FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
BRIDGE REPLACEMENT OVER THE LITTLE MIAMI SCENIC TRAIL
BRIDGE NO. GRE-42-0263
GRE-42-02.63/20.21
GREENE COUNTY, OHIO
PID#: 102746

Prepared For:

PALMER ENGINEERING COMPANY
8350 East Kemper Rd, Suite B
Cincinnati, Ohio 45249

Prepared by:

NATIONAL ENGINEERING AND ARCHITECTURAL SERVICES INC.
2800 Corporate Exchange Drive, Suite 240
Columbus, Ohio 43231

NEAS PROJECT 18-0020

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National Engineering & Architectural Services Inc.

EXECUTIVE SUMMARY

The Ohio Department of Transportation (ODOT) has proposed a bridge replacement project (GRE-42-02.63/20.21, PID 102746) which includes the replacement of the existing Bridge GRE-42-0263 located along State Route 42 (SR 42) about a half mile south of the village of Spring Valley in Greene County, Ohio. The proposed bridge replacement project is planned to consist of the replacement of the existing five span structure as well as roadway work along the project roadway segment.

National Engineering & Architectural Services, Inc. (NEAS) has been contracted to perform geotechnical engineering services for the project. The purpose of the geotechnical engineering services was to perform geotechnical explorations within the project limits to obtain information concerning the subsurface soil and groundwater conditions relevant to the design and construction of the project. Between December 16, 2019 and December 19, 2019, NEAS performed the subsurface exploration program for the project. The subsequent document presents the results of the structure foundation exploration with respect to the proposed replacement of Bridge GRE-42-0263. As part of the project, NEAS advanced 3 project borings and conducted laboratory testing to characterize the soils for engineering purposes.

The subsurface profile at the bridge site is relatively uniform and consistent with the geological model for the project. The subsurface profile generally consists of embankment fill soils underlain by alluvial deposits, followed by glacial outwash soils, all over glacial till. The referenced embankment fill soils consisted of both medium stiff to hard, cohesive material and loose to very dense non-cohesive material. The alluvial soils encountered underlying the embankment fill can be described as soft to hard cohesive material while the outwash encountered at the site consists predominantly of medium dense to very dense non-cohesive granular soils. Glacial till soils encountered at the site consisted of both very stiff to hard cohesive and very dense coarse- and fine-grained granular material. Bedrock was not encountered within depths of the borings performed at the bridge replacement site

A deep foundation system analysis was performed at the referenced bridge replacement site based on developed soil profiles at the boring locations. For the analyses, 14-inch closed-ended cast-in-place (CIP) friction pipe piles were considered at each substructure location. Based on loading information provided by Palmer Engineering via email on September 25, 2020, a maximum total factored load of 259 kips per pile was assumed at each abutment. To obtain the required UBV (pile resistance) at each abutment location, estimated pile lengths are anticipated to 50 ft with pile tip elevations ranging from 717 ft and 720 ft amsl. Analyses of pile drivability was conducted for the considered pile type and soil profiles. Based on our analysis using a Delmag D19-42 diesel hammer and minimum wall thicknesses calculated in accordance with the ODOT Construction and Materials Specifications (CSM), the piles would not be overstressed during the pile installation process. The stability of the proposed roadway embankments is not anticipated to be a concern, however, as sidehill fills are planned as part of the project, special benching may be required along certain sections of US-42 to blend proposed embankment soils with existing. In regards to settlement at the proposed bridge replacement site, settlement is not anticipated to be a concern as the majority of the settlement is anticipated to be immediate and the remaining consolidation settlement is anticipated to occur within the first 90 days following embankment construction. Furthermore, downdrag loads are not anticipated to be a concern at this project as the combined effect of the factored downdrag load and the sum of factored loads was determined to be well below the factored structural axial resistance of the subject piles.

It is our opinion that subgrade conditions are generally satisfactory, and pavement can be designed without the need for extreme levels of remediation. In general, it is recommended that the proposed subgrade soils of the project be “reworked” and prepared in accordance with typical Subgrade Compaction and Proof Rolling (Item 204) procedures and specifications.

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1. INTRODUCTION

1.1. General

National Engineering and Architectural Services Inc. (NEAS) presents our Structure Foundation Exploration Report for the proposed Bridge GRE-42-0263 replacement as part of the GRE-42-02.63/20.21 (PID 102746) project. The referenced bridge is located within Spring Valley Township, Greene County, Ohio and carries U.S. Route 42 (US-42) over the Little Miami Scenic Trail. This report presents: 1) a summary of the encountered surficial and subsurface conditions at the existing bridge site; 2) our recommendations for replacement bridge foundation design and construction in accordance with the Load and Resistance Factor Design (LRFD) method as set forth in AASHTO's Publication *LRFD Bridge Design Specifications, 8th Edition* (BDS) (AASHTO, 2017) and *ODOT's 2020 Bridge Design Manual* (BDM); and, 3) our recommendations for subgrade stabilization and pavement design parameters in accordance with ODOT's *Geotechnical Bulletin 1* (GB1) (ODOT [1], 2019) and *Pavement Design Manual* (PDM) (ODOT PDM, 2019).

The exploration for the referenced bridge replacement was conducted in general accordance with NEAS's proposal to Palmer Engineering Company, dated October 3, 2019 and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT, 2019).

The scope of work performed by NEAS as part of the referenced project included: a review of published geotechnical information; performing 3 total test borings; laboratory testing of soil samples in accordance with the SGE; performing geotechnical engineering analysis to assess foundation design and construction considerations; and development of this summary report.

1.2. Proposed Construction

The existing GRE-42-0263 bridge, originally built in 1955, consists of a five-span, reinforced concrete continuous slab bridge that is approximately 207 ft in length (abutment to abutment) with an approximate roadway width of 32 ft (railing to railing). The structure carries one lane of traffic in each direction (northbound and southbound) on a reinforced continuous concrete deck atop stub abutments and piers of varying type. Existing Pier 1 and Pier 4 consist of capped pile type piers, while Pier 2 and Pier 3 consist of cap and column type piers. Each substructure is supported on 12-inch diameter cast-in-place (CIP) reinforced concrete pipe piles.

It is our understanding that ODOT plans to replace the existing bridge (GRE-42-0263) with a single span, prestressed concrete beam bridge with a reinforced concrete deck atop semi-integral stub abutments that is approximately 138 ft in length (abutment to abutment). The proposed replacement will also include the addition of up to 20 ft of new embankment fill at the existing abutment locations as the overall bridge length is being shortened. The bridge is proposed to have an approximate roadway width of 32 ft (parapet to parapet). The proposed widened structures will likely be supported by a deep foundation system consisting of driven CIP reinforced concrete pipe piles.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Southern Ohio Loamy Till Plain, which is characterized by end and recessional moraines, commonly associated with boulder belts, between relatively flat-lying ground moraine, cut by steep-valleyed large streams with surface soils consisting of loamy till. Buried valleys are common and are generally filled with outwash and alternate between broad floodplains and narrows. Elevations of the region ranges from 530 to 1,150 ft above mean sea level (amsl), with moderate relief (200 ft). The geology within this region is described as loamy, high-lime Wisconsinan-age till, outwash and loess over Lower Paleozoic-age carbonate rocks (i.e., limestone or dolostone) and shales. (ODGS, 1998).

Based on the quaternary geology map of Ohio, the overburden soils at the site are made up of a combination of alluvium and alluvial terraces, Wisconsinan-age glacial outwash deposits, as well as late Wisconsinan-age end moraine loam till. The alluvium, deposited in present and former floodplains, consists of a range of material from silty clay in areas of fine-grained deposits to coarse sand, gravel or cobbles in areas of shallow bedrock. The Wisconsinan -age glacial outwash consists of undifferentiated deposits of sand and gravel occurring as valley terraces or low plains and is typically well sorted and stratified. The late Wisconsinan-age end moraine consists of hummocky ridges of loam till, typically higher than adjacent terrain, overlain by a thin layer (less than 3 ft) of loess (Pavey, et al., 1999).

Based on the Bedrock Geologic Units Map of Ohio (USGS & ODGS, 2006), bedrock within the project area consists of shale and limestone of the Grant Lake Formations, Undivided, generally underlain by either the Fairview Formation or Miamitown Shale, Undivided. This unit is comprised of Ordovician-age interbedded shale and limestone. The interbedded shale and limestone in this formation is described as gray to bluish-gray in color weathering light gray to yellowish-gray, planar to lenticular, and fossiliferous. The bedrock in this formation is thin to medium bedded in the lower half and thin to thick bedded in the upper half. Based on the ODNR bedrock topography map of Ohio, bedrock elevations at the bridge site can be expected to be at an approximate elevation of 550 ft amsl, putting bedrock at depths between 235 and 210 ft below ground surface (bgs).

The soils at the project site have been mapped (Web Soil Survey) by the Natural Resources Conservation Service (NRCS) (USDA, 2015) as Ockley silt loam (OcB) directly underlying the bridge site and as Ross loam (Rs) and Pits, gravel (Pg) immediately to the west and east of the bridge site, respectively. The Ockley series is described as very deep, well-drained stratified sandy and gravelly outwash formed in as much as 20 inches of loess or silty material and in underlying loamy outwash typically on stream terraces and outwash plains. Ockley soils are comprised of both coarse- and fine-grained soils and classify as A-1-a, A-2, A-4, A-6 and A-7-6 type soils according to the AASHTO method of soil classification. The Ross series is described as very deep, well-drained soils formed in loamy alluvium on flood plains and low terraces. Ross soils are comprised predominantly of fine-grained soils and classify as A-4, A-6 and A-7-6 type soils according to the AASHTO method of soil classification. Pits, gravels are characterized as soils that have been excavated for sand or gravel and are typically comprised of well-drained sand or sand and gravel.

2.2. Hydrology/Hydrogeology

At the bridge site, groundwater is anticipated to be near elevations consistent with that of the nearby Little Miami River (approximate elevation 740 ft amsl) located approximately 1200 ft west of the site. Although the indicated elevations may be generally representative of the local groundwater table, perched

groundwater systems may be existent due to the presence of fine-grained soils in areas making it difficult for groundwater to permeate to the natural phreatic surface.

The bridge site is located within both the 0.2% and 1% Annual Chance Flood Hazard area based on available mapping by the Federal Emergency Management Agency's (FEMA) National Flood Hazard mapping program (FEMA, 2016). The 1% Annual Chance Flood elevation at the bridge site is at an approximate elevation of 755 ft amsl.

2.3. Mining and Oil/Gas Production

No abandoned mines are noted on ODNR's Abandoned Underground Mine Locator within the immediate vicinity of the project's boundaries (ODNR [1], 2016).

No active oil or gas wells are noted on ODNR's Ohio Oil & Gas Locator within the immediate vicinity of the project's boundaries (ODNR [2], 2016).

2.4. Historical Records and Previous Phases of Project Exploration

The following report/plans were available for review and evaluation for this report:

- The original plans for the existing bridge previously designated as Bridge No. GR-42-26 were available for review as part of the GRE-42-1.90 Project prepared by the State of Ohio Department of Highways, approved February 15, 1954.

A historic record search was performed through ODOT's Geotechnical Data Management System (GeoMS); however, no geotechnical data or information were available for review within the project limits. Therefore, historic borings are not referenced within this report nor within the project developed Structure Foundation Exploration Sheets.

2.5. Site Reconnaissance

A field reconnaissance visit for Bridge GRE-042-02.63 was conducted on November 25, 2019, during which site conditions were noted and photographed. During our field reconnaissance, no geohazards were observed within the immediate vicinity of the proposed bridge site. Land use of the area surrounding the proposed bridge site can be described as a mix of wooded, residential and agricultural properties.

The existing bridge carrying US-42 over the Little Miami Scenic Trail consists of a five-span bridge supported on stub abutments and piers varying in type. The two center piers are cap and column type piers, while the two outer piers adjacent to the rear and forward abutments are capped pile type piers. At the referenced bridge site, US-42 is supported on embankments at both the rear and forward abutment locations. Existing embankment and spill-through slopes appeared to be approximately 2 Horizontal to 1 Vertical (2H:1V) with no signs of instability observed during our site visit. The spill-through slope adjacent to the rear abutment was observed to show minor signs of surface erosion (Photograph 1). The spill-through slope adjacent to the forward abutment appeared to be partially protected with concrete, though significant signs of surface erosion were observed initiating in areas that were not protected (Photograph 2). Overall, the bridge appeared to be in fair condition with no severe signs of distress. Signs of corrosion and concrete spalling were observed on the underside of the bridge deck with potential bridge deck repairs also observed (Photograph 3). No apparent signs of structural distress due to geotechnical concerns were noted during our field reconnaissance visit.

The concrete wearing course atop the bridge deck and approach slab were observed to be in good condition with occasional medium to high severity longitudinal cracking and spalling at the edges of the deck (Photograph 4). In general, the asphalt pavement leading to the bridge approaches appeared be in good condition with minimal signs of pavement distress. Pavement at the bridge site appeared to be generally well drained, with no signs of ponding or drainage issues observed during our field visit. Drainage was conveyed by open ditches located along the sides of US-42 with some drainage being directed down the spill-though slopes of the bridge along a swale protected by riprap (Photograph 5).

Photograph 1: Rear Abutment Slope

Photograph 2: Forward Abutment Slope

Photograph 3: Underside of Bridge Deck

Photograph 4: Bridge Deck Wearing Course Surface

Photograph 5: Spill-Through Slope with Drainage Swale Protection

3. GEOTECHNICAL EXPLORATION

3.1. Field Exploration Program

The exploration for the proposed bridge replacement was conducted by NEAS between December 16, 2019 and December 19, 2019 and included 3 borings drilled to depths between 21.5 and 86.5 ft bgs. The boring locations were selected by NEAS in general accordance with the guidelines contained in the SGE with the intent to evaluate subsurface soil and groundwater conditions. Bridge borings (B-001-0-18 and B-002-0-18) were located near proposed substructure locations while the roadway embankment boring (B-003-0-18) was located near the existing forward abutment location. Borings were performed in locations that were not restricted by, underground utilities or dictated by terrain (i.e. steep embankment slopes). Each as-drilled project boring location and corresponding ground surface elevation was surveyed in the field by NEAS (project surveyor) following completion. Each individual project boring log (included within Appendix B) includes the recorded boring latitude and longitude location (based on the surveyed Ohio State Plane South, NAD83, location) and the corresponding ground surface elevation. A summary of the referenced bridge borings including depth, location, elevation and type is presented in Table 1 below.

Table 1: Project Boring Summary

Boring Number	Location (Sta/Offset)	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)	Boring Type
B-001-0-18	44+81, 11' RT.	39.602838	-84.009867	778.1	86.5	Bridge (Rear Abutment)
B-002-0-18	46+83, 24' LT.	39.603086	-84.009213	763.6	61.5	Bridge (Forward Abutment)
B-003-0-18	47+55, 11' RT.	39.603052	-84.008931	786.7	21.5	Roadway/Subgrade (Existing Embankment)

Notes:
1. As-drilled boring location and corresponding ground surface elevation was surveyed in the field by NEAS Inc.

Borings were drilled using a CME 55X track mounted drilling rig utilizing 3.25-inch diameter hollow stem augers. In general, soil samples were recovered at intervals of 2.5-ft to depths between 20 and 35 ft bgs and at 5.0-ft intervals thereafter using a split spoon sampler (AASHTO T-206 "Standard Method for Penetration Test and Split Barrel Sampling of Soils."). Samples collected from the top 9 ft of borings B-001-0-18 and B-003-0-18 were sampled continuously for subgrade evaluation purposes. The soil samples obtained from the exploration program were visually observed in the field by the NEAS field representative and preserved for review by a Geologist and possible laboratory testing. Standard penetration tests (SPT) were conducted using a CME auto hammer that has been calibrated to be 82% efficient as indicated on the boring logs.

Field/boring logs were prepared by drilling personnel, and included lithological description, SPT results recorded as blows per 6-inch increment of penetration and estimated unconfined shear strength values on specimens exhibiting cohesion (using a hand-penetrometer). Groundwater level observations were recorded both during and after the completion of drilling. These groundwater level observations are included on the individual boring logs. After completing the borings, the boreholes were backfilled with either auger cuttings, bentonite chips, or a combination of these materials, and patched with cold patch asphalt and/or quickset concrete where necessary and appropriate.

3.2. Laboratory Testing Program

The laboratory testing program consisted of classification testing, moisture content determinations, consolidation testing and direct shear testing. The individual laboratory data sheets and results are included in Appendix B. Additionally, data from the laboratory testing program were incorporated onto the boring logs. Soil samples are retained at the laboratory for 60 days following report submittal, after which time they will be discarded.

3.2.1. Classification Testing

Representative soil samples were selected for index properties (Atterberg Limits) and gradation testing for classification purposes on approximately 39% of the samples. At each boring location, samples were selected for testing with the intent of identification and classification of all significant soil units. Soils not selected for testing were compared to laboratory tested samples/strata and classified visually. Moisture content testing was conducted on all samples. The laboratory testing was performed in general accordance with applicable AASHTO specifications.

A final classification of the soil strata was made in accordance with AASHTO M-145 "Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes," as modified by ODOT "Classification of Soils" once laboratory test results became available. The results of the soil classification are presented on the boring logs provided in Appendix B.

3.2.2. Standard Penetration Test Results

Standard Penetration Tests (SPT) and split-barrel (commonly known as split-spoon) sampling of soils were performed at varying intervals (i.e., continuous, 2.5-ft or 5.0-ft intervals) in the project borings performed. To account for the high efficiency (automatic) hammers used during SPT sampling, field SPT N-values were converted based on the calibrated efficiency (energy ratio) of the specific drill rig's hammer. Field N-values were converted to an equivalent rod energy of 60% (N_{60}) for use in analysis or for correlation purposes. The resulting N_{60} values are presented on the boring logs provided in Appendix B.

3.2.3. Consolidation Testing

One (1) consolidation tests was performed in accordance with ASTM D 2435-04 "Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading". Consolidation testing was performed on a relatively undisturbed cohesive soil sample collected from boring B-001-0-18. The results of the test are presented in Table 3 below, while the laboratory testing report is included within Appendix B.

Table 2: Consolidation Test Results

Boring Number	Depth (ft)	Elevation (ft)	Compression Index (Cc)	Recompression Index (Cr)	Preconsolidation Pressure (psf)	Void Ratio
B-001-0-18	14.1 - 14.2	764.0 - 763.9	0.055	0.006	6,000	0.322

4. GEOTECHNICAL FINDINGS

The subsurface conditions encountered during NEAS's explorations are described in the following subsections and on each boring log presented in Appendix B. The boring logs represent NEAS's interpretation of the subsurface conditions encountered at each boring location based on our site observations, field logs, visual review of the soil samples by NEAS's geologist, and laboratory test results. The lines designating the interfaces between various soil strata on the boring logs represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The subsurface soil and groundwater characterizations included herein, including summary test data, are based on the subsurface findings from the geotechnical explorations performed by NEAS as part of the referenced project, and consideration of the geological history of the site.

4.1. Subsurface Conditions

The subsurface profile at the bridge site is relatively uniform and consistent with the geological model for the project. The subsurface profile generally consists of embankment fill soils underlain by alluvial deposits, followed by glacial outwash soils, all over glacial till. The referenced embankment fill soils consisted of both medium stiff to hard, cohesive material and loose to very dense non-cohesive material. The alluvial soils encountered underlying the embankment fill can be described as soft to hard cohesive material while the outwash encountered at the site consists predominantly of medium dense to very dense non-cohesive granular soils. Glacial till soils encountered at the site consisted of both very stiff to hard cohesive and very dense coarse- and fine-grained granular material. Bedrock was not encountered within depths of the borings performed at the bridge site.

4.1.1. Overburden Soil

At the proposed bridge replacement site, four different subsurface materials were encountered. Those materials consisted of: 1) "man-made" fill soils; 2) natural alluvially deposited soils; 3) glacial outwash deposits; and, 4) glacial till soils. These materials and the general profile are further described below.

Fill soils were encountered in the project borings performed at the bridge side at the ground surface and extended to depths between 14.5 ft and 27 ft bgs (elevations 765.2 and 750.6 ft amsl). Based on laboratory testing results and a visual review of the fill samples obtained, the fill at the site is comprised of both cohesive and non-cohesive soils. The cohesive fill soils encountered are classified on the boring log as

Sandy Silt (A-4a), Silt and Clay (A-6a), Silty Clay (A-6b) and Clay (A-7-6). This cohesive material can be described as having a medium stiff to hard consistency based on converted SPT-N (N_{60}) values between 8 and 14 blows per foot (bpf) and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 1.5 and in excess of 4.5 tons per square foot (tsf). Natural moisture contents of the cohesive fill ranged from 8 to 23 percent. Based on Atterberg Limits test performed on representative samples of the cohesive fill soils, the liquid and plastic limits ranged from 21 to 42 percent and from 14 to 20 percent, respectively. The non-cohesive fill soils encountered are classified on the boring logs as Gravel with Sand (A-1-b), Coarse and Fine Sand (A-3a), Sandy Silt (A-4a) and Silt and Clay (A-6a). These non-cohesive fill soils be described as having a relative compactness of loose to very dense based on N_{60} values between 10 and 59 bpf. Moisture contents of the non-cohesive fill soils ranged from 9 to 14 percent.

The soil stratum encountered immediately beneath the fill in borings B-001-0-18 and B-002-0-18 generally consisted of natural alluvial soils and extended to depths between 30.8 and 48.3 ft bgs (elevations 732.9 and 729.9 ft amsl). Based on laboratory testing results and a visual review of the natural alluvial soil samples obtained, this strata is comprised of cohesive soils that are classified on the boring logs as Sandy Silt (A-4a), Silt and Clay (A-6a), Silty Clay (A-6b) and Clay (A-7-6). The cohesive alluvium can be described as having a consistency ranging from soft to hard correlating to N_{60} values between 11 and 31 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 0.25 and in excess of 4.5 tsf. Natural moisture contents of the alluvial soils ranged from 12 to 35 percent. Based on Atterberg Limits test performed on representative samples of the alluvial soils, the liquid and plastic limits ranged from 24 to 35 percent and from 15 to 22 percent, respectively.

The glacial outwash soils encountered underlying the alluvial soils at the site (borings B-001-0-18 and B-002-0-18) extended to depths between 40.8 and 78.3 ft bgs (elevations 722.9 and 699.8 ft amsl) and was comprised predominantly of granular material that is classified on the boring logs as Gravel and Stone Fragments with Sand (A-1-b), Gravel and Stone Fragments with Sand and Silt (A-2-4), and Coarse and Fine Sand (A-3a). The relative compactness of the non-cohesive glacial outwash can generally be described as medium dense to very dense correlating to N_{60} values between 30 and 67 bpf. Natural moisture contents of the outwash ranged from 9 to 17 percent.

The soil stratum encountered beneath the outwash deposits generally consisted of glacial till comprised of stratified cohesive fine-grained soil and non-cohesive coarse- and fine-grained soil. The till soils extended to borehole termination depths in each boring in which it was encountered (borings B-001-0-18 and B-002-0-18) at depths ranging from 61.5 to 86.5 ft bgs (elevations 702.1 to 691.6 ft amsl). The cohesive till encountered is classified on the borings logs as Sandy Silt (A-4a) and Silt and Clay (A-6a). The cohesive soils in this stratum can be described as having a very stiff to hard consistency based on N_{60} values between 37 and 50 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 2.25 and in excess of 4.5 tsf. Natural moisture contents of the cohesive soil in this stratum ranged from 11 to 14 percent. Based on Atterberg Limits test performed on a representative sample of the cohesive till, the liquid and plastic limits were estimated to be 25 percent and 15 percent, respectively. The non-cohesive till soils encountered are classified on the boring logs as Coarse and Fine Sand (A-3a), Sandy Silt (A-4a), and Silt (A-4b). These non-cohesive soils are described as having a relative compactness of very dense correlating to N_{60} values between 59 and 74 bpf. The natural moisture content of the non-cohesive till ranged from 12 to 15 percent.

4.1.2. Groundwater

Groundwater measurements were taken during the boring drilling procedures and are reported on the project boring logs (Appendix B). Groundwater was encountered during drilling in each of the project bridge borings performed at the site (borings B-001-0-18 and B-002-0-18). Based on these borings, groundwater was encountered at depths between 23 and 45 ft bgs (between elevations 740.6 and 733.2 ft amsl).

It should be noted that groundwater is affected by many hydrologic characteristics in the area and may vary from those measured at the time of the exploration.

5. ANALYSIS AND RECOMMENDATIONS

We understand that the existing five-span bridge structure along US-42 crossing the Little Miami Scenic Trail (GRE-42-0263) in Greene County, Ohio is proposed to be replaced with a new structure. It is also our understanding that roadway work along US-42 near the existing bridge approaches is planned to be performed. Based on the Stage 2 Pan Set dated March 6, 2020 for the referenced replacement structure, the existing bridge will be replaced with a new single span bridge structure designated as GRE-42-0263 (over the Little Miami Scenic Trail). The new bridge deck will be constructed on semi-integral, stub type abutments supported by the natural subsurface material through a deep foundation system consisting of 14-inch diameter driven, closed-ended CIP pipe piles. For this purpose, a deep foundation system analysis was performed at the replacement bridge site. Additionally, as roadway work is also planned as part of the proposed project (i.e., approach pavement replacement and addition of new embankment fill), subgrade, embankment stability and settlement analyses were performed.

For deep foundation analysis purposes, the proposed bearing elevation for each substructure was based on the elevations shown in the referenced Stage 2 Pan Set, while design pile loads are based on design information provided by Palmer Engineering via email on September 25, 2020. The driven pile foundation will be designed according to LRFD BDS (AASHTO, 2017) and ODOT BDM (ODOT [1], 2020) criteria. The subgrade analysis was performed in accordance with ODOT's Geotechnical Bulletin 1 (GB1) to estimate pavement design parameters to be used for pavement section design as well as provide recommendations regarding proposed subgrade stabilization. Embankment stability analysis was performed to evaluate the impact that the planned alterations may have on the global stability of the existing and/or proposed embankment slopes at the site, while settlement/downdrag analysis was performed to evaluate the impact the settlement may have on the proposed construction.

Based on our evaluation of the subsurface conditions and our geotechnical engineering analyses of the proposed bridge replacement project, it is our opinion that the bridge foundations can be supported on driven pile foundation as indicated in Section 5.2 of this report. Furthermore, settlement and downdrag is not anticipated to be a concern at the bridge replacement site as the majority of the settlement is anticipated to be immediate and the remaining consolidation settlement is anticipated to occur within the first 90 days following embankment construction. The stability of the proposed roadway embankments is not anticipated to be a concern, however, as sidehill fills are planned as part of the project, special benching may be required along certain sections of US-42 to blend proposed embankment soils with existing. With respect to proposed roadway subgrade preparation, it is our opinion that subgrade conditions are generally satisfactory, and pavement can be designed without the need for extreme levels of remediation. In general, it is recommended that the proposed subgrade soils of the project be "reworked" and prepared in accordance with typical Subgrade Compaction and Proof Rolling (Item 204) procedures and specifications. The following sections provide further detail about the analyses performed and associated recommendations.

5.1. Soil Profile for Analysis

For analysis purposes, each substructure location was reviewed, and a generalized material profile was developed for analysis. Utilizing the generalized soil profile, engineering properties for each soil strata were estimated based on the field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory (i.e., Atterberg Limits, grain size, etc.) test results using correlations provided in published engineering manuals, research reports and guidance documents. The developed soil profile and estimated engineering soil properties for use in analysis (with sited correlation/reference material) is summarized within Tables 3 through 5 below.

Table 3: Soil Profile and Estimated Engineering Properties - At Boring B-001-0-18

Bridge GRE-42-0263: Rear Abutment, B-001-0-18					
Soil Description	**Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**	**Setup Factor (f_{su})**
Sandy Silt Elevation (778.1 ft - 770.6 ft)	115	-	-	34	1.2
Silt and Clay Elevation (770.6 ft - 768.6 ft)	112	1750	200	24	1.5
Sandy Silt Elevation (768.6 ft - 743.6 ft)	135	2600	250	27	1.2
Silt and Clay Elevation (743.6 ft - 739.8 ft)	128	3750	300	28	1.5
Clay Elevation (739.8 ft - 734.8 ft)	120	1350	150	22	2.0
Silt and Clay Elevation (734.8 ft - 729.8 ft)	125	3100	250	27	1.5
Coarse and Fine Sand Elevation (729.8 ft - 724.8 ft)	120	-	-	30	1.0
Gravel with Sand Elevation (724.8 ft - 699.8 ft)	132	-	-	36	1.0
Silt and Clay Elevation (699.8 ft - 691.6 ft)	130	5400	350	31	1.5

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 4: Soil Profile and Estimated Engineering Properties - At Boring B-002-0-18

Bridge GRE-42-0263: Forward Abutment, B-002-0-18					
Soil Description	**Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**	**Driving A Pile Reduction Factor**
Gravel with Sand Elevation (763.6 ft - 760.6 ft)	110	-	-	35	1.0
Sandy Silt Elevation (760.6 ft - 758.1 ft)	110	1350	150	24	1.2
Silty Clay Elevation (758.1 ft - 749.1 ft)	120	1600	150	23	1.75
Sandy Silt Elevation (749.1 ft - 746.6 ft)	128	3600	300	29	1.2
Silty Clay Elevation (746.6 ft - 744.1 ft)	128	3850	300	28	1.75
Silt and Clay Elevation (744.1 ft - 732.9 ft)	125	3000	250	27	1.5
Gravel with Sand and Silt Elevation (732.9 ft - 730.3 ft)	140	-	-	36	1.2
Coarse and Fine Sand Elevation (730.3 ft - 725.3 ft)	128	-	-	35	1.0
Gravel with Sand and Silt Elevation (725.3 ft - 722.9 ft)	132	-	-	36	1.2
Sandy Silt Elevation (722.9 ft - 715.3 ft)	135	6300	400	34	1.2
Coarse and Fine Sand Elevation (715.3 ft - 712.6 ft)	135	-	-	36	1.0
Silt Elevation (712.6 ft - 711.6 ft)	135	-	-	36	1.5
Sandy Silt Elevation (711.6 ft - 702.1 ft)	140	-	-	36	1.2

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$ <52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 5: Soil Profile and Estimated Engineering Properties - At Boring B-003-0-18

Bridge GRE-42-0263: Embankment Stability, B-003-0-18				
Soil Description	**Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**
Sandy Silt Elevation (786.7 ft - 767.2 ft)	122	-	-	32
Clay Elevation (767.2 ft - 765.2 ft)	120	1500	150	22

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$ <52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

For settlement analysis purposes, the generalized soil profile estimated at each boring location was reviewed and soil layers from each of the borings with similar behavior (i.e., cohesive or non-cohesive/granular) and characteristics (i.e., relative compactness/consistency, moisture content, etc.) were grouped into generalized soil units (i.e., Soil Types) and weighted average values of the estimated engineering soil properties were assigned to each Soil Type to develop a generalized soil profile for settlement analysis. The summary of the settlement parameters (with sited correlation/reference material) developed for each Soil Type are presented in Table 6, below.

Table 6: Settlement Parameters for Analysis

US-42 Embankment Fill: Settlement Analysis, B-001-0-18, B-002-0-18, B-003-0-18								
Soil Description	Unit Weight (pcf)	Elastic Modulus[1] (psf)	Poissons Ratio[1], v	Void Ratio e_o	Compression Index[2], C_c	Recompression Index[3], C_r	OCR[4]	Coeff. of Consol.[5], C_v
Soil Type 1 Elevation (786.8 ft - 756.2 ft)	125	174800	0.23	-	-	-	-	-
Soil Type 2 Elevation (775.8 ft - 750.7 ft)	118	742500	0.40	0.638	0.17	0.034	4.0	0.60
Soil Type 3 Elevation (765.3 ft - 729.9 ft)	140[6]	1677000	0.45	0.322[6]	0.055[6]	0.006[6]	6.0	0.60[6]
Soil Type 4 Elevation (743.4 ft - 699.9 ft)	130	567500	0.36	-	-	-	-	-
SoilType 5 Elevation (699.9 ft - 691.7 ft)	140[6]	2000000	0.50	0.322[6]	0.055[6]	0.006[6]	6.0	0.60[6]
Soil Type 6 Elevation (725.9 ft - <691.7 ft)	135	360000	0.35	-	-	-	-	

Notes:
1. *Values interpreted from 2017 AASHTO LRFD BDS Table C10.4.6.3-1*
2. *Values calculated from Kulhawy and Mayne, 1990, Equation 6-6.*
3. *Values calculated from Kulhawy and Mayne, 1990, Equation 6-9.*
4. *Values interpreted from Mayne and Kemper, 1988, Figure 7.*
5. *Values interpreted from FHWA GEC No. 5, Boeckmann, et al., 2016, Figure 6-37.*
6. *Based on laboratory test results of material similar in composition and consistency.*

In addition to the Soil Type parameters presented above, a graphical depiction of the generalized subsurface profile is located within Appendix C. The generalized subsurface profile includes: a color coded general interpretation of the Soil Types between borings, a graphical interpretation of the soil strata identified by the project soil borings along the referenced roadway profile, representative boring data (N_{60}-values, moisture contents, and groundwater levels), current ground surface elevation, proposed fill, and proposed bridge substructure locations. Additionally, as shown in the referenced generalized subsurface profile, it is anticipated that the bridge replacement project will require varying heights of new embankment fill. In absence of other guidance relating to soil properties of proposed embankment fills, the soil parameters of the new fill were assumed to be consistent with those recommended in the ODOT BDM Table 307-1 for "On-site soil varying from sandy lean clay to silty sand" and are presented in Table 7 below.

Table 7: Design Parameters for New Fill Soils

New Embankment Fill Soil Parameters			
Type of Soil	Soil Unit Weight (pcf)	Friction Angle (°)	Cohesion (psf)
On-site soil varying from sandy lean clay to silty sand	120	30	0

Notes:
1. *Per Section 204.6.2.1 of the ODOT BDM*

5.1. Parameters for Lateral Load Analysis

Deep foundation elements subjected to horizontal loads and/or moments should be analyzed for maximum bending moments and lateral deflections. The required structural resistance to lateral load can be obtained by increasing the diameter or the embedment depth of the foundation element. The generalized soil parameters, including recommended lateral soil modulus, and soil/ strain to be used to analyze the laterally loaded piles by the p-y curve method are presented in Table 8, below.

Table 8: Generalized Soil Parameters for Lateral Load Analysis

LPILE Parameters For Soil and Intermediate Geo-Materials							
Boring Number	p-y model	Elevation (ft amsl)	Effective Unit Weight (pcf)	Friction Angle	Undrained Shear Strength (psf)	Lateral Soil Modulus Parameter, k (pci)	Soil Strain Parameter, E_{50} (%)
B-001-0-18	Sand (Reese)	778.1 - 770.6	125	34	-	140	-
	Stiff Clay w/o Water	770.6 - 763.6	120	23	1,350	420	0.0077
	Sand (Reese)	763.6 - 756.1	128	33	-	105	-
	Stiff Clay w/o Water	756.1 - 750.6	118	23	1,150	310	0.0085
	Stiff Clay w/o Water	750.6 - 739.8	128	28	3,650	1215	0.0047
	Stiff Clay w/o Water	739.8 - 734.8	120	22	1,350	420	0.0077
	Stiff Clay w/o Water	734.8 - 729.8	83.8	27	3,100	1040	0.0050
	Sand (Reese)	729.8 - 724.8	57.6	29	-	25	-
	Sand (Reese)	724.8 - 699.8	69.6	36	-	125	-
	Stiff Clay with Water	699.8 - 691.6	67.6	30	4,600	1,540	0.0043
B-002-0-18	Sand (Reese)	763.6 - 760.6	120	35	-	175	-
	Stiff Clay w/o Water	760.6 - 749.1	120	23	1,600	540	0.0070
	Stiff Clay with Water	749.1 - 732.9	95.1	27	3,350	1,125	0.0048
	Sand (Reese)	732.9 - 722.9	69.6	36	-	125	-
	Stiff Clay with Water	722.9 - 715.3	72.6	34	6,000	2,000	0.0039
	Sand (Reese)	715.3 - 702.1	72.6	36	-	125	-

5.2. Bridge Foundation Analysis and Recommendations

A foundation review was completed for a deep foundation pile system for the referenced bridge replacement based on the design information within: 1) the Stage 2 Pan Set, prepared by Palmer Engineering dated March 6, 2020; 2) historical plans; and 3) pile loads provided by Palmer via email on September 25, 2020. A deep pile foundation will be designed according to LRFD and ODOT BDM criteria. Utilizing the computer program *Driven* developed by Federal Highway Administration (FHWA), a static pile analysis was performed to estimate required driven pile lengths needed to achieve the Ultimate Bearing Value (UBV) for a single pile. Input information for the Driven program was based on the soil characteristics gathered during the geotechnical exploration (i.e., SPT results, laboratory test results, etc.) and our geotechnical experience. Tables 3 and 4 in Section 5.1. of this report present each soil strata and their engineering properties that were used in the analysis. Groundwater elevation used in the analysis was assumed to match that of each boring per substructure as encountered during our field investigation and as shown on each individual boring log (Appendix B). Additionally, pile drivability was evaluated using the computer program GRLWEAP developed by GRL Engineers, Inc.

Based on our evaluation of the subsurface conditions and our geotechnical engineering analysis of the proposed bridge widening project, it is our opinion that the proposed bridge foundations can be supported on driven 14-inch diameter CIP pipe piles. Based on the pile loading information provided by Palmer on September 25, 2020, a maximum total factored load of 259 kip per pile was assumed for both abutment locations. Utilizing the reference design loads, the piles will be friction piles and it is our opinion they will be seated within the hard/dense to very dense natural subsurface material at elevations between 717 and 720 ft amsl.

5.2.1. Deep Foundation Analysis

Based on the determined soil profile and our estimated engineering soil properties, a pile analysis was performed using the computer program *Driven* to determine the estimated geotechnical pile length at each substructure (*Drive* results included within Appendix D). For the purposes of this report and our analysis,

the term 'geotechnical pile length' has been assumed to represent the length of pile from bottom of pile cap (assumed pile cap bearing elevation) to the depth at which the maximum Ultimate Bearing Value (UBV) is obtained.

The UBV is determined in accordance with Section 202.2.3.2.b of the ODOT BDM in which the total factored load for the highest loaded pile at each substructure is divided by the appropriate driven pile resistance factor. It is recommended that the piles for the referenced project be installed according to ODOT's CMS 507 and CMS 523, and therefore, a driven pile resistance factor of 0.7 should be used.

The estimated nominal skin friction (Rs), pile tip bearing values (Rp) and required geotechnical pile length of a 14-inch diameter CIP pile driven to the indicated UBV per substructure location are given in Table 9 below (*Driven* results included within Appendix D).

