ARKANSAS DEPARTMENT OF TRANSPORTATION

SUBSURFACE INVESTIGATION

STATE JOB NO. 050342

FEDERAL AID PROJECT NO. NHPP-0073(72)

CYPRESS BAYOU – HWY. 267 STRS. & APPRS. (S)

STATE HIGHWAY 31 **SECTION** 3 & 4

IN LONOKE & WHITE **COUNTY**

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May 24, 2022
Job No. 18-077

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GEOTECHNICAL INVESTIGATION
ARDOT 050342: LONOKE CO. LINE-HWY. 267 STRS. & APPRS. (S)
HWY. 31 over CYPRESS BAYOU
LONOKE and WHITE COUNTY, ARKANSAS

INTRODUCTION

This report provides the final results of the geotechnical investigation performed for the Hwy. 31 replacement bridge over Cypress Bayou (Bridge #02867) in White County and Lonoke County, Arkansas. This project is one facet of ARDOT Job 050342 Lonoke Co. Line - Hwy. 267 Strs. & Apprs. (S). This geotechnical investigation was authorized by the Crafton Tull & Associates, Inc. Subconsultant Task Order Agreement of May 8, 2018. The field studies were delayed by inclement weather and access limitations. Results of this study have been provided as data were developed. Interim recommendations for subgrade support parameters were provided on April 17, 2019. This final report includes the pile capacities as provided on June 21, 2021.

It is understood that the replacement bridge will be continuous composite integral W-beam units with seven (7) bents, six (6) spans, and a total length of approximately 256 feet. A preliminary bridge layout is shown in Appendix A. The anticipated moderate structural loads of the new bridge will be supported on steel shell pile foundations. The overpass end and side embankments will utilize simple slopes with approximate 2-horizontal to 1-vertical (2H:1V) configurations.

The purposes of this phase of the geotechnical investigation were to explore subsurface conditions in the approach road and replacement bridge alignment at Cypress Bayou. The data developed through the field and laboratory studies were utilized to develop recommendations to guide design and construction of foundations, embankments, earthwork, and pavements. These purposes were achieved by a multi-phased study that has included:

- Drilling sample borings to evaluate subsurface conditions and to obtain samples for laboratory testing.
- Performing laboratory tests to establish pertinent engineering properties of the foundation and subgrade strata.
- Analyzing field and laboratory data to develop recommendations and conclusions for seismic site class, seismic design category/seismic performance zone, foundation design, embankment configuration, site grading, and construction considerations.

The results of the field and laboratory studies are discussed in the following report sections. Conclusions, results of analyses, and recommendations are discussed in subsequent report sections.

SUBSURFACE EXPLORATION

Subsurface conditions in the Hwy. 31 over Cypress Bayou alignment were evaluated by drilling four (4) sample borings to depths of 80 to 110 ft below existing grades in the structure location and four (4) sample borings to 4.5-ft depth in the plan roadway alignment. Because of limited access and to limit disruption of highway traffic, the roadway borings were advanced using hand-auger methods.

The site vicinity is shown on Plate 1. The approximate boring locations at the new bridge and pavement locations are shown on Plates 2a and 2b. Logs of the borings, presenting descriptions of the subsurface strata encountered and results of the field and laboratory tests, are included as Plates 3 through 16. The centerline station and offset of the boring locations and the inferred ground surface elevation are noted on the logs. The approximate boring surface elevation was inferred from the topographic information provided by the Engineer (Crafton Tull & Associates). It must be recognized that the elevations shown are approximate and actual elevations may vary. A key to the terms and symbols used on the logs is presented as Plate 17.

To aid in visualizing subsurface conditions at the replacement bridge location, a generalized subsurface profile is presented as Plate 18. The stratigraphy illustrated by the profile has been inferred between discrete boring locations. In view of the natural variations in stratigraphy and conditions, variations from the stratigraphy illustrated by the profiles should be anticipated.

The replacement bridge borings (Borings A1, A2, A3, and A4) were drilled using a CME 850X track-mounted drill rig using a combination of dry-auger and rotary-wash drilling methods. Soil samples were typically obtained using a 2-in.-diameter split-barrel sampler driven into the strata

by blows of a 140-lb automatic hammer or automatic hammer dropped 30 in. as per Standard Penetration Test (SPT) procedures. The number of blows required to drive the standard split-barrel sampler the final 12 in. of an 18-in. total drive, or portion thereof, is defined as the Standard Penetration Number (N). Recorded N-values are shown on the boring logs in the "Blows Per Ft" column.

The roadway borings performed for this project (Borings A6, A7, A8, and A9) were drilled using hand-auger methods because of limited site access and to limit disruption of highway traffic. Soil samples were obtained using a “bucket” auger. Undrained shear strength (cohesion) of each soil sample was estimated using a calibrated hand penetrometer. Estimated undrained shear strength is shown on the logs, in tons per sq ft, as a small circle enclosing an "x" plotted at the appropriate depth.

All samples were removed from sampling tools in the field, examined, and visually classified by the field geologist or geotechnical engineer. Samples were then placed in appropriate containers to prevent moisture loss and/or change in condition during transfer to our laboratory for further examination and testing.

The borings were advanced using dry-auger procedures to the extent possible to facilitate groundwater observations. Observations regarding groundwater are noted in the lower portion of each log and are discussed in subsequent sections of this report. All boreholes were backfilled after obtaining final water level readings.

LABORATORY TESTING

Pertinent physical and engineering characteristics of the foundation and subgrade soils were evaluated by performing laboratory tests including natural water content determinations and classification tests. Tests were performed on selected representative soil samples. Laboratory test results are shown on the logs. The laboratory testing program is discussed in the following report sections.

The laboratory testing program included 71 natural water content determinations performed to develop information on *in-situ* soil water content for each boring. The results of these tests are plotted on the logs as solid circles, in accordance with the scale and symbols shown in the legend located in the upper-right corner.

To verify field visual classification and to evaluate soil plasticity, 22 liquid and plastic limit (Atterberg limits) determinations and 28 sieve analyses, including one (1) hydrometer analysis were performed on selected representative samples. The Atterberg limits are plotted on the log as pluses

inter-connected with a dashed line using the water content scale. The percentage of soil passing through the No. 200 Sieve is noted in the "- No. 200 %" column on the appropriate log forms. In addition, specific gravity was measured for use in each hydrometer analysis of particle size distribution. A summary of laboratory test results and classification by the Unified Soil Classification System and AASHTO classification is presented in Appendix B. Grain-size distribution curves are also included in Appendix B.

To evaluate the moisture-density relationship of the subgrade soils, two (2) laboratory moisture-density relationship (Standard Proctor) tests (AASHTO T 99) were performed on representative bulk soil samples obtained in the approach road alignment. The Proctor tests and bulk sample classification test results are provided in Appendix C.

Pavement subgrade support properties were evaluated by performing California Bearing Ratio (CBR) tests (AASHTO T-193) on the representative bulk samples. For the CBR tests, the specimens were molded at approximately the optimum water content and 95 percent of the maximum dry density as determined by the appropriate laboratory Proctor tests. The CBR test results are also presented graphically in Appendix C. Classification test results are also shown on the CBR test reports.

GENERAL SITE AND SUBSURFACE CONDITIONS

Site Conditions

The replacement bridge project alignment is oriented north-south on Hwy. 31 over Cypress Bayou, with White County on the north and Lonoke County on the south. The roadway alignment is on an embankment with a height on the order of 10 ft above the surrounding, low-lying terrain. Aside from the embankment, the terrain is generally flat with little vertical relief. The area surrounding the alignment is thickly wooded and poorly drained. The area typically has standing water after a rain event and Cypress Bayou stream levels fluctuate widely. Surface drainage adjacent to the roadway embankment is considered very poor to poor.

Site Geology

The 050342 project alignment is located in the western limits of the Mississippi Embayment Physiographic Province. The site vicinity is the mapped exposure of Quaternary Alluvium. The Alluvium is comprised of recent stream-deposited alluvial sediments which include gravel, sand, silt, clay and mixtures of these clastic components. The thickness of the Alluvial deposits is

variable and these units typically overly consolidated Tertiary and Cretaceous sediments. The depth of bedrock (Paleozoic rocks) in this area is reported to be about 200 feet.

Seismic Conditions

In light of the results of the borings drilled at the Hwy. 31 over Cypress Bayou location and the surface geology of the project locale, a Seismic Site Class D (stiff soil profile) is considered applicable for the site with respect to the criteria of the AASHTO LRFD Bridge Design Specifications Seventh Edition 2014[1].

The 2014 edition of the AASHTO Guide Specifications indicates that the Peak Ground Acceleration (PGA) having a 7 percent chance of exceedance in 75 years (or mean return period of approximately 1000 years) for the bridge locations is predicted to be 0.263 for a Site Class D. Based on the Hwy. 31 over Cypress Bayou bridge location, the short period spectral acceleration coefficient (S_{DS}) value is 0.581g and the 1-sec period spectral acceleration coefficient the 1.0-sec period spectral acceleration coefficient (S_{D1}) value is 0.263g. Table 3.10.6-1 indicates that a Seismic Performance Zone 2 is fitting for the bridge site.

Liquefaction analyses were performed to evaluate the liquefaction potential of the subsurface soils. The analyses were performed utilizing the methodology and procedures proposed by Idriss and Boulanger[2] in 2008. A design PGA (A_s) value of 0.263, as per the site-specific seismic analysis, and an earthquake Moment Magnitude (M_w) of 4.8 were utilized.

The results of the liquefaction analyses are provided in Appendix D as plots of calculated factors of safety against liquefaction potential. The results of the analyses indicate an acceptable factor of safety against liquefaction and a low potential for liquefaction triggering for all cases considered.

Subsurface Conditions

Based on the results of the borings, the subsurface stratigraphy may be generalized into several primary strata as follows.

Stratum I: The natural surface and near-surface soils are very soft to stiff gray, yellowish tan brown, grayish brown, tan, and reddish tan fine sandy clay, silty clay, and very loose to loose fine sandy silt extending to 6- to 13-ft depth. The fine sandy clay and silty clay have low to medium plasticity with very low to moderate

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1 AASHTO LRFD Bridge Design Specifications, 7th Edition; AASHTO; 2014

2 "Soil Liquefaction during Earthquakes." Earthquake Engineering Research Institute, MNO-12, Idriss and Boulanger, 2008.

shear strength and high to moderate compressibility. The fine sandy silt typically exhibits very low to low relative density and high compressibility.

The natural soils typically classify as A-4, A-6, and A-7-6 by the AASHTO classification system (AASHTO M 145), correlating with poor subgrade support for pavement structures.

Stratum II: Loose to dense gray and tan silty fine sand is below Stratum I and extends to 13- to 28-ft depth is. The silty fine sand exhibits variable low to high relative density and high to low compressibility. The silty fine sand is poorly graded and fine-grained with 42 to 48 percent passing the No. 200 sieve (0.074mm).

Stratum III: Medium dense to very dense gray fine to medium sand is below the fine sandy silt and extends to depths of 50 to 53 feet. SPT N-values in the fine to medium sand range from 11 blows per ft to in excess of 50 blows per ft and average 38 blows per ft, indicating variable low to high relative density.

Stratum IV: The basal stratum encountered below about 50- to 53-ft depth is very stiff to hard dark brownish gray and dark gray clay. The clay has a varved structure and high to very high plasticity. SPT N-values typically are in excess of 50 blows per ft, indicative of high shear strength and low compressibility.

Groundwater Conditions

Groundwater was encountered at depths of 3 to 14 ft below existing grades in April and July 2019. Groundwater levels will vary, depending upon seasonal precipitation, surface runoff and infiltration, and water levels in the nearby Cypress Bayou and other surface water features.

ANALYSES and RECOMMENDATIONS

Foundation Design

Foundations for the new bridge structure must satisfy two (2) basic and independent design criteria: a) foundations must have an acceptable factor of safety against bearing failure under maximum design loads, and b) foundation movement due to consolidation or swelling and liquefaction of the underlying strata should not exceed tolerable limits for the structure. Construction factors, such as installation of foundations, excavation procedures and surface and groundwater conditions, must also be considered.

In light of the results of the borings and the anticipated moderate bridge foundation loads, we recommend a deep foundation system comprised of piling be utilized to support the foundation loads at the bridge ends and interior bents of the new bridge. Recommendations for piling are discussed in the following report sections.

Piling

We recommend the bridge foundation loads be supported on a deep foundation system comprised of steel shell piles. We understand that 18-in.-diameter steel shell piles are preliminarily planned for the bridge ends (Bents 1 and 7). The intermediate bents (Bents 2 through 6) are planned to have 28-in.-diameter steel shell piles. All steel shell piles should be filled with concrete after initial driving. Shear rings, shear studs, or other equivalents may be considered on the inside walls of the steel shells to enhance bonding between the concrete and the steel shells.

Nominal single pile capacity curves for 18- and 28-in.-diameter steel shells are provided in Appendix E. Nominal axial pile capacities have been developed using static pile capacity formulae, the results of the borings, and the plan pile cap bottom elevations shown on the preliminary bridge layout drawing. For the interior bents, the upper 6 ft of pile length (slightly over 2.4 times the maximum pile diameter) was ignored to consider potential scour. If scour depths exceed this depth, adjustment of the capacity curves could be warranted.

Based on AASHTO LRFD design procedures, an effective resistance factor (φ_{stat}) of 0.45 is recommended for evaluation of pile factored geotechnical compression capacity. For evaluation of factored uplift capacities, a resistance factor (φ_{up}) of 0.35 is recommended. These resistance factors are based on Strength Limit States. For Extreme Events Limit States, resistance factors of 1.0 and 0.8 are recommended for evaluating compression and uplift capacities, respectively.

Post-construction settlement of piles driven to the factored capacities and bearing in or below the dense sand units should be less than 0.5 inch. Given the relatively minor amount of embankment fill anticipated at the new bridge ends and the anticipated construction sequence with embankment construction completed several months before pile driving, downdrag loads due to long-term embankment settlement are expected to be negligible. Pre-boring is not expected to be required for pile installation.

As a minimum, safe bearing capacity of production piles should be determined by Standard Specifications for Highway Construction, 2014 Edition, Section 805.09, Method B. Blow counts on steel piles should be limited to about 20 blows per inch. Practical pile refusal may be defined as a penetration of 0.5 in. or less for the final 10 blows. Driving records should be available for review by the Engineer during pile installation.

Piles should be installed in compliance with Standard Specifications for Highway Construction, 2014 Edition, Section 805. Pile points are recommended to facilitate pile penetration into the dense to very dense sand bearing stratum.

To develop estimates of required minimum hammer energy, driveability analyses were performed utilizing wave equation analysis of piles (WEAP) methods and the computer program GRLWEAP 2014[3]. A yield strength (f_y) of 45 kips per sq in. was assumed for all piles. Wall thicknesses of 0.5 in. and 0.75 in. were assumed for the 18- and 28-in.-diameter steel shell piles, respectively. The results of driveability analyses are provided in Appendix F.

Based on the results of driveability analyses, we recommend a pile-hammer system with a minimum hammer energy 41 ft-kips for the end bents (Bents 1 and 7) and 91 ft-kips for the intermediate bents (Bents 2 through 6). A specific review and analysis of the pile-hammer system proposed by the Contractor should be performed by the Engineer or Department prior to hammer acceptance and beginning of driving.

The nominal axial capacities are based on single, isolated foundations. Piles spaced closer than three (3) pile diameters may develop lower individual capacity due to group effects. The potential for group capacity reductions should be evaluated for pile spacing closer than three (3) diameters.

Battered piles can be utilized to resist lateral loads. The axial capacity of battered piles may be taken as equivalent to that of a vertical pile with the same tip elevation and embedment. Special driving equipment is typically required where pile batter exceeds about 1-horizontal to 4-vertical.

Any jetting of piles should be approved by the Engineer or Department. Where jetting is to be utilized, containment of jetted materials must be provided unless otherwise approved by environmental agencies or other authorities. As a minimum, the final 5 ft of pile penetration should be achieved by use of an impact hammer. Where jetting is used to facilitate pile penetration, the jetting pressure and flow rate through jet pipes will directly affect jetting effort. Excess flow and pressure can result in poor controllability and poor alignment of the pile being installed and/or misalignment and compromising of the adjacent piles. Too low water flow or pressure can make the jetting technique ineffective.

Embankment Slope Stability

The replacement bridge will include new end slope configurations on the north and south ends of the bridge and side slopes on the west and east sides of the bridge. The plan embankment

[3] GRLWEAP 2014; Pile Dynamics, Inc.

configurations for the north and south bridge ends and side slopes are planned with 2-horizontal to 1-vertical (2H:1V) configurations.

To evaluate suitability of the plan configurations, slope stability analyses have been performed. A 250 lbs per sq ft uniform surcharge from vehicles was included for the stability analyses. Stability analyses were performed using the computer program SLOPE/W 2007[4] and a Morgenstern-Price analysis. For the embankment slopes, four (4) general loading conditions were evaluated, i.e., End of Construction, Long Term, Rapid Drawdown, and Seismic Conditions. For analysis of the seismic condition, a horizontal seismic acceleration coefficient (k_h) of one-half the peak acceleration value (A_s) was used, a value of 0.131. For evaluating the rapid drawdown condition, a water surface elevation drop from El 210 to existing grade has been assumed. The sections used for the analyses are shown in the graphical results provided in Appendix F.

For the purposes of the stability analyses, unclassified embankment as per Standard Specifications for Highway Construction, 2014 Edition, Subsection 210.06 was assumed for embankment fill. Accordingly, an undrained shear strength value of 1500 lbs per sq ft has been assumed for the embankment fill. Depending on the specific borrow utilized for embankments, verification of stability could be warranted.

The results of the stability analyses performed for this study indicate that stability of the plan 2H:1V embankment side and end slope configurations are acceptable with respect to all loading conditions evaluated. It is our conclusion that the plan embankment slope configurations are suitable with respect to slope stability. The 2H:1V slopes should be protected from erosion by concrete riprap or dumped riprap.

Subgrade Support Parameters

The laboratory test results indicate that the subgrade soils are predominantly fine grained fine sandy silt, sandy, silty clay, and fine sandy clay. These soils include classifications of A-4, A-6, and A-7-6 as per the AASHTO classification system (AASHTO M 145). We believe that the on-site soils and locally-available borrow are likely to be similar soils with similar classification.

We recommend that the pavement subgrade be evaluated by the Engineer during pavement construction. Areas of unstable or otherwise unsuitable subgrade should be improved by undercut and replacement or treatment with additives approved by the Engineer. Based on the results of the borings and our site observations, it is opined that undercuts on the order of 2 to 3 ft, more or less,

[4] Slope/W 2007; GEO-SLOPE International; 2008.

below existing grades could be warranted for subgrade improvement. Alternatively, addition of lime, cement, or other suitable additives could be utilized to develop a stable, non-pumping subgrade. We also recommend that any soils classifying as A-7-6 and soils with a plasticity index (PI) in excess of 18 be excluded from use as subgrade within 18 in. of the plan subgrade elevation. The top 18 in. of subgrade soils should have a maximum plasticity index (PI) of 18. Where A-7-5 or A-7-6 soils are encountered at the subgrade elevation, we recommend that these soils be undercut as required to provide at least 18 in. of low-plasticity subgrade soils. Alternatively, stabilization additives may be utilized to develop a stable subgrade with a maximum PI of 18.

Based on the results of the borings and laboratory tests and correlation with the AASHTO classification, subgrade support of the on-site soils is expected to be poor to fair. The following parameters are recommended for use in pavement design for a subgrade of the on-site soils and similar borrow soils.

- Resilient Modulus (M_R): 2615 lbs per sq inch
- R value: 7.2

Site Grading and Subgrade Preparation Considerations

Site grading/site preparation in the bridge and approach road alignment should include necessary clearing and grubbing of trees and underbrush and stripping the organic-containing surface soils in work areas. Where fill depths in excess of 3 ft are planned, stumps may be left after close cutting trees to grade, as per ARDOT criteria. Otherwise, tree stumps must be completely excavated and stumpholes properly backfilled.

The depth of stripping will be variable, with deeper stripping depths in wooded areas, and less stripping required in the areas of higher terrain. In general, the stripping depth in open areas is expected to be about 6 to 9 in. in cleared areas but may be 24 in. or more in the wooded areas, areas with thick underbrush, and where existing ditches are mucked out. The zone of organic surface soils should be completely stripped in the embankment footprint areas and at least 5 ft beyond the projected embankment toes.

Where existing pavements are to be demolished, consideration may be given to utilizing the processed asphalt concrete and aggregate base for embankment fill. In this case, the demolished materials should be thoroughly blended and processed to a reasonably well-graded mixture with a maximum particle size of 2 in. as per Standard Specifications for Highway Construction, 2014 Edition, Section 212. If abandoned pavements are within 3 ft of the plan subgrade elevation, the

existing pavement surface should be scarified to a minimum depth of 6 inches. The scarified material should be recompacted to a stable condition.

Following required pavement demolition, clearing and grubbing, and stripping, and prior to fill placement or otherwise continuing with subgrade preparation, the extent of weak and unsuitable soils should be determined. Thorough proof-rolling should be performed to verify subgrade stability. Proof-rolling should be performed with a loaded tandem-wheel dump truck or similar equipment. Unstable soils exhibiting a tendency to rut and/or pump should be undercut and replaced with suitable fill. Care should be taken that undercuts, stump holes, and other excavations or low areas resulting from subgrade preparation are properly backfilled with compacted fill. Based on the results of the borings, localized undercutting could be required to develop subgrade stability. Potential undercut depths are estimated to be on the order of 2 to 3 ft, more or less.

In areas of deep fills, the potential exists for use of thick initial lifts ("bridging"), as per ARDOT criteria. Bridge lifts will be subject to some consolidation. Settlement of a primarily granular fill suitable for use in bridging would be expected to be relatively rapid and long-term post-construction settlement would not be expected to be a significant concern. Where clayey soils are placed in thick lifts, long term settlement will be more significant. Consequently, we recommend that the use of “bridging” techniques be limited to granular borrow soils, i.e., sand or gravel. Where fill amounts are limited to less than about 3 ft, bridging will be less effective and the potential for undercut or stabilization will increase. Use of bridging techniques and fill lift thickness must be specifically approved by the Engineer or Department.

Subgrade preparation and mass undercuts should extend at least 10 ft beyond the embankment toes to the extent possible. Subgrade preparation in roadway areas should extend at least 3 ft outside pavement shoulder edges to the extent possible. The existing drainage features should be completely mucked out and all loose and/or organic soils removed prior to fill placement.

Fill and backfill may consist of unclassified borrow free of organics and other deleterious materials as per Standard Specifications for Highway Construction, 2014 Edition, Subsection 210.06. Granular soils must be protected from erosion with a minimum 18-in.-thick armor of clayey soil. The on-site silty clay and sandy clay are typically suitable for this use.

Subgrade preparation should comply with Standard Specifications for Highway Construction, 2014 Edition, Section 212. Embankments should be constructed in accordance with Standard Specifications for Highway Construction, 2014 Edition, Section 210. Fill and backfill

should be placed in nominal 6- to 10-in.-thick loose lifts. All fill and backfill must be placed in horizontal lifts. Where fill is placed against existing slopes, short vertical cuts should be "notched" in the existing slope face to facilitate bonding of horizontal fill lifts. The in-place density and water content should be determined for each lift and should be tested to verify compliance with the specified density and water content prior to placement of subsequent lifts.

CONSTRUCTION CONSIDERATIONS

Surface Drainage

Positive surface drainage should be established at the start of the work, be maintained during construction and following completion of the project to prevent surface water ponding and subsequent saturation of subgrade soils. Density and water content of all earthwork should be maintained until the embankments and bridge work are completed. Subgrade soils that become saturated by ponding water or runoff should be excavated to undisturbed soils. The embankment subgrade should be evaluated by the Engineer during subgrade preparation.

Groundwater was encountered at 3- to 14-ft depth (approximately El 197± to El 191±) in April and July 2019. In addition, shallow perched groundwater may be encountered in the near-surface soils. Seepage into excavations and cuts can typically be controlled by ditching or sump-and-pump methods. If seepage into excavations becomes a problem, backfill should consist of select granular backfill (AASHTO M43, No. 57 stone), stone backfill (ARDOT Standard Specifications Section 207), or clean aggregate (ARDOT Standard Specifications Subsections 403.01 and 403.02 Class 3 mineral aggregate) to an elevation above the inflow of seepage. In areas of seepage infiltration, the granular fill should be fully encapsulated with a filter fabric complying with Standard Specifications for Highway Construction, 2014 Edition, Subsection 625.02, Type 2 and vented to positive discharge.

Piling

Piles should be installed in compliance with 2014 Edition of Standard Specifications for Highway Construction, Section 805. Piles should be carefully examined prior to driving and piles with structural defects should be rejected.

Pile installation should be monitored by qualified personnel to maintain specific and complete driving records and observe pile installation procedures. Driving records should be available for review by the Engineer or Department during pile installation. Compatible driving equipment should be utilized based on the results of drivability analyses performed by the

Department. Blow counts on steel piles should be limited to about 20 blows per inch. As a minimum, safe bearing capacity of production piles should be determined by Standard Specifications for Highway Construction, 2014 Edition, Section 805.09, Method B.

The Piling Contractor should have demonstrable experience in installing steel shell piles of similar sizes in subsurface conditions similar to those at this site. Where jetting piles is approved by the Engineer or Department, the Contractor should have appropriate equipment with sufficient jetting pressure/flow rate and adequate hammer energy to install piles to the plan tip elevation.

CLOSURE

The Engineer, Department, or a designated representative thereof should monitor site preparation, grading work, ground improvements, and all foundation and embankment construction. Subsurface conditions significantly at variance with those encountered in the borings should be brought to the attention of the Geotechnical Engineer. The conclusions and recommendations of this report should then be reviewed in light of the new information.

The following illustrations are attached and complete this submittal.

Plate 1	Site Vicinity
Plate 2	Plan of Borings
Plates 3 through 16	Boring Logs
Plate 17	Key to Terms and Symbols
Plate 18	Generalized Subsurface Profile
Appendix A	Preliminary Bridge Layout
Appendix B	Classification Test Results
Appendix C	Proctor and CBR Test Results
Appendix D	Liquefaction Analysis Results
Appendix E	Nominal Pile Capacity Curves
Appendix F	WEAP Analysis Results
Appendix G	Stability Analysis Results

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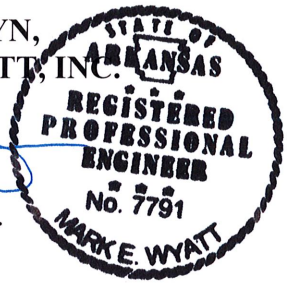
We appreciate the opportunity to be of service to you on this project phase. Should you have any questions regarding this report, or if we may be of additional assistance during final design or construction, please call on us.

Sincerely,

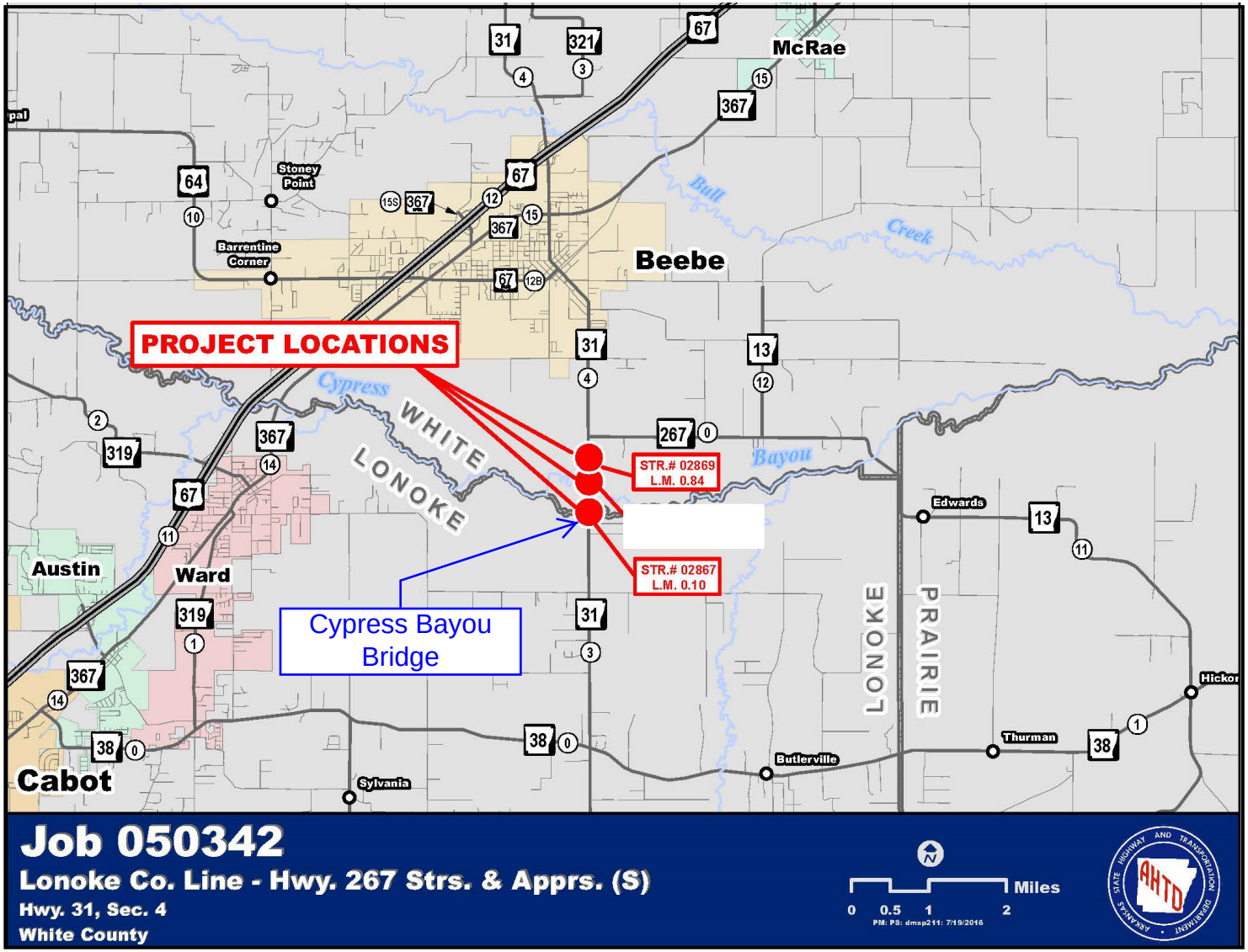
GRUBBS, HOSKYN, BARTON &WYATT, INC.



Mark E. Wyatt, P.E.
President

BJD/VMS/MEW:jw

Copies Submitted: Crafton Tull & Associates, Inc.
Attn: Mr. Mike Burns, P.E. (1-electronic)
Attn: Mr. Chuck Wipf, P.E. (1-electronic)

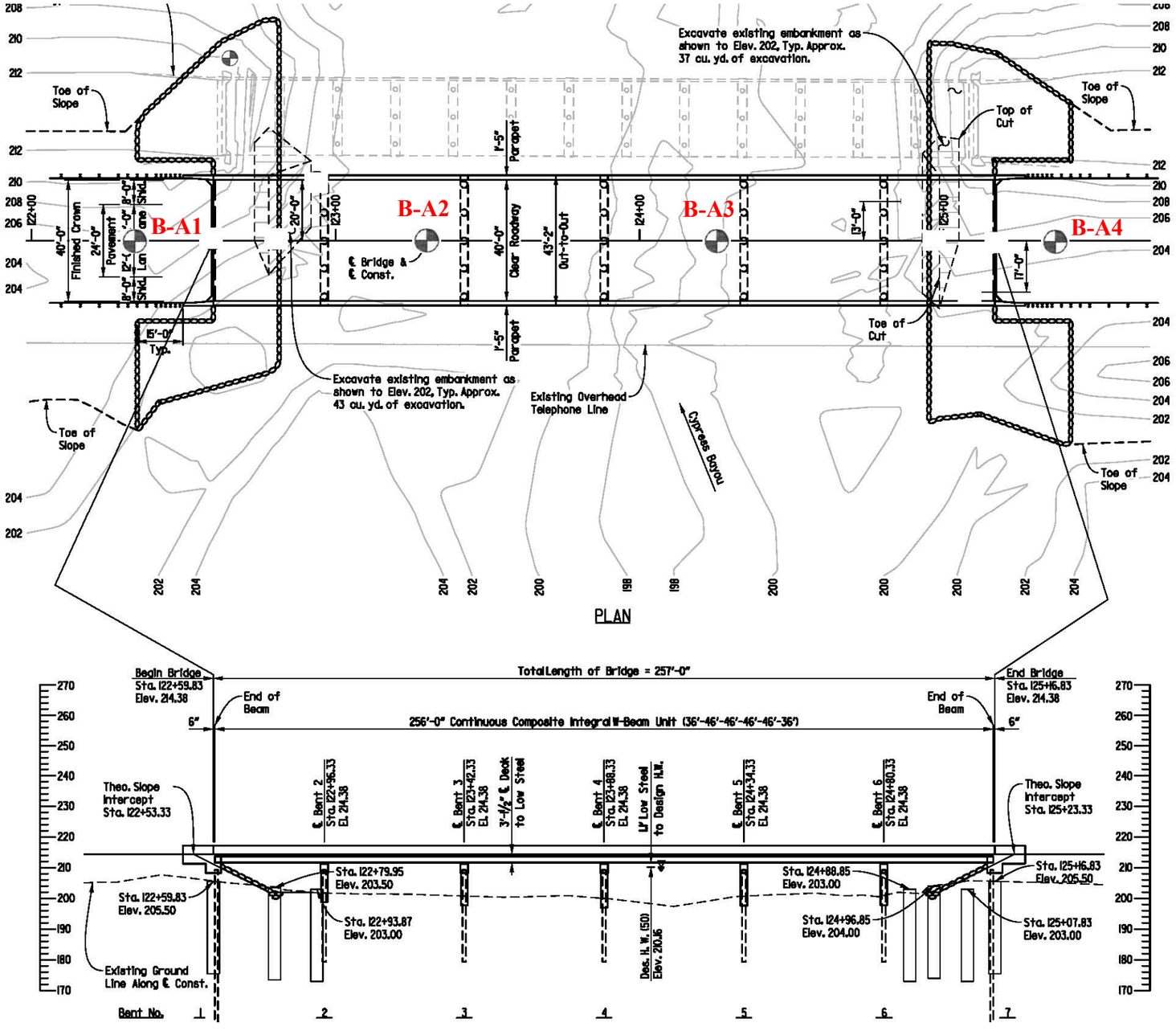


Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS

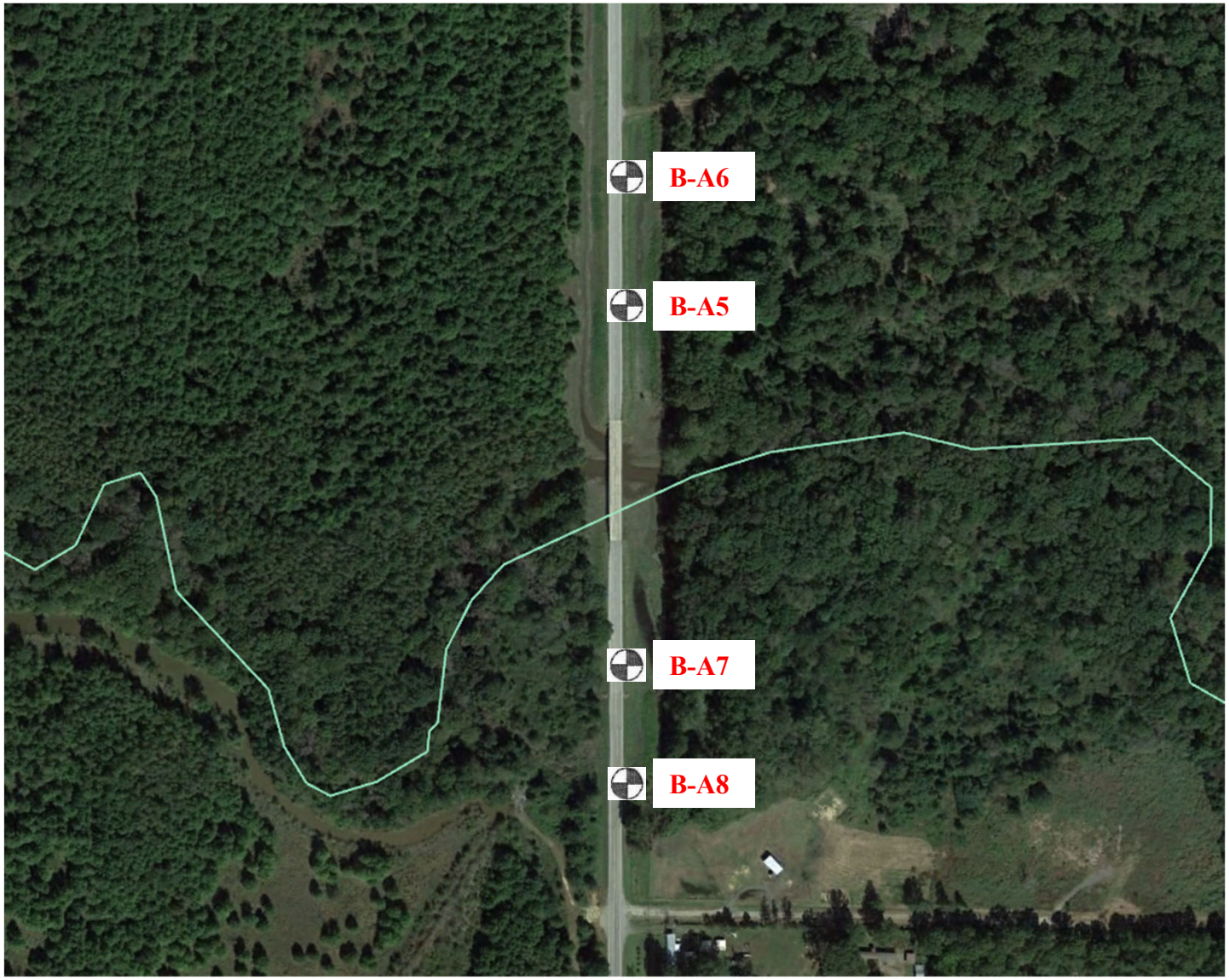
Site Vicinity Map
050342 Hwy. 31 over Cypress Bayou
Lonoke and White County, Arkansas

Job No. 18-077

Plate 1



Grubbs, Hoskyn, Barton & Wyatt, INC. CONSULTING ENGINEERS	**PLAN OF BORINGS** **050342 Hwy. 31 over Cypress Bayou** **Lonoke and White County, Arkansas**	**Scale: As Shown** **Date: July 2019**	**Job No. 18-077**	**PLATE 2A**



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PLAN OF BORINGS
050342 Hwy. 31 over Cypress Bayou
Lonoke and White County, Arkansas

Scale: N.T.S.
Job No.: 18-077
Plate 2B

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A1

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 18.5 ft /Wash

LOCATION: Approx Sta 122+35, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL: 206±				
			Firm grayish tan silty clay, slightly sandy w/occasional organics (fill)	9			81
			Firm to stiff gray and yellowish tan silty clay, slightly sandy w/occasional ferrous nodules and silt pockets	10			
5			- stiff below 4 ft	13			79
				16			
10				15			
			Medium dense gray and yellowish brown silty fine sand	23			48
15							
			- gray below 18 ft				
20			- loose at 18 - 23 ft	8		-NON-PLASTIC-	42
			- medium dense below 23 ft	13			
25							
			Dense to very dense gray fine to medium sand, slightly silty	50/11"			
30							
			- dense at 33 to 43 ft				
35				38			8
			- with clay pockets and trace fine gravel below 38 ft	44			
40							
			- dense to very dense below 43 ft	50/11"			

COMPLETION DEPTH: 110.0 ft
DATE: 4-2-19

DEPTH TO WATER IN BORING: 13.5 ft

DATE: 4/2/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 7-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A1

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 18.5 ft /Wash

LOCATION: Approx Sta 122+35, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			(continued)				
50				50/8"			
55			Very stiff to hard dark brownish gray clay, varved	50/9"			
60				50/8"			
65			- blocky below 63 ft	50/9"			
70				50/8"			
75				50/9"		86	99
80				50/8"			
85				50/9"			
				50/8"			

COMPLETION DEPTH: 110.0 ft
DATE: 4-2-19

DEPTH TO WATER IN BORING: 13.5 ft

DATE: 4/2/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 7-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A1

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 18.5 ft /Wash

LOCATION: Approx Sta 122+35, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			(continued)				
95				50/8"		96 →	100
100				50/8"			
105							
110				50/5"			
115							
120							
125							
130							

COMPLETION DEPTH: 110.0 ft
DATE: 4-2-19

DEPTH TO WATER IN BORING: 13.5 ft

DATE: 4/2/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 7-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A2

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 10 ft /Wash

LOCATION: Approx Sta 123+30, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL: 201±				
			Very soft brown and grayish brown silty clay, slightly sandy w/occasional organic inclusions	0/WOH			
			- firm to stiff at 2 to 4 ft	10			79
5			- very soft to soft below 4 ft - wood at 5 ft	4			
			Firm tan and gray fine sandy clay, silty	9			68
			- stiff below 8 ft				
10				18			
			Medium dense gray and tan silty fine sand w/silt seams and pockets	23			48
15							
20			- tree trunk at 19 to 20 ft	11			
			Dense grayish brown and tan fine to medium sand, slightly silty w/occasional clay pockets	31			
25							
30				36			5
			- medium dense at 33 - 38 ft				
35				21			
			- dense at 38 - 43 ft				
40				37			
			- medium dense with fewer clay pockets below 43 ft	11			

COMPLETION DEPTH: 80.0 ft
DATE: 4-3-19

DEPTH TO WATER IN BORING: 8.5 ft

DATE: 4/3/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 7-17-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A2

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 10 ft /Wash

LOCATION: Approx Sta 123+30, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			(continued)				
50			Very stiff to hard dark gray clay, varved	50/10"			
				50/11"		81	99
55							
				50/11"			
60							
				50/8"			
65							
				50/11"			
70							
				50/11"		93	100
75							
				50/9"			
80			NOTE: Boring abandoned on 04/03/19 due to high water. Drilling resumed 04/30/19.				
85							

COMPLETION DEPTH: 80.0 ft
DATE: 4-3-19

DEPTH TO WATER IN BORING: 8.5 ft

DATE: 4/3/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 7-17-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A3

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 13.5 ft /Wash

LOCATION: Approx Sta 124+25, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL: 200±				
			Soft brownish gray and tan silty clay w/ferrous stains (fill)	5			
			Very soft gray and reddish tan silty clay, slightly sandy w/occasional rootlets and ferrous stains	2			80
5			Stiff tan, brown and gray fine sandy clay, silty w/ferrous stains	17			71
			Medium dense gray and tan fine sandy silt w/ferrous stains	18			
10				18		-NON-PLASTIC- g_s=2.665	52
15				16			
			Medium dense gray fine to medium sand, slightly silty	20			
20							
			- dense at 23 to 28 ft	31			10
25							
			- tan and gray at 28 to 33 ft - medium dense at 28 to 38 ft	12			
30							
				19			
35							
			- dense at 38 to 43 ft	33			
40							
			- medium dense to dense at 43 to 48 ft	30			

COMPLETION DEPTH: 85.0 ft
DATE: 7-12-19

DEPTH TO WATER IN BORING: 3 ft
DATE: 7/12/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A3

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 13.5 ft /Wash

LOCATION: Approx Sta 124+25, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			(continued)				
50			- dense to very dense below 48 ft	50			
55			Very stiff to hard dark gray silty clay, slightly sandy, varved	50/8"			
60				50/10"			87
65				50/6"			
70				50/10"			
75				50			
80				50/11"			
85				50/10"		88	84

COMPLETION DEPTH: 85.0 ft
DATE: 7-12-19

DEPTH TO WATER IN BORING: 3 ft

DATE: 7/12/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A4

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 13.5 ft /Wash

LOCATION: Approx Sta 125+35, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL: 205±				
			Stiff brown silty clay (fill)	18			
			Firm tan and gray silty clay, slightly sandy w/ferrous stains and nodules	7			
5				9			82
			- stiff below 6 ft	16			
			Dense gray and tan fine sandy clay, silty w/silty fine sand pockets	34			54
10							
			Medium dense gray fine to medium sand, slightly silty	15			
15							
				22			
20							
			- with clayey fine sand pockets at 13 to 23 ft	20			22
25							
			- dense at 28 to 43 ft	38			
30							
				40			
35							
				36			
40							
			- dense to very dense below 43 ft	50/9"			

COMPLETION DEPTH: 100.0 ft
DATE: 7-13-19

DEPTH TO WATER IN BORING: 14 ft
DATE: 7/13/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A4

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 13.5 ft /Wash

LOCATION: Approx Sta 125+35, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
50			(continued)	50/11"			
55			Very stiff to hard dark gray silt clay, slightly sandy, varved	50/9"			88
60				50/10"			
65				50/8"			
70				50/9"			
75				50/10"			
80				50/11"			
85				50/9"			
				50/8"			

COMPLETION DEPTH: 100.0 ft
DATE: 7-13-19

DEPTH TO WATER IN BORING: 14 ft

DATE: 7/13/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A4

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Auger to 13.5 ft /Wash

LOCATION: Approx Sta 125+35, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			(continued)				
95				50/8"			
100				50/8"			
105							
110							
115							
120							
125							
130							

COMPLETION DEPTH: 100.0 ft
DATE: 7-13-19

DEPTH TO WATER IN BORING: 14 ft
DATE: 7/13/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A5

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Hand Auger

LOCATION: ±250 ft N of N Bridge End

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
1			Very soft to soft tan and reddish tan silty clay w/rootlets, wet				
2			- tan, reddish tan and gray, slightly sandy below 2 ft				83
3							
4							
5							
6							
7							
8							
9							

COMPLETION DEPTH: 4.5 ft
DATE: 7-16-19

DEPTH TO WATER IN BORING: 0.5 ft
DATE: 7/16/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 8-16-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A6

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Hand Auger

LOCATION: 500 ft N of N Bridge End

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
			3 Inches: Loose brown silt w/organics (topsoil, fill)				
1			Very loose to loose tan fine sandy silt, wet (fill)				
2						-NON-PLASTIC-	52
			Firm to stiff tan and gray silty clay, sandy w/silt pockets and ferrous nodules and stains				78
3							
4							
5							
6							
7							
8							
9							

COMPLETION DEPTH: 4.0 ft
DATE: 3-22-19

DEPTH TO WATER IN BORING: Dry

DATE: 3/22/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 7-16-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A7

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Hand Auger

LOCATION: ±250 ft S of S Bridge End

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
1			Firm brown and light brown silty clay w/rootlets				
2			- soft, tan, slightly sandy below 2 ft				
3							81
4							
5							
6							
7							
8							
9							

COMPLETION DEPTH: 4.5 ft
DATE: 7-16-19

DEPTH TO WATER IN BORING: 1.0 ft
DATE: 7/16/2019

LGBNEW 18-077__CYPRESS BAYOU.GPJ 8-16-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. A8

050342 Hwy 31 over Cypress Bayou
White County, Arkansas

TYPE: Hand Auger LOCATION: 500 ft S of S Bridge End

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
1			Firm brown fine sandy clay w/silt (fill) - with numerous organics to 0.5 ft - stiff below 0.5 ft				64
2			- brown and gray below 1.5 ft				
3			Stiff tan and gray silty clay w/occasional ferrous stains				
4							
5							
6							
7							
8							
9							

COMPLETION DEPTH: 4.0 ft
DATE: 3-25-19

DEPTH TO WATER
IN BORING: Dry
DATE: 3/25/2019

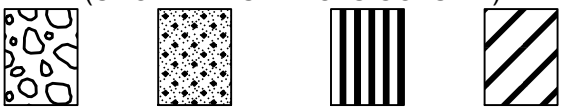
LGBNEW 18-077__CYPRESS BAYOU.GPJ 7-16-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL TYPES

(SHOWN IN SYMBOLS COLUMN)



Gravel Sand Silt Clay

Predominant type shown heavy

SAMPLER TYPES

(SHOWN ON SAMPLES COLUMN)

Shelby Tube | Rock Core | Split Spoon | No Recovery | Cutting

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on No. 200 sieve): Includes (I) Clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as determined by laboratory tests.

DESCRIPTIVE TERM	N-VALUE	RELATIVE DENSITY
VERY LOOSE	0-4	0-15%
LOOSE	4-10	15-35%
MEDIUM DENSE	10-30	35-65%
DENSE	30-50	65-85%
VERY DENSE	50 and above	85-100%

FINE GRAINED SOILS (major portion passing No. 200 sieve): Includes (1) Inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests.

