	143.8
Point 47	12.9	143.8

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	41,42,44,45,43,39,38,40,34,33	2,664.4
Region 2	Glacial Till	33,34,40,38,39,36,37,35,31,30	381.25
Region 3	Soft Clay (North)	30,31,35,29,28	500
Region 4	Med Stiff Clay (North)	29,35,37,36,27,26,25	1,245
Region 5	Lower Fill (North)	28,29,25,26,27,24,22,20,18,13,12,16,14,15,17,19,21,23	1,918.5
Region 6	Upper Fill (North)	15,14,16,12,13,11,9,7,8,10	166.21
Region 7	Embankment Fill	21,19,17,15,10,8,7,9,11,13,18,20,22,6,4,5	159.46
Region 8	Pavement Box	5,4,6,3,1,2	62.85

Current Slip Surface

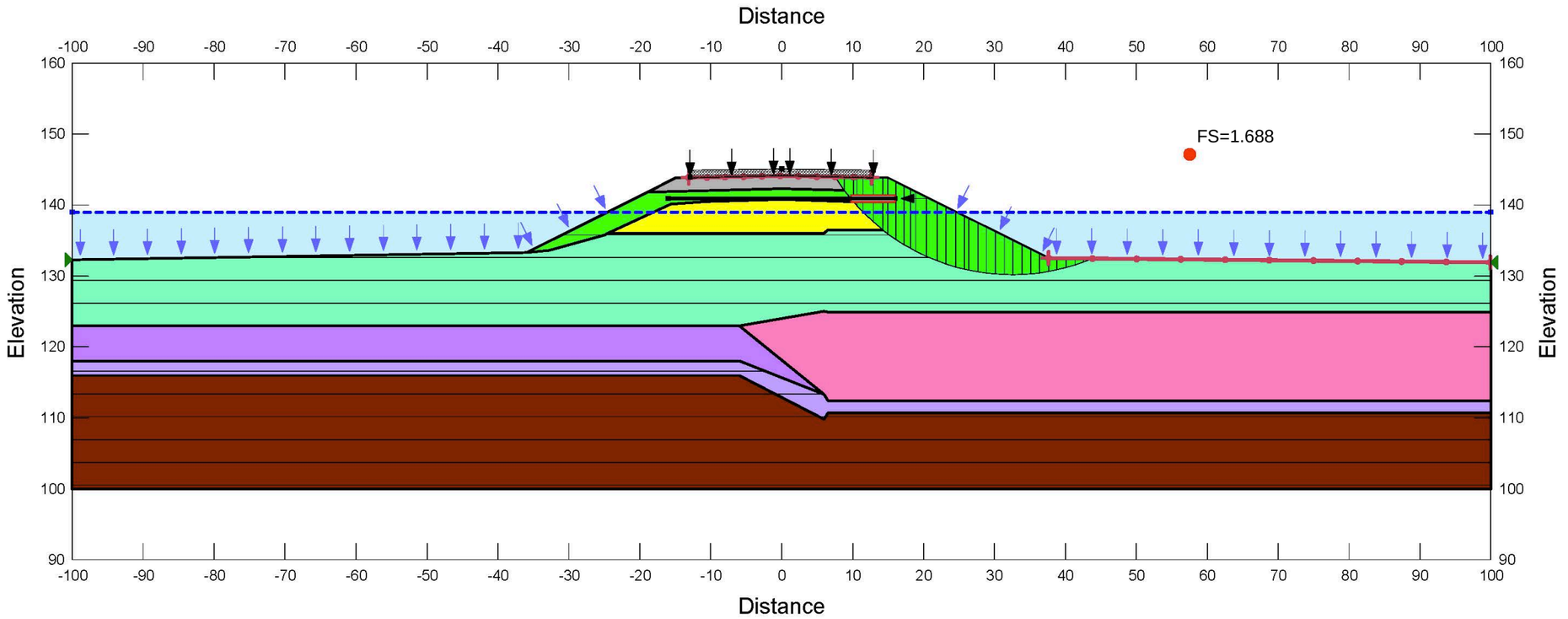
Slip Surface: 975
F of S: 1.685
Volume: 180.55434 ft³
Weight: 20,911.445 lbs
Resisting Moment: 210,850.93 lbs-ft
Activating Moment: 125,090.91 lbs-ft
Resisting Force: 7,562.3432 lbs
Activating Force: 4,487.2065 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (38.1, 132.49519) ft

Entry: (7.94, 143.9412) ft
Radius: 23.091352 ft
Center: (28.883091, 153.66732) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	8.4293779	143.00263	-0	189.31569	137.5459	0
Slice 2	9.4426662	141.24421	-0	351.73165	219.78633	0
Slice 3	10.283288	139.99355	-0	447.27898	324.9672	0
Slice 4	10.824145	139.28137	-0	520.03141	377.82493	0
Slice 5	11.511217	138.4708	33.021772	601.87856	413.29865	0
Slice 6	12.437072	137.47153	95.376535	723.77177	456.55586	0
Slice 7	13.169927	136.75072	140.35476	639.91966	362.95514	0
Slice 8	13.829891	136.16455	176.93204	720.40773	339.6013	0
Slice 9	14.609964	135.52229	217.0089	795.00507	361.17209	0
Slice 10	15.575	134.8097	261.47473	848.06678	366.54339	0
Slice 11	16.725	134.04759	309.03012	882.94843	358.62396	0
Slice 12	17.745161	133.44608	346.56474	905.92001	349.52396	0
Slice 13	18.545161	133.02319	372.95297	917.46774	340.25059	0
Slice 14	19.4	132.62022	398.09858	919.92487	326.07326	0
Slice 15	20.4	132.19738	424.48379	913.7225	305.71027	0
Slice 16	21.4	131.82849	447.50207	911.02581	289.64178	0
Slice 17	22.338351	131.52759	466.27864	905.08123	274.19429	0
Slice 18	23.215054	131.28699	481.29196	897.02316	259.77768	0
Slice 19	24.091756	131.08297	494.02244	883.99834	243.68399	0
Slice 20	25.165054	130.88635	506.29189	880.97727	234.12941	0
Slice 21	26.1	130.74629	515.0313	886.41703	232.06756	0
Slice 22	26.909091	130.66618	520.03062	885.14582	228.1493	0
Slice 23	27.927273	130.60139	524.07333	878.51732	221.48118	0
Slice 24	28.945455	130.58167	525.30391	866.27465	213.06216	0
Slice 25	29.963636	130.6069	523.72957	848.25324	202.78489	0
Slice 26	30.981818	130.67723	519.34107	824.23291	190.51757	0

Slice 27	32	130.79307	512.11239	793.9281	176.098	0
Slice 28	33.018182	130.95513	501.99999	756.97417	159.32555	0
Slice 29	34.036364	131.1644	488.94144	712.90825	139.94999	0
Slice 30	35.054545	131.42222	472.8534	661.14201	117.65578	0
Slice 31	36.072727	131.73031	453.62881	600.92268	92.039427	0
Slice 32	37.090909	132.09082	431.13296	531.27566	62.576104	0
Slice 33	37.85	132.38984	412.47426	448.60965	22.579895	0



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Lower Fill (North)	Mohr-Coulomb	1	111	0	32	0
	Med Stiff Clay (North)	Mohr-Coulomb		113	642	0	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft Clay (North)	Mohr-Coulomb		91	350	0	0
	Upper Fill (North)	Mohr-Coulomb	1	121	0	36	0

HNTB

HNTB PROJECT NUMBER 63738

NORTH ABUTMENT | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

EAST SIDE
STATION 20+00

East Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 109
Date: 10/19/2017
Time: 12:54:35 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_North_Abutment_Undrained_HighGWT_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 20+00 Transverse w Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:54:44 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

East Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)

Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 350 psf
Phi': 0 °
Phi-B: 0 °

Med Stiff Clay (North)

Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 642 psf
Phi': 0 °

Phi-B: 0 °

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-13.1, 143.838) ft
Left-Zone Right Coordinate: (12.7, 143.846) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (37.6, 132.5) ft
Right-Zone Right Coordinate: (99.9, 131.90096) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 132.3) ft
Right Coordinate: (100, 131.9) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	100	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-12.9	143.9
	-12.9	144.9
	0	145.1
	12.9	144.9

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (16, 140.9) ft
Inside Point: (-16, 140.9) ft
Slip Surface Intersection: (9.7642441, 140.9) ft
Length: 32 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 956.14923 lbs
Pullout Force per Length: 153.33333 lbs/ft
Available Length: 6.2357559 ft
Required Length: 6.2357559 ft
Governing Component: Pullout Resistance (Active Zone)

Points

	X (ft)	Y (ft)
Point 1	0	144.1
Point 2	-15	143.8
Point 3	15	143.8
Point 4	0	142.3
Point 5	-18.9	141.8
Point 6	18.9	141.8
Point 7	0.2	140.8

Point 8	-10.6	140.5
Point 9	10.6	140.4
Point 10	-15.6	140.1
Point 11	17.3	139.6
Point 12	6.5	136.5
Point 13	21.9	136.5
Point 14	-6	136
Point 15	-24.5	136
Point 16	6	136
Point 17	-24.9	135.8
Point 18	25.8	133.8
Point 19	-32.8	133.6
Point 20	26.4	133.5
Point 21	-36	133.3
Point 22	37.6	132.5
Point 23	-100	132.3
Point 24	100	131.9
Point 25	6	125
Point 26	6.5	124.9
Point 27	100	124.9
Point 28	-100	123
Point 29	-6	123
Point 30	-100	118
Point 31	-6	118
Point 32	-1	116
Point 33	-100	116
Point 34	-6	116
Point 35	6	113.3
Point 36	100	112.4
Point 37	6.5	112.4
Point 38	6.5	110.7

Point 39	100	110.7
Point 40	6	109.8
Point 41	-100	100
Point 42	-6	100
Point 43	100	100
Point 44	6	100
Point 45	6.5	100
Point 46	-12.9	143.8
Point 47	12.9	143.8

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	41,42,44,45,43,39,38,40,34,33	2,664.4
Region 2	Glacial Till	33,34,40,38,39,36,37,35,31,30	381.25
Region 3	Soft Clay (North)	30,31,35,29,28	500
Region 4	Med Stiff Clay (North)	29,35,37,36,27,26,25	1,245
Region 5	Lower Fill (North)	28,29,25,26,27,24,22,20,18,13,12,16,14,15,17,19,21,23	1,918.5
Region 6	Upper Fill (North)	15,14,16,12,13,11,9,7,8,10	166.21
Region 7	Embankment Fill	21,19,17,15,10,8,7,9,11,13,18,20,22,6,4,5	159.46
Region 8	Pavement Box	5,4,6,3,1,2	62.85

Current Slip Surface

Slip Surface: 985
F of S: 1.688
Volume: 186.3449 ft³
Weight: 21,543.027 lbs
Resisting Moment: 272,586.13 lbs-ft
Activating Moment: 161,447.84 lbs-ft
Resisting Force: 7,806.5742 lbs
Activating Force: 4,623.9693 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (43.83, 132.4401) ft
Entry: (7.54, 143.9492) ft
Radius: 29.490277 ft
Center: (32.494027, 159.66457) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	8.185058	143.0078	-0	218.38596	158.66668	0
Slice 2	9.4904787	141.24184	-0	388.68437	242.87695	0
Slice 3	10.375421	140.16256	-0	478.90339	347.94368	0
Slice 4	11.027367	139.45393	-0	537.54247	390.54747	0
Slice 5	12.177367	138.31241	42.905473	658.56366	447.30186	0
Slice 6	13.571788	137.06241	120.90547	620.8797	363.25254	0
Slice 7	14.621788	136.21178	173.98475	740.36349	353.91271	0
Slice 8	15.575	135.52063	217.11264	785.45681	355.14085	0
Slice 9	16.725	134.75371	264.96848	815.07605	343.74536	0
Slice 10	17.745161	134.13257	303.7275	835.57127	332.33287	0
Slice 11	18.545161	133.6849	331.66216	846.51916	321.71836	0
Slice 12	19.65	133.13133	366.2051	847.01307	300.44217	0
Slice 13	21.15	132.45558	408.37167	844.74767	272.67799	0
Slice 14	22.557527	131.90751	442.57146	842.27634	249.76333	0
Slice 15	23.872581	131.47106	469.80599	834.46152	227.86206	0
Slice 16	25.165054	131.10704	492.52087	837.38586	215.49556	0
Slice 17	26.1	130.87745	506.84705	849.67242	214.22106	0
Slice 18	27.022222	130.6933	518.33822	855.68108	210.79521	0
Slice 19	28.266667	130.48563	531.2965	858.38312	204.3864	0
Slice 20	29.511111	130.33221	540.87003	854.6488	196.07074	0
Slice 21	30.755556	130.23218	547.11181	844.39767	185.76482	0
Slice 22	32	130.185	550.05584	827.50148	173.36728	0
Slice 23	33.244444	130.19042	549.71798	803.77969	158.75537	0
Slice 24	34.488889	130.24846	546.09641	772.99286	141.78064	0
Slice 25	35.733333	130.35943	539.17158	734.83347	122.26312	0
Slice 26	36.977778	130.52395	528.90569	688.91305	99.983693	0
Slice 27	38.223	130.74309	515.23091	626.91044	69.785119	0
Slice 28	39.469	131.01819	498.06469	598.55176	62.79129	0
Slice 29	40.715	131.35077	477.31166	562.43622	53.191726	0

Slice 30	41.961	131.7429	452.84334	517.86739	40.631533	0
Slice 31	43.207	132.19711	424.50027	463.96058	24.657535	0

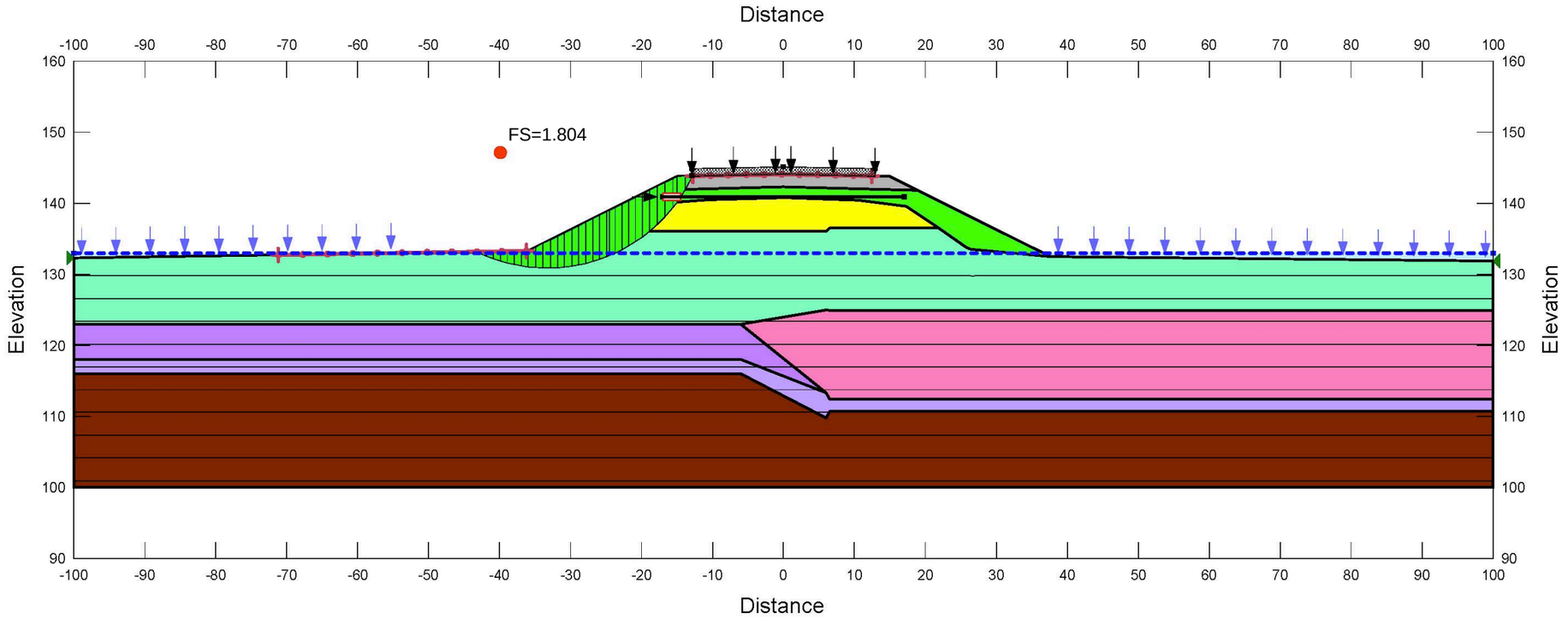
NORTH APPROACH EMBANKMENT

GLOBAL STABILITY ANALYSIS

WEST SIDE

WATER EL. 133 FEET

HNTB



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Lower Fill (North)	Mohr-Coulomb	1	111	0	32	0
	Med Stiff Clay (North)	Mohr-Coulomb	1	113	0	30	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft Clay (North)	Mohr-Coulomb	1	91	0	27	0
	Upper Fill (North)	Mohr-Coulomb	1	121	0	36	0

HNTB

HNTB PROJECT NUMBER 63738

NORTH ABUTMENT | DRAINED

PREPARED BY: MRR | CHECKED BY: BAM | BACK CHECKED BY: MRR

DATE: 10/16/2017 | DATE: 10/18/2017 | DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

WEST SIDE
STATION 20+00

West Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 114
Date: 10/18/2017
Time: 5:43:43 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_North_Abutment_Drained_LowGWT_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 20+00 Transverse w Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:56:08 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

West Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock
Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)
Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)
Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Med Stiff Clay (North)
Model: Mohr-Coulomb
Unit Weight: 113 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-71.2, 132.75) ft
Left-Zone Right Coordinate: (-36.2, 133.29688) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-12.8, 143.844) ft
Right-Zone Right Coordinate: (12.4, 143.852) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 132.3) ft
Right Coordinate: (100, 131.9) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	100	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-12.9	143.9
	-12.9	144.9
	0	145.1
	12.9	144.9

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (-17, 140.9) ft
Inside Point: (17, 140.9) ft
Slip Surface Intersection: (-14.500089, 140.9) ft
Length: 34 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 383.31968 lbs
Pullout Force per Length: 153.33333 lbs/ft
Available Length: 2.4999109 ft
Required Length: 2.4999109 ft
Governing Component: Pullout Resistance (Active Zone)

Points

	X (ft)	Y (ft)
Point 1	0	144.1
Point 2	-15	143.8
Point 3	15	143.8
Point 4	0	142.3

Point 5	-18.9	141.8
Point 6	18.9	141.8
Point 7	0.2	140.8
Point 8	-10.6	140.5
Point 9	10.6	140.4
Point 10	-15.6	140.1
Point 11	17.3	139.6
Point 12	6.5	136.5
Point 13	21.9	136.5
Point 14	-6	136
Point 15	-24.5	136
Point 16	6	136
Point 17	-24.9	135.8
Point 18	25.8	133.8
Point 19	-32.8	133.6
Point 20	26.4	133.5
Point 21	-36	133.3
Point 22	37.6	132.5
Point 23	-100	132.3
Point 24	100	131.9
Point 25	6	125
Point 26	6.5	124.9
Point 27	100	124.9
Point 28	-100	123
Point 29	-6	123
Point 30	-100	118
Point 31	-6	118
Point 32	-1	116
Point 33	-100	116
Point 34	-6	116
Point 35	6	113.3

Point 36	100	112.4
Point 37	6.5	112.4
Point 38	6.5	110.7
Point 39	100	110.7
Point 40	6	109.8
Point 41	-100	100
Point 42	-6	100
Point 43	100	100
Point 44	6	100
Point 45	6.5	100
Point 46	-12.9	143.8
Point 47	12.9	143.8

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	41,42,44,45,43,39,38,40,34,33	2,664.4
Region 2	Glacial Till	33,34,40,38,39,36,37,35,31,30	381.25
Region 3	Soft Clay (North)	30,31,35,29,28	500
Region 4	Med Stiff Clay (North)	29,35,37,36,27,26,25	1,245
Region 5	Lower Fill (North)	28,29,25,26,27,24,22,20,18,13,12,16,14,15,17,19,21,23	1,918.5
Region 6	Upper Fill (North)	15,14,16,12,13,11,9,7,8,10	166.21
Region 7	Embankment Fill	21,19,17,15,10,8,7,9,11,13,18,20,22,6,4,5	159.46
Region 8	Pavement Box	5,4,6,3,1,2	62.85

Current Slip Surface

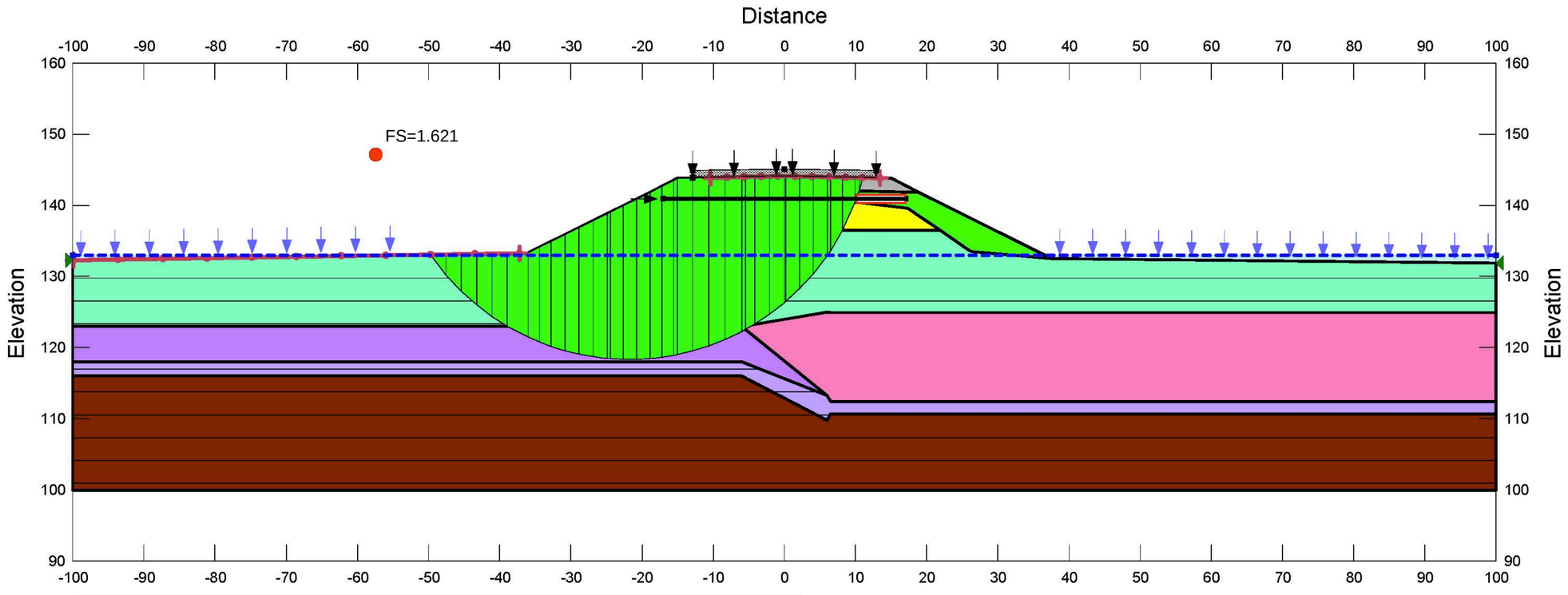
Slip Surface: 975
F of S: 1.804
Volume: 123.36528 ft³
Weight: 14,149.473 lbs
Resisting Moment: 180,946.93 lbs-ft
Activating Moment: 100,295.45 lbs-ft
Resisting Force: 6,872.9532 lbs
Activating Force: 3,810.1932 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (-43.2, 133.1875) ft

Entry: (-12.8, 143.844) ft
Radius: 22.618466 ft
Center: (-33.25311, 153.5014) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-43.003786	133.09375	-0	16.037141	10.021118	0
Slice 2	-42.321317	132.78713	13.283139	62.193636	30.56267	0
Slice 3	-41.348807	132.38781	38.200601	116.77756	49.10033	0
Slice 4	-40.376297	132.03997	59.90574	161.7285	63.625923	0
Slice 5	-39.403786	131.74114	78.553008	198.32151	74.839663	0
Slice 6	-38.431276	131.48931	94.267247	227.51975	83.265405	0
Slice 7	-37.458766	131.28288	107.14841	250.0659	89.30476	0
Slice 8	-36.486255	131.12059	117.27506	266.54195	93.272306	0
Slice 9	-35.466667	130.99789	124.93192	311.14593	116.35943	0
Slice 10	-34.4	130.91834	129.89565	380.84673	156.81164	0
Slice 11	-33.333333	130.88936	131.70386	441.09541	193.32929	0
Slice 12	-32.30625	130.90816	130.53071	490.44354	224.8985	0
Slice 13	-31.31875	130.97125	126.59426	530.04651	252.10494	0
Slice 14	-30.33125	131.07798	119.93436	562.72992	276.68937	0
Slice 15	-29.34375	131.22898	110.51178	588.68948	298.79859	0
Slice 16	-28.35625	131.42516	98.269712	608.05619	318.54994	0
Slice 17	-27.36875	131.66776	83.131995	620.90114	336.03546	0
Slice 18	-26.38125	131.95832	65.00058	627.23777	351.32479	0
Slice 19	-25.39375	132.29884	43.752086	627.02161	364.46725	0
Slice 20	-24.7	132.56357	27.233354	623.34367	372.49107	0
Slice 21	-24.099323	132.82263	11.067635	617.90608	379.19475	0
Slice 22	-23.221277	133.23631	-0	608.00504	379.92371	0
Slice 23	-22.266538	133.738	-0	592.87621	370.47017	0
Slice 24	-21.311799	134.30025	-0	571.97458	357.40939	0
Slice 25	-20.35706	134.92859	-0	545.14316	340.64325	0
Slice 26	-19.389845	135.64025	-0	535.41528	334.5646	0

Slice 27	-18.35	136.50265	-0	475.565	345.5182	0
Slice 28	-17.25	137.53615	-0	419.70221	304.9315	0
Slice 29	-16.15	138.72402	-0	353.53737	256.85993	0
Slice 30	-15.3	139.75231	-0	310.15275	225.33916	0
Slice 31	-14.407992	141.03927	-0	212.96773	133.07701	0
Slice 32	-13.357992	142.78475	-0	66.884662	48.594551	0
Slice 33	-12.85	143.7395	-0	127.62184	92.722694	0



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Lower Fill (North)	Mohr-Coulomb	1	111	0	32	0
	Med Stiff Clay (North)	Mohr-Coulomb		113	642	0	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft Clay (North)	Mohr-Coulomb		91	350	0	0
	Upper Fill (North)	Mohr-Coulomb	1	121	0	36	0

HNTB

HNTB PROJECT NUMBER 63738

NORTH ABUTMENT | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

WEST SIDE
STATION 20+00

West Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 109
Date: 10/18/2017
Time: 5:55:19 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_North_Abutment_Undrained_LowGWT_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 20+00 Transverse w Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:50:38 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

West Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock
Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)
Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)
Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 350 psf
Phi': 0 °
Phi-B: 0 °

Med Stiff Clay (North)
Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 642 psf
Phi': 0 °

Phi-B: 0 °

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-99.9, 132.30156) ft
Left-Zone Right Coordinate: (-37.2, 133.28125) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-10.4, 143.892) ft
Right-Zone Right Coordinate: (13.4, 143.832) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 132.3) ft
Right Coordinate: (100, 131.9) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	100	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-12.9	143.9
	-12.9	144.9
	0	145.1
	12.9	144.9

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (-17, 140.9) ft
Inside Point: (17, 140.9) ft
Slip Surface Intersection: (10.105609, 140.9) ft
Length: 34 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 1,057.14 lbs
Pullout Force per Length: 153.33333 lbs/ft
Available Length: 6.8943913 ft
Required Length: 6.8943913 ft
Governing Component: Pullout Resistance

Points

	X (ft)	Y (ft)
Point 1	0	144.1
Point 2	-15	143.8
Point 3	15	143.8
Point 4	0	142.3
Point 5	-18.9	141.8
Point 6	18.9	141.8
Point 7	0.2	140.8

Point 8	-10.6	140.5
Point 9	10.6	140.4
Point 10	-15.6	140.1
Point 11	17.3	139.6
Point 12	6.5	136.5
Point 13	21.9	136.5
Point 14	-6	136
Point 15	-24.5	136
Point 16	6	136
Point 17	-24.9	135.8
Point 18	25.8	133.8
Point 19	-32.8	133.6
Point 20	26.4	133.5
Point 21	-36	133.3
Point 22	37.6	132.5
Point 23	-100	132.3
Point 24	100	131.9
Point 25	6	125
Point 26	6.5	124.9
Point 27	100	124.9
Point 28	-100	123
Point 29	-6	123
Point 30	-100	118
Point 31	-6	118
Point 32	-1	116
Point 33	-100	116
Point 34	-6	116
Point 35	6	113.3
Point 36	100	112.4
Point 37	6.5	112.4
Point 38	6.5	110.7

Point 39	100	110.7
Point 40	6	109.8
Point 41	-100	100
Point 42	-6	100
Point 43	100	100
Point 44	6	100
Point 45	6.5	100
Point 46	-12.9	143.8
Point 47	12.9	143.8

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	41,42,44,45,43,39,38,40,34,33	2,664.4
Region 2	Glacial Till	33,34,40,38,39,36,37,35,31,30	381.25
Region 3	Soft Clay (North)	30,31,35,29,28	500
Region 4	Med Stiff Clay (North)	29,35,37,36,27,26,25	1,245
Region 5	Lower Fill (North)	28,29,25,26,27,24,22,20,18,13,12,16,14,15,17,19,21,23	1,918.5
Region 6	Upper Fill (North)	15,14,16,12,13,11,9,7,8,10	166.21
Region 7	Embankment Fill	21,19,17,15,10,8,7,9,11,13,18,20,22,6,4,5	159.46
Region 8	Pavement Box	5,4,6,3,1,2	62.85

Current Slip Surface

Slip Surface: 1,076
F of S: 1.621
Volume: 953.32194 ft³
Weight: 106,296.91 lbs
Resisting Moment: 1,128,130.9 lbs-ft
Activating Moment: 695,854.82 lbs-ft
Resisting Force: 26,340.972 lbs
Activating Force: 16,246.983 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (-49.74, 133.08531) ft
Entry: (11.02, 143.8796) ft
Radius: 33.864414 ft
Center: (-21.800842, 152.22172) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-49.710688	133.04266	-0	16.079183	10.047389	0
Slice 2	-48.604724	131.60054	87.32606	325.96897	149.12064	0
Slice 3	-46.451422	129.05545	246.13971	720.57709	296.46138	0
Slice 4	-44.29812	126.95132	377.43781	983.51914	378.72165	0
Slice 5	-42.144818	125.18275	487.79645	1,179.7113	432.3564	0
Slice 6	-39.991516	123.68634	581.1723	1,332.2342	469.31556	0
Slice 7	-37.457433	122.23895	0	1,395.323	0	350
Slice 8	-35.2	121.1331	0	1,518.5276	0	350
Slice 9	-33.6	120.49082	0	1,651.9762	0	350
Slice 10	-31.8125	119.88758	0	1,789.593	0	350
Slice 11	-29.8375	119.34046	0	1,929.6614	0	350
Slice 12	-27.8625	118.91935	0	2,057.7495	0	350
Slice 13	-25.8875	118.61951	0	2,174.2331	0	350
Slice 14	-24.7	118.48223	0	2,239.8742	0	350
Slice 15	-23.566667	118.41629	0	2,300.0097	0	350
Slice 16	-21.7	118.37032	0	2,394.3611	0	350
Slice 17	-19.833333	118.42744	0	2,478.5655	0	350
Slice 18	-18.075	118.57313	0	2,558.7673	0	350
Slice 19	-16.425	118.79717	0	2,630.7305	0	350
Slice 20	-15.3	118.98854	0	2,679.555	0	350
Slice 21	-13.95	119.2976	0	2,651.6321	0	350
Slice 22	-11.75	119.90564	0	2,830.5156	0	350
Slice 23	-9.45	120.71411	0	2,728.1627	0	350
Slice 24	-7.15	121.71723	0	2,606.6616	0	350
Slice 25	-5.728973	122.4157	0	2,534.2794	0	350
Slice 26	-4.8183561	122.93269	0	2,380.3183	0	642
Slice 27	-3.1340747	123.99439	561.94976	2,111.5221	968.28026	0
Slice 28	-1.0446916	125.49661	468.21126	1,903.1252	896.63369	0
Slice 29	0.1	126.39277	412.29116	1,796.3921	864.88226	0

Slice 30	1.1666667	127.37097	351.25131	1,653.1042	813.48797	0
Slice 31	3.1	129.31521	229.93076	1,403.2657	733.181	0
Slice 32	5.0731794	131.68302	82.179523	1,111.4696	643.17181	0
Slice 33	6.289846	133.31219	-0	926.03805	578.6528	0
Slice 34	7.3464637	135.06219	-0	757.10738	473.0932	0
Slice 35	9.0677377	138.46264	-0	433.7936	315.1695	0
Slice 36	10.216856	141.22387	-0	260.95808	163.06471	0
Slice 37	10.755582	142.95103	-0	136.48855	99.164733	0

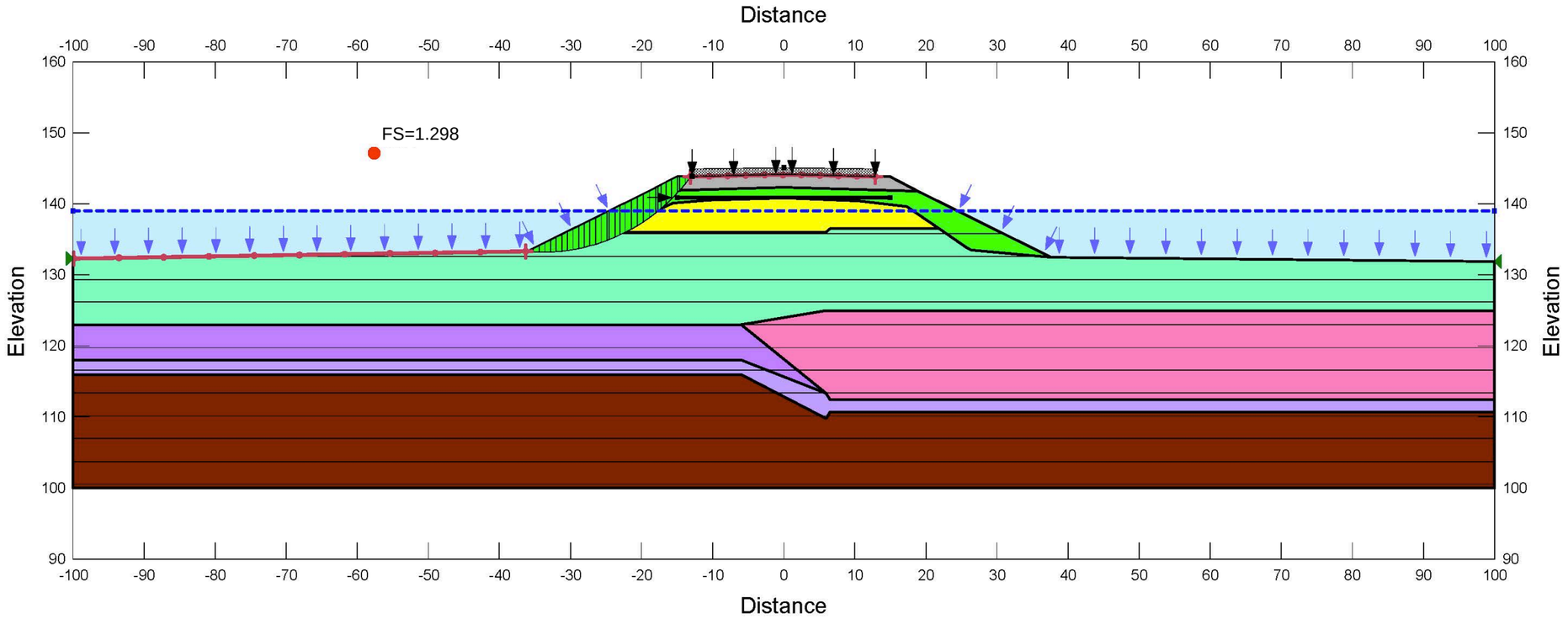
NORTH APPROACH EMBANKMENT

GLOBAL STABILITY ANALYSIS

WEST SIDE

WATER EL. 139 FEET

HNTB



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Lower Fill (North)	Mohr-Coulomb	1	111	0	32	0
	Med Stiff Clay (North)	Mohr-Coulomb	1	113	0	30	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft Clay (North)	Mohr-Coulomb	1	91	0	27	0
	Upper Fill (North)	Mohr-Coulomb	1	121	0	36	0

HNTB

HNTB PROJECT NUMBER 63738

NORTH ABUTMENT | DRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

WEST SIDE
STATION 20+00

West Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 118
Date: 10/18/2017
Time: 5:43:39 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_North_Abutment_Drained_HighGWT_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 20+00 Transverse w Geogrid\
Last Solved Date: 11/7/2017
Last Solved Time: 3:12:16 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

West Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)

Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Med Stiff Clay (North)

Model: Mohr-Coulomb
Unit Weight: 113 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-99.9, 132.30156) ft
Left-Zone Right Coordinate: (-36.3, 133.29531) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-13.1, 143.838) ft
Right-Zone Right Coordinate: (12.9, 143.842) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 132.3) ft
Right Coordinate: (100, 131.9) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	100	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-12.9	143.9
	-12.9	144.9
	0	145.1
	12.9	144.9

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (-15, 140.9) ft
Inside Point: (15, 140.9) ft
Slip Surface Intersection: () ft
Length: 30 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	0	144.1
Point 2	-15	143.8
Point 3	15	143.8
Point 4	0	142.3

Point 5	-18.9	141.8
Point 6	18.9	141.8
Point 7	0.2	140.8
Point 8	-10.6	140.5
Point 9	10.6	140.4
Point 10	-15.6	140.1
Point 11	17.3	139.6
Point 12	6.5	136.5
Point 13	21.9	136.5
Point 14	-6	136
Point 15	-24.5	136
Point 16	6	136
Point 17	-24.9	135.8
Point 18	25.8	133.8
Point 19	-32.8	133.6
Point 20	26.4	133.5
Point 21	-36	133.3
Point 22	37.6	132.5
Point 23	-100	132.3
Point 24	100	131.9
Point 25	6	125
Point 26	6.5	124.9
Point 27	100	124.9
Point 28	-100	123
Point 29	-6	123
Point 30	-100	118
Point 31	-6	118
Point 32	-1	116
Point 33	-100	116
Point 34	-6	116
Point 35	6	113.3

Point 36	100	112.4
Point 37	6.5	112.4
Point 38	6.5	110.7
Point 39	100	110.7
Point 40	6	109.8
Point 41	-100	100
Point 42	-6	100
Point 43	100	100
Point 44	6	100
Point 45	6.5	100
Point 46	-12.9	143.8
Point 47	12.9	143.8

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	41,42,44,45,43,39,38,40,34,33	2,664.4
Region 2	Glacial Till	33,34,40,38,39,36,37,35,31,30	381.25
Region 3	Soft Clay (North)	30,31,35,29,28	500
Region 4	Med Stiff Clay (North)	29,35,37,36,27,26,25	1,245
Region 5	Lower Fill (North)	28,29,25,26,27,24,22,20,18,13,12,16,14,15,17,19,21,23	1,918.5
Region 6	Upper Fill (North)	15,14,16,12,13,11,9,7,8,10	166.21
Region 7	Embankment Fill	21,19,17,15,10,8,7,9,11,13,18,20,22,6,4,5	159.46
Region 8	Pavement Box	5,4,6,3,1,2	62.85

Current Slip Surface

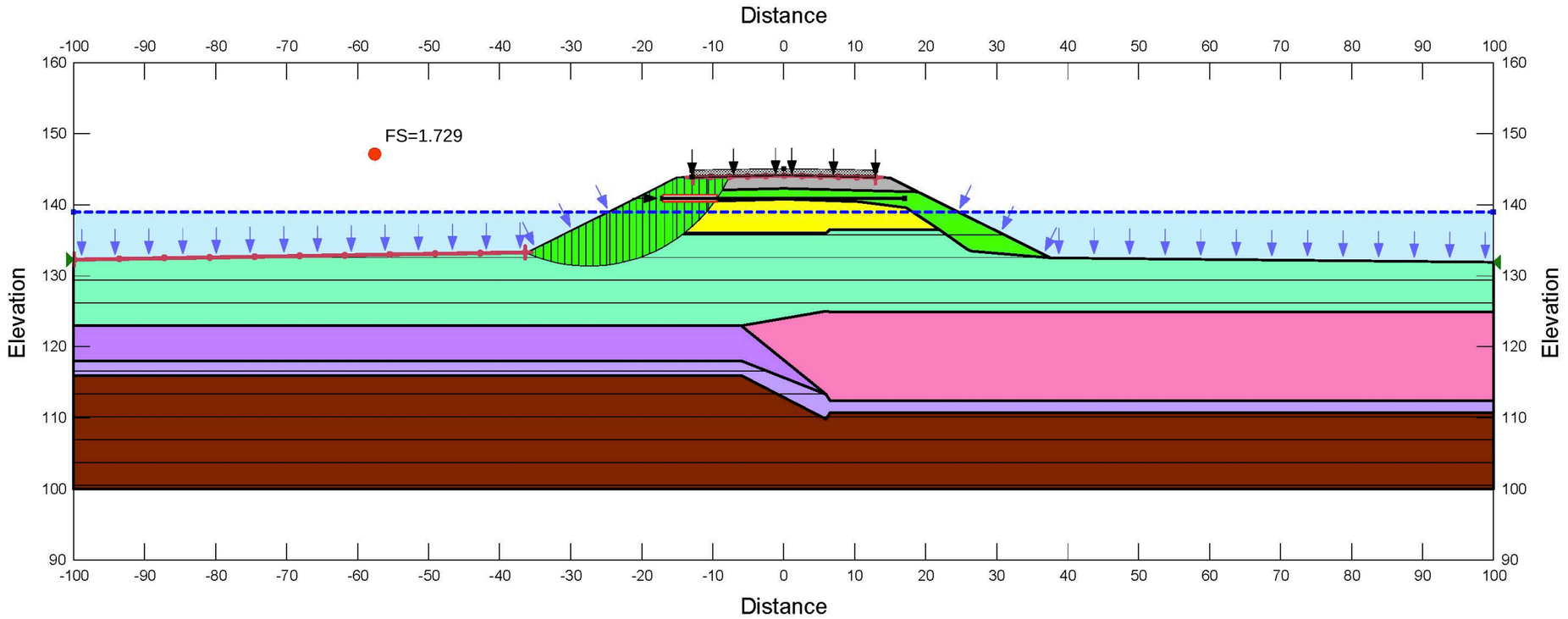
Slip Surface: 1,215
F of S: 1.298
Volume: 65.394793 ft³
Weight: 7,597.6573 lbs
Resisting Moment: 76,371.326 lbs-ft
Activating Moment: 58,844.377 lbs-ft
Resisting Force: 2,543.3073 lbs
Activating Force: 1,960.4842 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (-36.3, 133.29531) ft

Entry: (-13.1, 143.838) ft
Radius: 25.810791 ft
Center: (-33.986449, 159.00221) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-36.15	133.28269	356.75987	366.92739	6.3533725	0
Slice 2	-35.6	133.24502	359.11086	423.95576	40.519592	0
Slice 3	-34.8	133.20734	361.46169	444.55006	51.919378	0
Slice 4	-34	133.19452	362.26201	461.3337	61.906864	0
Slice 5	-33.2	133.2065	361.51415	474.49422	70.597785	0
Slice 6	-32.405	133.24295	359.23995	483.83714	77.856966	0
Slice 7	-31.615	133.30365	355.45222	489.5598	83.799717	0
Slice 8	-30.825	133.38886	350.13542	492.1666	88.750932	0
Slice 9	-30.035	133.49881	343.27421	491.74529	92.775029	0
Slice 10	-29.245	133.63384	334.84849	488.36758	95.929375	0
Slice 11	-28.455	133.79434	324.83308	482.09062	98.265416	0
Slice 12	-27.665	133.98081	313.19737	472.95821	99.829651	0
Slice 13	-26.875	134.19383	299.90478	461.0016	100.66446	0
Slice 14	-26.085	134.4341	284.91216	446.24008	100.80887	0
Slice 15	-25.295	134.70242	268.16902	428.68131	100.29921	0
Slice 16	-24.716471	134.91433	254.94574	414.20417	99.515715	0
Slice 17	-24.146083	135.14452	240.58167	410.29884	106.05106	0
Slice 18	-23.388837	135.4709	220.21602	410.58396	118.95509	0
Slice 19	-22.648062	135.81885	198.50358	407.29124	130.46501	0
Slice 20	-21.855465	136.22486	173.16846	393.63831	160.18072	0
Slice 21	-21.011046	136.69532	143.81214	376.67965	169.18815	0
Slice 22	-20.166628	137.20864	111.78082	354.72367	176.50831	0
Slice 23	-19.322209	137.76795	76.880009	327.62818	182.17921	0
Slice 24	-18.443902	138.40367	37.21098	296.51134	188.39274	0
Slice 25	-17.830708	138.87391	7.8681137	273.71212	193.14698	0
Slice 26	-17.478736	139.16214	-0	260.98356	189.61565	0

Slice 27	-16.903216	139.66049	-0	250.12461	156.2952	0
Slice 28	-16.14193	140.36106	-0	222.59177	139.09077	0
Slice 29	-15.380643	141.12151	-0	191.79398	119.84618	0
Slice 30	-14.821846	141.7151	-0	160.79541	100.47612	0
Slice 31	-14.257768	142.37038	-0	104.29187	75.772479	0
Slice 32	-13.485923	143.33308	-0	34.097523	24.7733	0



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Lower Fill (North)	Mohr-Coulomb	1	111	0	32	0
	Med Stiff Clay (North)	Mohr-Coulomb		113	642	0	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft Clay (North)	Mohr-Coulomb		91	350	0	0
	Upper Fill (North)	Mohr-Coulomb	1	121	0	36	0

HNTB

HNTB PROJECT NUMBER 63738

NORTH ABUTMENT | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

WEST SIDE
STATION 20+00

West Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 109
Date: 10/19/2017
Time: 12:54:35 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_North_Abutment_Undrained_HighGWT_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 20+00 Transverse w Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:54:42 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

West Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)

Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 350 psf
Phi': 0 °
Phi-B: 0 °

Med Stiff Clay (North)

Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 642 psf
Phi': 0 °

Phi-B: 0 °

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-99.9, 132.30156) ft
Left-Zone Right Coordinate: (-36.4, 133.29375) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-12.8, 143.844) ft
Right-Zone Right Coordinate: (12.9, 143.842) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 132.3) ft
Right Coordinate: (100, 131.9) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	100	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-12.9	143.9
	-12.9	144.9
	0	145.1
	12.9	144.9

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (-17, 140.9) ft
Inside Point: (17, 140.9) ft
Slip Surface Intersection: (-9.4102847, 140.9) ft
Length: 34 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 1,163.7564 lbs
Pullout Force per Length: 153.33333 lbs/ft
Available Length: 7.5897153 ft
Required Length: 7.5897153 ft
Governing Component: Pullout Resistance (Active Zone)

Points

	X (ft)	Y (ft)
Point 1	0	144.1
Point 2	-15	143.8
Point 3	15	143.8
Point 4	0	142.3
Point 5	-18.9	141.8
Point 6	18.9	141.8
Point 7	0.2	140.8

Point 8	-10.6	140.5
Point 9	10.6	140.4
Point 10	-15.6	140.1
Point 11	17.3	139.6
Point 12	6.5	136.5
Point 13	21.9	136.5
Point 14	-6	136
Point 15	-24.5	136
Point 16	6	136
Point 17	-24.9	135.8
Point 18	25.8	133.8
Point 19	-32.8	133.6
Point 20	26.4	133.5
Point 21	-36	133.3
Point 22	37.6	132.5
Point 23	-100	132.3
Point 24	100	131.9
Point 25	6	125
Point 26	6.5	124.9
Point 27	100	124.9
Point 28	-100	123
Point 29	-6	123
Point 30	-100	118
Point 31	-6	118
Point 32	-1	116
Point 33	-100	116
Point 34	-6	116
Point 35	6	113.3
Point 36	100	112.4
Point 37	6.5	112.4
Point 38	6.5	110.7

Point 39	100	110.7
Point 40	6	109.8
Point 41	-100	100
Point 42	-6	100
Point 43	100	100
Point 44	6	100
Point 45	6.5	100
Point 46	-12.9	143.8
Point 47	12.9	143.8

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	41,42,44,45,43,39,38,40,34,33	2,664.4
Region 2	Glacial Till	33,34,40,38,39,36,37,35,31,30	381.25
Region 3	Soft Clay (North)	30,31,35,29,28	500
Region 4	Med Stiff Clay (North)	29,35,37,36,27,26,25	1,245
Region 5	Lower Fill (North)	28,29,25,26,27,24,22,20,18,13,12,16,14,15,17,19,21,23	1,918.5
Region 6	Upper Fill (North)	15,14,16,12,13,11,9,7,8,10	166.21
Region 7	Embankment Fill	21,19,17,15,10,8,7,9,11,13,18,20,22,6,4,5	159.46
Region 8	Pavement Box	5,4,6,3,1,2	62.85

Current Slip Surface

Slip Surface: 1,239
F of S: 1.729
Volume: 167.01304 ft³
Weight: 19,429.813 lbs
Resisting Moment: 194,034.15 lbs-ft
Activating Moment: 112,192.48 lbs-ft
Resisting Force: 7,382.8156 lbs
Activating Force: 4,269.7314 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (-36.4, 133.29375) ft
Entry: (-7.66, 143.9468) ft
Radius: 21.811095 ft
Center: (-27.423979, 153.17225) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-36.2	133.20584	361.55545	394.26165	20.4371	0
Slice 2	-35.466667	132.90628	380.24829	473.8199	58.47003	0
Slice 3	-34.4	132.51452	404.69418	548.86501	90.087935	0
Slice 4	-33.333333	132.18425	425.30295	612.86137	117.19951	0
Slice 5	-32.30625	131.92065	441.7514	664.91014	139.44506	0
Slice 6	-31.31875	131.71759	454.42268	706.65512	157.61232	0
Slice 7	-30.33125	131.56153	464.16061	741.42521	173.25415	0
Slice 8	-29.34375	131.45147	471.02856	769.67268	186.61356	0
Slice 9	-28.35625	131.3867	475.07012	791.7517	197.88462	0
Slice 10	-27.36875	131.36682	476.31054	807.93754	207.22355	0
Slice 11	-26.38125	131.39171	474.7575	818.44015	214.75675	0
Slice 12	-25.39375	131.46152	470.40137	823.41378	220.58664	0
Slice 13	-24.716471	131.53065	466.08749	824.07009	223.69235	0
Slice 14	-24.049804	131.62928	459.93283	838.29958	236.42979	0
Slice 15	-23.1	131.79936	449.31962	863.73102	258.95298	0
Slice 16	-22.166667	132.00971	436.19417	882.55259	278.91569	0
Slice 17	-21.233333	132.26381	420.33807	895.24177	296.75276	0
Slice 18	-20.3	132.5633	401.65009	901.73293	312.48644	0
Slice 19	-19.366667	132.91019	380.00435	914.3746	333.91159	0
Slice 20	-18.443902	133.30188	355.5624	911.7319	347.53328	0
Slice 21	-17.390854	133.81746	323.39066	900.71361	360.75142	0
Slice 22	-16.196951	134.48555	281.70139	880.5357	374.19321	0
Slice 23	-15.3	135.04485	246.8013	865.9593	386.89286	0
Slice 24	-14.488197	135.62275	210.74049	803.12981	370.16593	0
Slice 25	-13.438197	136.45013	159.112	685.07792	382.13661	0
Slice 26	-12.386186	137.38983	100.47469	751.82251	473.23189	0
Slice 27	-11.358557	138.4397	34.962699	620.39713	425.34301	0
Slice 28	-10.722371	139.14571	-0	563.45787	409.3761	0
Slice 29	-10.126555	139.90886	-0	462.76963	336.22182	0

Slice 30	-9.1511847	141.29874	-0	354.77661	221.68903	0
Slice 31	-8.1546296	143.00899	-0	192.30687	139.71912	0

Project: Final Design of Burnham Bridge Replacement	**Job No:59522**	**Design Criteria Document:**
Client: MaineDOT	**Discipline: Geotech**	**Calculation No:**

Name or Description of Calculation:

Calc. Rev. No.	Originator	Checker	Senior Technical Reviewer (if required)	Confirmation Required (Y/N)
01	M. Restrepo	B. Materek		

Calculation Objective:

The objective of this calculation is to examine the global stability in the longitudinal direction of the bridge abutments for the replacement of the Burnham Bridge. Multiple analyses were performed to ensure stability for slip surfaces developing behind the abutment and extending beyond the toe of slope (global analysis) for the North and South Abutment.

Calculation Methodology/List of Assumptions:

- Soil Parameters have been developed from borings performed by Schonewald Engineering Associates between March of 2016 and July of 2017.
- The stratigraphy of the following cross-section has been developed from borings BB-WGLC-102, BB-WGLC-104, BB-WGLC-201, BB-WGLC-202, BB-WGLC-203, and BB-WGLC-204.
- The groundwater was assumed to correspond to the average low water elevation and the 50 year flood event (Q50).
- Global stability analyses performed in accordance with AASHTO LRFD Bridge Design Specifications Section 11.6.2.3.
- A live load traffic surcharge of 250 psf was applied at the crest of the slope behind the approach slab in accordance with AASHTO LRFD.
- Spenser's method was used to develop the critical slip surface.
- The abutments were modeled with a unit weight of 145 pcf and cohesion of 50,000 psf. The unit weight is a composite weight of concrete and retained fill.
- The retained structural backfill fill was assumed to have a unit weight of 115 psf and a friction angle of 32º.
- Abutment piles have been designed to provide additional shear reinforcement in the longitudinal direction of the bridge alignment. To achieve a non-optimized factor of safety of 1.5 at both abutments a mobilized shear resistance of 2.75 kips per linear foot of abutment is required.
- The reported factors of safety include the contribution from 3 layers of geogrid reinforcing placed directly behind each abutment.
- Analyses results using both optimized and non-optimized slip surfaces have been reported.

References/Inputs:

SLOPE/W version 8.16.2 by GeoStudio 2016
MaineDOT Boring logs performed by Schonewald Engineering Associates
Contract Document Drawing No. 8, 9, 18, and 19

Attachments:

- Analysis at Abutment 1 (South)
- Analysis at Abutment 2 (North)

Conclusions:

Table 1: Summary of Stability Results for Proposed Bridge Abutments

Location	Loading Condition	Water Elevation	Factor of Safety	
			Optimized	Non-Optimized
North Abutment	Undrained	133.0	1.42	1.64
		139.0	1.51	1.66
	Drained	133.0	1.47	1.56
		139.0	1.46	1.53
South Abutment	Undrained	133.0	1.43	1.52
		139.0	1.59	1.67
	Drained	133.0	1.46	1.56
		139.0	1.41	1.53

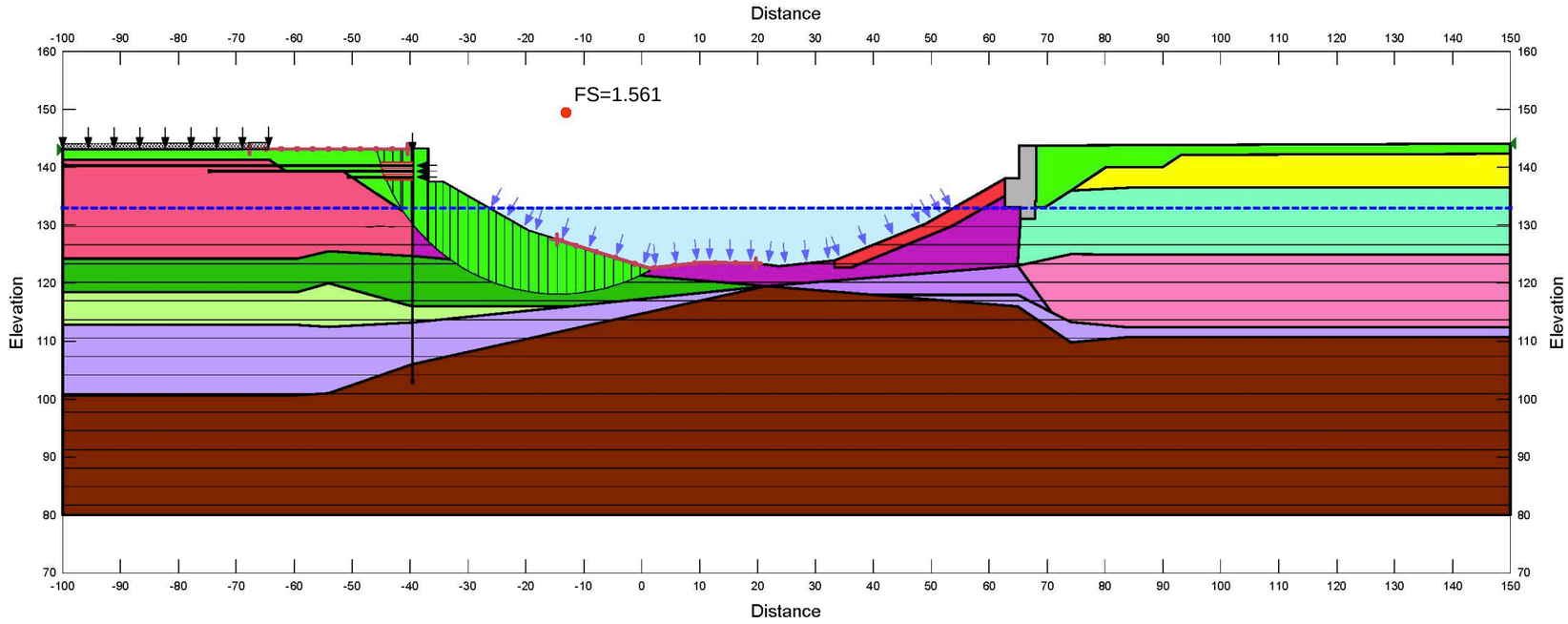
Document Check:	Name	Signature	Date
Originator:	M. Restrepo		10/16/17
Checker:	B. Materek		10/18/17
BackChecker:	M. Restrepo		11/07/17
Updater:	B. Materek		11/07/17
Verifier:	M. Restrepo		11/09/17

ABUTMENT 1 (SOUTH)

GLOBAL STABILITY ANALYSIS

WATER EL. 133 FEET

HNTB



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Abutment	Mohr-Coulomb	145	50,000	0	0	1
	Alluvium	Mohr-Coulomb	108	0	30	0	1
	Bedrock	Bedrock (Impenetrable)					1
	Fill (South)	Mohr-Coulomb	114	0	33	0	1
	Gabion Blanket	Mohr-Coulomb	130	0	45	0	1
	Glacial Till	Mohr-Coulomb	126	0	38	0	1
	Lower Fill (North)	Mohr-Coulomb	111	0	32	0	1
	Med Stiff Clay (North)	Mohr-Coulomb	113	0	30	0	1
	Organic Silt	Mohr-Coulomb	103	0	25	0	1
	Soft Clay (North)	Mohr-Coulomb	91	0	27	0	1
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	106	0	28	0	1
	Structural Fill	Mohr-Coulomb	115	0	32	0	1
	Upper Fill (North)	Mohr-Coulomb	121	0	36	0	1

HNTB

HNTB PROJECT NUMBER 63738

BURNHAM BRIDGE | DRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

SOUTH ABUTMENT

South Abutment Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Margarita Restrepo-Espinosa
Revision Number: 124
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Time: 10:53:08 AM
Tool Version: 8.16.2.14053
File Name: Burnham_Bridge_Slope_Stability_Analysis__Drained_Geogrid_133.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\Longitudinal\Drained\
Last Solved Date: 11/8/2017
Last Solved Time: 10:53:24 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

South Abutment Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Structural Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 108 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)

Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Med Stiff Clay (North)

Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

Abutment

Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 50,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-67.70133, 143.15321) ft
Left-Zone Right Coordinate: (-40.40222, 143.19818) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-14.625, 127.5) ft
Right-Zone Right Coordinate: (19.7, 123.4043) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 143.1) ft
Right Coordinate: (150, 144.1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	150	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-100	143.1

	-100	144.1
	-64.4	144.3

Reinforcements

Reinforcement 1

Type: Pile
Outside Point: (-39.6, 141.7) ft
Inside Point: (-39.6, 103) ft
Slip Surface Intersection: (-39.6, 130.25077) ft
Length: 38.7 ft
Direction: 90 °
Shear Force: 2,850 lbs
Shear Reduction Factor: 1
Pile Spacing: 1 ft
Shear Option: Parallel to Slip
Shear Force Applied: 2,850 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft

Reinforcement 2

Type: Geosynthetic
Outside Point: (-39.6, 140.36) ft
Inside Point: (-99.6, 140.36) ft
Slip Surface Intersection: (-44.983385, 140.36) ft
Length: 60 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 92 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 61.333333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 330.18092 lbs
Pullout Force per Length: 61.333333 lbs/ft
Available Length: 5.3833846 ft
Required Length: 5.3833846 ft
Governing Component: Pullout Resistance (Active Zone)

Reinforcement 3

Type: Geosynthetic
Outside Point: (-39.6, 139.36) ft
Inside Point: (-74.6, 139.36) ft
Slip Surface Intersection: (-44.672816, 139.36) ft
Length: 35 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 184 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No

Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 122.66667 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 622.26543 lbs
Pullout Force per Length: 122.66667 lbs/ft
Available Length: 5.072816 ft
Required Length: 5.072816 ft
Governing Component: Pullout Resistance (Active Zone)

Reinforcement 4

Type: Geosynthetic
Outside Point: (-39.6, 138.36) ft
Inside Point: (-50.6, 138.36) ft
Slip Surface Intersection: (-44.329001, 138.36) ft
Length: 11 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 276 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 184 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 870.13617 lbs
Pullout Force per Length: 184 lbs/ft
Available Length: 4.7290009 ft
Required Length: 4.7290009 ft
Governing Component: Pullout Resistance (Active Zone)

Points

	X (ft)	Y (ft)
Point 1	150	144.1
Point 2	150	143.8
Point 3	68.2	143.8
Point 4	65.2	143.8
Point 5	-36.8	143.2
Point 6	-39.3	143.2
Point 7	-100	143.1
Point 8	65.2	142.8
Point 9	150	142.3
Point 10	-36.8	142.2

Point 11	93.2	142.2
Point 12	-39.3	141.7
Point 13	-39.8	141.7
Point 14	-100	141.3
Point 15	-64.3	141.3
Point 16	80.1	140
Point 17	89.9	140
Point 18	84.1	140
Point 19	-61.5	139.4
Point 20	-59.4	139.4
Point 21	-54.1	139.4
Point 22	-51.7	139.4
Point 23	62.7	138.1
Point 24	65.2	138.1
Point 25	-36.8	137.5
Point 26	-34.3	137.5
Point 27	84.1	136.5
Point 28	150	136.5
Point 29	74.1	136
Point 30	62.7	135.1
Point 31	-34.3	134.5
Point 32	65.2	134.1
Point 33	65.4	134.1
Point 34	67.9	134.1
Point 35	68.2	134.1
Point 36	-39.8	133.5
Point 37	-39.6	133.5
Point 38	69.7	133.1
Point 39	62.7	133.1
Point 40	65.4	133.1
Point 41	67.9	133.1

Point 42	-37.1	132.5
Point 43	-34.3	132.5
Point 44	-39.6	132.5
Point 45	-41.3	132.5
Point 46	57.7	132.2
Point 47	57.3	132
Point 48	65.4	131.1
Point 49	67.9	131.1
Point 50	-39.6	130.5
Point 51	-37.1	130.5
Point 52	49.1	130.3
Point 53	53.6	129.9
Point 54	-19.5	129
Point 55	-23.7	128.4
Point 56	-54.1	125.5
Point 57	74.1	125
Point 58	84.1	124.9
Point 59	150	124.9
Point 60	-39.6	124.7
Point 61	-59.4	124.3
Point 62	-100	124.3
Point 63	33.3	123.9
Point 64	10.6	123.6
Point 65	19.9	123.4
Point 66	64.9	123
Point 67	23.7	122.9
Point 68	36.3	122.8
Point 69	33.3	122.8
Point 70	1.3	122.6
Point 71	57.7	122.4
Point 72	-3.2	122.1

Point 73	1.3	122.1
Point 74	-54.1	120
Point 75	21.5	119.5
Point 76	-100	118.5
Point 77	-59.4	118.5
Point 78	64.9	118
Point 79	-39.6	116
Point 80	-12.4	116
Point 81	64.9	116
Point 82	74.1	113.3
Point 83	-39.6	113.2
Point 84	-100	112.8
Point 85	-59.4	112.8
Point 86	-54.1	112.5
Point 87	150	112.4
Point 88	84.1	112.4
Point 89	150	110.7
Point 90	84.1	110.7
Point 91	74.1	109.8
Point 92	-39.6	106
Point 93	-54.1	101
Point 94	-100	100.7
Point 95	-59.4	100.7
Point 96	40.1	118
Point 97	-100	80
Point 98	150	80
Point 99	-64	141.09643
Point 100	70.8	115

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	97,98,89,90,91,81,96,75,92,93,95,94	7,559.4
Region 2	Glacial Till	89,87,88,82,100,78,96,81,91,90	188.2
Region 3	Glacial Till	94,95,93,92,75,80,83,86,85,84	909.19
Region 4	Soft to Med Stiff Clay (South)	84,85,86,83,80,79,74,77,76	379.15
Region 5	Abutment	13,12,6,5,10,25,26,31,43,42,51,50,44,37,36	48.65
Region 6	Structural Fill	14,15,99,19,20,21,22,45,44,37,36,13,12,6,7	202.41
Region 7	Organic Silt	76,77,74,79,80,75,60,56,61,62	681.76
Region 8	Fill (South)	62,61,56,60,50,44,45,22,21,20,19,99,15,14	920.14
Region 9	Abutment	48,49,41,34,35,3,4,8,24,23,30,39,40	49.3
Region 10	Soft Clay (North)	75,96,78,100,66,71	141.43
Region 11	Med Stiff Clay (North)	66,100,82,88,87,59,58,57	1,006.8
Region 12	Structural Fill	41,38,29,16,18,17,11,9,2,1,3,35,34	238.31
Region 13	Upper Fill (North)	29,27,28,9,11,17,18,16	387.58
Region 14	Lower Fill (North)	48,66,57,58,59,28,27,29,38,41,49	959.51
Region 15	Gabion Blanket	63,69,68,53,47,46,30,23,52	73.44
Region 16	Gabion Blanket	31,55,72,73,70,54,26	78.295
Region 17	Alluvium	60,75,71,66,48,40,39,30,46,47,53,68,69,63,67,65,64,70,73,72,55,31,43,42,51,50	487.25

Current Slip Surface

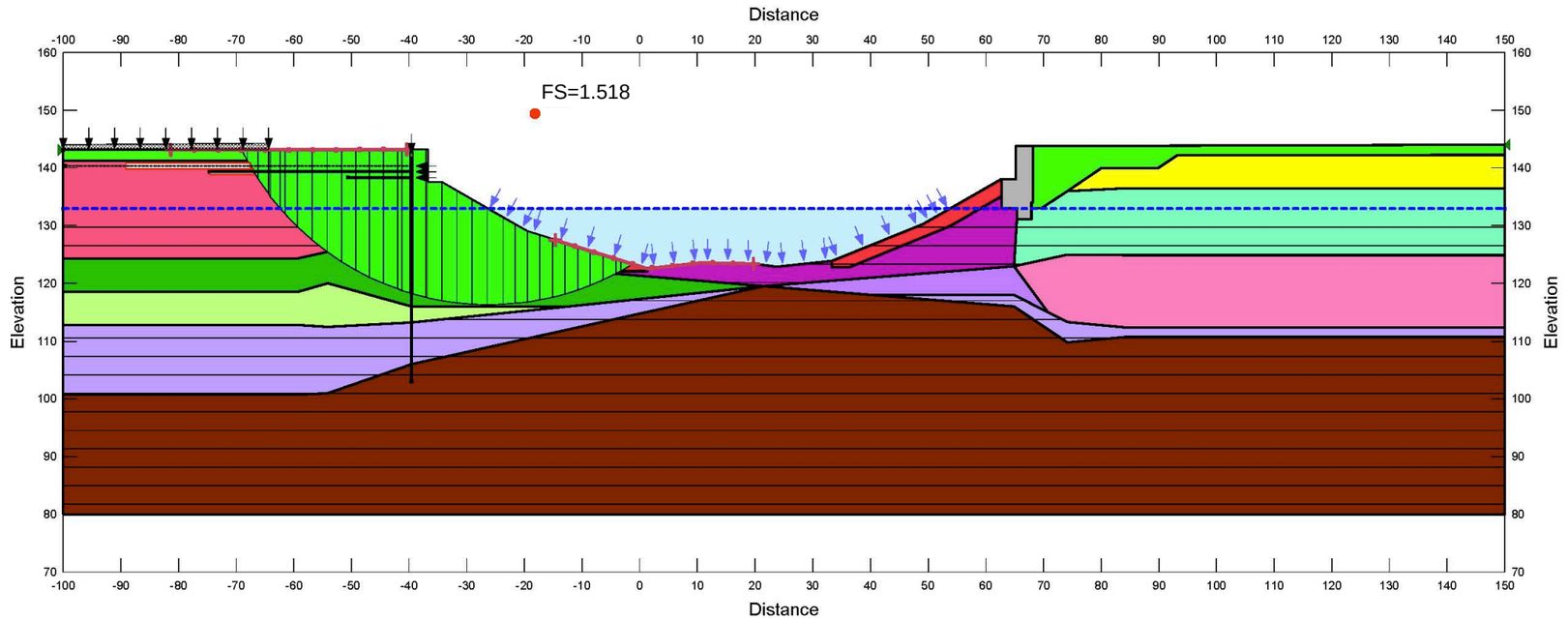
Slip Surface: 1,032
F of S: 1.561

Volume: 436.16594 ft³
Weight: 50,449.376 lbs
Resisting Moment: 483,337.24 lbs-ft
Activating Moment: 309,722.91 lbs-ft
Resisting Force: 11,726.583 lbs
Activating Force: 7,510.2603 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (2.191815, 122.69589) ft
Entry: (-45.862042, 143.18919) ft
Radius: 32.316958 ft
Center: (-14.370425, 150.44617) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-45.147314	140.88784	-0	111.33016	69.566806	0
Slice 2	-43.717858	137.02377	-0	366.62223	229.09099	0
Slice 3	-42.288403	134.23052	-0	593.51157	370.86719	0
Slice 4	-41.410062	132.75	15.6	753.94646	461.37007	0
Slice 5	-40.523224	131.5016	93.500398	866.89505	502.24836	0
Slice 6	-39.7	130.37698	163.67638	-5,646.3438	-3,773.0712	0
Slice 7	-39.45	130.06618	183.07035	1,317.9836	655.2425	0
Slice 8	-38.2	128.67745	269.72693	1,491.6706	705.48954	0
Slice 9	-36.95	127.32682	354.00658	1,640.4897	742.75134	0
Slice 10	-36.175	126.60862	398.82195	1,090.3185	399.23571	0
Slice 11	-34.925	125.52151	466.65791	1,214.4253	431.72372	0
Slice 12	-33.729239	124.57894	525.47428	1,205.4106	392.56142	0
Slice 13	-32.42596	123.65806	582.93713	1,271.4403	321.05429	0
Slice 14	-30.821987	122.64858	645.92892	1,302.9358	306.36735	0
Slice 15	-29.079074	121.68712	705.92392	1,320.9739	286.80251	0
Slice 16	-27.336162	120.85952	757.56607	1,322.899	263.61906	0
Slice 17	-25.773529	120.21689	797.66578	1,335.1713	250.64293	0
Slice 18	-24.391176	119.73068	828.0058	1,362.4827	249.23067	0
Slice 19	-23	119.31117	854.18314	1,378.8045	244.63497	0
Slice 20	-21.6	118.95644	876.31805	1,384.0661	236.76681	0
Slice 21	-20.2	118.66732	894.35908	1,382.001	227.39114	0
Slice 22	-18.685	118.42908	909.2251	1,381.7689	220.3508	0

Slice 23	-17.055	118.2513	920.31901	1,389.1752	218.63124	0
Slice 24	-15.425	118.15672	926.22061	1,387.7962	215.23621	0
Slice 25	-13.795	118.14462	926.97561	1,377.5599	210.11088	0
Slice 26	-12.165	118.21491	922.58983	1,358.3146	203.1818	0
Slice 27	-10.535	118.36812	913.02939	1,329.8218	194.35348	0
Slice 28	-8.905	118.60546	898.2194	1,291.7441	183.50357	0
Slice 29	-7.275	118.92883	878.04093	1,243.6279	170.47601	0
Slice 30	-5.645	119.34093	852.32607	1,184.8775	155.07128	0
Slice 31	-4.015	119.84535	820.85046	1,114.7169	137.03217	0
Slice 32	-2.4740094	120.40867	785.69873	1,031.4798	114.6096	0
Slice 33	-1.0220283	121.02559	747.20299	935.09237	87.614258	0
Slice 34	0.42692731	121.72749	703.40456	829.86628	73.01271	0
Slice 35	1.2249462	122.14135	677.57957	781.69083	104.11126	0
Slice 36	1.7459075	122.4393	658.98767	692.76003	19.498479	0



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
	Abutment	Mohr-Coulomb	145	50,000	0	0				
	Alluvium	Mohr-Coulomb	108	0	30	0	1			
	Bedrock	Bedrock (Impenetrable)					1			
	Fill (South)	Mohr-Coulomb	114	0	33	0	1			
	Gabion Blanket	Mohr-Coulomb	130	0	45	0	1			
	Glacial Till	Mohr-Coulomb	126	0	38	0	1			
	Lower Fill (North)	Mohr-Coulomb	111	0	32	0	1			
	Med Stiff Clay (North)	Mohr-Coulomb	113	642	0	0				
	Organic Silt	S=f(depth)	103					320	8	1,000
	Soft Clay (North)	Mohr-Coulomb	91	350	0	0				
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	106	506	0	0				
	Structural Fill	Mohr-Coulomb	115	0	32	0	1			
	Upper Fill (North)	Mohr-Coulomb	121	0	36	0	1			

HNTB

HNTB PROJECT NUMBER 63738

BURNHAM BRIDGE | UNDRAINED

PREPARED BY: MRR | CHECKED BY: BAM | BACK CHECKED BY: MRR

DATE: 10/16/2017 | DATE: 10/18/2017 | DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

SOUTH ABUTMENT

South Abutment Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Margarita Restrepo-Espinosa
Revision Number: 110
Date: 11/8/2017
Time: 11:54:19 AM
Tool Version: 8.16.2.14053
File Name: Burnham_Bridge_Slope_Stability_Analysis__Undrained_Geogrid_133.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\Longitudinal\Undrained\
Last Solved Date: 11/8/2017
Last Solved Time: 11:54:28 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

South Abutment Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Structural Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 108 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)
Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 350 psf
Phi': 0 °
Phi-B: 0 °

Med Stiff Clay (North)
Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 642 psf
Phi': 0 °
Phi-B: 0 °

Glacial Till
Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)
Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt
Model: S=f(depth)
Unit Weight: 103 pcf
C-Top of Layer: 320 psf
C-Rate of Change: 8 (lbs/ft^2)/ft
C-Maximum: 1,000 psf

Soft to Med Stiff Clay (South)
Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 506 psf
Phi': 0 °
Phi-B: 0 °

Abutment
Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 50,000 psf
Phi': 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-81.3, 143.13081) ft
Left-Zone Right Coordinate: (-40.40222, 143.19818) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-14.625, 127.5) ft
Right-Zone Right Coordinate: (19.7, 123.4043) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 143.1) ft
Right Coordinate: (150, 144.1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	150	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-100	143.1
	-100	144.1
	-64.4	144.3

Reinforcements

Reinforcement 1

Type: Pile
Outside Point: (-39.6, 141.7) ft
Inside Point: (-39.6, 103) ft
Slip Surface Intersection: (-39.6, 118.28351) ft

Length: 38.7 ft
Direction: 90 °
Shear Force: 2,850 lbs
Shear Reduction Factor: 1
Pile Spacing: 1 ft
Shear Option: Parallel to Slip
Shear Force Applied: 2,850 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft

Reinforcement 2

Type: Geosynthetic
Outside Point: (-39.6, 140.36) ft
Inside Point: (-99.6, 140.36) ft
Slip Surface Intersection: (-67.519933, 140.36) ft
Length: 60 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 92 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 61.333333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 1,324 lbs
Pullout Force per Length: 61.333333 lbs/ft
Available Length: 27.919933 ft
Required Length: 21.586957 ft
Governing Component: Tensile Capacity

Reinforcement 3

Type: Geosynthetic
Outside Point: (-39.6, 139.36) ft
Inside Point: (-74.6, 139.36) ft
Slip Surface Intersection: (-66.927006, 139.36) ft
Length: 35 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 184 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 122.66667 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 941.22057 lbs
Pullout Force per Length: 122.66667 lbs/ft
Available Length: 7.6729938 ft
Required Length: 7.6729938 ft
Governing Component: Pullout Resistance

Reinforcement 4

Type: Geosynthetic

Outside Point: (-39.6, 138.36) ft
Inside Point: (-50.6, 138.36) ft
Slip Surface Intersection: () ft
Length: 11 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 276 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 184 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	150	144.1
Point 2	150	143.8
Point 3	68.2	143.8
Point 4	65.2	143.8
Point 5	-36.8	143.2
Point 6	-39.3	143.2
Point 7	-100	143.1
Point 8	65.2	142.8
Point 9	150	142.3
Point 10	-36.8	142.2
Point 11	93.2	142.2
Point 12	-39.3	141.7
Point 13	-39.8	141.7
Point 14	-100	141.3
Point 15	-64.3	141.3
Point 16	80.1	140
Point 17	89.9	140

Point 18	84.1	140
Point 19	-61.5	139.4
Point 20	-59.4	139.4
Point 21	-54.1	139.4
Point 22	-51.7	139.4
Point 23	62.7	138.1
Point 24	65.2	138.1
Point 25	-36.8	137.5
Point 26	-34.3	137.5
Point 27	84.1	136.5
Point 28	150	136.5
Point 29	74.1	136
Point 30	62.7	135.1
Point 31	-34.3	134.5
Point 32	65.2	134.1
Point 33	65.4	134.1
Point 34	67.9	134.1
Point 35	68.2	134.1
Point 36	-39.8	133.5
Point 37	-39.6	133.5
Point 38	69.7	133.1
Point 39	62.7	133.1
Point 40	65.4	133.1
Point 41	67.9	133.1
Point 42	-37.1	132.5
Point 43	-34.3	132.5
Point 44	-39.6	132.5
Point 45	-41.3	132.5
Point 46	57.7	132.2
Point 47	57.3	132
Point 48	65.4	131.1

Point 49	67.9	131.1
Point 50	-39.6	130.5
Point 51	-37.1	130.5
Point 52	49.1	130.3
Point 53	53.6	129.9
Point 54	-19.5	129
Point 55	-23.7	128.4
Point 56	-54.1	125.5
Point 57	74.1	125
Point 58	84.1	124.9
Point 59	150	124.9
Point 60	-39.6	124.7
Point 61	-59.4	124.3
Point 62	-100	124.3
Point 63	33.3	123.9
Point 64	10.6	123.6
Point 65	19.9	123.4
Point 66	64.9	123
Point 67	23.7	122.9
Point 68	36.3	122.8
Point 69	33.3	122.8
Point 70	1.3	122.6
Point 71	57.7	122.4
Point 72	-3.2	122.1
Point 73	1.3	122.1
Point 74	-54.1	120
Point 75	21.5	119.5
Point 76	-100	118.5
Point 77	-59.4	118.5
Point 78	64.9	118
Point 79	-39.6	116

Point 80	-12.4	116
Point 81	64.9	116
Point 82	74.1	113.3
Point 83	-39.6	113.2
Point 84	-100	112.8
Point 85	-59.4	112.8
Point 86	-54.1	112.5
Point 87	150	112.4
Point 88	84.1	112.4
Point 89	150	110.7
Point 90	84.1	110.7
Point 91	74.1	109.8
Point 92	-39.6	106
Point 93	-54.1	101
Point 94	-100	100.7
Point 95	-59.4	100.7
Point 96	40.1	118
Point 97	-100	80
Point 98	150	80
Point 99	-64	141.09643
Point 100	70.8	115

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	97,98,89,90,91,81,96,75,92,93,95,94	7,559.4
Region 2	Glacial Till	89,87,88,82,100,78,96,81,91,90	188.2
Region 3	Glacial Till	94,95,93,92,75,80,83,86,85,84	909.19
Region 4	Soft to Med Stiff Clay (South)	84,85,86,83,80,79,74,77,76	379.15
Region 5	Abutment	13,12,6,5,10,25,26,31,43,42,51,50,44,37,36	48.65
Region 6	Structural Fill	14,15,99,19,20,21,22,45,44,37,36,13,12,6,7	202.41

Region 7	Organic Silt	76,77,74,79,80,75,60,56,61,62	681.76
Region 8	Fill (South)	62,61,56,60,50,44,45,22,21,20,19,99,15,14	920.14
Region 9	Abutment	48,49,41,34,35,3,4,8,24,23,30,39,40	49.3
Region 10	Soft Clay (North)	75,96,78,100,66,71	141.43
Region 11	Med Stiff Clay (North)	66,100,82,88,87,59,58,57	1,006.8
Region 12	Structural Fill	41,38,29,16,18,17,11,9,2,1,3,35,34	238.31
Region 13	Upper Fill (North)	29,27,28,9,11,17,18,16	387.58
Region 14	Lower Fill (North)	48,66,57,58,59,28,27,29,38,41,49	959.51
Region 15	Gabion Blanket	63,69,68,53,47,46,30,23,52	73.44
Region 16	Gabion Blanket	31,55,72,73,70,54,26	78.295
Region 17	Alluvium	60,75,71,66,48,40,39,30,46,47,53,68,69,63,67,65,64,70,73,72,55,31,43,42,51,50	487.25

Current Slip Surface

Slip Surface: 414
F of S: 1.518
Volume: 964.13761 ft³
Weight: 108,959.23 lbs
Resisting Moment: 1,439,907.9 lbs-ft
Activating Moment: 948,649.05 lbs-ft
Resisting Force: 25,756.879 lbs
Activating Force: 16,970.795 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (-1.1991668, 123.36897) ft
Entry: (-69.030666, 143.15102) ft
Radius: 47.73481 ft
Center: (-26.127413, 164.07763) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-68.553975	142.22551	-0	197.7494	123.56754	0
Slice 2	-67.157963	139.74952	-0	366.19602	237.81048	0
Slice 3	-65.319321	136.87456	-0	585.49753	380.22654	0

Slice 4	-64.35	135.48324	-0	597.56629	388.06409	0
Slice 5	-64.15	135.21878	-0	571.34591	371.03637	0
Slice 6	-63.179949	134.01057	-0	653.16901	424.17292	0
Slice 7	-61.929949	132.51234	30.430275	798.09948	498.53021	0
Slice 8	-60.45	130.93722	128.71775	965.07445	543.13639	0
Slice 9	-58.101905	128.67729	269.73726	1,219.8218	616.99209	0
Slice 10	-55.505714	126.49022	406.21001	1,478.1628	696.13428	0
Slice 11	-52.95381	124.62313	0	1,857.7708	0	326.48532
Slice 12	-50.494203	123.05441	0	2,042.3437	0	337.97321
Slice 13	-48.082609	121.71329	0	2,205.6348	0	347.6377
Slice 14	-45.671014	120.54703	0	2,352.4639	0	355.90334
Slice 15	-43.25942	119.54183	0	2,483.9507	0	362.88054
Slice 16	-41.676812	118.94816	0	2,574.5336	0	366.93142
Slice 17	-40.55	118.58057	0	2,617.995	0	369.37472
Slice 18	-39.7	118.31317	0	416.87782	0	371.13881
Slice 19	-39.45	118.23991	0	2,991.0504	0	371.57858
Slice 20	-38.2	117.90868	0	3,050.7654	0	373.37738
Slice 21	-36.95	117.58613	0	3,060.9327	0	375.10674
Slice 22	-35.55	117.29942	0	2,259.515	0	376.4472
Slice 23	-32.996721	116.85803	0	2,135.3692	0	378.23988
Slice 24	-30.386258	116.5513	0	2,033.7273	0	378.9164
Slice 25	-27.77189	116.38909	0	1,915.4786	0	378.43412
Slice 26	-25.082353	116.3743	0	1,829.079	0	376.72128
Slice 27	-22.65	116.48129	0	1,776.4424	0	374.20923
Slice 28	-20.55	116.68157	0	1,712.081	0	371.17725
Slice 29	-18.405947	116.98451	0	1,646.5677	0	367.29393
Slice 30	-16.217842	117.39614	0	1,593.6664	0	362.51112
Slice 31	-14.029737	117.9151	0	1,528.9133	0	356.86966
Slice 32	-11.841632	118.54507	0	1,451.7489	0	350.34011
Slice 33	-9.6535269	119.29075	0	1,361.4713	0	342.88488
Slice 34	-7.4654217	120.15805	0	1,257.2021	0	334.4567

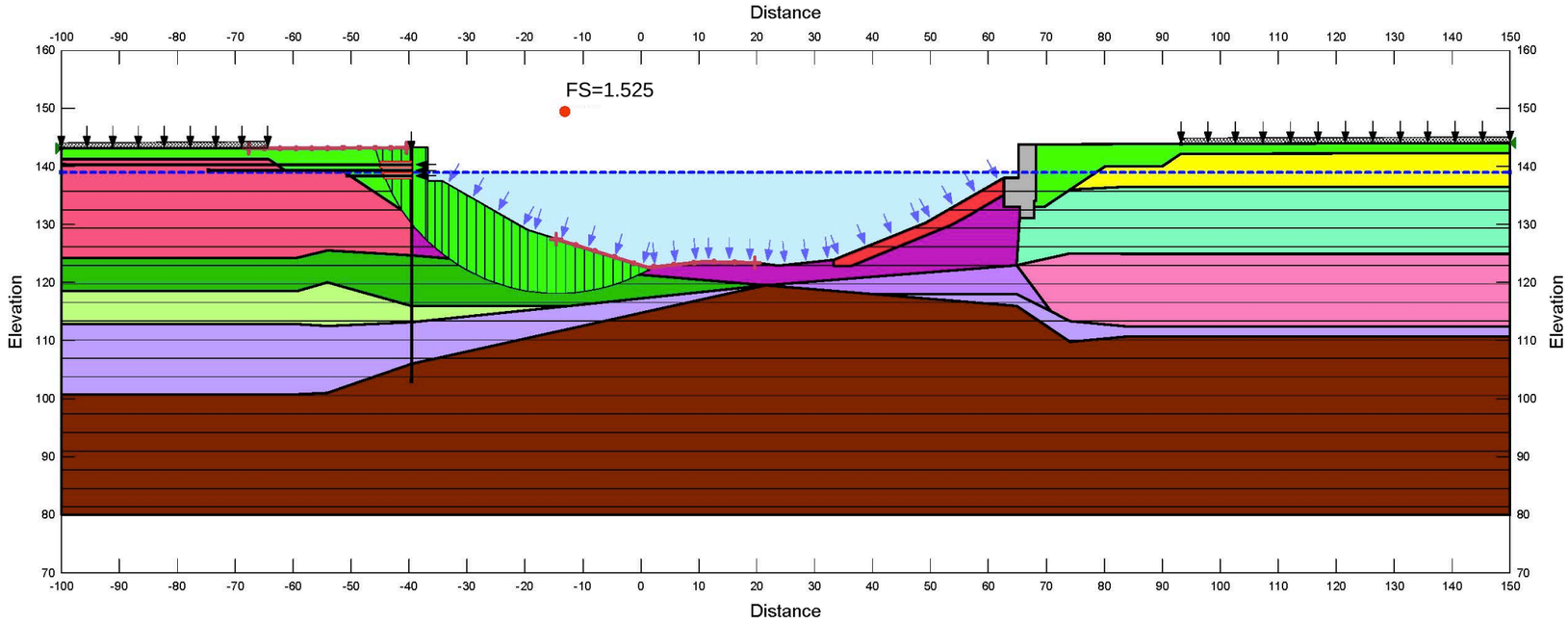
Slice 35	-5.2773166	121.15437	0	1,137.8384	0	324.9964
Slice 36	-3.7557832	121.91262	691.85254	977.57589	164.96245	0
Slice 37	-2.2637346	122.7542	639.3378	888.13859	248.80079	0

ABUTMENT 1 (SOUTH)

GLOBAL STABILITY ANALYSIS

WATER EL. 139 FEET

HNTB



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Abutment	Mohr-Coulomb	145	50,000	0	0	1
	Alluvium	Mohr-Coulomb	108	0	30	0	1
	Bedrock	Bedrock (Impenetrable)					1
	Fill (South)	Mohr-Coulomb	114	0	33	0	1
	Gabion Blanket	Mohr-Coulomb	130	0	45	0	1
	Glacial Till	Mohr-Coulomb	126	0	38	0	1
	Lower Fill (North)	Mohr-Coulomb	111	0	32	0	1
	Med Stiff Clay (North)	Mohr-Coulomb	113	0	30	0	1
	Organic Silt	Mohr-Coulomb	103	0	25	0	1
	Soft Clay (North)	Mohr-Coulomb	91	0	27	0	1
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	106	0	28	0	1
	Structural Fill	Mohr-Coulomb	115	0	32	0	1
	Upper Fill (North)	Mohr-Coulomb	121	0	36	0	1

HNTB

HNTB PROJECT NUMBER 63738

BURNHAM BRIDGE | DRAINED

PREPARED BY: MRR | CHECKED BY: BAM | BACK CHECKED BY: MRR

DATE: 10/16/2017 | DATE: 10/18/2017 | DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

SOUTH ABUTMENT

South Abutment Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Margarita Restrepo-Espinosa
Revision Number: 128
Date: 11/8/2017
Time: 11:09:04 AM
Tool Version: 8.16.2.14053
File Name: Burnham_Bridge_Slope_Stability_Analysis__Drained_Geogrid_139.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\Longitudinal\Drained\
Last Solved Date: 11/8/2017
Last Solved Time: 11:09:15 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

South Abutment Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Structural Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 108 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)

Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Med Stiff Clay (North)

Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

Abutment

Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 50,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-67.70133, 143.15321) ft
Left-Zone Right Coordinate: (-40.40222, 143.19818) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-14.625, 127.5) ft
Right-Zone Right Coordinate: (19.7, 123.4043) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 143.1) ft
Right Coordinate: (150, 144.1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	150	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-100	143.1

	-100	144.1
	-64.4	144.3

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	93.2	143.9
	93.2	144.9
	150	145.1

Reinforcements

Reinforcement 1

Type: Pile
Outside Point: (-39.6, 141.7) ft
Inside Point: (-39.6, 103) ft
Slip Surface Intersection: (-39.6, 130.25077) ft
Length: 38.7 ft
Direction: 90 °
Shear Force: 600 lbs
Shear Reduction Factor: 1
Pile Spacing: 1 ft
Shear Option: Parallel to Slip
Shear Force Applied: 600 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft

Reinforcement 2

Type: Geosynthetic
Outside Point: (-39.6, 140.36) ft
Inside Point: (-99.6, 140.36) ft
Slip Surface Intersection: (-45.004618, 140.36) ft
Length: 60 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 92 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 61.333333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 331.48323 lbs
Pullout Force per Length: 61.333333 lbs/ft
Available Length: 5.4046178 ft
Required Length: 5.4046178 ft

Governing Component: Pullout Resistance (Active Zone)

Reinforcement 3

Type: Geosynthetic
Outside Point: (-39.6, 139.36) ft
Inside Point: (-74.6, 139.36) ft
Slip Surface Intersection: (-44.701554, 139.36) ft
Length: 35 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 184 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 122.66667 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 625.79066 lbs
Pullout Force per Length: 122.66667 lbs/ft
Available Length: 5.1015543 ft
Required Length: 5.1015543 ft
Governing Component: Pullout Resistance (Active Zone)

Reinforcement 4

Type: Geosynthetic
Outside Point: (-39.6, 138.36) ft
Inside Point: (-50.6, 138.36) ft
Slip Surface Intersection: (-44.302893, 138.36) ft
Length: 11 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 276 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 184 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 865.33224 lbs
Pullout Force per Length: 184 lbs/ft
Available Length: 4.7028926 ft
Required Length: 4.7028926 ft
Governing Component: Pullout Resistance (Active Zone)

Points

	X (ft)	Y (ft)
Point 1	150	144.1
Point 2	150	143.8
Point 3	68.2	143.8

Point 4	65.2	143.8
Point 5	-36.8	143.2
Point 6	-39.3	143.2
Point 7	-100	143.1
Point 8	65.2	142.8
Point 9	150	142.3
Point 10	-36.8	142.2
Point 11	93.2	142.2
Point 12	-39.3	141.7
Point 13	-39.8	141.7
Point 14	-100	141.3
Point 15	-64.3	141.3
Point 16	80.1	140
Point 17	89.9	140
Point 18	84.1	140
Point 19	-61.5	139.4
Point 20	-59.4	139.4
Point 21	-54.1	139.4
Point 22	-51.7	139.4
Point 23	62.7	138.1
Point 24	65.2	138.1
Point 25	-36.8	137.5
Point 26	-34.3	137.5
Point 27	84.1	136.5
Point 28	150	136.5
Point 29	74.1	136
Point 30	62.7	135.1
Point 31	-34.3	134.5
Point 32	65.2	134.1
Point 33	65.4	134.1
Point 34	67.9	134.1

Point 35	68.2	134.1
Point 36	-39.8	133.5
Point 37	-39.6	133.5
Point 38	69.7	133.1
Point 39	62.7	133.1
Point 40	65.4	133.1
Point 41	67.9	133.1
Point 42	-37.1	132.5
Point 43	-34.3	132.5
Point 44	-39.6	132.5
Point 45	-41.3	132.5
Point 46	57.7	132.2
Point 47	57.3	132
Point 48	65.4	131.1
Point 49	67.9	131.1
Point 50	-39.6	130.5
Point 51	-37.1	130.5
Point 52	49.1	130.3
Point 53	53.6	129.9
Point 54	-19.5	129
Point 55	-23.7	128.4
Point 56	-54.1	125.5
Point 57	74.1	125
Point 58	84.1	124.9
Point 59	150	124.9
Point 60	-39.6	124.7
Point 61	-59.4	124.3
Point 62	-100	124.3
Point 63	33.3	123.9
Point 64	10.6	123.6
Point 65	19.9	123.4

Point 66	64.9	123
Point 67	23.7	122.9
Point 68	36.3	122.8
Point 69	33.3	122.8
Point 70	1.3	122.6
Point 71	57.7	122.4
Point 72	-3.2	122.1
Point 73	1.3	122.1
Point 74	-54.1	120
Point 75	21.5	119.5
Point 76	-100	118.5
Point 77	-59.4	118.5
Point 78	64.9	118
Point 79	-39.6	116
Point 80	-12.4	116
Point 81	64.9	116
Point 82	74.1	113.3
Point 83	-39.6	113.2
Point 84	-100	112.8
Point 85	-59.4	112.8
Point 86	-54.1	112.5
Point 87	150	112.4
Point 88	84.1	112.4
Point 89	150	110.7
Point 90	84.1	110.7
Point 91	74.1	109.8
Point 92	-39.6	106
Point 93	-54.1	101
Point 94	-100	100.7
Point 95	-59.4	100.7
Point 96	40.1	118

Point 97	-100	80
Point 98	150	80
Point 99	-64	141.09643
Point 100	70.8	115

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	97,98,89,90,91,81,96,75,92,93,95,94	7,559.4
Region 2	Glacial Till	89,87,88,82,100,78,96,81,91,90	188.2
Region 3	Glacial Till	94,95,93,92,75,80,83,86,85,84	909.19
Region 4	Soft to Med Stiff Clay (South)	84,85,86,83,80,79,74,77,76	379.15
Region 5	Abutment	13,12,6,5,10,25,26,31,43,42,51,50,44,37,36	48.65
Region 6	Structural Fill	14,15,99,19,20,21,22,45,44,37,36,13,12,6,7	202.41
Region 7	Organic Silt	76,77,74,79,80,75,60,56,61,62	681.76
Region 8	Fill (South)	62,61,56,60,50,44,45,22,21,20,19,99,15,14	920.14
Region 9	Abutment	48,49,41,34,35,3,4,8,24,23,30,39,40	49.3
Region 10	Soft Clay (North)	75,96,78,100,66,71	141.43
Region 11	Med Stiff Clay (North)	66,100,82,88,87,59,58,57	1,006.8
Region 12	Structural Fill	41,38,29,16,18,17,11,9,2,1,3,35,34	238.31
Region 13	Upper Fill (North)	29,27,28,9,11,17,18,16	387.58
Region 14	Lower Fill (North)	48,66,57,58,59,28,27,29,38,41,49	959.51
Region 15	Gabion Blanket	63,69,68,53,47,46,30,23,52	73.44

Region 16	Gabion Blanket	31,55,72,73,70,54,26	78.295
Region 17	Alluvium	60,75,71,66,48,40,39,30,46,47,53,68,69,63,67,65,64,70,73,72,55,31,43,42,51,50	487.25

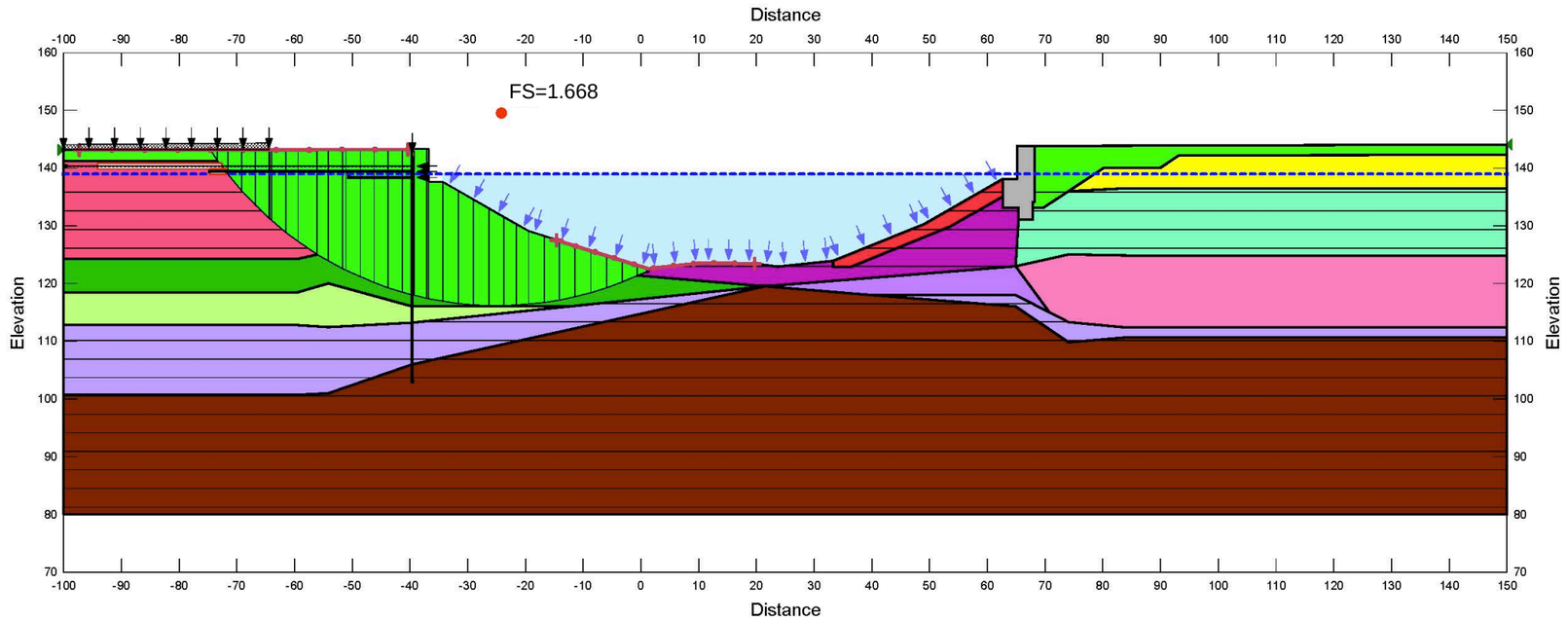
Current Slip Surface

Slip Surface: 1,032
F of S: 1.525
Volume: 436.14453 ft³
Weight: 50,446.873 lbs
Resisting Moment: 437,282.74 lbs-ft
Activating Moment: 286,761.77 lbs-ft
Resisting Force: 10,742.539 lbs
Activating Force: 7,040.5862 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (2.191815, 122.69589) ft
Entry: (-45.862042, 143.18919) ft
Radius: 32.316958 ft
Center: (-14.370425, 150.44617) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-45.227247	141.09459	-0	100.11199	62.556916	0
Slice 2	-43.755951	137.15112	115.37035	407.88059	182.78069	0
Slice 3	-42.082949	133.90112	318.17035	743.68843	265.89321	0
Slice 4	-40.523224	131.5016	467.9004	997.6941	344.05205	0
Slice 5	-39.7	130.37698	538.07638	-136.19497	-437.87694	0
Slice 6	-39.45	130.06618	557.47035	1,427.8129	502.49251	0
Slice 7	-38.2	128.67745	644.12693	1,596.4852	549.84433	0
Slice 8	-36.95	127.32682	728.40658	1,739.555	583.78681	0
Slice 9	-36.175	126.60862	773.22195	1,252.0214	276.43497	0
Slice 10	-34.925	125.52151	841.05791	1,371.0692	306.00214	0
Slice 11	-33.729239	124.57894	899.87428	1,375.318	274.49755	0
Slice 12	-32.370272	123.62286	959.53369	1,472.0288	238.9804	0
Slice 13	-30.793859	122.62857	1,021.5769	1,548.2018	245.56924	0
Slice 14	-29.217446	121.75534	1,076.067	1,612.2278	250.0159	0
Slice 15	-27.641033	120.99232	1,123.6791	1,665.0406	252.441	0
Slice 16	-26.06462	120.33112	1,164.9383	1,707.3582	252.93457	0