Table 9: Deep Foundation Analysis Summary

Pile Type	Geotechnical Pile Length[(1)] (ft)	Geotechnical Pile Tip Elevation (ft)	Nominal Side Resistance (kips)	Nominal Point Resistance (kips)	Ultimate Bearing Value (kips)
GRE-42-0263 Rear Abutment, B-001-0-19					
14-inch CIP	44.3	717.7	207.9	162.1	370.0
GRE-42-0263 Forward Abutment, B-002-0-19					
14-inch CIP	45.9	720.4	309.4	60.6	370.0

Notes:
1. The length of pile from bottom of pile cap to the elevation at which maximum UBV obtained.

5.2.2. Pile Drivability

NEAS's pile drivability evaluation estimated a Delmag D19-42 diesel hammer to determine if the pile type or size being considered would be overstressed (i.e., compressive stresses experienced by pile during driving are greater than 90% of the yield strength of the steel) at any time during pile installation. The results of the evaluation indicated that the 14-inch diameter CIP piles would not be overstressed during the pile installation process based on: 1) a minimum wall thickness consist with that shown in the referenced Stage 2 Plan Set (i.e., 0.5 inches); 2) the use of ASTM A 252 Grade 2 steel piles; and, 3) our developed model used in the computer program *GRLWEAP*.. *GRLWEAP* results for each substructure location are included within Appendix E.

It should be noted that the driving resistance of CIP piles through soils encountered at the bridge site is expected to be high. Drivability is difficult to assess quantitatively as the field test results (i.e., SPT N_{60} values, pocket penetrometer values, etc.) tend to be very high. Furthermore, pile drivability is highly reliant upon the specific equipment used in construction; therefore, it is recommended that the contractor provide an analysis to demonstrate that the equipment and pile combination planned for use is capable of obtaining the UBV without over-stressing the piles.

5.2.3. Pile Foundation Recommendations

Based on our evaluation of the subsurface conditions and our geotechnical engineering analysis for the proposed bridge replacement project, it is our opinion that the bridge foundations can be supported on driven friction CIP piles seated within the hard/dense to very dense natural subsurface material encountered at the site.

Pile lengths based on: 1) our Deep Foundation Analysis (presented in Section 5.2.1); and, 2) the "Estimated Length" and "Order Length" definitions and formulas presented in Section 305.3.5.2 "Estimated Pile Length" of the ODOT BDM, are presented in Table 10 below.

Table 10: Estimated Pile Lengths

Pile Type	Bottom of Pile Cap Elevation[1] (ft)	Geotechnical Pile Tip Elevation (ft)	Estimated Pile Length[2] (ft)	Order Length[2] (ft)
GRE-42-0263 Rear Abutment, B-001-0-19				
14-inch CIP	762.0	717.7	50	55
GRE-42-0263 Forward Abutment, B-002-0-19				
14-inch CIP	766.3	720.4	50	55

Notes:
1. *Elevation assumed to match proposed bottom of pile cap elevations as indicated in referenced Stage 2 Site Plan.*
2. *Based on definitions and formulas presented in Section 305.3.5.2 of the 2020 BDM.*
3. *Geotechnical pile tip elevation estimated for friction CIP piles.*

5.3. Settlement Analysis

In order to estimate the maximum total and differential settlement that could result within the subsurface soils supporting the proposed US-42 embankment soils, NEAS reviewed: 1) the Stage 2 Plan Set for the GRE-42-2.63/20.21 project, prepared by Palmer Engineering dated March 6, 2020; 2) Service Limit State loading conditions; and, 3) the generalized subsurface profile and Settlement Parameters for Analysis provided in Section 5.1. of this report. Utilizing this information and the software entitled *FoSSA 2.0* by ADAMA Engineering, Inc., a settlement model was developed and analyzed to for both elastic (immediate) and consolidation (long term) settlement. Outputs of our *FoSSA 2.0* settlement analysis are included within Appendix G.

Based on our analyses, the estimated maximum total settlement associated with the loads induced by the proposed new embankment is about 4.6 inches at approximate STA. 46+83. This settlement will begin as the embankment load is applied and will dissipate with time. However, the amount of settlement and the time required for the settlement to occur is mostly dependent on the thickness of the underlying compressible soil, the uniformity and properties of these layers (i.e., compaction, material type, compressibility, etc.), and the proposed embankment fill height/surcharge load. Due to: 1) the presence of granular material within the soil profile at the site; 2) the consolidation properties of the cohesive alluvial soil; and 3) the over-consolidated nature of the deeper cohesive till soils at the site, this settlement magnitude is not anticipated to be a concern as the elastic settlement (approximately 3.5 inches) is anticipated to occur immediately and a majority of consolidation settlement (approximately 0.8 inches) is expected to be complete within the first 90 days. As the roadway itself is not anticipated to experience a significant amount of long-term settlement this settlement magnitude is not anticipated to be a concern for pavements or at-grade structures (i.e., guardrails, signage, etc.).

5.3.1. Downdrag Analysis

Based on our settlement analysis it was determined that the identified settlement magnitudes (approximately 3.5 inches of elastic settlement and 1.1 inches of consolidation settlement) may induce downdrag loading on the proposed forward abutment CIP pile foundation. Per Section 305.3.2.2 “Downdrag and Drag Load” of the ODOT BDM, as greater than 0.4 inches of consolidation (long-term) settlement is anticipated to occur, a check should be performed to determine if the factored structural axial resistance of the pile at the Strength Limit State is equal to or greater than the combined effect of the factored downdrag load and the sum of factored loads (highest loaded pile at each substructure).

In order to perform this check, NEAS reviewed: 1) the Stage 2 Plan Set for the GRE-42-2.63/20.21 project, prepared by Palmer Engineering dated March 6, 2020; 2) the forward abutment permanent and transient loading information provided by Palmer Engineering on August 26, 2020; and, 3) the proposed 14-inch

CIP pile properties (0.5 inch wall thickness, 35 kips per square inch yield stress). Utilizing this information and geotechnical resistance information presented in Section 5.2.1 of this report, the location of the neutral plane per the Goudreault and Fellenius (1994) method was calculated to be about 31 ft at the forward abutment. At the depth of the neutral plane it was subsequently determined that the combination of permanent and downdrag loads was on the order of 259 kips with a factored load on the order of 346 kips. The combined effect of the factored downdrag load and the sum of factored loads was determined to be well below the factored structural axial resistance of the subject pile (i.e., calculated to be 716 kips). Therefore, downdrag loads are not anticipated to be a concern for the project proposed pile foundations. Under the referenced factored downdrag load and the sum of factored loads, the elastic compression of the pile was calculated to be 0.02 inches. Neutral plane and downdrag loading pile check results are included within Appendix I.

5.4. Embankment Stability Analysis

For purposes of evaluating the stability of the planned embankments proposed as part of the project, NEAS reviewed the cross-sections along the length of the project roadway segments to identify sections that were interpreted to represented conditions that posed the greatest potential for slope instability as a result of the planned construction. In general, sections along the proposed roadway alignments were reviews to identify planned alterations that may present a combination of existing subsurface conditions and planned site grading (i.e., cutting and/or filling) that would potentially be critical to the stability of the existing and/or proposed slopes at the site. Based on our review of the available information along the referenced alignments and the associated soil properties, the cross-section at STA. 47+07 (US-42 alignment) was selected to be analyzed for global stability. For this section, NEAS developed a representative model to use as the basis for global stability analyses. The model was developed from NEAS's interpretation of the available information which included: 1) the roadway cross-sections prepared as part of the Feasibility Study Report for the GRE-42-2.63/20.21 project, prepared by Palmer Engineering dated April 2019; and, 2) test borings and laboratory data developed as part of this report. With respect to the soil's engineering properties, the provided Soil Profile and Estimated Engineering Properties Tables presented in Section 5.1 of this report were used in our analysis.

The above referenced slope stability model was analyzed for long-term (Effective Stress) and short-term (Total Stress) slope stability utilizing the software entitled Slide 7.0 by Rocscience, Inc. Specifically, the Modified Bishop and Spencer analysis methods were used to calculate a factor of safety (FOS) for circular and block type slope failures, respectively. The FOS is the ratio of the resisting forces and the driving forces, with the desired safety factor being more than about 1.3 which equates to an AASHTO resistance factor less than 0.75. Per AASHTO's LRFD BDS. For the analysis, a resistance factor of 0.75 or lower is targeted as the slope does not contain or support a structural element. Based on our slope stability analysis at the referenced location, the minimum slope stability safety factors exceeded the desired value of 1.3. The graphical output of the slope stability program (cross-sectional model, calculated safety factor, and critical failure plane) is presented in Appendix H.

5.5. Subgrade Analysis and Recommendations

A subgrade analysis was performed to identify the method, location and dimensions (including depth) of subgrade stabilization for the proposed full depth pavement replacement within the project limits. In addition to identifying stabilization recommendations, pavement design parameters are also determined to aid in pavement section design. The subgrade analysis was performed in general accordance with ODOT's GB1 criteria utilizing the ODOT provided *GB1: Subgrade Analysis Spreadsheet*

(GB1_SubgradeAnalysis.xls, Version 14.5 dated January 18, 2019). The subsections below present the results of our GB1 analysis including pavement design parameters and unsuitable subgrade conditions identified within the project limits. GB1 analysis spreadsheet is provided in Appendix I.

It should be noted that for the purposes of this report and our analysis, the term ' proposed subgrade' has been assumed to represent soils and/or soil conditions from 1.5 ft (assumed pavement section thickness) below proposed final pavement grades to a depth of 7.5 ft below the proposed pavement grades. Additionally, for analysis purposes, the proposed roadway grades were assumed to match that as shown in the Feasibility Study Report for the GRE-42-2.63/20.21 project, prepared by Palmer Engineering dated April 2019.

5.5.1. Pavement Design Recommendations

It is our understanding a pavement analysis is to be performed to determine the design pavement section for the roadway segment to undergo full depth replacement within the project limits. A GB1 analysis was performed using ODOT's *GB1: Subgrade Analysis Spreadsheet* as indicated above. Input information for the spreadsheet was based on the subgrade soil data obtained during our field exploration program. The subgrade analysis parameters recommended for use in pavement design are presented in Table 11 below. Provided in the table are ranges of maximum, minimum and average N_{60L} values as well as design CBR value recommended for use in pavement design.

Table 11: Pavement Design Values

Maximum N_{60L}	Minimum N_{60L}	Average N_{60L}	Average PI Values	Design CBR
16	10	13	6	8

5.5.2. Unsuitable Subgrade

Per ODOT's GB1, the presence of select subgrade conditions is prohibited within the subgrade zone for new pavement construction. These prohibited subgrade conditions generally include the presence of rock, specific soil types (A-4b, A-2-5, A-5, A-7-5, A-8a, A-8b), and soils with a liquid limit greater than 65 percent. With respect to the project planned roadways, these subgrade conditions were not encountered within the subgrade depths of the borings performed for the project.

5.5.1. Unstable Subgrade

Per ODOT's GB1, the presence of select subgrade conditions within the top 3 ft of subgrade indicate an unstable subgrade and may require stabilization beyond typical subgrade compaction practices. Subgrade stabilization depths are recommended per *Figure B - Subgrade Stabilization* within the GB1 for soils in which: 1) the lowest N_{60} value (N_{60L}) at the referenced boring location is less than or equal to 12 bpf; 2) the average hand penetrometer value is less than or equal to 1.5 tsf; or, 3) the soil has either an N_{60L} less than or equal to 15 bpf or an average hand penetrometer value of 1.875 tsf where the moisture content is greater than optimum plus 3 percent as per *Figure A – Optimum Moisture Content* within the GB1. With respect to unstable soils, one (1) sample from boring B-003-0-18 encountered soils with an N_{60} value below 12 bpf within 3 ft of top of proposed subgrade.

5.5.2. Stabilization Recommendations

No unsuitable soils were encountered along the roadway and within the subgrade depths of the referenced project borings performed while one sample was determined to be unstable per ODOT's GB1. Therefore,

based on: 1) the hand penetrometer values of the subgrade samples obtained; 2) the depth at which the unstable soil sample was encountered; and, 3) the performance of the existing pavement at the site, it is our opinion that the subgrade at the site can be stabilized utilizing typical compaction practices. It is recommended that the project subgrade soils be "reworked" and prepared in accordance with typical Subgrade Compaction and Proof Rolling (Item 204) procedures and specifications for all new pavement sections. Subgrade compaction efforts should extend to 18 inches beyond the edge of the surface of the pavement, paved shoulders, or paved medians, including under new curbs and gutters.

6. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of characterizing the subsurface conditions at the site of the proposed replacement of Bridge GRE-42-0263 over the Little Miami Scenic Bike Trail. This report has been prepared for Palmer Engineering, ODOT and their design consultants to be used solely in evaluating the soils underlying the bridge site and presenting geotechnical engineering recommendations specific to this project. The assessment of general site environmental conditions or the presence of pollutants in the soil, rock and groundwater of the site was beyond the scope of this geotechnical exploration. Our recommendations are based on the results of our field explorations, laboratory tests result from representative soil samples, and geotechnical engineering analyses. The results of the field explorations and laboratory tests, which form the basis of our recommendations, are presented in the appendices as noted. This report does not reflect any variations that may occur between the borings or elsewhere on the site, or variations whose nature and extent may not become evident until a later stage of construction. In the event that any changes in the nature, design or location of the proposed bridge replacement is made, the conclusions and recommendations contained in this report should not be considered valid until they are reviewed and have been modified or verified in writing by a geotechnical engineer.

It has been a pleasure to be of service to Palmer Engineering in performing this geotechnical exploration for the GRE-42-2.63/20.21 project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

National Engineering and Architectural Services Inc.

Brendan P. Andrews, P.E.
Project Manager/ Sr. Geotechnical Engineer

Kevin C. Arens, P.E.
Geotechnical Engineer

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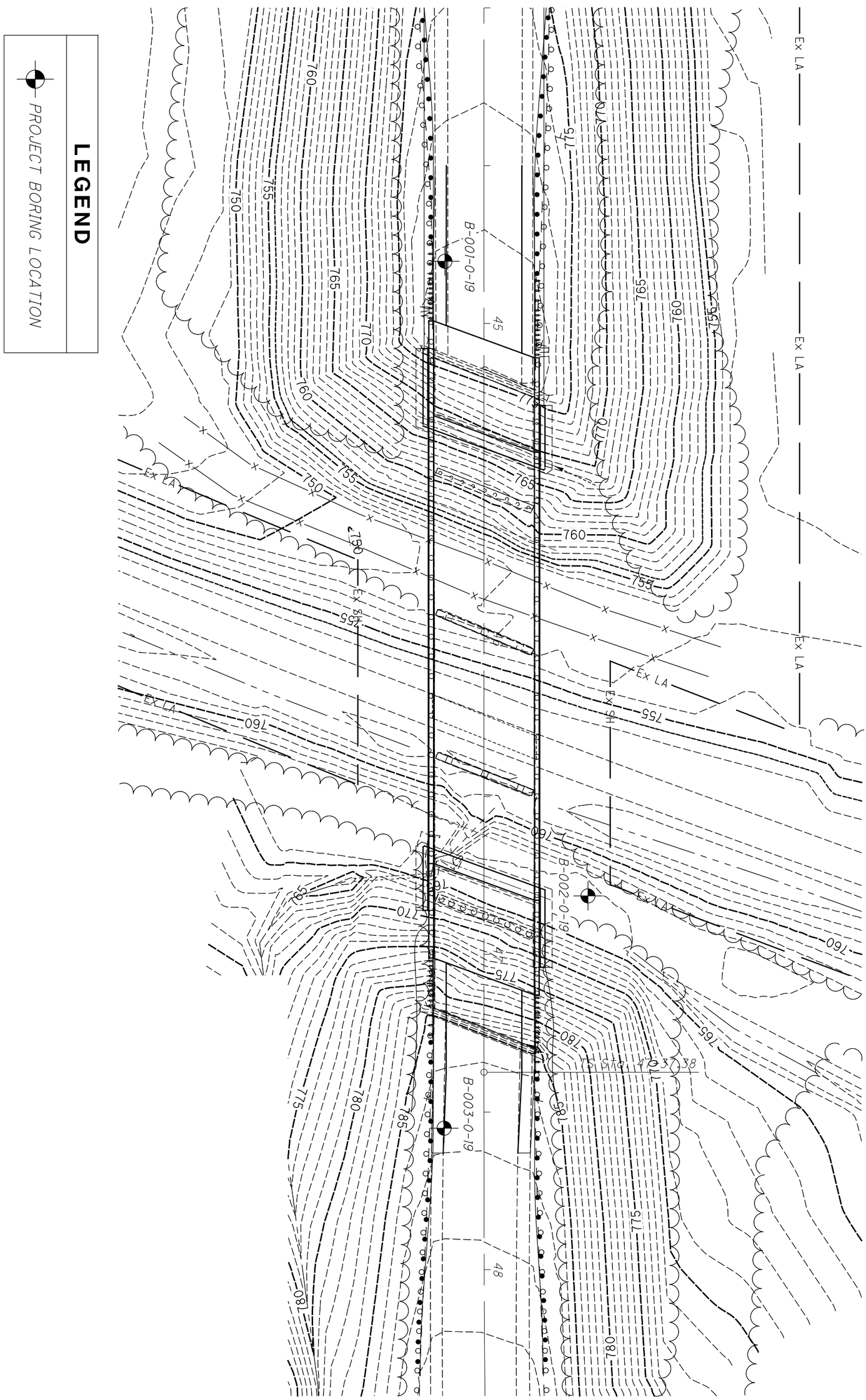
APPENDIX A

BORING LOCATION PLAN

P:\18-0020 (102746 GRE-042-02.63_20.21)\102746\geotechnical\docs\proposal\TargetBoringPlan-KMZs\TargetBoringPlan_082819.dgn Sheet 2/14/2020 11:39:45 AM karens



1/1	GRE-42-2.63/20.21	BORING LOCATION PLAN	DRAWN KCA	0 15 30	N
			CHECKED BPA	HORIZONTAL SCALE IN FEET	

APPENDIX B

SOIL BORING LOGS & LABORATORY TEST RESULTS

PROJECT: GRE-42-02.63	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 44+81, 11' RT.
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / J.HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: US-42
PID: 102746 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/5/19	ELEVATION: 778.1 (MSL) EOB: 86.5 ft.
START: 12/18/19 END: 12/18/19	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 82	LAT / LONG: 39.602833, -84.009865

EXPLORATION ID B-001-0-18

PAGE 1 OF 3

MATERIAL DESCRIPTION AND NOTES	ELEV. 778.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, LITTLE GRAVEL, LITTLE CLAY, DAMP	775.1	1																
		2	7 9 12	29	67	SS-1	-	14	20	32	23	11	NP	NP	NP	9	A-3a (0)	
STIFF TO VERY STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE TO LITTLE GRAVEL AND STONE FRAGMENTS, CONTAINS >1.25" STONE FRAGMENTS AND TRACE IRON STAINING, DAMP		3																
		4	4 7 5	16	22	SS-2	3.50	8	18	30	33	11	17	15	2	11	A-4a (2)	
		5	4 5 7	16	67	SS-3	3.50	-	-	-	-	-	-	-	-	10	A-4a (V)	
	770.6	6	4 6 6	16	100	SS-4	1.50	-	-	-	-	-	-	-	-	11	A-4a (V)	
STIFF, BROWN, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, CONTAINS TRACE IRON STAINING, MOIST	768.6	7																
		8	2 4 6	14	67	SS-5	1.50	-	-	-	-	-	-	-	-	16	A-6a (V)	
STIFF TO HARD, BROWNISH GRAY AND BROWN, **SANDY SILT**, LITTLE TO SOME CLAY, TRACE TO LITTLE GRAVEL, CONTAINS TRACE IRON STAINING, DAMP		9																
		10	2 3 3	8	100	SS-6	2.00	9	16	24	32	19	22	14	8	12	A-4a (3)	
		11																
		12			92	ST-1	3.50	9	13	24	33	21	24	15	9	11	A-4a (4)	
		13																
		14	4 7 7	19	56	SS-7	4.5+	-	-	-	-	-	-	-	-	11	A-4a (V)	
		15																
		16																
		17																
		18	2 9 10	26	56	SS-8	4.5+	20	18	25	22	15	20	14	6	9	A-4a (0)	
		19																
		20																
		21	4 11 12	31	67	SS-9	4.5+	-	-	-	-	-	-	-	-	11	A-4a (V)	
		22																
		23	2 3 5	11	100	SS-10	1.50	-	-	-	-	-	-	-	-	12	A-4a (V)	
		24																
		25																
		26	2 2 4	8	67	SS-11	3.25	9	15	23	32	21	23	15	8	12	A-4a (4)	
		27																
@27.5' TO 29.0'; SS-12 CONTAINS NO INTACT SOIL FOR HP READINGS		28	3 8 11	26	56	SS-12	-	-	-	-	-	-	-	-	-	12	A-4a (V)	
		29																

PID: 102746	SFN:	PROJECT: GRE-42-02.63	STATION / OFFSET: 44+81, 11' RT.	START: 12/18/19	END: 12/18/19	PG 2 OF 3	B-001-0-18

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
STIFF TO HARD, BROWNISH GRAY AND BROWN, **SANDY SILT**, LITTLE TO SOME CLAY, TRACE TO LITTLE GRAVEL, CONTAINS TRACE IRON STAINING, DAMP *(continued)*	748.1																	
	743.6	31	3 11 12	31	56	SS-13	2.50	8	13	24	32	23	24	15	9	12	A-4a (4)	
		32																
		33	3 7 15	30	33	SS-14	4.25	-	-	-	-	-	-	-	-	13	A-4a (V)	
		34																
HARD, DARK BROWN AND DARK GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		35																
		36	3 9 13	30	44	SS-15	4.5+	2	5	11	48	34	35	22	13	18	A-6a (9)	
	739.8	37																
STIFF, GRAY WITH BLACK MOTTLES, **CLAY**, "AND" SILT, LITTLE SAND, TRACE GRAVEL, SLIGHTLY ORGANIC, WET		38																
		39																
		40																
		41	3 4 4	11	100	SS-16	1.25	-	-	-	-	-	-	-	-	35	A-7-6 (V)	
	734.8	42																
VERY SOFT, DARK GRAY, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, MOIST		43																
		44																
W 733.1		45																
		46	8 9 9	25	100	SS-17	0.25	-	-	-	-	-	-	-	-	19	A-6a (V)	
	729.8	47																
LOOSE, BROWN, **COARSE AND FINE SAND**, LITTLE GRAVEL, LITTLE SILT, TRACE CLAY, WET		48																
		49																
		50																
		51	1 1 5	8	100	SS-18	-	-	-	-	-	-	-	-	-	15	A-3a (V)	
	724.8	52																
DENSE TO VERY DENSE, BROWN AND GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE TO LITTLE SILT, TRACE CLAY, MOIST TO WET		53																
		54																
		55																
		56	14 15 17	44	100	SS-19	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
		57																
		58																
		59																
		60																
		61	7 16 17	45	100	SS-20	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	

PID: 102746	SFN:	PROJECT: GRE-42-02.63	STATION / OFFSET: 44+81, 11' RT.	START: 12/18/19	END: 12/18/19	PG 3 OF 3	B-001-0-18

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DENSE TO VERY DENSE, BROWN AND GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE TO LITTLE SILT, TRACE CLAY, MOIST TO WET *(continued)*	716.0	63																
		64																
		65	15 17 19	49	100	SS-21	-	-	-	-	-	-	-	-	-	16	A-1-b (V)	
		66																
		67																
		68																
		69																
		70	8 19 20	53	100	SS-22	-	-	-	-	-	-	-	-	-	12	A-1-b (V)	
		71																
		72																
		73																
		74																
		75	12 14 22	49	100	SS-23	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
		76																
		77																
	699.8	78																
VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, SOME SAND, SOME GRAVEL, MOIST		79																
		80	50	-	100	SS-24	2.25	-	-	-	-	-	-	-	-	14	A-6a (V)	
		81																
		82																
		83																
		84																
@85.0' TO 86.5'; SS-25 BECOMES TRACE GRAVEL		85	9 11 16	37	100	SS-25	2.75	-	-	-	-	-	-	-	-	13	A-6a (V)	
	691.6	86 EOB																

NOTES: GROUNDWATER ENCOUNTERED AT 45.0' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 130 GAL. BENTONITE GROUT

National Engineering & Architectural Services Inc.

5710 Westbourne Avenue
Columbus, OH 43213
614.892.0162

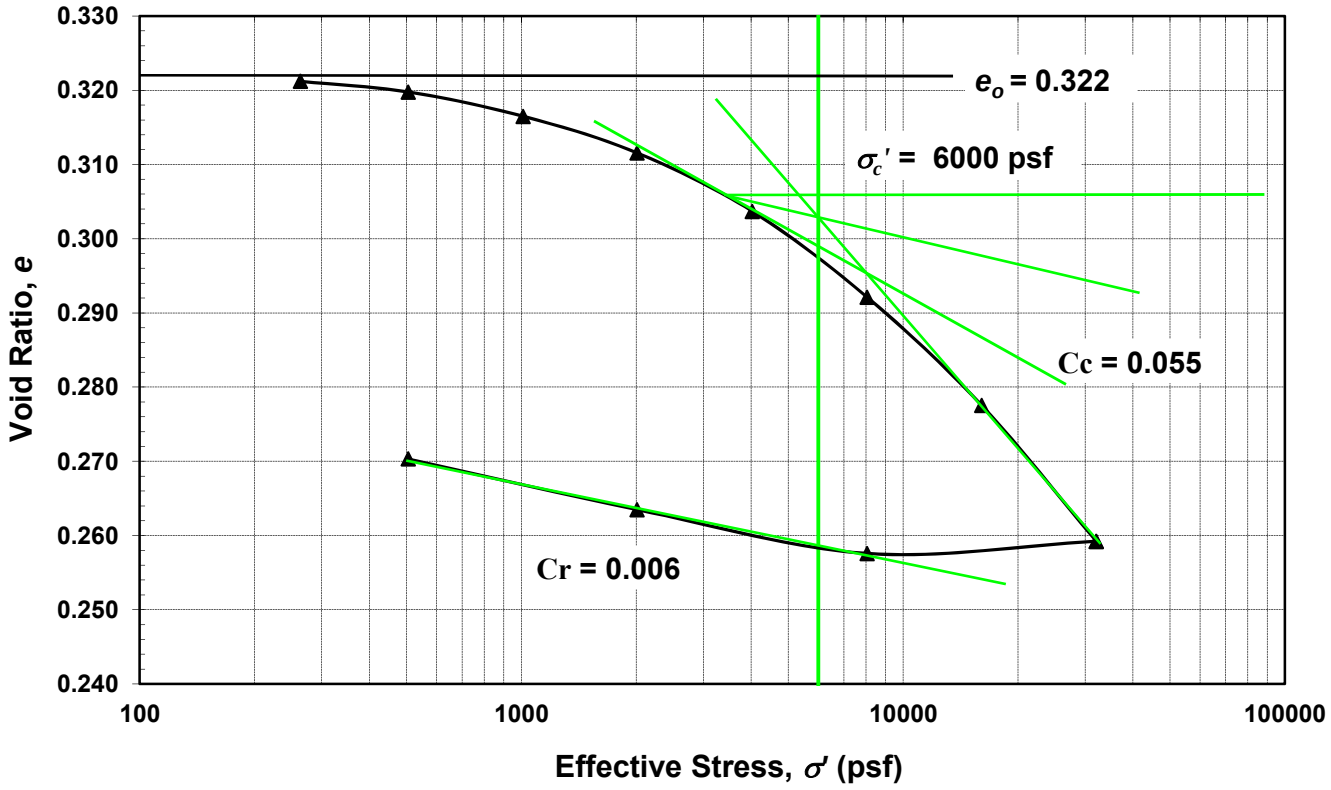
Consolidation Test

Project Name:	GRE-42-2.63/20.21	Prepared by:	LR
Source:	B-001-0-18 ST-1 (14.1' - 14.2')	Checked by:	ZM
Description:	Very stiff, brownish gray, SANDY SILT, some clay, trace gravel, damp.	Date:	1/22/2020
Notes:	Gravel up to 3/8" was discovered in the sample after testing		
Test Specification:	ASTM D 2435		
Initial Void Ratio:	0.322	Initial Bulk Unit Weight (lb/ft^3):	142
In-situ Vertical Effective Stress (psf):	1900	Dry Unit Weight (lb/ft^3):	127

Compression and Swelling Index

Compression Index (Cc):	0.055	Preconsolidation Pressure (σ_c') (psf):	**6000**
Recompression Index (Cr):	0.006	Over-Consolidation Ratio (OCR):	**3.2**

Consolidation Curve



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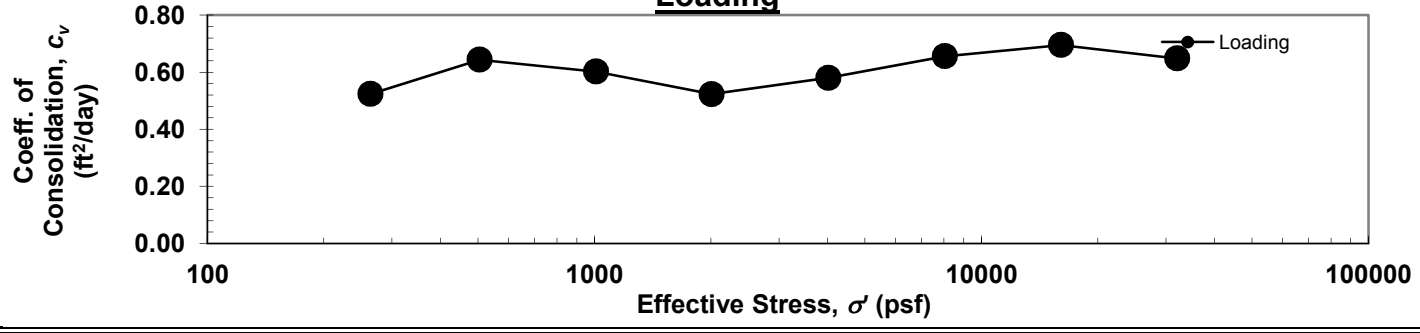
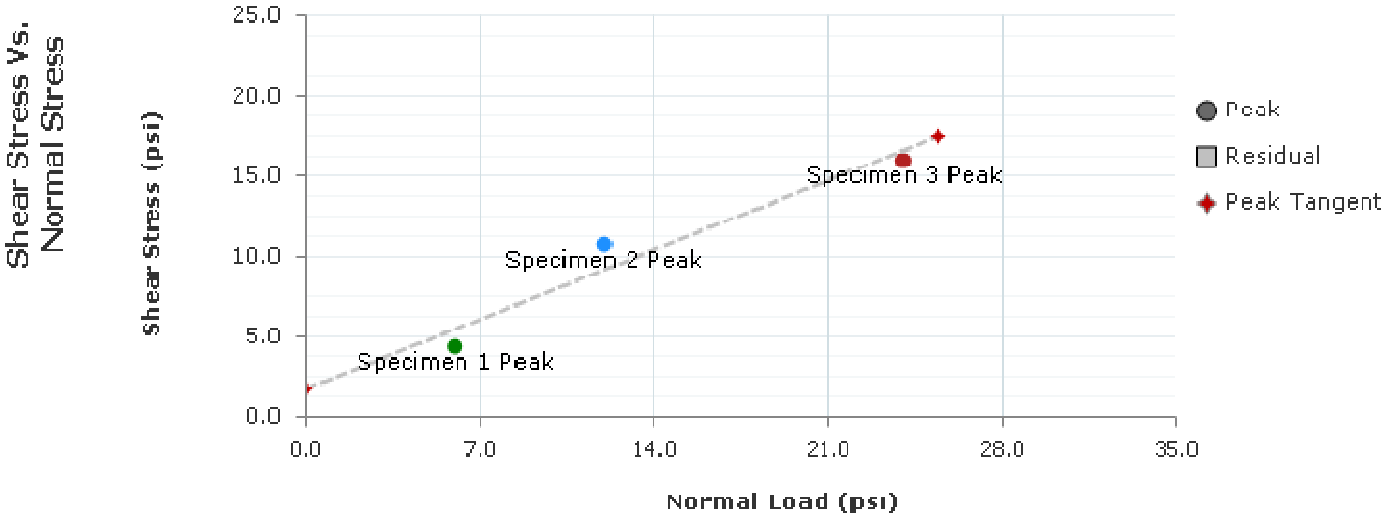


National Engineering & Architectural Services Inc.

Direct Shear Test

D3080

Project: GRE-42-2.63/20.21
Project Number: 102746
Location: B-001-0-18 ST-1
Client Name: Palmer Engineering



C (psi): 1.8
Phi (°): 31.7

Residual C (psi): NA
Residual Phi (°): NA

	Specimen Number							
Initial	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Moisture (%):	12.0	12.7	11.3					
Dry Density (pcf):	124.9	121.1	125.0					
Void Ratio:	0.335	0.377	0.333					
Saturation (%):	95.6	90.2	90.6					
Diameter (in):	2.4948	2.4948	2.4948					
Height (in):	1.0115	1.0110	1.0058					
Final	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Moisture (%):	13.6	14.9	13.5					
Dry Density (pcf):	126.1	123.0	129.0					
Void Ratio:	0.322	0.355	0.293					
Saturation (%):	113.0	112.1	123.2					
Height (in):	1.0021	1.0025	0.9827					
Normal Stress (psi):	6.0	12.0	24.0					
Peak Shear Stress (psi):	4.4	10.8	16.0					
Residual Stress (psi):	NA	NA	NA					
Horizontal Deformation (%):	4.7	6.9	4.2					
Rate (in/min):	0.002541	0.007726	0.000767					

National Engineering & Architectural Services Inc.

Direct Shear Test

D3080

Project: GRE-42-2.63/20.21
Project Number: 102746
Sampling Date: 1/7/2020
Sample Number: ST-1
Sample Depth: 12.5 - 14.5 ft
Location: B-001-0-18 ST-1
Client Name: Palmer Engineering
Remarks: Soaked Specimen. Tested by: LR

Information Parameters	Specimen Number 1	2	3	4	5	6	7	8
Liquid Limit:	24	24	24					
Plastic Limit:	15	15	15					
Specific Gravity:	2.67	2.67	2.67					
Specific Gravity Method:	ASSUMED	ASSUMED	ASSUMED					
Initial Parameters	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Test Temperature (°C):	22.2	22.2	22.2					
Sample Shape:	ROUND	ROUND	ROUND					
Height (in):	1.0115	1.0110	1.0058					
Diameter (in):	2.4948	2.4948	2.4948					
Area (in²):	4.888	4.888	4.888					
Volume (in³):	4.9447	4.9422	4.9170					
Moisture (%):	12.0	12.7	11.3					
Dry Density (pcf):	124.9	121.1	125.0					
Wet Density (pcf):	139.8	136.5	139.2					
Saturation (%):	95.6	90.2	90.6					
Void Ratio:	0.335	0.377	0.333					
Porosity (%):	25.1	27.4	25.0					
Consolidation Parameters	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Initial Reference Height (in):	1.0115	1.0110	1.0058					
Final Reference Height (in):	1.0021	1.0025	0.9827					
Height (in):	1.0021	1.0025	0.9827					
Final Parameters	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Moisture Content (%)	13.6	14.9	13.5					
Dry Density (pcf):	126.1	123.0	129.0					
Wet Density (pcf):	143.3	141.4	146.4					
Saturation (%):	113.0	112.1	123.2					
Void Ratio:	0.322	0.355	0.293					
Porosity (%):	24.4	26.2	22.6					

National Engineering & Architectural Services Inc.

Direct Shear Test

D3080

Project:	GRE-42-2.63/20.21
Project Number:	102746
Sampling Date:	1/7/2020
Sample Number:	ST-1
Sample Depth:	12.5 - 14.5 ft
Location:	B-001-0-18 ST-1
Client Name:	Palmer Engineering
Remarks:	Soaked Specimen. Tested by: LR

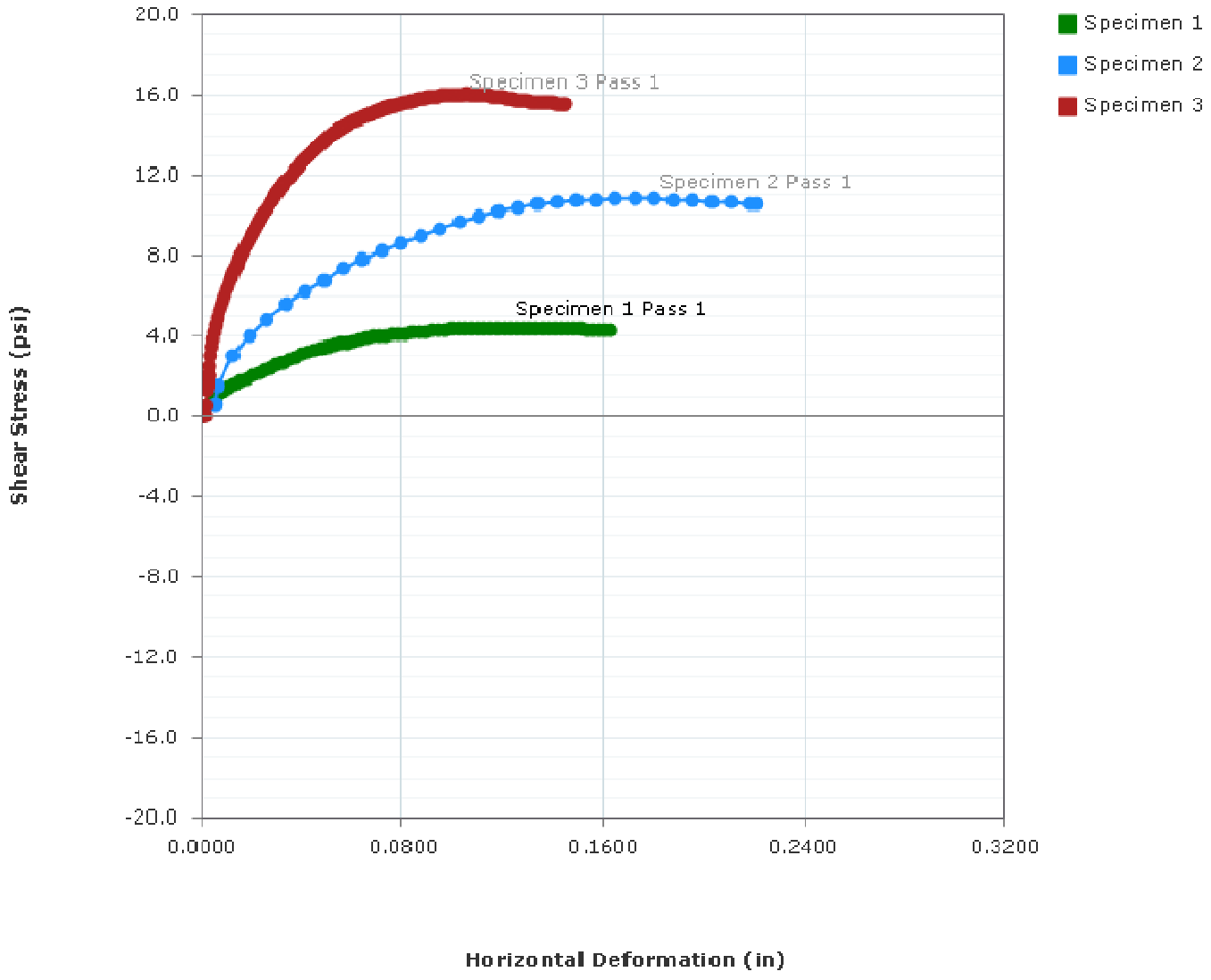
Specific Gravity:	2.67	Plastic Limit:	15	Liquid Limit:	24
Type:	Undisturbed	Soil Classification:	A-4a		
Specimen Description:	Very stiff, brownish gray, SANDY SILT, little clay, little gravel, damp.				