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH TON/SQ. FT.
VERY SOFT	Less than 0.25
SOFT	0.25-0.50
FIRM	0.50-1.00
STIFF	1.00-2.00
VERY STIFF	2.00-4.00
HARD	4.00 and higher

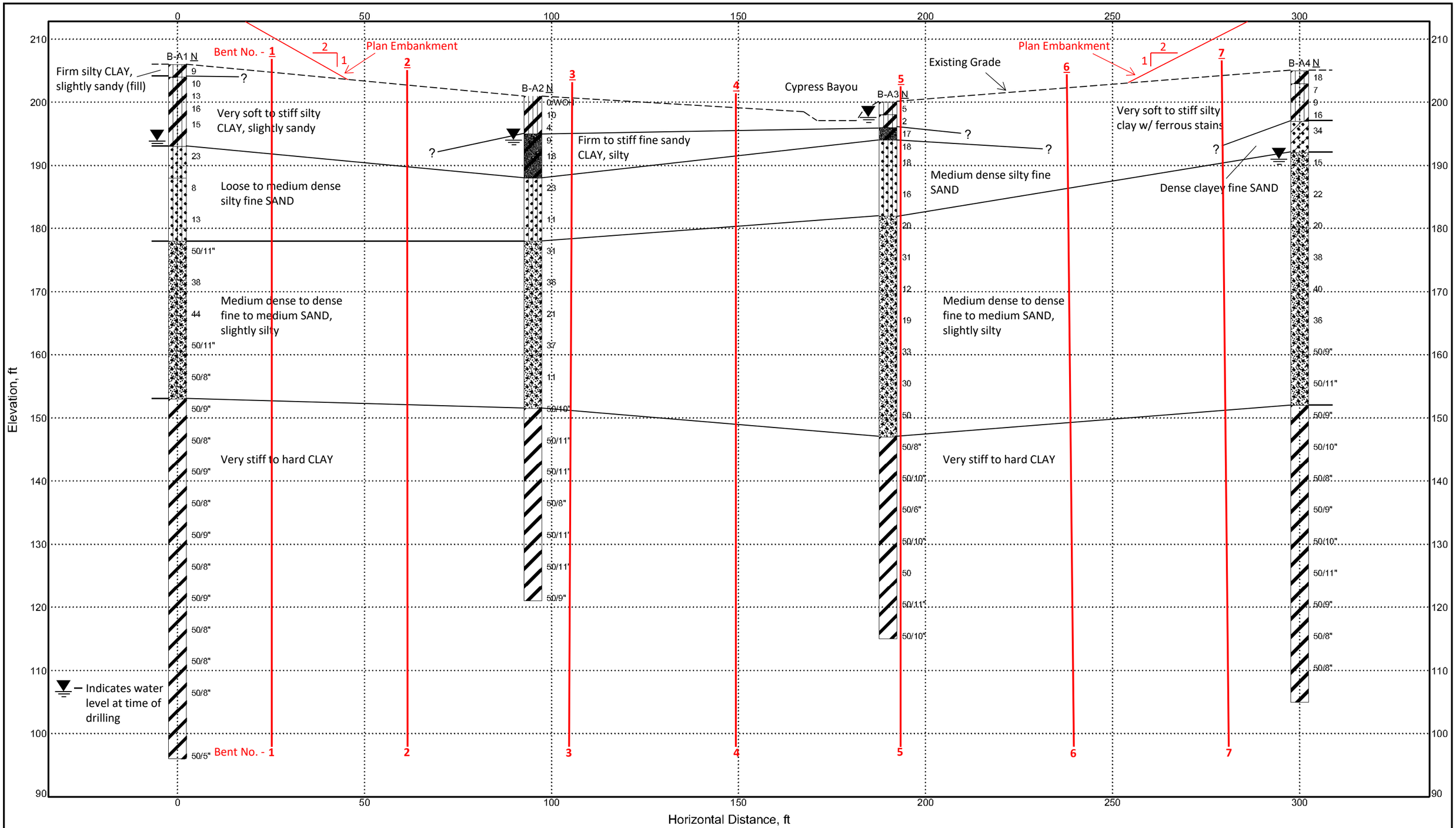
NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

TERMS CHARACTERIZING SOIL STRUCTURE

SLICKENSIDED - having inclined planes of weakness that are slick and glossy in appearance.
FISSURED - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
LAMINATED - composed of thin layers of varying color and texture.
INTERBEDDED - composed of alternate layers of different soil types.
CALCAREOUS - containing appreciable quantities of calcium carbonate.
WELL GRADED - having a wide range in grain sizes and substantial amounts of all intermediate particle sizes.
POORLY GRADED - predominantly of one grain size, or having a range of sizes with some intermediate sizes missing.

Terms used on this report for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No.3-357, Waterways Experiment Station, March 1953

KEY 7-16-19



Grubbs, Hoskyn, Barton & Wyatt, Inc.

NOTES:
1. Subsurface conditions have been inferred between discrete boring locations. Actual conditions may vary.
2. Ground surface approximate.

SCALE: As Shown

Generalized Subsurface Profile
050342 Hwy 31 over Cypress Bayou
White County, Arkansas

Project Number: 18-077

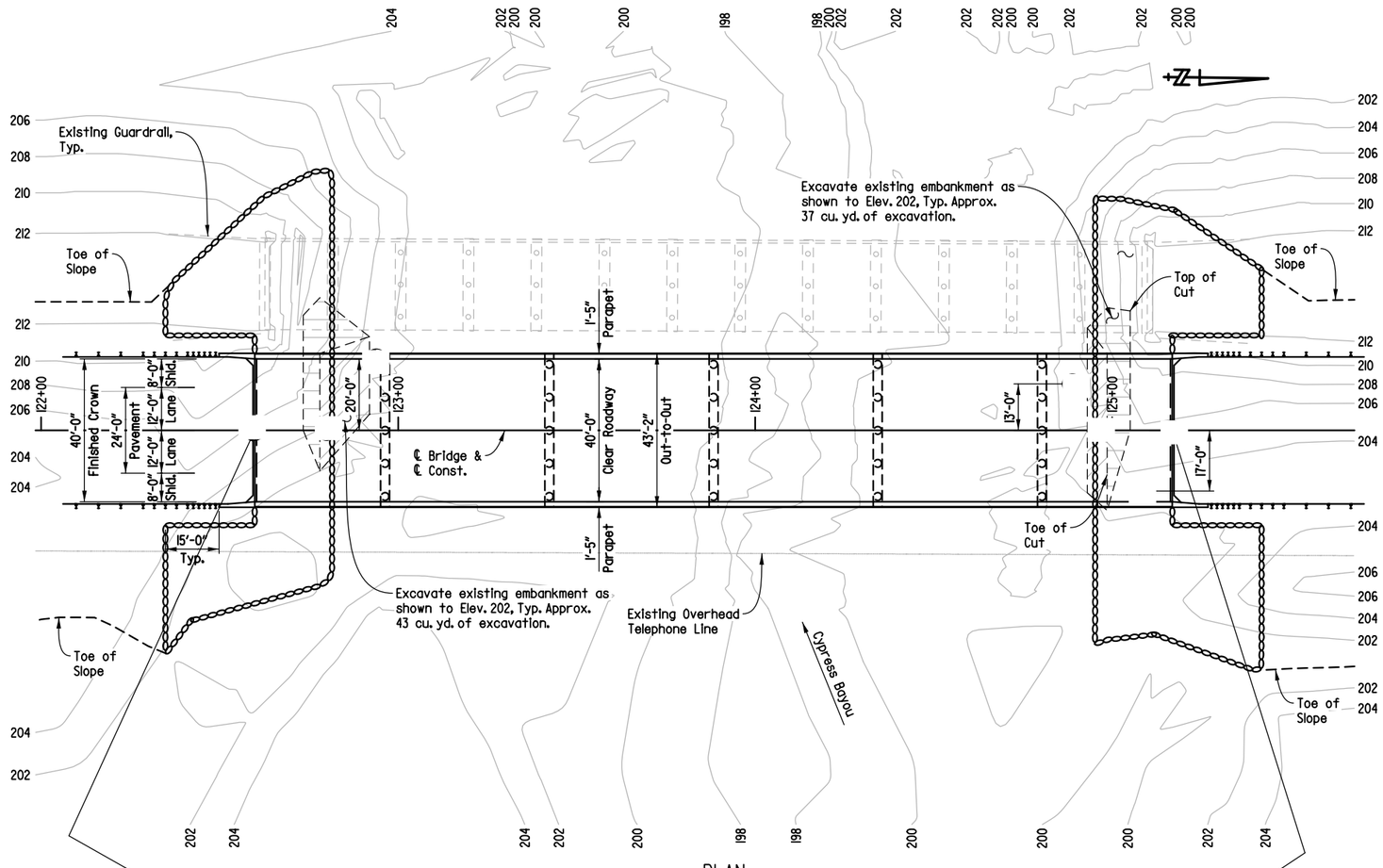
Plate 18

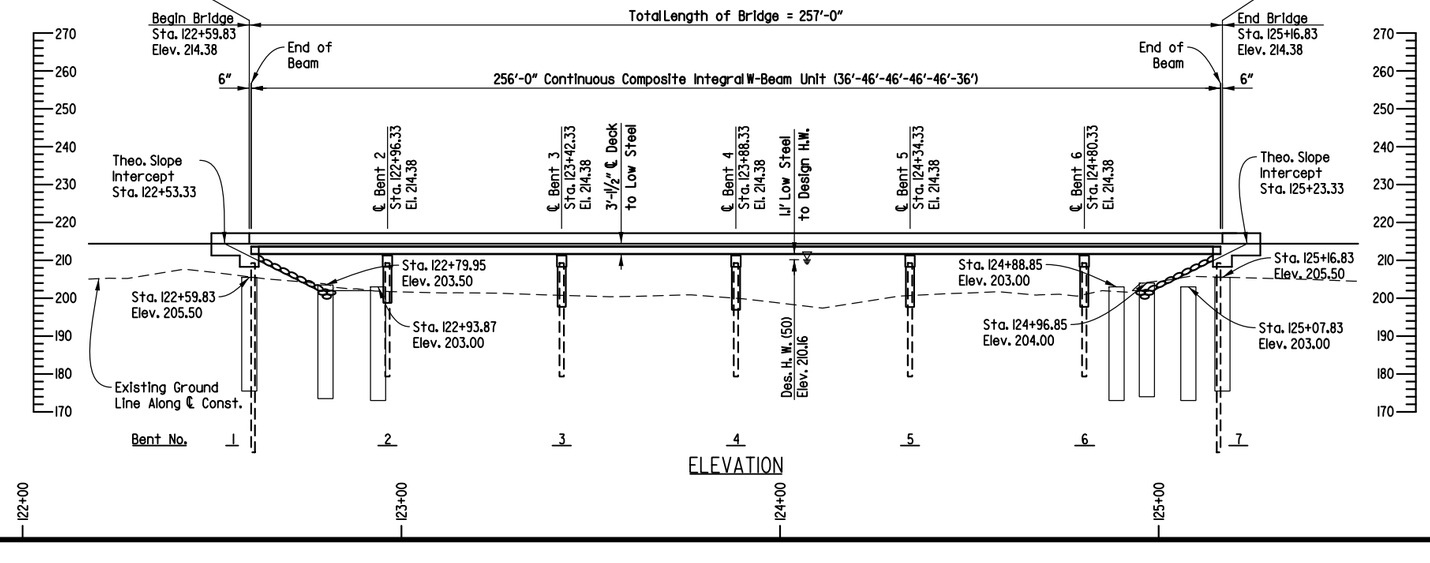
APPENDIX A

DATE REVISED	DATE FILMED	DATE REVISED	DATE FILMED

FED.RD. DIST.NO.	STATE	FED.AID PROJ.NO.	SHEET NO.	TOTAL SHEETS
4	ARK.			
JOB NO.		050342	1	1
1 XXXXX		LAYOUT		XXXXX

For R/W Data, See Roadway Plans.





PRELIMINARY SUBJECT TO REVISION

LAYOUT OF BRIDGE OVER CYPRESS BAYOU HWY. 267 STRS. & APPRS. (S) WHITE COUNTY

ROUTE 31 SEC. 4

ARKANSAS STATE HIGHWAY COMMISSION

LITTLE ROCK, ARK.

DRAWN BY: LDG DATE: 02-15-19 FILENAME: CB Boring Locations.dgn
CHECKED BY: CAW DATE: XX-XX-XX SCALE: 1" = 20'
DESIGNED BY: LDG DATE: 02-15-19

BRIDGE NO. XXXXX DRAWING NO. XXXXX

USER: lg5169
DESIGN FILE: G:\18105701_050342\TRANSP\dgn\bridge\CB Boring Locations.dgn SCALE: 1:40
PLOTTED: 2/15/2019 13:55

G:\18105701_050342\TRANSP\dgn\bridge\CB Boring Locations.dgn 2/15/2019 13:55

APPENDIX B

SUMMARY of CLASSIFICATION TEST RESULTS

PROJECT: 050342 Hwy 31 over Cypress Bayou
LOCATION: Lonoke and White County, Arkansas
GHBW JOB NUMBER: 18-077

BORING NO.	SAMPLE DEPTH (ft)	WATER CONTENT (%)	ATTERBERG LIMITS			SIEVE ANALYSIS PERCENT PASSING					UNIFIED CLASS.	AASHTO CLASS.
			LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	3/8 in.	#4	#10	#40	#200		
A1	0.5-1.5	34	43	25	18	---	100	---	---	81	CL	A-7-6
A1	4.5-5.5	27	47	24	23	---	100	---	---	79	CL	A-7-6
A1	14-15	19	---	---	---	---	100	---	---	48	SM	A-4
A1	19-20	22	NON-PLASTIC			---	100	---	---	42	SM	A-4
A1	34-35	23	---	---	---	100	100	99	77	8	SM-SP	A-3
A1	74-75	37	86	35	51	---	100	---	---	99	CH	A-7-5
A1	94-95	36	96	31	65	---	---	---	---	100	CH	A-7-5
A2	2.5-3.5	30	38	21	17	---	100	---	---	79	CH	A-6
A2	6.5-7.5	21	22	18	4	---	100	---	---	68	ML-CL	A-4
A2	14-15	18	---	---	---	100	100	100	100	48	SM	A-4
A2	29-30	22	---	---	---	100	100	100	83	5	SM-SP	A-3
A2	54-55	38	81	39	42	---	100	---	---	99	MH	A-7-5
A2	74-75	36	93	32	61	---	---	---	---	100	CH	A-7-5
A3	2.5-3.5	24	30	19	11	---	100	---	---	80	CL	A-6
A3	4.5-5.5	19	23	18	5	---	100	---	---	71	ML-CL	A-4
A3	9-10	17	NON-PLASTIC			100	100	100	100	52	ML	A-4
A3	24-25	25	---	---	---	100	100	100	95	10	SM-SP	A-3
A3	59-60	39	73	43	30	---	100	---	---	87	MH	A-7-5
A3	84-85	33	88	35	53	---	100	---	---	84	CH	A-7-5

SUMMARY of CLASSIFICATION TEST RESULTS

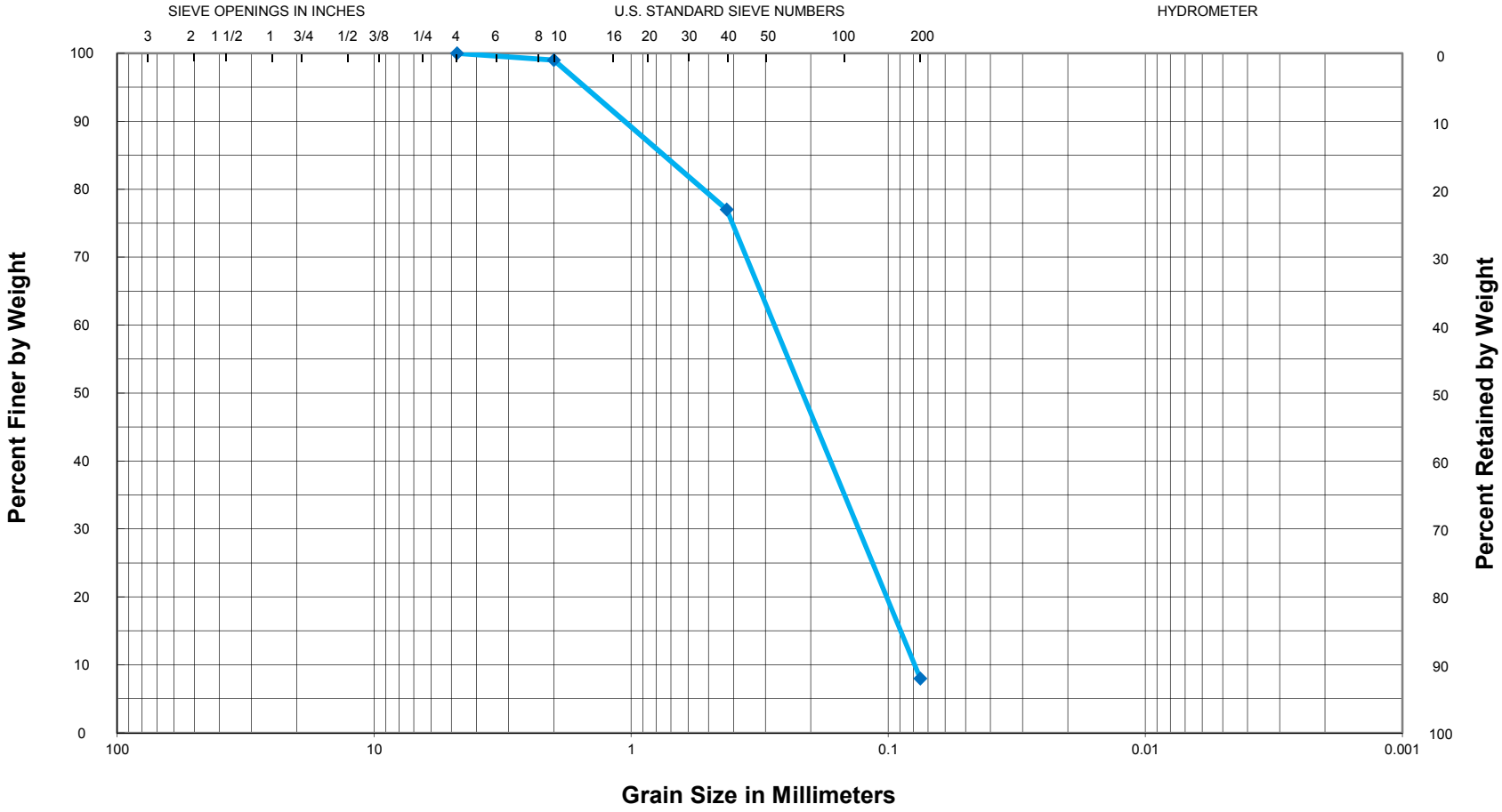
PROJECT: 050342 Hwy 31 over Cypress Bayou
LOCATION: Lonoke and White County, Arkansas
GHBW JOB NUMBER: 18-077

BORING NO.	SAMPLE DEPTH (ft)	WATER CONTENT (%)	ATTERBERG LIMITS			SIEVE ANALYSIS PERCENT PASSING					UNIFIED CLASS.	AASHTO CLASS.
			LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	3/8 in.	#4	#10	#40	#200		
A4	4.5-5.5	23	34	19	15	---	97	---	---	82	CL	A-6
A4	9-10	19	23	16	7	---	96	---	---	54	ML-CL	A-4
A4	24-25	18	---	---	---	100	100	100	75	22	SM	A-2-4
A4	54-55	38	67	42	25	---	94	---	---	88	MH	A-7-5
A5	2.5-3.5	30	32	19	13	---	100	---	---	83	CL	A-6
A6	1.5-2	21	NON-PLASTIC			---	93	---	---	52	ML	A-4
A6	2-2.5	22	32	19	13	---	99	---	---	78	CL	A-6
A7	2.5-3.5	42	41	25	16	---	100	---	---	81	CL	A-7-6
A8	0.5-1	17	29	19	10	---	92	---	---	64	CL	A-4

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

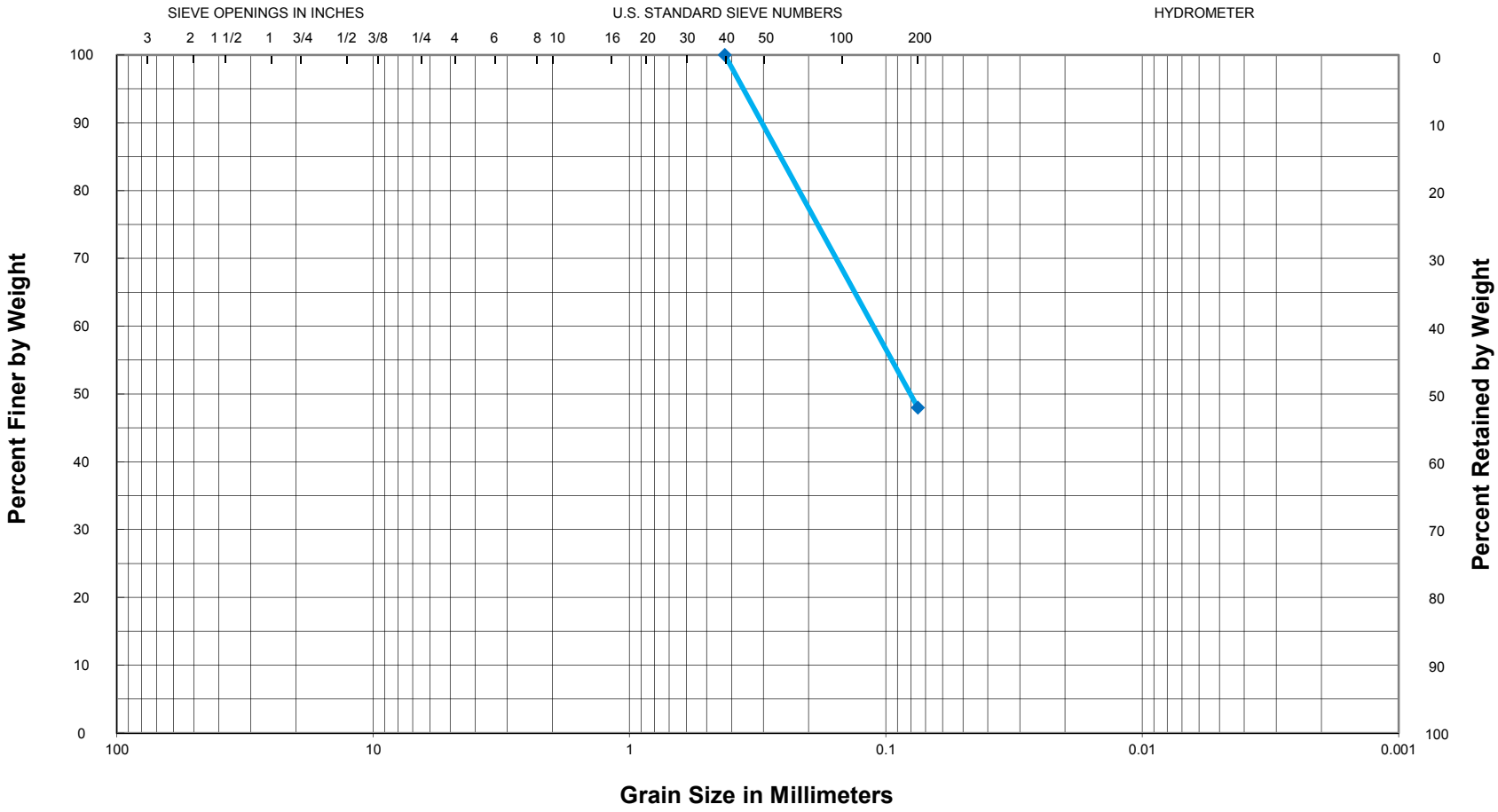
Sample: Boring A1, 34-35 ft
Description: Gray fine to medium SAND, slightly silty

USCS Classification = SM-SP
AASHTO Classification = A-3

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

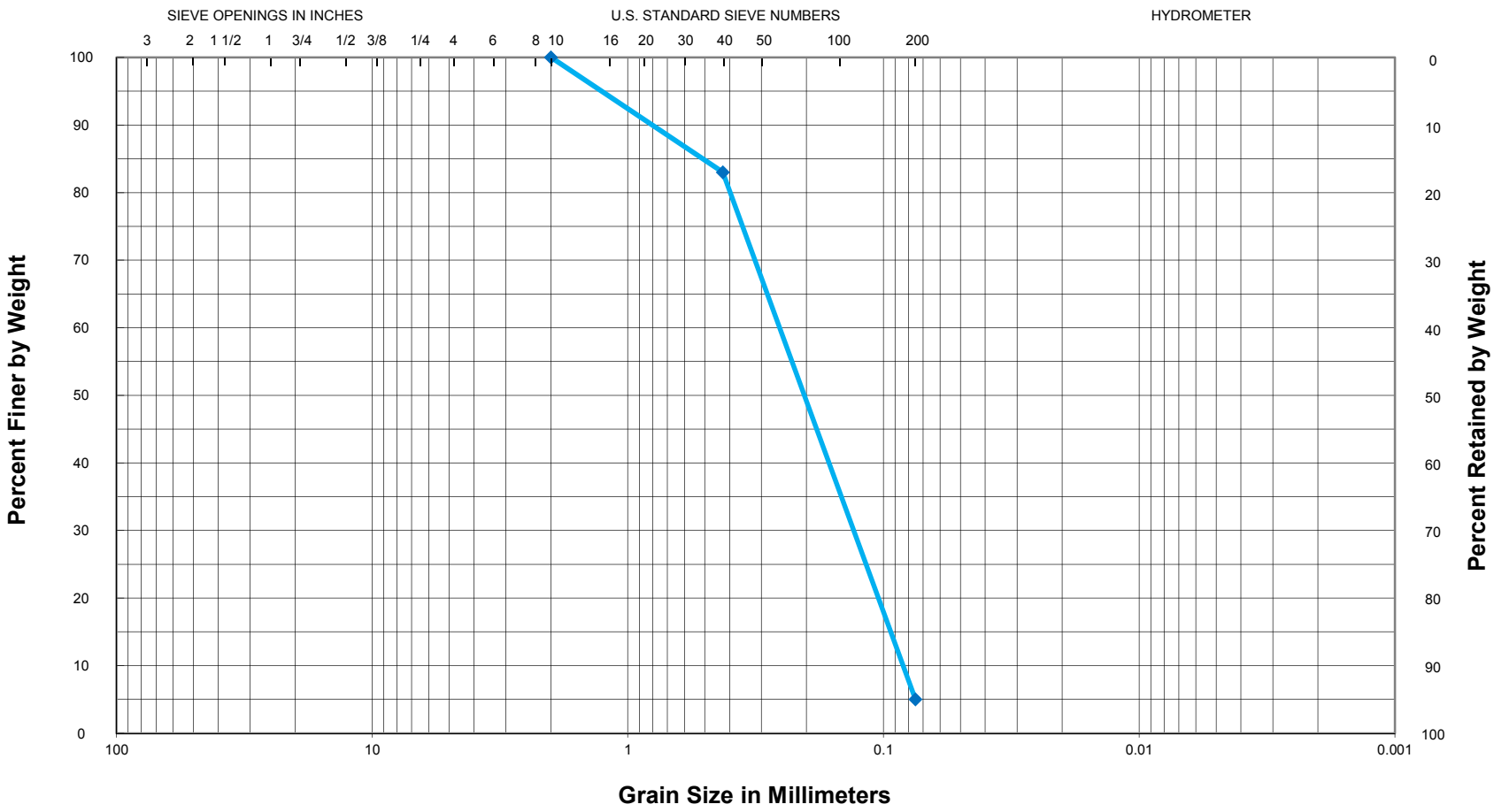
Sample: Boring A2, 14-15 ft
Description: Gray and tan silty fine SAND w/ silt seams and pockets

USCS Classification = SM
AASHTO Classification = A-4

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

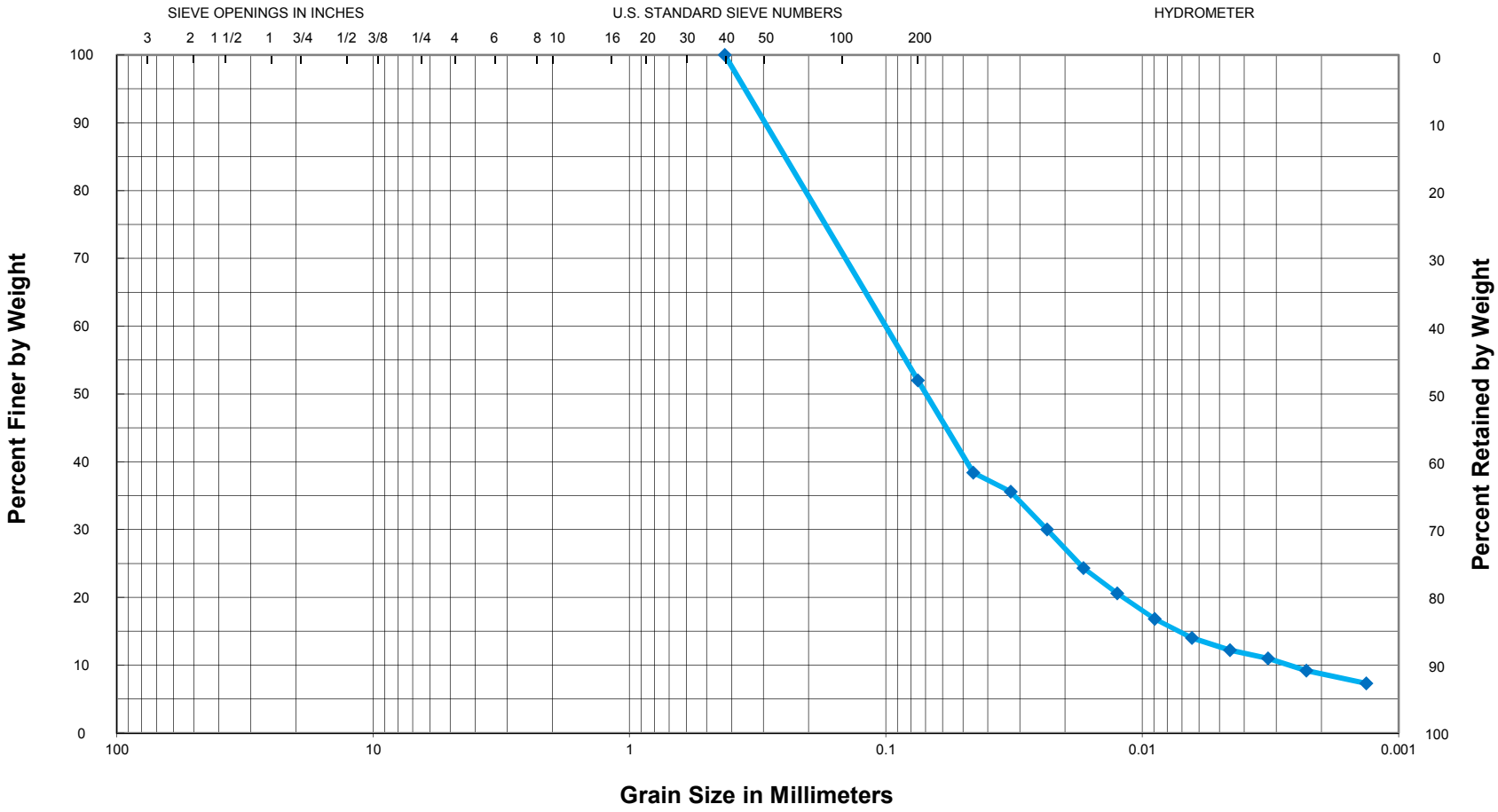
Sample: Boring A2, 29-30 ft
Description: Grayish brown and tan fine to medium SAND w/ occasional clay pockets

USCS Classification = SM-SP
AASHTO Classification = A-3

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE		

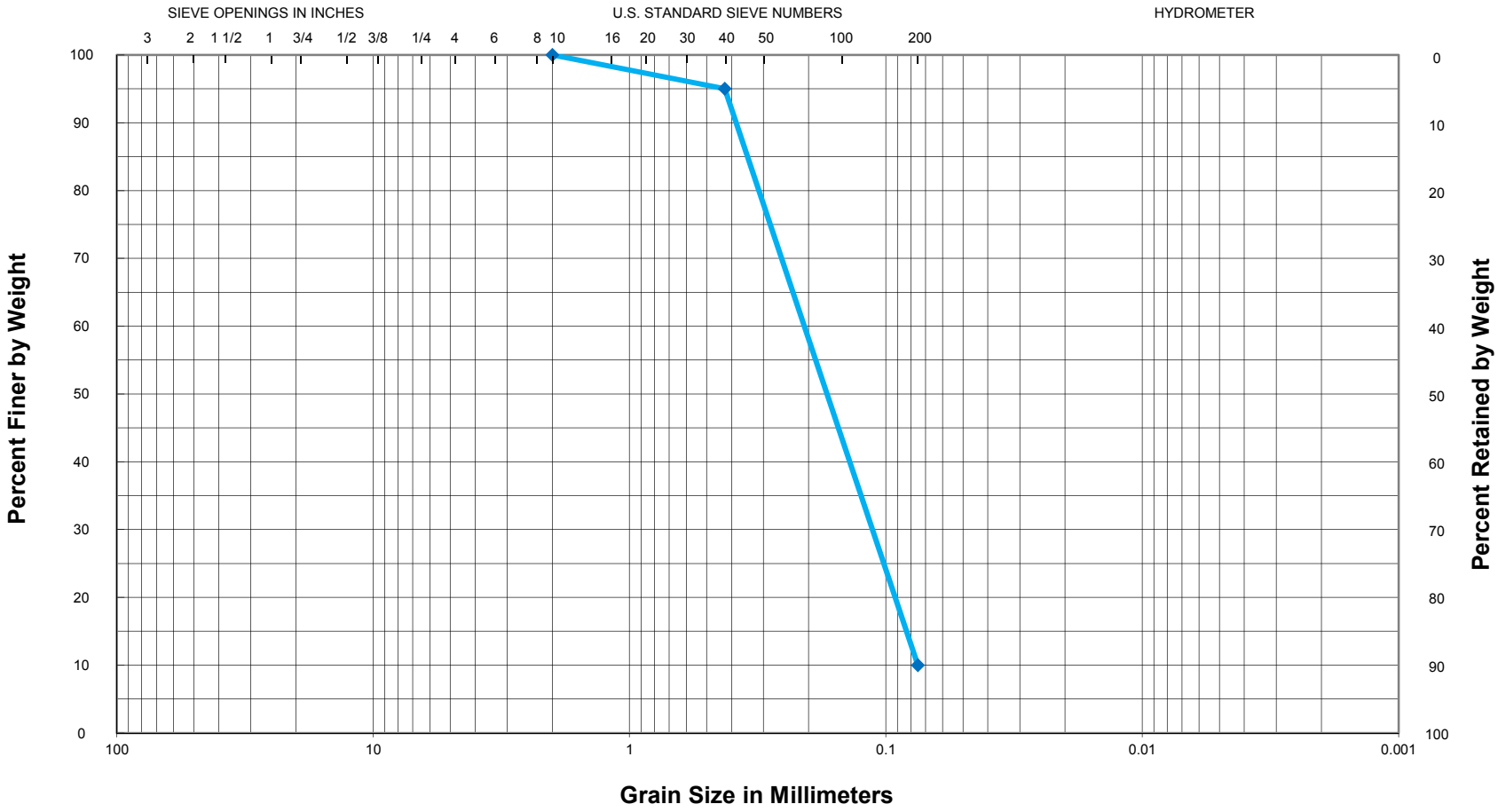
Sample: Boring A3, 9-10 ft; NON-PLASTIC
Description: Gray and tan fine sandy SILT w/ ferrous stains

USCS Classification = ML
AASHTO Classification = A-4

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

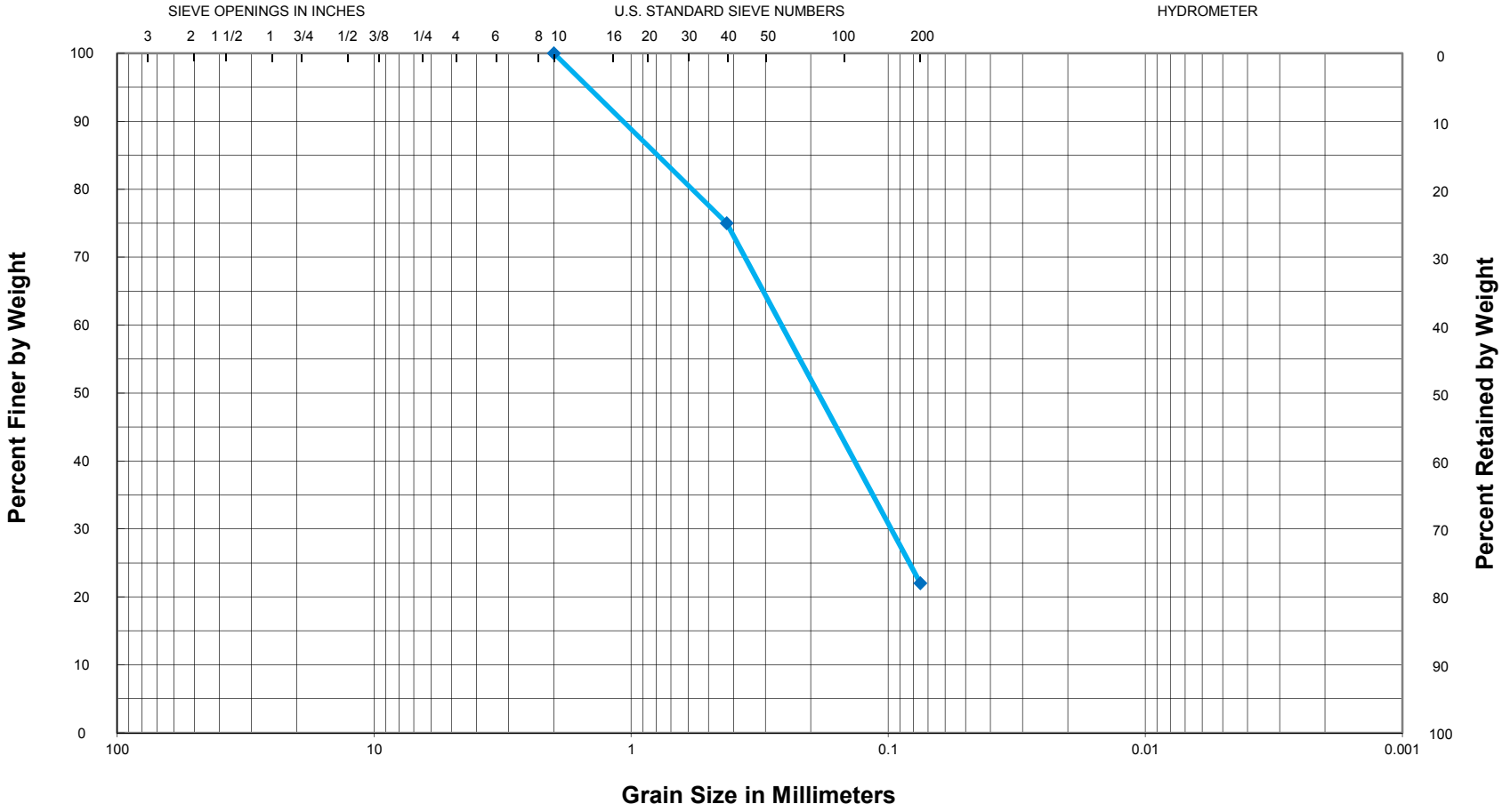
Sample: Boring A3, 24-25 ft
Description: Gray fine to medium SAND, slightly silty

USCS Classification = SM-SP
AASHTO Classification = A-3

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

Sample: Boring A4, 24-25 ft
Description: Gray fine to medium SAND, slightly silty

USCS Classification = SM
AASHTO Classification = A-2-4

APPENDIX C

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS

P.O. Box 30970
Little Rock, Arkansas 72260-0970
#1 Trigon Place 72209
(501) 455-2536
FAX (501) 455-4137

REPORT OF STANDARD PROCTOR TEST
(AASHTO T-99)

Project: ARDOT 050342 Bridges - White County, Arkansas Job No: 18-077
Material Description: Brown, tan, and gray fine sandy CLAY
Location Sampled/Source: TP 3/22A - Hwy. 31 over Cypress Bayou
Sample Depth, ft: 1-3
Date Sampled: 3/22/2019
Date Tested: 4/2/2019
Tested By: LLC
Report Date: 4/8/2019

LAB COMPACTION PROCEDURE: AASHTO T-99 Method: A	
Maximum Unit Dry Wt. (pcf):	103.9
Optimum Water Content (%):	18.5

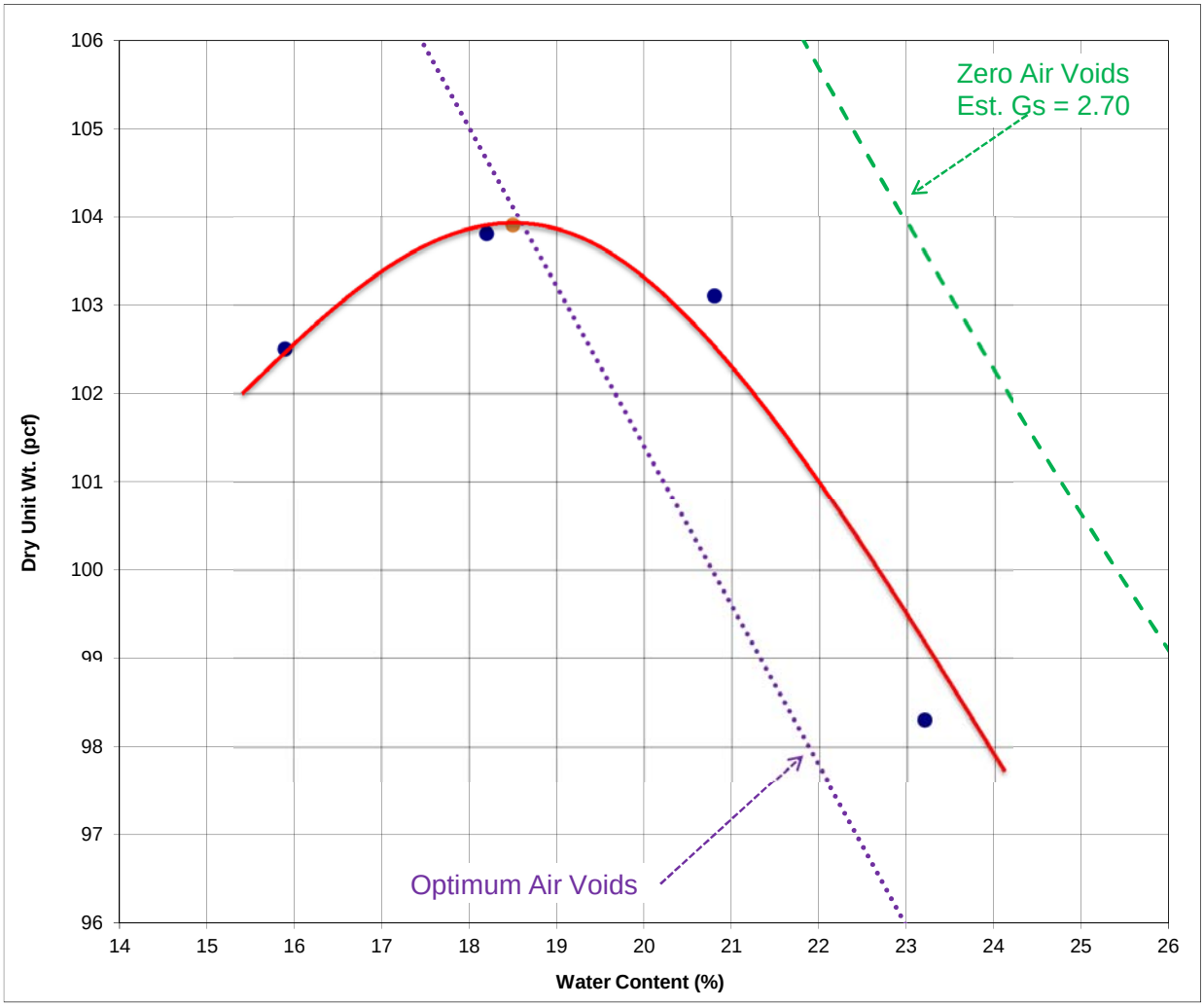
As Recieved Water Content: 23.5 %

ATTERBERG LIMITS AASHTO T-89 & T-90
Liquid Limit: 31
Plastic Limit: 19
Plasticity Index: 12

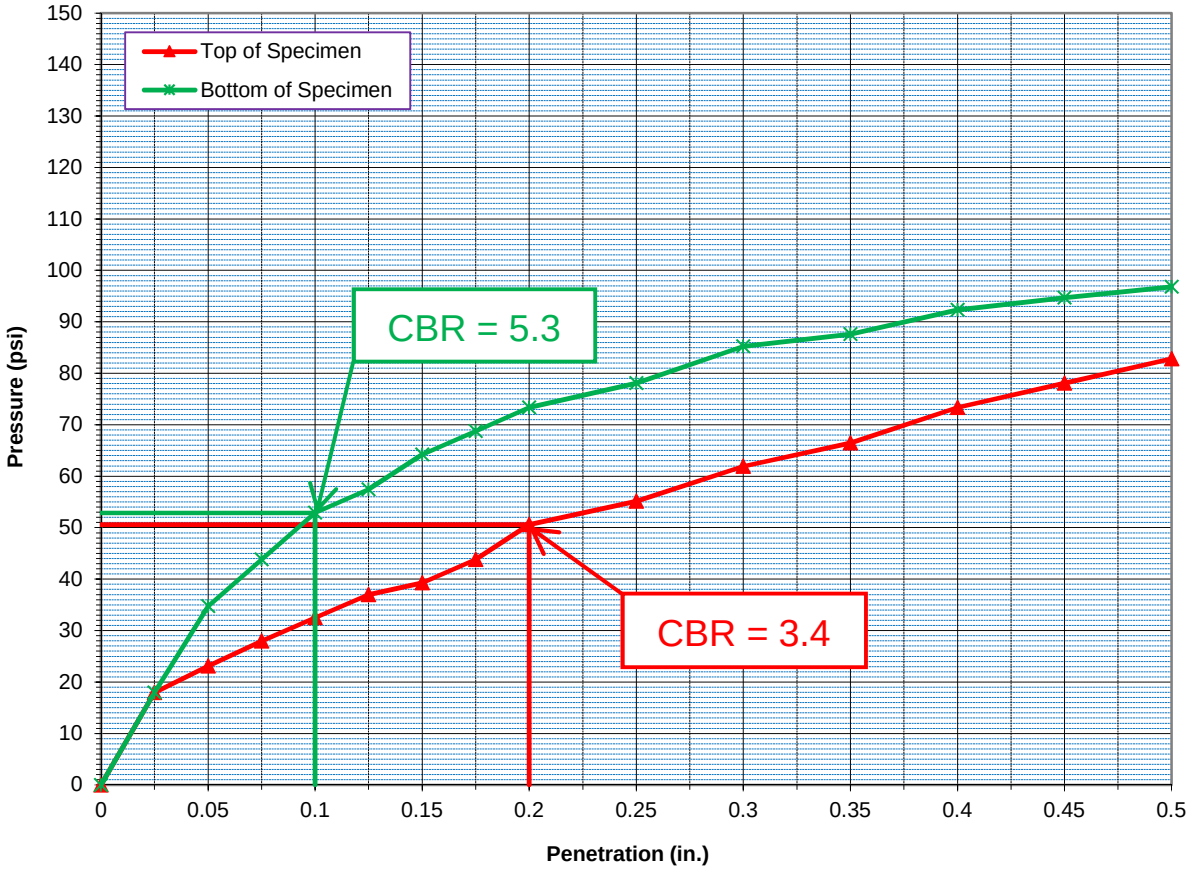
USCS Classification:
CL

AASHTO Classification:
A-6

GRADATION AASHTO T-88	
Sieve Number	Percent Passing
2 in.	100
3/4 in.	100
3/8 in.	100
#4	100
#10	97
#40	91
#200	75



Laboratory CBR Test Report
(AASHTO T-193)



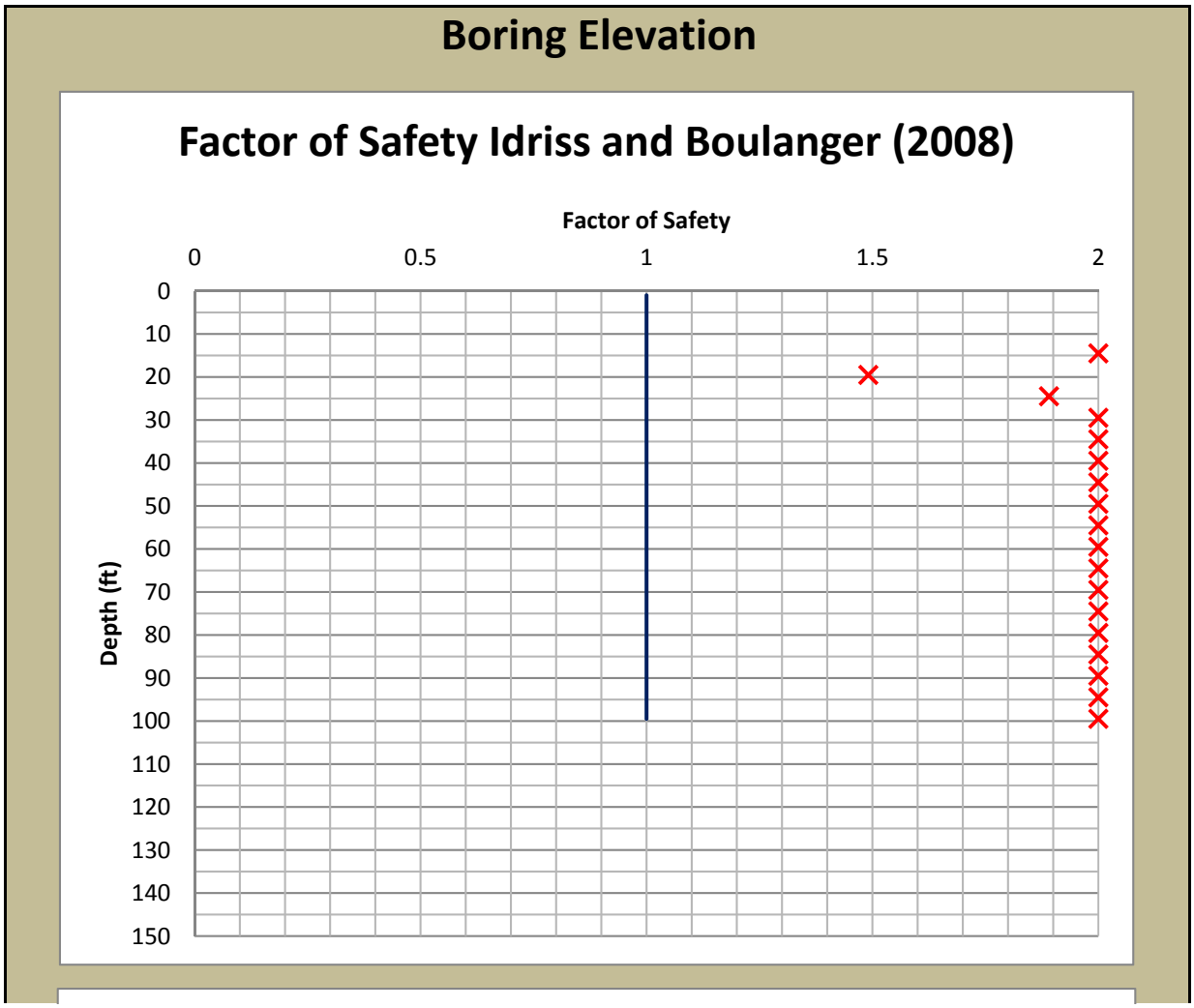
Boring No./Depth, ft	Classification		Natural Moisture Content, %	Assumed Specific Gravity	Liquid Limit, %	Plastic Limit, %	% Retained No.4	% Passing No.200
	USCS	AASHTO						
3/22A @ 1-3	CL	A-6	21.6	2.70	31	19	0	75
PROCTOR TEST RESULTS (AASHTO T-99)				**MATERIAL DESCRIPTION**				
Optimum Moisture Content = 18.5% Maximum Dry Density = 103.9 pcf				Brown, tan, and gray fine sandy CLAY				