Slice 17	-24.488207	119.76511	1,200.2569	1,739.733	251.56184	0
Slice 18	-23	119.31117	1,228.5831	1,757.9707	246.85747	0
Slice 19	-21.6	118.95644	1,250.718	1,763.1822	238.96597	0
Slice 20	-20.2	118.66732	1,268.7591	1,761.0435	229.556	0
Slice 21	-18.685	118.42908	1,283.6251	1,757.8541	221.13662	0
Slice 22	-17.055	118.2513	1,294.719	1,765.2931	219.4323	0
Slice 23	-15.425	118.15672	1,300.6206	1,763.9439	216.05122	0
Slice 24	-13.795	118.14462	1,301.3756	1,753.7478	210.9446	0
Slice 25	-12.165	118.21491	1,296.9898	1,734.5668	204.04549	0
Slice 26	-10.535	118.36812	1,287.4294	1,706.178	195.26569	0
Slice 27	-8.905	118.60546	1,272.6194	1,668.2623	184.49129	0
Slice 28	-7.275	118.92883	1,252.4409	1,620.3876	171.57636	0
Slice 29	-5.645	119.34093	1,226.7261	1,561.9853	156.33391	0
Slice 30	-4.015	119.84535	1,195.2505	1,492.3135	138.52277	0
Slice 31	-2.4740094	120.40867	1,160.0987	1,409.7406	116.40991	0
Slice 32	-1.0220283	121.02559	1,121.603	1,314.2244	89.820829	0
Slice 33	0.42692731	121.72749	1,077.8046	1,210.435	76.574192	0
Slice 34	1.2249462	122.14135	1,051.9796	1,164.9787	112.99913	0
Slice 35	1.7459075	122.4393	1,033.3877	1,071.1592	21.807377	0



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
	Abutment	Mohr-Coulomb	145	50,000	0	0				
	Alluvium	Mohr-Coulomb	108	0	30	0	1			
	Bedrock	Bedrock (Impenetrable)					1			
	Fill (South)	Mohr-Coulomb	114	0	33	0	1			
	Gabion Blanket	Mohr-Coulomb	130	0	45	0	1			
	Glacial Till	Mohr-Coulomb	126	0	38	0	1			
	Lower Fill (North)	Mohr-Coulomb	111	0	32	0	1			
	Med Stiff Clay (North)	Mohr-Coulomb	113	642	0	0				
	Organic Silt	S=f(depth)	103					320	8	1,000
	Soft Clay (North)	Mohr-Coulomb	91	350	0	0				
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	106	506	0	0				
	Structural Fill	Mohr-Coulomb	115	0	32	0	1			
	Upper Fill (North)	Mohr-Coulomb	121	0	36	0	1			

HNTB

HNTB PROJECT NUMBER 63738

BURNHAM BRIDGE | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

SOUTH ABUTMENT

South Abutment Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Margarita Restrepo-Espinosa
Revision Number: 113
Date: 11/8/2017
Time: 12:10:48 PM
Tool Version: 8.16.2.14053
File Name: Burnham_Bridge_Slope_Stability_Analysis__Undrained_Geogrid_139.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\Longitudinal\Undrained\
Last Solved Date: 11/8/2017
Last Solved Time: 12:10:56 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

South Abutment Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Structural Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 108 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)
Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 350 psf
Phi': 0 °
Phi-B: 0 °

Med Stiff Clay (North)
Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 642 psf
Phi': 0 °
Phi-B: 0 °

Glacial Till
Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)
Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt
Model: S=f(depth)
Unit Weight: 103 pcf
C-Top of Layer: 320 psf
C-Rate of Change: 8 (lbs/ft^2)/ft
C-Maximum: 1,000 psf

Soft to Med Stiff Clay (South)
Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 506 psf
Phi': 0 °
Phi-B: 0 °

Abutment
Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 50,000 psf
Phi': 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-97.3, 143.10445) ft
Left-Zone Right Coordinate: (-40.40222, 143.19818) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-14.625, 127.5) ft
Right-Zone Right Coordinate: (19.7, 123.4043) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 143.1) ft
Right Coordinate: (150, 144.1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	150	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-100	143.1
	-100	144.1
	-64.4	144.3

Reinforcements

Reinforcement 1

Type: Pile
Outside Point: (-39.6, 141.7) ft
Inside Point: (-39.6, 103) ft
Slip Surface Intersection: (-39.6, 118.04642) ft

Length: 38.7 ft
Direction: 90 °
Shear Force: 600 lbs
Shear Reduction Factor: 1
Pile Spacing: 1 ft
Shear Option: Parallel to Slip
Shear Force Applied: 600 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft

Reinforcement 2

Type: Geosynthetic
Outside Point: (-39.6, 140.36) ft
Inside Point: (-99.6, 140.36) ft
Slip Surface Intersection: (-72.595331, 140.36) ft
Length: 60 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 92 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 61.333333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 1,324 lbs
Pullout Force per Length: 61.333333 lbs/ft
Available Length: 27.004669 ft
Required Length: 21.586957 ft
Governing Component: Tensile Capacity

Reinforcement 3

Type: Geosynthetic
Outside Point: (-39.6, 139.36) ft
Inside Point: (-74.6, 139.36) ft
Slip Surface Intersection: (-71.853253, 139.36) ft
Length: 35 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 184 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 122.66667 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 336.93428 lbs
Pullout Force per Length: 122.66667 lbs/ft
Available Length: 2.7467469 ft
Required Length: 2.7467469 ft
Governing Component: Pullout Resistance

Reinforcement 4

Type: Geosynthetic

Outside Point: (-39.6, 138.36) ft
Inside Point: (-50.6, 138.36) ft
Slip Surface Intersection: () ft
Length: 11 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 276 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 184 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	150	144.1
Point 2	150	143.8
Point 3	68.2	143.8
Point 4	65.2	143.8
Point 5	-36.8	143.2
Point 6	-39.3	143.2
Point 7	-100	143.1
Point 8	65.2	142.8
Point 9	150	142.3
Point 10	-36.8	142.2
Point 11	93.2	142.2
Point 12	-39.3	141.7
Point 13	-39.8	141.7
Point 14	-100	141.3
Point 15	-64.3	141.3
Point 16	80.1	140
Point 17	89.9	140

Point 18	84.1	140
Point 19	-61.5	139.4
Point 20	-59.4	139.4
Point 21	-54.1	139.4
Point 22	-51.7	139.4
Point 23	62.7	138.1
Point 24	65.2	138.1
Point 25	-36.8	137.5
Point 26	-34.3	137.5
Point 27	84.1	136.5
Point 28	150	136.5
Point 29	74.1	136
Point 30	62.7	135.1
Point 31	-34.3	134.5
Point 32	65.2	134.1
Point 33	65.4	134.1
Point 34	67.9	134.1
Point 35	68.2	134.1
Point 36	-39.8	133.5
Point 37	-39.6	133.5
Point 38	69.7	133.1
Point 39	62.7	133.1
Point 40	65.4	133.1
Point 41	67.9	133.1
Point 42	-37.1	132.5
Point 43	-34.3	132.5
Point 44	-39.6	132.5
Point 45	-41.3	132.5
Point 46	57.7	132.2
Point 47	57.3	132
Point 48	65.4	131.1

Point 49	67.9	131.1
Point 50	-39.6	130.5
Point 51	-37.1	130.5
Point 52	49.1	130.3
Point 53	53.6	129.9
Point 54	-19.5	129
Point 55	-23.7	128.4
Point 56	-54.1	125.5
Point 57	74.1	125
Point 58	84.1	124.9
Point 59	150	124.9
Point 60	-39.6	124.7
Point 61	-59.4	124.3
Point 62	-100	124.3
Point 63	33.3	123.9
Point 64	10.6	123.6
Point 65	19.9	123.4
Point 66	64.9	123
Point 67	23.7	122.9
Point 68	36.3	122.8
Point 69	33.3	122.8
Point 70	1.3	122.6
Point 71	57.7	122.4
Point 72	-3.2	122.1
Point 73	1.3	122.1
Point 74	-54.1	120
Point 75	21.5	119.5
Point 76	-100	118.5
Point 77	-59.4	118.5
Point 78	64.9	118
Point 79	-39.6	116

Point 80	-12.4	116
Point 81	64.9	116
Point 82	74.1	113.3
Point 83	-39.6	113.2
Point 84	-100	112.8
Point 85	-59.4	112.8
Point 86	-54.1	112.5
Point 87	150	112.4
Point 88	84.1	112.4
Point 89	150	110.7
Point 90	84.1	110.7
Point 91	74.1	109.8
Point 92	-39.6	106
Point 93	-54.1	101
Point 94	-100	100.7
Point 95	-59.4	100.7
Point 96	40.1	118
Point 97	-100	80
Point 98	150	80
Point 99	-64	141.09643
Point 100	70.8	115

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	97,98,89,90,91,81,96,75,92,93,95,94	7,559.4
Region 2	Glacial Till	89,87,88,82,100,78,96,81,91,90	188.2
Region 3	Glacial Till	94,95,93,92,75,80,83,86,85,84	909.19
Region 4	Soft to Med Stiff Clay (South)	84,85,86,83,80,79,74,77,76	379.15
Region 5	Abutment	13,12,6,5,10,25,26,31,43,42,51,50,44,37,36	48.65

Region 6	Structural Fill	14,15,99,19,20,21,22,45,44,37,36,13,12,6,7	202.41
Region 7	Organic Silt	76,77,74,79,80,75,60,56,61,62	681.76
Region 8	Fill (South)	62,61,56,60,50,44,45,22,21,20,19,99,15,14	920.14
Region 9	Abutment	48,49,41,34,35,3,4,8,24,23,30,39,40	49.3
Region 10	Soft Clay (North)	75,96,78,100,66,71	141.43
Region 11	Med Stiff Clay (North)	66,100,82,88,87,59,58,57	1,006.8
Region 12	Structural Fill	41,38,29,16,18,17,11,9,2,1,3,35,34	238.31
Region 13	Upper Fill (North)	29,27,28,9,11,17,18,16	387.58
Region 14	Lower Fill (North)	48,66,57,58,59,28,27,29,38,41,49	959.51
Region 15	Gabion Blanket	63,69,68,53,47,46,30,23,52	73.44
Region 16	Gabion Blanket	31,55,72,73,70,54,26	78.295
Region 17	Alluvium	60,75,71,66,48,40,39,30,46,47,53,68,69,63,67,65,64,70,73,72,55,31,43,42,51,50	487.25

Current Slip Surface

Slip Surface: 545
F of S: 1.668
Volume: 1,076.1451 ft³
Weight: 121,408.59 lbs
Resisting Moment: 1,882,930.2 lbs-ft
Activating Moment: 1,129,097.1 lbs-ft
Resisting Force: 28,069.59 lbs
Activating Force: 16,827.311 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (2.191815, 122.69589) ft
Entry: (-74.540888, 143.14194) ft
Radius: 59.297737 ft
Center: (-24.834739, 175.47645) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-73.916886	142.22097	-0	233.47078	145.88874	0
Slice 2	-72.439495	140.15	-0	390.88918	253.8464	0
Slice 3	-70.388421	137.56104	89.791367	627.95521	349.48769	0
Slice 4	-67.993053	134.84975	258.97531	909.7644	422.62738	0

Slice 5	-65.597684	132.44295	409.16014	1,168.6388	493.21121	0
Slice 6	-64.35	131.26377	482.7409	1,133.7459	422.76759	0
Slice 7	-64.15	131.08623	493.81932	1,124.2261	409.39095	0
Slice 8	-62.75	129.9132	567.01659	1,239.6569	436.81775	0
Slice 9	-60.45	128.08394	681.16194	1,443.445	495.03238	0
Slice 10	-57.72417	126.17687	800.16334	1,660.9032	558.971	0
Slice 11	-55.07417	124.4812	0	1,940.9758	0	326.38588
Slice 12	-52.9	123.25857	0	2,075.5277	0	337.40177
Slice 13	-51.398551	122.46257	0	2,174.1928	0	343.10711
Slice 14	-49.872464	121.74091	0	2,252.3375	0	348.2068
Slice 15	-47.423188	120.6656	0	2,381.5143	0	355.72818
Slice 16	-44.973913	119.71858	0	2,498.3434	0	362.22328
Slice 17	-42.524638	118.89339	0	2,603.3436	0	367.74376
Slice 18	-40.55	118.30437	0	2,681.595	0	371.58439
Slice 19	-39.7	118.07231	0	2,456.0117	0	373.06564
Slice 20	-39.45	118.00827	0	3,033.8314	0	373.43172
Slice 21	-38.2	117.71559	0	3,101.4244	0	374.92207
Slice 22	-36.95	117.42976	0	3,085.112	0	376.35769
Slice 23	-35.55	117.16874	0	2,288.6062	0	377.49267
Slice 24	-32.975	116.75534	0	2,296.1951	0	379.04662
Slice 25	-30.325	116.44842	0	2,282.0707	0	379.69772
Slice 26	-27.675	116.26163	0	2,255.3146	0	379.38781
Slice 27	-25.025	116.19382	0	2,215.9518	0	378.12601
Slice 28	-22.65	116.22829	0	2,164.2791	0	376.23326
Slice 29	-20.55	116.34309	0	2,102.5637	0	373.88508
Slice 30	-18.141667	116.57352	0	2,031.5569	0	370.40194
Slice 31	-15.425	116.94624	0	1,973.697	0	365.57052
Slice 32	-12.708333	117.44847	0	1,901.8009	0	359.70301
Slice 33	-9.9916667	118.08362	0	1,815.3595	0	352.77214
Slice 34	-7.275	118.85618	0	1,713.7249	0	344.74203
Slice 35	-4.5583333	119.77188	0	1,596.0833	0	335.56683

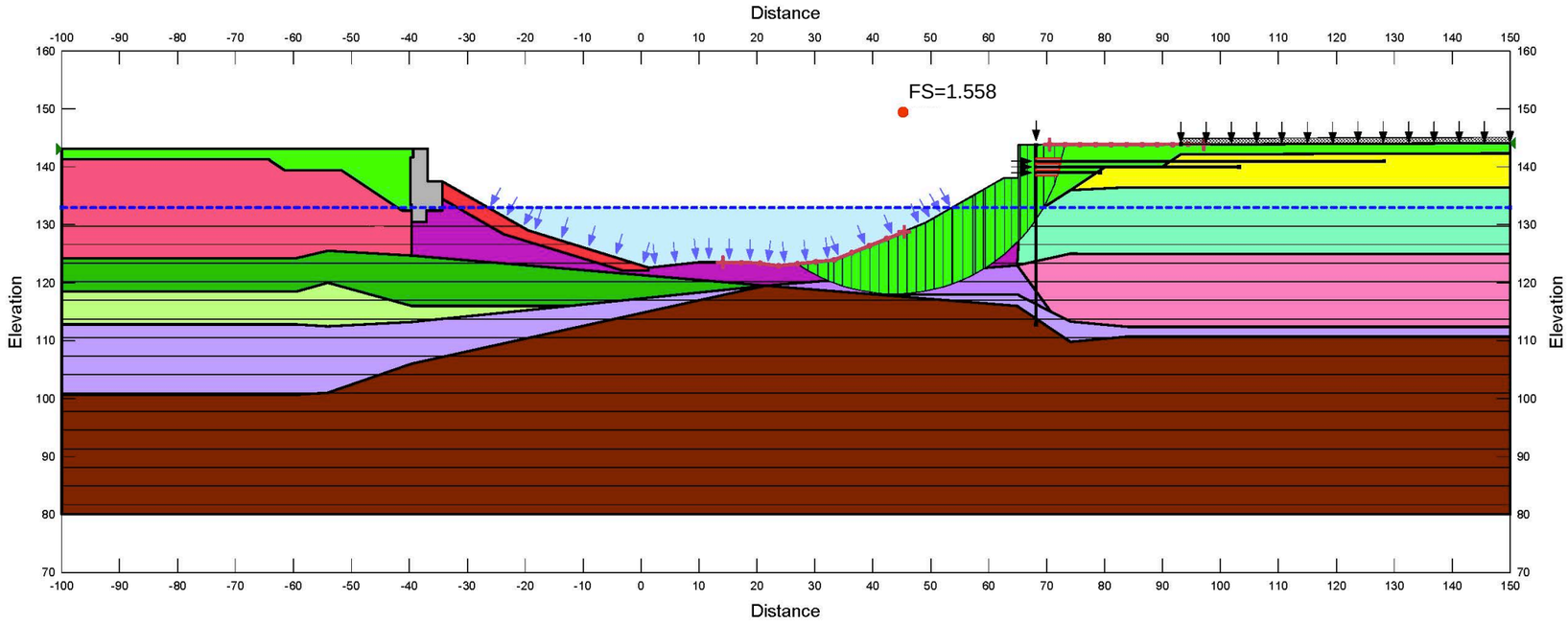
Slice 36	-1.8777788	120.82169	0	1,454.2023	0	325.34328
Slice 37	0.21972965	121.73853	1,077.1155	1,249.3579	99.444175	0
Slice 38	1.1475084	122.17433	1,049.9217	1,200.4854	150.56374	0
Slice 39	1.7459075	122.47228	1,031.3298	1,082.1402	29.335406	0

ABUTMENT 2 (NORTH)

GLOBAL STABILITY ANALYSIS

WATER EL. 133 FEET

HNTB



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Abutment	Mohr-Coulomb	145	50,000	0	0	1
	Alluvium	Mohr-Coulomb	108	0	30	0	1
	Bedrock	Bedrock (Impenetrable)					1
	Fill (South)	Mohr-Coulomb	114	0	33	0	1
	Gabion Blanket	Mohr-Coulomb	130	0	45	0	1
	Glacial Till	Mohr-Coulomb	126	0	38	0	1
	Lower Fill (North)	Mohr-Coulomb	111	0	32	0	1
	Med Stiff Clay (North)	Mohr-Coulomb	113	0	30	0	1
	Organic Silt	Mohr-Coulomb	103	0	25	0	1
	Soft Clay (North)	Mohr-Coulomb	91	0	27	0	1
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	106	0	28	0	1
	Structural Fill	Mohr-Coulomb	115	0	32	0	1
	Upper Fill (North)	Mohr-Coulomb	121	0	36	0	1

HNTB

HNTB PROJECT NUMBER 63738

BURNHAM BRIDGE | DRAINED

PREPARED BY: MRR | CHECKED BY: BAM | BACK CHECKED BY: MRR

DATE: 10/16/2017 | DATE: 10/18/2017 | DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

NORTH ABUTMENT

North Abutment Slope Stability

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Tool Version: 8.16.2.14053
File Name: Burnham_Bridge_Slope_Stability_Analysis__Drained_Geogrid_133.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\Longitudinal\Drained\
Last Solved Date: 11/8/2017
Last Solved Time: 10:53:28 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

North Abutment Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Structural Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 108 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)

Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Med Stiff Clay (North)

Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

Abutment

Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 50,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (14.1, 123.52473) ft
Left-Zone Right Coordinate: (45.39688, 128.8) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (70.5, 143.80844) ft
Right-Zone Right Coordinate: (97.1, 143.90599) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 143.1) ft
Right Coordinate: (150, 144.1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	150	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	93.2	143.9

	93.2	144.9
	150	145.1

Reinforcements

Reinforcement 1

Type: Pile
Outside Point: (68.2, 143.8) ft
Inside Point: (68.2, 112.8) ft
Slip Surface Intersection: (68.2, 130.94256) ft
Length: 31 ft
Direction: 90 °
Shear Force: 2,850 lbs
Shear Reduction Factor: 1
Pile Spacing: 1 ft
Shear Option: Parallel to Slip
Shear Force Applied: 2,850 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft

Reinforcement 2

Type: Geosynthetic
Outside Point: (68.2, 141) ft
Inside Point: (128.2, 141) ft
Slip Surface Intersection: (72.427444, 141) ft
Length: 60 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 92 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 61.333333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 259.2832 lbs
Pullout Force per Length: 61.333333 lbs/ft
Available Length: 4.2274435 ft
Required Length: 4.2274435 ft
Governing Component: Pullout Resistance (Active Zone)

Reinforcement 3

Type: Geosynthetic
Outside Point: (68.2, 140) ft
Inside Point: (103.2, 140) ft
Slip Surface Intersection: (72.167505, 140) ft
Length: 35 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 184 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No

Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 122.66667 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 486.68061 lbs
Pullout Force per Length: 122.66667 lbs/ft
Available Length: 3.9675049 ft
Required Length: 3.9675049 ft
Governing Component: Pullout Resistance (Active Zone)

Reinforcement 4

Type: Geosynthetic
Outside Point: (68.2, 139) ft
Inside Point: (79.2, 139) ft
Slip Surface Intersection: (71.907566, 139) ft
Length: 11 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 276 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 184 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 682.19221 lbs
Pullout Force per Length: 184 lbs/ft
Available Length: 3.7075664 ft
Required Length: 3.7075664 ft
Governing Component: Pullout Resistance (Active Zone)

Points

	X (ft)	Y (ft)
Point 1	150	144.1
Point 2	150	143.8
Point 3	68.2	143.8
Point 4	65.2	143.8
Point 5	-36.8	143.2
Point 6	-39.3	143.2
Point 7	-100	143.1
Point 8	65.2	142.8
Point 9	150	142.3
Point 10	-36.8	142.2

Point 11	93.2	142.2
Point 12	-39.3	141.7
Point 13	-39.8	141.7
Point 14	-100	141.3
Point 15	-64.3	141.3
Point 16	80.1	140
Point 17	89.9	140
Point 18	84.1	140
Point 19	-61.5	139.4
Point 20	-59.4	139.4
Point 21	-54.1	139.4
Point 22	-51.7	139.4
Point 23	62.7	138.1
Point 24	65.2	138.1
Point 25	-36.8	137.5
Point 26	-34.3	137.5
Point 27	84.1	136.5
Point 28	150	136.5
Point 29	74.1	136
Point 30	62.7	135.1
Point 31	-34.3	134.5
Point 32	65.2	134.1
Point 33	65.4	134.1
Point 34	67.9	134.1
Point 35	68.2	134.1
Point 36	-39.8	133.5
Point 37	-39.6	133.5
Point 38	69.7	133.1
Point 39	62.7	133.1
Point 40	65.4	133.1
Point 41	67.9	133.1

Point 42	-37.1	132.5
Point 43	-34.3	132.5
Point 44	-39.6	132.5
Point 45	-41.3	132.5
Point 46	57.7	132.2
Point 47	57.3	132
Point 48	65.4	131.1
Point 49	67.9	131.1
Point 50	-39.6	130.5
Point 51	-37.1	130.5
Point 52	49.1	130.3
Point 53	53.6	129.9
Point 54	-19.5	129
Point 55	-23.7	128.4
Point 56	-54.1	125.5
Point 57	74.1	125
Point 58	84.1	124.9
Point 59	150	124.9
Point 60	-39.6	124.7
Point 61	-59.4	124.3
Point 62	-100	124.3
Point 63	33.3	123.9
Point 64	10.6	123.6
Point 65	19.9	123.4
Point 66	64.9	123
Point 67	23.7	122.9
Point 68	36.3	122.8
Point 69	33.3	122.8
Point 70	1.3	122.6
Point 71	57.7	122.4
Point 72	-3.2	122.1

Point 73	1.3	122.1
Point 74	-54.1	120
Point 75	21.5	119.5
Point 76	-100	118.5
Point 77	-59.4	118.5
Point 78	64.9	118
Point 79	-39.6	116
Point 80	-12.4	116
Point 81	64.9	116
Point 82	74.1	113.3
Point 83	-39.6	113.2
Point 84	-100	112.8
Point 85	-59.4	112.8
Point 86	-54.1	112.5
Point 87	150	112.4
Point 88	84.1	112.4
Point 89	150	110.7
Point 90	84.1	110.7
Point 91	74.1	109.8
Point 92	-39.6	106
Point 93	-54.1	101
Point 94	-100	100.7
Point 95	-59.4	100.7
Point 96	40.1	118
Point 97	-100	80
Point 98	150	80
Point 99	-64	141.09643
Point 100	70.8	115

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	97,98,89,90,91,81,96,75,92,93,95,94	7,559.4
Region 2	Glacial Till	89,87,88,82,100,78,96,81,91,90	188.2
Region 3	Glacial Till	94,95,93,92,75,80,83,86,85,84	909.19
Region 4	Soft to Med Stiff Clay (South)	84,85,86,83,80,79,74,77,76	379.15
Region 5	Abutment	13,12,6,5,10,25,26,31,43,42,51,50,44,37,36	48.65
Region 6	Structural Fill	14,15,99,19,20,21,22,45,44,37,36,13,12,6,7	202.41
Region 7	Organic Silt	76,77,74,79,80,75,60,56,61,62	681.76
Region 8	Fill (South)	62,61,56,60,50,44,45,22,21,20,19,99,15,14	920.14
Region 9	Abutment	48,49,41,34,35,3,4,8,24,23,30,39,40	49.3
Region 10	Soft Clay (North)	75,96,78,100,66,71	141.43
Region 11	Med Stiff Clay (North)	66,100,82,88,87,59,58,57	1,006.8
Region 12	Structural Fill	41,38,29,16,18,17,11,9,2,1,3,35,34	238.31
Region 13	Upper Fill (North)	29,27,28,9,11,17,18,16	387.58
Region 14	Lower Fill (North)	48,66,57,58,59,28,27,29,38,41,49	959.51
Region 15	Gabion Blanket	63,69,68,53,47,46,30,23,52	73.44
Region 16	Gabion Blanket	31,55,72,73,70,54,26	78.295
Region 17	Alluvium	60,75,71,66,48,40,39,30,46,47,53,68,69,63,67,65,64,70,73,72,55,31,43,42,51,50	487.25

Current Slip Surface

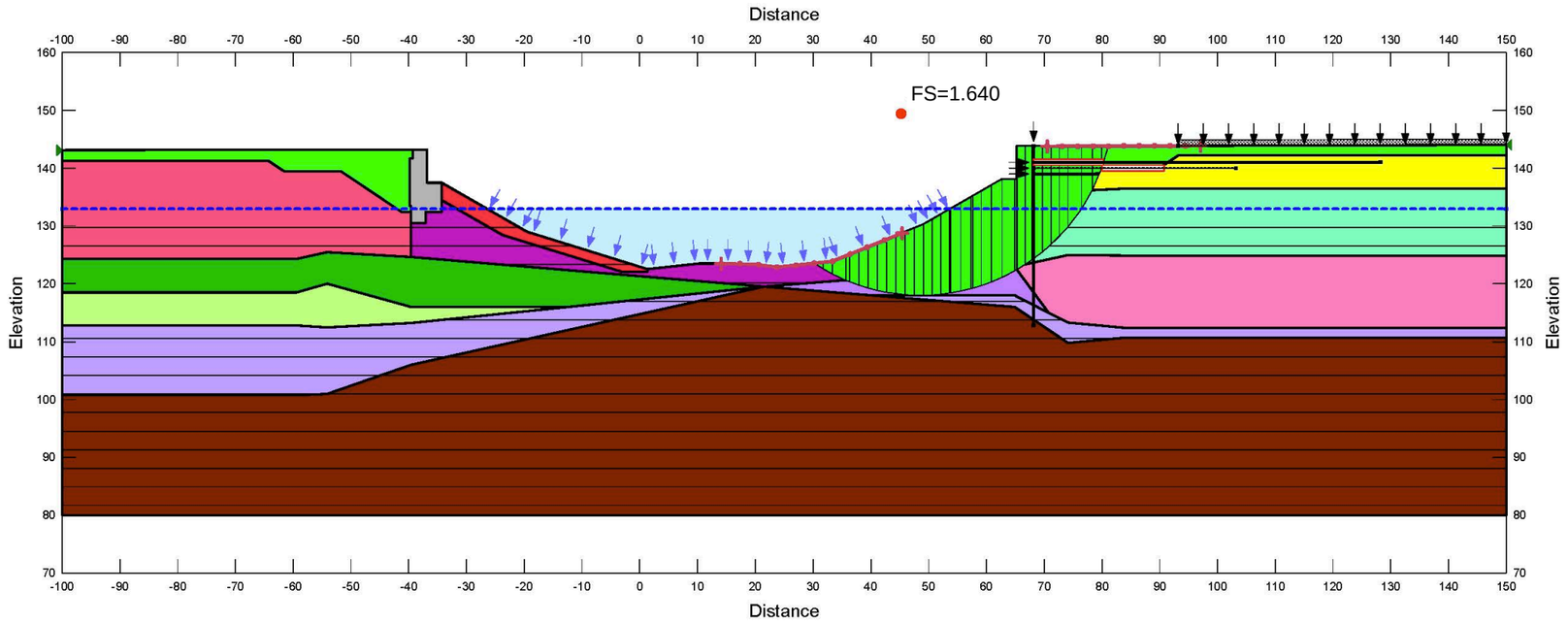
Slip Surface: 505
F of S: 1.558

Volume: 440.19366 ft³
Weight: 50,238.621 lbs
Resisting Moment: 466,701.89 lbs-ft
Activating Moment: 299,558.15 lbs-ft
Resisting Force: 12,237.005 lbs
Activating Force: 7,849.8652 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (26.9832, 123.242) ft
Entry: (73.16, 143.81819) ft
Radius: 29.693278 ft
Center: (43.729822, 147.76222) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	27.866566	122.68324	643.76567	713.28249	40.135556	0
Slice 2	29.6333	121.64765	708.38678	846.04643	79.477835	0
Slice 3	31.400033	120.76734	763.31816	954.17431	110.19085	0
Slice 4	32.7917	120.16242	801.0651	1,016.0569	109.54377	0
Slice 5	34.05	119.70225	829.77983	1,115.0027	145.3283	0
Slice 6	35.55	119.22852	859.34064	1,194.5993	170.82284	0
Slice 7	37.1	118.83019	884.19615	1,258.0352	190.48052	0
Slice 8	38.7	118.50931	904.21877	1,305.8953	204.66439	0
Slice 9	40.3	118.2787	918.60935	1,344.3341	216.91761	0
Slice 10	41.9	118.13622	927.49981	1,373.7628	227.38233	0
Slice 11	43.5	118.08062	930.9696	1,394.4715	236.166	0
Slice 12	45.1	118.11139	929.0493	1,406.6478	243.34857	0
Slice 13	46.7	118.22881	921.72201	1,410.3872	248.98733	0
Slice 14	48.3	118.43393	908.9226	1,405.6987	253.12008	0
Slice 15	49.85	118.71663	891.28246	1,402.0508	260.24949	0
Slice 16	51.35	119.07387	868.99028	1,397.043	269.05629	0
Slice 17	52.85	119.51524	841.44886	1,383.6298	276.25497	0
Slice 18	53.703846	119.79443	824.02749	1,372.8047	279.61594	0
Slice 19	54.680769	120.17808	800.08792	1,380.0078	295.48394	0
Slice 20	56.426923	120.93796	752.67151	1,389.5922	324.52732	0
Slice 21	57.5	121.45591	720.35101	1,389.3949	340.8949	0
Slice 22	58.389655	121.95232	689.37502	1,382.0025	352.91132	0

Slice 23	59.240756	122.44295	658.76015	1,372.3179	363.57583	0
Slice 24	60.226651	123.09318	618.18551	1,330.1986	411.08097	0
Slice 25	61.87555	124.28164	544.02541	1,268.859	418.48287	0
Slice 26	63.314949	125.45878	470.57236	1,258.4695	454.89263	0
Slice 27	64.564949	126.62474	397.81604	1,122.965	418.66493	0
Slice 28	65.3	127.35642	352.15965	1,652.5223	812.55676	0
Slice 29	66.025	128.17347	301.17526	1,552.6655	782.01788	0
Slice 30	67.275	129.69953	205.94945	1,353.1325	716.83952	0
Slice 31	68.05	130.72839	141.74816	1,184.7469	651.7379	0
Slice 32	68.846754	131.97128	64.192176	-240.31555	-190.27755	0
Slice 33	70.424391	134.93765	-0	539.11994	336.87953	0
Slice 34	72.257637	140.34674	-0	151.3568	94.578224	0



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
	Abutment	Mohr-Coulomb	145	50,000	0	0				
	Alluvium	Mohr-Coulomb	108	0	30	0	1			
	Bedrock	Bedrock (Impenetrable)					1			
	Fill (South)	Mohr-Coulomb	114	0	33	0	1			
	Gabion Blanket	Mohr-Coulomb	130	0	45	0	1			
	Glacial Till	Mohr-Coulomb	126	0	38	0	1			
	Lower Fill (North)	Mohr-Coulomb	111	0	32	0	1			
	Med Stiff Clay (North)	Mohr-Coulomb	113	642	0	0				
	Organic Silt	S=f(depth)	103					320	8	1,000
	Soft Clay (North)	Mohr-Coulomb	91	350	0	0				
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	106	506	0	0				
	Structural Fill	Mohr-Coulomb	115	0	32	0	1			
	Upper Fill (North)	Mohr-Coulomb	121	0	36	0	1			

HNTB

HNTB PROJECT NUMBER 63738

BURNHAM BRIDGE | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

NORTH ABUTMENT

North Abutment Slope Stability

Report generated using GeoStudio 2016. Copyright © 1991-2017 GEO-SLOPE International Ltd.

File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Margarita Restrepo-Espinosa
Revision Number: 110
Date: 11/8/2017
Time: 11:54:19 AM
Tool Version: 8.16.2.14053
File Name: Burnham_Bridge_Slope_Stability_Analysis__Undrained_Geogrid_133.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\Longitudinal\Undrained\
Last Solved Date: 11/8/2017
Last Solved Time: 11:54:31 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

North Abutment Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Structural Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 108 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)
Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 350 psf
Phi': 0 °
Phi-B: 0 °

Med Stiff Clay (North)
Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 642 psf
Phi': 0 °
Phi-B: 0 °

Glacial Till
Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)
Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt
Model: S=f(depth)
Unit Weight: 103 pcf
C-Top of Layer: 320 psf
C-Rate of Change: 8 (lbs/ft^2)/ft
C-Maximum: 1,000 psf

Soft to Med Stiff Clay (South)
Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 506 psf
Phi': 0 °
Phi-B: 0 °

Abutment
Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 50,000 psf
Phi': 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (14.1, 123.52473) ft
Left-Zone Right Coordinate: (45.39688, 128.8) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (70.5, 143.80844) ft
Right-Zone Right Coordinate: (97.1, 143.90599) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 143.1) ft
Right Coordinate: (150, 144.1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	150	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	93.2	143.9
	93.2	144.9
	150	145.1

Reinforcements

Reinforcement 1

Type: Pile
Outside Point: (68.2, 143.8) ft
Inside Point: (68.2, 112.8) ft
Slip Surface Intersection: (68.2, 124.3868) ft

Length: 31 ft
Direction: 90 °
Shear Force: 2,850 lbs
Shear Reduction Factor: 1
Pile Spacing: 1 ft
Shear Option: Parallel to Slip
Shear Force Applied: 2,850 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft

Reinforcement 2

Type: Geosynthetic
Outside Point: (68.2, 141) ft
Inside Point: (128.2, 141) ft
Slip Surface Intersection: (80.287127, 141) ft
Length: 60 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 92 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 61.333333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 741.34379 lbs
Pullout Force per Length: 61.333333 lbs/ft
Available Length: 12.087127 ft
Required Length: 12.087127 ft
Governing Component: Pullout Resistance (Active Zone)

Reinforcement 3

Type: Geosynthetic
Outside Point: (68.2, 140) ft
Inside Point: (103.2, 140) ft
Slip Surface Intersection: (79.987606, 140) ft
Length: 35 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 184 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 122.66667 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 1,324 lbs
Pullout Force per Length: 122.66667 lbs/ft
Available Length: 11.787606 ft
Required Length: 10.793478 ft
Governing Component: Tensile Capacity

Reinforcement 4

Type: Geosynthetic

Outside Point: (68.2, 139) ft
Inside Point: (79.2, 139) ft
Slip Surface Intersection: () ft
Length: 11 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 276 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 184 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	150	144.1
Point 2	150	143.8
Point 3	68.2	143.8
Point 4	65.2	143.8
Point 5	-36.8	143.2
Point 6	-39.3	143.2
Point 7	-100	143.1
Point 8	65.2	142.8
Point 9	150	142.3
Point 10	-36.8	142.2
Point 11	93.2	142.2
Point 12	-39.3	141.7
Point 13	-39.8	141.7
Point 14	-100	141.3
Point 15	-64.3	141.3
Point 16	80.1	140
Point 17	89.9	140

Point 18	84.1	140
Point 19	-61.5	139.4
Point 20	-59.4	139.4
Point 21	-54.1	139.4
Point 22	-51.7	139.4
Point 23	62.7	138.1
Point 24	65.2	138.1
Point 25	-36.8	137.5
Point 26	-34.3	137.5
Point 27	84.1	136.5
Point 28	150	136.5
Point 29	74.1	136
Point 30	62.7	135.1
Point 31	-34.3	134.5
Point 32	65.2	134.1
Point 33	65.4	134.1
Point 34	67.9	134.1
Point 35	68.2	134.1
Point 36	-39.8	133.5
Point 37	-39.6	133.5
Point 38	69.7	133.1
Point 39	62.7	133.1
Point 40	65.4	133.1
Point 41	67.9	133.1
Point 42	-37.1	132.5
Point 43	-34.3	132.5
Point 44	-39.6	132.5
Point 45	-41.3	132.5
Point 46	57.7	132.2
Point 47	57.3	132
Point 48	65.4	131.1

Point 49	67.9	131.1
Point 50	-39.6	130.5
Point 51	-37.1	130.5
Point 52	49.1	130.3
Point 53	53.6	129.9
Point 54	-19.5	129
Point 55	-23.7	128.4
Point 56	-54.1	125.5
Point 57	74.1	125
Point 58	84.1	124.9
Point 59	150	124.9
Point 60	-39.6	124.7
Point 61	-59.4	124.3
Point 62	-100	124.3
Point 63	33.3	123.9
Point 64	10.6	123.6
Point 65	19.9	123.4
Point 66	64.9	123
Point 67	23.7	122.9
Point 68	36.3	122.8
Point 69	33.3	122.8
Point 70	1.3	122.6
Point 71	57.7	122.4
Point 72	-3.2	122.1
Point 73	1.3	122.1
Point 74	-54.1	120
Point 75	21.5	119.5
Point 76	-100	118.5
Point 77	-59.4	118.5
Point 78	64.9	118
Point 79	-39.6	116

Point 80	-12.4	116
Point 81	64.9	116
Point 82	74.1	113.3
Point 83	-39.6	113.2
Point 84	-100	112.8
Point 85	-59.4	112.8
Point 86	-54.1	112.5
Point 87	150	112.4
Point 88	84.1	112.4
Point 89	150	110.7
Point 90	84.1	110.7
Point 91	74.1	109.8
Point 92	-39.6	106
Point 93	-54.1	101
Point 94	-100	100.7
Point 95	-59.4	100.7
Point 96	40.1	118
Point 97	-100	80
Point 98	150	80
Point 99	-64	141.09643
Point 100	70.8	115

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	97,98,89,90,91,81,96,75,92,93,95,94	7,559.4
Region 2	Glacial Till	89,87,88,82,100,78,96,81,91,90	188.2
Region 3	Glacial Till	94,95,93,92,75,80,83,86,85,84	909.19
Region 4	Soft to Med Stiff Clay (South)	84,85,86,83,80,79,74,77,76	379.15
Region 5	Abutment	13,12,6,5,10,25,26,31,43,42,51,50,44,37,36	48.65
Region 6	Structural Fill	14,15,99,19,20,21,22,45,44,37,36,13,12,6,7	202.41

Region 7	Organic Silt	76,77,74,79,80,75,60,56,61,62	681.76
Region 8	Fill (South)	62,61,56,60,50,44,45,22,21,20,19,99,15,14	920.14
Region 9	Abutment	48,49,41,34,35,3,4,8,24,23,30,39,40	49.3
Region 10	Soft Clay (North)	75,96,78,100,66,71	141.43
Region 11	Med Stiff Clay (North)	66,100,82,88,87,59,58,57	1,006.8
Region 12	Structural Fill	41,38,29,16,18,17,11,9,2,1,3,35,34	238.31
Region 13	Upper Fill (North)	29,27,28,9,11,17,18,16	387.58
Region 14	Lower Fill (North)	48,66,57,58,59,28,27,29,38,41,49	959.51
Region 15	Gabion Blanket	63,69,68,53,47,46,30,23,52	73.44
Region 16	Gabion Blanket	31,55,72,73,70,54,26	78.295
Region 17	Alluvium	60,75,71,66,48,40,39,30,46,47,53,68,69,63,67,65,64,70,73,72,55,31,43,42,51,50	487.25

Current Slip Surface

Slip Surface: 658
F of S: 1.640
Volume: 593.16102 ft³
Weight: 67,200.718 lbs
Resisting Moment: 780,735.42 lbs-ft
Activating Moment: 475,978.44 lbs-ft
Resisting Force: 19,013.407 lbs
Activating Force: 11,594.315 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (30.199562, 123.57704) ft
Entry: (81.14, 143.84746) ft
Radius: 33.400297 ft
Center: (48.614622, 151.44217) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	30.974671	123.09471	618.09039	731.30788	65.366148	0
Slice 2	32.52489	122.18609	674.78785	849.52339	100.88361	0
Slice 3	34.502126	121.19886	736.3911	1,064.2057	189.26383	0

Slice 4	36.002126	120.51643	0	1,219.0792	0	350
Slice 5	37.1	120.10103	0	1,264.6528	0	350
Slice 6	38.7	119.55834	0	1,321.2619	0	350
Slice 7	40.3	119.10388	0	1,369.8429	0	350
Slice 8	41.9	118.73396	0	1,410.7168	0	350
Slice 9	43.5	118.44573	0	1,444.13	0	350
Slice 10	45.1	118.23704	0	1,470.2646	0	350
Slice 11	46.7	118.10642	0	1,489.2457	0	350
Slice 12	48.3	118.05293	0	1,501.1455	0	350
Slice 13	49.85	118.07316	0	1,516.8778	0	350
Slice 14	51.35	118.16257	0	1,530.3354	0	350
Slice 15	52.85	118.32012	0	1,537.3521	0	350
Slice 16	53.703846	118.43204	0	1,538.8594	0	350
Slice 17	54.680769	118.60936	0	1,565.6761	0	350
Slice 18	56.426923	118.98078	0	1,614.7425	0	350
Slice 19	57.5	119.2461	0	1,641.2455	0	350
Slice 20	58.389655	119.51243	0	1,658.4711	0	350
Slice 21	59.984483	120.05141	0	1,682.2898	0	350
Slice 22	61.794828	120.76821	0	1,698.3785	0	350
Slice 23	63.8	121.71914	0	1,748.1724	0	350
Slice 24	65.05	122.36591	0	1,681.518	0	350
Slice 25	65.236928	122.47189	0	2,707.744	0	350
Slice 26	65.336928	122.52956	0	2,524.7702	0	642
Slice 27	66.084269	122.98612	0	2,394.9156	0	642
Slice 28	67.334269	123.78917	574.7555	2,163.5937	992.81627	0
Slice 29	68.05	124.27947	544.16089	2,053.4318	943.09715	0
Slice 30	68.95	124.96278	501.52264	961.76336	287.59032	0
Slice 31	70.433333	126.17193	426.07176	1,542.4016	697.56026	0
Slice 32	71.9	127.51888	342.02205	1,371.16	643.07672	0
Slice 33	73.366667	129.04302	246.91541	1,184.5697	585.91145	0
Slice 34	75.280909	131.42669	98.174293	907.61181	505.7927	0

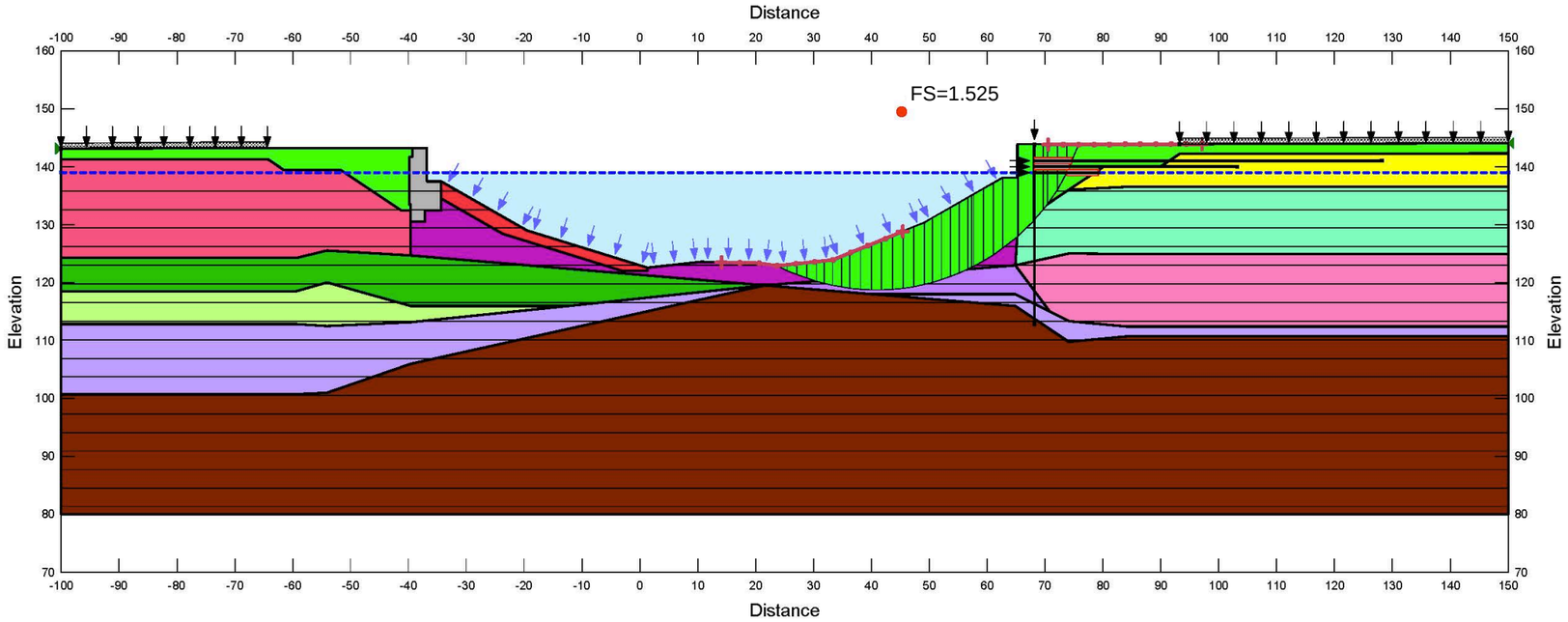
Slice 35	77.401114	134.60601	-0	598.25353	373.8303	0
Slice 36	79.149987	138.0592	-0	308.72547	224.30218	0
Slice 37	80.549782	141.87692	-0	93.239141	58.262282	0

ABUTMENT 2 (NORTH)

GLOBAL STABILITY ANALYSIS

WATER EL. 139 FEET

HNTB



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Abutment	Mohr-Coulomb	145	50,000	0	0	1
	Alluvium	Mohr-Coulomb	108	0	30	0	1
	Bedrock	Bedrock (Impenetrable)					1
	Fill (South)	Mohr-Coulomb	114	0	33	0	1
	Gabion Blanket	Mohr-Coulomb	130	0	45	0	1
	Glacial Till	Mohr-Coulomb	126	0	38	0	1
	Lower Fill (North)	Mohr-Coulomb	111	0	32	0	1
	Med Stiff Clay (North)	Mohr-Coulomb	113	0	30	0	1
	Organic Silt	Mohr-Coulomb	103	0	25	0	1
	Soft Clay (North)	Mohr-Coulomb	91	0	27	0	1
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	106	0	28	0	1
	Structural Fill	Mohr-Coulomb	115	0	32	0	1
	Upper Fill (North)	Mohr-Coulomb	121	0	36	0	1

HNTB

HNTB PROJECT NUMBER 63738

BURNHAM BRIDGE | DRAINED

PREPARED BY: MRR | CHECKED BY: BAM | BACK CHECKED BY: MRR

DATE: 10/16/2017 | DATE: 10/18/2017 | DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

NORTH ABUTMENT

North Abutment Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Margarita Restrepo-Espinosa
Revision Number: 128
Date: 11/8/2017
Time: 11:09:04 AM
Tool Version: 8.16.2.14053
File Name: Burnham_Bridge_Slope_Stability_Analysis__Drained_Geogrid_139.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\Longitudinal\Drained\
Last Solved Date: 11/8/2017
Last Solved Time: 11:09:17 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

North Abutment Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Structural Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 108 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)

Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Med Stiff Clay (North)

Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

Abutment

Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 50,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (14.1, 123.52473) ft
Left-Zone Right Coordinate: (45.39688, 128.8) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (70.5, 143.80844) ft
Right-Zone Right Coordinate: (97.1, 143.90599) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 143.1) ft
Right Coordinate: (150, 144.1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	150	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-100	143.1

	-100	144.1
	-64.4	144.3

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	93.2	143.9
	93.2	144.9
	150	145.1

Reinforcements

Reinforcement 1

Type: Pile
Outside Point: (68.2, 143.8) ft
Inside Point: (68.2, 112.8) ft
Slip Surface Intersection: (68.2, 130.87568) ft
Length: 31 ft
Direction: 90 °
Shear Force: 600 lbs
Shear Reduction Factor: 1
Pile Spacing: 1 ft
Shear Option: Parallel to Slip
Shear Force Applied: 600 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft

Reinforcement 2

Type: Geosynthetic
Outside Point: (68.2, 141) ft
Inside Point: (128.2, 141) ft
Slip Surface Intersection: (74.631077, 141) ft
Length: 60 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 92 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 61.333333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 394.43939 lbs
Pullout Force per Length: 61.333333 lbs/ft
Available Length: 6.4310771 ft
Required Length: 6.4310771 ft

Governing Component: Pullout Resistance (Active Zone)

Reinforcement 3

Type: Geosynthetic
Outside Point: (68.2, 140) ft
Inside Point: (103.2, 140) ft
Slip Surface Intersection: (74.210658, 140) ft
Length: 35 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 184 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 122.66667 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 737.30737 lbs
Pullout Force per Length: 122.66667 lbs/ft
Available Length: 6.0106579 ft
Required Length: 6.0106579 ft
Governing Component: Pullout Resistance (Active Zone)

Reinforcement 4

Type: Geosynthetic
Outside Point: (68.2, 139) ft
Inside Point: (79.2, 139) ft
Slip Surface Intersection: (73.790239, 139) ft
Length: 11 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 276 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 184 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 995.39609 lbs
Pullout Force per Length: 184 lbs/ft
Available Length: 5.4097613 ft
Required Length: 5.4097613 ft
Governing Component: Pullout Resistance

Points

	X (ft)	Y (ft)
Point 1	150	144.1
Point 2	150	143.8
Point 3	68.2	143.8

Point 4	65.2	143.8
Point 5	-36.8	143.2
Point 6	-39.3	143.2
Point 7	-100	143.1
Point 8	65.2	142.8
Point 9	150	142.3
Point 10	-36.8	142.2
Point 11	93.2	142.2
Point 12	-39.3	141.7
Point 13	-39.8	141.7
Point 14	-100	141.3
Point 15	-64.3	141.3
Point 16	80.1	140
Point 17	89.9	140
Point 18	84.1	140
Point 19	-61.5	139.4
Point 20	-59.4	139.4
Point 21	-54.1	139.4
Point 22	-51.7	139.4
Point 23	62.7	138.1
Point 24	65.2	138.1
Point 25	-36.8	137.5
Point 26	-34.3	137.5
Point 27	84.1	136.5
Point 28	150	136.5
Point 29	74.1	136
Point 30	62.7	135.1
Point 31	-34.3	134.5
Point 32	65.2	134.1
Point 33	65.4	134.1
Point 34	67.9	134.1

Point 35	68.2	134.1
Point 36	-39.8	133.5
Point 37	-39.6	133.5
Point 38	69.7	133.1
Point 39	62.7	133.1
Point 40	65.4	133.1
Point 41	67.9	133.1
Point 42	-37.1	132.5
Point 43	-34.3	132.5
Point 44	-39.6	132.5
Point 45	-41.3	132.5
Point 46	57.7	132.2
Point 47	57.3	132
Point 48	65.4	131.1
Point 49	67.9	131.1
Point 50	-39.6	130.5
Point 51	-37.1	130.5
Point 52	49.1	130.3
Point 53	53.6	129.9
Point 54	-19.5	129
Point 55	-23.7	128.4
Point 56	-54.1	125.5
Point 57	74.1	125
Point 58	84.1	124.9
Point 59	150	124.9
Point 60	-39.6	124.7
Point 61	-59.4	124.3
Point 62	-100	124.3
Point 63	33.3	123.9
Point 64	10.6	123.6
Point 65	19.9	123.4

Point 66	64.9	123
Point 67	23.7	122.9
Point 68	36.3	122.8
Point 69	33.3	122.8
Point 70	1.3	122.6
Point 71	57.7	122.4
Point 72	-3.2	122.1
Point 73	1.3	122.1
Point 74	-54.1	120
Point 75	21.5	119.5
Point 76	-100	118.5
Point 77	-59.4	118.5
Point 78	64.9	118
Point 79	-39.6	116
Point 80	-12.4	116
Point 81	64.9	116
Point 82	74.1	113.3
Point 83	-39.6	113.2
Point 84	-100	112.8
Point 85	-59.4	112.8
Point 86	-54.1	112.5
Point 87	150	112.4
Point 88	84.1	112.4
Point 89	150	110.7
Point 90	84.1	110.7
Point 91	74.1	109.8
Point 92	-39.6	106
Point 93	-54.1	101
Point 94	-100	100.7
Point 95	-59.4	100.7
Point 96	40.1	118

Point 97	-100	80
Point 98	150	80
Point 99	-64	141.09643
Point 100	70.8	115

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	97,98,89,90,91,81,96,75,92,93,95,94	7,559.4
Region 2	Glacial Till	89,87,88,82,100,78,96,81,91,90	188.2
Region 3	Glacial Till	94,95,93,92,75,80,83,86,85,84	909.19
Region 4	Soft to Med Stiff Clay (South)	84,85,86,83,80,79,74,77,76	379.15
Region 5	Abutment	13,12,6,5,10,25,26,31,43,42,51,50,44,37,36	48.65
Region 6	Structural Fill	14,15,99,19,20,21,22,45,44,37,36,13,12,6,7	202.41
Region 7	Organic Silt	76,77,74,79,80,75,60,56,61,62	681.76
Region 8	Fill (South)	62,61,56,60,50,44,45,22,21,20,19,99,15,14	920.14
Region 9	Abutment	48,49,41,34,35,3,4,8,24,23,30,39,40	49.3
Region 10	Soft Clay (North)	75,96,78,100,66,71	141.43
Region 11	Med Stiff Clay (North)	66,100,82,88,87,59,58,57	1,006.8
Region 12	Structural Fill	41,38,29,16,18,17,11,9,2,1,3,35,34	238.31
Region 13	Upper Fill (North)	29,27,28,9,11,17,18,16	387.58
Region 14	Lower Fill (North)	48,66,57,58,59,28,27,29,38,41,49	959.51
Region 15	Gabion Blanket	63,69,68,53,47,46,30,23,52	73.44

Region 16	Gabion Blanket	31,55,72,73,70,54,26	78.295
Region 17	Alluvium	60,75,71,66,48,40,39,30,46,47,53,68,69,63,67,65,64,70,73,72,55,31,43,42,51,50	487.25

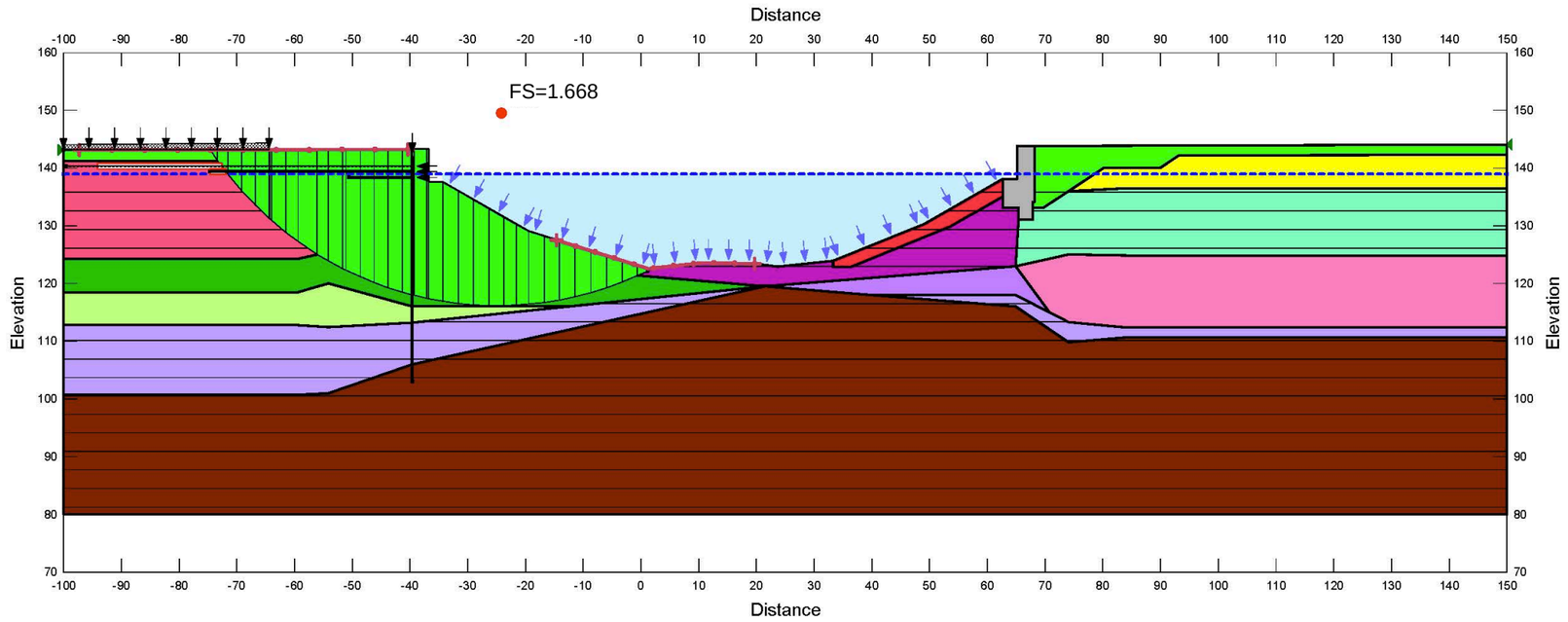
Current Slip Surface

Slip Surface: 393
F of S: 1.525
Volume: 440.98946 ft³
Weight: 50,749.203 lbs
Resisting Moment: 543,956.41 lbs-ft
Activating Moment: 356,785.09 lbs-ft
Resisting Force: 11,894.991 lbs
Activating Force: 7,797.6233 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (23.766838, 122.90696) ft
Entry: (75.82, 143.82795) ft
Radius: 36.963468 ft
Center: (40.816181, 155.70358) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	24.6044	122.49804	1,029.7221	1,090.4165	35.04192	0
Slice 2	26.279523	121.73074	1,077.6018	1,187.5633	63.486329	0
Slice 3	27.954647	121.06139	1,119.369	1,270.3103	87.145977	0
Slice 4	29.629771	120.48441	1,155.3731	1,340.195	106.70698	0
Slice 5	31.1755	120.02701	1,183.9144	1,386.5802	103.2634	0
Slice 6	32.591833	119.674	1,205.9425	1,419.5429	108.83483	0
Slice 7	34.05	119.37267	1,224.7454	1,504.5245	142.55455	0
Slice 8	35.55	119.12501	1,240.1991	1,561.8444	163.88648	0
Slice 9	37.214286	118.92749	1,252.5245	1,608.0553	181.152	0
Slice 10	39.042857	118.79402	1,260.8532	1,642.1451	194.2779	0
Slice 11	40.871429	118.75146	1,263.509	1,666.9908	205.58425	0
Slice 12	42.7	118.7995	1,260.5114	1,682.7855	215.1594	0
Slice 13	44.528571	118.93849	1,251.8383	1,689.6381	223.07013	0
Slice 14	46.357143	119.16947	1,237.4248	1,687.5784	229.36474	0
Slice 15	48.185714	119.49422	1,217.1606	1,676.5588	234.07508	0
Slice 16	49.85	119.86938	1,193.7509	1,670.0561	242.68964	0

Slice 17	51.35	120.28149	1,168.0352	1,662.1529	251.76556	0
Slice 18	52.85	120.76283	1,137.9996	1,647.3788	259.54168	0
Slice 19	54.370566	121.32494	1,102.9237	1,622.7721	264.87601	0
Slice 20	55.911697	121.97361	1,062.4468	1,587.9556	267.76013	0
Slice 21	56.991131	122.46879	1,031.5474	1,549.0524	298.78166	0
Slice 22	57.5	122.72028	1,015.8546	1,530.9744	297.40453	0
Slice 23	58.533333	123.27676	981.13047	1,489.1051	293.27931	0
Slice 24	60.2	124.24555	920.67767	1,413.8814	284.75131	0
Slice 25	61.866667	125.33671	852.5896	1,326.43	273.5719	0
Slice 26	63.95	126.91899	753.85527	1,260.9589	292.77641	0
Slice 27	65.3	128.01201	685.65046	1,748.5277	664.1594	0
Slice 28	66.65	129.32459	603.74528	1,597.9308	621.23607	0
Slice 29	68.05	130.71222	517.1574	1,393.4857	547.59071	0
Slice 30	68.95	131.75682	451.97461	862.77748	256.69812	0
Slice 31	70.063625	133.10864	367.62095	917.36069	343.51551	0
Slice 32	71.267997	134.80436	261.80799	729.31319	292.12967	0
Slice 33	72.949491	137.5147	92.682893	448.79772	222.52525	0
Slice 34	74.805119	141.41397	-0	138.16594	86.335658	0



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
	Abutment	Mohr-Coulomb	145	50,000	0	0				
	Alluvium	Mohr-Coulomb	108	0	30	0	1			
	Bedrock	Bedrock (Impenetrable)					1			
	Fill (South)	Mohr-Coulomb	114	0	33	0	1			
	Gabion Blanket	Mohr-Coulomb	130	0	45	0	1			
	Glacial Till	Mohr-Coulomb	126	0	38	0	1			
	Lower Fill (North)	Mohr-Coulomb	111	0	32	0	1			
	Med Stiff Clay (North)	Mohr-Coulomb	113	642	0	0				
	Organic Silt	S=f(depth)	103					320	8	1,000
	Soft Clay (North)	Mohr-Coulomb	91	350	0	0				
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	106	506	0	0				
	Structural Fill	Mohr-Coulomb	115	0	32	0	1			
	Upper Fill (North)	Mohr-Coulomb	121	0	36	0	1			

HNTB

HNTB PROJECT NUMBER 63738

BURNHAM BRIDGE | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

SOUTH ABUTMENT

South Abutment Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Margarita Restrepo-Espinosa
Revision Number: 113
Date: 11/8/2017
Time: 12:10:48 PM
Tool Version: 8.16.2.14053
File Name: Burnham_Bridge_Slope_Stability_Analysis__Undrained_Geogrid_139.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\Longitudinal\Undrained\
Last Solved Date: 11/8/2017
Last Solved Time: 12:10:56 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

South Abutment Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Structural Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Fill (North)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lower Fill (North)

Model: Mohr-Coulomb
Unit Weight: 111 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 108 pcf

Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Clay (North)
Model: Mohr-Coulomb
Unit Weight: 91 pcf
Cohesion': 350 psf
Phi': 0 °
Phi-B: 0 °

Med Stiff Clay (North)
Model: Mohr-Coulomb
Unit Weight: 113 pcf
Cohesion': 642 psf
Phi': 0 °
Phi-B: 0 °

Glacial Till
Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)
Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt
Model: S=f(depth)
Unit Weight: 103 pcf
C-Top of Layer: 320 psf
C-Rate of Change: 8 (lbs/ft^2)/ft
C-Maximum: 1,000 psf

Soft to Med Stiff Clay (South)
Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 506 psf
Phi': 0 °
Phi-B: 0 °

Abutment
Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion': 50,000 psf
Phi': 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-97.3, 143.10445) ft
Left-Zone Right Coordinate: (-40.40222, 143.19818) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-14.625, 127.5) ft
Right-Zone Right Coordinate: (19.7, 123.4043) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 143.1) ft
Right Coordinate: (150, 144.1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	150	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-100	143.1
	-100	144.1
	-64.4	144.3

Reinforcements

Reinforcement 1

Type: Pile
Outside Point: (-39.6, 141.7) ft
Inside Point: (-39.6, 103) ft
Slip Surface Intersection: (-39.6, 118.04642) ft

Length: 38.7 ft
Direction: 90 °
Shear Force: 600 lbs
Shear Reduction Factor: 1
Pile Spacing: 1 ft
Shear Option: Parallel to Slip
Shear Force Applied: 600 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft

Reinforcement 2

Type: Geosynthetic
Outside Point: (-39.6, 140.36) ft
Inside Point: (-99.6, 140.36) ft
Slip Surface Intersection: (-72.595331, 140.36) ft
Length: 60 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 92 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 61.333333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 1,324 lbs
Pullout Force per Length: 61.333333 lbs/ft
Available Length: 27.004669 ft
Required Length: 21.586957 ft
Governing Component: Tensile Capacity

Reinforcement 3

Type: Geosynthetic
Outside Point: (-39.6, 139.36) ft
Inside Point: (-74.6, 139.36) ft
Slip Surface Intersection: (-71.853253, 139.36) ft
Length: 35 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 184 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 122.66667 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 336.93428 lbs
Pullout Force per Length: 122.66667 lbs/ft
Available Length: 2.7467469 ft
Required Length: 2.7467469 ft
Governing Component: Pullout Resistance

Reinforcement 4

Type: Geosynthetic

Outside Point: (-39.6, 138.36) ft
Inside Point: (-50.6, 138.36) ft
Slip Surface Intersection: () ft
Length: 11 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 276 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 184 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	150	144.1
Point 2	150	143.8
Point 3	68.2	143.8
Point 4	65.2	143.8
Point 5	-36.8	143.2
Point 6	-39.3	143.2
Point 7	-100	143.1
Point 8	65.2	142.8
Point 9	150	142.3
Point 10	-36.8	142.2
Point 11	93.2	142.2
Point 12	-39.3	141.7
Point 13	-39.8	141.7
Point 14	-100	141.3
Point 15	-64.3	141.3
Point 16	80.1	140
Point 17	89.9	140

Point 18	84.1	140
Point 19	-61.5	139.4
Point 20	-59.4	139.4
Point 21	-54.1	139.4
Point 22	-51.7	139.4
Point 23	62.7	138.1
Point 24	65.2	138.1
Point 25	-36.8	137.5
Point 26	-34.3	137.5
Point 27	84.1	136.5
Point 28	150	136.5
Point 29	74.1	136
Point 30	62.7	135.1
Point 31	-34.3	134.5
Point 32	65.2	134.1
Point 33	65.4	134.1
Point 34	67.9	134.1
Point 35	68.2	134.1
Point 36	-39.8	133.5
Point 37	-39.6	133.5
Point 38	69.7	133.1
Point 39	62.7	133.1
Point 40	65.4	133.1
Point 41	67.9	133.1
Point 42	-37.1	132.5
Point 43	-34.3	132.5
Point 44	-39.6	132.5
Point 45	-41.3	132.5
Point 46	57.7	132.2
Point 47	57.3	132
Point 48	65.4	131.1

Point 49	67.9	131.1
Point 50	-39.6	130.5
Point 51	-37.1	130.5
Point 52	49.1	130.3
Point 53	53.6	129.9
Point 54	-19.5	129
Point 55	-23.7	128.4
Point 56	-54.1	125.5
Point 57	74.1	125
Point 58	84.1	124.9
Point 59	150	124.9
Point 60	-39.6	124.7
Point 61	-59.4	124.3
Point 62	-100	124.3
Point 63	33.3	123.9
Point 64	10.6	123.6
Point 65	19.9	123.4
Point 66	64.9	123
Point 67	23.7	122.9
Point 68	36.3	122.8
Point 69	33.3	122.8
Point 70	1.3	122.6
Point 71	57.7	122.4
Point 72	-3.2	122.1
Point 73	1.3	122.1
Point 74	-54.1	120
Point 75	21.5	119.5
Point 76	-100	118.5
Point 77	-59.4	118.5
Point 78	64.9	118
Point 79	-39.6	116

Point 80	-12.4	116
Point 81	64.9	116
Point 82	74.1	113.3
Point 83	-39.6	113.2
Point 84	-100	112.8
Point 85	-59.4	112.8
Point 86	-54.1	112.5
Point 87	150	112.4
Point 88	84.1	112.4
Point 89	150	110.7
Point 90	84.1	110.7
Point 91	74.1	109.8
Point 92	-39.6	106
Point 93	-54.1	101
Point 94	-100	100.7
Point 95	-59.4	100.7
Point 96	40.1	118
Point 97	-100	80
Point 98	150	80
Point 99	-64	141.09643
Point 100	70.8	115

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	97,98,89,90,91,81,96,75,92,93,95,94	7,559.4
Region 2	Glacial Till	89,87,88,82,100,78,96,81,91,90	188.2
Region 3	Glacial Till	94,95,93,92,75,80,83,86,85,84	909.19
Region 4	Soft to Med Stiff Clay (South)	84,85,86,83,80,79,74,77,76	379.15
Region 5	Abutment	13,12,6,5,10,25,26,31,43,42,51,50,44,37,36	48.65

Region 6	Structural Fill	14,15,99,19,20,21,22,45,44,37,36,13,12,6,7	202.41
Region 7	Organic Silt	76,77,74,79,80,75,60,56,61,62	681.76
Region 8	Fill (South)	62,61,56,60,50,44,45,22,21,20,19,99,15,14	920.14
Region 9	Abutment	48,49,41,34,35,3,4,8,24,23,30,39,40	49.3
Region 10	Soft Clay (North)	75,96,78,100,66,71	141.43
Region 11	Med Stiff Clay (North)	66,100,82,88,87,59,58,57	1,006.8
Region 12	Structural Fill	41,38,29,16,18,17,11,9,2,1,3,35,34	238.31
Region 13	Upper Fill (North)	29,27,28,9,11,17,18,16	387.58
Region 14	Lower Fill (North)	48,66,57,58,59,28,27,29,38,41,49	959.51
Region 15	Gabion Blanket	63,69,68,53,47,46,30,23,52	73.44
Region 16	Gabion Blanket	31,55,72,73,70,54,26	78.295
Region 17	Alluvium	60,75,71,66,48,40,39,30,46,47,53,68,69,63,67,65,64,70,73,72,55,31,43,42,51,50	487.25

Current Slip Surface

Slip Surface: 545
F of S: 1.668
Volume: 1,076.1451 ft³
Weight: 121,408.59 lbs
Resisting Moment: 1,882,930.2 lbs-ft
Activating Moment: 1,129,097.1 lbs-ft
Resisting Force: 28,069.59 lbs
Activating Force: 16,827.311 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (2.191815, 122.69589) ft
Entry: (-74.540888, 143.14194) ft
Radius: 59.297737 ft
Center: (-24.834739, 175.47645) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-73.916886	142.22097	-0	233.47078	145.88874	0
Slice 2	-72.439495	140.15	-0	390.88918	253.8464	0
Slice 3	-70.388421	137.56104	89.791367	627.95521	349.48769	0
Slice 4	-67.993053	134.84975	258.97531	909.7644	422.62738	0

Slice 5	-65.597684	132.44295	409.16014	1,168.6388	493.21121	0
Slice 6	-64.35	131.26377	482.7409	1,133.7459	422.76759	0
Slice 7	-64.15	131.08623	493.81932	1,124.2261	409.39095	0
Slice 8	-62.75	129.9132	567.01659	1,239.6569	436.81775	0
Slice 9	-60.45	128.08394	681.16194	1,443.445	495.03238	0
Slice 10	-57.72417	126.17687	800.16334	1,660.9032	558.971	0
Slice 11	-55.07417	124.4812	0	1,940.9758	0	326.38588
Slice 12	-52.9	123.25857	0	2,075.5277	0	337.40177
Slice 13	-51.398551	122.46257	0	2,174.1928	0	343.10711
Slice 14	-49.872464	121.74091	0	2,252.3375	0	348.2068
Slice 15	-47.423188	120.6656	0	2,381.5143	0	355.72818
Slice 16	-44.973913	119.71858	0	2,498.3434	0	362.22328
Slice 17	-42.524638	118.89339	0	2,603.3436	0	367.74376
Slice 18	-40.55	118.30437	0	2,681.595	0	371.58439
Slice 19	-39.7	118.07231	0	2,456.0117	0	373.06564
Slice 20	-39.45	118.00827	0	3,033.8314	0	373.43172
Slice 21	-38.2	117.71559	0	3,101.4244	0	374.92207
Slice 22	-36.95	117.42976	0	3,085.112	0	376.35769
Slice 23	-35.55	117.16874	0	2,288.6062	0	377.49267
Slice 24	-32.975	116.75534	0	2,296.1951	0	379.04662
Slice 25	-30.325	116.44842	0	2,282.0707	0	379.69772
Slice 26	-27.675	116.26163	0	2,255.3146	0	379.38781
Slice 27	-25.025	116.19382	0	2,215.9518	0	378.12601
Slice 28	-22.65	116.22829	0	2,164.2791	0	376.23326
Slice 29	-20.55	116.34309	0	2,102.5637	0	373.88508
Slice 30	-18.141667	116.57352	0	2,031.5569	0	370.40194
Slice 31	-15.425	116.94624	0	1,973.697	0	365.57052
Slice 32	-12.708333	117.44847	0	1,901.8009	0	359.70301
Slice 33	-9.9916667	118.08362	0	1,815.3595	0	352.77214
Slice 34	-7.275	118.85618	0	1,713.7249	0	344.74203
Slice 35	-4.5583333	119.77188	0	1,596.0833	0	335.56683

Slice 36	-1.8777788	120.82169	0	1,454.2023	0	325.34328
Slice 37	0.21972965	121.73853	1,077.1155	1,249.3579	99.444175	0
Slice 38	1.1475084	122.17433	1,049.9217	1,200.4854	150.56374	0
Slice 39	1.7459075	122.47228	1,031.3298	1,082.1402	29.335406	0

Project: Final Design of Burnham Bridge Replacement	**Job No:59522**	**Design Criteria Document:**
Client: MaineDOT	**Discipline: Geotech**	**Calculation No: Station 18+50**

Name or Description of Calculation:

Calc. Rev. No.	Originator	Checker	Senior Technical Reviewer (if required)	Confirmation Required (Y/N)
01	M. Restrepo	B. Materek		

Calculation Objective:

The objective of this calculation is to examine the global stability in the transverse direction of the South Approach embankment for the replacement of the Burnham Bridge. Station 18+50 was examined because it is representative of the South Approach embankment. Multiple analyses were performed to ensure stability for slip surfaces developing on top of the embankment and extending beyond the toe of slope (global analysis) for the east and west sides of the embankment.

Calculation Methodology/List of Assumptions:

- Soil Parameters have been developed from borings performed by Schonewald Engineering Associates between March of 2016 and July of 2017.
- The stratigraphy of the following cross-section has been developed from borings BB-WGLC-102, BB-WGLC-201, and BB-WGLC-202.
- The groundwater was assumed to correspond to the average low water elevation and the 50 year flood event (Q50).
- Global stability analyses performed in accordance with AASHTO LRFD Bridge Design Specifications Section 11.6.2.3.
- A live load traffic surcharge of 250 psf was applied at the crest of the slope in accordance with AASHTO LRFD.
- Spenser's method was used to develop the critical slip surface.
- The retained structural backfill fill was assumed to have a unit weight of 115 psf and a friction angle of 32º.
- The reported factors of safety include the contribution from geogrid reinforcing placed directly behind each abutment.
- Analyses results using both optimized and non-optimized slip surfaces have been reported.

References/Inputs:

SLOPE/W version 8.16.2 by GeoStudio 2016
MaineDOT Boring logs performed by Schonewald Engineering Associates
Contract Document Drawing No. 8, 9, and 18.

Attachments:

- South Approach Embankment Analysis (Analysis @ East Side)
- South Approach Embankment Analysis (Analysis @ West Side)

Conclusions:

Table 1: Summary of Stability Results for Proposed Approach Embankment

Location	Station	Water level	Condition	East - Factor of Safety		West - Factor of Safety	
				Optimized	Non-Optimized	Optimized	Non-Optimized
South Approach	18+50	133.0	Undrained	1.30	1.39	1.39	1.48
		139.0	Undrained	1.49	1.56	1.72	1.83
		133.0	Drained	1.51	1.56	1.50	1.57
		139.0	Drained	1.50	1.64	1.51	1.62

Document Check:	Name	Signature	Date
Originator:	M. Restrepo		10/16/17
Checker:	B. Materek		10/18/17
BackChecker:	M. Restrepo		11/07/17
Updater:	B. Materek		11/07/17
Verifier:	M. Restrepo		11/09/17

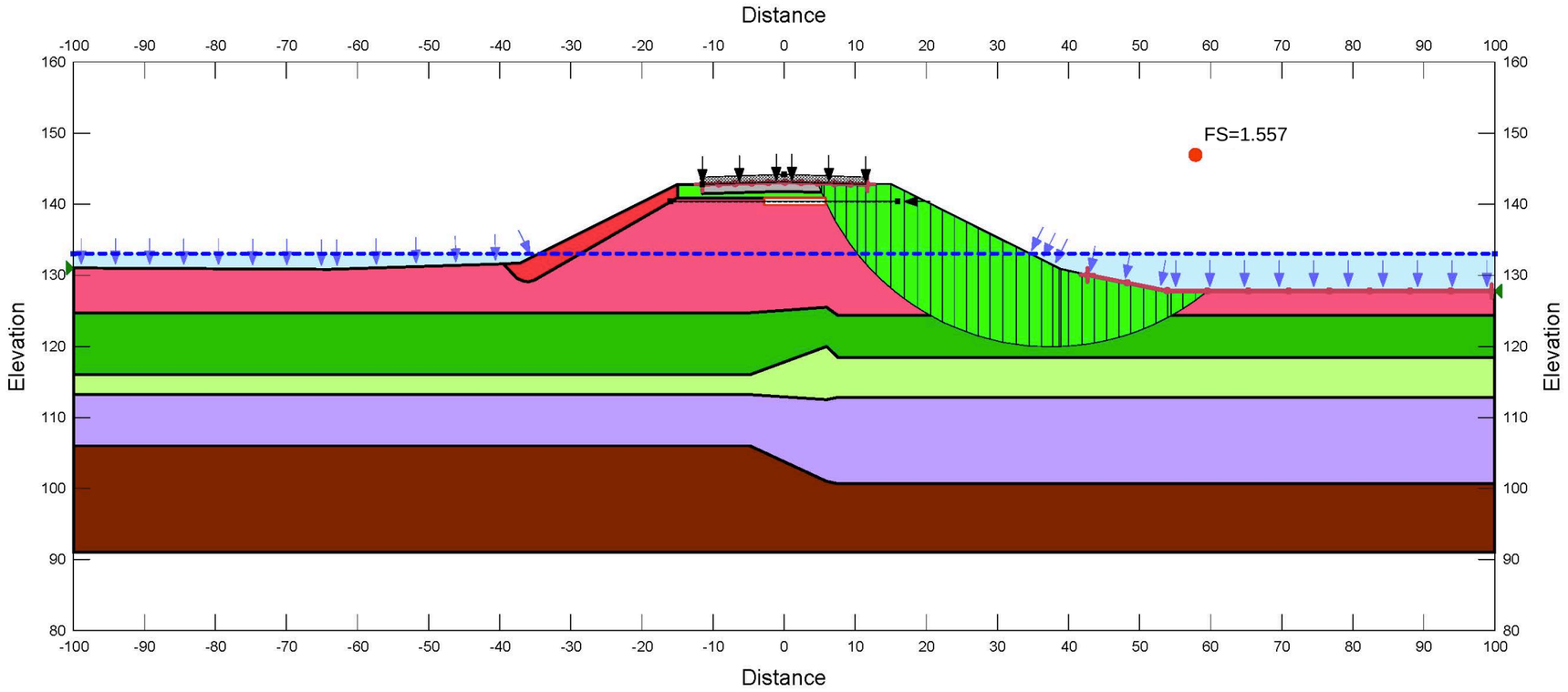
SOUTH APPROACH EMBANKMENT

GLOBAL STABILITY ANALYSIS

EAST SIDE

WATER EL. 133 FEET

HNTB



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Fill (South)	Mohr-Coulomb	1	114	0	33	0
	Gabion Blanket	Mohr-Coulomb	1	130	0	45	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Organic Silt	Mohr-Coulomb	1	103	0	25	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	1	106	0	28	0

HNTB

HNTB PROJECT NUMBER 63738

SOUTH ABUTMENT | DRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

EAST SIDE
STATION 18+50

East Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 141
Date: 10/18/2017
Time: 5:35:37 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_South_Abutment_Drained_LowGTW_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 18+50 Transverse w Geogrid\Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:48:46 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

East Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: Mohr-Coulomb
Unit Weight: 103 pcf

Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-11.5, 142.8) ft
Left-Zone Right Coordinate: (11.7, 142.8) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (42.7, 130.04132) ft
Right-Zone Right Coordinate: (99.5, 127.8) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 131) ft
Right Coordinate: (100, 127.8) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	100	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-11.5	142.8
	-11.5	143.8
	0	144.2
	11.5	143.8

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (16, 140.36) ft
Inside Point: (-16, 140.36) ft
Slip Surface Intersection: (5.8327494, 140.36) ft
Length: 32 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 1,324 lbs
Pullout Force per Length: 153.33333 lbs/ft
Available Length: 10.167251 ft
Required Length: 8.6347826 ft
Governing Component: Tensile Capacity

Points

	X (ft)	Y (ft)
Point 1	0	143.1
Point 2	11.5	142.8
Point 3	-11.5	142.8
Point 4	-12.9	142.8

Point 5	12.9	142.8
Point 6	15	142.8
Point 7	-15	142.8
Point 8	-11.5	141.5
Point 9	11.5	141.5
Point 10	15	140.9
Point 11	-15	140.9
Point 12	-37.1	131.7
Point 13	-39.5	131.6
Point 14	-100	131
Point 15	38.9	130.8
Point 16	-64	130.8
Point 17	41.9	130.2
Point 18	-37.6	129.6
Point 19	-35.1	129.3
Point 20	-36.8	129.2
Point 21	-36	129.1
Point 22	40	128.3
Point 23	37.8	128
Point 24	100	127.8
Point 25	38.7	127.8
Point 26	54	127.8
Point 27	6	125.5
Point 28	-100	124.7
Point 29	-4.8	124.7
Point 30	7.6	124.3
Point 31	100	124.3
Point 32	6	120
Point 33	7.6	118.4
Point 34	100	118.4
Point 35	-4.8	116

Point 36	-100	116
Point 37	-4.8	113.2
Point 38	-100	113.2
Point 39	7.6	112.8
Point 40	100	112.8
Point 41	6	112.5
Point 42	-100	106
Point 43	-4.8	106
Point 44	6	101
Point 45	7.6	100.7
Point 46	-100	91
Point 47	100	91
Point 48	0	141.8
Point 49	100	100.7

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	46,47,49,45,44,43,42	2,475
Region 2	Glacial Till	42,43,44,45,49,40,39,41,37,38	1,923.3
Region 3	Soft to Med Stiff Clay (South)	38,37,41,39,40,34,33,32,35,36	850.1
Region 4	Pavement Box	3,8,48,9,2,1	29.9
Region 5	Embankment Fill	3,4,7,11,10,6,5,2,9,48,8	30.55
Region 6	Gabion Blanket	7,12,13,18,20,21,19,11	62.415
Region 7	Gabion Blanket	6,15,17,22,25,23,10	68.41
Region 8	Organic Silt	36,35,32,33,34,31,30,27,29,28	1,459.2
Region 9	Fill (South)	28,29,27,30,31,24,26,17,22,25,23,10,11,19,21,20,18,13,16,14	1,565.2

Current Slip Surface

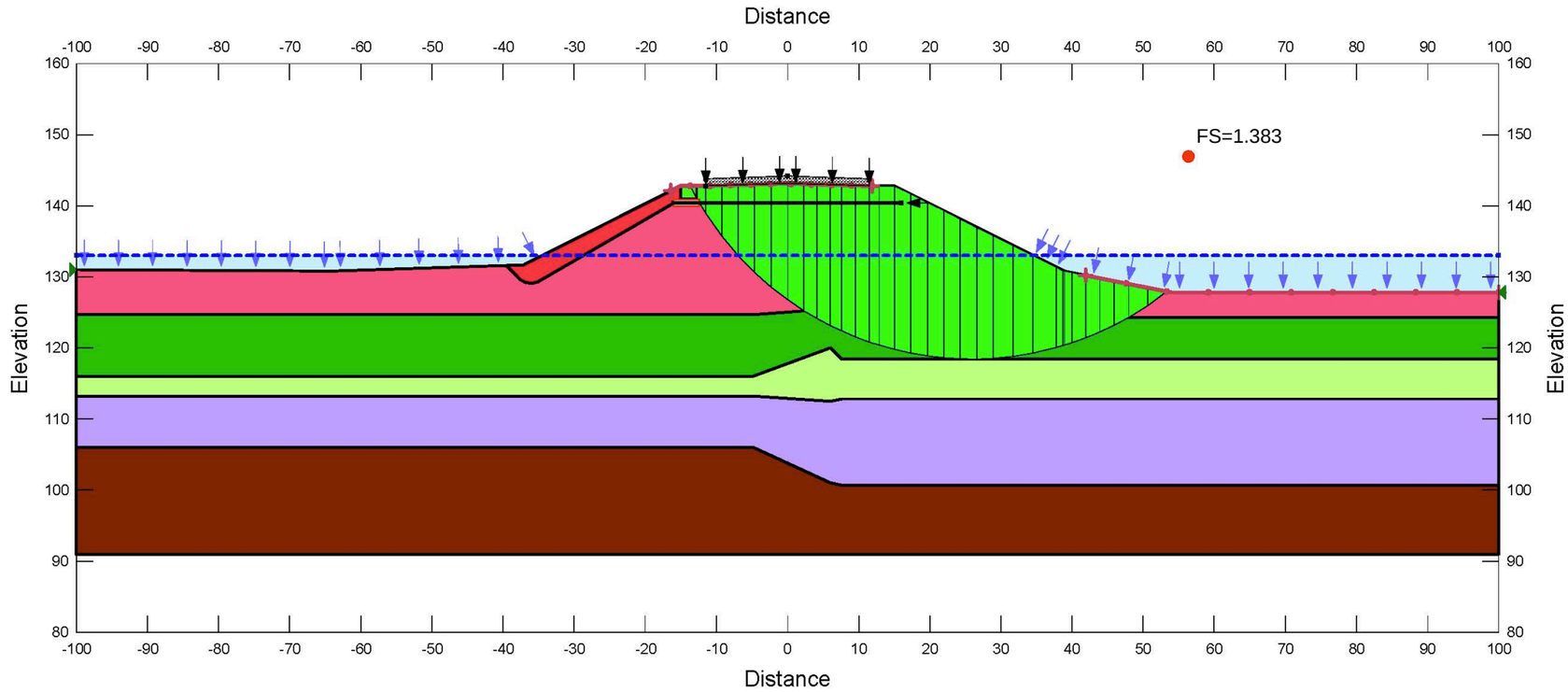
Slip Surface: 888
F of S: 1.557
Volume: 562.66063 ft³
Weight: 64,292.208 lbs
Resisting Moment: 821,502.02 lbs-ft
Activating Moment: 527,805.43 lbs-ft

Resisting Force: 19,364.194 lbs
Activating Force: 12,440.222 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (59.585905, 127.8) ft
Entry: (4.7399524, 142.97635) ft
Radius: 34.857852 ft
Center: (37.533016, 154.79518) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	4.9916606	142.31978	-0	138.35389	100.51998	0
Slice 2	5.403874	141.28161	-0	212.96713	133.07663	0
Slice 3	6.3585397	139.30203	-0	344.5893	223.77891	0
Slice 4	7.9468609	136.42503	-0	560.32319	363.87813	0
Slice 5	9.5351821	134.07299	-0	761.49473	494.52046	0
Slice 6	10.914671	132.30717	43.232884	942.14971	583.76342	0
Slice 7	12.2	130.87305	132.72192	932.57217	519.42883	0
Slice 8	13.95	129.16561	239.26621	1,130.7543	578.93912	0
Slice 9	15.941285	127.45605	345.94261	1,326.0585	636.49468	0
Slice 10	17.823854	126.06687	432.62704	1,427.3013	645.949	0
Slice 11	19.706423	124.86055	507.9016	1,497.4687	642.63241	0
Slice 12	21.479216	123.86837	569.81357	1,588.0112	474.79336	0
Slice 13	23.142233	123.05969	620.27542	1,613.276	463.04379	0
Slice 14	24.805249	122.35638	664.16188	1,625.9515	448.48988	0
Slice 15	26.468266	121.75169	701.89432	1,626.6208	431.20704	0
Slice 16	28.131282	121.24028	733.80655	1,615.7056	411.23626	0
Slice 17	29.888714	120.7991	761.33628	1,591.633	387.17374	0
Slice 18	31.740562	120.4348	784.06819	1,553.1003	358.60557	0
Slice 19	33.59241	120.17333	800.38447	1,500.8146	326.61593	0
Slice 20	35.33875	120.01618	810.19055	1,467.0108	306.28033	0
Slice 21	36.979583	119.95138	814.23359	1,454.9662	298.7785	0
Slice 22	38.25	119.94761	814.46898	1,437.6597	290.59859	0
Slice 23	38.8	119.96051	813.66428	1,425.3453	285.23155	0
Slice 24	39.45	119.99444	811.54682	1,407.731	278.00525	0

Slice 25	40.95	120.11835	803.81499	1,370.3743	264.19094	0
Slice 26	42.764286	120.3432	789.78459	1,326.7348	250.384	0
Slice 27	44.492857	120.6506	770.60243	1,293.688	243.91879	0
Slice 28	46.221429	121.0493	745.72385	1,249.8657	235.08518	0
Slice 29	47.95	121.54257	714.94335	1,194.4228	223.58493	0
Slice 30	49.678571	122.13473	677.99268	1,126.2556	209.02843	0
Slice 31	51.407143	122.83129	634.52775	1,043.9035	190.89506	0
Slice 32	53.135714	123.63926	584.10994	945.39345	168.46927	0
Slice 33	54.209162	124.18605	549.9907	866.95082	147.80093	0
Slice 34	55.279588	124.80973	511.07287	833.54118	209.41337	0
Slice 35	57.002115	125.89976	443.055	691.09049	161.07613	0
Slice 36	58.724642	127.14003	365.66213	508.94548	93.049294	0



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
	Bedrock	Bedrock (Impenetrable)	1							
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0			
	Fill (South)	Mohr-Coulomb	1	114	0	33	0			
	Gabion Blanket	Mohr-Coulomb	1	130	0	45	0			
	Glacial Till	Mohr-Coulomb	1	126	0	38	0			
	Organic Silt	S=f(depth)		103				320	8	1,000
	Pavement Box	Mohr-Coulomb	1	130	0	36	0			
	Soft to Med Stiff Clay (South)	Mohr-Coulomb		106	506	0	0			

HNTB

HNTB PROJECT NUMBER 63738

SOUTH ABUTMENT | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

EAST SIDE
STATION 18+50

East Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 127
Date: 10/18/2017
Time: 5:40:36 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_South_Abutment_Undrained_LowGTW_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 18+50 Transverse w Geogrid\Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 11:59:36 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

East Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: S=f(depth)
Unit Weight: 103 pcf

C-Top of Layer: 320 psf
C-Rate of Change: 8 (lbs/ft²)/ft
C-Maximum: 1,000 psf

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 506 psf
Phi': 0 °
Phi-B: 0 °

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-16.4, 142.09683) ft
Left-Zone Right Coordinate: (11.9, 142.8) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (41.9, 130.2) ft
Right-Zone Right Coordinate: (100, 127.8) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 131) ft
Right Coordinate: (100, 127.8) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	100	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-11.5	142.8
	-11.5	143.8
	0	144.2
	11.5	143.8

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (16, 140.4) ft
Inside Point: (-16, 140.4) ft
Slip Surface Intersection: (-12.398206, 140.4) ft
Length: 32 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 552.27503 lbs
Pullout Force per Length: 153.33333 lbs/ft
Available Length: 3.6017937 ft
Required Length: 3.6017937 ft
Governing Component: Pullout Resistance

Points

	X (ft)	Y (ft)
Point 1	0	143.1
Point 2	11.5	142.8
Point 3	-11.5	142.8
Point 4	-12.9	142.8
Point 5	12.9	142.8
Point 6	15	142.8
Point 7	-15	142.8

Point 8	-11.5	141.5
Point 9	11.5	141.5
Point 10	15	140.9
Point 11	-15	140.9
Point 12	-37.1	131.7
Point 13	-39.5	131.6
Point 14	-100	131
Point 15	38.9	130.8
Point 16	-64	130.8
Point 17	41.9	130.2
Point 18	-37.6	129.6
Point 19	-35.1	129.3
Point 20	-36.8	129.2
Point 21	-36	129.1
Point 22	40	128.3
Point 23	37.8	128
Point 24	100	127.8
Point 25	38.7	127.8
Point 26	54	127.8
Point 27	6	125.5
Point 28	-100	124.7
Point 29	-4.8	124.7
Point 30	7.6	124.3
Point 31	100	124.3
Point 32	6	120
Point 33	7.6	118.4
Point 34	100	118.4
Point 35	-4.8	116
Point 36	-100	116
Point 37	-4.8	113.2
Point 38	-100	113.2

Point 39	7.6	112.8
Point 40	100	112.8
Point 41	6	112.5
Point 42	-100	106
Point 43	-4.8	106
Point 44	6	101
Point 45	7.6	100.7
Point 46	-100	91
Point 47	100	91
Point 48	0	141.8
Point 49	100	100.7

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	46,47,49,45,44,43,42	2,475
Region 2	Glacial Till	42,43,44,45,49,40,39,41,37,38	1,923.3
Region 3	Soft to Med Stiff Clay (South)	38,37,41,39,40,34,33,32,35,36	850.1
Region 4	Pavement Box	3,8,48,9,2,1	29.9
Region 5	Embankment Fill	3,4,7,11,10,6,5,2,9,48,8	30.55
Region 6	Gabion Blanket	7,12,13,18,20,21,19,11	62.415
Region 7	Gabion Blanket	6,15,17,22,25,23,10	68.41
Region 8	Organic Silt	36,35,32,33,34,31,30,27,29,28	1,459.2
Region 9	Fill (South)	28,29,27,30,31,24,26,17,22,25,23,10,11,19,21,20,18,13,16,14	1,565.2

Current Slip Surface

Slip Surface: 150
F of S: 1.383
Volume: 940.68613 ft^3
Weight: 106,873.84 lbs
Resisting Moment: 1,347,426.2 lbs-ft
Activating Moment: 974,715.89 lbs-ft
Resisting Force: 25,979.345 lbs
Activating Force: 18,789.592 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (53.344199, 127.93008) ft

Entry: (-13.719219, 142.8) ft
Radius: 44.399214 ft
Center: (25.903148, 162.83393) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-13.309609	142.02801	-0	44.45703	27.779836	0
Slice 2	-12.799935	141.07801	-0	102.15743	63.835046	0
Slice 3	-12.099935	139.90562	-0	176.30324	114.49266	0
Slice 4	-10.369717	137.30526	-0	513.21705	333.28705	0
Slice 5	-8.1091505	134.34964	-0	767.21413	498.23468	0
Slice 6	-5.8157228	131.81077	74.207876	1,033.1533	622.74646	0
Slice 7	-3.4894337	129.59305	212.59337	1,302.4449	707.75786	0
Slice 8	-1.1631446	127.66929	332.63613	1,548.6985	789.72013	0
Slice 9	1.1517076	126.0001	436.79385	1,765.3212	862.7557	0
Slice 10	3.2275614	124.67699	0	2,131.0624	0	324.94119
Slice 11	5.0758538	123.63675	0	2,246.3806	0	334.35836
Slice 12	6.8	122.76431	0	2,353.1971	0	337.08554
Slice 13	8.575	121.96947	0	2,452.8671	0	338.64424
Slice 14	10.525	121.19594	0	2,544.8172	0	344.83252
Slice 15	12.2	120.60867	0	2,359.5434	0	349.53063
Slice 16	13.95	120.08789	0	2,431.8537	0	353.69688
Slice 17	16.163566	119.53256	0	2,478.0115	0	358.13951
Slice 18	18.490698	119.07375	0	2,423.5371	0	361.80999
Slice 19	20.817829	118.74246	0	2,353.5482	0	364.46034
Slice 20	23.144961	118.53581	0	2,271.2271	0	366.11354
Slice 21	25.472093	118.45206	0	2,175.183	0	366.78353
Slice 22	27.799225	118.49051	0	2,065.3794	0	366.47592
Slice 23	30.351676	118.68019	0	1,928.2405	0	364.95844
Slice 24	33.129448	119.04935	0	1,760.2148	0	362.00519
Slice 25	36.159167	119.66843	0	1,607.1947	0	357.05253
Slice 26	38.25	120.18858	0	1,520.5985	0	352.89138

Slice 27	38.8	120.34922	0	1,491.7306	0	351.60624
Slice 28	39.45	120.55581	0	1,456.9164	0	349.95353
Slice 29	40.95	121.07435	0	1,376.7	0	345.80524
Slice 30	42.909705	121.83549	0	1,275.075	0	339.71611
Slice 31	44.929114	122.73338	0	1,177.0891	0	332.53294
Slice 32	46.948523	123.75622	0	1,064.714	0	324.35023
Slice 33	49.304721	125.13585	490.72277	861.68269	240.90419	0
Slice 34	51.997706	126.95089	377.4644	560.2518	118.70353	0

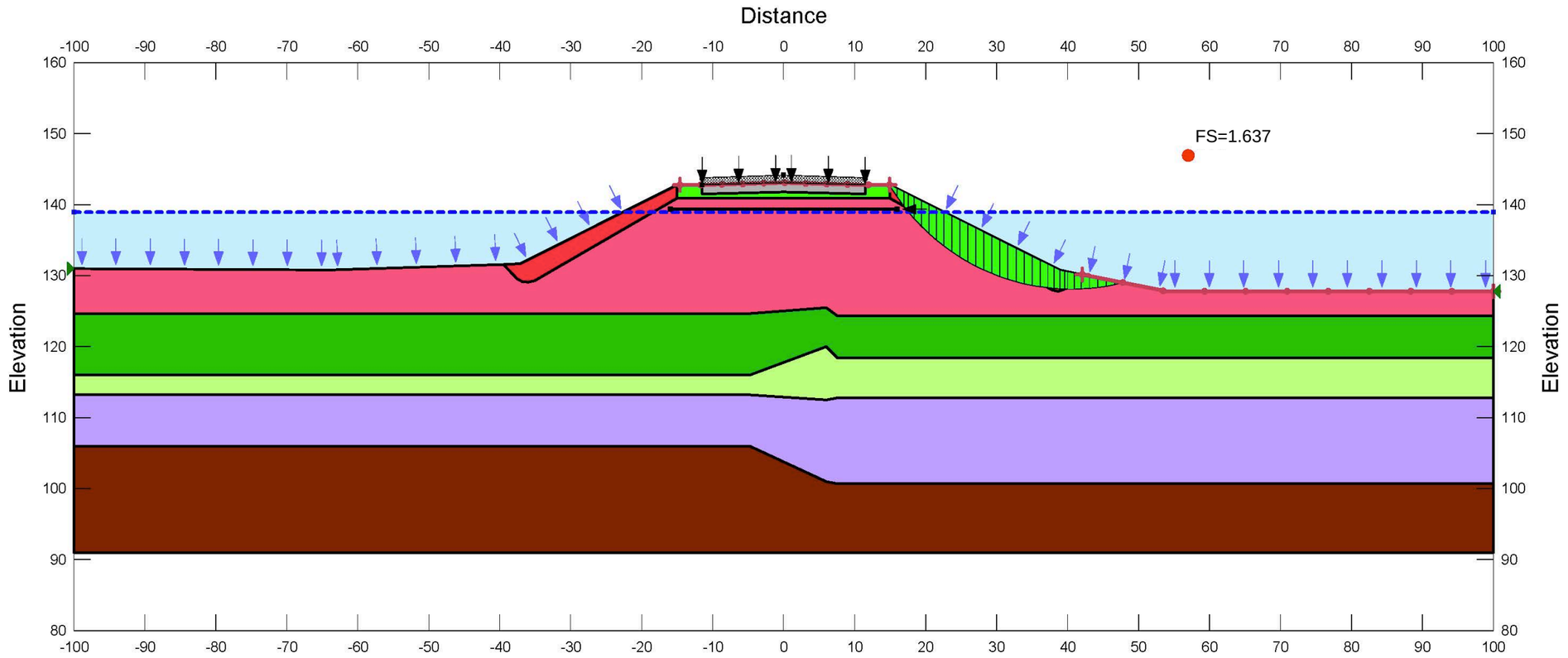
SOUTH APPROACH EMBANKMENT

GLOBAL STABILITY ANALYSIS

EAST SIDE

WATER EL. 139 FEET

HNTB



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Fill (South)	Mohr-Coulomb	1	114	0	33	0
	Gabion Blanket	Mohr-Coulomb	1	130	0	45	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Organic Silt	Mohr-Coulomb	1	103	0	25	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	1	106	0	28	0