Specimen 1 Failure Sketch	Specimen 2 Failure Sketch	Specimen 3 Failure Sketch	Specimen 4 Failure Sketch	Specimen 5 Failure Sketch	Specimen 6 Failure Sketch	Specimen 7 Failure Sketch	Specimen 8 Failure Sketch
							

National Engineering & Architectural Services Inc.

Graph - Stress Deformation

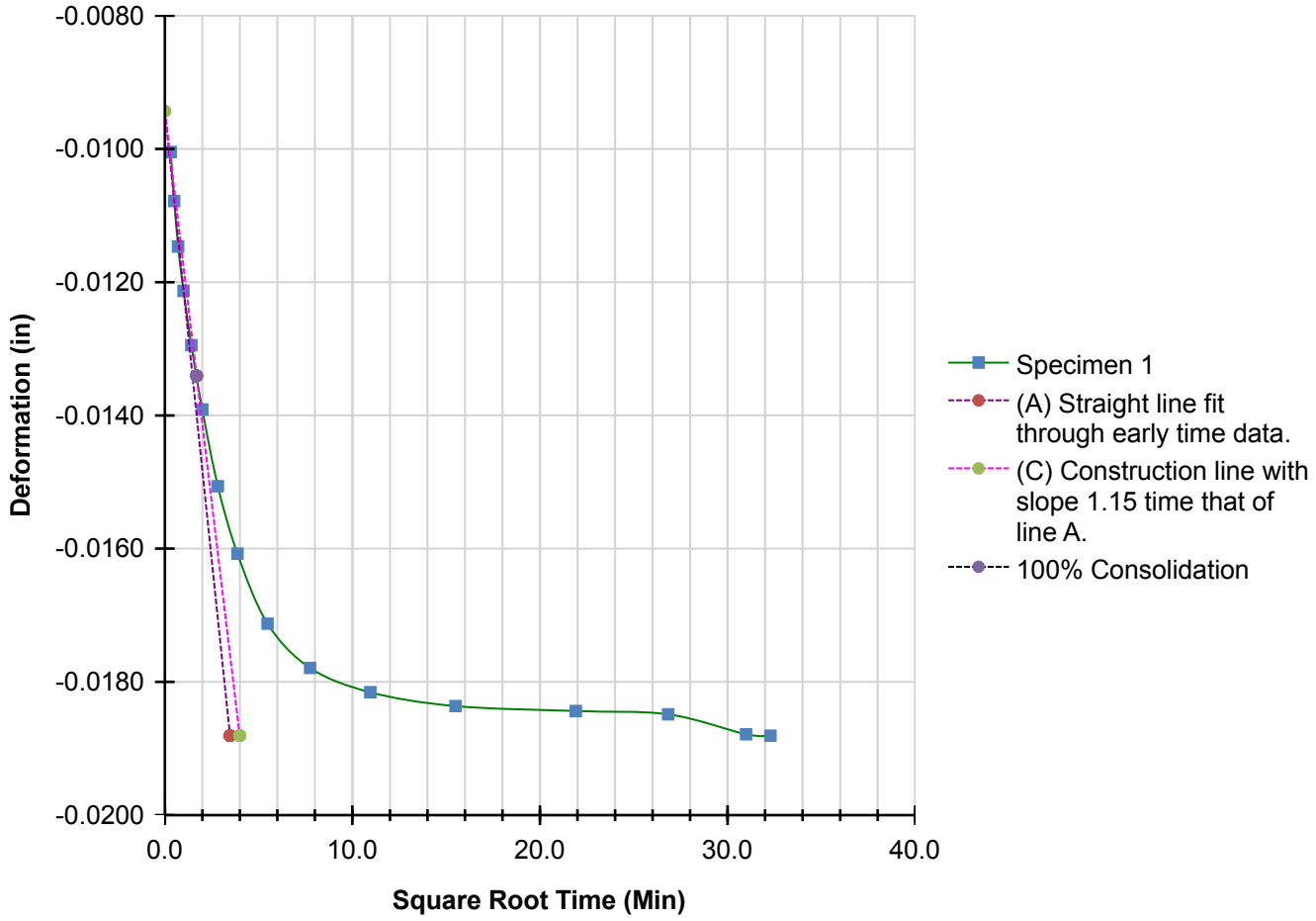
D3080



National Engineering & Architectural Services Inc.

Square Root Time - Specimen 1 - Sequence 1 - 6.0 (psi)

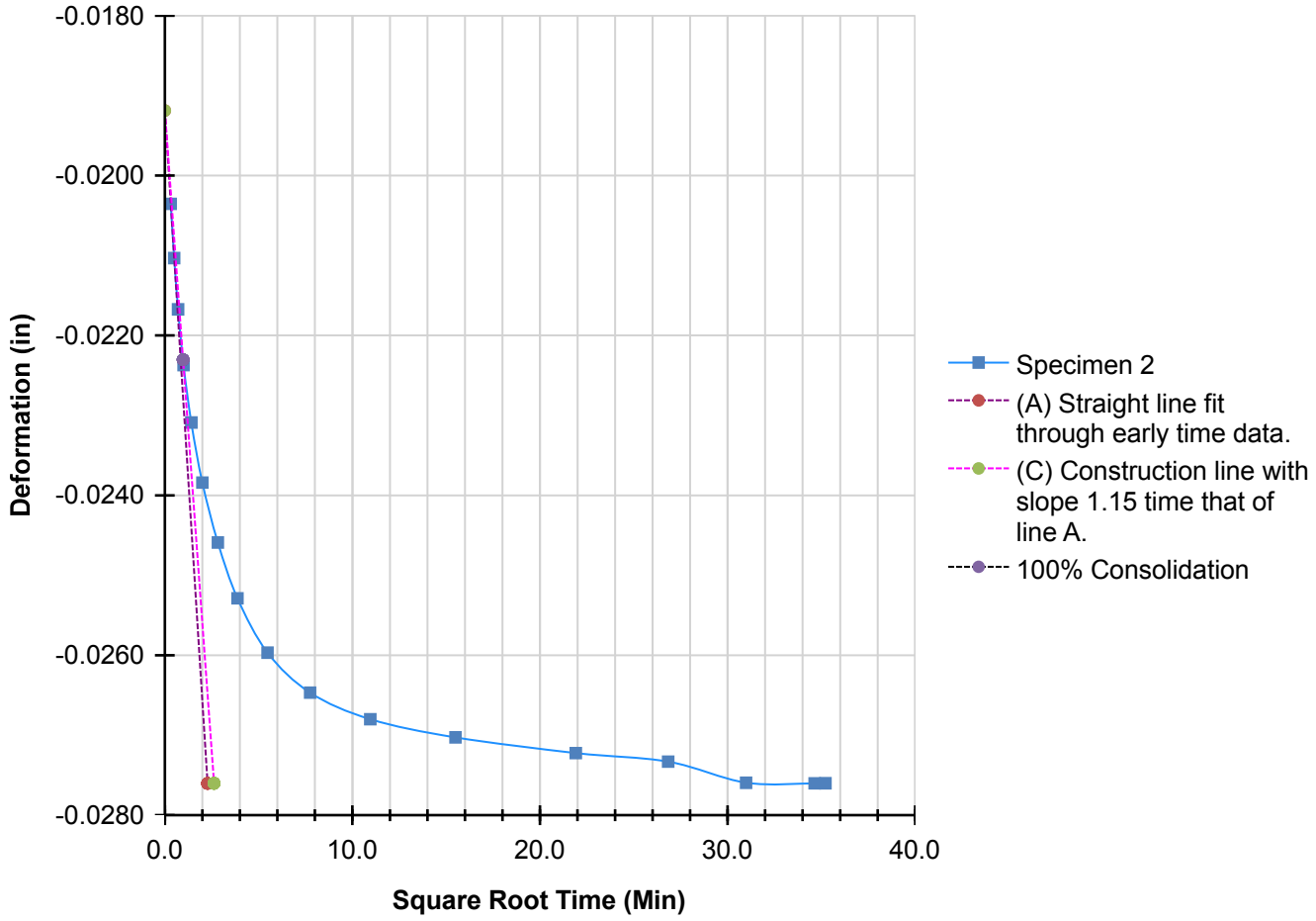
D3080



Tangent Construction Results	
T90 (Min):	2.866
T50 (Min):	1.592
Cv (in²/Min):	0.074

Square Root Time - Specimen 2 - Sequence 1 - 12.0 (psi)

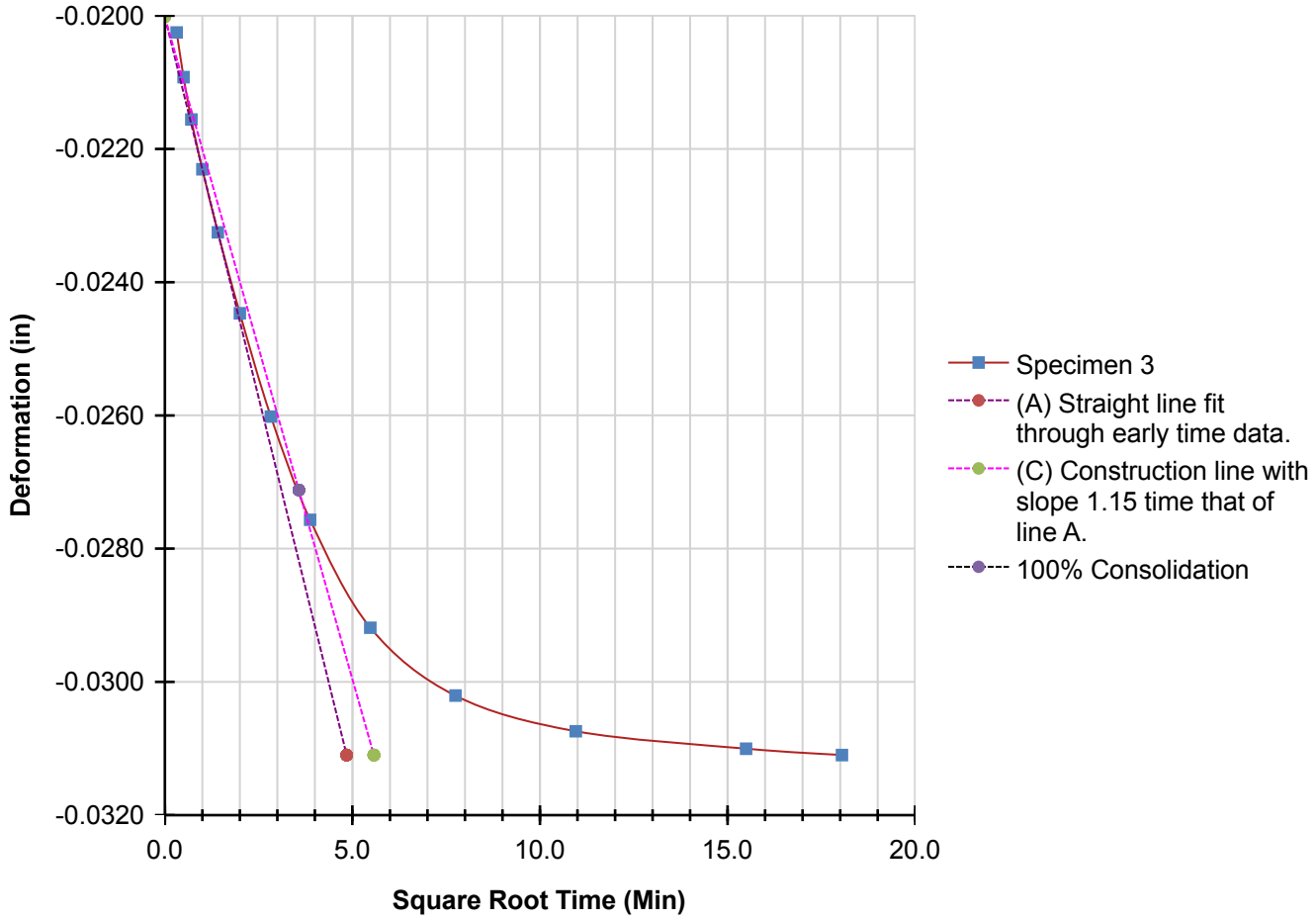
D3080



Tangent Construction Results	
T90 (Min):	0.942
T50 (Min):	0.523
Cv (in²/Min):	0.226

Square Root Time - Specimen 3 - Sequence 1 - 12.0 (psi)

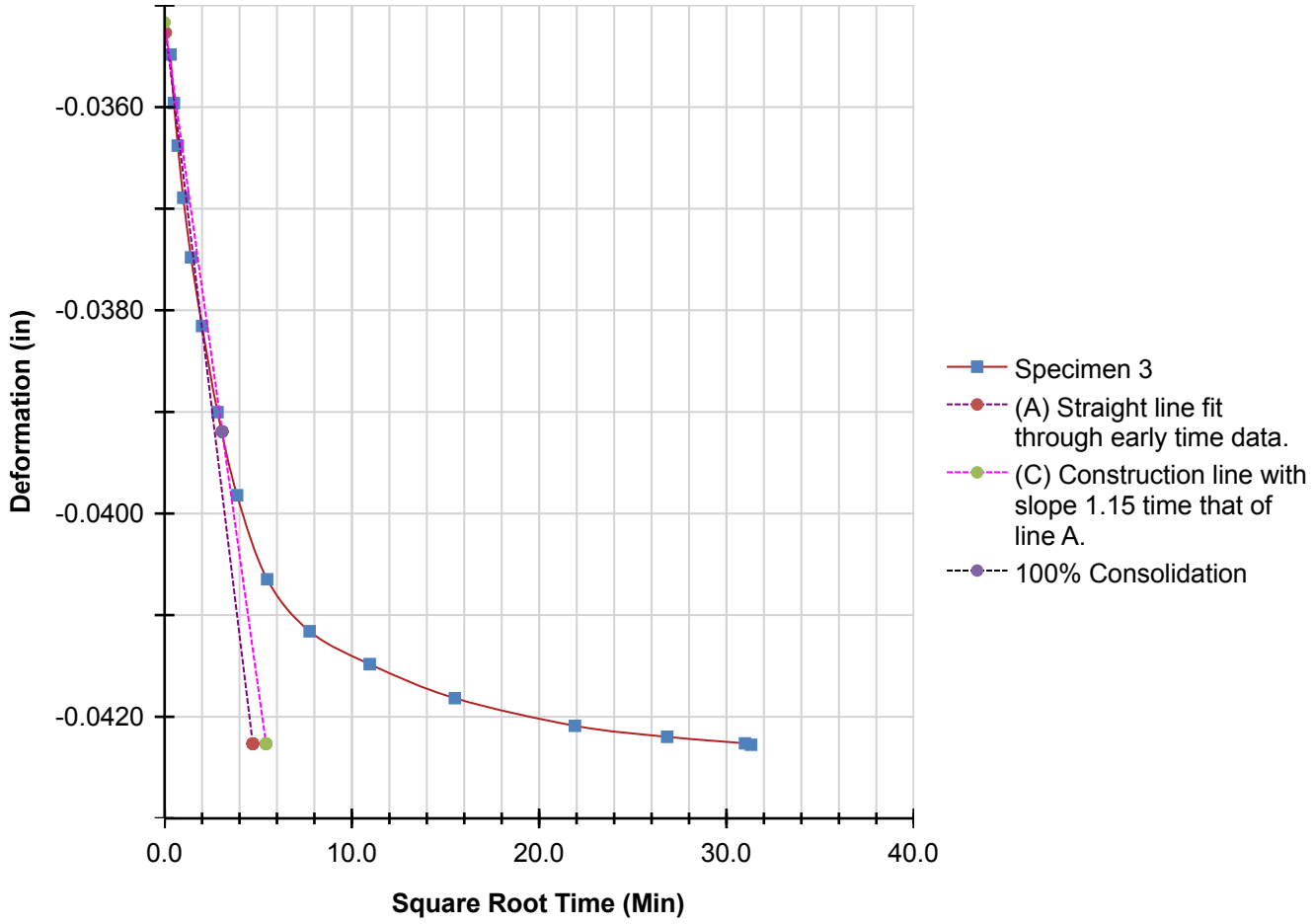
D3080



Tangent Construction Results	
T90 (Min):	12.758
T50 (Min):	7.088
Cv (in²/Min):	0.016

Square Root Time - Specimen 3 - Sequence 2 - 24.0 (psi)

D3080



Tangent Construction Results	
T90 (Min):	9.447
T50 (Min):	5.249
Cv (in²/Min):	0.022

PROJECT: GRE-42-02.63	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 46+83, 24' LT.
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / J.HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: US-42
PID: 102746 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/5/19	ELEVATION: 763.6 (MSL) EOB: 61.5 ft.
START: 12/17/19 END: 12/17/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82	LAT / LONG: 39.603110, -84.009227

EXPLORATION ID B-002-0-18

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
LOOSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP	763.6																	
	760.6		4 2 4	8	100	SS-1A	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
VERY STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP						SS-1B	2.50	10	17	23	31	19	21	14	7	13	A-4a (3)	
	758.1		2 5 5	14	100	SS-2A	2.25	-	-	-	-	-	-	-	-	12	A-4a (V)	
STIFF TO VERY STIFF, BROWN AND DARK GRAY, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, CONTAINS TRACE IRON STAINING, DAMP TO MOIST						SS-2B	2.25	-	-	-	-	-	-	-	-	14	A-6b (V)	
			2 4 5	12	100	SS-3	1.50	-	-	-	-	-	-	-	-	22	A-6b (V)	
			3 4 5	12	100	SS-4	2.75	3	10	23	31	33	35	17	18	19	A-6b (9)	
	749.1		3 5 5	14	100	SS-5	2.25	-	-	-	-	-	-	-	-	23	A-6b (V)	
VERY STIFF, BROWN, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP																		
	746.6		6 8 13	29	100	SS-6	3.50	7	13	21	33	26	26	16	10	13	A-4a (5)	
STIFF, BROWN AND GRAY, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, MOIST																		
	744.1		8 10 13	31	100	SS-7	1.50	-	-	-	-	-	-	-	-	23	A-6b (V)	
STIFF TO HARD, BROWN AND BROWNISH GRAY, **SILT AND CLAY**, SOME TO "AND" SAND, TRACE GRAVEL, DAMP TO MOIST																		
			6 8 14	30	100	SS-8	4.25	6	12	22	33	27	28	15	13	13	A-6a (6)	
		W 740.6																
			3 5 8	18	100	SS-9	1.25	8	15	21	30	26	31	16	15	17	A-6a (6)	

PID: 102746	SFN:	PROJECT: GRE-42-02.63	STATION / OFFSET: 46+83, 24' LT.	START: 12/17/19	END: 12/17/19	PG 2 OF 2	B-002-0-18

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
	733.6																	
	732.9		8			SS-10A	4.50	-	-	-	-	-	-	-	-	12	A-6a (V)	
VERY DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, MOIST		31	29 20	67	78	SS-10B	-	-	-	-	-	-	-	-	-	13	A-2-4 (V)	
	730.3	32																
MEDIUM DENSE, BROWN AND GRAY, **COARSE AND FINE SAND**, TRACE SILT, TRACE GRAVEL, TRACE CLAY, WET		33																
		34																
		35	6															
		36	8 14	30	67	SS-11	-	-	-	-	-	-	-	-	-	17	A-3a (V)	
	725.3	37																
VERY DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP		38																
		39																
	722.9	40	12			SS-12A	-	-	-	-	-	-	-	-	-	10	A-2-4 (V)	
VERY STIFF TO HARD, GRAY, **SANDY SILT**, SOME CLAY, TRACE TO LITTLE GRAVEL, GLACIAL TILL, DAMP		41	22 17	53	83	SS-12B	3.75	-	-	-	-	-	-	-	-	14	A-4a (V)	
		42																
		43																
		44																
		45	8															
		46	12 23	48	56	SS-13	4.5+	14	11	20	32	23	25	15	10	11	A-4a (4)	
	715.3	47																
VERY DENSE, GRAY, **COARSE AND FINE SAND**, LITTLE SILT, TRACE GRAVEL, TRACE CLAY, GLACIAL TILL, MOIST		48																
		49																
	712.6	50	12			SS-14A	-	-	-	-	-	-	-	-	-	13	A-3a (V)	
VERY STIFF, GRAY, **SILT**, SOME SAND, LITTLE CLAY, TRACE GRAVEL, GLACIAL TILL, DAMP	711.6	51	19 25	60	83	SS-14B	3.50	-	-	-	-	-	-	-	-	13	A-4b (V)	
VERY STIFF TO HARD, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, GLACIAL TILL, SS-15 CONTAINS SILT LENSES, DAMP		52																
		53																
		54																
		55	12															
		56	20 23	59	89	SS-15	3.75	4	7	25	46	18	19	16	3	15	A-4a (6)	
		57																
		58																
		59																
		60	14															
	702.1	61	24 30	74	67	SS-16	4.5+	-	-	-	-	-	-	-	-	12	A-4a (V)	
		EOB																

NOTES: GROUNDWATER ENCOUNTERED AT 23.0' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 90 GAL. BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 2/24/20 16:01 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\GRE-42-02.63\GINT FILES\GRE-42-2.63.GPJ

PROJECT: GRE-42-02.63	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 47+55, 11' RT.
TYPE: SUBGRADE	SAMPLING FIRM / LOGGER: NEAS / J.HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: US-42
PID: 102746 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/5/19	ELEVATION: 786.7 (MSL) EOB: 21.5 ft.
START: 12/16/19 END: 12/16/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82	LAT / LONG: 39.603048, -84.008930

EXPLORATION ID B-003-0-18

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
HARD, BROWN, **SANDY SILT**, LITTLE GRAVEL, LITTLE CLAY, DAMP	786.7																	
@1.5' TO 3.0'; SS-1 CONTAINS NO RECOVERY			6 7 5	16	0	SS-1	-	-	-	-	-	-	-	-	-	-		
	782.2		7 4 4	11	33	SS-2	4.50	17	18	22	28	15	21	15	6	11	A-4a (2)	
VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, "AND" SAND, LITTLE GRAVEL, DAMP	780.7		4 4 3	10	56	SS-3	3.75	12	17	25	25	21	27	16	11	14	A-6a (3)	
MEDIUM STIFF, BROWN, **SANDY SILT**, LITTLE GRAVEL, LITTLE CLAY, DAMP			4 4 5	12	56	SS-4	0.75	-	-	-	-	-	-	-	-	13	A-4a (V)	
@7.5' TO 11.0'; SS-5 AND SS-6A BECOME VERY STIFF			3 3 4	10	44	SS-5	3.75	-	-	-	-	-	-	-	-	11	A-4a (V)	
	775.7		2 3 5	11	67	SS-6A	2.50	-	-	-	-	-	-	-	-	12	A-4a (V)	
VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	774.7					SS-6B	2.25	-	-	-	-	-	-	-	-	22	A-6a (V)	
VERY STIFF, BROWN, **SANDY SILT**, LITTLE TO SOME CLAY, TRACE TO LITTLE GRAVEL AND STONE FRAGMENTS, DAMP			3 5 5	14	67	SS-7	-	8	17	24	29	22	24	15	9	14	A-4a (3)	
@12.5' TO 14.0'; SS-7 CONTAINS NO INTACT SOIL FOR HP READINGS			6 18 25	59	100	SS-8	2.50	15	19	24	26	16	22	15	7	11	A-4a (1)	
	767.2		2 3 4	10	44	SS-9	2.75	-	-	-	-	-	-	-	-	11	A-4a (V)	
HARD, BROWNISH GRAY, **CLAY**, SOME SILT, SOME SAND, TRACE GRAVEL, MOIST	765.2	EOB	2 4 5	12	56	SS-10	4.50	3	8	20	34	35	42	20	22	21	A-7-6 (12)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

APPENDIX C

GENERALIZED PROFILE FOR SETTLEMENT ANALYSIS

SUBSURFACE DIAGRAM

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

CLIENT ODOT

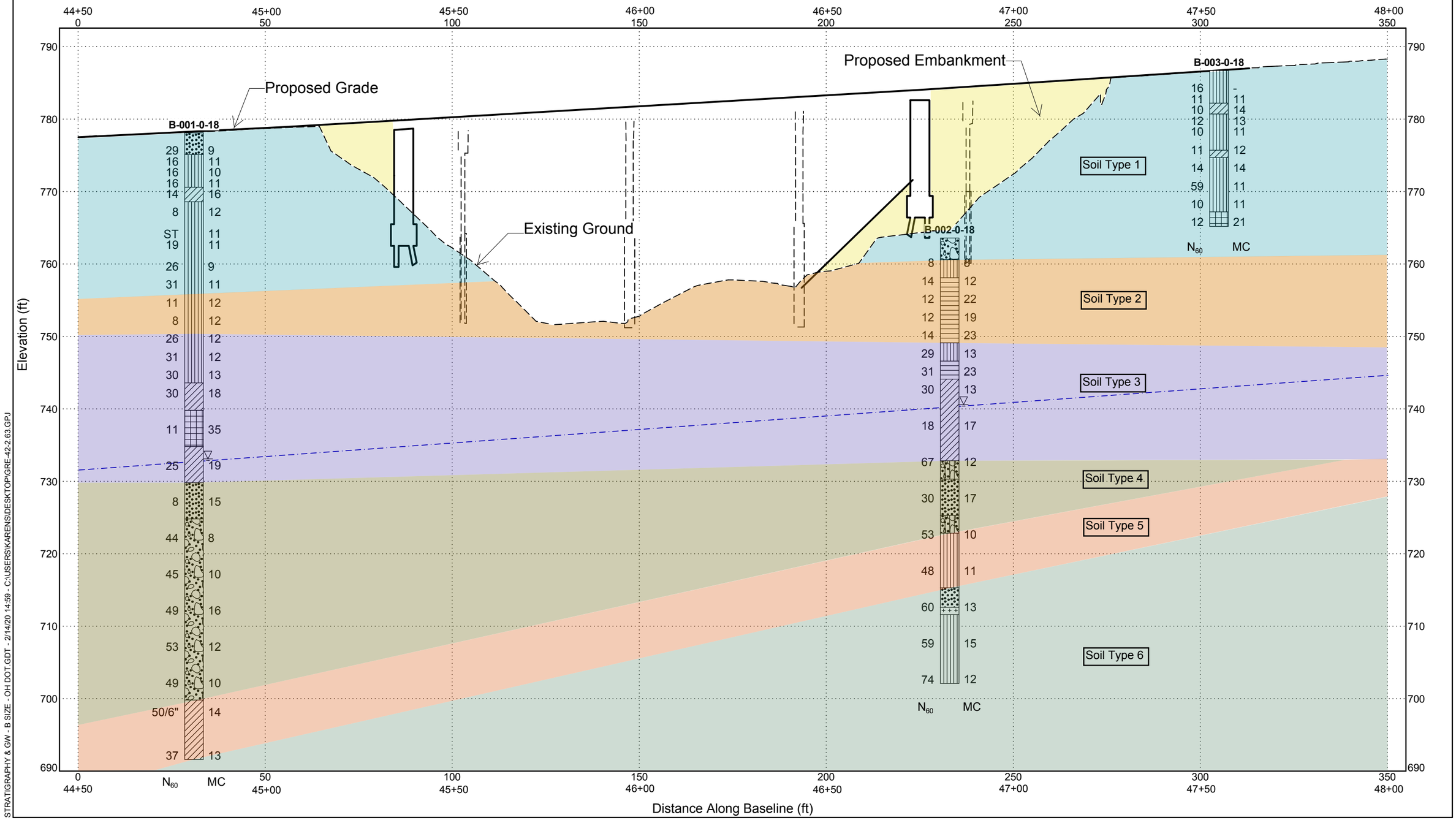
PROJECT NUMBER 102746

PROJECT NAME GRE-42-02.63/20.21

PROJECT LOCATION Spring Valley, OH

- Ohio DOT: A-3a, coarse and fine sand
- Ohio DOT: A-7-6, clay
- Ohio DOT: A-2-4, gravel and/or stone fragments with sand and silt
- Ohio DOT: A-4a, sandy silt
- Ohio DOT: A-1-b, gravel and/or stone fragments with sand
- Ohio DOT: A-4b, silt
- Ohio DOT: A-6a, silt and clay
- Ohio DOT: A-6b, silty clay

MC - Moisture Content (%) N_{60} - Corrected SPT-N Value (blows per foot)



STRATIGRAPHY & GW - B SIZE - OH DOT.GDT - 2/14/20 14:59 - C:\USERS\KAREN\DESKTOP\GRE-42-2.63.GPJ

APPENDIX D

DRIVEN ANALYSIS

REAR ABUTMENT

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\XPMUSER\DESKTOP\RA_14IN.DVN
Project Name: GRE-42-0263-RA Project Date: 01/23/2020
Project Client: ODOT
Computed By:
Project Manager: BPA

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 14.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	10.90 ft
	- Driving/Restrike	10.90 ft
	- Ultimate:	10.90 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	18.40 ft	17.00%	135.00 pcf	2600.00 psf	T-80 Same
2	Cohesive	3.80 ft	33.00%	128.00 pcf	3750.00 psf	T-80 Same
3	Cohesive	5.00 ft	50.00%	120.00 pcf	1350.00 psf	T-80 Same
4	Cohesive	5.00 ft	33.00%	125.00 pcf	3100.00 psf	T-80 Same
5	Cohesionless	5.00 ft	0.00%	120.00 pcf	30.0/30.0	Nordlund
6	Cohesionless	25.00 ft	0.00%	132.00 pcf	36.0/36.0	Nordlund
7	Cohesive	8.20 ft	33.00%	130.00 pcf	5400.00 psf	T-80 Sand

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1050.60 psf	0.04 Kips
9.01 ft	Cohesive	N/A	N/A	1050.60 psf	34.69 Kips
18.01 ft	Cohesive	N/A	N/A	1172.07 psf	77.37 Kips
18.39 ft	Cohesive	N/A	N/A	1179.34 psf	79.49 Kips
18.41 ft	Cohesive	N/A	N/A	892.50 psf	79.58 Kips
22.19 ft	Cohesive	N/A	N/A	892.50 psf	91.95 Kips
22.21 ft	Cohesive	N/A	N/A	1166.25 psf	92.02 Kips
27.19 ft	Cohesive	N/A	N/A	1166.25 psf	113.31 Kips
27.21 ft	Cohesive	N/A	N/A	880.35 psf	113.38 Kips
32.19 ft	Cohesive	N/A	N/A	880.35 psf	129.45 Kips
32.21 ft	Cohesionless	2866.57 psf	19.99	N/A	129.52 Kips
37.19 ft	Cohesionless	3009.99 psf	19.99	N/A	148.24 Kips
37.21 ft	Cohesionless	3154.63 psf	23.99	N/A	148.35 Kips
46.21 ft	Cohesionless	3467.83 psf	23.99	N/A	223.57 Kips
55.21 ft	Cohesionless	3781.03 psf	23.99	N/A	312.38 Kips
62.19 ft	Cohesionless	4023.93 psf	23.99	N/A	390.60 Kips
62.21 ft	Cohesive	N/A	N/A	5400.00 psf	390.92 Kips
70.39 ft	Cohesive	N/A	N/A	5400.00 psf	552.82 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
9.01 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
18.01 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
18.39 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
18.41 ft	Cohesive	N/A	N/A	N/A	36.08 Kips
22.19 ft	Cohesive	N/A	N/A	N/A	36.08 Kips
22.21 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
27.19 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
27.21 ft	Cohesive	N/A	N/A	N/A	29.83 Kips
32.19 ft	Cohesive	N/A	N/A	N/A	29.83 Kips
32.21 ft	Cohesionless	2866.86 psf	30.00	14.24 Kips	14.24 Kips
37.19 ft	Cohesionless	3153.70 psf	30.00	14.24 Kips	14.24 Kips
37.21 ft	Cohesionless	3154.98 psf	77.60	162.06 Kips	162.06 Kips
46.21 ft	Cohesionless	3781.38 psf	77.60	162.06 Kips	162.06 Kips
55.21 ft	Cohesionless	4407.78 psf	77.60	162.06 Kips	162.06 Kips
62.19 ft	Cohesionless	4893.58 psf	77.60	162.06 Kips	162.06 Kips
62.21 ft	Cohesive	N/A	N/A	N/A	51.95 Kips
70.39 ft	Cohesive	N/A	N/A	N/A	51.95 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.04 Kips	25.01 Kips	25.05 Kips
9.01 ft	34.69 Kips	25.01 Kips	59.71 Kips
18.01 ft	77.37 Kips	25.01 Kips	102.38 Kips
18.39 ft	79.49 Kips	25.01 Kips	104.51 Kips
18.41 ft	79.58 Kips	36.08 Kips	115.66 Kips
22.19 ft	91.95 Kips	36.08 Kips	128.02 Kips
22.21 ft	92.02 Kips	12.99 Kips	105.01 Kips
27.19 ft	113.31 Kips	12.99 Kips	126.30 Kips
27.21 ft	113.38 Kips	29.83 Kips	143.21 Kips
32.19 ft	129.45 Kips	29.83 Kips	159.28 Kips
32.21 ft	129.52 Kips	14.24 Kips	143.76 Kips
37.19 ft	148.24 Kips	14.24 Kips	162.48 Kips
37.21 ft	148.35 Kips	162.06 Kips	310.42 Kips
46.21 ft	223.57 Kips	162.06 Kips	385.63 Kips
55.21 ft	312.38 Kips	162.06 Kips	474.44 Kips
62.19 ft	390.60 Kips	162.06 Kips	552.66 Kips
62.21 ft	390.92 Kips	51.95 Kips	442.87 Kips
70.39 ft	552.82 Kips	51.95 Kips	604.77 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1050.60 psf	0.03 Kips
9.01 ft	Cohesive	N/A	N/A	1050.60 psf	28.80 Kips
18.01 ft	Cohesive	N/A	N/A	1172.07 psf	64.22 Kips
18.39 ft	Cohesive	N/A	N/A	1179.34 psf	65.98 Kips
18.41 ft	Cohesive	N/A	N/A	892.50 psf	66.04 Kips
22.19 ft	Cohesive	N/A	N/A	892.50 psf	74.32 Kips
22.21 ft	Cohesive	N/A	N/A	1166.25 psf	74.36 Kips
27.19 ft	Cohesive	N/A	N/A	1166.25 psf	85.00 Kips
27.21 ft	Cohesive	N/A	N/A	880.35 psf	85.05 Kips
32.19 ft	Cohesive	N/A	N/A	880.35 psf	95.82 Kips
32.21 ft	Cohesionless	2866.57 psf	19.99	N/A	95.89 Kips
37.19 ft	Cohesionless	3009.99 psf	19.99	N/A	114.61 Kips
37.21 ft	Cohesionless	3154.63 psf	23.99	N/A	114.72 Kips
46.21 ft	Cohesionless	3467.83 psf	23.99	N/A	189.94 Kips
55.21 ft	Cohesionless	3781.03 psf	23.99	N/A	278.74 Kips
62.19 ft	Cohesionless	4023.93 psf	23.99	N/A	356.97 Kips
62.21 ft	Cohesive	N/A	N/A	5400.00 psf	357.18 Kips
70.39 ft	Cohesive	N/A	N/A	5400.00 psf	465.65 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
9.01 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
18.01 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
18.39 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
18.41 ft	Cohesive	N/A	N/A	N/A	36.08 Kips
22.19 ft	Cohesive	N/A	N/A	N/A	36.08 Kips
22.21 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
27.19 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
27.21 ft	Cohesive	N/A	N/A	N/A	29.83 Kips
32.19 ft	Cohesive	N/A	N/A	N/A	29.83 Kips
32.21 ft	Cohesionless	2866.86 psf	30.00	14.24 Kips	14.24 Kips
37.19 ft	Cohesionless	3153.70 psf	30.00	14.24 Kips	14.24 Kips
37.21 ft	Cohesionless	3154.98 psf	77.60	162.06 Kips	162.06 Kips
46.21 ft	Cohesionless	3781.38 psf	77.60	162.06 Kips	162.06 Kips
55.21 ft	Cohesionless	4407.78 psf	77.60	162.06 Kips	162.06 Kips
62.19 ft	Cohesionless	4893.58 psf	77.60	162.06 Kips	162.06 Kips
62.21 ft	Cohesive	N/A	N/A	N/A	51.95 Kips
70.39 ft	Cohesive	N/A	N/A	N/A	51.95 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.03 Kips	25.01 Kips	25.05 Kips
9.01 ft	28.80 Kips	25.01 Kips	53.81 Kips
18.01 ft	64.22 Kips	25.01 Kips	89.23 Kips
18.39 ft	65.98 Kips	25.01 Kips	90.99 Kips
18.41 ft	66.04 Kips	36.08 Kips	102.12 Kips
22.19 ft	74.32 Kips	36.08 Kips	110.40 Kips
22.21 ft	74.36 Kips	12.99 Kips	87.35 Kips
27.19 ft	85.00 Kips	12.99 Kips	97.99 Kips
27.21 ft	85.05 Kips	29.83 Kips	114.88 Kips
32.19 ft	95.82 Kips	29.83 Kips	125.64 Kips
32.21 ft	95.89 Kips	14.24 Kips	110.13 Kips
37.19 ft	114.61 Kips	14.24 Kips	128.85 Kips
37.21 ft	114.72 Kips	162.06 Kips	276.78 Kips
46.21 ft	189.94 Kips	162.06 Kips	352.00 Kips
55.21 ft	278.74 Kips	162.06 Kips	440.81 Kips
62.19 ft	356.97 Kips	162.06 Kips	519.03 Kips
62.21 ft	357.18 Kips	51.95 Kips	409.13 Kips
70.39 ft	465.65 Kips	51.95 Kips	517.61 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1050.60 psf	0.04 Kips
9.01 ft	Cohesive	N/A	N/A	1050.60 psf	34.69 Kips
18.01 ft	Cohesive	N/A	N/A	1172.07 psf	77.37 Kips
18.39 ft	Cohesive	N/A	N/A	1179.34 psf	79.49 Kips
18.41 ft	Cohesive	N/A	N/A	892.50 psf	79.58 Kips
22.19 ft	Cohesive	N/A	N/A	892.50 psf	91.95 Kips
22.21 ft	Cohesive	N/A	N/A	1166.25 psf	92.02 Kips
27.19 ft	Cohesive	N/A	N/A	1166.25 psf	113.31 Kips
27.21 ft	Cohesive	N/A	N/A	880.35 psf	113.38 Kips
32.19 ft	Cohesive	N/A	N/A	880.35 psf	129.45 Kips
32.21 ft	Cohesionless	2866.57 psf	19.99	N/A	129.52 Kips
37.19 ft	Cohesionless	3009.99 psf	19.99	N/A	148.24 Kips
37.21 ft	Cohesionless	3154.63 psf	23.99	N/A	148.35 Kips
46.21 ft	Cohesionless	3467.83 psf	23.99	N/A	223.57 Kips
55.21 ft	Cohesionless	3781.03 psf	23.99	N/A	312.38 Kips
62.19 ft	Cohesionless	4023.93 psf	23.99	N/A	390.60 Kips
62.21 ft	Cohesive	N/A	N/A	5400.00 psf	390.92 Kips
70.39 ft	Cohesive	N/A	N/A	5400.00 psf	552.82 Kips