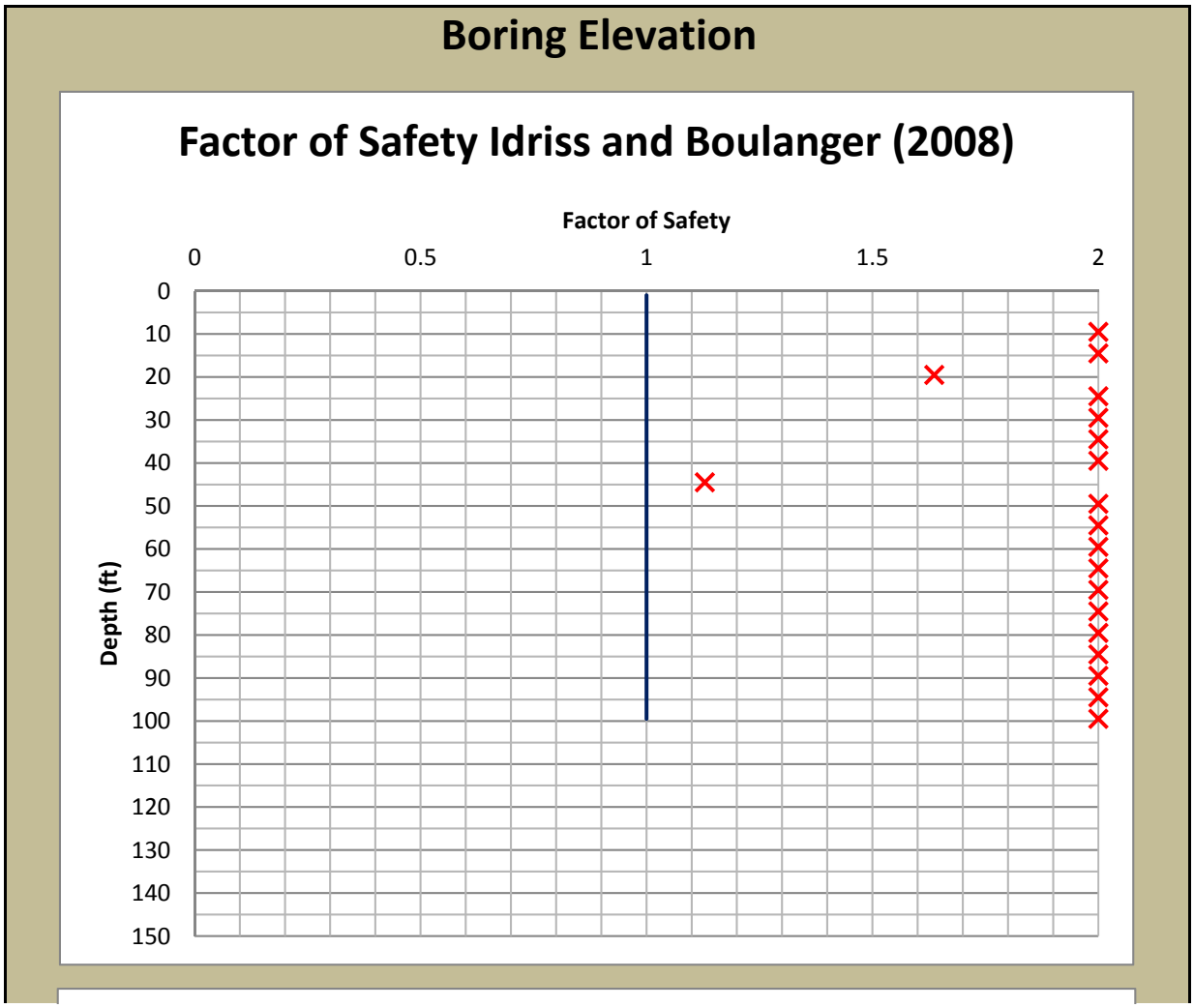
Remarks:
As Molded: 117.6 pcf @ 20.8%; Percent swell: 0.7%

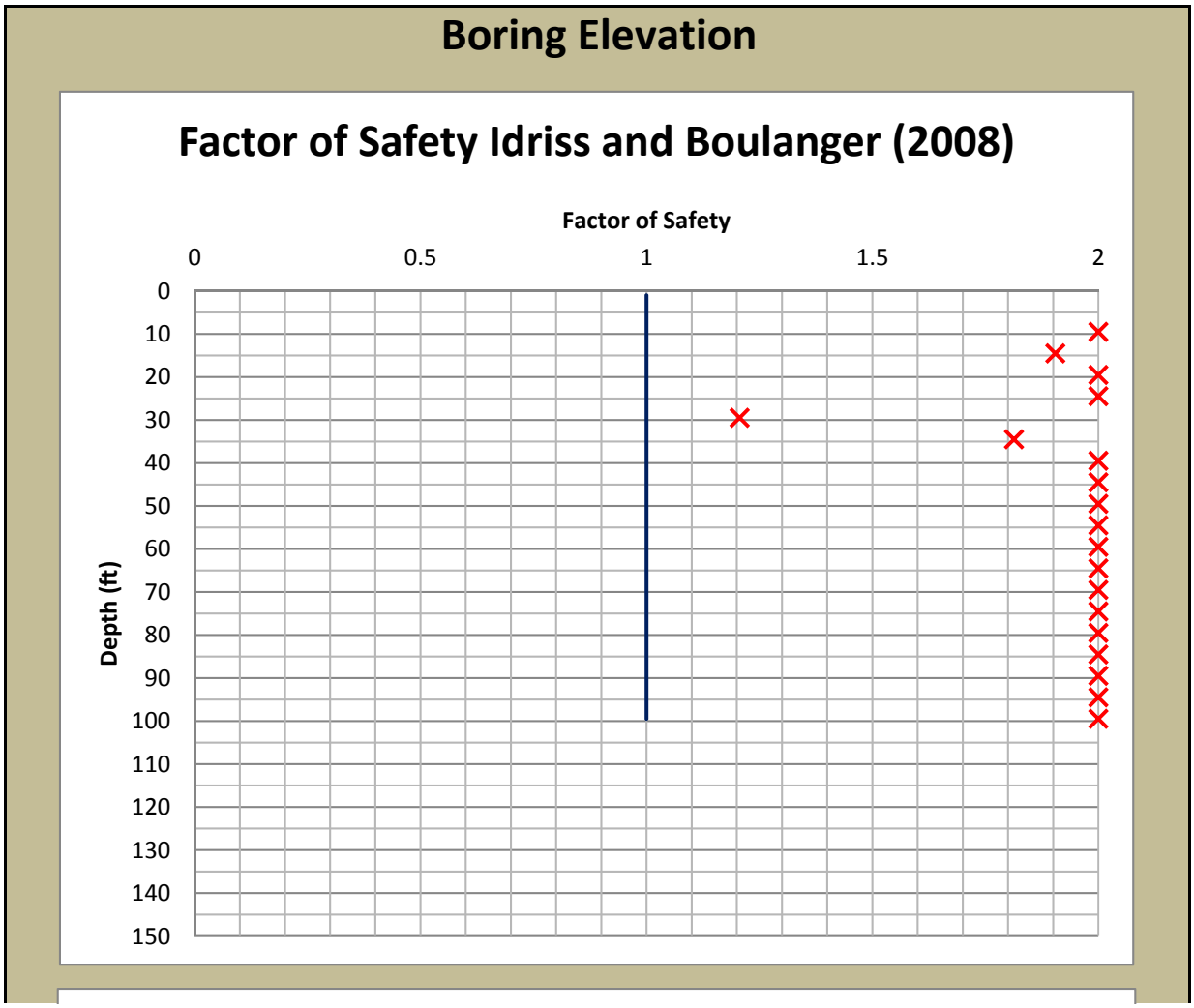
Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS

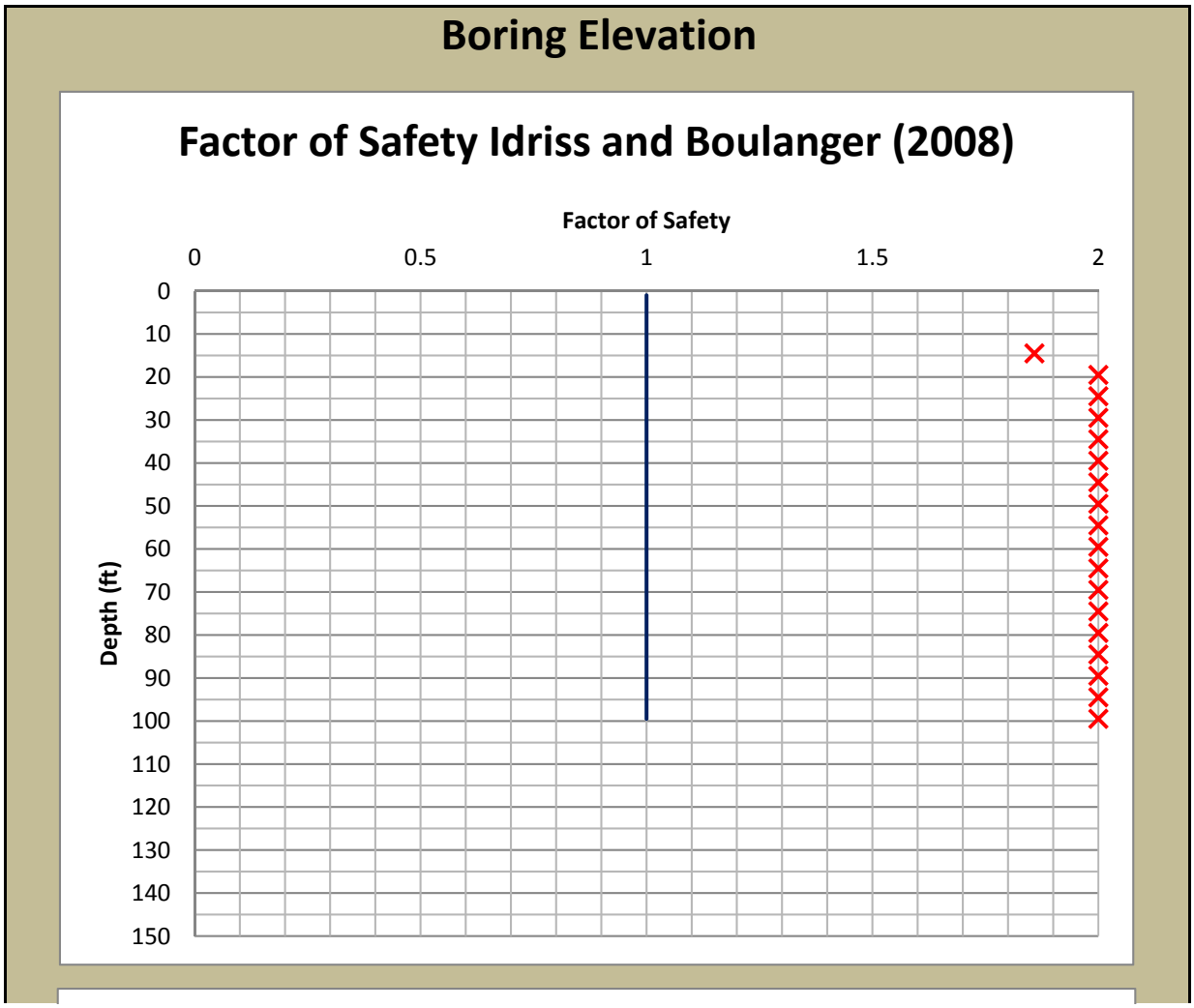
Project: ARDOT 050342 - Bridges
GHBW Project Number: 18-077
Location: White County, Arkansas
Sample Date: 3/22/19
Test Date: 4/2/19

APPENDIX D

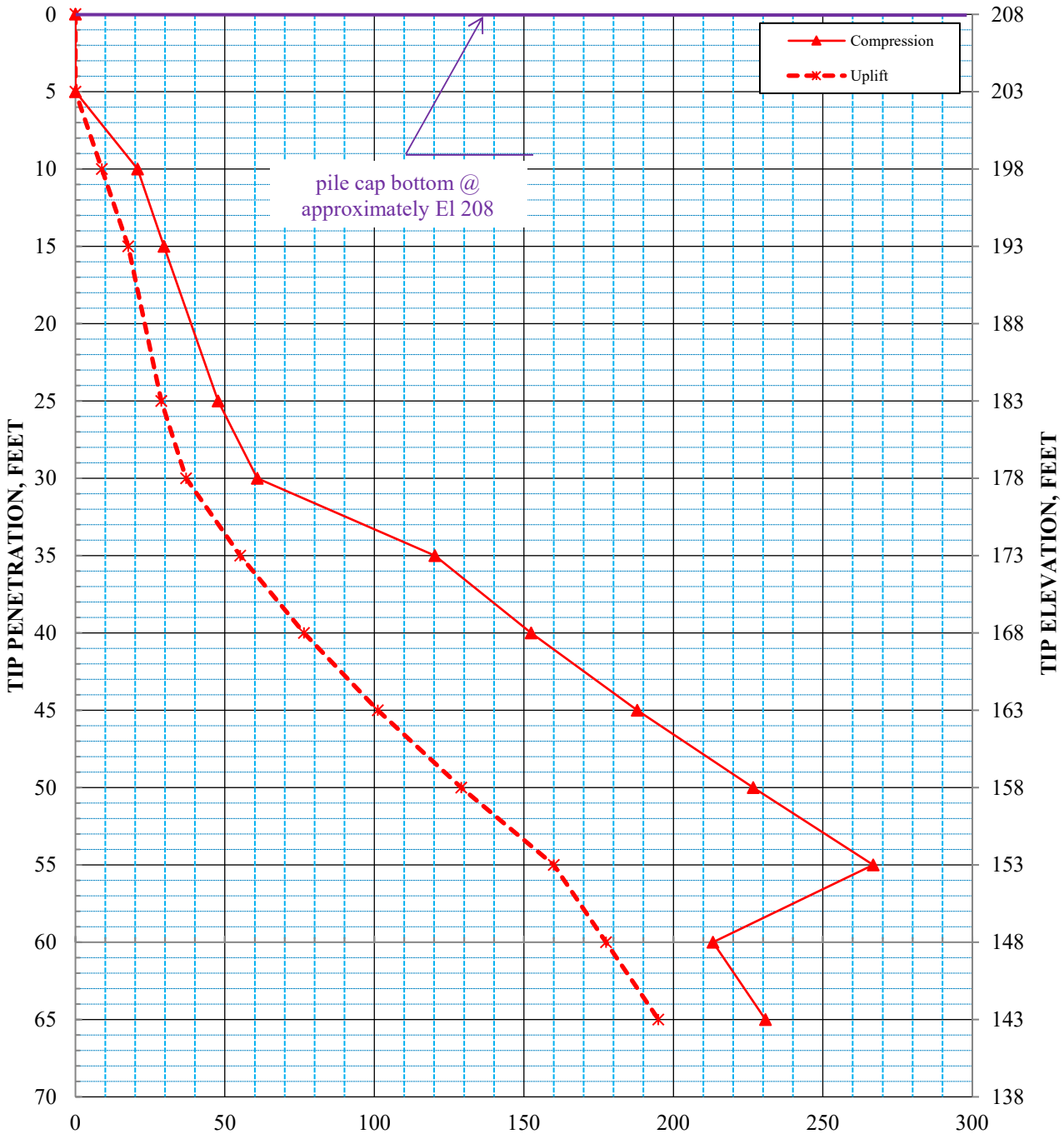

Boring Elevation
Factor of Safety Idriss and Boulanger (2008)
Factor of Safety
0
0.5
1
1.5
2
Depth (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150


Boring Elevation
Factor of Safety Idriss and Boulanger (2008)
Factor of Safety
0
0.5
1
1.5
2
Depth (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150


Boring Elevation
Factor of Safety Idriss and Boulanger (2008)
Factor of Safety
0
0.5
1
1.5
2
Depth (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

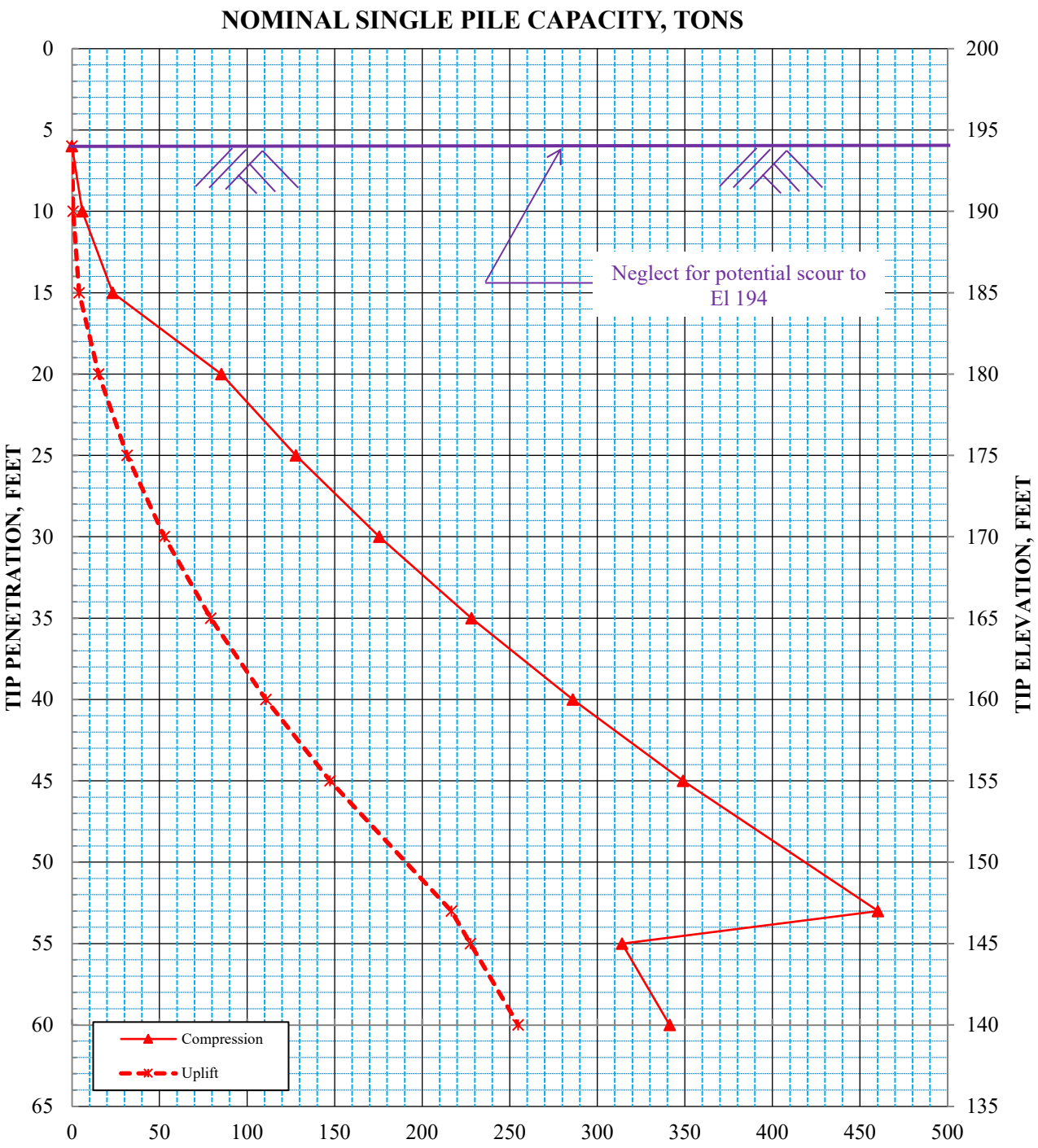

Boring Elevation
Factor of Safety Idriss and Boulanger (2008)
Factor of Safety
0
0.5
1
1.5
2
Depth (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

APPENDIX E



18-in.-diameter Steel Shells
Bridge Ends
ARDOT 050342 Hwy. 31 over Cypress Bayou
White County, Arkansas

Notes: 1. Piles assumed to be driven to plan tip elevation.
2. No downdrag.

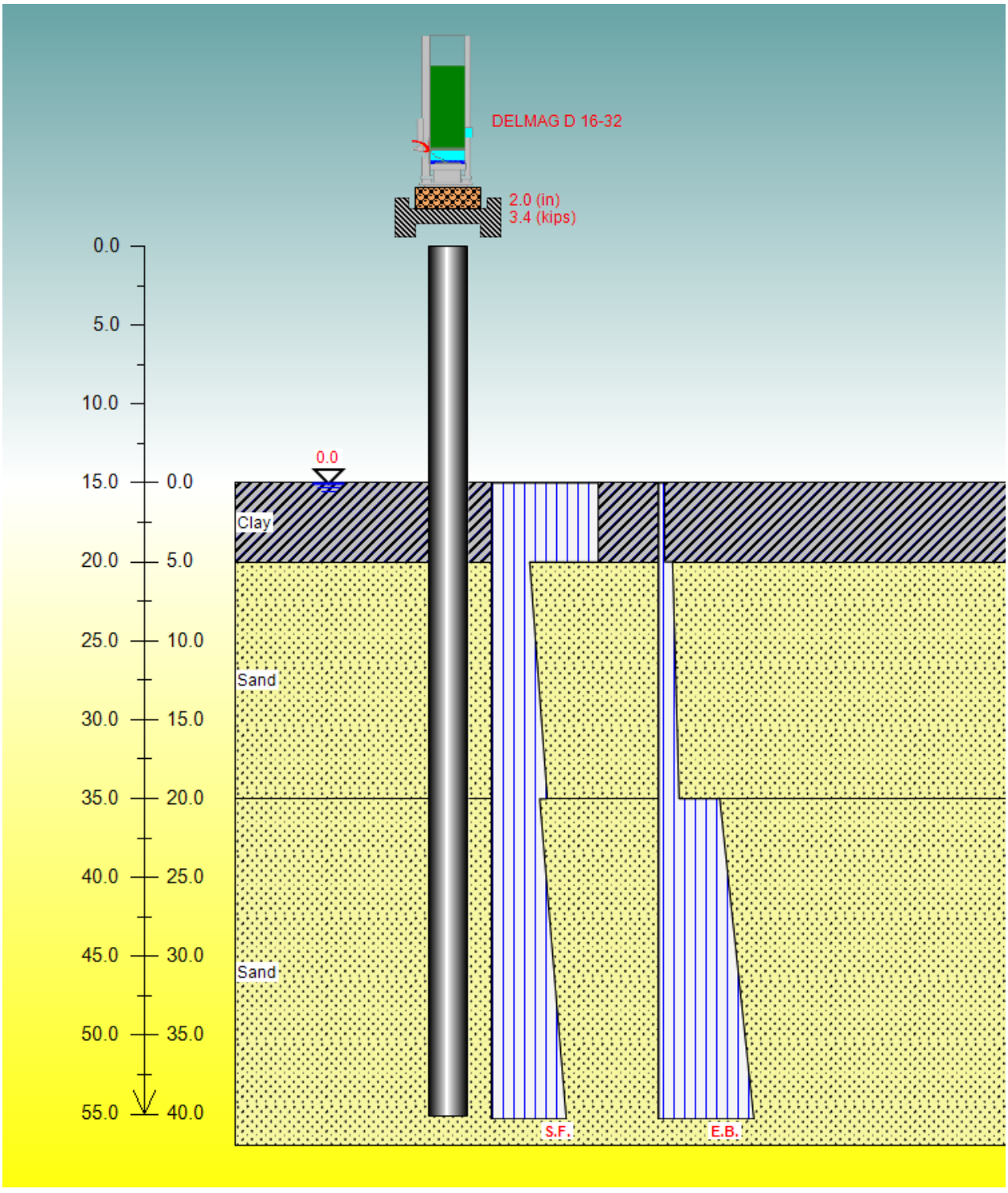


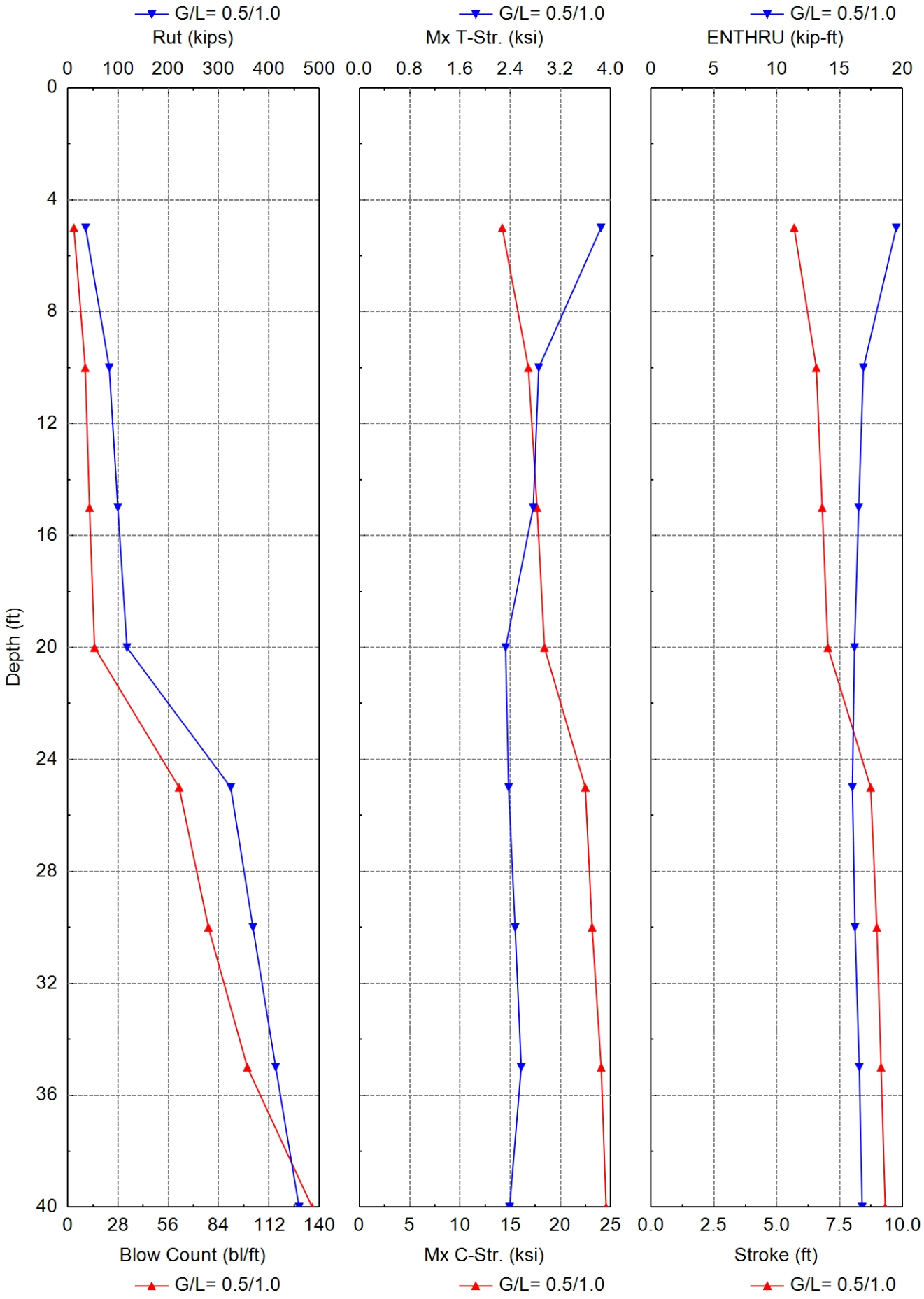
28-in.-diameter Steel Shells
Intermediate Bents
ARDOT 050342 Hwy. 31 over Cypress Bayou
White County, Arkansas

Notes: 1. Piles assumed to be driven to plan tip elevation.
2. No downdrag.

APPENDIX F

Cypress Bayou Bents 1 and 7



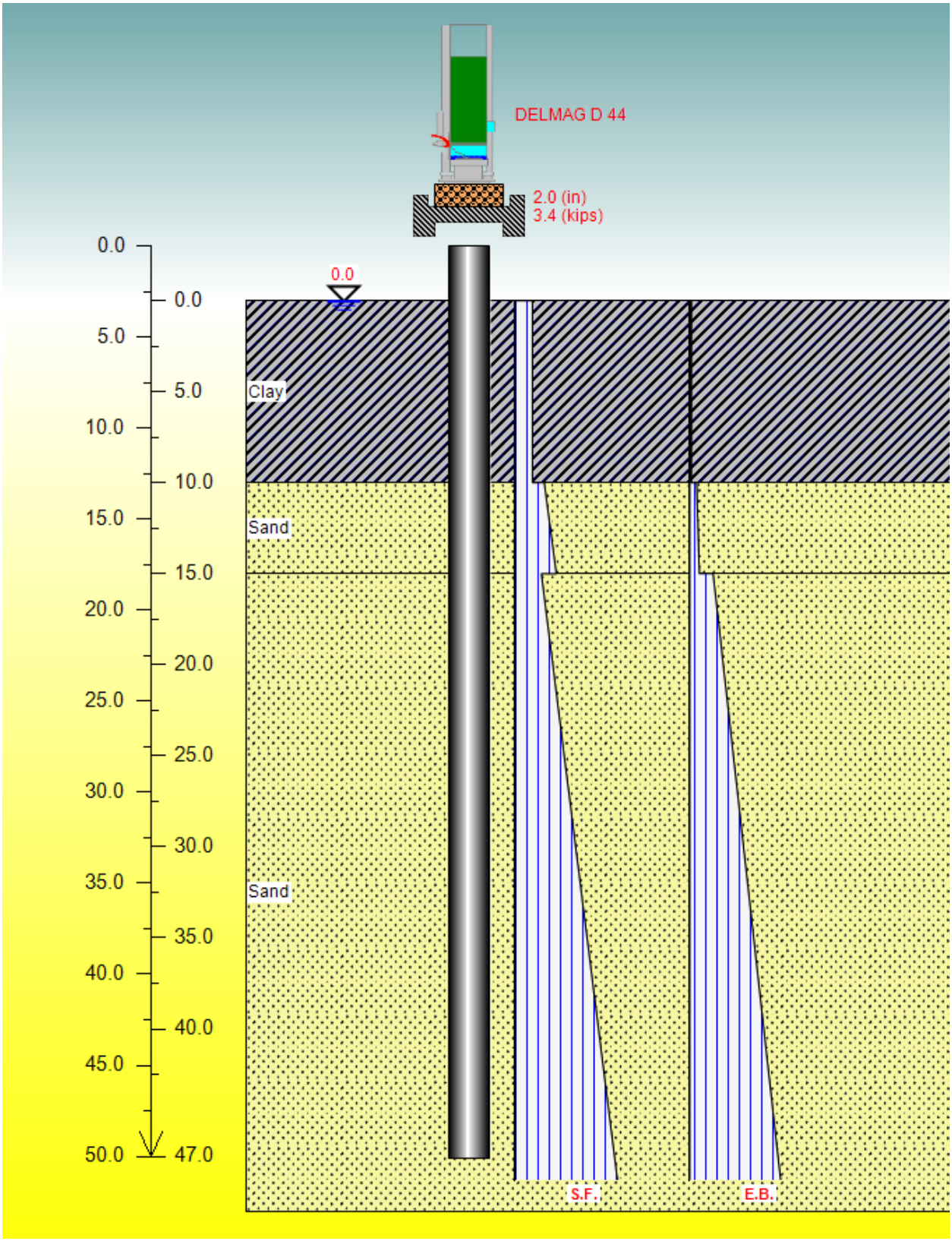

G/L= 0.5/1.0
Rut (kips)
0 100 200 300 400 500
G/L= 0.5/1.0
Mx T-Str. (ksi)
0.0 0.8 1.6 2.4 3.2 4.0
G/L= 0.5/1.0
ENTHRU (kip-ft)
0 5 10 15 20
Depth (ft)
0 4 8 12 16 20 24 28 32 36 40
0 28 56 84 112 140
Blow Count (bl/ft)
G/L= 0.5/1.0
0 5 10 15 20 25
Mx C-Str. (ksi)
G/L= 0.5/1.0
0.0 2.5 5.0 7.5 10.0
Stroke (ft)
G/L= 0.5/1.0

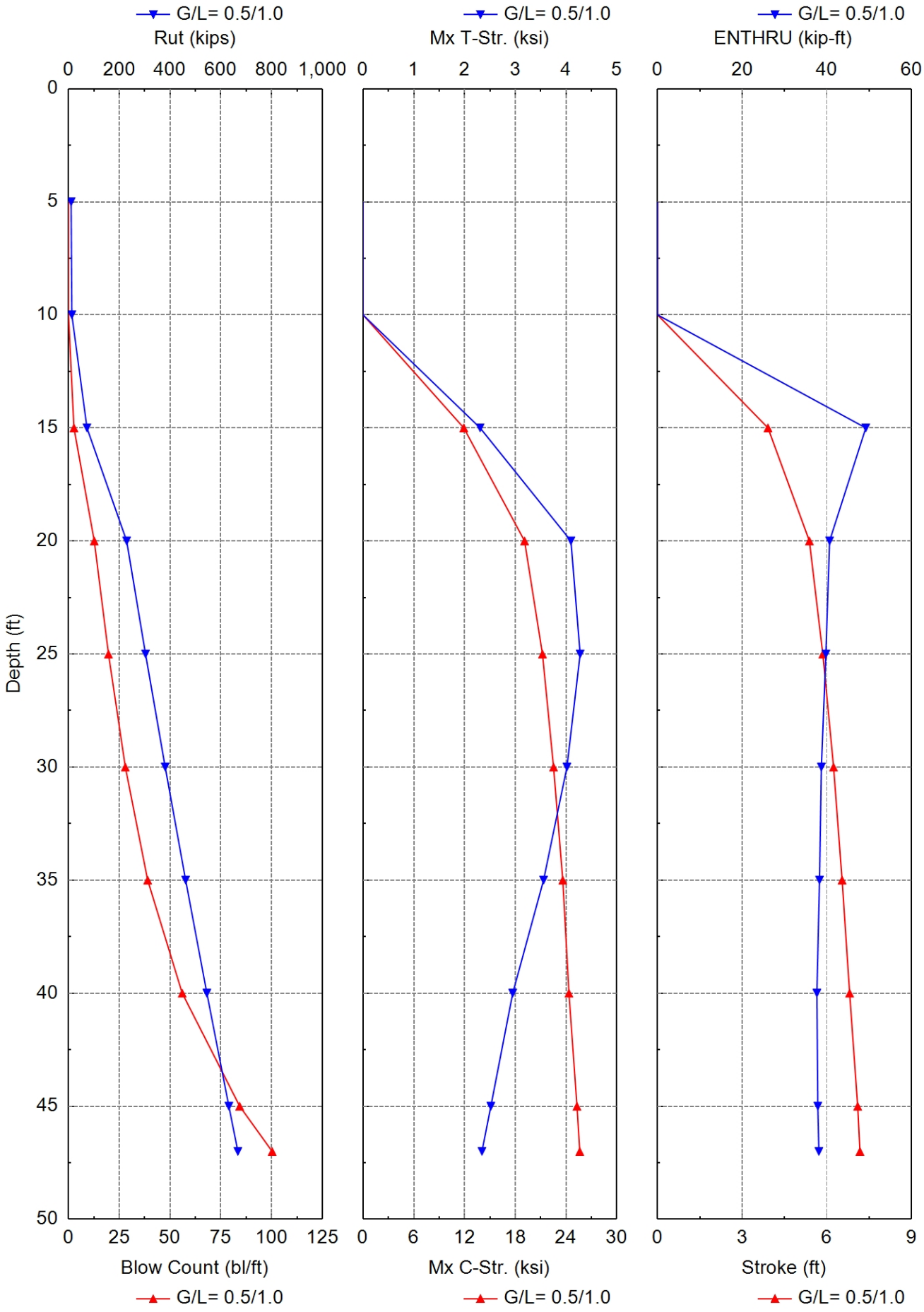
Gain/Loss Factor at Shaft/Toe = 0.500/1.000

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
5.0	35.5	11.6	23.9	3.4	14.201	3.844	5.69	19.5	D 16-32
10.0	82.5	19.0	63.5	9.7	16.802	2.853	6.57	16.9	D 16-32
15.0	99.5	27.4	72.1	12.1	17.665	2.766	6.81	16.5	D 16-32
20.0	117.7	36.9	80.8	14.9	18.403	2.325	7.03	16.2	D 16-32
25.0	324.1	46.2	277.9	62.0	22.464	2.374	8.73	16.0	D 16-32
30.0	368.2	56.6	311.6	78.3	23.136	2.477	8.98	16.2	D 16-32
35.0	413.5	68.2	345.3	100.0	24.043	2.574	9.15	16.6	D 16-32
40.0	460.1	81.1	379.0	136.1	24.534	2.389	9.32	16.8	D 16-32

Total driving time: 43 minutes; Total Number of Blows: 1733 (starting at penetration 5.0 ft)

Cypress Bayou Bents 2 through 6




G/L= 0.5/1.0
Rut (kips)
0 200 400 600 800 1,000
Mx T-Str. (ksi)
0 1 2 3 4 5
ENTHRU (kip-ft)
0 20 40 60
Depth (ft)
0 5 10 15 20 25 30 35 40 45 50
Blow Count (bl/ft)
0 25 50 75 100 125
Mx C-Str. (ksi)
0 6 12 18 24 30
Stroke (ft)
0 3 6 9

Gain/Loss Factor at Shaft/Toe = 0.500/1.000

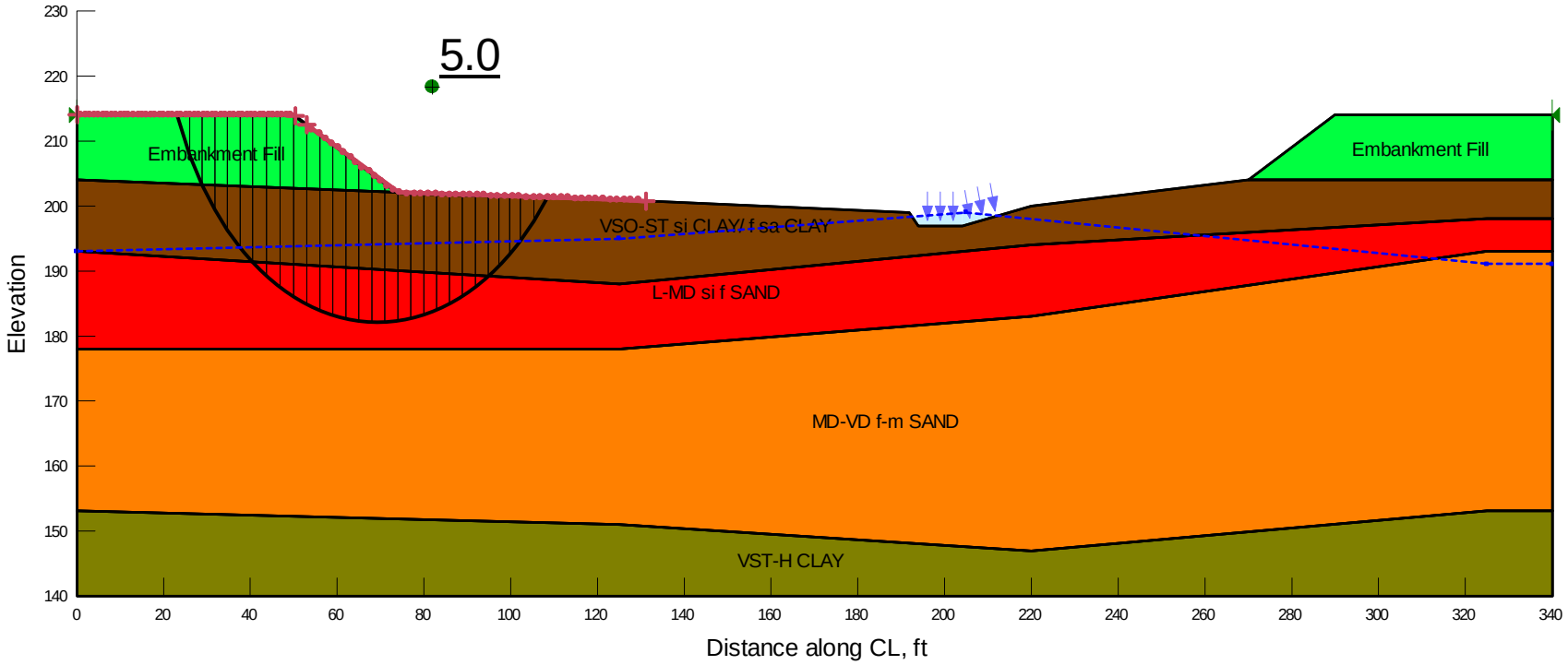
Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
5.0	10.4	2.7	7.7	0.3	0.000	0.000	9.49	0.0	D 44
10.0	13.3	5.6	7.7	0.3	0.000	0.000	9.49	0.0	D 44
15.0	72.8	15.1	57.8	2.7	11.910	2.306	3.91	49.2	D 44
20.0	229.2	23.6	205.6	12.7	19.090	4.095	5.38	40.7	D 44
25.0	303.5	35.3	268.2	19.7	21.205	4.276	5.86	39.8	D 44
30.0	381.0	50.1	330.9	28.0	22.516	4.016	6.24	38.7	D 44
35.0	461.5	68.0	393.5	39.0	23.604	3.556	6.54	38.3	D 44
40.0	545.1	88.9	456.2	56.0	24.336	2.949	6.81	37.7	D 44
45.0	631.8	113.0	518.9	84.3	25.284	2.518	7.10	37.9	D 44
47.0	667.4	123.4	543.9	100.3	25.612	2.343	7.18	38.1	D 44

Total driving time: 26 minutes; Total Number of Blows: 1187 (starting at penetration 5.0 ft)

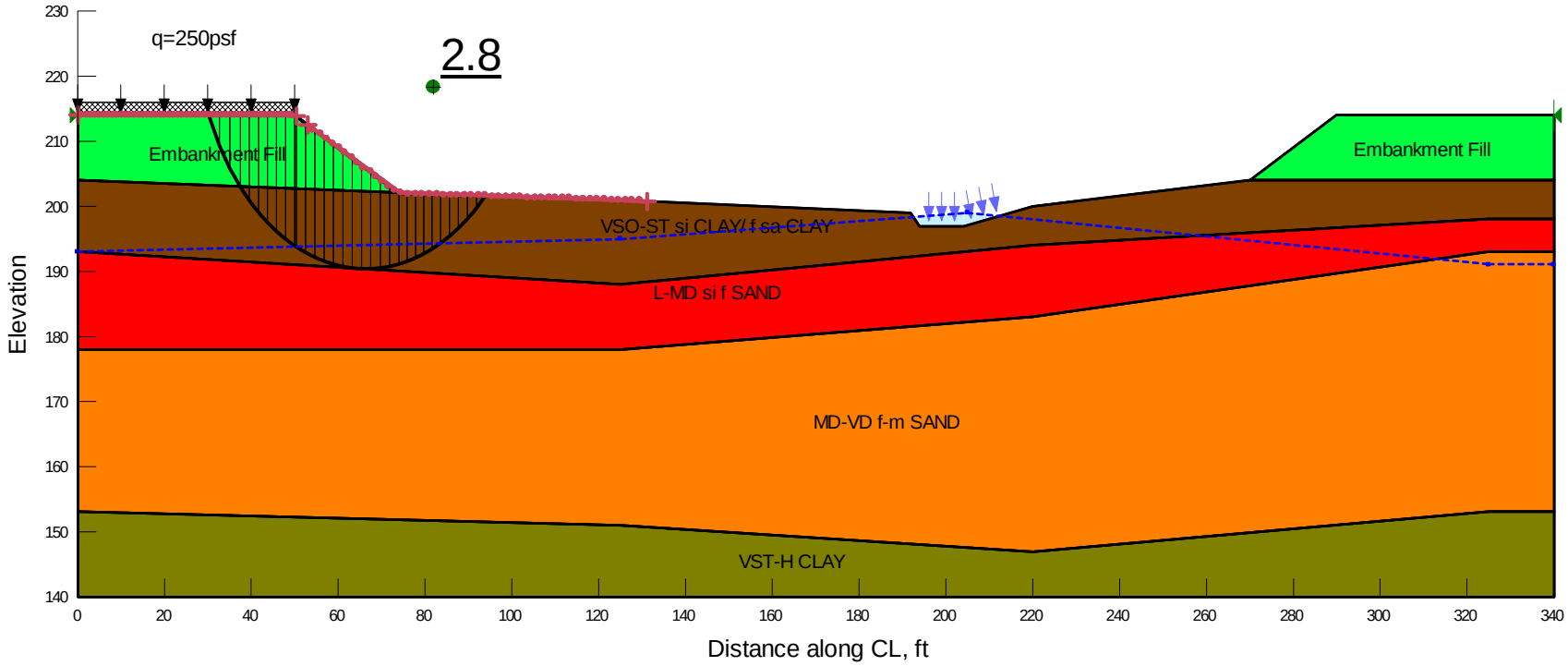
APPENDIX G

Summary of Stability Analysis Results
ARDOT 050342 Hwy. 31 over Cypress Bayou
GHBW Job No. 18-077
White County, Arkansas

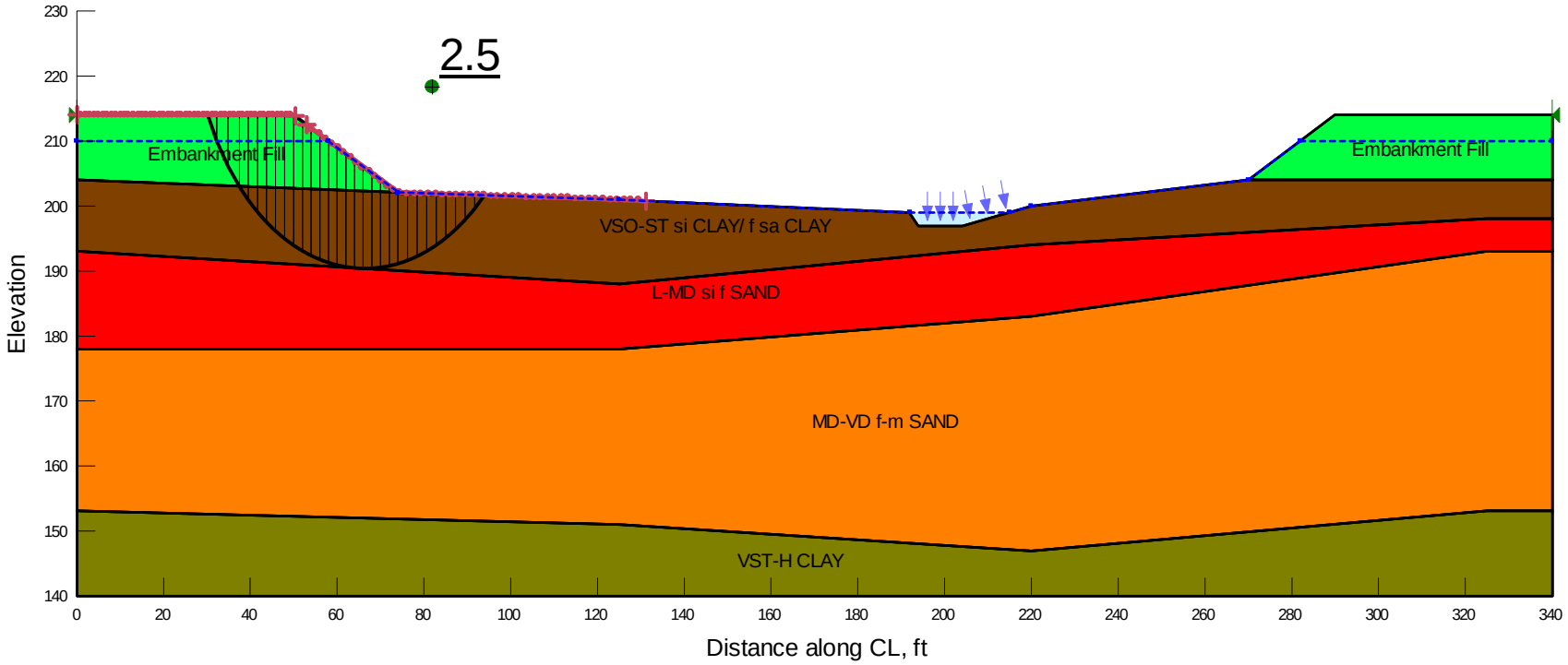
Bridge End	Design Loading Condition	Calculated Minimum Factor of Safety
South End Slope (Bent 1) (2H:1V)	End of Construction	5.0
	Long Term	2.8
	Rapid Drawdown from El 210 to Existing Grade	2.5
	Seismic ($k_h = A_S/2 = 0.131$)	2.1
South Side Slope (Bent 1) (2H:1V)	End of Construction	3.0
	Long Term	3.4
	Rapid Drawdown from El 210 to Existing Grade	3.0
	Seismic ($k_h = A_S/2 = 0.131$)	2.6
North End Slope (Bent 7) (2H:1V)	End of Construction	4.8
	Long Term	3.0
	Rapid Drawdown from El 210 to Existing Grade	2.7
	Seismic ($k_h = A_S/2 = 0.131$)	2.4
North End Side Slope (Bent 7) (2H:1V)	End of Construction	4.7
	Long Term	3.5
	Rapid Drawdown from El 210 to Existing Grade	2.9
	Seismic ($k_h = A_S/2 = 0.131$)	2.7