HNTB

HNTB PROJECT NUMBER 63738

SOUTH ABUTMENT | DRAINED

PREPARED BY: MRR | CHECKED BY: BAM | BACK CHECKED BY: MRR

DATE: 10/16/2017 | DATE: 10/18/2017 | DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

EAST SIDE
STATION 18+50

East Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 145
Date: 10/18/2017
Time: 5:35:42 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_South_Abutment_Drained_HighGTW_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 18+50 Transverse w Geogrid\Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:49:38 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

East Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: Mohr-Coulomb
Unit Weight: 103 pcf

Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-14.6, 142.8) ft
Left-Zone Right Coordinate: (14.9, 142.8) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (42.1, 130.16033) ft
Right-Zone Right Coordinate: (100, 127.8) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 131) ft
Right Coordinate: (100, 127.8) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	100	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-11.5	142.8
	-11.5	143.8
	0	144.2
	11.5	143.8

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (16, 139.4) ft
Inside Point: (-16, 139.4) ft
Slip Surface Intersection: () ft
Length: 32 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	0	143.1
Point 2	11.5	142.8
Point 3	-11.5	142.8
Point 4	-12.9	142.8

Point 5	12.9	142.8
Point 6	15	142.8
Point 7	-15	142.8
Point 8	-11.5	141.5
Point 9	11.5	141.5
Point 10	15	140.9
Point 11	-15	140.9
Point 12	-37.1	131.7
Point 13	-39.5	131.6
Point 14	-100	131
Point 15	38.9	130.8
Point 16	-64	130.8
Point 17	41.9	130.2
Point 18	-37.6	129.6
Point 19	-35.1	129.3
Point 20	-36.8	129.2
Point 21	-36	129.1
Point 22	40	128.3
Point 23	37.8	128
Point 24	100	127.8
Point 25	38.7	127.8
Point 26	54	127.8
Point 27	6	125.5
Point 28	-100	124.7
Point 29	-4.8	124.7
Point 30	7.6	124.3
Point 31	100	124.3
Point 32	6	120
Point 33	7.6	118.4
Point 34	100	118.4
Point 35	-4.8	116

Point 36	-100	116
Point 37	-4.8	113.2
Point 38	-100	113.2
Point 39	7.6	112.8
Point 40	100	112.8
Point 41	6	112.5
Point 42	-100	106
Point 43	-4.8	106
Point 44	6	101
Point 45	7.6	100.7
Point 46	-100	91
Point 47	100	91
Point 48	0	141.8
Point 49	100	100.7

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	46,47,49,45,44,43,42	2,475
Region 2	Glacial Till	42,43,44,45,49,40,39,41,37,38	1,923.3
Region 3	Soft to Med Stiff Clay (South)	38,37,41,39,40,34,33,32,35,36	850.1
Region 4	Pavement Box	3,8,48,9,2,1	29.9
Region 5	Embankment Fill	3,4,7,11,10,6,5,2,9,48,8	30.55
Region 6	Gabion Blanket	7,12,13,18,20,21,19,11	62.415
Region 7	Gabion Blanket	6,15,17,22,25,23,10	68.41
Region 8	Organic Silt	36,35,32,33,34,31,30,27,29,28	1,459.2
Region 9	Fill (South)	28,29,27,30,31,24,26,17,22,25,23,10,11,19,21,20,18,13,16,14	1,565.2

Current Slip Surface

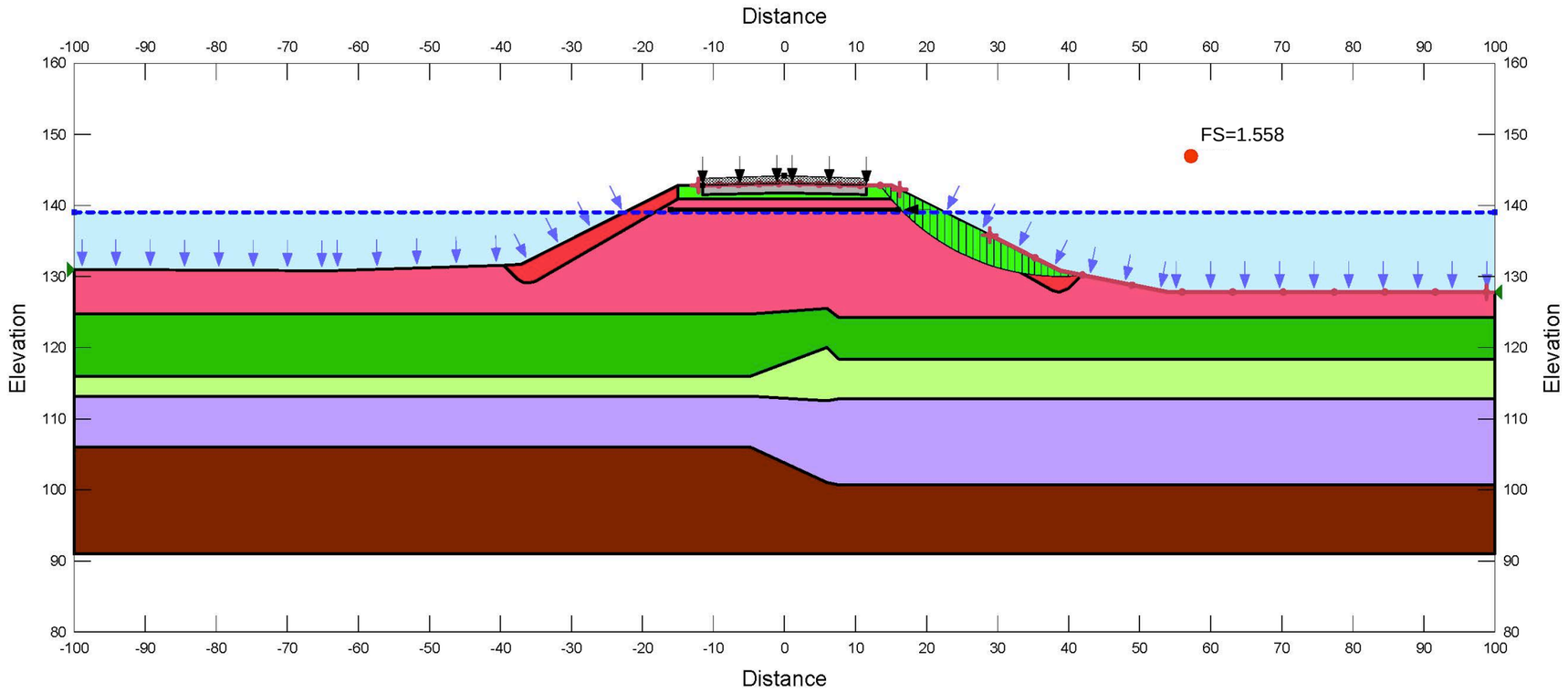
Slip Surface: 1,227
F of S: 1.637
Volume: 112.43689 ft³
Weight: 13,878.664 lbs
Resisting Moment: 148,286.28 lbs-ft
Activating Moment: 90,571.413 lbs-ft

Resisting Force: 4,371.9509 lbs
Activating Force: 2,670.2605 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (47.8021, 129.02934) ft
Entry: (14.9, 142.8) ft
Radius: 29.764048 ft
Center: (40.551286, 157.89669) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	14.95	142.71568	-0	5.2997106	3.3116267	0
Slice 2	15.475659	141.88637	-0	41.921368	41.921368	0
Slice 3	16.426978	140.48245	-0	106.3953	106.3953	0
Slice 4	17.228988	139.41175	-0	179.44622	116.53374	0
Slice 5	17.956739	138.53166	29.224563	230.62977	130.79408	0
Slice 6	18.884414	137.50415	93.340786	296.68021	132.05016	0
Slice 7	19.936962	136.43939	159.78182	362.57088	131.69275	0
Slice 8	20.989511	135.47465	219.98154	419.08661	129.30035	0
Slice 9	22.042059	134.59744	274.72001	467.0592	124.90653	0
Slice 10	23.13258	133.77196	326.22998	522.52347	127.47448	0
Slice 11	24.261074	132.99543	374.68528	586.65938	137.65759	0
Slice 12	25.389567	132.29218	418.56775	644.34223	146.61966	0
Slice 13	26.518061	131.65631	458.24637	695.89504	154.33085	0
Slice 14	27.646554	131.08299	494.02113	741.57647	160.76431	0
Slice 15	28.775048	130.56829	526.13842	781.592	165.89349	0
Slice 16	29.903542	130.10894	554.80196	816.10193	169.69019	0
Slice 17	31.032035	129.70223	580.18094	845.2273	172.12312	0
Slice 18	32.160529	129.3459	602.41603	869.05396	173.15669	0
Slice 19	33.289022	129.03808	621.62389	887.63542	172.74991	0
Slice 20	34.417516	128.77723	637.90071	900.99468	170.85522	0
Slice 21	35.54601	128.5621	651.3248	909.12493	167.41736	0
Slice 22	36.674503	128.39169	661.95866	911.98957	162.37197	0
Slice 23	37.654062	128.27693	669.11981	909.62111	240.5013	0
Slice 24	38.484687	128.20739	673.45862	899.57961	226.12099	0

Slice 25	39.252036	128.1631	676.22241	870.70937	194.48696	0
Slice 26	39.802036	128.14273	677.49336	864.08893	121.17658	0
Slice 27	40.475	128.13653	677.8804	850.82031	112.30849	0
Slice 28	41.425	128.14927	677.08582	825.97597	96.690395	0
Slice 29	42.49021	128.20175	673.81052	804.85166	85.099113	0
Slice 30	43.67063	128.3025	667.52384	786.96638	77.56689	0
Slice 31	44.85105	128.4509	658.26401	762.62051	67.769901	0
Slice 32	46.03147	128.64767	645.9857	731.40719	55.473364	0
Slice 33	47.21189	128.89379	630.62737	692.82459	40.391347	0



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
	Bedrock	Bedrock (Impenetrable)	1							
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0			
	Fill (South)	Mohr-Coulomb	1	114	0	33	0			
	Gabion Blanket	Mohr-Coulomb	1	130	0	45	0			
	Glacial Till	Mohr-Coulomb	1	126	0	38	0			
	Organic Silt	S=f(depth)		103				320	8	1,000
	Pavement Box	Mohr-Coulomb	1	130	0	36	0			
	Soft to Med Stiff Clay (South)	Mohr-Coulomb		106	506	0	0			

HNTB

HNTB PROJECT NUMBER 63738

SOUTH ABUTMENT | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

EAST SIDE
STATION 18+50

East Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 129
Date: 10/18/2017
Time: 5:40:50 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_South_Abutment_Undrained_HighGTW_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 18+50 Transverse w Geogrid\Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:47:24 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

East Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: S=f(depth)
Unit Weight: 103 pcf

C-Top of Layer: 320 psf
C-Rate of Change: 8 (lbs/ft²)/ft
C-Maximum: 1,000 psf

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 506 psf
Phi': 0 °
Phi-B: 0 °

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-12.1, 142.8) ft
Left-Zone Right Coordinate: (16.195, 142.2) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (28.9, 135.82092) ft
Right-Zone Right Coordinate: (98.8, 127.8) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 131) ft
Right Coordinate: (100, 127.8) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	100	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-11.5	142.8
	-11.5	143.8
	0	144.2
	11.5	143.8

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (16, 139.4) ft
Inside Point: (-16, 139.4) ft
Slip Surface Intersection: () ft
Length: 32 ft
Direction: 0 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	0	143.1
Point 2	11.5	142.8
Point 3	-11.5	142.8
Point 4	-12.9	142.8
Point 5	12.9	142.8
Point 6	15	142.8
Point 7	-15	142.8

Point 8	-11.5	141.5
Point 9	11.5	141.5
Point 10	15	140.9
Point 11	-15	140.9
Point 12	-37.1	131.7
Point 13	-39.5	131.6
Point 14	-100	131
Point 15	38.9	130.8
Point 16	-64	130.8
Point 17	41.9	130.2
Point 18	-37.6	129.6
Point 19	-35.1	129.3
Point 20	-36.8	129.2
Point 21	-36	129.1
Point 22	40	128.3
Point 23	37.8	128
Point 24	100	127.8
Point 25	38.7	127.8
Point 26	54	127.8
Point 27	6	125.5
Point 28	-100	124.7
Point 29	-4.8	124.7
Point 30	7.6	124.3
Point 31	100	124.3
Point 32	6	120
Point 33	7.6	118.4
Point 34	100	118.4
Point 35	-4.8	116
Point 36	-100	116
Point 37	-4.8	113.2
Point 38	-100	113.2

Point 39	7.6	112.8
Point 40	100	112.8
Point 41	6	112.5
Point 42	-100	106
Point 43	-4.8	106
Point 44	6	101
Point 45	7.6	100.7
Point 46	-100	91
Point 47	100	91
Point 48	0	141.8
Point 49	100	100.7

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	46,47,49,45,44,43,42	2,475
Region 2	Glacial Till	42,43,44,45,49,40,39,41,37,38	1,923.3
Region 3	Soft to Med Stiff Clay (South)	38,37,41,39,40,34,33,32,35,36	850.1
Region 4	Pavement Box	3,8,48,9,2,1	29.9
Region 5	Embankment Fill	3,4,7,11,10,6,5,2,9,48,8	30.55
Region 6	Gabion Blanket	7,12,13,18,20,21,19,11	62.415
Region 7	Gabion Blanket	6,15,17,22,25,23,10	68.41
Region 8	Organic Silt	36,35,32,33,34,31,30,27,29,28	1,459.2
Region 9	Fill (South)	28,29,27,30,31,24,26,17,22,25,23,10,11,19,21,20,18,13,16,14	1,565.2

Current Slip Surface

Slip Surface: 1,116
F of S: 1.558
Volume: 85.68763 ft³
Weight: 10,698.297 lbs
Resisting Moment: 133,061.15 lbs-ft
Activating Moment: 85,429.572 lbs-ft
Resisting Force: 3,780.6245 lbs
Activating Force: 2,427.0862 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (41.927314, 130.19458) ft

Entry: (13.492671, 142.8) ft
Radius: 31.227249 ft
Center: (38.684494, 161.253) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	13.869503	142.30645	-0	33.528623	20.951009	0
Slice 2	14.623168	141.35717	-0	101.54517	63.452467	0
Slice 3	15.444814	140.40559	-0	174.7054	113.45501	0
Slice 4	16.333236	139.45486	-0	218.7714	142.07181	0
Slice 5	17.172167	138.62418	23.451107	262.16727	155.02408	0
Slice 6	17.962815	137.89762	68.788687	304.08208	152.80131	0
Slice 7	18.884414	137.11517	117.61317	346.90989	148.90703	0
Slice 8	19.936962	136.28826	169.21236	389.35677	142.96345	0
Slice 9	20.989511	135.53101	216.46489	424.80371	135.29681	0
Slice 10	22.042059	134.83741	259.7459	453.60939	125.89642	0
Slice 11	23.062218	134.22042	298.24568	488.84722	123.77809	0
Slice 12	24.049987	133.67294	332.40863	532.02796	129.63431	0
Slice 13	25.037756	133.17087	363.73791	571.14962	134.69474	0
Slice 14	26.025525	132.71181	392.38334	606.31074	138.92608	0
Slice 15	27.013295	132.29371	418.47278	637.58917	142.29585	0
Slice 16	28.001064	131.91481	442.11569	665.04407	144.77138	0
Slice 17	28.988833	131.57362	463.40589	688.71729	146.31893	0
Slice 18	29.976602	131.26885	482.42382	708.63446	146.90291	0
Slice 19	30.964371	130.99939	499.23823	724.80558	146.48515	0
Slice 20	31.95214	130.7643	513.90764	737.22535	145.02422	0
Slice 21	32.93991	130.5628	526.48137	745.87309	142.47465	0
Slice 22	33.889311	130.39956	536.6676	749.07249	212.40489	0
Slice 23	34.800346	130.27165	544.64881	745.29732	200.64851	0
Slice 24	35.71138	130.17097	550.93127	737.33455	186.40328	0
Slice 25	36.622414	130.09725	555.53145	725.02626	169.49481	0
Slice 26	37.533449	130.0503	558.46129	708.18533	149.72404	0

Slice 27	38.444483	130.02999	559.72834	686.59082	126.86248	0
Slice 28	39.398465	130.03789	559.2354	635.93852	76.703119	0
Slice 29	40.395395	130.07665	556.81702	621.15045	64.333432	0
Slice 30	41.39693	130.14787	552.37267	600.72471	48.352042	0
Slice 31	41.913657	130.19316	549.54666	585.29822	23.217334	0

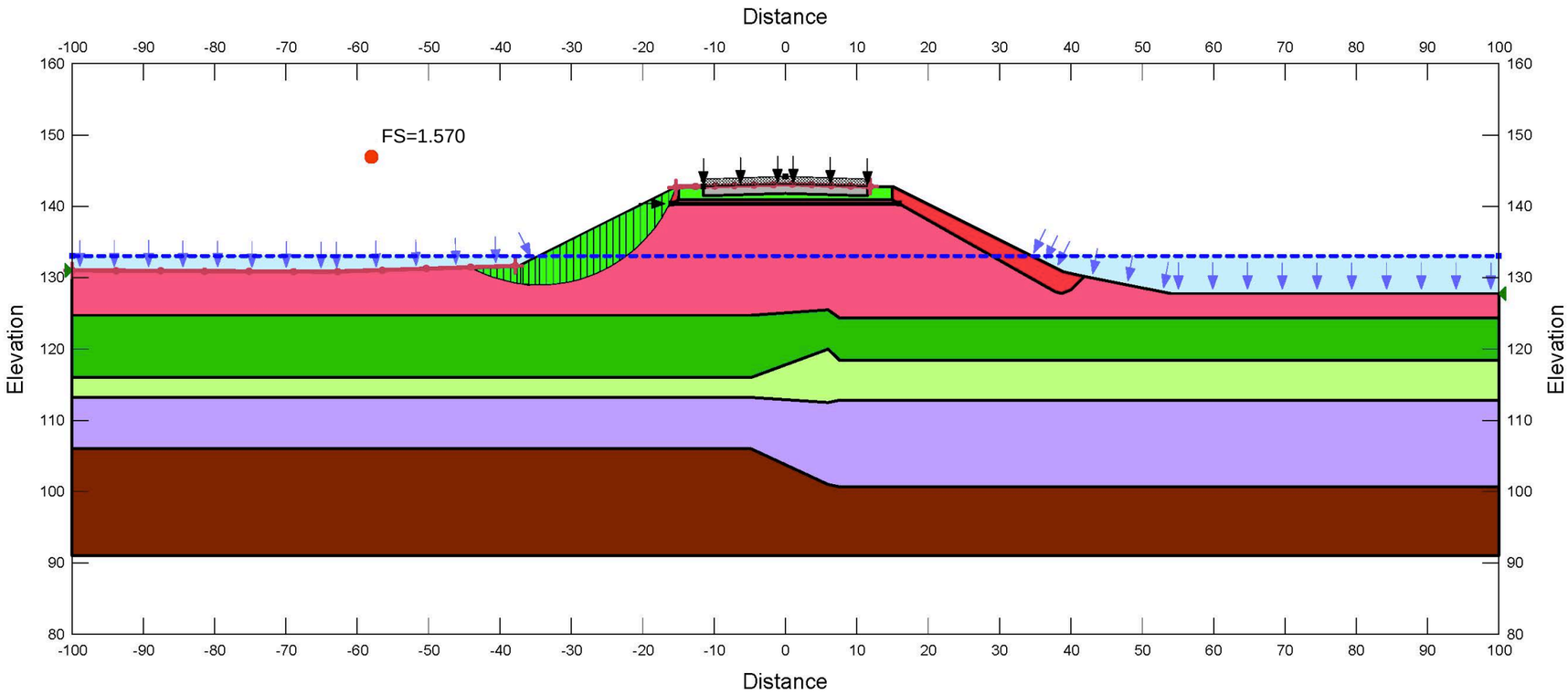
SOUTH APPROACH EMBANKMENT

GLOBAL STABILITY ANALYSIS

WEST SIDE

WATER EL. 133 FEET

HNTB



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Fill (South)	Mohr-Coulomb	1	114	0	33	0
	Gabion Blanket	Mohr-Coulomb	1	130	0	45	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Organic Silt	Mohr-Coulomb	1	103	0	25	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	1	106	0	28	0

HNTB

HNTB PROJECT NUMBER 63738

SOUTH ABUTMENT | DRAINED

PREPARED BY: MRR | CHECKED BY: BAM | BACK CHECKED BY: MRR

DATE: 10/16/2017 | DATE: 10/18/2017 | DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

WEST SIDE
STATION 18+50

West Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 141
Date: 10/18/2017
Time: 5:35:37 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_South_Abutment_Drained_LowGTW_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 18+50 Transverse w Geogrid\Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:48:48 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

West Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: Mohr-Coulomb
Unit Weight: 103 pcf

Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-100, 131) ft
Left-Zone Right Coordinate: (-37.9, 131.66667) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-15.3, 142.64932) ft
Right-Zone Right Coordinate: (11.9, 142.8) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 131) ft
Right Coordinate: (100, 127.8) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	100	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-11.5	142.8
	-11.5	143.8
	0	144.2
	11.5	143.8

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (-16, 140.4) ft
Inside Point: (16, 140.4) ft
Slip Surface Intersection: () ft
Length: 32 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	0	143.1
Point 2	11.5	142.8
Point 3	-11.5	142.8
Point 4	-12.9	142.8

Point 5	12.9	142.8
Point 6	15	142.8
Point 7	-15	142.8
Point 8	-11.5	141.5
Point 9	11.5	141.5
Point 10	15	140.9
Point 11	-15	140.9
Point 12	-37.1	131.7
Point 13	-39.5	131.6
Point 14	-100	131
Point 15	38.9	130.8
Point 16	-64	130.8
Point 17	41.9	130.2
Point 18	-37.6	129.6
Point 19	-35.1	129.3
Point 20	-36.8	129.2
Point 21	-36	129.1
Point 22	40	128.3
Point 23	37.8	128
Point 24	100	127.8
Point 25	38.7	127.8
Point 26	54	127.8
Point 27	6	125.5
Point 28	-100	124.7
Point 29	-4.8	124.7
Point 30	7.6	124.3
Point 31	100	124.3
Point 32	6	120
Point 33	7.6	118.4
Point 34	100	118.4
Point 35	-4.8	116

Point 36	-100	116
Point 37	-4.8	113.2
Point 38	-100	113.2
Point 39	7.6	112.8
Point 40	100	112.8
Point 41	6	112.5
Point 42	-100	106
Point 43	-4.8	106
Point 44	6	101
Point 45	7.6	100.7
Point 46	-100	91
Point 47	100	91
Point 48	0	141.8
Point 49	100	100.7

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	46,47,49,45,44,43,42	2,475
Region 2	Glacial Till	42,43,44,45,49,40,39,41,37,38	1,923.3
Region 3	Soft to Med Stiff Clay (South)	38,37,41,39,40,34,33,32,35,36	850.1
Region 4	Pavement Box	3,8,48,9,2,1	29.9
Region 5	Embankment Fill	3,4,7,11,10,6,5,2,9,48,8	30.55
Region 6	Gabion Blanket	7,12,13,18,20,21,19,11	62.415
Region 7	Gabion Blanket	6,15,17,22,25,23,10	68.41
Region 8	Organic Silt	36,35,32,33,34,31,30,27,29,28	1,459.2
Region 9	Fill (South)	28,29,27,30,31,24,26,17,22,25,23,10,11,19,21,20,18,13,16,14	1,565.2

Current Slip Surface

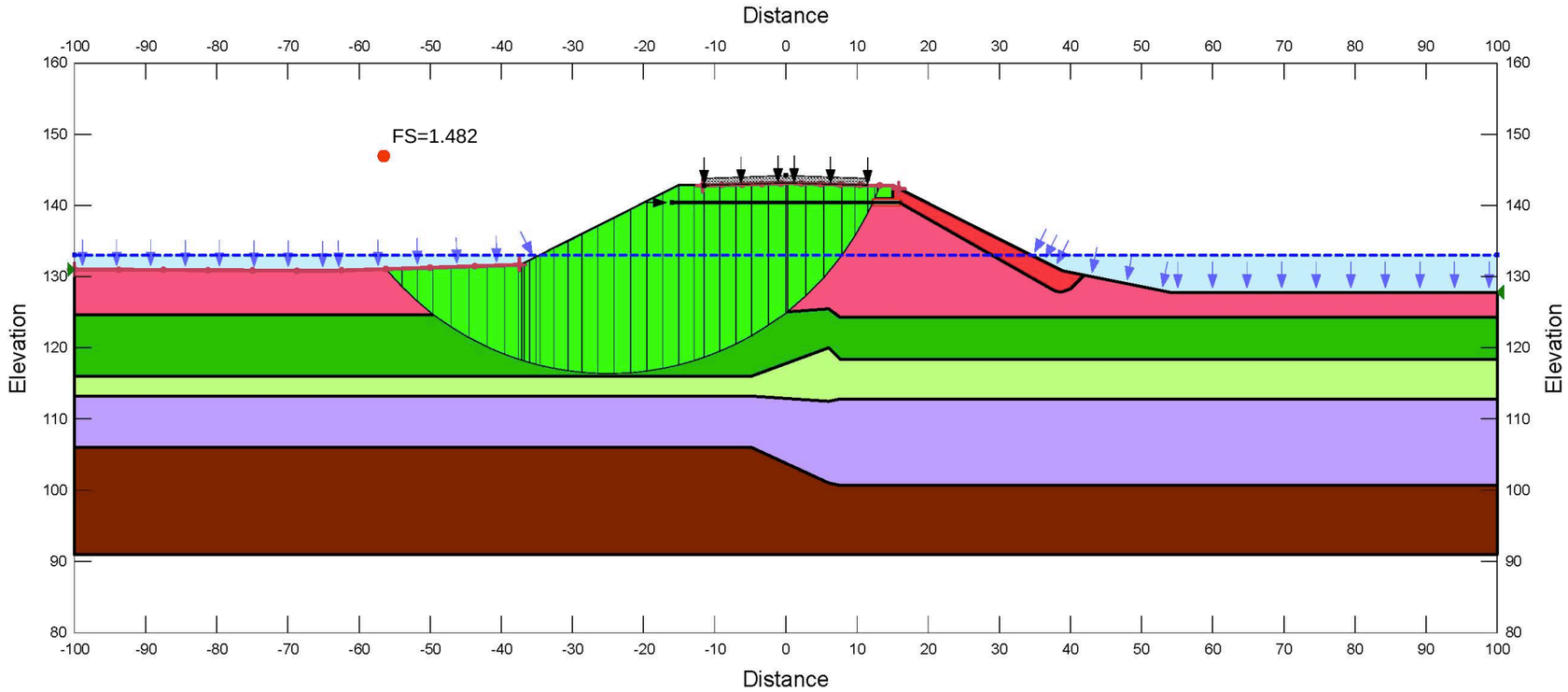
Slip Surface: 1,097
F of S: 1.570
Volume: 118.4079 ft³
Weight: 14,471.597 lbs
Resisting Moment: 146,170.6 lbs-ft
Activating Moment: 93,120.316 lbs-ft

Resisting Force: 6,206.2231 lbs
Activating Force: 3,951.8819 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (-44.107656, 131.44955) ft
Entry: (-15.300001, 142.64932) ft
Radius: 20.204396 ft
Center: (-34.419873, 149.17987) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-43.64689	131.21292	111.51395	174.32501	40.789979	0
Slice 2	-42.725359	130.76844	139.24963	244.75781	68.517815	0
Slice 3	-41.803828	130.37961	163.51218	298.89579	87.919144	0
Slice 4	-40.882297	130.04304	184.51403	340.47826	101.28436	0
Slice 5	-39.960766	129.75601	202.42517	371.95389	110.09324	0
Slice 6	-39.025	129.51334	217.56748	407.7192	123.48597	0
Slice 7	-38.075	129.31472	229.96167	446.2713	140.47311	0
Slice 8	-37.35	129.19067	237.70208	467.41654	149.17832	0
Slice 9	-36.95	129.13509	241.17026	493.79192	164.05442	0
Slice 10	-36.4	129.07676	244.81024	514.91736	175.40961	0
Slice 11	-35.55	129.01214	248.84227	538.01447	187.79062	0
Slice 12	-34.805856	128.98131	250.76652	549.73041	194.14942	0
Slice 13	-34.026468	128.98514	250.52741	573.79023	209.92933	0
Slice 14	-33.055982	129.02743	247.8883	611.64625	236.22718	0
Slice 15	-32.085496	129.11673	242.31602	641.09785	258.97195	0
Slice 16	-31.115009	129.25367	233.77103	662.61789	278.49641	0
Slice 17	-30.144523	129.43924	222.19133	676.55217	295.06538	0
Slice 18	-29.174036	129.67484	207.49006	683.13885	308.88994	0
Slice 19	-28.233813	129.95172	190.2127	682.73786	319.84958	0
Slice 20	-27.323853	130.26882	170.42576	675.87578	328.24308	0
Slice 21	-26.413893	130.63597	147.51549	662.70634	334.56885	0
Slice 22	-25.503933	131.05623	121.29147	643.13751	338.89078	0
Slice 23	-24.593973	131.5334	91.516097	617.00118	341.254	0
Slice 24	-23.684013	132.07226	57.890996	584.04165	341.68623	0

Slice 25	-22.774053	132.67889	20.037208	543.89721	340.19866	0
Slice 26	-21.822844	133.39604	-0	496.96938	322.73569	0
Slice 27	-20.830387	134.24356	-0	443.96136	288.31188	0
Slice 28	-19.83793	135.21313	-0	383.7513	249.21101	0
Slice 29	-18.845472	136.33279	-0	315.87695	205.13289	0
Slice 30	-17.853015	137.6472	-0	239.75643	155.69965	0
Slice 31	-16.860558	139.23633	-0	154.73466	100.48586	0
Slice 32	-15.832165	141.38097	-0	42.561729	42.561729	0



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
	Bedrock	Bedrock (Impenetrable)	1							
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0			
	Fill (South)	Mohr-Coulomb	1	114	0	33	0			
	Gabion Blanket	Mohr-Coulomb	1	130	0	45	0			
	Glacial Till	Mohr-Coulomb	1	126	0	38	0			
	Organic Silt	S=f(depth)		103				320	8	1,000
	Pavement Box	Mohr-Coulomb	1	130	0	36	0			
	Soft to Med Stiff Clay (South)	Mohr-Coulomb		106	506	0	0			

HNTB

HNTB PROJECT NUMBER 63738

SOUTH ABUTMENT | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR LOW GROUND WATER TABLE

WEST SIDE
STATION 18+50

West Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 127
Date: 10/18/2017
Time: 5:40:36 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_South_Abutment_Undrained_LowGTW_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 18+50 Transverse w Geogrid\Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 11:59:38 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

West Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: S=f(depth)
Unit Weight: 103 pcf

C-Top of Layer: 320 psf
C-Rate of Change: 8 (lbs/ft²)/ft
C-Maximum: 1,000 psf

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 506 psf
Phi': 0 °
Phi-B: 0 °

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-100, 131) ft
Left-Zone Right Coordinate: (-37.46531, 131.68478) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-11.7, 142.8) ft
Right-Zone Right Coordinate: (15.9, 142.34812) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 131) ft
Right Coordinate: (100, 127.8) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	133
Coordinate 2	100	133

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-11.5	142.8
	-11.5	143.8
	0	144.2
	11.5	143.8

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (-16, 140.4) ft
Inside Point: (16, 140.4) ft
Slip Surface Intersection: (12.23072, 140.4) ft
Length: 32 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 577.95619 lbs
Pullout Force per Length: 153.33333 lbs/ft
Available Length: 3.7692795 ft
Required Length: 3.7692795 ft
Governing Component: Pullout Resistance

Points

	X (ft)	Y (ft)
Point 1	0	143.1
Point 2	11.5	142.8
Point 3	-11.5	142.8
Point 4	-12.9	142.8
Point 5	12.9	142.8
Point 6	15	142.8
Point 7	-15	142.8

Point 8	-11.5	141.5
Point 9	11.5	141.5
Point 10	15	140.9
Point 11	-15	140.9
Point 12	-37.1	131.7
Point 13	-39.5	131.6
Point 14	-100	131
Point 15	38.9	130.8
Point 16	-64	130.8
Point 17	41.9	130.2
Point 18	-37.6	129.6
Point 19	-35.1	129.3
Point 20	-36.8	129.2
Point 21	-36	129.1
Point 22	40	128.3
Point 23	37.8	128
Point 24	100	127.8
Point 25	38.7	127.8
Point 26	54	127.8
Point 27	6	125.5
Point 28	-100	124.7
Point 29	-4.8	124.7
Point 30	7.6	124.3
Point 31	100	124.3
Point 32	6	120
Point 33	7.6	118.4
Point 34	100	118.4
Point 35	-4.8	116
Point 36	-100	116
Point 37	-4.8	113.2
Point 38	-100	113.2

Point 39	7.6	112.8
Point 40	100	112.8
Point 41	6	112.5
Point 42	-100	106
Point 43	-4.8	106
Point 44	6	101
Point 45	7.6	100.7
Point 46	-100	91
Point 47	100	91
Point 48	0	141.8
Point 49	100	100.7

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	46,47,49,45,44,43,42	2,475
Region 2	Glacial Till	42,43,44,45,49,40,39,41,37,38	1,923.3
Region 3	Soft to Med Stiff Clay (South)	38,37,41,39,40,34,33,32,35,36	850.1
Region 4	Pavement Box	3,8,48,9,2,1	29.9
Region 5	Embankment Fill	3,4,7,11,10,6,5,2,9,48,8	30.55
Region 6	Gabion Blanket	7,12,13,18,20,21,19,11	62.415
Region 7	Gabion Blanket	6,15,17,22,25,23,10	68.41
Region 8	Organic Silt	36,35,32,33,34,31,30,27,29,28	1,459.2
Region 9	Fill (South)	28,29,27,30,31,24,26,17,22,25,23,10,11,19,21,20,18,13,16,14	1,565.2

Current Slip Surface

Slip Surface: 954
F of S: 1.482
Volume: 1,079.3785 ft^3
Weight: 121,482.08 lbs
Resisting Moment: 1,329,431 lbs-ft
Activating Moment: 897,112.02 lbs-ft
Resisting Force: 26,939.575 lbs
Activating Force: 18,178.494 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (-56.219654, 131.05405) ft

Entry: (13.235583, 142.8) ft
Radius: 40.764913 ft
Center: (-24.914545, 157.16474) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-55.111132	129.82949	197.83955	401.50534	132.26211	0
Slice 2	-52.894087	127.55736	339.62062	775.16839	282.84803	0
Slice 3	-50.677042	125.60489	461.45464	1,042.5875	377.39212	0
Slice 4	-48.309955	123.81704	0	1,183.5479	0	327.06367
Slice 5	-45.792825	122.18293	0	1,336.4618	0	340.13656
Slice 6	-43.275695	120.79637	0	1,462.3069	0	351.22903
Slice 7	-40.758565	119.62971	0	1,564.4065	0	360.56233
Slice 8	-38.55	118.76115	0	1,654.9836	0	367.51081
Slice 9	-37.35	118.34376	0	1,708.6168	0	370.8499
Slice 10	-36.95	118.21733	0	1,729.7213	0	371.86138
Slice 11	-36.4	118.05351	0	1,761.817	0	373.17192
Slice 12	-35.55	117.81442	0	1,805.8771	0	375.08463
Slice 13	-34.805856	117.61922	0	1,839.2082	0	376.6462
Slice 14	-33.541225	117.33545	0	1,918.3702	0	378.91638
Slice 15	-31.600252	116.96385	0	2,047.4894	0	381.88916
Slice 16	-29.65928	116.68869	0	2,165.8178	0	384.09046
Slice 17	-27.54806	116.50105	0	2,282.1328	0	385.59159
Slice 18	-25.266595	116.41732	0	2,394.6114	0	386.26146
Slice 19	-22.985129	116.46153	0	2,492.9864	0	385.90772
Slice 20	-20.703664	116.63412	0	2,577.2692	0	384.52702
Slice 21	-18.422198	116.93674	0	2,648.4942	0	382.10608
Slice 22	-16.140733	117.37236	0	2,704.0413	0	378.62111
Slice 23	-13.95	117.91722	0	2,658.1139	0	374.26225
Slice 24	-12.2	118.44039	0	2,585.294	0	370.07688
Slice 25	-10.383333	119.09647	0	2,764.6368	0	364.82822
Slice 26	-8.15	120.0268	0	2,654.4394	0	357.38562

Slice 27	-5.9166667	121.11942	0	2,527.8787	0	348.64464
Slice 28	-3.6	122.44464	0	2,376.0505	0	338.75399
Slice 29	-1.2	124.04043	0	2,195.299	0	327.40992
Slice 30	0.11086804	124.98576	0	2,098.5877	0	320.62407
Slice 31	1.5041098	126.16484	426.51389	1,684.6988	817.07484	0
Slice 32	4.0688572	128.55691	277.24872	1,377.804	714.70899	0
Slice 33	6.6336046	131.42806	98.08904	1,029.7875	605.05203	0
Slice 34	8.8119838	134.32298	-0	726.66343	471.90075	0
Slice 35	10.603995	137.24349	-0	484.11352	314.387	0
Slice 36	11.982539	139.87051	-0	164.27039	106.67844	0
Slice 37	12.682539	141.41925	-0	73.727073	46.069788	0
Slice 38	13.067792	142.36925	-0	22.087321	13.80169	0

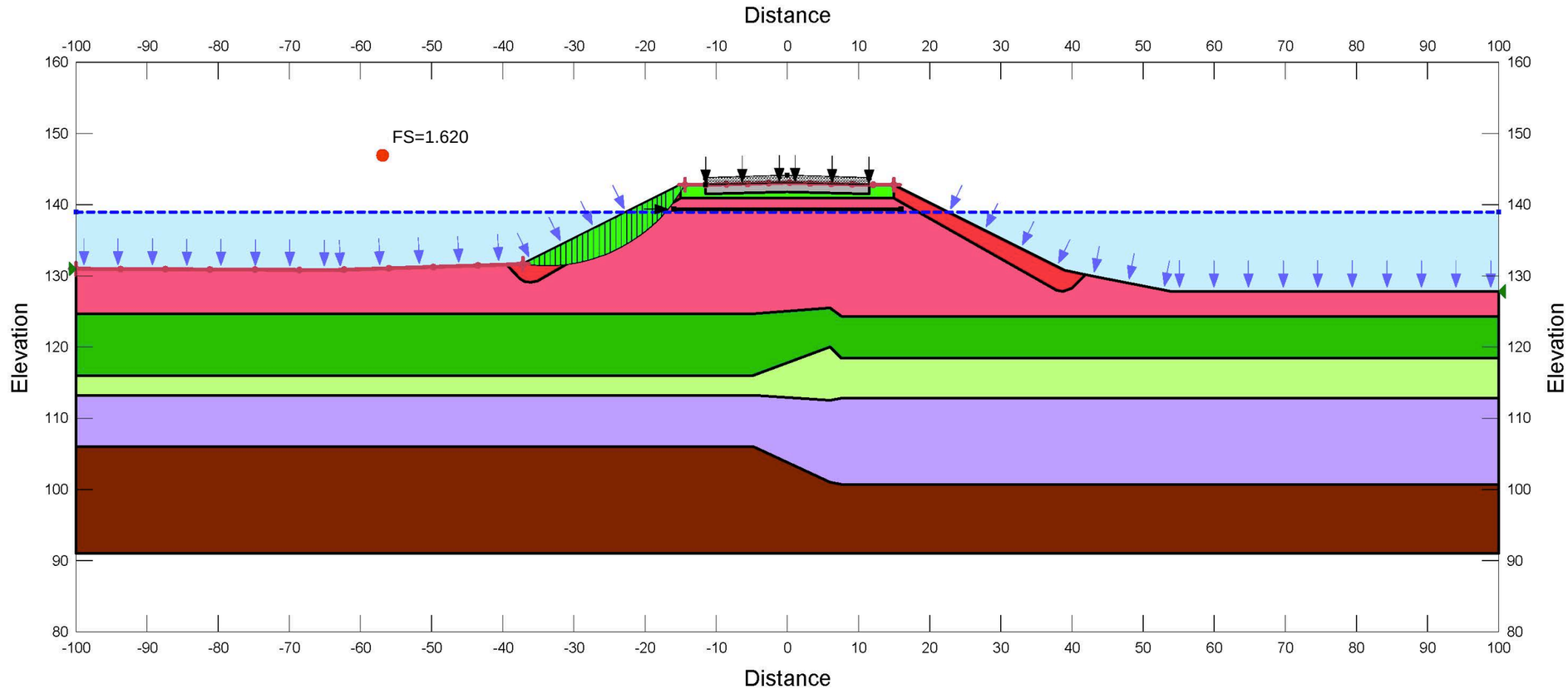
SOUTH APPROACH EMBANKMENT

GLOBAL STABILITY ANALYSIS

WEST SIDE

WATER EL. 139 FEET

HNTB



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0
	Fill (South)	Mohr-Coulomb	1	114	0	33	0
	Gabion Blanket	Mohr-Coulomb	1	130	0	45	0
	Glacial Till	Mohr-Coulomb	1	126	0	38	0
	Organic Silt	Mohr-Coulomb	1	103	0	25	0
	Pavement Box	Mohr-Coulomb	1	130	0	36	0
	Soft to Med Stiff Clay (South)	Mohr-Coulomb	1	106	0	28	0

HNTB

HNTB PROJECT NUMBER 63738

SOUTH ABUTMENT | DRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

WEST SIDE
STATION 18+50

West Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 145
Date: 10/18/2017
Time: 5:35:42 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_South_Abutment_Drained_HighGTW_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 18+50 Transverse w Geogrid\Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:49:40 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

West Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: Mohr-Coulomb
Unit Weight: 103 pcf

Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-100, 131) ft
Left-Zone Right Coordinate: (-37.2, 131.69583) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-14.4, 142.8) ft
Right-Zone Right Coordinate: (15, 142.8) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 131) ft
Right Coordinate: (100, 127.8) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	100	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-11.5	142.8
	-11.5	143.8
	0	144.2
	11.5	143.8

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (-16, 139.4) ft
Inside Point: (16, 139.4) ft
Slip Surface Intersection: () ft
Length: 32 ft
Direction: 180 °
F of S Dependent: No
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: No
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	0	143.1
Point 2	11.5	142.8
Point 3	-11.5	142.8
Point 4	-12.9	142.8

Point 5	12.9	142.8
Point 6	15	142.8
Point 7	-15	142.8
Point 8	-11.5	141.5
Point 9	11.5	141.5
Point 10	15	140.9
Point 11	-15	140.9
Point 12	-37.1	131.7
Point 13	-39.5	131.6
Point 14	-100	131
Point 15	38.9	130.8
Point 16	-64	130.8
Point 17	41.9	130.2
Point 18	-37.6	129.6
Point 19	-35.1	129.3
Point 20	-36.8	129.2
Point 21	-36	129.1
Point 22	40	128.3
Point 23	37.8	128
Point 24	100	127.8
Point 25	38.7	127.8
Point 26	54	127.8
Point 27	6	125.5
Point 28	-100	124.7
Point 29	-4.8	124.7
Point 30	7.6	124.3
Point 31	100	124.3
Point 32	6	120
Point 33	7.6	118.4
Point 34	100	118.4
Point 35	-4.8	116

Point 36	-100	116
Point 37	-4.8	113.2
Point 38	-100	113.2
Point 39	7.6	112.8
Point 40	100	112.8
Point 41	6	112.5
Point 42	-100	106
Point 43	-4.8	106
Point 44	6	101
Point 45	7.6	100.7
Point 46	-100	91
Point 47	100	91
Point 48	0	141.8
Point 49	100	100.7

Regions

	Material	Points	Area (ft²)
Region 1	Bedrock	46,47,49,45,44,43,42	2,475
Region 2	Glacial Till	42,43,44,45,49,40,39,41,37,38	1,923.3
Region 3	Soft to Med Stiff Clay (South)	38,37,41,39,40,34,33,32,35,36	850.1
Region 4	Pavement Box	3,8,48,9,2,1	29.9
Region 5	Embankment Fill	3,4,7,11,10,6,5,2,9,48,8	30.55
Region 6	Gabion Blanket	7,12,13,18,20,21,19,11	62.415
Region 7	Gabion Blanket	6,15,17,22,25,23,10	68.41
Region 8	Organic Silt	36,35,32,33,34,31,30,27,29,28	1,459.2
Region 9	Fill (South)	28,29,27,30,31,24,26,17,22,25,23,10,11,19,21,20,18,13,16,14	1,565.2

Current Slip Surface

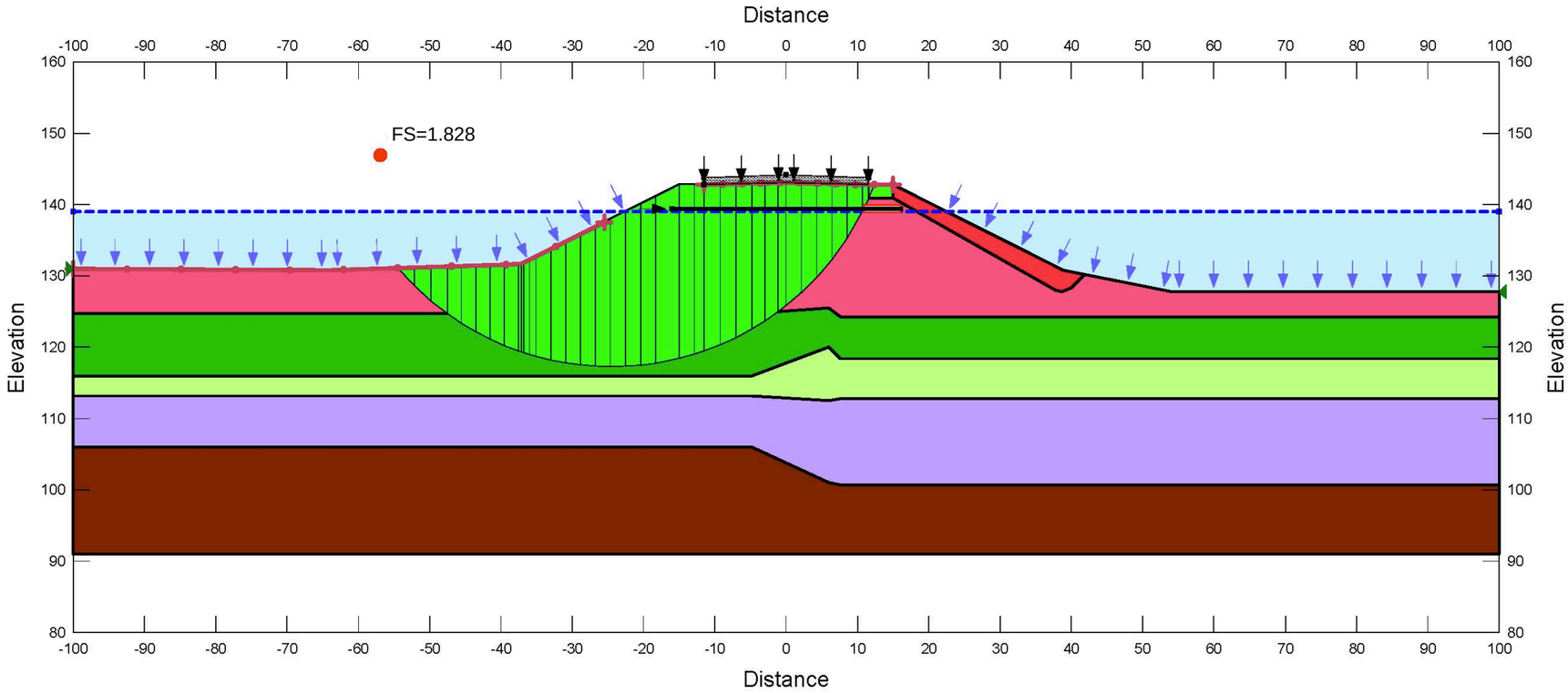
Slip Surface: 1,216
F of S: 1.620
Volume: 71.033993 ft³
Weight: 8,898.5761 lbs
Resisting Moment: 82,318.596 lbs-ft
Activating Moment: 50,825.613 lbs-ft

Resisting Force: 3,235.1592 lbs
Activating Force: 1,997.0748 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (-37.2, 131.69583) ft
Entry: (-14.4, 142.8) ft
Radius: 22.261656 ft
Center: (-33.811656, 153.69812) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-37.15	131.68825	456.25323	479.95205	23.698824	0
Slice 2	-36.725856	131.63126	459.80965	554.21045	94.400802	0
Slice 3	-35.977569	131.54526	465.17548	588.71442	123.53894	0
Slice 4	-35.229281	131.48481	468.94805	617.55073	148.60268	0
Slice 5	-34.480993	131.44967	471.14038	641.17407	170.03369	0
Slice 6	-33.732706	131.43974	471.75994	659.95675	188.19681	0
Slice 7	-32.984418	131.45499	470.80885	674.20521	203.39636	0
Slice 8	-32.236131	131.49545	468.28388	684.17224	215.88836	0
Slice 9	-31.487843	131.56128	464.17638	690.06636	225.88998	0
Slice 10	-30.725157	131.65496	458.33076	686.52116	148.18858	0
Slice 11	-29.948072	131.77784	450.66261	681.34035	149.80388	0
Slice 12	-29.170987	131.92915	441.22076	672.9112	150.46153	0
Slice 13	-28.393902	132.10949	429.96785	661.26382	150.20536	0
Slice 14	-27.616817	132.31958	416.85799	646.41236	149.07435	0
Slice 15	-26.839732	132.56033	401.83572	628.35522	147.10348	0
Slice 16	-26.062648	132.83278	384.83476	607.07503	144.32452	0
Slice 17	-25.285563	133.1382	365.77629	582.53803	140.76672	0
Slice 18	-24.508478	133.47809	344.56691	554.69321	136.45761	0
Slice 19	-23.731393	133.85423	321.09586	523.47074	131.42379	0
Slice 20	-22.954308	134.26873	295.23152	488.78002	125.69187	0
Slice 21	-22.209639	134.70337	268.1097	461.79707	125.78205	0
Slice 22	-21.497385	135.15742	239.77675	441.97401	131.30843	0
Slice 23	-20.785131	135.65101	208.977	417.94428	135.70494	0
Slice 24	-20.072877	136.18748	175.50122	389.4998	138.9723	0

Slice 25	-19.360622	136.77093	139.09408	356.38275	141.10891	0
Slice 26	-18.648368	137.40642	99.439347	318.27249	142.1119	0
Slice 27	-17.992182	138.04105	59.838304	278.62188	142.07972	0
Slice 28	-17.392065	138.67211	20.460204	237.83759	141.16653	0
Slice 29	-16.560162	139.65327	-0	182.34434	118.4158	0
Slice 30	-15.51416	141.05038	-0	94.325313	94.325313	0
Slice 31	-14.7	142.29711	-0	30.453276	19.029319	0



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
	Bedrock	Bedrock (Impenetrable)	1							
	Embankment Fill	Mohr-Coulomb	1	115	0	32	0			
	Fill (South)	Mohr-Coulomb	1	114	0	33	0			
	Gabion Blanket	Mohr-Coulomb	1	130	0	45	0			
	Glacial Till	Mohr-Coulomb	1	126	0	38	0			
	Organic Silt	S=f(depth)		103				320	8	1,000
	Pavement Box	Mohr-Coulomb	1	130	0	36	0			
	Soft to Med Stiff Clay (South)	Mohr-Coulomb		106	506	0	0			

HNTB

HNTB PROJECT NUMBER 63738

SOUTH ABUTMENT | UNDRAINED

PREPARED BY: MRR	CHECKED BY: BAM	BACK CHECKED BY: MRR
DATE: 10/16/2017	DATE: 10/18/2017	DATE: 11/07/2017

GLOBAL STABILITY ANALYSIS
NON-OPTIMIZED FAILURE SURFACE
FOR HIGH GROUND WATER TABLE

WEST SIDE
STATION 18+50

West Side Slope Stability

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File Information

File Version: 8.16
Created By: Margarita Restrepo-Espinosa
Last Edited By: Britain Materek
Revision Number: 129
Date: 10/18/2017
Time: 5:40:50 PM
Tool Version: 8.16.2.14053
File Name: Slope_Stability_Analysis_South_Abutment_Undrained_HighGTW_Geogrid.gsz
Directory: \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Slope Stability\Final\STA 18+50 Transverse w Geogrid\Geogrid\
Last Solved Date: 10/19/2017
Last Solved Time: 12:47:26 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

West Side Slope Stability

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: Yes
- Critical Slip Surface Optimizations
  - Maximum Iterations: 2,000
  - Convergence Tolerance: 1e-007
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 4 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Bedrock

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gabion Blanket

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Glacial Till

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill (South)

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Organic Silt

Model: S=f(depth)
Unit Weight: 103 pcf

C-Top of Layer: 320 psf
C-Rate of Change: 8 (lbs/ft²)/ft
C-Maximum: 1,000 psf

Soft to Med Stiff Clay (South)

Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion': 506 psf
Phi': 0 °
Phi-B: 0 °

Pavement Box

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-100, 131) ft
Left-Zone Right Coordinate: (-25.5, 137.52624) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (-11.5, 142.8) ft
Right-Zone Right Coordinate: (15, 142.8) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100, 131) ft
Right Coordinate: (100, 127.8) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-100	139
Coordinate 2	100	139

Maximum Suction: 0 psf

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-11.5	142.8
	-11.5	143.8
	0	144.2
	11.5	143.8

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (-16, 139.4) ft
Inside Point: (16, 139.4) ft
Slip Surface Intersection: (10.876718, 139.4) ft
Length: 32 ft
Direction: 180 °
F of S Dependent: Yes
Pullout Resistance: 230 psf
Resistance Reduction Factor: 1.5
Force Distribution: Distributed
Anchorage: Yes
Tensile Capacity: 1,986 lbs
Reduction Factor: 1.5
Force Orientation: 0
Factored Pullout Resistance: 153.33333 lbs/ft
Max. Pullout Force: 1,324 lbs
Pullout Force: 429.85132 lbs
Pullout Force per Length: 83.901552 lbs/ft
Available Length: 5.1232821 ft
Required Length: 5.1232821 ft
Governing Component: Pullout Resistance

Points

	X (ft)	Y (ft)
Point 1	0	143.1
Point 2	11.5	142.8
Point 3	-11.5	142.8
Point 4	-12.9	142.8
Point 5	12.9	142.8
Point 6	15	142.8
Point 7	-15	142.8

Point 8	-11.5	141.5
Point 9	11.5	141.5
Point 10	15	140.9
Point 11	-15	140.9
Point 12	-37.1	131.7
Point 13	-39.5	131.6
Point 14	-100	131
Point 15	38.9	130.8
Point 16	-64	130.8
Point 17	41.9	130.2
Point 18	-37.6	129.6
Point 19	-35.1	129.3
Point 20	-36.8	129.2
Point 21	-36	129.1
Point 22	40	128.3
Point 23	37.8	128
Point 24	100	127.8
Point 25	38.7	127.8
Point 26	54	127.8
Point 27	6	125.5
Point 28	-100	124.7
Point 29	-4.8	124.7
Point 30	7.6	124.3
Point 31	100	124.3
Point 32	6	120
Point 33	7.6	118.4
Point 34	100	118.4
Point 35	-4.8	116
Point 36	-100	116
Point 37	-4.8	113.2
Point 38	-100	113.2

Point 39	7.6	112.8
Point 40	100	112.8
Point 41	6	112.5
Point 42	-100	106
Point 43	-4.8	106
Point 44	6	101
Point 45	7.6	100.7
Point 46	-100	91
Point 47	100	91
Point 48	0	141.8
Point 49	100	100.7

Regions

	Material	Points	Area (ft^2)
Region 1	Bedrock	46,47,49,45,44,43,42	2,475
Region 2	Glacial Till	42,43,44,45,49,40,39,41,37,38	1,923.3
Region 3	Soft to Med Stiff Clay (South)	38,37,41,39,40,34,33,32,35,36	850.1
Region 4	Pavement Box	3,8,48,9,2,1	29.9
Region 5	Embankment Fill	3,4,7,11,10,6,5,2,9,48,8	30.55
Region 6	Gabion Blanket	7,12,13,18,20,21,19,11	62.415
Region 7	Gabion Blanket	6,15,17,22,25,23,10	68.41
Region 8	Organic Silt	36,35,32,33,34,31,30,27,29,28	1,459.2
Region 9	Fill (South)	28,29,27,30,31,24,26,17,22,25,23,10,11,19,21,20,18,13,16,14	1,565.2

Current Slip Surface

Slip Surface: 833
F of S: 1.828
Volume: 1,003.127 ft^3
Weight: 113,303.54 lbs
Resisting Moment: 1,174,627.1 lbs-ft
Activating Moment: 642,797.98 lbs-ft
Resisting Force: 25,357.936 lbs
Activating Force: 13,874.146 lbs
F of S Rank (Analysis): 2 of 1,332 slip surfaces
F of S Rank (Query): 2 of 1,332 slip surfaces
Exit: (-54.467648, 131.11126) ft

Entry: (12.349218, 142.8) ft
Radius: 39.368597 ft
Center: (-24.503921, 156.64675) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-53.308082	129.86417	570.07584	773.02231	131.79498	0
Slice 2	-50.98895	127.56119	713.78182	1,103.3649	252.99818	0
Slice 3	-48.669818	125.60265	835.99466	1,353.7941	336.26285	0
Slice 4	-46.508971	124.02459	0	1,503.8509	0	325.40326
Slice 5	-44.506408	122.75819	0	1,622.6316	0	335.53451
Slice 6	-42.503845	121.65216	0	1,724.2322	0	344.38269
Slice 7	-40.501282	120.69165	0	1,810.355	0	352.06683
Slice 8	-38.55	119.88319	0	1,898.5672	0	358.5345
Slice 9	-37.35	119.43392	0	1,956.5763	0	362.1286
Slice 10	-36.95	119.29764	0	1,990.0123	0	363.2189
Slice 11	-36.4	119.12085	0	2,024.0272	0	364.63321
Slice 12	-35.55	118.86249	0	2,070.9951	0	366.70009
Slice 13	-34.05548	118.4696	0	2,136.9817	0	369.84317
Slice 14	-31.966441	118.00655	0	2,216.3252	0	373.54761
Slice 15	-29.877402	117.66085	0	2,283.1778	0	376.31316
Slice 16	-27.788363	117.42941	0	2,337.9168	0	378.16473
Slice 17	-25.699324	117.31019	0	2,380.7978	0	379.11849
Slice 18	-23.610285	117.30217	0	2,411.9662	0	379.18263
Slice 19	-21.497385	117.40776	0	2,465.9477	0	378.33795
Slice 20	-19.360622	117.63046	0	2,542.8436	0	376.55636
Slice 21	-16.646121	118.10692	0	2,618.3393	0	372.74466
Slice 22	-13.95	118.73484	0	2,591.092	0	367.72128
Slice 23	-12.2	119.25749	0	2,521.1136	0	363.54006
Slice 24	-10.383333	119.91715	0	2,704.4006	0	358.26284
Slice 25	-8.15	120.85669	0	2,597.1374	0	350.74644
Slice 26	-5.9166667	121.96542	0	2,472.7208	0	341.87668

Slice 27	-3.8810332	123.12932	0	2,343.1061	0	333.11005
Slice 28	-2.0430995	124.33352	0	2,209.4412	0	324.56559
Slice 29	-0.56206636	125.40299	848.4532	1,943.7754	711.31052	0
Slice 30	1.0688102	126.74786	764.53344	1,774.6069	655.9494	0
Slice 31	3.2064306	128.72265	641.30657	1,529.4517	576.76821	0
Slice 32	5.344051	131.02856	497.41789	1,255.4351	492.26214	0
Slice 33	7.4816714	133.76809	326.471	944.70066	401.48303	0
Slice 34	9.6192918	137.13117	116.61478	583.29403	303.06505	0
Slice 35	11.094051	139.8609	-0	327.06534	212.39872	0
Slice 36	11.539146	140.8109	-0	118.33165	76.845469	0
Slice 37	11.963755	141.85	-0	55.198419	34.4918	0

HNTB	Prepared by: IC	Approved by:	Document number: QF 06
Calculation Cover Sheet	Revision Number: 0	Revision Date:	Page 1 of 2

Project: Burnham Bridge	Job No: 637738	Design Criteria Document:
Client: MEDOT	Discipline: Geotechnical	Calculation No: 1

Name or Description of Calculation: Settlement Analysis

Calc. Rev. No.	Originator	Checker	Senior Technical Reviewer (if required)	Confirmation Required (Y/N)
0	IC	BAM		

Calculation Objective:
Calculate anticipated settlement at the north and south approach embankments given the placement of additional fill.

Calculation Methodology/List of Assumptions:
See geotechnical report for a list of assumptions and design methodology used.

References/Inputs:
Soil Borings BB-WGLC-101, BB-WGLC-102, BB-WGLC-103, BB-WGLC-104, BB-WGLC-201, BB-WGLC-202, BB-WGLC-203, and BB-WGLC-104

Attachments: (List each attachment following the subject calculation)

1. Settle3d output file and graphs.
2. Cross section profile.
3. Subsurface exploration summary table for borings.

Conclusions:

Settlement for Abutment 1 and the south approach was evaluated for the short term condition at 0.1 years after loading and 100 years after loading. The short term maximum settlement within the footprint of the 30-foot-wide roadway was 0.3 inches, which also corresponds to the maximum settlement experienced by the embankment in the short-term analysis. The 100-year analysis indicates that a maximum total settlement of approximately 3.6 inches at Station18+50 occurs at 33 feet to the right of the baseline under the embankment slope, which is 18 feet to the right of the edge of roadway. The highest magnitude of settlement within the footprint of the 30-foot-wide roadway is 1.7 inches at 100 years at 15 feet to the right of the baseline, but the magnitude of settlement at the center of the roadway is estimated at 1.3 inches.

Settlement for Abutment 2 and the north approach was evaluated for short term settlement at 0.1 years after loading and 100 years after loading. The short term maximum settlement within the footprint of the 30-foot-wide roadway was 0.84 inches, which also corresponds to the maximum settlement experienced by the embankment in the short-term analysis. The 100-year analysis indicates that a maximum total

settlement of approximately 1.3 inches at Station 20+00 occurs at 33 feet to the right of the baseline, which is 18 feet to the right of the edge of roadway. The highest magnitude of settlement within the footprint of the 30-foot-wide roadway is 1.02 inches at 100 years at 15 feet to the right of the baseline, while at the center of the roadway, the magnitude of settlement is anticipated to be 1.0 inches.

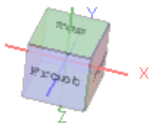
Document Check:	Name	Signature	Date
Originator:	I. Couto		10/6/17
Checker:	B. Materek		10/18/17
BackChecker:	I. Couto		11/6/17
Updater:			
Verifier:			

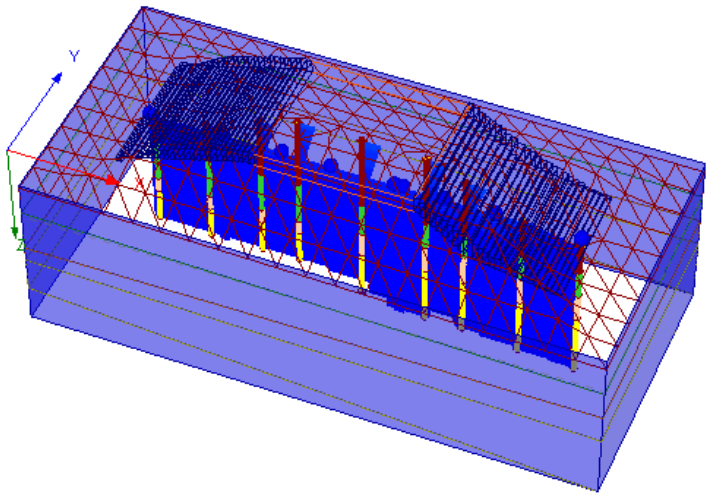
ABUTMENT 1 (SOUTH)

SETTLE3D ANALYSIS

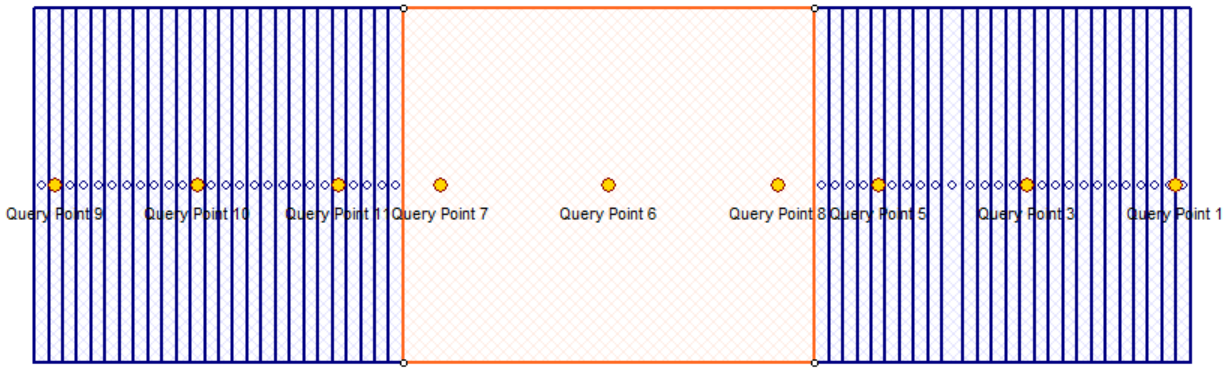
HNTB

Overview

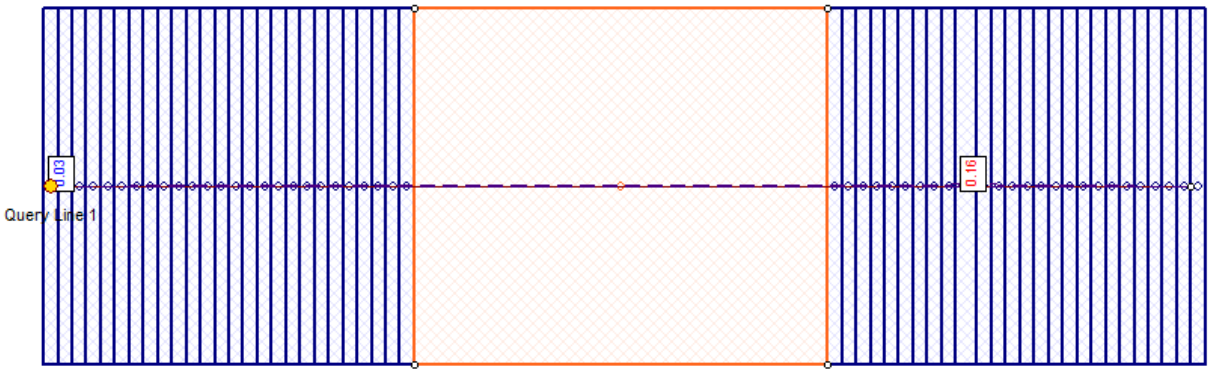




- **Query Points**



- **Query Line**



Settle3D Analysis Information

Project Settings

Document Name	South Abutment.s3z
Date Created	10/11/2017, 2:06:27 PM
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	years
Permeability Units	feet/year
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [years]
1	Stage 1	0
2	Stage 2	0.1
3	Stage 3	100

Results (relative to Stage: Stage 1 = 0 y)

Time taken to compute: 1.67912 seconds

Stage: Stage 1 = 0 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0
Loading Stress XX [ksf]	0	0
Loading Stress YY [ksf]	0	0
Effective Stress ZZ [ksf]	0	0
Effective Stress XX [ksf]	0	0
Effective Stress YY [ksf]	0	0
Total Stress ZZ [ksf]	0	0
Total Stress XX [ksf]	0	0
Total Stress YY [ksf]	0	0
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0
Pore Water Pressure [ksf]	0	0
Excess Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0	0
Over-consolidation Ratio	0	0
Void Ratio	0	0
Permeability [ft/y]	0	0
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0

Stage: Stage 2 = 0.1 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.277146
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0.277146
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.0702893	0.905149
Loading Stress XX [ksf]	-0.00701584	0.825732
Loading Stress YY [ksf]	-0.000636151	0.462285
Effective Stress ZZ [ksf]	-4.44089e-016	0.905149
Effective Stress XX [ksf]	-0.00701584	0.825732
Effective Stress YY [ksf]	-0.000636151	0.462285
Total Stress ZZ [ksf]	0.0702893	0.905149
Total Stress XX [ksf]	0.0723982	1.1184
Total Stress YY [ksf]	0.0854658	1.07345
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	60.838
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	60.838
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0.00334727
Pore Water Pressure [ksf]	0	0.779411
Excess Pore Water Pressure [ksf]	0	0.779411
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0	0.900081
Over-consolidation Ratio	-1.77636e-015	2.70894e-014
Void Ratio	0	0
Permeability [ft/y]	0	0
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	-100	0
Undrained Shear Strength	-5.55112e-017	0.0144435

Stage: Stage 3 = 100 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.66697
Total Consolidation Settlement [in]	0	3.46334
Virgin Consolidation Settlement [in]	0	1.47301
Recompression Consolidation Settlement [in]	0	1.99215
Immediate Settlement [in]	0	0.277146
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.0702893	0.905149
Loading Stress XX [ksf]	-0.00701584	0.825732
Loading Stress YY [ksf]	-0.000636151	0.462285
Effective Stress ZZ [ksf]	0.0702893	0.905149
Effective Stress XX [ksf]	0.0723982	1.1184
Effective Stress YY [ksf]	0.0854658	1.07345
Total Stress ZZ [ksf]	0.0702893	0.905149
Total Stress XX [ksf]	0.0723982	1.1184
Total Stress YY [ksf]	0.0854658	1.07345
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	6.17075
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	60.838
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	7.49367
Total Strain	6.46627e-005	0.0906538
Pore Water Pressure [ksf]	-2.67941e-005	4.47087e-005
Excess Pore Water Pressure [ksf]	-2.67941e-005	4.47087e-005
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0	0.900081
Over-consolidation Ratio	-1.44725	0
Void Ratio	-0.187708	0
Permeability [ft/y]	0	10.1142
Coefficient of Consolidation [ft^2/y]	0	0
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	-0.000159979	2.00422e-006
Undrained Shear Strength	0	0.0207631

Loads

1. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.125 ksf
Depth	-131.5 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-40.5	-12.5
-39.5	-12.5
-39.5	12.5
-40.5	12.5

2. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.125 ksf
Depth	-132.9 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-39.5	-12.5
-38.5	-12.5
-38.5	12.5
-39.5	12.5

3. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.063 ksf
Depth	-133.2 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-38.5	-12.5
-37.5	-12.5
-37.5	12.5
-38.5	12.5

4. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.063 ksf
Depth	-133.54 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-37.5	-12.5
-36.5	-12.5
-36.5	12.5
-37.5	12.5

5. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.063 ksf
Depth	-133.86 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-36.5	-12.5
-35.5	-12.5
-35.5	12.5
-36.5	12.5

6. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.125 ksf
Depth	-134.18 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-35.5	-12.5
-34.5	-12.5
-34.5	12.5
-35.5	12.5

7. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.188 ksf
Depth	-134.5 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-34.5	-12.5
-33.5	-12.5
-33.5	12.5
-34.5	12.5

8. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.25 ksf
Depth	-134.8 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-33.5	-12.5
-32.5	-12.5
-32.5	12.5
-33.5	12.5

9. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.313 ksf
Depth	-135.14 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-32.5	-12.5
-31.5	-12.5
-31.5	12.5
-32.5	12.5

10. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.313 ksf
Depth	-135.46 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-31.5	-12.5
-30.5	-12.5
-30.5	12.5
-31.5	12.5

11. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-135.78 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-30.5	-12.5
-29.5	-12.5
-29.5	12.5
-30.5	12.5

12. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-136.1 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-29.5	-12.5
-28.5	-12.5
-28.5	12.5
-29.5	12.5

13. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-136.4 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-28.5	-12.5
-27.5	-12.5
-27.5	12.5
-28.5	12.5

14. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-136.74 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-27.5	-12.5
-26.5	-12.5
-26.5	12.5
-27.5	12.5

15. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-137.06 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-26.5	-12.5
-25.5	-12.5
-25.5	12.5
-26.5	12.5

16. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-137.38 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-25.5	-12.5
-24.5	-12.5
-24.5	12.5
-25.5	12.5

17. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-137.7 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-24.5	-12.5
-23.5	-12.5
-23.5	12.5
-24.5	12.5

18. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-138.02 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-23.5	-12.5
-22.5	-12.5
-22.5	12.5
-23.5	12.5

19. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.438 ksf
Depth	-138.34 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-22.5	-12.5
-21.5	-12.5
-21.5	12.5
-22.5	12.5

20. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.406 ksf
Depth	-138.66 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-21.5	-12.5
-20.5	-12.5
-20.5	12.5
-21.5	12.5

21. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-138.98 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-20.5	-12.5
-19.5	-12.5
-19.5	12.5
-20.5	12.5

22. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-139.3 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-19.5	-12.5
-18.5	-12.5
-18.5	12.5
-19.5	12.5

23. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-139.6 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-18.5	-12.5
-17.5	-12.5
-17.5	12.5
-18.5	12.5

24. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-139.9 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-17.5	-12.5
-16.5	-12.5
-16.5	12.5
-17.5	12.5

25. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-140.26 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-16.5	-12.5
-15.5	-12.5
-15.5	12.5
-16.5	12.5

26. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.39 ksf
Depth	-140 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-15.5	-12.5
-14.5	-12.5
-14.5	12.5
-15.5	12.5

27. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.5 ksf
Depth	-140 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
14.5	-12.5
15.5	-12.5
15.5	12.5
14.5	12.5

28. Fill Load: "Fill Load 27"

Label	Fill Load 27
Load Type	Flexible
Area of Load	725 ft^2
Load	0.39 ksf
Depth	-140 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-14.5	12.5
-14.5	-12.5
14.5	-12.5
14.5	12.5

29. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.5 ksf
Depth	-139.3 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
15.5	-12.5
16.5	-12.5
16.5	12.5
15.5	12.5

30. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.5 ksf
Depth	-138.5 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
16.5	-12.5
17.5	-12.5
17.5	12.5
16.5	12.5

31. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.5 ksf
Depth	-137.8 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
17.5	-12.5
18.5	-12.5
18.5	12.5
17.5	12.5

32. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.562 ksf
Depth	-137 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
18.5	-12.5
19.5	-12.5
19.5	12.5
18.5	12.5

33. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.563 ksf
Depth	-136.3 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
19.5	-12.5
20.5	-12.5
20.5	12.5
19.5	12.5

34. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.563 ksf
Depth	-135.6 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
20.5	-12.5
21.5	-12.5
21.5	12.5
20.5	12.5

35. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.563 ksf
Depth	-134.8 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
21.5	-12.5
22.5	-12.5
22.5	12.5
21.5	12.5

36. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.625 ksf
Depth	-134 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
22.5	-12.5
23.5	-12.5
23.5	12.5
22.5	12.5

37. Rectangular Load: "Rectangular Load 36"

Length	1.5 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	37.5 ft^2
Load	0.63 ksf
Depth	-133 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
23.5	-12.5
25	-12.5
25	12.5
23.5	12.5

38. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.563 ksf
Depth	-132.8 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
25	-12.5
26	-12.5
26	12.5
25	12.5

39. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.5 ksf
Depth	-132.7 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
26	-12.5
27	-12.5
27	12.5
26	12.5

40. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.438 ksf
Depth	-132.5 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
27	-12.5
28	-12.5
28	12.5
27	12.5

41. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-132.32 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
28	-12.5
29	-12.5
29	12.5
28	12.5

42. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.375 ksf
Depth	-132.15 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
29	-12.5
30	-12.5
30	12.5
29	12.5

43. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.313 ksf
Depth	-131.98 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
30	-12.5
31	-12.5
31	12.5
30	12.5

44. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.313 ksf
Depth	-131.81 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
31	-12.5
32	-12.5
32	12.5
31	12.5

45. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.25 ksf
Depth	-131.64 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
32	-12.5
33	-12.5
33	12.5
32	12.5

46. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.188 ksf
Depth	-131.47 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
33	-12.5
34	-12.5
34	12.5
33	12.5

47. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.156 ksf
Depth	-131.3 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
34	-12.5
35	-12.5
35	12.5
34	12.5

48. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.125 ksf
Depth	-131.13 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
35	-12.5
36	-12.5
36	12.5
35	12.5

49. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.0625 ksf
Depth	-130.79 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
36	-12.5
37	-12.5
37	12.5
36	12.5

50. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.0625 ksf
Depth	-130.62 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
37	-12.5
38	-12.5
38	12.5
37	12.5

51. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.0625 ksf
Depth	-130.45 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
38	-12.5
39	-12.5
39	12.5
38	12.5

52. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.0625 ksf
Depth	-130.28 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
39	-12.5
40	-12.5
40	12.5
39	12.5

53. Rectangular Load: "Rectangular Load 36"

Length	1 ft
Width	25 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	25 ft^2
Load	0.0625 ksf
Depth	-130.11 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

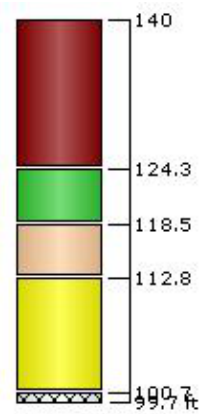
X [ft]	Y [ft]
40	-12.5
41	-12.5
41	12.5
40	12.5

Soil Layers

Ground Surface Drained: Yes

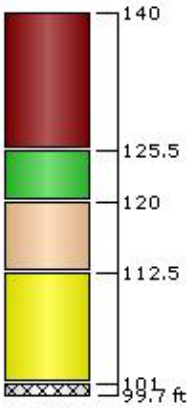
BB-201: (7.6, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper Fill)	15.7	-140	Yes
2	Organic Silt (Organics)	5.8	-124.3	No
3	Soft to Medium Still Clay (OC Clay)	5.7	-118.5	Yes
4	Gravel and Sand (Till)	12.1	-112.8	Yes



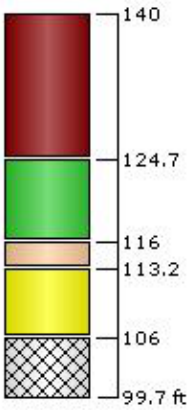
BB-102: (6, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper Fill)	14.5	-140	Yes
2	Organic Silt (Organics)	5.5	-125.5	No
3	Soft to Medium Still Clay (OC Clay)	7.5	-120	Yes
4	Gravel and Sand (Till)	11.5	-112.5	Yes



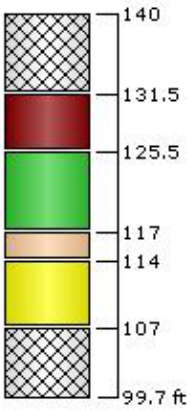
BB-202: (-5.8, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper Fill)	15.3	-140	Yes
2	Organic Silt (Organics)	8.7	-124.7	No
3	Soft to Medium Still Clay (OC Clay)	2.8	-116	Yes
4	Gravel and Sand (Till)	7.2	-113.2	Yes



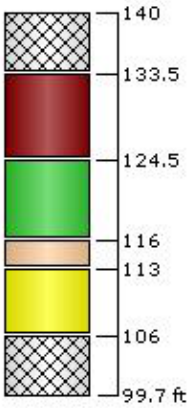
X-1: (-40, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper Fill)	6	-131.5	Yes
2	Organic Silt (Organics)	8.5	-125.5	No
3	Soft to Medium Still Clay (OC Clay)	3	-117	Yes
4	Gravel and Sand (Till)	7	-114	Yes



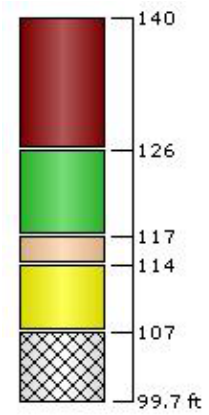
X-2: (-26, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper Fill)	9	-133.5	Yes
2	Organic Silt (Organics)	8.5	-124.5	No
3	Soft to Medium Still Clay (OC Clay)	3	-116	Yes
4	Gravel and Sand (Till)	7	-113	Yes



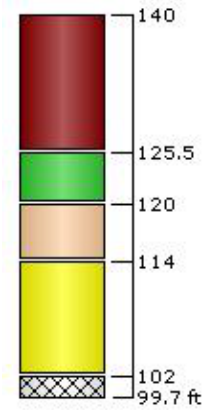
X-3: (-15, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper Fill)	14	-140	Yes
2	Organic Silt (Organics)	9	-126	No
3	Soft to Medium Still Clay (OC Clay)	3	-117	Yes
4	Gravel and Sand (Till)	7	-114	Yes



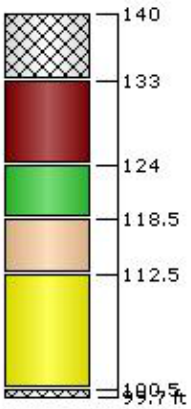
X-4: (15, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper Fill)	14.5	-140	Yes
2	Organic Silt (Organics)	5.5	-125.5	No
3	Soft to Medium Still Clay (OC Clay)	6	-120	Yes
4	Gravel and Sand (Till)	12	-114	Yes



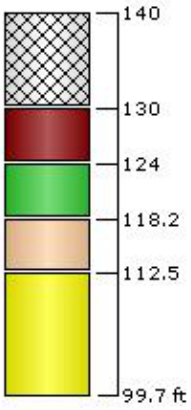
X-5: (24.5, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper Fill)	9	-133	Yes
2	Organic Silt (Organics)	5.5	-124	No
3	Soft to Medium Still Clay (OC Clay)	6	-118.5	Yes
4	Gravel and Sand (Till)	12	-112.5	Yes



X-6: (40, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper Fill)	6	-130	Yes
2	Organic Silt (Organics)	5.8	-124	No
3	Soft to Medium Still Clay (OC Clay)	5.7	-118.2	Yes
4	Gravel and Sand (Till)	12.8	-112.5	Yes



Soil Properties

Property	Sand and Gravel Layer (Upper Fill)	Organic Silt (Organics)	Soft to Medium Still Clay (OC Clay)	Gravel and Sand (Till)
Color				
Unit Weight [kips/ft^3]	0.113	0.103	0.106	0.126
Saturated Unit Weight [kips/ft^3]	0.1131	0.103	0.106	0.126
K0	1	1	1	1
Immediate Settlement	Enabled	Disabled	Disabled	Enabled
Es [ksf]	268.9	-	-	1123
Esur [ksf]	268.9	-	-	1123
Primary Consolidation	Disabled	Enabled	Enabled	Disabled
Material Type		Non-Linear	Non-Linear	
Cc	-	1.39	0.42	-
Cr	-	0.315	0.05	-
e0	-	1.039	1.039	-
OCR	-	1.5	4.94	-
Cv [ft^2/y]	-	250	180	-
Cvr [ft^2/y]	-	250	180	-
B-bar	-	1	1	-
Secondary Consolidation	Disabled	Standard	Standard	Disabled
Ca	-	0.15	0.07	-
Car	-	0.15	0.07	-
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Grid Name	Default Grid	Default Grid	Default Grid	Default Grid

Groundwater

Groundwater method	Grids
Water Unit Weight	0.0624 kips/ft^3

Groundwater Grid: Default Grid

X	Y	Depth (ft)
7.6	0	-132
6	0	-132
-5.8	0	-132
-40	0	-132
-26	0	-132
-15	0	-132
15	0	-132
24.5	0	-132
40	0	-132

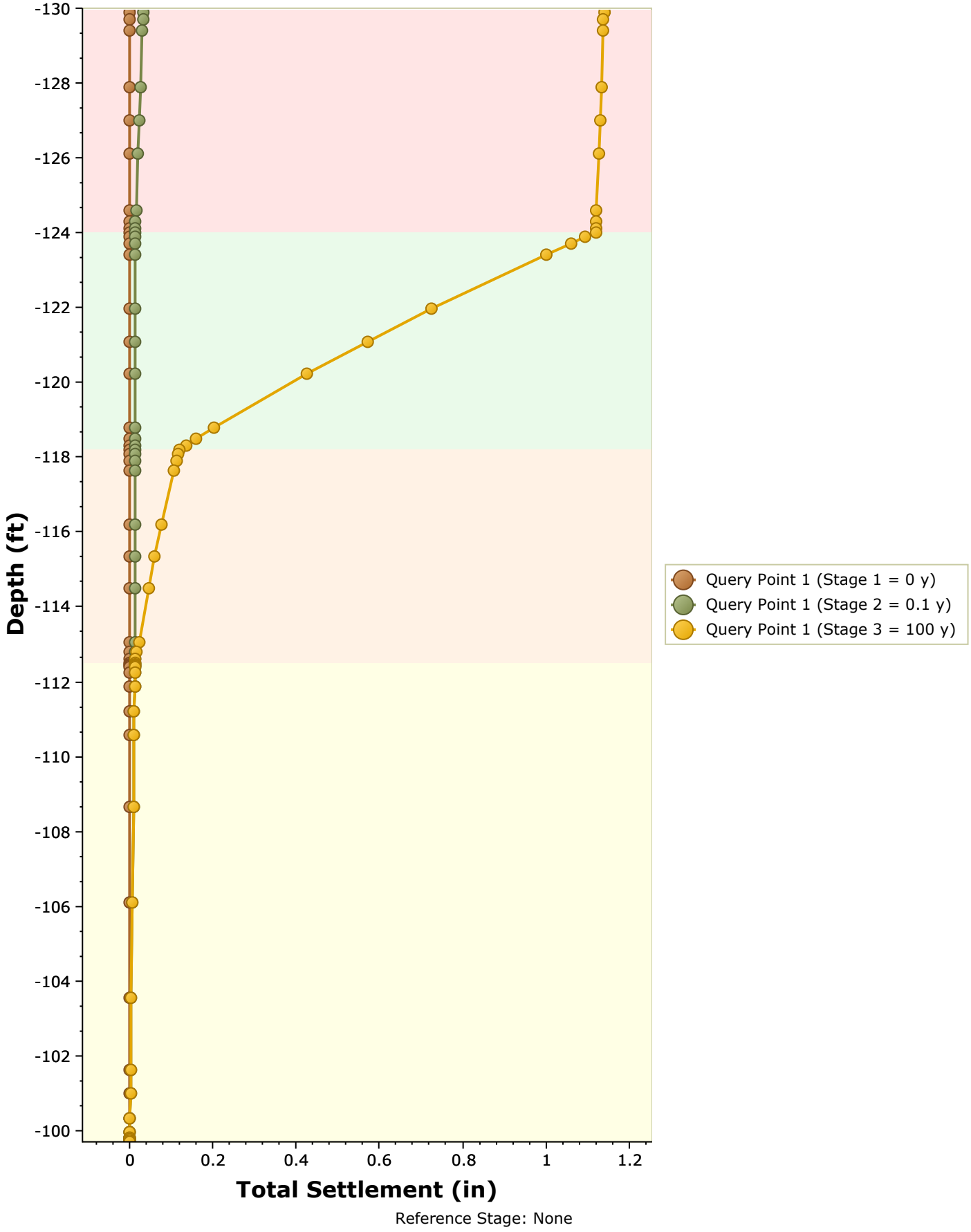
Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	40, 0	Auto: 49
2	Query Point 2	35.5, 1.77636e-015	Auto: 57
3	Query Point 3	29.5, 1.77636e-015	Auto: 63
4	Query Point 4	24.25, 1.77636e-015	Auto: 69
5	Query Point 5	19, 0	Auto: 65
6	Query Point 6	-7.90479e-014, 6.21725e-015	Auto: 67
7	Query Point 7	-11.8881, -2.3043e-015	Auto: 71
8	Query Point 8	11.8952, -1.2481e-015	Auto: 67

Query Lines

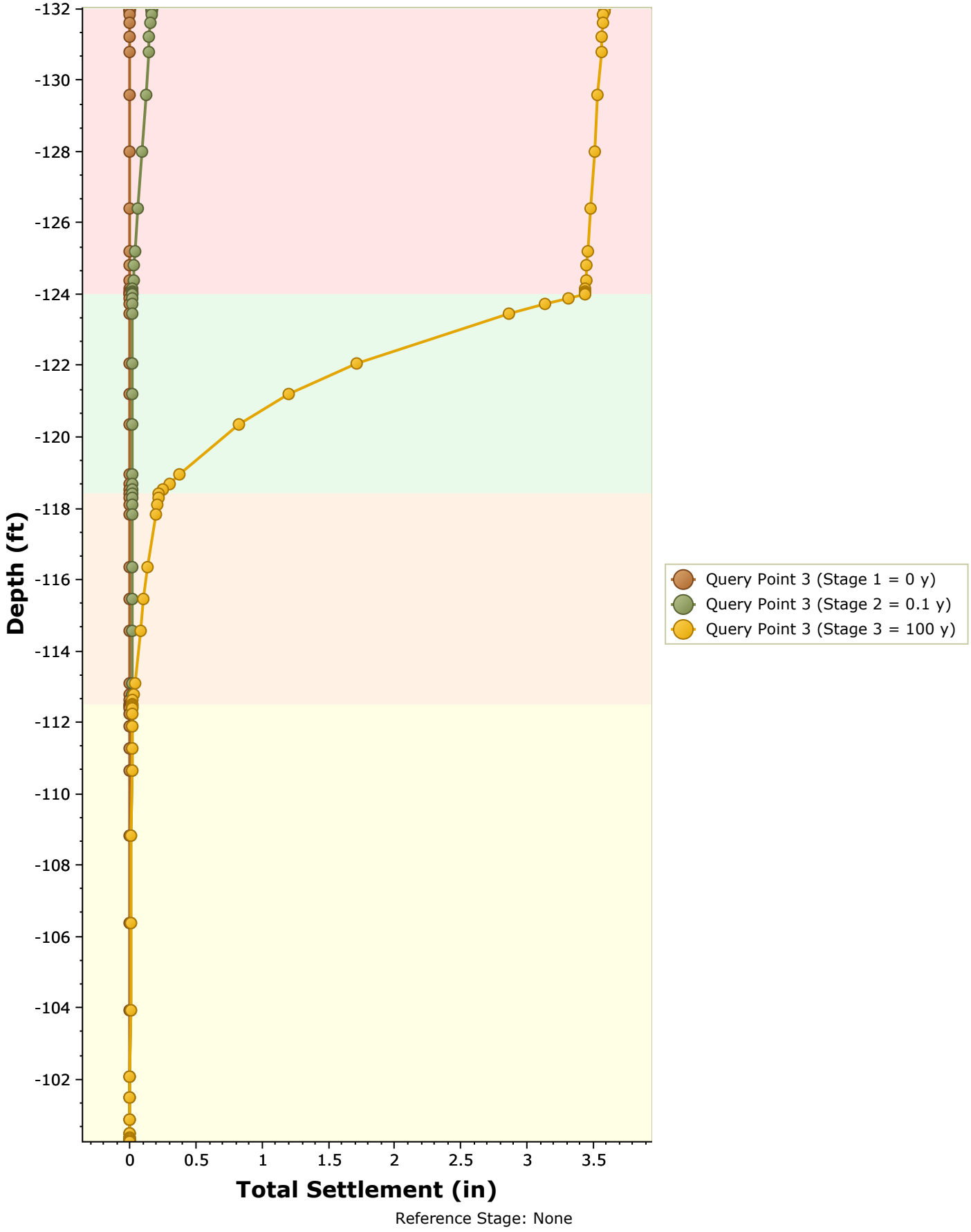
Line #	Query Line Name	Start Location	End Location	Horizontal Divisions	Vertical Divisions
1	Query Line 1	-40, -3.55271e-015	40, 0	50	Auto: 65