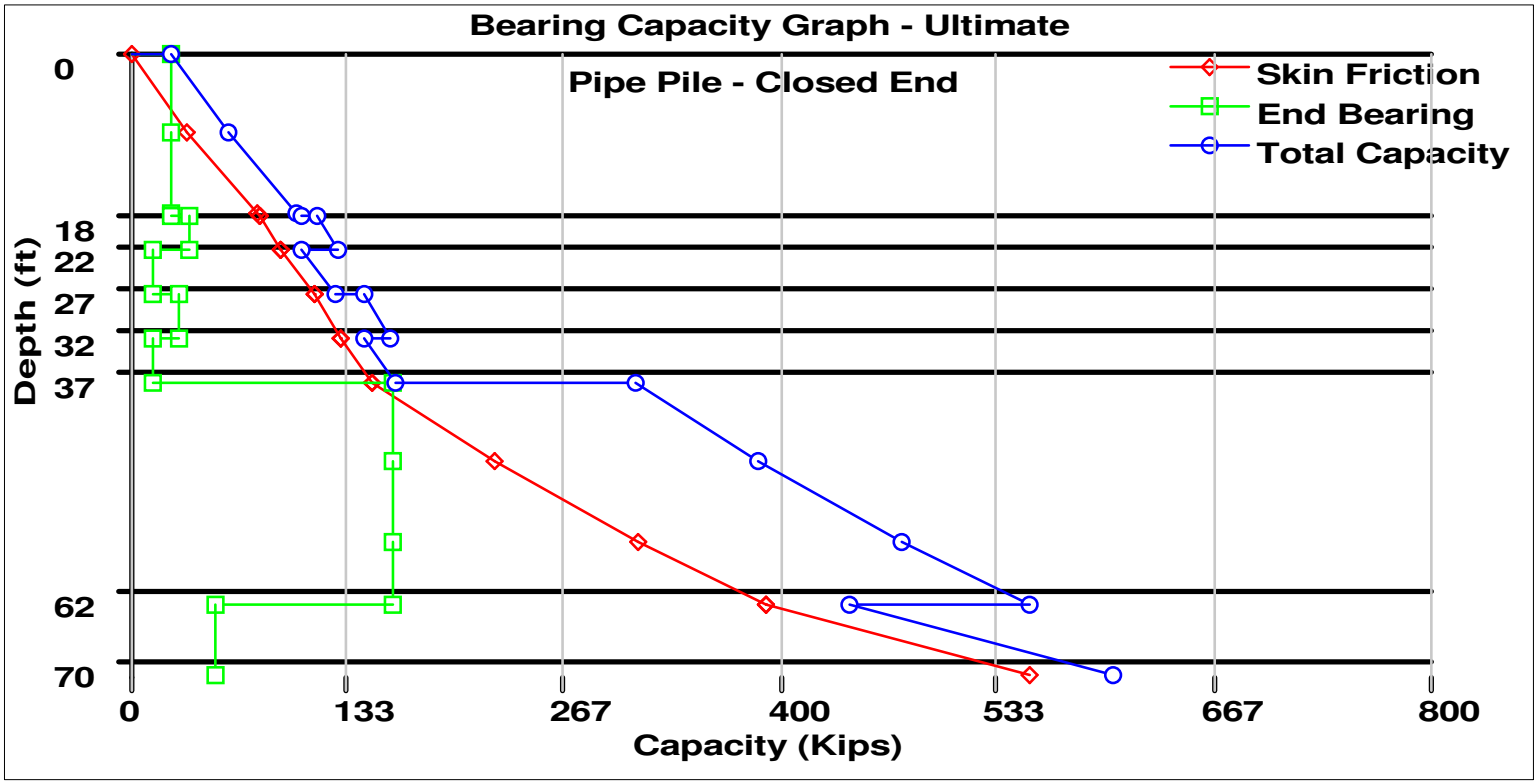
ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
9.01 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
18.01 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
18.39 ft	Cohesive	N/A	N/A	N/A	25.01 Kips
18.41 ft	Cohesive	N/A	N/A	N/A	36.08 Kips
22.19 ft	Cohesive	N/A	N/A	N/A	36.08 Kips
22.21 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
27.19 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
27.21 ft	Cohesive	N/A	N/A	N/A	29.83 Kips
32.19 ft	Cohesive	N/A	N/A	N/A	29.83 Kips
32.21 ft	Cohesionless	2866.86 psf	30.00	14.24 Kips	14.24 Kips
37.19 ft	Cohesionless	3153.70 psf	30.00	14.24 Kips	14.24 Kips
37.21 ft	Cohesionless	3154.98 psf	77.60	162.06 Kips	162.06 Kips
46.21 ft	Cohesionless	3781.38 psf	77.60	162.06 Kips	162.06 Kips
55.21 ft	Cohesionless	4407.78 psf	77.60	162.06 Kips	162.06 Kips
62.19 ft	Cohesionless	4893.58 psf	77.60	162.06 Kips	162.06 Kips
62.21 ft	Cohesive	N/A	N/A	N/A	51.95 Kips
70.39 ft	Cohesive	N/A	N/A	N/A	51.95 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.04 Kips	25.01 Kips	25.05 Kips
9.01 ft	34.69 Kips	25.01 Kips	59.71 Kips
18.01 ft	77.37 Kips	25.01 Kips	102.38 Kips
18.39 ft	79.49 Kips	25.01 Kips	104.51 Kips
18.41 ft	79.58 Kips	36.08 Kips	115.66 Kips
22.19 ft	91.95 Kips	36.08 Kips	128.02 Kips
22.21 ft	92.02 Kips	12.99 Kips	105.01 Kips
27.19 ft	113.31 Kips	12.99 Kips	126.30 Kips
27.21 ft	113.38 Kips	29.83 Kips	143.21 Kips
32.19 ft	129.45 Kips	29.83 Kips	159.28 Kips
32.21 ft	129.52 Kips	14.24 Kips	143.76 Kips
37.19 ft	148.24 Kips	14.24 Kips	162.48 Kips
37.21 ft	148.35 Kips	162.06 Kips	310.42 Kips
46.21 ft	223.57 Kips	162.06 Kips	385.63 Kips
55.21 ft	312.38 Kips	162.06 Kips	474.44 Kips
62.19 ft	390.60 Kips	162.06 Kips	552.66 Kips
62.21 ft	390.92 Kips	51.95 Kips	442.87 Kips
70.39 ft	552.82 Kips	51.95 Kips	604.77 Kips

Filename: C:\DOCUME~1\XPMUSER\DESKTOP\RA_14IN.DVN



FORWARD ABUTMENT

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\XPMUSER\DESKTOP\FA_14IN.DVN
Project Name: GRE-42-0263-FA Project Date: 01/23/2020
Project Client: ODOT
Computed By:
Project Manager: BPA

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 14.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	23.00 ft
	- Driving/Restrike	23.00 ft
	- Ultimate:	23.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	3.00 ft	0.00%	110.00 pcf	35.0/35.0	Nordlund
2	Cohesive	2.50 ft	17.00%	110.00 pcf	1350.00 psf	T-80 Sand
3	Cohesive	9.00 ft	43.00%	120.00 pcf	1600.00 psf	T-80 Same
4	Cohesive	2.50 ft	17.00%	128.00 pcf	3600.00 psf	T-80 Same
5	Cohesive	2.50 ft	43.00%	128.00 pcf	3850.00 psf	T-80 Same
6	Cohesive	11.20 ft	33.00%	125.00 pcf	3000.00 psf	T-80 Same
7	Cohesionless	2.60 ft	17.00%	140.00 pcf	36.0/36.0	Nordlund
8	Cohesionless	5.00 ft	0.00%	128.00 pcf	35.0/35.0	Nordlund
9	Cohesionless	2.40 ft	17.00%	132.00 pcf	36.0/36.0	Nordlund
10	Cohesive	7.60 ft	17.00%	135.00 pcf	6300.00 psf	T-80 Sand
11	Cohesionless	2.70 ft	0.00%	135.00 pcf	36.0/36.0	Nordlund
12	Cohesionless	1.00 ft	33.00%	135.00 pcf	36.0/36.0	Nordlund
13	Cohesionless	9.50 ft	17.00%	140.00 pcf	36.0/36.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.55 psf	23.33	N/A	0.00 Kips
2.99 ft	Cohesionless	164.45 psf	23.33	N/A	1.02 Kips
3.01 ft	Cohesive	N/A	N/A	1350.00 psf	1.08 Kips
5.49 ft	Cohesive	N/A	N/A	1350.00 psf	13.35 Kips
5.51 ft	Cohesive	N/A	N/A	1287.72 psf	13.45 Kips
14.49 ft	Cohesive	N/A	N/A	1287.72 psf	55.83 Kips
14.51 ft	Cohesive	N/A	N/A	867.09 psf	55.91 Kips
16.99 ft	Cohesive	N/A	N/A	867.09 psf	63.79 Kips
17.01 ft	Cohesive	N/A	N/A	916.30 psf	63.85 Kips
19.49 ft	Cohesive	N/A	N/A	916.30 psf	72.18 Kips
19.51 ft	Cohesive	N/A	N/A	907.69 psf	72.25 Kips
28.51 ft	Cohesive	N/A	N/A	907.69 psf	102.19 Kips
30.69 ft	Cohesive	N/A	N/A	907.69 psf	109.44 Kips
30.71 ft	Cohesionless	3244.91 psf	23.99	N/A	109.56 Kips
33.29 ft	Cohesionless	3345.01 psf	23.99	N/A	130.36 Kips
33.31 ft	Cohesionless	3446.61 psf	23.33	N/A	130.51 Kips
38.29 ft	Cohesionless	3609.95 psf	23.33	N/A	167.86 Kips
38.31 ft	Cohesionless	3774.63 psf	23.99	N/A	168.03 Kips
40.69 ft	Cohesionless	3857.45 psf	23.99	N/A	190.15 Kips
40.71 ft	Cohesive	N/A	N/A	6300.00 psf	190.48 Kips
48.29 ft	Cohesive	N/A	N/A	6300.00 psf	365.51 Kips
48.31 ft	Cohesionless	4493.44 psf	23.99	N/A	365.85 Kips
50.99 ft	Cohesionless	4590.73 psf	23.99	N/A	395.50 Kips
51.01 ft	Cohesionless	4689.46 psf	23.99	N/A	395.72 Kips
51.99 ft	Cohesionless	4725.04 psf	23.99	N/A	406.88 Kips
52.01 ft	Cohesionless	4762.09 psf	23.99	N/A	407.11 Kips
61.01 ft	Cohesionless	5111.29 psf	23.99	N/A	517.97 Kips
61.49 ft	Cohesionless	5129.91 psf	23.99	N/A	524.31 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.10 psf	64.00	115.03 Kips	0.05 Kips
2.99 ft	Cohesionless	328.90 psf	64.00	115.03 Kips	15.30 Kips
3.01 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
5.49 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
5.51 ft	Cohesive	N/A	N/A	N/A	15.39 Kips
14.49 ft	Cohesive	N/A	N/A	N/A	15.39 Kips
14.51 ft	Cohesive	N/A	N/A	N/A	34.64 Kips
16.99 ft	Cohesive	N/A	N/A	N/A	34.64 Kips
17.01 ft	Cohesive	N/A	N/A	N/A	37.04 Kips
19.49 ft	Cohesive	N/A	N/A	N/A	37.04 Kips
19.51 ft	Cohesive	N/A	N/A	N/A	28.86 Kips
28.51 ft	Cohesive	N/A	N/A	N/A	28.86 Kips
30.69 ft	Cohesive	N/A	N/A	N/A	28.86 Kips
30.71 ft	Cohesionless	3245.30 psf	77.60	162.06 Kips	162.06 Kips
33.29 ft	Cohesionless	3445.50 psf	77.60	162.06 Kips	162.06 Kips
33.31 ft	Cohesionless	3446.94 psf	64.00	115.03 Kips	115.03 Kips
38.29 ft	Cohesionless	3773.62 psf	64.00	115.03 Kips	115.03 Kips
38.31 ft	Cohesionless	3774.98 psf	77.60	162.06 Kips	162.06 Kips
40.69 ft	Cohesionless	3940.62 psf	77.60	162.06 Kips	162.06 Kips
40.71 ft	Cohesive	N/A	N/A	N/A	60.61 Kips
48.29 ft	Cohesive	N/A	N/A	N/A	60.61 Kips
48.31 ft	Cohesionless	4493.81 psf	77.60	162.06 Kips	162.06 Kips
50.99 ft	Cohesionless	4688.37 psf	77.60	162.06 Kips	162.06 Kips
51.01 ft	Cohesionless	4689.83 psf	77.60	162.06 Kips	162.06 Kips
51.99 ft	Cohesionless	4760.97 psf	77.60	162.06 Kips	162.06 Kips
52.01 ft	Cohesionless	4762.48 psf	77.60	162.06 Kips	162.06 Kips
61.01 ft	Cohesionless	5460.88 psf	77.60	162.06 Kips	162.06 Kips
61.49 ft	Cohesionless	5498.12 psf	77.60	162.06 Kips	162.06 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.05 Kips	0.05 Kips
2.99 ft	1.02 Kips	15.30 Kips	16.32 Kips
3.01 ft	1.08 Kips	12.99 Kips	14.07 Kips
5.49 ft	13.35 Kips	12.99 Kips	26.34 Kips
5.51 ft	13.45 Kips	15.39 Kips	28.84 Kips
14.49 ft	55.83 Kips	15.39 Kips	71.22 Kips
14.51 ft	55.91 Kips	34.64 Kips	90.54 Kips
16.99 ft	63.79 Kips	34.64 Kips	98.43 Kips
17.01 ft	63.85 Kips	37.04 Kips	100.90 Kips
19.49 ft	72.18 Kips	37.04 Kips	109.22 Kips
19.51 ft	72.25 Kips	28.86 Kips	101.11 Kips
28.51 ft	102.19 Kips	28.86 Kips	131.06 Kips
30.69 ft	109.44 Kips	28.86 Kips	138.31 Kips
30.71 ft	109.56 Kips	162.06 Kips	271.62 Kips
33.29 ft	130.36 Kips	162.06 Kips	292.42 Kips
33.31 ft	130.51 Kips	115.03 Kips	245.54 Kips
38.29 ft	167.86 Kips	115.03 Kips	282.89 Kips
38.31 ft	168.03 Kips	162.06 Kips	330.09 Kips
40.69 ft	190.15 Kips	162.06 Kips	352.22 Kips
40.71 ft	190.48 Kips	60.61 Kips	251.09 Kips
48.29 ft	365.51 Kips	60.61 Kips	426.12 Kips
48.31 ft	365.85 Kips	162.06 Kips	527.91 Kips
50.99 ft	395.50 Kips	162.06 Kips	557.56 Kips
51.01 ft	395.72 Kips	162.06 Kips	557.79 Kips
51.99 ft	406.88 Kips	162.06 Kips	568.95 Kips
52.01 ft	407.11 Kips	162.06 Kips	569.17 Kips
61.01 ft	517.97 Kips	162.06 Kips	680.04 Kips
61.49 ft	524.31 Kips	162.06 Kips	686.37 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.55 psf	23.33	N/A	0.00 Kips
2.99 ft	Cohesionless	164.45 psf	23.33	N/A	1.02 Kips
3.01 ft	Cohesive	N/A	N/A	1350.00 psf	1.07 Kips
5.49 ft	Cohesive	N/A	N/A	1350.00 psf	11.25 Kips
5.51 ft	Cohesive	N/A	N/A	1287.72 psf	11.31 Kips
14.49 ft	Cohesive	N/A	N/A	1287.72 psf	35.47 Kips
14.51 ft	Cohesive	N/A	N/A	867.09 psf	35.53 Kips
16.99 ft	Cohesive	N/A	N/A	867.09 psf	42.07 Kips
17.01 ft	Cohesive	N/A	N/A	916.30 psf	42.11 Kips
19.49 ft	Cohesive	N/A	N/A	916.30 psf	46.86 Kips
19.51 ft	Cohesive	N/A	N/A	907.69 psf	46.90 Kips
28.51 ft	Cohesive	N/A	N/A	907.69 psf	66.96 Kips
30.69 ft	Cohesive	N/A	N/A	907.69 psf	71.82 Kips
30.71 ft	Cohesionless	3244.91 psf	23.99	N/A	71.92 Kips
33.29 ft	Cohesionless	3345.01 psf	23.99	N/A	89.18 Kips
33.31 ft	Cohesionless	3446.61 psf	23.33	N/A	89.33 Kips
38.29 ft	Cohesionless	3609.95 psf	23.33	N/A	126.68 Kips
38.31 ft	Cohesionless	3774.63 psf	23.99	N/A	126.82 Kips
40.69 ft	Cohesionless	3857.45 psf	23.99	N/A	145.19 Kips
40.71 ft	Cohesive	N/A	N/A	6300.00 psf	145.46 Kips
48.29 ft	Cohesive	N/A	N/A	6300.00 psf	290.73 Kips
48.31 ft	Cohesionless	4493.44 psf	23.99	N/A	291.07 Kips
50.99 ft	Cohesionless	4590.73 psf	23.99	N/A	320.72 Kips
51.01 ft	Cohesionless	4689.46 psf	23.99	N/A	320.87 Kips
51.99 ft	Cohesionless	4725.04 psf	23.99	N/A	328.35 Kips
52.01 ft	Cohesionless	4762.09 psf	23.99	N/A	328.54 Kips
61.01 ft	Cohesionless	5111.29 psf	23.99	N/A	420.56 Kips
61.49 ft	Cohesionless	5129.91 psf	23.99	N/A	425.82 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.10 psf	64.00	115.03 Kips	0.05 Kips
2.99 ft	Cohesionless	328.90 psf	64.00	115.03 Kips	15.30 Kips
3.01 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
5.49 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
5.51 ft	Cohesive	N/A	N/A	N/A	15.39 Kips
14.49 ft	Cohesive	N/A	N/A	N/A	15.39 Kips
14.51 ft	Cohesive	N/A	N/A	N/A	34.64 Kips
16.99 ft	Cohesive	N/A	N/A	N/A	34.64 Kips
17.01 ft	Cohesive	N/A	N/A	N/A	37.04 Kips
19.49 ft	Cohesive	N/A	N/A	N/A	37.04 Kips
19.51 ft	Cohesive	N/A	N/A	N/A	28.86 Kips
28.51 ft	Cohesive	N/A	N/A	N/A	28.86 Kips
30.69 ft	Cohesive	N/A	N/A	N/A	28.86 Kips
30.71 ft	Cohesionless	3245.30 psf	77.60	162.06 Kips	162.06 Kips
33.29 ft	Cohesionless	3445.50 psf	77.60	162.06 Kips	162.06 Kips
33.31 ft	Cohesionless	3446.94 psf	64.00	115.03 Kips	115.03 Kips
38.29 ft	Cohesionless	3773.62 psf	64.00	115.03 Kips	115.03 Kips
38.31 ft	Cohesionless	3774.98 psf	77.60	162.06 Kips	162.06 Kips
40.69 ft	Cohesionless	3940.62 psf	77.60	162.06 Kips	162.06 Kips
40.71 ft	Cohesive	N/A	N/A	N/A	60.61 Kips
48.29 ft	Cohesive	N/A	N/A	N/A	60.61 Kips
48.31 ft	Cohesionless	4493.81 psf	77.60	162.06 Kips	162.06 Kips
50.99 ft	Cohesionless	4688.37 psf	77.60	162.06 Kips	162.06 Kips
51.01 ft	Cohesionless	4689.83 psf	77.60	162.06 Kips	162.06 Kips
51.99 ft	Cohesionless	4760.97 psf	77.60	162.06 Kips	162.06 Kips
52.01 ft	Cohesionless	4762.48 psf	77.60	162.06 Kips	162.06 Kips
61.01 ft	Cohesionless	5460.88 psf	77.60	162.06 Kips	162.06 Kips
61.49 ft	Cohesionless	5498.12 psf	77.60	162.06 Kips	162.06 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.05 Kips	0.05 Kips
2.99 ft	1.02 Kips	15.30 Kips	16.32 Kips
3.01 ft	1.07 Kips	12.99 Kips	14.06 Kips
5.49 ft	11.25 Kips	12.99 Kips	24.24 Kips
5.51 ft	11.31 Kips	15.39 Kips	26.70 Kips
14.49 ft	35.47 Kips	15.39 Kips	50.86 Kips
14.51 ft	35.53 Kips	34.64 Kips	70.17 Kips
16.99 ft	42.07 Kips	34.64 Kips	76.71 Kips
17.01 ft	42.11 Kips	37.04 Kips	79.15 Kips
19.49 ft	46.86 Kips	37.04 Kips	83.90 Kips
19.51 ft	46.90 Kips	28.86 Kips	75.77 Kips
28.51 ft	66.96 Kips	28.86 Kips	95.83 Kips
30.69 ft	71.82 Kips	28.86 Kips	100.69 Kips
30.71 ft	71.92 Kips	162.06 Kips	233.98 Kips
33.29 ft	89.18 Kips	162.06 Kips	251.24 Kips
33.31 ft	89.33 Kips	115.03 Kips	204.36 Kips
38.29 ft	126.68 Kips	115.03 Kips	241.71 Kips
38.31 ft	126.82 Kips	162.06 Kips	288.89 Kips
40.69 ft	145.19 Kips	162.06 Kips	307.25 Kips
40.71 ft	145.46 Kips	60.61 Kips	206.07 Kips
48.29 ft	290.73 Kips	60.61 Kips	351.34 Kips
48.31 ft	291.07 Kips	162.06 Kips	453.13 Kips
50.99 ft	320.72 Kips	162.06 Kips	482.78 Kips
51.01 ft	320.87 Kips	162.06 Kips	482.94 Kips
51.99 ft	328.35 Kips	162.06 Kips	490.41 Kips
52.01 ft	328.54 Kips	162.06 Kips	490.60 Kips
61.01 ft	420.56 Kips	162.06 Kips	582.62 Kips
61.49 ft	425.82 Kips	162.06 Kips	587.88 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.55 psf	23.33	N/A	0.00 Kips
2.99 ft	Cohesionless	164.45 psf	23.33	N/A	1.02 Kips
3.01 ft	Cohesive	N/A	N/A	1350.00 psf	1.08 Kips
5.49 ft	Cohesive	N/A	N/A	1350.00 psf	13.35 Kips
5.51 ft	Cohesive	N/A	N/A	1287.72 psf	13.45 Kips
14.49 ft	Cohesive	N/A	N/A	1287.72 psf	55.83 Kips
14.51 ft	Cohesive	N/A	N/A	867.09 psf	55.91 Kips
16.99 ft	Cohesive	N/A	N/A	867.09 psf	63.79 Kips
17.01 ft	Cohesive	N/A	N/A	916.30 psf	63.85 Kips
19.49 ft	Cohesive	N/A	N/A	916.30 psf	72.18 Kips
19.51 ft	Cohesive	N/A	N/A	907.69 psf	72.25 Kips
28.51 ft	Cohesive	N/A	N/A	907.69 psf	102.19 Kips
30.69 ft	Cohesive	N/A	N/A	907.69 psf	109.44 Kips
30.71 ft	Cohesionless	3244.91 psf	23.99	N/A	109.56 Kips
33.29 ft	Cohesionless	3345.01 psf	23.99	N/A	130.36 Kips
33.31 ft	Cohesionless	3446.61 psf	23.33	N/A	130.51 Kips
38.29 ft	Cohesionless	3609.95 psf	23.33	N/A	167.86 Kips
38.31 ft	Cohesionless	3774.63 psf	23.99	N/A	168.03 Kips
40.69 ft	Cohesionless	3857.45 psf	23.99	N/A	190.15 Kips
40.71 ft	Cohesive	N/A	N/A	6300.00 psf	190.48 Kips
48.29 ft	Cohesive	N/A	N/A	6300.00 psf	365.51 Kips
48.31 ft	Cohesionless	4493.44 psf	23.99	N/A	365.85 Kips
50.99 ft	Cohesionless	4590.73 psf	23.99	N/A	395.50 Kips
51.01 ft	Cohesionless	4689.46 psf	23.99	N/A	395.72 Kips
51.99 ft	Cohesionless	4725.04 psf	23.99	N/A	406.88 Kips
52.01 ft	Cohesionless	4762.09 psf	23.99	N/A	407.11 Kips
61.01 ft	Cohesionless	5111.29 psf	23.99	N/A	517.97 Kips
61.49 ft	Cohesionless	5129.91 psf	23.99	N/A	524.31 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.10 psf	64.00	115.03 Kips	0.05 Kips
2.99 ft	Cohesionless	328.90 psf	64.00	115.03 Kips	15.30 Kips
3.01 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
5.49 ft	Cohesive	N/A	N/A	N/A	12.99 Kips
5.51 ft	Cohesive	N/A	N/A	N/A	15.39 Kips
14.49 ft	Cohesive	N/A	N/A	N/A	15.39 Kips
14.51 ft	Cohesive	N/A	N/A	N/A	34.64 Kips
16.99 ft	Cohesive	N/A	N/A	N/A	34.64 Kips
17.01 ft	Cohesive	N/A	N/A	N/A	37.04 Kips
19.49 ft	Cohesive	N/A	N/A	N/A	37.04 Kips
19.51 ft	Cohesive	N/A	N/A	N/A	28.86 Kips
28.51 ft	Cohesive	N/A	N/A	N/A	28.86 Kips
30.69 ft	Cohesive	N/A	N/A	N/A	28.86 Kips
30.71 ft	Cohesionless	3245.30 psf	77.60	162.06 Kips	162.06 Kips
33.29 ft	Cohesionless	3445.50 psf	77.60	162.06 Kips	162.06 Kips
33.31 ft	Cohesionless	3446.94 psf	64.00	115.03 Kips	115.03 Kips
38.29 ft	Cohesionless	3773.62 psf	64.00	115.03 Kips	115.03 Kips
38.31 ft	Cohesionless	3774.98 psf	77.60	162.06 Kips	162.06 Kips
40.69 ft	Cohesionless	3940.62 psf	77.60	162.06 Kips	162.06 Kips
40.71 ft	Cohesive	N/A	N/A	N/A	60.61 Kips
48.29 ft	Cohesive	N/A	N/A	N/A	60.61 Kips
48.31 ft	Cohesionless	4493.81 psf	77.60	162.06 Kips	162.06 Kips
50.99 ft	Cohesionless	4688.37 psf	77.60	162.06 Kips	162.06 Kips
51.01 ft	Cohesionless	4689.83 psf	77.60	162.06 Kips	162.06 Kips
51.99 ft	Cohesionless	4760.97 psf	77.60	162.06 Kips	162.06 Kips
52.01 ft	Cohesionless	4762.48 psf	77.60	162.06 Kips	162.06 Kips
61.01 ft	Cohesionless	5460.88 psf	77.60	162.06 Kips	162.06 Kips
61.49 ft	Cohesionless	5498.12 psf	77.60	162.06 Kips	162.06 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.05 Kips	0.05 Kips
2.99 ft	1.02 Kips	15.30 Kips	16.32 Kips
3.01 ft	1.08 Kips	12.99 Kips	14.07 Kips
5.49 ft	13.35 Kips	12.99 Kips	26.34 Kips
5.51 ft	13.45 Kips	15.39 Kips	28.84 Kips
14.49 ft	55.83 Kips	15.39 Kips	71.22 Kips
14.51 ft	55.91 Kips	34.64 Kips	90.54 Kips
16.99 ft	63.79 Kips	34.64 Kips	98.43 Kips
17.01 ft	63.85 Kips	37.04 Kips	100.90 Kips
19.49 ft	72.18 Kips	37.04 Kips	109.22 Kips
19.51 ft	72.25 Kips	28.86 Kips	101.11 Kips
28.51 ft	102.19 Kips	28.86 Kips	131.06 Kips
30.69 ft	109.44 Kips	28.86 Kips	138.31 Kips
30.71 ft	109.56 Kips	162.06 Kips	271.62 Kips
33.29 ft	130.36 Kips	162.06 Kips	292.42 Kips
33.31 ft	130.51 Kips	115.03 Kips	245.54 Kips
38.29 ft	167.86 Kips	115.03 Kips	282.89 Kips
38.31 ft	168.03 Kips	162.06 Kips	330.09 Kips
40.69 ft	190.15 Kips	162.06 Kips	352.22 Kips
40.71 ft	190.48 Kips	60.61 Kips	251.09 Kips
48.29 ft	365.51 Kips	60.61 Kips	426.12 Kips
48.31 ft	365.85 Kips	162.06 Kips	527.91 Kips
50.99 ft	395.50 Kips	162.06 Kips	557.56 Kips
51.01 ft	395.72 Kips	162.06 Kips	557.79 Kips
51.99 ft	406.88 Kips	162.06 Kips	568.95 Kips
52.01 ft	407.11 Kips	162.06 Kips	569.17 Kips
61.01 ft	517.97 Kips	162.06 Kips	680.04 Kips
61.49 ft	524.31 Kips	162.06 Kips	686.37 Kips

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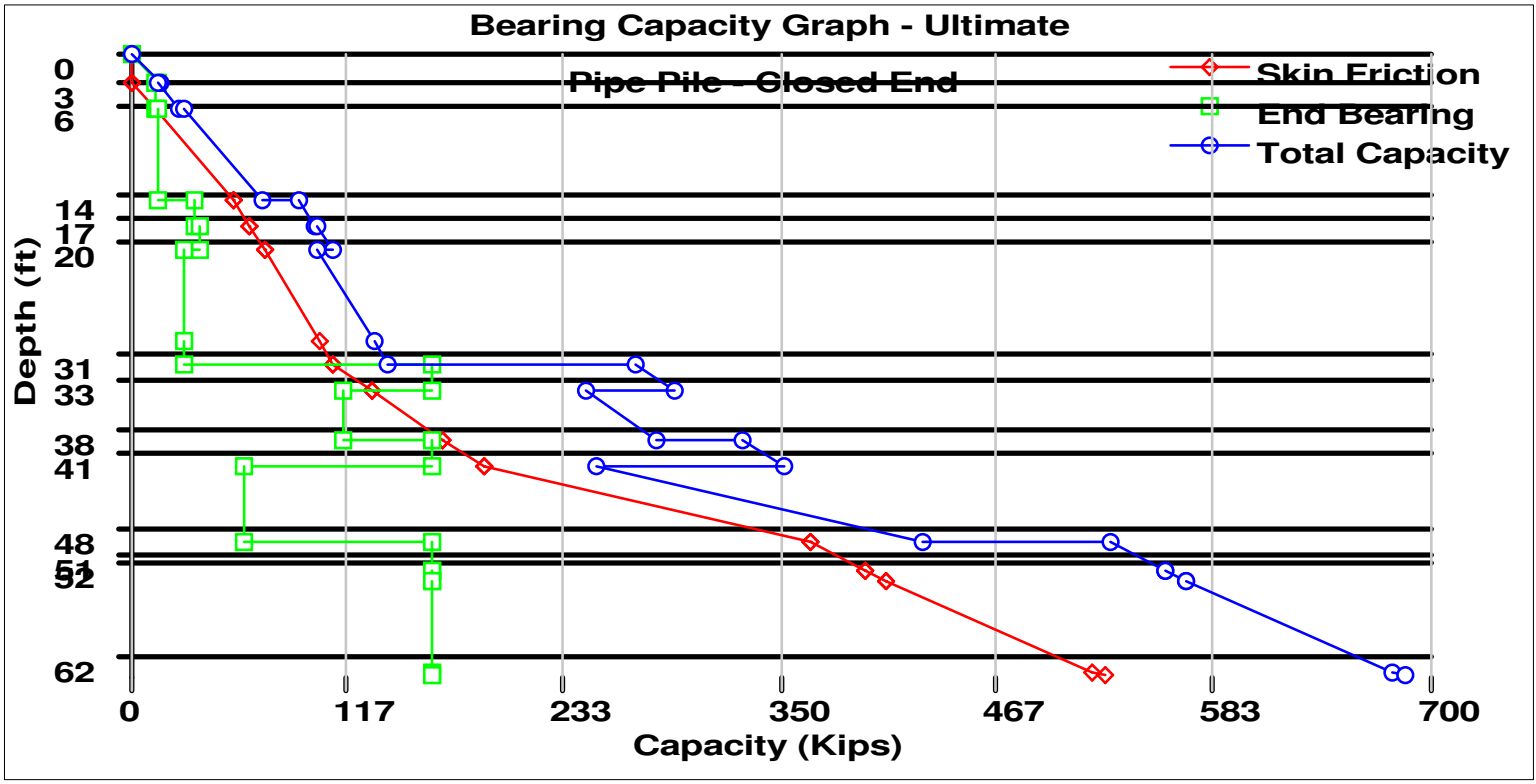


APPENDIX E

PILE DRIVABILITY ANALYSIS

REAR ABUTMENT

Gain/Loss 3 at Shaft and Toe 0.500 / 1.000

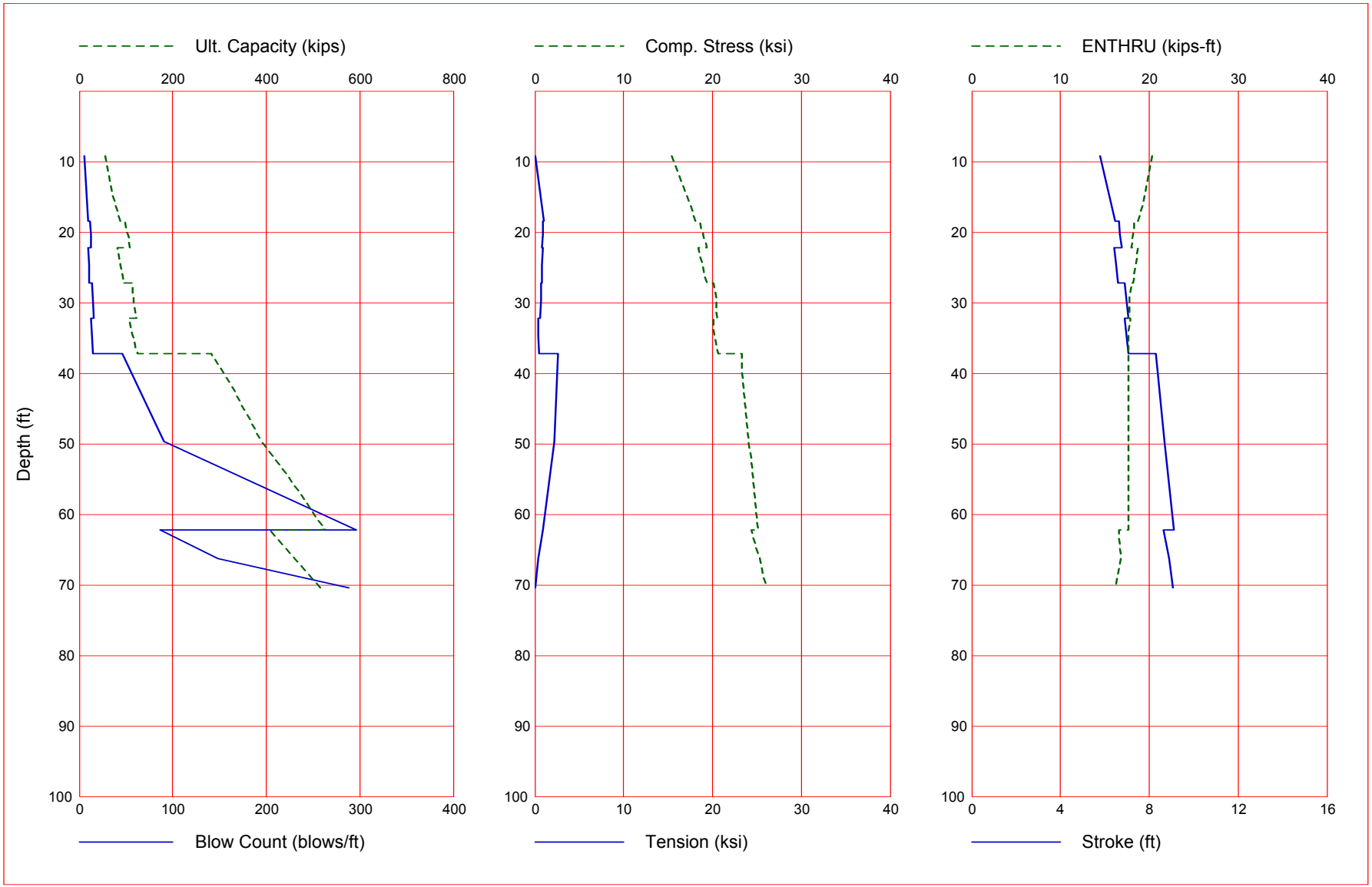
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
9.2	56.1	29.4	26.7	5.7	15.369	-0.055	5.80	20.3
18.4	87.3	60.5	26.7	10.1	18.089	-1.042	6.45	18.7
18.4	99.2	60.6	38.6	11.6	18.549	-0.935	6.62	18.3
20.3	103.3	64.8	38.6	12.2	18.961	-0.933	6.69	18.2
22.2	107.5	68.9	38.6	12.8	19.388	-0.850	6.76	18.0
22.2	82.9	69.0	13.9	9.7	18.435	-0.946	6.43	18.7
24.7	88.2	74.3	13.9	10.4	18.912	-0.847	6.52	18.5
27.2	93.5	79.6	13.9	11.1	19.347	-0.835	6.61	18.2
27.2	111.5	79.7	31.9	13.6	20.084	-0.709	6.91	18.0
29.7	116.9	85.0	31.9	14.5	20.433	-0.695	6.99	17.8
32.2	122.3	90.4	31.9	15.6	20.552	-0.608	7.08	17.6
32.2	105.7	90.5	15.2	12.9	20.073	-0.361	6.88	17.9
34.7	114.8	99.6	15.2	13.9	20.174	-0.396	6.97	17.7
37.2	124.3	109.1	15.2	15.1	20.691	-0.436	7.07	17.6
37.2	282.6	109.4	173.2	45.8	23.271	-2.604	8.29	17.7
49.7	390.5	217.3	173.2	90.2	24.016	-2.204	8.69	17.7
62.2	524.6	351.4	173.2	296.4	25.110	-0.886	9.09	17.6
62.2	407.4	351.9	55.5	86.7	24.324	-0.861	8.63	16.6
66.3	461.2	405.7	55.5	148.0	25.320	-0.424	8.91	16.8
70.4	515.6	460.1	55.5	288.1	26.029	0.000	9.07	16.2