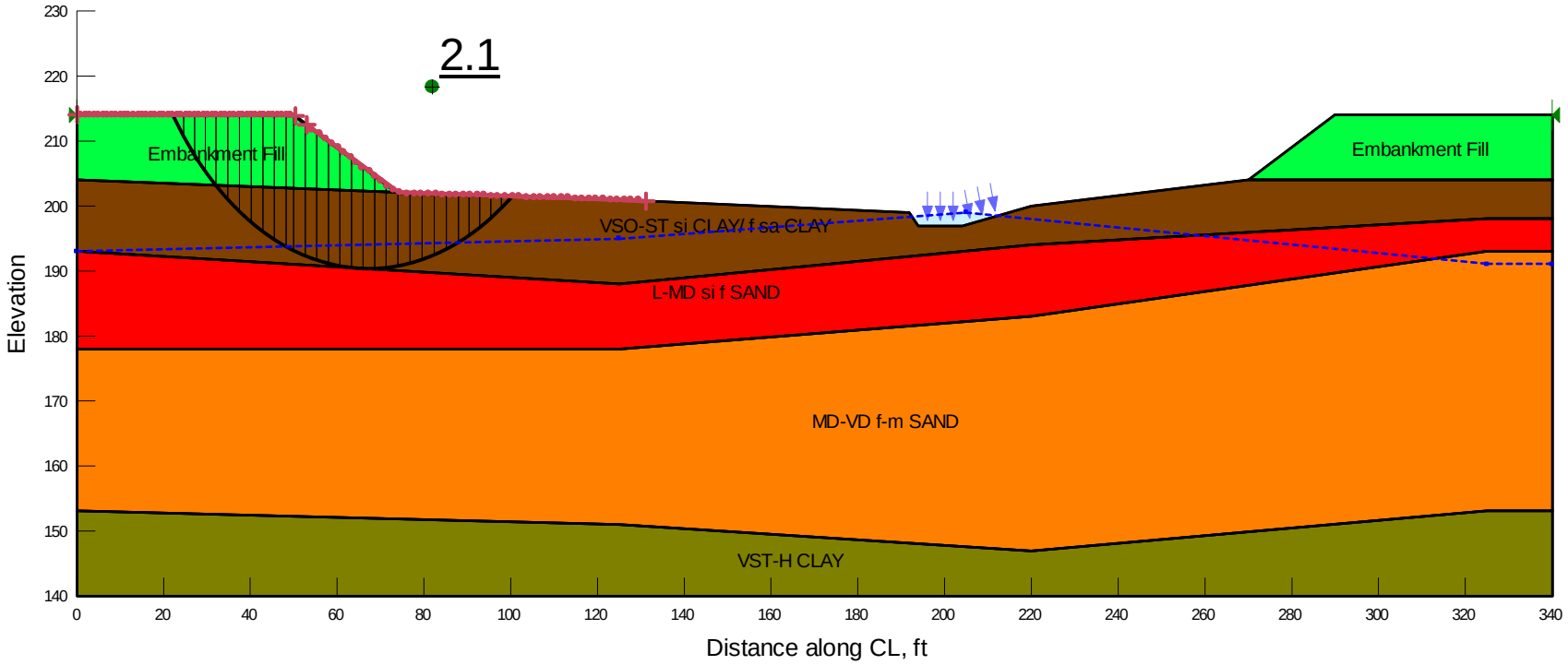
Results of Stability Analyses – End of Construction
Bent 1 End Slope at Approximately Sta 122+53
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



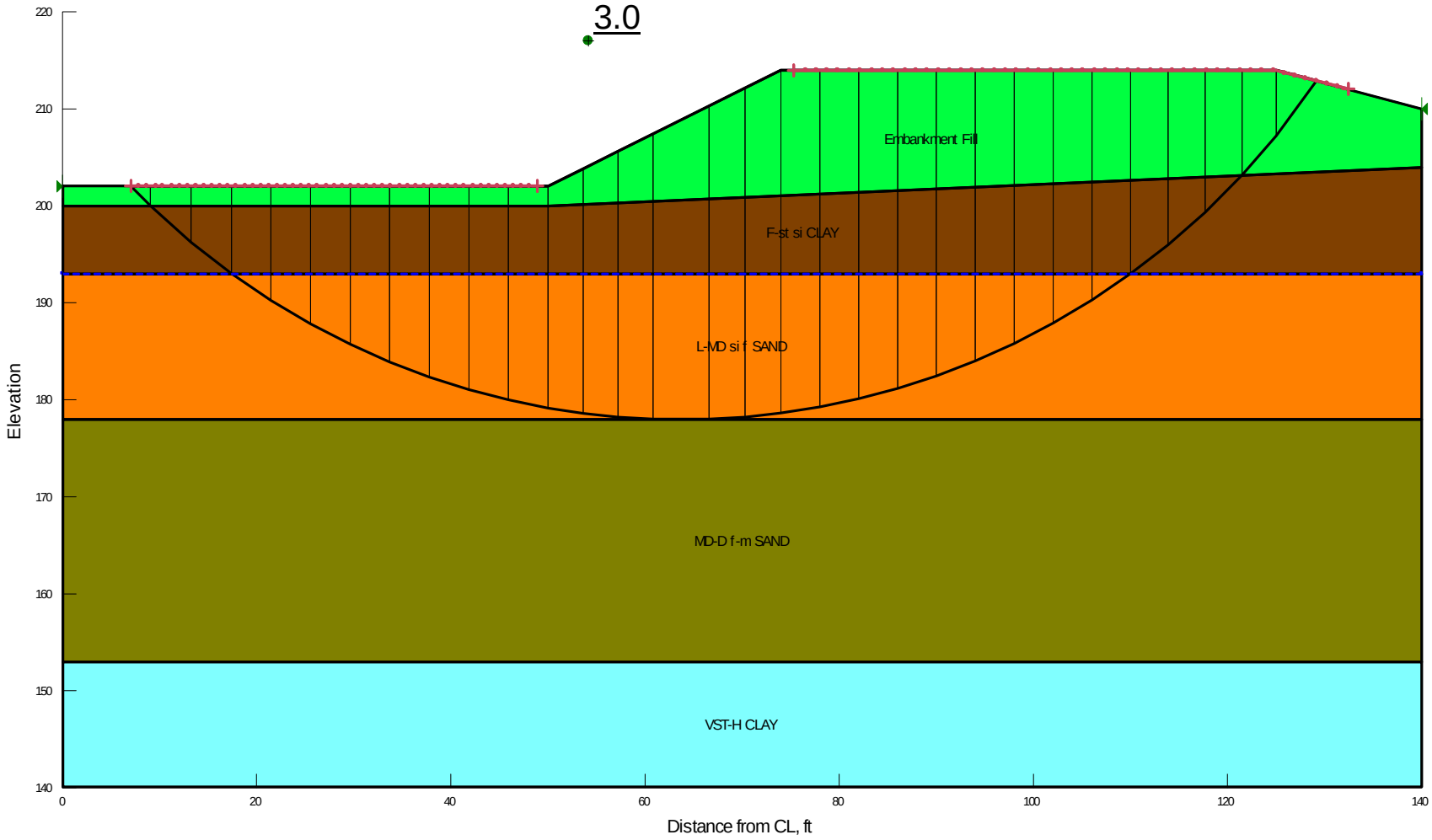
Results of Stability Analyses – Long Term Condition
Bent 1 End Slope at Approximately Sta 122+53
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



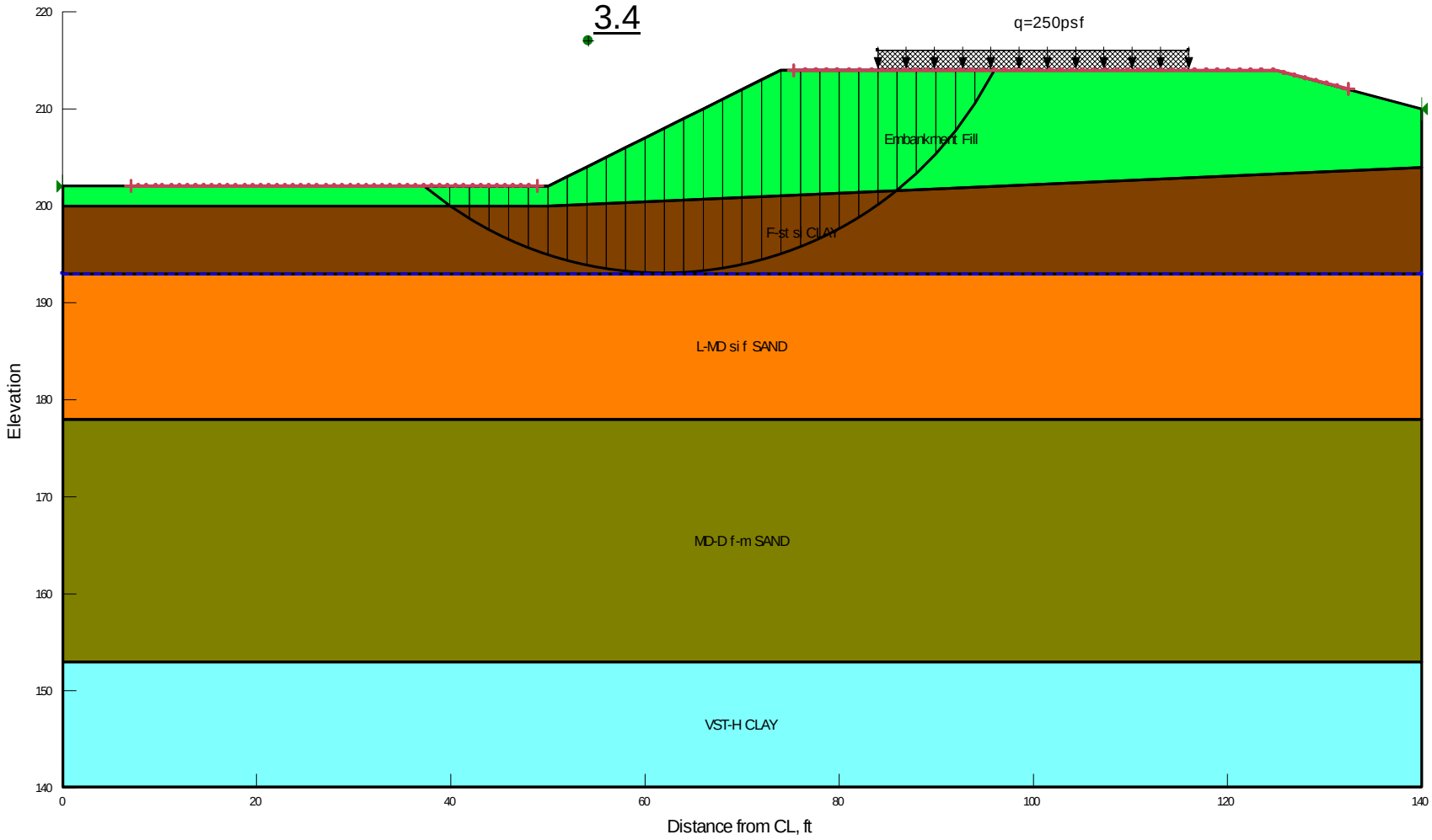
Results of Stability Analyses – Rapid Drawdown Condition, El 210 to Existing Grade
Bent 1 End Slope at Approximately Sta 122+53
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



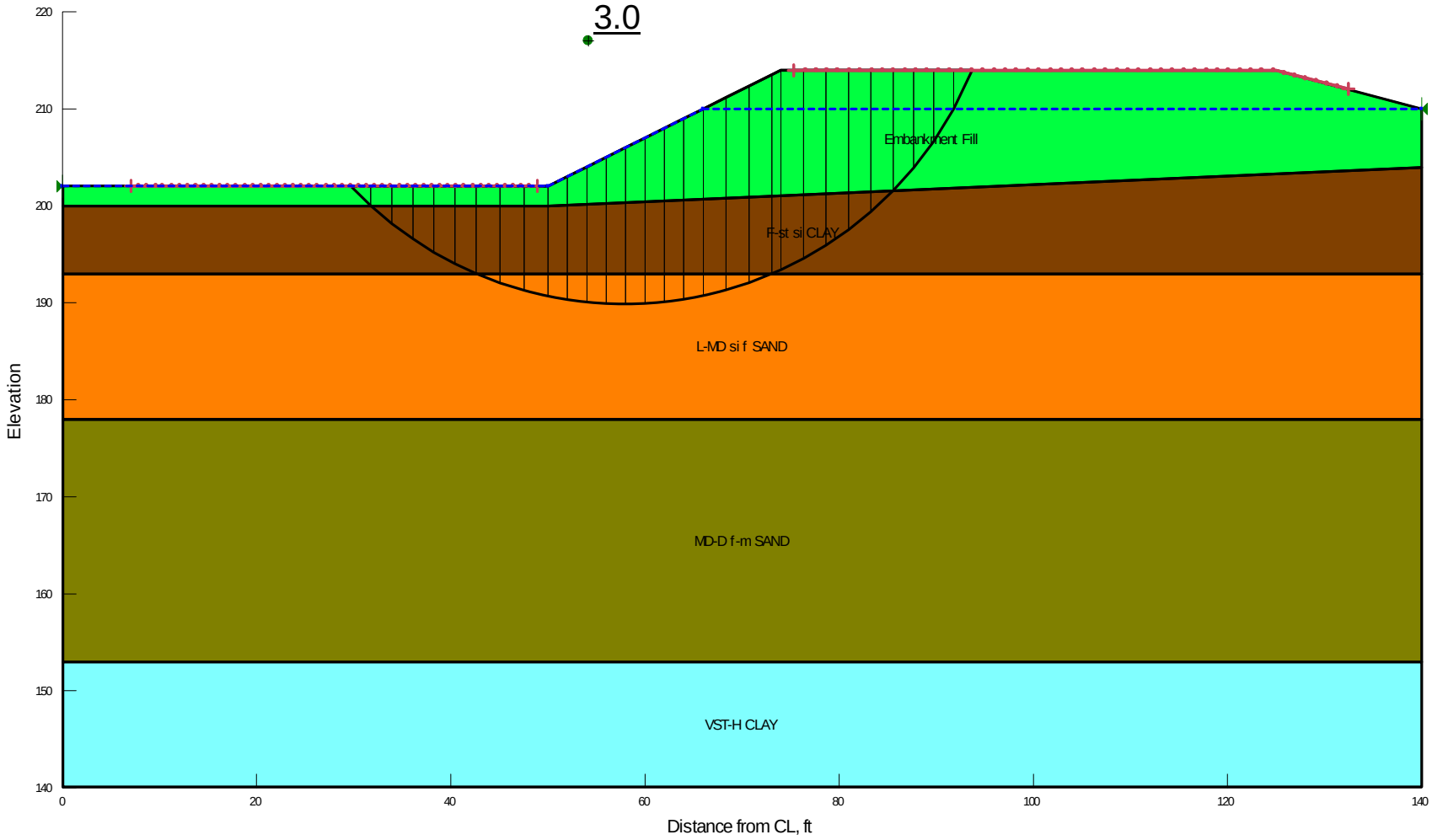
Results of Stability Analyses – Seismic Condition ($k_h = A_S /2 = 0.131$)
Bent 1 End Slope at Approximately Sta 122+53
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



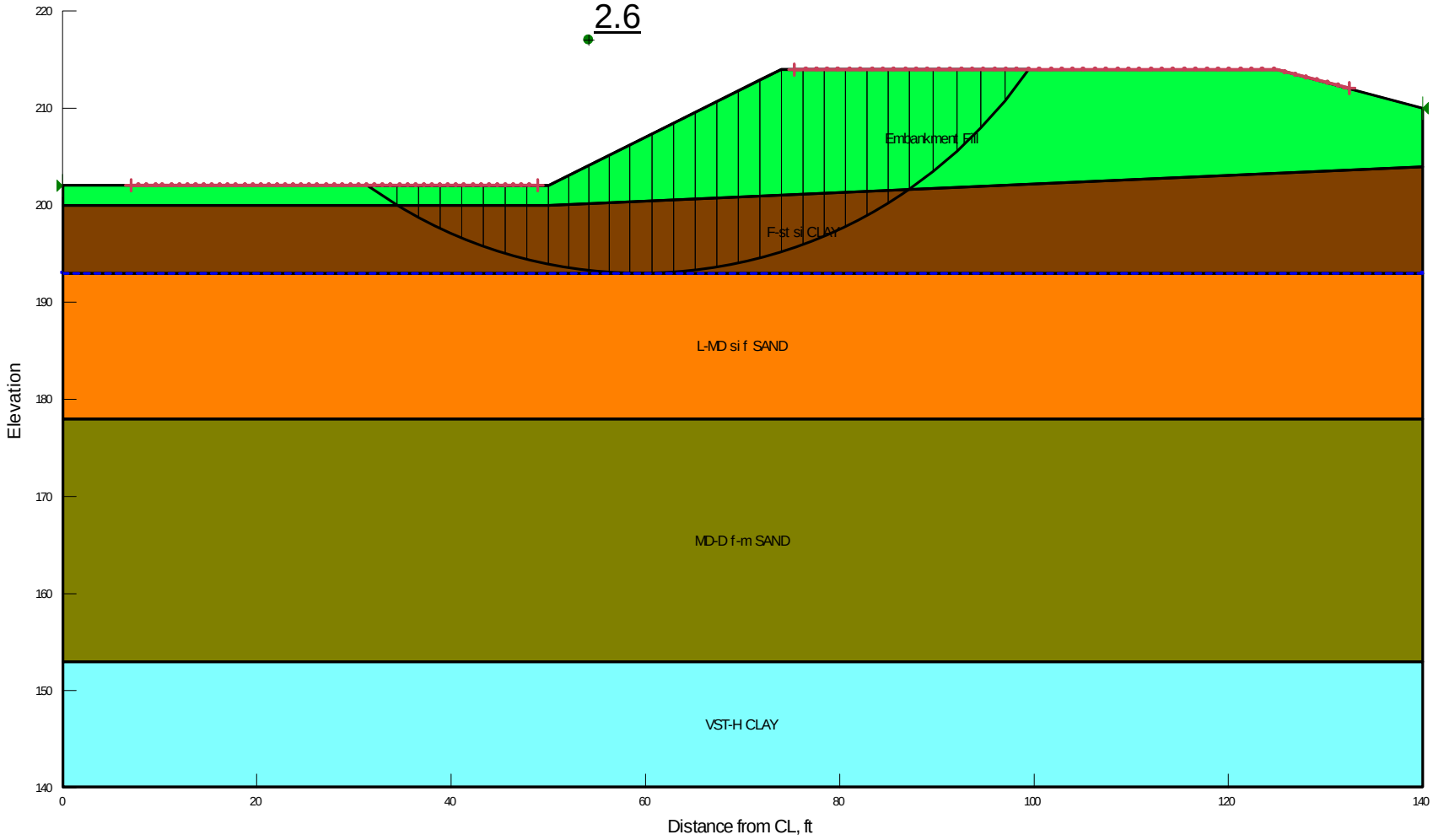
Results of Stability Analyses – End of Construction
Bent 1 Side Slope at Approximately Sta 122+60
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



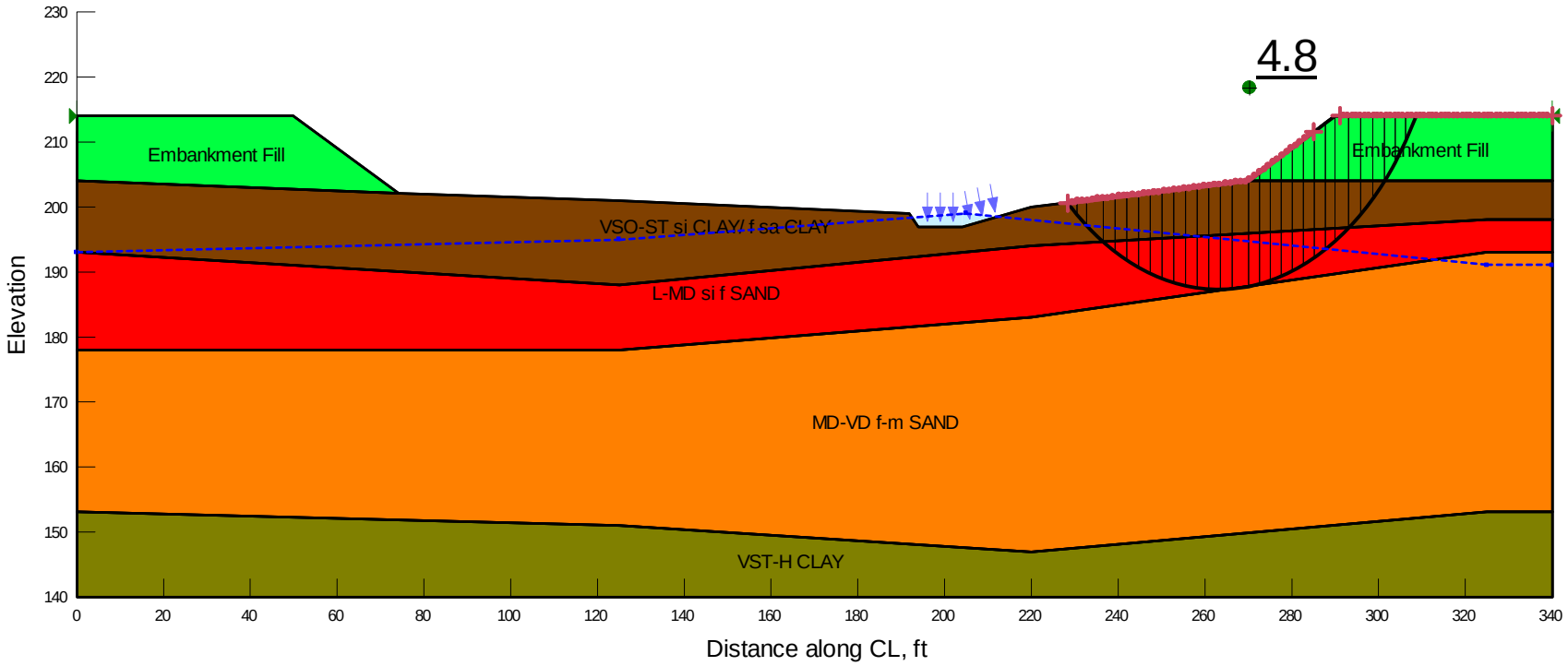
Results of Stability Analyses – Long Term Condition
Bent 1 Side Slope at Approximately Sta 122+60
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



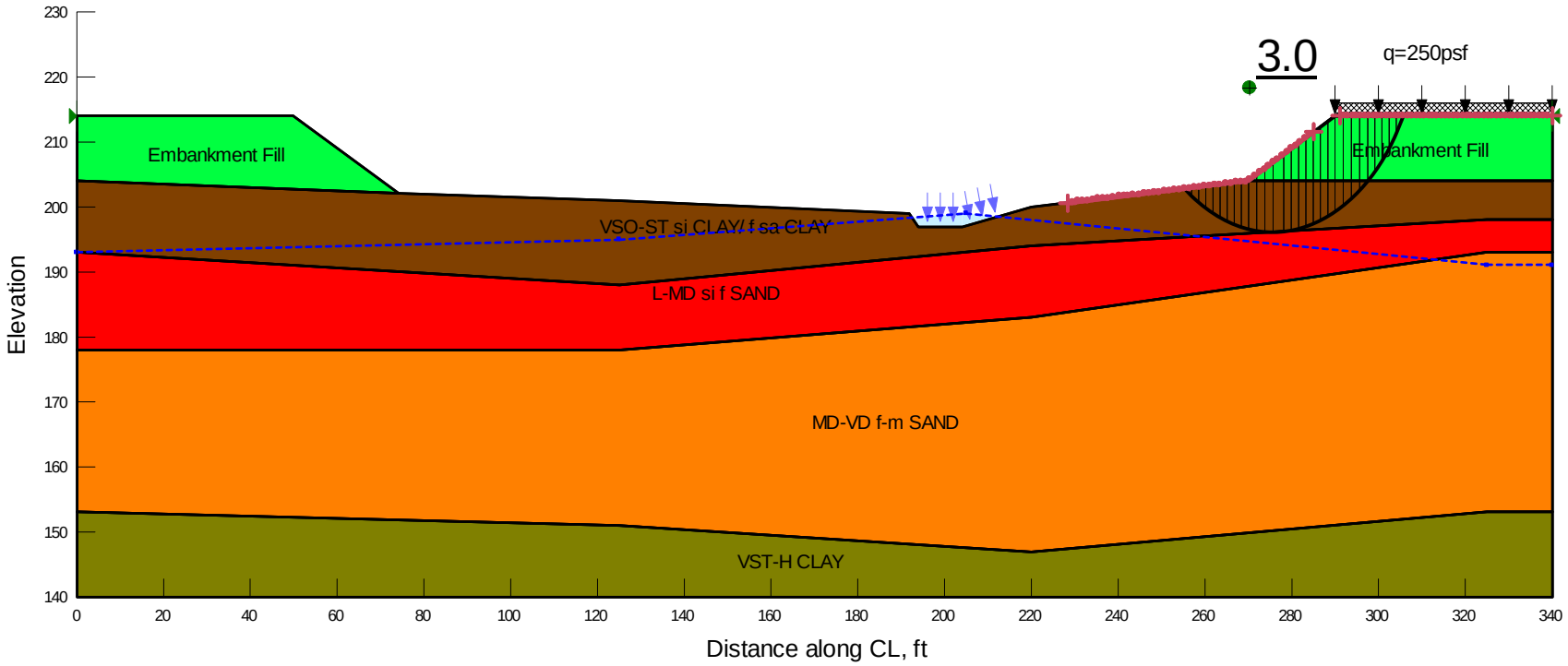
Results of Stability Analyses – Rapid Drawdown Condition, El 210 to Existing Grade
Bent 1 Side Slope at Approximately Sta 122+60
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



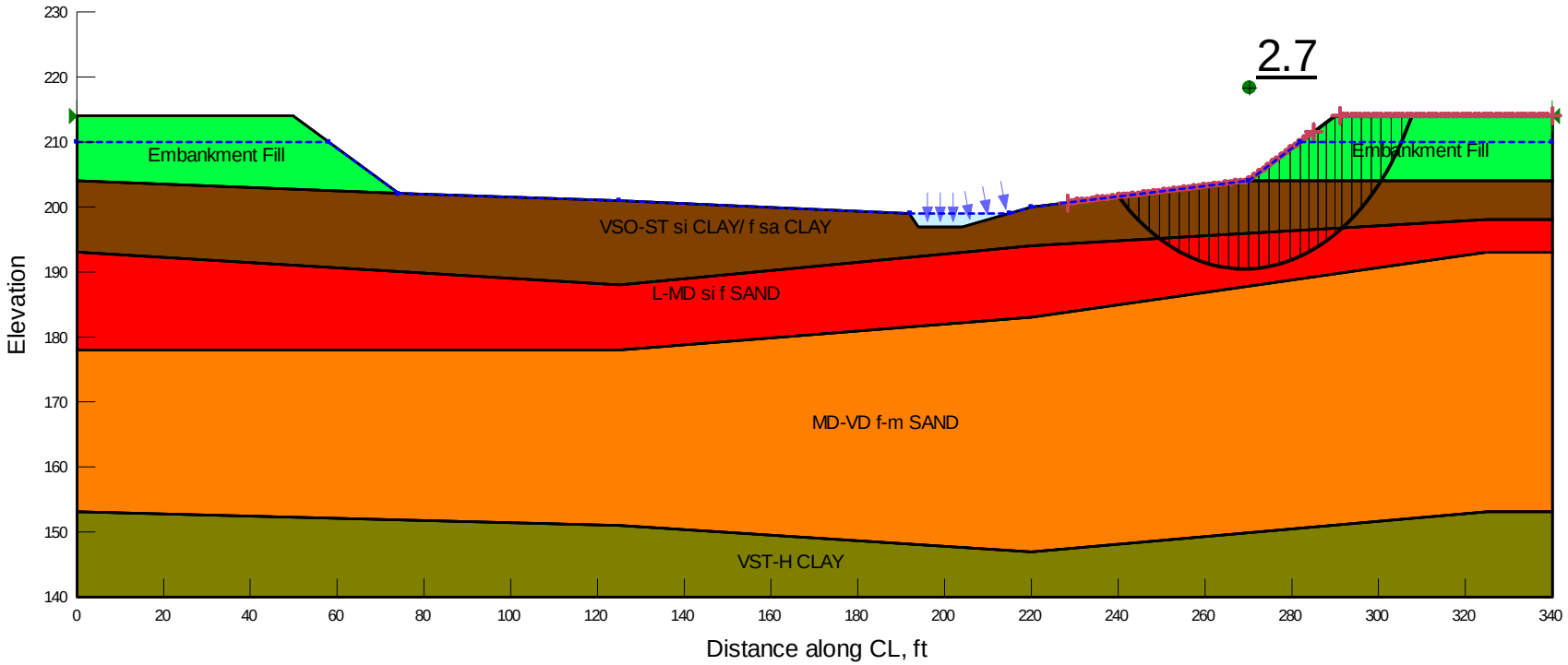
Results of Stability Analyses – Seismic Condition ($k_h = A_S /2 = 0.131$)
Bent 1 Side Slope at Approximately Sta 122+60
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



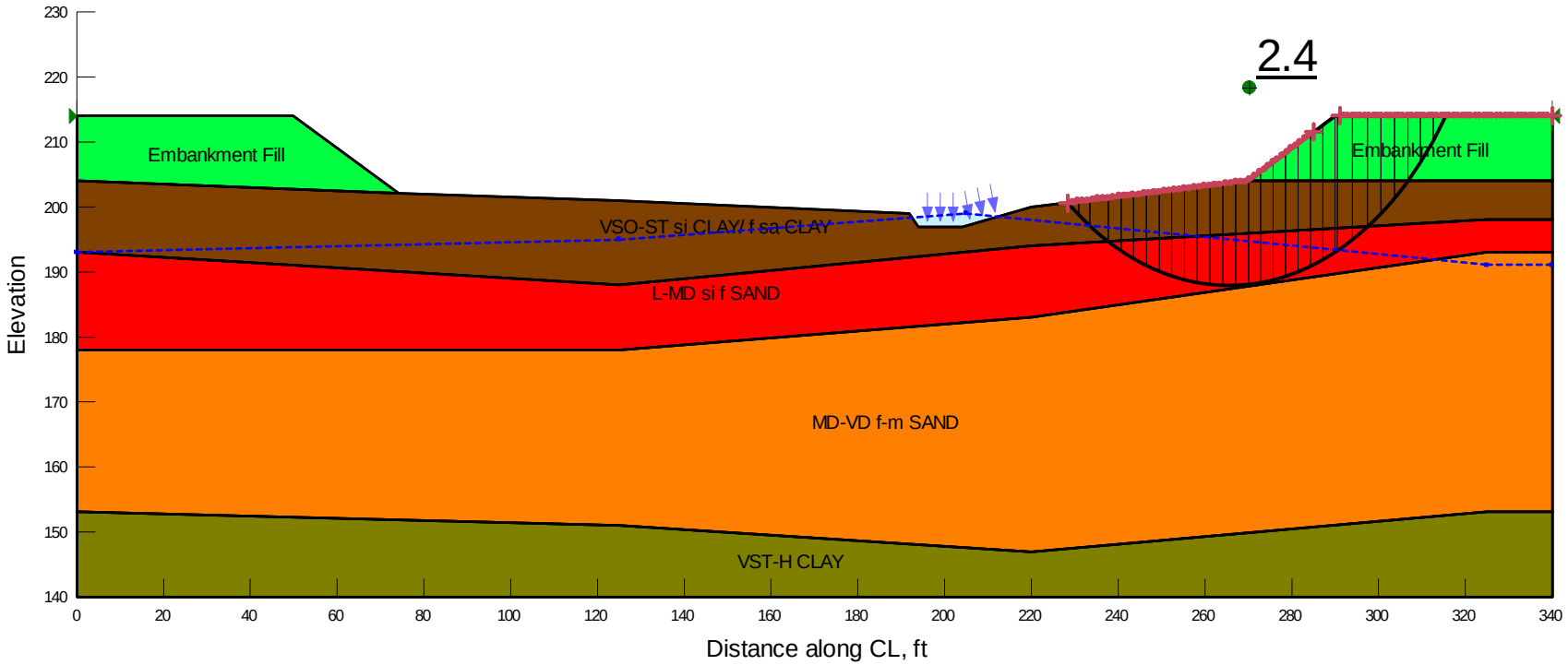
Results of Stability Analyses – End of Construction
Bent 7 End Slope at Approximately Sta 125+23
2H:1V Slope, H=10 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



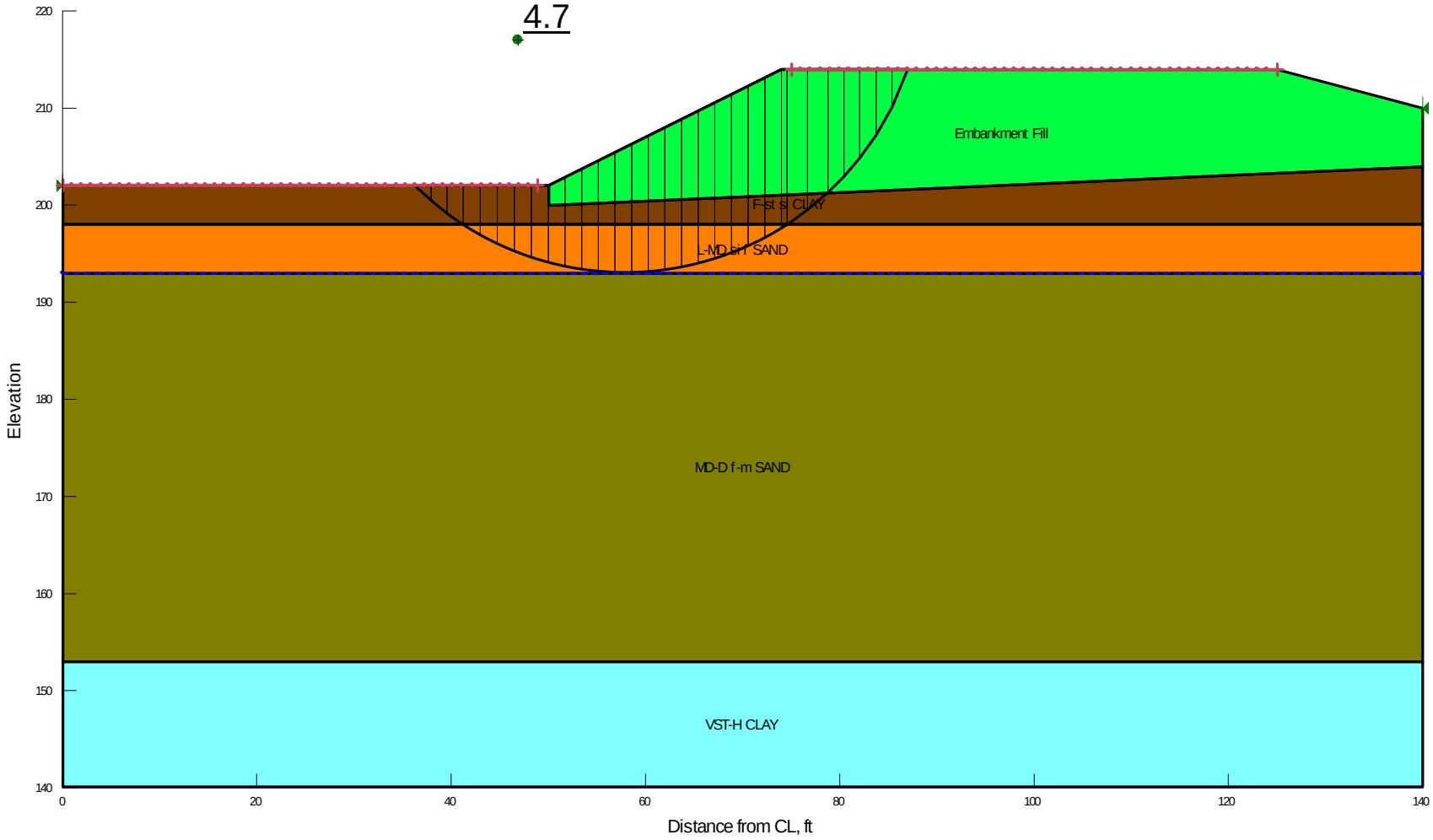
Results of Stability Analyses – Long Term Condition
Bent 7 End Slope at Approximately Sta 125+23
2H:1V Slope, H=10 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



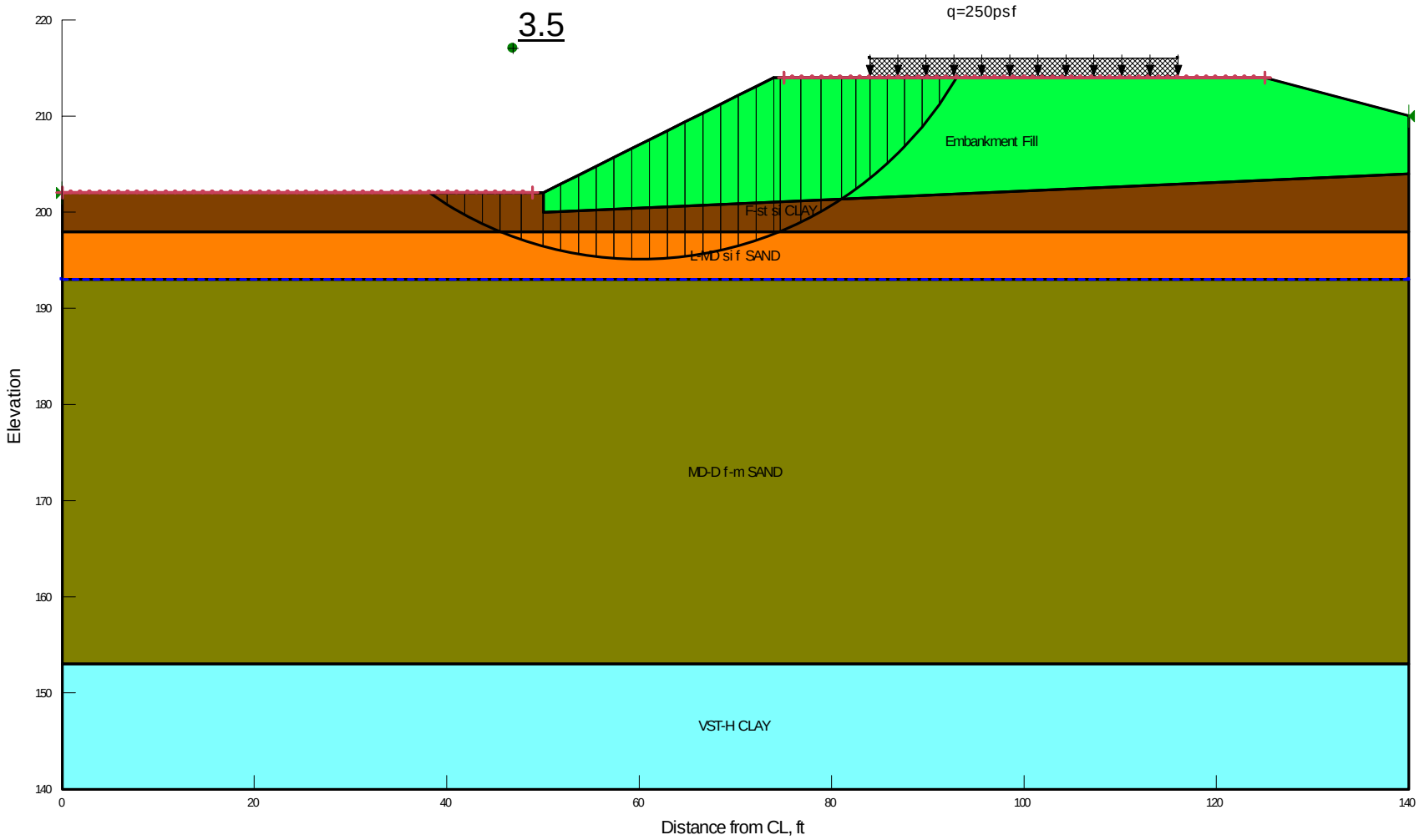
Results of Stability Analyses – Rapid Drawdown Condition, El 210 to El 199
Bent 7 End Slope at Approximately Sta 125+23
2H:1V Slope, H=10 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



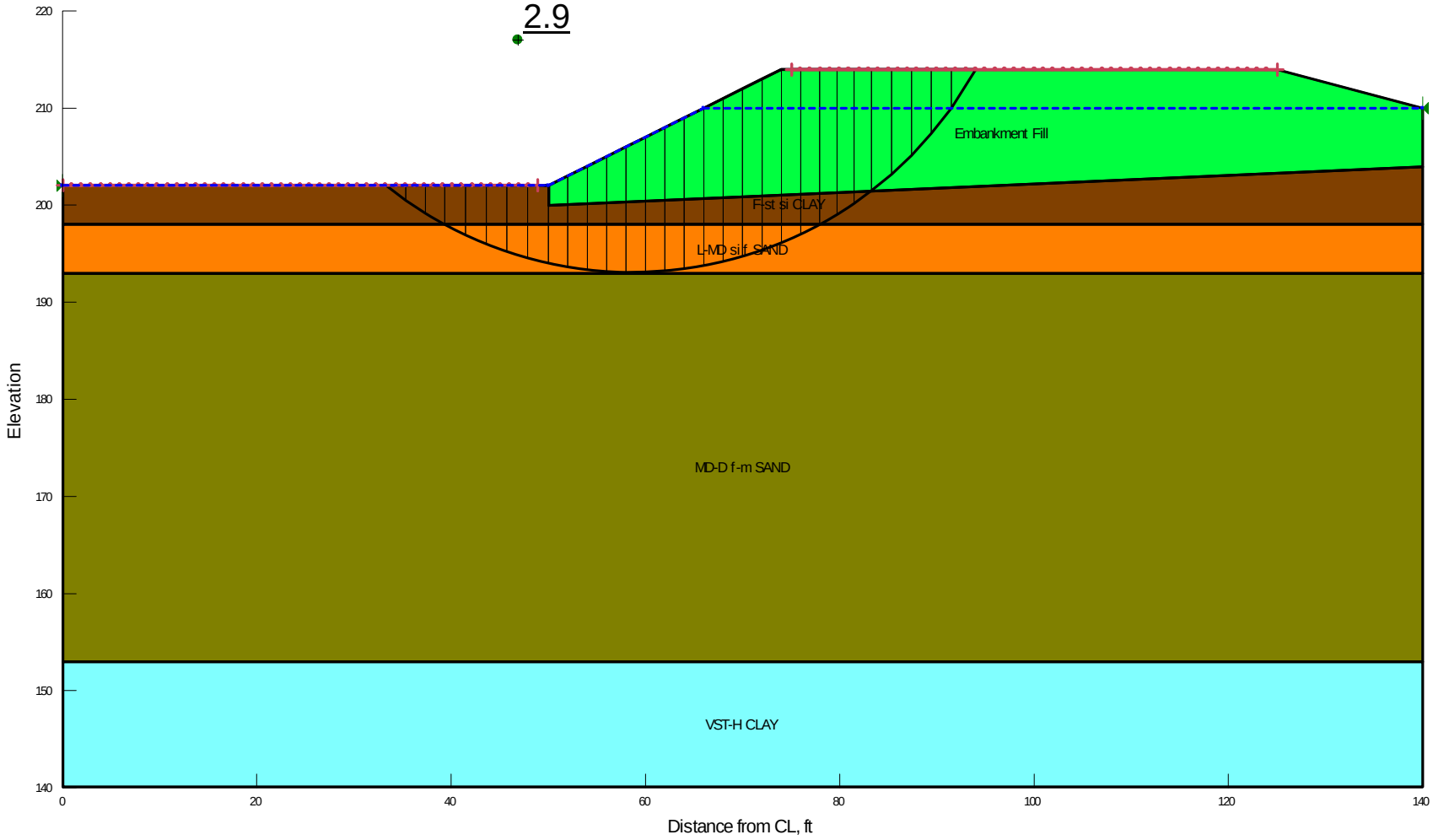
Results of Stability Analyses – Seismic Condition ($k_h = A_S /2 = 0.131$)
Bent 7 End Slope at Approximately Sta 125+23
2H:1V Slope, H=10 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



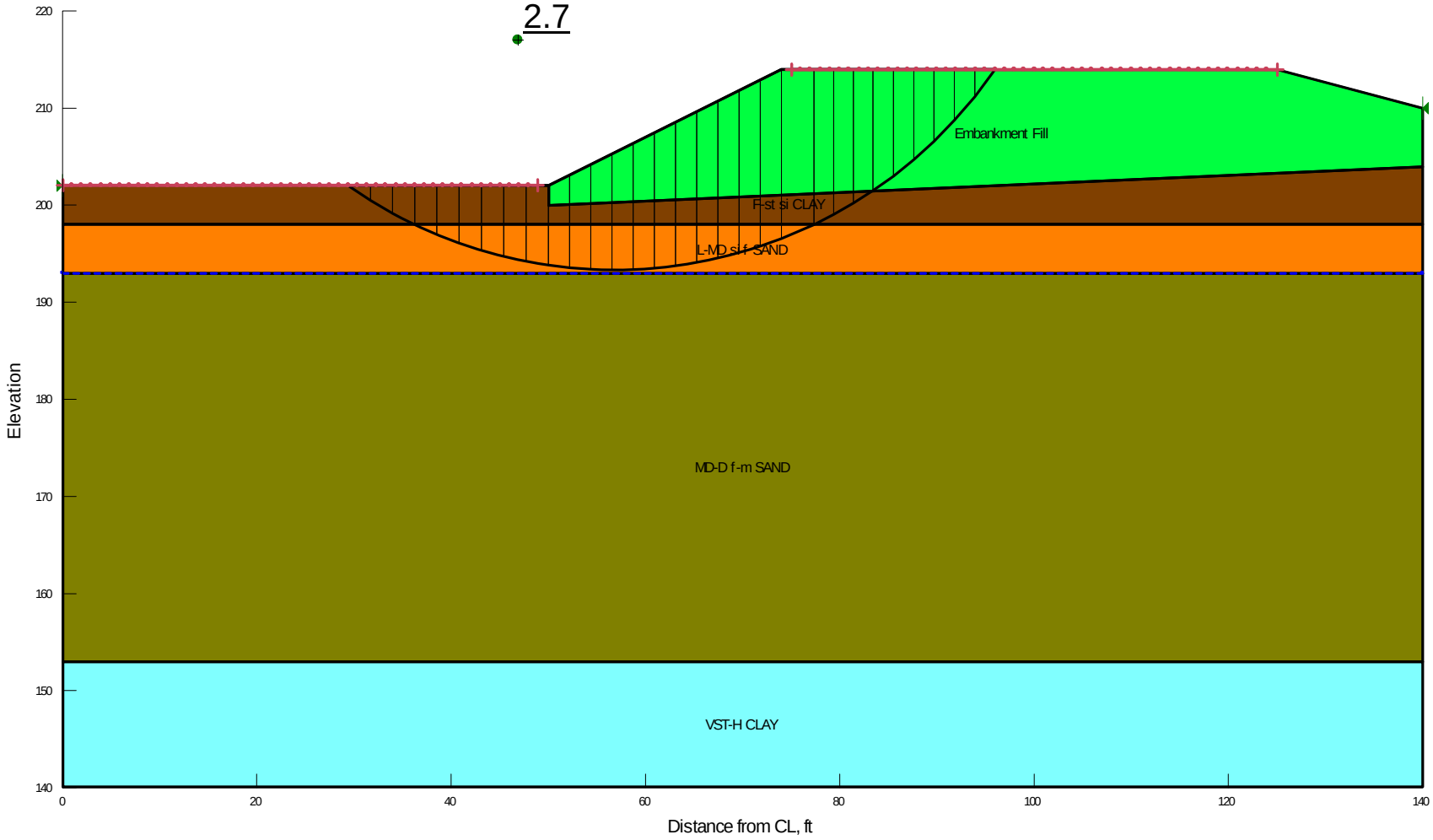
Results of Stability Analyses – End of Construction
Bent 7 Side Slope at Approximately Sta 125+20
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



Results of Stability Analyses – Long Term Condition
Bent 7 Side Slope at Approximately Sta 125+20
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



Results of Stability Analyses – Rapid Drawdown Condition, El 210 to El 199
Bent 7 Side Slope at Approximately Sta 125+20
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou



Results of Stability Analyses – Seismic Condition ($k_h = A_S /2 = 0.131$)
Bent 7 Side Slope at Approximately Sta 125+20
2H:1V Slope, H=12 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Cypress Bayou

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May 23, 2022
Job No. 18-077

Crafton Tull & Associates, Inc.
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Rogers, Arkansas 72756

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Senior Vice President, Transportation

GEOTECHNICAL INVESTIGATION
ARDOT 050342: LONOKE CO. LINE-HWY. 267 STRS. & APPRS. (S)
HWY. 31 over RED CUT SLOUGH
WHITE COUNTY, ARKANSAS

INTRODUCTION

The final results of the geotechnical investigation performed for the Hwy. 31 over Red Cut Slough Replacement Bridge (Bridge #02867) in White County, Arkansas are presented in this report. This project is one facet of ARDOT Job 050342 Lonoke Co. Line - Hwy. 267 Strs. & Apprs. (S). This geotechnical investigation was authorized by the Crafton Tull & Associates, Inc. Subconsultant Task Order Agreement of May 8, 2018. The field studies were delayed by inclement weather and access limitations. Results of this study have been provided as data were developed. Interim recommendations for subgrade support parameters were provided on April 17, 2019. This final report includes the pile capacities as provided on August 23, 2021 and the results of driveability analyses performed in January 2022.