Total Settlement vs. Depth



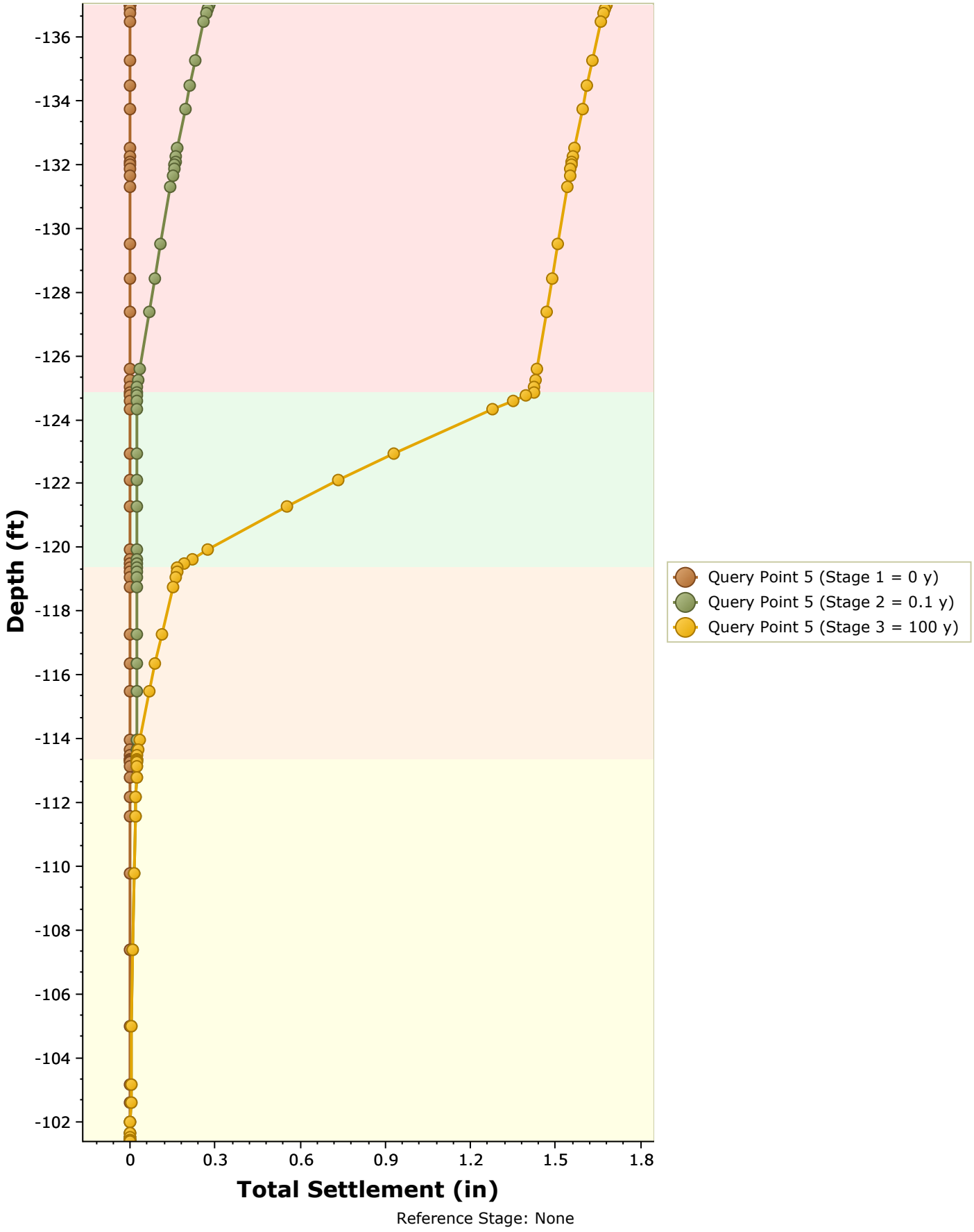
Reference Stage: None

Total Settlement vs. Depth



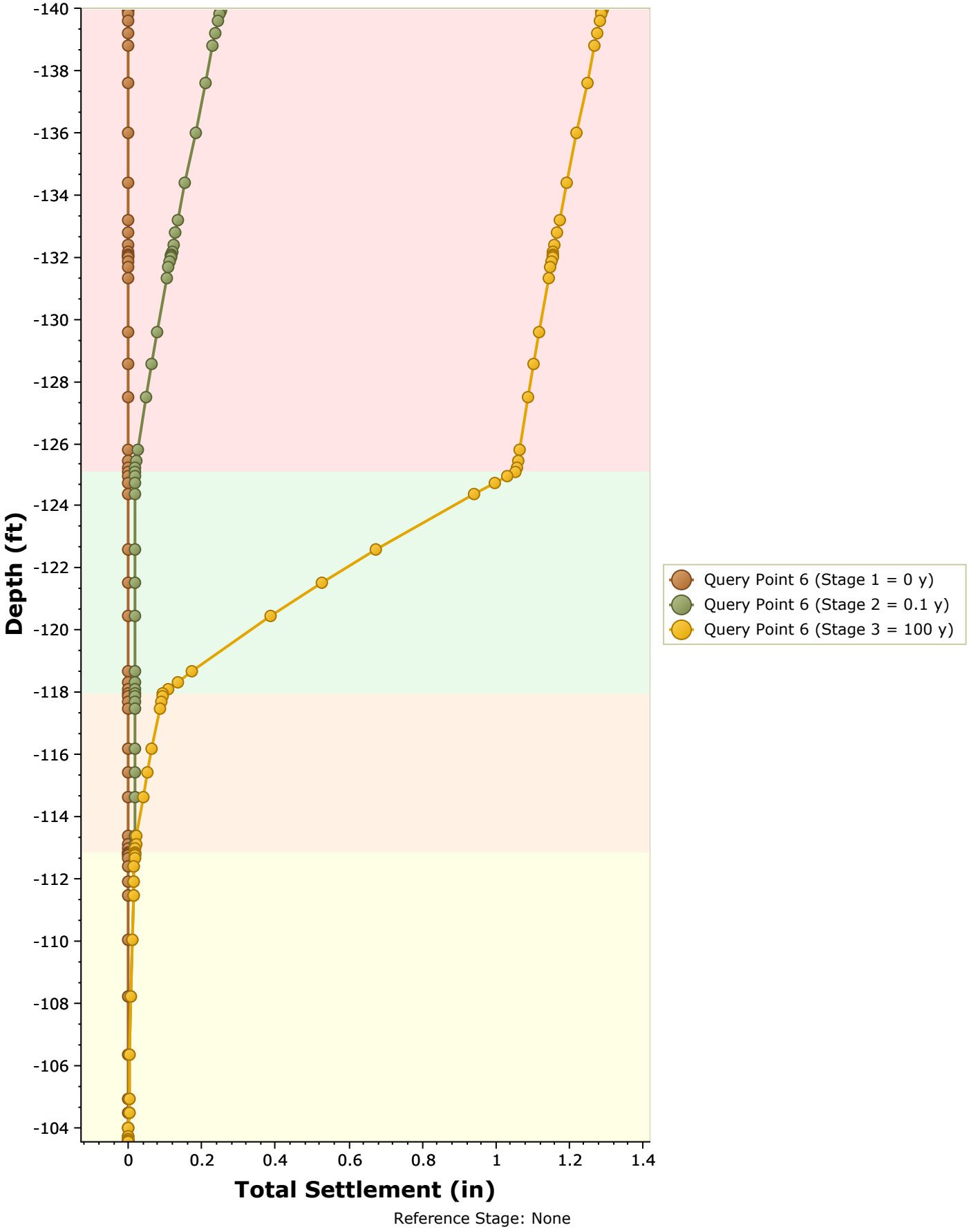
Reference Stage: None

Total Settlement vs. Depth



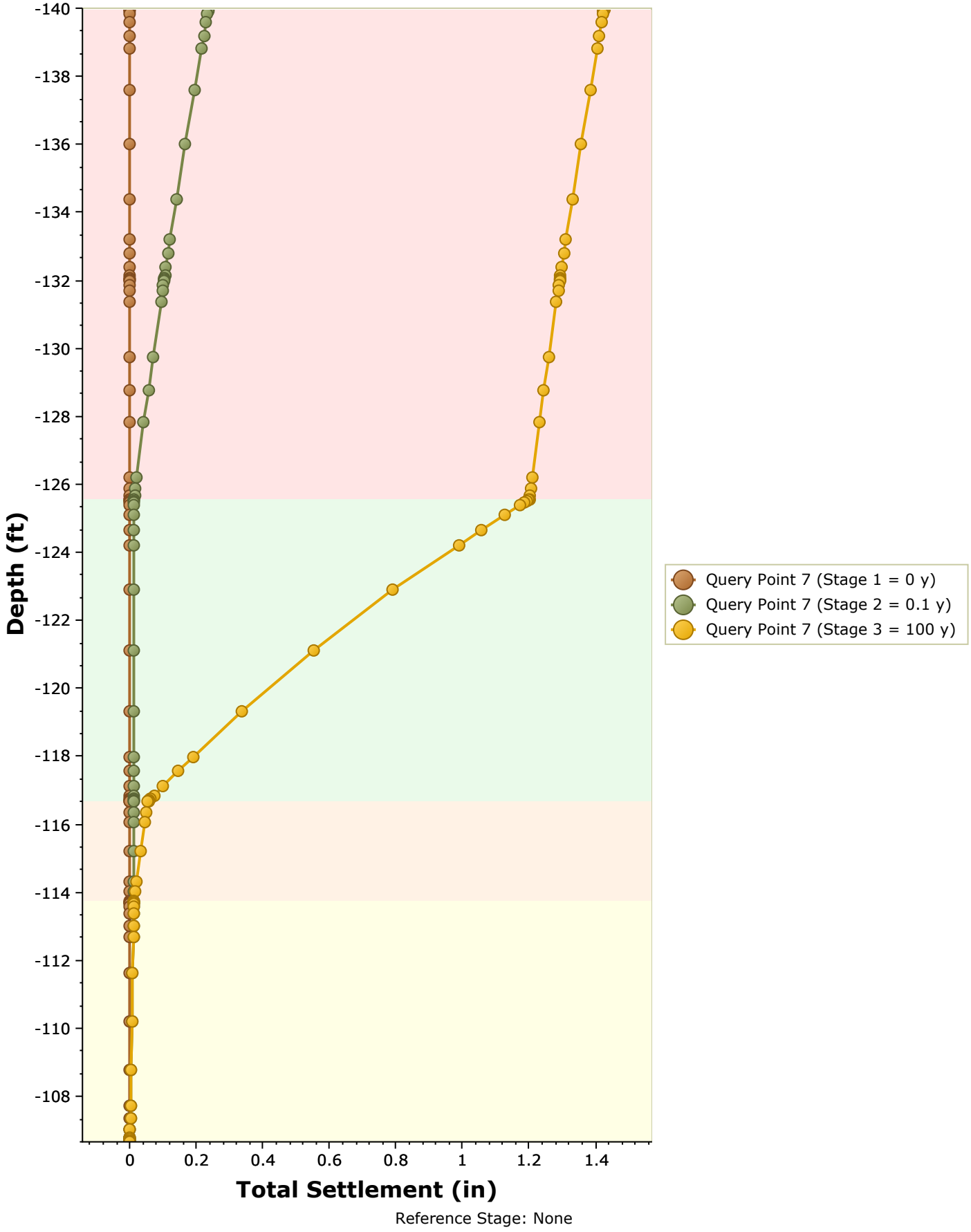
Reference Stage: None

Total Settlement vs. Depth



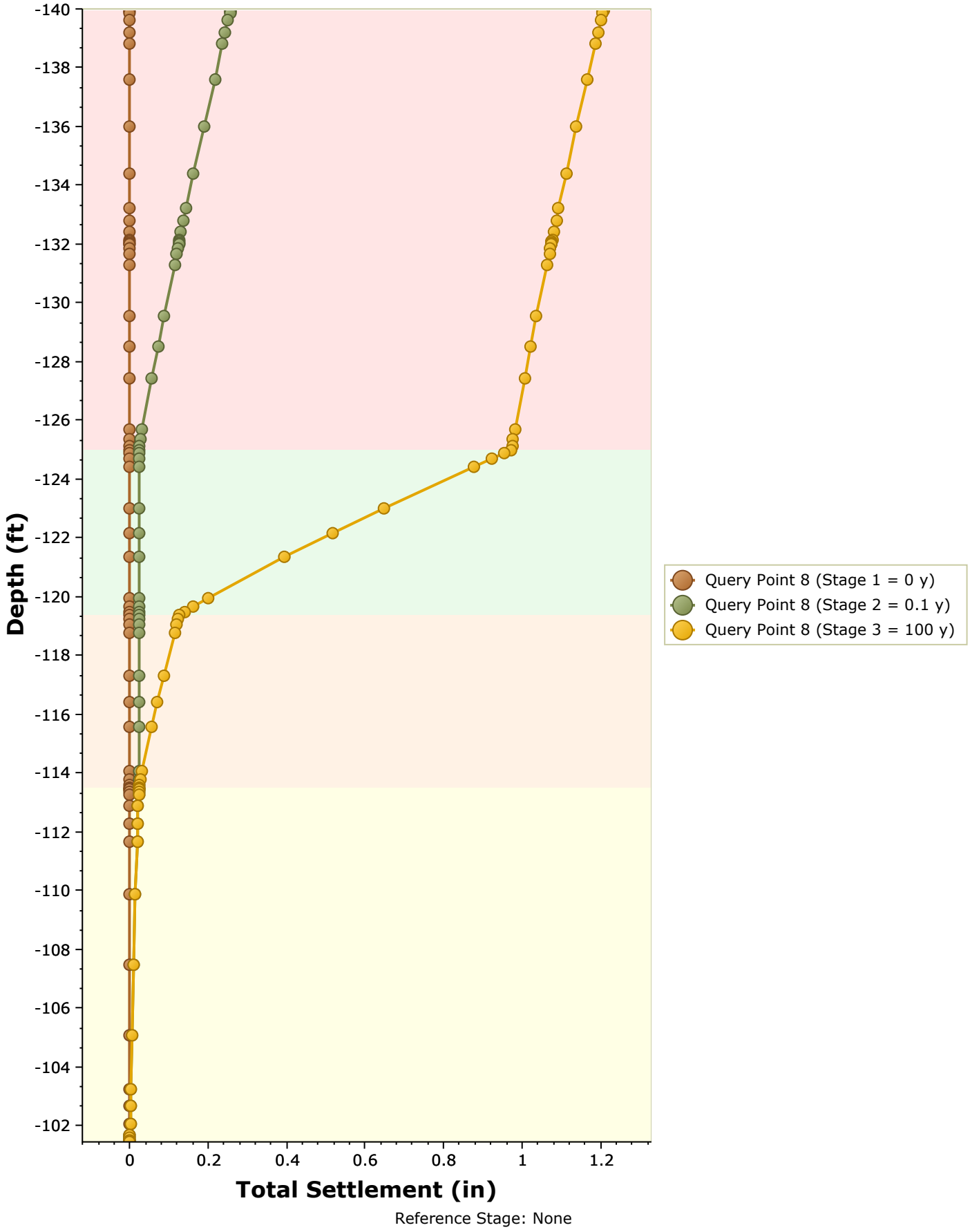
Reference Stage: None

Total Settlement vs. Depth



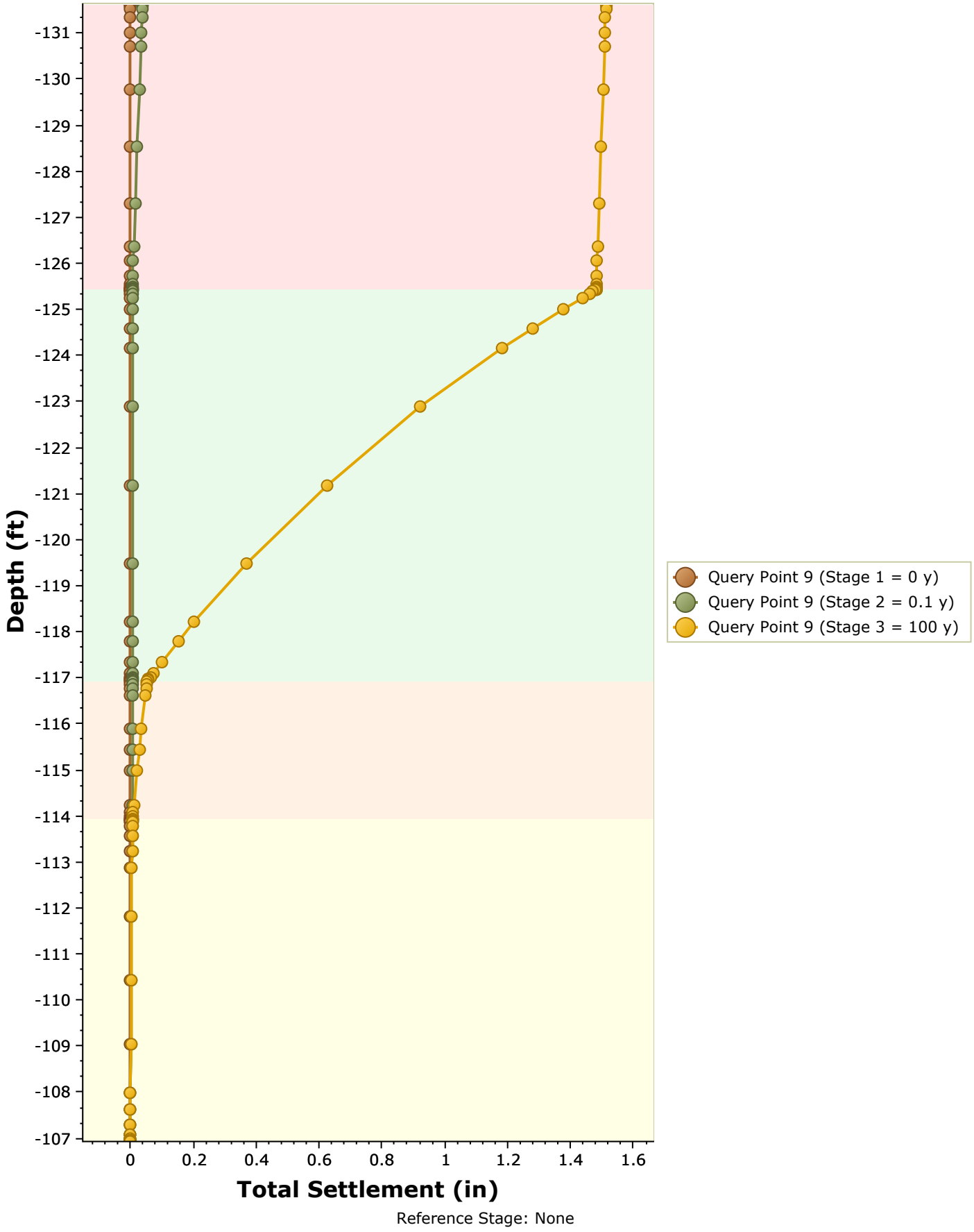
Reference Stage: None

Total Settlement vs. Depth



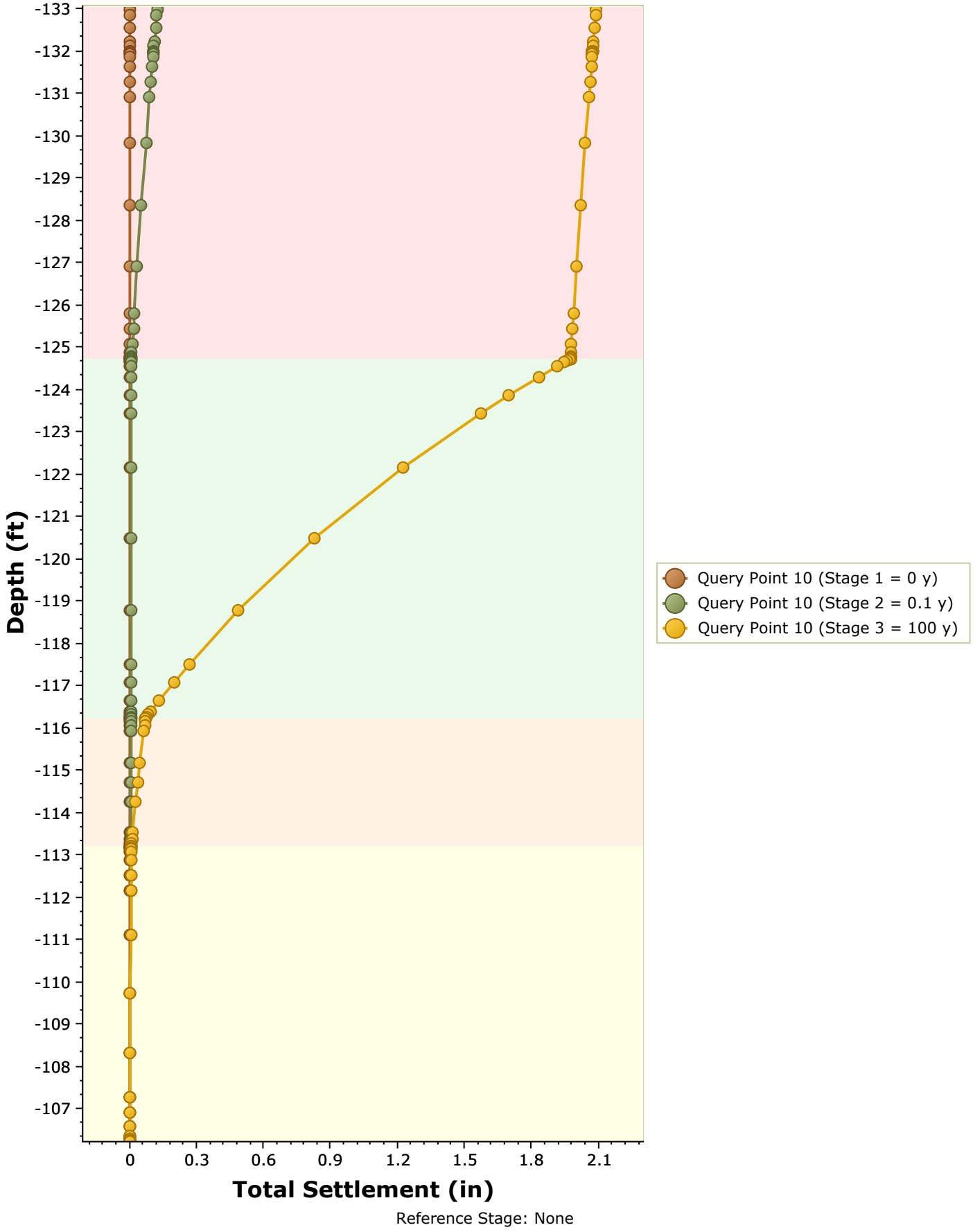
Reference Stage: None

Total Settlement vs. Depth



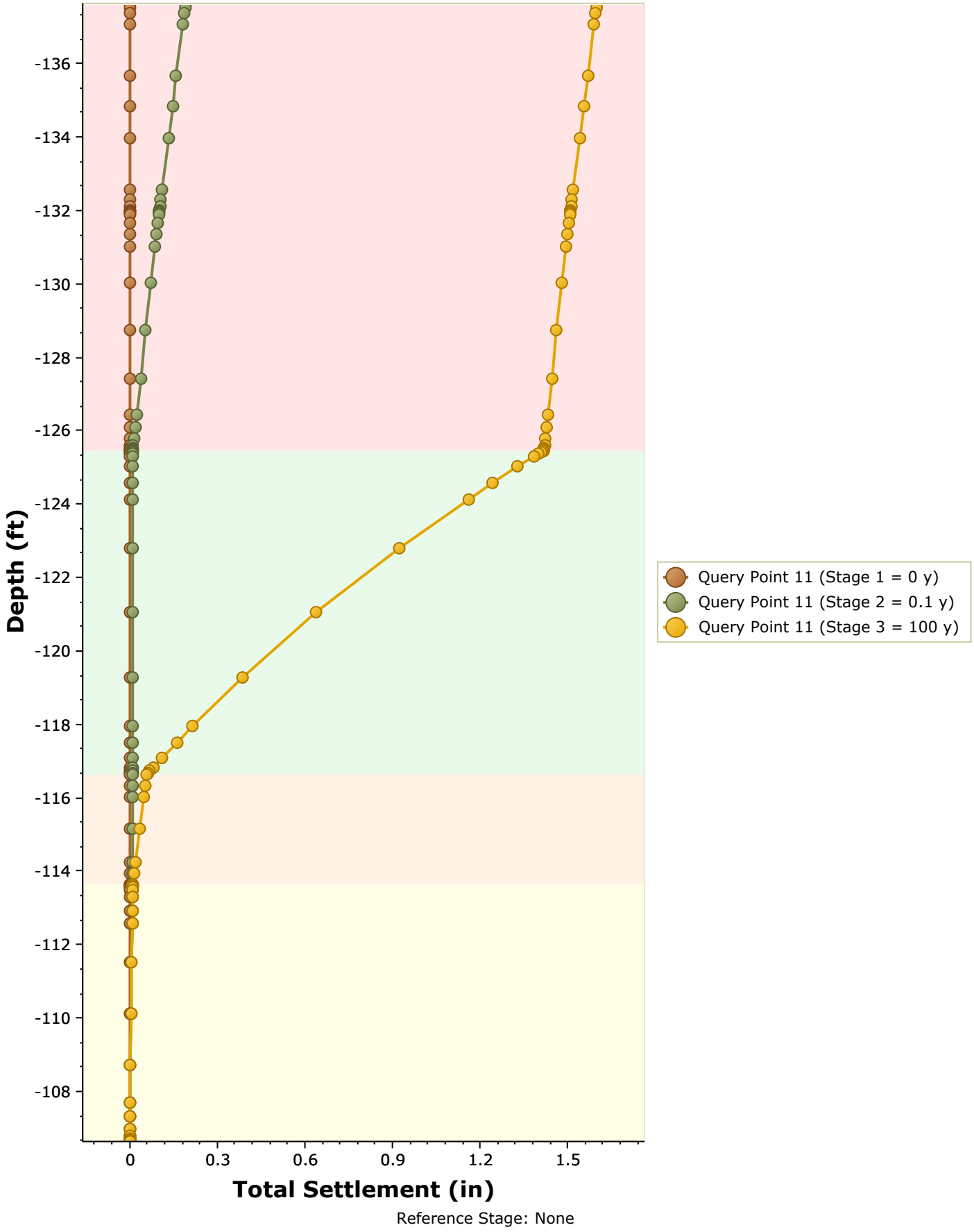
Reference Stage: None

Total Settlement vs. Depth



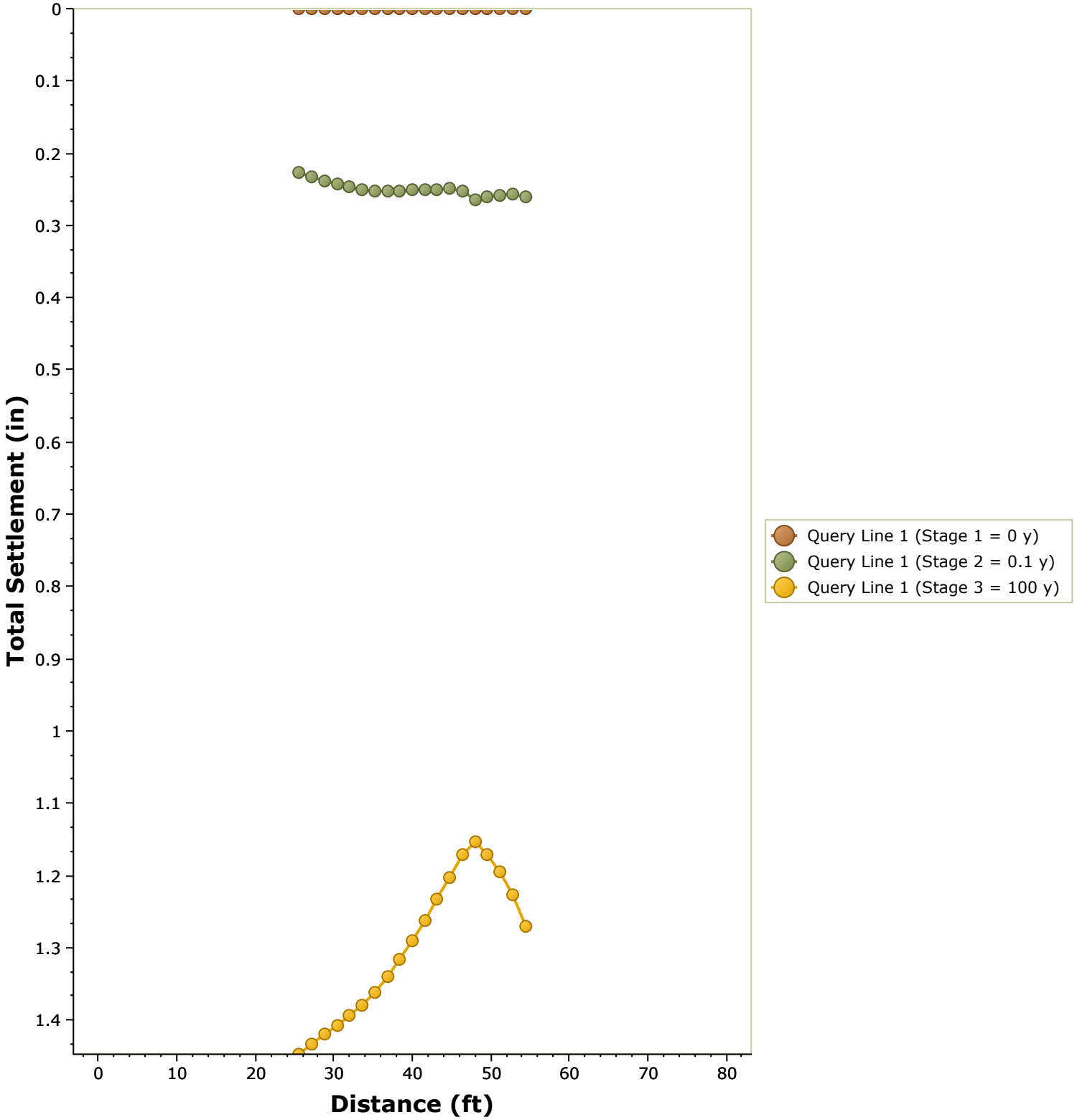
Reference Stage: None

Total Settlement vs. Depth



Reference Stage: None

Distance vs. Total Settlement

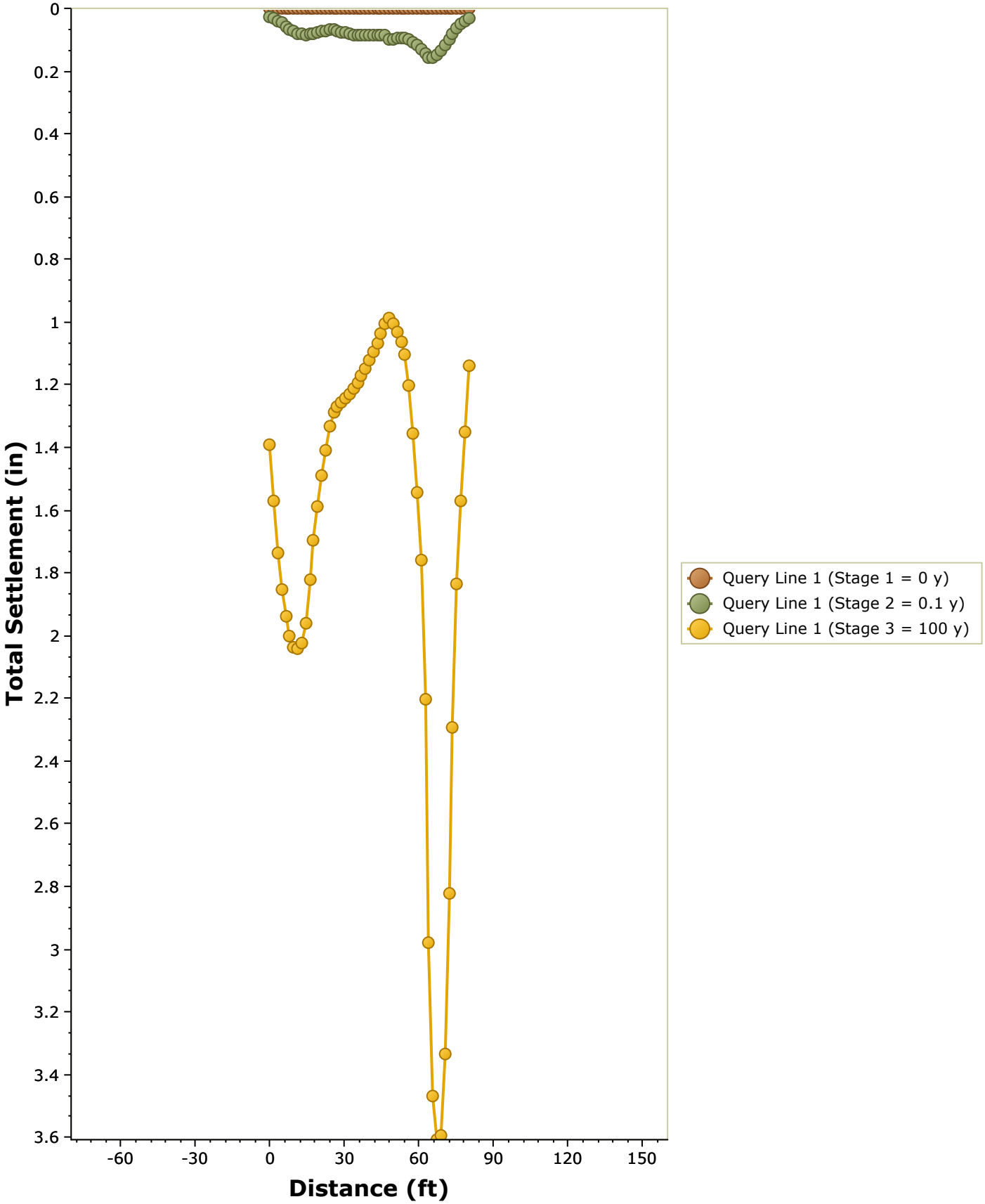


Reference Stage: None
Total Settlement at Depth = -140 ft

rocscience	*Project*	
	Analysis Description	
	Drawn By	*Company*
	Date 10/11/2017, 2:06:27 PM	*File Name* South Abutment.s3z

SETTLE3D 4.012

Distance vs. Total Settlement



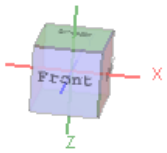
Reference Stage: None
Total Settlement at Depth = -130 ft

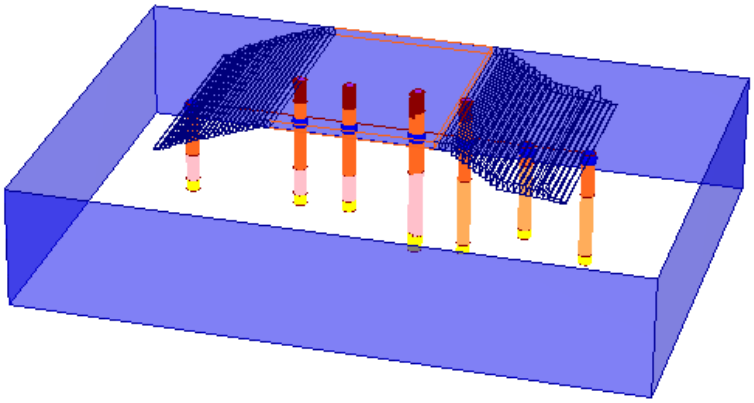
ABUTMENT 2 (NORTH)

SETTLE3D ANALYSIS

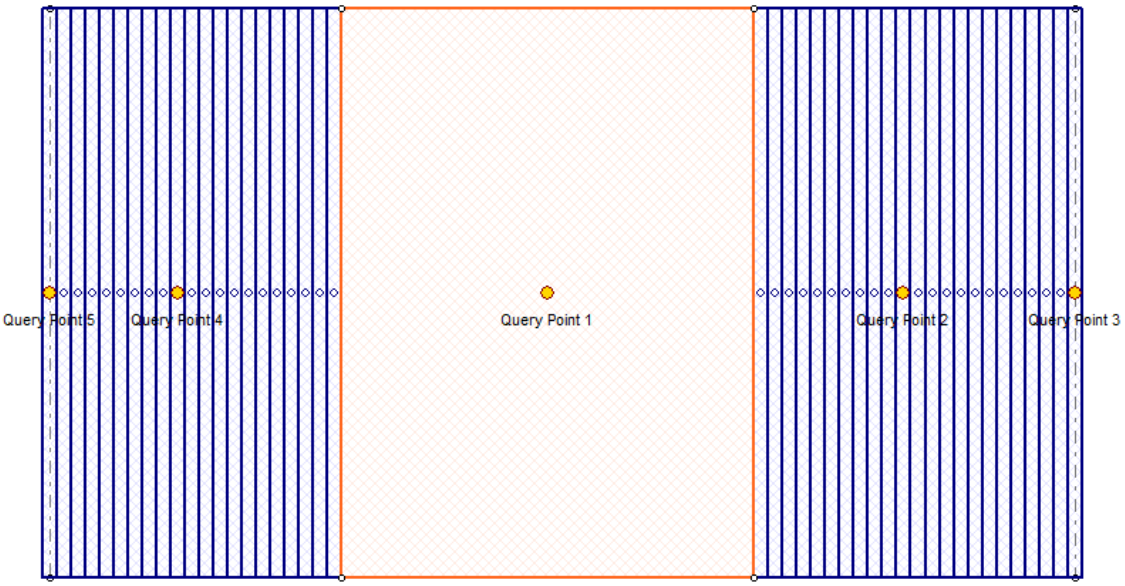
HNTB

Overview

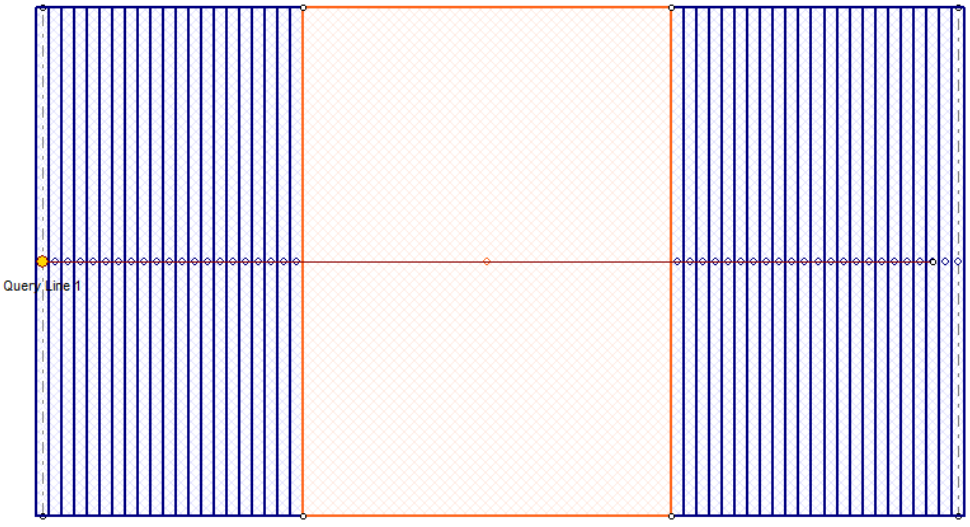




- **Query Points**



- **Query Line**



Settle3D Analysis Information

Project Settings

Document Name	North Abutment.s3z
Date Created	10/11/2017, 2:06:27 PM
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	years
Permeability Units	feet/year
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [years]
1	Stage 1	0
2	Stage 2	0.1
3	Stage 3	100

Results

Time taken to compute: 34.3788 seconds

Stage: Stage 1 = 0 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0
Loading Stress XX [ksf]	0	0
Loading Stress YY [ksf]	0	0
Effective Stress ZZ [ksf]	0	1.991
Effective Stress XX [ksf]	0	1.991
Effective Stress YY [ksf]	0	1.991
Total Stress ZZ [ksf]	0	3.31831
Total Stress XX [ksf]	0	3.31831
Total Stress YY [ksf]	0	3.31831
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0
Pore Water Pressure [ksf]	0	1.36828
Excess Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0.000174	9.29481
Over-consolidation Ratio	1	4.94
Void Ratio	0	1.039
Permeability [ft/y]	0	0.492662
Coefficient of Consolidation [ft^2/y]	0	350
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	100
Undrained Shear Strength	0	0

Stage: Stage 2 = 0.1 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.880827
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0.880827
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0.889675
Loading Stress XX [ksf]	-0.0220679	0.92873
Loading Stress YY [ksf]	0	0.502737
Effective Stress ZZ [ksf]	0	1.991
Effective Stress XX [ksf]	-0.0215335	2.00617
Effective Stress YY [ksf]	0	2.00948
Total Stress ZZ [ksf]	0	3.57087
Total Stress XX [ksf]	-0.0215335	3.58604
Total Stress YY [ksf]	0	3.58935
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	26.128
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	26.128
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0.0124732
Pore Water Pressure [ksf]	0	1.60656
Excess Pore Water Pressure [ksf]	0	0.611343
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0.000174	9.29481
Over-consolidation Ratio	1	4.94
Void Ratio	0	1.039
Permeability [ft/y]	0	0.492662
Coefficient of Consolidation [ft^2/y]	0	350
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	-5.55112e-017	0.0205486

Stage: Stage 3 = 100 y

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.34123
Total Consolidation Settlement [in]	0	0.962648
Virgin Consolidation Settlement [in]	0	0.0180431
Recompression Consolidation Settlement [in]	0	0.962648
Immediate Settlement [in]	0	0.880827
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0.889675
Loading Stress XX [ksf]	-0.0220679	0.92873
Loading Stress YY [ksf]	0	0.502737
Effective Stress ZZ [ksf]	0	2.24356
Effective Stress XX [ksf]	-0.0215335	2.25873
Effective Stress YY [ksf]	0	2.26204
Total Stress ZZ [ksf]	0	3.57087
Total Stress XX [ksf]	-0.0215335	3.58604
Total Stress YY [ksf]	0	3.58935
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	13.6688
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	26.128
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	64.5388
Total Strain	0	0.0124732
Pore Water Pressure [ksf]	0	1.36828
Excess Pore Water Pressure [ksf]	-0.000447339	0.000527368
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.000174	9.29481
Over-consolidation Ratio	1	4.58693
Void Ratio	0	1.03785
Permeability [ft/y]	0	4.52683
Coefficient of Consolidation [ft^2/y]	0	350
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	100
Undrained Shear Strength	0	0.0362984

Loads

1. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.39 ksf
Depth	-140 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-15.5	-20
-14.5	-20
-14.5	20
-15.5	20

2. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.39 ksf
Depth	-140 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
14.5	-20
15.5	-20
15.5	20
14.5	20

3. Fill Load: "Fill Load 3"

Label	Fill Load 3
Load Type	Flexible
Area of Load	1160 ft^2
Load	0.39 ksf
Depth	-140 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-14.5	20
-14.5	-20
14.5	-20
14.5	20

4. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-140 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-16.5	-20
-15.5	-20
-15.5	20
-16.5	20

5. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-139.65 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-17.5	-20
-16.5	-20
-16.5	20
-17.5	20

6. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-139.3 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-18.5	-20
-17.5	-20
-17.5	20
-18.5	20

7. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-138.95 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-19.5	-20
-18.5	-20
-18.5	20
-19.5	20

8. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-138.6 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-20.5	-20
-19.5	-20
-19.5	20
-20.5	20

9. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-138.25 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-21.5	-20
-20.5	-20
-20.5	20
-21.5	20

10. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-137.9 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-22.5	-20
-21.5	-20
-21.5	20
-22.5	20

11. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-137.55 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-23.5	-20
-22.5	-20
-22.5	20
-23.5	20

12. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-137.2 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-24.5	-20
-23.5	-20
-23.5	20
-24.5	20

13. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-136.85 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-25.5	-20
-24.5	-20
-24.5	20
-25.5	20

14. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.312 ksf
Depth	-136.5 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-26.5	-20
-25.5	-20
-25.5	20
-26.5	20

15. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.313 ksf
Depth	-136.15 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-27.5	-20
-26.5	-20
-26.5	20
-27.5	20

16. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.313 ksf
Depth	-135.8 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-28.5	-20
-27.5	-20
-27.5	20
-28.5	20

17. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.25 ksf
Depth	-135.45 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-29.5	-20
-28.5	-20
-28.5	20
-29.5	20

18. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.25 ksf
Depth	-135.1 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-30.5	-20
-29.5	-20
-29.5	20
-30.5	20

19. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.25 ksf
Depth	-134.75 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-31.5	-20
-30.5	-20
-30.5	20
-31.5	20

20. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.188 ksf
Depth	-134.4 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-32.5	-20
-31.5	-20
-31.5	20
-32.5	20

21. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.125 ksf
Depth	-133.7 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-33.5	-20
-32.5	-20
-32.5	20
-33.5	20

22. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.063 ksf
Depth	-133.35 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-34.5	-20
-33.5	-20
-33.5	20
-34.5	20

23. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.063 ksf
Depth	-133 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
-35.5	-20
-34.5	-20
-34.5	20
-35.5	20

24. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.39 ksf
Depth	-140 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
15.5	-20
16.5	-20
16.5	20
15.5	20

25. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.39 ksf
Depth	-140 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
16.5	-20
17.5	-20
17.5	20
16.5	20

26. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.39 ksf
Depth	-139.33 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
17.5	-20
18.5	-20
18.5	20
17.5	20

27. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-138.67 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
18.5	-20
19.5	-20
19.5	20
18.5	20

28. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.438 ksf
Depth	-138.01 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
19.5	-20
20.5	-20
20.5	20
19.5	20

29. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.438 ksf
Depth	-137.35 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
20.5	-20
21.5	-20
21.5	20
20.5	20

30. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.5 ksf
Depth	-136.69 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
21.5	-20
22.5	-20
22.5	20
21.5	20

31. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.5 ksf
Depth	-136.03 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
22.5	-20
23.5	-20
23.5	20
22.5	20

32. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.5 ksf
Depth	-135.37 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
23.5	-20
24.5	-20
24.5	20
23.5	20

33. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.562 ksf
Depth	-134.71 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
24.5	-20
25.5	-20
25.5	20
24.5	20

34. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.562 ksf
Depth	-134.05 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
25.5	-20
26.5	-20
26.5	20
25.5	20

35. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.5 ksf
Depth	-133.959 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
26.5	-20
27.5	-20
27.5	20
26.5	20

36. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.5 ksf
Depth	-133.868 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
27.5	-20
28.5	-20
28.5	20
27.5	20

37. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.5 ksf
Depth	-133.777 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
28.5	-20
29.5	-20
29.5	20
28.5	20

38. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.5 ksf
Depth	-133.686 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
29.5	-20
30.5	-20
30.5	20
29.5	20

39. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.438 ksf
Depth	-133.595 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
30.5	-20
31.5	-20
31.5	20
30.5	20

40. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.375 ksf
Depth	-133.504 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
31.5	-20
32.5	-20
32.5	20
31.5	20

41. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.25 ksf
Depth	-133.413 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
32.5	-20
33.5	-20
33.5	20
32.5	20

42. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.88 ksf
Depth	-133.322 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
33.5	-20
34.5	-20
34.5	20
33.5	20

43. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.19 ksf
Depth	-133.231 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
34.5	-20
35.5	-20
35.5	20
34.5	20

44. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.125 ksf
Depth	-133.14 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

X [ft]	Y [ft]
35.5	-20
36.5	-20
36.5	20
35.5	20

45. Rectangular Load: "Rectangular Load 1"

Length	1 ft
Width	40 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	40 ft^2
Load	0.063 ksf
Depth	-133 ft
Installation Stage	Stage 2 = 0.1 y

Coordinates

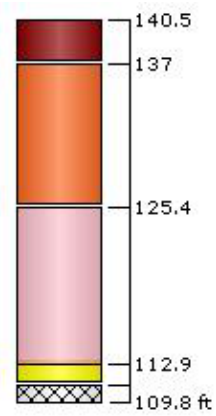
X [ft]	Y [ft]
36.5	-20
37.5	-20
37.5	20
36.5	20

Soil Layers

Ground Surface Drained: Yes

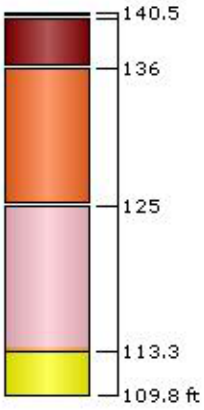
BB-104: (6.4, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper fill)	3.5	-140.5	Yes
2	Sand and Gravel Layer (Lower fill)	11.6	-137	Yes
3	Very Soft to Soft Clay & Silt	12.5	-125.4	No
4	Soft to Medium Stiff Clay (OC Clay)	0	-112.9	Yes
5	Gravel and Sand (Till)	1.7	-112.9	Yes



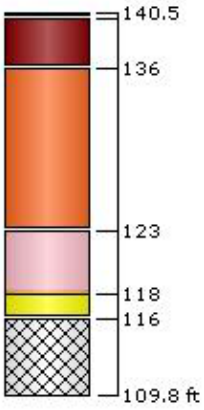
BB-204: (6.1, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper fill)	4	-140	Yes
2	Sand and Gravel Layer (Lower fill)	11	-136	Yes
3	Very Soft to Soft Clay & Silt	11.7	-125	No
4	Soft to Medium Stiff Clay (OC Clay)	0	-113.3	Yes
5	Gravel and Sand (Till)	3.5	-113.3	Yes



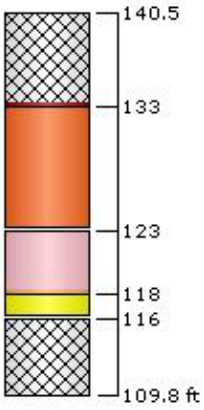
BB-203: (-6, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper fill)	4	-140	Yes
2	Sand and Gravel Layer (Lower fill)	13	-136	Yes
3	Very Soft to Soft Clay & Silt	5	-123	No
4	Soft to Medium Stiff Clay (OC Clay)	0	-118	Yes
5	Gravel and Sand (Till)	2	-118	Yes



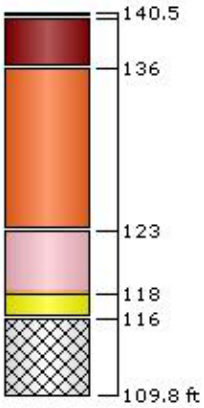
X-1: (-35, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper fill)	0	-133	Yes
2	Sand and Gravel Layer (Lower fill)	10	-133	Yes
3	Very Soft to Soft Clay & Silt	5	-123	No
4	Soft to Medium Stiff Clay (OC Clay)	0	-118	Yes
5	Gravel and Sand (Till)	2	-118	Yes



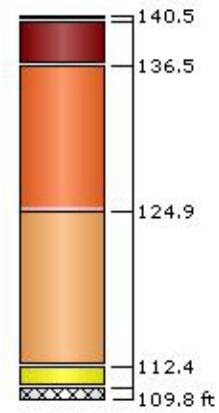
X-2: (-15, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper fill)	4	-140	Yes
2	Sand and Gravel Layer (Lower fill)	13	-136	Yes
3	Very Soft to Soft Clay & Silt	5	-123	No
4	Soft to Medium Stiff Clay (OC Clay)	0	-118	Yes
5	Gravel and Sand (Till)	2	-118	Yes



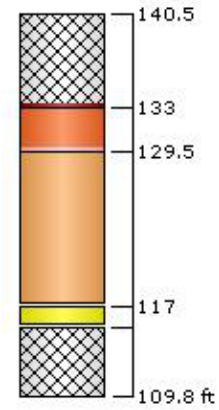
X-3: (15, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper fill)	3.5	-140	Yes
2	Sand and Gravel Layer (Lower fill)	11.6	-136.5	Yes
3	Very Soft to Soft Clay & Silt	0	-124.9	No
4	Soft to Medium Stiff Clay (OC Clay)	12.5	-124.9	Yes
5	Gravel and Sand (Till)	1.7	-112.4	Yes



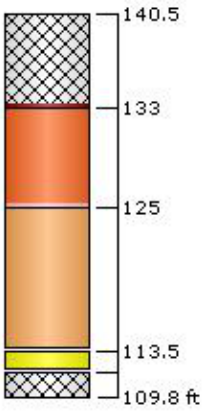
X-4: (26, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper fill)	0	-133	Yes
2	Sand and Gravel Layer (Lower fill)	3.5	-133	Yes
3	Very Soft to Soft Clay & Silt	0	-129.5	No
4	Soft to Medium Stiff Clay (OC Clay)	12.5	-129.5	Yes
5	Gravel and Sand (Till)	1.7	-117	Yes



X-5: (37, 0)

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sand and Gravel Layer (Upper fill)	0	-133	Yes
2	Sand and Gravel Layer (Lower fill)	8	-133	Yes
3	Very Soft to Soft Clay & Silt	0	-125	No
4	Soft to Medium Stiff Clay (OC Clay)	11.5	-125	Yes
5	Gravel and Sand (Till)	1.7	-113.5	Yes


140.5
133
125
113.5
109.8 ft

Soil Properties

Property	Sand and Gravel Layer (Upper fill)	Sand and Gravel Layer (Lower fill)	Soft to Medium Stiff Clay (OC Clay)	Very Soft to Soft Clay & Silt
Color				
Unit Weight [kips/ft^3]	0.12	0.111	0.113	0.091
Saturated Unit Weight [kips/ft^3]	0.12	0.111	0.113	0.091
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Disabled	Disabled
Es [ksf]	482.9	69.8	-	-
Esur [ksf]	482.9	69.8	-	-
Primary Consolidation	Disabled	Disabled	Enabled	Enabled
Material Type			Non-Linear	Non-Linear
Cc	-	-	0.42	0.9
Cr	-	-	0.05	0.04
e0	-	-	1.039	1.039
OCR	-	-	4.94	1.36
Cv [ft^2/y]	-	-	180	350
Cvr [ft^2/y]	-	-	180	350
B-bar	-	-	1	1
Secondary Consolidation	Disabled	Disabled	Standard	Standard
Ca	-	-	0.07	0.07
Car	-	-	0.07	0.07
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Grid Name	Default Grid	Default Grid	Default Grid	Default Grid

Property	Gravel and Sand (Till)
Color	
Unit Weight [kips/ft^3]	0.126
Saturated Unit Weight [kips/ft^3]	0.126
K0	1
Immediate Settlement	Enabled
Es [ksf]	1123
Esur [ksf]	1123
B-bar	-
Undrained Su A [kips/ft2]	0
Undrained Su S	0.2
Undrained Su m	0.8
Grid Name	Default Grid

Groundwater

Groundwater method Grids
Water Unit Weight 0.0624 kips/ft^3

Groundwater Grid: Default Grid

X	Y	Depth (ft)
6.4	0	-132
6.1	0	-132
-6	0	-132
-35	0	-132
-15	0	-132
15	0	-132
26	0	-132
37	0	-132

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
3	Query Point 3	37, 3.55271e-015	Auto
4	Query Point 5	-35, -6.03961e-014	Auto
5	Query Point 4	-26, -3.55271e-014	Auto
6	Query Point 2	25, -3.55271e-015	Auto
7	Query Point 1	-8.88178e-016, -1.95399e-014	Auto

Query Lines

Line #	Query Line Name	Start Location	End Location	Horizontal Divisions	Vertical Divisions
1	Query Line 1	-35, -6.03961e-014	35, 3.55271e-015	20	Auto

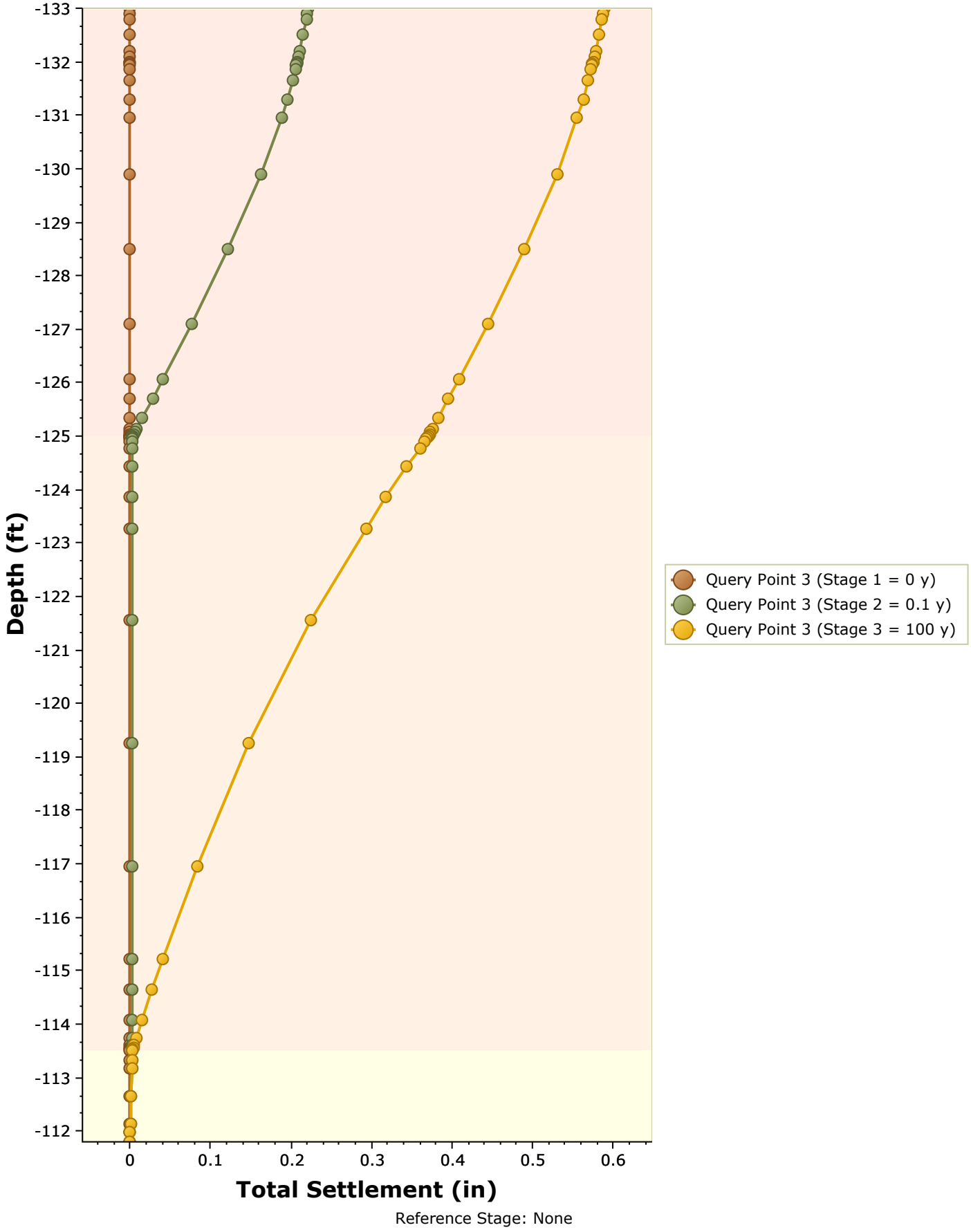
Field Point Grid

Number of points 1075
Expansion Factor 1

Grid Coordinates

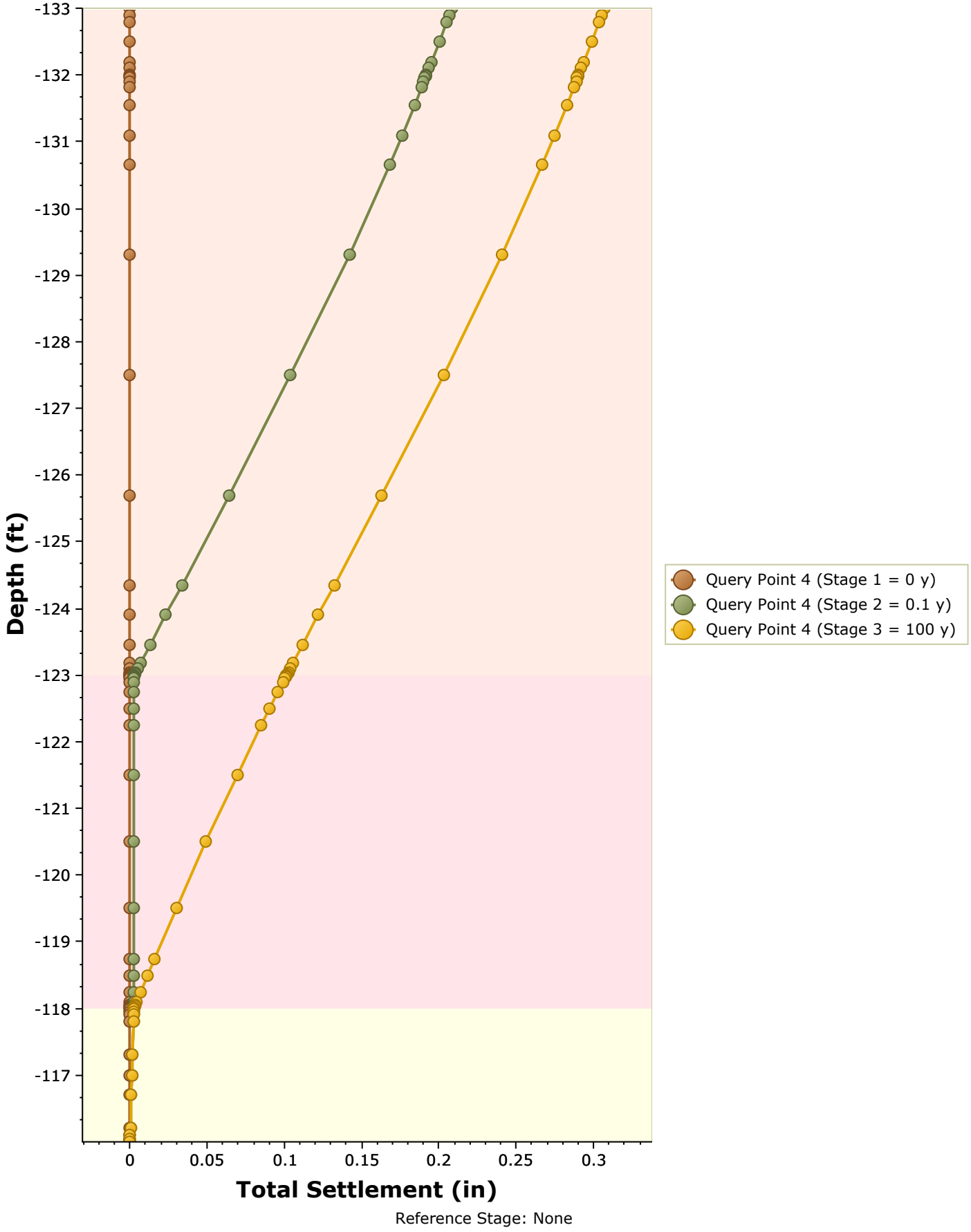
X [ft]	Y [ft]
57.5	40
57.5	-40
-55.5	-40
-55.5	40

Total Settlement vs. Depth



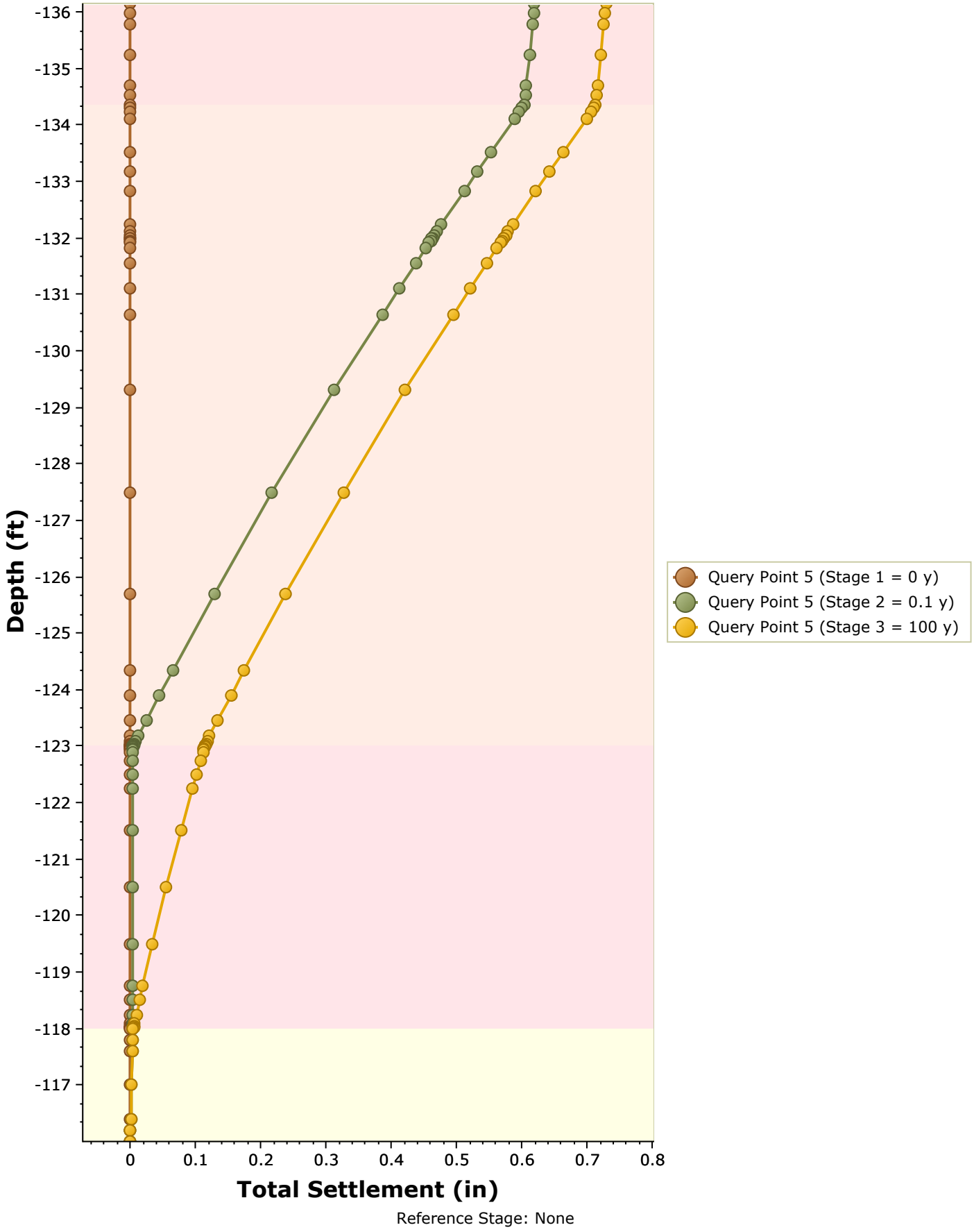
Reference Stage: None

Total Settlement vs. Depth



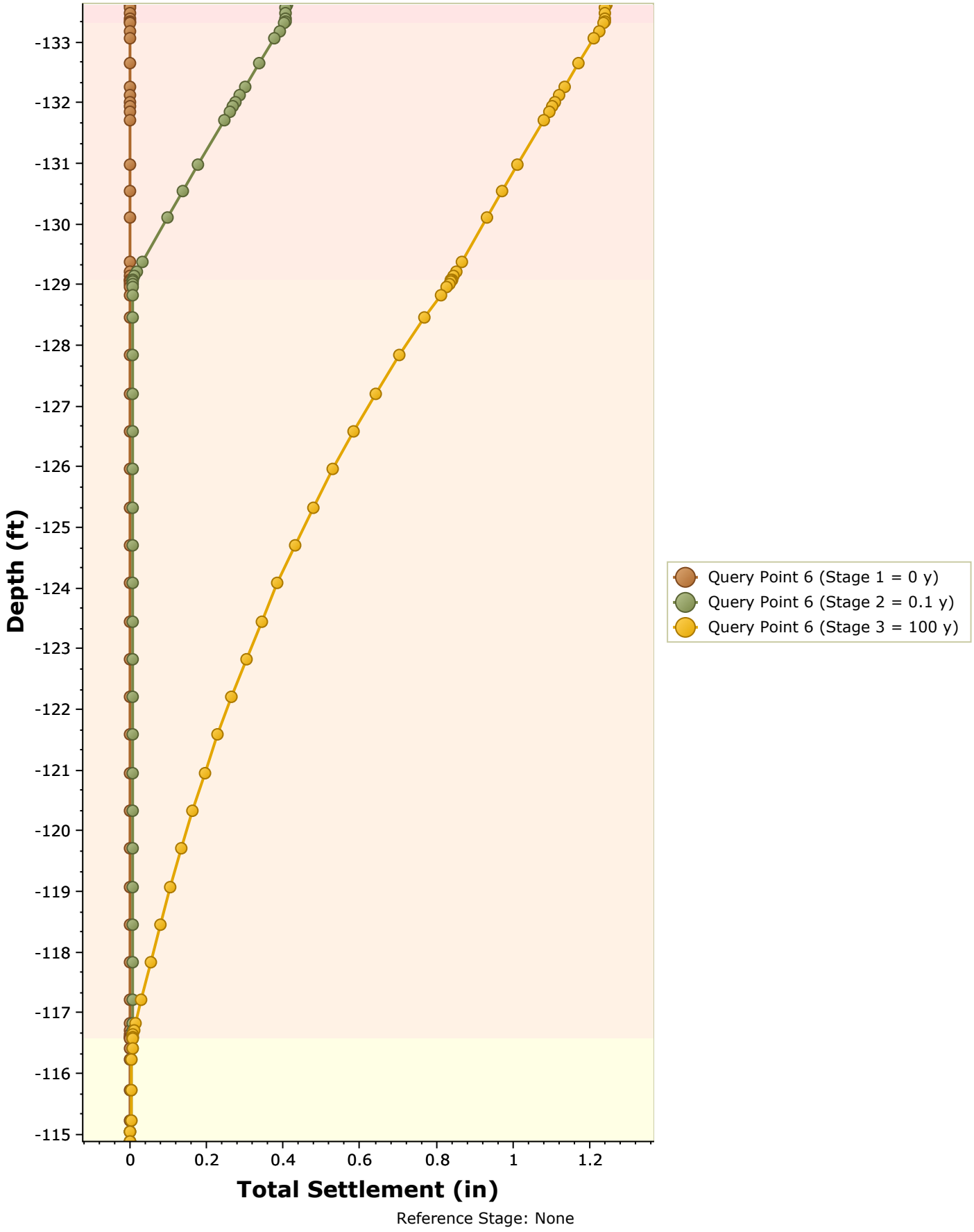
Reference Stage: None

Total Settlement vs. Depth



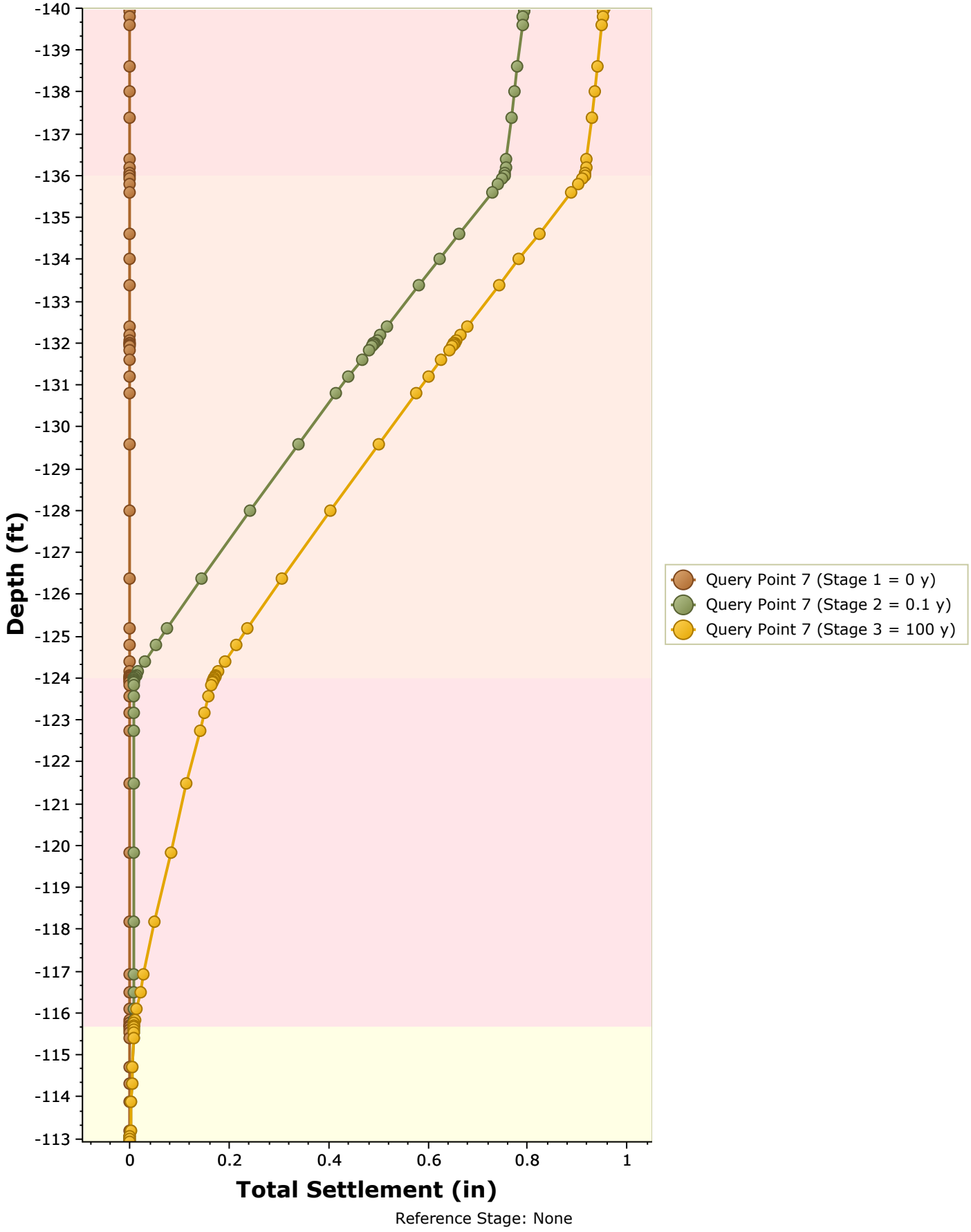
Reference Stage: None

Total Settlement vs. Depth



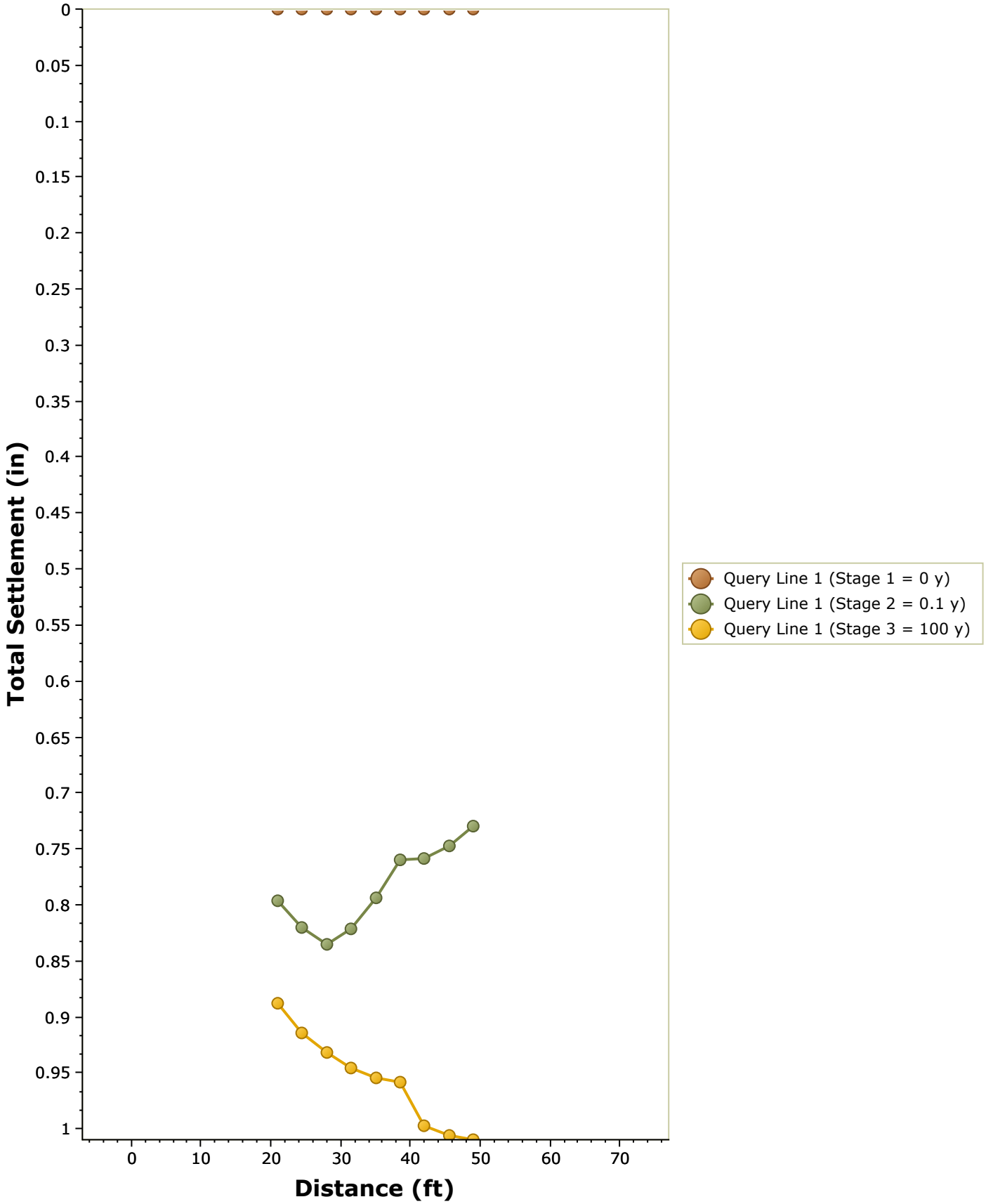
Reference Stage: None

Total Settlement vs. Depth



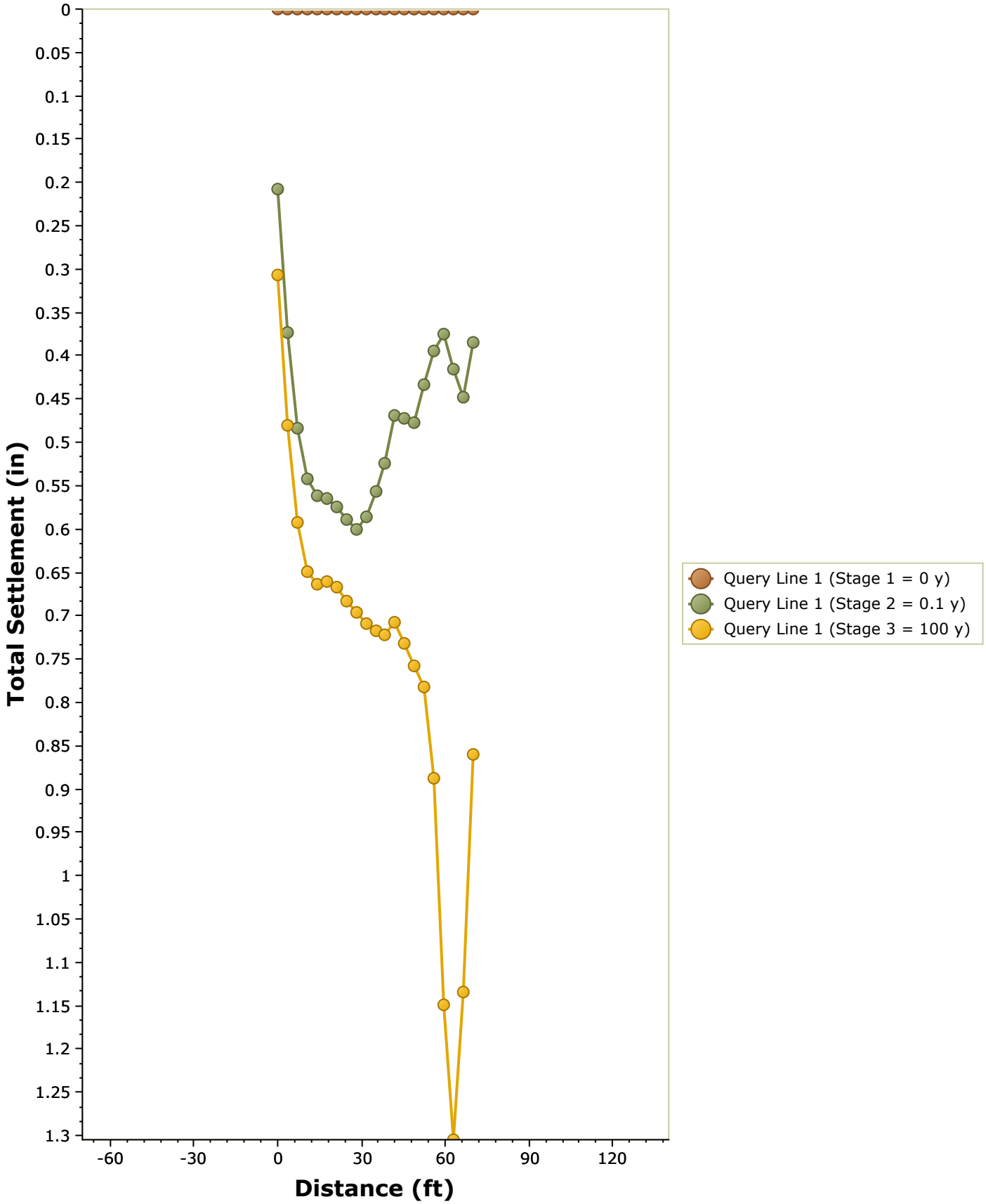
Reference Stage: None

Distance vs. Total Settlement



Reference Stage: None
Total Settlement at Depth = -140 ft

Distance vs. Total Settlement



Reference Stage: None
Total Settlement at Depth = -133 ft

HNTB	Prepared by: M. Ellis	Approved by: D. Evans	Document number: QF 06
Calculation Cover Sheet	Revision Number: 0	Revision Date: 1/22/2016	Page 1 of 2

Project: Burnham Bridge Replacement	**Job No: 63738**	**Design Criteria Document:**
Client: Maine DOT	**Discipline: Geotech**	**Calculation No: Abutment 1 (South) Piles**

Name or Description of Calculation:

Calc. Rev. No.	Originator	Checker	Senior Technical Reviewer (if required)	Confirmation Required (Y/N)
01	K. Reidy	B. Materek		

Calculation Objective:

The objective of this calculation is to calculate the required embedment, spacing and size of H-piles required to support Abutment 1 (South). Additionally, the amount of load induced on the piles due to downdrag was also evaluated. Abutment 1 was evaluated with the worst case boring scenario with BB-WGLC-201 for lateral analysis and BB-WGLC-202 for axial analysis. Additionally, drivability analyses were performed to develop a relationship between nominal axial geotechnical compressive resistance and the corresponding stresses in the pile assuming the piles are driven to those resistances.

Calculation Methodology/List of Assumptions:

- Soil Parameters have been developed from borings performed by Schonewald Engineering Associates, Inc. under the direction of HNTB between March 26 and March 31, 2016 and July 25 and July 27, 2017.
- Stratigraphy for lateral analysis was developed based on BB-WGLC-201.
- Stratigraphy for axial analysis was developed based on BB-WGLC-202.
- The groundwater was assumed to be elevation +133.0 ft due to governing case for slope stability analysis leading to worst loading conditions for pile analysis.
- Analysis was performed in accordance with AASHTO LRFD Bridge Design Specifications version 2014 with 2016 Interim Revisions, MaineDOT BDG, and recommendations in the "Integral Abutment Bridge Design Guidelines" by Vermont Department of Transportation.
- Loads were provided by HNTB Maine office on August 28, 2017. Downdrag load calculated and applied to length of pile that had 0.4 inches of settlement or more.
- Breaking forces and additional shear forces from the slope stability analysis were applied to the piles in the lateral analysis.
- Assumed no corrosion due to isolation casing with clean sand protecting the upper 10 feet of pile length.
- Top of pile in model is modeled as bottom of cap elevation.
- Lateral analysis was evaluated with the following load cases:
    1. Displacement & slope (0 degrees) to evaluate if plastic hinge forms.
    2. Displacement and moment to evaluate if second plastic hinge forms [if first plastic hinge does not form, this load case does not need to be evaluated]
    3. Use shear and moment where the braking and slope stability shear forces are added to the maximum moment and shear experienced in load case 2 to obtain a combined displacement.
    4. Repeat load case 1 with new combined displacement.
    5. Repeat load case 2 with same process.
- Preliminary drivability evaluations were conducted using the software program GRL WEAP 2010 distributed by GRL Engineers, Inc.
- Drivability analyses were performed assuming a Delmag 36-32 diesel hammer for this assessment using a Fuel Setting of 4

References/Inputs:

LPile version 2016.9.06 by Ensoft Inc.
APile version 2015.7.3 by Ensoft Inc.
Maine DOT Boring logs performed by HNTB
Contract Document Drawing No. 26 & 27

Attachments:

- Reference Plans
- Boring Logs & Location Plan
- Soil Parameters & Summary
- Abutment 1 Lateral Analysis – Boring 201
- Abutment 1 Axial Analysis – Boring 202 for downdrag
- Abutment 1 Downdrag calculation

Conclusions:

A total of 5 HP14x102 piles for each abutment spaced at 6 ft on center driven to the following elevations and resistances:

Table 1: Pile Tip Elevations and Nominal Driving Resistances

Location	Minimum Pile Tip Elevation (ft)	Estimated Pile Tip Elevation (ft)	Factored Axial Load (kips)	Minimum Required Nominal Driving Resistance (kips)
Abutment 1	106.0	100.0	357	550

Estimated Factored Drivability Resistance is 650 kips at 45 ksi.

Document Check:	Name	Signature	Date
Originator:	K. Reidy		10/17/2017
Checker:	B. Materek		10/18/2017
BackChecker:	K. Reidy		10/18/2017
Updater:	K. Reidy		10/31/2017
Verifier:	B. Materek		11/09/2017

ABUTMENT 1 (SOUTH)

PILE ELEVATION VIEW SKETCH

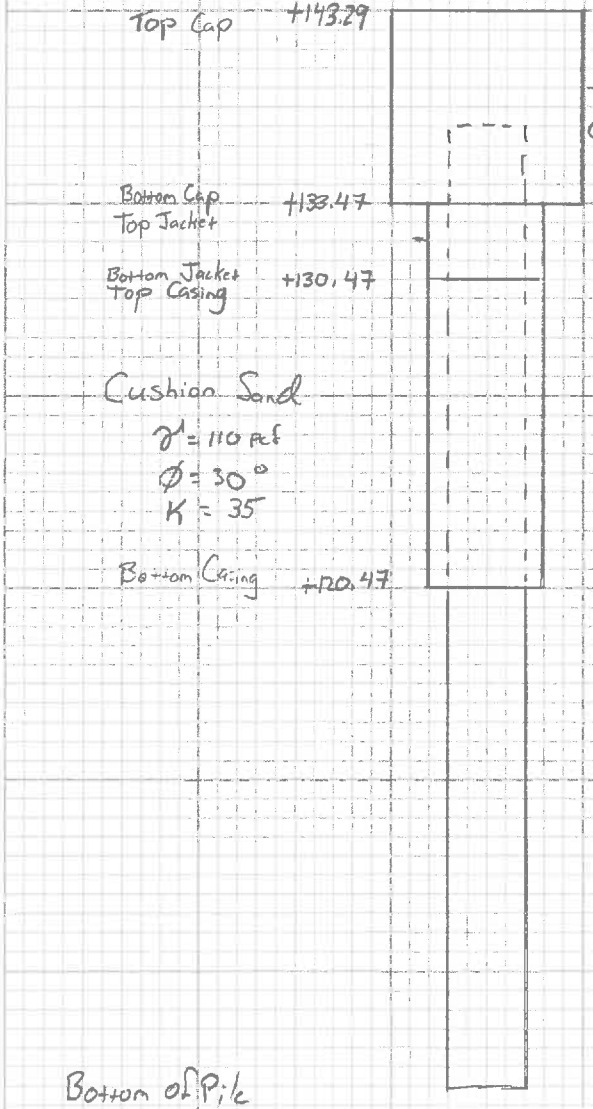
HNTB

Calculations for	Burnham Bridge	Job No. 63738	Sheet No.
Made by	KRR	Date	10/13/17
Checked by		Date	
Backchecked by		Date	

HNTB

WL@+133

SOUTH ABUTMENT
SINGLE PILE VIEW
(NTS)



[202]
Strata EL +143.29
Granular Borrow
γ = 115 pcf
Φ = 32°
K = 77/51 pci
+132.47
Fill
γ = 113 pcf
Φ = 33°
K = 102/64 pci
+124.7
Org. Silt
γ = 103.4 pcf
C = 280 psf
+116
Soft – Med Stiff Clay
γ = 106 pcf
C = 506 psf
+113.2
Till
γ = 126 pcf
Φ = 38°
K = 244/140 pci
+106
TOR

[201]
Strata EL +143.29
Granular Borrow
γ = 115 pcf
Φ = 32°
K = 77/51 pci
+132.47
Fill
γ = 113 pcf
Φ = 33°
K = 102/64 pci
+124.3
Org. Silt
γ = 103.4 pcf
C = 280 psf
+118.5
Soft – Med Stiff Clay
γ = 106 pcf
C = 506 psf
+112.8
Till
γ = 126 pcf
Φ = 38°
K = 244/140 pci
+100.7
TOR

ABUTMENT 1 (SOUTH)

LATERAL & AXIAL ANALYSIS NOTES

HNTB

Notes

South Abutment

Changes to loading on piles

1. Piles will now be taking shear forces from the slope stability analysis, current assumption is 17.1k + 6k for braking
2. South abutment may have downdrag, see hand calc (52 kips)
3. Governing case for WL is +133.00 ft EL
4. No corrosion in model
5. 10 ft isolation casing with cushion sand placed
6. Top of pile in LPILE is modeled as the bottom of the cap.
7. Boring 201 and Boring 202 both evaluated for deep and shallow rock, respectively.
8. Load cases are evaluated in the following procedure:
    1. displacement & slope (0) to evaluate if plastic hinge occurs
    2. displacement and moment [if first plastic hinge occurs to evaluate if second plastic hinge forms and fails]
    3. shear and moment [input max moment from 2 and also the shear from 2 plus what we are expecting the piles
    to experience from the soil, to obtain the combined displacement for evaluation]
    4. repeat step 1 with new "total" displacement to evaluate worst case of soil mobilization and full thermal movement
    5. Repeat step 2

ABUTMENT 1 (SOUTH)

AXIAL ANALYSIS FOR DOWNDRAG

HNTB

Calculations for	Burnham Bridge	Job No.	63738	Sheet No.
Made by	KRR	Date		
Checked by		Date		
Backchecked by		Date		

HNTB

Additional Factored Downdrag Load @ South Abutment w/HP14x102 pile

Top of Pile EL: +133.47

AASHTO BDS 2015 3.11.8: Account for DD if settlement ≥ 0.4 in

Settle 3D shows < 0.4 in. settlement @ EL +120.00'

Total skin friction applied to pile from top of pile to EL +120.00'

f_s = 36.9 kips

Downdrag Load Factor for piles: 1.4

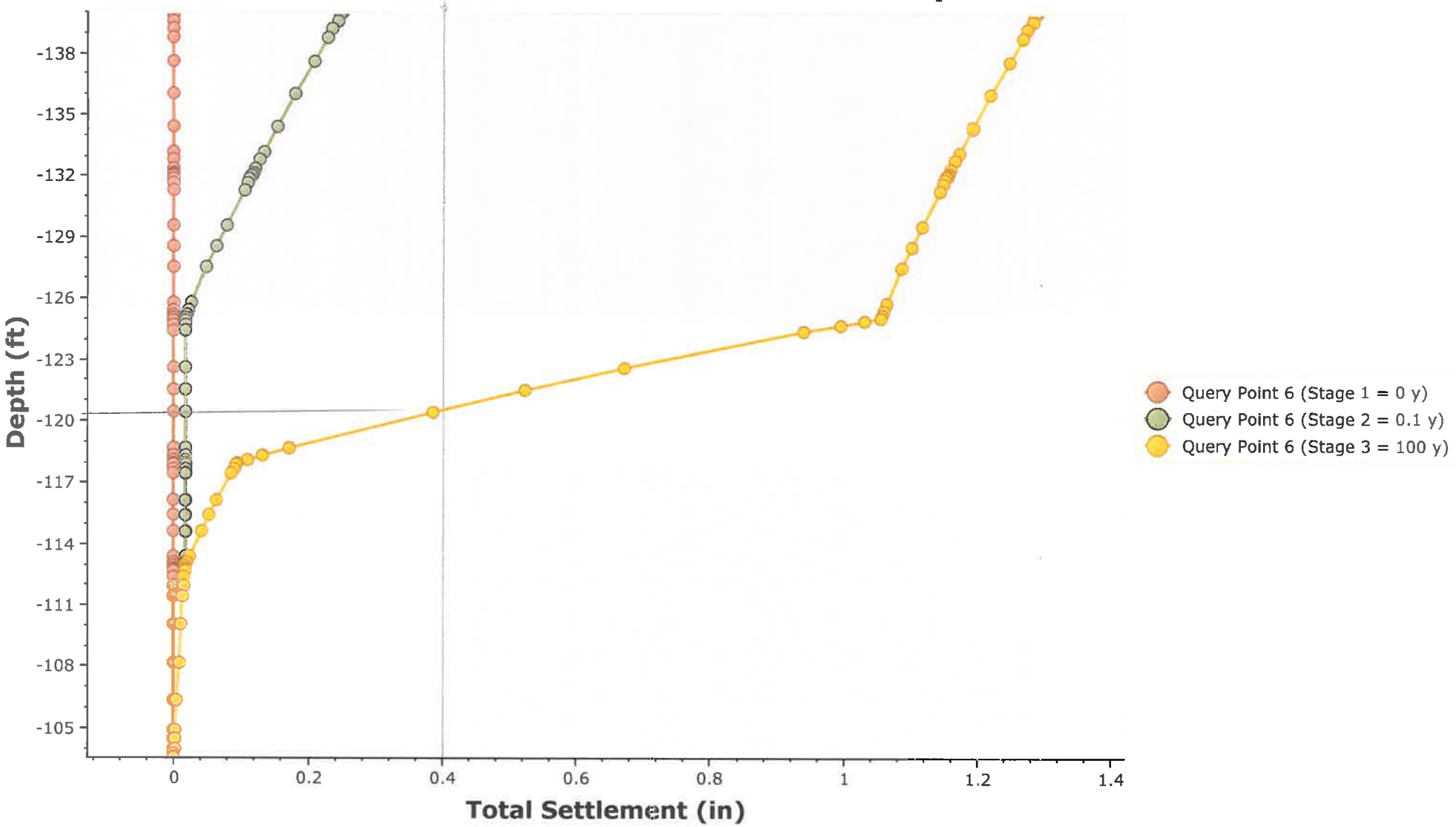
AASHTO LRFD BDS 2015 Table 3.4.1-2

Factored DD Load = 36.9 kips x 1.4

= 51.66 kips

Use 52 kips

Total Settlement vs. Depth



Reference Stage: None

rocscience	Project		
	Analysis Description		
	Drawn By	Company	
	Date: 10/11/2017, 2:06:27 PM	File Name: South Abutment.s3z	

SETTLE3D 4.012

APILE for Windows, Version 2015.7.3

Serial Number : 160779486

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.
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This program is licensed to :

HNTB Corporation
Parsippany, New Jersey

Path to file locations : T:\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Deep Foundations\Piles\South Abutment\FINAL DESIGN\APile\HP14x102\
Name of input data file : South Abut - HP14x102 - Boring 202 - Downdrag.ap7d
Name of output file : South Abut - HP14x102 - Boring 202 - Downdrag.ap7o
Name of plot output file : South Abut - HP14x102 - Boring 202 - Downdrag.ap7p

Time and Date of Analysis

Date: October 17, 2017 Time: 13:50:01

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****
* INPUT INFORMATION *
****

Burnham Bridge - South Abutment - HP14x89

DESIGNER : KRR

JOB NUMBER : 63738

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)
- API RP 2A (American Petroleum Institute)

TYPE OF LOADING :
- COMPRESSION

PILE TYPE :

H-Pile/Steel Pile

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 30.00 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 37.50 FT.
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 10.82 FT.
- PERIMETER OF PILE = 57.60 IN.
- TIP AREA OF PILE = 30.00 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	SAND	0.00	115.00	32.00	0.00
10.29	SAND	0.00	115.00	32.00	0.00
10.29	SAND	0.00	52.60	32.00	0.00
10.82	SAND	0.00	52.60	32.00	0.00
10.82	SAND	0.00	50.60	33.00	0.00
12.82	SAND	0.00	50.60	33.00	0.00
12.82	SAND	0.00	47.60	30.00	0.00
22.82	SAND	0.00	47.60	30.00	0.00
22.82	CLAY	0.00	41.00	0.00	0.00
27.29	CLAY	0.00	41.00	0.00	0.00
27.29	CLAY	0.00	43.50	0.00	0.00
30.09	CLAY	0.00	43.50	0.00	0.00
30.09	SAND	0.00	64.00	38.00	0.00
37.29	SAND	0.00	64.00	38.00	0.00
37.29	SAND	0.00	100.00	50.00	0.00
50.00	SAND	0.00	100.00	50.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.28	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.28	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.51	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.51	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
10.29	1.000	1.000
10.29	1.000	1.000
10.82	1.000	1.000
10.82	1.000	1.000
12.82	1.000	1.000
12.82	1.000	1.000
22.82	1.000	1.000
22.82	1.000	1.000
27.29	1.000	1.000
27.29	1.000	1.000
30.09	1.000	1.000
30.09	1.000	1.000
37.29	1.000	1.000
37.29	1.000	1.000
50.00	1.000	1.000

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****
* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.3	0.3
1.00	0.0	0.6	0.6
2.00	0.0	1.2	1.2
3.00	0.0	1.8	1.8
4.00	0.0	2.4	2.4
5.00	0.0	3.0	3.0
6.00	0.0	3.6	3.6

7.00	0.0	4.2	4.2
8.00	0.0	4.8	4.8
9.00	0.0	5.4	5.4
10.00	0.0	6.1	6.1
11.00	1.3	6.5	7.8
12.00	4.0	5.9	9.9
13.00	6.9	5.1	12.0
14.00	9.6	4.3	13.9
15.00	12.1	3.1	15.2
16.00	14.6	2.8	17.4
17.00	17.2	2.8	20.0
18.00	19.9	2.8	22.7
19.00	22.7	2.8	25.5
20.00	25.6	2.8	28.3
21.00	28.5	2.6	31.1
22.00	31.5	2.1	33.7
23.00	34.6	1.6	36.3
24.00	36.9	1.2	38.0
25.00	38.2	0.7	38.9
26.00	39.6	0.6	40.1
27.00	40.9	0.6	41.6
28.00	42.3	0.7	43.0
29.00	44.1	3.1	47.2
30.00	46.6	11.0	57.6
31.00	49.0	19.2	68.2
32.00	54.4	27.5	81.9
33.00	62.8	36.1	98.9
34.00	71.4	39.4	110.8
35.00	80.3	40.4	120.7
36.00	89.4	48.5	137.9
37.00	98.8	73.4	172.1

****
* API RP-2A (1994) *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0
1.00	0.0	0.0	0.0
2.00	0.0	0.0	0.0
3.00	0.0	0.0	0.0
4.00	0.0	0.0	0.0
5.00	0.0	0.0	0.0
6.00	0.0	0.0	0.0
7.00	0.0	0.0	0.0
8.00	0.0	0.0	0.0
9.00	0.0	0.0	0.0
10.00	0.0	0.0	0.0
11.00	0.0	0.0	0.0
12.00	0.0	0.0	0.0
13.00	0.0	0.0	0.0
14.00	0.0	0.0	0.0
15.00	0.0	0.0	0.0
16.00	0.0	0.0	0.0
17.00	0.0	0.0	0.0
18.00	0.0	0.0	0.0
19.00	0.0	0.0	0.0
20.00	0.0	0.0	0.0
21.00	0.0	0.0	0.0

22.00	0.0	0.1	0.1
23.00	0.0	0.3	0.3
24.00	0.7	0.4	1.0
25.00	2.0	0.5	2.5
26.00	3.4	0.6	3.9
27.00	4.7	0.6	5.3
28.00	6.0	0.7	6.8
29.00	7.9	0.8	8.7
30.00	10.4	0.7	11.0
31.00	12.8	0.5	13.3
32.00	14.0	0.3	14.3
33.00	14.0	0.1	14.1
34.00	14.0	0.0	14.0
35.00	14.0	0.0	14.0
36.00	14.0	0.0	14.0
37.00	14.0	0.0	14.0

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

****
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING *
****

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.1000E-01
			0.0000E+00	0.2000E-01
			0.0000E+00	0.4000E-01
			0.0000E+00	0.6000E-01
			0.0000E+00	0.8000E-01
			0.0000E+00	0.9000E-01
			0.0000E+00	0.1000E+00
			0.0000E+00	0.5000E+00
			0.0000E+00	0.2000E+01
2	10	0.5170E+01		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.1000E-01
			0.0000E+00	0.2000E-01
			0.0000E+00	0.4000E-01
			0.0000E+00	0.6000E-01
			0.0000E+00	0.8000E-01
			0.0000E+00	0.9000E-01
			0.0000E+00	0.1000E+00
			0.0000E+00	0.5000E+00
			0.0000E+00	0.2000E+01
3	10	0.1025E+02		
			0.0000E+00	0.0000E+00
			0.3860E+00	0.1000E-01
			0.7721E+00	0.2000E-01
			0.1544E+01	0.4000E-01
			0.2316E+01	0.6000E-01
			0.3088E+01	0.8000E-01

			0.3474E+01	0.9000E-01
			0.3860E+01	0.1000E+00
			0.3860E+01	0.5000E+00
			0.3860E+01	0.2000E+01
4	10	0.1029E+02		
			0.0000E+00	0.0000E+00
			0.3860E+00	0.1000E-01
			0.7721E+00	0.2000E-01
			0.1544E+01	0.4000E-01
			0.2316E+01	0.6000E-01
			0.3088E+01	0.8000E-01
			0.3474E+01	0.9000E-01
			0.3860E+01	0.1000E+00
			0.3860E+01	0.5000E+00
			0.3860E+01	0.2000E+01
5	10	0.1082E+02		
			0.0000E+00	0.0000E+00
			0.3860E+00	0.1000E-01
			0.7721E+00	0.2000E-01
			0.1544E+01	0.4000E-01
			0.2316E+01	0.6000E-01
			0.3088E+01	0.8000E-01
			0.3474E+01	0.9000E-01
			0.3860E+01	0.1000E+00
			0.3860E+01	0.5000E+00
			0.3860E+01	0.2000E+01
6	10	0.1125E+02		
			0.0000E+00	0.0000E+00
			0.4031E+00	0.1000E-01
			0.8062E+00	0.2000E-01
			0.1612E+01	0.4000E-01
			0.2419E+01	0.6000E-01
			0.3225E+01	0.8000E-01
			0.3628E+01	0.9000E-01
			0.4031E+01	0.1000E+00
			0.4031E+01	0.5000E+00
			0.4031E+01	0.2000E+01
7	10	0.1129E+02		
			0.0000E+00	0.0000E+00
			0.4031E+00	0.1000E-01
			0.8062E+00	0.2000E-01
			0.1612E+01	0.4000E-01
			0.2419E+01	0.6000E-01
			0.3225E+01	0.8000E-01
			0.3628E+01	0.9000E-01
			0.4031E+01	0.1000E+00
			0.4031E+01	0.5000E+00
			0.4031E+01	0.2000E+01
8	10	0.1208E+02		
			0.0000E+00	0.0000E+00
			0.4090E+00	0.1000E-01
			0.8180E+00	0.2000E-01
			0.1636E+01	0.4000E-01
			0.2454E+01	0.6000E-01
			0.3272E+01	0.8000E-01
			0.3681E+01	0.9000E-01
			0.4090E+01	0.1000E+00
			0.4090E+01	0.5000E+00
			0.4090E+01	0.2000E+01
9	10	0.1278E+02		
			0.0000E+00	0.0000E+00
			0.4090E+00	0.1000E-01
			0.8180E+00	0.2000E-01

			0.1636E+01	0.4000E-01
			0.2454E+01	0.6000E-01
			0.3272E+01	0.8000E-01
			0.3681E+01	0.9000E-01
			0.4090E+01	0.1000E+00
			0.4090E+01	0.5000E+00
			0.4090E+01	0.2000E+01
10	10	0.1282E+02		
			0.0000E+00	0.0000E+00
			0.4090E+00	0.1000E-01
			0.8180E+00	0.2000E-01
			0.1636E+01	0.4000E-01
			0.2454E+01	0.6000E-01
			0.3272E+01	0.8000E-01
			0.3681E+01	0.9000E-01
			0.4090E+01	0.1000E+00
			0.4090E+01	0.5000E+00
			0.4090E+01	0.2000E+01
11	10	0.1785E+02		
			0.0000E+00	0.0000E+00
			0.3961E+00	0.1000E-01
			0.7922E+00	0.2000E-01
			0.1584E+01	0.4000E-01
			0.2377E+01	0.6000E-01
			0.3169E+01	0.8000E-01
			0.3565E+01	0.9000E-01
			0.3961E+01	0.1000E+00
			0.3961E+01	0.5000E+00
			0.3961E+01	0.2000E+01
12	10	0.2278E+02		
			0.0000E+00	0.0000E+00
			0.3868E+00	0.1000E-01
			0.7735E+00	0.2000E-01
			0.1547E+01	0.4000E-01
			0.2321E+01	0.6000E-01
			0.3094E+01	0.8000E-01
			0.3481E+01	0.9000E-01
			0.3868E+01	0.1000E+00
			0.3868E+01	0.5000E+00
			0.3868E+01	0.2000E+01
13	10	0.2282E+02		
			0.0000E+00	0.0000E+00
			0.1160E+01	0.2934E-01
			0.1934E+01	0.5684E-01
			0.2901E+01	0.1045E+00
			0.3481E+01	0.1467E+00
			0.3868E+01	0.1833E+00
			0.3481E+01	0.3667E+00
			0.3481E+01	0.5500E+00
			0.3481E+01	0.9167E+00
			0.3481E+01	0.3667E+01
14	10	0.2508E+02		
			0.0000E+00	0.0000E+00
			0.5833E+00	0.2934E-01
			0.9722E+00	0.5684E-01
			0.1458E+01	0.1045E+00
			0.1750E+01	0.1467E+00
			0.1944E+01	0.1833E+00
			0.1750E+01	0.3667E+00
			0.1750E+01	0.5500E+00
			0.1750E+01	0.9167E+00
			0.1750E+01	0.3667E+01
15	10	0.2725E+02		

			0.0000E+00	0.0000E+00
			0.7010E+00	0.2934E-01
			0.1168E+01	0.5684E-01
			0.1753E+01	0.1045E+00
			0.2103E+01	0.1467E+00
			0.2337E+01	0.1833E+00
			0.2103E+01	0.3667E+00
			0.2103E+01	0.5500E+00
			0.2103E+01	0.9167E+00
			0.2103E+01	0.3667E+01
16	10	0.2729E+02		
			0.0000E+00	0.0000E+00
			0.7010E+00	0.2934E-01
			0.1168E+01	0.5684E-01
			0.1753E+01	0.1045E+00
			0.2103E+01	0.1467E+00
			0.2337E+01	0.1833E+00
			0.2103E+01	0.3667E+00
			0.2103E+01	0.5500E+00
			0.2103E+01	0.9167E+00
			0.2103E+01	0.3667E+01
17	10	0.2872E+02		
			0.0000E+00	0.0000E+00
			0.9365E+00	0.2934E-01
			0.1561E+01	0.5684E-01
			0.2341E+01	0.1045E+00
			0.2809E+01	0.1467E+00
			0.3122E+01	0.1833E+00
			0.2809E+01	0.3667E+00
			0.2809E+01	0.5500E+00
			0.2809E+01	0.9167E+00
			0.2809E+01	0.3667E+01
18	10	0.3005E+02		
			0.0000E+00	0.0000E+00
			0.1690E+01	0.2934E-01
			0.2817E+01	0.5684E-01
			0.4225E+01	0.1045E+00
			0.5070E+01	0.1467E+00
			0.5634E+01	0.1833E+00
			0.5070E+01	0.3667E+00
			0.5070E+01	0.5500E+00
			0.5070E+01	0.9167E+00
			0.5070E+01	0.3667E+01
19	10	0.3009E+02		
			0.0000E+00	0.0000E+00
			0.5634E+00	0.1000E-01
			0.1127E+01	0.2000E-01
			0.2253E+01	0.4000E-01
			0.3380E+01	0.6000E-01
			0.4507E+01	0.8000E-01
			0.5070E+01	0.9000E-01
			0.5634E+01	0.1000E+00
			0.5634E+01	0.5000E+00
			0.5634E+01	0.2000E+01
20	10	0.3372E+02		
			0.0000E+00	0.0000E+00
			0.1268E+01	0.1000E-01
			0.2535E+01	0.2000E-01
			0.5071E+01	0.4000E-01
			0.7606E+01	0.6000E-01
			0.1014E+02	0.8000E-01
			0.1141E+02	0.9000E-01
			0.1268E+02	0.1000E+00

			0.1268E+02	0.5000E+00
			0.1268E+02	0.2000E+01
21	10	0.3725E+02		
			0.0000E+00	0.0000E+00
			0.1353E+01	0.1000E-01
			0.2706E+01	0.2000E-01
			0.5413E+01	0.4000E-01
			0.8119E+01	0.6000E-01
			0.1083E+02	0.8000E-01
			0.1218E+02	0.9000E-01
			0.1353E+02	0.1000E+00
			0.1353E+02	0.5000E+00
			0.1353E+02	0.2000E+01
22	10	0.3729E+02		
			0.0000E+00	0.0000E+00
			0.1353E+01	0.1000E-01
			0.2706E+01	0.2000E-01
			0.5413E+01	0.4000E-01
			0.8119E+01	0.6000E-01
			0.1083E+02	0.8000E-01
			0.1218E+02	0.9000E-01
			0.1353E+02	0.1000E+00
			0.1353E+02	0.5000E+00
			0.1353E+02	0.2000E+01
23	10	0.4367E+02		
			0.0000E+00	0.0000E+00
			0.1353E+01	0.1000E-01
			0.2706E+01	0.2000E-01
			0.5413E+01	0.4000E-01
			0.8119E+01	0.6000E-01
			0.1083E+02	0.8000E-01
			0.1218E+02	0.9000E-01
			0.1353E+02	0.1000E+00
			0.1353E+02	0.5000E+00
			0.1353E+02	0.2000E+01
24	10	0.4996E+02		
			0.0000E+00	0.0000E+00
			0.1353E+01	0.1000E-01
			0.2706E+01	0.2000E-01
			0.5413E+01	0.4000E-01
			0.8119E+01	0.6000E-01
			0.1083E+02	0.8000E-01
			0.1218E+02	0.9000E-01
			0.1353E+02	0.1000E+00
			0.1353E+02	0.5000E+00
			0.1353E+02	0.2000E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.4587E+01	0.9167E-02
0.9174E+01	0.1833E-01
0.1835E+02	0.3667E-01
0.3669E+02	0.2383E+00
0.5504E+02	0.7701E+00
0.6605E+02	0.1338E+01
0.7339E+02	0.1833E+01
0.7339E+02	0.2750E+01
0.7339E+02	0.3667E+01

LOAD VERSUS SETTLEMENT CURVE
****

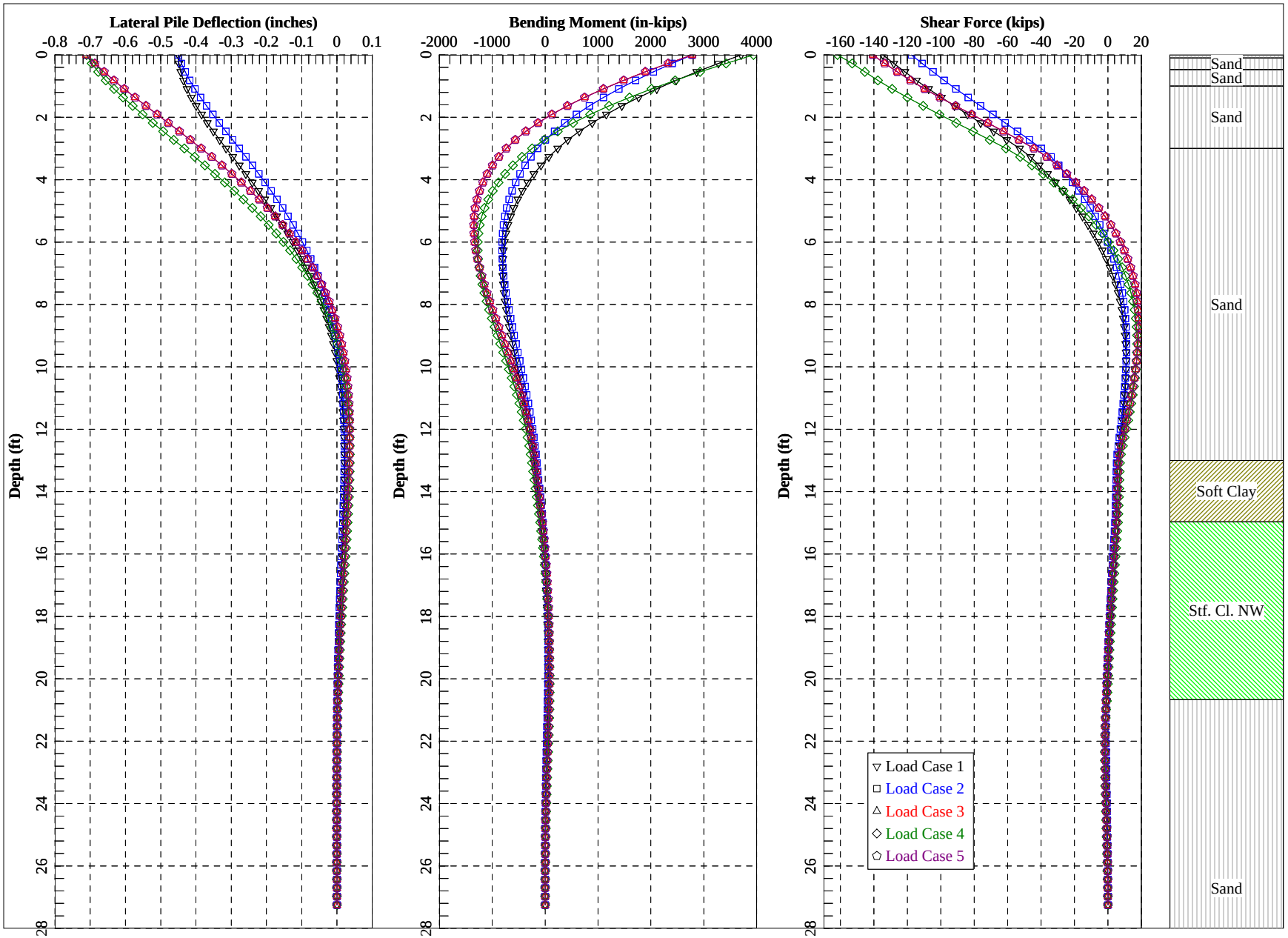
TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.1813E+00	0.1712E-03	0.5003E-01	0.1000E-03
0.1813E+01	0.1712E-02	0.5003E+00	0.1000E-02
0.9064E+01	0.8561E-02	0.2502E+01	0.5000E-02
0.1816E+02	0.1713E-01	0.5003E+01	0.1000E-01
0.8350E+02	0.8227E-01	0.1956E+02	0.5000E-01
0.1344E+03	0.1525E+00	0.2411E+02	0.1000E+00
0.1577E+03	0.5643E+00	0.4572E+02	0.5000E+00
0.1715E+03	0.1071E+01	0.5950E+02	0.1000E+01
0.1854E+03	0.2079E+01	0.7339E+02	0.2000E+01

ABUTMENT 1 (SOUTH)

LATERAL ANALYSIS

HNTB

LPILE - South Abutment - Expansion - HP14x102 - BB-WCLG-201



LPile for Windows, Version 2016-09.006

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Deep Foundations\Piles\South Abutment\FINAL DESIGN\LPILE - 2017-10-15 with DD\HP14x102 Boring 201\

Name of input data file:
SAbut_HP14x102_Weak_Expansion.lp9d

Name of output report file:
SAbut_HP14x102_Weak_Expansion.lp9o

Name of plot output file:
SAbut_HP14x102_Weak_Expansion.lp9p

Name of runtime message file:
SAbut_HP14x102_Weak_Expansion.lp9r

Date and Time of Analysis

Date: October 30, 2017 Time: 18:34:36

Problem Title

Project Name: Burnham Bridge

Job Number: 63738

Client: Maine DOT

Engineer: BAM/KRR

Description: South Abutment_HP14x89_5 Piles_Weak Axis_No Corrosion

Program Options and Settings

Computational Options:
- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined	=	1
Total length of pile	=	27.250 ft
Depth of ground surface below top of pile	=	-9.8200 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.0000
2	27.250	14.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile with a specified moment capacity

Cross-sectional Shape	=	Weak H-Pile
Length of section	=	27.250000 ft
Flange Width	=	14.800000 in
Section Depth	=	14.000000 in
Flange Thickness	=	0.705000 in
Web Thickness	=	0.705000 in
Section Area	=	29.743950 sq. in
Moment of Inertia	=	381.278191 in^4
Elastic Modulus	=	29000000. psi
Plastic Moment Capacity	=	3940000. in-lb
Top Elastic Bending Stiffness	=	1.1057E+10 lbs-in^2
Bot Elastic Bending Stiffness	=	1.1057E+10 lbs-in^2
Shear Capacity at top of section	=	296100. lbs
Shear Capacity at bottom of section	=	296100. lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 9 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	-9.820000 ft
Distance from top of pile to bottom of layer	=	0.100000 ft
Effective unit weight at top of layer	=	115.000000 pcf
Effective unit weight at bottom of layer	=	115.000000 pcf

Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	0.100000 ft
Distance from top of pile to bottom of layer	=	0.470000 ft
Effective unit weight at top of layer	=	115.000000 pcf
Effective unit weight at bottom of layer	=	115.000000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	0.470000 ft
Distance from top of pile to bottom of layer	=	1.000000 ft
Effective unit weight at top of layer	=	52.600000 pcf
Effective unit weight at bottom of layer	=	52.600000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	51.000000 pci
Subgrade k at bottom of layer	=	51.000000 pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	1.000000 ft
Distance from top of pile to bottom of layer	=	3.000000 ft
Effective unit weight at top of layer	=	50.600000 pcf
Effective unit weight at bottom of layer	=	50.600000 pcf
Friction angle at top of layer	=	33.000000 deg.
Friction angle at bottom of layer	=	33.000000 deg.
Subgrade k at top of layer	=	64.000000 pci
Subgrade k at bottom of layer	=	64.000000 pci

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	3.000000 ft
Distance from top of pile to bottom of layer	=	13.000000 ft
Effective unit weight at top of layer	=	47.600000 pcf
Effective unit weight at bottom of layer	=	47.600000 pcf
Friction angle at top of layer	=	30.000000 deg.
Friction angle at bottom of layer	=	30.000000 deg.
Subgrade k at top of layer	=	35.000000 pci
Subgrade k at bottom of layer	=	35.000000 pci

Layer 6 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer	=	13.000000 ft
Distance from top of pile to bottom of layer	=	14.970000 ft
Effective unit weight at top of layer	=	41.000000 pcf
Effective unit weight at bottom of layer	=	41.000000 pcf
Undrained cohesion at top of layer	=	280.000000 psf
Undrained cohesion at bottom of layer	=	280.000000 psf
Epsilon-50 at top of layer	=	0.0000
Epsilon-50 at bottom of layer	=	0.0000

NOTE: Default values for Epsilon-50 will be computed for this layer.