Total Continuous Driving Time 124.00 minutes; Total Number of Blows 4953 (starting at penetration 9.2 ft)

National Engineering & Architectural Ser
GRE-42-0263-RA : 01/23/2020 :

Nov 24 2020
GRLWEAP Version 2010

Gain/Loss 3 at Shaft and Toe 0.500 / 1.000



GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

♀

Input File: C:\USERS\KARENS\DESKTOP\NEW FOLDER\RA\GRL FILES\RA_14IN.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (10/17/2016)

Input File Contents

GRE-42-0263-RA : 01/23/2020 :

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	41	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	153.930	14.000	Pipe

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
2.500	21.200	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
70.380	21.20	29000.0	492.000	3.665	0	0.850	0.010

FFatigue	F0	0-Bottom
0	0.000	0.000

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 19-42	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
4.00	129.10	12.60	11.86	10.81	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
16.65	124.70	157.70	0.0020	0.0020	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1600.00	1440.00	1295.00	1165.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
10.8100	0.8000	1600.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.233	0.150	0.150	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	1.05	26.73	0.10	0.12	0.20	0.15	1.21	0.00	0.000
9.01	1.05	26.73	0.10	0.12	0.20	0.15	1.21	0.00	0.000
18.01	1.17	26.73	0.10	0.12	0.20	0.15	1.21	0.00	0.000
18.39	1.18	26.73	0.10	0.12	0.20	0.15	1.21	0.00	0.000
18.41	0.89	38.57	0.10	0.12	0.20	0.15	1.49	0.00	0.000
22.19	0.89	38.57	0.10	0.12	0.20	0.15	1.49	0.00	0.000
22.21	1.17	13.89	0.10	0.12	0.20	0.15	2.00	0.00	0.000
27.19	1.17	13.89	0.10	0.12	0.20	0.15	2.00	0.00	0.000
27.21	0.88	31.89	0.10	0.12	0.20	0.15	1.49	0.00	0.000
32.19	0.88	31.89	0.10	0.12	0.20	0.15	1.49	0.00	0.000
32.21	0.98	15.22	0.10	0.12	0.05	0.15	1.00	0.00	0.000
37.19	1.07	15.22	0.10	0.12	0.05	0.15	1.00	0.00	0.000
37.21	2.07	173.24	0.10	0.12	0.05	0.15	1.00	0.00	0.000
46.21	2.49	173.24	0.10	0.12	0.05	0.15	1.00	0.00	0.000
55.21	2.90	173.24	0.10	0.12	0.05	0.15	1.00	0.00	0.000
62.19	3.22	173.24	0.10	0.12	0.05	0.15	1.00	0.00	0.000
62.21	5.40	55.53	0.10	0.12	0.20	0.15	1.49	0.00	0.000
70.38	5.40	55.53	0.10	0.12	0.20	0.15	1.49	0.00	0.000

Gain/Loss factors: shaft and toe

0.40000	0.45000	0.50000	0.55000	0.60000
1.00000	1.00000	1.00000	1.00000	1.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
9.20	0.00	0.00	0.000	0.0	0.000	0.000	0.000
18.38	0.00	0.00	0.000	0.0	0.000	0.000	0.000
18.42	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.30	0.00	0.00	0.000	0.0	0.000	0.000	0.000
22.18	0.00	0.00	0.000	0.0	0.000	0.000	0.000
22.22	0.00	0.00	0.000	0.0	0.000	0.000	0.000
24.70	0.00	0.00	0.000	0.0	0.000	0.000	0.000
27.18	0.00	0.00	0.000	0.0	0.000	0.000	0.000
27.22	0.00	0.00	0.000	0.0	0.000	0.000	0.000
29.70	0.00	0.00	0.000	0.0	0.000	0.000	0.000
32.18	0.00	0.00	0.000	0.0	0.000	0.000	0.000
32.22	0.00	0.00	0.000	0.0	0.000	0.000	0.000
34.70	0.00	0.00	0.000	0.0	0.000	0.000	0.000
37.18	0.00	0.00	0.000	0.0	0.000	0.000	0.000
37.22	0.00	0.00	0.000	0.0	0.000	0.000	0.000
49.70	0.00	0.00	0.000	0.0	0.000	0.000	0.000
62.18	0.00	0.00	0.000	0.0	0.000	0.000	0.000
62.22	0.00	0.00	0.000	0.0	0.000	0.000	0.000
66.28	0.00	0.00	0.000	0.0	0.000	0.000	0.000

70.38	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

♀ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

GRE-42-0263-RA : 01/23/2020 :

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	2.500	5618.0	0.800	0.0100	5.8
Combined Pile Top		15287.0			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	1600.00	Actual Pressure	(psi)	1600.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	21.20	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	5618.0	Stiffness	(kips/in)	0.0

♀
GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth	(ft)	9.2	Standard Soil Setup		
Shaft Gain/Loss Factor		0.400	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in2)	153.930	Pile Type		Pipe
Pile Size	(inch)	14.000			

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s

0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model — Total Capacity Rut (kips) 54.9

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	7.6	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	70.38	3.7	21.2
Toe						26.7	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:
Uniform pile
No. of Slacks/Splices 0
Pile Segments: Automatic
Pile Damping (%) 1
Pile Damping Fact.(k/ft/s) 0.744

Driveability Analysis
Soil Damping Option Smith
Max No Analysis Iterations 0
Time Increment/Critical 160
Output Time Interval 1
Analysis Time-Input (ms) 0
Output Level: Normal
Gravity Mass, Pile, Hammer: 32.170 32.170 32.170
Output Segment Generation: Automatic

Depth ft	Stroke ft	Pressure Ratio	Efficy
9.20	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
54.9	5.5	5.77	5.82	-0.09	2	11	15.26	13	6	20.4	49.2
55.5	5.6	5.79	5.83	-0.07	2	11	15.32	13	6	20.4	49.1
56.1	5.7	5.80	5.84	-0.06	2	12	15.37	13	6	20.3	49.1
56.7	5.8	5.82	5.86	-0.05	2	12	15.40	13	6	20.3	49.0
57.3	5.8	5.83	5.87	-0.05	2	12	15.45	14	6	20.2	48.9

♀

Depth (ft) 18.4
Standard Soil Setup
Shaft Gain/Loss Factor 0.400
Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930
Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model — Total Capacity Rut (kips) 84.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	5.0	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	56.97	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	10.4	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	10.8	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	11.3	0.200	0.100	70.38	3.7	21.2
Toe						26.7	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
18.38	10.81	1.00	0.800

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National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
84.8	9.8	6.41	6.43	-1.03	16	50	17.92	15	6	18.8	46.6
86.0	10.0	6.43	6.45	-1.05	16	50	18.00	15	6	18.7	46.5
87.3	10.1	6.45	6.47	-1.04	16	50	18.09	15	6	18.7	46.5
88.5	10.3	6.47	6.49	-1.03	16	50	18.17	15	6	18.6	46.4
89.7	10.4	6.50	6.51	-1.00	16	50	18.26	15	6	18.6	46.3

♀

GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 18.4 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 96.7

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	5.1	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	56.97	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	10.4	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	10.8	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	11.3	0.200	0.100	70.38	3.7	21.2
Toe						38.6	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
18.42	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
96.7	11.2	6.58	6.59	-0.90	16	47	18.40	15	6	18.4	46.0
98.0	11.4	6.60	6.61	-0.92	16	47	18.46	15	6	18.3	45.9
99.2	11.6	6.62	6.63	-0.94	16	47	18.55	15	6	18.3	45.9
100.5	11.7	6.64	6.65	-0.95	16	47	18.63	15	6	18.3	45.8
101.7	11.9	6.66	6.67	-0.95	16	47	18.68	15	6	18.2	45.7

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 20.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model — Total Capacity Rut (kips) 100.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	0.6	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	53.62	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	10.7	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	11.1	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	8.7	0.200	0.100	70.38	3.7	21.2
Toe						38.6	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
20.30	10.81	1.00	0.800

♀

GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
100.4	11.7	6.64	6.65	-0.93	16	47	18.78	15	6	18.2	45.8
101.9	12.0	6.66	6.68	-0.93	16	47	18.87	15	6	18.2	45.7
103.3	12.2	6.69	6.70	-0.93	16	47	18.96	15	6	18.2	45.6
104.8	12.4	6.71	6.72	-0.93	16	47	19.05	15	6	18.1	45.5
106.2	12.6	6.73	6.74	-0.92	16	46	19.14	15	6	18.1	45.5

♀
GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 22.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 104.2

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D Quake s/ft	inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	6.3	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	53.62	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	10.5	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	10.9	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	10.7	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	6.6	0.200	0.100	70.38	3.7	21.2
Toe						38.6	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
22.18	10.81	1.00	0.800

♀
GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
104.2	12.3	6.71	6.71	-0.87	15	47	19.19	15	6	18.1	45.6
105.8	12.6	6.73	6.74	-0.86	15	47	19.29	15	6	18.1	45.5
107.5	12.8	6.76	6.77	-0.85	15	46	19.39	15	6	18.0	45.4
109.1	13.0	6.85	6.78	-0.82	15	46	19.63	15	6	18.2	45.2
110.8	13.3	6.87	6.80	-0.89	15	43	19.74	15	6	18.1	45.2

♀
GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 22.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2

70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model — Total Capacity Rut (kips) 79.5

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	6.5	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	53.62	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	10.5	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	10.9	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	10.7	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	6.6	0.200	0.100	70.38	3.7	21.2
Toe						13.9	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
22.22	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
79.5	9.2	6.36	6.38	-0.75	15	50	18.18	15	6	18.8	46.8
81.2	9.5	6.40	6.41	-0.86	15	50	18.31	15	6	18.8	46.7
82.9	9.7	6.43	6.44	-0.95	15	50	18.44	15	6	18.7	46.6
84.5	10.0	6.45	6.47	-0.97	15	50	18.56	15	6	18.7	46.5
86.2	10.2	6.48	6.50	-0.96	15	50	18.66	15	6	18.6	46.4

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 24.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L ft	b Top in2	Area ksi	E-Mod lb/ft3	Spec Wt ft	Perim	C Index ft/s	Wave Sp k/ft/s	EA/c
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2	
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2	

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model — Total Capacity Rut (kips) 83.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	3.8	0.200	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	50.27	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	10.4	0.200	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	10.8	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	11.2	0.200	0.100	63.68	3.7	21.2

20	0.243	15287	0.000	0.000	1.00	7.2	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	6.0	0.200	0.100	70.38	3.7	21.2
Toe						13.9	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
24.70	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
83.8	9.9	6.45	6.47	-0.91	14	50	18.65	14	6	18.7	46.5
86.0	10.1	6.49	6.50	-0.89	14	50	18.79	14	6	18.6	46.3
88.2	10.4	6.52	6.53	-0.85	10	49	18.91	14	6	18.5	46.2
90.3	10.7	6.55	6.57	-0.86	10	49	19.04	14	6	18.4	46.1
92.5	11.0	6.59	6.60	-0.84	10	48	19.17	14	6	18.3	46.0

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 27.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 88.0

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	1.1	0.200	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	46.92	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	10.7	0.200	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	11.1	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	8.4	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	6.2	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	70.38	3.7	21.2
Toe						13.9	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
27.18	10.81	1.00	0.800

♀

GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
88.0	10.4	6.53	6.54	-0.86	10	49	19.01	14	6	18.4	46.2
90.7	10.8	6.57	6.58	-0.87	10	49	19.18	14	6	18.3	46.0
93.5	11.1	6.61	6.62	-0.83	10	49	19.35	14	6	18.2	45.9
96.2	11.5	6.65	6.67	-0.79	14	47	19.47	14	6	18.1	45.8
98.9	11.9	6.70	6.71	-0.77	14	47	19.64	14	6	18.0	45.6

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 27.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 106.1

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	1.2	0.200	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	46.92	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	10.7	0.200	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	11.1	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	8.4	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	6.2	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	70.38	3.7	21.2
Toe						31.9	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
27.22	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
106.1	12.7	6.76	6.77	-0.67	14	47	19.68	14	6	17.9	45.4
108.8	13.1	6.87	6.80	-0.62	14	47	19.95	14	6	18.0	45.1
111.5	13.6	6.91	6.84	-0.71	14	43	20.08	14	6	18.0	45.0
114.3	14.1	6.94	6.88	-0.82	14	43	20.22	14	6	17.9	44.9
117.0	14.5	6.98	6.92	-0.84	14	42	20.40	14	6	17.8	44.8

♀

GRE-42-0263-RA : 01/23/2020 : 11/24/2020

National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 29.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 110.9

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	8.8	0.200	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	10.6	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	11.0	0.200	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	9.6	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	6.4	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	6.3	0.200	0.100	70.38	3.7	21.2
Toe						31.9	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
29.70	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
110.9	13.5	6.91	6.84	-0.56	13	43	20.13	13	6	17.9	45.0
113.9	14.0	6.95	6.89	-0.68	13	43	20.26	13	6	17.8	44.9
116.9	14.5	6.99	6.93	-0.69	13	41	20.43	13	6	17.8	44.7
119.9	15.1	7.03	6.98	-0.73	13	41	20.56	13	6	17.7	44.6
122.9	15.7	7.07	7.02	-0.73	12	41	20.74	13	6	17.6	44.5

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 32.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s

0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model — Total Capacity Rut (kips) 115.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
12	0.243	15287	0.000	0.000	1.00	6.2	0.200	0.100	40.22	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	43.57	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	10.5	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	10.9	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	10.8	0.200	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	6.6	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	6.1	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	6.5	0.200	0.100	70.38	3.7	21.2
Toe						31.9	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
32.18	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
115.8	14.3	6.98	6.93	-0.53	12	41	20.22	12	6	17.7	44.8
119.0	14.9	7.03	6.98	-0.59	12	41	20.39	12	6	17.7	44.6
122.3	15.6	7.08	7.02	-0.61	11	40	20.55	12	6	17.6	44.5
125.5	16.2	7.12	7.07	-0.61	11	40	20.67	12	6	17.5	44.3
128.8	16.9	7.16	7.12	-0.58	11	40	20.85	12	6	17.5	44.2

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 32.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model — Total Capacity Rut (kips) 99.2

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
12	0.243	15287	0.000	0.000	1.00	6.3	0.200	0.100	40.22	3.7	21.2

13	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	43.57	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	10.5	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	10.9	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	10.7	0.200	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	6.6	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	6.1	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	6.6	0.199	0.100	70.38	3.7	21.2
Toe						15.2	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
32.22	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
99.2	11.9	6.72	6.73	-0.69	9	49	19.60	12	6	17.9	45.6
102.4	12.4	6.83	6.77	-0.56	9	49	19.91	12	6	18.0	45.3
105.7	12.9	6.88	6.81	-0.36	9	49	20.07	12	6	17.9	45.1
109.0	13.4	6.92	6.87	-0.42	8	41	20.19	12	6	17.8	45.0
112.2	14.0	6.97	6.91	-0.48	9	41	20.37	12	6	17.7	44.8

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 34.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 108.3

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
11	0.243	15287	0.000	0.000	1.00	3.6	0.200	0.100	36.87	3.7	21.2
12	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	40.22	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	10.4	0.200	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	10.8	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	11.2	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	7.3	0.200	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	6.0	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	5.9	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	6.5	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	10.8	0.085	0.100	70.38	3.7	21.2
Toe						15.2	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
34.70	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
108.3	12.8	6.88	6.82	-0.32	18	9	19.90	11	6	17.9	45.1
111.6	13.4	6.92	6.87	-0.33	12	43	20.06	11	6	17.8	45.0
114.8	13.9	6.97	6.92	-0.40	7	45	20.17	11	6	17.7	44.8
118.1	14.5	7.02	6.96	-0.36	8	40	20.33	11	6	17.6	44.7
121.3	15.1	7.06	7.01	-0.38	9	40	20.51	11	6	17.5	44.5

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 37.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 117.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
10	0.243	15287	0.000	0.000	1.00	0.9	0.200	0.100	33.51	3.7	21.2
11	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	36.87	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	10.7	0.200	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	11.1	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	8.5	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	6.2	0.200	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	6.5	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	9.3	0.123	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	12.8	0.050	0.100	70.38	3.7	21.2
Toe						15.2	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
37.18	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020

National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
117.8	13.9	6.98	6.92	-0.55	6	45	20.35	11	6	17.7	44.8
121.1	14.5	7.02	6.97	-0.46	6	44	20.52	11	6	17.6	44.7
124.3	15.1	7.07	7.02	-0.44	5	36	20.69	11	6	17.6	44.5
127.6	15.7	7.12	7.07	-0.49	6	36	20.81	11	6	17.4	44.3
130.9	16.4	7.16	7.12	-0.61	11	34	20.99	11	6	17.4	44.2

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 37.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 276.1

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
10	0.243	15287	0.000	0.000	1.00	1.1	0.200	0.100	33.51	3.7	21.2
11	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	36.87	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	10.7	0.200	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	11.1	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	8.5	0.200	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	6.2	0.200	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	6.5	0.200	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	9.3	0.121	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	12.9	0.050	0.100	70.38	3.7	21.2
Toe						173.2	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
37.22	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
276.1	43.8	8.23	8.23	-2.52	11	25	23.07	11	6	17.7	41.1
279.3	44.9	8.26	8.26	-2.56	11	25	23.16	11	6	17.7	41.1
282.6	45.8	8.29	8.28	-2.60	11	25	23.27	11	6	17.7	41.0
285.8	46.9	8.31	8.30	-2.65	11	25	23.35	11	6	17.7	41.0
289.1	47.8	8.34	8.32	-2.70	11	25	23.47	11	6	17.8	40.9

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 49.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 384.0

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
7	0.243	15287	0.000	0.000	1.00	8.5	0.200	0.100	23.46	3.7	21.2
8	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	26.81	3.7	21.2
9	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	30.16	3.7	21.2
10	0.243	15287	0.000	0.000	1.00	10.6	0.200	0.100	33.51	3.7	21.2
11	0.243	15287	0.000	0.000	1.00	11.0	0.200	0.100	36.87	3.7	21.2
12	0.243	15287	0.000	0.000	1.00	9.8	0.200	0.100	40.22	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	6.4	0.200	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	6.3	0.200	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	7.8	0.164	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	12.6	0.050	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	22.6	0.050	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	27.8	0.050	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	29.7	0.050	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	31.6	0.050	0.100	70.38	3.7	21.2
Toe						173.2	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
49.70	10.81	1.00	0.800

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
384.0	84.3	8.64	8.70	-2.30	7	22	23.84	7	5	17.7	40.1
387.3	87.1	8.66	8.72	-2.25	7	22	23.93	7	5	17.7	40.1
390.5	90.2	8.69	8.74	-2.20	7	22	24.02	7	5	17.7	40.0
393.8	92.4	8.71	8.76	-2.15	7	22	24.14	7	5	17.7	40.0
397.1	95.6	8.73	8.78	-2.09	7	22	24.22	7	5	17.7	40.0

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Depth (ft) 62.2 Standard Soil Setup

Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 518.1

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
3	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	10.05	3.7	21.2
4	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	13.41	3.7	21.2
6	0.243	15287	0.000	0.000	1.00	10.4	0.200	0.100	20.11	3.7	21.2
7	0.243	15287	0.000	0.000	1.00	10.9	0.200	0.100	23.46	3.7	21.2
8	0.243	15287	0.000	0.000	1.00	11.0	0.200	0.100	26.81	3.7	21.2
9	0.243	15287	0.000	0.000	1.00	6.6	0.200	0.100	30.16	3.7	21.2
10	0.243	15287	0.000	0.000	1.00	5.8	0.200	0.100	33.51	3.7	21.2
11	0.243	15287	0.000	0.000	1.00	6.1	0.200	0.100	36.87	3.7	21.2
12	0.243	15287	0.000	0.000	1.00	6.5	0.200	0.100	40.22	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	12.1	0.057	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	18.8	0.050	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	27.3	0.050	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	29.2	0.050	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	31.0	0.050	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	32.9	0.050	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	34.8	0.050	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	36.7	0.050	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	38.6	0.050	0.100	70.38	3.7	21.2
Toe						173.2	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.18	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
518.1	262.8	9.07	9.04	-0.82	3	18	24.95	3	4	17.6	39.3
521.4	281.1	9.08	9.05	-0.85	3	18	25.01	3	4	17.5	39.3
524.6	296.4	9.09	9.06	-0.89	3	18	25.11	3	4	17.6	39.3
527.9	317.3	9.09	9.07	-0.92	3	17	25.17	3	4	17.5	39.3
531.1	337.0	9.10	9.08	-0.94	3	17	25.27	3	4	17.5	39.2

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National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 62.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model Total Capacity Rut (kips) 400.9

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	0.0	0.000	0.100	6.70	3.7	21.2
3	0.243	15287	0.000	0.000	1.00	5.8	0.200	0.100	10.05	3.7	21.2
4	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	13.41	3.7	21.2
6	0.243	15287	0.000	0.000	1.00	10.4	0.200	0.100	20.11	3.7	21.2
7	0.243	15287	0.000	0.000	1.00	10.9	0.200	0.100	23.46	3.7	21.2
8	0.243	15287	0.000	0.000	1.00	11.0	0.200	0.100	26.81	3.7	21.2
9	0.243	15287	0.000	0.000	1.00	6.6	0.200	0.100	30.16	3.7	21.2
10	0.243	15287	0.000	0.000	1.00	5.8	0.200	0.100	33.51	3.7	21.2
11	0.243	15287	0.000	0.000	1.00	6.1	0.200	0.100	36.87	3.7	21.2
12	0.243	15287	0.000	0.000	1.00	6.5	0.200	0.100	40.22	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	12.1	0.056	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	19.0	0.050	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	27.3	0.050	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	29.2	0.050	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	31.1	0.050	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	32.9	0.050	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	34.8	0.050	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	36.7	0.050	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	38.6	0.051	0.100	70.38	3.7	21.2
Toe						55.5	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.22	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
400.9	81.6	8.59	8.64	-0.91	3	22	24.09	3	4	16.5	40.3
404.2	84.5	8.61	8.66	-0.90	3	22	24.19	3	4	16.5	40.3
407.4	86.7	8.63	8.68	-0.86	3	22	24.32	3	4	16.6	40.2
410.7	89.9	8.65	8.69	-0.83	3	22	24.42	3	4	16.6	40.2
414.0	93.0	8.67	8.71	-0.80	3	22	24.52	3	4	16.5	40.1

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 66.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe

Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model — Total Capacity Rut (kips) 449.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	0.0	0.000	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	8.0	0.200	0.100	6.70	3.7	21.2
3	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	10.05	3.7	21.2
4	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	13.41	3.7	21.2
5	0.243	15287	0.000	0.000	1.00	10.5	0.200	0.100	16.76	3.7	21.2
6	0.243	15287	0.000	0.000	1.00	11.0	0.200	0.100	20.11	3.7	21.2
7	0.243	15287	0.000	0.000	1.00	10.0	0.200	0.100	23.46	3.7	21.2
8	0.243	15287	0.000	0.000	1.00	6.5	0.200	0.100	26.81	3.7	21.2
9	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	30.16	3.7	21.2
10	0.243	15287	0.000	0.000	1.00	6.3	0.200	0.100	33.51	3.7	21.2
11	0.243	15287	0.000	0.000	1.00	7.5	0.172	0.100	36.87	3.7	21.2
12	0.243	15287	0.000	0.000	1.00	12.5	0.050	0.100	40.22	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	21.9	0.050	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	27.7	0.050	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	29.6	0.050	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	31.5	0.050	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	33.3	0.050	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	35.2	0.050	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	37.1	0.050	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	39.1	0.098	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	40.0	0.200	0.100	70.38	3.7	21.2
Toe						55.5	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
66.28	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
449.4	131.0	8.87	8.86	-0.43	2	21	25.07	2	4	16.7	39.7
455.3	138.5	8.89	8.88	-0.40	2	18	25.21	2	4	16.8	39.7
461.2	148.0	8.91	8.90	-0.42	2	18	25.32	2	4	16.8	39.6
467.2	158.6	8.94	8.92	-0.44	2	18	25.43	2	4	16.8	39.6
473.1	168.9	8.96	8.94	-0.45	2	18	25.57	2	4	16.8	39.6

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Depth (ft) 70.4 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
70.4	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 8.518

Pile and Soil Model — Total Capacity Rut (kips) 498.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.243	15287	0.010	0.000	0.85	10.3	0.200	0.100	3.35	3.7	21.2
2	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	6.70	3.7	21.2
3	0.243	15287	0.000	0.000	1.00	10.3	0.200	0.100	10.05	3.7	21.2
4	0.243	15287	0.000	0.000	1.00	10.6	0.200	0.100	13.41	3.7	21.2
5	0.243	15287	0.000	0.000	1.00	11.1	0.200	0.100	16.76	3.7	21.2
6	0.243	15287	0.000	0.000	1.00	9.0	0.200	0.100	20.11	3.7	21.2
7	0.243	15287	0.000	0.000	1.00	6.3	0.200	0.100	23.46	3.7	21.2
8	0.243	15287	0.000	0.000	1.00	5.7	0.200	0.100	26.81	3.7	21.2
9	0.243	15287	0.000	0.000	1.00	6.4	0.200	0.100	30.16	3.7	21.2
10	0.243	15287	0.000	0.000	1.00	8.7	0.137	0.100	33.51	3.7	21.2
11	0.243	15287	0.000	0.000	1.00	12.7	0.050	0.100	36.87	3.7	21.2
12	0.243	15287	0.000	0.000	1.00	25.0	0.050	0.100	40.22	3.7	21.2
13	0.243	15287	0.000	0.000	1.00	28.1	0.050	0.100	43.57	3.7	21.2
14	0.243	15287	0.000	0.000	1.00	30.0	0.050	0.100	46.92	3.7	21.2
15	0.243	15287	0.000	0.000	1.00	31.9	0.050	0.100	50.27	3.7	21.2
16	0.243	15287	0.000	0.000	1.00	33.8	0.050	0.100	53.62	3.7	21.2
17	0.243	15287	0.000	0.000	1.00	35.6	0.050	0.100	56.97	3.7	21.2
18	0.243	15287	0.000	0.000	1.00	37.5	0.050	0.100	60.33	3.7	21.2
19	0.243	15287	0.000	0.000	1.00	39.5	0.136	0.100	63.68	3.7	21.2
20	0.243	15287	0.000	0.000	1.00	40.0	0.200	0.100	67.03	3.7	21.2
21	0.243	15287	0.000	0.000	1.00	40.0	0.200	0.100	70.38	3.7	21.2
Toe						55.5	0.150	0.117			

5.098 kips total unreduced pile weight (g= 32.17 ft/s2)
5.098 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
70.38	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
498.4	223.8	9.03	8.99	0.00	1	0	25.79	1	3	16.3	39.4
507.0	252.8	9.05	9.00	0.00	1	0	25.91	1	3	16.3	39.4
515.6	288.1	9.07	9.02	0.00	1	0	26.03	1	3	16.2	39.4
524.2	332.2	9.08	9.04	0.00	1	0	26.14	1	3	16.2	39.3
532.8	389.1	9.10	9.05	0.00	1	0	26.25	1	3	16.2	39.3

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SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.400 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
9.2	54.9	28.2	26.7	5.5	15.262	-0.095	5.77	20.4
18.4	84.8	58.1	26.7	9.8	17.924	-1.032	6.41	18.8

18.4	96.7	58.2	38.6	11.2	18.404	-0.903	6.58	18.4
20.3	100.4	61.9	38.6	11.7	18.779	-0.928	6.64	18.2
22.2	104.2	65.6	38.6	12.3	19.189	-0.872	6.71	18.1
22.2	79.5	65.7	13.9	9.2	18.184	-0.748	6.36	18.8
24.7	83.8	69.9	13.9	9.9	18.652	-0.913	6.45	18.7
27.2	88.0	74.1	13.9	10.4	19.010	-0.860	6.53	18.4
27.2	106.1	74.2	31.9	12.7	19.675	-0.673	6.76	17.9
29.7	110.9	79.0	31.9	13.5	20.126	-0.563	6.91	17.9
32.2	115.8	83.9	31.9	14.3	20.217	-0.534	6.98	17.7
32.2	99.2	84.0	15.2	11.9	19.599	-0.687	6.72	17.9
34.7	108.3	93.1	15.2	12.8	19.898	-0.316	6.88	17.9
37.2	117.8	102.6	15.2	13.9	20.353	-0.554	6.98	17.7
37.2	276.1	102.8	173.2	43.8	23.069	-2.524	8.23	17.7
49.7	384.0	210.8	173.2	84.3	23.844	-2.301	8.64	17.7
62.2	518.1	344.9	173.2	262.8	24.946	-0.818	9.07	17.6
62.2	400.9	345.4	55.5	81.6	24.095	-0.912	8.59	16.5
66.3	449.4	393.9	55.5	131.0	25.069	-0.428	8.87	16.7
70.4	498.4	442.9	55.5	223.8	25.788	0.000	9.03	16.3

Total Driving Time 110 minutes; Total No. of Blows 4428
Starting at penetration 9.2 ft

G/L at Shaft and Toe: 0.450 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
9.2	55.5	28.8	26.7	5.6	15.316	-0.067	5.79	20.4
18.4	86.0	59.3	26.7	10.0	18.003	-1.051	6.43	18.7
18.4	98.0	59.4	38.6	11.4	18.458	-0.924	6.60	18.3
20.3	101.9	63.3	38.6	12.0	18.872	-0.931	6.66	18.2
22.2	105.8	67.2	38.6	12.6	19.289	-0.862	6.73	18.1
22.2	81.2	67.3	13.9	9.5	18.308	-0.860	6.40	18.8
24.7	86.0	72.1	13.9	10.1	18.786	-0.894	6.49	18.6
27.2	90.7	76.9	13.9	10.8	19.179	-0.868	6.57	18.3
27.2	108.8	76.9	31.9	13.1	19.949	-0.621	6.87	18.0
29.7	113.9	82.0	31.9	14.0	20.261	-0.684	6.95	17.8
32.2	119.0	87.1	31.9	14.9	20.385	-0.585	7.03	17.7
32.2	102.4	87.2	15.2	12.4	19.907	-0.555	6.83	18.0
34.7	111.6	96.3	15.2	13.4	20.059	-0.334	6.92	17.8
37.2	121.1	105.9	15.2	14.5	20.522	-0.456	7.02	17.6
37.2	279.3	106.1	173.2	44.9	23.156	-2.563	8.26	17.7
49.7	387.3	214.1	173.2	87.1	23.934	-2.254	8.66	17.7
62.2	521.4	348.1	173.2	281.1	25.013	-0.845	9.08	17.5
62.2	404.2	348.6	55.5	84.5	24.190	-0.895	8.61	16.5
66.3	455.3	399.8	55.5	138.5	25.212	-0.402	8.89	16.8
70.4	507.0	451.5	55.5	252.8	25.911	0.000	9.05	16.3

Total Driving Time 117 minutes; Total No. of Blows 4689
Starting at penetration 9.2 ft

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.500 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
9.2	56.1	29.4	26.7	5.7	15.369	-0.055	5.80	20.3
18.4	87.3	60.5	26.7	10.1	18.089	-1.042	6.45	18.7
18.4	99.2	60.6	38.6	11.6	18.549	-0.935	6.62	18.3
20.3	103.3	64.8	38.6	12.2	18.961	-0.933	6.69	18.2
22.2	107.5	68.9	38.6	12.8	19.388	-0.850	6.76	18.0
22.2	82.9	69.0	13.9	9.7	18.435	-0.946	6.43	18.7

24.7	88.2	74.3	13.9	10.4	18.912	-0.847	6.52	18.5
27.2	93.5	79.6	13.9	11.1	19.347	-0.835	6.61	18.2
27.2	111.5	79.7	31.9	13.6	20.084	-0.709	6.91	18.0
29.7	116.9	85.0	31.9	14.5	20.433	-0.695	6.99	17.8
32.2	122.3	90.4	31.9	15.6	20.552	-0.608	7.08	17.6
32.2	105.7	90.5	15.2	12.9	20.073	-0.361	6.88	17.9
34.7	114.8	99.6	15.2	13.9	20.174	-0.396	6.97	17.7
37.2	124.3	109.1	15.2	15.1	20.691	-0.436	7.07	17.6
37.2	282.6	109.4	173.2	45.8	23.271	-2.604	8.29	17.7
49.7	390.5	217.3	173.2	90.2	24.016	-2.204	8.69	17.7
62.2	524.6	351.4	173.2	296.4	25.110	-0.886	9.09	17.6
62.2	407.4	351.9	55.5	86.7	24.324	-0.861	8.63	16.6
66.3	461.2	405.7	55.5	148.0	25.320	-0.424	8.91	16.8
70.4	515.6	460.1	55.5	288.1	26.029	0.000	9.07	16.2

Total Driving Time 124 minutes; Total No. of Blows 4953
Starting at penetration 9.2 ft

G/L at Shaft and Toe: 0.550 1.000

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
9.2	56.7	30.0	26.7	5.8	15.400	-0.049	5.82	20.3
18.4	88.5	61.8	26.7	10.3	18.175	-1.026	6.47	18.6
18.4	100.5	61.9	38.6	11.7	18.635	-0.945	6.64	18.3
20.3	104.8	66.2	38.6	12.4	19.055	-0.926	6.71	18.1
22.2	109.1	70.5	38.6	13.0	19.629	-0.825	6.85	18.2
22.2	84.5	70.6	13.9	10.0	18.565	-0.967	6.45	18.7
24.7	90.3	76.5	13.9	10.7	19.042	-0.857	6.55	18.4
27.2	96.2	82.3	13.9	11.5	19.472	-0.793	6.65	18.1
27.2	114.3	82.4	31.9	14.1	20.217	-0.818	6.94	17.9
29.7	119.9	88.0	31.9	15.1	20.563	-0.730	7.03	17.7
32.2	125.5	93.6	31.9	16.2	20.671	-0.610	7.12	17.5
32.2	109.0	93.7	15.2	13.4	20.191	-0.422	6.92	17.8
34.7	118.1	102.8	15.2	14.5	20.334	-0.359	7.02	17.6
37.2	127.6	112.4	15.2	15.7	20.811	-0.494	7.12	17.4
37.2	285.8	112.6	173.2	46.9	23.354	-2.651	8.31	17.7
49.7	393.8	220.6	173.2	92.4	24.135	-2.146	8.71	17.7
62.2	527.9	354.6	173.2	317.3	25.174	-0.915	9.09	17.5
62.2	410.7	355.2	55.5	89.9	24.423	-0.834	8.65	16.6
66.3	467.2	411.6	55.5	158.6	25.427	-0.438	8.94	16.8
70.4	524.2	468.7	55.5	332.2	26.142	0.000	9.08	16.2

Total Driving Time 132 minutes; Total No. of Blows 5270
Starting at penetration 9.2 ft

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GRE-42-0263-RA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.600 1.000

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
9.2	57.3	30.6	26.7	5.8	15.454	-0.054	5.83	20.2
18.4	89.7	63.0	26.7	10.4	18.256	-1.003	6.50	18.6
18.4	101.7	63.1	38.6	11.9	18.684	-0.955	6.66	18.2
20.3	106.2	67.7	38.6	12.6	19.144	-0.920	6.73	18.1
22.2	110.8	72.2	38.6	13.3	19.736	-0.888	6.87	18.1
22.2	86.2	72.3	13.9	10.2	18.660	-0.961	6.48	18.6
24.7	92.5	78.6	13.9	11.0	19.166	-0.845	6.59	18.3
27.2	98.9	85.0	13.9	11.9	19.640	-0.766	6.70	18.0
27.2	117.0	85.1	31.9	14.5	20.396	-0.836	6.98	17.8
29.7	122.9	91.0	31.9	15.7	20.741	-0.730	7.07	17.6

32.2	128.8	96.9	31.9	16.9	20.846	-0.576	7.16	17.5
32.2	112.2	97.0	15.2	14.0	20.370	-0.485	6.97	17.7
34.7	121.3	106.1	15.2	15.1	20.505	-0.384	7.06	17.5
37.2	130.9	115.6	15.2	16.4	20.995	-0.614	7.16	17.4
37.2	289.1	115.9	173.2	47.8	23.468	-2.696	8.34	17.8
49.7	397.1	223.8	173.2	95.6	24.221	-2.093	8.73	17.7
62.2	531.1	357.9	173.2	337.0	25.275	-0.945	9.10	17.5
62.2	414.0	358.4	55.5	93.0	24.517	-0.796	8.67	16.5
66.3	473.1	417.5	55.5	168.9	25.572	-0.451	8.96	16.8
70.4	532.8	477.3	55.5	389.1	26.255	0.000	9.10	16.2

Total Driving Time 141 minutes; Total No. of Blows 5611
Starting at penetration 9.2 ft

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
9.20	70.38	0.00	10.81	1.00	0.80	1.00	1.00
18.38	70.38	0.00	10.81	1.00	0.80	1.00	1.00
18.42	70.38	0.00	10.81	1.00	0.80	1.00	1.00
20.30	70.38	0.00	10.81	1.00	0.80	1.00	1.00
22.18	70.38	0.00	10.81	1.00	0.80	1.00	1.00
22.22	70.38	0.00	10.81	1.00	0.80	1.00	1.00
24.70	70.38	0.00	10.81	1.00	0.80	1.00	1.00
27.18	70.38	0.00	10.81	1.00	0.80	1.00	1.00
27.22	70.38	0.00	10.81	1.00	0.80	1.00	1.00
29.70	70.38	0.00	10.81	1.00	0.80	1.00	1.00
32.18	70.38	0.00	10.81	1.00	0.80	1.00	1.00
32.22	70.38	0.00	10.81	1.00	0.80	1.00	1.00
34.70	70.38	0.00	10.81	1.00	0.80	1.00	1.00
37.18	70.38	0.00	10.81	1.00	0.80	1.00	1.00
37.22	70.38	0.00	10.81	1.00	0.80	1.00	1.00
49.70	70.38	0.00	10.81	1.00	0.80	1.00	1.00
62.18	70.38	0.00	10.81	1.00	0.80	1.00	1.00
62.22	70.38	0.00	10.81	1.00	0.80	1.00	1.00
66.28	70.38	0.00	10.81	1.00	0.80	1.00	1.00
70.38	70.38	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft2	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.01	1.05	26.73	0.100	0.117	0.200	0.150	0.340	0.000	0.000
9.01	1.05	26.73	0.100	0.117	0.200	0.150	0.340	0.000	0.000
18.01	1.17	26.73	0.100	0.117	0.200	0.150	0.340	0.000	0.000
18.39	1.18	26.73	0.100	0.117	0.200	0.150	0.340	0.000	0.000
18.41	0.89	38.57	0.100	0.117	0.200	0.150	0.660	0.000	0.000
22.19	0.89	38.57	0.100	0.117	0.200	0.150	0.660	0.000	0.000
22.21	1.17	13.89	0.100	0.117	0.200	0.150	1.000	0.000	0.000
27.19	1.17	13.89	0.100	0.117	0.200	0.150	1.000	0.000	0.000
27.21	0.88	31.89	0.100	0.117	0.200	0.150	0.660	0.000	0.000
32.19	0.88	31.89	0.100	0.117	0.200	0.150	0.660	0.000	0.000
32.21	0.98	15.22	0.100	0.117	0.050	0.150	0.000	0.000	0.000
37.19	1.07	15.22	0.100	0.117	0.050	0.150	0.000	0.000	0.000
37.21	2.07	173.24	0.100	0.117	0.050	0.150	0.000	0.000	0.000
46.21	2.49	173.24	0.100	0.117	0.050	0.150	0.000	0.000	0.000