We understand the replacement bridge will be continuous composite integral W-beam units with four (4) bents, three (3) spans, and a total length of approximately 125 feet. A preliminary bridge layout is provided in Appendix A. We also understand that the anticipated moderate structural loads of the new bridge will be supported on steel shell pile foundations. The end and side embankments will utilize simple slopes with approximate 2-horizontal to 1-vertical (2H:1V) configuration to transition grades.

Recommendations for seismic site classification and bridge foundations for the planned replacement bridge are discussed in the following report sections. Additionally, stability analyses have been performed for the plan embankment configurations and subgrade parameters have been

provided for use pavement design. The results of the field and laboratory studies are discussed in the following report sections. Conclusions, results of analyses, and recommendations are discussed in subsequent report sections.

SUBSURFACE EXPLORATION

Subsurface conditions in the Hwy. 31 over Red Cut Slough alignment have been evaluated by drilling two (2) sample borings to depths of 80 to 100 ft below existing grades in the structure area and two (2) sample borings to 2.5- to 5-ft depth in the plan roadway alignment. Because of limited access and to limit disruption of highway traffic, the pavement borings were advanced using hand-auger methods.

The site vicinity is shown on Plate 1. The approximate boring locations at the replacement bridge and pavement locations are shown on Plates 2a and 2b, respectively. Logs of the borings, presenting descriptions of the subsurface strata encountered and results of the field and laboratory tests, are included as Plates 3 through 8. The centerline station and offset of the boring locations and the inferred ground surface elevation are noted on the logs. The approximate boring surface elevation was inferred from the topographic information provided by the Engineer (Crafton Tull & Associates). It must be recognized that the elevations shown are approximate and actual elevations may vary. A key to the terms and symbols used on the logs is presented as Plate 9.

To aid in visualizing subsurface conditions at the replacement bridge location, a generalized subsurface profile is presented as Plate 10. The stratigraphy illustrated by the profile has been inferred between discrete boring locations. In view of the natural variations in stratigraphy and conditions, variations from the stratigraphy illustrated by the profile should be anticipated.

The bridge borings were drilled with a track-mounted CME 850X rotary drilling rig using a combination of dry-auger and rotary-wash drilling methods. Soil samples were typically obtained using a 2-in.-diameter split-barrel sampler driven into the strata by blows of a 140-lb automatic hammer dropped 30 in. as per Standard Penetration Test (SPT) procedures. The number of blows required to drive the standard split-barrel sampler the final 12 in. of an 18-in. total drive, or portion thereof, is defined as the Standard Penetration Number (N). Recorded N-values are shown on the boring logs in the "Blows Per Ft" column.

As noted, two (2) pavement borings were performed using hand-auger methods because of limited site access and to limit disruption of highway traffic. Soil samples were obtained using a

"bucket" auger. Undrained shear strength (cohesion) of each soil sample was estimated using a calibrated hand penetrometer. Estimated undrained shear strength is shown on the logs, in tons per sq ft, as a small circle enclosing an "x" plotted at the appropriate depth

All samples were removed from sampling tools in the field, examined, and visually classified by the field geologist or geotechnical engineer. Samples were then placed in appropriate containers to prevent moisture loss and/or change in condition during transfer to our laboratory for further examination and testing.

The borings were advanced using dry-auger procedures to the extent possible to facilitate groundwater observations. Observations regarding groundwater are noted in the lower portion of each log and are discussed in subsequent sections of this report. All boreholes were backfilled after obtaining final water level readings.

LABORATORY TESTING

Pertinent physical and engineering characteristics of the foundation and subgrade soils were evaluated by performing laboratory tests including natural water content determinations and classification tests. Tests were performed on selected representative soil samples. Laboratory test results are shown on the logs.

The laboratory testing program included 53 natural water content determinations performed to develop information on *in-situ* soil water content for each boring. The results of these tests are plotted on the logs as solid circles, in accordance with the scale and symbols shown in the legend located in the upper-right corner.

To verify visual classification and to evaluate soil plasticity, 11 liquid and plastic limit (Atterberg limits) determinations and 17 sieve analyses, including two (2) hydrometer tests were performed on selected representative samples. The Atterberg limits are plotted on the log as pluses inter-connected with a dashed line using the water content scale. The percentage of soil passing through the No. 200 Sieve is noted in the "- No. 200 %" column on the appropriate log forms. In addition, specific gravity was measured for use in each hydrometer analysis of particle size distribution. A summary of laboratory test results and classification by the Unified Soil Classification System and AASHTO classification is presented in Appendix B. Grain-size distribution curves are also included in Appendix B.

To evaluate the moisture-density relationship of the subgrade soils, one (1) laboratory moisture-density relationship (Standard Proctor) test (AASHTO T 99) was performed on a

representative bulk soil sample obtained in the approach road alignment. The Proctor test and bulk sample classification test results are provided in Appendix C. Pavement subgrade support properties of the potential subgrade soils were evaluated by performing one (1) California Bearing Ratio (CBR, AASHTO T-193) test on the collected bulk sample. The CBR test results are also provided in Appendix C.

GENERAL SITE AND SUBSURFACE CONDITIONS

Site Conditions

The Red Cut Slough Replacement Bridge location is at Log Mile 0.84 of Hwy. 31 in White County, Arkansas. The roadway alignment is oriented north-south and the bridge site is about 2.5 miles south of Beebe. The existing roadway is on an embankment several feet above the surrounding, low-lying terrain. The project area is primarily a wooded and undeveloped area. The area is rural with scattered residences along Hwy. 31. At the project site, the bayou channel is relatively flat, wide, and shallow with slow flow. During the course of the field studies (March 2019 to July 2019), heavy rains caused the stream levels in the slough to fluctuate widely and backwater encroaches to near the existing bridge ends.

Site Geology

The project alignment is located in the Mississippi Embayment Physiographic Province. The site vicinity is within the mapped exposure of Quaternary Alluvium. The Alluvium is comprised of recent stream-deposited alluvial sediments which include gravel, sand, silt, clay and mixtures of these clastic components. The thickness of the Alluvial deposits is variable and these units typically overly consolidated Tertiary and Cretaceous sediments. The depth of bedrock (Paleozoic rocks) in this area is reported to be about 200 feet.

Seismic Conditions

In light of the results of the borings drilled at the Hwy. 31 over Red Cut Slough location and the surface geology of the project locale, a Seismic Site Class D (stiff soil profile) is considered applicable for the site with respect to the criteria of the AASHTO LRFD Bridge Design Specifications Seventh Edition 2014[1].

The 2014 edition of the AASHTO Guide Specifications indicates that the Peak Ground Acceleration (PGA) having a 7 percent chance of exceedance in 75 years (or mean return period of

[1] AASHTO LRFD Bridge Design Specifications, 7th Edition; AASHTO; 2014

approximately 1000 years) for the bridge locations is predicted to be 0.263 for a Site Class D. Based on the Hwy. 31 over Red Cut Slough bridge location, the short period spectral acceleration coefficient (S_{DS}) value is 0.582g and the 1-sec period spectral acceleration coefficient the 1.0-sec period spectral acceleration coefficient (S_{D1}) value is 0.263g. Table 3.10.6-1 indicates that a Seismic Performance Zone 2 is fitting for the bridge site.

Liquefaction analyses were performed to evaluate the liquefaction potential of the subsurface soils. The analyses were performed utilizing the methodology and procedures proposed by Idriss and Boulanger[2] in 2008. A design PGA (A_s) value of 0.263, as per the site-specific seismic analysis, and an earthquake Moment Magnitude (M_w) of 4.8 were utilized.

The results of the liquefaction analyses are provided in Appendix D as plots of calculated factors of safety against liquefaction potential. The potentially liquefiable zones are indicated on the generalized subsurface profile also provided in Appendix D. As shown in Appendix D, the liquefiable zone is of limited extent.

Subsurface Conditions

The results of the borings indicate that the subsurface conditions along the project alignment are relatively consistent. The surficial soils are typically on-site fill consisting of very soft to soft silty clay. These soils classify as A-4, A-6, and A-7-6 by the AASHTO classification system (AASHTO M145), correlating with poor subgrade support for structures. The on-site fill extends to about 2- to 4-depth. Below the on-site fill is natural very soft to stiff silty clay which extends to about 13-ft depth. Like the on-site fill, these soils classify as A-4, A-6, and A-7-6 by the AASHTO classification system, correlating with poor subgrade support for structures.

Below the silty clay is soft to very stiff clayey silt. The clayey silt is relatively weak with high compressibility. Liquefaction analyses indicate a low potential for liquefaction triggering in a seismic event.

Below 18- to 23-ft depth is loose to medium dense silty fine sand and fine sandy silt. The loose silty fine sand is locally present on the north side of the bridge and extends to 33-ft depth. As the unit is below the water table and its relative density is considered low, there is some potential for liquefaction triggering.

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[2] "Soil Liquefaction during Earthquakes." Earthquake Engineering Research Institute, MNO-12, Idriss and Boulanger, 2008.

Underlying the silty fine sand and fine sandy silt is medium dense to very dense fine to medium sand. The fine to medium sand units have medium to high relatively density and low compressibility.

The basal unit encountered below 58-ft depth in the borings is very stiff to hard clay. The clay has a varved structure with high to very high plasticity. SPT N-values typically are in excess of 50 blows per ft, indicative of high shear strength and low compressibility.

Groundwater Conditions

Groundwater was encountered at depths of 4 to 6.5 ft below existing grades in July 2019. Groundwater levels will vary, depending upon seasonal precipitation, surface runoff and infiltration, and stream levels in the nearby Red Cut Slough and other surface water features.

ANALYSES and RECOMMENDATIONS

Foundation Design

Foundations for the new bridge structure must satisfy two (2) basic and independent design criteria: a) foundations must have acceptable bearing capacity with respect to maximum design loads, and b) foundation movement due to consolidation, swelling and/or liquefaction of the underlying strata should not exceed tolerable limits for the structure. Construction factors, such as installation of foundations, excavation procedures and surface and groundwater conditions, must also be considered.

In light of the results of the borings and the anticipated moderate bridge foundation loads, we recommend a deep foundation system comprised of piling for support the foundation loads at the bridge ends and interior bents of the new bridge. Recommendations for piling are discussed in the following report sections.

Piling

We recommend the bridge foundation loads be supported on a deep foundation system comprised of steel shell piles. We understand that 18-in.-diameter steel shell piles are preliminarily planned for bridge ends and intermediate bents will utilize 28-in.-diameter steel shell piles. All steel shell piles should be filled with concrete after initial driving. Shear rings, shear studs, or other equivalents may be considered on the inside walls of the steel shells to enhance bonding between the concrete and the steel shells.

Nominal single pile capacity curves for 18- and 28-in.-diameter steel shells are provided in Appendix E. Nominal axial pile capacities have been developed using static pile capacity

formulae, the results of the borings, and the plan pile cap bottom elevations shown on the preliminary bridge layout drawing. Soil shear strength was reduced in liquefiable zones. In addition, downdrag loads from liquefaction were considered where appropriate.

For locations where there is the potential for liquefaction, two (2) potential earthquake scenarios / seismic conditions, characterized by respective soil shear strength parameters, have been evaluated in developing axial pile capacity. These conditions include the following.

- Static Pre-Earthquake (Pre-Q) Scenario: This scenario evaluates a condition prior to the occurrence of design earthquake. Since the foundation soils have not liquefied, full shear strength is assumed for the foundation soils.
- Seismic End-of-Earthquake (EOQ) Scenario: This scenario models a condition immediately after occurrence of the design earthquake. The foundation soils are liquefied at this moment and full excess pore water pressure is generated. Consequently, residual shear strength of full liquefaction is utilized for the liquefied foundation soils. Downdrag is assumed to be mobilized on the piles by the liquefied soils and soils above the liquefied zone as a result of liquefaction settlement.

Based on AASHTO LRFD design procedures, an effective resistance factor (φ_{stat}) of 0.45 is recommended for evaluation of factored geotechnical compression capacity. For evaluation of factored uplift capacities, a resistance factor (φ_{up}) of 0.35 is recommended. These resistance factors are based on Strength Limit States. For Extreme Events Limit States, resistance factors of 1.0 and 0.8 are recommended for evaluating compression and uplift capacities, respectively. Downdrag loads due to seismic (liquefaction) settlement have been considered in developing the nominal pile capacity curves.

As a minimum, safe bearing capacity of production piles should be determined by Standard Specifications for Highway Construction, 2014 Edition, Section 805.09, Method B. Blow counts on steel piles should be limited to about 20 blows per inch. Practical pile refusal may be defined as a penetration of 0.5 in. or less for the final 10 blows. Driving records should be available for review by the Engineer during pile installation.

Piles should be installed in compliance with Standard Specifications for Highway Construction, 2014 Edition, Section 805. Pre-boring is not expected to be required for pile installation.

To evaluate suitable driving equipment, driveability analyses were performed utilizing wave equation analysis of piles (WEAP) methods and the computer program GRLWEAP 2014[3].

[3] GRLWEAP 2014; Pile Dynamics, Inc.

A yield strength (f_y) of 45 kips per sq in. was assumed for all piles. Wall thicknesses of 0.5 in. and 0.75 in. were assumed for the 18- and 28-in.-diameter steel shell piles, respectively. The results of driveability analyses are provided in Appendix F.

Based on the results of driveability analyses, we recommend a pile-hammer system with a minimum hammer energy 41 ft-kips for the end bents (Bents 1 and 4) and 91 ft-kips for the intermediate bents (Bents 2 and 3). A specific review and analysis of the pile-hammer system proposed by the Contractor should be performed by the Engineer or Department prior to hammer acceptance and beginning of driving.

The steel shell piles will be driven into dense fine to medium sand units. The nominal axial capacities are based on single, isolated foundations. Piles spaced closer than three (3) pile diameters may develop lower individual capacity due to group effects. The potential for group capacity reductions should be evaluated for pile spacing closer than three (3) diameters.

Battered piles can be utilized to resist lateral loads. The axial capacity of battered piles may be taken as equivalent to that of a vertical pile with the same tip elevation and embedment. Special driving equipment is typically required where pile batter exceeds about 1-horizontal to 4-vertical.

Embankment Slope Stability

The replacement bridge will include new end slope configurations on the north and south ends of the bridge and side slopes on the west and east sides of the bridge. The plan embankment configurations for the north and south bridge ends and side slopes are planned with 2-horizontal to 1-vertical (2H:1V) configurations.

To evaluate suitability of the plan configurations, slope stability analyses have been performed. A 250 lbs per sq ft uniform surcharge from vehicles was included for the stability analyses. Stability analyses were performed using the computer program SLOPE/W 2007[4] and a Morgenstern-Price analysis. For the embankment slopes, four (4) general loading conditions were evaluated, i.e., End of Construction, Long Term, Rapid Drawdown, and Seismic Conditions. For analysis of the seismic condition, a horizontal seismic acceleration coefficient (k_h) of one-half the peak acceleration (A_s) was used, a value of 0.131. For evaluating the rapid drawdown condition, a water surface elevation drop from El 210 to El 203 has been assumed.

For the purposes of the stability analyses, unclassified embankment as per Standard Specifications for Highway Construction, 2014 Edition, Subsection 210.06 was assumed for

[4] Slope/W 2007; GEO-SLOPE International; 2008.

embankment fill. Accordingly, an undrained shear strength value of 1500 lbs per sq ft has been assumed for the embankment fill. Depending on the specific borrow utilized for embankments, verification of stability could be warranted.

Stability analysis results are provided in Appendix G. The results of the stability analyses performed for this study indicate that stability of the plan embankment side and end slope configurations are acceptable with respect to all loading conditions evaluated. It is our conclusion that the plan embankment slope configurations are suitable with respect to slope stability.

Subgrade Support for Pavements

The laboratory test results indicate that the subgrade soils are predominantly fine grained fine sandy silt, sandy, silty clay, and fine sandy clay. These soils include classifications of A-4, A-6, and A-7-6 as per the AASHTO classification system (AASHTO M145). We believe that the on-site soils and locally-available borrow are likely to be similar soils with similar classification.

We recommend that the pavement subgrade be evaluated by the Engineer during pavement construction. Areas of unstable or otherwise unsuitable subgrade should be improved by undercut and replacement or treatment with additives approved by the Engineer. Based on the results of the borings and our site observations, it is opined that undercuts on the order of 2 to 3 ft, more or less, below existing grades could be warranted for subgrade improvement. Deeper undercuts may be warranted where new embankments extend into low-lying and poorly-drained areas.

As an alternative to undercutting, addition of lime, cement, or other suitable additives could be utilized to develop a stable, non-pumping subgrade. We also recommend that any soils classifying as A-7-6 and soils with a plasticity index (PI) in excess of 18 be excluded from use as subgrade within 18 in. of the plan subgrade elevation. The top 18 in. of subgrade soils should have a maximum plasticity index (PI) of 18. Where A-7-5 or A-7-6 soils are encountered at the subgrade elevation, we recommend that these soils be undercut as required to provide at least 18 in. of low-plasticity subgrade soils. Alternatively, stabilization additives may be utilized to develop a stable subgrade with a maximum PI of 18.

Based on the results of the borings and laboratory tests and correlation with the AASHTO classification, subgrade support of the on-site soils is expected to be poor to fair. The following parameters are recommended for use in pavement design for a subgrade of the on-site soils and similar borrow soils.

- Resilient Modulus (M_R): 2615 lbs per sq inch
- R value: 7.2

Site Grading and Subgrade Preparation Considerations

Site grading and site preparation in the bridge alignment should include necessary clearing and grubbing of trees and underbrush and stripping the organic-containing surface soils in work areas. Where fill depths in excess of 3 ft are planned, stumps may be left after close cutting trees to grade, as per ARDOT criteria. Otherwise, tree stumps must be completely excavated and stumpholes properly backfilled.

The depth of stripping will be variable, with deeper stripping depths in wooded areas, and less stripping required in the areas of higher terrain. In general, the stripping depth is estimated to be about 6 to 9 in. in cleared areas but may be 18 to 24 in. or more in the localized wooded areas and areas with thick underbrush. The zone of organic surface soils should be completely stripped in the embankment footprint areas and at least 5 ft beyond the projected embankment toe to the extent possible.

Where existing pavements are to be demolished, consideration may be given to utilizing the processed asphalt concrete and aggregate base for embankment fill. In this case, the demolished materials should be thoroughly blended and processed to a reasonably well-graded mixture with a maximum particle size of 2 in. as per Standard Specifications for Highway Construction, 2014 Edition, Section 212. If abandoned pavements are within 3 ft of the plan subgrade elevation, the existing pavement surface should be scarified to a minimum depth of 6 inches. The scarified material should be recompacted to a stable condition.

Following required pavement demolition, clearing and grubbing, and stripping, and prior to fill placement or otherwise continuing with subgrade preparation, the extent of weak and unsuitable soils should be determined. Thorough proof-rolling should be performed to verify subgrade stability. Proof-rolling should be performed with a loaded tandem-wheel dump truck or similar equipment. Unstable soils exhibiting a tendency to rut and/or pump should be undercut and replaced with suitable fill. Care should be taken that undercuts, stump holes, and other excavations or low areas resulting from subgrade preparation are properly backfilled with compacted fill. Based on the results of the borings, localized undercutting could be required to develop subgrade stability. Potential undercut depths are estimated to be on the order of 2 to 3 ft, more or less. Deeper undercuts could be required in areas where new embankments extend into the low-lying and poorly-drained areas outside the current embankment alignment.

In areas of deep fills, the potential exists for use of thick initial lifts ("bridging"), as per ARDOT criteria. Bridge lifts will be subject to some consolidation. Settlement of a primarily granular fill suitable for use in bridging would be expected to be relatively rapid and long-term post-construction settlement would not be expected to be a significant concern. Where clayey soils are placed in thick lifts, long term settlement will be more significant. Consequently, we recommend that the use of "bridging" techniques be limited to granular borrow soils, i.e., sand or gravel. Where fill amounts are limited to less than about 3 ft, bridging will be less effective and the potential for undercut or stabilization will increase. Use of bridging techniques and fill lift thickness must be specifically approved by the Engineer or Department.

Subgrade preparation and mass undercuts should extend at least 5 ft beyond the embankment toes to the extent possible. Subgrade preparation in roadway areas should extend at least 3 ft outside pavement shoulder edges to the extent possible. The existing drainage features should be completely mucked out and all loose and/or organic soils removed prior to fill placement.

Fill and backfill may consist of unclassified borrow free of organics and other deleterious materials as per Standard Specifications for Highway Construction, 2014 Edition, Subsection 210.06. Granular soils must be protected from erosion with a minimum 18-in.-thick armor of clayey soil. The on-site silty clay and sandy clay are typically suitable for this use. We recommend that embankment slopes steeper than 2.5H:1V configuration be protected from erosion by use of riprap.

Subgrade preparation should comply with Standard Specifications for Highway Construction, 2014 Edition, Section 212. Embankments should be constructed in accordance with Standard Specifications for Highway Construction, 2014 Edition, Section 210. Fill and backfill should be placed in nominal 6- to 10-in.-thick loose lifts. All fill and backfill must be placed in horizontal lifts. Where fill is placed against existing slopes, short vertical cuts should be "notched" in the existing slope face to facilitate bonding of horizontal fill lifts. The in-place density and water content should be determined for each lift and should be tested to verify compliance with the specified density and water content prior to placement of subsequent lifts.

CONSTRUCTION CONSIDERATIONS

Surface Drainage

Positive surface drainage should be established at the start of the work, be maintained during construction and following completion of the work to prevent surface water ponding and subsequent

saturation of subgrade soils. Density and water content of all earthwork should be maintained until the retaining wall, embankments, and bridge and pavement work is completed.

Subgrade soils that become saturated by ponding water or runoff should be excavated to undisturbed soil. The embankment subgrade should be evaluated by the Engineer during subgrade preparation.

Shallow perched groundwater could be encountered in the near-surface soils. The volume of groundwater produced can be highly variable depending on the condition of the soils in the immediate vicinity of the excavation. In addition, seasonal surface seeps or springs could develop.

Seepage into excavations and cuts can typically be controlled by ditching or sump-and-pump methods. If seepage into excavations becomes a problem, backfill should consist of select granular backfill (AASHTO M43, No. 57 stone), stone backfill (Standard Specifications for Highway Construction, 2014 Edition, Section 207), or clean aggregate (Standard Specifications for Highway Construction, 2014 Edition, Subsections 403.01 and 403.02 Class 3 mineral aggregate) up to an elevation above the inflow of seepage. In areas of seepage infiltration, the granular fill should be encapsulated with a filter fabric complying with Standard Specifications for Highway Construction, 2014 Edition, Subsection 625.02, Type 2 and vented to positive discharge. Where surface seeps or springs are encountered during site grading, we recommend the seepage be directed via French drains or blanket drains to positive discharge at daylight or to storm drainage lines.

Piling

Piles should be installed in compliance with 2014 Edition of Standard Specifications for Highway Construction, Section 805. Piles should be carefully examined prior to driving and piles with structural defects should be rejected.

Pile installation should be monitored by qualified personnel to maintain specific and complete driving records and observe pile installation procedures. Driving records should be available for review by the Engineer or Department during pile installation. Compatible driving equipment should be utilized based on the results of drivability analyses performed by the Department. Blow counts on steel piles should be limited to about 20 blows per inch. As a minimum, safe bearing capacity of production piles should be determined by Standard Specifications for Highway Construction, 2014 Edition, Section 805.09, Method B.

The Piling Contractor should have demonstrable experience in installing steel shell piles of similar sizes in subsurface conditions similar to those at this site. The Contractor should have

appropriate equipment with sufficient jetting pressure/flow rate and adequate hammer energy to install piles to the plan tip elevation.

CLOSURE

The Engineer, Department, or a designated representative thereof should monitor site preparation, grading work, ground improvements, and all foundation and embankment construction. Subsurface conditions significantly at variance with those encountered in the borings should be brought to the attention of the Geotechnical Engineer. The conclusions and recommendations of this report should then be reviewed in light of the new information.

The following illustrations are attached and complete this submittal.

Plate 1	Site Vicinity
Plate 2	Plan of Borings
Plates 3 through 8	Boring Logs
Plate 9	Key to Terms and Symbols
Plate 10	Generalized Subsurface Profile
Appendix A	Preliminary Bridge Layout
Appendix B	Classification Test Results
Appendix C	Proctor and CBR Test Results
Appendix D	Liquefaction Analysis Results
Appendix E	Nominal Pile Capacity Curves
Appendix F	WEAP Analysis Results
Appendix G	Stability Analysis Results

* * * * *

We appreciate the opportunity to be of service to you on this project. Should you have any questions regarding this report, or if we may be of additional assistance during final design or construction, please call on us.

Sincerely,

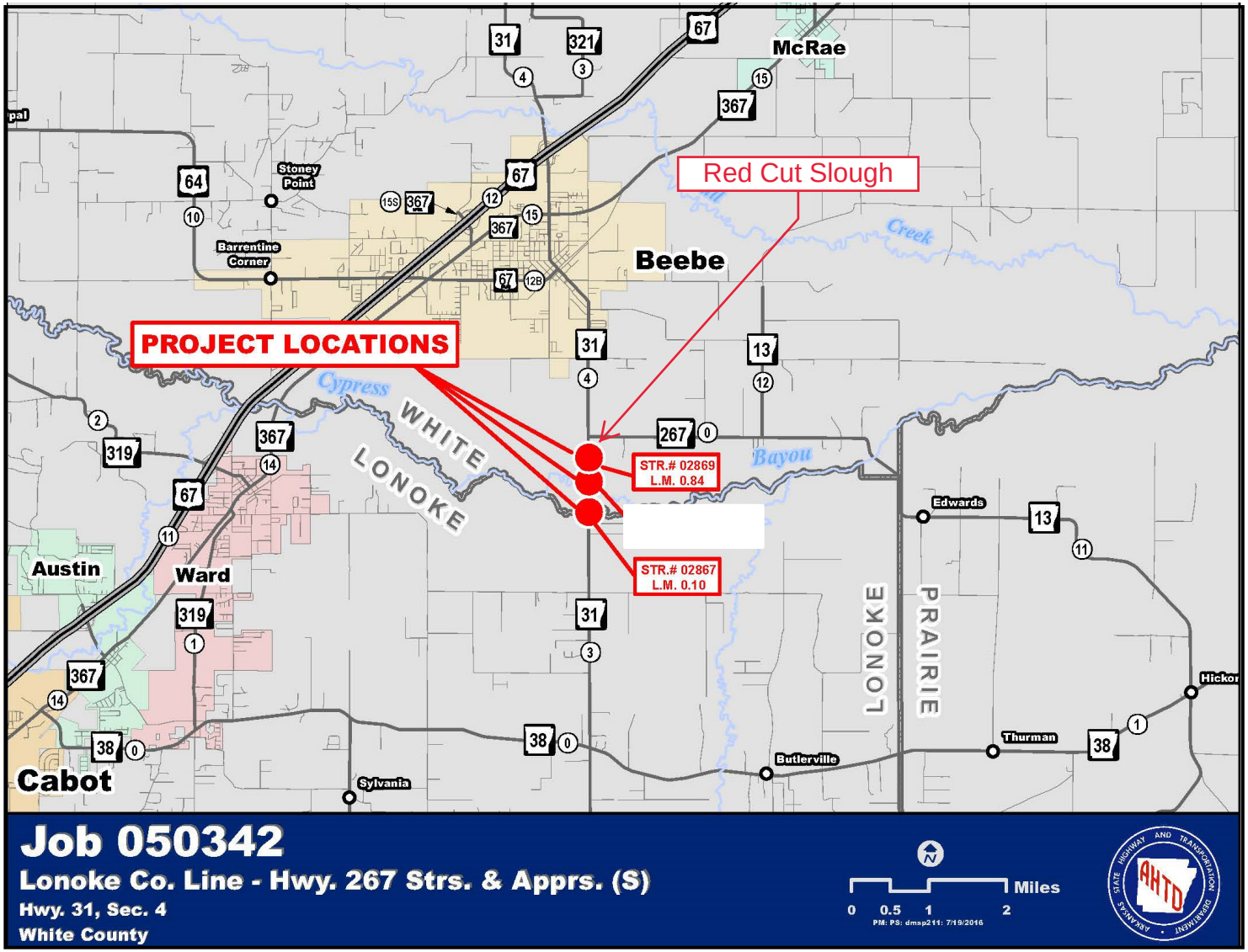
GRUBBS, HOSKYN, BARTON &WYATT, INC.

STATE OF ARKANSAS REGISTERED PROFESSIONAL ENGINEER No. 7791 MARK E. WYATT

Mark E. Wyatt, P.E.
President

BJD/VMS/MEW:jw

Copies Submitted: Crafton Tull & Associates, Inc.
Attn: Mr. Mike Burns, P.E. (1-electronic)
Attn: Mr. Chuck Wipf, P.E. (1-electronic)

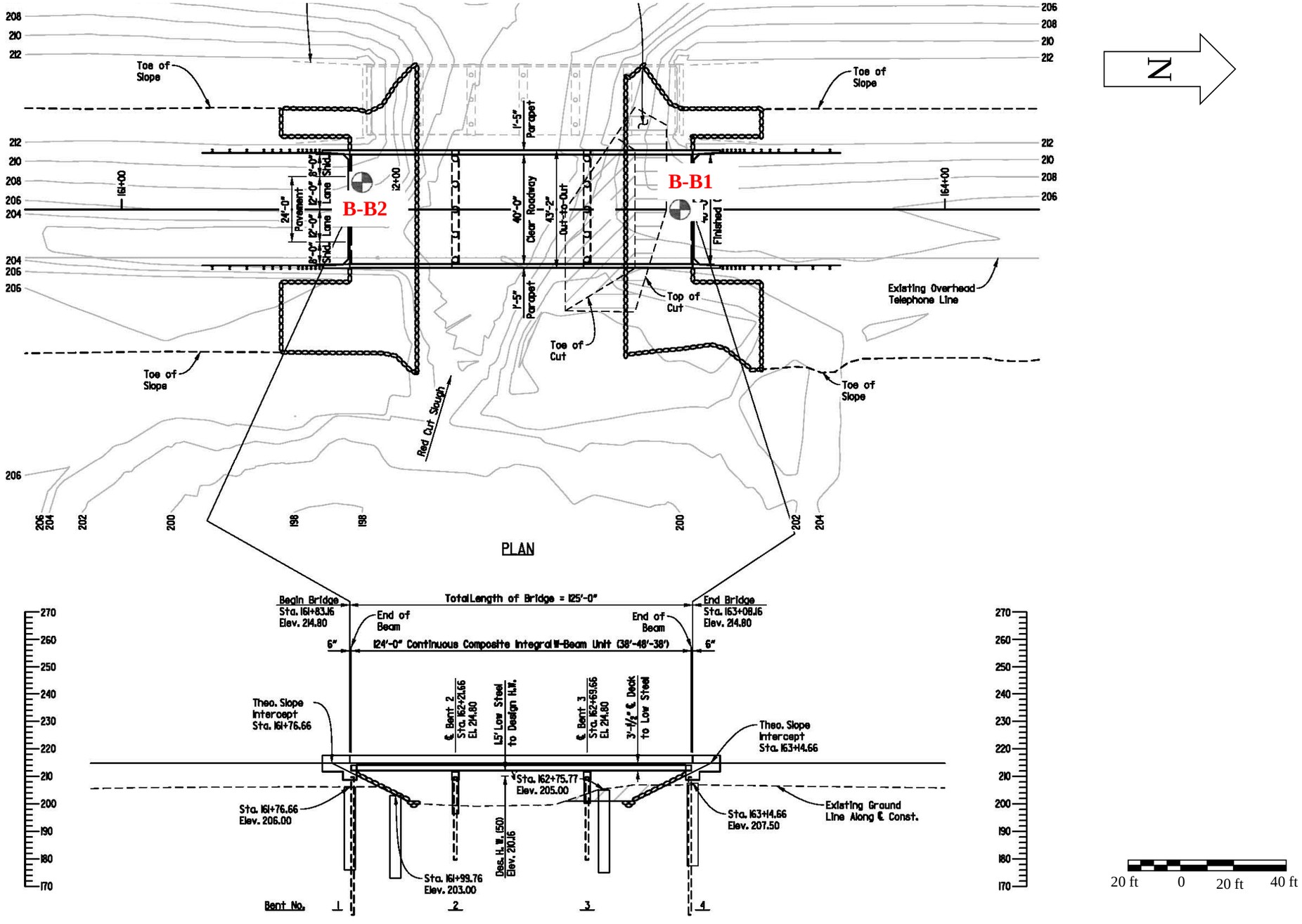


Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS

Site Vicinity Map
050342 Hwy. 31 over Red Cut Slough
Lonoke and White County, Arkansas

Job No. 18-077

Plate 1



Grubbs, Hoskyn, Barton & Wyatt, INC. CONSULTING ENGINEERS	**PLAN OF BORINGS** **050342 Hwy. 31 over Red Cut Slough** **White County, Arkansas**	**Scale: As Shown** **Date: July 2019**	**Job No. 18-077**	**PLATE 2A**

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS

PLAN OF BORINGS
050342 Hwy. 31 over Red Cut Slough
White County, Arkansas

Scale: N.T.S.
Job No.: 18-077
Plate 2B

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. B1

050342 Hwy 31 over Red Cut Slough
White County, Arkansas

TYPE: Auger to 8.5 ft /Wash

LOCATION: Approx Sta 163+05, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL: 207±				
			Soft brown, reddish brown and gray fine sandy clay, silty w/occasional rootlets and ferrous stains (fill)	5			58
			- very soft below 2 ft	0/WOH			
5			Very soft light gray silty clay, slightly sandy w/ferrous stains and nodules	1			
			- firm at 6 to 8 ft	7			
			- firm to stiff at 8 to 13 ft	10		g_s=2.692	82
10							
			- firm gray and reddish tan below 13 ft	9		g_s=2.689	81
15							
			Medium dense gray and reddish tan fine sandy silt	26			54
20							
			Medium dense gray silty fine sand	13			
25							
			- loose below 28 ft	9			
30							
			Medium dense gray fine to medium sand, slightly silty	25			
35							
				25			
40							
			- dense below 43 ft	45			

COMPLETION DEPTH: 85.0 ft
DATE: 7-20-19

DEPTH TO WATER IN BORING: 4.0

DATE: 7/20/2019

LGBNEW 18-077_RED CUT SLOUGH.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. B1

050342 Hwy 31 over Red Cut Slough
White County, Arkansas

TYPE: Auger to 8.5 ft /Wash

LOCATION: Approx Sta 163+05, CL

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			(continued)				
50			Dense gray fine sand, slighlty silty	39			6
55				41			
60			Very stiff to hard dark gray clay, varved	51		83	97
65			- very stiff at 63 to 68 ft	34			
70			- very stiff to hard below 68 ft	50/11"			
75				50/7"			
80				50/6"			
85				50/5"			

COMPLETION DEPTH: 85.0 ft
DATE: 7-20-19

DEPTH TO WATER IN BORING: 4.0
DATE: 7/20/2019

LGBNEW 18-077_RED CUT SLOUGH.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. B2

050342 Hwy 31 over Red Cut Slough
White County, Arkansas

TYPE: Auger to 8.5 ft /Wash

LOCATION: Approx Sta 161+85, 10 ft Lt

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL: 208±				
			Soft reddish brown and tan fine sandy clay, silty w/trace fine gravel and occasional rootlets and ferrous stains (fill)	5			69
			Stiff gray and grayish tan silty clay, slightly sandy w/ferrous stains and nodules	11			
5			- firm at 4 to 6 ft	9			90
			- stiff below 6 ft	16			
10				15			
			Soft grayish tan and reddish tan clayey silt, slightly sandy w/ferrous stains	6			80
15							
			- very stiff below 18 ft				
20				29			
			Medium dense gray silty fine sand	13			40
25							
30				26			
			Medium dense gray fine to medium sand, slightly silty	20			
35							
			- dense at 38 to 43 ft	31			7
40							
			- medium dense below 43 ft	25			

COMPLETION DEPTH: 100.0 ft
DATE: 7-18-19

DEPTH TO WATER IN BORING: 6.5 ft

DATE: 7/18/2019

LGBNEW 18-077_RED CUT SLOUGH.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. B2

050342 Hwy 31 over Red Cut Slough
White County, Arkansas

TYPE: Auger to 8.5 ft /Wash

LOCATION: Approx Sta 161+85, 10 ft Lt

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			(continued)				
50			Dense gray fine sand, slightly silty	43			5
55			- dense to very dense below 53 ft	50/11"			
60			Very stiff to hard dark gray clay, varved	50/10"		91	98
65			- very stiff at 63 to 68 ft	44			
70			- very stiff to hard below 68 ft	50/10"			
75				50/9"			
80				50/9"			
85				50/8"			
				50/8"			

COMPLETION DEPTH: 100.0 ft
DATE: 7-18-19

DEPTH TO WATER IN BORING: 6.5 ft
DATE: 7/18/2019

LGBNEW 18-077_RED CUT SLOUGH.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. B2

050342 Hwy 31 over Red Cut Slough
White County, Arkansas

TYPE: Auger to 8.5 ft /Wash

LOCATION: Approx Sta 161+85, 10 ft Lt

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			(continued)				
95				50/8"			
100				50/8"			
105							
110							
115							
120							
125							
130							

COMPLETION DEPTH: 100.0 ft
DATE: 7-18-19

DEPTH TO WATER IN BORING: 6.5 ft

DATE: 7/18/2019

LGBNEW 18-077_RED CUT SLOUGH.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. B4

050342 Hwy 31 over Red Cut Slough
White County, Arkansas

TYPE: Hand Auger

LOCATION: 500 ft N of N Bridge End

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
			Firm brown fine sandy clay w/organics (fill)				
1			Medium dense brown silty fine to coarse sand, slightly clayey w/some fine to coarse gravel (fill)				25
2			Medium dense to dense brownish tan silt, slightly clayey w/a little fine gravel (fill)				86
			Soft brownish yellow, tan and gray silty clay, wet - seep at 2.25 ft				
3							
4							
5							
6							
7							
8							
9							

COMPLETION DEPTH: 2.5 ft
DATE: 3-25-19

DEPTH TO WATER IN BORING: 2.5 ft
DATE: 3/25/2019

LGBNEW 18-077_RED CUT SLOUGH.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

LOG OF BORING NO. B6

050342 Hwy 31 over Red Cut Slough
White County, Arkansas

TYPE: Hand Auger

LOCATION: 500 ft S of S Bridge End

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200 %
			SURF. EL:				
1			Stiff brown fine sandy clay, silty w/a little fine to coarse gravel (fill) - with numerous organics to 0.5 ft				55
2			- firm to stiff at 1.5 - 2.5 ft				
3			- firm at 2.5 to 3.5 ft				
4			- stiff, tan below 3.5 ft				
5			Firm to stiff tan and gray silty clay w/some ferrous stains				
6							
7							
8							
9							

COMPLETION DEPTH: 5.0 ft
DATE: 3-25-19

DEPTH TO WATER IN BORING: Dry

DATE: 3/25/2019

LGBNEW 18-077_RED CUT SLOUGH.GPJ 8-19-19

Grubbs, Hoskyn, Barton & Wyatt, Inc.
Consulting Engineers

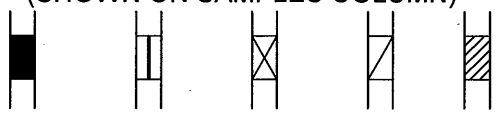
SYMBOLS AND TERMS USED ON BORING LOGS

SOIL TYPES
(SHOWN IN SYMBOLS COLUMN)

Gravel Sand Silt Clay

Predominant type shown heavy

SAMPLER TYPES
(SHOWN ON SAMPLES COLUMN)



Shelby Tube | Rock Core | Split Spoon | No Recovery | Cutting

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on No. 200 sieve): Includes (I) Clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as determined by laboratory tests.

DESCRIPTIVE TERM	N-VALUE	RELATIVE DENSITY
VERY LOOSE	0-4	0-15%
LOOSE	4-10	15-35%
MEDIUM DENSE	10-30	35-65%
DENSE	30-50	65-85%
VERY DENSE	50 and above	85-100%

FINE GRAINED SOILS (major portion passing No. 200 sieve): Includes (1) Inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests.

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH TON/SQ. FT.
VERY SOFT	Less than 0.25
SOFT	0.25-0.50
FIRM	0.50-1.00
STIFF	1.00-2.00
VERY STIFF	2.00-4.00
HARD	4.00 and higher

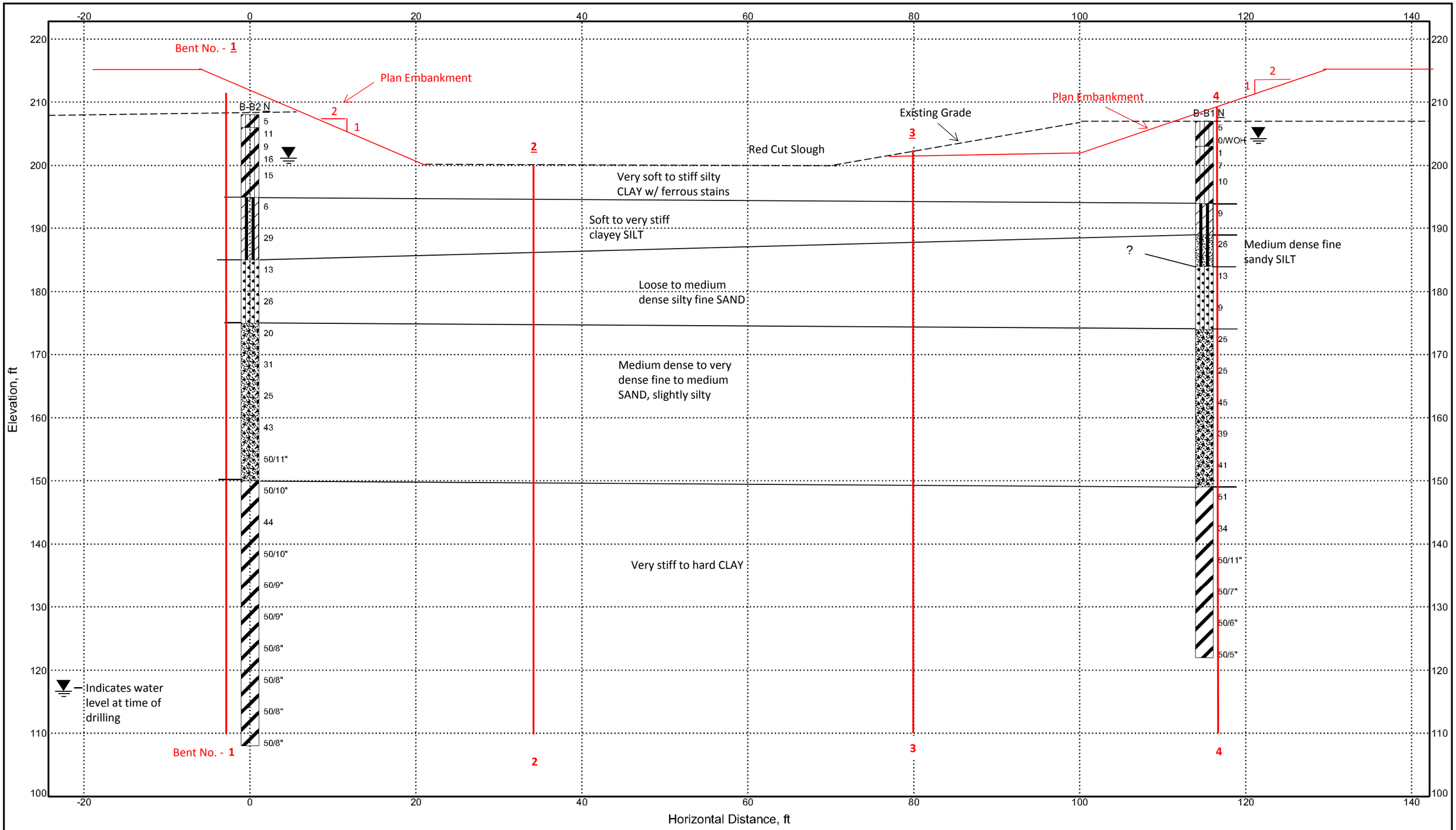
NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

TERMS CHARACTERIZING SOIL STRUCTURE

SLICKENSIDED - having inclined planes of weakness that are slick and glossy in appearance.
FISSURED - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
LAMINATED - composed of thin layers of varying color and texture.
INTERBEDDED - composed of alternate layers of different soil types.
CALCAREOUS - containing appreciable quantities of calcium carbonate.
WELL GRADED - having a wide range in grain sizes and substantial amounts of all intermediate particle sizes.
POORLY GRADED - predominantly of one grain size, or having a range of sizes with some intermediate sizes missing.

Terms used on this report for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No.3-357, Waterways Experiment Station, March 1953

KEY 7-28-11



Grubbs, Hoskyn,
Barton & Wyatt, Inc.

NOTES:
1. Subsurface conditions have been inferred between discrete boring locations. Actual conditions may vary.
2. Ground surface approximate.

SCALE:
As Shown

Generalized Subsurface Profile
050342 Hwy 31 over Red Cut Slough
White County, Arkansas

Project Number: 18-077

PLATE 10

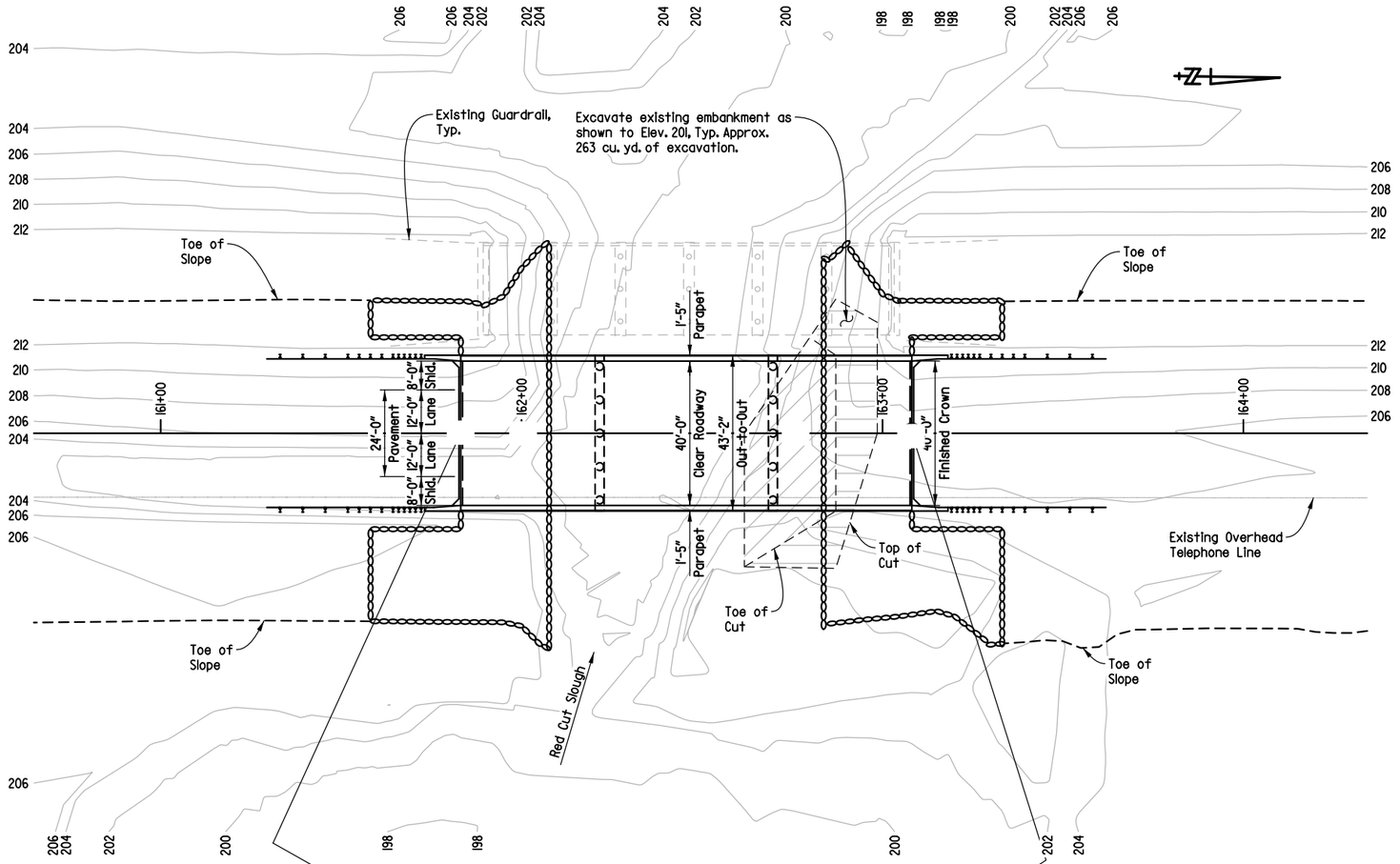
APPENDIX A

For R/W Data, See Roadway Plans.