Layer 7 is stiff clay without free water

Distance from top of pile to top of layer	=	14.970000 ft
Distance from top of pile to bottom of layer	=	20.670000 ft
Effective unit weight at top of layer	=	43.500000 pcf
Effective unit weight at bottom of layer	=	43.500000 pcf
Undrained cohesion at top of layer	=	506.000000 psf
Undrained cohesion at bottom of layer	=	506.000000 psf
Epsilon-50 at top of layer	=	0.0000
Epsilon-50 at bottom of layer	=	0.0000

NOTE: Default values for Epsilon-50 will be computed for this layer.

Layer 8 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	20.670000 ft
Distance from top of pile to bottom of layer	=	32.770000 ft
Effective unit weight at top of layer	=	64.000000 pcf
Effective unit weight at bottom of layer	=	64.000000 pcf
Friction angle at top of layer	=	38.000000 deg.
Friction angle at bottom of layer	=	38.000000 deg.
Subgrade k at top of layer	=	140.000000 pci
Subgrade k at bottom of layer	=	140.000000 pci

Layer 9 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	32.770000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	100.000000 pcf
Effective unit weight at bottom of layer	=	100.000000 pcf
Uniaxial compressive strength at top of layer	=	5000. psi
Uniaxial compressive strength at bottom of layer	=	5000. psi
Initial modulus of rock at top of layer	=	125000. psi
Initial modulus of rock at bottom of layer	=	125000. psi
RQD of rock at top of layer	=	35.000000 %
RQD of rock at bottom of layer	=	35.000000 %
k rm of rock at top of layer	=	0.0010000
k rm of rock at bottom of layer	=	0.0010000

(Depth of the lowest soil layer extends 22.750 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm
1	Sand	-9.8200	115.0000	--	32.0000	--	--	--
	(Reese, et al.)	0.10000	115.0000	--	32.0000	--	--	--
2	Sand	0.10000	115.0000	--	32.0000	--	--	--
	(Reese, et al.)	0.4700	115.0000	--	32.0000	--	--	--
3	Sand	0.4700	52.6000	--	32.0000	--	--	--
	(Reese, et al.)	1.0000	52.6000	--	32.0000	--	--	--
4	Sand	1.0000	50.6000	--	33.0000	--	--	--
	(Reese, et al.)	3.0000	50.6000	--	33.0000	--	--	--
5	Sand	3.0000	47.6000	--	30.0000	--	--	--
	(Reese, et al.)	13.0000	47.6000	--	30.0000	--	--	--
6	Soft	13.0000	41.0000	280.0000	--	--	--	default
	Clay	14.9700	41.0000	280.0000	--	--	--	default
7	Stiff Clay	14.9700	43.5000	506.0000	--	--	--	default
	w/o Free Water	20.6700	43.5000	506.0000	--	--	--	default
8	Sand	20.6700	64.0000	--	38.0000	--	--	--
	(Reese, et al.)	32.7700	64.0000	--	38.0000	--	--	--
9	Weak	32.7700	100.0000	--	--	5000.	35.0000	0.00100
	Rock	50.0000	100.0000	--	--	5000.	35.0000	0.00100

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 5

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = -0.450000 in	S = 0.0000 in/in	357000.	N.A.
2	4	y = -0.450000 in	M = 2779290. in-lbs	357000.	N.A.

3	1	V =	-140606. lbs	M =	2779290. in-lbs	357000.	No
4	5	y =	-0.710400 in	S =	0.0000 in/in	357000.	N.A.
5	4	y =	-0.710400 in	M =	2786638. in-lbs	357000.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic-plastic section properties

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Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	-9.8200	0.00	N.A.	No	0.00	2593.
2	0.1000	9.9200	Yes	No	2593.	283.6797
3	0.4700	10.2900	Yes	No	2876.	1071.
4	1.0000	10.8200	Yes	No	3948.	12481.
5	3.0000	12.8200	Yes	No	16428.	199118.
6	13.0000	13.0000	No	No	215547.	5800.
7	14.9700	14.9700	No	No	221346.	30262.
8	20.6700	14.0810	No	No	251608.	692206.
9	32.7700	42.5900	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = -0.450000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 357000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.4500	3705938.	-134624.	0.00	80041.	1.11E+10	1902.	6912.	0.00
0.2725	-0.4482	3275825.	-128073.	0.00103	72144.	1.11E+10	1996.	14564.	0.00
0.5450	-0.4432	2865927.	-121421.	0.00194	64619.	1.11E+10	2073.	15292.	0.00
0.8175	-0.4355	2477204.	-114569.	0.00273	57482.	1.11E+10	2118.	15903.	0.00
1.0900	-0.4254	2110273.	-107279.	0.00341	50746.	1.11E+10	2341.	17992.	0.00
1.3625	-0.4132	1767642.	-99580.	0.00398	44455.	1.11E+10	2368.	18741.	0.00
1.6350	-0.3993	1449724.	-91806.	0.00446	38618.	1.11E+10	2386.	19539.	0.00
1.9075	-0.3841	1156820.	-83989.	0.00484	33241.	1.11E+10	2395.	20393.	0.00
2.1800	-0.3677	889128.	-76156.	0.00515	28326.	1.11E+10	2396.	21307.	0.00
2.4525	-0.3504	646746.	-68334.	0.00537	23876.	1.11E+10	2388.	22289.	0.00
2.7250	-0.3325	429679.	-60547.	0.00553	19891.	1.11E+10	2374.	23346.	0.00
2.9975	-0.3142	237850.	-52818.	0.00563	16369.	1.11E+10	2353.	24490.	0.00
3.2700	-0.2957	71102.	-46312.	0.00568	13308.	1.11E+10	1626.	17978.	0.00
3.5425	-0.2771	-78286.	-41112.	0.00568	13440.	1.11E+10	1555.	18352.	0.00
3.8150	-0.2586	-211018.	-36148.	0.00563	15877.	1.11E+10	1481.	18726.	0.00
4.0875	-0.2403	-327844.	-31432.	0.00555	18021.	1.11E+10	1403.	19101.	0.00
4.3600	-0.2223	-429549.	-26973.	0.00544	19889.	1.11E+10	1324.	19475.	0.00
4.6325	-0.2047	-516953.	-22778.	0.00530	21493.	1.11E+10	1242.	19849.	0.00
4.9050	-0.1876	-590892.	-18849.	0.00514	22851.	1.11E+10	1160.	20223.	0.00

5.1775	-0.1711	-652223.	-15191.	0.00495	23977.	1.11E+10	1078.	20598.	0.00
5.4500	-0.1552	-701805.	-11801.	0.00475	24887.	1.11E+10	995.3185	20972.	0.00
5.7225	-0.1400	-740503.	-8680.	0.00454	25598.	1.11E+10	913.8277	21346.	0.00
5.9950	-0.1255	-769173.	-5823.	0.00432	26124.	1.11E+10	833.6133	21720.	0.00
6.2675	-0.1118	-788664.	-3225.	0.00409	26482.	1.11E+10	755.1083	22095.	0.00
6.5400	-0.09877	-799809.	-881.1307	0.00385	26686.	1.11E+10	678.6979	22469.	0.00
6.8125	-0.08657	-803420.	1217.	0.00361	26753.	1.11E+10	604.7191	22843.	0.00
7.0850	-0.07513	-800287.	3078.	0.00338	26695.	1.11E+10	533.4622	23217.	0.00
7.3575	-0.06448	-791174.	4711.	0.00314	26528.	1.11E+10	465.1723	23592.	0.00
7.6300	-0.05458	-776814.	6126.	0.00291	26264.	1.11E+10	400.0504	23966.	0.00
7.9025	-0.04544	-757908.	7333.	0.00268	25917.	1.11E+10	338.2559	24340.	0.00
8.1750	-0.03704	-735123.	8343.	0.00246	25499.	1.11E+10	279.9085	24714.	0.00
8.4475	-0.02934	-709091.	9169.	0.00225	25021.	1.11E+10	225.0908	25089.	0.00
8.7200	-0.02233	-680408.	9821.	0.00204	24494.	1.11E+10	173.8509	25463.	0.00
8.9925	-0.01597	-649631.	10312.	0.00185	23929.	1.11E+10	126.2051	25837.	0.00
9.2650	-0.01025	-617280.	10653.	0.00166	23335.	1.11E+10	82.1406	26211.	0.00
9.5375	-0.00512	-583838.	10855.	0.00148	22721.	1.11E+10	41.6190	26586.	0.00
9.8100	-5.55E-04	-549749.	10930.	0.00131	22095.	1.11E+10	4.5784	26960.	0.00
10.0825	0.00348	-515421.	10890.	0.00116	21465.	1.11E+10	-29.0627	27334.	0.00
10.3550	0.00701	-481226.	10746.	0.00101	20837.	1.11E+10	-59.4033	27708.	0.00
10.6275	0.01008	-447501.	10507.	8.72E-04	20218.	1.11E+10	-86.5561	28083.	0.00
10.9000	0.01271	-414546.	10185.	7.45E-04	19613.	1.11E+10	-110.6451	28457.	0.00
11.1725	0.01495	-382631.	9788.	6.27E-04	19027.	1.11E+10	-131.8028	28831.	0.00
11.4450	0.01681	-351994.	9327.	5.18E-04	18465.	1.11E+10	-150.1672	29205.	0.00
11.7175	0.01834	-322840.	8811.	4.18E-04	17930.	1.11E+10	-165.8792	29580.	0.00
11.9900	0.01955	-295349.	8247.	3.27E-04	17425.	1.11E+10	-179.0802	29954.	0.00
12.2625	0.02048	-269671.	7643.	2.43E-04	16953.	1.11E+10	-189.9096	30328.	0.00
12.5350	0.02114	-245931.	7008.	1.67E-04	16518.	1.11E+10	-198.5025	30702.	0.00
12.8075	0.02157	-224228.	6349.	9.77E-05	16119.	1.11E+10	-204.9875	31077.	0.00
13.0800	0.02178	-204639.	5950.	3.42E-05	15759.	1.11E+10	-38.5339	5785.	0.00
13.3525	0.02179	-185392.	5824.	-2.34E-05	15406.	1.11E+10	-38.5418	5783.	0.00
13.6250	0.02163	-166493.	5698.	-7.55E-05	15059.	1.11E+10	-38.4439	5813.	0.00
13.8975	0.02130	-147948.	5573.	-1.22E-04	14719.	1.11E+10	-38.2493	5872.	0.00
14.1700	0.02083	-129761.	5448.	-1.63E-04	14385.	1.11E+10	-37.9660	5960.	0.00
14.4425	0.02023	-111935.	5325.	-1.99E-04	14057.	1.11E+10	-37.6009	6077.	0.00
14.7150	0.01953	-94472.	5203.	-2.29E-04	13737.	1.11E+10	-37.1600	6222.	0.00
14.9875	0.01873	-77374.	4972.	-2.55E-04	13423.	1.11E+10	-103.9950	18152.	0.00
15.2600	0.01786	-61361.	4634.	-2.75E-04	13129.	1.11E+10	-102.7672	18811.	0.00
15.5325	0.01693	-46426.	4300.	-2.91E-04	12855.	1.11E+10	-101.4051	19581.	0.00
15.8050	0.01596	-32559.	3971.	-3.03E-04	12600.	1.11E+10	-99.9156	20472.	0.00
16.0775	0.01495	-19750.	3647.	-3.11E-04	12365.	1.11E+10	-98.3045	21496.	0.00
16.3500	0.01393	-7984.	3328.	-3.15E-04	12149.	1.11E+10	-96.5768	22673.	0.00
16.6225	0.01290	2751.	3015.	-3.15E-04	12053.	1.11E+10	-94.7368	24022.	0.00
16.8950	0.01187	12472.	2709.	-3.13E-04	12231.	1.11E+10	-92.7879	25571.	0.00
17.1675	0.01085	21197.	2409.	-3.08E-04	12392.	1.11E+10	-90.7328	27351.	0.00
17.4400	0.00985	28945.	2116.	-3.01E-04	12534.	1.11E+10	-88.5736	29404.	0.00
17.7125	0.00888	35735.	1830.	-2.91E-04	12659.	1.11E+10	-86.3116	31782.	0.00
17.9850	0.00795	41590.	1551.	-2.80E-04	12766.	1.11E+10	-83.9473	34549.	0.00
18.2575	0.00705	46533.	1281.	-2.67E-04	12857.	1.11E+10	-81.4805	37789.	0.00
18.5300	0.00620	50589.	1018.	-2.52E-04	12931.	1.11E+10	-78.9097	41612.	0.00
18.8025	0.00540	53783.	764.8229	-2.37E-04	12990.	1.11E+10	-76.2323	46163.	0.00
19.0750	0.00465	56144.	520.1020	-2.21E-04	13033.	1.11E+10	-73.4441	51635.	0.00
19.3475	0.00396	57700.	284.6900	-2.04E-04	13062.	1.11E+10	-70.5387	58299.	0.00
19.6200	0.00332	58482.	58.9860	-1.87E-04	13076.	1.11E+10	-67.5066	66535.	0.00
19.8925	0.00274	58522.	-156.5728	-1.69E-04	13077.	1.11E+10	-64.3337	76904.	0.00
20.1650	0.00221	57853.	-361.4920	-1.52E-04	13065.	1.11E+10	-60.9991	90263.	0.00
20.4375	0.00174	56513.	-555.1906	-1.35E-04	13040.	1.11E+10	-57.4709	107996.	0.00
20.7100	0.00133	54538.	-760.2790	-1.19E-04	13004.	1.11E+10	-67.9655	167720.	0.00
20.9825	9.63E-04	51818.	-952.8642	-1.03E-04	12954.	1.11E+10	-49.8237	169217.	0.00
21.2550	6.51E-04	48547.	-1090.	-8.83E-05	12894.	1.11E+10	-33.9663	170714.	0.00
21.5275	3.85E-04	44897.	-1179.	-7.45E-05	12827.	1.11E+10	-20.2955	172211.	0.00
21.8000	1.64E-04	41013.	-1226.	-6.18E-05	12755.	1.11E+10	-8.6883	173708.	0.00
22.0725	-1.86E-05	37023.	-1239.	-5.02E-05	12682.	1.11E+10	0.9969	175205.	0.00
22.3450	-1.65E-04	33030.	-1222.	-3.99E-05	12609.	1.11E+10	8.9142	176702.	0.00
22.6175	-2.79E-04	29122.	-1183.	-3.07E-05	12537.	1.11E+10	15.2248	178199.	0.00
22.8900	-3.66E-04	25366.	-1125.	-2.26E-05	12468.	1.11E+10	20.0924	179696.	0.00
23.1625	-4.27E-04	21816.	-1054.	-1.56E-05	12403.	1.11E+10	23.6799	181193.	0.00
23.4350	-4.68E-04	18512.	-972.0956	-9.69E-06	12342.	1.11E+10	26.1451	182690.	0.00
23.7075	-4.91E-04	15482.	-884.1585	-4.66E-06	12287.	1.11E+10	27.6391	184187.	0.00
23.9800	-4.98E-04	12741.	-792.6919	-4.86E-07	12236.	1.11E+10	28.3038	185684.	0.00
24.2525	-4.94E-04	10298.	-700.1934	2.92E-06	12192.	1.11E+10	28.2703	187181.	0.00
24.5250	-4.79E-04	8155.	-608.7508	5.65E-06	12152.	1.11E+10	27.6579	188678.	0.00
24.7975	-4.57E-04	6304.	-520.0823	7.79E-06	12118.	1.11E+10	26.5736	190175.	0.00
25.0700	-4.28E-04	4735.	-435.5772	9.42E-06	12089.	1.11E+10	25.1114	191672.	0.00
25.3425	-3.95E-04	3433.	-356.3384	1.06E-05	12065.	1.11E+10	23.3527	193169.	0.00
25.6150	-3.59E-04	2380.	-283.2235	1.15E-05	12046.	1.11E+10	21.3659	194666.	0.00
25.8875	-3.20E-04	1554.	-216.8855	1.21E-05	12031.	1.11E+10	19.2078	196163.	0.00
26.1600	-2.80E-04	933.3821	-157.8112	1.24E-05	12020.	1.11E+10	16.9233	197660.	0.00
26.4325	-2.39E-04	493.1391	-106.3571	1.26E-05	12011.	1.11E+10	14.5471	199157.	0.00
26.7050	-1.97E-04	208.2760	-62.7828	1.28E-05	12006.	1.11E+10	12.1039	200654.	0.00
26.9775	-1.55E-04	52.7668	-27.2803	1.28E-05	12003.	1.11E+10	9.6102	202151.	0.00
27.2500	-1.14E-04	0.00	0.00	1.28E-05	12002.	1.11E+10	7.0750	101824.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =    -0.45000000 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =       3705938. inch-lbs
Maximum shear force              =       -134624. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             13
Number of zero deflection points =              2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Displacement and Moment (Loading Type 4)

```
Displacement of pile head                        =    -0.450000 inches
Moment at pile head                              =    2779290.0 in-lbs
Axial load at pile head                          =     357000.0 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.4500	2779290.	-117506.	0.00223	63028.	1.11E+10	1902.	6912.	0.00
0.2725	-0.4414	2402132.	-111169.	0.00300	56104.	1.11E+10	1973.	14621.	0.00
0.5450	-0.4304	2045245.	-104626.	0.00366	49552.	1.11E+10	2028.	15407.	0.00
0.8175	-0.4174	1709337.	-97955.	0.00421	43385.	1.11E+10	2053.	16080.	0.00
1.0900	-0.4028	1394788.	-90922.	0.00467	37610.	1.11E+10	2249.	18256.	0.00
1.3625	-0.3869	1103805.	-83553.	0.00504	32268.	1.11E+10	2258.	19081.	0.00
1.6350	-0.3699	836581.	-76170.	0.00533	27361.	1.11E+10	2258.	19965.	0.00
1.9075	-0.3521	593217.	-68796.	0.00554	22893.	1.11E+10	2252.	20914.	0.00
2.1800	-0.3337	373725.	-61455.	0.00568	18864.	1.11E+10	2238.	21937.	0.00
2.4525	-0.3149	178039.	-54167.	0.00576	15271.	1.11E+10	2219.	23043.	0.00
2.7250	-0.2960	6020.	-46951.	0.00579	12113.	1.11E+10	2194.	24244.	0.00
2.9975	-0.2770	-142536.	-39823.	0.00577	14619.	1.11E+10	2165.	25554.	0.00
3.2700	-0.2582	-267895.	-33962.	0.00571	16921.	1.11E+10	1420.	17978.	0.00
3.5425	-0.2397	-377979.	-29442.	0.00561	18942.	1.11E+10	1345.	18352.	0.00
3.8150	-0.2215	-473550.	-25168.	0.00549	20696.	1.11E+10	1269.	18726.	0.00
4.0875	-0.2038	-555392.	-21148.	0.00534	22199.	1.11E+10	1190.	19101.	0.00
4.3600	-0.1866	-624313.	-17384.	0.00516	23464.	1.11E+10	1111.	19475.	0.00
4.6325	-0.1700	-681134.	-13879.	0.00497	24508.	1.11E+10	1032.	19849.	0.00
4.9050	-0.1541	-726683.	-10633.	0.00476	25344.	1.11E+10	953.2022	20223.	0.00
5.1775	-0.1389	-761788.	-7644.	0.00454	25988.	1.11E+10	875.0072	20598.	0.00
5.4500	-0.1244	-787275.	-4909.	0.00431	26456.	1.11E+10	798.0543	20972.	0.00
5.7225	-0.1107	-803956.	-2422.	0.00408	26763.	1.11E+10	722.7574	21346.	0.00
5.9950	-0.09778	-812631.	-178.3955	0.00384	26922.	1.11E+10	649.4851	21720.	0.00
6.2675	-0.08563	-814080.	1829.	0.00360	26948.	1.11E+10	578.5609	22095.	0.00
6.5400	-0.07426	-809062.	3610.	0.00336	26856.	1.11E+10	510.2645	22469.	0.00
6.8125	-0.06368	-798309.	5171.	0.00312	26659.	1.11E+10	444.8320	22843.	0.00
7.0850	-0.05387	-782523.	6524.	0.00288	26369.	1.11E+10	382.4585	23217.	0.00
7.3575	-0.04481	-762377.	7678.	0.00266	25999.	1.11E+10	323.2987	23592.	0.00
7.6300	-0.03649	-738512.	8644.	0.00243	25561.	1.11E+10	267.4697	23966.	0.00
7.9025	-0.02889	-711531.	9433.	0.00222	25066.	1.11E+10	215.0530	24340.	0.00
8.1750	-0.02198	-682005.	10056.	0.00201	24524.	1.11E+10	166.0965	24714.	0.00
8.4475	-0.01572	-650468.	10525.	0.00182	23945.	1.11E+10	120.6173	25089.	0.00
8.7200	-0.01009	-617416.	10850.	0.00163	23338.	1.11E+10	78.6045	25463.	0.00
8.9925	-0.00507	-583311.	11044.	0.00145	22712.	1.11E+10	40.0216	25837.	0.00
9.2650	-6.00E-04	-548576.	11118.	0.00128	22074.	1.11E+10	4.8090	26211.	0.00
9.5375	0.00333	-513601.	11081.	0.00113	21432.	1.11E+10	-27.1125	26586.	0.00
9.8100	0.00677	-478738.	10945.	9.81E-04	20792.	1.11E+10	-55.8397	26960.	0.00
10.0825	0.00975	-444307.	10721.	8.44E-04	20160.	1.11E+10	-81.4840	27334.	0.00
10.3550	0.01229	-410594.	10417.	7.18E-04	19541.	1.11E+10	-104.1683	27708.	0.00
10.6275	0.01444	-377853.	10044.	6.01E-04	18940.	1.11E+10	-124.0253	28083.	0.00
10.9000	0.01622	-346308.	9611.	4.94E-04	18360.	1.11E+10	-141.1941	28457.	0.00
11.1725	0.01767	-316152.	9125.	3.96E-04	17807.	1.11E+10	-155.8183	28831.	0.00
11.4450	0.01882	-287554.	8596.	3.07E-04	17282.	1.11E+10	-168.0433	29205.	0.00
11.7175	0.01968	-260654.	8030.	2.26E-04	16788.	1.11E+10	-178.0142	29580.	0.00
11.9900	0.02029	-235567.	7435.	1.52E-04	16327.	1.11E+10	-185.8740	29954.	0.00
12.2625	0.02068	-212386.	6817.	8.61E-05	15902.	1.11E+10	-191.7611	30328.	0.00
12.5350	0.02085	-191182.	6184.	2.65E-05	15512.	1.11E+10	-195.8077	30702.	0.00
12.8075	0.02085	-172007.	5540.	-2.72E-05	15160.	1.11E+10	-198.1382	31077.	0.00
13.0800	0.02068	-154890.	5154.	-7.56E-05	14846.	1.11E+10	-37.8738	5990.	0.00
13.3525	0.02035	-138125.	5030.	-1.19E-04	14538.	1.11E+10	-37.6767	6053.	0.00
13.6250	0.01990	-121715.	4907.	-1.57E-04	14237.	1.11E+10	-37.3940	6145.	0.00
13.8975	0.01933	-105663.	4786.	-1.91E-04	13942.	1.11E+10	-37.0320	6266.	0.00
14.1700	0.01865	-89970.	4665.	-2.20E-04	13654.	1.11E+10	-36.5961	6417.	0.00
14.4425	0.01789	-74638.	4547.	-2.44E-04	13373.	1.11E+10	-36.0911	6598.	0.00
14.7150	0.01705	-59666.	4429.	-2.64E-04	13098.	1.11E+10	-35.5216	6812.	0.00
14.9875	0.01616	-45053.	4207.	-2.80E-04	12830.	1.11E+10	-100.2370	20283.	0.00
15.2600	0.01522	-31496.	3882.	-2.91E-04	12581.	1.11E+10	-98.7562	21212.	0.00
15.5325	0.01426	-18985.	3562.	-2.98E-04	12351.	1.11E+10	-97.1536	22282.	0.00
15.8050	0.01327	-7505.	3247.	-3.02E-04	12140.	1.11E+10	-95.4345	23511.	0.00
16.0775	0.01228	2956.	2938.	-3.03E-04	12057.	1.11E+10	-93.6030	24923.	0.00
16.3500	0.01129	12415.	2635.	-3.01E-04	12230.	1.11E+10	-91.6629	26544.	0.00
16.6225	0.01031	20890.	2339.	-2.96E-04	12386.	1.11E+10	-89.6168	28411.	0.00
16.8950	0.00936	28400.	2049.	-2.88E-04	12524.	1.11E+10	-87.4669	30565.	0.00
17.1675	0.00843	34964.	1767.	-2.79E-04	12644.	1.11E+10	-85.2147	33062.	0.00

17.4400	0.00753	40606.	1492.	-2.68E-04	12748.	1.11E+10	-82.8607	35971.	0.00
17.7125	0.00668	45347.	1225.	-2.55E-04	12835.	1.11E+10	-80.4047	39383.	0.00
17.9850	0.00586	49213.	966.1992	-2.41E-04	12906.	1.11E+10	-77.8454	43414.	0.00
18.2575	0.00510	52229.	716.0021	-2.26E-04	12961.	1.11E+10	-75.1803	48218.	0.00
18.5300	0.00438	54423.	474.7000	-2.10E-04	13002.	1.11E+10	-72.4051	54007.	0.00
18.8025	0.00372	55825.	242.6634	-1.94E-04	13027.	1.11E+10	-69.5133	61069.	0.00
19.0750	0.00311	56464.	20.2896	-1.78E-04	13039.	1.11E+10	-66.4952	69820.	0.00
19.3475	0.00256	56372.	-191.9848	-1.61E-04	13037.	1.11E+10	-63.3363	80871.	0.00
19.6200	0.00206	55584.	-393.6644	-1.44E-04	13023.	1.11E+10	-60.0151	95163.	0.00
19.8925	0.00162	54134.	-584.1632	-1.28E-04	12996.	1.11E+10	-56.4979	114236.	0.00
20.1650	0.00122	52062.	-762.7514	-1.12E-04	12958.	1.11E+10	-52.7303	140804.	0.00
20.4375	8.82E-04	49408.	-928.4563	-9.74E-05	12910.	1.11E+10	-48.6182	180190.	0.00
20.7100	5.88E-04	46218.	-1057.	-8.32E-05	12851.	1.11E+10	-30.1477	167720.	0.00
20.9825	3.38E-04	42688.	-1135.	-7.01E-05	12786.	1.11E+10	-17.4889	169217.	0.00
21.2550	1.29E-04	38958.	-1175.	-5.80E-05	12718.	1.11E+10	-6.7566	170714.	0.00
21.5275	-4.14E-05	35141.	-1182.	-4.71E-05	12648.	1.11E+10	2.1826	172211.	0.00
21.8000	-1.78E-04	31336.	-1163.	-3.72E-05	12578.	1.11E+10	9.4730	173708.	0.00
22.0725	-2.85E-04	27621.	-1123.	-2.85E-05	12510.	1.11E+10	15.2650	175205.	0.00
22.3450	-3.65E-04	24059.	-1066.	-2.09E-05	12444.	1.11E+10	19.7112	176702.	0.00
22.6175	-4.21E-04	20701.	-995.7827	-1.42E-05	12382.	1.11E+10	22.9627	178199.	0.00
22.8900	-4.58E-04	17580.	-917.0926	-8.59E-06	12325.	1.11E+10	25.1658	179696.	0.00
23.1625	-4.78E-04	14723.	-832.6837	-3.81E-06	12273.	1.11E+10	26.4604	181193.	0.00
23.4350	-4.83E-04	12143.	-745.3126	1.62E-07	12225.	1.11E+10	26.9775	182690.	0.00
23.7075	-4.76E-04	9848.	-657.3241	3.41E-06	12183.	1.11E+10	26.8380	184187.	0.00
23.9800	-4.61E-04	7837.	-570.6856	6.03E-06	12146.	1.11E+10	26.1519	185684.	0.00
24.2525	-4.37E-04	6102.	-487.0238	8.09E-06	12114.	1.11E+10	25.0174	187181.	0.00
24.5250	-4.08E-04	4632.	-407.6637	9.68E-06	12087.	1.11E+10	23.5209	188678.	0.00
24.7975	-3.74E-04	3413.	-333.6673	1.09E-05	12065.	1.11E+10	21.7369	190175.	0.00
25.0700	-3.37E-04	2425.	-265.8716	1.17E-05	12047.	1.11E+10	19.7284	191672.	0.00
25.3425	-2.97E-04	1647.	-204.9257	1.23E-05	12033.	1.11E+10	17.5474	193169.	0.00
25.6150	-2.56E-04	1056.	-151.3261	1.27E-05	12022.	1.11E+10	15.2353	194666.	0.00
25.8875	-2.14E-04	627.4873	-105.4486	1.30E-05	12014.	1.11E+10	12.8243	196163.	0.00
26.1600	-1.71E-04	335.9732	-67.5780	1.31E-05	12009.	1.11E+10	10.3381	197660.	0.00
26.4325	-1.28E-04	154.8875	-37.9337	1.32E-05	12005.	1.11E+10	7.7929	199157.	0.00
26.7050	-8.47E-05	57.0774	-16.6917	1.32E-05	12003.	1.11E+10	5.1992	200654.	0.00
26.9775	-4.14E-05	14.8417	-4.0016	1.32E-05	12003.	1.11E+10	2.5624	202151.	0.00
27.2500	1.85E-06	0.00	0.00	1.32E-05	12002.	1.11E+10	-0.1149	101824.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

```
Pile-head deflection             =    -0.45000000 inches
Computed slope at pile head      =     0.00223269 radians
Maximum bending moment           =       2779290. inch-lbs
Maximum shear force              =       -117506. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             13
Number of zero deflection points =              3
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Moment (Loading Type 1)

```
Shear force at pile head                          =    -140606.0 lbs
Applied moment at pile head                       =    2779290.0 in-lbs
Axial thrust load on pile head                    =     357000.0 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.7104	2779290.	-140606.	0.00688	63028.	1.11E+10	2140.	4925.	0.00
0.2725	-0.6865	2322436.	-133424.	0.00764	54641.	1.11E+10	2252.	10728.	0.00
0.5450	-0.6604	1888863.	-125886.	0.00826	46681.	1.11E+10	2358.	11676.	0.00
0.8175	-0.6325	1479855.	-118039.	0.00876	39172.	1.11E+10	2441.	12622.	0.00
1.0900	-0.6032	1096442.	-109558.	0.00914	32132.	1.11E+10	2745.	14884.	0.00
1.3625	-0.5728	742007.	-100430.	0.00941	25625.	1.11E+10	2838.	16202.	0.00
1.6350	-0.5416	417661.	-90997.	0.00958	19670.	1.11E+10	2932.	17699.	0.00
1.9075	-0.5101	124518.	-81364.	0.00966	14288.	1.11E+10	2960.	18975.	0.00
2.1800	-0.4784	-137019.	-71770.	0.00966	14518.	1.11E+10	2908.	19874.	0.00
2.4525	-0.4469	-367416.	-62359.	0.00959	18748.	1.11E+10	2849.	20843.	0.00
2.7250	-0.4157	-567225.	-53151.	0.00945	22416.	1.11E+10	2783.	21891.	0.00
2.9975	-0.3851	-737079.	-44165.	0.00925	25535.	1.11E+10	2712.	23030.	0.00
3.2700	-0.3552	-877675.	-36538.	0.00902	28116.	1.11E+10	1953.	17978.	0.00
3.5425	-0.3262	-997086.	-30352.	0.00874	30308.	1.11E+10	1831.	18352.	0.00
3.8150	-0.2981	-1096579.	-24568.	0.00843	32135.	1.11E+10	1707.	18726.	0.00
4.0875	-0.2710	-1177441.	-19189.	0.00809	33619.	1.11E+10	1583.	19101.	0.00
4.3600	-0.2451	-1240968.	-14213.	0.00774	34786.	1.11E+10	1460.	19475.	0.00

4.6325	-0.2204	-1288455.	-9638.	0.00736	35658.	1.11E+10	1338.	19849.	0.00
4.9050	-0.1970	-1321190.	-5459.	0.00698	36259.	1.11E+10	1218.	20223.	0.00
5.1775	-0.1748	-1340440.	-1666.	0.00658	36612.	1.11E+10	1101.	20598.	0.00
5.4500	-0.1540	-1347453.	1749.	0.00618	36741.	1.11E+10	987.3595	20972.	0.00
5.7225	-0.1344	-1343442.	4797.	0.00579	36667.	1.11E+10	877.2205	21346.	0.00
5.9950	-0.1161	-1329588.	7493.	0.00539	36413.	1.11E+10	771.2312	21720.	0.00
6.2675	-0.09912	-1307028.	9849.	0.00500	35999.	1.11E+10	669.7473	22095.	0.00
6.5400	-0.08340	-1276856.	11881.	0.00462	35445.	1.11E+10	573.0603	22469.	0.00
6.8125	-0.06891	-1240114.	13605.	0.00425	34770.	1.11E+10	481.4003	22843.	0.00
7.0850	-0.05562	-1197797.	15037.	0.00389	33993.	1.11E+10	394.9391	23217.	0.00
7.3575	-0.04349	-1150844.	16196.	0.00354	33131.	1.11E+10	313.7931	23592.	0.00
7.6300	-0.03248	-1100138.	17098.	0.00321	32200.	1.11E+10	238.0273	23966.	0.00
7.9025	-0.02252	-1046506.	17762.	0.00289	31216.	1.11E+10	167.6588	24340.	0.00
8.1750	-0.01358	-990721.	18204.	0.00259	30191.	1.11E+10	102.6610	24714.	0.00
8.4475	-0.00560	-933496.	18442.	0.00230	29141.	1.11E+10	42.9673	25089.	0.00
8.7200	0.00148	-875489.	18493.	0.00204	28076.	1.11E+10	-11.5241	25463.	0.00
8.9925	0.00771	-817304.	18375.	0.00179	27008.	1.11E+10	-60.9465	25837.	0.00
9.2650	0.01316	-759487.	18103.	0.00155	25946.	1.11E+10	-105.4603	26211.	0.00
9.5375	0.01787	-702537.	17693.	0.00134	24901.	1.11E+10	-145.2487	26586.	0.00
9.8100	0.02189	-646896.	17160.	0.00114	23879.	1.11E+10	-180.5136	26960.	0.00
10.0825	0.02530	-592963.	16519.	9.53E-04	22889.	1.11E+10	-211.4714	27334.	0.00
10.3550	0.02813	-541086.	15784.	7.86E-04	21936.	1.11E+10	-238.3493	27708.	0.00
10.6275	0.03044	-491571.	14967.	6.33E-04	21027.	1.11E+10	-261.3813	28083.	0.00
10.9000	0.03227	-444681.	14080.	4.94E-04	20166.	1.11E+10	-280.8044	28457.	0.00
11.1725	0.03367	-400641.	13136.	3.69E-04	19358.	1.11E+10	-296.8553	28831.	0.00
11.4450	0.03468	-359636.	12144.	2.57E-04	18605.	1.11E+10	-309.7665	29205.	0.00
11.7175	0.03535	-321819.	11115.	1.56E-04	17911.	1.11E+10	-319.7639	29580.	0.00
11.9900	0.03570	-287311.	10057.	6.61E-05	17277.	1.11E+10	-327.0630	29954.	0.00
12.2625	0.03578	-256201.	8980.	-1.42E-05	16706.	1.11E+10	-331.8664	30328.	0.00
12.5350	0.03561	-228550.	7890.	-8.59E-05	16198.	1.11E+10	-334.3613	30702.	0.00
12.8075	0.03522	-204396.	6797.	-1.50E-04	15755.	1.11E+10	-334.7166	31077.	0.00
13.0800	0.03463	-183751.	6176.	-2.07E-04	15376.	1.11E+10	-44.9698	4246.	0.00
13.3525	0.03386	-163523.	6029.	-2.59E-04	15005.	1.11E+10	-44.6354	4310.	0.00
13.6250	0.03294	-143716.	5884.	-3.04E-04	14641.	1.11E+10	-44.2252	4390.	0.00
13.8975	0.03188	-124332.	5740.	-3.44E-04	14285.	1.11E+10	-43.7438	4488.	0.00
14.1700	0.03069	-105373.	5598.	-3.78E-04	13937.	1.11E+10	-43.1952	4602.	0.00
14.4425	0.02940	-86840.	5458.	-4.06E-04	13597.	1.11E+10	-42.5832	4735.	0.00
14.7150	0.02803	-68731.	5320.	-4.29E-04	13264.	1.11E+10	-41.9113	4889.	0.00
14.9875	0.02660	-51048.	5065.	-4.47E-04	12940.	1.11E+10	-113.4934	13953.	0.00
15.2600	0.02511	-34560.	4697.	-4.60E-04	12637.	1.11E+10	-111.8739	14568.	0.00
15.5325	0.02359	-19256.	4334.	-4.67E-04	12356.	1.11E+10	-110.1419	15266.	0.00
15.8050	0.02206	-5124.	3977.	-4.71E-04	12097.	1.11E+10	-108.3012	16057.	0.00
16.0775	0.02051	7852.	3626.	-4.71E-04	12147.	1.11E+10	-106.3552	16955.	0.00
16.3500	0.01898	19688.	3281.	-4.67E-04	12364.	1.11E+10	-104.3065	17974.	0.00
16.6225	0.01746	30402.	2944.	-4.59E-04	12561.	1.11E+10	-102.1573	19132.	0.00
16.8950	0.01597	40013.	2614.	-4.49E-04	12737.	1.11E+10	-99.9093	20453.	0.00
17.1675	0.01453	48542.	2291.	-4.36E-04	12894.	1.11E+10	-97.5634	21964.	0.00
17.4400	0.01312	56011.	1976.	-4.20E-04	13031.	1.11E+10	-95.1201	23700.	0.00
17.7125	0.01178	62444.	1669.	-4.03E-04	13149.	1.11E+10	-92.5792	25705.	0.00
17.9850	0.01049	67865.	1370.	-3.83E-04	13248.	1.11E+10	-89.9397	28035.	0.00
18.2575	0.00927	72301.	1081.	-3.63E-04	13330.	1.11E+10	-87.1997	30761.	0.00
18.5300	0.00812	75779.	800.1769	-3.41E-04	13394.	1.11E+10	-84.3562	33978.	0.00
18.8025	0.00704	78330.	529.1576	-3.18E-04	13441.	1.11E+10	-81.4048	37809.	0.00
19.0750	0.00604	79983.	267.9763	-2.95E-04	13471.	1.11E+10	-78.3391	42423.	0.00
19.3475	0.00511	80770.	17.0215	-2.71E-04	13485.	1.11E+10	-75.1501	48056.	0.00
19.6200	0.00427	80726.	-223.2829	-2.47E-04	13485.	1.11E+10	-71.8251	55043.	0.00
19.8925	0.00350	79887.	-452.4622	-2.23E-04	13469.	1.11E+10	-68.3458	63883.	0.00
20.1650	0.00281	78288.	-669.9680	-2.00E-04	13440.	1.11E+10	-64.6853	75352.	0.00
20.4375	0.00219	75972.	-875.1411	-1.77E-04	13397.	1.11E+10	-60.8028	90726.	0.00
20.7100	0.00165	72978.	-1113.	-1.55E-04	13342.	1.11E+10	-84.5958	167720.	0.00
20.9825	0.00118	69055.	-1351.	-1.34E-04	13270.	1.11E+10	-60.9481	169217.	0.00
21.2550	7.73E-04	64457.	-1516.	-1.14E-04	13186.	1.11E+10	-40.3551	170714.	0.00
21.5275	4.31E-04	59404.	-1620.	-9.59E-05	13093.	1.11E+10	-22.6741	172211.	0.00
21.8000	1.46E-04	54089.	-1669.	-7.92E-05	12995.	1.11E+10	-7.7313	173708.	0.00
22.0725	-8.72E-05	48672.	-1674.	-6.40E-05	12896.	1.11E+10	4.6698	175205.	0.00
22.3450	-2.73E-04	43289.	-1642.	-5.04E-05	12797.	1.11E+10	14.7405	176702.	0.00
22.6175	-4.17E-04	38048.	-1581.	-3.83E-05	12701.	1.11E+10	22.6998	178199.	0.00
22.8900	-5.24E-04	33037.	-1497.	-2.78E-05	12609.	1.11E+10	28.7687	179696.	0.00
23.1625	-5.99E-04	28322.	-1396.	-1.88E-05	12522.	1.11E+10	33.1653	181193.	0.00
23.4350	-6.46E-04	23952.	-1283.	-1.10E-05	12442.	1.11E+10	36.1004	182690.	0.00
23.7075	-6.71E-04	19959.	-1162.	-4.53E-06	12369.	1.11E+10	37.7744	184187.	0.00
23.9800	-6.76E-04	16364.	-1037.	8.40E-07	12303.	1.11E+10	38.3748	185684.	0.00
24.2525	-6.65E-04	13173.	-912.3375	5.21E-06	12244.	1.11E+10	38.0741	187181.	0.00
24.5250	-6.42E-04	10385.	-789.5448	8.69E-06	12193.	1.11E+10	37.0285	188678.	0.00
24.7975	-6.08E-04	7989.	-671.1610	1.14E-05	12149.	1.11E+10	35.3775	190175.	0.00
25.0700	-5.67E-04	5969.	-558.9665	1.35E-05	12112.	1.11E+10	33.2430	191672.	0.00
25.3425	-5.20E-04	4302.	-454.3711	1.50E-05	12081.	1.11E+10	30.7298	193169.	0.00
25.6150	-4.69E-04	2962.	-358.4691	1.61E-05	12057.	1.11E+10	27.9259	194666.	0.00
25.8875	-4.15E-04	1920.	-272.0932	1.68E-05	12038.	1.11E+10	24.9034	196163.	0.00
26.1600	-3.59E-04	1144.	-195.8653	1.72E-05	12023.	1.11E+10	21.7192	197660.	0.00
26.4325	-3.02E-04	599.0327	-130.2432	1.75E-05	12013.	1.11E+10	18.4166	199157.	0.00
26.7050	-2.45E-04	251.0709	-75.5641	1.76E-05	12007.	1.11E+10	15.0263	200654.	0.00
26.9775	-1.87E-04	63.6970	-32.0819	1.77E-05	12004.	1.11E+10	11.5683	202151.	0.00
27.2500	-1.29E-04	0.00	0.00	1.77E-05	12002.	1.11E+10	8.0536	101824.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

Pile-head deflection = -0.71039561 inches
Computed slope at pile head = 0.00688257 radians
Maximum bending moment = 2779290. inch-lbs
Maximum shear force = -140606. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 22
Number of zero deflection points = 2

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 4

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = -0.710400 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 357000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.7104	3940346.	-161788.	0.00	84344.	1.40E+09	2140.	4925.	0.00
0.2725	-0.6953	3422751.	-152959.	0.00511	74842.	1.11E+10	2252.	10592.	0.00
0.5450	-0.6770	2928059.	-145421.	0.00605	65760.	1.11E+10	2358.	11391.	0.00
0.8175	-0.6558	2457572.	-137573.	0.00685	57122.	1.11E+10	2441.	12174.	0.00
1.0900	-0.6322	2012342.	-129093.	0.00751	48948.	1.11E+10	2745.	14201.	0.00
1.3625	-0.6067	1595775.	-119964.	0.00804	41300.	1.11E+10	2838.	15296.	0.00
1.6350	-0.5796	1209002.	-110531.	0.00846	34199.	1.11E+10	2932.	16539.	0.00
1.9075	-0.5514	853158.	-100789.	0.00876	27666.	1.11E+10	3027.	17950.	0.00
2.1800	-0.5223	529383.	-90755.	0.00897	21722.	1.11E+10	3111.	19475.	0.00
2.4525	-0.4927	238687.	-80655.	0.00908	16385.	1.11E+10	3067.	20355.	0.00
2.7250	-0.4629	-19296.	-70710.	0.00911	12357.	1.11E+10	3015.	21298.	0.00
2.9975	-0.4331	-245033.	-60948.	0.00907	16501.	1.11E+10	2956.	22313.	0.00
3.2700	-0.4036	-439082.	-52488.	0.00897	20064.	1.11E+10	2219.	17978.	0.00
3.5425	-0.3745	-609254.	-45425.	0.00882	23188.	1.11E+10	2102.	18352.	0.00
3.8150	-0.3459	-756744.	-38750.	0.00861	25896.	1.11E+10	1981.	18726.	0.00
4.0875	-0.3181	-882791.	-32473.	0.00837	28210.	1.11E+10	1858.	19101.	0.00
4.3600	-0.2912	-988663.	-26599.	0.00810	30154.	1.11E+10	1734.	19475.	0.00
4.6325	-0.2652	-1075651.	-21132.	0.00779	31751.	1.11E+10	1610.	19849.	0.00
4.9050	-0.2402	-1145057.	-16072.	0.00746	33025.	1.11E+10	1486.	20223.	0.00
5.1775	-0.2164	-1198182.	-11414.	0.00712	34000.	1.11E+10	1363.	20598.	0.00
5.4500	-0.1937	-1236319.	-7155.	0.00676	34700.	1.11E+10	1242.	20972.	0.00
5.7225	-0.1722	-1260747.	-3286.	0.00639	35149.	1.11E+10	1124.	21346.	0.00
5.9950	-0.1519	-1272720.	201.6819	0.00601	35369.	1.11E+10	1009.	21720.	0.00
6.2675	-0.1329	-1273463.	3320.	0.00563	35382.	1.11E+10	897.8362	22095.	0.00
6.5400	-0.1151	-1264166.	6080.	0.00526	35212.	1.11E+10	790.6652	22469.	0.00
6.8125	-0.09848	-1245978.	8498.	0.00489	34878.	1.11E+10	687.9575	22843.	0.00
7.0850	-0.08310	-1220004.	10587.	0.00452	34401.	1.11E+10	590.0081	23217.	0.00
7.3575	-0.06890	-1187300.	12365.	0.00417	33800.	1.11E+10	497.0494	23592.	0.00
7.6300	-0.05584	-1148871.	13846.	0.00382	33095.	1.11E+10	409.2547	23966.	0.00
7.9025	-0.04390	-1105669.	15050.	0.00349	32302.	1.11E+10	326.7417	24340.	0.00
8.1750	-0.03302	-1058592.	15992.	0.00317	31437.	1.11E+10	249.5760	24714.	0.00
8.4475	-0.02317	-1008480.	16691.	0.00286	30517.	1.11E+10	177.7755	25089.	0.00
8.7200	-0.01430	-956120.	17163.	0.00257	29556.	1.11E+10	111.3144	25463.	0.00
8.9925	-0.00634	-902239.	17427.	0.00230	28567.	1.11E+10	50.1273	25837.	0.00
9.2650	7.34E-04	-847510.	17500.	0.00204	27562.	1.11E+10	-5.8859	26211.	0.00
9.5375	0.00699	-792552.	17397.	0.00180	26553.	1.11E+10	-56.8559	26586.	0.00
9.8100	0.01249	-737928.	17136.	0.00157	25550.	1.11E+10	-102.9396	26960.	0.00
10.0825	0.01726	-684150.	16732.	0.00136	24563.	1.11E+10	-144.3152	27334.	0.00
10.3550	0.02138	-631679.	16199.	0.00117	23600.	1.11E+10	-181.1785	27708.	0.00
10.6275	0.02489	-580928.	15554.	9.86E-04	22668.	1.11E+10	-213.7381	28083.	0.00
10.9000	0.02783	-532261.	14808.	8.22E-04	21774.	1.11E+10	-242.2113	28457.	0.00
11.1725	0.03026	-486000.	13976.	6.71E-04	20925.	1.11E+10	-266.8202	28831.	0.00
11.4450	0.03222	-442425.	13069.	5.34E-04	20125.	1.11E+10	-287.7877	29205.	0.00
11.7175	0.03375	-401774.	12099.	4.09E-04	19379.	1.11E+10	-305.3335	29580.	0.00
11.9900	0.03490	-364250.	11078.	2.96E-04	18690.	1.11E+10	-319.6709	29954.	0.00
12.2625	0.03569	-330018.	10014.	1.93E-04	18061.	1.11E+10	-331.0029	30328.	0.00
12.5350	0.03616	-299211.	8917.	1.00E-04	17496.	1.11E+10	-339.5196	30702.	0.00
12.8075	0.03634	-271931.	7798.	1.57E-05	16995.	1.11E+10	-345.3944	31077.	0.00
13.0800	0.03626	-248251.	7158.	-6.13E-05	16560.	1.11E+10	-45.6657	4118.	0.00
13.3525	0.03594	-224974.	7009.	-1.31E-04	16133.	1.11E+10	-45.5307	4142.	0.00
13.6250	0.03541	-202105.	6861.	-1.94E-04	15713.	1.11E+10	-45.3024	4184.	0.00
13.8975	0.03467	-179652.	6713.	-2.51E-04	15301.	1.11E+10	-44.9874	4243.	0.00
14.1700	0.03376	-157617.	6566.	-3.01E-04	14896.	1.11E+10	-44.5915	4319.	0.00
14.4425	0.03271	-136005.	6421.	-3.44E-04	14499.	1.11E+10	-44.1200	4411.	0.00
14.7150	0.03151	-114817.	6278.	-3.81E-04	14110.	1.11E+10	-43.5778	4522.	0.00
14.9875	0.03021	-94056.	6015.	-4.12E-04	13729.	1.11E+10	-117.1656	12681.	0.00
15.2600	0.02882	-74515.	5634.	-4.37E-04	13370.	1.11E+10	-115.7908	13138.	0.00
15.5325	0.02735	-56187.	5258.	-4.56E-04	13034.	1.11E+10	-114.2901	13663.	0.00
15.8050	0.02583	-39061.	4887.	-4.70E-04	12720.	1.11E+10	-112.6686	14261.	0.00
16.0775	0.02428	-23127.	4522.	-4.80E-04	12427.	1.11E+10	-110.9308	14942.	0.00
16.3500	0.02270	-8371.	4162.	-4.84E-04	12156.	1.11E+10	-109.0804	15715.	0.00
16.6225	0.02111	5222.	3808.	-4.85E-04	12098.	1.11E+10	-107.1205	16593.	0.00

16.8950	0.01953	17667.	3461.	-4.81E-04	12327.	1.11E+10	-105.0535	17592.	0.00
17.1675	0.01796	28983.	3121.	-4.74E-04	12535.	1.11E+10	-102.8813	18730.	0.00
17.4400	0.01642	39189.	2789.	-4.64E-04	12722.	1.11E+10	-100.6050	20030.	0.00
17.7125	0.01492	48306.	2464.	-4.51E-04	12889.	1.11E+10	-98.2253	21521.	0.00
17.9850	0.01347	56356.	2147.	-4.36E-04	13037.	1.11E+10	-95.7419	23240.	0.00
18.2575	0.01207	63362.	1838.	-4.18E-04	13166.	1.11E+10	-93.1541	25231.	0.00
18.5300	0.01074	69351.	1537.	-3.99E-04	13276.	1.11E+10	-90.4600	27553.	0.00
18.8025	0.00947	74348.	1246.	-3.77E-04	13367.	1.11E+10	-87.6568	30281.	0.00
19.0750	0.00827	78382.	964.3674	-3.55E-04	13441.	1.11E+10	-84.7404	33516.	0.00
19.3475	0.00715	81483.	692.2291	-3.31E-04	13498.	1.11E+10	-81.7050	37391.	0.00
19.6200	0.00610	83683.	430.2240	-3.07E-04	13539.	1.11E+10	-78.5427	42092.	0.00
19.8925	0.00514	85013.	178.7853	-2.82E-04	13563.	1.11E+10	-75.2424	47876.	0.00
20.1650	0.00426	85510.	-61.6110	-2.57E-04	13572.	1.11E+10	-71.7890	55122.	0.00
20.4375	0.00346	85209.	-290.4292	-2.31E-04	13567.	1.11E+10	-68.1610	64400.	0.00
20.7100	0.00275	84151.	-632.1228	-2.06E-04	13547.	1.11E+10	-140.8259	167720.	0.00
20.9825	0.00211	81557.	-1041.	-1.82E-04	13500.	1.11E+10	-109.2768	169217.	0.00
21.2550	0.00156	77767.	-1353.	-1.58E-04	13430.	1.11E+10	-81.2648	170714.	0.00
21.5275	0.00108	73081.	-1578.	-1.36E-04	13344.	1.11E+10	-56.7051	172211.	0.00
21.8000	6.68E-04	67763.	-1729.	-1.15E-04	13247.	1.11E+10	-35.4604	173708.	0.00
22.0725	3.24E-04	62043.	-1815.	-9.59E-05	13142.	1.11E+10	-17.3521	175205.	0.00
22.3450	4.02E-05	56116.	-1847.	-7.85E-05	13033.	1.11E+10	-2.1713	176702.	0.00
22.6175	-1.89E-04	50146.	-1834.	-6.27E-05	12923.	1.11E+10	10.3119	178199.	0.00
22.8900	-3.70E-04	44269.	-1784.	-4.88E-05	12815.	1.11E+10	20.3402	179696.	0.00
23.1625	-5.08E-04	38594.	-1704.	-3.65E-05	12711.	1.11E+10	28.1621	181193.	0.00
23.4350	-6.09E-04	33207.	-1603.	-2.59E-05	12612.	1.11E+10	34.0252	182690.	0.00
23.7075	-6.78E-04	28173.	-1485.	-1.68E-05	12520.	1.11E+10	38.1717	184187.	0.00
23.9800	-7.19E-04	23537.	-1355.	-9.19E-06	12435.	1.11E+10	40.8340	185684.	0.00
24.2525	-7.38E-04	19330.	-1220.	-2.85E-06	12357.	1.11E+10	42.2313	187181.	0.00
24.5250	-7.38E-04	15567.	-1081.	2.31E-06	12288.	1.11E+10	42.5671	188678.	0.00
24.7975	-7.23E-04	12254.	-942.7287	6.43E-06	12227.	1.11E+10	42.0273	190175.	0.00
25.0700	-6.96E-04	9386.	-807.3402	9.63E-06	12175.	1.11E+10	40.7791	191672.	0.00
25.3425	-6.60E-04	6952.	-676.9503	1.20E-05	12130.	1.11E+10	38.9701	193169.	0.00
25.6150	-6.17E-04	4931.	-553.1842	1.38E-05	12093.	1.11E+10	36.7278	194666.	0.00
25.8875	-5.69E-04	3302.	-437.2821	1.50E-05	12063.	1.11E+10	34.1604	196163.	0.00
26.1600	-5.19E-04	2036.	-330.1622	1.58E-05	12040.	1.11E+10	31.3564	197660.	0.00
26.4325	-4.66E-04	1105.	-232.4832	1.63E-05	12023.	1.11E+10	28.3861	199157.	0.00
26.7050	-4.12E-04	477.8062	-144.7032	1.65E-05	12011.	1.11E+10	25.3020	200654.	0.00
26.9775	-3.58E-04	120.5530	-67.1354	1.66E-05	12005.	1.11E+10	22.1401	202151.	0.00
27.2500	-3.04E-04	0.00	0.00	1.66E-05	12002.	1.11E+10	18.9213	101824.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 4:

```
Pile-head deflection             =    -0.71040000 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =       3940346. inch-lbs
Maximum shear force              =       -161788. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             29
Number of zero deflection points =              2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 5

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = -0.710400 inches
Moment at pile head = 2786638.0 in-lbs
Axial load at pile head = 357000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.7104	2786638.	-140732.	0.00686	63163.	1.11E+10	2140.	4925.	0.00
0.2725	-0.6866	2329392.	-133550.	0.00762	54768.	1.11E+10	2252.	10727.	0.00
0.5450	-0.6606	1895425.	-126012.	0.00825	46801.	1.11E+10	2358.	11674.	0.00
0.8175	-0.6327	1486021.	-118165.	0.00875	39285.	1.11E+10	2441.	12619.	0.00
1.0900	-0.6034	1102210.	-109684.	0.00913	32238.	1.11E+10	2746.	14880.	0.00
1.3625	-0.5730	747375.	-100555.	0.00940	25724.	1.11E+10	2838.	16196.	0.00
1.6350	-0.5419	422628.	-91122.	0.00958	19762.	1.11E+10	2932.	17691.	0.00
1.9075	-0.5104	129081.	-81488.	0.00966	14372.	1.11E+10	2961.	18972.	0.00
2.1800	-0.4787	-132847.	-71890.	0.00966	14441.	1.11E+10	2909.	19872.	0.00
2.4525	-0.4472	-363623.	-62474.	0.00958	18678.	1.11E+10	2850.	20839.	0.00
2.7250	-0.4160	-563799.	-53261.	0.00945	22353.	1.11E+10	2785.	21886.	0.00
2.9975	-0.3854	-734004.	-44271.	0.00925	25478.	1.11E+10	2714.	23025.	0.00
3.2700	-0.3555	-874936.	-36638.	0.00902	28066.	1.11E+10	1955.	17978.	0.00
3.5425	-0.3265	-994665.	-30446.	0.00874	30264.	1.11E+10	1832.	18352.	0.00
3.8150	-0.2984	-1094460.	-24657.	0.00843	32096.	1.11E+10	1709.	18726.	0.00
4.0875	-0.2713	-1175606.	-19272.	0.00809	33586.	1.11E+10	1585.	19101.	0.00

4.3600	-0.2454	-1239399.	-14291.	0.00774	34757.	1.11E+10	1462.	19475.	0.00
4.6325	-0.2207	-1287134.	-9710.	0.00736	35633.	1.11E+10	1340.	19849.	0.00
4.9050	-0.1973	-1320099.	-5525.	0.00698	36239.	1.11E+10	1220.	20223.	0.00
5.1775	-0.1751	-1339562.	-1727.	0.00659	36596.	1.11E+10	1103.	20598.	0.00
5.4500	-0.1542	-1346770.	1693.	0.00619	36728.	1.11E+10	988.9615	20972.	0.00
5.7225	-0.1346	-1342938.	4747.	0.00579	36658.	1.11E+10	878.7718	21346.	0.00
5.9950	-0.1163	-1329245.	7447.	0.00540	36406.	1.11E+10	772.7259	21720.	0.00
6.2675	-0.09933	-1306831.	9808.	0.00501	35995.	1.11E+10	671.1801	22095.	0.00
6.5400	-0.08360	-1276789.	11844.	0.00462	35443.	1.11E+10	574.4270	22469.	0.00
6.8125	-0.06910	-1240165.	13573.	0.00425	34771.	1.11E+10	482.6974	22843.	0.00
7.0850	-0.05580	-1197950.	15010.	0.00389	33996.	1.11E+10	396.1639	23217.	0.00
7.3575	-0.04365	-1151086.	16172.	0.00354	33136.	1.11E+10	314.9437	23592.	0.00
7.6300	-0.03262	-1100456.	17078.	0.00321	32206.	1.11E+10	239.1024	23966.	0.00
7.9025	-0.02266	-1046890.	17745.	0.00289	31223.	1.11E+10	168.6579	24340.	0.00
8.1750	-0.01371	-991159.	18190.	0.00259	30199.	1.11E+10	103.5838	24714.	0.00
8.4475	-0.00571	-933979.	18431.	0.00231	29150.	1.11E+10	43.8145	25089.	0.00
8.7200	0.00138	-876007.	18485.	0.00204	28085.	1.11E+10	-10.7516	25463.	0.00
8.9925	0.00763	-817848.	18369.	0.00179	27018.	1.11E+10	-60.2474	25837.	0.00
9.2650	0.01308	-760051.	18099.	0.00156	25956.	1.11E+10	-104.8328	26211.	0.00
9.5375	0.01780	-703112.	17691.	0.00134	24911.	1.11E+10	-144.6906	26586.	0.00
9.8100	0.02184	-647478.	17160.	0.00114	23890.	1.11E+10	-180.0225	26960.	0.00
10.0825	0.02525	-593545.	16521.	9.56E-04	22900.	1.11E+10	-211.0448	27334.	0.00
10.3550	0.02809	-541664.	15787.	7.88E-04	21947.	1.11E+10	-237.9844	27708.	0.00
10.6275	0.03040	-492141.	14971.	6.35E-04	21038.	1.11E+10	-261.0751	28083.	0.00
10.9000	0.03224	-445239.	14085.	4.96E-04	20177.	1.11E+10	-280.5538	28457.	0.00
11.1725	0.03365	-401184.	13141.	3.71E-04	19368.	1.11E+10	-296.6570	28831.	0.00
11.4450	0.03467	-360162.	12150.	2.59E-04	18615.	1.11E+10	-309.6174	29205.	0.00
11.7175	0.03534	-322327.	11121.	1.58E-04	17920.	1.11E+10	-319.6607	29580.	0.00
11.9900	0.03570	-287798.	10064.	6.75E-05	17286.	1.11E+10	-327.0023	29954.	0.00
12.2625	0.03578	-256667.	8987.	-1.30E-05	16715.	1.11E+10	-331.8451	30328.	0.00
12.5350	0.03561	-228995.	7897.	-8.48E-05	16207.	1.11E+10	-334.3760	30702.	0.00
12.8075	0.03523	-204820.	6803.	-1.49E-04	15763.	1.11E+10	-334.7642	31077.	0.00
13.0800	0.03464	-184154.	6182.	-2.06E-04	15383.	1.11E+10	-44.9763	4246.	0.00
13.3525	0.03387	-163905.	6036.	-2.58E-04	15012.	1.11E+10	-44.6433	4309.	0.00
13.6250	0.03295	-144077.	5891.	-3.03E-04	14648.	1.11E+10	-44.2345	4390.	0.00
13.8975	0.03189	-124672.	5747.	-3.43E-04	14291.	1.11E+10	-43.7543	4487.	0.00
14.1700	0.03071	-105692.	5605.	-3.77E-04	13943.	1.11E+10	-43.2069	4601.	0.00
14.4425	0.02942	-87137.	5464.	-4.06E-04	13602.	1.11E+10	-42.5960	4734.	0.00
14.7150	0.02805	-69008.	5326.	-4.29E-04	13269.	1.11E+10	-41.9251	4887.	0.00
14.9875	0.02662	-51304.	5072.	-4.47E-04	12944.	1.11E+10	-113.5291	13947.	0.00
15.2600	0.02513	-34795.	4703.	-4.59E-04	12641.	1.11E+10	-111.9120	14561.	0.00
15.5325	0.02361	-19471.	4340.	-4.67E-04	12360.	1.11E+10	-110.1824	15258.	0.00
15.8050	0.02208	-5319.	3983.	-4.71E-04	12100.	1.11E+10	-108.3442	16049.	0.00
16.0775	0.02053	7677.	3632.	-4.71E-04	12143.	1.11E+10	-106.4005	16945.	0.00
16.3500	0.01900	19532.	3287.	-4.67E-04	12361.	1.11E+10	-104.3542	17963.	0.00
16.6225	0.01748	30265.	2949.	-4.59E-04	12558.	1.11E+10	-102.2074	19120.	0.00
16.8950	0.01599	39894.	2619.	-4.49E-04	12735.	1.11E+10	-99.9617	20439.	0.00
17.1675	0.01454	48441.	2296.	-4.36E-04	12892.	1.11E+10	-97.6182	21949.	0.00
17.4400	0.01314	55927.	1981.	-4.20E-04	13029.	1.11E+10	-95.1773	23683.	0.00
17.7125	0.01179	62376.	1674.	-4.03E-04	13148.	1.11E+10	-92.6388	25686.	0.00
17.9850	0.01051	67813.	1375.	-3.84E-04	13247.	1.11E+10	-90.0018	28013.	0.00
18.2575	0.00928	72264.	1085.	-3.63E-04	13329.	1.11E+10	-87.2644	30737.	0.00
18.5300	0.00813	75757.	804.4196	-3.41E-04	13393.	1.11E+10	-84.4235	33949.	0.00
18.8025	0.00705	78321.	533.1756	-3.18E-04	13440.	1.11E+10	-81.4749	37776.	0.00
19.0750	0.00605	79987.	271.7605	-2.95E-04	13471.	1.11E+10	-78.4121	42385.	0.00
19.3475	0.00512	80787.	20.5619	-2.71E-04	13486.	1.11E+10	-75.2262	48010.	0.00
19.6200	0.00428	80755.	-219.9970	-2.47E-04	13485.	1.11E+10	-71.9046	54988.	0.00
19.8925	0.00351	79926.	-449.4428	-2.24E-04	13470.	1.11E+10	-68.4292	63815.	0.00
20.1650	0.00281	78338.	-667.2292	-2.00E-04	13441.	1.11E+10	-64.7734	75267.	0.00
20.4375	0.00220	76030.	-872.6997	-1.77E-04	13398.	1.11E+10	-60.8966	90615.	0.00
20.7100	0.00165	73044.	-1111.	-1.55E-04	13343.	1.11E+10	-84.8619	167720.	0.00
20.9825	0.00118	69126.	-1350.	-1.34E-04	13272.	1.11E+10	-61.1741	169217.	0.00
21.2550	7.77E-04	64530.	-1516.	-1.14E-04	13187.	1.11E+10	-40.5438	170714.	0.00
21.5275	4.33E-04	59478.	-1620.	-9.61E-05	13094.	1.11E+10	-22.8286	172211.	0.00
21.8000	1.48E-04	54162.	-1670.	-7.93E-05	12997.	1.11E+10	-7.8547	173708.	0.00
22.0725	-8.54E-05	48742.	-1675.	-6.41E-05	12897.	1.11E+10	4.5743	175205.	0.00
22.3450	-2.71E-04	43355.	-1644.	-5.05E-05	12798.	1.11E+10	14.6697	176702.	0.00
22.6175	-4.16E-04	38110.	-1583.	-3.85E-05	12702.	1.11E+10	22.6507	178199.	0.00
22.8900	-5.23E-04	33094.	-1499.	-2.79E-05	12610.	1.11E+10	28.7384	179696.	0.00
23.1625	-5.98E-04	28373.	-1398.	-1.88E-05	12523.	1.11E+10	33.1510	181193.	0.00
23.4350	-6.46E-04	23998.	-1284.	-1.11E-05	12443.	1.11E+10	36.0996	182690.	0.00
23.7075	-6.71E-04	20000.	-1164.	-4.59E-06	12370.	1.11E+10	37.7848	184187.	0.00
23.9800	-6.76E-04	16399.	-1039.	7.96E-07	12304.	1.11E+10	38.3944	185684.	0.00
24.2525	-6.66E-04	13203.	-913.8953	5.17E-06	12245.	1.11E+10	38.1010	187181.	0.00
24.5250	-6.42E-04	10410.	-791.0048	8.66E-06	12194.	1.11E+10	37.0613	188678.	0.00
24.7975	-6.09E-04	8010.	-672.5064	1.14E-05	12149.	1.11E+10	35.4148	190175.	0.00
25.0700	-5.68E-04	5985.	-560.1844	1.35E-05	12112.	1.11E+10	33.2837	191672.	0.00
25.3425	-5.21E-04	4315.	-455.4518	1.50E-05	12082.	1.11E+10	30.7730	193169.	0.00
25.6150	-4.70E-04	2972.	-359.4056	1.61E-05	12057.	1.11E+10	27.9709	194666.	0.00
25.8875	-4.16E-04	1927.	-272.8803	1.68E-05	12038.	1.11E+10	24.9497	196163.	0.00
26.1600	-3.60E-04	1148.	-196.4993	1.72E-05	12024.	1.11E+10	21.7665	197660.	0.00
26.4325	-3.03E-04	601.3916	-130.7216	1.75E-05	12013.	1.11E+10	18.4646	199157.	0.00
26.7050	-2.46E-04	252.1231	-75.8847	1.76E-05	12007.	1.11E+10	15.0748	200654.	0.00
26.9775	-1.88E-04	63.9610	-32.2430	1.77E-05	12004.	1.11E+10	11.6173	202151.	0.00
27.2500	-1.30E-04	0.00	0.00	1.77E-05	12002.	1.11E+10	8.1032	101824.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the

magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 5:

Pile-head deflection = -0.71040000 inches
Computed slope at pile head = 0.00686465 radians
Maximum bending moment = 2786638. inch-lbs
Maximum shear force = -140732. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 13
Number of zero deflection points = 2

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	-0.4500	S, rad	0.00	357000.	-0.4500	0.00	-134624.	3705938.
2	y, in	-0.4500	M, in-lb	2779290.	357000.	-0.4500	0.00223	-117506.	2779290.
3	V, lb	-140606.	M, in-lb	2779290.	357000.	-0.7104	0.00688	-140606.	2779290.
4	y, in	-0.7104	S, rad	0.00	357000.	-0.7104	0.00	-161788.	3940346.
5	y, in	-0.7104	M, in-lb	2786638.	357000.	-0.7104	0.00686	-140732.	2786638.

Maximum pile-head deflection = -0.7104000000 inches
Maximum pile-head rotation = 0.0068825711 radians = 0.394342 deg.

The analysis ended normally.

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INTEGRAL ABUTMENT PILE DESIGN WORKSHEET - EXPANSION South Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Slope. Displacement is equal to the thermal expansion of the bridge and the slope is assumed to be zero to represent a fixed head condition. No corrosion. Isolation casing for top 10 ft. Boring 201. Downdrag present.

Input factored load per pile to be assessed

P_u=	357	kips	Factored applied superstructure and substructure vertical dead and live load distributed to each pile. (Includes 52 kips factored downdrag load)

Input steel H-pile strengths

F_y=	50	ksi	Yield strength of steel H pile section.
E_s=	29000	ksi	Elastic modulus of steel H pile section.

Select axial resistance factors for the strength limit state from AASHTO Section 6.5.4.2

ϕ_{cu}=	0.70	dim	Axial resistance factor for the upper zone of the pile for combined axial and flexure with no damage.
ϕ_{cl}=	0.50	dim	Axial resistance factor for the lower zone of the pile in compression (Use 0.50 for severe driving & 0.60 for good driving).
ϕ_f=	1.00	dim	Flexure resistance factor for the upper zone of the pile for combined axial and flexure with no damage.

Calculate the required Nominal Axial Pile Resistance

R_{n_up}=	510.0	kips	Required nominal resistance for upper zone of pile [$R_{n_up} = P_u / \phi_{cu}$].
R_{n_low}=	714	kips	Required nominal resistance for lower zone of pile [$R_{n_low} = P_u / \phi_{cl}$].
R_n=	714.0	kips	Required nominal resistance for pile [Max of R_{n_up}, R_{n_low}].

Calculate the required area of steel

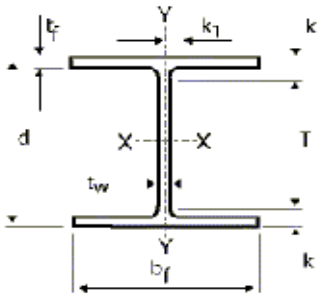
A_{s_req}=	17.850	in^2	Required area of steel to satisfy axial compression [$A_{s_req} = R_n / 0.8 * F_y$].

Choose preliminary HP-Pile Section

HP 14x102		Preliminary HP Section to be assessed for use at integral abutment.

Input HP shape properties

A_s=	30.000	in^2	Area of section
d=	14.000	in	Section depth
t_w=	0.705	in	Web thickness
b_f=	14.800	in	Flange width
t_f=	0.705	in	Flange thickness
k=	1.375	in	Distance from flange to fillet
T=	11.250	in	Web height excluding fillet
I_{xx}=	1050.000	in^4	Moment of Inertia about strong axis of HP section
S_{xx}=	150.000	in^3	Section modulus for strong axis bending
r_{xx}=	5.920	in	Radius of gyration for strong axis
Z_{xx}=	169.000	in^3	Plastic modulus for strong axis bending
I_{yy}=	380.000	in^4	Moment of Inertia about weak axis of HP section
S_{yy}=	51.400	in^3	Section modulus for weak axis bending
r_{yy}=	3.560	in	Radius of gyration
Z_{yy}=	78.800	in^3	Plastic modulus for weak axis bending



Input plate buckling coefficients for HP shape from AASHTO Table 6.9.4.2.1-1

k_f=	0.56	dim	Plate buckling coefficient for flanges
k_w=	1.49	dim	Plate buckling coefficient for web

Calculate and check pile properties

λ_f=	10.5	dim	Slenderness ratio for the compression flange as per AASHTO Eq. 6.12.2.2.1-3 [$\lambda_f = b_f / (2 * t_f)$]
λ_w=	16.0	dim	Slenderness ratio for the web as per AASHTO Eq. X.X.X.X.X-X [$\lambda_w = T / t_w$]

Check	OK	Check for flange buckling [OK if $\lambda_f \le k_f * (E*F_y)^{0.5}$]	13.49
Check	OK	Check for web buckling [OK if $\lambda_w \le k_w * (E*F_y)^{0.5}$]	35.88

Determine L-Pile load case parameters for displacement and slope

δ=	-0.45	in	Pile head displacement due to thermal expansion
θ=	0	rad	Slope of pile head (assuming no rotation)
P_u=	357000	lb	Axial load at pile head

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET (Cont.) South Abutment Strength I

Run L-Pile and determine the following parameters using Displacement and Slope input

M_{u_top}=	3705938	in-lb	Maximum moment at top of the pile from Lpile output
I_{b_top}=	3.40	ft	Depth of first virtual pin (zero moment on moment depth plot)
I_{b_bot}=	16.55	ft	Depth of second virtual pin (zero moment on moment depth plot)
I_{b_2nd}=	13.15297	ft	Total unbraced length from Lpile moment vs depth plot [$I_{b_2nd} = I_{b_bot} - I_{b_top}$]

x_0	x	x_1	y_0	y	y_1
71102	0	-78286	3.27	3.3997	3.5425
-7984	0	2751	16.35	16.553	16.623

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	1.2	dim	Effective length factor for upper section (fixed at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.033035	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * I_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.343386	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * I_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1479.6	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \le 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1300.5	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \le 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1035.7	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{n_top}$]
P_{r_2nd}=	910.4	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{n_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{n_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.345	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.392	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.476	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Calculate slenderness ratios for flexure resistance

λ_{pf}=	9.15	dim	Limiting slenderness ratio for a compact flange as per AASHTO Eq. 6.12.2.2.1-4 [$\lambda_{pf} = 0.38 * (E_s / F_y)^{0.5}$]
λ_{rf}=	19.99	dim	Limiting slenderness ratio for a non-compact flange as per AASHTO Eq. 6.12.2.2.1-5 [$\lambda_{pf} = 0.83 * (E_s / F_y)^{0.5}$]

Calculate nominal flexure resistance of pile as per AASHTO Section 6.12.2.2.1

M_n=	3770.0	in-kips	Nominal flexure resistance as per AASHTO Eq. 6.12.2.2.1-1

If $\lambda_f \le \lambda_{pf}$, then: $M_n = M_p$

If $\lambda_{pf} < \lambda_f \le \lambda_{rf}$, then:

$$M_n = \left[1 - \left(1 - \frac{S_y}{Z_y}\right)\left(\frac{\lambda_f - \lambda_{pf}}{0.45\sqrt{\frac{E}{F_{yf}}}}\right)\right] F_{yf} Z_y$$

Calculate the flexure resistance

M_r=	3770.0	in-kips	Factored flexure resistance as per AASHTO Eq. 6.12.1.2.1-1 [$M_r = \phi_f * M_n$]

Calculate the moment that will cause a plastic hinge at the pile cap

M_p=	2779.3	in-kips	Moment that will cause a plastic hinge at the pile cap [(9.0 /8.0) * (1- P_u / P_{r_top}) * M_r]

3706 in-kips

Check to determine if plastic hinge has formed

YES - Additional Analysis Required See below for explanation

YES: Since the applied moment exceeded the moment that would create a plastic hinge, it can be assumed that the pile head has entered plastic deformation and therefore the moment that can be applied to the pile head cannot exceed Mp. Additional analysis is required using the plastic moment to limit the bending resistance at the pile head, recalculate the unbraced length, and verify that a plastic hinge does not develop in the second pile segment.

NO: The applied moment does not exceed the moment that would create a plastic hinge at the pile head. No further analysis is required.

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

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INTEGRAL ABUTMENT PILE DESIGN WORKSHEET South Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Moment. Displacement is equal to the thermal expansion of the bridge and the moment is equal to the plastic resistance. Pile head conditions are assumed to be pinned.

Determine L-Pile load case parameters for displacement and moment as input

δ=	-0.45	in	Pile head displacement due to thermal expansion
M_p=	2779290	in-lb	Plastic moment capacity
P_u=	357000	lb	Axial load at pile head

Run L-Pile and determine the following parameters

M_{u_top}=	2779290	in-lb	Maximum moment at top of the pile from Lpile output
M_{u_2nd}=	-814080	in-lb	Maximum moment from Lpile moment vs depth plot.

l_{b_top}=	2.74	ft	Depth of first virtual pin (zero moment on moment depth plot)
l_{b_bot}=	16.00	ft	Depth of second virtual pin (zero moment on moment depth plot)
l_{b_2nd}=	13.26	ft	Total unbraced length from Lpile moment vs depth plot [$l_{b_2nd} = l_{b_bot} - l_{b_top}$]

	x_0	x	x_1	y_0	y	y_1
	6020	0	-1E+05	2.725	2.736	2.9975
	-7505	0	2956	15.805	16	16.078

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	2.1	dim	Effective length factor for upper section (pinned at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.065527	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * l_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.349232	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * l_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1459.7	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \leq 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1297.4	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \leq 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1021.8	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{r_top}$]
P_{r_2nd}=	908.2	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{r_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{r_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.349	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.393	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.476	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check second pile segment for plastic hinge

M_{p_2nd} =	0.59	dim	Check for plastic hinge in second segment of pile
Check	OK		Check for plastic hinge in second segment of pile ("OK" if $M_{p_2nd} < 1.0$)

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

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INTEGRAL ABUTMENT PILE DESIGN WORKSHEET - EXPANSION PLUS South Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Slope. Displacement is equal to the thermal expansion of the bridge and the slope is assumed to be zero to represent a fixed head condition. No corrosion. Isolation casing for top 10 ft. Boring 201. Downdrag present. Deflections account for 17.1k shear force from slope stability analysis and 6k of braking force.

Input factored load per pile to be assessed

P_u=	357	kips	Factored applied superstructure and substructure vertical dead and live load distributed to each pile. (Includes 52 kips factored downdrag load)

Input steel H-pile strengths

F_y=	50	ksi	Yield strength of steel H pile section.
E_s=	29000	ksi	Elastic modulus of steel H pile section.

Select axial resistance factors for the strength limit state from AASHTO Section 6.5.4.2

ϕ_{cu}=	0.70	dim	Axial resistance factor for the upper zone of the pile for combined axial and flexure with no damage.
ϕ_{cl}=	0.50	dim	Axial resistance factor for the lower zone of the pile in compression (Use 0.50 for severe driving & 0.60 for good driving).
ϕ_f=	1.00	dim	Flexure resistance factor for the upper zone of the pile for combined axial and flexure with no damage.

Calculate the required Nominal Axial Pile Resistance

R_{n_up}=	510.0	kips	Required nominal resistance for upper zone of pile [$R_{n_up} = P_u / \phi_{cu}$].
R_{n_low}=	714	kips	Required nominal resistance for lower zone of pile [$R_{n_low} = P_u / \phi_{cl}$].
R_n=	714.0	kips	Required nominal resistance for pile [Max of R_{n_up}, R_{n_low}].

Calculate the required area of steel

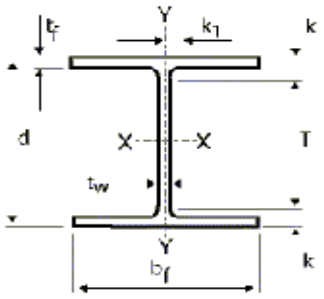
A_{s_req}=	17.850	in^2	Required area of steel to satisfy axial compression [$A_{s_req} = R_n / 0.8 * F_y$].

Choose preliminary HP-Pile Section

HP 14x102		Preliminary HP Section to be assessed for use at integral abutment.

Input HP shape properties

A_s=	30.000	in^2	Area of section
d=	14.000	in	Section depth
t_w=	0.705	in	Web thickness
b_f=	14.800	in	Flange width
t_f=	0.705	in	Flange thickness
k=	1.375	in	Distance from flange to fillet
T=	11.250	in	Web height excluding fillet
I_{xx}=	1050.000	in^4	Moment of Inertia about strong axis of HP section
S_{xx}=	150.000	in^3	Section modulus for strong axis bending
r_{xx}=	5.920	in	Radius of gyration for strong axis
Z_{xx}=	169.000	in^3	Plastic modulus for strong axis bending
I_{yy}=	380.000	in^4	Moment of Inertia about weak axis of HP section
S_{yy}=	51.400	in^3	Section modulus for weak axis bending
r_{yy}=	3.560	in	Radius of gyration
Z_{yy}=	78.800	in^3	Plastic modulus for weak axis bending



Input plate buckling coefficients for HP shape from AASHTO Table 6.9.4.2.1-1

k_f=	0.56	dim	Plate buckling coefficient for flanges
k_w=	1.49	dim	Plate buckling coefficient for web

Calculate and check pile properties

λ_f=	10.5	dim	Slenderness ratio for the compression flange as per AASHTO Eq. 6.12.2.2.1-3 [$\lambda_f = b_f / (2 * t_f)$]
λ_w=	16.0	dim	Slenderness ratio for the web as per AASHTO Eq. X.X.X.X.X-X [$\lambda_w = T / t_w$]

Check	OK	Check for flange buckling [OK if $\lambda_f \le k_f * (E*F_y)^{0.5}$]	13.49
Check	OK	Check for web buckling [OK if $\lambda_w \le k_w * (E*F_y)^{0.5}$]	35.88

Determine L-Pile load case parameters for displacement and slope

δ=	-0.7104	in	Pile head displacement due to thermal expansion
θ=	0	rad	Slope of pile head (assuming no rotation)
P_u=	357000	lb	Axial load at pile head

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET (Cont.) South Abutment Strength I

Run L-Pile and determine the following parameters using Displacement and Slope input

M_{u_top}=	3940346	in-lb	Maximum moment at top of the pile from Lpile output
I_{b_top}=	2.70	ft	Depth of first virtual pin (zero moment on moment depth plot)
I_{b_bot}=	16.52	ft	Depth of second virtual pin (zero moment on moment depth plot)
I_{b_2nd}=	13.8132	ft	Total unbraced length from Lpile moment vs depth plot [$I_{b_2nd} = I_{b_bot} - I_{b_top}$]

x_0	x	x_1	y_0	y	y_1
238687	0	-19296	2.4525	2.7046	2.725
-8371	0	5222	16.35	16.518	16.623

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	1.2	dim	Effective length factor for upper section (fixed at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.020908	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * I_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.378724	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * I_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1487.0	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \le 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1281.6	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \le 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1040.9	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{n_top}$]
P_{r_2nd}=	897.1	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{n_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{n_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.343	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.398	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.476	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Calculate slenderness ratios for flexure resistance

λ_{pf}=	9.15	dim	Limiting slenderness ratio for a compact flange as per AASHTO Eq. 6.12.2.2.1-4 [$\lambda_{pf} = 0.38 * (E_s / F_y)^{0.5}$]
λ_{rf}=	19.99	dim	Limiting slenderness ratio for a non-compact flange as per AASHTO Eq. 6.12.2.2.1-5 [$\lambda_{pf} = 0.83 * (E_s / F_y)^{0.5}$]

Calculate nominal flexure resistance of pile as per AASHTO Section 6.12.2.2.1

M_n=	3770.0	in-kips	Nominal flexure resistance as per AASHTO Eq. 6.12.2.2.1-1

If $\lambda_f \le \lambda_{pf}$, then: $M_n = M_p$

If $\lambda_{pf} < \lambda_f \le \lambda_{rf}$, then:

$$M_n = \left[1 - \left(1 - \frac{S_y}{Z_y}\right)\left(\frac{\lambda_f - \lambda_{pf}}{0.45\sqrt{\frac{E}{F_{yf}}}}\right)\right] F_{yf} Z_y$$

Calculate the flexure resistance

M_r=	3770.0	in-kips	Factored flexure resistance as per AASHTO Eq. 6.12.1.2.1-1 [$M_r = \phi_f * M_n$]

Calculate the moment that will cause a plastic hinge at the pile cap

M_p=	2786.6	in-kips	Moment that will cause a plastic hinge at the pile cap [(9.0 /8.0) * (1- P_u / P_{r_top}) * M_r]

3940 in-kips

Check to determine if plastic hinge has formed

YES - Additional Analysis Required See below for explanation

YES: Since the applied moment exceeded the moment that would create a plastic hinge, it can be assumed that the pile head has entered plastic deformation and therefore the moment that can be applied to the pile head cannot exceed Mp. Additional analysis is required using the plastic moment to limit the bending resistance at the pile head, recalculate the unbraced length, and verify that a plastic hinge does not develop in the second pile segment.

NO: The applied moment does not exceed the moment that would create a plastic hinge at the pile head. No further analysis is required.

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

HNTB	For	Burnham Bridge	Job No.	63738	Sheet No.	3 of 3
	Made by	KRR	Check		Backcheck	
	Date	10/13/2017	Date		Date	

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET South Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Moment. Displacement is equal to the thermal expansion of the bridge and the moment is equal to the plastic resistance. Pile head conditions are assumed to be pinned.

Determine L-Pile load case parameters for displacement and moment as input

δ=	-0.7104	in	Pile head displacement due to thermal expansion
M_p=	2786638	in-lb	Plastic moment capacity
P_u=	357000	lb	Axial load at pile head

Run L-Pile and determine the following parameters

M_{u_top}=	2786638	in-lb	Maximum moment at top of the pile from Lpile output
M_{u_2nd}=	-1346770	in-lb	Maximum moment from Lpile moment vs depth plot.

l_{b_top}=	2.04	ft	Depth of first virtual pin (zero moment on moment depth plot)
l_{b_bot}=	15.92	ft	Depth of second virtual pin (zero moment on moment depth plot)
l_{b_2nd}=	13.87	ft	Total unbraced length from Lpile moment vs depth plot [$l_{b_2nd} = l_{b_bot} - l_{b_top}$]

x_0	x	x_1	y_0	y	y_1
129081	0	-1E+05	1.9075	2.0418	2.18
-5319	0	7677	15.805	15.917	16.078

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	2.1	dim	Effective length factor for upper section (pinned at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.036492	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * l_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.382106	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * l_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1477.4	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \leq 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1279.8	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \leq 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1034.2	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{r_top}$]
P_{r_2nd}=	895.9	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{r_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{r_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.345	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.399	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.476	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

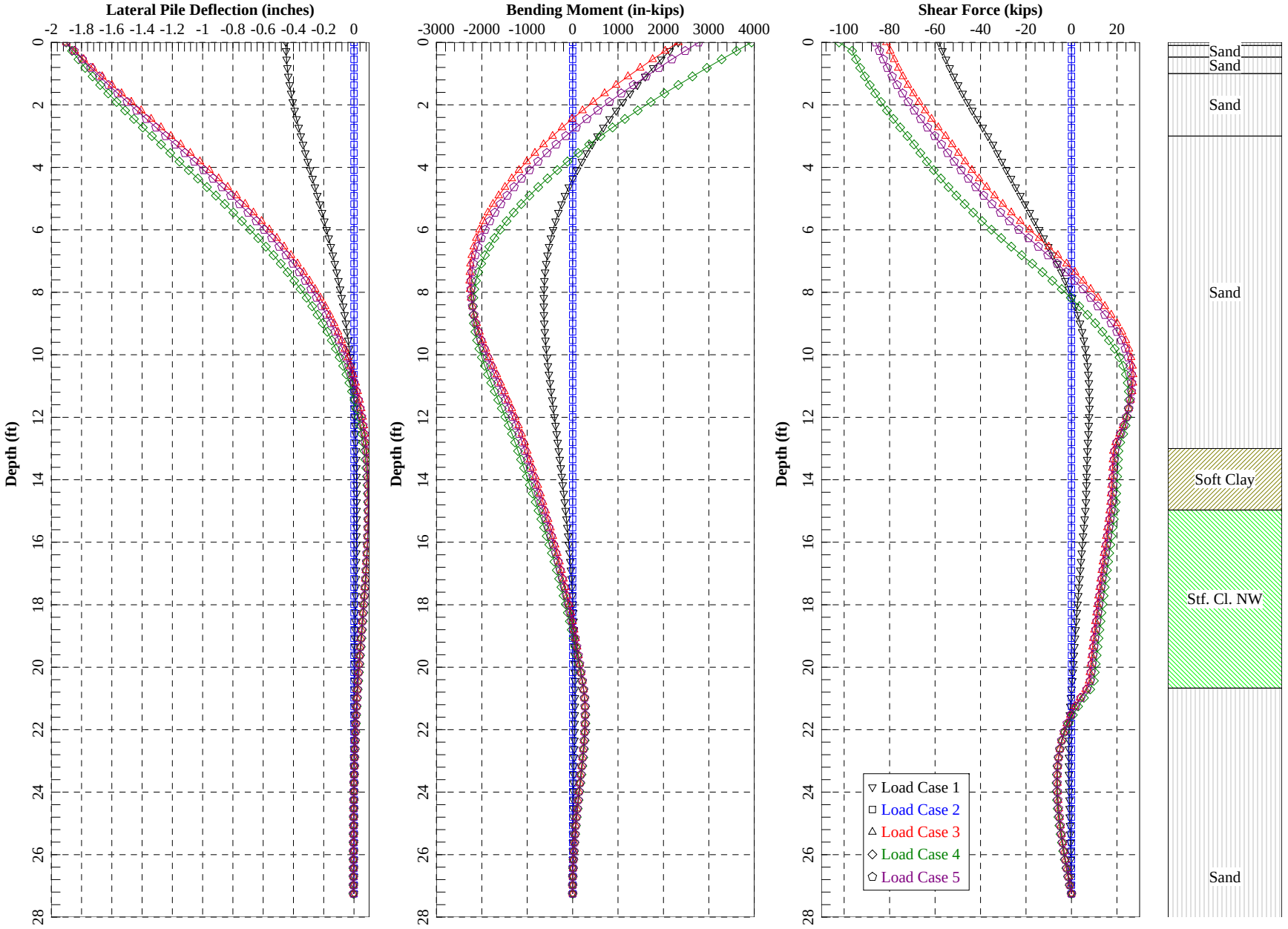
Check second pile segment for plastic hinge

M_{p_2nd} =	0.72	dim	Check for plastic hinge in second segment of pile
Check	OK		Check for plastic hinge in second segment of pile ("OK" if $M_{p_2nd} < 1.0$)

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

LPILE - South Abutment - Contraction - HP14x102 - BB-WCLG-201



LPile for Windows, Version 2016-09.006

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Deep Foundations\Piles\South Abutment\FINAL DESIGN\LPILE - 2017-10-15 with DD\HP14x102 Boring 201\

Name of input data file:
SAbut_HP14x102_Weak_Contraction.lp9d

Name of output report file:
SAbut_HP14x102_Weak_Contraction.lp9o

Name of plot output file:
SAbut_HP14x102_Weak_Contraction.lp9p

Name of runtime message file:
SAbut_HP14x102_Weak_Contraction.lp9r

Date and Time of Analysis

Date: October 30, 2017 Time: 18:11:01

Problem Title

Project Name: Burnham Bridge

Job Number: 63738

Client: Maine DOT

Engineer: BAM/KRR

Description: South Abutment_HP14x89_5 Piles_Weak Axis_No Corrosion

Program Options and Settings

Computational Options:
- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined	=	1
Total length of pile	=	27.250 ft
Depth of ground surface below top of pile	=	-4.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.0000
2	27.250	14.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile with a specified moment capacity

Cross-sectional Shape	=	Weak H-Pile
Length of section	=	27.250000 ft
Flange Width	=	14.800000 in
Section Depth	=	14.000000 in
Flange Thickness	=	0.705000 in
Web Thickness	=	0.705000 in
Section Area	=	29.743950 sq. in
Moment of Inertia	=	381.278191 in^4
Elastic Modulus	=	29000000. psi
Plastic Moment Capacity	=	3940000. in-lb
Top Elastic Bending Stiffness	=	1.1057E+10 lbs-in^2
Bot Elastic Bending Stiffness	=	1.1057E+10 lbs-in^2
Shear Capacity at top of section	=	296100. lbs
Shear Capacity at bottom of section	=	296100. lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 9 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	-4.000000 ft
Distance from top of pile to bottom of layer	=	0.100000 ft
Effective unit weight at top of layer	=	115.000000 pcf
Effective unit weight at bottom of layer	=	115.000000 pcf

Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	0.100000 ft
Distance from top of pile to bottom of layer	=	0.470000 ft
Effective unit weight at top of layer	=	115.000000 pcf
Effective unit weight at bottom of layer	=	115.000000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	0.470000 ft
Distance from top of pile to bottom of layer	=	1.000000 ft
Effective unit weight at top of layer	=	52.600000 pcf
Effective unit weight at bottom of layer	=	52.600000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	51.000000 pci
Subgrade k at bottom of layer	=	51.000000 pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	1.000000 ft
Distance from top of pile to bottom of layer	=	3.000000 ft
Effective unit weight at top of layer	=	50.600000 pcf
Effective unit weight at bottom of layer	=	50.600000 pcf
Friction angle at top of layer	=	33.000000 deg.
Friction angle at bottom of layer	=	33.000000 deg.
Subgrade k at top of layer	=	64.000000 pci
Subgrade k at bottom of layer	=	64.000000 pci

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	3.000000 ft
Distance from top of pile to bottom of layer	=	13.000000 ft
Effective unit weight at top of layer	=	47.600000 pcf
Effective unit weight at bottom of layer	=	47.600000 pcf
Friction angle at top of layer	=	30.000000 deg.
Friction angle at bottom of layer	=	30.000000 deg.
Subgrade k at top of layer	=	35.000000 pci
Subgrade k at bottom of layer	=	35.000000 pci

Layer 6 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer	=	13.000000 ft
Distance from top of pile to bottom of layer	=	14.970000 ft
Effective unit weight at top of layer	=	41.000000 pcf
Effective unit weight at bottom of layer	=	41.000000 pcf
Undrained cohesion at top of layer	=	280.000000 psf
Undrained cohesion at bottom of layer	=	280.000000 psf
Epsilon-50 at top of layer	=	0.0000
Epsilon-50 at bottom of layer	=	0.0000

NOTE: Default values for Epsilon-50 will be computed for this layer.