55.21	2.90	173.24	0.100	0.117	0.050	0.150	0.000	0.000	0.000
62.19	3.22	173.24	0.100	0.117	0.050	0.150	0.000	0.000	0.000
62.21	5.40	55.53	0.100	0.117	0.200	0.150	0.660	0.000	0.000
70.38	5.40	55.53	0.100	0.117	0.200	0.150	0.660	0.000	0.000

FORWARD ABUTMENT

Gain/Loss 3 at Shaft and Toe 0.570 / 1.000

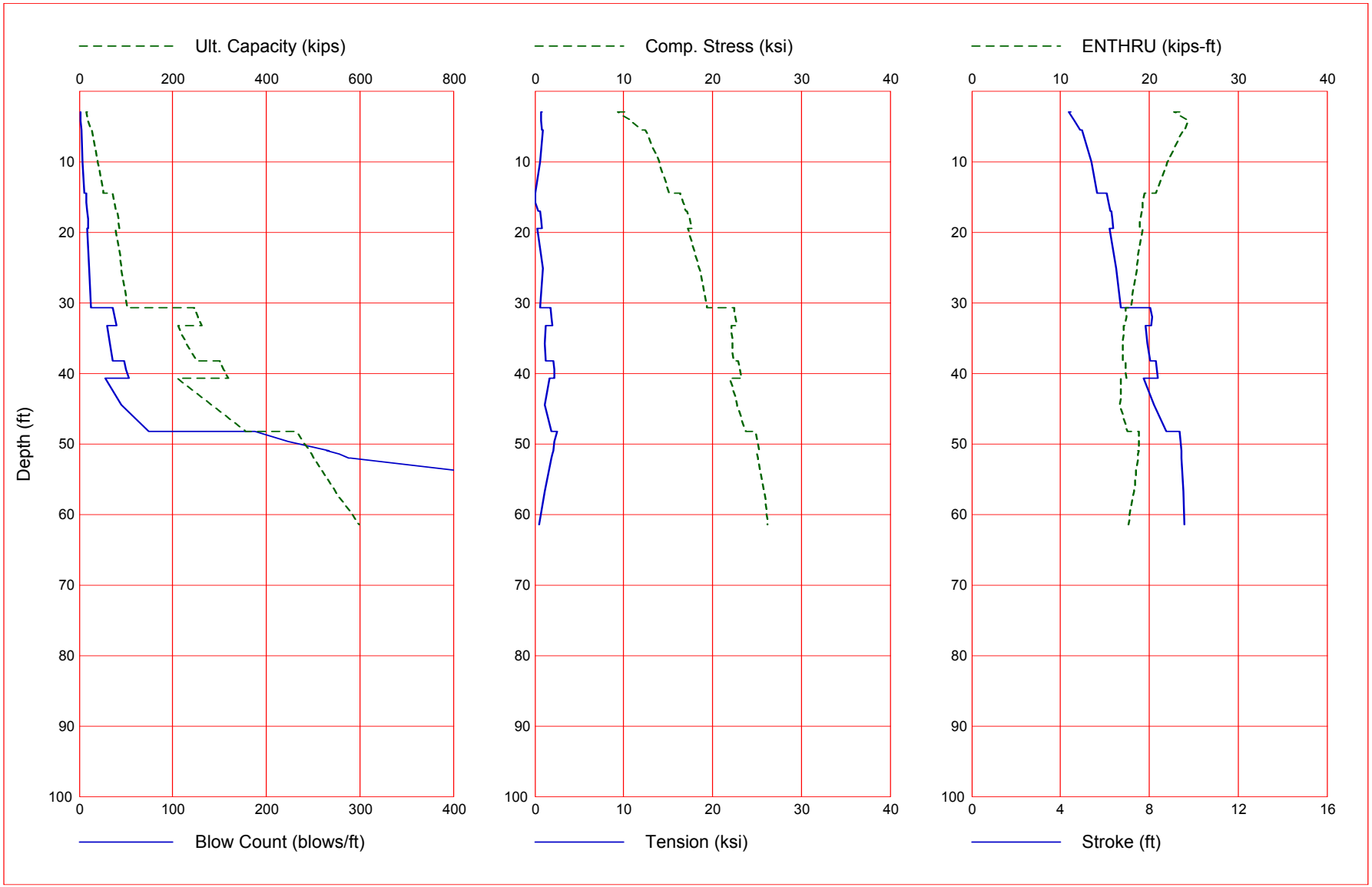
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
3.0	17.3	1.0	16.3	1.7	10.062	-0.835	4.47	23.4
3.0	15.0	1.1	13.9	1.5	9.346	-0.705	4.37	22.8
4.2	20.0	6.2	13.9	1.8	10.831	-0.644	4.62	24.4
5.5	25.1	11.2	13.9	2.1	12.007	-0.834	4.87	24.0
5.5	27.8	11.3	16.5	2.3	12.420	-0.864	4.96	23.8
10.0	39.8	23.4	16.5	3.7	14.042	-0.579	5.38	22.0
14.5	51.9	35.5	16.5	5.2	15.077	-0.095	5.67	20.7
14.5	72.6	35.6	37.0	7.7	16.375	0.000	6.08	19.5
15.8	75.8	38.8	37.0	8.1	16.674	-0.024	6.15	19.3
17.0	79.1	42.0	37.0	8.6	16.995	-0.342	6.23	19.2
17.0	81.7	42.1	39.6	9.0	17.135	-0.543	6.28	19.1
18.2	84.1	44.5	39.6	9.4	17.407	-0.684	6.33	18.9
19.5	86.4	46.8	39.6	9.7	17.680	-0.750	6.37	18.9
19.5	77.8	46.9	30.9	8.5	17.254	-0.235	6.22	19.2
25.1	90.2	59.4	30.9	10.6	18.533	-0.950	6.49	18.6
30.7	102.7	71.8	30.9	12.3	19.328	-0.597	6.72	18.0
30.7	245.2	72.0	173.2	36.1	22.438	-1.753	8.06	17.3
32.0	253.6	80.4	173.2	37.7	22.587	-1.886	8.11	17.4
33.3	262.3	89.1	173.2	39.9	22.669	-1.965	8.08	17.2
33.3	212.3	89.4	123.0	29.8	22.104	-1.239	7.81	17.1
35.8	230.5	107.6	123.0	32.8	22.235	-1.138	7.93	17.0
38.3	249.5	126.6	123.0	35.8	22.351	-1.232	8.04	17.0
38.3	300.1	126.9	173.2	48.2	22.903	-2.128	8.31	17.3
39.5	309.1	135.9	173.2	50.6	23.107	-2.176	8.35	17.3
40.7	318.3	145.1	173.2	52.8	23.259	-2.192	8.40	17.4
40.7	210.4	145.6	64.8	27.9	21.929	-1.645	7.74	16.8
44.5	282.9	218.1	64.8	45.2	22.746	-1.141	8.22	16.7
48.3	355.3	290.5	64.8	74.9	23.700	-1.886	8.75	17.5
48.3	464.3	291.1	173.2	187.5	24.760	-2.537	9.36	18.8
49.7	478.9	305.7	173.2	223.2	25.061	-2.211	9.41	18.8
51.0	493.8	320.5	173.2	267.2	25.187	-2.107	9.45	18.7
51.0	494.1	320.9	173.2	264.6	25.204	-2.097	9.45	18.8
51.5	497.8	324.6	173.2	278.0	25.033	-1.995	9.46	18.7
52.0	501.5	328.2	173.2	288.3	25.132	-1.884	9.47	18.7
52.0	501.8	328.6	173.2	289.7	25.141	-1.875	9.47	18.7
56.7	548.4	375.1	173.2	594.7	25.882	-1.114	9.55	18.3
61.5	598.8	425.6	173.2	4204.6	26.225	-0.491	9.59	17.7

Total Continuous Driving Time 397.00 minutes; Total Number of Blows 15322 (starting at penetration 3.0 ft)

National Engineering & Architectural Ser
GRE-42-0263-FA : 01/23/2020 :

Nov 24 2020
GRLWEAP Version 2010

Gain/Loss 3 at Shaft and Toe 0.570 / 1.000



GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

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Input File: C:\USERS\KARENS\DESKTOP\NEW FOLDER\FA\GRL FILES\FA_14IN.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (10/17/2016)

Input File Contents

GRE-42-0263-FA : 01/23/2020 :

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	41	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	153.930	14.000	Pipe

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
2.500	21.200	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
61.480	21.20	29000.0	492.000	3.665	0	0.850	0.010

FFatigue	F0	0-Bottom
0	0.000	0.000

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 19-42	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
4.00	129.10	12.60	11.86	10.81	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
16.65	124.70	157.70	0.0020	0.0020	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1600.00	1440.00	1295.00	1165.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
10.8100	0.8000	1600.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.175	0.150	0.150	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.05	0.10	0.12	0.05	0.15	1.00	0.00	0.000
2.99	0.19	16.36	0.10	0.12	0.05	0.15	1.00	0.00	0.000
3.01	1.35	13.89	0.10	0.12	0.20	0.15	1.21	0.00	0.000
5.49	1.35	13.89	0.10	0.12	0.20	0.15	1.21	0.00	0.000
5.51	1.29	16.45	0.10	0.12	0.20	0.15	1.75	0.00	0.000
14.49	1.29	16.45	0.10	0.12	0.20	0.15	1.75	0.00	0.000
14.51	0.87	37.03	0.10	0.12	0.20	0.15	1.21	0.00	0.000
16.99	0.87	37.03	0.10	0.12	0.20	0.15	1.21	0.00	0.000
17.01	0.92	39.59	0.10	0.12	0.20	0.15	1.75	0.00	0.000
19.49	0.92	39.59	0.10	0.12	0.20	0.15	1.75	0.00	0.000
19.51	0.91	30.85	0.10	0.12	0.20	0.15	1.49	0.00	0.000
28.51	0.91	30.85	0.10	0.12	0.20	0.15	1.49	0.00	0.000
30.69	0.91	30.85	0.10	0.12	0.20	0.15	1.49	0.00	0.000
30.71	2.13	173.24	0.10	0.12	0.05	0.15	1.21	0.00	0.000
33.29	2.27	173.24	0.10	0.12	0.05	0.15	1.21	0.00	0.000
33.31	1.95	122.96	0.10	0.12	0.05	0.15	1.00	0.00	0.000
38.29	2.14	122.96	0.10	0.12	0.05	0.15	1.00	0.00	0.000
38.31	2.48	173.24	0.10	0.12	0.05	0.15	1.21	0.00	0.000
40.69	2.59	173.24	0.10	0.12	0.05	0.15	1.21	0.00	0.000
40.71	6.30	64.79	0.10	0.12	0.20	0.15	1.21	0.00	0.000
48.29	6.30	64.79	0.10	0.12	0.20	0.15	1.21	0.00	0.000
48.31	2.95	173.24	0.10	0.12	0.05	0.15	1.00	0.00	0.000
50.99	3.08	173.24	0.10	0.12	0.05	0.15	1.00	0.00	0.000
51.01	3.08	173.24	0.10	0.12	0.05	0.15	1.49	0.00	0.000
51.99	3.13	173.24	0.10	0.12	0.05	0.15	1.49	0.00	0.000
52.01	3.13	173.24	0.10	0.12	0.05	0.15	1.21	0.00	0.000
61.01	3.59	173.24	0.10	0.12	0.05	0.15	1.21	0.00	0.000
61.48	3.61	173.24	0.10	0.12	0.05	0.15	1.21	0.00	0.000

Gain/Loss factors: shaft and toe

0.48400	0.52700	0.57000	0.61300	0.65600
1.00000	1.00000	1.00000	1.00000	1.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
2.98	0.00	0.00	0.000	0.0	0.000	0.000	0.000
3.02	0.00	0.00	0.000	0.0	0.000	0.000	0.000
4.25	0.00	0.00	0.000	0.0	0.000	0.000	0.000
5.48	0.00	0.00	0.000	0.0	0.000	0.000	0.000
5.52	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
14.48	0.00	0.00	0.000	0.0	0.000	0.000	0.000
14.52	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.75	0.00	0.00	0.000	0.0	0.000	0.000	0.000

16.98	0.00	0.00	0.000	0.0	0.000	0.000	0.000
17.02	0.00	0.00	0.000	0.0	0.000	0.000	0.000
18.25	0.00	0.00	0.000	0.0	0.000	0.000	0.000
19.48	0.00	0.00	0.000	0.0	0.000	0.000	0.000
19.52	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.10	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.68	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.72	0.00	0.00	0.000	0.0	0.000	0.000	0.000
32.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
33.28	0.00	0.00	0.000	0.0	0.000	0.000	0.000
33.32	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.80	0.00	0.00	0.000	0.0	0.000	0.000	0.000
38.28	0.00	0.00	0.000	0.0	0.000	0.000	0.000
38.32	0.00	0.00	0.000	0.0	0.000	0.000	0.000
39.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.68	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.72	0.00	0.00	0.000	0.0	0.000	0.000	0.000
44.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
48.28	0.00	0.00	0.000	0.0	0.000	0.000	0.000
48.32	0.00	0.00	0.000	0.0	0.000	0.000	0.000
49.65	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.98	0.00	0.00	0.000	0.0	0.000	0.000	0.000
51.02	0.00	0.00	0.000	0.0	0.000	0.000	0.000
51.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
51.98	0.00	0.00	0.000	0.0	0.000	0.000	0.000
52.02	0.00	0.00	0.000	0.0	0.000	0.000	0.000
56.73	0.00	0.00	0.000	0.0	0.000	0.000	0.000
61.48	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

♀ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

GRE-42-0263-FA : 01/23/2020 :

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	2.500	5618.0	0.800	0.0100	5.8
Combined Pile Top		15000.0			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight (kips)	4.00	Ram Length (inch)	129.10
Maximum Stroke (ft)	11.86		
Rated Stroke (ft)	10.81	Efficiency	0.800
Maximum Pressure (psi)	1600.00	Actual Pressure (psi)	1600.00
Compression Exponent	1.350	Expansion Exponent	1.250
Ram Diameter (inch)	12.60		
Combustion Delay (s)	0.00200	Ignition Duration (s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	21.20	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	5618.0	Stiffness	(kips/in)	0.0

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
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Depth	(ft)	3.0	Standard Soil Setup		
Shaft Gain/Loss Factor		0.484	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in2)	153.930	Pile Type	Pipe
Pile Size	(inch)	14.000		

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0		21.20	29000.	492.0	3.7	0	16524.	37.2
61.5		21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 17.3

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	1.0	0.050	0.100	61.48	3.7	21.2
Toe						16.3	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile			Pile Segments: Automatic	
No. of Slacks/Splices		0	Pile Damping (%)	1
			Pile Damping Fact.(k/ft/s)	0.744
Driveability Analysis				
Soil Damping Option		Smith		
Max No Analysis Iterations		0	Time Increment/Critical	160
Output Time Interval		1	Analysis Time-Input (ms)	0

Output Level: Normal
Gravity Mass, Pile, Hammer: 32.170 32.170 32.170
Output Segment Generation: Automatic

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
2.98	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt

kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
17.3	1.7	4.47	4.49	-0.83	5	42	10.06	1	4	23.4	55.9
17.3	1.7	4.47	4.49	-0.83	5	42	10.06	1	4	23.4	55.9
17.3	1.7	4.47	4.49	-0.83	5	42	10.06	1	4	23.4	55.9
17.3	1.7	4.47	4.49	-0.83	5	42	10.06	1	4	23.4	55.9
17.3	1.7	4.47	4.49	-0.83	5	42	10.06	1	4	23.4	55.9

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National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 3.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 15.0

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	1.1	0.060	0.100	61.48	3.7	21.2
Toe						13.9	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
3.02	10.81	1.00	0.800

♀
GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft) down	up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
15.0	1.5	4.37	4.38	-0.63	5	42	9.30	1	4	22.8	56.6
15.0	1.5	4.37	4.38	-0.63	5	42	9.30	1	4	22.8	56.6
15.0	1.5	4.37	4.38	-0.70	6	42	9.35	1	4	22.8	56.6
15.0	1.5	4.37	4.38	-0.63	5	42	9.30	1	3	22.8	56.6
15.0	1.5	4.37	4.38	-0.65	5	42	9.31	1	4	22.8	56.6

♀
GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 4.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s

0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 19.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	0.1	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	5.9	0.180	0.100	61.48	3.7	21.2
Toe						13.9	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
4.25	10.81	1.00	0.800

♀

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
19.8	1.8	4.62	4.64	-0.64	3	10	10.79	1	4	24.4	55.2
19.9	1.8	4.62	4.65	-0.65	3	10	10.83	1	4	24.4	55.1
20.0	1.8	4.62	4.66	-0.64	3	10	10.83	1	4	24.4	55.1
20.2	1.8	4.63	4.66	-0.65	3	10	10.86	1	4	24.4	55.1
20.3	1.8	4.63	4.66	-0.66	3	10	10.90	1	4	24.4	55.1

♀

GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 5.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 24.7

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	0.5	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	10.3	0.193	0.100	61.48	3.7	21.2
Toe						13.9	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
5.48	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
24.7	2.1	4.80	4.84	-0.74	3	10	11.75	1	4	23.9	54.0
24.9	2.1	4.85	4.84	-0.82	3	10	11.92	1	4	24.0	53.8
25.1	2.1	4.87	4.85	-0.83	3	10	12.01	1	4	24.0	53.8
25.3	2.2	4.82	4.87	-0.75	3	10	11.90	1	4	23.8	53.9
25.5	2.2	4.88	4.87	-0.83	3	10	12.07	1	4	24.0	53.7

♀

Depth (ft) 5.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 27.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	0.5	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	10.4	0.194	0.100	61.48	3.7	21.2
Toe						16.5	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
5.52	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
27.4	2.3	4.94	4.92	-0.87	3	10	12.35	1	4	23.8	53.4
27.6	2.3	4.95	4.94	-0.88	3	10	12.42	1	4	23.8	53.3
27.8	2.3	4.96	4.94	-0.86	3	10	12.42	1	4	23.8	53.3
28.0	2.4	4.97	4.95	-0.88	3	10	12.48	1	4	23.8	53.2
28.2	2.4	4.98	4.96	-0.87	3	10	12.54	1	4	23.8	53.2

♀

Depth (ft) 10.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 37.6

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	1.7	0.116	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	11.7	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	61.48	3.7	21.2
Toe						16.5	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
10.00	10.81	1.00	0.800

♀
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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
37.6	3.4	5.31	5.29	-0.67	3	10	13.84	1	4	22.3	51.5
38.7	3.6	5.34	5.33	-0.62	3	10	13.96	2	4	22.2	51.3
39.8	3.7	5.38	5.37	-0.58	3	10	14.04	3	4	22.0	51.2
41.0	3.8	5.41	5.40	-0.53	3	10	14.16	4	4	21.9	51.0
42.1	4.0	5.45	5.43	-0.47	3	10	14.26	5	4	21.8	50.8

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 14.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 47.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2

1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	0.1	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	5.8	0.179	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	9.9	0.200	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	61.48	3.7	21.2
Toe						16.5	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
14.48	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
47.8	4.7	5.56	5.61	-0.27	2	10	14.68	7	5	21.0	50.1
49.9	5.0	5.61	5.66	-0.19	2	10	14.89	11	6	20.9	49.9
51.9	5.2	5.67	5.71	-0.10	2	10	15.08	11	6	20.7	49.6
53.9	5.5	5.72	5.77	-0.08	2	11	15.27	11	6	20.5	49.4
56.0	5.8	5.77	5.81	-0.08	2	11	15.48	11	6	20.4	49.2

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 14.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 68.5

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	0.1	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	6.0	0.180	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	9.8	0.200	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	61.48	3.7	21.2
Toe						37.0	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	

14.52	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
68.5	7.1	5.99	6.03	-0.07	2	11	16.07	12	6	19.7	48.2
70.6	7.4	6.04	6.07	-0.03	2	11	16.23	12	6	19.6	48.0
72.6	7.7	6.08	6.11	0.00	1	0	16.38	12	6	19.5	47.8
74.6	8.0	6.13	6.16	0.00	1	0	16.52	12	6	19.4	47.7
76.7	8.3	6.17	6.20	-0.14	15	50	16.65	12	6	19.3	47.5

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 15.8 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 71.6

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	0.5	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	10.4	0.194	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	8.1	0.200	0.100	61.48	3.7	21.2
Toe						37.0	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
15.75	10.81	1.00	0.800

♀

GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
71.6	7.5	6.06	6.09	-0.02	2	11	16.38	12	6	19.5	47.9
73.7	7.8	6.11	6.14	0.00	1	0	16.54	12	6	19.4	47.7
75.8	8.1	6.15	6.19	-0.02	15	50	16.67	12	6	19.3	47.6
77.9	8.4	6.20	6.23	-0.27	15	50	16.83	12	6	19.2	47.4
80.0	8.8	6.24	6.27	-0.46	15	50	16.98	12	6	19.1	47.2

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 17.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 74.7

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	2.3	0.140	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	11.4	0.200	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	54.65	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	8.4	0.200	0.100	61.48	3.7	21.2
Toe						37.0	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
16.98	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
74.7	8.0	6.13	6.16	0.00	1	0	16.67	12	6	19.4	47.6
76.9	8.3	6.18	6.21	-0.12	15	50	16.83	12	6	19.3	47.4
79.1	8.6	6.23	6.25	-0.34	15	50	17.00	12	6	19.2	47.3
81.2	8.9	6.27	6.30	-0.53	15	49	17.17	12	6	19.1	47.1
83.4	9.3	6.32	6.34	-0.67	14	49	17.30	12	6	19.0	46.9

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 17.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 77.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	2.4	0.144	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	11.3	0.200	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	54.65	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	8.4	0.200	0.100	61.48	3.7	21.2
Toe						39.6	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
17.02	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
77.4	8.3	6.18	6.21	-0.15	14	50	16.80	12	6	19.2	47.4
79.6	8.6	6.23	6.25	-0.36	14	50	16.97	12	6	19.2	47.3
81.7	9.0	6.28	6.30	-0.54	14	49	17.14	12	6	19.1	47.1
83.9	9.3	6.32	6.34	-0.67	14	49	17.28	12	6	19.0	46.9
86.1	9.7	6.36	6.39	-0.74	14	48	17.42	12	6	18.9	46.8

♀

GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 18.2 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 79.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	0.2	0.050	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	7.1	0.185	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	9.3	0.200	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	7.9	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	7.5	0.200	0.100	61.48	3.7	21.2
Toe						39.6	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
18.25	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
79.4	8.6	6.23	6.25	-0.33	14	50	17.06	12	6	19.2	47.3
81.7	9.0	6.28	6.30	-0.54	14	49	17.23	12	6	19.0	47.1
84.1	9.4	6.33	6.35	-0.68	14	49	17.41	12	6	18.9	46.9
86.4	9.7	6.37	6.40	-0.76	14	48	17.56	12	6	18.8	46.7
88.8	10.1	6.42	6.44	-0.82	14	48	17.74	12	6	18.8	46.5

♀

Depth (ft) 19.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 81.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	0.7	0.050	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	10.9	0.196	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	51.23	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	8.2	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	6.4	0.200	0.100	61.48	3.7	21.2
Toe						39.6	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
19.48	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
81.4	8.9	6.27	6.30	-0.50	14	49	17.28	12	6	19.0	47.1
83.9	9.3	6.33	6.35	-0.68	14	49	17.49	12	6	18.9	46.9
86.4	9.7	6.37	6.40	-0.75	14	48	17.68	12	6	18.9	46.7
89.0	10.2	6.43	6.45	-0.82	13	46	17.86	12	6	18.8	46.5
91.5	10.6	6.48	6.49	-0.92	14	46	18.02	12	6	18.6	46.3

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Depth (ft) 19.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 72.7

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	0.7	0.050	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	11.0	0.196	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	51.23	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	8.2	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	6.4	0.200	0.100	61.48	3.7	21.2
Toe						30.9	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
19.52	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
72.7	7.8	6.12	6.14	-0.05	2	11	16.86	12	6	19.4	47.7
75.2	8.2	6.17	6.20	-0.03	6	47	17.05	12	6	19.3	47.5
77.8	8.5	6.22	6.25	-0.24	14	49	17.25	12	6	19.2	47.3
80.3	8.9	6.28	6.30	-0.48	14	49	17.44	12	6	19.0	47.1
82.8	9.3	6.33	6.35	-0.68	14	49	17.63	12	6	18.9	46.9

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National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 25.1 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model					Total Capacity Rut (kips)					83.9
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	0.2	0.050	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	7.2	0.185	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	9.3	0.200	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	7.9	0.200	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	7.5	0.200	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	6.4	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	61.48	3.7	21.2
Toe						30.9	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
25.10	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
83.9	9.5	6.37	6.39	-0.65	12	48	18.02	12	6	18.8	46.8
87.1	10.1	6.43	6.45	-0.80	12	48	18.27	12	6	18.7	46.5
90.2	10.6	6.49	6.51	-0.95	12	46	18.53	12	6	18.6	46.3
93.4	11.0	6.55	6.56	-0.94	12	46	18.76	12	6	18.5	46.1
96.5	11.4	6.60	6.62	-0.87	12	45	19.00	12	6	18.3	45.9

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Depth (ft) 30.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model					Total Capacity Rut (kips)					95.1
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	2.4	0.144	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	11.3	0.200	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	40.99	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	8.4	0.200	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	5.9	0.200	0.100	51.23	3.7	21.2

16	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	54.65	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	61.48	3.7	21.2
Toe						30.9	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
30.68	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
95.1	11.3	6.59	6.61	-0.82	10	45	18.81	10	5	18.3	45.9
98.9	11.8	6.65	6.67	-0.72	11	45	19.04	11	6	18.1	45.7
102.7	12.3	6.72	6.73	-0.60	10	44	19.33	11	6	18.0	45.5
106.4	12.9	6.77	6.79	-0.59	11	42	19.58	11	6	17.9	45.4
110.2	13.4	6.89	6.83	-0.62	11	42	19.94	11	6	17.9	45.1

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Depth (ft) 30.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L ft	b Top in2	Area ksi	E-Mod lb/ft3	Spec Wt ft	Perim	C Index ft/s	Wave Sp k/ft/s	EA/c
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2	
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2	

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 237.7

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	2.6	0.147	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	11.3	0.200	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	40.99	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	8.4	0.200	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	5.9	0.200	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	54.65	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	6.9	0.198	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
30.72	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
237.7	34.3	8.00	7.99	-1.57	10	26	22.08	11	6	17.3	41.8
241.4	35.2	8.03	8.02	-1.67	10	25	22.25	11	6	17.3	41.7
245.2	36.1	8.06	8.06	-1.75	10	25	22.44	11	6	17.3	41.6
249.0	36.9	8.09	8.08	-1.84	10	25	22.65	11	6	17.4	41.5
252.7	38.0	8.12	8.12	-1.90	10	25	22.80	11	6	17.3	41.5

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Depth (ft) 32.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 245.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	0.2	0.050	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	7.4	0.186	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	9.2	0.200	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	7.9	0.200	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	7.4	0.200	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	6.4	0.200	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	54.65	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	12.5	0.111	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
32.00	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
245.8	35.7	8.05	8.04	-1.74	10	25	22.24	10	5	17.4	41.6
249.7	36.8	8.08	8.08	-1.82	10	25	22.38	10	5	17.3	41.6
253.6	37.7	8.11	8.11	-1.89	10	25	22.59	10	5	17.4	41.5
257.6	38.8	8.15	8.14	-1.94	10	25	22.76	10	5	17.4	41.4
261.5	40.2	8.10	8.17	-2.00	10	25	22.79	10	5	17.2	41.4

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Depth (ft) 33.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0		21.20	29000.	492.0	3.7	0	16524.	37.2
61.5		21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 254.1

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	0.7	0.050	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	11.2	0.197	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	37.57	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	8.2	0.200	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	6.3	0.200	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	51.23	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	18.2	0.068	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
33.28	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
254.1	37.3	8.09	8.09	-1.86	10	25	22.46	10	5	17.4	41.5
258.2	38.4	8.13	8.12	-1.91	10	25	22.63	10	5	17.4	41.4
262.3	39.9	8.08	8.16	-1.96	10	25	22.67	10	5	17.2	41.5
266.5	40.7	8.20	8.19	-2.00	10	25	22.98	10	5	17.4	41.3
270.6	42.4	8.16	8.24	-2.06	10	24	23.02	10	5	17.2	41.2

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 33.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0		21.20	29000.	492.0	3.7	0	16524.	37.2
61.5		21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model					Total Capacity Rut (kips)			204.1		
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	0.8	0.050	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	11.2	0.197	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	37.57	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	8.2	0.200	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	6.3	0.200	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	51.23	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	18.4	0.067	0.100	61.48	3.7	21.2
Toe						123.0	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
33.32	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
204.1	28.3	7.74	7.73	-1.37	10	30	21.71	10	5	17.0	42.5
208.2	29.1	7.78	7.77	-1.30	10	30	21.89	10	5	17.0	42.4
212.3	29.8	7.81	7.80	-1.24	10	29	22.10	10	5	17.1	42.3
216.5	30.7	7.85	7.84	-1.21	10	28	22.27	10	5	17.0	42.2
220.6	31.6	7.89	7.88	-1.18	10	28	22.45	10	5	17.0	42.1

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Depth (ft) 35.8 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model					Total Capacity Rut (kips)			222.3		
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	0.3	0.050	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	8.8	0.190	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	8.5	0.200	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	8.0	0.200	0.100	40.99	3.7	21.2

13	0.247	15000	0.000	0.000	1.00	7.1	0.200	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	6.6	0.200	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	51.23	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	14.2	0.095	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	24.3	0.050	0.100	61.48	3.7	21.2
Toe						123.0	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
35.80	10.81	1.00	0.800

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National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
222.3	31.0	7.86	7.85	-1.23	9	28	21.85	9	5	17.0	42.1
226.4	31.8	7.89	7.88	-1.20	9	28	22.07	9	5	17.1	42.1
230.5	32.8	7.93	7.92	-1.14	9	28	22.23	9	5	17.0	42.0
234.6	33.7	7.96	7.95	-1.07	9	27	22.41	9	5	17.0	41.9
238.8	34.5	7.99	7.99	-1.13	9	26	22.59	9	5	17.0	41.8

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 38.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 241.3

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	0.1	0.050	0.100	23.91	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	5.4	0.177	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	10.1	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	34.16	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	7.9	0.200	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	6.2	0.200	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	47.82	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	10.1	0.140	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	23.3	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	26.0	0.050	0.100	61.48	3.7	21.2
Toe						123.0	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
38.28	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
241.3	34.0	7.97	7.96	-1.18	8	26	22.01	8	5	17.0	41.8
245.4	34.9	8.00	8.00	-1.21	8	26	22.18	8	5	17.0	41.8
249.5	35.8	8.04	8.03	-1.23	8	26	22.35	8	5	17.0	41.7
253.7	36.6	8.06	8.06	-1.24	8	25	22.52	8	5	17.0	41.6
257.8	37.5	8.10	8.09	-1.22	8	25	22.69	8	5	17.0	41.5

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 38.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 291.9

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	0.1	0.050	0.100	23.91	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	5.5	0.178	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	10.0	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	34.16	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	7.9	0.200	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	6.2	0.200	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	47.82	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	10.2	0.138	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	23.4	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	26.0	0.050	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
38.32	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min

291.9	45.2	8.33	8.33	-2.01	8	23	22.70	8	5	17.4	40.9
296.0	46.9	8.27	8.36	-2.08	8	23	22.73	8	5	17.3	41.0
300.1	48.2	8.31	8.39	-2.13	8	23	22.90	8	5	17.3	40.9
304.3	49.7	8.34	8.41	-2.17	8	23	23.04	8	5	17.3	40.8
308.4	50.9	8.37	8.44	-2.22	8	23	23.22	8	5	17.3	40.8

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 39.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 300.5

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	0.4	0.050	0.100	23.91	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	9.8	0.192	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	8.1	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	8.1	0.200	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	6.8	0.200	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	6.7	0.200	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	47.82	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	15.4	0.085	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	24.6	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	25.8	0.050	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
39.50	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
300.5	47.1	8.38	8.37	-2.07	8	23	22.92	8	5	17.5	40.8
304.8	49.2	8.32	8.40	-2.12	8	23	22.93	8	5	17.3	40.9
309.1	50.6	8.35	8.43	-2.18	8	23	23.11	8	5	17.3	40.8
313.4	52.0	8.39	8.45	-2.22	8	23	23.29	8	5	17.4	40.7
317.8	53.4	8.42	8.48	-2.27	8	22	23.47	8	5	17.4	40.6

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 40.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 309.3

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	1.5	0.100	0.100	23.91	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	11.8	0.200	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	30.74	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	8.4	0.200	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	6.0	0.200	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	44.40	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	21.2	0.055	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	25.5	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	25.7	0.050	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
40.68	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
309.3	49.2	8.42	8.40	-2.10	8	23	23.03	8	5	17.5	40.7
313.8	51.3	8.37	8.44	-2.15	8	23	23.07	8	5	17.3	40.8
318.3	52.8	8.40	8.47	-2.19	8	22	23.26	8	5	17.4	40.7
322.8	54.4	8.43	8.49	-2.23	8	22	23.45	8	5	17.4	40.6
327.3	56.0	8.47	8.52	-2.28	8	22	23.64	8	5	17.4	40.5

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 40.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
	Pile and Soil Model					Total Capacity Rut (kips)			201.4		
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	1.6	0.111	0.100	23.91	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	11.7	0.200	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	30.74	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	8.4	0.200	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	6.0	0.200	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	44.40	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	21.4	0.054	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	25.5	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	25.9	0.052	0.100	61.48	3.7	21.2
Toe						64.8	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
40.72	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
201.4	26.4	7.68	7.65	-1.83	8	30	21.58	8	5	17.0	42.7
205.9	27.2	7.71	7.70	-1.76	8	29	21.75	8	5	16.9	42.5
210.4	27.9	7.74	7.73	-1.64	8	29	21.93	8	5	16.8	42.4
214.9	28.6	7.78	7.77	-1.52	8	29	22.15	8	5	16.7	42.4
219.4	29.4	7.82	7.81	-1.38	8	29	22.32	8	5	16.6	42.2

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 44.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
	Pile and Soil Model					Total Capacity Rut (kips)			270.9		
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	0.0	0.050	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	3.0	0.156	0.100	20.49	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	11.1	0.200	0.100	23.91	3.7	21.2

8	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	27.32	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	8.3	0.200	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	6.0	0.200	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	40.99	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	7.4	0.187	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	22.7	0.050	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	25.7	0.050	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	29.7	0.087	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	61.48	3.7	21.2
Toe						64.8	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
44.50	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
270.9	41.9	8.12	8.20	-1.07	6	24	22.35	7	5	16.7	41.4
276.9	43.4	8.17	8.24	-1.11	6	23	22.57	7	5	16.7	41.3
282.9	45.2	8.22	8.29	-1.14	6	23	22.75	7	5	16.7	41.1
288.8	46.9	8.26	8.33	-1.17	6	23	22.96	7	5	16.8	41.0
294.8	48.6	8.31	8.37	-1.21	6	23	23.17	7	5	16.8	40.9

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 48.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 340.3

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
4	0.247	15000	0.000	0.000	1.00	0.0	0.050	0.100	13.66	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	4.5	0.171	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	10.5	0.200	0.100	20.49	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	23.91	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	8.1	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	6.1	0.200	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	37.57	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	9.0	0.157	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	23.1	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	25.9	0.050	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	33.6	0.112	0.100	54.65	3.7	21.2

17	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	61.48	3.7	21.2
Toe						64.8	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
48.28	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
340.3	67.0	8.66	8.67	-1.74	6	21	23.31	5	4	17.4	40.2
347.8	70.6	8.71	8.72	-1.82	6	21	23.52	5	4	17.5	40.1
355.3	74.9	8.75	8.76	-1.89	6	21	23.70	5	4	17.5	40.0
362.8	79.0	8.80	8.80	-1.95	6	21	23.92	5	4	17.6	39.9
370.2	83.9	8.84	8.84	-1.99	6	21	24.10	5	4	17.6	39.8

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 48.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
	ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 449.4

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
4	0.247	15000	0.000	0.000	1.00	0.0	0.050	0.100	13.66	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	4.6	0.172	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	10.4	0.200	0.100	20.49	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	23.91	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	8.0	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	6.1	0.200	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	37.57	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	9.2	0.154	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	23.1	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	25.9	0.050	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	34.0	0.114	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	62.6	0.199	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
48.32	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
449.4	156.0	9.30	9.25	-2.67	6	20	24.42	5	4	18.8	38.9
456.9	169.5	9.33	9.28	-2.61	6	20	24.59	5	4	18.8	38.8
464.3	187.5	9.36	9.31	-2.54	6	20	24.76	5	4	18.8	38.7
471.8	205.4	9.39	9.33	-2.47	6	20	24.93	5	4	18.8	38.7
479.3	229.5	9.42	9.36	-2.40	6	20	25.10	5	4	18.8	38.6

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Depth (ft) 49.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 463.9

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
4	0.247	15000	0.000	0.000	1.00	0.4	0.050	0.100	13.66	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	9.5	0.192	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	8.2	0.200	0.100	20.49	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	23.91	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	8.0	0.200	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	6.6	0.200	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	37.57	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	15.0	0.088	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	24.5	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	25.8	0.050	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	48.6	0.170	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	52.7	0.164	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
49.65	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
463.9	182.6	9.35	9.30	-2.39	5	20	24.71	5	4	18.8	38.7
471.4	203.1	9.38	9.33	-2.30	5	20	24.87	5	4	18.8	38.7
478.9	223.2	9.41	9.35	-2.21	5	20	25.06	5	4	18.8	38.6
486.4	250.7	9.44	9.38	-2.13	5	20	25.24	5	4	18.8	38.6
493.9	280.2	9.46	9.40	-2.05	5	20	25.40	5	4	18.8	38.5