DATE REVISED	DATE FILMED	DATE REVISED	DATE FILMED

FED.RD. DIST.NO.	STATE	FED.AID PROJ.NO.	SHEET NO.	TOTAL SHEETS
4	ARK.			
JOB NO.		050342	1	1

(1) XXXXX LAYOUT XXXXX



PRELIMINARY SUBJECT TO REVISION

LAYOUT OF BRIDGE OVER RED CUT SLOUGH HWY. 267 STRS. & APPRS. (S) WHITE COUNTY

ROUTE 31 SEC. 4

ARKANSAS STATE HIGHWAY COMMISSION

LITTLE ROCK, ARK.

DRAWN BY: LDG DATE: 02-15-19 FILENAME: RCS Boring Locations.dgn
CHECKED BY: CAW DATE: XX-XX-XX SCALE: 1" = 20'
DESIGNED BY: LDG DATE: 02-15-19

BRIDGE NO. XXXXX DRAWING NO. XXXXX

USER: lg5169
DESIGN FILE: G:\180570I_050342\TRANSP\dgn\bridge\RCS Boring Locations.dgn SCALE: 1:40
PLOTTED: 2/15/2019 14:00

G:\180570I_050342\TRANSP\dgn\bridge\RCS Boring Locations.dgn 2/15/2019 14:00

APPENDIX B

SUMMARY of CLASSIFICATION TEST RESULTS

PROJECT: 050342 Hwy 31 over Red Cut Slough
LOCATION: White County, Arkansas
GHBW JOB NUMBER: 18-077

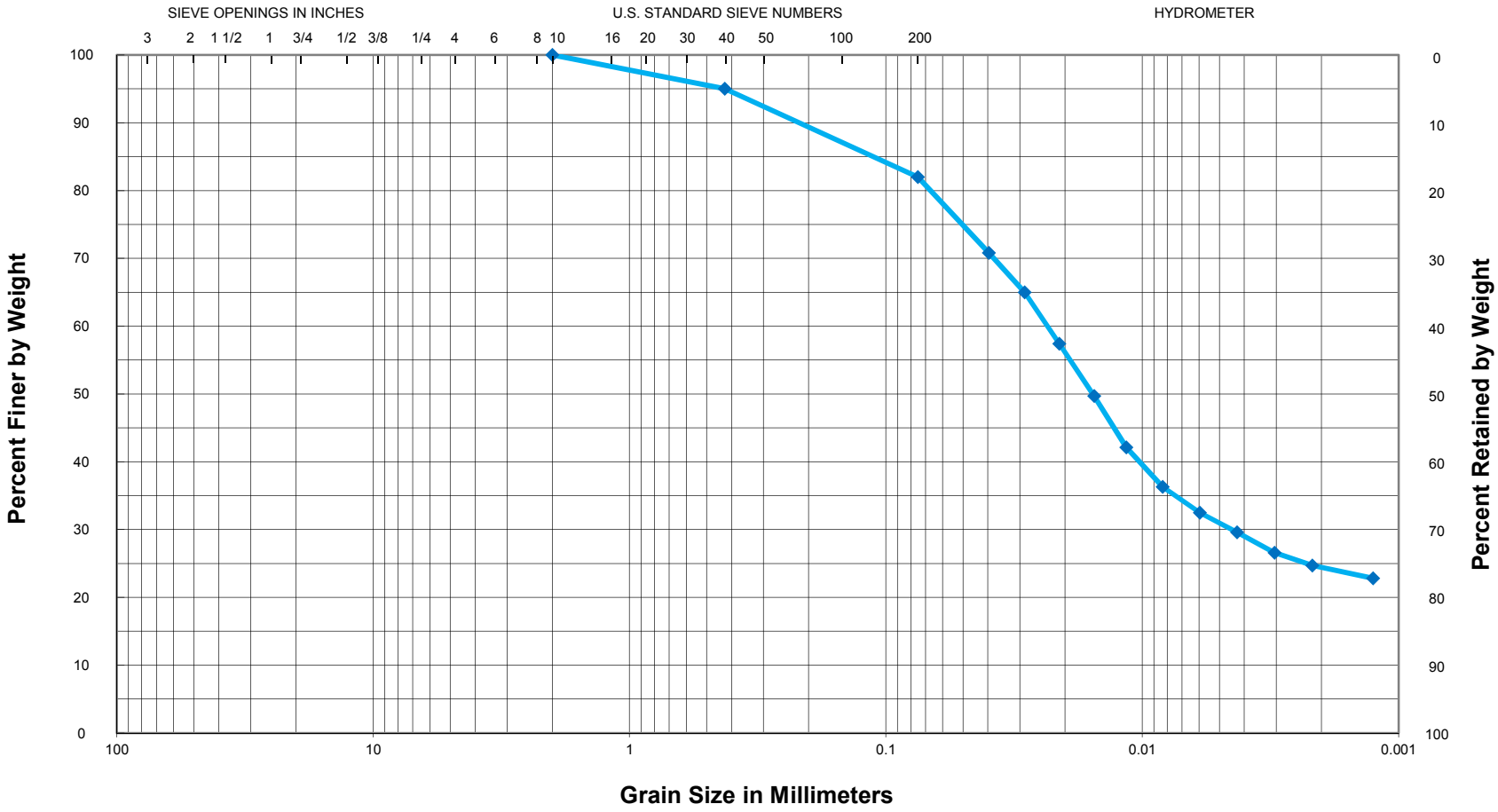
BORING NO.	SAMPLE DEPTH (ft)	WATER CONTENT (%)	ATTERBERG LIMITS			SIEVE ANALYSIS PERCENT PASSING								UNIFIED CLASS.	AASHTO CLASS.
			LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	2 in.	1 in.	3/4 in.	3/8 in.	#4	#10	#40	#200		
B1	0.5-1.5	26	35	23	12	---	---	---	---	100	---	---	58	CL	A-6
B1	9-10	26	29	17	12	100	100	100	100	100	100	95	82	CL	A-6
B1	14-15	21	25	17	8	100	100	100	100	100	99	94	81	CL	A-4
B1	19-20	17	---	---	---	100	100	100	100	100	100	100	54	ML	A-4
B1	29-30	17	---	---	---	---	---	---	---	100	---	---	33	SM	A-2-4
B1	49-50	24	---	---	---	100	100	100	100	100	100	91	6	SM-SP	A-3
B1	59-60	35	83	33	50	---	---	---	---	100	---	---	97	CH	A-7-5
B2	0.5-1.5	23	32	19	13	---	---	---	---	97	---	---	69	CL	A-6
B2	4.5-5.5	26	47	21	26	---	---	---	---	100	---	---	90	CL	A-7-6
B2	14-15	22	22	18	4	---	---	---	---	100	---	---	80	ML-CL	A-4
B2	24-25	21	---	---	---	---	---	---	---	100	---	---	40	SM	A-4
B2	39-40	26	---	---	---	100	100	100	100	100	100	71	7	SM-SP	A-3
B2	49-50	24	---	---	---	100	100	100	100	100	100	99	5	SM-SP	A-3
B2	59-60	35	91	34	57	---	---	---	---	100	---	---	98	CH	A-7-5
B4	0.5-1	11	20	18	2	100	93	88	83	76	65	47	25	SM	A-1-b
B4	1.5-2	18	25	22	3	100	100	100	100	99	98	93	86	ML	A-4
B6	0.5-1	19	26	21	5	100	100	100	95	86	81	74	55	ML-CL	A-4

Grubbs, Hoskyn,
Barton & Wyatt, Inc.
CONSULTING ENGINEERS

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE		

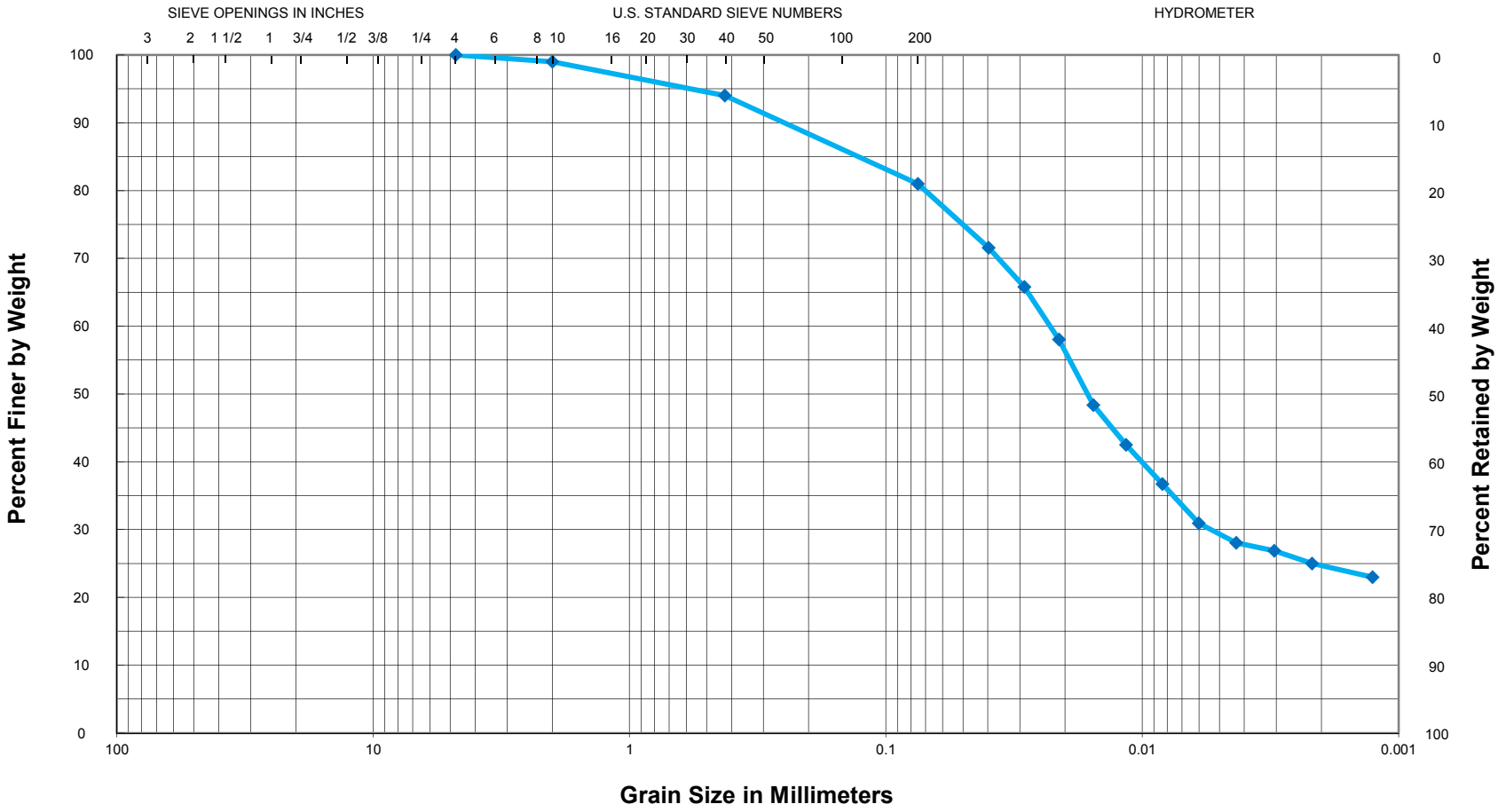
Sample: Boring B1, 9-10 ft; LL = 29, PL = 17, PI = 12
Description: Light gray silty CLAY, slightly sandy w/ ferrous stains and nodules

USCS Classification = CL
AASHTO Classification = A-6

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE		

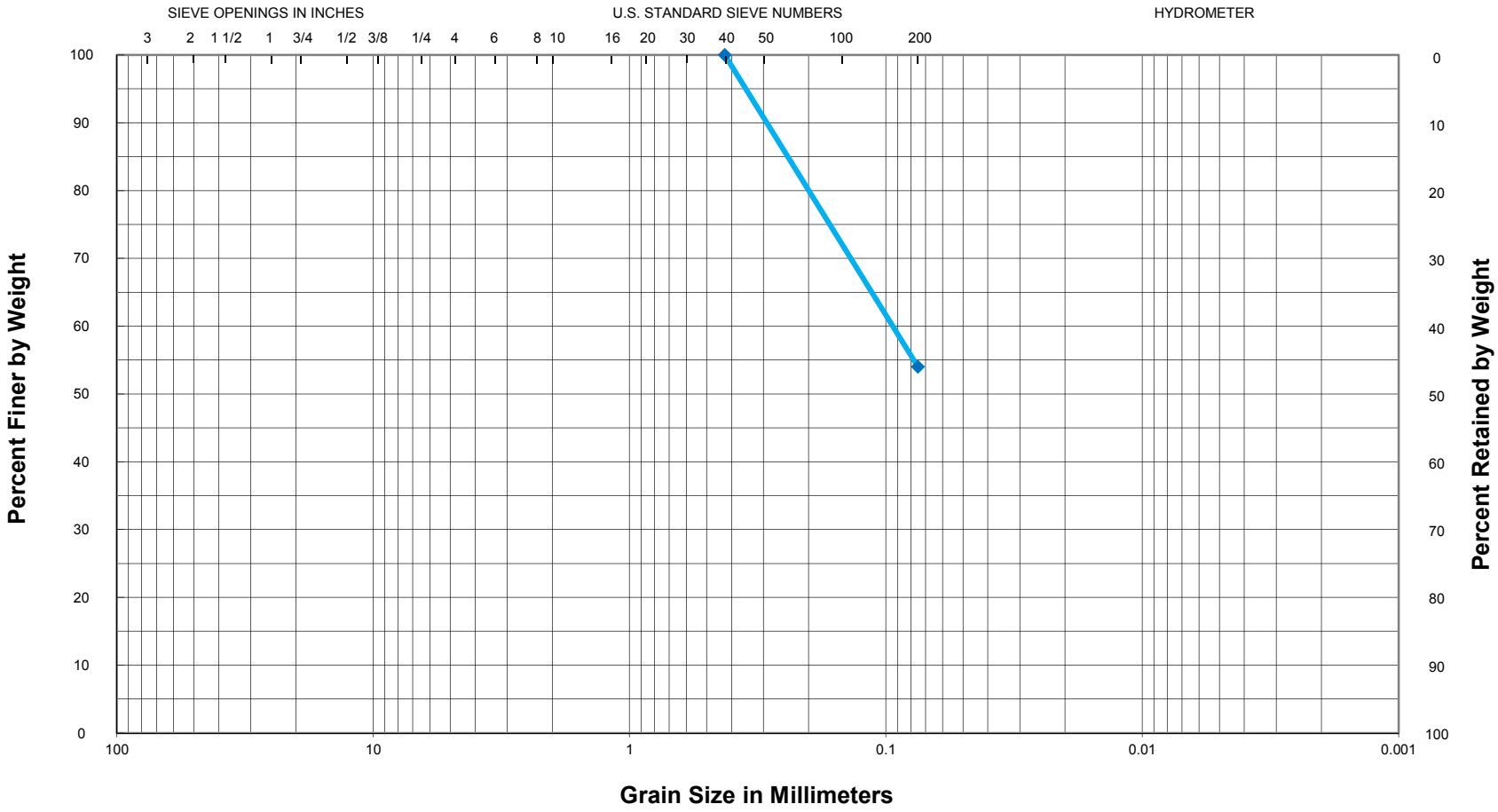
Sample: Boring B1, 14-15 ft; LL = 25, PL = 17, PI = 8
Description: Gray and reddish tan silty CLAY, slightly sandy

USCS Classification = CL
AASHTO Classification = A-4

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

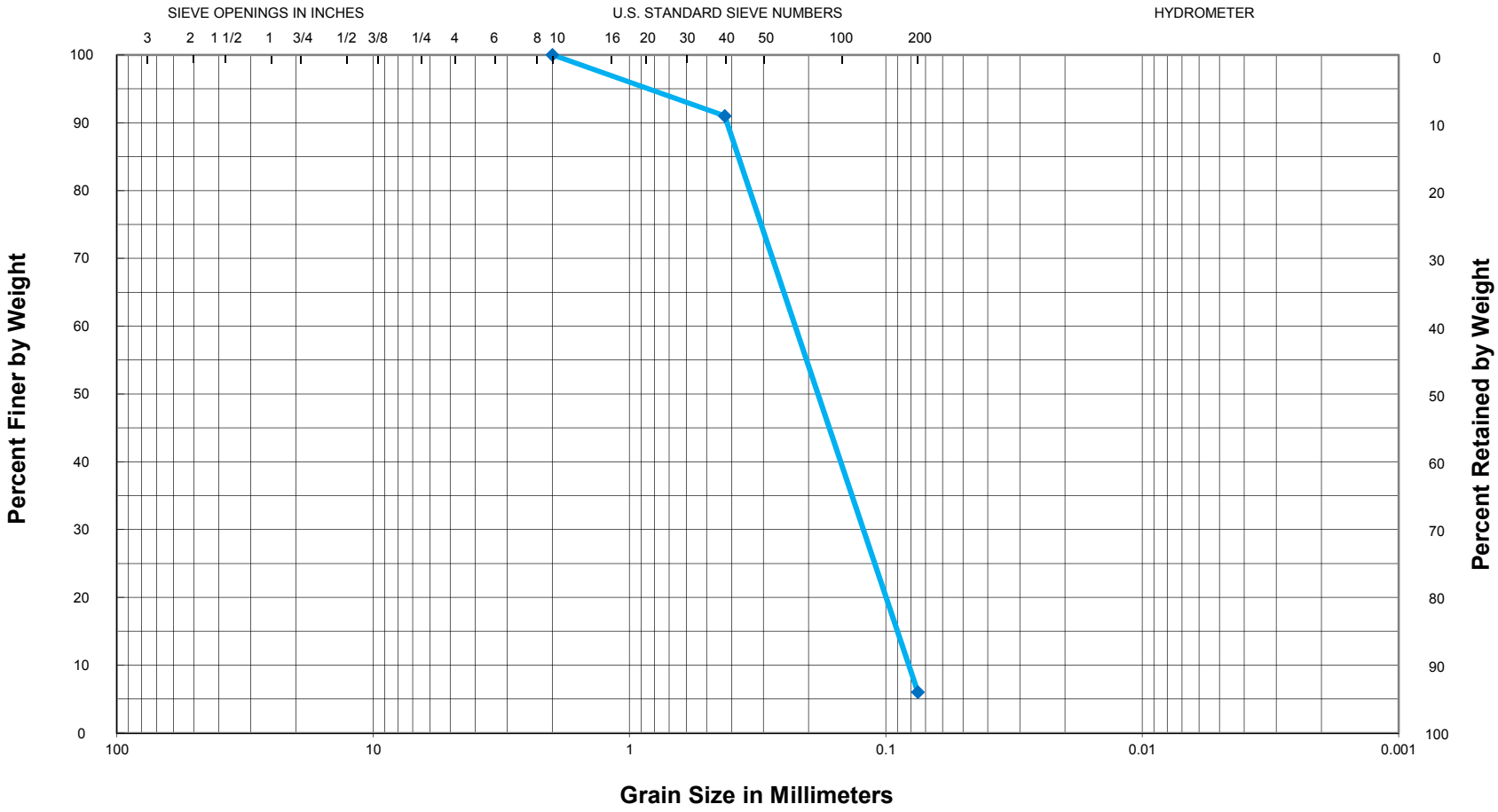
Sample: Boring B1, 19-20 ft
Description: Gray and reddish tan silty fine SAND

USCS Classification = ML
AASHTO Classification = A-4

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

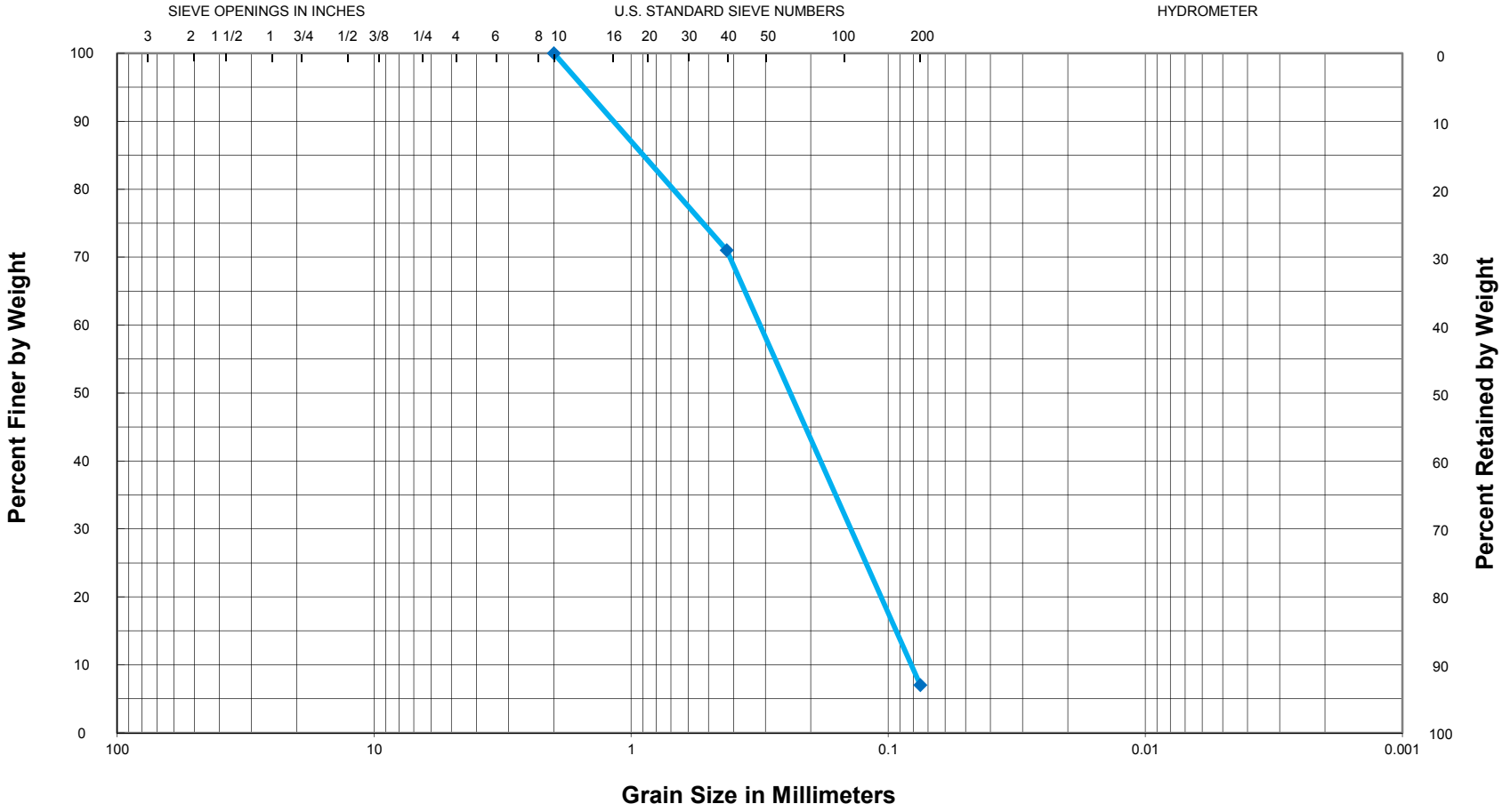
Sample: Boring B1, 49-50 ft
Description: Gray fine to medium SAND, slightly silty

USCS Classification = SM-SP
AASHTO Classification = A-3

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

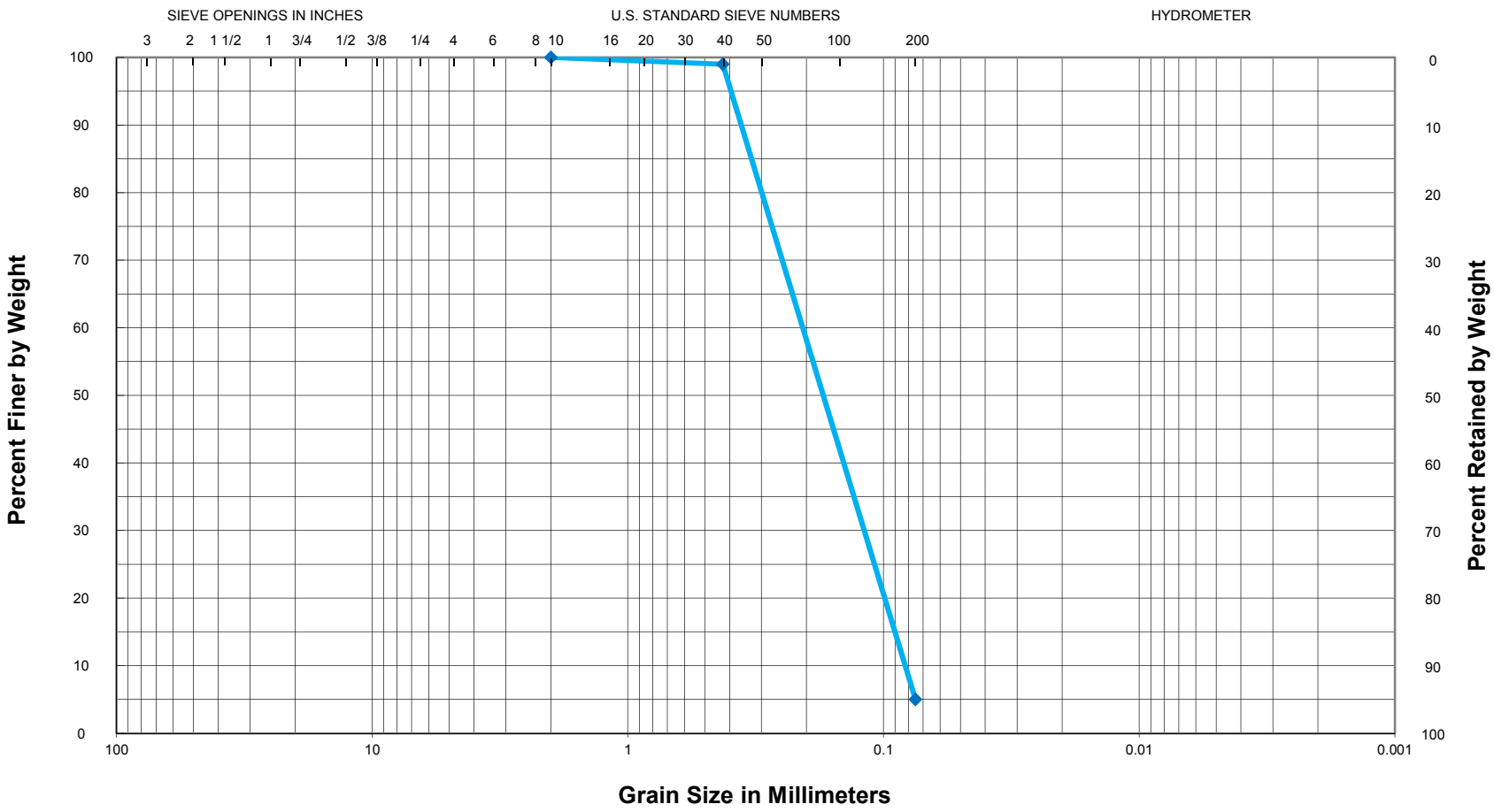
Sample: Boring B2, 39-40 ft
Description: Gray fine to medium SAND, slightly silty

USCS Classification = SM-SP
AASHTO Classification = A-3

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

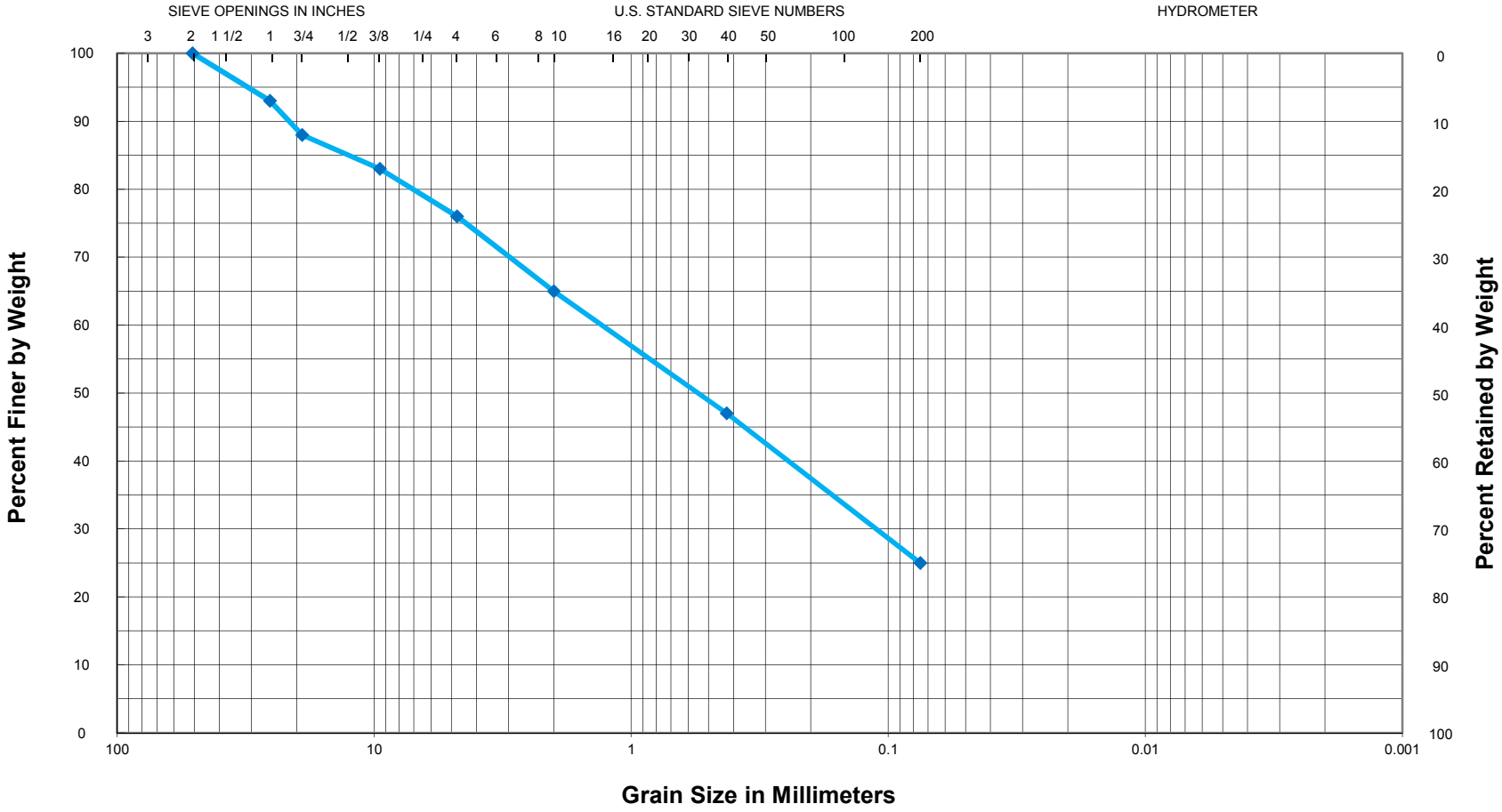
Sample: Boring B2, 49-50 ft
Description: Gray fine SAND, slightly silty

USCS Classification = SM-SP
AASHTO Classification = A-3

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

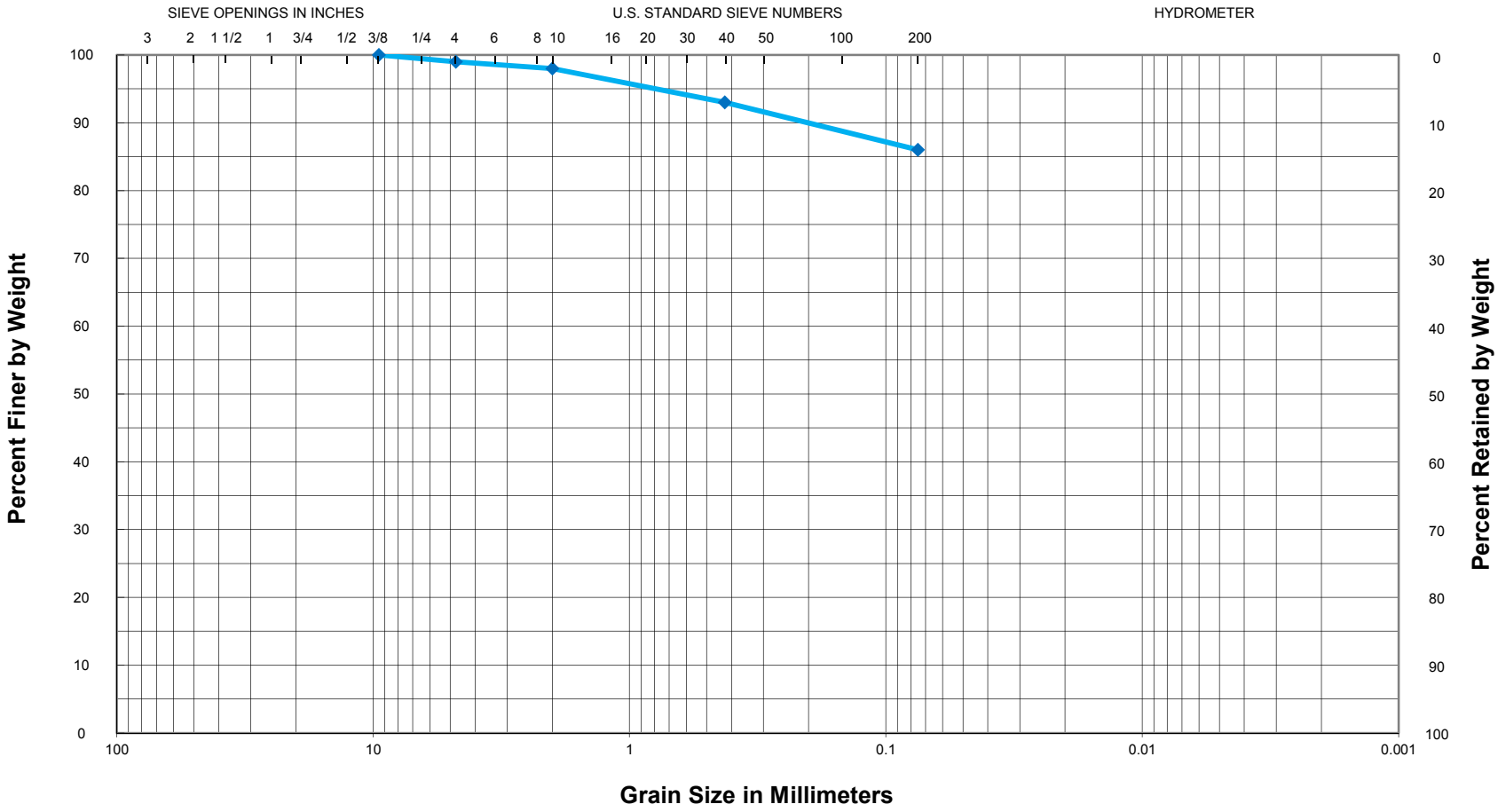
Sample: Boring B4, 0.5-1 ft; LL = 20, PL = 18, PI = 2
Description: Brown silty fine to coarse SAND, slightly clayey w/ some fine to coarse gravel (fill)

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

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

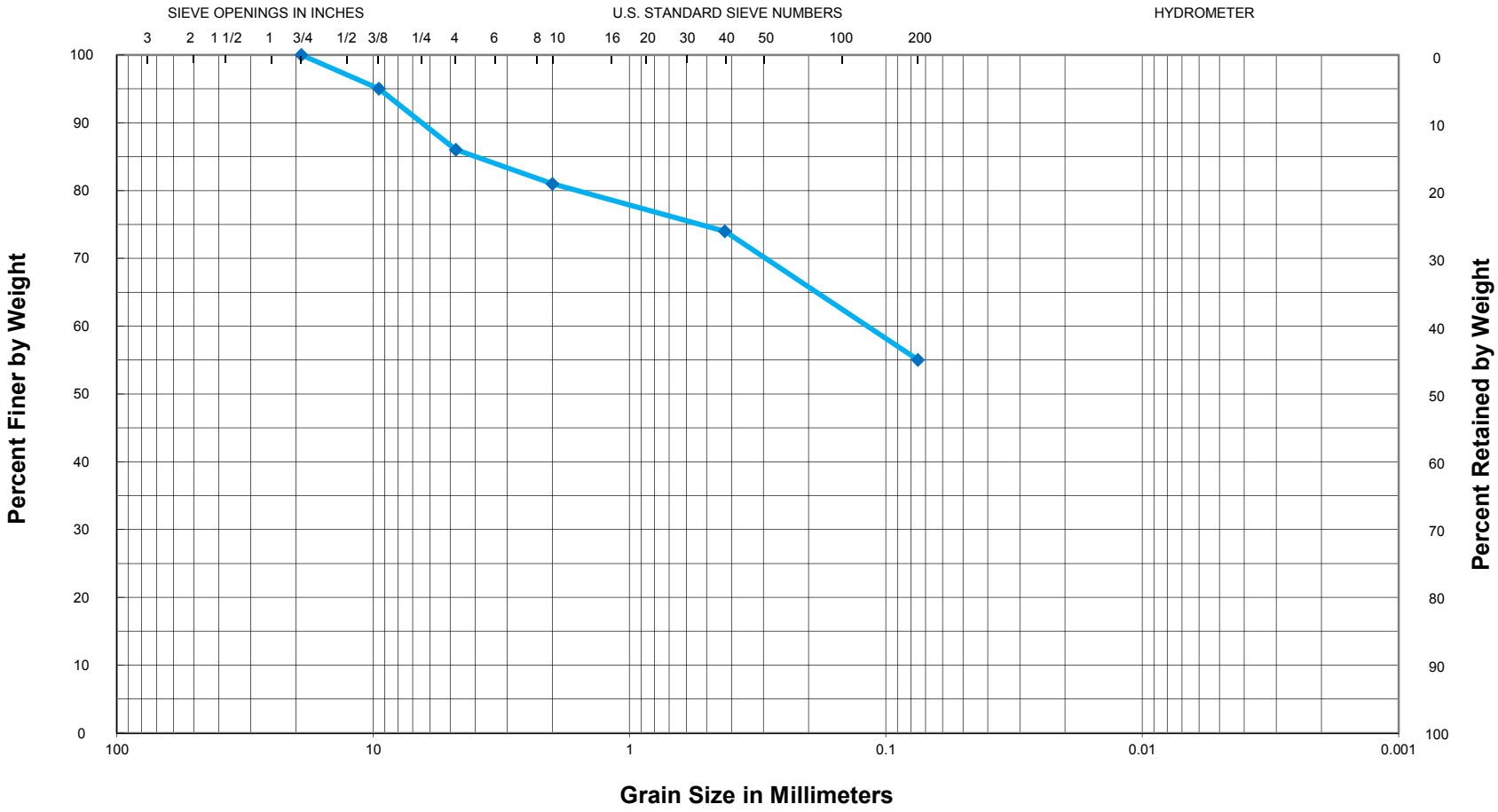
Sample: Boring B4, 1.5-2 ft; LL = 25, PL = 22, PI = 3
Description: Brownish tan SILT, slightly clayey w/ a little fine gravel

USCS Classification = ML
AASHTO Classification = A-4

18-077

GRAIN SIZE CURVE

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS



GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

Sample: Boring B6, 0.5-1 ft; LL = 26, PL = 21, PI = 5
Description: Brown fine sandy CLAY, silty w/ a little fine gravel (fill)

USCS Classification = ML-CL
AASHTO Classification = A-4

APPENDIX C

Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS

P.O. Box 30970
Little Rock, Arkansas 72260-0970
#1 Trigon Place 72209
(501) 455-2536
FAX (501) 455-4137

REPORT OF STANDARD PROCTOR TEST
(AASHTO T-99)

Project: ARDOT 050342 Bridges - White County, Arkansas Job No: 18-077
Material Description: Brown and tan fine sandy CLAY, silty
Location Sampled/Source: TP 3/25B - Hwy. 31 over Red Cut Slough
Sample Depth, ft: 0.5-2.5
Date Sampled: 3/25/2019
Date Tested: 3/29/2019
Tested By: LLC
Report Date: 3/29/2019

LAB COMPACTION PROCEDURE: AASHTO T-99 Method: A	
Maximum Unit Dry Wt. (pcf):	111.0
Optimum Water Content (%):	15.2

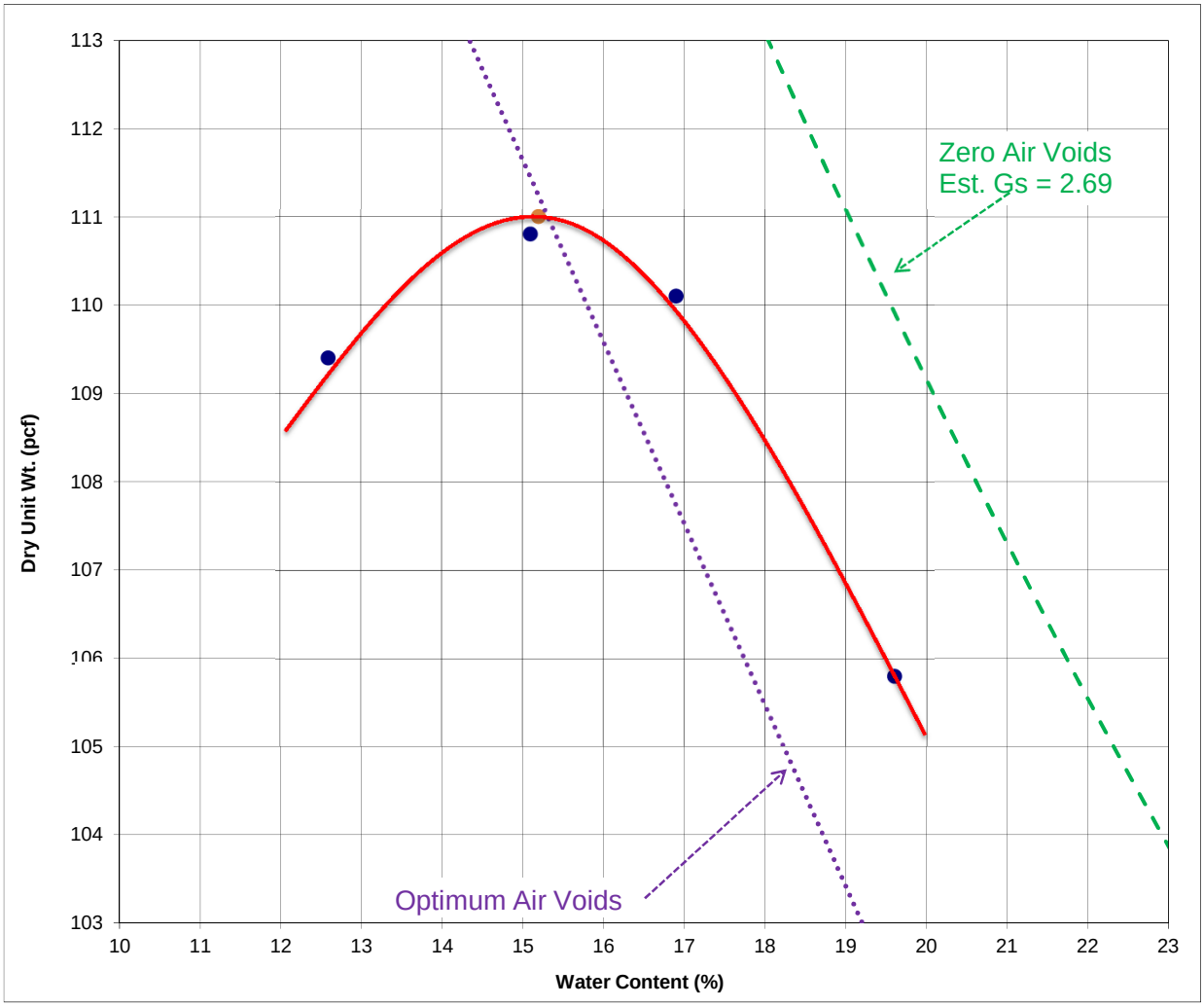
As Recieved Water Content: 20.0 %

ATTERBERG LIMITS AASHTO T-89 & T-90
Liquid Limit: 25
Plastic Limit: 18
Plasticity Index: 7

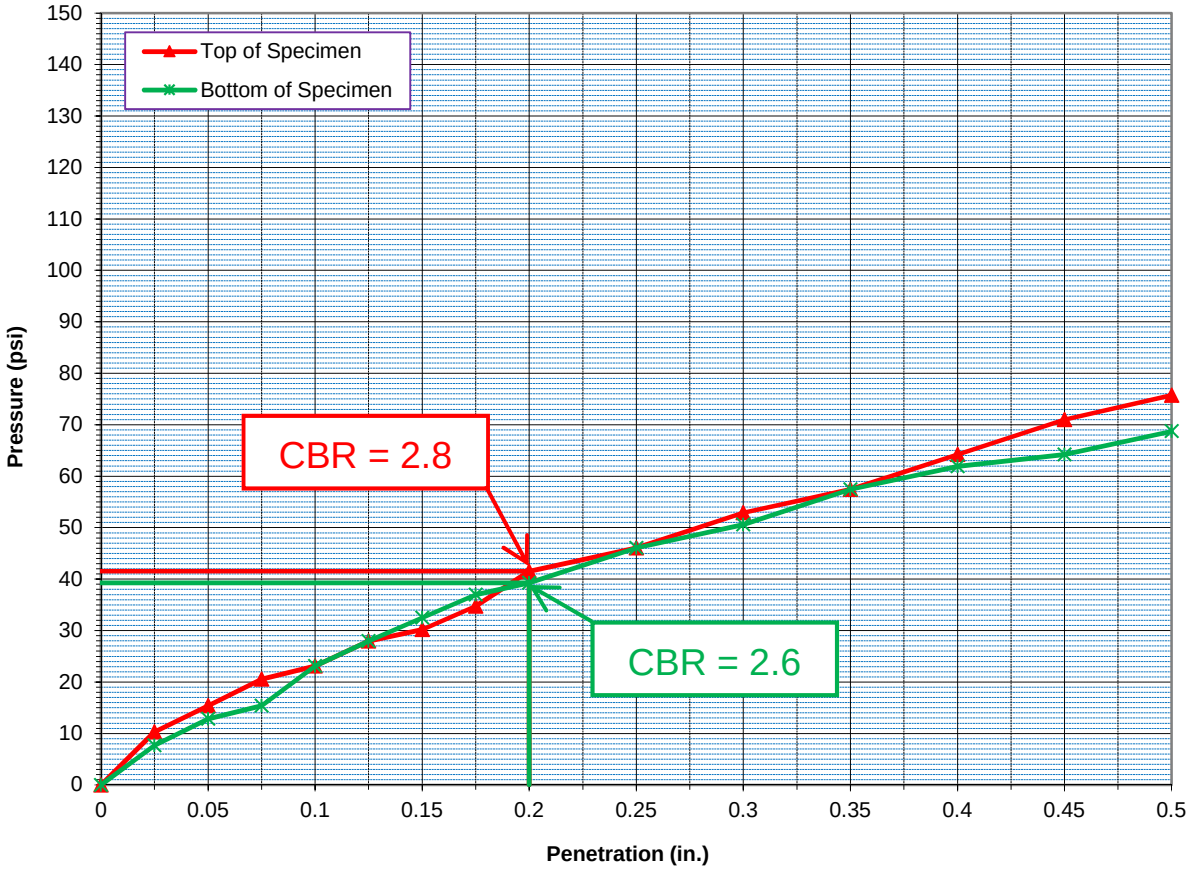
USCS Classification:
ML-CL

AASHTO Classification:
A-4

GRADATION AASHTO T-88	
Sieve Number	Percent Passing
2 in.	100
3/4 in.	99
3/8 in.	98
#4	97
#10	95
#40	91
#200	76



Laboratory CBR Test Report
(AASHTO T-193)