Layer 7 is stiff clay without free water

Distance from top of pile to top of layer	=	14.970000 ft
Distance from top of pile to bottom of layer	=	20.670000 ft
Effective unit weight at top of layer	=	43.500000 pcf
Effective unit weight at bottom of layer	=	43.500000 pcf
Undrained cohesion at top of layer	=	506.000000 psf
Undrained cohesion at bottom of layer	=	506.000000 psf
Epsilon-50 at top of layer	=	0.0000
Epsilon-50 at bottom of layer	=	0.0000

NOTE: Default values for Epsilon-50 will be computed for this layer.

Layer 8 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	20.670000 ft
Distance from top of pile to bottom of layer	=	32.770000 ft
Effective unit weight at top of layer	=	64.000000 pcf
Effective unit weight at bottom of layer	=	64.000000 pcf
Friction angle at top of layer	=	38.000000 deg.
Friction angle at bottom of layer	=	38.000000 deg.
Subgrade k at top of layer	=	140.000000 pci
Subgrade k at bottom of layer	=	140.000000 pci

Layer 9 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	32.770000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	100.000000 pcf
Effective unit weight at bottom of layer	=	100.000000 pcf
Uniaxial compressive strength at top of layer	=	5000. psi
Uniaxial compressive strength at bottom of layer	=	5000. psi
Initial modulus of rock at top of layer	=	125000. psi
Initial modulus of rock at bottom of layer	=	125000. psi
RQD of rock at top of layer	=	35.000000 %
RQD of rock at bottom of layer	=	35.000000 %
k rm of rock at top of layer	=	0.0010000
k rm of rock at bottom of layer	=	0.0010000

(Depth of the lowest soil layer extends 22.750 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm
1	Sand	-4.0000	115.0000	--	32.0000	--	--	--
	(Reese, et al.)	0.10000	115.0000	--	32.0000	--	--	--
2	Sand	0.10000	115.0000	--	32.0000	--	--	--
	(Reese, et al.)	0.4700	115.0000	--	32.0000	--	--	--
3	Sand	0.4700	52.6000	--	32.0000	--	--	--
	(Reese, et al.)	1.0000	52.6000	--	32.0000	--	--	--
4	Sand	1.0000	50.6000	--	33.0000	--	--	--
	(Reese, et al.)	3.0000	50.6000	--	33.0000	--	--	--
5	Sand	3.0000	47.6000	--	30.0000	--	--	--
	(Reese, et al.)	13.0000	47.6000	--	30.0000	--	--	--
6	Soft Clay	13.0000	41.0000	280.0000	--	--	--	default
	w/o Free Water	14.9700	41.0000	280.0000	--	--	--	default
7	Stiff Clay	14.9700	43.5000	506.0000	--	--	--	default
	w/o Free Water	20.6700	43.5000	506.0000	--	--	--	default
8	Sand	20.6700	64.0000	--	38.0000	--	--	--
	(Reese, et al.)	32.7700	64.0000	--	38.0000	--	--	--
9	Weak Rock	32.7700	100.0000	--	--	5000.	35.0000	0.00100
		50.0000	100.0000	--	--	5000.	35.0000	0.00100

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 5

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = -0.450000 in	S = 0.0000 in/in	357000.	N.A.
2	4	y = 0.0000 in	M = 0.0000 in-lbs	357000.	N.A.

3	1	V =	-81394. lbs	M =	2324281. in-lbs	357000.	No
4	5	y =	-1.901400 in	S =	0.0000 in/in	357000.	N.A.
5	4	y =	-1.901400 in	M =	2775813. in-lbs	357000.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic-plastic section properties

---

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	-4.0000	0.00	N.A.	No	0.00	553.9119
2	0.1000	4.1000	Yes	No	553.9119	145.5706
3	0.4700	4.4700	Yes	No	699.4825	541.8743
4	1.0000	5.0000	Yes	No	1241.	6509.
5	3.0000	7.0000	Yes	No	7750.	140348.
6	13.0000	13.0000	No	No	148098.	5800.
7	14.9700	14.9700	No	No	153897.	30262.
8	20.6700	13.3858	No	No	184159.	574339.
9	32.7700	36.7700	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = -0.450000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 357000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.4500	2324281.	-58294.	0.00	54675.	1.11E+10	433.0817	1574.	0.00
0.2725	-0.4489	2135772.	-56767.	6.60E-04	51214.	1.11E+10	463.8939	3379.	0.00
0.5450	-0.4457	1951485.	-55213.	0.00126	47830.	1.11E+10	486.7224	3571.	0.00
0.8175	-0.4406	1771729.	-53590.	0.00181	44530.	1.11E+10	505.6517	3753.	0.00
1.0900	-0.4338	1596768.	-51822.	0.00231	41318.	1.11E+10	575.7861	4340.	0.00
1.3625	-0.4255	1427413.	-49896.	0.00276	38209.	1.11E+10	602.1147	4627.	0.00
1.6350	-0.4158	1264003.	-47888.	0.00316	35209.	1.11E+10	626.3510	4926.	0.00
1.9075	-0.4048	1106854.	-45801.	0.00351	32324.	1.11E+10	649.6426	5247.	0.00
2.1800	-0.3928	956270.	-43636.	0.00381	29559.	1.11E+10	674.5945	5615.	0.00
2.4525	-0.3799	812569.	-41393.	0.00407	26921.	1.11E+10	697.6856	6005.	0.00
2.7250	-0.3662	676048.	-39077.	0.00430	24414.	1.11E+10	718.8258	6419.	0.00
2.9975	-0.3518	546980.	-36695.	0.00448	22045.	1.11E+10	737.9465	6859.	0.00
3.2700	-0.3369	425614.	-34523.	0.00462	19816.	1.11E+10	590.3726	5730.	0.00
3.5425	-0.3216	310413.	-32575.	0.00473	17701.	1.11E+10	600.9897	6111.	0.00
3.8150	-0.3060	201532.	-30595.	0.00480	15702.	1.11E+10	609.9836	6519.	0.00
4.0875	-0.2902	99103.	-28589.	0.00485	13822.	1.11E+10	617.3759	6957.	0.00
4.3600	-0.2743	3242.	-26560.	0.00486	12062.	1.11E+10	623.2048	7430.	0.00
4.6325	-0.2584	-85956.	-24515.	0.00485	13581.	1.11E+10	627.5233	7942.	0.00
4.9050	-0.2425	-168414.	-22459.	0.00481	15094.	1.11E+10	630.3993	8499.	0.00

5.1775	-0.2269	-244074.	-20395.	0.00475	16483.	1.11E+10	631.8546	9107.	0.00
5.4500	-0.2115	-312893.	-18329.	0.00467	17747.	1.11E+10	631.4259	9764.	0.00
5.7225	-0.1963	-374852.	-16269.	0.00457	18884.	1.11E+10	628.9799	10476.	0.00
5.9950	-0.1816	-429957.	-14219.	0.00445	19896.	1.11E+10	624.5036	11247.	0.00
6.2675	-0.1672	-478235.	-12188.	0.00432	20782.	1.11E+10	617.9922	12084.	0.00
6.5400	-0.1534	-519739.	-10181.	0.00417	21544.	1.11E+10	609.4475	12996.	0.00
6.8125	-0.1400	-554548.	-8205.	0.00401	22184.	1.11E+10	598.8781	13991.	0.00
7.0850	-0.1271	-582761.	-6267.	0.00384	22702.	1.11E+10	586.2969	15080.	0.00
7.3575	-0.1149	-604504.	-4413.	0.00367	23101.	1.11E+10	547.8710	15598.	0.00
7.6300	-0.1032	-620180.	-2693.	0.00348	23389.	1.11E+10	503.8968	15973.	0.00
7.9025	-0.09207	-630254.	-1117.	0.00330	23573.	1.11E+10	460.2441	16347.	0.00
8.1750	-0.08158	-635189.	317.6064	0.00311	23664.	1.11E+10	417.1686	16721.	0.00
8.4475	-0.07171	-635443.	1613.	0.00292	23669.	1.11E+10	374.9045	17095.	0.00
8.7200	-0.06246	-631470.	2771.	0.00274	23596.	1.11E+10	333.6642	17470.	0.00
8.9925	-0.05381	-623711.	3797.	0.00255	23453.	1.11E+10	293.6376	17844.	0.00
9.2650	-0.04577	-612596.	4694.	0.00237	23249.	1.11E+10	254.9925	18218.	0.00
9.5375	-0.03832	-598543.	5467.	0.00219	22991.	1.11E+10	217.8750	18592.	0.00
9.8100	-0.03145	-581955.	6121.	0.00202	22687.	1.11E+10	182.4097	18967.	0.00
10.0825	-0.02514	-563214.	6663.	0.00185	22343.	1.11E+10	148.7004	19341.	0.00
10.3550	-0.01938	-542689.	7097.	0.00168	21966.	1.11E+10	116.8311	19715.	0.00
10.6275	-0.01414	-520728.	7430.	0.00152	21563.	1.11E+10	86.8668	20089.	0.00
10.9000	-0.00940	-497658.	7668.	0.00137	21139.	1.11E+10	58.8548	20464.	0.00
11.1725	-0.00515	-473787.	7818.	0.00123	20701.	1.11E+10	32.8259	20838.	0.00
11.4450	-0.00136	-449401.	7886.	0.00109	20253.	1.11E+10	8.7955	21212.	0.00
11.7175	0.00200	-424766.	7879.	9.65E-04	19801.	1.11E+10	-13.2347	21586.	0.00
11.9900	0.00495	-400126.	7803.	8.43E-04	19348.	1.11E+10	-33.2754	21961.	0.00
12.2625	0.00752	-375703.	7665.	7.28E-04	18900.	1.11E+10	-51.3484	22335.	0.00
12.5350	0.00972	-351700.	7470.	6.21E-04	18459.	1.11E+10	-67.4850	22709.	0.00
12.8075	0.01158	-328297.	7226.	5.20E-04	18030.	1.11E+10	-81.7240	23083.	0.00
13.0800	0.01312	-305655.	7039.	4.26E-04	17614.	1.11E+10	-32.5455	8112.	0.00
13.3525	0.01437	-283255.	6931.	3.39E-04	17203.	1.11E+10	-33.5449	7636.	0.00
13.6250	0.01534	-261116.	6820.	2.59E-04	16796.	1.11E+10	-34.2853	7309.	0.00
13.8975	0.01606	-239253.	6707.	1.85E-04	16395.	1.11E+10	-34.8136	7089.	0.00
14.1700	0.01655	-217680.	6593.	1.17E-04	15999.	1.11E+10	-35.1633	6949.	0.00
14.4425	0.01683	-196408.	6478.	5.60E-05	15608.	1.11E+10	-35.3593	6872.	0.00
14.7150	0.01691	-175446.	6362.	1.04E-06	15224.	1.11E+10	-35.4212	6848.	0.00
14.9875	0.01683	-154803.	6139.	-4.78E-05	14845.	1.11E+10	-101.2496	19670.	0.00
15.2600	0.01660	-135188.	5808.	-9.07E-05	14484.	1.11E+10	-100.9010	19875.	0.00
15.5325	0.01624	-116606.	5479.	-1.28E-04	14143.	1.11E+10	-100.3474	20207.	0.00
15.8050	0.01576	-99057.	5152.	-1.60E-04	13821.	1.11E+10	-99.6069	20662.	0.00
16.0775	0.01519	-82538.	4828.	-1.87E-04	13518.	1.11E+10	-98.6944	21241.	0.00
16.3500	0.01454	-67047.	4507.	-2.09E-04	13233.	1.11E+10	-97.6222	21950.	0.00
16.6225	0.01383	-52576.	4190.	-2.26E-04	12968.	1.11E+10	-96.4007	22796.	0.00
16.8950	0.01306	-39118.	3877.	-2.40E-04	12721.	1.11E+10	-95.0385	23792.	0.00
17.1675	0.01226	-26662.	3568.	-2.50E-04	12492.	1.11E+10	-93.5429	24953.	0.00
17.4400	0.01143	-15198.	3265.	-2.56E-04	12281.	1.11E+10	-91.9200	26300.	0.00
17.7125	0.01058	-4711.	2967.	-2.59E-04	12089.	1.11E+10	-90.1749	27858.	0.00
17.9850	0.00974	4814.	2676.	-2.59E-04	12091.	1.11E+10	-88.3117	29661.	0.00
18.2575	0.00889	13392.	2390.	-2.56E-04	12248.	1.11E+10	-86.3337	31750.	0.00
18.5300	0.00806	21042.	2111.	-2.51E-04	12389.	1.11E+10	-84.2431	34176.	0.00
18.8025	0.00725	27785.	1839.	-2.44E-04	12513.	1.11E+10	-82.0414	37005.	0.00
19.0750	0.00647	33640.	1575.	-2.35E-04	12620.	1.11E+10	-79.7294	40323.	0.00
19.3475	0.00571	38632.	1318.	-2.24E-04	12712.	1.11E+10	-77.3066	44239.	0.00
19.6200	0.00500	42783.	1069.	-2.12E-04	12788.	1.11E+10	-74.7715	48899.	0.00
19.8925	0.00433	46121.	829.1815	-1.99E-04	12849.	1.11E+10	-72.1212	54498.	0.00
20.1650	0.00370	48671.	597.8747	-1.85E-04	12896.	1.11E+10	-69.3509	61302.	0.00
20.4375	0.00312	50462.	375.8344	-1.70E-04	12929.	1.11E+10	-66.4536	69687.	0.00
20.7100	0.00259	51526.	91.6614	-1.55E-04	12948.	1.11E+10	-107.3525	135747.	0.00
20.9825	0.00210	51424.	-228.2118	-1.40E-04	12947.	1.11E+10	-88.2887	137244.	0.00
21.2550	0.00167	50360.	-488.4740	-1.25E-04	12927.	1.11E+10	-70.8931	138741.	0.00
21.5275	0.00129	48521.	-694.6200	-1.10E-04	12893.	1.11E+10	-55.1900	140238.	0.00
21.8000	9.50E-04	46075.	-852.1674	-9.63E-05	12848.	1.11E+10	-41.1692	141735.	0.00
22.0725	6.57E-04	43173.	-966.5531	-8.31E-05	12795.	1.11E+10	-28.7914	143232.	0.00
22.3450	4.07E-04	39948.	-1043.	-7.08E-05	12736.	1.11E+10	-17.9937	144729.	0.00
22.6175	1.94E-04	36516.	-1087.	-5.95E-05	12673.	1.11E+10	-8.6939	146226.	0.00
22.8900	1.76E-05	32979.	-1102.	-4.92E-05	12608.	1.11E+10	-0.7952	147723.	0.00
23.1625	-1.27E-04	29423.	-1094.	-4.00E-05	12543.	1.11E+10	5.8101	149220.	0.00
23.4350	-2.44E-04	25918.	-1066.	-3.18E-05	12478.	1.11E+10	11.2365	150717.	0.00
23.7075	-3.35E-04	22525.	-1022.	-2.46E-05	12416.	1.11E+10	15.6029	152214.	0.00
23.9800	-4.05E-04	19290.	-965.6195	-1.84E-05	12357.	1.11E+10	19.0291	153711.	0.00
24.2525	-4.56E-04	16252.	-899.1360	-1.32E-05	12301.	1.11E+10	21.6336	155208.	0.00
24.5250	-4.91E-04	13441.	-825.2912	-8.79E-06	12249.	1.11E+10	23.5315	156705.	0.00
24.7975	-5.13E-04	10876.	-746.2154	-5.20E-06	12202.	1.11E+10	24.8329	158202.	0.00
25.0700	-5.25E-04	8572.	-663.6906	-2.32E-06	12160.	1.11E+10	25.6410	159699.	0.00
25.3425	-5.28E-04	6540.	-579.1739	-8.65E-08	12123.	1.11E+10	26.0512	161196.	0.00
25.6150	-5.26E-04	4785.	-493.8251	1.59E-06	12090.	1.11E+10	26.1499	162693.	0.00
25.8875	-5.18E-04	3307.	-408.5380	2.78E-06	12063.	1.11E+10	26.0135	164190.	0.00
26.1600	-5.07E-04	2106.	-323.9728	3.59E-06	12041.	1.11E+10	25.7083	165687.	0.00
26.4325	-4.95E-04	1180.	-240.5920	4.07E-06	12024.	1.11E+10	25.2891	167184.	0.00
26.7050	-4.81E-04	523.4995	-158.6973	4.32E-06	12012.	1.11E+10	24.7994	168681.	0.00
26.9775	-4.66E-04	132.0109	-78.4679	4.42E-06	12005.	1.11E+10	24.2706	170178.	0.00
27.2500	-4.52E-04	0.00	0.00	4.44E-06	12002.	1.11E+10	23.7220	85838.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =    -0.45000000 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =       2324281. inch-lbs
Maximum shear force              =        -58294. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             13
Number of zero deflection points =              2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = 0.000000 inches
Moment at pile head = 0.0 in-lbs
Axial load at pile head = 357000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	6043.	0.00
0.2725	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	12909.	0.00
0.5450	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	9096.	0.00
0.8175	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	9641.	0.00
1.0900	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	12783.	0.00
1.3625	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	13467.	0.00
1.6350	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	14152.	0.00
1.9075	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	14836.	0.00
2.1800	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	15520.	0.00
2.4525	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	16205.	0.00
2.7250	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	16889.	0.00
2.9975	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	17573.	0.00
3.2700	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	9985.	0.00
3.5425	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	10359.	0.00
3.8150	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	10733.	0.00
4.0875	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	11107.	0.00
4.3600	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	11482.	0.00
4.6325	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	11856.	0.00
4.9050	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	12230.	0.00
5.1775	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	12604.	0.00
5.4500	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	12979.	0.00
5.7225	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	13353.	0.00
5.9950	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	13727.	0.00
6.2675	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	14101.	0.00
6.5400	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	14476.	0.00
6.8125	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	14850.	0.00
7.0850	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	15224.	0.00
7.3575	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	15598.	0.00
7.6300	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	15973.	0.00
7.9025	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	16347.	0.00
8.1750	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	16721.	0.00
8.4475	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	17095.	0.00
8.7200	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	17470.	0.00
8.9925	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	17844.	0.00
9.2650	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	18218.	0.00
9.5375	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	18592.	0.00
9.8100	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	18967.	0.00
10.0825	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	19341.	0.00
10.3550	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	19715.	0.00
10.6275	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	20089.	0.00
10.9000	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	20464.	0.00
11.1725	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	20838.	0.00
11.4450	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	21212.	0.00
11.7175	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	21586.	0.00
11.9900	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	21961.	0.00
12.2625	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	22335.	0.00
12.5350	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	22709.	0.00
12.8075	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	23083.	0.00
13.0800	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	410958.	0.00
13.3525	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	410958.	0.00
13.6250	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	410958.	0.00
13.8975	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	410958.	0.00
14.1700	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	410958.	0.00
14.4425	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	410958.	0.00
14.7150	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	410958.	0.00
14.9875	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
15.2600	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
15.5325	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
15.8050	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
16.0775	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
16.3500	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
16.6225	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
16.8950	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
17.1675	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00

17.4400	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
17.7125	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
17.9850	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
18.2575	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
18.5300	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
18.8025	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
19.0750	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
19.3475	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
19.6200	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
19.8925	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
20.1650	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
20.4375	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	424563.	0.00
20.7100	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	135747.	0.00
20.9825	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	137244.	0.00
21.2550	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	138741.	0.00
21.5275	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	140238.	0.00
21.8000	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	141735.	0.00
22.0725	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	143232.	0.00
22.3450	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	144729.	0.00
22.6175	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	146226.	0.00
22.8900	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	147723.	0.00
23.1625	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	149220.	0.00
23.4350	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	150717.	0.00
23.7075	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	152214.	0.00
23.9800	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	153711.	0.00
24.2525	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	155208.	0.00
24.5250	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	156705.	0.00
24.7975	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	158202.	0.00
25.0700	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	159699.	0.00
25.3425	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	161196.	0.00
25.6150	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	162693.	0.00
25.8875	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	164190.	0.00
26.1600	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	165687.	0.00
26.4325	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	167184.	0.00
26.7050	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	168681.	0.00
26.9775	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	170178.	0.00
27.2500	0.00	0.00	0.00	0.00	12002.	1.11E+10	0.00	85838.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection = 0.000000 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = 0.000000 inch-lbs
Maximum shear force = 0.000000 lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 0

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = -81394.0 lbs
Applied moment at pile head = 2324281.0 in-lbs
Axial thrust load on pile head = 357000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-1.9014	2324281.	-81394.	0.01704	54675.	1.11E+10	477.4907	410.5859	0.00
0.2725	-1.8446	2040385.	-79771.	0.01768	49462.	1.11E+10	515.0794	913.1102	0.00
0.5450	-1.7858	1761292.	-78036.	0.01825	44339.	1.11E+10	546.3535	1000.	0.00
0.8175	-1.7253	1487433.	-76203.	0.01873	39311.	1.11E+10	574.4165	1089.	0.00
1.0900	-1.6633	1219202.	-74181.	0.01913	34386.	1.11E+10	662.4617	1302.	0.00
1.3625	-1.6002	957635.	-71947.	0.01945	29584.	1.11E+10	703.7717	1438.	0.00
1.6350	-1.5361	703262.	-69577.	0.01969	24914.	1.11E+10	745.9888	1588.	0.00
1.9075	-1.4714	456623.	-67065.	0.01986	20386.	1.11E+10	790.2329	1756.	0.00
2.1800	-1.4062	218276.	-64402.	0.01996	16010.	1.11E+10	838.7211	1950.	0.00
2.4525	-1.3408	-11177.	-61578.	0.02000	12208.	1.11E+10	888.5823	2167.	0.00
2.7250	-1.2754	-231126.	-58588.	0.01996	16246.	1.11E+10	939.8164	2410.	0.00
2.9975	-1.2103	-440945.	-55429.	0.01986	20098.	1.11E+10	992.4234	2681.	0.00
3.2700	-1.1456	-640000.	-52469.	0.01970	23752.	1.11E+10	818.2347	2336.	0.00
3.5425	-1.0814	-830085.	-49725.	0.01948	27242.	1.11E+10	859.9696	2600.	0.00
3.8150	-1.0181	-1010687.	-46843.	0.01921	30558.	1.11E+10	902.6956	2899.	0.00
4.0875	-0.9558	-1181288.	-43819.	0.01889	33690.	1.11E+10	946.4126	3238.	0.00
4.3600	-0.8946	-1341362.	-40652.	0.01851	36629.	1.11E+10	991.1207	3623.	0.00

4.6325	-0.8347	-1490374.	-37336.	0.01809	39365.	1.11E+10	1037.	4062.	0.00
4.9050	-0.7763	-1627786.	-33869.	0.01763	41887.	1.11E+10	1084.	4564.	0.00
5.1775	-0.7194	-1753049.	-30248.	0.01713	44187.	1.11E+10	1131.	5142.	0.00
5.4500	-0.6642	-1865612.	-26470.	0.01660	46254.	1.11E+10	1180.	5809.	0.00
5.7225	-0.6108	-1964914.	-22530.	0.01603	48077.	1.11E+10	1230.	6582.	0.00
5.9950	-0.5594	-2050391.	-18427.	0.01544	49646.	1.11E+10	1280.	7484.	0.00
6.2675	-0.5099	-2121471.	-14205.	0.01482	50951.	1.11E+10	1302.	8350.	0.00
6.5400	-0.4624	-2177896.	-10022.	0.01419	51987.	1.11E+10	1256.	8883.	0.00
6.8125	-0.4171	-2220137.	-5993.	0.01354	52763.	1.11E+10	1208.	9473.	0.00
7.0850	-0.3739	-2248690.	-2122.	0.01287	53287.	1.11E+10	1159.	10134.	0.00
7.3575	-0.3329	-2264076.	1584.	0.01221	53569.	1.11E+10	1108.	10883.	0.00
7.6300	-0.2941	-2266833.	5122.	0.01154	53620.	1.11E+10	1056.	11745.	0.00
7.9025	-0.2574	-2257513.	8491.	0.01087	53449.	1.11E+10	1004.	12752.	0.00
8.1750	-0.2230	-2236678.	11688.	0.01020	53066.	1.11E+10	951.3306	13950.	0.00
8.4475	-0.1907	-2204899.	14706.	0.00955	52483.	1.11E+10	894.9823	15345.	0.00
8.7200	-0.1606	-2162788.	17532.	0.00890	51710.	1.11E+10	833.4845	16975.	0.00
8.9925	-0.1325	-2111019.	20077.	0.00827	50759.	1.11E+10	723.0423	17844.	0.00
9.2650	-0.1065	-2050789.	22230.	0.00765	49653.	1.11E+10	593.2429	18218.	0.00
9.5375	-0.08245	-1983508.	23966.	0.00706	48418.	1.11E+10	468.7637	18592.	0.00
9.8100	-0.06033	-1910529.	25304.	0.00648	47078.	1.11E+10	349.9085	18967.	0.00
10.0825	-0.04006	-1833150.	26264.	0.00593	45658.	1.11E+10	236.9182	19341.	0.00
10.3550	-0.02156	-1752604.	26864.	0.00540	44179.	1.11E+10	129.9762	19715.	0.00
10.6275	-0.00476	-1670063.	27124.	0.00489	42664.	1.11E+10	29.2126	20089.	0.00
10.9000	0.01043	-1586633.	27065.	0.00441	41132.	1.11E+10	-65.2902	20464.	0.00
11.1725	0.02409	-1503354.	26707.	0.00395	39603.	1.11E+10	-153.4918	20838.	0.00
11.4450	0.03629	-1421197.	26072.	0.00352	38095.	1.11E+10	-235.3878	21212.	0.00
11.7175	0.04711	-1341066.	25178.	0.00311	36623.	1.11E+10	-311.0035	21586.	0.00
11.9900	0.05664	-1263798.	24048.	0.00273	35205.	1.11E+10	-380.3875	21961.	0.00
12.2625	0.06495	-1190161.	22701.	0.00236	33853.	1.11E+10	-443.6048	22335.	0.00
12.5350	0.07210	-1120857.	21157.	0.00202	32581.	1.11E+10	-500.7304	22709.	0.00
12.8075	0.07817	-1056519.	19436.	0.00170	31399.	1.11E+10	-551.8421	23083.	0.00
13.0800	0.08322	-997718.	18435.	0.00140	30320.	1.11E+10	-60.2356	2367.	0.00
13.3525	0.08731	-939216.	18236.	0.00111	29246.	1.11E+10	-61.2055	2292.	0.00
13.6250	0.09049	-881045.	18035.	8.41E-04	28178.	1.11E+10	-61.9390	2238.	0.00
13.8975	0.09281	-823232.	17832.	5.89E-04	27116.	1.11E+10	-62.4649	2201.	0.00
14.1700	0.09434	-765802.	17627.	3.54E-04	26062.	1.11E+10	-62.8060	2177.	0.00
14.4425	0.09513	-708780.	17421.	1.36E-04	25015.	1.11E+10	-62.9803	2165.	0.00
14.7150	0.09523	-652186.	17215.	-6.51E-05	23976.	1.11E+10	-63.0029	2163.	0.00
14.9875	0.09470	-596041.	16857.	-2.50E-04	22945.	1.11E+10	-155.9025	5383.	0.00
15.2600	0.09360	-541358.	16348.	-4.18E-04	21941.	1.11E+10	-155.4459	5431.	0.00
15.5325	0.09197	-488149.	15841.	-5.70E-04	20965.	1.11E+10	-154.7654	5503.	0.00
15.8050	0.08987	-436427.	15336.	-7.07E-04	20015.	1.11E+10	-153.8742	5599.	0.00
16.0775	0.08735	-386199.	14835.	-8.28E-04	19093.	1.11E+10	-152.7829	5720.	0.00
16.3500	0.08445	-337472.	14337.	-9.35E-04	18198.	1.11E+10	-151.5006	5866.	0.00
16.6225	0.08123	-290249.	13844.	-0.00103	17331.	1.11E+10	-150.0343	6040.	0.00
16.8950	0.07772	-244529.	13356.	-0.00111	16492.	1.11E+10	-148.3900	6243.	0.00
17.1675	0.07399	-200312.	12874.	-0.00117	15680.	1.11E+10	-146.5721	6478.	0.00
17.4400	0.07005	-157593.	12398.	-0.00123	14896.	1.11E+10	-144.5841	6749.	0.00
17.7125	0.06597	-116365.	11929.	-0.00127	14139.	1.11E+10	-142.4284	7060.	0.00
17.9850	0.06177	-76621.	11467.	-0.00130	13409.	1.11E+10	-140.1063	7417.	0.00
18.2575	0.05750	-38348.	11013.	-0.00131	12706.	1.11E+10	-137.6183	7827.	0.00
18.5300	0.05319	-1533.	10567.	-0.00132	12031.	1.11E+10	-134.9640	8298.	0.00
18.8025	0.04888	33839.	10130.	-0.00131	12624.	1.11E+10	-132.1422	8841.	0.00
19.0750	0.04460	67787.	9703.	-0.00130	13247.	1.11E+10	-129.1508	9469.	0.00
19.3475	0.04039	100330.	9286.	-0.00127	13844.	1.11E+10	-125.9869	10201.	0.00
19.6200	0.03627	131491.	8880.	-0.00124	14417.	1.11E+10	-122.6470	11057.	0.00
19.8925	0.03228	161295.	8484.	-0.00120	14964.	1.11E+10	-119.1270	12066.	0.00
20.1650	0.02845	189770.	8101.	-0.00114	15486.	1.11E+10	-115.4225	13266.	0.00
20.4375	0.02480	216945.	7730.	-0.00108	15985.	1.11E+10	-111.5295	14704.	0.00
20.7100	0.02136	242853.	6241.	-0.00102	16461.	1.11E+10	-799.3291	122348.	0.00
20.9825	0.01816	260130.	3713.	-9.41E-04	16778.	1.11E+10	-746.5019	134422.	0.00
21.2550	0.01521	269334.	1438.	-8.63E-04	16947.	1.11E+10	-645.2184	138741.	0.00
21.5275	0.01252	271547.	-494.8825	-7.83E-04	16988.	1.11E+10	-536.7321	140238.	0.00
21.8000	0.01009	267926.	-2087.	-7.03E-04	16921.	1.11E+10	-437.1632	141735.	0.00
22.0725	0.00792	259539.	-3369.	-6.25E-04	16767.	1.11E+10	-346.7192	143232.	0.00
22.3450	0.00600	247354.	-4370.	-5.50E-04	16544.	1.11E+10	-265.3969	144729.	0.00
22.6175	0.00432	232246.	-5119.	-4.79E-04	16266.	1.11E+10	-193.0140	146226.	0.00
22.8900	0.00286	214994.	-5646.	-4.13E-04	15950.	1.11E+10	-129.2390	147723.	0.00
23.1625	0.00161	196286.	-5978.	-3.52E-04	15606.	1.11E+10	-73.6191	149220.	0.00
23.4350	5.56E-04	176723.	-6140.	-2.97E-04	15247.	1.11E+10	-25.6059	150717.	0.00
23.7075	-3.31E-04	156825.	-6157.	-2.48E-04	14882.	1.11E+10	15.4204	152214.	0.00
23.9800	-0.00107	137038.	-6049.	-2.05E-04	14518.	1.11E+10	50.1298	153711.	0.00
24.2525	-0.00167	117739.	-5838.	-1.67E-04	14164.	1.11E+10	79.2221	155208.	0.00
24.5250	-0.00216	99247.	-5539.	-1.35E-04	13825.	1.11E+10	103.4098	156705.	0.00
24.7975	-0.00255	81827.	-5168.	-1.08E-04	13505.	1.11E+10	123.4016	158202.	0.00
25.0700	-0.00286	65697.	-4738.	-8.62E-05	13209.	1.11E+10	139.8884	159699.	0.00
25.3425	-0.00311	51041.	-4258.	-6.89E-05	12940.	1.11E+10	153.5306	161196.	0.00
25.6150	-0.00332	38009.	-3738.	-5.58E-05	12700.	1.11E+10	164.9459	162693.	0.00
25.8875	-0.00348	26728.	-3182.	-4.62E-05	12493.	1.11E+10	174.6994	164190.	0.00
26.1600	-0.00362	17305.	-2597.	-3.97E-05	12320.	1.11E+10	183.2935	165687.	0.00
26.4325	-0.00374	9836.	-1985.	-3.57E-05	12183.	1.11E+10	191.1585	167184.	0.00
26.7050	-0.00385	4408.	-1347.	-3.36E-05	12083.	1.11E+10	198.6440	168681.	0.00
26.9775	-0.00396	1103.	-685.7662	-3.28E-05	12023.	1.11E+10	206.0101	170178.	0.00
27.2500	-0.00407	0.00	0.00	-3.26E-05	12002.	1.11E+10	213.4188	85838.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

Pile-head deflection = -1.90142230 inches
Computed slope at pile head = 0.01703765 radians
Maximum bending moment = 2324281. inch-lbs
Maximum shear force = -81394. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 36
Number of zero deflection points = 2

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 4

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = -1.901400 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 357000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-1.9014	3940084.	-102250.	0.00	84340.	5.46E+08	477.4887	410.5891	0.00
0.2725	-1.8628	3607857.	-96541.	0.01234	78240.	1.11E+10	515.0771	904.1815	0.00
0.5450	-1.8207	3279893.	-94806.	0.01336	72219.	1.11E+10	546.3508	981.2555	0.00
0.8175	-1.7754	2956638.	-92973.	0.01428	66284.	1.11E+10	574.4134	1058.	0.00
1.0900	-1.7273	2638505.	-90951.	0.01511	60444.	1.11E+10	662.4578	1254.	0.00
1.3625	-1.6766	2326544.	-88717.	0.01584	54716.	1.11E+10	703.7672	1373.	0.00
1.6350	-1.6237	2021306.	-86347.	0.01649	49112.	1.11E+10	745.9838	1502.	0.00
1.9075	-1.5688	1723346.	-83835.	0.01704	43642.	1.11E+10	790.2273	1647.	0.00
2.1800	-1.5123	1433241.	-81172.	0.01751	38316.	1.11E+10	838.7148	1814.	0.00
2.4525	-1.4543	1151610.	-78348.	0.01789	33145.	1.11E+10	888.5752	1998.	0.00
2.7250	-1.3953	879082.	-75358.	0.01819	28142.	1.11E+10	939.8084	2203.	0.00
2.9975	-1.3354	616300.	-72199.	0.01841	23317.	1.11E+10	992.4146	2430.	0.00
3.2700	-1.2749	363918.	-69239.	0.01855	18684.	1.11E+10	818.2271	2099.	0.00
3.5425	-1.2140	120159.	-66495.	0.01863	14208.	1.11E+10	859.9612	2316.	0.00
3.8150	-1.1531	-114447.	-63613.	0.01863	14104.	1.11E+10	902.6863	2560.	0.00
4.0875	-1.0922	-339360.	-60590.	0.01856	18233.	1.11E+10	946.4024	2833.	0.00
4.3600	-1.0317	-554036.	-57422.	0.01843	22174.	1.11E+10	991.1095	3141.	0.00
4.6325	-0.9717	-757923.	-54106.	0.01823	25917.	1.11E+10	1037.	3489.	0.00
4.9050	-0.9124	-950462.	-50640.	0.01798	29452.	1.11E+10	1083.	3883.	0.00
5.1775	-0.8541	-1131088.	-47019.	0.01767	32768.	1.11E+10	1131.	4331.	0.00
5.4500	-0.7968	-1299227.	-43240.	0.01731	35855.	1.11E+10	1180.	4842.	0.00
5.7225	-0.7409	-1454301.	-39301.	0.01691	38702.	1.11E+10	1230.	5427.	0.00
5.9950	-0.6863	-1595727.	-35197.	0.01646	41299.	1.11E+10	1280.	6100.	0.00
6.2675	-0.6332	-1722913.	-30927.	0.01596	43634.	1.11E+10	1332.	6877.	0.00
6.5400	-0.5819	-1835263.	-26486.	0.01544	45697.	1.11E+10	1384.	7780.	0.00
6.8125	-0.5323	-1932176.	-21871.	0.01488	47476.	1.11E+10	1438.	8835.	0.00
7.0850	-0.4845	-2013045.	-17225.	0.01430	48961.	1.11E+10	1403.	9470.	0.00
7.3575	-0.4388	-2078214.	-12723.	0.01369	50157.	1.11E+10	1351.	10066.	0.00
7.6300	-0.3950	-2128223.	-8396.	0.01307	51075.	1.11E+10	1296.	10729.	0.00
7.9025	-0.3533	-2163640.	-4250.	0.01244	51725.	1.11E+10	1240.	11476.	0.00
8.1750	-0.3136	-2185053.	-289.1591	0.01179	52118.	1.11E+10	1183.	12329.	0.00
8.4475	-0.2761	-2193067.	3483.	0.01115	52266.	1.11E+10	1125.	13317.	0.00
8.7200	-0.2407	-2188298.	7065.	0.01050	52178.	1.11E+10	1066.	14484.	0.00
8.9925	-0.2075	-2171372.	10454.	0.00985	51867.	1.11E+10	1007.	15865.	0.00
9.2650	-0.1763	-2142933.	13640.	0.00922	51345.	1.11E+10	941.7124	17466.	0.00
9.5375	-0.1472	-2103684.	16548.	0.00859	50625.	1.11E+10	836.9798	18592.	0.00
9.8100	-0.1201	-2054759.	19056.	0.00797	49726.	1.11E+10	696.8448	18967.	0.00
10.0825	-0.09506	-1997673.	21115.	0.00737	48678.	1.11E+10	562.2676	19341.	0.00
10.3550	-0.07192	-1933886.	22743.	0.00679	47507.	1.11E+10	433.5974	19715.	0.00
10.6275	-0.05064	-1864794.	23960.	0.00623	46239.	1.11E+10	311.1187	20089.	0.00
10.9000	-0.03117	-1791732.	24788.	0.00569	44897.	1.11E+10	195.0556	20464.	0.00
11.1725	-0.01343	-1715965.	25247.	0.00517	43506.	1.11E+10	85.5768	20838.	0.00
11.4450	0.00265	-1638691.	25359.	0.00468	42088.	1.11E+10	-17.1980	21212.	0.00
11.7175	0.01715	-1561036.	25145.	0.00420	40662.	1.11E+10	-113.1922	21586.	0.00
11.9900	0.03013	-1484051.	24630.	0.00375	39249.	1.11E+10	-202.3662	21961.	0.00
12.2625	0.04168	-1408718.	23833.	0.00332	37866.	1.11E+10	-284.7100	22335.	0.00
12.5350	0.05187	-1335943.	22779.	0.00292	36529.	1.11E+10	-360.2370	22709.	0.00
12.8075	0.06077	-1266559.	21488.	0.00253	35256.	1.11E+10	-428.9760	23083.	0.00
13.0800	0.06844	-1201325.	20695.	0.00217	34058.	1.11E+10	-56.4347	2696.	0.00
13.3525	0.07495	-1136279.	20507.	0.00182	32864.	1.11E+10	-58.1700	2538.	0.00
13.6250	0.08036	-1071463.	20315.	0.00150	31674.	1.11E+10	-59.5373	2423.	0.00
13.8975	0.08474	-1006914.	20118.	0.00119	30489.	1.11E+10	-60.5987	2339.	0.00
14.1700	0.08814	-942665.	19919.	9.01E-04	29309.	1.11E+10	-61.3988	2278.	0.00
14.4425	0.09063	-878747.	19717.	6.31E-04	28136.	1.11E+10	-61.9714	2236.	0.00
14.7150	0.09227	-815189.	19514.	3.81E-04	26969.	1.11E+10	-62.3429	2209.	0.00
14.9875	0.09312	-752015.	19158.	1.49E-04	25809.	1.11E+10	-155.2472	5452.	0.00
15.2600	0.09324	-690243.	18650.	-6.41E-05	24675.	1.11E+10	-155.2988	5446.	0.00
15.5325	0.09270	-629892.	18143.	-2.59E-04	23567.	1.11E+10	-155.0720	5470.	0.00
15.8050	0.09155	-570982.	17637.	-4.37E-04	22485.	1.11E+10	-154.5877	5522.	0.00
16.0775	0.08984	-513528.	17132.	-5.97E-04	21430.	1.11E+10	-153.8629	5600.	0.00
16.3500	0.08764	-457542.	16631.	-7.41E-04	20403.	1.11E+10	-152.9116	5705.	0.00
16.6225	0.08500	-403033.	16133.	-8.68E-04	19402.	1.11E+10	-151.7451	5838.	0.00

16.8950	0.08196	-350007.	15639.	-9.79E-04	18428.	1.11E+10	-150.3726	5999.	0.00
17.1675	0.07859	-298469.	15150.	-0.00108	17482.	1.11E+10	-148.8015	6191.	0.00
17.4400	0.07493	-248418.	14666.	-0.00116	16563.	1.11E+10	-147.0377	6417.	0.00
17.7125	0.07103	-199854.	14188.	-0.00122	15672.	1.11E+10	-145.0854	6679.	0.00
17.9850	0.06694	-152773.	13717.	-0.00127	14807.	1.11E+10	-142.9480	6983.	0.00
18.2575	0.06269	-107167.	13254.	-0.00131	13970.	1.11E+10	-140.6273	7335.	0.00
18.5300	0.05835	-63028.	12798.	-0.00134	13160.	1.11E+10	-138.1244	7741.	0.00
18.8025	0.05394	-20344.	12351.	-0.00135	12376.	1.11E+10	-135.4394	8210.	0.00
19.0750	0.04952	20898.	11912.	-0.00135	12386.	1.11E+10	-132.5712	8755.	0.00
19.3475	0.04511	60716.	11484.	-0.00134	13117.	1.11E+10	-129.5183	9389.	0.00
19.6200	0.04076	99128.	11066.	-0.00131	13822.	1.11E+10	-126.2784	10130.	0.00
19.8925	0.03651	136156.	10658.	-0.00128	14502.	1.11E+10	-122.8486	11002.	0.00
20.1650	0.03239	171823.	10263.	-0.00123	15157.	1.11E+10	-119.2262	12036.	0.00
20.4375	0.02844	206155.	9879.	-0.00118	15787.	1.11E+10	-115.4088	13270.	0.00
20.7100	0.02468	239183.	8263.	-0.00111	16394.	1.11E+10	-872.7206	115611.	0.00
20.9825	0.02116	262795.	5497.	-0.00104	16827.	1.11E+10	-819.2681	126597.	0.00
21.2550	0.01789	277557.	2916.	-9.59E-04	17098.	1.11E+10	-759.1727	138741.	0.00
21.5275	0.01489	284106.	630.7085	-8.76E-04	17218.	1.11E+10	-638.6937	140238.	0.00
21.8000	0.01217	283726.	-1276.	-7.92E-04	17211.	1.11E+10	-527.3764	141735.	0.00
22.0725	0.00972	277610.	-2834.	-7.09E-04	17099.	1.11E+10	-425.5821	143232.	0.00
22.3450	0.00753	266847.	-4075.	-6.28E-04	16902.	1.11E+10	-333.4257	144729.	0.00
22.6175	0.00561	252426.	-5030.	-5.51E-04	16637.	1.11E+10	-250.8105	146226.	0.00
22.8900	0.00393	235237.	-5730.	-4.79E-04	16321.	1.11E+10	-177.4610	147723.	0.00
23.1625	0.00248	216069.	-6205.	-4.12E-04	15969.	1.11E+10	-112.9538	149220.	0.00
23.4350	0.00123	195618.	-6483.	-3.52E-04	15594.	1.11E+10	-56.7470	150717.	0.00
23.7075	1.76E-04	174493.	-6589.	-2.97E-04	15206.	1.11E+10	-8.2071	152214.	0.00
23.9800	-7.10E-04	153220.	-6548.	-2.48E-04	14815.	1.11E+10	33.3666	153711.	0.00
24.2525	-0.00145	132251.	-6381.	-2.06E-04	14430.	1.11E+10	68.7187	155208.	0.00
24.5250	-0.00206	111971.	-6107.	-1.70E-04	14058.	1.11E+10	98.6175	156705.	0.00
24.7975	-0.00256	92707.	-5743.	-1.40E-04	13704.	1.11E+10	123.8361	158202.	0.00
25.0700	-0.00297	74735.	-5304.	-1.15E-04	13375.	1.11E+10	145.1357	159699.	0.00
25.3425	-0.00331	58289.	-4799.	-9.53E-05	13073.	1.11E+10	163.2499	161196.	0.00
25.6150	-0.00360	43569.	-4240.	-8.03E-05	12802.	1.11E+10	178.8708	162693.	0.00
25.8875	-0.00384	30746.	-3633.	-6.93E-05	12567.	1.11E+10	192.6355	164190.	0.00
26.1600	-0.00405	19973.	-2982.	-6.18E-05	12369.	1.11E+10	205.1147	165687.	0.00
26.4325	-0.00424	11386.	-2293.	-5.71E-05	12211.	1.11E+10	216.8002	167184.	0.00
26.7050	-0.00442	5113.	-1565.	-5.47E-05	12096.	1.11E+10	228.0938	168681.	0.00
26.9775	-0.00460	1277.	-800.9716	-5.37E-05	12026.	1.11E+10	239.2960	170178.	0.00
27.2500	-0.00477	0.00	0.00	-5.36E-05	12002.	1.11E+10	250.5949	85838.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 4:

```
Pile-head deflection             =    -1.90140000 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =       3940084. inch-lbs
Maximum shear force              =       -102250. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             30
Number of zero deflection points =              2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 5

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = -1.901400 inches
Moment at pile head = 2775813.0 in-lbs
Axial load at pile head = 357000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-1.9014	2775813.	-86148.	0.01543	62964.	1.11E+10	477.4887	410.5891	0.00
0.2725	-1.8496	2478165.	-84525.	0.01621	57500.	1.11E+10	515.0773	910.6373	0.00
0.5450	-1.7954	2185170.	-82790.	0.01690	52121.	1.11E+10	546.3513	995.0937	0.00
0.8175	-1.7391	1897262.	-80957.	0.01750	46835.	1.11E+10	574.4141	1080.	0.00
1.0900	-1.6809	1614841.	-78935.	0.01802	41650.	1.11E+10	662.4590	1289.	0.00
1.3625	-1.6212	1338946.	-76701.	0.01846	36585.	1.11E+10	703.7687	1420.	0.00
1.6350	-1.5602	1070115.	-74331.	0.01882	31649.	1.11E+10	745.9857	1564.	0.00
1.9075	-1.4981	808890.	-71819.	0.01909	26853.	1.11E+10	790.2296	1725.	0.00
2.1800	-1.4353	555837.	-69156.	0.01930	22207.	1.11E+10	838.7176	1911.	0.00
2.4525	-1.3719	311559.	-66331.	0.01942	17722.	1.11E+10	888.5786	2118.	0.00
2.7250	-1.3082	76676.	-63342.	0.01948	13410.	1.11E+10	939.8124	2349.	0.00
2.9975	-1.2445	-148185.	-60183.	0.01947	14723.	1.11E+10	992.4192	2608.	0.00
3.2700	-1.1809	-362382.	-57222.	0.01940	18656.	1.11E+10	818.2312	2266.	0.00
3.5425	-1.1176	-567705.	-54479.	0.01926	22425.	1.11E+10	859.9659	2516.	0.00
3.8150	-1.0549	-763637.	-51597.	0.01906	26022.	1.11E+10	902.6916	2798.	0.00
4.0875	-0.9930	-949652.	-48573.	0.01881	29437.	1.11E+10	946.4084	3117.	0.00

4.3600	-0.9319	-1125220.	-45406.	0.01850	32661.	1.11E+10	991.1162	3478.	0.00
4.6325	-0.8720	-1289802.	-42090.	0.01814	35682.	1.11E+10	1037.	3888.	0.00
4.9050	-0.8133	-1442852.	-38623.	0.01774	38492.	1.11E+10	1084.	4357.	0.00
5.1775	-0.7560	-1583817.	-35002.	0.01729	41080.	1.11E+10	1131.	4893.	0.00
5.4500	-0.7002	-1712141.	-31224.	0.01681	43436.	1.11E+10	1180.	5510.	0.00
5.7225	-0.6461	-1827257.	-27284.	0.01628	45550.	1.11E+10	1230.	6223.	0.00
5.9950	-0.5937	-1928595.	-23181.	0.01573	47410.	1.11E+10	1280.	7051.	0.00
6.2675	-0.5432	-2015578.	-18910.	0.01514	49007.	1.11E+10	1332.	8017.	0.00
6.5400	-0.4947	-2087625.	-14571.	0.01454	50330.	1.11E+10	1322.	8741.	0.00
6.8125	-0.4481	-2144812.	-10325.	0.01391	51380.	1.11E+10	1274.	9299.	0.00
7.0850	-0.4037	-2187631.	-6239.	0.01327	52166.	1.11E+10	1225.	9920.	0.00
7.3575	-0.3613	-2216601.	-2319.	0.01262	52698.	1.11E+10	1173.	10617.	0.00
7.6300	-0.3211	-2232262.	1431.	0.01196	52985.	1.11E+10	1121.	11410.	0.00
7.9025	-0.2831	-2235170.	5008.	0.01130	53039.	1.11E+10	1067.	12326.	0.00
8.1750	-0.2472	-2225895.	8409.	0.01064	52868.	1.11E+10	1013.	13402.	0.00
8.4475	-0.2135	-2205017.	11633.	0.00999	52485.	1.11E+10	958.5938	14681.	0.00
8.7200	-0.1819	-2173127.	14671.	0.00934	51900.	1.11E+10	899.2629	16163.	0.00
8.9925	-0.1524	-2130872.	17501.	0.00870	51124.	1.11E+10	831.8694	17844.	0.00
9.2650	-0.1250	-2078986.	20000.	0.00808	50171.	1.11E+10	696.5221	18218.	0.00
9.5375	-0.09960	-2018934.	22065.	0.00747	49069.	1.11E+10	566.3283	18592.	0.00
9.8100	-0.07614	-1952129.	23713.	0.00689	47842.	1.11E+10	441.6417	18967.	0.00
10.0825	-0.05457	-1879928.	24963.	0.00632	46517.	1.11E+10	322.7504	19341.	0.00
10.3550	-0.03481	-1803627.	25834.	0.00578	45116.	1.11E+10	209.8816	19715.	0.00
10.6275	-0.01680	-1724459.	26346.	0.00525	43662.	1.11E+10	103.2063	20089.	0.00
10.9000	-4.55E-04	-1643592.	26519.	0.00476	42178.	1.11E+10	2.8443	20464.	0.00
11.1725	0.01430	-1562127.	26375.	0.00428	40682.	1.11E+10	-91.1303	20838.	0.00
11.4450	0.02755	-1481097.	25934.	0.00383	39194.	1.11E+10	-178.6828	21212.	0.00
11.7175	0.03936	-1401466.	25217.	0.00341	37732.	1.11E+10	-259.8117	21586.	0.00
11.9900	0.04981	-1324130.	24245.	0.00300	36313.	1.11E+10	-334.5424	21961.	0.00
12.2625	0.05899	-1249914.	23039.	0.00262	34950.	1.11E+10	-402.9204	22335.	0.00
12.5350	0.06696	-1179575.	21620.	0.00226	33659.	1.11E+10	-465.0045	22709.	0.00
12.8075	0.07379	-1113801.	20008.	0.00192	32451.	1.11E+10	-520.8599	23083.	0.00
13.0800	0.07953	-1053211.	19060.	0.00160	31339.	1.11E+10	-59.3329	2439.	0.00
13.3525	0.08427	-992893.	18864.	0.00130	30231.	1.11E+10	-60.4868	2347.	0.00
13.6250	0.08804	-932878.	18664.	0.00102	29129.	1.11E+10	-61.3760	2280.	0.00
13.8975	0.09091	-873198.	18463.	7.48E-04	28034.	1.11E+10	-62.0356	2231.	0.00
14.1700	0.09293	-813880.	18259.	4.99E-04	26945.	1.11E+10	-62.4927	2199.	0.00
14.4425	0.09417	-754949.	18054.	2.67E-04	25863.	1.11E+10	-62.7689	2180.	0.00
14.7150	0.09468	-696428.	17849.	5.22E-05	24788.	1.11E+10	-62.8814	2172.	0.00
14.9875	0.09451	-638340.	17491.	-1.45E-04	23722.	1.11E+10	-155.8259	5392.	0.00
15.2600	0.09373	-581697.	16982.	-3.26E-04	22682.	1.11E+10	-155.5021	5425.	0.00
15.5325	0.09238	-526516.	16475.	-4.89E-04	21669.	1.11E+10	-154.9408	5485.	0.00
15.8050	0.09052	-472810.	15969.	-6.37E-04	20683.	1.11E+10	-154.1571	5569.	0.00
16.0775	0.08821	-420590.	15467.	-7.69E-04	19724.	1.11E+10	-153.1631	5678.	0.00
16.3500	0.08549	-369861.	14968.	-8.86E-04	18793.	1.11E+10	-151.9690	5813.	0.00
16.6225	0.08242	-320631.	14473.	-9.88E-04	17889.	1.11E+10	-150.5830	5975.	0.00
16.8950	0.07903	-272899.	13983.	-0.00108	17013.	1.11E+10	-149.0116	6166.	0.00
17.1675	0.07538	-226667.	13499.	-0.00115	16164.	1.11E+10	-147.2601	6388.	0.00
17.4400	0.07151	-181931.	13021.	-0.00121	15343.	1.11E+10	-145.3326	6646.	0.00
17.7125	0.06746	-138687.	12549.	-0.00126	14549.	1.11E+10	-143.2318	6943.	0.00
17.9850	0.06328	-96926.	12084.	-0.00129	13782.	1.11E+10	-140.9597	7284.	0.00
18.2575	0.05901	-56639.	11627.	-0.00132	13042.	1.11E+10	-138.5171	7676.	0.00
18.5300	0.05468	-17813.	11178.	-0.00133	12329.	1.11E+10	-135.9040	8128.	0.00
18.8025	0.05033	19565.	10739.	-0.00133	12362.	1.11E+10	-133.1194	8648.	0.00
19.0750	0.04601	55514.	10308.	-0.00132	13022.	1.11E+10	-130.1615	9252.	0.00
19.3475	0.04173	90051.	9888.	-0.00129	13656.	1.11E+10	-127.0278	9953.	0.00
19.6200	0.03755	123199.	9478.	-0.00126	14264.	1.11E+10	-123.7152	10774.	0.00
19.8925	0.03348	154981.	9079.	-0.00122	14848.	1.11E+10	-120.2199	11742.	0.00
20.1650	0.02956	185425.	8692.	-0.00117	15407.	1.11E+10	-116.5380	12891.	0.00
20.4375	0.02582	214558.	8317.	-0.00111	15942.	1.11E+10	-112.6658	14266.	0.00
20.7100	0.02229	242413.	6792.	-0.00104	16453.	1.11E+10	-820.3466	120322.	0.00
20.9825	0.01900	261412.	4196.	-9.69E-04	16802.	1.11E+10	-767.3034	132066.	0.00
21.2550	0.01596	272116.	1834.	-8.90E-04	16998.	1.11E+10	-676.9694	138741.	0.00
21.5275	0.01318	275487.	-196.3738	-8.09E-04	17060.	1.11E+10	-565.0523	140238.	0.00
21.8000	0.01066	272721.	-1876.	-7.28E-04	17009.	1.11E+10	-462.1373	141735.	0.00
22.0725	0.00841	264920.	-3234.	-6.49E-04	16866.	1.11E+10	-368.4731	143232.	0.00
22.3450	0.00642	253087.	-4301.	-5.72E-04	16649.	1.11E+10	-284.0881	144729.	0.00
22.6175	0.00467	238128.	-5107.	-5.00E-04	16374.	1.11E+10	-208.8224	146226.	0.00
22.8900	0.00315	220855.	-5681.	-4.32E-04	16057.	1.11E+10	-142.3586	147723.	0.00
23.1625	0.00185	201983.	-6051.	-3.69E-04	15711.	1.11E+10	-84.2508	149220.	0.00
23.4350	7.37E-04	182141.	-6245.	-3.12E-04	15346.	1.11E+10	-33.9511	150717.	0.00
23.7075	-1.97E-04	161873.	-6285.	-2.62E-04	14974.	1.11E+10	9.1655	152214.	0.00
23.9800	-9.74E-04	141646.	-6195.	-2.17E-04	14603.	1.11E+10	45.7783	153711.	0.00
24.2525	-0.00161	121861.	-5995.	-1.78E-04	14240.	1.11E+10	76.6008	155208.	0.00
24.5250	-0.00214	102852.	-5703.	-1.44E-04	13891.	1.11E+10	102.3618	156705.	0.00
24.7975	-0.00256	84903.	-5333.	-1.17E-04	13561.	1.11E+10	123.7888	158202.	0.00
25.0700	-0.00290	68247.	-4899.	-9.41E-05	13255.	1.11E+10	141.5929	159699.	0.00
25.3425	-0.00317	53083.	-4412.	-7.61E-05	12977.	1.11E+10	156.4554	161196.	0.00
25.6150	-0.00340	39573.	-3880.	-6.24E-05	12729.	1.11E+10	169.0152	162693.	0.00
25.8875	-0.00358	27856.	-3309.	-5.24E-05	12514.	1.11E+10	179.8579	164190.	0.00
26.1600	-0.00374	18053.	-2705.	-4.57E-05	12334.	1.11E+10	189.5050	165687.	0.00
26.4325	-0.00388	10270.	-2071.	-4.15E-05	12191.	1.11E+10	198.4042	167184.	0.00
26.7050	-0.00401	4606.	-1408.	-3.93E-05	12087.	1.11E+10	206.9198	168681.	0.00
26.9775	-0.00414	1152.	-717.9395	-3.84E-05	12024.	1.11E+10	215.3231	170178.	0.00
27.2500	-0.00426	0.00	0.00	-3.82E-05	12002.	1.11E+10	223.7836	85838.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the

magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 5:

```
Pile-head deflection             =    -1.90140000 inches
Computed slope at pile head      =     0.01543453 radians
Maximum bending moment           =       2775813. inch-lbs
Maximum shear force              =        -86148. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             11
Number of zero deflection points =              2
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

```
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians
```

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	-0.4500	S, rad	0.00	357000.	-0.4500	0.00	-58294.	2324281.
2	y, in	0.00	M, in-lb	0.00	357000.	0.00	0.00	0.00	0.00
3	V, lb	-81394.	M, in-lb	2324281.	357000.	-1.9014	0.01704	-81394.	2324281.
4	y, in	-1.9014	S, rad	0.00	357000.	-1.9014	0.00	-102250.	3940084.
5	y, in	-1.9014	M, in-lb	2775813.	357000.	-1.9014	0.01543	-86148.	2775813.

Maximum pile-head deflection = -1.9014222977 inches
Maximum pile-head rotation = 0.0170376486 radians = 0.976185 deg.

The analysis ended normally.

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	Made by	KRR	Check	BAM	Backcheck	
	Date	10/13/2017	Date	10/18/2017	Date	

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET - CONTRACTION South Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Slope. Displacement is equal to the thermal expansion of the bridge and the slope is assumed to be zero to represent a fixed head condition. No corrosion. Isolation casing for top 10 ft. Boring 201. Downdrag present.

Input factored load per pile to be assessed

P_u=	357	kips	Factored applied superstructure and substructure vertical dead and live load distributed to each pile. (Includes 52 kips factored downdrag load)

Input steel H-pile strengths

F_y=	50	ksi	Yield strength of steel H pile section.
E_s=	29000	ksi	Elastic modulus of steel H pile section.

Select axial resistance factors for the strength limit state from AASHTO Section 6.5.4.2

ϕ_{cu}=	0.70	dim	Axial resistance factor for the upper zone of the pile for combined axial and flexure with no damage.
ϕ_{cl}=	0.50	dim	Axial resistance factor for the lower zone of the pile in compression (Use 0.50 for severe driving & 0.60 for good driving).
ϕ_f=	1.00	dim	Flexure resistance factor for the upper zone of the pile for combined axial and flexure with no damage.

Calculate the required Nominal Axial Pile Resistance

R_{n_up}=	510.0	kips	Required nominal resistance for upper zone of pile [$R_{n_up} = P_u / \phi_{cu}$].
R_{n_low}=	714	kips	Required nominal resistance for lower zone of pile [$R_{n_low} = P_u / \phi_{cl}$].
R_n=	714.0	kips	Required nominal resistance for pile [Max of R_{n_up}, R_{n_low}].

Calculate the required area of steel

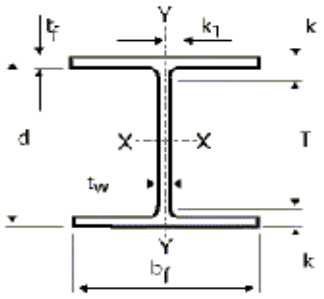
A_{s_req}=	17.850	in^2	Required area of steel to satisfy axial compression [$A_{s_req} = R_n / 0.8 * F_y$].

Choose preliminary HP-Pile Section

HP 14x102		Preliminary HP Section to be assessed for use at integral abutment.

Input HP shape properties

A_s=	30.000	in^2	Area of section
d=	14.000	in	Section depth
t_w=	0.705	in	Web thickness
b_f=	14.800	in	Flange width
t_f=	0.705	in	Flange thickness
k=	1.375	in	Distance from flange to fillet
T=	11.250	in	Web height excluding fillet
I_{xx}=	1050.000	in^4	Moment of Inertia about strong axis of HP section
S_{xx}=	150.000	in^3	Section modulus for strong axis bending
r_{xx}=	5.920	in	Radius of gyration for strong axis
Z_{xx}=	169.000	in^3	Plastic modulus for strong axis bending
I_{yy}=	380.000	in^4	Moment of Inertia about weak axis of HP section
S_{yy}=	51.400	in^3	Section modulus for weak axis bending
r_{yy}=	3.560	in	Radius of gyration
Z_{yy}=	78.800	in^3	Plastic modulus for weak axis bending



Input plate buckling coefficients for HP shape from AASHTO Table 6.9.4.2.1-1

k_f=	0.56	dim	Plate buckling coefficient for flanges
k_w=	1.49	dim	Plate buckling coefficient for web

Calculate and check pile properties

λ_f=	10.5	dim	Slenderness ratio for the compression flange as per AASHTO Eq. 6.12.2.2.1-3 [$\lambda_f = b_f / (2 * t_f)$]
λ_w=	16.0	dim	Slenderness ratio for the web as per AASHTO Eq. X.X.X.X.X-X [$\lambda_w = T / t_w$]

Check	OK	Check for flange buckling [OK if $\lambda_f \le k_f * (E*F_y)^{0.5}$]	13.49
Check	OK	Check for web buckling [OK if $\lambda_w \le k_w * (E*F_y)^{0.5}$]	35.88

Determine L-Pile load case parameters for displacement and slope

δ=	-0.45	in	Pile head displacement due to thermal expansion
θ=	0	rad	Slope of pile head (assuming no rotation)
P_u=	357000	lb	Axial load at pile head

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET (Cont.) South Abutment Strength I

Run L-Pile and determine the following parameters using Displacement and Slope input

M_{u_top}=	2324281	in-lb	Maximum moment at top of the pile from Lpile output
l_{b_top}=	4.37	ft	Depth of first virtual pin (zero moment on moment depth plot)
l_{b_bot}=	17.85	ft	Depth of second virtual pin (zero moment on moment depth plot)
l_{b_2nd}=	13.47737	ft	Total unbraced length from Lpile moment vs depth plot [$l_{b_2nd} = l_{b_bot} - l_{b_top}$]

x_0	x	x_1	y_0	y	y_1
3242	0	-85956	4.36	4.3699	4.6325
-4711	0	4814	17.713	17.847	17.985

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	1.2	dim	Effective length factor for upper section (fixed at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.054581	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * l_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.360533	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * l_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1466.4	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \le 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1291.3	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \le 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1026.5	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{n_top}$]
P_{r_2nd}=	903.9	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{n_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{n_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.348	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.395	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.476	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Calculate slenderness ratios for flexure resistance

λ_{pf}=	9.15	dim	Limiting slenderness ratio for a compact flange as per AASHTO Eq. 6.12.2.2.1-4 [$\lambda_{pf} = 0.38 * (E_s / F_y)^{0.5}$]
λ_{rf}=	19.99	dim	Limiting slenderness ratio for a non-compact flange as per AASHTO Eq. 6.12.2.2.1-5 [$\lambda_{pf} = 0.83 * (E_s / F_y)^{0.5}$]

Calculate nominal flexure resistance of pile as per AASHTO Section 6.12.2.2.1

M_n=	3770.0	in-kips	Nominal flexure resistance as per AASHTO Eq. 6.12.2.2.1-1

If $\lambda_f \le \lambda_{pf}$, then: $M_n = M_p$

If $\lambda_{pf} < \lambda_f \le \lambda_{rf}$, then:

$$M_n = \left[1 - \left(1 - \frac{S_y}{Z_y}\right)\left(\frac{\lambda_f - \lambda_{pf}}{0.45\sqrt{\frac{E}{F_{yf}}}}\right)\right] F_{yf} Z_y$$

Calculate the flexure resistance

M_r=	3770.0	in-kips	Factored flexure resistance as per AASHTO Eq. 6.12.1.2.1-1 [$M_r = \phi_f * M_n$]

Calculate the moment that will cause a plastic hinge at the pile cap

M_p=	2766.1	in-kips	Moment that will cause a plastic hinge at the pile cap [(9.0 /8.0) * (1- P_u / P_{r_top}) * M_r]

2324 in-kips

Check to determine if plastic hinge has formed

NO - Analysis Complete See below for explanation

YES: Since the applied moment exceeded the moment that would create a plastic hinge, it can be assumed that the pile head has entered plastic deformation and therefore the moment that can be applied to the pile head cannot exceed Mp. Additional analysis is required using the plastic moment to limit the bending resistance at the pile head, recalculate the unbraced length, and verify that a plastic hinge does not develop in the second pile segment.

NO: The applied moment does not exceed the moment that would create a plastic hinge at the pile head. No further analysis is required.

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

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INTEGRAL ABUTMENT PILE DESIGN WORKSHEET - CONTRACTION PLUS South Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Slope. Displacement is equal to the thermal expansion of the bridge and the slope is assumed to be zero to represent a fixed head condition. No corrosion. Isolation casing for top 10 ft. Boring 201. Downdrag present. Deflections account for 17.1k shear force from slope stability analysis and 6k of braking force.

Input factored load per pile to be assessed

P_u=	357	kips	Factored applied superstructure and substructure vertical dead and live load distributed to each pile. (Includes 52 kips factored downdrag load)

Input steel H-pile strengths

F_y=	50	ksi	Yield strength of steel H pile section.
E_s=	29000	ksi	Elastic modulus of steel H pile section.

Select axial resistance factors for the strength limit state from AASHTO Section 6.5.4.2

ϕ_{cu}=	0.70	dim	Axial resistance factor for the upper zone of the pile for combined axial and flexure with no damage.
ϕ_{cl}=	0.50	dim	Axial resistance factor for the lower zone of the pile in compression (Use 0.50 for severe driving & 0.60 for good driving).
ϕ_f=	1.00	dim	Flexure resistance factor for the upper zone of the pile for combined axial and flexure with no damage.

Calculate the required Nominal Axial Pile Resistance

R_{n_up}=	510.0	kips	Required nominal resistance for upper zone of pile [$R_{n_up} = P_u / \phi_{cu}$].
R_{n_low}=	714	kips	Required nominal resistance for lower zone of pile [$R_{n_low} = P_u / \phi_{cl}$].
R_n=	714.0	kips	Required nominal resistance for pile [Max of R_{n_up}, R_{n_low}].

Calculate the required area of steel

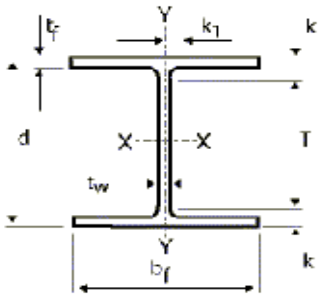
A_{s_req}=	17.850	in^2	Required area of steel to satisfy axial compression [$A_{s_req} = R_n / 0.8 * F_y$].

Choose preliminary HP-Pile Section

HP 14x102		Preliminary HP Section to be assessed for use at integral abutment.

Input HP shape properties

A_s=	30.000	in^2	Area of section
d=	14.000	in	Section depth
t_w=	0.705	in	Web thickness
b_f=	14.800	in	Flange width
t_f=	0.705	in	Flange thickness
k=	1.375	in	Distance from flange to fillet
T=	11.250	in	Web height excluding fillet
I_{xx}=	1050.000	in^4	Moment of Inertia about strong axis of HP section
S_{xx}=	150.000	in^3	Section modulus for strong axis bending
r_{xx}=	5.920	in	Radius of gyration for strong axis
Z_{xx}=	169.000	in^3	Plastic modulus for strong axis bending
I_{yy}=	380.000	in^4	Moment of Inertia about weak axis of HP section
S_{yy}=	51.400	in^3	Section modulus for weak axis bending
r_{yy}=	3.560	in	Radius of gyration
Z_{yy}=	78.800	in^3	Plastic modulus for weak axis bending



Input plate buckling coefficients for HP shape from AASHTO Table 6.9.4.2.1-1

k_f=	0.56	dim	Plate buckling coefficient for flanges
k_w=	1.49	dim	Plate buckling coefficient for web

Calculate and check pile properties

λ_f=	10.5	dim	Slenderness ratio for the compression flange as per AASHTO Eq. 6.12.2.2.1-3 [$\lambda_f = b_f / (2 * t_f)$]
λ_w=	16.0	dim	Slenderness ratio for the web as per AASHTO Eq. X.X.X.X.X-X [$\lambda_w = T / t_w$]

Check	OK	Check for flange buckling [OK if $\lambda_f \le k_f * (E*F_y)^{0.5}$]	13.49
Check	OK	Check for web buckling [OK if $\lambda_w \le k_w * (E*F_y)^{0.5}$]	35.88

Determine L-Pile load case parameters for displacement and slope

δ=	-1.9014	in	Pile head displacement due to thermal expansion
θ=	0	rad	Slope of pile head (assuming no rotation)
P_u=	357000	lb	Axial load at pile head

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET (Cont.) South Abutment Strength I

Run L-Pile and determine the following parameters using Displacement and Slope input

M_{u_top}=	3940084	in-lb	Maximum moment at top of the pile from Lpile output
I_{b_top}=	3.68	ft	Depth of first virtual pin (zero moment on moment depth plot)
I_{b_bot}=	18.94	ft	Depth of second virtual pin (zero moment on moment depth plot)
I_{b_2nd}=	15.25485	ft	Total unbraced length from Lpile moment vs depth plot [$I_{b_2nd} = I_{b_bot} - I_{b_top}$]

x_0	x	x_1	y_0	y	y_1
120159	0	-1E+05	3.5425	3.6821	3.815
-20344	0	20898	18.803	18.937	19.075

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	1.2	dim	Effective length factor for upper section (fixed at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.038751	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * I_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.461903	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * I_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1476.0	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \le 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1238.0	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \le 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1033.2	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{n_top}$]
P_{r_2nd}=	866.6	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{n_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{n_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.346	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.412	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.476	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Calculate slenderness ratios for flexure resistance

λ_{pf}=	9.15	dim	Limiting slenderness ratio for a compact flange as per AASHTO Eq. 6.12.2.2.1-4 [$\lambda_{pf} = 0.38 * (E_s / F_y)^{0.5}$]
λ_{rf}=	19.99	dim	Limiting slenderness ratio for a non-compact flange as per AASHTO Eq. 6.12.2.2.1-5 [$\lambda_{pf} = 0.83 * (E_s / F_y)^{0.5}$]

Calculate nominal flexure resistance of pile as per AASHTO Section 6.12.2.2.1

M_n=	3770.0	in-kips	Nominal flexure resistance as per AASHTO Eq. 6.12.2.2.1-1

If $\lambda_f \le \lambda_{pf}$, then: $M_n = M_p$

If $\lambda_{pf} < \lambda_f \le \lambda_{rf}$, then:

$$M_n = \left[1 - \left(1 - \frac{S_y}{Z_y}\right)\left(\frac{\lambda_f - \lambda_{pf}}{0.45\sqrt{\frac{E}{F_{yf}}}}\right)\right] F_{yf} Z_y$$

Calculate the flexure resistance

M_r=	3770.0	in-kips	Factored flexure resistance as per AASHTO Eq. 6.12.1.2.1-1 [$M_r = \phi_f * M_n$]

Calculate the moment that will cause a plastic hinge at the pile cap

M_p=	2775.8	in-kips	Moment that will cause a plastic hinge at the pile cap [(9.0 /8.0) * (1- P_u / P_{r_top}) * M_r]

3940 in-kips

Check to determine if plastic hinge has formed

YES - Additional Analysis Required See below for explanation

YES: Since the applied moment exceeded the moment that would create a plastic hinge, it can be assumed that the pile head has entered plastic deformation and therefore the moment that can be applied to the pile head cannot exceed Mp. Additional analysis is required using the plastic moment to limit the bending resistance at the pile head, recalculate the unbraced length, and verify that a plastic hinge does not develop in the second pile segment.

NO: The applied moment does not exceed the moment that would create a plastic hinge at the pile head. No further analysis is required.

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

HNTB	For	Burnham Bridge	Job No.	63738	Sheet No.	3 of 3
	Made by	KRR	Check		Backcheck	
	Date	10/13/2017	Date		Date	

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET South Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Moment. Displacement is equal to the thermal expansion of the bridge and the moment is equal to the plastic resistance. Pile head conditions are assumed to be pinned.

Determine L-Pile load case parameters for displacement and moment as input

δ=	-1.9014	in	Pile head displacement due to thermal expansion
M_p=	2775813	in-lb	Plastic moment capacity
P_u=	357000	lb	Axial load at pile head

Run L-Pile and determine the following parameters

M_{u_top}=	2775813	in-lb	Maximum moment at top of the pile from Lpile output
M_{u_2nd}=	-2235170	in-lb	Maximum moment from Lpile moment vs depth plot.

l_{b_top}=	2.82	ft	Depth of first virtual pin (zero moment on moment depth plot)
l_{b_bot}=	18.66	ft	Depth of second virtual pin (zero moment on moment depth plot)
l_{b_2nd}=	15.84	ft	Total unbraced length from Lpile moment vs depth plot [$l_{b_2nd} = l_{b_bot} - l_{b_top}$]

x_0	x	x_1	y_0	y	y_1
76676	0	-1E+05	2.725	2.8179	2.9975
-17813	0	19565	18.53	18.66	18.803

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	2.1	dim	Effective length factor for upper section (pinned at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.069507	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * l_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.49814	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * l_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1457.3	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \leq 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1219.5	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \leq 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1020.1	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{r_top}$]
P_{r_2nd}=	853.7	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{r_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{r_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.350	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.418	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.476	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check second pile segment for plastic hinge

M_{p_2nd} =	0.95	dim	Check for plastic hinge in second segment of pile
Check	OK		Check for plastic hinge in second segment of pile ("OK" if $M_{p_2nd} < 1.0$)

References:

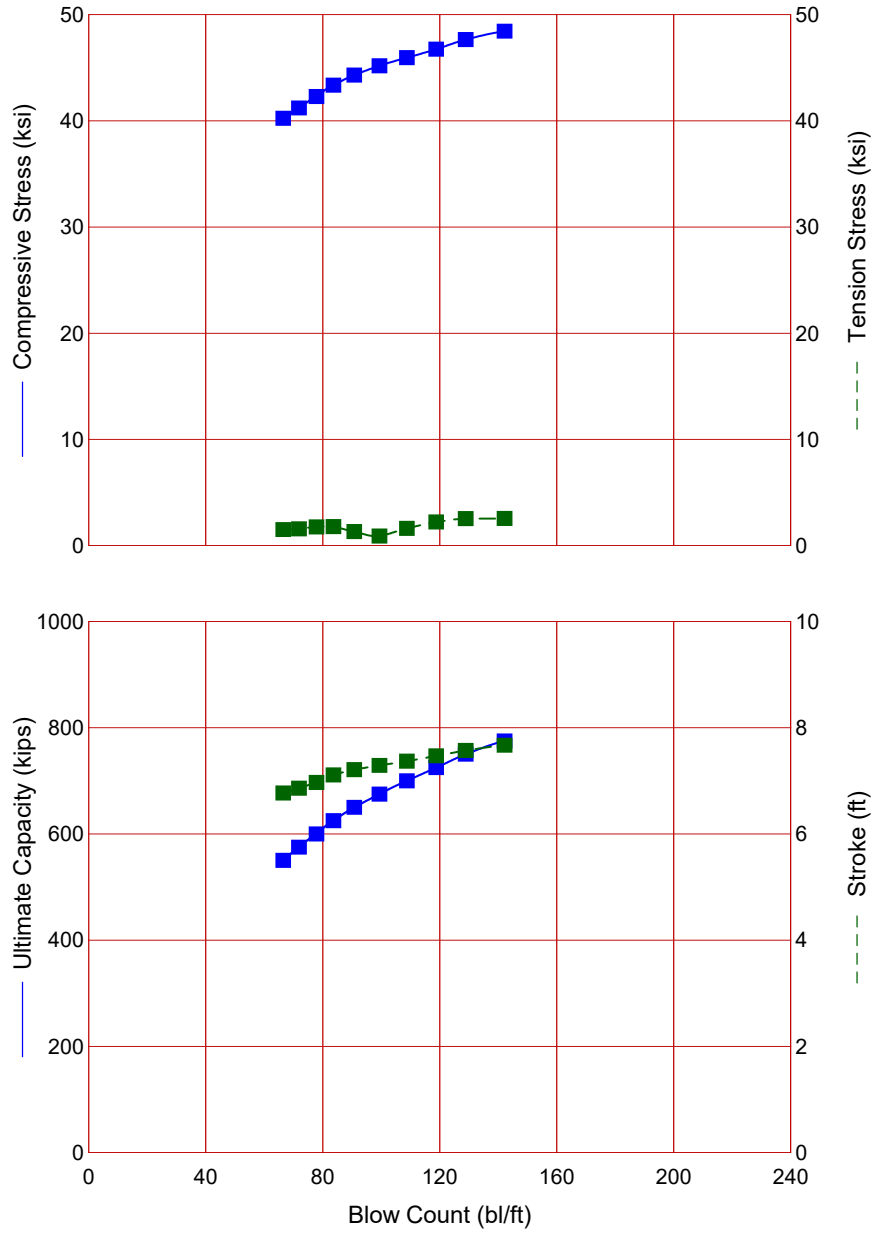
1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

ABUTMENT 1 (SOUTH)
WEAP ANALYSIS

HNTB

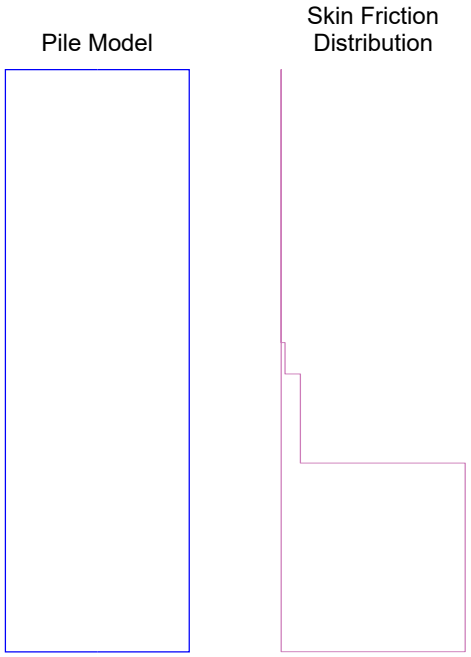
HNTB Corporation
HP 14x102

09-Nov-2017
GRLWEAP Version 2010



DELMAG D 36-32

Ram Weight	7.93	kips
Efficiency	0.800	
Pressure	1057 (72%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.070	in
Skin Damping	0.057	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	37.30	ft
Pile Penetration	19.80	ft
Pile Top Area	30.00	in2



Res. Shaft = 8 %
(Proportional)

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HP 14x102

09-Nov-2017
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
550.0	40.22	1.52	66.5	6.77	23.07
575.0	41.20	1.58	71.9	6.86	23.32
600.0	42.28	1.76	77.9	6.97	23.56
625.0	43.35	1.79	83.7	7.11	23.98
650.0	44.29	1.32	90.8	7.21	24.24
675.0	45.18	0.91	99.4	7.29	24.39
700.0	45.94	1.63	108.8	7.37	24.54
725.0	46.74	2.23	118.8	7.47	24.79
750.0	47.64	2.54	128.9	7.57	25.16
775.0	48.44	2.56	142.2	7.67	25.47

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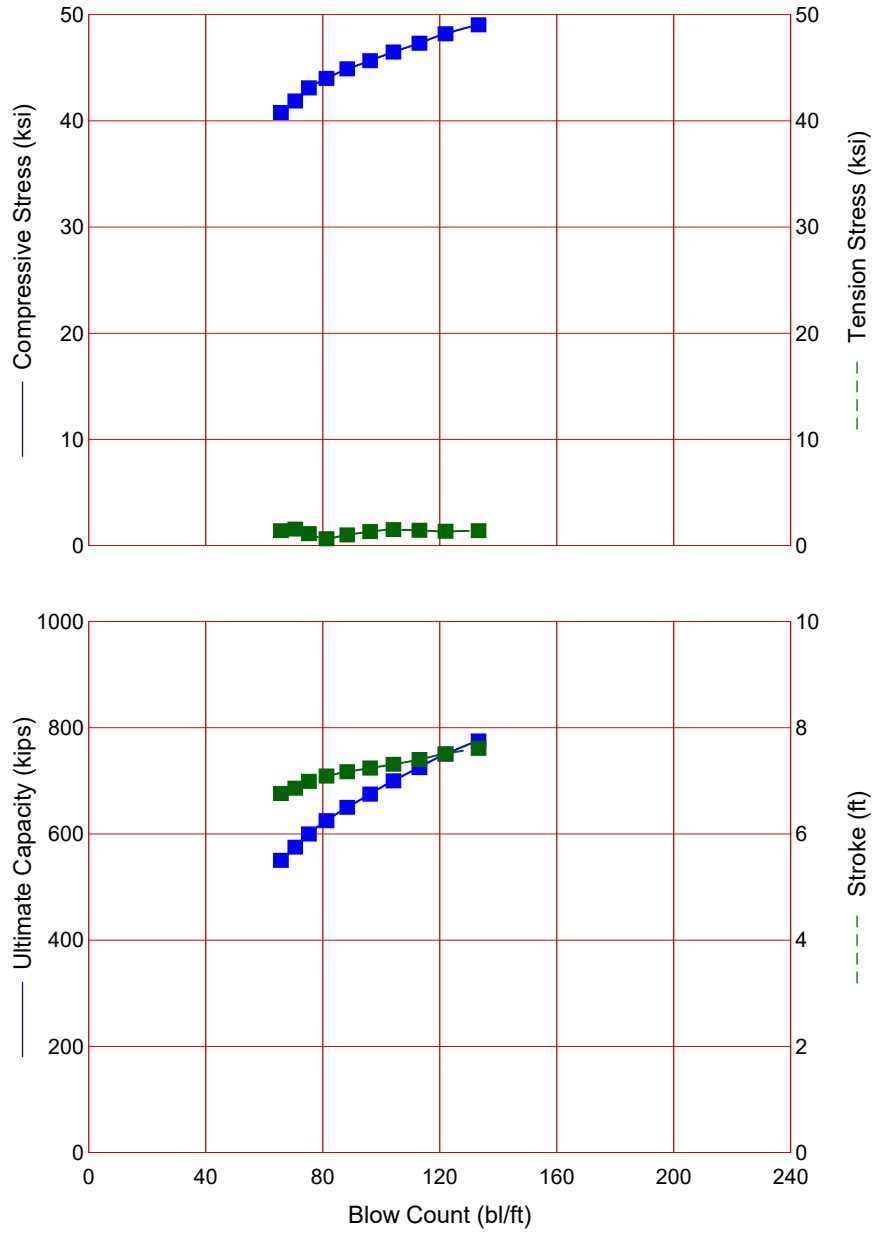
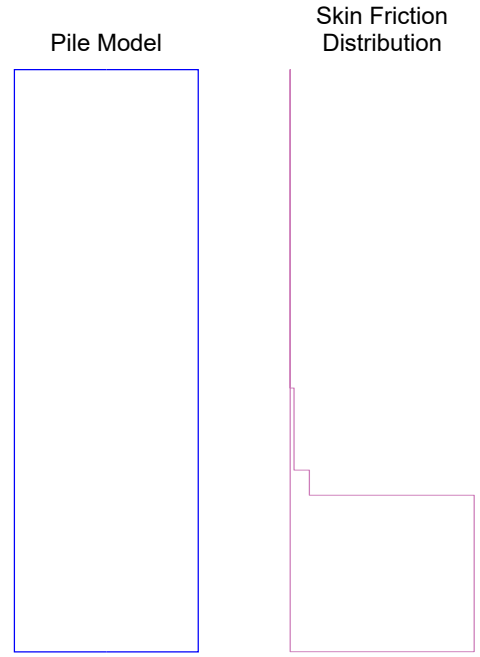
HP 14x102

09-Nov-2017
GRLWEAP Version 2010



DELMAG D 36-32

Ram Weight	7.93	kips
Efficiency	0.800	
Pressure	1057 (72%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.070	in
Skin Damping	0.054	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	32.00	ft
Pile Penetration	14.50	ft
Pile Top Area	30.00	in2



Res. Shaft = 8 %
(Proportional)

HNTB Corporation
HP 14x102

09-Nov-2017
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
550.0	40.77	1.41	65.7	6.76	22.47
575.0	41.86	1.56	70.6	6.86	22.70
600.0	43.09	1.13	75.3	6.99	23.10
625.0	43.98	0.66	81.3	7.09	23.26
650.0	44.88	1.02	88.4	7.17	23.33
675.0	45.65	1.32	96.2	7.24	23.44
700.0	46.47	1.51	104.2	7.31	23.63
725.0	47.29	1.44	113.1	7.40	23.85
750.0	48.19	1.36	122.0	7.51	24.17
775.0	49.02	1.41	133.3	7.61	24.34

HNTB	Prepared by: M. Ellis	Approved by: D. Evans	Document number: QF 06
Calculation Cover Sheet	Revision Number: 0	Revision Date: 1/22/2016	Page 1 of 2

Project: Burnham Bridge Replacement	**Job No: 63738**	**Design Criteria Document:**
Client: Maine DOT	**Discipline: Geotech**	**Calculation No: Abutment 2 (North) Piles**

Name or Description of Calculation:

Calc. Rev. No.	Originator	Checker	Senior Technical Reviewer (if required)	Confirmation Required (Y/N)
01	K. Reidy	B. Materek		

Calculation Objective:

The objective of this calculation is to calculate the required embedment, spacing and size of H-piles required to support Abutment 2 (North). Additionally, the amount of load induced on the piles due to downdrag was also evaluated. Abutment 2 was evaluated with the worst case boring scenario with BB-WGLC-104 for lateral analysis and BB-WGLC-203 for axial analysis. Additionally, drivability analyses were performed to develop a relationship between nominal axial geotechnical compressive resistance and the corresponding stresses in the pile assuming the piles are driven to those resistances.

Calculation Methodology/List of Assumptions:

- Soil Parameters have been developed from borings performed by Schonewald Engineering Associates, Inc. under the direction of HNTB between March 26 and March 31, 2016 and July 25 and July 27, 2017.
- Stratigraphy for lateral analysis was developed based on BB-WGLC-104.
- Stratigraphy for axial analysis was developed based on BB-WGLC-203.
- The groundwater was assumed to be elevation +133.0 ft due to governing case for slope stability analysis leading to worst loading conditions for pile analysis.
- Analysis was performed in accordance with AASHTO LRFD Bridge Design Specifications version 2014 with 2016 Interim Revisions, MaineDOT BDG, and recommendations in the "Integral Abutment Bridge Design Guidelines" by Vermont Department of Transportation.
- Loads were provided by HNTB Maine office on August 28, 2017. Downdrag load calculated and applied to length of pile that had 0.4 inches of settlement or more.
- Breaking forces and additional shear forces from the slope stability analysis were applied to the piles in the lateral analysis.
- Assumed no corrosion due to isolation casing with clean sand protecting the upper 10 feet of pile length.
- Top of pile in model is modeled as bottom of cap elevation.
- Lateral analysis was evaluated with the following load cases:
    1. Displacement & slope (0 degrees) to evaluate if plastic hinge forms.
    2. Displacement and moment to evaluate if second plastic hinge forms [if first plastic hinge does not form, this load case does not need to be evaluated]
    3. Use shear and moment where the braking and slope stability shear forces are added to the maximum moment and shear experienced in load case 2 to obtain a combined displacement.
    4. Repeat load case 1 with new combined displacement.
    5. Repeat load case 2 with same process.
- Preliminary drivability evaluations were conducted using the software program GRL WEAP 2010 distributed by GRL Engineers, Inc.
- Drivability analyses were performed assuming a Delmag 36-32 diesel hammer for this assessment using a Fuel Setting of 4

References/Inputs:

LPile version 2016.9.06 by Ensoft Inc.
APile version 2015.7.3 by Ensoft Inc.
Maine DOT Boring logs performed by HNTB
Contract Document Drawing No. 26 & 27

Attachments:

- Reference Plans
- Boring Logs & Location Plan
- Soil Parameters & Summary
- Abutment 2 Lateral Analysis – Boring 104
- Abutment 2 Axial Analysis – Boring 203
- Abutment 2 Downdrag calculation

Conclusions:

A total of 5 HP14x102 piles for each abutment spaced at 6 ft on center driven to the following elevations and resistances:

Table 1: Pile Tip Elevations and Nominal Driving Resistances

Location	Minimum Pile Tip Elevation (ft)	Estimated Pile Tip Elevation (ft)	Factored Axial Load (kips)	Minimum Required Nominal Driving Resistance (kips)
Abutment 2	116.0	110.0	345	531

Estimated Factored Drivability Resistance is 575 kips at 45 ksi.