♀

Depth (ft) 51.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 478.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
4	0.247	15000	0.000	0.000	1.00	1.7	0.114	0.100	13.66	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	11.7	0.200	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	20.49	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	8.4	0.200	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	6.0	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	34.16	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	21.4	0.054	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	25.5	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	26.0	0.053	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	54.65	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	43.2	0.104	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
50.98	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
478.8	214.7	9.41	9.35	-2.30	5	20	24.87	5	4	18.8	38.6
486.3	238.7	9.43	9.37	-2.20	5	20	25.06	5	4	18.8	38.6
493.8	267.2	9.45	9.40	-2.11	5	20	25.19	5	4	18.7	38.6
501.3	292.6	9.47	9.41	-2.02	5	20	25.39	5	4	18.8	38.5
508.7	327.0	9.49	9.42	-1.93	5	20	25.57	5	4	18.8	38.5

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Depth (ft) 51.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 479.2

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
4	0.247	15000	0.000	0.000	1.00	1.8	0.123	0.100	13.66	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	11.6	0.200	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	20.49	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	8.4	0.200	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	6.0	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	34.16	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	21.7	0.053	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	25.5	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	26.4	0.058	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	54.65	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	42.8	0.102	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
51.02	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
479.2	215.8	9.41	9.35	-2.29	5	20	24.86	5	4	18.8	38.6
486.7	239.6	9.43	9.37	-2.19	5	20	25.04	5	4	18.8	38.6
494.1	264.6	9.45	9.39	-2.10	5	20	25.20	5	4	18.8	38.6
501.6	294.1	9.47	9.41	-2.01	5	20	25.38	5	4	18.8	38.5
509.1	329.1	9.50	9.42	-1.92	5	20	25.56	5	4	18.8	38.5

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 51.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe

Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model — Total Capacity Rut (kips) 482.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
3	0.247	15000	0.000	0.000	1.00	0.0	0.050	0.100	10.25	3.7	21.2
4	0.247	15000	0.000	0.000	1.00	3.7	0.165	0.100	13.66	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	10.8	0.200	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	20.49	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	8.2	0.200	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	6.0	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	34.16	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	8.2	0.172	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	22.9	0.050	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	25.8	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	31.5	0.099	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	54.65	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	37.3	0.068	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
51.50	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
482.4	226.7	9.42	9.36	-2.18	5	20	24.69	5	4	18.7	38.6
490.1	249.6	9.44	9.38	-2.09	5	20	24.86	5	4	18.7	38.6
497.8	278.0	9.46	9.41	-1.99	5	20	25.03	5	4	18.7	38.5
505.5	311.3	9.48	9.42	-1.90	5	20	25.20	5	4	18.7	38.5
513.1	350.7	9.51	9.43	-1.81	5	20	25.37	5	4	18.7	38.5

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 52.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model					Total Capacity Rut (kips)			485.8		
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
3	0.247	15000	0.000	0.000	1.00	0.1	0.050	0.100	10.25	3.7	21.2
4	0.247	15000	0.000	0.000	1.00	5.5	0.178	0.100	13.66	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	10.0	0.200	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	20.49	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	7.9	0.200	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	6.2	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	34.16	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	10.2	0.138	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	23.4	0.050	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	26.0	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	36.6	0.128	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	60.8	0.194	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	33.7	0.050	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
51.98	10.81	1.00	0.800

♀

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
485.8	233.6	9.43	9.37	-2.08	5	20	24.80	4	4	18.7	38.6
493.6	261.8	9.45	9.38	-1.98	5	20	24.93	4	4	18.7	38.6
501.5	288.3	9.47	9.40	-1.88	5	20	25.13	4	4	18.7	38.5
509.3	323.9	9.50	9.42	-1.79	5	20	25.30	4	4	18.7	38.5
517.2	366.9	9.51	9.44	-1.68	5	20	25.46	4	4	18.7	38.5

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 52.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model					Total Capacity Rut (kips)			486.1		
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2

2	0.247	15000	0.000	0.000	1.00	0.0	0.000	0.100	6.83	3.7	21.2
3	0.247	15000	0.000	0.000	1.00	0.1	0.050	0.100	10.25	3.7	21.2
4	0.247	15000	0.000	0.000	1.00	5.7	0.179	0.100	13.66	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	9.9	0.200	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	20.49	3.7	21.2
8	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	6.2	0.200	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	34.16	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	10.4	0.136	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	23.4	0.050	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	26.0	0.050	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	37.1	0.130	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	60.5	0.193	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	33.6	0.050	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
52.02	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
486.1	234.6	9.43	9.37	-2.07	5	20	24.81	4	4	18.7	38.6
493.9	259.7	9.45	9.39	-1.97	5	20	24.97	4	4	18.7	38.6
501.8	289.7	9.47	9.40	-1.88	5	20	25.14	4	4	18.7	38.5
509.7	325.6	9.50	9.42	-1.78	5	20	25.31	4	4	18.7	38.5
517.5	369.1	9.52	9.44	-1.67	5	20	25.47	4	4	18.7	38.5

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 56.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
	61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 530.7

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	0.0	0.000	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	0.5	0.050	0.100	6.83	3.7	21.2
3	0.247	15000	0.000	0.000	1.00	10.4	0.194	0.100	10.25	3.7	21.2
4	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	13.66	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	8.1	0.200	0.100	20.49	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	6.7	0.200	0.100	23.91	3.7	21.2

8	0.247	15000	0.000	0.000	1.00	6.7	0.200	0.100	27.32	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	30.74	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	16.1	0.080	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	24.8	0.050	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	25.8	0.050	0.100	44.40	3.7	21.2
14	0.247	15000	0.000	0.000	1.00	51.4	0.177	0.100	47.82	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	51.23	3.7	21.2
16	0.247	15000	0.000	0.000	1.00	50.9	0.156	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	31.3	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	32.7	0.050	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
56.73	10.81	1.00	0.800

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
530.7	411.0	9.52	9.45	-1.25	9	19	25.54	3	4	18.4	38.4
539.6	483.5	9.53	9.46	-1.09	3	17	25.72	3	4	18.4	38.4
548.4	594.7	9.55	9.47	-1.11	3	17	25.88	3	4	18.3	38.4
557.2	730.6	9.56	9.48	-1.16	3	17	26.09	3	4	18.3	38.4
566.0	955.4	9.57	9.50	-1.17	3	17	26.24	3	4	18.2	38.3

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 61.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.20	29000.	492.0	3.7	0	16524.	37.2
61.5	21.20	29000.	492.0	3.7	0	16524.	37.2

Wave Travel Time 2L/c (ms) 7.441

Pile and Soil Model Total Capacity Rut (kips) 579.1

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	15000	0.010	0.000	0.85	2.7	0.149	0.100	3.42	3.7	21.2
2	0.247	15000	0.000	0.000	1.00	11.2	0.200	0.100	6.83	3.7	21.2
3	0.247	15000	0.000	0.000	1.00	7.8	0.200	0.100	10.25	3.7	21.2
5	0.247	15000	0.000	0.000	1.00	8.4	0.200	0.100	17.08	3.7	21.2
6	0.247	15000	0.000	0.000	1.00	5.9	0.200	0.100	20.49	3.7	21.2
7	0.247	15000	0.000	0.000	1.00	6.9	0.200	0.100	23.91	3.7	21.2
9	0.247	15000	0.000	0.000	1.00	7.0	0.196	0.100	30.74	3.7	21.2
10	0.247	15000	0.000	0.000	1.00	22.6	0.050	0.100	34.16	3.7	21.2
11	0.247	15000	0.000	0.000	1.00	25.6	0.050	0.100	37.57	3.7	21.2
12	0.247	15000	0.000	0.000	1.00	28.7	0.078	0.100	40.99	3.7	21.2
13	0.247	15000	0.000	0.000	1.00	62.8	0.200	0.100	44.40	3.7	21.2
15	0.247	15000	0.000	0.000	1.00	40.3	0.088	0.100	51.23	3.7	21.2

16	0.247	15000	0.000	0.000	1.00	30.0	0.050	0.100	54.65	3.7	21.2
17	0.247	15000	0.000	0.000	1.00	33.4	0.050	0.100	58.06	3.7	21.2
18	0.247	15000	0.000	0.000	1.00	35.1	0.050	0.100	61.48	3.7	21.2
Toe						173.2	0.150	0.117			

4.453 kips total unreduced pile weight (g= 32.17 ft/s2)
4.453 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
61.48	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
579.1	1180.1	9.58	9.50	-0.63	9	18	25.85	2	4	17.9	38.3
589.0	1863.1	9.59	9.52	-0.51	2	17	26.03	2	4	17.8	38.3
598.8	4204.6	9.59	9.51	-0.49	2	17	26.22	2	4	17.7	38.3
608.7	9999.0	9.60	9.52	-0.47	2	17	26.45	2	4	17.7	38.3
618.6	9999.0	9.60	9.52	-0.45	2	17	26.64	2	4	17.6	38.3

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.484 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
3.0	17.3	1.0	16.3	1.7	10.062	-0.835	4.47	23.4
3.0	15.0	1.1	13.9	1.5	9.296	-0.631	4.37	22.8
4.2	19.8	5.9	13.9	1.8	10.791	-0.639	4.62	24.4
5.5	24.7	10.8	13.9	2.1	11.753	-0.736	4.80	23.9
5.5	27.4	10.9	16.5	2.3	12.354	-0.871	4.94	23.8
10.0	37.6	21.2	16.5	3.4	13.842	-0.670	5.31	22.3
14.5	47.8	31.4	16.5	4.7	14.683	-0.272	5.56	21.0
14.5	68.5	31.5	37.0	7.1	16.074	-0.068	5.99	19.7
15.8	71.6	34.6	37.0	7.5	16.381	-0.023	6.06	19.5
17.0	74.7	37.7	37.0	8.0	16.666	0.000	6.13	19.4
17.0	77.4	37.8	39.6	8.3	16.805	-0.150	6.18	19.2
18.2	79.4	39.8	39.6	8.6	17.058	-0.329	6.23	19.2
19.5	81.4	41.8	39.6	8.9	17.281	-0.500	6.27	19.0
19.5	72.7	41.9	30.9	7.8	16.863	-0.055	6.12	19.4
25.1	83.9	53.1	30.9	9.5	18.015	-0.649	6.37	18.8
30.7	95.1	64.3	30.9	11.3	18.809	-0.821	6.59	18.3
30.7	237.7	64.4	173.2	34.3	22.077	-1.571	8.00	17.3
32.0	245.8	72.5	173.2	35.7	22.240	-1.743	8.05	17.4
33.3	254.1	80.9	173.2	37.3	22.456	-1.858	8.09	17.4
33.3	204.1	81.1	123.0	28.3	21.714	-1.370	7.74	17.0
35.8	222.3	99.3	123.0	31.0	21.854	-1.230	7.86	17.0
38.3	241.3	118.3	123.0	34.0	22.009	-1.182	7.97	17.0
38.3	291.9	118.6	173.2	45.2	22.700	-2.013	8.33	17.4
39.5	300.5	127.3	173.2	47.1	22.922	-2.073	8.38	17.5
40.7	309.3	136.1	173.2	49.2	23.032	-2.097	8.42	17.5
40.7	201.4	136.6	64.8	26.4	21.581	-1.832	7.68	17.0
44.5	270.9	206.1	64.8	41.9	22.348	-1.066	8.12	16.7
48.3	340.3	275.5	64.8	67.0	23.306	-1.738	8.66	17.4
48.3	449.4	276.1	173.2	156.0	24.418	-2.671	9.30	18.8
49.7	463.9	290.7	173.2	182.6	24.709	-2.390	9.35	18.8
51.0	478.8	305.6	173.2	214.7	24.872	-2.296	9.41	18.8

51.0	479.2	305.9	173.2	215.8	24.857	-2.287	9.41	18.8
51.5	482.4	309.2	173.2	226.7	24.685	-2.182	9.42	18.7
52.0	485.8	312.5	173.2	233.6	24.802	-2.077	9.43	18.7
52.0	486.1	312.8	173.2	234.6	24.810	-2.069	9.43	18.7
56.7	530.7	357.5	173.2	411.0	25.538	-1.254	9.52	18.4
61.5	579.1	405.9	173.2	1180.1	25.848	-0.625	9.58	17.9

Total Driving Time 178 minutes; Total No. of Blows 6906
Starting at penetration 3.0 ft
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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.527 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
3.0	17.3	1.0	16.3	1.7	10.062	-0.835	4.47	23.4
3.0	15.0	1.1	13.9	1.5	9.297	-0.632	4.37	22.8
4.2	19.9	6.1	13.9	1.8	10.834	-0.650	4.62	24.4
5.5	24.9	11.0	13.9	2.1	11.924	-0.821	4.85	24.0
5.5	27.6	11.1	16.5	2.3	12.417	-0.880	4.95	23.8
10.0	38.7	22.3	16.5	3.6	13.955	-0.624	5.34	22.2
14.5	49.9	33.4	16.5	5.0	14.890	-0.194	5.61	20.9
14.5	70.6	33.5	37.0	7.4	16.227	-0.034	6.04	19.6
15.8	73.7	36.7	37.0	7.8	16.538	0.000	6.11	19.4
17.0	76.9	39.9	37.0	8.3	16.831	-0.120	6.18	19.3
17.0	79.6	40.0	39.6	8.6	16.973	-0.361	6.23	19.2
18.2	81.7	42.1	39.6	9.0	17.231	-0.542	6.28	19.0
19.5	83.9	44.3	39.6	9.3	17.489	-0.675	6.33	18.9
19.5	75.2	44.4	30.9	8.2	17.049	-0.030	6.17	19.3
25.1	87.1	56.2	30.9	10.1	18.270	-0.795	6.43	18.7
30.7	98.9	68.0	30.9	11.8	19.038	-0.718	6.65	18.1
30.7	241.4	68.2	173.2	35.2	22.254	-1.668	8.03	17.3
32.0	249.7	76.5	173.2	36.8	22.379	-1.815	8.08	17.3
33.3	258.2	85.0	173.2	38.4	22.627	-1.911	8.13	17.4
33.3	208.2	85.3	123.0	29.1	21.885	-1.305	7.78	17.0
35.8	226.4	103.4	123.0	31.8	22.065	-1.196	7.89	17.1
38.3	245.4	122.5	123.0	34.9	22.182	-1.214	8.00	17.0
38.3	296.0	122.8	173.2	46.9	22.730	-2.075	8.27	17.3
39.5	304.8	131.6	173.2	49.2	22.927	-2.125	8.32	17.3
40.7	313.8	140.6	173.2	51.3	23.073	-2.150	8.37	17.3
40.7	205.9	141.1	64.8	27.2	21.751	-1.756	7.71	16.9
44.5	276.9	212.1	64.8	43.4	22.570	-1.109	8.17	16.7
48.3	347.8	283.0	64.8	70.6	23.523	-1.824	8.71	17.5
48.3	456.9	283.6	173.2	169.5	24.588	-2.608	9.33	18.8
49.7	471.4	298.2	173.2	203.1	24.868	-2.300	9.38	18.8
51.0	486.3	313.0	173.2	238.7	25.056	-2.196	9.43	18.8
51.0	486.7	313.4	173.2	239.6	25.043	-2.188	9.43	18.8
51.5	490.1	316.9	173.2	249.6	24.856	-2.086	9.44	18.7
52.0	493.6	320.4	173.2	261.8	24.932	-1.980	9.45	18.7
52.0	493.9	320.7	173.2	259.7	24.972	-1.971	9.45	18.7
56.7	539.6	366.3	173.2	483.5	25.725	-1.090	9.53	18.4
61.5	589.0	415.8	173.2	1863.1	26.035	-0.510	9.59	17.8

Total Driving Time 233 minutes; Total No. of Blows 9042
Starting at penetration 3.0 ft
♀

GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

G/L at Shaft and Toe: 0.570 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
3.0	17.3	1.0	16.3	1.7	10.062	-0.835	4.47	23.4
3.0	15.0	1.1	13.9	1.5	9.346	-0.705	4.37	22.8
4.2	20.0	6.2	13.9	1.8	10.831	-0.644	4.62	24.4
5.5	25.1	11.2	13.9	2.1	12.007	-0.834	4.87	24.0
5.5	27.8	11.3	16.5	2.3	12.420	-0.864	4.96	23.8
10.0	39.8	23.4	16.5	3.7	14.042	-0.579	5.38	22.0
14.5	51.9	35.5	16.5	5.2	15.077	-0.095	5.67	20.7
14.5	72.6	35.6	37.0	7.7	16.375	0.000	6.08	19.5
15.8	75.8	38.8	37.0	8.1	16.674	-0.024	6.15	19.3
17.0	79.1	42.0	37.0	8.6	16.995	-0.342	6.23	19.2
17.0	81.7	42.1	39.6	9.0	17.135	-0.543	6.28	19.1
18.2	84.1	44.5	39.6	9.4	17.407	-0.684	6.33	18.9
19.5	86.4	46.8	39.6	9.7	17.680	-0.750	6.37	18.9
19.5	77.8	46.9	30.9	8.5	17.254	-0.235	6.22	19.2
25.1	90.2	59.4	30.9	10.6	18.533	-0.950	6.49	18.6
30.7	102.7	71.8	30.9	12.3	19.328	-0.597	6.72	18.0
30.7	245.2	72.0	173.2	36.1	22.438	-1.753	8.06	17.3
32.0	253.6	80.4	173.2	37.7	22.587	-1.886	8.11	17.4
33.3	262.3	89.1	173.2	39.9	22.669	-1.965	8.08	17.2
33.3	212.3	89.4	123.0	29.8	22.104	-1.239	7.81	17.1
35.8	230.5	107.6	123.0	32.8	22.235	-1.138	7.93	17.0
38.3	249.5	126.6	123.0	35.8	22.351	-1.232	8.04	17.0
38.3	300.1	126.9	173.2	48.2	22.903	-2.128	8.31	17.3
39.5	309.1	135.9	173.2	50.6	23.107	-2.176	8.35	17.3
40.7	318.3	145.1	173.2	52.8	23.259	-2.192	8.40	17.4
40.7	210.4	145.6	64.8	27.9	21.929	-1.645	7.74	16.8
44.5	282.9	218.1	64.8	45.2	22.746	-1.141	8.22	16.7
48.3	355.3	290.5	64.8	74.9	23.700	-1.886	8.75	17.5
48.3	464.3	291.1	173.2	187.5	24.760	-2.537	9.36	18.8
49.7	478.9	305.7	173.2	223.2	25.061	-2.211	9.41	18.8
51.0	493.8	320.5	173.2	267.2	25.187	-2.107	9.45	18.7
51.0	494.1	320.9	173.2	264.6	25.204	-2.097	9.45	18.8
51.5	497.8	324.6	173.2	278.0	25.033	-1.995	9.46	18.7
52.0	501.5	328.2	173.2	288.3	25.132	-1.884	9.47	18.7
52.0	501.8	328.6	173.2	289.7	25.141	-1.875	9.47	18.7
56.7	548.4	375.1	173.2	594.7	25.882	-1.114	9.55	18.3
61.5	598.8	425.6	173.2	4204.6	26.225	-0.491	9.59	17.7

Total Driving Time 397 minutes; Total No. of Blows 15322
Starting at penetration 3.0 ft
♀
GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.613 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
3.0	17.3	1.0	16.3	1.7	10.062	-0.835	4.47	23.4
3.0	15.0	1.1	13.9	1.5	9.296	-0.629	4.37	22.8
4.2	20.2	6.3	13.9	1.8	10.858	-0.647	4.63	24.4
5.5	25.3	11.4	13.9	2.2	11.898	-0.754	4.82	23.8
5.5	28.0	11.6	16.5	2.4	12.482	-0.879	4.97	23.8
10.0	41.0	24.5	16.5	3.8	14.164	-0.526	5.41	21.9
14.5	53.9	37.5	16.5	5.5	15.271	-0.076	5.72	20.5
14.5	74.6	37.6	37.0	8.0	16.522	0.000	6.13	19.4
15.8	77.9	40.9	37.0	8.4	16.831	-0.270	6.20	19.2
17.0	81.2	44.2	37.0	8.9	17.167	-0.533	6.27	19.1

17.0	83.9	44.3	39.6	9.3	17.279	-0.668	6.32	19.0
18.2	86.4	46.8	39.6	9.7	17.560	-0.757	6.37	18.8
19.5	89.0	49.4	39.6	10.2	17.863	-0.821	6.43	18.8
19.5	80.3	49.5	30.9	8.9	17.444	-0.483	6.28	19.0
25.1	93.4	62.5	30.9	11.0	18.764	-0.940	6.55	18.5
30.7	106.4	75.6	30.9	12.9	19.578	-0.586	6.77	17.9
30.7	249.0	75.7	173.2	36.9	22.649	-1.839	8.09	17.4
32.0	257.6	84.3	173.2	38.8	22.758	-1.942	8.15	17.4
33.3	266.5	93.2	173.2	40.7	22.981	-1.999	8.20	17.4
33.3	216.5	93.5	123.0	30.7	22.270	-1.214	7.85	17.0
35.8	234.6	111.7	123.0	33.7	22.407	-1.067	7.96	17.0
38.3	253.7	130.7	123.0	36.6	22.519	-1.235	8.06	17.0
38.3	304.3	131.0	173.2	49.7	23.043	-2.169	8.34	17.3
39.5	313.4	140.2	173.2	52.0	23.289	-2.222	8.39	17.4
40.7	322.8	149.6	173.2	54.4	23.452	-2.232	8.43	17.4
40.7	214.9	150.1	64.8	28.6	22.153	-1.521	7.78	16.7
44.5	288.8	224.1	64.8	46.9	22.958	-1.173	8.26	16.8
48.3	362.8	298.0	64.8	79.0	23.916	-1.951	8.80	17.6
48.3	471.8	298.6	173.2	205.4	24.932	-2.471	9.39	18.8
49.7	486.4	313.1	173.2	250.7	25.236	-2.127	9.44	18.8
51.0	501.3	328.0	173.2	292.6	25.392	-2.017	9.47	18.8
51.0	501.6	328.4	173.2	294.1	25.377	-2.008	9.47	18.8
51.5	505.5	332.2	173.2	311.3	25.198	-1.902	9.48	18.7
52.0	509.3	336.1	173.2	323.9	25.297	-1.787	9.50	18.7
52.0	509.7	336.4	173.2	325.6	25.306	-1.777	9.50	18.7
56.7	557.2	384.0	173.2	730.6	26.093	-1.156	9.56	18.3
61.5	608.7	435.5	173.2	9999.0	26.452	-0.470	9.60	17.7

Refusal occurred; no driving time output possible

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020

National Engineering & Architectural Ser GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.656 1.000

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
3.0	17.3	1.0	16.3	1.7	10.062	-0.835	4.47	23.4
3.0	15.0	1.1	13.9	1.5	9.311	-0.651	4.37	22.8
4.2	20.3	6.4	13.9	1.8	10.896	-0.659	4.63	24.4
5.5	25.5	11.6	13.9	2.2	12.069	-0.829	4.88	24.0
5.5	28.2	11.8	16.5	2.4	12.535	-0.872	4.98	23.8
10.0	42.1	25.6	16.5	4.0	14.258	-0.467	5.45	21.8
14.5	56.0	39.5	16.5	5.8	15.479	-0.076	5.77	20.4
14.5	76.7	39.6	37.0	8.3	16.650	-0.144	6.17	19.3
15.8	80.0	43.0	37.0	8.8	16.984	-0.464	6.24	19.1
17.0	83.4	46.4	37.0	9.3	17.303	-0.666	6.32	19.0
17.0	86.1	46.5	39.6	9.7	17.422	-0.741	6.36	18.9
18.2	88.8	49.2	39.6	10.1	17.735	-0.815	6.42	18.8
19.5	91.5	51.9	39.6	10.6	18.022	-0.915	6.48	18.6
19.5	82.8	52.0	30.9	9.3	17.633	-0.680	6.33	18.9
25.1	96.5	65.7	30.9	11.4	18.997	-0.872	6.60	18.3
30.7	110.2	79.3	30.9	13.4	19.944	-0.620	6.89	17.9
30.7	252.7	79.5	173.2	38.0	22.796	-1.902	8.12	17.3
32.0	261.5	88.3	173.2	40.2	22.792	-2.000	8.10	17.2
33.3	270.6	97.3	173.2	42.4	23.022	-2.060	8.16	17.2
33.3	220.6	97.6	123.0	31.6	22.447	-1.179	7.89	17.0
35.8	238.8	115.8	123.0	34.5	22.585	-1.128	7.99	17.0
38.3	257.8	134.8	123.0	37.5	22.689	-1.220	8.10	17.0
38.3	308.4	135.1	173.2	50.9	23.223	-2.221	8.37	17.3
39.5	317.8	144.5	173.2	53.4	23.469	-2.266	8.42	17.4
40.7	327.3	154.1	173.2	56.0	23.637	-2.280	8.47	17.4

40.7	219.4	154.7	64.8	29.4	22.316	-1.383	7.82	16.6
44.5	294.8	230.0	64.8	48.6	23.170	-1.215	8.31	16.8
48.3	370.2	305.4	64.8	83.9	24.097	-1.987	8.84	17.6
48.3	479.3	306.1	173.2	229.5	25.100	-2.402	9.42	18.8
49.7	493.9	320.6	173.2	280.2	25.399	-2.052	9.46	18.8
51.0	508.7	335.5	173.2	327.0	25.572	-1.930	9.49	18.8
51.0	509.1	335.9	173.2	329.1	25.555	-1.921	9.50	18.8
51.5	513.1	339.9	173.2	350.7	25.369	-1.807	9.51	18.7
52.0	517.2	343.9	173.2	366.9	25.460	-1.684	9.51	18.7
52.0	517.5	344.3	173.2	369.1	25.469	-1.674	9.52	18.7
56.7	566.0	392.8	173.2	955.4	26.239	-1.170	9.57	18.2
61.5	618.6	445.3	173.2	9999.0	26.642	-0.451	9.60	17.6

Refusal occurred; no driving time output possible

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GRE-42-0263-FA : 01/23/2020 : 11/24/2020
National Engineering & Architectural Ser GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
2.98	61.48	0.00	10.81	1.00	0.80	1.00	1.00
3.02	61.48	0.00	10.81	1.00	0.80	1.00	1.00
4.25	61.48	0.00	10.81	1.00	0.80	1.00	1.00
5.48	61.48	0.00	10.81	1.00	0.80	1.00	1.00
5.52	61.48	0.00	10.81	1.00	0.80	1.00	1.00
10.00	61.48	0.00	10.81	1.00	0.80	1.00	1.00
14.48	61.48	0.00	10.81	1.00	0.80	1.00	1.00
14.52	61.48	0.00	10.81	1.00	0.80	1.00	1.00
15.75	61.48	0.00	10.81	1.00	0.80	1.00	1.00
16.98	61.48	0.00	10.81	1.00	0.80	1.00	1.00
17.02	61.48	0.00	10.81	1.00	0.80	1.00	1.00
18.25	61.48	0.00	10.81	1.00	0.80	1.00	1.00
19.48	61.48	0.00	10.81	1.00	0.80	1.00	1.00
19.52	61.48	0.00	10.81	1.00	0.80	1.00	1.00
25.10	61.48	0.00	10.81	1.00	0.80	1.00	1.00
30.68	61.48	0.00	10.81	1.00	0.80	1.00	1.00
30.72	61.48	0.00	10.81	1.00	0.80	1.00	1.00
32.00	61.48	0.00	10.81	1.00	0.80	1.00	1.00
33.28	61.48	0.00	10.81	1.00	0.80	1.00	1.00
33.32	61.48	0.00	10.81	1.00	0.80	1.00	1.00
35.80	61.48	0.00	10.81	1.00	0.80	1.00	1.00
38.28	61.48	0.00	10.81	1.00	0.80	1.00	1.00
38.32	61.48	0.00	10.81	1.00	0.80	1.00	1.00
39.50	61.48	0.00	10.81	1.00	0.80	1.00	1.00
40.68	61.48	0.00	10.81	1.00	0.80	1.00	1.00
40.72	61.48	0.00	10.81	1.00	0.80	1.00	1.00
44.50	61.48	0.00	10.81	1.00	0.80	1.00	1.00
48.28	61.48	0.00	10.81	1.00	0.80	1.00	1.00
48.32	61.48	0.00	10.81	1.00	0.80	1.00	1.00
49.65	61.48	0.00	10.81	1.00	0.80	1.00	1.00
50.98	61.48	0.00	10.81	1.00	0.80	1.00	1.00
51.02	61.48	0.00	10.81	1.00	0.80	1.00	1.00
51.50	61.48	0.00	10.81	1.00	0.80	1.00	1.00
51.98	61.48	0.00	10.81	1.00	0.80	1.00	1.00
52.02	61.48	0.00	10.81	1.00	0.80	1.00	1.00
56.73	61.48	0.00	10.81	1.00	0.80	1.00	1.00
61.48	61.48	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft2	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.01	0.00	0.05	0.100	0.117	0.050	0.150	0.000	0.000	0.000
2.99	0.19	16.36	0.100	0.117	0.050	0.150	0.000	0.000	0.000
3.01	1.35	13.89	0.100	0.117	0.200	0.150	0.396	0.000	0.000
5.49	1.35	13.89	0.100	0.117	0.200	0.150	0.396	0.000	0.000
5.51	1.29	16.45	0.100	0.117	0.200	0.150	1.000	0.000	0.000
14.49	1.29	16.45	0.100	0.117	0.200	0.150	1.000	0.000	0.000
14.51	0.87	37.03	0.100	0.117	0.200	0.150	0.396	0.000	0.000
16.99	0.87	37.03	0.100	0.117	0.200	0.150	0.396	0.000	0.000
17.01	0.92	39.59	0.100	0.117	0.200	0.150	1.000	0.000	0.000
19.49	0.92	39.59	0.100	0.117	0.200	0.150	1.000	0.000	0.000
19.51	0.91	30.85	0.100	0.117	0.200	0.150	0.768	0.000	0.000
28.51	0.91	30.85	0.100	0.117	0.200	0.150	0.768	0.000	0.000
30.69	0.91	30.85	0.100	0.117	0.200	0.150	0.768	0.000	0.000
30.71	2.13	173.24	0.100	0.117	0.050	0.150	0.396	0.000	0.000
33.29	2.27	173.24	0.100	0.117	0.050	0.150	0.396	0.000	0.000
33.31	1.95	122.96	0.100	0.117	0.050	0.150	0.000	0.000	0.000
38.29	2.14	122.96	0.100	0.117	0.050	0.150	0.000	0.000	0.000
38.31	2.48	173.24	0.100	0.117	0.050	0.150	0.396	0.000	0.000
40.69	2.59	173.24	0.100	0.117	0.050	0.150	0.396	0.000	0.000
40.71	6.30	64.79	0.100	0.117	0.200	0.150	0.396	0.000	0.000
48.29	6.30	64.79	0.100	0.117	0.200	0.150	0.396	0.000	0.000
48.31	2.95	173.24	0.100	0.117	0.050	0.150	0.000	0.000	0.000
50.99	3.08	173.24	0.100	0.117	0.050	0.150	0.000	0.000	0.000
51.01	3.08	173.24	0.100	0.117	0.050	0.150	0.768	0.000	0.000
51.99	3.13	173.24	0.100	0.117	0.050	0.150	0.768	0.000	0.000
52.01	3.13	173.24	0.100	0.117	0.050	0.150	0.396	0.000	0.000
61.01	3.59	173.24	0.100	0.117	0.050	0.150	0.396	0.000	0.000
61.48	3.61	173.24	0.100	0.117	0.050	0.150	0.396	0.000	0.000

APPENDIX F

SETTLEMENT ANALYSIS

US-42 Settlement Analysis

PROJECT IDENTIFICATION

Title: US-42 Settlement Analysis
Project Number: GRE-42-02.63 - PID 102746 -
Client: Palmer Engineering Company
Designer: KCA
Station Number:

Description:

Company's information:

Name: NEAS Inc.
Street: 2868 East Kemper Road
Cincinnati, OH 45241
Telephone #:
Fax #:
E-Mail:

Original file path and name: P:\18-0020 .....)\Analysis\Settlement\Fossa Files\FoSSA021720.2ST
Original date and time of creating this file: Mon Feb 03 13:56:44 2020

GEOMETRY: Analysis of a 2D geometry

INPUT DATA – FOUNDATION LAYERS – 6 layers

	Wet Unit Weight, γ [lb/ft³]	Poisson's Ratio μ	Description of Soil
1	125.00	0.23	Soil Type 1
2	118.00	0.40	Soil Type 2
3	140.00	0.45	Soil Type 3
4	130.00	0.36	Soil Type 4
5	140.00	0.50	Soil Type 5
6	135.00	0.35	Soil Type 6

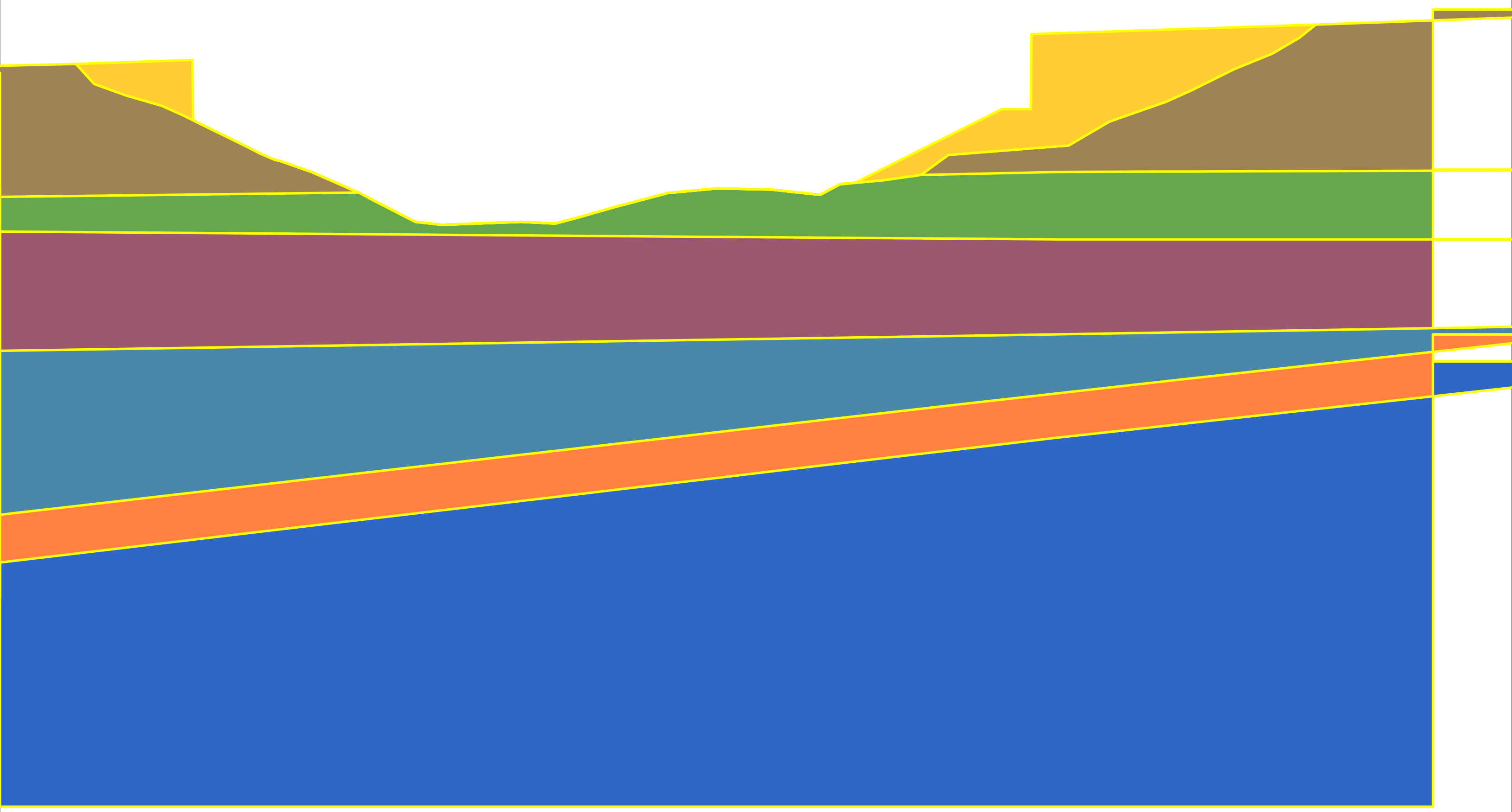
INPUT DATA – EMBANKMENT LAYERS -- 1 layers

	Wet Unit Weight, γ [lb/ft³]	Description of Soil
1	120.00	Proposed Embankment

INPUT DATA OF WATER

Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]
1	0.00	733.10
2	31.00	733.10
3	232.00	740.60
4	350.00	744.70

DRAWING OF SPECIFIED GEOMETRY



INPUT DATA FOR CONSOLIDATION –– $\alpha = 1/2$

Layer #	Underging Consolidation [Yes/No]	OCR = Pc / Po	Cc	Cr	e0	Cv [ft ²/day]	Drains at :
1	No	N/A	N/A	N/A	N/A	N/A	N/A
2	Yes	4.00	0.170	0.034	0.638	0.6000	Top
3	Yes	6.00	0.055	0.006	0.322	0.6000	Top & Bot.
4	No	N/A	N/A	N/A	N/A	N/A	N/A
5	Yes	6.00	0.055	0.006	0.322	0.6000	Top & Bot.
6	No	N/A	N/A	N/A	N/A	N/A	N/A