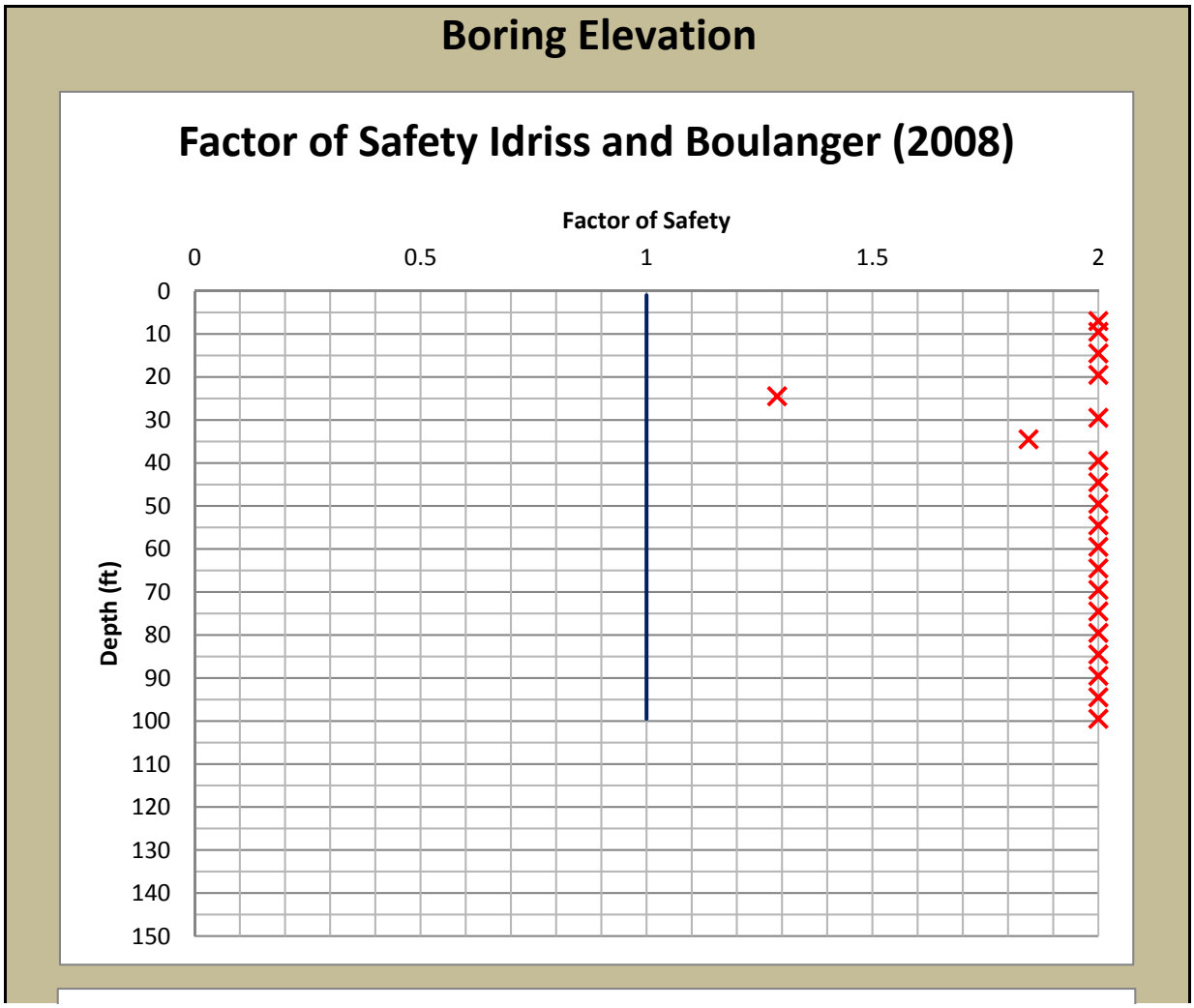
Boring No./Depth, ft	Classification		Natural Moisture Content, %	Assumed Specific Gravity	Liquid Limit, %	Plastic Limit, %	% Retained No.4	% Passing No.200
	USCS	AASHTO						
3/25B @ 0.5-2.5	ML-CL	A-4	19.6	2.69	25	18	3	76
PROCTOR TEST RESULTS (AASHTO T-99)				**MATERIAL DESCRIPTION**				
Optimum Moisture Content = 15.2% Maximum Dry Density = 111.0 pcf				Brown and tan fine sandy CLAY, silty				

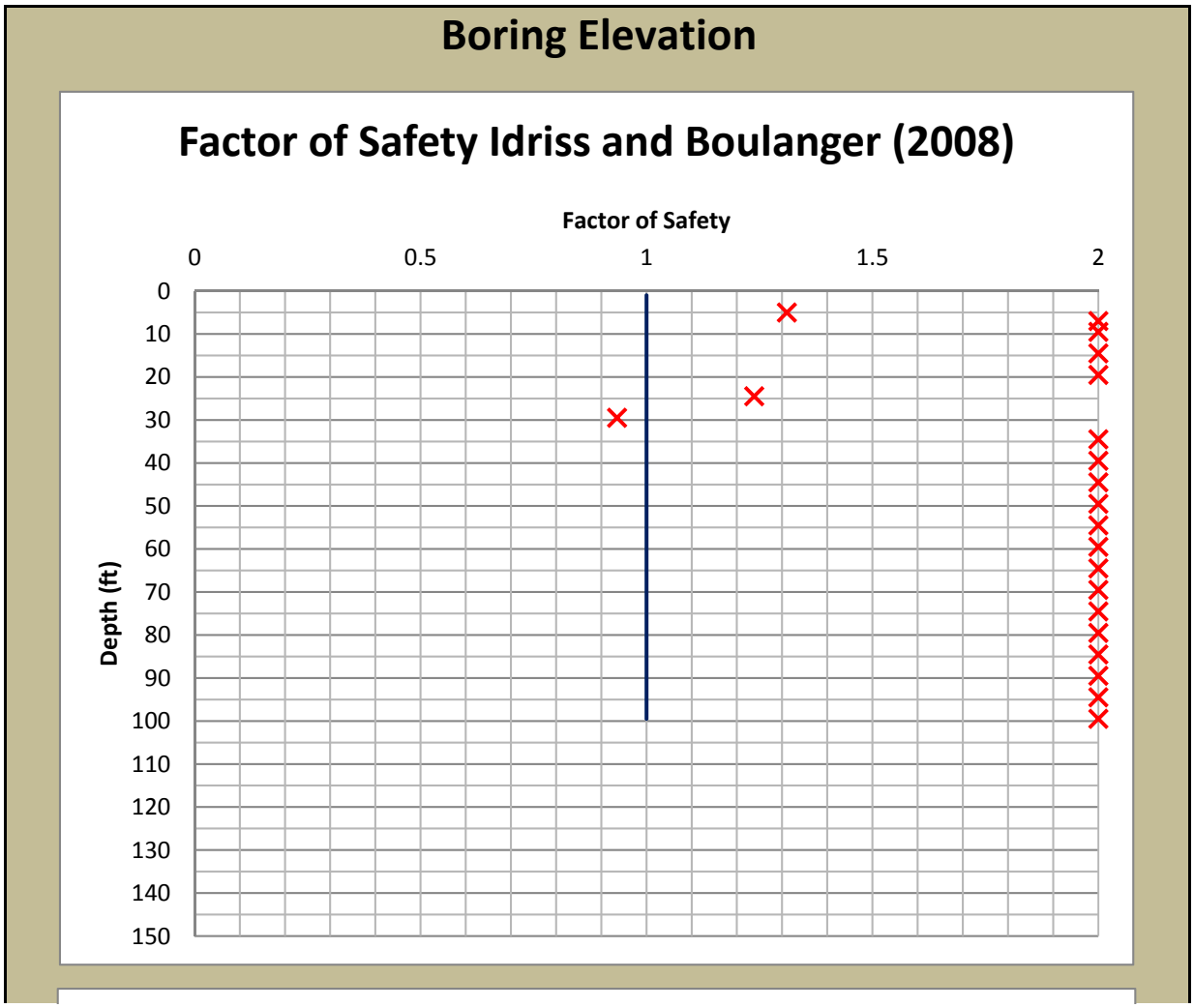
Remarks:
As Molded: 123.7 pcf @ 17.5%; Percent swell: 0.5%

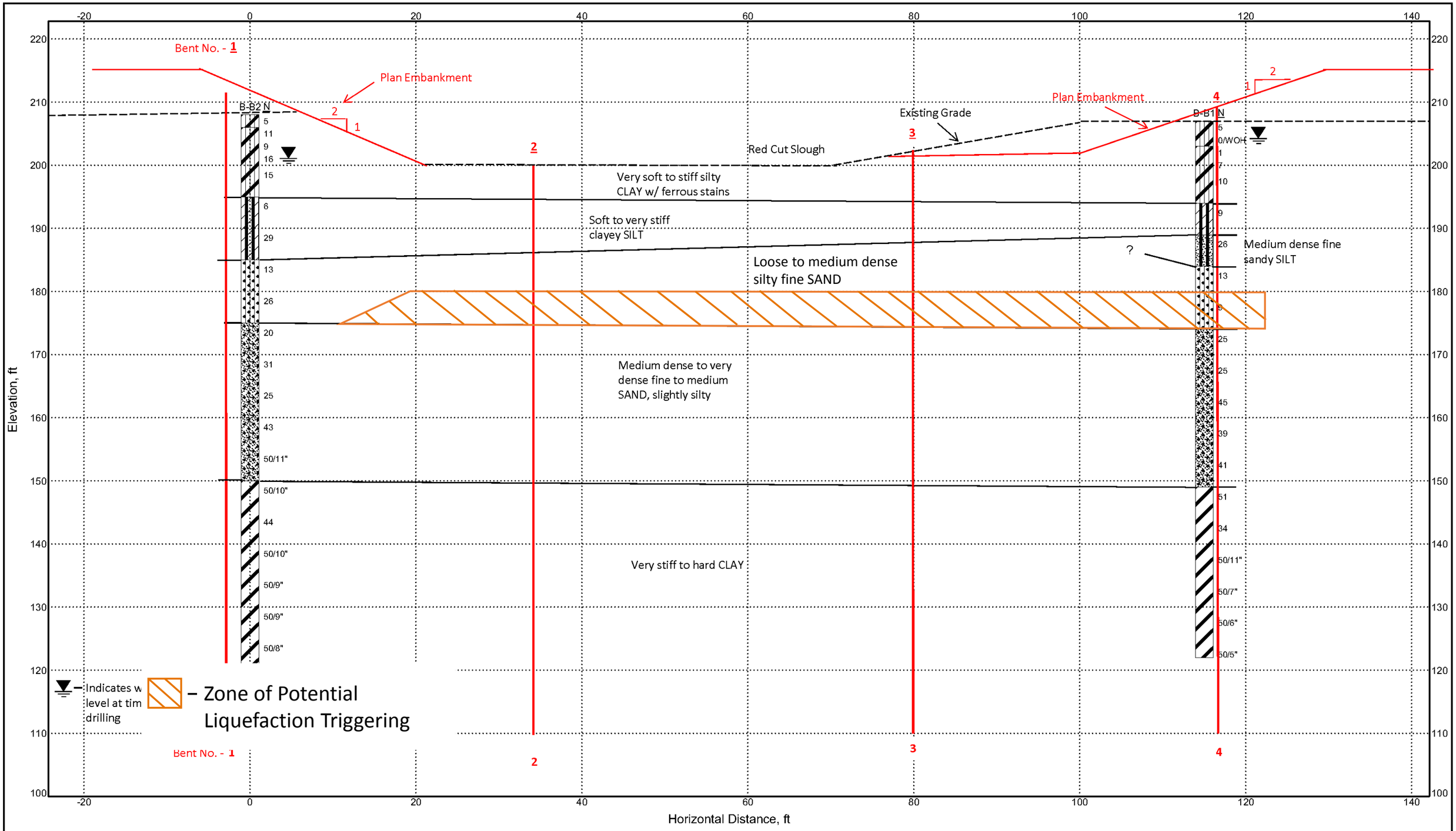
Grubbs, Hoskyn, Barton & Wyatt, INC.
CONSULTING ENGINEERS

Project: ARDOT 050342 - Bridges
GHBW Project Number: 18-077
Location: White County, Arkansas
Sample Date: 3/25/19
Test Date: 3/29/19

APPENDIX D


Boring Elevation
Factor of Safety Idriss and Boulanger (2008)
Factor of Safety
0
0.5
1
1.5
2
Depth (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150


Boring Elevation
Factor of Safety Idriss and Boulanger (2008)
Factor of Safety
0
0.5
1
1.5
2
Depth (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150



Grubbs, Hoskyn, Barton & Wyatt, Inc.

NOTES:
1. Subsurface conditions have been inferred between discrete boring locations. Actual conditions may vary.
2. Ground surface approximate.

SCALE:
As Shown

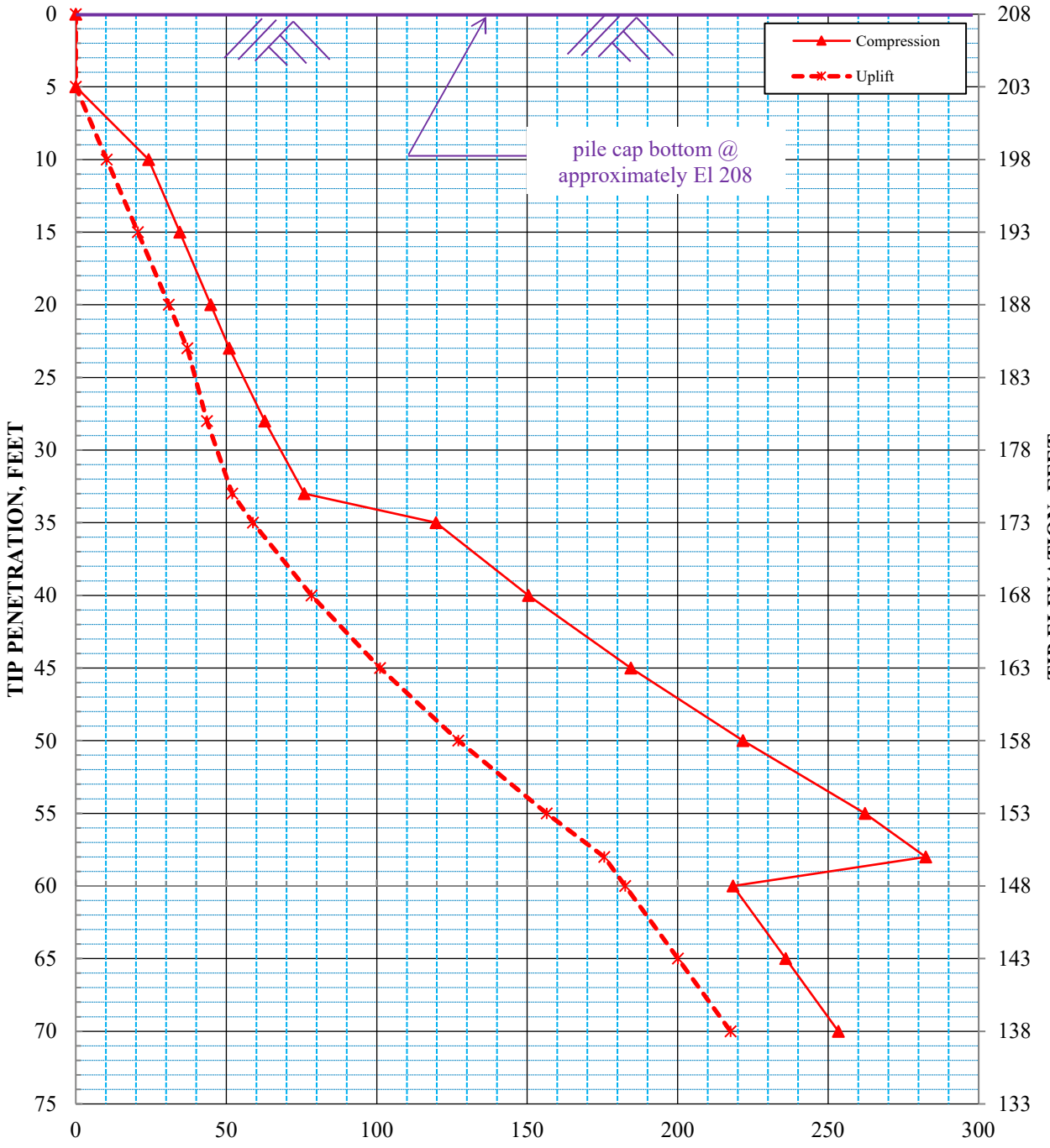
Potential Liquefaction Zone

050342 Hwy 31 over Red Cut Slough
White County, Arkansas

Project Number: 18-077

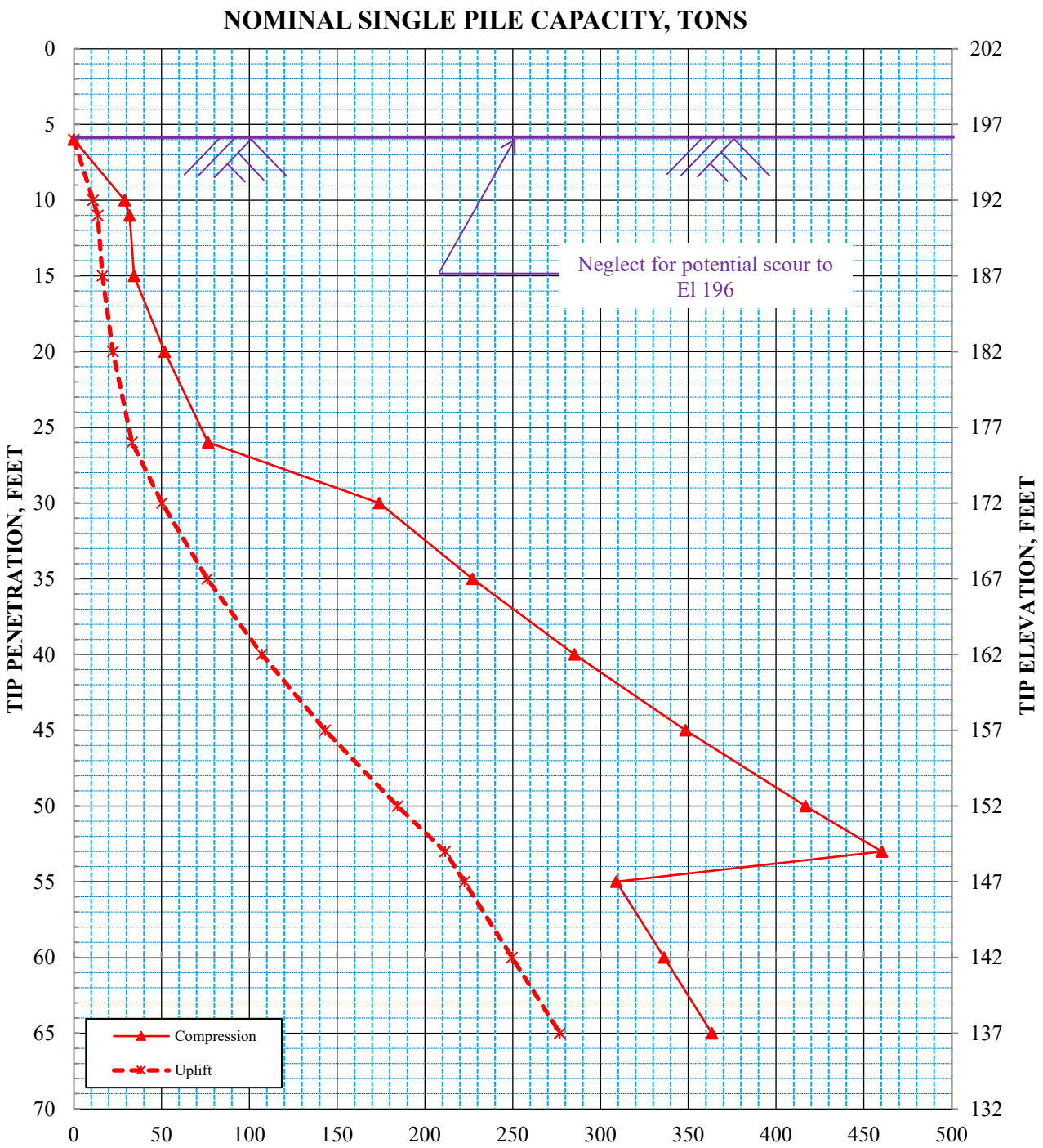
PLATE 3

APPENDIX E

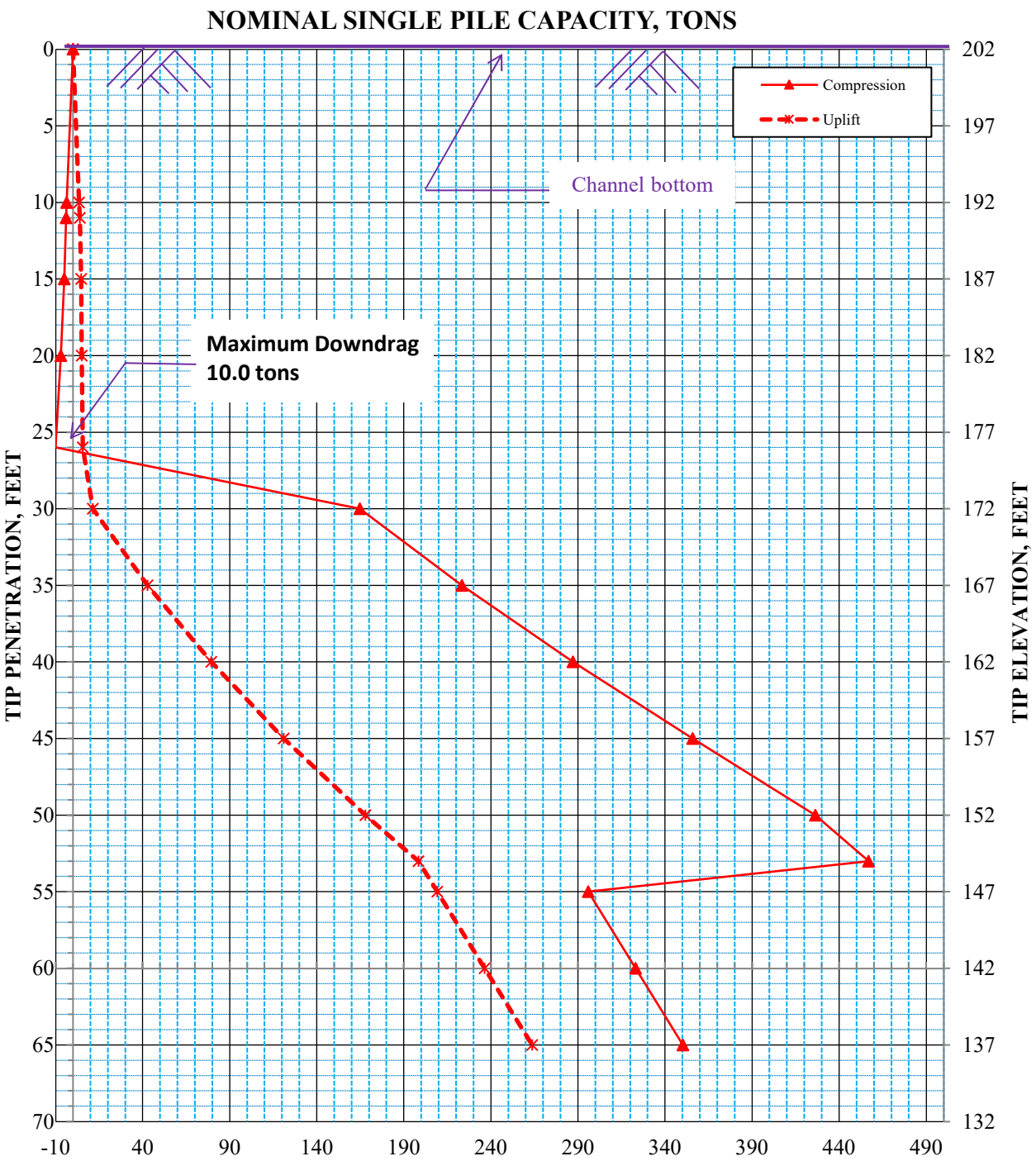


18-in.-diameter Steel Shells
Bridge Ends
ARDOT 050342 Hwy. 31 over Red Cut Slough
White County, Arkansas

Notes: 1. Piles assumed to be driven to plan tip elevation.
2. No downdrag.



Notes: 1. Piles assumed to be driven to plan tip elevation.
2. No downdrag.

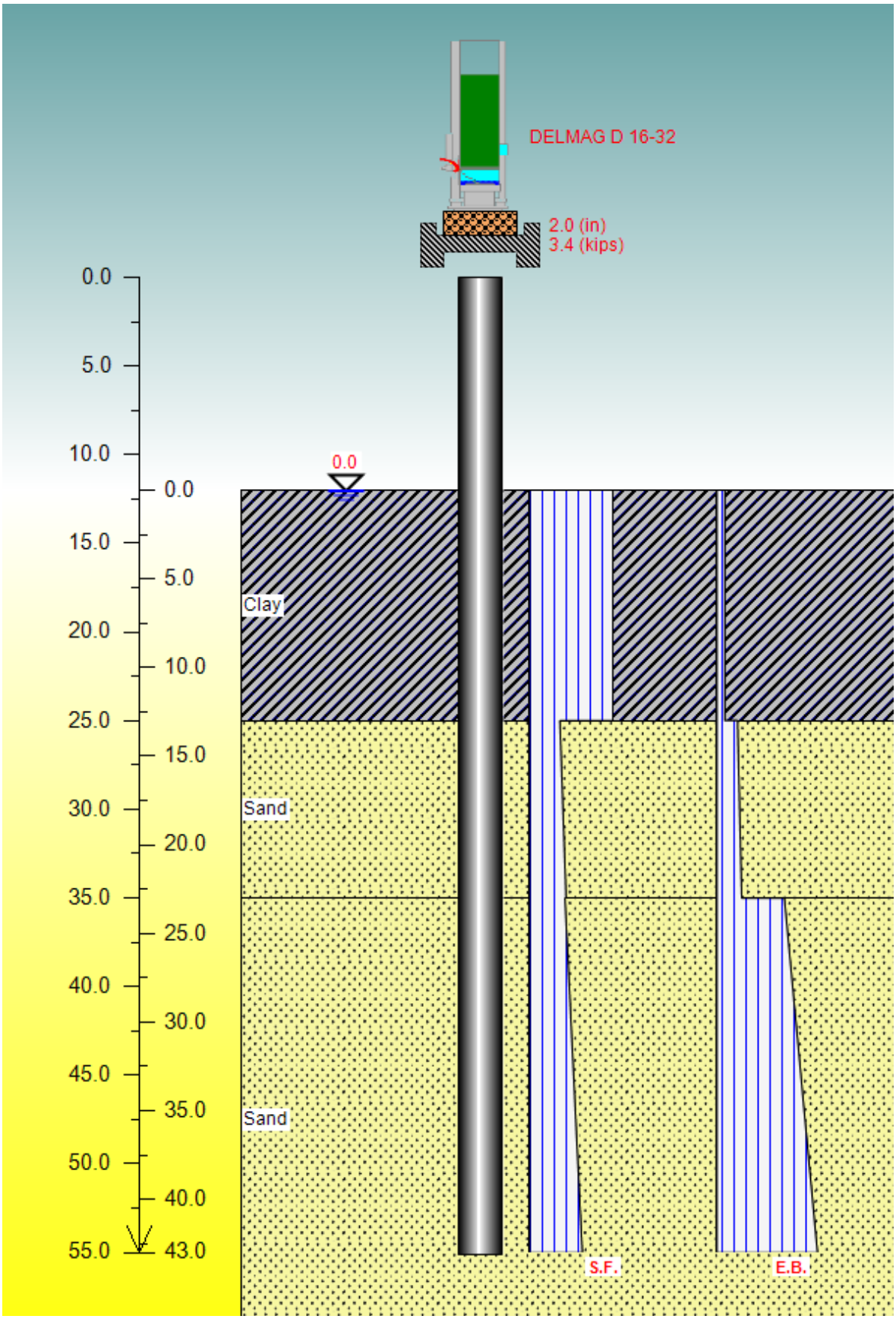


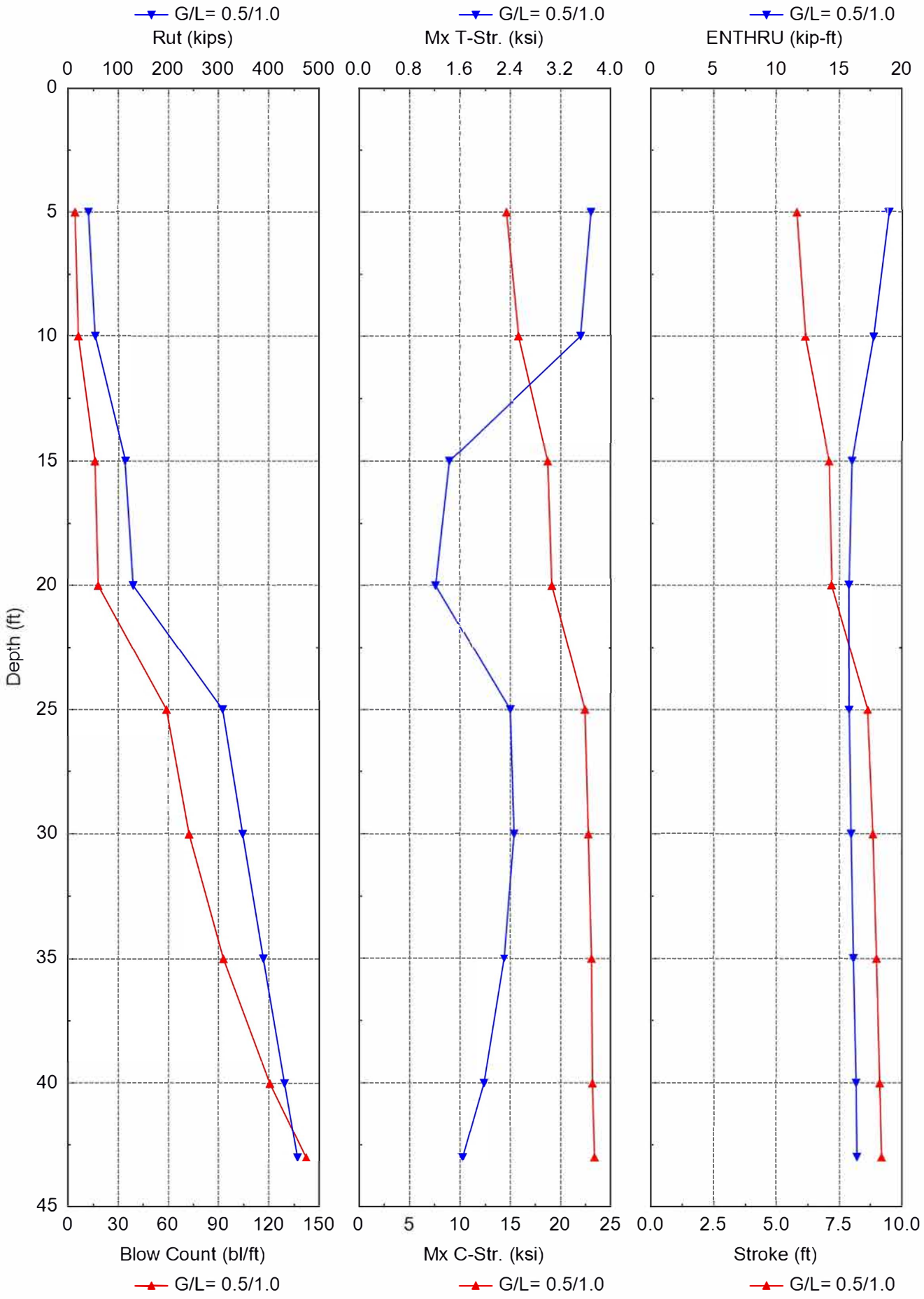
28-in.-diameter Steel Shells
Interior Bents - End of Earthquake Condition
ARDOT 050342 Hwy. 31 over Red Cut Slough
White County, Arkansas

Notes: 1. Piles assumed to be driven to plan tip elevation.
2. Liquefaction downdrag to El 174.

APPENDIX F

Red Cut Slough Bents 1 and 4



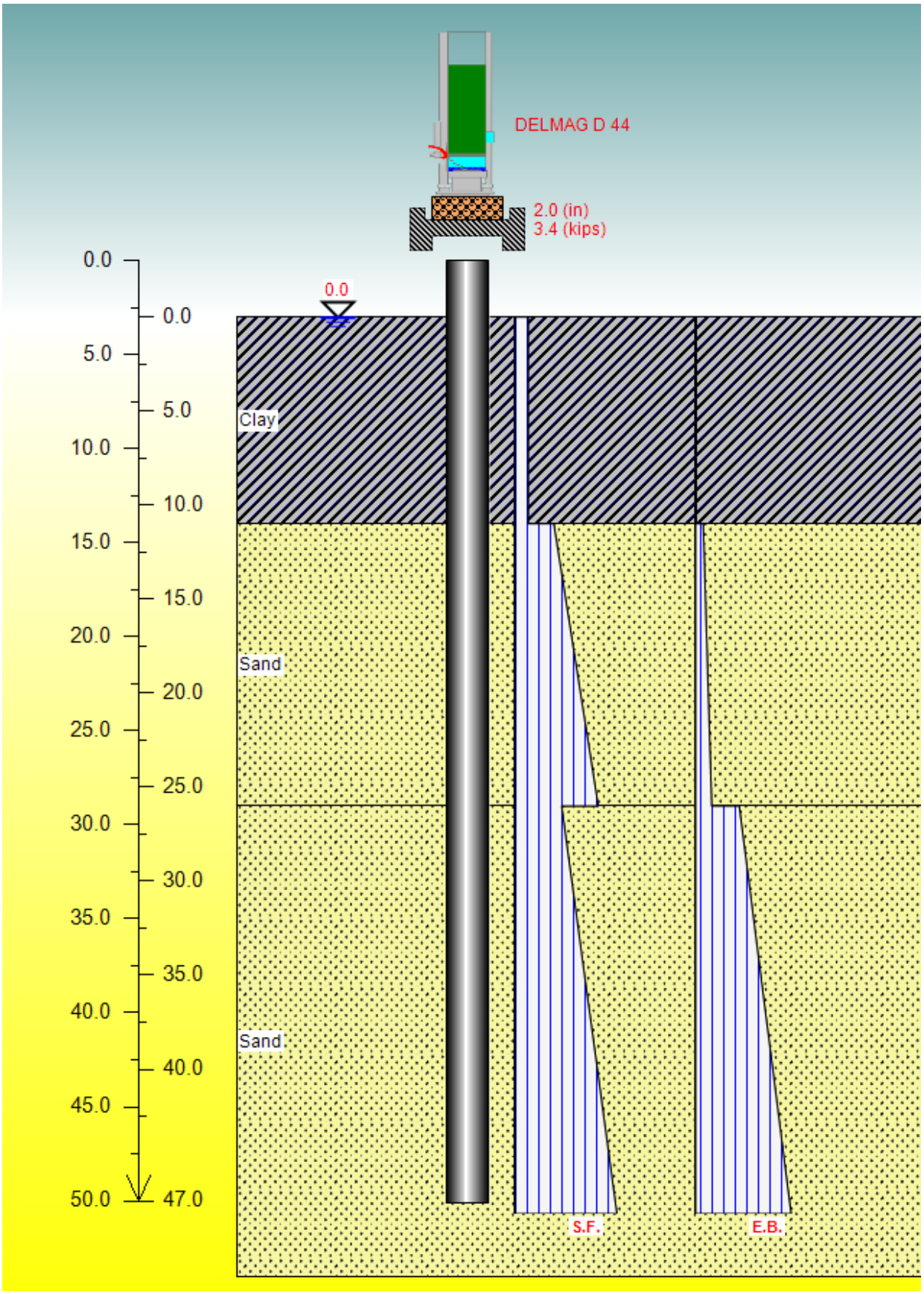

G/L= 0.5/1.0
Rut (kips)
0 100 200 300 400 500
G/L= 0.5/1.0
Mx T-Str. (ksi)
0.0 0.8 1.6 2.4 3.2 4.0
G/L= 0.5/1.0
ENTHRU (kip-ft)
0 5 10 15 20
Depth (ft)
0 5 10 15 20 25 30 35 40 45
0 30 60 90 120 150
Blow Count (bl/ft)
G/L= 0.5/1.0
0 5 10 15 20 25
Mx C-Str. (ksi)
G/L= 0.5/1.0
0.0 2.5 5.0 7.5 10.0
Stroke (ft)
G/L= 0.5/1.0

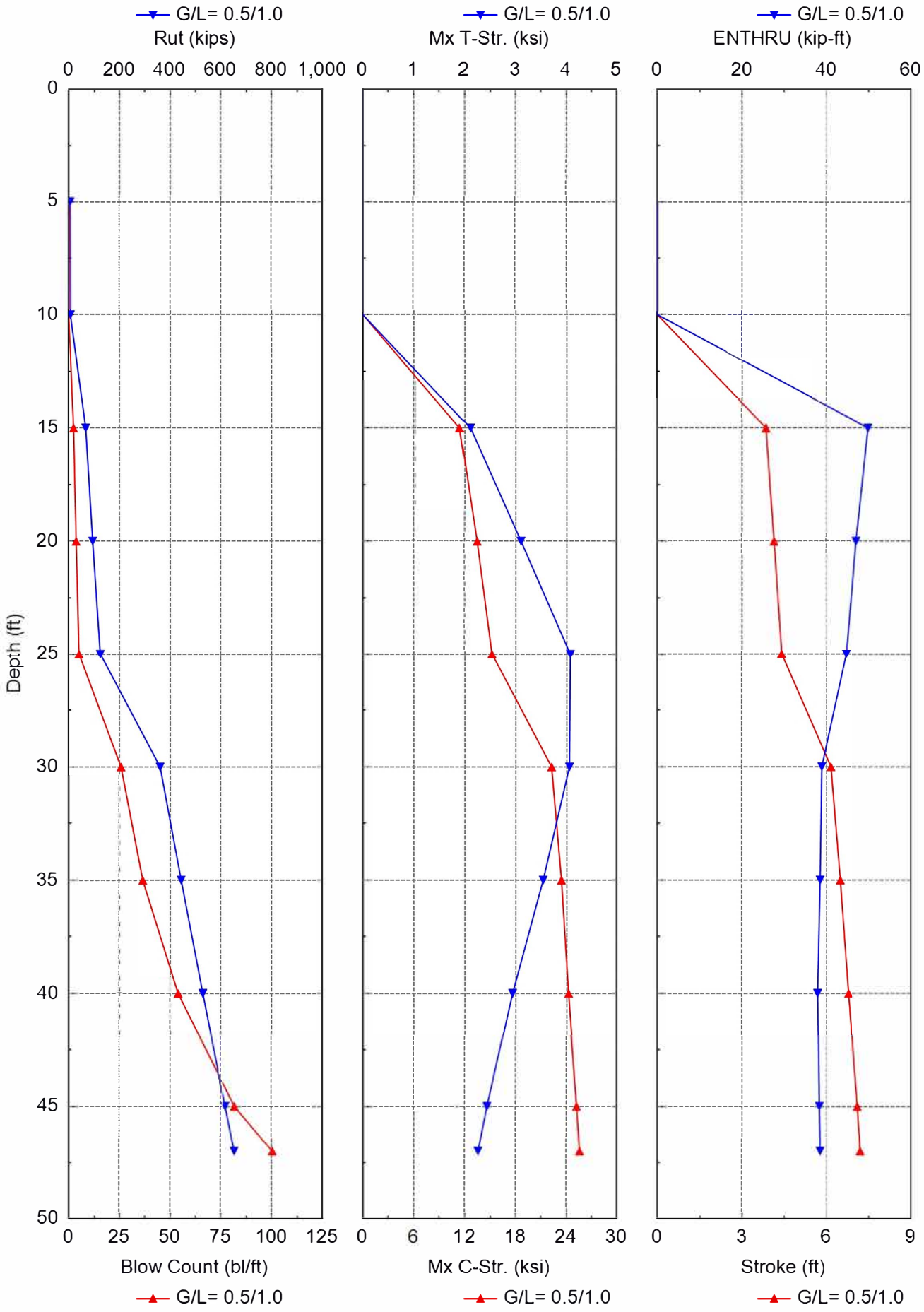
Gain/Loss Factor at Shaft/Toe = 0.500/1.000

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
5.0	40.4	12.6	27.8	4.1	14.603	3.683	5.81	19.0	D 16-32
10.0	53.8	26.0	27.8	6.1	15.821	3.515	6.16	17.7	D 16-32
15.0	113.4	37.6	75.8	16.0	18.706	1.436	7.09	16.0	D 16-32
20.0	129.6	46.3	83.3	18.0	19.120	1.216	7.21	15.8	D 16-32
25.0	307.7	55.7	252.1	58.8	22.417	2.397	8.63	15.8	D 16-32
30.0	347.6	66.0	281.6	72.3	22.754	2.457	8.84	15.9	D 16-32
35.0	388.7	77.5	311.2	92.8	23.068	2.299	8.98	16.1	D 16-32
40.0	430.8	90.1	340.8	120.5	23.161	1.978	9.11	16.3	D 16-32
43.0	456.7	98.2	358.5	142.2	23.367	1.637	9.18	16.4	D 16-32

Total driving time: 50 minutes; Total Number of Blows: 2025 (starting at penetration 5.0 ft)

Red Cut Slough Bents 2 and 3




G/L= 0.5/1.0
Rut (kips)
0 200 400 600 800 1,000
Mx T-Str. (ksi)
0 1 2 3 4 5
ENTHRU (kip-ft)
0 20 40 60
Depth (ft)
0 5 10 15 20 25 30 35 40 45 50
Blow Count (bl/ft)
0 25 50 75 100 125
Mx C-Str. (ksi)
0 6 12 18 24 30
Stroke (ft)
0 3 6 9
G/L= 0.5/1.0

Gain/Loss Factor at Shaft/Toe = 0.500/1.000

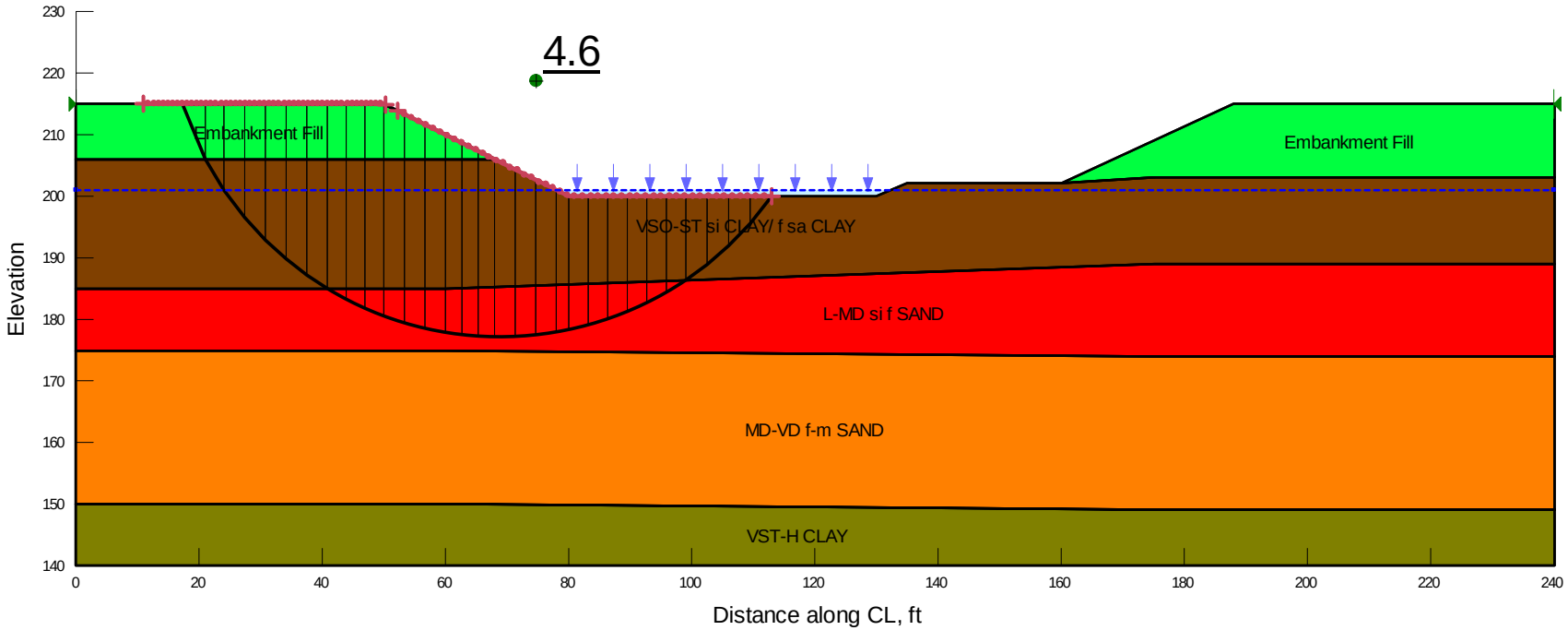
Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
5.0	5.2	1.4	3.8	0.3	0.000	0.000	9.49	0.0	D 44
10.0	6.6	2.8	3.8	0.3	0.000	0.000	9.49	0.0	D 44
15.0	67.2	9.5	57.6	2.4	11.394	2.109	3.85	49.8	D 44
20.0	94.6	20.0	74.6	3.7	13.424	3.100	4.14	47.0	D 44
25.0	124.8	33.2	91.5	5.1	15.172	4.072	4.41	44.7	D 44
30.0	360.5	43.7	316.8	25.8	22.217	4.054	6.16	38.9	D 44
35.0	443.4	55.1	388.3	36.5	23.380	3.536	6.49	38.5	D 44
40.0	528.7	68.8	459.9	53.9	24.223	2.936	6.79	37.9	D 44
45.0	616.3	84.9	531.4	81.6	25.209	2.435	7.09	38.3	D 44
47.0	652.0	92.0	560.1	100.3	25.561	2.258	7.19	38.5	D 44

Total driving time: 22 minutes; Total Number of Blows: 1025 (starting at penetration 5.0 ft)

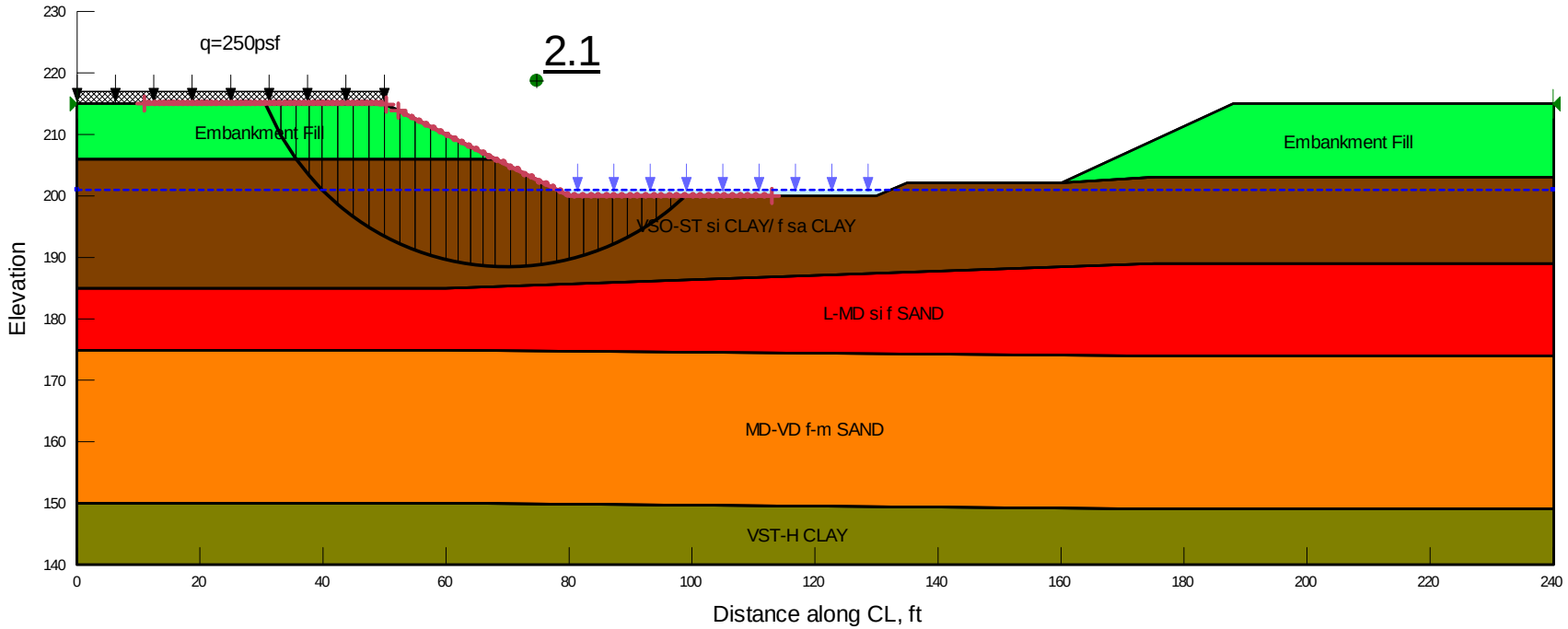
APPENDIX G

Summary of Stability Analysis Results
ARDOT 050342 Hwy. 31 over Red Cut Slough
GHBW Job No. 18-077
White County, Arkansas

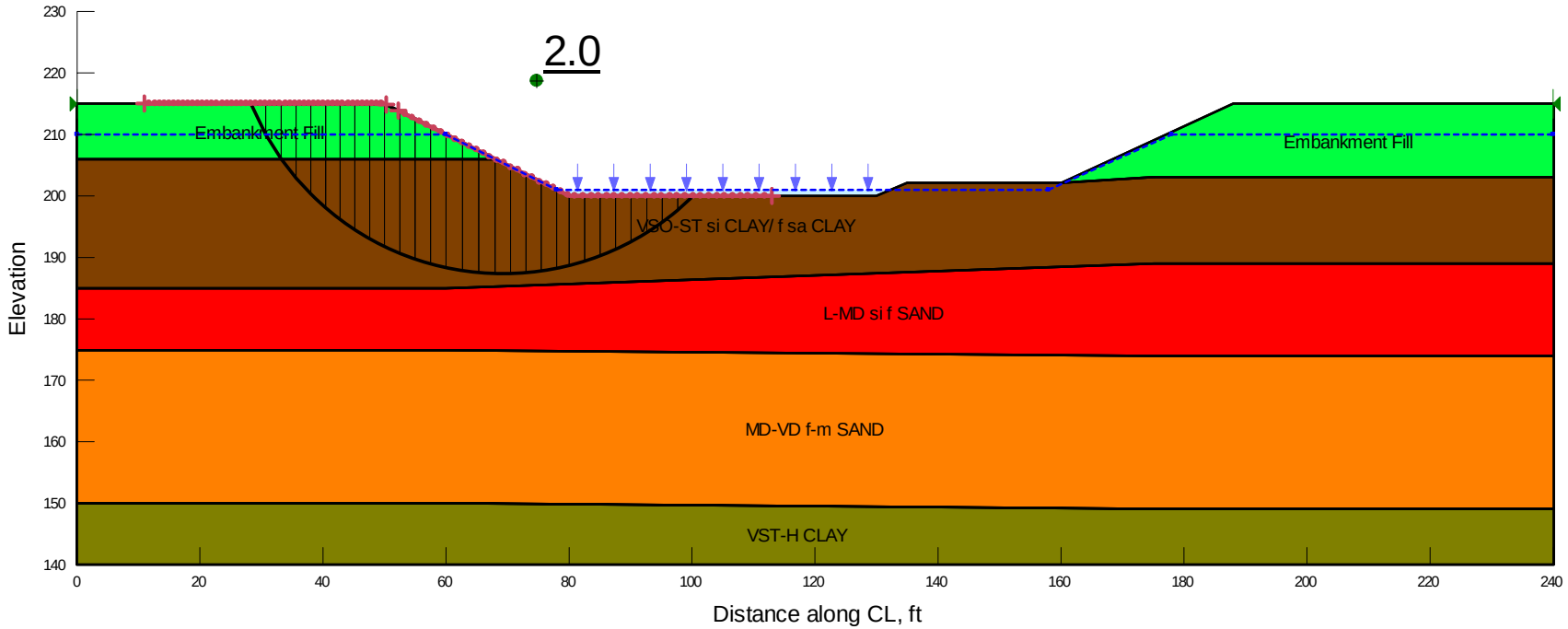
Bridge End	Design Loading Condition	Calculated Minimum Factor of Safety
South End Slope (Bent 1) (2H:1V)	End of Construction	4.6
	Long Term	2.1
	Rapid Drawdown from El 210 to El 203	2.0
	Seismic ($k_h = A_S/2 = 0.131$)	1.5
South Side Slope (Bent 1) (2H:1V)	End of Construction	3.2
	Long Term	3.0
	Rapid Drawdown from El 210 to Existing Grade	3.0
	Seismic ($k_h = A_S/2 = 0.131$)	2.0
North End Slope (Bent 4) (2H:1V)	End of Construction	4.6
	Long Term	2.4
	Rapid Drawdown from El 210 to El 203	2.4
	Seismic ($k_h = A_S/2 = 0.131$)	1.8
North End Side Slope (Bent 4) (2H:1V)	End of Construction	3.3
	Long Term	2.6
	Rapid Drawdown from El 210 to El 203	2.6
	Seismic ($k_h = A_S/2 = 0.131$)	1.8