Document Check:	Name	Signature	Date
Originator:	K. Reidy		10/17/17
Checker:	B. Materek		10/18/17
BackChecker:	K. Reidy		10/18/17
Updater:	K. Reidy		10/31/17
Verifier:	B. Materek		11/09/17

ABUTMENT 2 (NORTH)

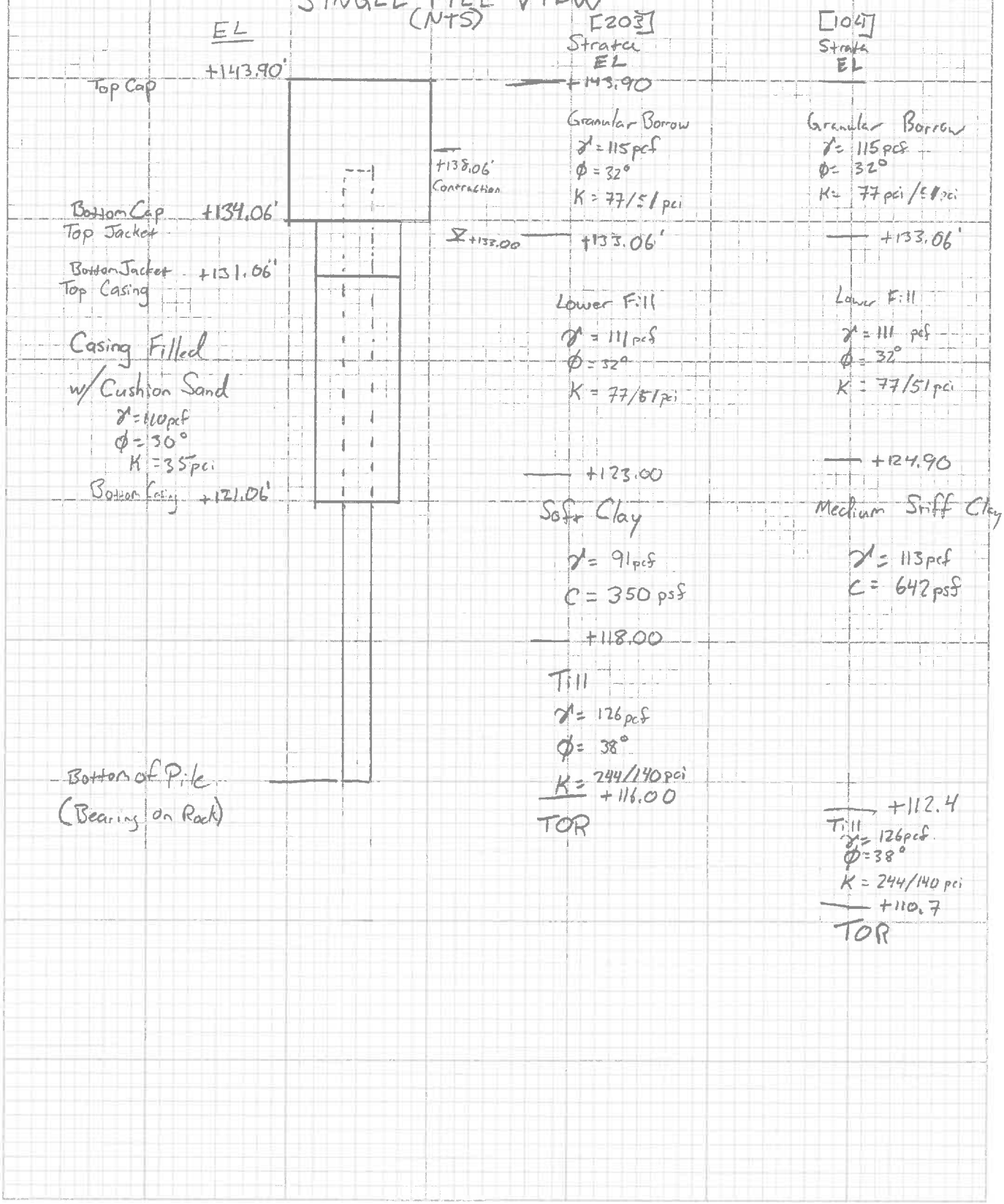
PILE ELEVATION VIEW SKETCH

Calculations for	Buchanan Bridge	Job No. 63738	Sheet No.
Made by	KRR	Date 10/13/17	
Checked by		Date	
Backchecked by		Date	

HNTB

WL @ +133

NORTH ABUTMENT SINGLE PILE VIEW (NTS)



ABUTMENT 2 (NORTH)

LATERAL & AXIAL ANALYSIS NOTES

HNTB

Notes

North Abutment

Changes to loading on piles

1. Piles will now be taking shear forces from the slope stability analysis, current assumption is 17.1k + 6k for braking
2. North abutment may have downdrag, see hand calc (40 kips)
3. Water elevation +133' in model due to controlling case with slope stability analysis
4. No corrosion in model
5. 10 ft isolation casing with cushion sand placed
6. Top of pile in LPILE is modeled as the bottom of the cap.
7. Boring 104 and Boring 203 both evaluated for deep and shallow rock, respectively.
8. Load cases are evaluated in the following procedure:
    1. displacement & slope (0) to evaluate if plastic hinge occurs
    2. displacement and moment [if first plastic hinge occurs to evaluate if second plastic hinge forms and fails]
    3. shear and moment [input max moment from 2 and also the shear from 2 plus what we are expecting the piles
    to experience from the soil, to obtain the combined displacement for evaluation]
    4. repeat step 1 with new "total" displacement to evaluate worst case of soil mobilization and full thermal movement
    5. Repeat step 2

ABUTMENT 2 (NORTH)

AXIAL ANALYSIS FOR DOWNDRAG

HNTB

Calculations for	Burnham Bridge	Job No. 63738	Sheet No.
Made by	KRR	Date	
Checked by		Date	
Backchecked by		Date	

HNTB

Additional Factored Downdrag Load @ North Abutment w/ HP14x102

Top of Pile EL: +134.66'

AASHTO BDS 2015 3.11.8: Account for DD if settlement ≥ 0.4 in

Settle 3D shows < 0.4 in settlement @ EL +124.00'

Total Skin Friction applied to pile from top of pile to EL + 124.00'

f_s = 28.5 kips

Downdrag Load Factor for Piles: 1.4

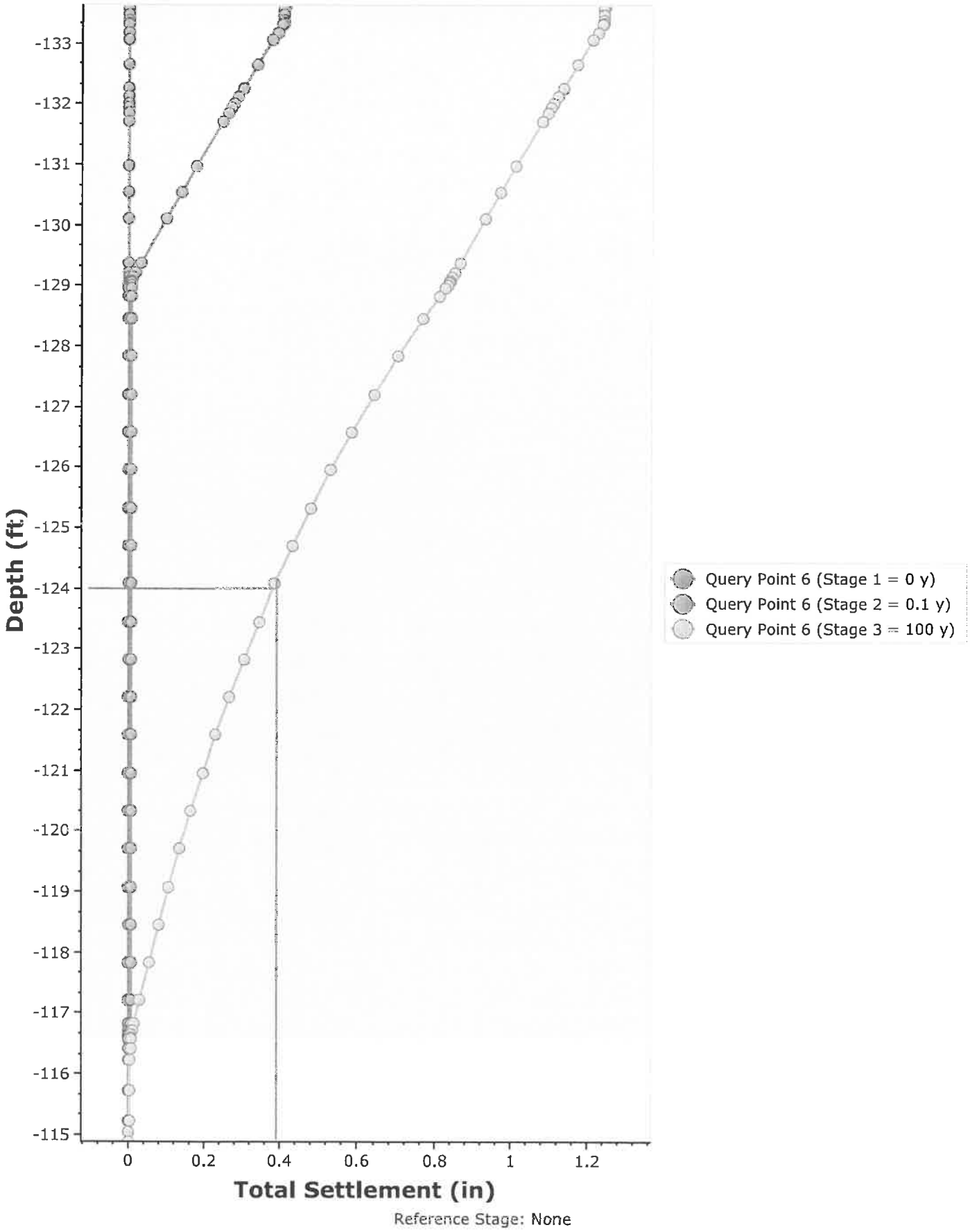
AASHTO LRFD BDS 2015 Table 3.4.1-2

Factored DD Load = 28.5 kips x 1.4

= 39.9 kips

Use 40 kips

Total Settlement vs. Depth



Reference Stage: None

APILE for Windows, Version 2015.7.3

Serial Number : 160779486

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.
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Path to file locations : \\fflw00\pmwork2\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Deep Foundations\Piles\North Abutment\FINAL DESIGN\APILE\HP14x102\DD\
Name of input data file : .ap7d
Name of output file : .ap7o
Name of plot output file : .ap7p

Time and Date of Analysis

Date: October 18, 2017 Time: 09:10:24

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****
* INPUT INFORMATION *
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Burnham Bridge - Boring 203 - North Abutment

DESIGNER : KRR

JOB NUMBER : 63738

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)
- API RP 2A (American Petroleum Institute)

TYPE OF LOADING :

- COMPRESSION

PILE TYPE :

H-Pile/Steel Pile

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 30.00 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 27.90 FT.
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 9.30 FT.
- PERIMETER OF PILE = 57.60 IN.
- TIP AREA OF PILE = 30.00 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	SAND	0.00	115.00	32.00	0.00
10.30	SAND	0.00	115.00	32.00	0.00
10.30	SAND	0.00	111.00	32.00	0.00
10.90	SAND	0.00	111.00	32.00	0.00
10.90	SAND	0.00	48.60	32.00	0.00
12.30	SAND	0.00	48.60	32.00	0.00
12.30	SAND	0.00	47.60	30.00	0.00
22.30	SAND	0.00	47.60	30.00	0.00
22.30	CLAY	0.00	29.00	0.00	0.00
25.90	CLAY	0.00	29.00	0.00	0.00
25.90	SAND	0.00	64.00	38.00	0.00
27.90	SAND	0.00	64.00	38.00	0.00
27.90	SAND	0.00	100.00	50.00	0.00
35.00	SAND	0.00	100.00	50.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

0.10E+08*	0.10E+08*	0.35	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.35	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
10.30	1.000	1.000
10.30	1.000	1.000
10.90	1.000	1.000
10.90	1.000	1.000
12.30	1.000	1.000
12.30	1.000	1.000
22.30	1.000	1.000
22.30	1.000	1.000
25.90	1.000	1.000
25.90	1.000	1.000
27.90	1.000	1.000
27.90	1.000	1.000
35.00	1.000	1.000

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* COMPUTATION RESULT *
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* FED. HWY. METHOD *
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PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.3	0.3
1.00	0.0	0.6	0.6
2.00	0.0	1.2	1.2
3.00	0.0	1.8	1.8
4.00	0.0	2.4	2.4
5.00	0.0	3.0	3.0
6.00	0.0	3.6	3.6
7.00	0.0	4.2	4.2
8.00	0.0	4.8	4.8
9.00	0.0	5.4	5.4
10.00	1.2	6.0	7.2
11.00	3.7	6.1	9.8
12.00	6.4	5.5	11.9
13.00	9.3	4.8	14.1
14.00	12.0	3.9	16.0

15.00	14.6	3.0	17.6
16.00	17.2	2.8	20.0
17.00	19.9	2.8	22.7
18.00	22.7	2.8	25.5
19.00	25.6	2.8	28.4
20.00	28.5	2.8	31.3
21.00	31.6	2.6	34.2
22.00	34.7	2.2	36.9
23.00	37.9	1.7	39.6
24.00	40.4	3.3	43.7
25.00	42.0	10.1	52.1
26.00	43.7	25.0	68.7
27.00	48.4	58.4	106.7

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* API RP-2A (1994) *
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PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0
1.00	0.0	0.0	0.0
2.00	0.0	0.0	0.0
3.00	0.0	0.0	0.0
4.00	0.0	0.0	0.0
5.00	0.0	0.0	0.0
6.00	0.0	0.0	0.0
7.00	0.0	0.0	0.0
8.00	0.0	0.0	0.0
9.00	0.0	0.0	0.0
10.00	0.0	0.0	0.0
11.00	0.0	0.0	0.0
12.00	0.0	0.0	0.0
13.00	0.0	0.0	0.0
14.00	0.0	0.0	0.0
15.00	0.0	0.0	0.0
16.00	0.0	0.0	0.0
17.00	0.0	0.0	0.0
18.00	0.0	0.0	0.0
19.00	0.0	0.0	0.0
20.00	0.0	0.0	0.0
21.00	0.0	0.0	0.0
22.00	0.0	0.2	0.2
23.00	0.0	0.3	0.3
24.00	0.8	0.4	1.3
25.00	2.5	0.4	2.9
26.00	4.2	0.3	4.5
27.00	5.0	0.2	5.2

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

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* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING *

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.1000E-01
			0.0000E+00	0.2000E-01
			0.0000E+00	0.4000E-01
			0.0000E+00	0.6000E-01
			0.0000E+00	0.8000E-01
			0.0000E+00	0.9000E-01
			0.0000E+00	0.1000E+00
			0.0000E+00	0.5000E+00
			0.0000E+00	0.2000E+01
2	10	0.5175E+01		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.1000E-01
			0.0000E+00	0.2000E-01
			0.0000E+00	0.4000E-01
			0.0000E+00	0.6000E-01
			0.0000E+00	0.8000E-01
			0.0000E+00	0.9000E-01
			0.0000E+00	0.1000E+00
			0.0000E+00	0.5000E+00
			0.0000E+00	0.2000E+01
3	10	0.1026E+02		
			0.0000E+00	0.0000E+00
			0.3779E+00	0.1000E-01
			0.7557E+00	0.2000E-01
			0.1511E+01	0.4000E-01
			0.2267E+01	0.6000E-01
			0.3023E+01	0.8000E-01
			0.3401E+01	0.9000E-01
			0.3779E+01	0.1000E+00
			0.3779E+01	0.5000E+00
			0.3779E+01	0.2000E+01
4	10	0.1030E+02		
			0.0000E+00	0.0000E+00
			0.3779E+00	0.1000E-01
			0.7557E+00	0.2000E-01
			0.1511E+01	0.4000E-01
			0.2267E+01	0.6000E-01
			0.3023E+01	0.8000E-01
			0.3401E+01	0.9000E-01
			0.3779E+01	0.1000E+00
			0.3779E+01	0.5000E+00
			0.3779E+01	0.2000E+01
5	10	0.1083E+02		
			0.0000E+00	0.0000E+00
			0.3779E+00	0.1000E-01
			0.7557E+00	0.2000E-01
			0.1511E+01	0.4000E-01
			0.2267E+01	0.6000E-01
			0.3023E+01	0.8000E-01
			0.3401E+01	0.9000E-01
			0.3779E+01	0.1000E+00
			0.3779E+01	0.5000E+00
			0.3779E+01	0.2000E+01
6	10	0.1126E+02		
			0.0000E+00	0.0000E+00

			0.4067E+00	0.1000E-01
			0.8134E+00	0.2000E-01
			0.1627E+01	0.4000E-01
			0.2440E+01	0.6000E-01
			0.3253E+01	0.8000E-01
			0.3660E+01	0.9000E-01
			0.4067E+01	0.1000E+00
			0.4067E+01	0.5000E+00
			0.4067E+01	0.2000E+01
7	10	0.1130E+02		
			0.0000E+00	0.0000E+00
			0.4067E+00	0.1000E-01
			0.8134E+00	0.2000E-01
			0.1627E+01	0.4000E-01
			0.2440E+01	0.6000E-01
			0.3253E+01	0.8000E-01
			0.3660E+01	0.9000E-01
			0.4067E+01	0.1000E+00
			0.4067E+01	0.5000E+00
			0.4067E+01	0.2000E+01
8	10	0.1183E+02		
			0.0000E+00	0.0000E+00
			0.4067E+00	0.1000E-01
			0.8134E+00	0.2000E-01
			0.1627E+01	0.4000E-01
			0.2440E+01	0.6000E-01
			0.3253E+01	0.8000E-01
			0.3660E+01	0.9000E-01
			0.4067E+01	0.1000E+00
			0.4067E+01	0.5000E+00
			0.4067E+01	0.2000E+01
9	10	0.1226E+02		
			0.0000E+00	0.0000E+00
			0.4065E+00	0.1000E-01
			0.8131E+00	0.2000E-01
			0.1626E+01	0.4000E-01
			0.2439E+01	0.6000E-01
			0.3252E+01	0.8000E-01
			0.3659E+01	0.9000E-01
			0.4065E+01	0.1000E+00
			0.4065E+01	0.5000E+00
			0.4065E+01	0.2000E+01
10	10	0.1230E+02		
			0.0000E+00	0.0000E+00
			0.4065E+00	0.1000E-01
			0.8131E+00	0.2000E-01
			0.1626E+01	0.4000E-01
			0.2439E+01	0.6000E-01
			0.3252E+01	0.8000E-01
			0.3659E+01	0.9000E-01
			0.4065E+01	0.1000E+00
			0.4065E+01	0.5000E+00
			0.4065E+01	0.2000E+01
11	10	0.1733E+02		
			0.0000E+00	0.0000E+00
			0.4100E+00	0.1000E-01
			0.8200E+00	0.2000E-01
			0.1640E+01	0.4000E-01
			0.2460E+01	0.6000E-01
			0.3280E+01	0.8000E-01
			0.3690E+01	0.9000E-01
			0.4100E+01	0.1000E+00
			0.4100E+01	0.5000E+00

			0.4100E+01	0.2000E+01
12	10	0.2226E+02		
			0.0000E+00	0.0000E+00
			0.4093E+00	0.1000E-01
			0.8187E+00	0.2000E-01
			0.1637E+01	0.4000E-01
			0.2456E+01	0.6000E-01
			0.3275E+01	0.8000E-01
			0.3684E+01	0.9000E-01
			0.4093E+01	0.1000E+00
			0.4093E+01	0.5000E+00
			0.4093E+01	0.2000E+01
13	10	0.2230E+02		
			0.0000E+00	0.0000E+00
			0.1228E+01	0.2934E-01
			0.2047E+01	0.5684E-01
			0.3070E+01	0.1045E+00
			0.3684E+01	0.1467E+00
			0.4093E+01	0.1833E+00
			0.3684E+01	0.3667E+00
			0.3684E+01	0.5500E+00
			0.3684E+01	0.9167E+00
			0.3684E+01	0.3667E+01
14	10	0.2413E+02		
			0.0000E+00	0.0000E+00
			0.7292E+00	0.2934E-01
			0.1215E+01	0.5684E-01
			0.1823E+01	0.1045E+00
			0.2187E+01	0.1467E+00
			0.2431E+01	0.1833E+00
			0.2187E+01	0.3667E+00
			0.2187E+01	0.5500E+00
			0.2187E+01	0.9167E+00
			0.2187E+01	0.3667E+01
15	10	0.2586E+02		
			0.0000E+00	0.0000E+00
			0.1369E+01	0.2934E-01
			0.2282E+01	0.5684E-01
			0.3423E+01	0.1045E+00
			0.4108E+01	0.1467E+00
			0.4564E+01	0.1833E+00
			0.4108E+01	0.3667E+00
			0.4108E+01	0.5500E+00
			0.4108E+01	0.9167E+00
			0.4108E+01	0.3667E+01
16	10	0.2590E+02		
			0.0000E+00	0.0000E+00
			0.4564E+00	0.1000E-01
			0.9129E+00	0.2000E-01
			0.1826E+01	0.4000E-01
			0.2739E+01	0.6000E-01
			0.3652E+01	0.8000E-01
			0.4108E+01	0.9000E-01
			0.4564E+01	0.1000E+00
			0.4564E+01	0.5000E+00
			0.4564E+01	0.2000E+01
17	10	0.2693E+02		
			0.0000E+00	0.0000E+00
			0.6698E+00	0.1000E-01
			0.1340E+01	0.2000E-01
			0.2679E+01	0.4000E-01
			0.4019E+01	0.6000E-01
			0.5359E+01	0.8000E-01

			0.6028E+01	0.9000E-01
			0.6698E+01	0.1000E+00
			0.6698E+01	0.5000E+00
			0.6698E+01	0.2000E+01
18	10	0.2786E+02		
			0.0000E+00	0.0000E+00
			0.6698E+00	0.1000E-01
			0.1340E+01	0.2000E-01
			0.2679E+01	0.4000E-01
			0.4019E+01	0.6000E-01
			0.5359E+01	0.8000E-01
			0.6028E+01	0.9000E-01
			0.6698E+01	0.1000E+00
			0.6698E+01	0.5000E+00
			0.6698E+01	0.2000E+01
19	10	0.2790E+02		
			0.0000E+00	0.0000E+00
			0.6698E+00	0.1000E-01
			0.1340E+01	0.2000E-01
			0.2679E+01	0.4000E-01
			0.4019E+01	0.6000E-01
			0.5359E+01	0.8000E-01
			0.6028E+01	0.9000E-01
			0.6698E+01	0.1000E+00
			0.6698E+01	0.5000E+00
			0.6698E+01	0.2000E+01
20	10	0.3148E+02		
			0.0000E+00	0.0000E+00
			0.6698E+00	0.1000E-01
			0.1340E+01	0.2000E-01
			0.2679E+01	0.4000E-01
			0.4019E+01	0.6000E-01
			0.5359E+01	0.8000E-01
			0.6028E+01	0.9000E-01
			0.6698E+01	0.1000E+00
			0.6698E+01	0.5000E+00
			0.6698E+01	0.2000E+01
21	10	0.3496E+02		
			0.0000E+00	0.0000E+00
			0.6698E+00	0.1000E-01
			0.1340E+01	0.2000E-01
			0.2679E+01	0.4000E-01
			0.4019E+01	0.6000E-01
			0.5359E+01	0.8000E-01
			0.6028E+01	0.9000E-01
			0.6698E+01	0.1000E+00
			0.6698E+01	0.5000E+00
			0.6698E+01	0.2000E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.3647E+01	0.9167E-02
0.7295E+01	0.1833E-01
0.1459E+02	0.3667E-01
0.2918E+02	0.2383E+00
0.4377E+02	0.7701E+00
0.5252E+02	0.1338E+01
0.5836E+02	0.1833E+01
0.5836E+02	0.2750E+01

0.5836E+02 0.3667E+01

LOAD VERSUS SETTLEMENT CURVE
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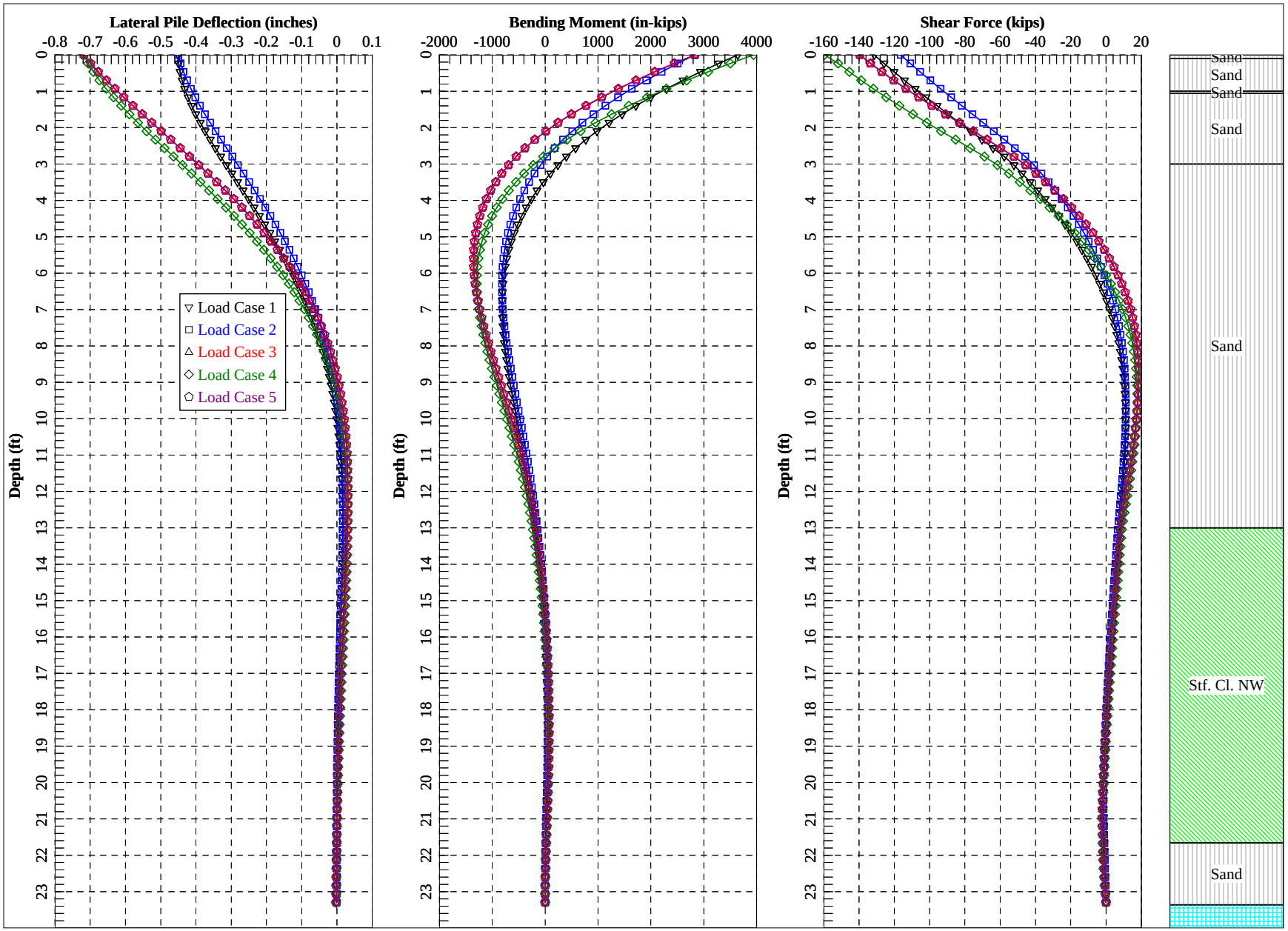
TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.1019E+00	0.1306E-03	0.3979E-01	0.1000E-03
0.1019E+01	0.1306E-02	0.3979E+00	0.1000E-02
0.5097E+01	0.6530E-02	0.1989E+01	0.5000E-02
0.1019E+02	0.1306E-01	0.3979E+01	0.1000E-01
0.4578E+02	0.6339E-01	0.1555E+02	0.5000E-01
0.7410E+02	0.1209E+00	0.1917E+02	0.1000E+00
0.9288E+02	0.5281E+00	0.3636E+02	0.5000E+00
0.1038E+03	0.1032E+01	0.4731E+02	0.1000E+01
0.1149E+03	0.2037E+01	0.5836E+02	0.2000E+01

ABUTMENT 2 (NORTH)

LATERAL ANALYSIS

HNTB

LPILE - North Abutment - Expansion - HP14x102 - BB-WCLG-104



LPile for Windows, Version 2016-09.006

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Deep Foundations\Piles\North Abutment\FINAL DESIGN\LPILE - HP14x102\DD\Boring 104\

Name of input data file:
NAbut_HP14x102_Weak_Expansion_Thermal.lp9d

Name of output report file:
NAbut_HP14x102_Weak_Expansion_Thermal.lp9o

Name of plot output file:
NAbut_HP14x102_Weak_Expansion_Thermal.lp9p

Name of runtime message file:
NAbut_HP14x102_Weak_Expansion_Thermal.lp9r

Date and Time of Analysis

Date: October 30, 2017 Time: 17:24:36

Problem Title

Project Name: Burnham Bridge

Job Number: 63738

Client: Maine DOT

Engineer: BAM-KRR

Description: North Abutment_HP14x89_5 Piles_Weak Axis_No Corrosion

Program Options and Settings

Computational Options:
- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 1
Total length of pile = 23.300 ft
Depth of ground surface below top of pile = -9.8400 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.0000
2	23.300	14.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

   Section 1 is an elastic pile with a specified moment capacity
   Cross-sectional Shape = Weak H-Pile
   Length of section = 23.300000 ft
   Flange Width = 14.800000 in
   Section Depth = 14.000000 in
   Flange Thickness = 0.705000 in
   Web Thickness = 0.705000 in
   Section Area = 29.743950 sq. in
   Moment of Inertia = 381.278191 in^4
   Elastic Modulus = 29000000. psi
   Plastic Moment Capacity = 3940000. in-lb
   Top Elastic Bending Stiffness = 1.1057E+10 lbs-in^2
   Bot Elastic Bending Stiffness = 1.1057E+10 lbs-in^2
   Shear Capacity at top of section = 296100. lbs
   Shear Capacity at bottom of section = 296100. lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 8 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer = -9.840000 ft
   Distance from top of pile to bottom of layer = 0.100000 ft
   Effective unit weight at top of layer = 115.000000 pcf
   Effective unit weight at bottom of layer = 115.000000 pcf

Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	0.100000 ft
Distance from top of pile to bottom of layer	=	1.000000 ft
Effective unit weight at top of layer	=	115.000000 pcf
Effective unit weight at bottom of layer	=	115.000000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	1.000000 ft
Distance from top of pile to bottom of layer	=	1.060000 ft
Effective unit weight at top of layer	=	111.000000 pcf
Effective unit weight at bottom of layer	=	111.000000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	1.060000 ft
Distance from top of pile to bottom of layer	=	3.000000 ft
Effective unit weight at top of layer	=	48.600000 pcf
Effective unit weight at bottom of layer	=	48.600000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	51.000000 pci
Subgrade k at bottom of layer	=	51.000000 pci

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	3.000000 ft
Distance from top of pile to bottom of layer	=	13.000000 ft
Effective unit weight at top of layer	=	47.600000 pcf
Effective unit weight at bottom of layer	=	47.600000 pcf
Friction angle at top of layer	=	30.000000 deg.
Friction angle at bottom of layer	=	30.000000 deg.
Subgrade k at top of layer	=	35.000000 pci
Subgrade k at bottom of layer	=	35.000000 pci

Layer 6 is stiff clay without free water

Distance from top of pile to top of layer	=	13.000000 ft
Distance from top of pile to bottom of layer	=	21.660000 ft
Effective unit weight at top of layer	=	50.600000 pcf
Effective unit weight at bottom of layer	=	50.600000 pcf
Undrained cohesion at top of layer	=	642.000000 psf
Undrained cohesion at bottom of layer	=	642.000000 psf
Epsilon-50 at top of layer	=	0.0000
Epsilon-50 at bottom of layer	=	0.0000

NOTE: Default values for Epsilon-50 will be computed for this layer.

Layer 7 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	21.660000 ft
Distance from top of pile to bottom of layer	=	23.360000 ft
Effective unit weight at top of layer	=	64.000000 pcf
Effective unit weight at bottom of layer	=	64.000000 pcf
Friction angle at top of layer	=	38.000000 deg.
Friction angle at bottom of layer	=	38.000000 deg.
Subgrade k at top of layer	=	140.000000 pci
Subgrade k at bottom of layer	=	140.000000 pci

Layer 8 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	23.360000 ft
Distance from top of pile to bottom of layer	=	30.000000 ft
Effective unit weight at top of layer	=	100.000000 pcf
Effective unit weight at bottom of layer	=	100.000000 pcf
Uniaxial compressive strength at top of layer	=	5000. psi
Uniaxial compressive strength at bottom of layer	=	5000. psi
Initial modulus of rock at top of layer	=	125000. psi
Initial modulus of rock at bottom of layer	=	125000. psi
RQD of rock at top of layer	=	35.000000 %
RQD of rock at bottom of layer	=	35.000000 %

k rm of rock at top of layer = 0.0010000
k rm of rock at bottom of layer = 0.0010000

(Depth of the lowest soil layer extends 6.700 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm
	Rock Mass Modulus kpy pci / psi							
1	Sand	-9.8400	115.0000	--	32.0000	--	--	--
77.0000	--							
	(Reese, et al.)	0.10000	115.0000	--	32.0000	--	--	--
77.0000	--							
2	Sand	0.10000	115.0000	--	32.0000	--	--	--
77.0000	--							
	(Reese, et al.)	1.0000	115.0000	--	32.0000	--	--	--
77.0000	--							
3	Sand	1.0000	111.0000	--	32.0000	--	--	--
77.0000	--							
	(Reese, et al.)	1.0600	111.0000	--	32.0000	--	--	--
77.0000	--							
4	Sand	1.0600	48.6000	--	32.0000	--	--	--
51.0000	--							
	(Reese, et al.)	3.0000	48.6000	--	32.0000	--	--	--
51.0000	--							
5	Sand	3.0000	47.6000	--	30.0000	--	--	--
35.0000	--							
	(Reese, et al.)	13.0000	47.6000	--	30.0000	--	--	--
35.0000	--							
6	Stiff Clay	13.0000	50.6000	642.0000	--	--	--	default
--	--							
	w/o Free Water	21.6600	50.6000	642.0000	--	--	--	default
--	--							
7	Sand	21.6600	64.0000	--	38.0000	--	--	--
140.0000	--							
	(Reese, et al.)	23.3600	64.0000	--	38.0000	--	--	--
140.0000	--							
8	Weak	23.3600	100.0000	--	--	5000.	35.0000	0.00100
--	125000.							
	Rock	30.0000	100.0000	--	--	5000.	35.0000	0.00100
--	125000.							

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 5

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = -0.450000 in	S = 0.0000 in/in	345000.	N.A.
2	4	y = -0.450000 in	M = 2828014. in-lbs	345000.	N.A.
3	1	V = -139529. lbs	M = 2828014. in-lbs	345000.	No
4	5	y = -0.718100 in	S = 0.0000 in/in	345000.	N.A.
5	4	y = -0.718100 in	M = 2835049. in-lbs	345000.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic-plastic section properties

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Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	-9.8400	0.00	N.A.	No	0.00	2602.
2	0.1000	9.9400	Yes	No	2602.	1374.
3	1.0000	10.8400	Yes	No	3976.	176.5841
4	1.0600	10.9000	Yes	No	4153.	11634.
5	3.0000	12.8400	Yes	No	15786.	203344.
6	13.0000	13.0000	No	No	219131.	58377.
7	21.6600	14.4034	No	No	277508.	147703.
8	23.3600	33.2000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = -0.450000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 345000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.4500	3643147.	-131396.	0.00	78485.	1.11E+10	1910.	5933.	0.00
0.2330	-0.4487	3283146.	-125814.	8.76E-04	71875.	1.11E+10	1991.	12405.	0.00
0.4660	-0.4451	2937907.	-120143.	0.00166	65537.	1.11E+10	2065.	12973.	0.00
0.6990	-0.4394	2608097.	-114274.	0.00236	59482.	1.11E+10	2133.	13573.	0.00
0.9320	-0.4319	2294326.	-108225.	0.00298	53721.	1.11E+10	2194.	14204.	0.00
1.1650	-0.4227	1997147.	-102033.	0.00353	48265.	1.11E+10	2235.	14784.	0.00
1.3980	-0.4122	1716956.	-95755.	0.00400	43121.	1.11E+10	2255.	15297.	0.00
1.6310	-0.4004	1453975.	-89432.	0.00440	38293.	1.11E+10	2268.	15840.	0.00
1.8640	-0.3876	1208372.	-83080.	0.00473	33784.	1.11E+10	2275.	16413.	0.00
2.0970	-0.3739	980261.	-76717.	0.00501	29596.	1.11E+10	2276.	17021.	0.00
2.3300	-0.3596	769706.	-70358.	0.00523	25730.	1.11E+10	2272.	17667.	0.00
2.5630	-0.3447	576725.	-64019.	0.00540	22187.	1.11E+10	2262.	18353.	0.00
2.7960	-0.3294	401291.	-57713.	0.00552	18966.	1.11E+10	2248.	19086.	0.00
3.0290	-0.3138	243335.	-52199.	0.00561	16066.	1.11E+10	1696.	15112.	0.00
3.2620	-0.2980	98578.	-47535.	0.00565	13409.	1.11E+10	1640.	15386.	0.00
3.4950	-0.2822	-33383.	-43033.	0.00566	12212.	1.11E+10	1580.	15660.	0.00
3.7280	-0.2664	-152980.	-38702.	0.00563	14408.	1.11E+10	1518.	15933.	0.00
3.9610	-0.2507	-260673.	-34548.	0.00558	16385.	1.11E+10	1453.	16207.	0.00
4.1940	-0.2352	-356944.	-30579.	0.00550	18152.	1.11E+10	1386.	16480.	0.00
4.4270	-0.2199	-442291.	-26799.	0.00540	19719.	1.11E+10	1318.	16754.	0.00
4.6600	-0.2049	-517229.	-23212.	0.00528	21095.	1.11E+10	1248.	17028.	0.00
4.8930	-0.1904	-582284.	-19821.	0.00514	22289.	1.11E+10	1178.	17301.	0.00
5.1260	-0.1762	-637988.	-16626.	0.00499	23312.	1.11E+10	1107.	17575.	0.00
5.3590	-0.1625	-684879.	-13628.	0.00482	24173.	1.11E+10	1037.	17848.	0.00
5.5920	-0.1492	-723494.	-10825.	0.00464	24882.	1.11E+10	967.2388	18122.	0.00
5.8250	-0.1365	-754372.	-8218.	0.00446	25449.	1.11E+10	898.1151	18396.	0.00
6.0580	-0.1243	-778044.	-5802.	0.00426	25883.	1.11E+10	830.0620	18669.	0.00
6.2910	-0.1127	-795038.	-3574.	0.00406	26195.	1.11E+10	763.3495	18943.	0.00
6.5240	-0.1016	-805870.	-1531.	0.00386	26394.	1.11E+10	698.2216	19217.	0.00
6.7570	-0.09108	-811047.	332.9061	0.00366	26489.	1.11E+10	634.8968	19490.	0.00
6.9900	-0.08114	-811063.	2022.	0.00345	26490.	1.11E+10	573.5682	19764.	0.00
7.2230	-0.07178	-806397.	3543.	0.00325	26404.	1.11E+10	514.4043	20037.	0.00
7.4560	-0.06299	-797513.	4902.	0.00304	26241.	1.11E+10	457.5493	20311.	0.00
7.6890	-0.05476	-784857.	6105.	0.00284	26008.	1.11E+10	403.1246	20585.	0.00
7.9220	-0.04708	-768859.	7160.	0.00265	25715.	1.11E+10	351.2288	20858.	0.00
8.1550	-0.03995	-749927.	8073.	0.00246	25367.	1.11E+10	301.9394	21132.	0.00
8.3880	-0.03335	-728452.	8852.	0.00227	24973.	1.11E+10	255.3135	21406.	0.00
8.6210	-0.02726	-704803.	9505.	0.00209	24539.	1.11E+10	211.3890	21679.	0.00

8.8540	-0.02168	-679330.	10038.	0.00191	24071.	1.11E+10	170.1859	21953.	0.00
9.0870	-0.01657	-652360.	10460.	0.00174	23576.	1.11E+10	131.7072	22226.	0.00
9.3200	-0.01192	-624202.	10778.	0.00158	23059.	1.11E+10	95.9406	22500.	0.00
9.5530	-0.00772	-595142.	11000.	0.00143	22525.	1.11E+10	62.8593	22774.	0.00
9.7860	-0.00393	-565445.	11133.	0.00128	21980.	1.11E+10	32.4235	23047.	0.00
10.0190	-5.49E-04	-535356.	11185.	0.00114	21428.	1.11E+10	4.5815	23321.	0.00
10.2520	0.00246	-505101.	11163.	0.00101	20872.	1.11E+10	-20.7286	23594.	0.00
10.4850	0.00510	-474885.	11073.	8.87E-04	20318.	1.11E+10	-43.5785	23868.	0.00
10.7180	0.00742	-444894.	10922.	7.71E-04	19767.	1.11E+10	-64.0478	24142.	0.00
10.9510	0.00942	-415295.	10718.	6.62E-04	19224.	1.11E+10	-82.2229	24415.	0.00
11.1840	0.01112	-386238.	10466.	5.61E-04	18690.	1.11E+10	-98.1965	24689.	0.00
11.4170	0.01255	-357854.	10172.	4.67E-04	18169.	1.11E+10	-112.0656	24963.	0.00
11.6500	0.01373	-330258.	9842.	3.80E-04	17662.	1.11E+10	-123.9314	25236.	0.00
11.8830	0.01468	-303552.	9481.	3.00E-04	17172.	1.11E+10	-133.8973	25510.	0.00
12.1160	0.01541	-277817.	9095.	2.26E-04	16700.	1.11E+10	-142.0692	25783.	0.00
12.3490	0.01594	-253126.	8689.	1.59E-04	16246.	1.11E+10	-148.5534	26057.	0.00
12.5820	0.01630	-229534.	8267.	9.80E-05	15813.	1.11E+10	-153.4568	26331.	0.00
12.8150	0.01649	-207086.	7833.	4.28E-05	15401.	1.11E+10	-156.8856	26604.	0.00
13.0480	0.01653	-185814.	7435.	-6.92E-06	15010.	1.11E+10	-127.8979	21628.	0.00
13.2810	0.01645	-165496.	7078.	-5.13E-05	14637.	1.11E+10	-127.7350	21712.	0.00
13.5140	0.01625	-146137.	6721.	-9.07E-05	14282.	1.11E+10	-127.3431	21914.	0.00
13.7470	0.01594	-127738.	6366.	-1.25E-04	13944.	1.11E+10	-126.7428	22229.	0.00
13.9800	0.01555	-110298.	6013.	-1.55E-04	13624.	1.11E+10	-125.9516	22652.	0.00
14.2130	0.01507	-93816.	5662.	-1.81E-04	13321.	1.11E+10	-124.9839	23185.	0.00
14.4460	0.01453	-78288.	5314.	-2.03E-04	13036.	1.11E+10	-123.8522	23829.	0.00
14.6790	0.01394	-63709.	4969.	-2.21E-04	12769.	1.11E+10	-122.5672	24589.	0.00
14.9120	0.01330	-50073.	4629.	-2.35E-04	12518.	1.11E+10	-121.1380	25472.	0.00
15.1450	0.01262	-37371.	4292.	-2.46E-04	12285.	1.11E+10	-119.5726	26489.	0.00
15.3780	0.01192	-25596.	3960.	-2.54E-04	12069.	1.11E+10	-117.8778	27653.	0.00
15.6110	0.01120	-14735.	3633.	-2.59E-04	11870.	1.11E+10	-116.0597	28977.	0.00
15.8440	0.01047	-4779.	3311.	-2.62E-04	11687.	1.11E+10	-114.1232	30483.	0.00
16.0770	0.00973	4287.	2995.	-2.62E-04	11678.	1.11E+10	-112.0729	32193.	0.00
16.3100	0.00900	12475.	2685.	-2.60E-04	11828.	1.11E+10	-109.9124	34136.	0.00
16.5430	0.00828	19802.	2381.	-2.56E-04	11963.	1.11E+10	-107.6447	36348.	0.00
16.7760	0.00757	26281.	2083.	-2.50E-04	12082.	1.11E+10	-105.2720	38872.	0.00
17.0090	0.00688	31932.	1792.	-2.43E-04	12185.	1.11E+10	-102.7959	41761.	0.00
17.2420	0.00622	36771.	1508.	-2.34E-04	12274.	1.11E+10	-100.2171	45083.	0.00
17.4750	0.00557	40818.	1232.	-2.24E-04	12348.	1.11E+10	-97.5352	48923.	0.00
17.7080	0.00496	44092.	963.0122	-2.13E-04	12408.	1.11E+10	-94.7489	53389.	0.00
17.9410	0.00438	46614.	702.1402	-2.02E-04	12455.	1.11E+10	-91.8548	58624.	0.00
18.1740	0.00383	48408.	449.5175	-1.90E-04	12488.	1.11E+10	-88.8481	64814.	0.00
18.4070	0.00332	49495.	205.4704	-1.78E-04	12508.	1.11E+10	-85.7206	72215.	0.00
18.6400	0.00284	49899.	-29.6466	-1.65E-04	12515.	1.11E+10	-82.4604	81182.	0.00
18.8730	0.00240	49647.	-255.4374	-1.52E-04	12510.	1.11E+10	-79.0495	92230.	0.00
19.1060	0.00199	48765.	-471.4430	-1.40E-04	12494.	1.11E+10	-75.4609	106136.	0.00
19.3390	0.00161	47281.	-677.1084	-1.28E-04	12467.	1.11E+10	-71.6531	124137.	0.00
19.5720	0.00127	45225.	-871.7284	-1.16E-04	12429.	1.11E+10	-67.5600	148356.	0.00
19.8050	9.65E-04	42630.	-1054.	-1.05E-04	12382.	1.11E+10	-63.0699	182807.	0.00
20.0380	6.86E-04	39532.	-1224.	-9.46E-05	12325.	1.11E+10	-57.9781	236253.	0.00
20.2710	4.36E-04	35970.	-1377.	-8.51E-05	12259.	1.11E+10	-51.8501	332798.	0.00
20.5040	2.11E-04	31995.	-1498.	-7.65E-05	12186.	1.11E+10	-34.6780	460592.	0.00
20.7370	8.03E-06	27740.	-1548.	-6.89E-05	12108.	1.11E+10	-1.3220	460592.	0.00
20.9700	-1.75E-04	23469.	-1510.	-6.24E-05	12030.	1.11E+10	28.8031	460592.	0.00
21.2030	-3.41E-04	19417.	-1402.	-5.70E-05	11955.	1.11E+10	48.2526	395496.	0.00
21.4360	-4.94E-04	15738.	-1261.	-5.26E-05	11888.	1.11E+10	53.0287	300334.	0.00
21.6690	-6.35E-04	12469.	-1140.	-4.90E-05	11828.	1.11E+10	33.6192	148007.	0.00
21.9020	-7.68E-04	9460.	-1035.	-4.62E-05	11773.	1.11E+10	40.9393	149101.	0.00
22.1350	-8.94E-04	6769.	-910.9652	-4.42E-05	11723.	1.11E+10	48.0040	150196.	0.00
22.3680	-0.00101	4451.	-767.0938	-4.28E-05	11681.	1.11E+10	54.9083	151290.	0.00
22.6010	-0.00113	2561.	-604.0251	-4.19E-05	11646.	1.11E+10	61.7360	152384.	0.00
22.8340	-0.00125	1154.	-421.8761	-4.14E-05	11620.	1.11E+10	68.5566	153479.	0.00
23.0670	-0.00136	282.2327	-220.5927	-4.12E-05	11604.	1.11E+10	75.4230	154573.	0.00
23.3000	-0.00148	0.00	0.00	-4.12E-05	11599.	1.11E+10	82.3686	77834.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =    -0.45000000 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =       3643147. inch-lbs
Maximum shear force              =       -131396. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             14
Number of zero deflection points =              2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Displacement and Moment (Loading Type 4)

Displacement of pile head = -0.450000 inches
Moment at pile head = 2828014.0 in-lbs
Axial load at pile head = 345000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.4500	2828014.	-116429.	0.00197	63519.	1.11E+10	1910.	5933.	0.00
0.2330	-0.4435	2507701.	-111001.	0.00264	57639.	1.11E+10	1973.	12441.	0.00
0.4660	-0.4352	2202203.	-105403.	0.00324	52030.	1.11E+10	2031.	13048.	0.00
0.6990	-0.4254	1912047.	-99652.	0.00376	46703.	1.11E+10	2082.	13687.	0.00
0.9320	-0.4142	1637703.	-93767.	0.00420	41666.	1.11E+10	2127.	14360.	0.00
1.1650	-0.4019	1379592.	-87781.	0.00459	36927.	1.11E+10	2154.	14986.	0.00
1.3980	-0.3886	1137984.	-81749.	0.00490	32492.	1.11E+10	2161.	15546.	0.00
1.6310	-0.3745	912988.	-75707.	0.00516	28361.	1.11E+10	2162.	16139.	0.00
1.8640	-0.3597	704668.	-69669.	0.00537	24536.	1.11E+10	2157.	16769.	0.00
2.0970	-0.3445	513041.	-63650.	0.00552	21018.	1.11E+10	2148.	17439.	0.00
2.3300	-0.3288	338084.	-57662.	0.00563	17806.	1.11E+10	2135.	18154.	0.00
2.5630	-0.3130	179735.	-51716.	0.00570	14899.	1.11E+10	2118.	18918.	0.00
2.7960	-0.2970	37897.	-45825.	0.00572	12295.	1.11E+10	2097.	19739.	0.00
3.0290	-0.2810	-87560.	-40771.	0.00572	13207.	1.11E+10	1519.	15112.	0.00
3.2620	-0.2650	-201124.	-36609.	0.00568	15291.	1.11E+10	1458.	15386.	0.00
3.4950	-0.2492	-303238.	-32619.	0.00562	17166.	1.11E+10	1396.	15660.	0.00
3.7280	-0.2336	-394367.	-28807.	0.00553	18839.	1.11E+10	1331.	15933.	0.00
3.9610	-0.2183	-474993.	-25177.	0.00542	20320.	1.11E+10	1265.	16207.	0.00
4.1940	-0.2033	-545612.	-21733.	0.00529	21616.	1.11E+10	1198.	16480.	0.00
4.4270	-0.1887	-606729.	-18477.	0.00514	22738.	1.11E+10	1131.	16754.	0.00
4.6600	-0.1745	-658859.	-15410.	0.00498	23695.	1.11E+10	1063.	17028.	0.00
4.8930	-0.1608	-702518.	-12533.	0.00481	24497.	1.11E+10	995.2632	17301.	0.00
5.1260	-0.1476	-738225.	-9844.	0.00463	25152.	1.11E+10	928.0038	17575.	0.00
5.3590	-0.1350	-766497.	-7342.	0.00444	25671.	1.11E+10	861.4920	17848.	0.00
5.5920	-0.1228	-787848.	-5025.	0.00424	26063.	1.11E+10	796.0104	18122.	0.00
5.8250	-0.1112	-802783.	-2889.	0.00404	26338.	1.11E+10	731.8175	18396.	0.00
6.0580	-0.1002	-811801.	-930.7633	0.00384	26503.	1.11E+10	669.1474	18669.	0.00
6.2910	-0.08977	-815391.	854.9823	0.00363	26569.	1.11E+10	608.2099	18943.	0.00
6.5240	-0.07991	-814026.	2473.	0.00343	26544.	1.11E+10	549.1909	19217.	0.00
6.7570	-0.07062	-808170.	3929.	0.00322	26436.	1.11E+10	492.2529	19490.	0.00
6.9900	-0.06190	-798268.	5229.	0.00302	26255.	1.11E+10	437.5357	19764.	0.00
7.2230	-0.05374	-784752.	6379.	0.00282	26006.	1.11E+10	385.1568	20037.	0.00
7.4560	-0.04615	-768032.	7386.	0.00262	25700.	1.11E+10	335.2125	20311.	0.00
7.6890	-0.03909	-748505.	8257.	0.00243	25341.	1.11E+10	287.7786	20585.	0.00
7.9220	-0.03256	-726546.	8999.	0.00224	24938.	1.11E+10	242.9117	20858.	0.00
8.1550	-0.02655	-702510.	9619.	0.00206	24497.	1.11E+10	200.6496	21132.	0.00
8.3880	-0.02103	-676734.	10125.	0.00189	24023.	1.11E+10	161.0132	21406.	0.00
8.6210	-0.01599	-649535.	10523.	0.00172	23524.	1.11E+10	124.0069	21679.	0.00
8.8540	-0.01141	-621208.	10822.	0.00156	23004.	1.11E+10	89.6202	21953.	0.00
9.0870	-0.00727	-592028.	11028.	0.00141	22468.	1.11E+10	57.8287	22226.	0.00
9.3200	-0.00355	-562252.	11149.	0.00126	21922.	1.11E+10	28.5953	22500.	0.00
9.5530	-2.30E-04	-532116.	11191.	0.00112	21368.	1.11E+10	1.8716	22774.	0.00
9.7860	0.00272	-501834.	11163.	9.91E-04	20812.	1.11E+10	-22.4016	23047.	0.00
10.0190	0.00531	-471606.	11069.	8.68E-04	20257.	1.11E+10	-44.2922	23321.	0.00
10.2520	0.00757	-441609.	10918.	7.52E-04	19707.	1.11E+10	-63.8765	23594.	0.00
10.4850	0.00952	-412003.	10715.	6.44E-04	19163.	1.11E+10	-81.2377	23868.	0.00
10.7180	0.01117	-382933.	10467.	5.44E-04	18629.	1.11E+10	-96.4647	24142.	0.00
10.9510	0.01256	-354522.	10179.	4.51E-04	18108.	1.11E+10	-109.6516	24415.	0.00
11.1840	0.01369	-326883.	9856.	3.64E-04	17600.	1.11E+10	-120.8963	24689.	0.00
11.4170	0.01459	-300109.	9505.	2.85E-04	17109.	1.11E+10	-130.2996	24963.	0.00
11.6500	0.01529	-274280.	9130.	2.12E-04	16635.	1.11E+10	-137.9645	25236.	0.00
11.8830	0.01578	-249463.	8736.	1.46E-04	16179.	1.11E+10	-143.9954	25510.	0.00
12.1160	0.01610	-225711.	8327.	8.62E-05	15743.	1.11E+10	-148.4971	25783.	0.00
12.3490	0.01626	-203065.	7908.	3.19E-05	15327.	1.11E+10	-151.5743	26057.	0.00
12.5820	0.01628	-181554.	7481.	-1.67E-05	14932.	1.11E+10	-153.3311	26331.	0.00
12.8150	0.01617	-161197.	7052.	-6.00E-05	14558.	1.11E+10	-153.8699	26604.	0.00
13.0480	0.01595	-142004.	6659.	-9.84E-05	14206.	1.11E+10	-126.7532	22225.	0.00
13.2810	0.01562	-123768.	6306.	-1.32E-04	13871.	1.11E+10	-126.1048	22571.	0.00
13.5140	0.01521	-106487.	5955.	-1.61E-04	13554.	1.11E+10	-125.2667	23030.	0.00
13.7470	0.01472	-90159.	5606.	-1.86E-04	13254.	1.11E+10	-124.2530	23601.	0.00
13.9800	0.01417	-74781.	5260.	-2.07E-04	12972.	1.11E+10	-123.0758	24287.	0.00
14.2130	0.01356	-60346.	4918.	-2.24E-04	12707.	1.11E+10	-121.7454	25096.	0.00
14.4460	0.01292	-46849.	4579.	-2.37E-04	12459.	1.11E+10	-120.2708	26034.	0.00
14.6790	0.01224	-34281.	4245.	-2.48E-04	12228.	1.11E+10	-118.6595	27114.	0.00
14.9120	0.01153	-22631.	3916.	-2.55E-04	12014.	1.11E+10	-116.9184	28348.	0.00
15.1450	0.01081	-11890.	3592.	-2.59E-04	11817.	1.11E+10	-115.0531	29755.	0.00
15.3780	0.01008	-2046.	3273.	-2.61E-04	11637.	1.11E+10	-113.0686	31357.	0.00
15.6110	0.00935	6915.	2960.	-2.60E-04	11726.	1.11E+10	-110.9691	33178.	0.00
15.8440	0.00863	15006.	2652.	-2.58E-04	11875.	1.11E+10	-108.7582	35253.	0.00
16.0770	0.00791	22244.	2352.	-2.53E-04	12007.	1.11E+10	-106.4388	37619.	0.00
16.3100	0.00721	28644.	2057.	-2.46E-04	12125.	1.11E+10	-104.0131	40326.	0.00
16.5430	0.00653	34224.	1770.	-2.39E-04	12227.	1.11E+10	-101.4827	43435.	0.00
16.7760	0.00588	39003.	1490.	-2.29E-04	12315.	1.11E+10	-98.8483	47021.	0.00
17.0090	0.00525	42999.	1217.	-2.19E-04	12388.	1.11E+10	-96.1099	51180.	0.00
17.2420	0.00465	46233.	952.7144	-2.08E-04	12448.	1.11E+10	-93.2664	56035.	0.00
17.4750	0.00409	48727.	696.0674	-1.96E-04	12494.	1.11E+10	-90.3152	61747.	0.00
17.7080	0.00356	50503.	447.8283	-1.83E-04	12526.	1.11E+10	-87.2522	68530.	0.00
17.9410	0.00307	51584.	208.3187	-1.70E-04	12546.	1.11E+10	-84.0708	76670.	0.00
18.1740	0.00261	51996.	-22.1164	-1.57E-04	12554.	1.11E+10	-80.7612	86571.	0.00
18.4070	0.00219	51764.	-243.0983	-1.44E-04	12549.	1.11E+10	-77.3087	98810.	0.00
18.6400	0.00180	50914.	-454.1962	-1.31E-04	12534.	1.11E+10	-73.6912	114250.	0.00
18.8730	0.00146	49476.	-654.9017	-1.18E-04	12507.	1.11E+10	-69.8749	134251.	0.00
19.1060	0.00114	47480.	-844.5839	-1.06E-04	12471.	1.11E+10	-65.8062	161106.	0.00

19.3390	8.62E-04	44958.	-1022.	-9.43E-05	12424.	1.11E+10	-61.3958	199041.	0.00
19.5720	6.15E-04	41945.	-1187.	-8.33E-05	12369.	1.11E+10	-56.4827	256950.	0.00
19.8050	3.96E-04	38480.	-1337.	-7.32E-05	12305.	1.11E+10	-50.7371	357836.	0.00
20.0380	2.05E-04	34609.	-1455.	-6.39E-05	12234.	1.11E+10	-33.8478	460592.	0.00
20.2710	3.90E-05	30465.	-1512.	-5.57E-05	12158.	1.11E+10	-6.4197	460592.	0.00
20.5040	-1.06E-04	26263.	-1496.	-4.85E-05	12081.	1.11E+10	17.4601	460592.	0.00
20.7370	-2.32E-04	22192.	-1418.	-4.24E-05	12006.	1.11E+10	38.2810	460592.	0.00
20.9700	-3.43E-04	18414.	-1297.	-3.73E-05	11937.	1.11E+10	48.3240	393820.	0.00
21.2030	-4.41E-04	15010.	-1158.	-3.30E-05	11875.	1.11E+10	51.5346	326908.	0.00
21.4360	-5.28E-04	12004.	-1010.	-2.96E-05	11819.	1.11E+10	53.9660	285862.	0.00
21.6690	-6.06E-04	9418.	-889.7947	-2.69E-05	11772.	1.11E+10	32.1011	148007.	0.00
21.9020	-6.78E-04	7081.	-794.3462	-2.48E-05	11729.	1.11E+10	36.1740	149101.	0.00
22.1350	-7.45E-04	5024.	-687.8072	-2.33E-05	11691.	1.11E+10	40.0342	150196.	0.00
22.3680	-8.09E-04	3279.	-570.6703	-2.22E-05	11659.	1.11E+10	43.7547	151290.	0.00
22.6010	-8.70E-04	1876.	-443.2384	-2.16E-05	11633.	1.11E+10	47.3984	152384.	0.00
22.8340	-9.29E-04	842.4078	-305.6536	-2.13E-05	11614.	1.11E+10	51.0170	153479.	0.00
23.0670	-9.89E-04	207.6146	-157.9317	-2.11E-05	11603.	1.11E+10	54.6496	154573.	0.00
23.3000	-0.00105	0.00	0.00	-2.11E-05	11599.	1.11E+10	58.3202	77834.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

```
Pile-head deflection             =    -0.45000000 inches
Computed slope at pile head      =     0.00196566 radians
Maximum bending moment           =       2828014. inch-lbs
Maximum shear force              =       -116429. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             13
Number of zero deflection points =              2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Moment (Loading Type 1)

```
Shear force at pile head                          =    -139529.0 lbs
Applied moment at pile head                       =    2828014.0 in-lbs
Axial thrust load on pile head                    =     345000.0 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.7181	2828014.	-139529.	0.00672	63519.	1.11E+10	2148.	4182.	0.00
0.2330	-0.6983	2439459.	-133388.	0.00739	56386.	1.11E+10	2244.	8985.	0.00
0.4660	-0.6768	2067854.	-126977.	0.00796	49563.	1.11E+10	2342.	9676.	0.00
0.6990	-0.6538	1714055.	-120287.	0.00844	43068.	1.11E+10	2443.	10445.	0.00
0.9320	-0.6296	1378933.	-113315.	0.00883	36915.	1.11E+10	2545.	11301.	0.00
1.1650	-0.6045	1063369.	-106075.	0.00914	31122.	1.11E+10	2634.	12184.	0.00
1.3980	-0.5786	768137.	-98608.	0.00937	25701.	1.11E+10	2707.	13084.	0.00
1.6310	-0.5521	493883.	-90935.	0.00953	20666.	1.11E+10	2781.	14086.	0.00
1.8640	-0.5253	241252.	-83053.	0.00962	16028.	1.11E+10	2856.	15204.	0.00
2.0970	-0.4983	10891.	-75123.	0.00965	11799.	1.11E+10	2816.	15802.	0.00
2.3300	-0.4713	-197455.	-67314.	0.00963	15224.	1.11E+10	2770.	16431.	0.00
2.5630	-0.4445	-384101.	-59641.	0.00955	18651.	1.11E+10	2719.	17101.	0.00
2.7960	-0.4179	-549400.	-52118.	0.00944	21686.	1.11E+10	2663.	17818.	0.00
3.0290	-0.3917	-693747.	-45435.	0.00928	24336.	1.11E+10	2117.	15112.	0.00
3.2620	-0.3660	-821373.	-39659.	0.00909	26679.	1.11E+10	2014.	15386.	0.00
3.4950	-0.3409	-933054.	-34175.	0.00887	28729.	1.11E+10	1909.	15660.	0.00
3.7280	-0.3164	-1029583.	-28985.	0.00862	30501.	1.11E+10	1803.	15933.	0.00
3.9610	-0.2927	-1111763.	-24092.	0.00835	32010.	1.11E+10	1697.	16207.	0.00
4.1940	-0.2697	-1180410.	-19498.	0.00806	33270.	1.11E+10	1590.	16480.	0.00
4.4270	-0.2476	-1236339.	-15201.	0.00775	34297.	1.11E+10	1484.	16754.	0.00
4.6600	-0.2264	-1280366.	-11199.	0.00743	35106.	1.11E+10	1379.	17028.	0.00
4.8930	-0.2061	-1313301.	-7488.	0.00711	35710.	1.11E+10	1275.	17301.	0.00
5.1260	-0.1867	-1335948.	-4065.	0.00677	36126.	1.11E+10	1173.	17575.	0.00
5.3590	-0.1682	-1349096.	-923.8188	0.00643	36367.	1.11E+10	1074.	17848.	0.00
5.5920	-0.1507	-1353521.	1943.	0.00609	36449.	1.11E+10	976.8141	18122.	0.00
5.8250	-0.1342	-1349979.	4543.	0.00575	36384.	1.11E+10	882.6982	18396.	0.00
6.0580	-0.1186	-1339207.	6883.	0.00541	36186.	1.11E+10	791.7170	18669.	0.00
6.2910	-0.1039	-1321919.	8975.	0.00507	35868.	1.11E+10	704.0990	18943.	0.00
6.5240	-0.09022	-1298804.	10826.	0.00474	35444.	1.11E+10	620.0382	19217.	0.00
6.7570	-0.07742	-1270525.	12447.	0.00441	34925.	1.11E+10	539.6952	19490.	0.00
6.9900	-0.06553	-1237717.	13849.	0.00410	34323.	1.11E+10	463.1981	19764.	0.00
7.2230	-0.05451	-1200986.	15043.	0.00379	33648.	1.11E+10	390.6444	20037.	0.00
7.4560	-0.04434	-1160908.	16039.	0.00349	32912.	1.11E+10	322.1025	20311.	0.00
7.6890	-0.03499	-1118029.	16850.	0.00320	32125.	1.11E+10	257.6130	20585.	0.00
7.9220	-0.02643	-1072864.	17485.	0.00293	31296.	1.11E+10	197.1906	20858.	0.00
8.1550	-0.01863	-1025895.	17958.	0.00266	30434.	1.11E+10	140.8262	21132.	0.00

8.3880	-0.01156	-977575.	18278.	0.00241	29547.	1.11E+10	88.4881	21406.	0.00
8.6210	-0.00517	-928325.	18458.	0.00217	28642.	1.11E+10	40.1245	21679.	0.00
8.8540	5.52E-04	-878534.	18508.	0.00194	27728.	1.11E+10	-4.3352	21953.	0.00
9.0870	0.00566	-828563.	18439.	0.00172	26811.	1.11E+10	-44.9781	22226.	0.00
9.3200	0.01018	-778742.	18262.	0.00152	25896.	1.11E+10	-81.9062	22500.	0.00
9.5530	0.01415	-729371.	17986.	0.00133	24990.	1.11E+10	-115.2344	22774.	0.00
9.7860	0.01760	-680723.	17622.	0.00115	24097.	1.11E+10	-145.0888	23047.	0.00
10.0190	0.02057	-633043.	17180.	9.83E-04	23221.	1.11E+10	-171.6048	23321.	0.00
10.2520	0.02310	-586551.	16667.	8.29E-04	22368.	1.11E+10	-194.9257	23594.	0.00
10.4850	0.02521	-541439.	16094.	6.86E-04	21539.	1.11E+10	-215.2007	23868.	0.00
10.7180	0.02694	-497877.	15468.	5.55E-04	20740.	1.11E+10	-232.5833	24142.	0.00
10.9510	0.02831	-456013.	14797.	4.34E-04	19971.	1.11E+10	-247.2302	24415.	0.00
11.1840	0.02937	-415969.	14089.	3.24E-04	19236.	1.11E+10	-259.2994	24689.	0.00
11.4170	0.03012	-377852.	13351.	2.24E-04	18536.	1.11E+10	-268.9490	24963.	0.00
11.6500	0.03062	-341744.	12588.	1.33E-04	17873.	1.11E+10	-276.3359	25236.	0.00
11.8830	0.03087	-307714.	11808.	5.06E-05	17248.	1.11E+10	-281.6146	25510.	0.00
12.1160	0.03090	-275810.	11016.	-2.32E-05	16663.	1.11E+10	-284.9359	25783.	0.00
12.3490	0.03074	-246067.	10217.	-8.92E-05	16117.	1.11E+10	-286.4464	26057.	0.00
12.5820	0.03040	-218502.	9417.	-1.48E-04	15611.	1.11E+10	-286.2867	26331.	0.00
12.8150	0.02991	-193123.	8619.	-2.00E-04	15145.	1.11E+10	-284.5912	26604.	0.00
13.0480	0.02928	-169921.	8015.	-2.46E-04	14719.	1.11E+10	-147.4982	14084.	0.00
13.2810	0.02853	-147831.	7604.	-2.86E-04	14313.	1.11E+10	-146.5475	14360.	0.00
13.5140	0.02768	-126851.	7195.	-3.21E-04	13928.	1.11E+10	-145.4408	14690.	0.00
13.7470	0.02674	-106976.	6790.	-3.50E-04	13563.	1.11E+10	-144.1875	15076.	0.00
13.9800	0.02572	-88203.	6389.	-3.75E-04	13218.	1.11E+10	-142.7958	15521.	0.00
14.2130	0.02464	-70524.	5992.	-3.95E-04	12894.	1.11E+10	-141.2729	16028.	0.00
14.4460	0.02351	-53933.	5599.	-4.11E-04	12589.	1.11E+10	-139.6251	16603.	0.00
14.6790	0.02235	-38420.	5211.	-4.22E-04	12304.	1.11E+10	-137.8581	17249.	0.00
14.9120	0.02115	-23975.	4829.	-4.30E-04	12039.	1.11E+10	-135.9767	17975.	0.00
15.1450	0.01994	-10588.	4451.	-4.35E-04	11793.	1.11E+10	-133.9854	18788.	0.00
15.3780	0.01872	1755.	4080.	-4.36E-04	11631.	1.11E+10	-131.8879	19698.	0.00
15.6110	0.01750	13066.	3714.	-4.34E-04	11839.	1.11E+10	-129.6877	20718.	0.00
15.8440	0.01629	23360.	3354.	-4.29E-04	12028.	1.11E+10	-127.3874	21860.	0.00
16.0770	0.01510	32653.	3002.	-4.22E-04	12198.	1.11E+10	-124.9896	23142.	0.00
16.3100	0.01393	40960.	2656.	-4.13E-04	12351.	1.11E+10	-122.4960	24584.	0.00
16.5430	0.01279	48300.	2317.	-4.02E-04	12486.	1.11E+10	-119.9081	26210.	0.00
16.7760	0.01169	54690.	1985.	-3.89E-04	12603.	1.11E+10	-117.2267	28049.	0.00
17.0090	0.01062	60151.	1661.	-3.74E-04	12703.	1.11E+10	-114.4519	30139.	0.00
17.2420	0.00959	64703.	1345.	-3.58E-04	12787.	1.11E+10	-111.5831	32523.	0.00
17.4750	0.00861	68366.	1038.	-3.42E-04	12854.	1.11E+10	-108.6189	35258.	0.00
17.7080	0.00768	71164.	738.1216	-3.24E-04	12906.	1.11E+10	-105.5565	38415.	0.00
17.9410	0.00680	73119.	447.4102	-3.06E-04	12941.	1.11E+10	-102.3916	42087.	0.00
18.1740	0.00597	74255.	165.6998	-2.87E-04	12962.	1.11E+10	-99.1179	46394.	0.00
18.4070	0.00520	74599.	-106.6924	-2.68E-04	12969.	1.11E+10	-95.7263	51500.	0.00
18.6400	0.00447	74176.	-369.4180	-2.49E-04	12961.	1.11E+10	-92.2033	57628.	0.00
18.8730	0.00380	73014.	-622.0832	-2.31E-04	12939.	1.11E+10	-88.5300	65099.	0.00
19.1060	0.00318	71143.	-864.2282	-2.13E-04	12905.	1.11E+10	-84.6782	74387.	0.00
19.3390	0.00261	68592.	-1095.	-1.95E-04	12858.	1.11E+10	-80.6059	86232.	0.00
19.5720	0.00209	65394.	-1315.	-1.78E-04	12800.	1.11E+10	-76.2478	101865.	0.00
19.8050	0.00162	61584.	-1521.	-1.62E-04	12730.	1.11E+10	-71.4976	123526.	0.00
20.0380	0.00119	57200.	-1714.	-1.47E-04	12649.	1.11E+10	-66.1670	155807.	0.00
20.2710	7.97E-04	52285.	-1890.	-1.33E-04	12559.	1.11E+10	-59.8807	210107.	0.00
20.5040	4.43E-04	46889.	-2046.	-1.21E-04	12460.	1.11E+10	-51.7005	326083.	0.00
20.7370	1.23E-04	41078.	-2146.	-1.09E-04	12353.	1.11E+10	-20.2463	460592.	0.00
20.9700	-1.68E-04	35098.	-2136.	-9.98E-05	12243.	1.11E+10	27.7502	460592.	0.00
21.2030	-4.35E-04	29326.	-2025.	-9.16E-05	12137.	1.11E+10	51.5202	331150.	0.00
21.4360	-6.81E-04	23950.	-1872.	-8.49E-05	12039.	1.11E+10	57.6116	236603.	0.00
21.6690	-9.10E-04	19019.	-1725.	-7.95E-05	11948.	1.11E+10	48.1545	148007.	0.00
21.9020	-0.00113	14459.	-1573.	-7.52E-05	11864.	1.11E+10	59.9988	149101.	0.00
22.1350	-0.00133	10366.	-1390.	-7.21E-05	11789.	1.11E+10	71.4625	150196.	0.00
22.3680	-0.00153	6828.	-1174.	-6.99E-05	11724.	1.11E+10	82.6904	151290.	0.00
22.6010	-0.00172	3935.	-927.3947	-6.85E-05	11671.	1.11E+10	93.8100	152384.	0.00
22.8340	-0.00191	1774.	-649.5588	-6.78E-05	11632.	1.11E+10	104.9281	153479.	0.00
23.0670	-0.00210	433.0905	-340.5253	-6.75E-05	11607.	1.11E+10	116.1258	154573.	0.00
23.3000	-0.00229	0.00	0.00	-6.75E-05	11599.	1.11E+10	127.4545	77834.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

```
Pile-head deflection             =    -0.71812239 inches
Computed slope at pile head      =     0.00672144 radians
Maximum bending moment           =       2828014. inch-lbs
Maximum shear force              =       -139529. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             24
Number of zero deflection points =              2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 4

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = -0.718100 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 345000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.7181	3940473.	-159568.	0.00	83943.	1.23E+09	2148.	4182.	0.00
0.2330	-0.7056	3502665.	-151904.	0.00491	75905.	1.11E+10	2244.	8893.	0.00
0.4660	-0.6906	3081548.	-145492.	0.00574	68174.	1.11E+10	2342.	9483.	0.00
0.6990	-0.6735	2677990.	-138803.	0.00647	60765.	1.11E+10	2443.	10140.	0.00
0.9320	-0.6544	2292874.	-131831.	0.00710	53695.	1.11E+10	2545.	10872.	0.00
1.1650	-0.6338	1927093.	-124591.	0.00764	46979.	1.11E+10	2634.	11621.	0.00
1.3980	-0.6117	1581433.	-117123.	0.00808	40633.	1.11E+10	2707.	12374.	0.00
1.6310	-0.5886	1256553.	-109450.	0.00844	34668.	1.11E+10	2781.	13212.	0.00
1.8640	-0.5646	953110.	-101569.	0.00872	29097.	1.11E+10	2856.	14146.	0.00
2.0970	-0.5398	671763.	-93477.	0.00892	23932.	1.11E+10	2932.	15186.	0.00
2.3300	-0.5147	413175.	-85235.	0.00906	19185.	1.11E+10	2963.	16096.	0.00
2.5630	-0.4892	177649.	-77007.	0.00913	14861.	1.11E+10	2923.	16706.	0.00
2.7960	-0.4636	-35071.	-68899.	0.00915	12243.	1.11E+10	2877.	17353.	0.00
3.0290	-0.4380	-225290.	-61567.	0.00912	15735.	1.11E+10	2367.	15112.	0.00
3.2620	-0.4126	-396947.	-55083.	0.00904	18887.	1.11E+10	2270.	15386.	0.00
3.4950	-0.3874	-550758.	-48876.	0.00892	21711.	1.11E+10	2170.	15660.	0.00
3.7280	-0.3627	-687470.	-42953.	0.00876	24220.	1.11E+10	2067.	15933.	0.00
3.9610	-0.3384	-807858.	-37321.	0.00858	26431.	1.11E+10	1962.	16207.	0.00
4.1940	-0.3147	-912712.	-31985.	0.00836	28356.	1.11E+10	1855.	16480.	0.00
4.4270	-0.2917	-1002840.	-26948.	0.00812	30010.	1.11E+10	1748.	16754.	0.00
4.6600	-0.2694	-1079060.	-22211.	0.00785	31410.	1.11E+10	1640.	17028.	0.00
4.8930	-0.2478	-1142192.	-17774.	0.00757	32569.	1.11E+10	1533.	17301.	0.00
5.1260	-0.2270	-1193059.	-13636.	0.00728	33503.	1.11E+10	1427.	17575.	0.00
5.3590	-0.2071	-1232480.	-9792.	0.00697	34226.	1.11E+10	1322.	17848.	0.00
5.5920	-0.1880	-1261265.	-6240.	0.00665	34755.	1.11E+10	1219.	18122.	0.00
5.8250	-0.1699	-1280213.	-2974.	0.00633	35103.	1.11E+10	1118.	18396.	0.00
6.0580	-0.1526	-1290112.	13.5117	0.00601	35285.	1.11E+10	1019.	18669.	0.00
6.2910	-0.1363	-1291729.	2729.	0.00568	35314.	1.11E+10	923.3673	18943.	0.00
6.5240	-0.1209	-1285812.	5181.	0.00536	35206.	1.11E+10	830.6629	19217.	0.00
6.7570	-0.1063	-1273087.	7379.	0.00503	34972.	1.11E+10	741.2759	19490.	0.00
6.9900	-0.09272	-1254257.	9331.	0.00471	34626.	1.11E+10	655.4094	19764.	0.00
7.2230	-0.07999	-1229998.	11049.	0.00440	34181.	1.11E+10	573.2325	20037.	0.00
7.4560	-0.06812	-1200957.	12542.	0.00409	33648.	1.11E+10	494.8808	20311.	0.00
7.6890	-0.05711	-1167754.	13822.	0.00379	33038.	1.11E+10	420.4584	20585.	0.00
7.9220	-0.04692	-1130980.	14899.	0.00350	32363.	1.11E+10	350.0396	20858.	0.00
8.1550	-0.03753	-1091193.	15785.	0.00322	31633.	1.11E+10	283.6702	21132.	0.00
8.3880	-0.02892	-1048922.	16491.	0.00295	30856.	1.11E+10	221.3696	21406.	0.00
8.6210	-0.02104	-1004665.	17029.	0.00269	30044.	1.11E+10	163.1326	21679.	0.00
8.8540	-0.01387	-958888.	17409.	0.00244	29203.	1.11E+10	108.9311	21953.	0.00
9.0870	-0.00739	-912025.	17643.	0.00221	28343.	1.11E+10	58.7166	22226.	0.00
9.3200	-0.00154	-864480.	17743.	0.00198	27470.	1.11E+10	12.4213	22500.	0.00
9.5530	0.00369	-816628.	17718.	0.00177	26592.	1.11E+10	-30.0393	22774.	0.00
9.7860	0.00834	-768811.	17580.	0.00157	25714.	1.11E+10	-68.7644	23047.	0.00
10.0190	0.01245	-721344.	17339.	0.00138	24842.	1.11E+10	-103.8668	23321.	0.00
10.2520	0.01605	-674514.	17004.	0.00120	23983.	1.11E+10	-135.4699	23594.	0.00
10.4850	0.01918	-628577.	16586.	0.00104	23139.	1.11E+10	-163.7066	23868.	0.00
10.7180	0.02186	-583768.	16093.	8.84E-04	22317.	1.11E+10	-188.7175	24142.	0.00
10.9510	0.02412	-540291.	15535.	7.42E-04	21518.	1.11E+10	-210.6486	24415.	0.00
11.1840	0.02601	-498329.	14919.	6.11E-04	20748.	1.11E+10	-229.6503	24689.	0.00
11.4170	0.02754	-458041.	14254.	4.90E-04	20008.	1.11E+10	-245.8753	24963.	0.00
11.6500	0.02875	-419563.	13548.	3.79E-04	19302.	1.11E+10	-259.4771	25236.	0.00
11.8830	0.02966	-383012.	12807.	2.78E-04	18631.	1.11E+10	-270.6090	25510.	0.00
12.1160	0.03030	-348483.	12038.	1.85E-04	17997.	1.11E+10	-279.4222	25783.	0.00
12.3490	0.03070	-316053.	11247.	1.01E-04	17402.	1.11E+10	-286.0647	26057.	0.00
12.5820	0.03087	-285782.	10441.	2.51E-05	16846.	1.11E+10	-290.6800	26331.	0.00
12.8150	0.03084	-257714.	9625.	-4.36E-05	16330.	1.11E+10	-293.4063	26604.	0.00
13.0480	0.03062	-231877.	9006.	-1.06E-04	15856.	1.11E+10	-149.1592	13619.	0.00
13.2810	0.03025	-207149.	8590.	-1.61E-04	15402.	1.11E+10	-148.6974	13746.	0.00
13.5140	0.02972	-183534.	8175.	-2.10E-04	14969.	1.11E+10	-148.0493	13927.	0.00
13.7470	0.02907	-161031.	7762.	-2.54E-04	14555.	1.11E+10	-147.2285	14161.	0.00
13.9800	0.02830	-139639.	7352.	-2.92E-04	14163.	1.11E+10	-146.2470	14448.	0.00
14.2130	0.02744	-119357.	6944.	-3.25E-04	13790.	1.11E+10	-145.1148	14789.	0.00
14.4460	0.02649	-100181.	6540.	-3.53E-04	13438.	1.11E+10	-143.8412	15185.	0.00
14.6790	0.02546	-82104.	6140.	-3.76E-04	13106.	1.11E+10	-142.4338	15639.	0.00
14.9120	0.02439	-65121.	5744.	-3.94E-04	12795.	1.11E+10	-140.8997	16156.	0.00
15.1450	0.02326	-49223.	5352.	-4.09E-04	12503.	1.11E+10	-139.2450	16738.	0.00
15.3780	0.02210	-34402.	4965.	-4.19E-04	12231.	1.11E+10	-137.4749	17393.	0.00
15.6110	0.02092	-20647.	4584.	-4.26E-04	11978.	1.11E+10	-135.5944	18126.	0.00
15.8440	0.01972	-7947.	4207.	-4.30E-04	11745.	1.11E+10	-133.6075	18947.	0.00
16.0770	0.01851	3710.	3837.	-4.30E-04	11667.	1.11E+10	-131.5179	19864.	0.00
16.3100	0.01731	14338.	3472.	-4.28E-04	11862.	1.11E+10	-129.3286	20890.	0.00
16.5430	0.01612	23951.	3114.	-4.23E-04	12039.	1.11E+10	-127.0420	22037.	0.00
16.7760	0.01494	32566.	2762.	-4.16E-04	12197.	1.11E+10	-124.6603	23324.	0.00
17.0090	0.01379	40198.	2417.	-4.07E-04	12337.	1.11E+10	-122.1848	24770.	0.00
17.2420	0.01267	46865.	2079.	-3.96E-04	12459.	1.11E+10	-119.6161	26400.	0.00
17.4750	0.01158	52586.	1748.	-3.83E-04	12564.	1.11E+10	-116.9543	28243.	0.00
17.7080	0.01053	57379.	1425.	-3.69E-04	12652.	1.11E+10	-114.1983	30337.	0.00
17.9410	0.00951	61266.	1109.	-3.54E-04	12724.	1.11E+10	-111.3459	32728.	0.00
18.1740	0.00854	64267.	802.2841	-3.39E-04	12779.	1.11E+10	-108.3935	35474.	0.00
18.4070	0.00762	66405.	503.4910	-3.22E-04	12818.	1.11E+10	-105.3355	38653.	0.00
18.6400	0.00674	67704.	213.4070	-3.05E-04	12842.	1.11E+10	-102.1638	42364.	0.00

18.8730	0.00591	68187.	-67.6333	-2.88E-04	12851.	1.11E+10	-98.8665	46744.	0.00
19.1060	0.00513	67881.	-339.2554	-2.71E-04	12845.	1.11E+10	-95.4268	51980.	0.00
19.3390	0.00440	66812.	-601.0274	-2.54E-04	12826.	1.11E+10	-91.8207	58344.	0.00
19.5720	0.00371	65009.	-852.4344	-2.37E-04	12793.	1.11E+10	-88.0127	66245.	0.00
19.8050	0.00308	62502.	-1093.	-2.21E-04	12746.	1.11E+10	-83.9501	76327.	0.00
20.0380	0.00248	59324.	-1321.	-2.05E-04	12688.	1.11E+10	-79.5510	89692.	0.00
20.2710	0.00193	55509.	-1537.	-1.91E-04	12618.	1.11E+10	-74.6810	108389.	0.00
20.5040	0.00141	51097.	-1738.	-1.77E-04	12537.	1.11E+10	-69.0992	136799.	0.00
20.7370	9.34E-04	46133.	-1922.	-1.65E-04	12446.	1.11E+10	-62.3097	186475.	0.00
20.9700	4.89E-04	40670.	-2083.	-1.54E-04	12346.	1.11E+10	-52.9776	303008.	0.00
21.2030	7.22E-05	34782.	-2174.	-1.45E-04	12238.	1.11E+10	-11.8911	460592.	0.00
21.4360	-3.20E-04	28794.	-2124.	-1.37E-04	12128.	1.11E+10	47.7278	417167.	0.00
21.6690	-6.92E-04	23171.	-2006.	-1.30E-04	12024.	1.11E+10	36.6101	148007.	0.00
21.9020	-0.00105	17829.	-1876.	-1.25E-04	11926.	1.11E+10	55.8295	149101.	0.00
22.1350	-0.00139	12919.	-1694.	-1.21E-04	11836.	1.11E+10	74.6498	150196.	0.00
22.3680	-0.00172	8590.	-1459.	-1.18E-04	11757.	1.11E+10	93.2443	151290.	0.00
22.6010	-0.00205	4987.	-1173.	-1.17E-04	11691.	1.11E+10	111.7689	152384.	0.00
22.8340	-0.00237	2257.	-834.1415	-1.16E-04	11640.	1.11E+10	130.3563	153479.	0.00
23.0670	-0.00270	545.9496	-443.4486	-1.15E-04	11609.	1.11E+10	149.1092	154573.	0.00
23.3000	-0.00302	0.00	0.00	-1.15E-04	11599.	1.11E+10	168.0930	77834.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 4:

Pile-head deflection = -0.71810000 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = 3940473. inch-lbs
Maximum shear force = -159568. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 30
Number of zero deflection points = 2

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 5

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = -0.718100 inches
Moment at pile head = 2835049.0 in-lbs
Axial load at pile head = 345000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.7181	2835049.	-139646.	0.00670	63649.	1.11E+10	2148.	4182.	0.00
0.2330	-0.6984	2446183.	-133506.	0.00737	56509.	1.11E+10	2244.	8985.	0.00
0.4660	-0.6769	2074264.	-127094.	0.00794	49681.	1.11E+10	2342.	9676.	0.00
0.6990	-0.6539	1720152.	-120404.	0.00842	43180.	1.11E+10	2443.	10443.	0.00
0.9320	-0.6298	1384714.	-113432.	0.00882	37021.	1.11E+10	2545.	11298.	0.00
1.1650	-0.6046	1068833.	-106192.	0.00913	31222.	1.11E+10	2634.	12181.	0.00
1.3980	-0.5787	773284.	-98725.	0.00936	25796.	1.11E+10	2707.	13079.	0.00
1.6310	-0.5523	498710.	-91051.	0.00952	20755.	1.11E+10	2781.	14080.	0.00
1.8640	-0.5255	245759.	-83170.	0.00961	16111.	1.11E+10	2856.	15197.	0.00
2.0970	-0.4986	15078.	-75238.	0.00965	11876.	1.11E+10	2817.	15801.	0.00
2.3300	-0.4716	-193582.	-67426.	0.00962	15153.	1.11E+10	2771.	16429.	0.00
2.5630	-0.4447	-380532.	-59750.	0.00955	18585.	1.11E+10	2720.	17099.	0.00
2.7960	-0.4182	-546128.	-52223.	0.00943	21626.	1.11E+10	2664.	17815.	0.00
3.0290	-0.3920	-690762.	-45536.	0.00928	24281.	1.11E+10	2119.	15112.	0.00
3.2620	-0.3663	-818664.	-39756.	0.00909	26629.	1.11E+10	2016.	15386.	0.00
3.4950	-0.3412	-930609.	-34267.	0.00887	28684.	1.11E+10	1911.	15660.	0.00
3.7280	-0.3167	-1027390.	-29073.	0.00862	30461.	1.11E+10	1805.	15933.	0.00
3.9610	-0.2930	-1109811.	-24176.	0.00835	31974.	1.11E+10	1698.	16207.	0.00
4.1940	-0.2700	-1178686.	-19577.	0.00806	33239.	1.11E+10	1592.	16480.	0.00
4.4270	-0.2479	-1234830.	-15275.	0.00775	34270.	1.11E+10	1486.	16754.	0.00
4.6600	-0.2267	-1279061.	-11268.	0.00744	35082.	1.11E+10	1380.	17028.	0.00
4.8930	-0.2063	-1312187.	-7554.	0.00711	35690.	1.11E+10	1277.	17301.	0.00
5.1260	-0.1869	-1335013.	-4126.	0.00677	36109.	1.11E+10	1175.	17575.	0.00
5.3590	-0.1685	-1348328.	-980.2726	0.00643	36353.	1.11E+10	1075.	17848.	0.00
5.5920	-0.1509	-1352907.	1891.	0.00609	36437.	1.11E+10	978.3165	18122.	0.00
5.8250	-0.1344	-1349509.	4494.	0.00575	36375.	1.11E+10	884.1597	18396.	0.00
6.0580	-0.1188	-1338869.	6839.	0.00541	36180.	1.11E+10	793.1334	18669.	0.00
6.2910	-0.1041	-1321702.	8934.	0.00507	35865.	1.11E+10	705.4667	18943.	0.00
6.5240	-0.09041	-1298698.	10789.	0.00474	35442.	1.11E+10	621.3543	19217.	0.00
6.7570	-0.07760	-1270519.	12414.	0.00442	34925.	1.11E+10	540.9570	19490.	0.00
6.9900	-0.06570	-1237801.	13820.	0.00410	34324.	1.11E+10	464.4036	19764.	0.00
7.2230	-0.05467	-1201151.	15017.	0.00379	33651.	1.11E+10	391.7920	20037.	0.00
7.4560	-0.04449	-1161146.	16016.	0.00349	32917.	1.11E+10	323.1909	20311.	0.00
7.6890	-0.03513	-1118330.	16830.	0.00321	32131.	1.11E+10	258.6415	20585.	0.00
7.9220	-0.02656	-1073220.	17468.	0.00293	31303.	1.11E+10	198.1588	20858.	0.00

8.1550	-0.01875	-1026298.	17943.	0.00266	30441.	1.11E+10	141.7340	21132.	0.00
8.3880	-0.01167	-978019.	18266.	0.00241	29555.	1.11E+10	89.3359	21406.	0.00
8.6210	-0.00528	-928802.	18448.	0.00217	28651.	1.11E+10	40.9128	21679.	0.00
8.8540	4.59E-04	-879039.	18501.	0.00194	27738.	1.11E+10	-3.6055	21953.	0.00
9.0870	0.00557	-829090.	18434.	0.00172	26821.	1.11E+10	-44.3059	22226.	0.00
9.3200	0.01010	-779284.	18258.	0.00152	25906.	1.11E+10	-81.2901	22500.	0.00
9.5530	0.01408	-729925.	17984.	0.00133	25000.	1.11E+10	-114.6728	22774.	0.00
9.7860	0.01754	-681283.	17622.	0.00115	24107.	1.11E+10	-144.5800	23047.	0.00
10.0190	0.02052	-633606.	17180.	9.85E-04	23232.	1.11E+10	-171.1470	23321.	0.00
10.2520	0.02305	-587112.	16669.	8.31E-04	22378.	1.11E+10	-194.5167	23594.	0.00
10.4850	0.02517	-541996.	16097.	6.88E-04	21550.	1.11E+10	-214.8385	23868.	0.00
10.7180	0.02690	-498427.	15472.	5.57E-04	20750.	1.11E+10	-232.2657	24142.	0.00
10.9510	0.02828	-456552.	14802.	4.36E-04	19981.	1.11E+10	-246.9548	24415.	0.00
11.1840	0.02934	-416496.	14094.	3.26E-04	19246.	1.11E+10	-259.0640	24689.	0.00
11.4170	0.03010	-378365.	13357.	2.25E-04	18546.	1.11E+10	-268.7511	24963.	0.00
11.6500	0.03060	-342241.	12595.	1.34E-04	17882.	1.11E+10	-276.1731	25236.	0.00
11.8830	0.03085	-308194.	11815.	5.19E-05	17257.	1.11E+10	-281.4845	25510.	0.00
12.1160	0.03089	-276271.	11023.	-2.20E-05	16671.	1.11E+10	-284.8363	25783.	0.00
12.3490	0.03073	-246508.	10225.	-8.81E-05	16125.	1.11E+10	-286.3747	26057.	0.00
12.5820	0.03040	-218924.	9424.	-1.47E-04	15618.	1.11E+10	-286.2407	26331.	0.00
12.8150	0.02991	-193524.	8626.	-1.99E-04	15152.	1.11E+10	-284.5686	26604.	0.00
13.0480	0.02928	-170301.	8022.	-2.45E-04	14726.	1.11E+10	-147.5198	14086.	0.00
13.2810	0.02854	-148190.	7611.	-2.85E-04	14320.	1.11E+10	-146.5731	14361.	0.00
13.5140	0.02769	-127189.	7203.	-3.20E-04	13934.	1.11E+10	-145.4703	14691.	0.00
13.7470	0.02675	-107294.	6798.	-3.50E-04	13569.	1.11E+10	-144.2209	15077.	0.00
13.9800	0.02573	-88500.	6397.	-3.75E-04	13224.	1.11E+10	-142.8329	15521.	0.00
14.2130	0.02465	-70802.	5999.	-3.95E-04	12899.	1.11E+10	-141.3137	16028.	0.00
14.4460	0.02352	-54191.	5607.	-4.11E-04	12594.	1.11E+10	-139.6696	16602.	0.00
14.6790	0.02236	-38658.	5218.	-4.22E-04	12309.	1.11E+10	-137.9062	17248.	0.00
14.9120	0.02116	-24194.	4836.	-4.30E-04	12043.	1.11E+10	-136.0285	17974.	0.00
15.1450	0.01995	-10788.	4458.	-4.35E-04	11797.	1.11E+10	-134.0408	18787.	0.00
15.3780	0.01873	1573.	4086.	-4.36E-04	11628.	1.11E+10	-131.9471	19697.	0.00
15.6110	0.01751	12902.	3720.	-4.34E-04	11836.	1.11E+10	-129.7506	20716.	0.00
15.8440	0.01630	23214.	3361.	-4.29E-04	12025.	1.11E+10	-127.4543	21859.	0.00
16.0770	0.01511	32524.	3008.	-4.22E-04	12196.	1.11E+10	-125.0604	23141.	0.00
16.3100	0.01394	40848.	2661.	-4.13E-04	12349.	1.11E+10	-122.5709	24583.	0.00
16.5430	0.01280	48204.	2322.	-4.02E-04	12484.	1.11E+10	-119.9872	26209.	0.00
16.7760	0.01169	54610.	1991.	-3.89E-04	12602.	1.11E+10	-117.3101	28049.	0.00
17.0090	0.01063	60086.	1667.	-3.74E-04	12702.	1.11E+10	-114.5398	30139.	0.00
17.2420	0.00960	64651.	1350.	-3.59E-04	12786.	1.11E+10	-111.6758	32524.	0.00
17.4750	0.00862	68328.	1042.	-3.42E-04	12853.	1.11E+10	-108.7165	35260.	0.00
17.7080	0.00769	71138.	742.4513	-3.24E-04	12905.	1.11E+10	-105.6593	38420.	0.00
17.9410	0.00681	73105.	451.4444	-3.06E-04	12941.	1.11E+10	-102.5001	42095.	0.00
18.1740	0.00598	74253.	169.4224	-2.87E-04	12962.	1.11E+10	-99.2324	46406.	0.00
18.4070	0.00520	74607.	-103.2989	-2.68E-04	12969.	1.11E+10	-95.8472	51518.	0.00
18.6400	0.00448	74193.	-366.3726	-2.50E-04	12961.	1.11E+10	-92.3314	57655.	0.00
18.8730	0.00381	73040.	-619.4072	-2.31E-04	12940.	1.11E+10	-88.6661	65138.	0.00
19.1060	0.00319	71175.	-861.9455	-2.13E-04	12906.	1.11E+10	-84.8235	74445.	0.00
19.3390	0.00262	68630.	-1093.	-1.95E-04	12859.	1.11E+10	-80.7620	86318.	0.00
19.5720	0.00209	65437.	-1313.	-1.78E-04	12800.	1.11E+10	-76.4174	101998.	0.00
19.8050	0.00162	61630.	-1520.	-1.62E-04	12730.	1.11E+10	-71.6848	123738.	0.00
20.0380	0.00119	57249.	-1713.	-1.47E-04	12650.	1.11E+10	-66.3796	156177.	0.00
20.2710	7.97E-04	52334.	-1890.	-1.33E-04	12560.	1.11E+10	-60.1358	210848.	0.00
20.5040	4.44E-04	46936.	-2047.	-1.21E-04	12461.	1.11E+10	-52.0477	328123.	0.00
20.7370	1.23E-04	41120.	-2148.	-1.10E-04	12354.	1.11E+10	-20.2224	460592.	0.00
20.9700	-1.69E-04	35136.	-2137.	-9.99E-05	12244.	1.11E+10	27.8263	460592.	0.00
21.2030	-4.36E-04	29361.	-2027.	-9.17E-05	12138.	1.11E+10	51.3180	329281.	0.00
21.4360	-6.82E-04	23980.	-1875.	-8.50E-05	12039.	1.11E+10	57.5004	235794.	0.00
21.6690	-9.11E-04	19042.	-1727.	-7.95E-05	11949.	1.11E+10	48.2213	148007.	0.00
21.9020	-0.00113	14477.	-1575.	-7.53E-05	11865.	1.11E+10	60.0782	149101.	0.00
22.1350	-0.00133	10378.	-1391.	-7.22E-05	11790.	1.11E+10	71.5542	150196.	0.00
22.3680	-0.00153	6836.	-1176.	-7.00E-05	11724.	1.11E+10	82.7939	151290.	0.00
22.6010	-0.00172	3939.	-928.5089	-6.86E-05	11671.	1.11E+10	93.9253	152384.	0.00
22.8340	-0.00191	1776.	-650.3345	-6.79E-05	11632.	1.11E+10	105.0550	153479.	0.00
23.0670	-0.00210	433.6115	-340.9297	-6.76E-05	11607.	1.11E+10	116.2645	154573.	0.00
23.3000	-0.00229	0.00	0.00	-6.76E-05	11599.	1.11E+10	127.6051	77834.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 5:

```
Pile-head deflection             =    -0.71810000 inches
Computed slope at pile head      =     0.00670375 radians
Maximum bending moment           =       2835049. inch-lbs
Maximum shear force              =       -139646. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             15
Number of zero deflection points =              2
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	-0.4500	S, rad	0.00	345000.	-0.4500	0.00	-131396.	3643147.
2	y, in	-0.4500	M, in-lb	2828014.	345000.	-0.4500	0.00197	-116429.	2828014.
3	V, lb	-139529.	M, in-lb	2828014.	345000.	-0.7181	0.00672	-139529.	2828014.
4	y, in	-0.7181	S, rad	0.00	345000.	-0.7181	0.00	-159568.	3940473.
5	y, in	-0.7181	M, in-lb	2835049.	345000.	-0.7181	0.00670	-139646.	2835049.

Maximum pile-head deflection = -0.7181223891 inches
Maximum pile-head rotation = 0.0067214397 radians = 0.385110 deg.

The analysis ended normally.

HNTB	For	Burnham Bridge	Job No.	63738	Sheet No.	1 of 3
	Made by	KRR	Check	BAM	Backcheck	
	Date	10/13/2017	Date	10/18/2017	Date	

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET - EXPANSION North Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Slope. Displacement is equal to the thermal expansion of the bridge and the slope is assumed to be zero to represent a fixed head condition. No corrosion. Isolation casing for top 10 ft. Downdrag present. Boring 104.

Input factored load per pile to be assessed

P_u=	345	kips	Factored applied superstructure and substructure vertical dead and live load distributed to each pile. (Includes 40 kips factored downdrag load)

Input steel H-pile strengths

F_y=	50	ksi	Yield strength of steel H pile section.
E_s=	29000	ksi	Elastic modulus of steel H pile section.

Select axial resistance factors for the strength limit state from AASHTO Section 6.5.4.2

ϕ_{cu}=	0.70	dim	Axial resistance factor for the upper zone of the pile for combined axial and flexure with no damage.
ϕ_{cl}=	0.50	dim	Axial resistance factor for the lower zone of the pile in compression (Use 0.50 for severe driving & 0.60 for good driving).
ϕ_f=	1.00	dim	Flexure resistance factor for the upper zone of the pile for combined axial and flexure with no damage.

Calculate the required Nominal Axial Pile Resistance

R_{n_up}=	492.9	kips	Required nominal resistance for upper zone of pile [$R_{n_up} = P_u / \phi_{cu}$].
R_{n_low}=	690	kips	Required nominal resistance for lower zone of pile [$R_{n_low} = P_u / \phi_{cl}$].
R_n=	690.0	kips	Required nominal resistance for pile [Max of R_{n_up}, R_{n_low}].

Calculate the required area of steel

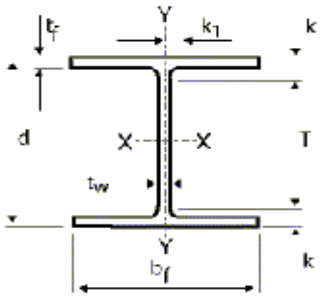
A_{s_req}=	17.250	in^2	Required area of steel to satisfy axial compression [$A_{s_req} = R_n / 0.8 * F_y$].

Choose preliminary HP-Pile Section

HP 14x102		Preliminary HP Section to be assessed for use at integral abutment.

Input HP shape properties

A_s=	30.000	in^2	Area of section
d=	14.000	in	Section depth
t_w=	0.705	in	Web thickness
b_f=	14.800	in	Flange width
t_f=	0.705	in	Flange thickness
k=	1.375	in	Distance from flange to fillet
T=	11.250	in	Web height excluding fillet
I_{xx}=	1050.000	in^4	Moment of Inertia about strong axis of HP section
S_{xx}=	150.000	in^3	Section modulus for strong axis bending
r_{xx}=	5.920	in	Radius of gyration for strong axis
Z_{xx}=	169.000	in^3	Plastic modulus for strong axis bending
I_{yy}=	380.000	in^4	Moment of Inertia about weak axis of HP section
S_{yy}=	51.400	in^3	Section modulus for weak axis bending
r_{yy}=	3.560	in	Radius of gyration
Z_{yy}=	78.800	in^3	Plastic modulus for weak axis bending



Input plate buckling coefficients for HP shape from AASHTO Table 6.9.4.2.1-1

k_f=	0.56	dim	Plate buckling coefficient for flanges
k_w=	1.49	dim	Plate buckling coefficient for web

Calculate and check pile properties

λ_f=	10.5	dim	Slenderness ratio for the compression flange as per AASHTO Eq. 6.12.2.2.1-3 [$\lambda_f = b_f / (2 * t_f)$]
λ_w=	16.0	dim	Slenderness ratio for the web as per AASHTO Eq. X.X.X.X.X-X [$\lambda_w = T / t_w$]

Check	OK	Check for flange buckling [OK if $\lambda_f \le k_f * (E*F_y)^{0.5}$]	13.49
Check	OK	Check for web buckling [OK if $\lambda_w \le k_w * (E*F_y)^{0.5}$]	35.88

Determine L-Pile load case parameters for displacement and slope

δ=	-0.45	in	Pile head displacement due to thermal expansion
θ=	0	rad	Slope of pile head (assuming no rotation)
P_u=	345000	lb	Axial load at pile head

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET (Cont.) North Abutment Strength I

Run L-Pile and determine the following parameters using Displacement and Slope input

M_{u_top}=	3643147	in-lb	Maximum moment at top of the pile from Lpile output
I_{b_top}=	3.44	ft	Depth of first virtual pin (zero moment on moment depth plot)
I_{b_bot}=	15.97	ft	Depth of second virtual pin (zero moment on moment depth plot)
I_{b_2nd}=	12.53077	ft	Total unbraced length from Lpile moment vs depth plot [$I_{b_2nd} = I_{b_bot} - I_{b_top}$]

x_0	x	x_1	y_0	y	y_1
98578	0	-33383	3.262	3.4361	3.495
-4779	0	4287	15.844	15.967	16.077

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	1.2	dim	Effective length factor for upper section (fixed at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.033746	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * I_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.311666	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * I_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1479.1	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \le 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1317.8	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \le 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1035.4	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{n_top}$]
P_{r_2nd}=	922.5	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{n_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{n_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.333	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.374	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.460	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Calculate slenderness ratios for flexure resistance

λ_{pf}=	9.15	dim	Limiting slenderness ratio for a compact flange as per AASHTO Eq. 6.12.2.2.1-4 [$\lambda_{pf} = 0.38 * (E_s / F_y)^{0.5}$]
λ_{rf}=	19.99	dim	Limiting slenderness ratio for a non-compact flange as per AASHTO Eq. 6.12.2.2.1-5 [$\lambda_{pf} = 0.83 * (E_s / F_y)^{0.5}$]

Calculate nominal flexure resistance of pile as per AASHTO Section 6.12.2.2.1

M_n=	3770.0	in-kips	Nominal flexure resistance as per AASHTO Eq. 6.12.2.2.1-1

If $\lambda_f \le \lambda_{pf}$, then: $M_n = M_p$

If $\lambda_{pf} < \lambda_f \le \lambda_{rf}$, then:

$$M_n = \left[1 - \left(1 - \frac{S_y}{Z_y}\right)\left(\frac{\lambda_f - \lambda_{pf}}{0.45\sqrt{\frac{E}{F_{yf}}}}\right)\right] F_{yf} Z_y$$

Calculate the flexure resistance

M_r=	3770.0	in-kips	Factored flexure resistance as per AASHTO Eq. 6.12.1.2.1-1 [$M_r = \phi_f * M_n$]

Calculate the moment that will cause a plastic hinge at the pile cap

M_p=	2828.0	in-kips	Moment that will cause a plastic hinge at the pile cap [(9.0 /8.0) * (1- P_u / P_{r_top}) * M_r]

3643 in-kips

Check to determine if plastic hinge has formed

YES - Additional Analysis Required See below for explanation

YES: Since the applied moment exceeded the moment that would create a plastic hinge, it can be assumed that the pile head has entered plastic deformation and therefore the moment that can be applied to the pile head cannot exceed Mp. Additional analysis is required using the plastic moment to limit the bending resistance at the pile head, recalculate the unbraced length, and verify that a plastic hinge does not develop in the second pile segment.

NO: The applied moment does not exceed the moment that would create a plastic hinge at the pile head. No further analysis is required.

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

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INTEGRAL ABUTMENT PILE DESIGN WORKSHEET North Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Moment. Displacement is equal to the thermal expansion of the bridge and the moment is equal to the plastic resistance. Pile head conditions are assumed to be pinned.

Determine L-Pile load case parameters for displacement and moment as input

δ=	-0.45	in	Pile head displacement due to thermal expansion
M_p=	2828014	in-lb	Plastic moment capacity
P_u=	345000	lb	Axial load at pile head

Run L-Pile and determine the following parameters

M_{u_top}=	2828014	in-lb	Maximum moment at top of the pile from Lpile output
M_{u_2nd}=	-815391	in-lb	Maximum moment from Lpile moment vs depth plot.

					x_0	x	x_1	y_0	y	y_1
l_{b_top}=	2.87	ft	Depth of first virtual pin (zero moment on moment depth plot)		37897	0	-87560	2.796	2.8664	3.029
l_{b_bot}=	15.43	ft	Depth of second virtual pin (zero moment on moment depth plot)		-2046	0	6915	15.378	15.431	15.611
l_{b_2nd}=	12.56	ft	Total unbraced length from Lpile moment vs depth plot [$l_{b_2nd} = l_{b_bot} - l_{b_top}$]							

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	2.1	dim	Effective length factor for upper section (pinned at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.071919	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * l_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.313363	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * l_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1455.8	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \leq 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1316.9	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \leq 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1019.1	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{r_top}$]
P_{r_2nd}=	921.8	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{r_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{r_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.339	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.374	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.460	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check second pile segment for plastic hinge

M_{p_2nd} =	0.57	dim	Check for plastic hinge in second segment of pile
Check	OK		Check for plastic hinge in second segment of pile ("OK" if $M_{p_2nd} < 1.0$)

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

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INTEGRAL ABUTMENT PILE DESIGN WORKSHEET - EXPANSION PLUS North Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Slope. Displacement is equal to the thermal expansion of the bridge and the slope is assumed to be zero to represent a fixed head condition. No corrosion. Isolation casing for top 10 ft. Boring 104. Downdrag present. Deflections account for 17.1k shear force from slope stability analysis and 6k of braking force.

Input factored load per pile to be assessed

P_u=	345	kips	Factored applied superstructure and substructure vertical dead and live load distributed to each pile. (Includes 40 kips factored downdrag load)

Input steel H-pile strengths

F_y=	50	ksi	Yield strength of steel H pile section.
E_s=	29000	ksi	Elastic modulus of steel H pile section.

Select axial resistance factors for the strength limit state from AASHTO Section 6.5.4.2

ϕ_{cu}=	0.70	dim	Axial resistance factor for the upper zone of the pile for combined axial and flexure with no damage.
ϕ_{cl}=	0.50	dim	Axial resistance factor for the lower zone of the pile in compression (Use 0.50 for severe driving & 0.60 for good driving).
ϕ_f=	1.00	dim	Flexure resistance factor for the upper zone of the pile for combined axial and flexure with no damage.

Calculate the required Nominal Axial Pile Resistance

R_{n_up}=	492.9	kips	Required nominal resistance for upper zone of pile [$R_{n_up} = P_u / \phi_{cu}$].
R_{n_low}=	690	kips	Required nominal resistance for lower zone of pile [$R_{n_low} = P_u / \phi_{cl}$].
R_n=	690.0	kips	Required nominal resistance for pile [Max of R_{n_up}, R_{n_low}].

Calculate the required area of steel

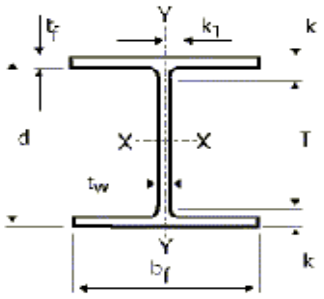
A_{s_req}=	17.250	in^2	Required area of steel to satisfy axial compression [$A_{s_req} = R_n / 0.8 * F_y$].

Choose preliminary HP-Pile Section

HP 14x102		Preliminary HP Section to be assessed for use at integral abutment.