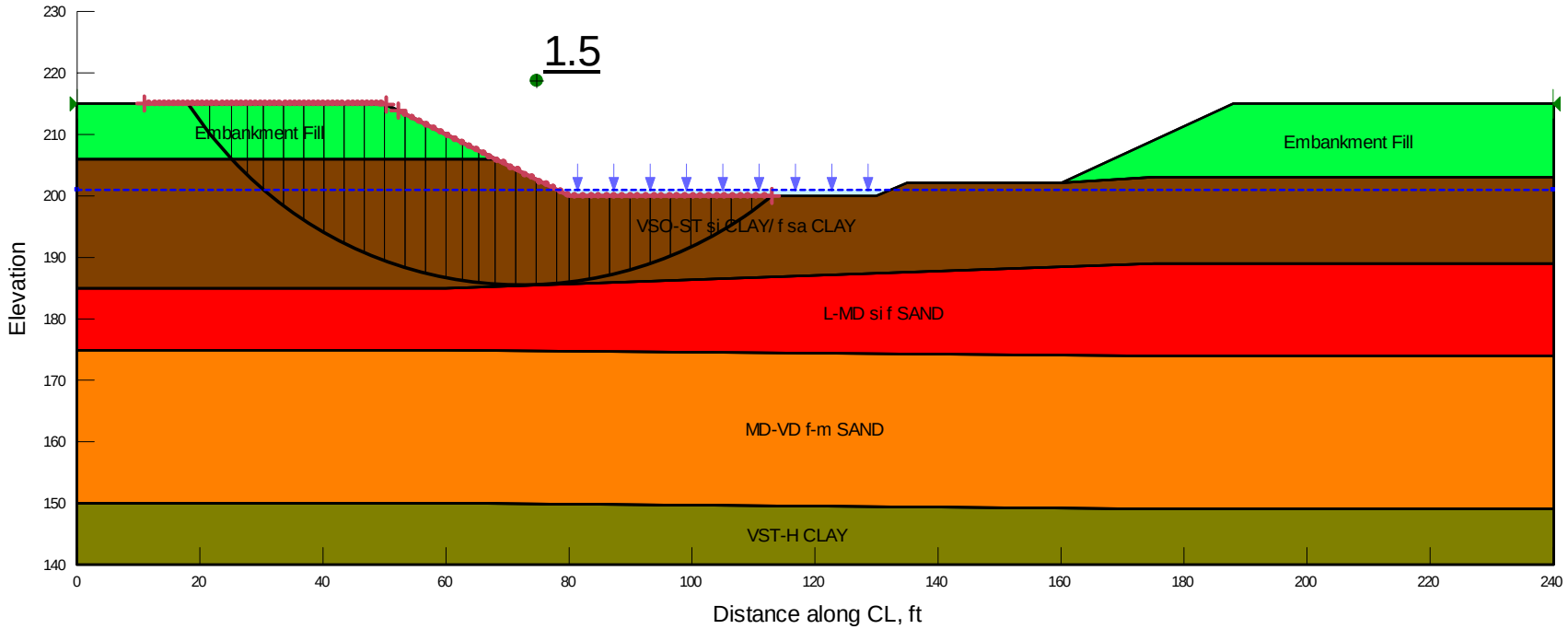
Results of Stability Analyses – End of Construction
Bent 1 End Slope at Approximately Sta 161+83
2H:1V Slope, H=15 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



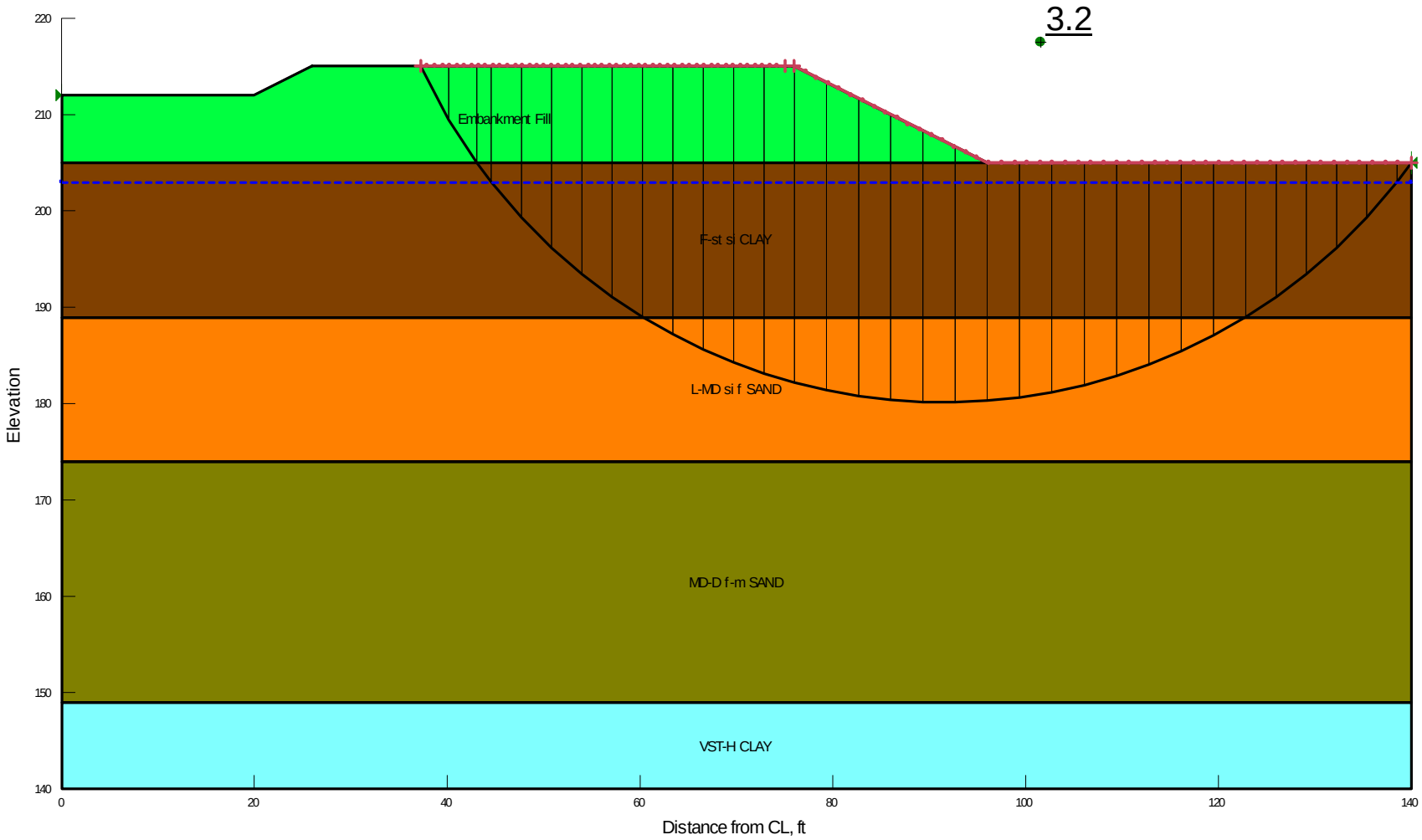
Results of Stability Analyses – Long Term Condition
Bent 1 End Slope at Approximately Sta 161+83
2H:1V Slope, H=15 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



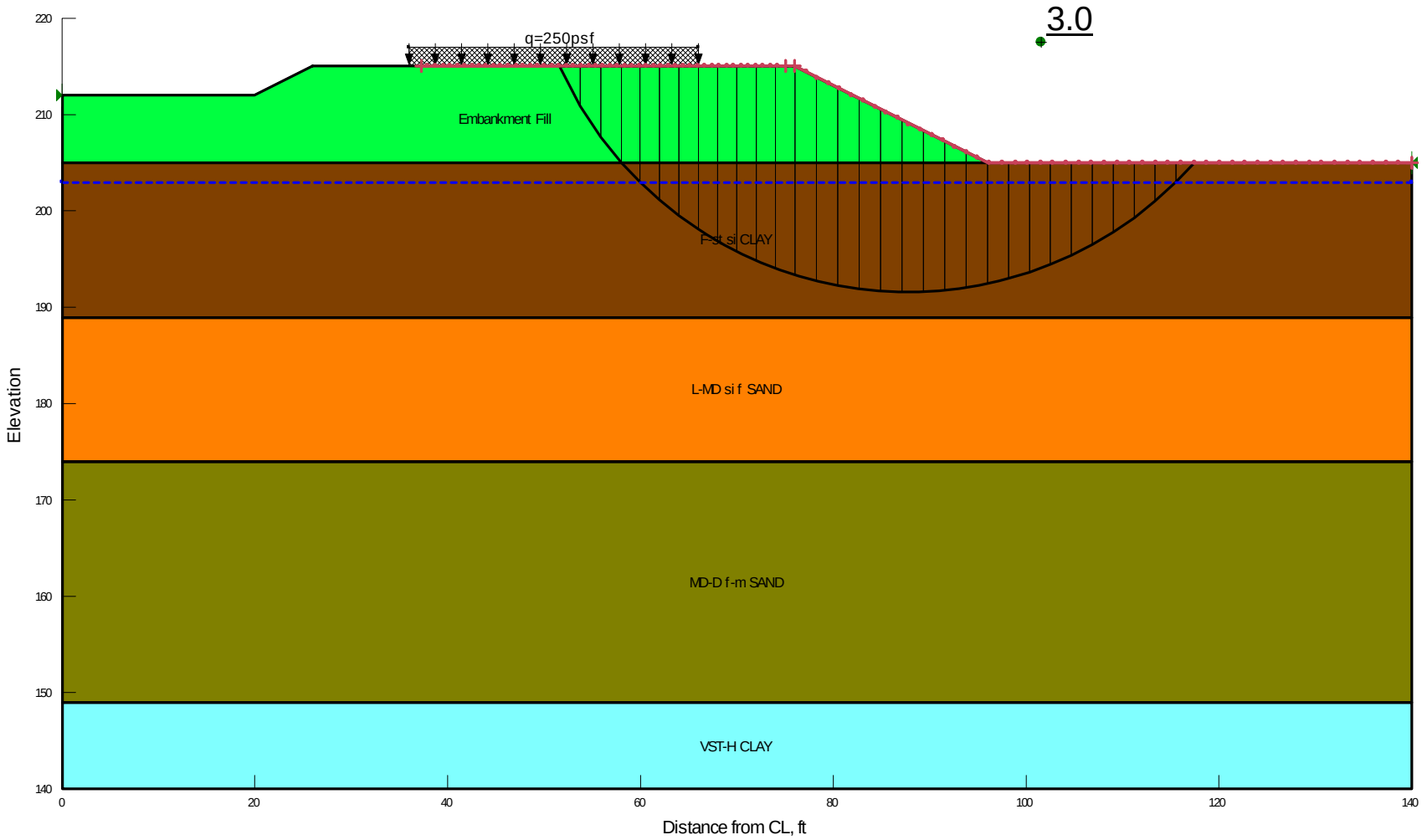
Results of Stability Analyses – Rapid Drawdown Condition, El 210 to El 203
Bent 1 End Slope at Approximately Sta 161+83
2H:1V Slope, H=15 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



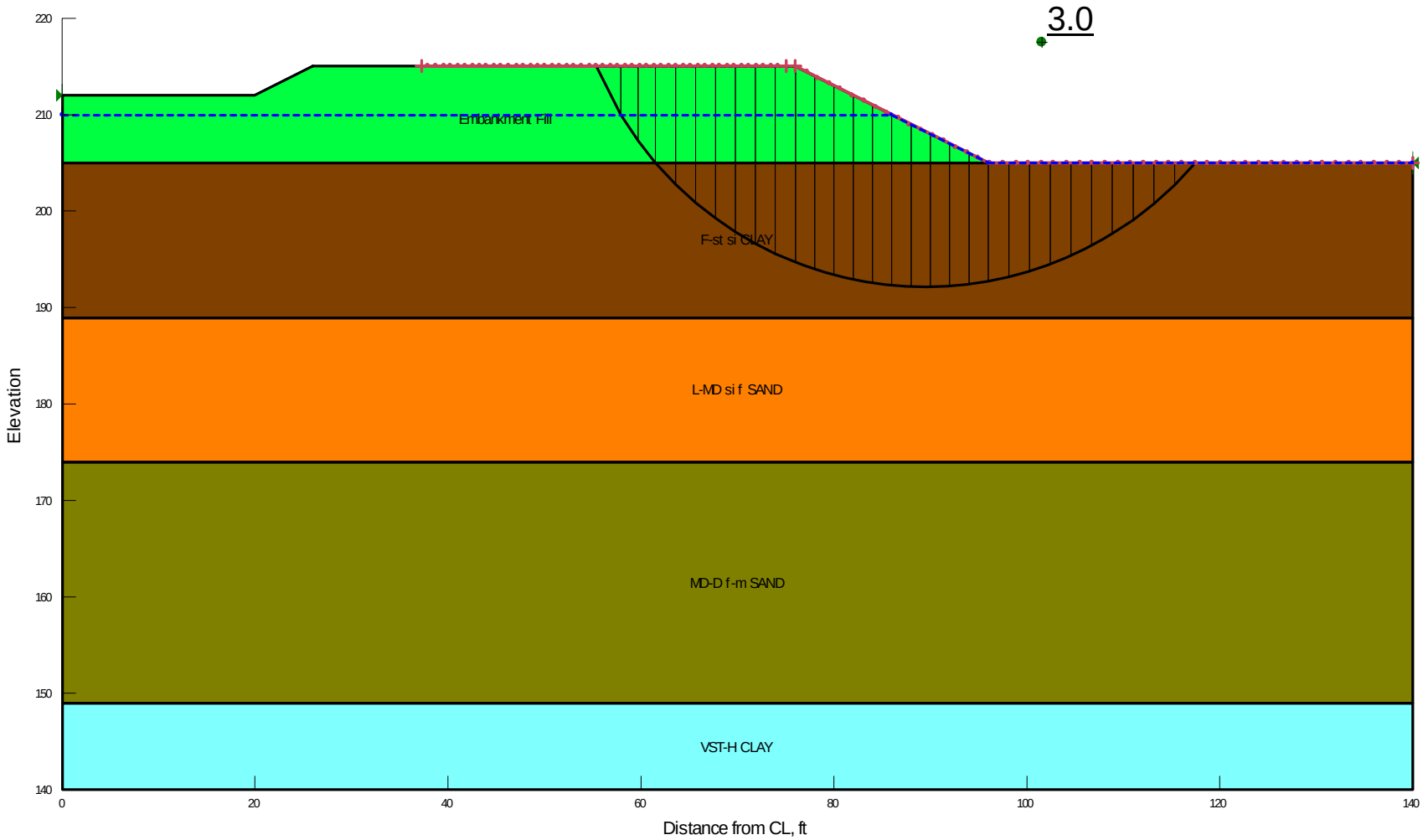
Results of Stability Analyses – Seismic Condition ($k_h = A_S /2 = 0.131$)
Bent 1 End Slope at Approximately Sta 161+83
2H:1V Slope, H=15 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



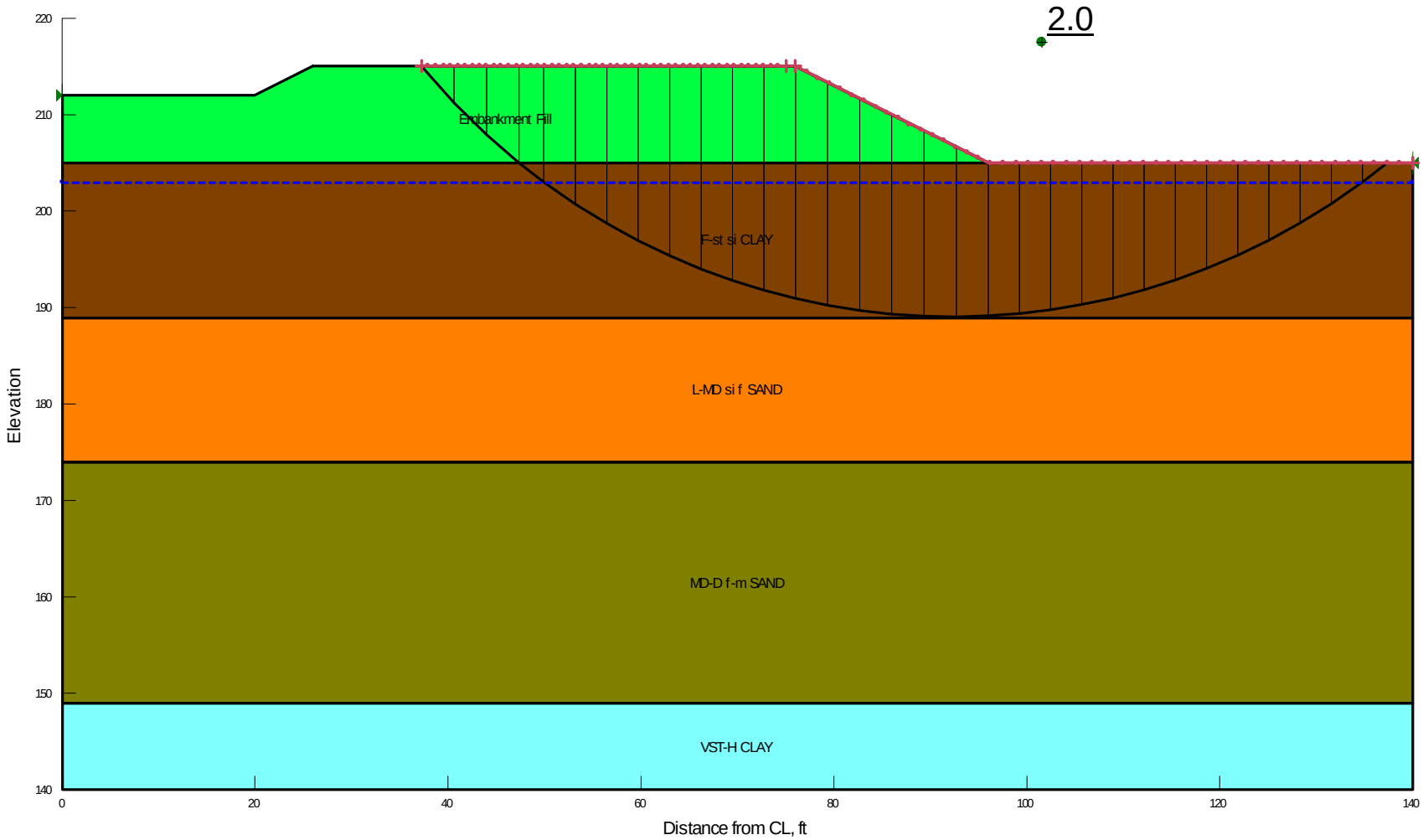
Results of Stability Analyses – End of Construction
Bent 1 Side Slope at Approximately Sta 161+83
2H:1V Slope, H=10 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



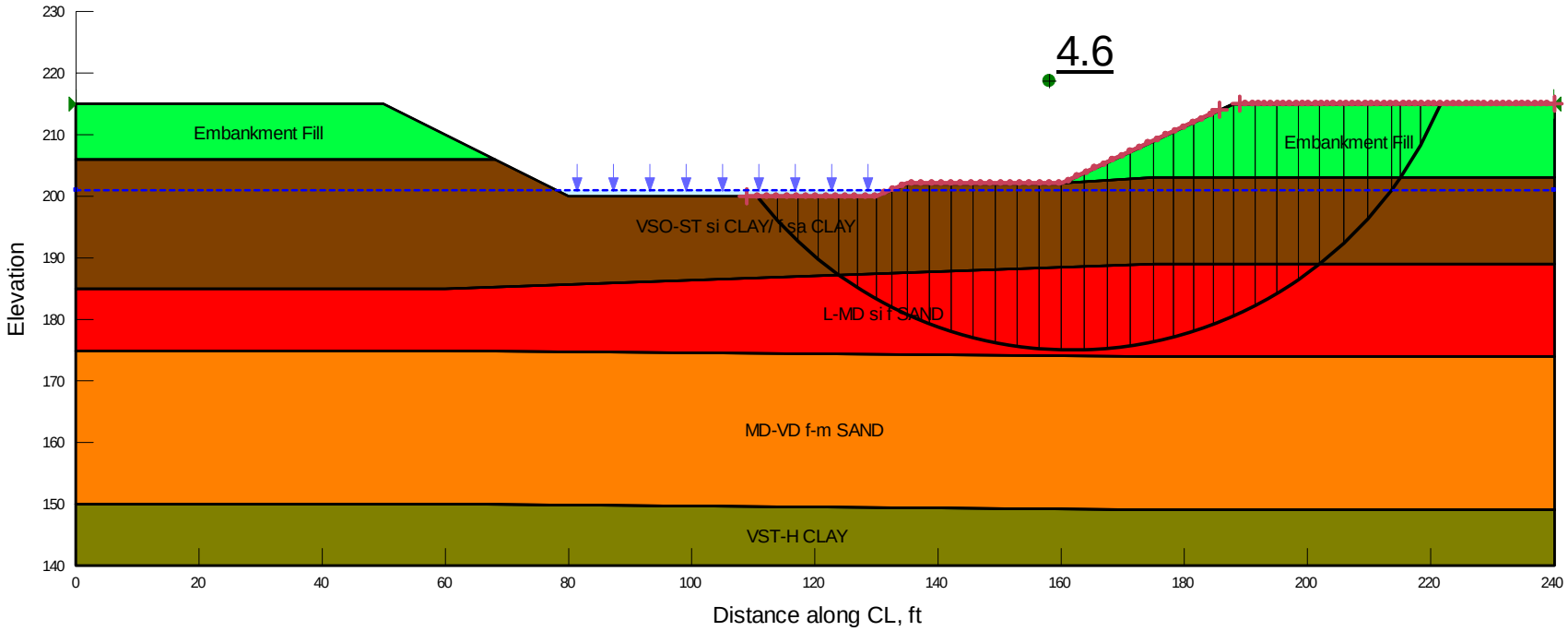
Results of Stability Analyses – Long Term Condition
Bent 1 Side Slope at Approximately Sta 161+83
2H:1V Slope, H=10 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



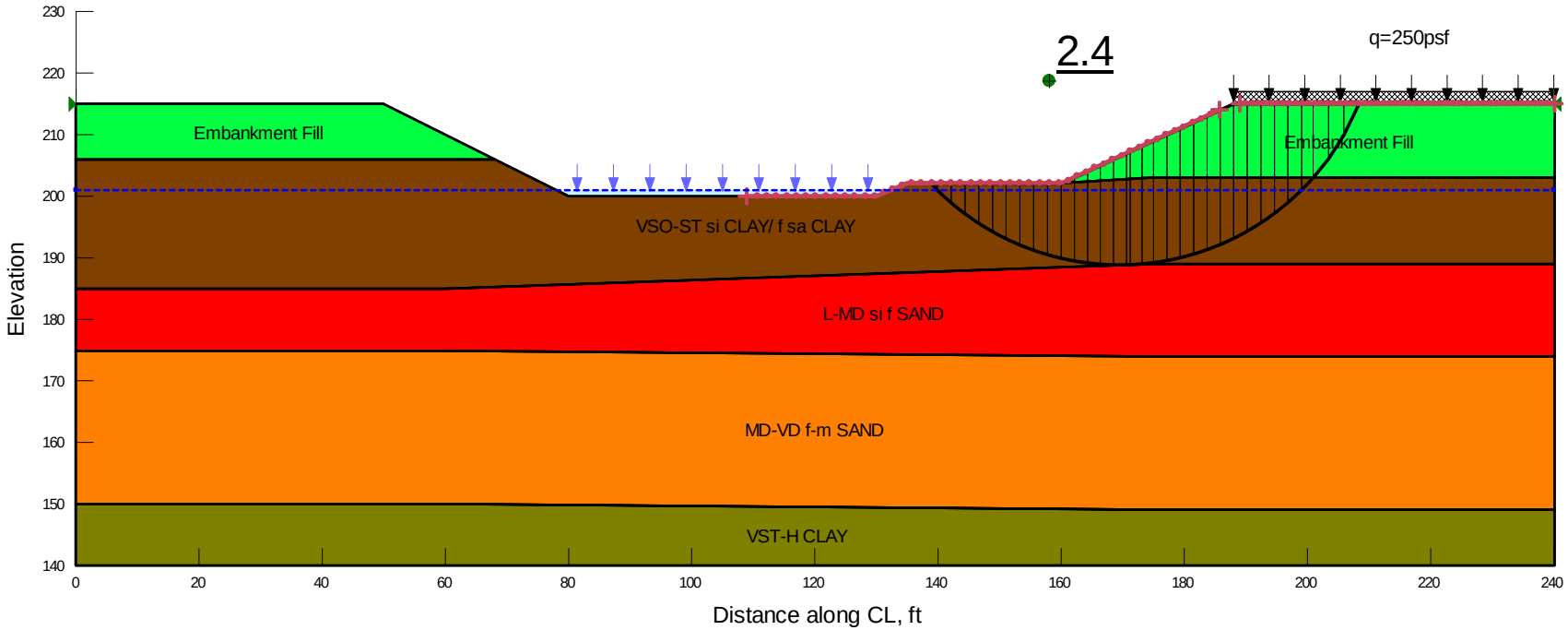
Results of Stability Analyses – Rapid Drawdown Condition, El 210 to Existing Grade
Bent 1 Side Slope at Approximately Sta 161+83
2H:1V Slope, H=10 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



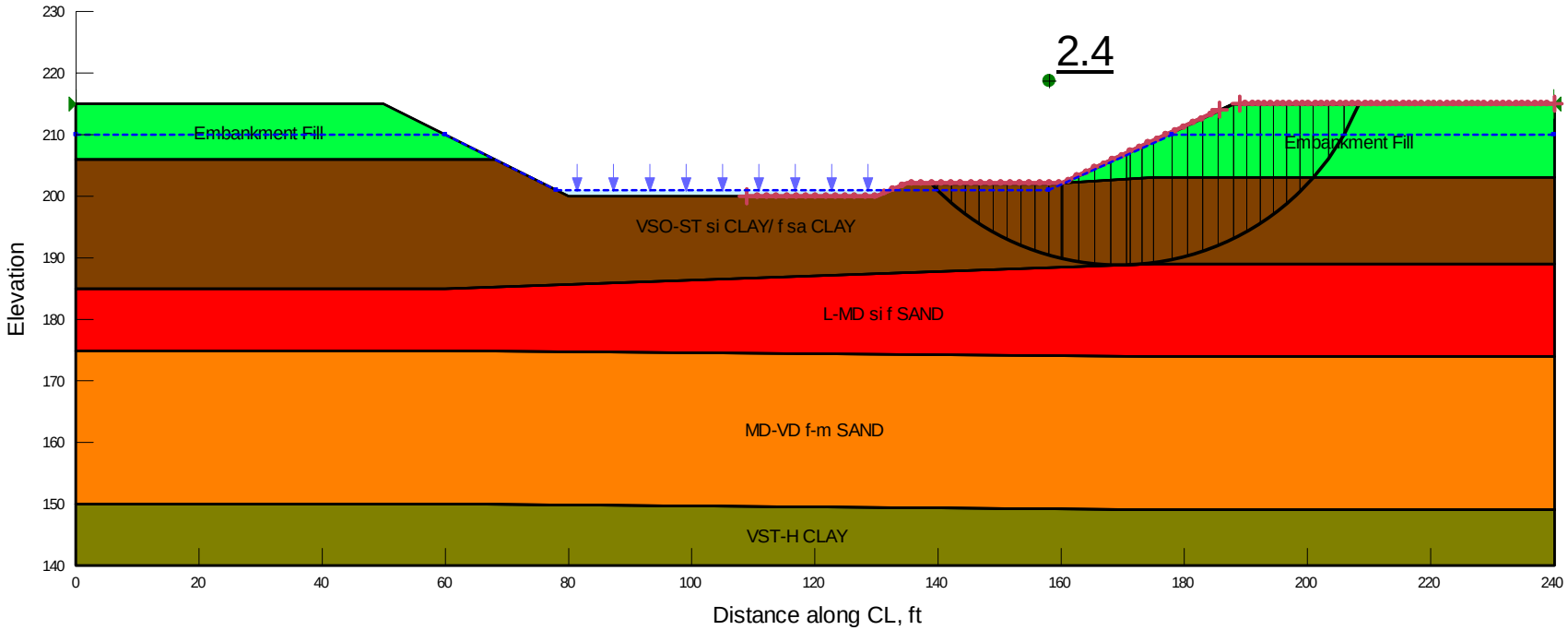
Results of Stability Analyses – Seismic Condition ($k_h = A_S /2 = 0.131$)
Bent 1 Side Slope at Approximately Sta 161+83
2H:1V Slope, H=10 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



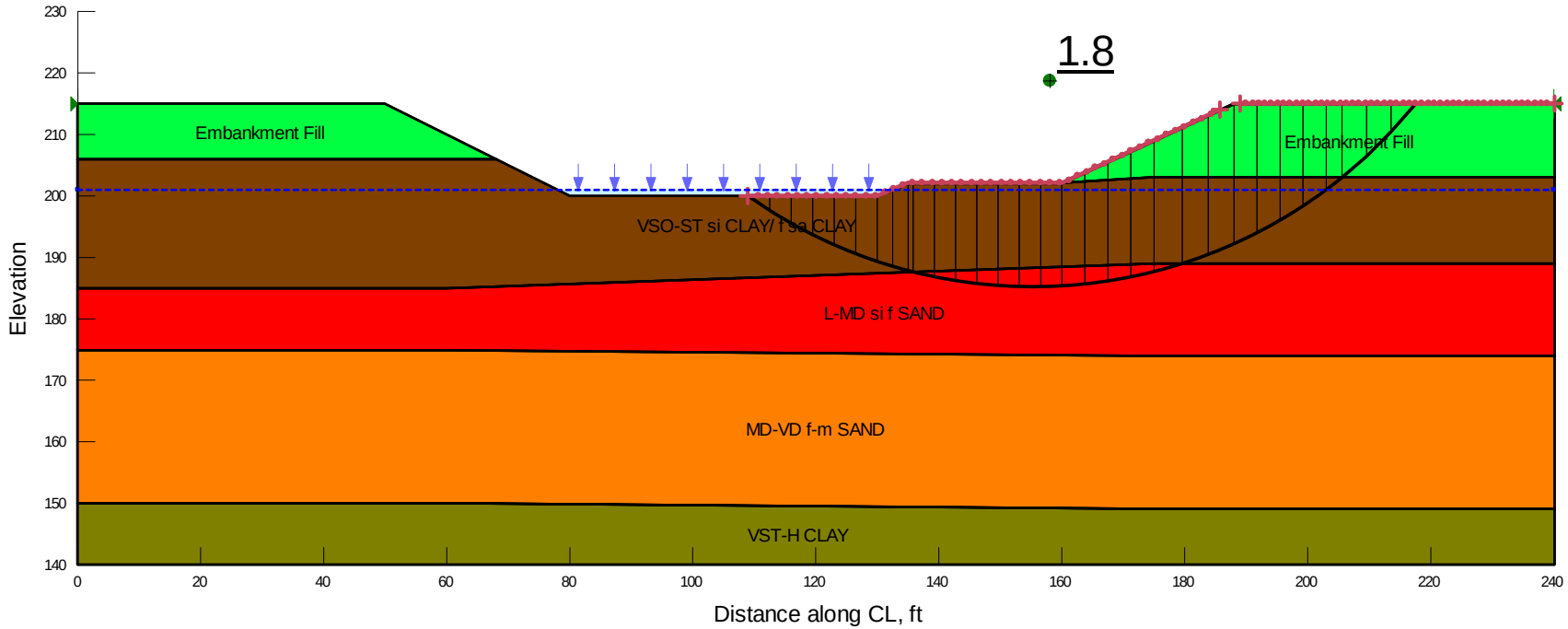
Results of Stability Analyses – End of Construction
Bent 4 End Slope at Approximately Sta 163+08
2H:1V Slope, H=13 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



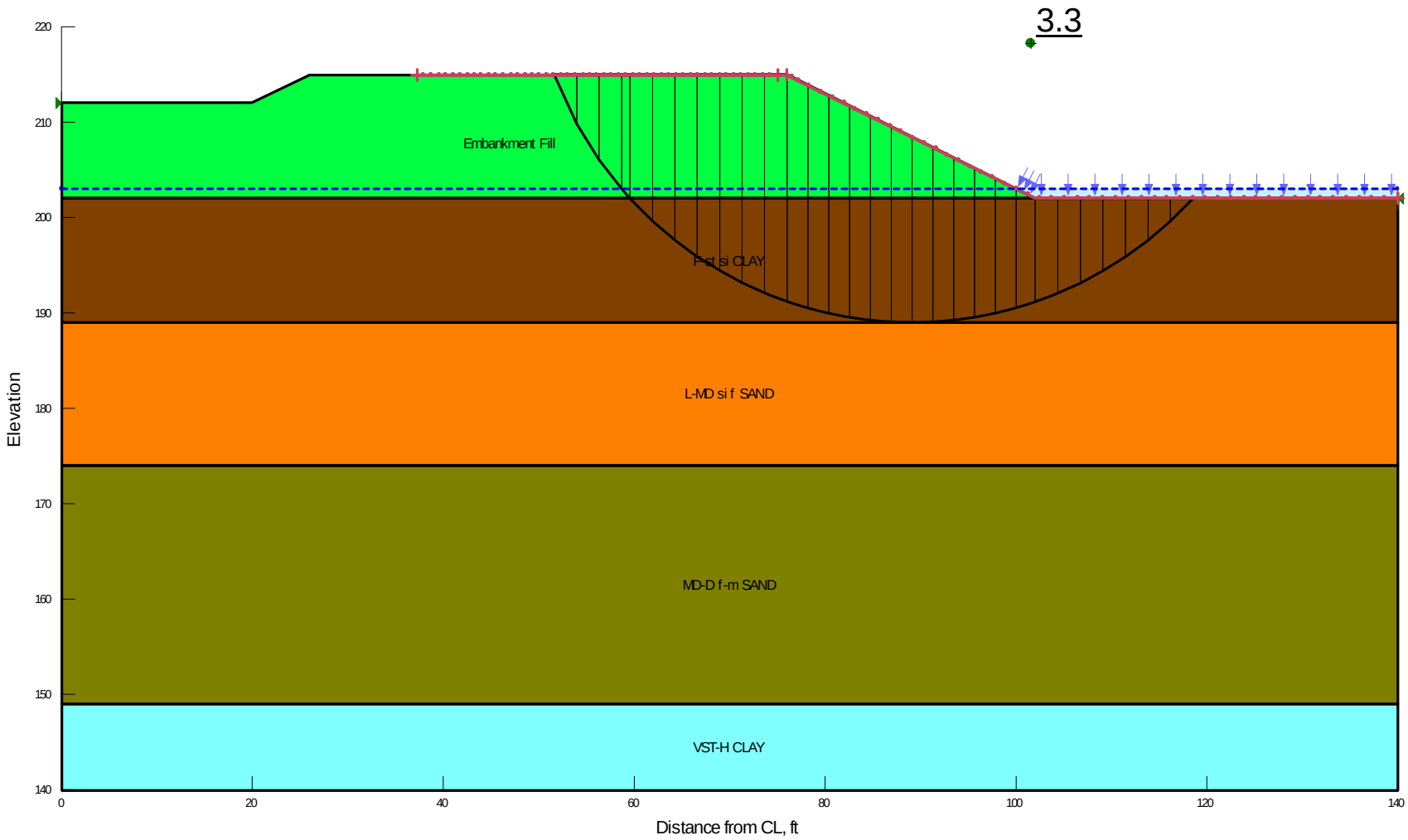
Results of Stability Analyses – Long Term Condition
Bent 4 End Slope at Approximately Sta 163+08
2H:1V Slope, H=13 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



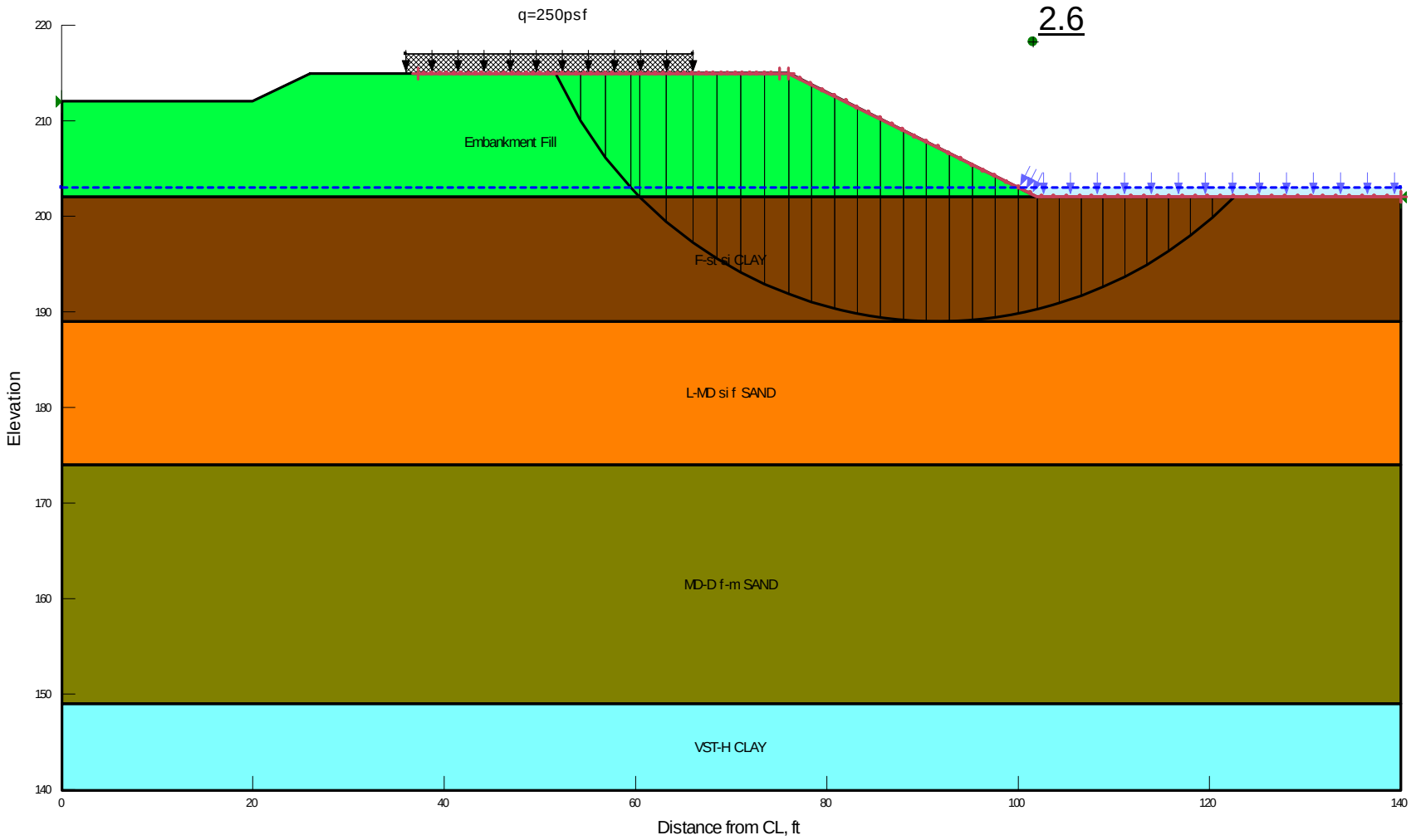
Results of Stability Analyses – Rapid Drawdown Condition, El 210 to El 203
Bent 4 End Slope at Approximately Sta 163+08
2H:1V Slope, H=13 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



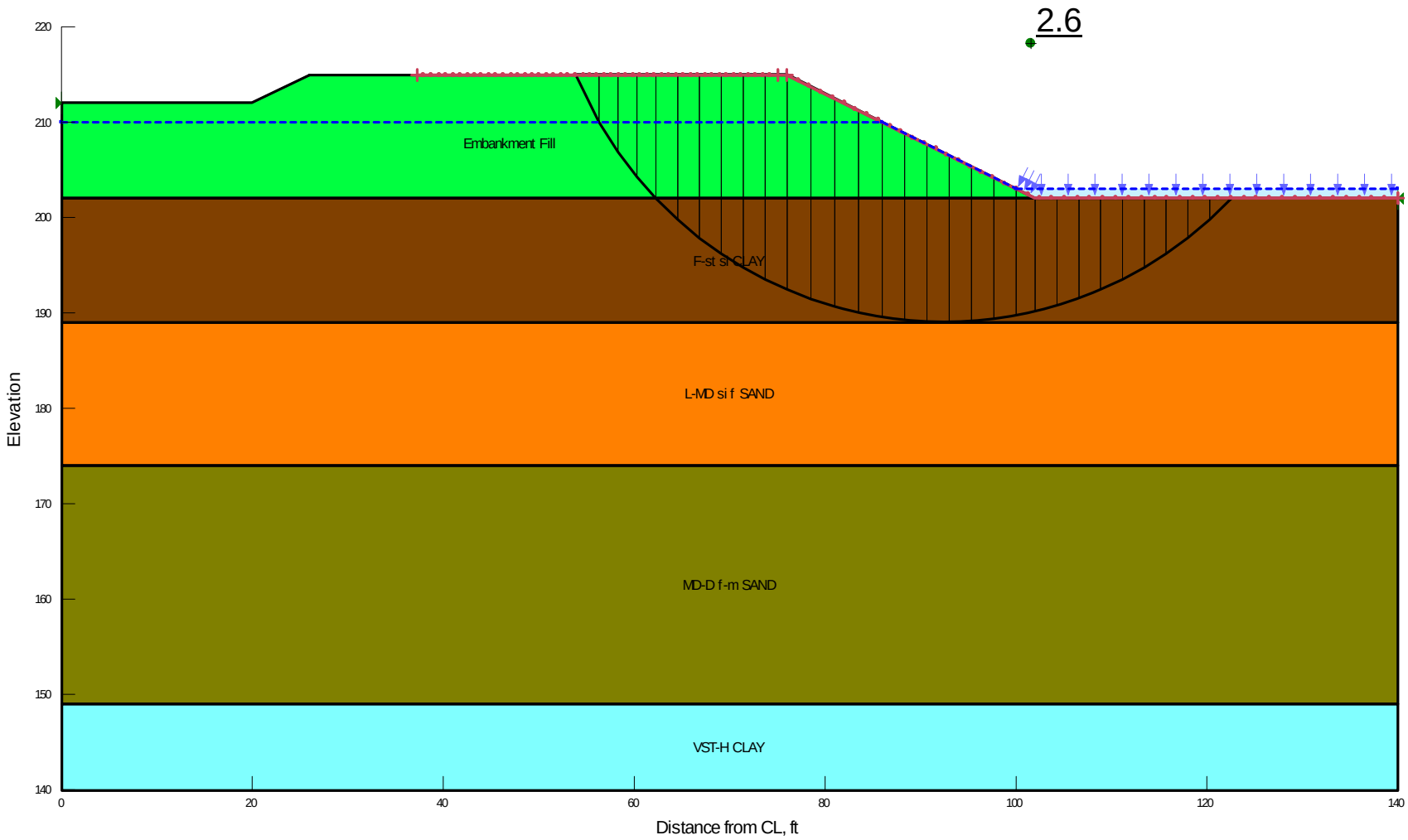
Results of Stability Analyses – Seismic Condition ($k_h = A_S /2 = 0.131$)
Bent 4 End Slope at Approximately Sta 163+08
2H:1V Slope, H=13 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



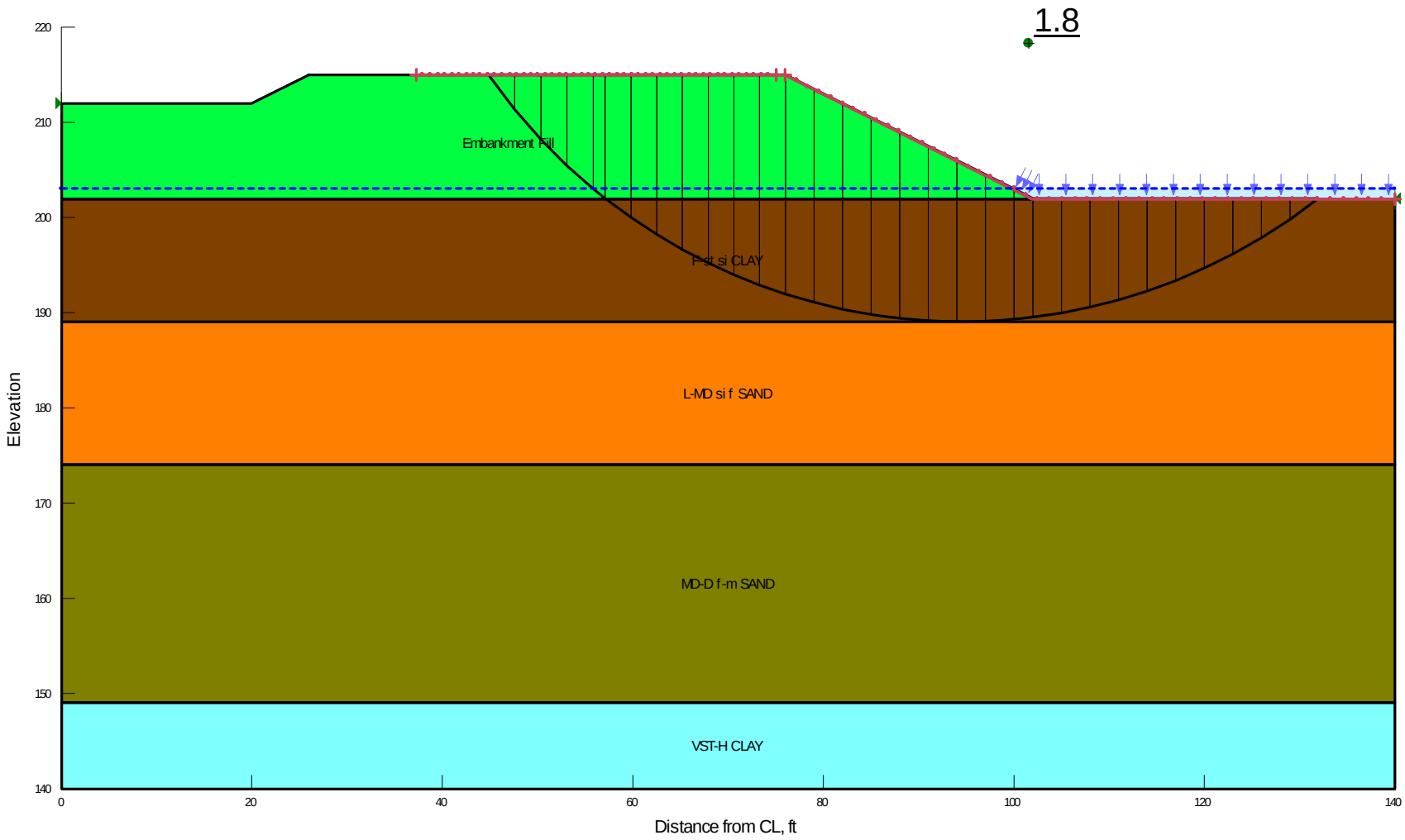
Results of Stability Analyses – End of Construction
Bent 4 Side Slope at Approximately Sta 163+08
2H:1V Slope, H=13 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



Results of Stability Analyses – Long Term Condition
Bent 4 Side Slope at Approximately Sta 163+08
2H:1V Slope, H=13 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



Results of Stability Analyses – Rapid Drawdown Condition, El 210 to El 203
Bent 4 Side Slope at Approximately Sta 163+08
2H:1V Slope, H=13 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough



Results of Stability Analyses – Seismic Condition ($k_h = A_S /2 = 0.131$)
Bent 4 Side Slope at Approximately Sta 163+08
2H:1V Slope, H=13 ft ±
18-077 – ARDOT Job No. 050342– Hwy. 31 over Red Cut Slough