Input HP shape properties

A_s=	30.000	in^2	Area of section
d=	14.000	in	Section depth
t_w=	0.705	in	Web thickness
b_f=	14.800	in	Flange width
t_f=	0.705	in	Flange thickness
k=	1.375	in	Distance from flange to fillet
T=	11.250	in	Web height excluding fillet
I_{xx}=	1050.000	in^4	Moment of Inertia about strong axis of HP section
S_{xx}=	150.000	in^3	Section modulus for strong axis bending
r_{xx}=	5.920	in	Radius of gyration for strong axis
Z_{xx}=	169.000	in^3	Plastic modulus for strong axis bending
I_{yy}=	380.000	in^4	Moment of Inertia about weak axis of HP section
S_{yy}=	51.400	in^3	Section modulus for weak axis bending
r_{yy}=	3.560	in	Radius of gyration
Z_{yy}=	78.800	in^3	Plastic modulus for weak axis bending



Input plate buckling coefficients for HP shape from AASHTO Table 6.9.4.2.1-1

k_f=	0.56	dim	Plate buckling coefficient for flanges
k_w=	1.49	dim	Plate buckling coefficient for web

Calculate and check pile properties

λ_f=	10.5	dim	Slenderness ratio for the compression flange as per AASHTO Eq. 6.12.2.2.1-3 [$\lambda_f = b_f / (2 * t_f)$]
λ_w=	16.0	dim	Slenderness ratio for the web as per AASHTO Eq. X.X.X.X.X-X [$\lambda_w = T / t_w$]

Check	OK	Check for flange buckling [OK if $\lambda_f \le k_f * (E*F_y)^{0.5}$]	13.49
Check	OK	Check for web buckling [OK if $\lambda_w \le k_w * (E*F_y)^{0.5}$]	35.88

Determine L-Pile load case parameters for displacement and slope

δ=	-0.7181	in	Pile head displacement due to thermal expansion
θ=	0	rad	Slope of pile head (assuming no rotation)
P_u=	345000	lb	Axial load at pile head

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET (Cont.) North Abutment Strength I

Run L-Pile and determine the following parameters using Displacement and Slope input

M_{u_top}=	3940473	in-lb	Maximum moment at top of the pile from Lpile output
I_{b_top}=	2.76	ft	Depth of first virtual pin (zero moment on moment depth plot)
I_{b_bot}=	16.00	ft	Depth of second virtual pin (zero moment on moment depth plot)
I_{b_2nd}=	13.24526	ft	Total unbraced length from Lpile moment vs depth plot [$I_{b_2nd} = I_{b_bot} - I_{b_top}$]

x_0	x	x_1	y_0	y	y_1
177649	0	-35071	2.563	2.7576	2.796
-7947	0	3710	15.844	16.003	16.077

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	1.2	dim	Effective length factor for upper section (fixed at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.021735	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * I_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.348222	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * I_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1486.5	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \le 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1297.9	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \le 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1040.6	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{n_top}$]
P_{r_2nd}=	908.6	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{n_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{n_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.332	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.380	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.460	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Calculate slenderness ratios for flexure resistance

λ_{pf}=	9.15	dim	Limiting slenderness ratio for a compact flange as per AASHTO Eq. 6.12.2.2.1-4 [$\lambda_{pf} = 0.38 * (E_s / F_y)^{0.5}$]
λ_{rf}=	19.99	dim	Limiting slenderness ratio for a non-compact flange as per AASHTO Eq. 6.12.2.2.1-5 [$\lambda_{pf} = 0.83 * (E_s / F_y)^{0.5}$]

Calculate nominal flexure resistance of pile as per AASHTO Section 6.12.2.2.1

M_n=	3770.0	in-kips	Nominal flexure resistance as per AASHTO Eq. 6.12.2.2.1-1

If $\lambda_f \le \lambda_{pf}$, then: $M_n = M_p$

If $\lambda_{pf} < \lambda_f \le \lambda_{rf}$, then:

$$M_n = \left[1 - \left(1 - \frac{S_y}{Z_y}\right)\left(\frac{\lambda_f - \lambda_{pf}}{0.45\sqrt{\frac{E}{F_{yf}}}}\right)\right] F_{yf} Z_y$$

Calculate the flexure resistance

M_r=	3770.0	in-kips	Factored flexure resistance as per AASHTO Eq. 6.12.1.2.1-1 [$M_r = \phi_f * M_n$]

Calculate the moment that will cause a plastic hinge at the pile cap

M_p=	2835.0	in-kips	Moment that will cause a plastic hinge at the pile cap [(9.0 /8.0) * (1- P_u / P_{r_top}) * M_r]

3940 in-kips

Check to determine if plastic hinge has formed

YES - Additional Analysis Required See below for explanation

YES: Since the applied moment exceeded the moment that would create a plastic hinge, it can be assumed that the pile head has entered plastic deformation and therefore the moment that can be applied to the pile head cannot exceed Mp. Additional analysis is required using the plastic moment to limit the bending resistance at the pile head, recalculate the unbraced length, and verify that a plastic hinge does not develop in the second pile segment.

NO: The applied moment does not exceed the moment that would create a plastic hinge at the pile head. No further analysis is required.

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

HNTB	For	Burnham Bridge	Job No.	63738	Sheet No.	3 of 3
	Made by	KRR	Check		Backcheck	
	Date	10/13/2017	Date		Date	

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET North Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Moment. Displacement is equal to the thermal expansion of the bridge and the moment is equal to the plastic resistance. Pile head conditions are assumed to be pinned.

Determine L-Pile load case parameters for displacement and moment as input

δ=	-0.7181	in	Pile head displacement due to thermal expansion
M_p=	2835049	in-lb	Plastic moment capacity
P_u=	345000	lb	Axial load at pile head

Run L-Pile and determine the following parameters

M_{u_top}=	2835049	in-lb	Maximum moment at top of the pile from Lpile output
M_{u_2nd}=	-1352907	in-lb	Maximum moment from Lpile moment vs depth plot.

l_{b_top}=	2.11	ft	Depth of first virtual pin (zero moment on moment depth plot)
l_{b_bot}=	15.35	ft	Depth of second virtual pin (zero moment on moment depth plot)
l_{b_2nd}=	13.23	ft	Total unbraced length from Lpile moment vs depth plot [$l_{b_2nd} = l_{b_bot} - l_{b_top}$]

x_0	x	x_1	y_0	y	y_1
15078	0	-2E+05	2.097	2.1138	2.33
-10788	0	1573	15.145	15.348	15.378

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	2.1	dim	Effective length factor for upper section (pinned at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.039113	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * l_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.347657	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * l_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1475.8	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \leq 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1298.2	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \leq 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1033.1	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{r_top}$]
P_{r_2nd}=	908.8	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{r_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{r_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.334	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.380	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.460	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

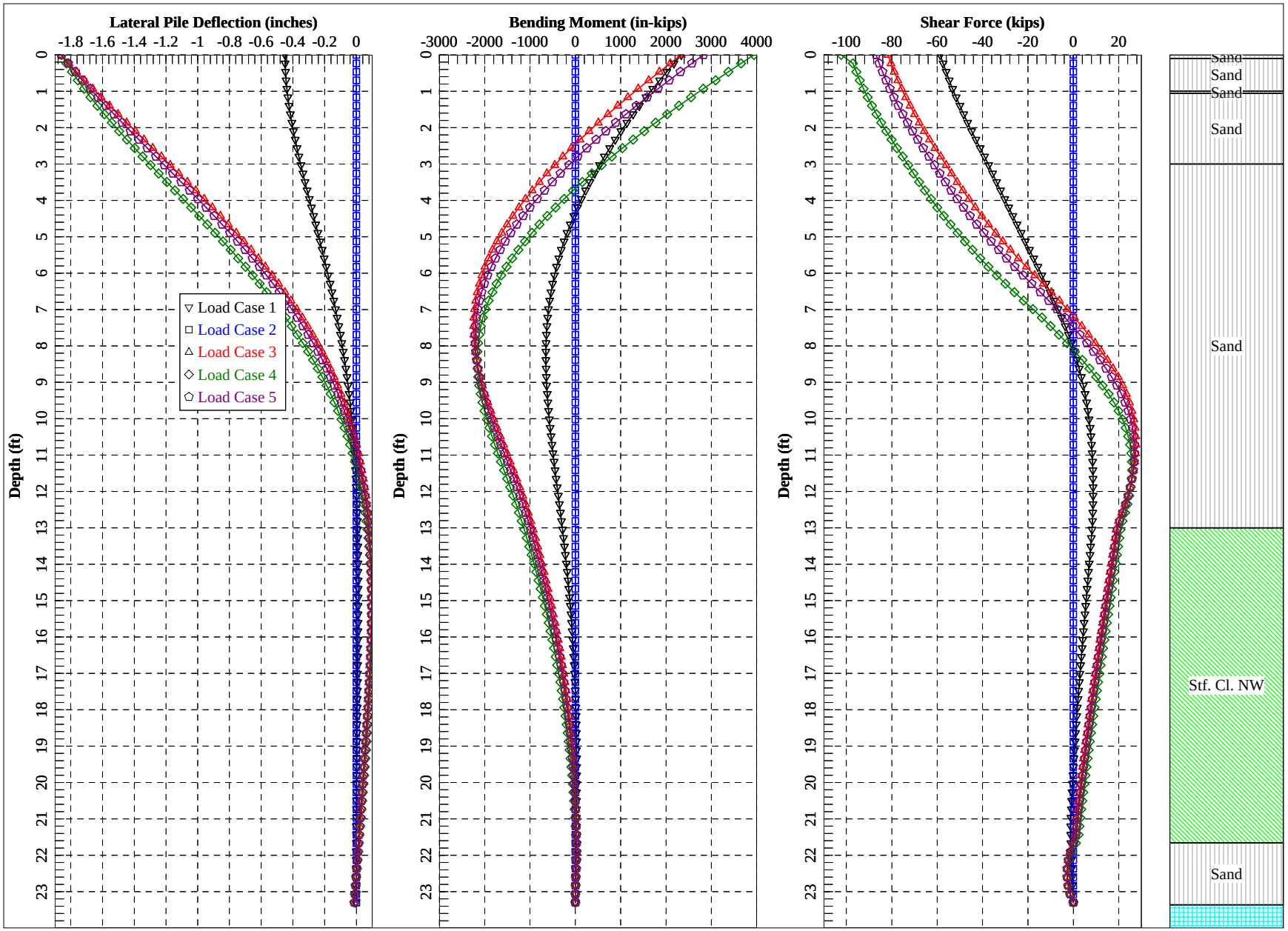
Check second pile segment for plastic hinge

M_{p_2nd} =	0.70	dim	Check for plastic hinge in second segment of pile
Check	OK		Check for plastic hinge in second segment of pile ("OK" if $M_{p_2nd} < 1.0$)

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

LPILE - North Abutment - Contraction - HP14x102 - BB-WCLG-104



LPile for Windows, Version 2016-09.006

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\63738_MEDOT_2015 GCA\Geotech\Burnham Bridge\Calcs\Deep Foundations\Piles\North Abutment\FINAL DESIGN\LPILE - HP14x102\DD\Boring 104\

Name of input data file:
NAbut_HP14x102_Weak_Contraction_Thermal.lp9d

Name of output report file:
NAbut_HP14x102_Weak_Contraction_Thermal.lp9o

Name of plot output file:
NAbut_HP14x102_Weak_Contraction_Thermal.lp9p

Name of runtime message file:
NAbut_HP14x102_Weak_Contraction_Thermal.lp9r

Date and Time of Analysis

Date: October 30, 2017 Time: 17:00:30

Problem Title

Project Name: Burnham Bridge

Job Number: 63738

Client: Maine DOT

Engineer: BAM-KRR

Description: North Abutment_HP14x89_5 Piles_Weak Axis_No Corrosion

Program Options and Settings

Computational Options:
- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined	=	1
Total length of pile	=	23.300 ft
Depth of ground surface below top of pile	=	-4.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.0000
2	23.300	14.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile with a specified moment capacity

Cross-sectional Shape	=	Weak H-Pile
Length of section	=	23.300000 ft
Flange Width	=	14.800000 in
Section Depth	=	14.000000 in
Flange Thickness	=	0.705000 in
Web Thickness	=	0.705000 in
Section Area	=	29.743950 sq. in
Moment of Inertia	=	381.278191 in^4
Elastic Modulus	=	29000000. psi
Plastic Moment Capacity	=	3940000. in-lb
Top Elastic Bending Stiffness	=	1.1057E+10 lbs-in^2
Bot Elastic Bending Stiffness	=	1.1057E+10 lbs-in^2
Shear Capacity at top of section	=	296100. lbs
Shear Capacity at bottom of section	=	296100. lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 8 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	-4.000000 ft
Distance from top of pile to bottom of layer	=	0.100000 ft
Effective unit weight at top of layer	=	115.000000 pcf
Effective unit weight at bottom of layer	=	115.000000 pcf

Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	0.100000 ft
Distance from top of pile to bottom of layer	=	1.000000 ft
Effective unit weight at top of layer	=	115.000000 pcf
Effective unit weight at bottom of layer	=	115.000000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	1.000000 ft
Distance from top of pile to bottom of layer	=	1.060000 ft
Effective unit weight at top of layer	=	111.000000 pcf
Effective unit weight at bottom of layer	=	111.000000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	77.000000 pci
Subgrade k at bottom of layer	=	77.000000 pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	1.060000 ft
Distance from top of pile to bottom of layer	=	3.000000 ft
Effective unit weight at top of layer	=	48.600000 pcf
Effective unit weight at bottom of layer	=	48.600000 pcf
Friction angle at top of layer	=	32.000000 deg.
Friction angle at bottom of layer	=	32.000000 deg.
Subgrade k at top of layer	=	51.000000 pci
Subgrade k at bottom of layer	=	51.000000 pci

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	3.000000 ft
Distance from top of pile to bottom of layer	=	13.000000 ft
Effective unit weight at top of layer	=	47.600000 pcf
Effective unit weight at bottom of layer	=	47.600000 pcf
Friction angle at top of layer	=	30.000000 deg.
Friction angle at bottom of layer	=	30.000000 deg.
Subgrade k at top of layer	=	35.000000 pci
Subgrade k at bottom of layer	=	35.000000 pci

Layer 6 is stiff clay without free water

Distance from top of pile to top of layer	=	13.000000 ft
Distance from top of pile to bottom of layer	=	21.660000 ft
Effective unit weight at top of layer	=	50.600000 pcf
Effective unit weight at bottom of layer	=	50.600000 pcf
Undrained cohesion at top of layer	=	642.000000 psf
Undrained cohesion at bottom of layer	=	642.000000 psf
Epsilon-50 at top of layer	=	0.0000
Epsilon-50 at bottom of layer	=	0.0000

NOTE: Default values for Epsilon-50 will be computed for this layer.

Layer 7 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	21.660000 ft
Distance from top of pile to bottom of layer	=	23.360000 ft
Effective unit weight at top of layer	=	64.000000 pcf
Effective unit weight at bottom of layer	=	64.000000 pcf
Friction angle at top of layer	=	38.000000 deg.
Friction angle at bottom of layer	=	38.000000 deg.
Subgrade k at top of layer	=	140.000000 pci
Subgrade k at bottom of layer	=	140.000000 pci

Layer 8 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	23.360000 ft
Distance from top of pile to bottom of layer	=	30.000000 ft
Effective unit weight at top of layer	=	100.000000 pcf
Effective unit weight at bottom of layer	=	100.000000 pcf
Uniaxial compressive strength at top of layer	=	5000. psi
Uniaxial compressive strength at bottom of layer	=	5000. psi
Initial modulus of rock at top of layer	=	125000. psi
Initial modulus of rock at bottom of layer	=	125000. psi
RQD of rock at top of layer	=	35.000000 %
RQD of rock at bottom of layer	=	35.000000 %

k rm of rock at top of layer = 0.0010000
k rm of rock at bottom of layer = 0.0010000

(Depth of the lowest soil layer extends 6.700 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm
1	Sand	-4.0000	115.0000	--	32.0000	--	--	--
	(Reese, et al.)	0.10000	115.0000	--	32.0000	--	--	--
2	Sand	0.10000	115.0000	--	32.0000	--	--	--
	(Reese, et al.)	1.0000	115.0000	--	32.0000	--	--	--
3	Sand	1.0000	111.0000	--	32.0000	--	--	--
	(Reese, et al.)	1.0600	111.0000	--	32.0000	--	--	--
4	Sand	1.0600	48.6000	--	32.0000	--	--	--
	(Reese, et al.)	3.0000	48.6000	--	32.0000	--	--	--
5	Sand	3.0000	47.6000	--	30.0000	--	--	--
	(Reese, et al.)	13.0000	47.6000	--	30.0000	--	--	--
6	Stiff Clay	13.0000	50.6000	642.0000	--	--	--	default
	w/o Free Water	21.6600	50.6000	642.0000	--	--	--	default
7	Sand	21.6600	64.0000	--	38.0000	--	--	--
	(Reese, et al.)	23.3600	64.0000	--	38.0000	--	--	--
8	Weak	23.3600	100.0000	--	--	5000.	35.0000	0.00100
	Rock	30.0000	100.0000	--	--	5000.	35.0000	0.00100

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 5

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = -0.450000 in	S = 0.0000 in/in	345000.	N.A.
2	4	y = 0.0000 in	M = 0.0000 in-lbs	345000.	N.A.
3	1	V = -81768. lbs	M = 2337351. in-lbs	345000.	No
4	5	y = -1.858800 in	S = 0.0000 in/in	345000.	N.A.
5	4	y = -1.858800 in	M = 2825216. in-lbs	345000.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic-plastic section properties

---

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	-4.0000	0.00	N.A.	No	0.00	553.9119
2	0.1000	4.1000	Yes	No	553.9119	706.1769
3	1.0000	5.0000	Yes	No	1260.	92.4769
4	1.0600	5.0600	Yes	No	1353.	6259.
5	3.0000	7.0000	Yes	No	7611.	145314.
6	13.0000	13.0000	No	No	152925.	58377.
7	21.6600	13.7833	No	No	211302.	123139.
8	23.3600	27.3600	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = -0.450000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 345000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.4500	2337351.	-58668.	0.00	54511.	1.11E+10	433.0817	1345.	0.00
0.2330	-0.4492	2174848.	-57376.	5.70E-04	51528.	1.11E+10	459.6322	2861.	0.00
0.4660	-0.4468	2015407.	-56057.	0.00110	48600.	1.11E+10	483.6409	3026.	0.00
0.6990	-0.4430	1859255.	-54672.	0.00159	45734.	1.11E+10	507.1210	3201.	0.00
0.9320	-0.4379	1706615.	-53201.	0.00204	42931.	1.11E+10	544.5635	3477.	0.00
1.1650	-0.4316	1557815.	-51637.	0.00245	40199.	1.11E+10	574.3073	3720.	0.00
1.3980	-0.4242	1413125.	-50003.	0.00283	37543.	1.11E+10	594.6877	3920.	0.00
1.6310	-0.4158	1272739.	-48314.	0.00317	34966.	1.11E+10	613.4983	4126.	0.00
1.8640	-0.4065	1136839.	-46574.	0.00347	32471.	1.11E+10	631.1616	4342.	0.00
2.0970	-0.3964	1005596.	-44782.	0.00374	30061.	1.11E+10	650.9495	4592.	0.00
2.3300	-0.3855	879197.	-42936.	0.00398	27740.	1.11E+10	669.3947	4855.	0.00
2.5630	-0.3741	757816.	-41040.	0.00419	25512.	1.11E+10	686.4472	5131.	0.00
2.7960	-0.3621	641616.	-39099.	0.00437	23379.	1.11E+10	702.0681	5421.	0.00
3.0290	-0.3497	530749.	-37267.	0.00451	21343.	1.11E+10	608.6038	4866.	0.00
3.2620	-0.3369	424510.	-35551.	0.00464	19393.	1.11E+10	618.9464	5137.	0.00
3.4950	-0.3237	323006.	-33807.	0.00473	17529.	1.11E+10	628.0368	5424.	0.00
3.7280	-0.3104	226333.	-32040.	0.00480	15754.	1.11E+10	635.8830	5728.	0.00
3.9610	-0.2969	134576.	-30253.	0.00485	14070.	1.11E+10	642.5023	6051.	0.00
4.1940	-0.2833	47809.	-28449.	0.00487	12477.	1.11E+10	647.9211	6394.	0.00
4.4270	-0.2697	-33904.	-26632.	0.00487	12221.	1.11E+10	652.1743	6762.	0.00
4.6600	-0.2561	-110511.	-24804.	0.00485	13628.	1.11E+10	655.3054	7155.	0.00
4.8930	-0.2426	-181968.	-22969.	0.00481	14940.	1.11E+10	657.3655	7578.	0.00
5.1260	-0.2292	-248241.	-21129.	0.00476	16157.	1.11E+10	658.3871	8033.	0.00
5.3590	-0.2159	-309307.	-19289.	0.00469	17278.	1.11E+10	658.0385	8521.	0.00
5.5920	-0.2029	-365154.	-17452.	0.00460	18303.	1.11E+10	656.1946	9041.	0.00
5.8250	-0.1902	-415781.	-15622.	0.00451	19232.	1.11E+10	652.8525	9598.	0.00
6.0580	-0.1777	-461203.	-13803.	0.00440	20066.	1.11E+10	648.0146	10194.	0.00
6.2910	-0.1656	-501446.	-12000.	0.00427	20805.	1.11E+10	641.6877	10834.	0.00
6.5240	-0.1538	-536551.	-10217.	0.00414	21450.	1.11E+10	633.8833	11521.	0.00
6.7570	-0.1424	-566570.	-8457.	0.00400	22001.	1.11E+10	624.6168	12261.	0.00
6.9900	-0.1314	-591567.	-6736.	0.00386	22460.	1.11E+10	606.7367	12906.	0.00
7.2230	-0.1209	-611677.	-5091.	0.00370	22829.	1.11E+10	569.7624	13179.	0.00
7.4560	-0.1107	-627183.	-3550.	0.00355	23114.	1.11E+10	532.7995	13453.	0.00
7.6890	-0.1010	-638371.	-2112.	0.00339	23319.	1.11E+10	496.0288	13727.	0.00
7.9220	-0.09179	-645526.	-775.5062	0.00323	23450.	1.11E+10	459.6202	14000.	0.00
8.1550	-0.08300	-648930.	459.4203	0.00306	23513.	1.11E+10	423.7321	14274.	0.00
8.3880	-0.07467	-648863.	1595.	0.00290	23512.	1.11E+10	388.5108	14547.	0.00
8.6210	-0.06680	-645601.	2633.	0.00273	23452.	1.11E+10	354.0908	14821.	0.00

8.8540	-0.05938	-639413.	3576.	0.00257	23338.	1.11E+10	320.5945	15095.	0.00
9.0870	-0.05242	-630563.	4427.	0.00241	23176.	1.11E+10	288.1317	15368.	0.00
9.3200	-0.04590	-619307.	5189.	0.00225	22969.	1.11E+10	256.8001	15642.	0.00
9.5530	-0.03982	-605892.	5865.	0.00210	22723.	1.11E+10	226.6854	15916.	0.00
9.7860	-0.03417	-590557.	6459.	0.00195	22441.	1.11E+10	197.8611	16189.	0.00
10.0190	-0.02894	-573531.	6973.	0.00180	22129.	1.11E+10	170.3893	16463.	0.00
10.2520	-0.02411	-555033.	7413.	0.00166	21789.	1.11E+10	144.3203	16736.	0.00
10.4850	-0.01967	-535271.	7782.	0.00152	21426.	1.11E+10	119.6938	17010.	0.00
10.7180	-0.01562	-514444.	8085.	0.00139	21044.	1.11E+10	96.5385	17284.	0.00
10.9510	-0.01192	-492736.	8324.	0.00126	20645.	1.11E+10	74.8730	17557.	0.00
11.1840	-0.00858	-470322.	8505.	0.00114	20234.	1.11E+10	54.7064	17831.	0.00
11.4170	-0.00557	-447367.	8632.	0.00102	19812.	1.11E+10	36.0382	18104.	0.00
11.6500	-0.00287	-424020.	8709.	9.11E-04	19384.	1.11E+10	18.8594	18378.	0.00
11.8830	-4.73E-04	-400422.	8740.	8.07E-04	18950.	1.11E+10	3.1527	18652.	0.00
12.1160	0.00164	-376703.	8729.	7.08E-04	18515.	1.11E+10	-11.1068	18925.	0.00
12.3490	0.00349	-352978.	8680.	6.16E-04	18079.	1.11E+10	-23.9511	19199.	0.00
12.5820	0.00509	-329354.	8597.	5.30E-04	17646.	1.11E+10	-35.4188	19473.	0.00
12.8150	0.00645	-305927.	8484.	4.49E-04	17216.	1.11E+10	-45.5547	19746.	0.00
13.0480	0.00760	-282781.	8273.	3.75E-04	16791.	1.11E+10	-105.3277	38755.	0.00
13.2810	0.00855	-260390.	7974.	3.06E-04	16380.	1.11E+10	-108.4672	35482.	0.00
13.5140	0.00931	-238783.	7667.	2.43E-04	15983.	1.11E+10	-110.8127	33273.	0.00
13.7470	0.00991	-217984.	7355.	1.85E-04	15601.	1.11E+10	-112.5424	31761.	0.00
13.9800	0.01035	-198012.	7039.	1.33E-04	15234.	1.11E+10	-113.7752	30739.	0.00
14.2130	0.01065	-178881.	6719.	8.52E-05	14883.	1.11E+10	-114.5949	30084.	0.00
14.4460	0.01083	-160602.	6398.	4.23E-05	14548.	1.11E+10	-115.0632	29719.	0.00
14.6790	0.01089	-143184.	6076.	3.87E-06	14228.	1.11E+10	-115.2270	29593.	0.00
14.9120	0.01085	-126631.	5754.	-3.02E-05	13924.	1.11E+10	-115.1227	29675.	0.00
15.1450	0.01072	-110948.	5433.	-6.03E-05	13636.	1.11E+10	-114.7794	29944.	0.00
15.3780	0.01051	-96135.	5113.	-8.65E-05	13364.	1.11E+10	-114.2208	30387.	0.00
15.6110	0.01023	-82191.	4794.	-1.09E-04	13108.	1.11E+10	-113.4661	30999.	0.00
15.8440	0.00990	-69114.	4478.	-1.28E-04	12868.	1.11E+10	-112.5314	31781.	0.00
16.0770	0.00952	-56900.	4165.	-1.44E-04	12644.	1.11E+10	-111.4303	32735.	0.00
16.3100	0.00909	-45544.	3856.	-1.57E-04	12435.	1.11E+10	-110.1738	33871.	0.00
16.5430	0.00864	-35037.	3549.	-1.67E-04	12242.	1.11E+10	-108.7717	35202.	0.00
16.7760	0.00816	-25372.	3247.	-1.75E-04	12065.	1.11E+10	-107.2319	36745.	0.00
17.0090	0.00766	-16540.	2950.	-1.80E-04	11903.	1.11E+10	-105.5609	38523.	0.00
17.2420	0.00715	-8529.	2657.	-1.83E-04	11756.	1.11E+10	-103.7640	40565.	0.00
17.4750	0.00664	-1326.	2370.	-1.85E-04	11623.	1.11E+10	-101.8452	42908.	0.00
17.7080	0.00612	5080.	2088.	-1.84E-04	11692.	1.11E+10	-99.8074	45598.	0.00
17.9410	0.00561	10705.	1812.	-1.82E-04	11796.	1.11E+10	-97.6517	48694.	0.00
18.1740	0.00510	15564.	1542.	-1.79E-04	11885.	1.11E+10	-95.3780	52272.	0.00
18.4070	0.00461	19673.	1279.	-1.74E-04	11960.	1.11E+10	-92.9841	56427.	0.00
18.6400	0.00413	23051.	1022.	-1.69E-04	12022.	1.11E+10	-90.4651	61290.	0.00
18.8730	0.00366	25716.	773.0729	-1.63E-04	12071.	1.11E+10	-87.8132	67032.	0.00
19.1060	0.00322	27688.	531.4574	-1.56E-04	12107.	1.11E+10	-85.0162	73894.	0.00
19.3390	0.00279	28989.	297.8916	-1.49E-04	12131.	1.11E+10	-82.0552	82218.	0.00
19.5720	0.00238	29641.	72.8724	-1.41E-04	12143.	1.11E+10	-78.9026	92517.	0.00
19.8050	0.00200	29669.	-143.0051	-1.34E-04	12144.	1.11E+10	-75.5162	105591.	0.00
20.0380	0.00164	29100.	-348.9955	-1.26E-04	12133.	1.11E+10	-71.8303	122786.	0.00
20.2710	0.00129	27962.	-544.1125	-1.19E-04	12112.	1.11E+10	-67.7383	146559.	0.00
20.5040	9.69E-04	26287.	-726.9586	-1.12E-04	12082.	1.11E+10	-63.0529	181997.	0.00
20.7370	6.64E-04	24113.	-895.3561	-1.06E-04	12042.	1.11E+10	-57.4032	241845.	0.00
20.9700	3.76E-04	21485.	-1045.	-1.00E-04	11993.	1.11E+10	-49.8701	371173.	0.00
21.2030	1.03E-04	18461.	-1139.	-9.52E-05	11938.	1.11E+10	-16.9469	460592.	0.00
21.4360	-1.57E-04	15301.	-1126.	-9.10E-05	11880.	1.11E+10	25.8402	460592.	0.00
21.6690	-4.06E-04	12338.	-1066.	-8.75E-05	11826.	1.11E+10	17.4988	120574.	0.00
21.9020	-6.46E-04	9510.	-1002.	-8.47E-05	11774.	1.11E+10	28.1099	121669.	0.00
22.1350	-8.79E-04	6899.	-908.6731	-8.26E-05	11726.	1.11E+10	38.6137	122763.	0.00
22.3680	-0.00111	4588.	-786.0713	-8.12E-05	11683.	1.11E+10	49.0843	123858.	0.00
22.6010	-0.00133	2660.	-634.1463	-8.03E-05	11648.	1.11E+10	59.5888	124952.	0.00
22.8340	-0.00156	1197.	-452.7225	-7.98E-05	11621.	1.11E+10	70.1850	126047.	0.00
23.0670	-0.00178	282.1529	-241.4809	-7.96E-05	11604.	1.11E+10	80.9177	127141.	0.00
23.3000	-0.00200	0.00	0.00	-7.96E-05	11599.	1.11E+10	91.8155	64118.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =    -0.45000000 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =       2337351. inch-lbs
Maximum shear force              =        -58668. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             16
Number of zero deflection points =              2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Displacement and Moment (Loading Type 4)

Displacement of pile head = 0.000000 inches
Moment at pile head = 0.0 in-lbs
Axial load at pile head = 345000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	5167.	0.00
0.2330	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	10936.	0.00
0.4660	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	11538.	0.00
0.6990	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	12140.	0.00
0.9320	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	12742.	0.00
1.1650	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	8838.	0.00
1.3980	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	9237.	0.00
1.6310	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	9635.	0.00
1.8640	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	10034.	0.00
2.0970	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	10433.	0.00
2.3300	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	10832.	0.00
2.5630	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	11230.	0.00
2.7960	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	11629.	0.00
3.0290	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	8254.	0.00
3.2620	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	8528.	0.00
3.4950	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	8802.	0.00
3.7280	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	9075.	0.00
3.9610	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	9349.	0.00
4.1940	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	9622.	0.00
4.4270	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	9896.	0.00
4.6600	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	10170.	0.00
4.8930	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	10443.	0.00
5.1260	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	10717.	0.00
5.3590	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	10990.	0.00
5.5920	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	11264.	0.00
5.8250	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	11538.	0.00
6.0580	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	11811.	0.00
6.2910	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	12085.	0.00
6.5240	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	12359.	0.00
6.7570	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	12632.	0.00
6.9900	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	12906.	0.00
7.2230	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	13179.	0.00
7.4560	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	13453.	0.00
7.6890	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	13727.	0.00
7.9220	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	14000.	0.00
8.1550	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	14274.	0.00
8.3880	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	14547.	0.00
8.6210	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	14821.	0.00
8.8540	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	15095.	0.00
9.0870	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	15368.	0.00
9.3200	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	15642.	0.00
9.5530	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	15916.	0.00
9.7860	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	16189.	0.00
10.0190	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	16463.	0.00
10.2520	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	16736.	0.00
10.4850	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	17010.	0.00
10.7180	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	17284.	0.00
10.9510	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	17557.	0.00
11.1840	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	17831.	0.00
11.4170	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	18104.	0.00
11.6500	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	18378.	0.00
11.8830	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	18652.	0.00
12.1160	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	18925.	0.00
12.3490	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	19199.	0.00
12.5820	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	19473.	0.00
12.8150	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	19746.	0.00
13.0480	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
13.2810	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
13.5140	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
13.7470	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
13.9800	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
14.2130	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
14.4460	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
14.6790	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
14.9120	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
15.1450	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
15.3780	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
15.6110	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
15.8440	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
16.0770	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
16.3100	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
16.5430	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
16.7760	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
17.0090	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
17.2420	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
17.4750	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
17.7080	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
17.9410	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
18.1740	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
18.4070	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
18.6400	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
18.8730	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
19.1060	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00

19.3390	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
19.5720	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
19.8050	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
20.0380	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
20.2710	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
20.5040	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
20.7370	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
20.9700	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
21.2030	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
21.4360	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	460592.	0.00
21.6690	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	120574.	0.00
21.9020	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	121669.	0.00
22.1350	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	122763.	0.00
22.3680	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	123858.	0.00
22.6010	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	124952.	0.00
22.8340	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	126047.	0.00
23.0670	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	127141.	0.00
23.3000	0.00	0.00	0.00	0.00	11599.	1.11E+10	0.00	64118.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection = 0.000000 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = 0.000000 inch-lbs
Maximum shear force = 0.000000 lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 0

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = -81768.0 lbs
Applied moment at pile head = 2337351.0 in-lbs
Axial thrust load on pile head = 345000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-1.8588	2337351.	-81768.	0.01665	54511.	1.11E+10	477.4907	359.1245	0.00
0.2330	-1.8114	2094250.	-80388.	0.01721	50048.	1.11E+10	509.7076	786.7621	0.00
0.4660	-1.7625	1854623.	-78919.	0.01771	45649.	1.11E+10	540.9553	858.1392	0.00
0.6990	-1.7124	1618773.	-77361.	0.01815	41319.	1.11E+10	573.4801	936.3861	0.00
0.9320	-1.6611	1387011.	-75690.	0.01853	37064.	1.11E+10	621.7404	1047.	0.00
1.1650	-1.6088	1159771.	-73893.	0.01885	32892.	1.11E+10	663.5083	1153.	0.00
1.3980	-1.5557	937435.	-71992.	0.01911	28810.	1.11E+10	696.7944	1252.	0.00
1.6310	-1.5019	720318.	-69996.	0.01932	24824.	1.11E+10	730.6405	1360.	0.00
1.8640	-1.4476	508737.	-67905.	0.01948	20939.	1.11E+10	765.4917	1479.	0.00
2.0970	-1.3930	303017.	-65710.	0.01958	17162.	1.11E+10	804.0943	1614.	0.00
2.3300	-1.3381	103508.	-63407.	0.01963	13499.	1.11E+10	843.5798	1763.	0.00
2.5630	-1.2832	-89431.	-60992.	0.01963	13241.	1.11E+10	883.9481	1926.	0.00
2.7960	-1.2283	-275438.	-58463.	0.01959	16656.	1.11E+10	925.1992	2106.	0.00
3.0290	-1.1736	-454144.	-56020.	0.01950	19937.	1.11E+10	821.9742	1958.	0.00
3.2620	-1.1193	-626314.	-53672.	0.01936	23098.	1.11E+10	857.9205	2143.	0.00
3.4950	-1.0654	-791625.	-51221.	0.01918	26133.	1.11E+10	894.5914	2348.	0.00
3.7280	-1.0120	-949749.	-48668.	0.01896	29036.	1.11E+10	931.9869	2575.	0.00
3.9610	-0.9594	-1100355.	-46009.	0.01870	31801.	1.11E+10	970.1069	2827.	0.00
4.1940	-0.9075	-1243108.	-43242.	0.01840	34422.	1.11E+10	1009.	3109.	0.00
4.4270	-0.8564	-1377671.	-40366.	0.01807	36892.	1.11E+10	1049.	3423.	0.00
4.6600	-0.8064	-1503702.	-37378.	0.01771	39206.	1.11E+10	1089.	3775.	0.00
4.8930	-0.7574	-1620853.	-34276.	0.01731	41357.	1.11E+10	1130.	4171.	0.00
5.1260	-0.7096	-1728776.	-31059.	0.01689	43338.	1.11E+10	1172.	4616.	0.00
5.3590	-0.6630	-1827119.	-27724.	0.01644	45144.	1.11E+10	1214.	5120.	0.00
5.5920	-0.6176	-1915525.	-24269.	0.01597	46767.	1.11E+10	1257.	5691.	0.00
5.8250	-0.5737	-1993635.	-20692.	0.01547	48201.	1.11E+10	1301.	6342.	0.00
6.0580	-0.5311	-2061087.	-16992.	0.01496	49439.	1.11E+10	1346.	7085.	0.00
6.2910	-0.4900	-2117516.	-13266.	0.01443	50475.	1.11E+10	1319.	7527.	0.00
6.5240	-0.4504	-2163116.	-9635.	0.01389	51312.	1.11E+10	1279.	7937.	0.00
6.7570	-0.4123	-2198193.	-6119.	0.01334	51956.	1.11E+10	1236.	8385.	0.00
6.9900	-0.3758	-2223068.	-2722.	0.01278	52413.	1.11E+10	1193.	8878.	0.00
7.2230	-0.3409	-2238072.	552.7767	0.01222	52688.	1.11E+10	1149.	9426.	0.00
7.4560	-0.3075	-2243546.	3703.	0.01165	52789.	1.11E+10	1104.	10042.	0.00
7.6890	-0.2757	-2239840.	6727.	0.01108	52721.	1.11E+10	1059.	10740.	0.00
7.9220	-0.2455	-2227308.	9625.	0.01052	52491.	1.11E+10	1014.	11543.	0.00
8.1550	-0.2169	-2206309.	12395.	0.00996	52105.	1.11E+10	967.5012	12472.	0.00

8.3880	-0.1898	-2177209.	15031.	0.00940	51571.	1.11E+10	918.2015	13524.	0.00
8.6210	-0.1643	-2140399.	17524.	0.00886	50895.	1.11E+10	865.1803	14723.	0.00
8.8540	-0.1403	-2096304.	19792.	0.00832	50086.	1.11E+10	757.4111	15095.	0.00
9.0870	-0.1178	-2045776.	21756.	0.00780	49158.	1.11E+10	647.3167	15368.	0.00
9.3200	-0.09669	-1989689.	23417.	0.00729	48128.	1.11E+10	540.9051	15642.	0.00
9.5530	-0.07701	-1928888.	24786.	0.00679	47012.	1.11E+10	438.3750	15916.	0.00
9.7860	-0.05870	-1864189.	25874.	0.00631	45824.	1.11E+10	339.8907	16189.	0.00
10.0190	-0.04171	-1796378.	26693.	0.00585	44579.	1.11E+10	245.5832	16463.	0.00
10.2520	-0.02599	-1726210.	27254.	0.00540	43291.	1.11E+10	155.5523	16736.	0.00
10.4850	-0.01148	-1654404.	27569.	0.00498	41973.	1.11E+10	69.8693	17010.	0.00
10.7180	0.00185	-1581649.	27650.	0.00457	40637.	1.11E+10	-11.4215	17284.	0.00
10.9510	0.01406	-1508596.	27511.	0.00418	39296.	1.11E+10	-88.2996	17557.	0.00
11.1840	0.02521	-1435867.	27163.	0.00381	37961.	1.11E+10	-160.7662	17831.	0.00
11.4170	0.03534	-1364044.	26618.	0.00345	36642.	1.11E+10	-228.8411	18104.	0.00
11.6500	0.04451	-1293677.	25889.	0.00312	35350.	1.11E+10	-292.5600	18378.	0.00
11.8830	0.05276	-1225281.	24988.	0.00280	34094.	1.11E+10	-351.9716	18652.	0.00
12.1160	0.06015	-1159339.	23927.	0.00250	32884.	1.11E+10	-407.1348	18925.	0.00
12.3490	0.06672	-1096296.	22717.	0.00221	31726.	1.11E+10	-458.1153	19199.	0.00
12.5820	0.07251	-1036568.	21371.	0.00194	30630.	1.11E+10	-504.9830	19473.	0.00
12.8150	0.07757	-980534.	19899.	0.00169	29601.	1.11E+10	-547.8085	19746.	0.00
13.0480	0.08193	-928543.	18867.	0.00144	28646.	1.11E+10	-190.7724	6510.	0.00
13.2810	0.08564	-877818.	18330.	0.00122	27715.	1.11E+10	-192.8959	6297.	0.00
13.5140	0.08873	-828386.	17788.	1.00E-03	26808.	1.11E+10	-194.6122	6132.	0.00
13.7470	0.09124	-780274.	17242.	7.97E-04	25924.	1.11E+10	-195.9704	6006.	0.00
13.9800	0.09319	-733504.	16693.	6.05E-04	25066.	1.11E+10	-197.0101	5911.	0.00
14.2130	0.09462	-688094.	16141.	4.25E-04	24232.	1.11E+10	-197.7631	5844.	0.00
14.4460	0.09557	-644063.	15588.	2.57E-04	23424.	1.11E+10	-198.2557	5800.	0.00
14.6790	0.09606	-601425.	15033.	9.96E-05	22641.	1.11E+10	-198.5099	5778.	0.00
14.9120	0.09612	-560192.	14478.	-4.73E-05	21884.	1.11E+10	-198.5439	5775.	0.00
15.1450	0.09579	-520374.	13923.	-1.84E-04	21153.	1.11E+10	-198.3731	5790.	0.00
15.3780	0.09509	-481980.	13369.	-3.11E-04	20448.	1.11E+10	-198.0107	5822.	0.00
15.6110	0.09406	-445017.	12816.	-4.28E-04	19769.	1.11E+10	-197.4676	5870.	0.00
15.8440	0.09270	-409489.	12265.	-5.36E-04	19117.	1.11E+10	-196.7533	5934.	0.00
16.0770	0.09106	-375399.	11716.	-6.35E-04	18491.	1.11E+10	-195.8756	6014.	0.00
16.3100	0.08915	-342748.	11170.	-7.26E-04	17892.	1.11E+10	-194.8411	6111.	0.00
16.5430	0.08700	-311538.	10626.	-8.09E-04	17319.	1.11E+10	-193.6551	6224.	0.00
16.7760	0.08463	-281765.	10087.	-8.84E-04	16772.	1.11E+10	-192.3219	6354.	0.00
17.0090	0.08206	-253427.	9551.	-9.51E-04	16252.	1.11E+10	-190.8446	6503.	0.00
17.2420	0.07931	-226519.	9020.	-0.00101	15758.	1.11E+10	-189.2255	6671.	0.00
17.4750	0.07640	-201036.	8493.	-0.00107	15290.	1.11E+10	-187.4655	6861.	0.00
17.7080	0.07335	-176968.	7972.	-0.00111	14848.	1.11E+10	-185.5646	7074.	0.00
17.9410	0.07017	-154308.	7456.	-0.00116	14432.	1.11E+10	-183.5218	7313.	0.00
18.1740	0.06688	-133046.	6946.	-0.00119	14042.	1.11E+10	-181.3344	7581.	0.00
18.4070	0.06350	-113168.	6442.	-0.00122	13677.	1.11E+10	-178.9986	7881.	0.00
18.6400	0.06004	-94662.	5945.	-0.00125	13337.	1.11E+10	-176.5089	8219.	0.00
18.8730	0.05652	-77513.	5455.	-0.00127	13022.	1.11E+10	-173.8576	8601.	0.00
19.1060	0.05293	-61704.	4973.	-0.00129	12732.	1.11E+10	-171.0349	9034.	0.00
19.3390	0.04931	-47218.	4499.	-0.00130	12466.	1.11E+10	-168.0280	9528.	0.00
19.5720	0.04565	-34033.	4034.	-0.00131	12224.	1.11E+10	-164.8203	10095.	0.00
19.8050	0.04197	-22129.	3578.	-0.00132	12005.	1.11E+10	-161.3903	10752.	0.00
20.0380	0.03827	-11480.	3132.	-0.00132	11810.	1.11E+10	-157.7105	11523.	0.00
20.2710	0.03456	-2062.	2696.	-0.00133	11637.	1.11E+10	-153.7444	12438.	0.00
20.5040	0.03085	6154.	2272.	-0.00133	11712.	1.11E+10	-149.4434	13543.	0.00
20.7370	0.02715	13201.	1861.	-0.00132	11841.	1.11E+10	-144.7411	14906.	0.00
20.9700	0.02346	19113.	1464.	-0.00132	11950.	1.11E+10	-139.5438	16635.	0.00
21.2030	0.01977	23930.	1082.	-0.00131	12038.	1.11E+10	-133.7136	18907.	0.00
21.4360	0.01611	27695.	717.0097	-0.00131	12107.	1.11E+10	-127.0358	22048.	0.00
21.6690	0.01247	30461.	-212.1040	-0.00130	12158.	1.11E+10	-537.5663	120574.	0.00
21.9020	0.00884	29017.	-1502.	-0.00129	12132.	1.11E+10	-384.7926	121669.	0.00
22.1350	0.00524	24557.	-2361.	-0.00129	12050.	1.11E+10	-230.0834	122763.	0.00
22.3680	0.00166	18293.	-2785.	-0.00128	11935.	1.11E+10	-73.3230	123858.	0.00
22.6010	-0.00192	11451.	-2768.	-0.00128	11809.	1.11E+10	85.6660	124952.	0.00
22.8340	-0.00548	5276.	-2303.	-0.00127	11696.	1.11E+10	247.0866	126047.	0.00
23.0670	-0.00904	1031.	-1383.	-0.00127	11618.	1.11E+10	411.1279	127141.	0.00
23.3000	-0.01260	0.00	0.00	-0.00127	11599.	1.11E+10	577.9229	64118.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

```
Pile-head deflection             =    -1.85877564 inches
Computed slope at pile head      =     0.01664790 radians
Maximum bending moment           =       2337351. inch-lbs
Maximum shear force              =        -81768. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             37
Number of zero deflection points =              2
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 4

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = -1.858800 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 345000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-1.8588	3940099.	-102334.	0.00	83936.	4.82E+08	477.4887	359.1184	0.00
0.2330	-1.8268	3655521.	-97124.	0.01190	78712.	1.11E+10	509.7053	780.1128	0.00
0.4660	-1.7923	3374035.	-95655.	0.01278	73544.	1.11E+10	540.9526	843.8983	0.00
0.6990	-1.7553	3095956.	-94097.	0.01360	68439.	1.11E+10	573.4770	913.4626	0.00
0.9320	-1.7162	2821604.	-92426.	0.01435	63402.	1.11E+10	621.7368	1013.	0.00
1.1650	-1.6751	2551425.	-90629.	0.01503	58441.	1.11E+10	663.5041	1107.	0.00
1.3980	-1.6322	2285810.	-88727.	0.01564	53565.	1.11E+10	696.7898	1194.	0.00
1.6310	-1.5876	2025086.	-86732.	0.01619	48778.	1.11E+10	730.6353	1287.	0.00
1.8640	-1.5417	1769579.	-84640.	0.01667	44087.	1.11E+10	765.4860	1388.	0.00
2.0970	-1.4944	1519624.	-82446.	0.01708	39498.	1.11E+10	804.0880	1504.	0.00
2.3300	-1.4461	1275585.	-80143.	0.01744	35018.	1.11E+10	843.5728	1631.	0.00
2.5630	-1.3969	1037830.	-77728.	0.01773	30653.	1.11E+10	883.9403	1769.	0.00
2.7960	-1.3470	806731.	-75198.	0.01796	26410.	1.11E+10	925.1907	1920.	0.00
3.0290	-1.2965	582669.	-72756.	0.01814	22296.	1.11E+10	821.9663	1773.	0.00
3.2620	-1.2456	364891.	-70407.	0.01826	18298.	1.11E+10	857.9119	1926.	0.00
3.4950	-1.1944	153730.	-67957.	0.01832	14421.	1.11E+10	894.5821	2094.	0.00
3.7280	-1.1431	-50475.	-65404.	0.01834	12526.	1.11E+10	931.9767	2280.	0.00
3.9610	-1.0919	-247382.	-62745.	0.01830	16141.	1.11E+10	970.0959	2484.	0.00
4.1940	-1.0408	-436644.	-59978.	0.01821	19615.	1.11E+10	1009.	2710.	0.00
4.4270	-0.9900	-617912.	-57102.	0.01808	22943.	1.11E+10	1049.	2961.	0.00
4.6600	-0.9397	-790833.	-54114.	0.01790	26118.	1.11E+10	1089.	3240.	0.00
4.8930	-0.8899	-955049.	-51012.	0.01768	29133.	1.11E+10	1130.	3550.	0.00
5.1260	-0.8409	-1110200.	-47795.	0.01742	31981.	1.11E+10	1172.	3896.	0.00
5.3590	-0.7925	-1255921.	-44460.	0.01712	34657.	1.11E+10	1214.	4283.	0.00
5.5920	-0.7451	-1391845.	-41005.	0.01678	37152.	1.11E+10	1257.	4718.	0.00
5.8250	-0.6987	-1517601.	-37428.	0.01642	39461.	1.11E+10	1301.	5207.	0.00
6.0580	-0.6533	-1632815.	-33728.	0.01602	41576.	1.11E+10	1346.	5759.	0.00
6.2910	-0.6091	-1737110.	-29902.	0.01559	43491.	1.11E+10	1391.	6386.	0.00
6.5240	-0.5661	-1830107.	-25948.	0.01514	45198.	1.11E+10	1437.	7098.	0.00
6.7570	-0.5245	-1911420.	-21866.	0.01467	46691.	1.11E+10	1483.	7905.	0.00
6.9900	-0.4841	-1980676.	-17781.	0.01418	47963.	1.11E+10	1439.	8310.	0.00
7.2230	-0.4452	-2038199.	-13822.	0.01367	49019.	1.11E+10	1393.	8750.	0.00
7.4560	-0.4077	-2084334.	-9992.	0.01315	49866.	1.11E+10	1346.	9231.	0.00
7.6890	-0.3717	-2119438.	-6297.	0.01261	50510.	1.11E+10	1298.	9761.	0.00
7.9220	-0.3372	-2143882.	-2738.	0.01208	50959.	1.11E+10	1248.	10351.	0.00
8.1550	-0.3042	-2158045.	681.9206	0.01153	51219.	1.11E+10	1198.	11014.	0.00
8.3880	-0.2727	-2162316.	3961.	0.01099	51298.	1.11E+10	1148.	11768.	0.00
8.6210	-0.2427	-2157087.	7099.	0.01044	51202.	1.11E+10	1097.	12637.	0.00
8.8540	-0.2143	-2142756.	10095.	0.00990	50938.	1.11E+10	1046.	13642.	0.00
9.0870	-0.1874	-2119729.	12941.	0.00936	50516.	1.11E+10	990.5586	14780.	0.00
9.3200	-0.1620	-2088440.	15593.	0.00882	49941.	1.11E+10	906.1589	15642.	0.00
9.5530	-0.1380	-2049558.	17958.	0.00830	49227.	1.11E+10	785.7656	15916.	0.00
9.7860	-0.1156	-2004034.	19992.	0.00779	48392.	1.11E+10	669.0781	16189.	0.00
10.0190	-0.09449	-1952789.	21705.	0.00729	47451.	1.11E+10	556.3324	16463.	0.00
10.2520	-0.07480	-1896720.	23109.	0.00680	46421.	1.11E+10	447.7275	16736.	0.00
10.4850	-0.05645	-1836687.	24215.	0.00633	45319.	1.11E+10	343.4276	17010.	0.00
10.7180	-0.03940	-1773522.	25035.	0.00587	44160.	1.11E+10	243.5640	17284.	0.00
10.9510	-0.02361	-1708020.	25583.	0.00543	42957.	1.11E+10	148.2376	17557.	0.00
11.1840	-0.00902	-1640943.	25871.	0.00501	41726.	1.11E+10	57.5211	17831.	0.00
11.4170	0.00441	-1573016.	25911.	0.00460	40478.	1.11E+10	-28.5381	18104.	0.00
11.6500	0.01672	-1504928.	25718.	0.00421	39228.	1.11E+10	-109.9149	18378.	0.00
11.8830	0.02797	-1437332.	25303.	0.00384	37987.	1.11E+10	-186.6041	18652.	0.00
12.1160	0.03821	-1370844.	24681.	0.00349	36767.	1.11E+10	-258.6167	18925.	0.00
12.3490	0.04747	-1306044.	23864.	0.00315	35577.	1.11E+10	-325.9773	19199.	0.00
12.5820	0.05581	-1243474.	22864.	0.00283	34428.	1.11E+10	-388.7202	19473.	0.00
12.8150	0.06328	-1183639.	21696.	0.00252	33330.	1.11E+10	-446.8869	19746.	0.00
13.0480	0.06990	-1127009.	20815.	0.00223	32290.	1.11E+10	-183.3487	7334.	0.00
13.2810	0.07573	-1071538.	20297.	0.00195	31272.	1.11E+10	-187.0566	6906.	0.00
13.5140	0.08080	-1017267.	19770.	0.00169	30275.	1.11E+10	-190.1121	6578.	0.00
13.7470	0.08516	-964235.	19235.	0.00143	29302.	1.11E+10	-192.6217	6324.	0.00
13.9800	0.08883	-912473.	18694.	0.00120	28351.	1.11E+10	-194.6644	6127.	0.00
14.2130	0.09185	-862010.	18147.	9.73E-04	27425.	1.11E+10	-196.3010	5975.	0.00
14.4460	0.09427	-812872.	17596.	7.61E-04	26523.	1.11E+10	-197.5791	5860.	0.00
14.6790	0.09611	-765080.	17043.	5.62E-04	25645.	1.11E+10	-198.5367	5776.	0.00
14.9120	0.09741	-718654.	16487.	3.74E-04	24793.	1.11E+10	-199.2047	5718.	0.00
15.1450	0.09820	-673609.	15929.	1.98E-04	23966.	1.11E+10	-199.6083	5683.	0.00
15.3780	0.09852	-629961.	15371.	3.33E-05	23165.	1.11E+10	-199.7686	5670.	0.00
15.6110	0.09839	-587721.	14812.	-1.21E-04	22389.	1.11E+10	-199.7028	5675.	0.00
15.8440	0.09784	-546898.	14254.	-2.64E-04	21640.	1.11E+10	-199.4256	5699.	0.00
16.0770	0.09691	-507502.	13697.	-3.97E-04	20916.	1.11E+10	-198.9491	5740.	0.00
16.3100	0.09562	-469537.	13142.	-5.21E-04	20219.	1.11E+10	-198.2834	5798.	0.00
16.5430	0.09400	-433007.	12589.	-6.35E-04	19549.	1.11E+10	-197.4368	5873.	0.00
16.7760	0.09207	-397915.	12038.	-7.40E-04	18904.	1.11E+10	-196.4161	5965.	0.00
17.0090	0.08986	-364262.	11491.	-8.36E-04	18287.	1.11E+10	-195.2267	6074.	0.00
17.2420	0.08739	-332046.	10947.	-9.24E-04	17695.	1.11E+10	-193.8724	6203.	0.00
17.4750	0.08469	-301264.	10407.	-0.00100	17130.	1.11E+10	-192.3560	6350.	0.00
17.7080	0.08178	-271913.	9871.	-0.00108	16591.	1.11E+10	-190.6788	6520.	0.00
17.9410	0.07867	-243986.	9341.	-0.00114	16078.	1.11E+10	-188.8409	6712.	0.00
18.1740	0.07539	-217476.	8815.	-0.00120	15592.	1.11E+10	-186.8409	6930.	0.00
18.4070	0.07195	-192374.	8296.	-0.00125	15131.	1.11E+10	-184.6760	7176.	0.00
18.6400	0.06838	-168669.	7783.	-0.00130	14696.	1.11E+10	-182.3416	7455.	0.00

18.8730	0.06470	-146347.	7277.	-0.00134	14286.	1.11E+10	-179.8311	7772.	0.00
19.1060	0.06090	-125396.	6778.	-0.00137	13901.	1.11E+10	-177.1356	8132.	0.00
19.3390	0.05702	-105799.	6286.	-0.00140	13541.	1.11E+10	-174.2434	8544.	0.00
19.5720	0.05307	-87539.	5804.	-0.00143	13206.	1.11E+10	-171.1393	9017.	0.00
19.8050	0.04905	-70595.	5330.	-0.00145	12895.	1.11E+10	-167.8036	9566.	0.00
20.0380	0.04498	-54945.	4866.	-0.00146	12608.	1.11E+10	-164.2107	10207.	0.00
20.2710	0.04087	-40566.	4412.	-0.00147	12344.	1.11E+10	-160.3270	10967.	0.00
20.5040	0.03674	-27431.	3969.	-0.00148	12103.	1.11E+10	-156.1082	11881.	0.00
20.7370	0.03258	-15509.	3539.	-0.00149	11884.	1.11E+10	-151.4941	13000.	0.00
20.9700	0.02842	-4767.	3123.	-0.00149	11687.	1.11E+10	-146.4011	14404.	0.00
21.2030	0.02425	4831.	2722.	-0.00149	11688.	1.11E+10	-140.7081	16224.	0.00
21.4360	0.02008	13327.	2337.	-0.00149	11844.	1.11E+10	-134.2317	18687.	0.00
21.6690	0.01593	20772.	1189.	-0.00148	11980.	1.11E+10	-686.8590	120574.	0.00
21.9020	0.01179	22841.	-487.8477	-0.00148	12018.	1.11E+10	-512.8751	121669.	0.00
22.1350	0.00766	20896.	-1675.	-0.00147	11983.	1.11E+10	-336.3580	122763.	0.00
22.3680	0.00355	16315.	-2365.	-0.00147	11899.	1.11E+10	-157.2657	123858.	0.00
22.6010	-5.49E-04	10502.	-2551.	-0.00146	11792.	1.11E+10	24.5291	124952.	0.00
22.8340	-0.00464	4878.	-2224.	-0.00146	11689.	1.11E+10	209.1983	126047.	0.00
23.0670	-0.00873	887.4033	-1377.	-0.00146	11615.	1.11E+10	396.9139	127141.	0.00
23.3000	-0.01282	0.00	0.00	-0.00146	11599.	1.11E+10	587.8013	64118.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 4:

Pile-head deflection = -1.85880000 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = 3940099. inch-lbs
Maximum shear force = -102334. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 31
Number of zero deflection points = 2

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 5

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = -1.858800 inches
Moment at pile head = 2825216.0 in-lbs
Axial load at pile head = 345000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-1.8588	2825216.	-86936.	0.01493	63468.	1.11E+10	477.4887	359.1184	0.00
0.2330	-1.8161	2569261.	-85556.	0.01561	58769.	1.11E+10	509.7055	784.7438	0.00
0.4660	-1.7715	2316664.	-84087.	0.01623	54131.	1.11E+10	540.9531	853.8038	0.00
0.6990	-1.7253	2067731.	-82529.	0.01679	49561.	1.11E+10	573.4777	929.3772	0.00
0.9320	-1.6776	1822776.	-80858.	0.01728	45064.	1.11E+10	621.7378	1036.	0.00
1.1650	-1.6287	1582238.	-79062.	0.01771	40648.	1.11E+10	663.5055	1139.	0.00
1.3980	-1.5786	1346500.	-77160.	0.01808	36320.	1.11E+10	696.7915	1234.	0.00
1.6310	-1.5276	1115882.	-75164.	0.01839	32086.	1.11E+10	730.6374	1337.	0.00
1.8640	-1.4758	890703.	-73073.	0.01864	27952.	1.11E+10	765.4885	1450.	0.00
2.0970	-1.4233	671291.	-70879.	0.01884	23923.	1.11E+10	804.0910	1580.	0.00
2.3300	-1.3704	458001.	-68575.	0.01898	20008.	1.11E+10	843.5762	1721.	0.00
2.5630	-1.3172	251195.	-66160.	0.01907	16211.	1.11E+10	883.9443	1876.	0.00
2.7960	-1.2638	51237.	-63631.	0.01911	12540.	1.11E+10	925.1952	2047.	0.00
3.0290	-1.2103	-141500.	-61188.	0.01910	14197.	1.11E+10	821.9706	1899.	0.00
3.2620	-1.1569	-327777.	-58840.	0.01904	17617.	1.11E+10	857.9168	2073.	0.00
3.4950	-1.1038	-507267.	-56390.	0.01894	20912.	1.11E+10	894.5875	2266.	0.00
3.7280	-1.0511	-679639.	-53836.	0.01879	24077.	1.11E+10	931.9827	2479.	0.00
3.9610	-0.9988	-844560.	-51177.	0.01859	27105.	1.11E+10	970.1025	2716.	0.00
4.1940	-0.9471	-1001691.	-48411.	0.01836	29989.	1.11E+10	1009.	2979.	0.00
4.4270	-0.8961	-1150691.	-45534.	0.01809	32725.	1.11E+10	1049.	3272.	0.00
4.6600	-0.8460	-1291212.	-42546.	0.01778	35305.	1.11E+10	1089.	3599.	0.00
4.8930	-0.7967	-1422907.	-39445.	0.01743	37723.	1.11E+10	1130.	3965.	0.00
5.1260	-0.7485	-1545422.	-36227.	0.01706	39972.	1.11E+10	1172.	4377.	0.00
5.3590	-0.7013	-1658402.	-32892.	0.01665	42046.	1.11E+10	1214.	4840.	0.00
5.5920	-0.6553	-1761485.	-29437.	0.01622	43939.	1.11E+10	1257.	5364.	0.00
5.8250	-0.6106	-1854311.	-25861.	0.01576	45643.	1.11E+10	1301.	5958.	0.00
6.0580	-0.5672	-1936513.	-22160.	0.01529	47152.	1.11E+10	1346.	6634.	0.00
6.2910	-0.5251	-2007721.	-18334.	0.01479	48459.	1.11E+10	1391.	7407.	0.00
6.5240	-0.4845	-2067564.	-14501.	0.01427	49558.	1.11E+10	1351.	7797.	0.00
6.7570	-0.4453	-2116342.	-10782.	0.01374	50454.	1.11E+10	1309.	8219.	0.00
6.9900	-0.4076	-2154370.	-7183.	0.01320	51152.	1.11E+10	1265.	8680.	0.00
7.2230	-0.3715	-2181979.	-3707.	0.01265	51659.	1.11E+10	1221.	9188.	0.00
7.4560	-0.3369	-2199513.	-357.6422	0.01210	51981.	1.11E+10	1175.	9754.	0.00
7.6890	-0.3038	-2207324.	2863.	0.01154	52124.	1.11E+10	1129.	10389.	0.00
7.9220	-0.2723	-2205771.	5954.	0.01099	52095.	1.11E+10	1082.	11111.	0.00

8.1550	-0.2424	-2195220.	8915.	0.01043	51902.	1.11E+10	1035.	11943.	0.00
8.3880	-0.2140	-2176040.	11743.	0.00988	51550.	1.11E+10	987.5981	12904.	0.00
8.6210	-0.1872	-2148609.	14432.	0.00933	51046.	1.11E+10	936.4462	13990.	0.00
8.8540	-0.1618	-2113333.	16963.	0.00879	50398.	1.11E+10	873.6502	15095.	0.00
9.0870	-0.1380	-2070711.	19245.	0.00826	49616.	1.11E+10	758.4966	15368.	0.00
9.3200	-0.1156	-2021655.	21209.	0.00774	48715.	1.11E+10	646.8692	15642.	0.00
9.5530	-0.09469	-1967049.	22867.	0.00724	47713.	1.11E+10	539.0003	15916.	0.00
9.7860	-0.07514	-1907749.	24229.	0.00675	46624.	1.11E+10	435.0861	16189.	0.00
10.0190	-0.05694	-1844582.	25306.	0.00628	45464.	1.11E+10	335.2880	16463.	0.00
10.2520	-0.04005	-1778344.	26110.	0.00582	44248.	1.11E+10	239.7346	16736.	0.00
10.4850	-0.02441	-1709799.	26653.	0.00538	42990.	1.11E+10	148.5239	17010.	0.00
10.7180	-0.00999	-1639675.	26947.	0.00495	41702.	1.11E+10	61.7255	17284.	0.00
10.9510	0.00328	-1568669.	27004.	0.00455	40399.	1.11E+10	-20.6172	17557.	0.00
11.1840	0.01544	-1497441.	26838.	0.00416	39091.	1.11E+10	-98.4838	17831.	0.00
11.4170	0.02654	-1426618.	26460.	0.00379	37791.	1.11E+10	-171.8749	18104.	0.00
11.6500	0.03664	-1356791.	25883.	0.00344	36509.	1.11E+10	-240.8087	18378.	0.00
11.8830	0.04577	-1288515.	25119.	0.00310	35255.	1.11E+10	-305.3186	18652.	0.00
12.1160	0.05399	-1222312.	24181.	0.00279	34040.	1.11E+10	-365.4496	18925.	0.00
12.3490	0.06135	-1158667.	23082.	0.00249	32871.	1.11E+10	-421.2557	19199.	0.00
12.5820	0.06789	-1098033.	21832.	0.00220	31758.	1.11E+10	-472.7965	19473.	0.00
12.8150	0.07365	-1040828.	20444.	0.00193	30708.	1.11E+10	-520.1343	19746.	0.00
13.0480	0.07868	-987434.	19452.	0.00167	29728.	1.11E+10	-188.8527	6711.	0.00
13.2810	0.08300	-935277.	18921.	0.00143	28770.	1.11E+10	-191.3980	6447.	0.00
13.5140	0.08667	-884387.	18383.	0.00120	27836.	1.11E+10	-193.4777	6242.	0.00
13.7470	0.08971	-834794.	17840.	9.82E-04	26925.	1.11E+10	-195.1533	6082.	0.00
13.9800	0.09216	-786524.	17292.	7.77E-04	26039.	1.11E+10	-196.4731	5960.	0.00
14.2130	0.09406	-739597.	16741.	5.84E-04	25177.	1.11E+10	-197.4755	5870.	0.00
14.4460	0.09543	-694034.	16188.	4.03E-04	24341.	1.11E+10	-198.1920	5807.	0.00
14.6790	0.09631	-649851.	15633.	2.33E-04	23530.	1.11E+10	-198.6484	5767.	0.00
14.9120	0.09674	-607062.	15078.	7.43E-05	22744.	1.11E+10	-198.8658	5748.	0.00
15.1450	0.09673	-565680.	14522.	-7.40E-05	21984.	1.11E+10	-198.8624	5748.	0.00
15.3780	0.09632	-525714.	13966.	-2.12E-04	21251.	1.11E+10	-198.6531	5766.	0.00
15.6110	0.09554	-487174.	13411.	-3.40E-04	20543.	1.11E+10	-198.2506	5802.	0.00
15.8440	0.09442	-450064.	12858.	-4.59E-04	19862.	1.11E+10	-197.6656	5853.	0.00
16.0770	0.09298	-414390.	12306.	-5.68E-04	19207.	1.11E+10	-196.9071	5921.	0.00
16.3100	0.09124	-380154.	11757.	-6.68E-04	18578.	1.11E+10	-195.9826	6005.	0.00
16.5430	0.08924	-347357.	11210.	-7.60E-04	17976.	1.11E+10	-194.8983	6106.	0.00
16.7760	0.08699	-315999.	10667.	-8.44E-04	17401.	1.11E+10	-193.6590	6224.	0.00
17.0090	0.08452	-286079.	10127.	-9.20E-04	16851.	1.11E+10	-192.2685	6360.	0.00
17.2420	0.08185	-257591.	9592.	-9.89E-04	16328.	1.11E+10	-190.7295	6516.	0.00
17.4750	0.07899	-230532.	9061.	-0.00105	15831.	1.11E+10	-189.0434	6692.	0.00
17.7080	0.07597	-204894.	8535.	-0.00111	15361.	1.11E+10	-187.2105	6890.	0.00
17.9410	0.07281	-180670.	8014.	-0.00115	14916.	1.11E+10	-185.2302	7113.	0.00
18.1740	0.06951	-157850.	7500.	-0.00120	14497.	1.11E+10	-183.1001	7365.	0.00
18.4070	0.06611	-136423.	6991.	-0.00123	14104.	1.11E+10	-180.8167	7647.	0.00
18.6400	0.06261	-116376.	6489.	-0.00127	13736.	1.11E+10	-178.3747	7966.	0.00
18.8730	0.05903	-97695.	5994.	-0.00129	13393.	1.11E+10	-175.7668	8326.	0.00
19.1060	0.05538	-80365.	5506.	-0.00132	13074.	1.11E+10	-172.9834	8734.	0.00
19.3390	0.05167	-64367.	5026.	-0.00133	12781.	1.11E+10	-170.0121	9200.	0.00
19.5720	0.04791	-49682.	4556.	-0.00135	12511.	1.11E+10	-166.8366	9736.	0.00
19.8050	0.04413	-36290.	4094.	-0.00136	12265.	1.11E+10	-163.4361	10356.	0.00
20.0380	0.04031	-24166.	3642.	-0.00137	12043.	1.11E+10	-159.7837	11083.	0.00
20.2710	0.03648	-13286.	3201.	-0.00137	11843.	1.11E+10	-155.8437	11945.	0.00
20.5040	0.03264	-3621.	2771.	-0.00137	11665.	1.11E+10	-151.5691	12984.	0.00
20.7370	0.02880	4860.	2354.	-0.00137	11688.	1.11E+10	-146.8955	14263.	0.00
20.9700	0.02496	12192.	1950.	-0.00137	11823.	1.11E+10	-141.7325	15880.	0.00
21.2030	0.02112	18413.	1562.	-0.00137	11937.	1.11E+10	-135.9482	17995.	0.00
21.4360	0.01731	23566.	1191.	-0.00136	12032.	1.11E+10	-129.3384	20897.	0.00
21.6690	0.01350	27702.	196.2413	-0.00136	12108.	1.11E+10	-582.3111	120574.	0.00
21.9020	0.00972	27280.	-1209.	-0.00135	12100.	1.11E+10	-423.0105	121669.	0.00
22.1350	0.00596	23544.	-2166.	-0.00134	12031.	1.11E+10	-261.5958	122763.	0.00
22.3680	0.00221	17757.	-2669.	-0.00134	11925.	1.11E+10	-97.9724	123858.	0.00
22.6010	-0.00152	11199.	-2711.	-0.00133	11805.	1.11E+10	68.0228	124952.	0.00
22.8340	-0.00525	5171.	-2285.	-0.00133	11694.	1.11E+10	236.5841	126047.	0.00
23.0670	-0.00897	991.3624	-1384.	-0.00133	11617.	1.11E+10	407.8960	127141.	0.00
23.3000	-0.01269	0.00	0.00	-0.00133	11599.	1.11E+10	582.0899	64118.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 5:

```
Pile-head deflection             =    -1.85880000 inches
Computed slope at pile head      =     0.01493137 radians
Maximum bending moment           =       2825216. inch-lbs
Maximum shear force              =        -86936. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             14
Number of zero deflection points =              2
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	-0.4500	S, rad	0.00	345000.	-0.4500	0.00	-58668.	2337351.
2	y, in	0.00	M, in-lb	0.00	345000.	0.00	0.00	0.00	0.00
3	V, lb	-81768.	M, in-lb	2337351.	345000.	-1.8588	0.01665	-81768.	2337351.
4	y, in	-1.8588	S, rad	0.00	345000.	-1.8588	0.00	-102334.	3940099.
5	y, in	-1.8588	M, in-lb	2825216.	345000.	-1.8588	0.01493	-86936.	2825216.

Maximum pile-head deflection = -1.8588000000 inches
Maximum pile-head rotation = 0.0166478969 radians = 0.953854 deg.

The analysis ended normally.

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INTEGRAL ABUTMENT PILE DESIGN WORKSHEET - CONTRACTION North Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Slope. Displacement is equal to the thermal expansion of the bridge and the slope is assumed to be zero to represent a fixed head condition. No corrosion. Isolation casing for top 10 ft. Downdrag present. Boring 104.

Input factored load per pile to be assessed

P_u=	345	kips	Factored applied superstructure and substructure vertical dead and live load distributed to each pile. (Includes 40 kips factored downdrag load)

Input steel H-pile strengths

F_y=	50	ksi	Yield strength of steel H pile section.
E_s=	29000	ksi	Elastic modulus of steel H pile section.

Select axial resistance factors for the strength limit state from AASHTO Section 6.5.4.2

ϕ_{cu}=	0.70	dim	Axial resistance factor for the upper zone of the pile for combined axial and flexure with no damage.
ϕ_{cl}=	0.50	dim	Axial resistance factor for the lower zone of the pile in compression (Use 0.50 for severe driving & 0.60 for good driving).
ϕ_f=	1.00	dim	Flexure resistance factor for the upper zone of the pile for combined axial and flexure with no damage.

Calculate the required Nominal Axial Pile Resistance

R_{n_up}=	492.9	kips	Required nominal resistance for upper zone of pile [$R_{n_up} = P_u / \phi_{cu}$].
R_{n_low}=	690	kips	Required nominal resistance for lower zone of pile [$R_{n_low} = P_u / \phi_{cl}$].
R_n=	690.0	kips	Required nominal resistance for pile [Max of R_{n_up}, R_{n_low}].

Calculate the required area of steel

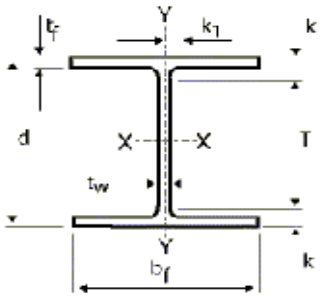
A_{s_req}=	17.250	in^2	Required area of steel to satisfy axial compression [$A_{s_req} = R_n / 0.8 * F_y$].

Choose preliminary HP-Pile Section

HP 14x102		Preliminary HP Section to be assessed for use at integral abutment.

Input HP shape properties

A_s=	30.000	in^2	Area of section
d=	14.000	in	Section depth
t_w=	0.705	in	Web thickness
b_f=	14.800	in	Flange width
t_f=	0.705	in	Flange thickness
k=	1.375	in	Distance from flange to fillet
T=	11.250	in	Web height excluding fillet
I_{xx}=	1050.000	in^4	Moment of Inertia about strong axis of HP section
S_{xx}=	150.000	in^3	Section modulus for strong axis bending
r_{xx}=	5.920	in	Radius of gyration for strong axis
Z_{xx}=	169.000	in^3	Plastic modulus for strong axis bending
I_{yy}=	380.000	in^4	Moment of Inertia about weak axis of HP section
S_{yy}=	51.400	in^3	Section modulus for weak axis bending
r_{yy}=	3.560	in	Radius of gyration
Z_{yy}=	78.800	in^3	Plastic modulus for weak axis bending



Input plate buckling coefficients for HP shape from AASHTO Table 6.9.4.2.1-1

k_f=	0.56	dim	Plate buckling coefficient for flanges
k_w=	1.49	dim	Plate buckling coefficient for web

Calculate and check pile properties

λ_f=	10.5	dim	Slenderness ratio for the compression flange as per AASHTO Eq. 6.12.2.2.1-3 [$\lambda_f = b_f / (2 * t_f)$]
λ_w=	16.0	dim	Slenderness ratio for the web as per AASHTO Eq. X.X.X.X.X-X [$\lambda_w = T / t_w$]

Check	OK	Check for flange buckling [OK if $\lambda_f \le k_f * (E*F_y)^{0.5}$]	13.49
Check	OK	Check for web buckling [OK if $\lambda_w \le k_w * (E*F_y)^{0.5}$]	35.88

Determine L-Pile load case parameters for displacement and slope

δ=	-0.45	in	Pile head displacement due to thermal expansion
θ=	0	rad	Slope of pile head (assuming no rotation)
P_u=	345000	lb	Axial load at pile head

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET (Cont.) North Abutment Strength I

Run L-Pile and determine the following parameters using Displacement and Slope input

M_{u_top}=	2337351	in-lb	Maximum moment at top of the pile from Lpile output
I_{b_top}=	4.33	ft	Depth of first virtual pin (zero moment on moment depth plot)
I_{b_bot}=	17.52	ft	Depth of second virtual pin (zero moment on moment depth plot)
I_{b_2nd}=	13.1929	ft	Total unbraced length from Lpile moment vs depth plot [$I_{b_2nd} = I_{b_bot} - I_{b_top}$]

x_0	x	x_1	y_0	y	y_1
47809	0	-33904	4.194	4.3303	4.427
-1326	0	5080	17.475	17.523	17.708

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	1.2	dim	Effective length factor for upper section (fixed at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.053597	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * I_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.345474	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * I_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1467.0	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \le 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1299.4	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \le 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1026.9	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{n_top}$]
P_{r_2nd}=	909.6	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{n_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{n_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.336	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.379	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.460	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Calculate slenderness ratios for flexure resistance

λ_{pf}=	9.15	dim	Limiting slenderness ratio for a compact flange as per AASHTO Eq. 6.12.2.2.1-4 [$\lambda_{pf} = 0.38 * (E_s / F_y)^{0.5}$]
λ_{rf}=	19.99	dim	Limiting slenderness ratio for a non-compact flange as per AASHTO Eq. 6.12.2.2.1-5 [$\lambda_{pf} = 0.83 * (E_s / F_y)^{0.5}$]

Calculate nominal flexure resistance of pile as per AASHTO Section 6.12.2.2.1

M_n=	3770.0	in-kips	Nominal flexure resistance as per AASHTO Eq. 6.12.2.2.1-1

If $\lambda_f \le \lambda_{pf}$, then: $M_n = M_p$

If $\lambda_{pf} < \lambda_f \le \lambda_{rf}$, then:

$$M_n = \left[1 - \left(1 - \frac{S_y}{Z_y}\right)\left(\frac{\lambda_f - \lambda_{pf}}{0.45\sqrt{\frac{E}{F_{yf}}}}\right)\right] F_{yf} Z_y$$

Calculate the flexure resistance

M_r=	3770.0	in-kips	Factored flexure resistance as per AASHTO Eq. 6.12.1.2.1-1 [$M_r = \phi_f * M_n$]

Calculate the moment that will cause a plastic hinge at the pile cap

M_p=	2816.3	in-kips	Moment that will cause a plastic hinge at the pile cap [(9.0 /8.0) * (1- P_u / P_{r_top}) * M_r]

2337 in-kips

Check to determine if plastic hinge has formed

NO - Analysis Complete See below for explanation

YES: Since the applied moment exceeded the moment that would create a plastic hinge, it can be assumed that the pile head has entered plastic deformation and therefore the moment that can be applied to the pile head cannot exceed Mp. Additional analysis is required using the plastic moment to limit the bending resistance at the pile head, recalculate the unbraced length, and verify that a plastic hinge does not develop in the second pile segment.

NO: The applied moment does not exceed the moment that would create a plastic hinge at the pile head. No further analysis is required.

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

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INTEGRAL ABUTMENT PILE DESIGN WORKSHEET - CONTRACTION PLUS North Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Slope. Displacement is equal to the thermal expansion of the bridge and the slope is assumed to be zero to represent a fixed head condition. No corrosion. Isolation casing for top 10 ft. Boring 104. Downdrag present. Deflections account for 17.1k shear force from slope stability analysis and 6k of braking force.

Input factored load per pile to be assessed

P_u=	345	kips	Factored applied superstructure and substructure vertical dead and live load distributed to each pile. (Includes 40 kips factored downdrag load)

Input steel H-pile strengths

F_y=	50	ksi	Yield strength of steel H pile section.
E_s=	29000	ksi	Elastic modulus of steel H pile section.

Select axial resistance factors for the strength limit state from AASHTO Section 6.5.4.2

ϕ_{cu}=	0.70	dim	Axial resistance factor for the upper zone of the pile for combined axial and flexure with no damage.
ϕ_{cl}=	0.50	dim	Axial resistance factor for the lower zone of the pile in compression (Use 0.50 for severe driving & 0.60 for good driving).
ϕ_f=	1.00	dim	Flexure resistance factor for the upper zone of the pile for combined axial and flexure with no damage.

Calculate the required Nominal Axial Pile Resistance

R_{n_up}=	492.9	kips	Required nominal resistance for upper zone of pile [$R_{n_up} = P_u / \phi_{cu}$].
R_{n_low}=	690	kips	Required nominal resistance for lower zone of pile [$R_{n_low} = P_u / \phi_{cl}$].
R_n=	690.0	kips	Required nominal resistance for pile [Max of R_{n_up}, R_{n_low}].

Calculate the required area of steel

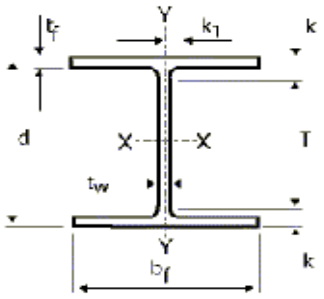
A_{s_req}=	17.250	in^2	Required area of steel to satisfy axial compression [$A_{s_req} = R_n / 0.8 * F_y$].

Choose preliminary HP-Pile Section

HP 14x102		Preliminary HP Section to be assessed for use at integral abutment.

Input HP shape properties

A_s=	30.000	in^2	Area of section
d=	14.000	in	Section depth
t_w=	0.705	in	Web thickness
b_f=	14.800	in	Flange width
t_f=	0.705	in	Flange thickness
k=	1.375	in	Distance from flange to fillet
T=	11.250	in	Web height excluding fillet
I_{xx}=	1050.000	in^4	Moment of Inertia about strong axis of HP section
S_{xx}=	150.000	in^3	Section modulus for strong axis bending
r_{xx}=	5.920	in	Radius of gyration for strong axis
Z_{xx}=	169.000	in^3	Plastic modulus for strong axis bending
I_{yy}=	380.000	in^4	Moment of Inertia about weak axis of HP section
S_{yy}=	51.400	in^3	Section modulus for weak axis bending
r_{yy}=	3.560	in	Radius of gyration
Z_{yy}=	78.800	in^3	Plastic modulus for weak axis bending



Input plate buckling coefficients for HP shape from AASHTO Table 6.9.4.2.1-1

k_f=	0.56	dim	Plate buckling coefficient for flanges
k_w=	1.49	dim	Plate buckling coefficient for web

Calculate and check pile properties

λ_f=	10.5	dim	Slenderness ratio for the compression flange as per AASHTO Eq. 6.12.2.2.1-3 [$\lambda_f = b_f / (2 * t_f)$]
λ_w=	16.0	dim	Slenderness ratio for the web as per AASHTO Eq. X.X.X.X.X-X [$\lambda_w = T / t_w$]

Check	OK	Check for flange buckling [OK if $\lambda_f \le k_f * (E*F_y)^{0.5}$]	13.49
Check	OK	Check for web buckling [OK if $\lambda_w \le k_w * (E*F_y)^{0.5}$]	35.88

Determine L-Pile load case parameters for displacement and slope

δ=	-1.8588	in	Pile head displacement due to thermal expansion
θ=	0	rad	Slope of pile head (assuming no rotation)
P_u=	345000	lb	Axial load at pile head

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET (Cont.) North Abutment Strength I

Run L-Pile and determine the following parameters using Displacement and Slope input

M_{u_top}=	3940099	in-lb	Maximum moment at top of the pile from Lpile output
l_{b_top}=	3.67	ft	Depth of first virtual pin (zero moment on moment depth plot)
l_{b_bot}=	21.09	ft	Depth of second virtual pin (zero moment on moment depth plot)
l_{b_2nd}=	17.41532	ft	Total unbraced length from Lpile moment vs depth plot [$l_{b_2nd} = l_{b_bot} - l_{b_top}$]

x_0	x	x_1	y_0	y	y_1
153730	0	-50475	3.495	3.6704	3.728
-4767	0	4831	20.97	21.086	21.203

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	1.2	dim	Effective length factor for upper section (fixed at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.038506	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * l_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.602001	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * l_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1476.2	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \le 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1168.0	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \le 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1033.3	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{n_top}$]
P_{r_2nd}=	817.6	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{n_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{n_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.334	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.422	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.460	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Calculate slenderness ratios for flexure resistance

λ_{pf}=	9.15	dim	Limiting slenderness ratio for a compact flange as per AASHTO Eq. 6.12.2.2.1-4 [$\lambda_{pf} = 0.38 * (E_s / F_y)^{0.5}$]
λ_{rf}=	19.99	dim	Limiting slenderness ratio for a non-compact flange as per AASHTO Eq. 6.12.2.2.1-5 [$\lambda_{pf} = 0.83 * (E_s / F_y)^{0.5}$]

Calculate nominal flexure resistance of pile as per AASHTO Section 6.12.2.2.1

M_n=	3770.0	in-kips	Nominal flexure resistance as per AASHTO Eq. 6.12.2.2.1-1

If $\lambda_f \le \lambda_{pf}$, then: $M_n = M_p$

If $\lambda_{pf} < \lambda_f \le \lambda_{rf}$, then:

$$M_n = \left[1 - \left(1 - \frac{S_y}{Z_y}\right)\left(\frac{\lambda_f - \lambda_{pf}}{0.45\sqrt{\frac{E}{F_{yf}}}}\right)\right] F_{yf} Z_y$$

Calculate the flexure resistance

M_r=	3770.0	in-kips	Factored flexure resistance as per AASHTO Eq. 6.12.1.2.1-1 [$M_r = \phi_f * M_n$]

Calculate the moment that will cause a plastic hinge at the pile cap

M_p=	2825.2	in-kips	Moment that will cause a plastic hinge at the pile cap [(9.0 /8.0) * (1- P_u / P_{r_top}) * M_r]

3940 in-kips

Check to determine if plastic hinge has formed

YES - Additional Analysis Required See below for explanation

YES: Since the applied moment exceeded the moment that would create a plastic hinge, it can be assumed that the pile head has entered plastic deformation and therefore the moment that can be applied to the pile head cannot exceed Mp. Additional analysis is required using the plastic moment to limit the bending resistance at the pile head, recalculate the unbraced length, and verify that a plastic hinge does not develop in the second pile segment.

NO: The applied moment does not exceed the moment that would create a plastic hinge at the pile head. No further analysis is required.

References:

1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

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	Date	10/13/2017	Date		Date	

INTEGRAL ABUTMENT PILE DESIGN WORKSHEET North Abutment Strength I

Introduction and Objective: The following calculations are in support of HP Pile design for integral abutments. L-Pile is used to determine the unbraced lengths of different pile segments, maximum moments both at the top of the pile and in the second segment, depth to fixity and shear at the top of the pile. All values highlighted in blue are parameters that require input from the user. Cells highlighted in green are automatically calculated and should not be edited.

Assumptions: L-Pile pile head conditions are Displacement and Moment. Displacement is equal to the thermal expansion of the bridge and the moment is equal to the plastic resistance. Pile head conditions are assumed to be pinned.

Determine L-Pile load case parameters for displacement and moment as input

δ=	-1.8588	in	Pile head displacement due to thermal expansion
M_p=	2825216	in-lb	Plastic moment capacity
P_u=	345000	lb	Axial load at pile head

Run L-Pile and determine the following parameters

M_{u_top}=	2825216	in-lb	Maximum moment at top of the pile from Lpile output
M_{u_2nd}=	-2207324	in-lb	Maximum moment from Lpile moment vs depth plot.

					x_0	x	x_1	y_0	y	y_1
l_{b_top}=	2.86	ft	Depth of first virtual pin (zero moment on moment depth plot)		51237	0	-1E+05	2.796	2.8579	3.029
l_{b_bot}=	20.60	ft	Depth of second virtual pin (zero moment on moment depth plot)		-3621	0	4860	20.504	20.603	20.737
l_{b_2nd}=	17.75	ft	Total unbraced length from Lpile moment vs depth plot [$l_{b_2nd} = l_{b_bot} - l_{b_top}$]							

Determine the effective length factors (AASHTO Table C4.6.2.5.1)

K_{top}=	2.1	dim	Effective length factor for upper section (pinned at top - pinned at bottom)
K_{2nd}=	1.0	dim	Effective length factor for upper section (pinned at top - pinned at bottom)

Calculate the normalized column slenderness factors for each pile segment (AAHSTO Section 6.9.4.1)

λ_{top}=	0.071496	dim	Normalized column slenderness factor of upper section [$\lambda_{top} = (K_{top} * l_{b_top} / r_y * \pi)^2 * (F_y/E_s)$]
λ_{2nd}=	0.625048	dim	Normalized column slenderness factor of upper section [$\lambda_{2nd} = (K_{2nd} * l_{b_2nd} / r_y * \pi)^2 * (F_y/E_s)$]

Calculate the nominal structural pile resistance for all pile segments

P_{n_top}=	1456.1	kips	Nominal structural pile resistance of first segment [$P_{n_top} = 0.66^{\lambda top} * F_y * A_s$] if $\lambda_{top} \leq 2.25$, otherwise [$P_{n_top} = (0.88 * F_y * A_s) / \lambda_{top}$]
P_{n_2nd}=	1156.9	kips	Nominal structural pile resistance of first segment [$P_{n_2nd} = 0.66^{\lambda 2nd} * F_y * A_s$] if $\lambda_{2nd} \leq 2.25$, otherwise [$P_{n_2nd} = (0.88 * F_y * A_s) / \lambda_{2nd}$]
P_{n_bot}=	1500.0	kips	Nominal structural pile resistance of first segment [$P_{n_bot} = 0.66^0 * F_y * A_s$]

Calculate the factored structural pile resistance for all segments

P_{r_top}=	1019.3	kips	Factored structural pile resistance for the first segment [$P_{r_top} = \phi_{cu} * P_{r_top}$]
P_{r_2nd}=	809.8	kips	Factored structural pile resistance for the second segment [$P_{r_2nd} = \phi_{cu} * P_{r_2nd}$]
P_{r_bot}=	750.0	kips	Factored structural pile resistance for the bottom segment [$P_{r_bot} = \phi_{cu} * P_{r_bot}$]

Check the applied load to structural resistance ratio

P_u / P_{r_top} =	0.338	dim	Applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
P_u / P_{r_2nd} =	0.426	dim	Applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
P_u / P_{r_bot} =	0.460	dim	Applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check	OK	Check applied load to structural resistance ratio for top pile segment ("OK" if $P_u / P_{r_top} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for second pile segment ("OK" if $P_u / P_{r_2nd} > 0.2$)
Check	OK	Check applied load to structural resistance ratio for bottom pile segment ("OK" if $P_u / P_{r_bot} < 1.0$)

Check second pile segment for plastic hinge

M_{p_2nd} =	0.9465	dim	Check for plastic hinge in second segment of pile
Check	OK		Check for plastic hinge in second segment of pile ("OK" if $M_{p_2nd} < 1.0$)

References:

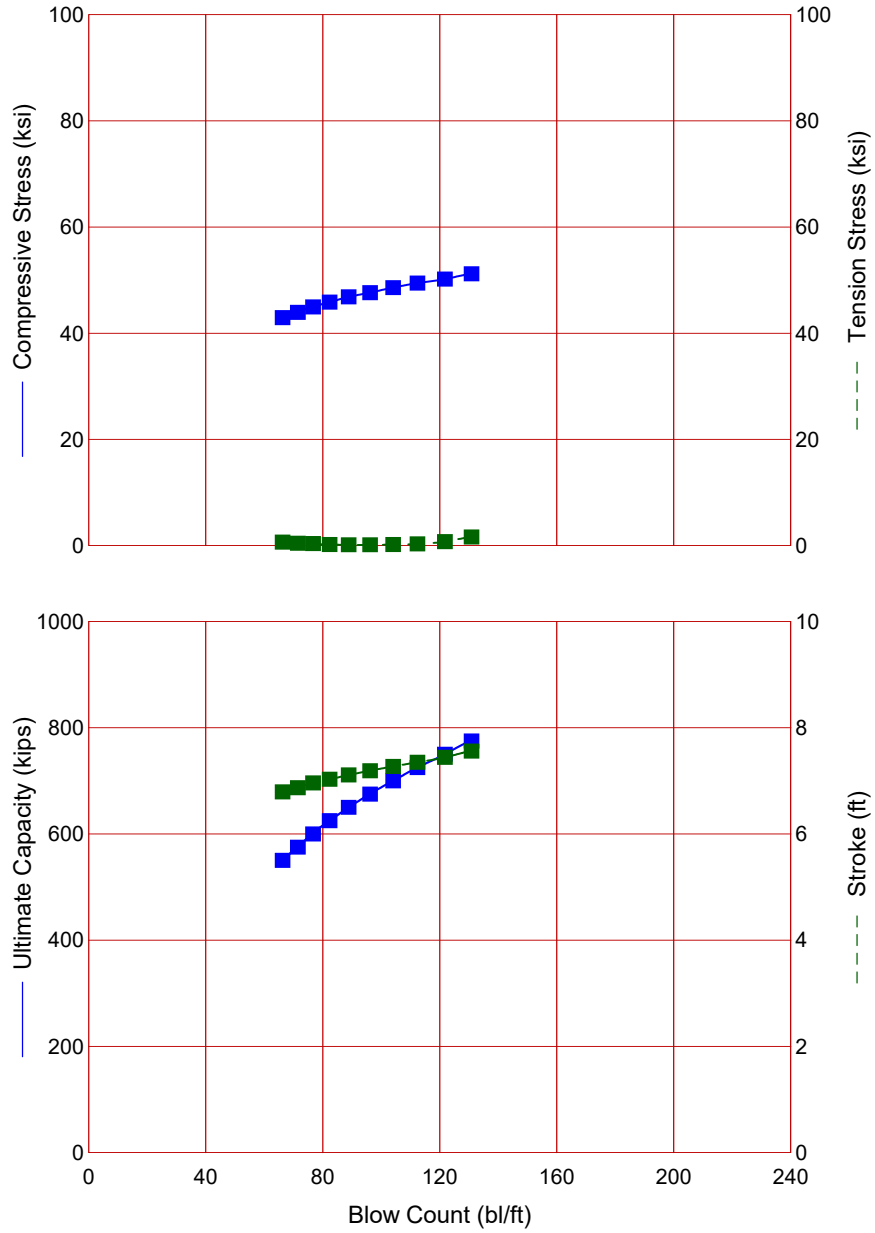
1. American Association of State Highway and Transportation Officials (2012). *AASHTO LRFD Bridge Design Specifications. Washington DC.*
2. Maine Department of Transportation (2003). *Bridge Design Guide with 2014 Interims.* Prepared by Elkerton & Associates.
3. Vtrans Integral Abutment Committee (2008). *Integral Abutment Bridge Design Guidelines Second Edition. Vtrans, Structures Section, Montpelier, Vermont.*

ABUTMENT 2 (NORTH)
WEAP ANALYSIS

HNTB

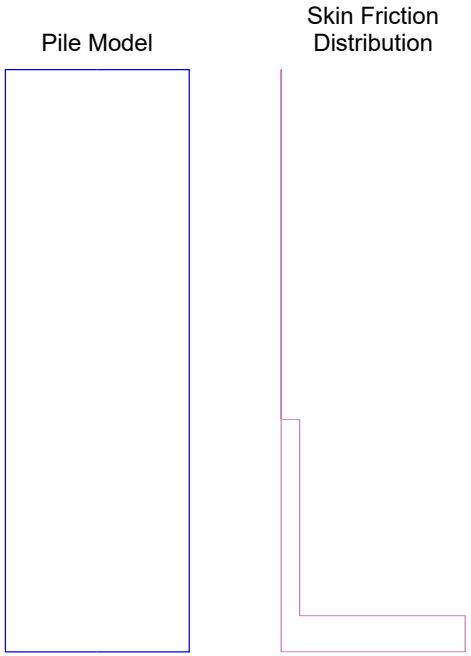
HNTB Corporation
HP 14x102

09-Nov-2017
GRLWEAP Version 2010



DELMAG D 36-32

Ram Weight	7.93	kips
Efficiency	0.800	
Pressure	1057 (72%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.070	in
Skin Damping	0.102	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	27.30	ft
Pile Penetration	10.90	ft
Pile Top Area	30.00	in2



Res. Shaft = 1 %
(Proportional)

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
550.0	42.91	0.66	66.3	6.79	21.73
575.0	43.93	0.44	71.5	6.87	21.76
600.0	44.94	0.40	76.7	6.96	21.92
625.0	45.86	0.21	82.4	7.03	22.03
650.0	46.85	0.16	88.9	7.11	22.12
675.0	47.63	0.16	96.2	7.19	22.19
700.0	48.58	0.20	104.1	7.27	22.27
725.0	49.44	0.33	112.4	7.35	22.42
750.0	50.19	0.76	121.8	7.44	22.55
775.0	51.19	1.63	130.9	7.56	22.81

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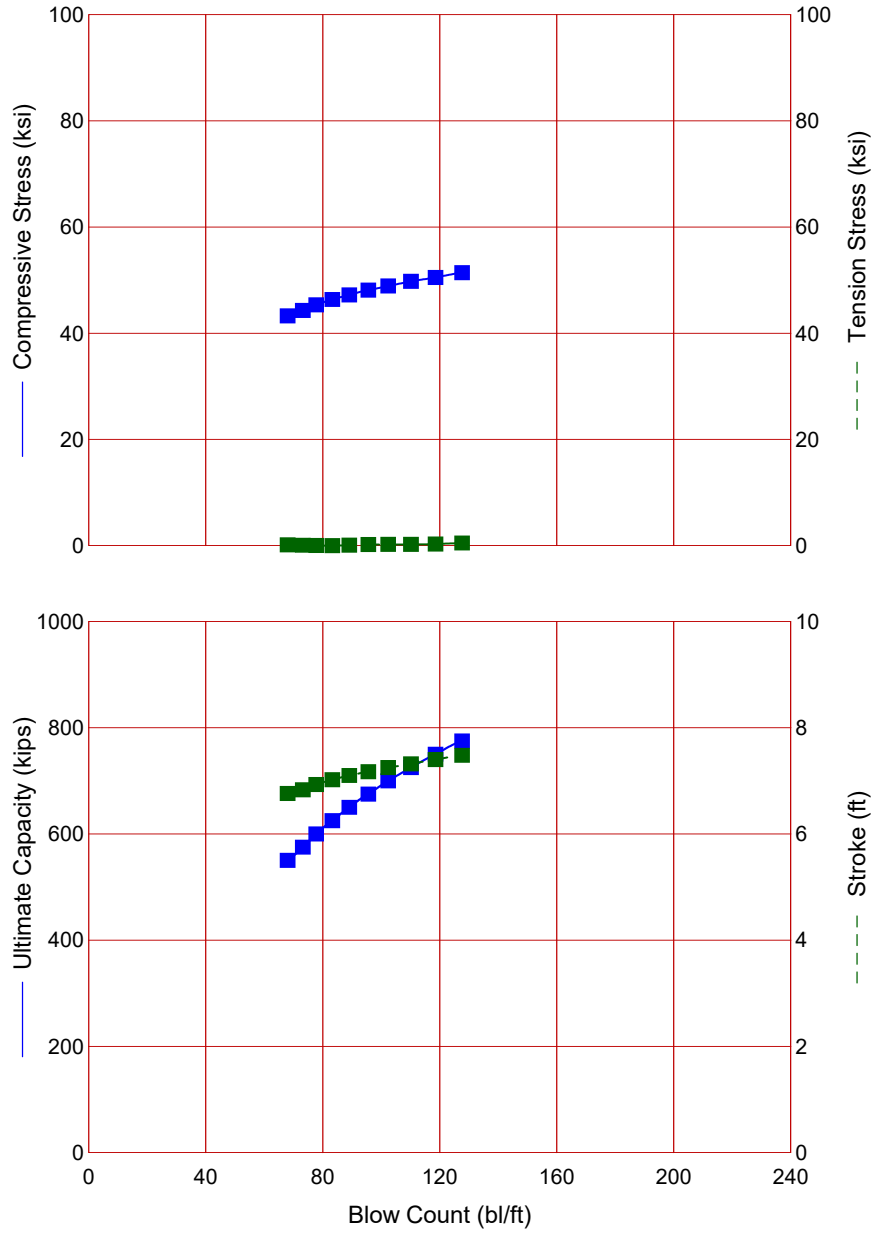
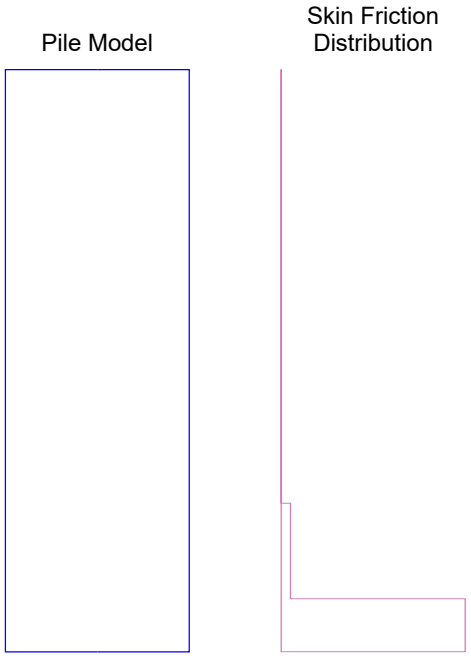


DELMAG D 36-32

Ram Weight	7.93	kips
Efficiency	0.800	
Pressure	1057 (72%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.070	in
Skin Damping	0.064	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	22.00	ft
Pile Penetration	5.60	ft
Pile Top Area	30.00	in2



Res. Shaft = 1 %
(Proportional)

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HP 14x102 GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
550.0	43.27	0.14	68.0	6.76	20.79
575.0	44.26	0.08	73.2	6.83	20.79
600.0	45.34	0.03	77.8	6.93	21.01
625.0	46.35	0.01	83.3	7.02	21.12
650.0	47.21	0.10	89.1	7.10	21.23
675.0	48.11	0.22	95.6	7.17	21.34
700.0	48.89	0.25	102.4	7.25	21.47
725.0	49.77	0.25	110.2	7.32	21.55
750.0	50.50	0.32	118.6	7.40	21.66
775.0	51.39	0.50	127.7	7.48	21.80