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
1	60.00	0.00	1	174800	0.2300	0.0047	778.90	778.88	0.02
			2	742500	0.4000	0.0007			
			3	1677000	0.4500	0.0010			
			4	567500	0.3600	0.0039			
			5	2000000	0.5000	0.0001			
			6	104423	0.3500	0.0088			
2	70.00	0.00	1	174800	0.2300	0.0385	774.74	774.69	0.06
			2	742500	0.4000	0.0021			
			3	1677000	0.4500	0.0017			
			4	567500	0.3600	0.0047			
			5	2000000	0.5000	0.0002			
			6	104423	0.3500	0.0106			
3	80.00	0.00	1	174800	0.2300	0.0458	771.50	771.43	0.07
			2	742500	0.4000	0.0024			
			3	1677000	0.4500	0.0019			
			4	567500	0.3600	0.0047			
			5	2000000	0.5000	0.0002			
			6	104423	0.3500	0.0121			
4	90.00	0.00	1	174800	0.2300	0.0093	766.72	766.69	0.03
			2	742500	0.4000	0.0012			
			3	1677000	0.4500	0.0011			
			4	567500	0.3600	0.0038			
			5	2000000	0.5000	0.0001			
			6	104423	0.3500	0.0129			
5	100.00	0.00	1	174800	0.2300	0.0008	762.23	762.21	0.02
			2	742500	0.4000	0.0001			
			3	1677000	0.4500	0.0002			
			4	567500	0.3600	0.0024			
			5	2000000	0.5000	0.0001			
			6	104423	0.3500	0.0132			
6	110.00	0.00	1	174800	0.2300	-0.0001	758.27	758.26	0.01
			2	742500	0.4000	-0.0004			
			3	1677000	0.4500	-0.0004			
			4	567500	0.3600	0.0011			
			5	2000000	0.5000	-0.0000			
			6	104423	0.3500	0.0125			
7	120.00	0.00	1	174800	0.2300	0.0000	753.33	753.32	0.01
			2	742500	0.4000	-0.0003			
			3	1677000	0.4500	-0.0007			
			4	567500	0.3600	0.0001			
			5	2000000	0.5000	-0.0001			
			6	104423	0.3500	0.0121			
8	130.00	0.00	1	174800	0.2300	0.0000	751.71	751.70	0.01
			2	742500	0.4000	-0.0002			
			3	1677000	0.4500	-0.0009			
			4	567500	0.3600	-0.0005			
			5	2000000	0.5000	-0.0002			
			6	104423	0.3500	0.0123			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
9	140.00	0.00	1	174800	0.2300	0.0000	752.09	752.07	0.01
			2	742500	0.4000	-0.0002			
			3	1677000	0.4500	-0.0010			
			4	567500	0.3600	-0.0008			
			5	2000000	0.5000	-0.0002			
			6	104423	0.3500	0.0142			
10	150.00	0.00	1	174800	0.2300	0.0000	752.77	752.76	0.02
			2	742500	0.4000	-0.0003			
			3	1677000	0.4500	-0.0011			
			4	567500	0.3600	-0.0006			
			5	2000000	0.5000	-0.0002			
			6	104423	0.3500	0.0190			
11	160.00	0.00	1	174800	0.2300	0.0000	755.55	755.53	0.02
			2	742500	0.4000	-0.0007			
			3	1677000	0.4500	-0.0011			
			4	567500	0.3600	-0.0002			
			5	2000000	0.5000	-0.0001			
			6	104423	0.3500	0.0265			
12	170.00	0.00	1	174800	0.2300	0.0000	757.43	757.40	0.04
			2	742500	0.4000	-0.0010			
			3	1677000	0.4500	-0.0010			
			4	567500	0.3600	0.0006			
			5	2000000	0.5000	-0.0000			
			6	104423	0.3500	0.0374			
13	180.00	0.00	1	174800	0.2300	0.0000	757.67	757.61	0.05
			2	742500	0.4000	-0.0011			
			3	1677000	0.4500	-0.0008			
			4	567500	0.3600	0.0019			
			5	2000000	0.5000	0.0001			
			6	104423	0.3500	0.0519			
14	190.00	0.00	1	174800	0.2300	0.0000	756.86	756.78	0.08
			2	742500	0.4000	-0.0007			
			3	1677000	0.4500	-0.0002			
			4	567500	0.3600	0.0038			
			5	2000000	0.5000	0.0004			
			6	104423	0.3500	0.0726			
15	200.00	0.00	1	174800	0.2300	0.0000	758.98	758.88	0.11
			2	742500	0.4000	0.0004			
			3	1677000	0.4500	0.0010			
			4	567500	0.3600	0.0064			
			5	2000000	0.5000	0.0008			
			6	104423	0.3500	0.0976			
16	210.00	0.00	1	174800	0.2300	0.0019	761.04	760.90	0.14
			2	742500	0.4000	0.0033			
			3	1677000	0.4500	0.0028			
			4	567500	0.3600	0.0092			
			5	2000000	0.5000	0.0012			
			6	104423	0.3500	0.1241			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
17	220.00	0.00	1	174800	0.2300	0.0151	764.02	763.82	0.19
			2	742500	0.4000	0.0079			
			3	1677000	0.4500	0.0051			
			4	567500	0.3600	0.0116			
			5	2000000	0.5000	0.0017			
			6	104423	0.3500	0.1518			
18	230.00	0.00	1	174800	0.2300	0.0320	764.80	764.55	0.24
			2	742500	0.4000	0.0142			
			3	1677000	0.4500	0.0071			
			4	567500	0.3600	0.0130			
			5	2000000	0.5000	0.0021			
			6	104423	0.3500	0.1729			
19	240.00	0.00	1	174800	0.2300	0.0686	768.67	768.38	0.29
			2	742500	0.4000	0.0166			
			3	1677000	0.4500	0.0077			
			4	567500	0.3600	0.0127			
			5	2000000	0.5000	0.0022			
			6	104423	0.3500	0.1859			
20	250.00	0.00	1	174800	0.2300	0.0758	772.39	772.10	0.29
			2	742500	0.4000	0.0135			
			3	1677000	0.4500	0.0068			
			4	567500	0.3600	0.0106			
			5	2000000	0.5000	0.0021			
			6	104423	0.3500	0.1848			
21	260.00	0.00	1	174800	0.2300	0.0669	777.06	776.80	0.26
			2	742500	0.4000	0.0086			
			3	1677000	0.4500	0.0048			
			4	567500	0.3600	0.0077			
			5	2000000	0.5000	0.0017			
			6	104423	0.3500	0.1717			
22	270.00	0.00	1	174800	0.2300	0.0382	781.56	781.36	0.20
			2	742500	0.4000	0.0035			
			3	1677000	0.4500	0.0026			
			4	567500	0.3600	0.0047			
			5	2000000	0.5000	0.0012			
			6	104423	0.3500	0.1488			
23	280.00	0.00	1	174800	0.2300	-0.0016	785.84	785.72	0.12
			2	742500	0.4000	-0.0001			
			3	1677000	0.4500	0.0008			
			4	567500	0.3600	0.0023			
			5	2000000	0.5000	0.0006			
			6	104423	0.3500	0.1193			
24	290.00	0.00	1	174800	0.2300	-0.0040	786.21	786.13	0.09
			2	742500	0.4000	-0.0014			
			3	1677000	0.4500	-0.0002			
			4	567500	0.3600	0.0009			
			5	2000000	0.5000	0.0002			
			6	104423	0.3500	0.0896			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
1	60.00	0.00	778.90	0.00	778.89
2	70.00	0.00	774.74	0.01	774.73
3	80.00	0.00	771.50	0.01	771.49
4	90.00	0.00	766.72	0.01	766.70
5	100.00	0.00	762.23	0.01	762.22
6	110.00	0.00	758.27	0.01	758.26
7	120.00	0.00	753.33	0.01	753.33
8	130.00	0.00	751.71	0.00	751.71
9	140.00	0.00	752.09	0.00	752.08
10	150.00	0.00	752.77	0.00	752.77
11	160.00	0.00	755.55	0.01	755.54
12	170.00	0.00	757.43	0.01	757.43
13	180.00	0.00	757.67	0.02	757.65
14	190.00	0.00	756.86	0.03	756.83
15	200.00	0.00	758.98	0.05	758.93
16	210.00	0.00	761.04	0.07	760.97
17	220.00	0.00	764.02	0.08	763.94
18	230.00	0.00	764.80	0.09	764.70
19	240.00	0.00	768.67	0.08	768.59
20	250.00	0.00	772.39	0.06	772.33
21	260.00	0.00	777.06	0.04	777.03
22	270.00	0.00	781.56	0.02	781.54
23	280.00	0.00	785.84	0.01	785.83
24	290.00	0.00	786.21	0.00	786.21

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	1	0.00	777.50	Soil Type 1
	2	64.50	779.00	
	3	67.60	775.60	
	4	73.20	773.60	
	5	79.10	771.90	
	6	82.70	770.30	
	7	93.90	764.80	
	8	96.00	763.70	
	9	98.40	762.70	
	10	99.50	762.40	
	11	104.70	760.60	
	12	111.30	757.70	
	13	112.80	757.10	
	14	114.60	756.10	
	15	122.40	752.10	
	16	127.00	751.60	
	17	140.40	752.10	
	18	146.30	751.80	
	19	150.10	752.80	
	20	156.40	754.60	
	21	165.50	757.00	
	22	173.80	757.80	
	23	183.00	757.60	
	24	191.50	756.70	
	25	194.90	758.50	
	26	202.30	759.20	
	27	208.70	760.10	
	28	213.40	763.50	
	29	233.90	765.10	
	30	240.90	769.20	
	31	250.60	772.60	
	32	255.00	774.60	
	33	262.10	778.10	
	34	268.70	780.80	
	35	273.30	783.50	
	36	276.10	785.70	
	37	300.60	786.60	
	38	325.60	787.50	
	39	350.00	788.30	

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
2	1	0.00	756.00	Soil Type 2
	2	31.00	756.10	
	3	112.80	757.09	
	4	114.60	756.09	
	5	122.40	752.09	
	6	127.00	751.59	
	7	140.40	752.09	
	8	146.30	751.79	
	9	150.10	752.79	
	10	156.40	754.59	
	11	165.50	756.99	
	12	173.80	757.79	
	13	183.00	757.59	
	14	191.50	756.69	
	15	194.90	758.49	
	16	202.30	759.19	
	17	208.70	760.09	
	18	232.00	760.60	
	19	350.00	761.00	
3	1	0.00	750.70	Soil Type 3
	2	31.00	750.60	
	3	232.00	749.10	
	4	350.00	749.10	
4	1	0.00	729.80	Soil Type 4
	2	31.00	729.80	
	3	232.00	732.90	
	4	339.70	734.70	
	5	350.00	732.90	
5	1	0.00	696.70	Soil Type 5
	2	31.00	699.80	
	3	232.00	722.90	
	4	339.70	734.69	
	5	350.00	732.89	
6	1	0.00	688.00	Soil Type 6
	2	31.00	691.60	
	3	232.00	715.30	
	4	350.00	728.30	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #		Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	X1 = 64.50 [ft]	1	64.50	779.00	Proposed Embankment
	X2 = 276.10 [ft]	2	84.40	779.70	
		3	84.50	769.40	
		4	93.90	764.80	
		5	96.00	763.70	
		6	98.40	762.70	
		7	99.50	762.40	
		8	104.70	760.60	
		9	111.30	757.70	
		10	112.80	757.10	
		11	114.60	756.10	
		12	122.40	752.10	
		13	127.00	751.60	
		14	140.40	752.10	
		15	146.30	751.80	
		16	150.10	752.80	
		17	156.40	754.60	
		18	165.50	757.00	
		19	173.80	757.80	
		20	183.00	757.60	
		21	191.50	756.70	
		22	194.90	758.50	
		23	197.60	758.80	
		24	222.50	771.30	
		25	227.50	771.30	
		26	227.60	784.10	
		27	276.10	785.70	

STA. 46+83 (Proposed Embankment)

TemporarySTA46+83.txt

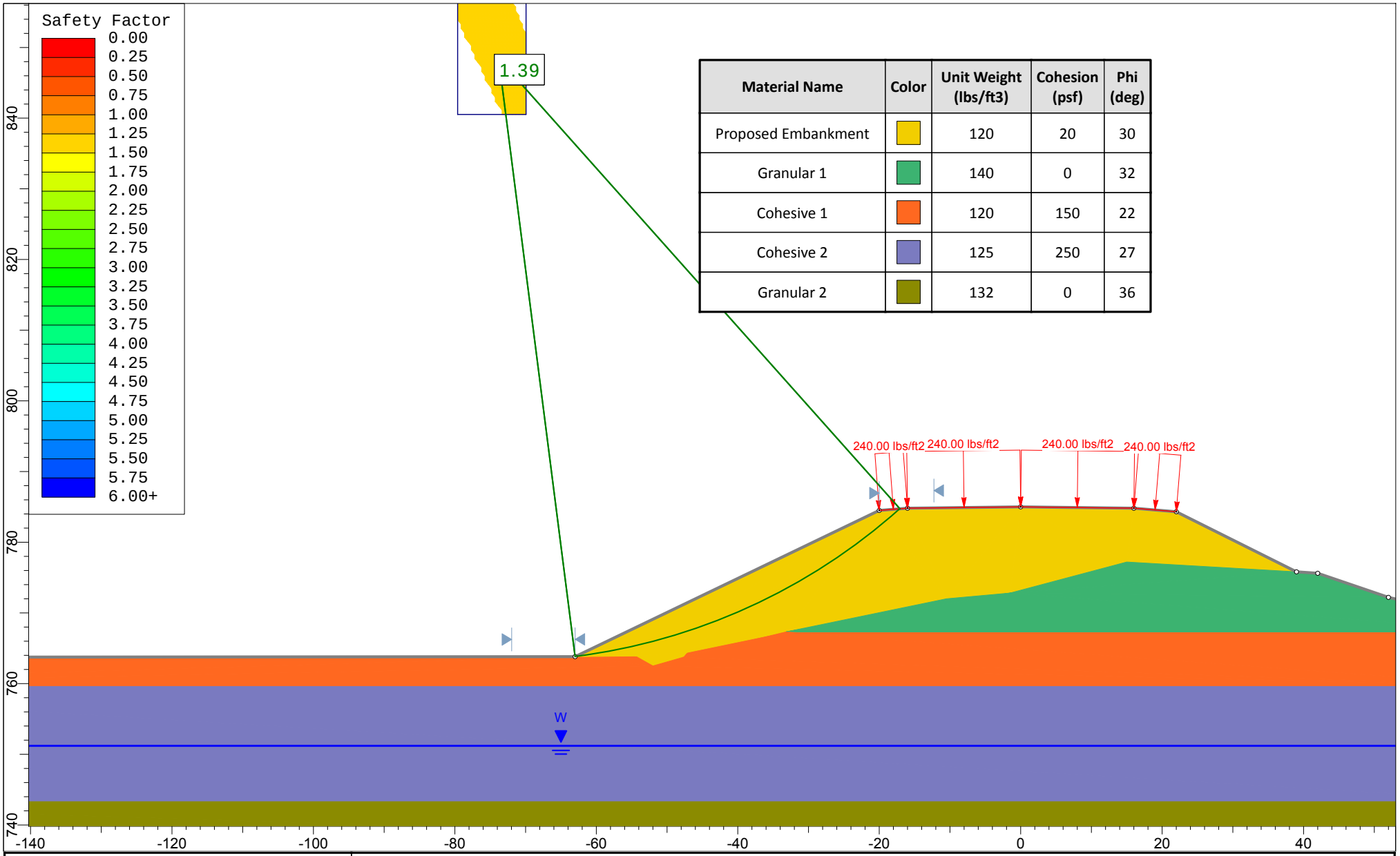
Time-Rate: Cumulative settlement of all consolidating layers.

0 days	9 days	17 days	26 days	34 days	43 days	52 days	60 days	69 days	78 days	86 days
t0	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0203	0.0282	0.0342	0.0391	0.0434	0.0472	0.0507	0.0538	0.0566	0.0591
0.0000	0.0034	0.0047	0.0058	0.0066	0.0073	0.0079	0.0083	0.0087	0.0090	0.0093
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0016	0.0020	0.0022	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total:										
0.0000	0.0253	0.0350	0.0422	0.0480	0.0531	0.0574	0.0614	0.0648	0.0680	0.0708

100 % of Settlement = 0.0971 ft

APPENDIX G

EMBANKMENT STABILITY ANALYSIS

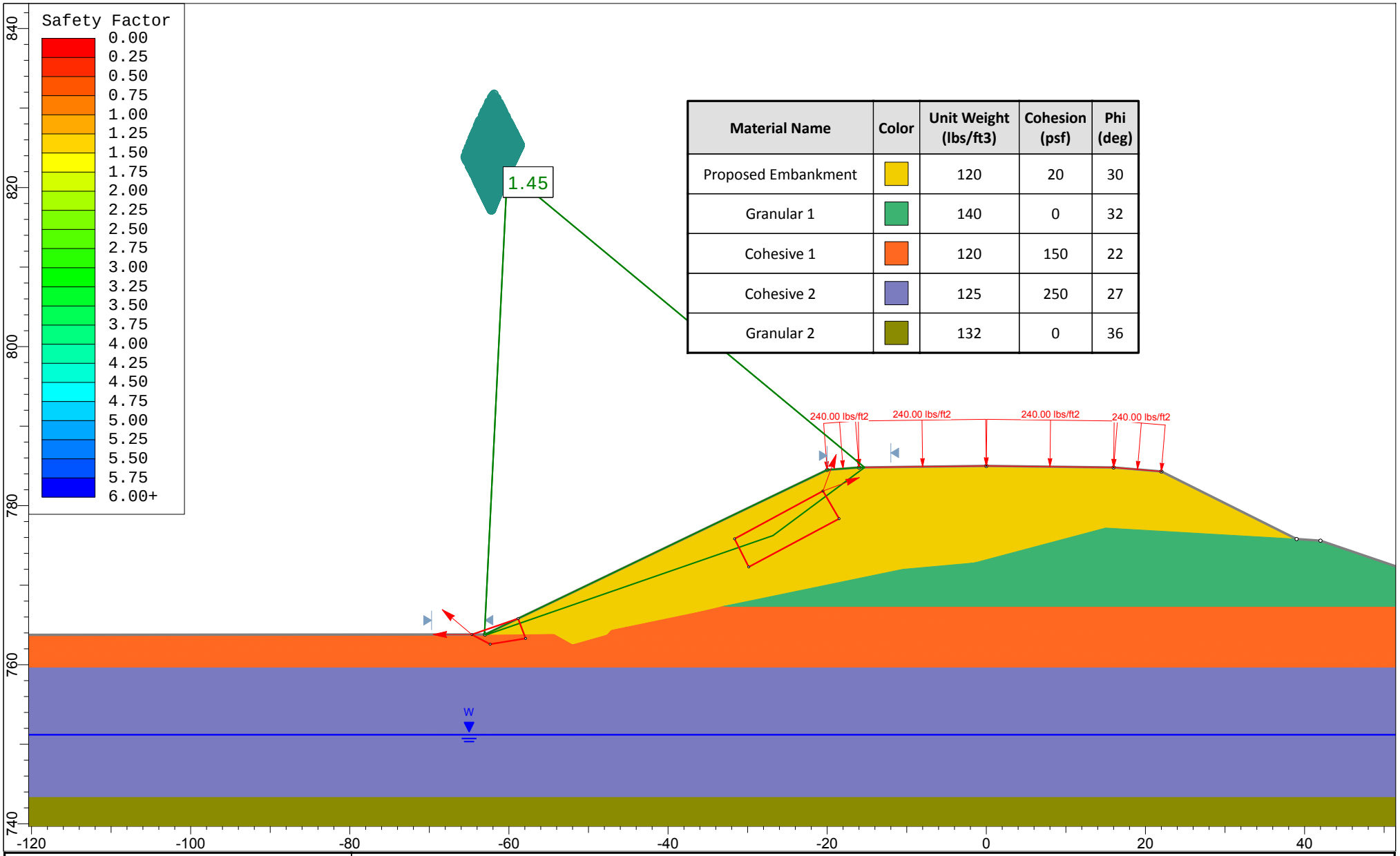


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Proposed Embankment		120	20	30
Granular 1		140	0	32
Cohesive 1		120	150	22
Cohesive 2		125	250	27
Granular 2		132	0	36

rocscience

SLIDEINTERPRET 7.038

Project	GRE-42-02.63, PID 102746		
Analysis Description	Embankment Stability Analysis - US-42 STA. 47+07 - Effective Stress - Circular Failure		
Drawn By	KCA	Scale 1:225	Company NEAS Inc.
Date	2/4/2020, 3:25:44 PM		File Name Slide_STA47+07_EffectiveCircular020420.slim

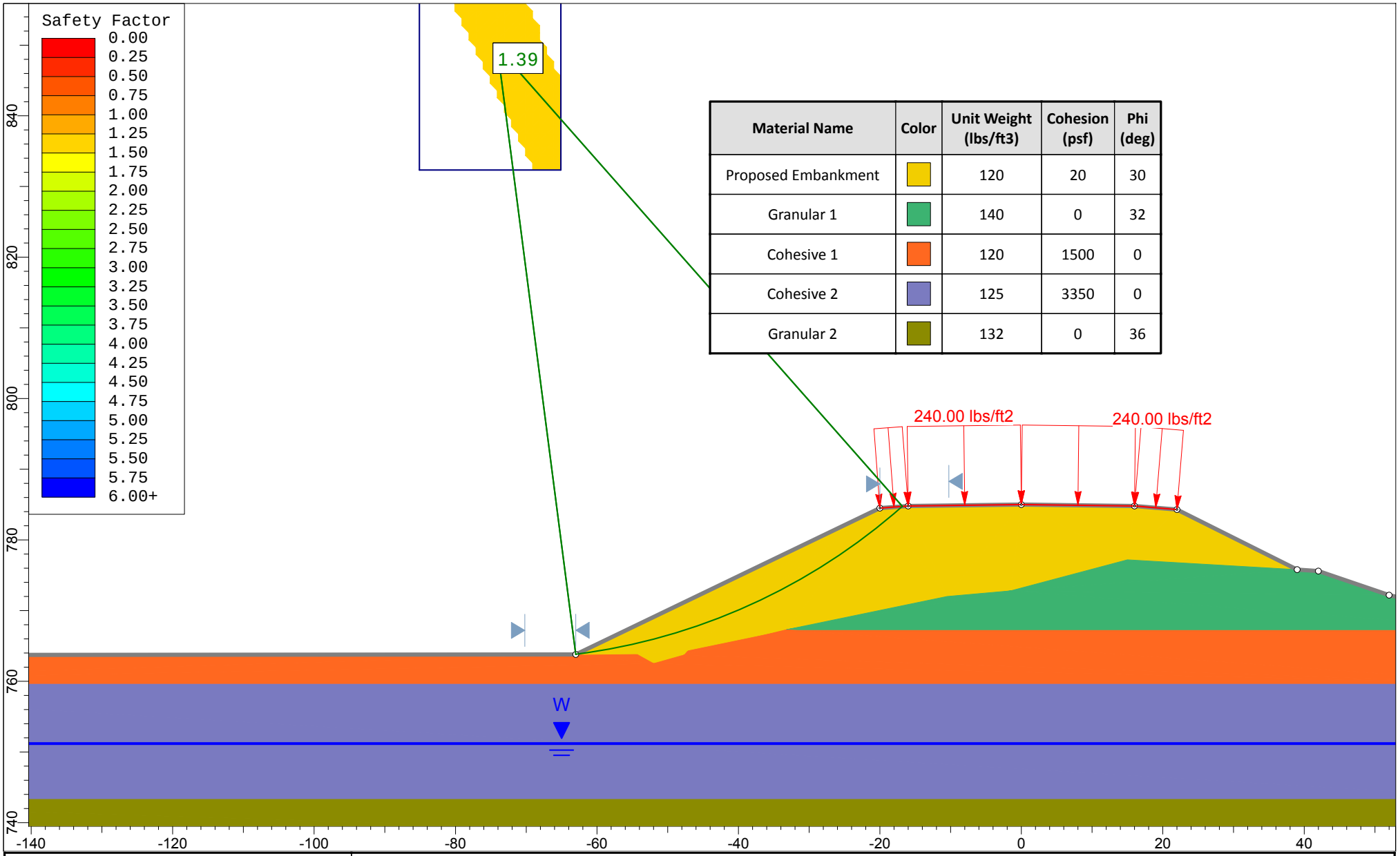


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Proposed Embankment		120	20	30
Granular 1		140	0	32
Cohesive 1		120	150	22
Cohesive 2		125	250	27
Granular 2		132	0	36

rocscience

SLIDEINTERPRET 7.038

Project	GRE-42-02.63, PID 102746		
Analysis Description	Embankment Stability Analysis - US-42 STA. 47+07 - Effective Stress -Block Failure		
Drawn By	KCA	*Scale* 1:200	*Company* NEAS Inc.
Date	2/4/2020, 3:25:44 PM	*File Name*	Slide_STA47+07_EffectiveBlock020420.slim

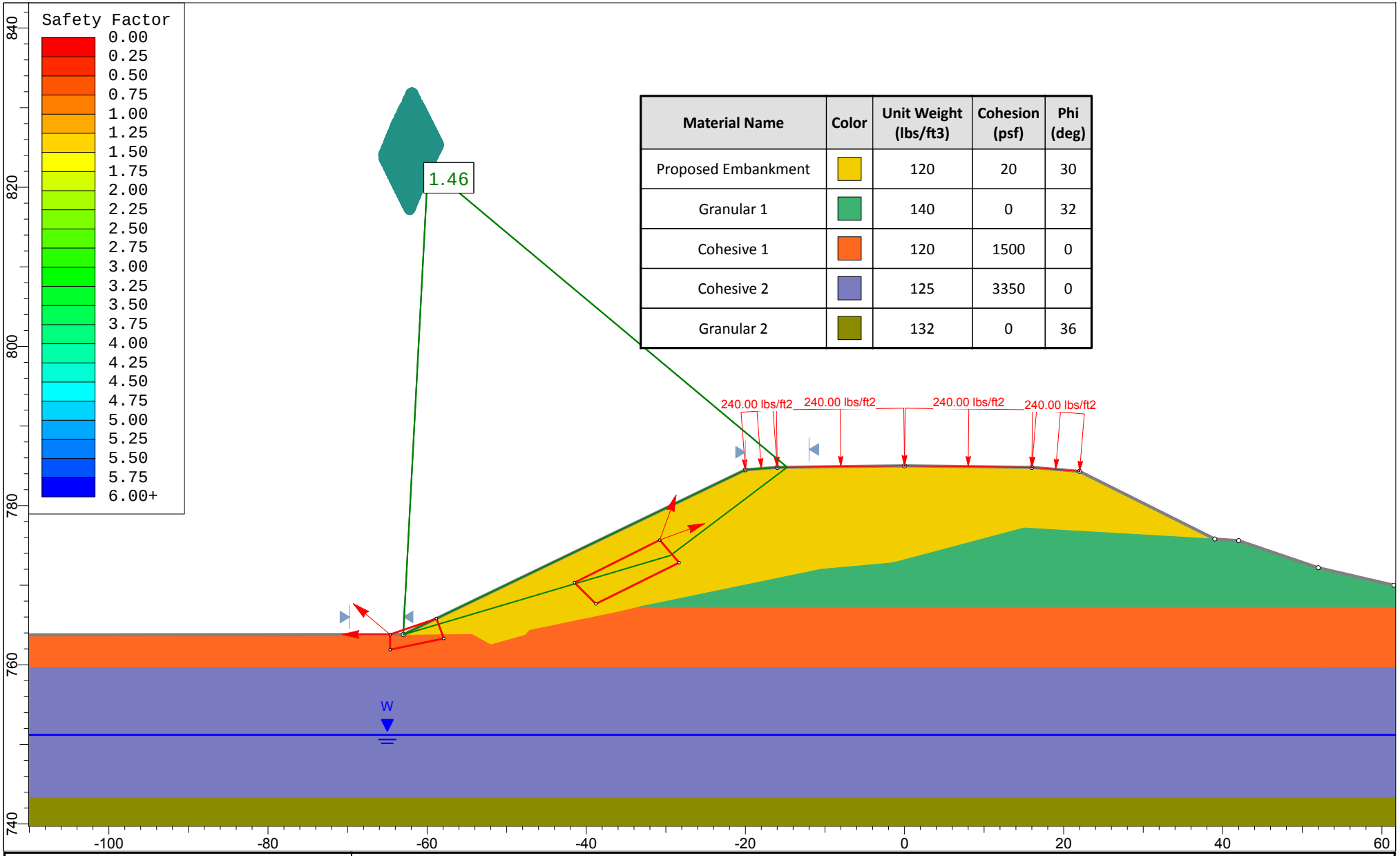


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Proposed Embankment		120	20	30
Granular 1		140	0	32
Cohesive 1		120	1500	0
Cohesive 2		125	3350	0
Granular 2		132	0	36

rocscience

SLIDEINTERPRET 7.038

Project	GRE-42-02.63, PID 102746		
Analysis Description	Embankment Stability Analysis - US-42 STA. 47+07 - Total Stress - Circular Failure		
Drawn By	KCA	Scale 1:225	Company NEAS Inc.
Date	2/4/2020, 3:25:44 PM		File Name Slide_STA47+07_TotalCircular020420.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Proposed Embankment		120	20	30
Granular 1		140	0	32
Cohesive 1		120	1500	0
Cohesive 2		125	3350	0
Granular 2		132	0	36

rocscience

SLIDEINTERPRET 7.038

Project	GRE-42-02.63, PID 102746		
Analysis Description	Embankment Stability Analysis - US-42 STA. 47+07 -Total Stress -Block Failure		
Drawn By	KCA	*Scale* 1:200	*Company* NEAS Inc.
Date	2/4/2020, 3:25:44 PM	*File Name*	Slide_STA47+07_TotalBlock020420.slim

APPENDIX H

GEOTECHNICAL BULLETIN 1 (GB1)
ANALYSIS SPREADSHEETS

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

GRE-42-2.63
PID 102746

Replacement of Bridge GRE-42-0263 over the Little Miami Scenic Bike Trail including roadway pavement approach work.

NEAS Inc.

Prepared By: KCA
Date prepared: Thursday, February 20, 2020

Brendan P. Andrews
2868 East Kemper Road
Cincinnati, OH 45241

(920) 427-0671
brendan.andrews@neasinc.com

NO. OF BORINGS: 2

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-18	CENTERLINE OF US-42	44+80	12	Rt	CME 55X Tracked	82	778.2	776.7	1.5 C
2	B-003-0-18	CENTERLINE OF US-42	47+55	13	Rt	CME 55X Tracked	82	786.8	785.3	1.5 C

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.5 1/18/2019

#	Boring	Sample	Sample Depth		Subgrade Depth		Standard Penetration		HP (tsf)	Physical Characteristics						Moisture		Ohio DOT		Sulfate Content (ppm)	Problem		Excavate and Replace (Item 204)		Recommendation (Enter depth in inches)
			From	To	From	To	N_{60}	N_{60L}		LL	PL	PI	% Silt	% Clay	P200	M_C	M_{OPT}	Class	GI		Unsuitable	Unstable	Unsuitable	Unstable	
1	B	SS-1	1.5	3.0	0.0	1.5	29			NP	NP	NP	23	11	34	9	8	A-3a	0						
	001-0	SS-2	3.0	4.5	1.5	3.0	16		3.5	17	15	2	33	11	44	11	10	A-4a	2						
	18	SS-3	4.5	6.0	3.0	4.5	16		3.5							10	10	A-4a	8						
		SS-4	6.0	7.5	4.5	6.0	16	16	1.5							11	10	A-4a	8						
2	B	SS-1	1.5	3.0	0.0	1.5	16										10	A-4a	8						
	003-0	SS-2	3.0	4.5	1.5	3.0	11		4.5	21	15	6	28	15	43	11	10	A-4a	2			N_{60}			
	18	SS-3	4.5	6.0	3.0	4.5	10		3.75	27	16	11	25	21	46	14	11	A-4a	3						
		SS-4	6.0	7.5	4.5	6.0	12	10	0.75							13	10	A-4a	8						

PID: PID 102746

County-Route-Section: GRE-42-2.63
No. of Borings: 2

Geotechnical Consultant: NEAS Inc.
Prepared By: KCA
Date prepared: 2/20/2020

Chemical Stabilization Options		
320	Rubblize & Roll	Option
206	Cement Stabilization	Option
	Lime Stabilization	No
206	Depth	12''

Excavate and Replace Stabilization Options	
Global Geotextile Override(N60L):	18''
Override(HP):	24''
Global Geogrid Override(N60L):	12''
Override(HP):	18''

Design CBR	8

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	0%	HP ≤ 0.5	0%
$N_{60} < 12$	25%	0.5 < HP ≤ 1	13%
$12 \leq N_{60} < 15$	13%	1 < HP ≤ 2	13%
$N_{60} \geq 20$	13%	HP > 2	50%
M+	0%		
Rock	0%		
Unsuitable	0%		

Excavate and Replace at Surface	
Average	0''
Maximum	0''
Minimum	0''

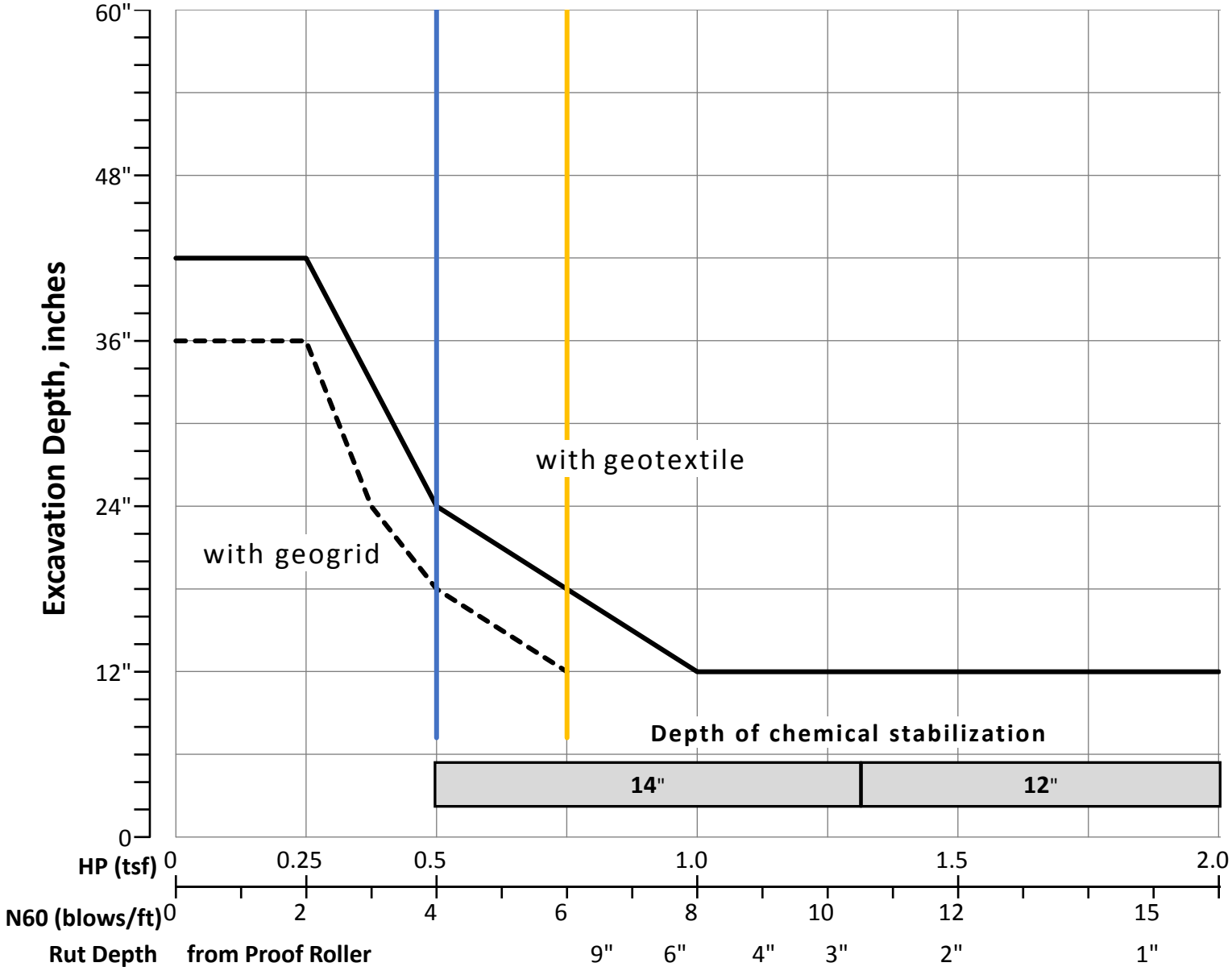
% Proposed Subgrade Surface	
Unstable & Unsuitable	25%
Unstable	25%
Unsuitable	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	16	13	2.92	22	15	6	27	15	42	11	10	5
Maximum	29	16	4.50	27	16	11	33	21	46	14	11	8
Minimum	10	10	0.75	17	15	2	23	11	34	9	8	0

Classification Counts by Sample

ODOT Class	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals
Count	0	0	0	0	0	0	0	0	1	7	0	0	0	0	0	0	0	0	8
Percent	0%	0%	0%	0%	0%	0%	0%	0%	13%	88%	0%	0%	0%	0%	0%	0%	0%	0%	100%
% Rock|Granular|Cohesive	0%	100%									0%								100%
Surface Class Count	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	4
Surface Class Percent	0%	0%	0%	0%	0%	0%	0%	0%	25%	75%	0%	0%	0%	0%	0%	0%	0%	0%	100%

GB1 Figure B – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
2.92	0.50	☑ HP
13.00	6.00	☑ N60L

Average HP
Average N_{60L}

The subgrade analysis workbook consists of five worksheets. Each worksheet functions independently. In all of the worksheets the fields are color coded as follows:

- Every yellow highlighted field indicates a field to be entered by the user.
- Every salmon field is to indicate a problem/issue.
- Every gray or green field is a heading/informational field.

IMPORTANT: The sequence of filling out the data needs to be followed as outlined below:

1. Cover Sheet: this worksheet is designed for the purpose of entering the project information. Enter all the following fields:

County-Route-Section	This includes the county, route, section number assigned to the project.
PID	the Project Identification Number
Project Description	See Cover Sheet for list of example details
Geotechnical Consultant	The Geotechnical Consultant performing the analysis.
Prepared By	The preparer of the subgrade analysis
Date prepared	The date the analysis is performed.
Contact Information	Name, address, telephone #, and email address
No. of Borings	Enter the total number of borings within the alignment that is being analyzed.

2. Boring Logs Entry Worksheet: this worksheet has a programming code that will run in the background every time the sheet is activated and will make the sheet unresponsive for less than a minute. The code is designed to read the total number of borings from the cover sheet and generate the needed number of fields.
   a. All yellow highlighted fields are user's entry.
   b. ODOT has developed a text table export from gINT *(GB 1 Borings Log Entry Tab)* that will allow for copy and paste of all highlighted fields with the exception of proposed subgrade elevation. The designer must provide a proposed subgrade elevation in order for the spreadsheet to function properly.
   c. The Cut/Fill field is a calculated field that, based on the difference between the boring elevation and the proposed subgrade elevation, will highlight the cell either gray and adds the letter "C" to the end in a cut situation or highlights the cell in light purple and adds the letter "F" to the end in a fill situation.
   d. Every duplicate boring ID will be highlighted in salmon background and red text.
   e. **IMPORTANT**: After entering all the borings' information, the user must click "Add Subgrade Analysis Entry Fields" button. This will generate all the required fields in the "Subgrade Analysis" Worksheet.

3. Subgrade Analysis Worksheet:
   a. The boring number and boring ID is read from the "Boring Logs Entry Worksheet" excluding every boring that has six feet or more of fill.
   b. All yellow highlighted fields are to be entered by the user and salmon highlighted fields indicates a problem or issue.
   c. Every sample that has a Sulfate Content greater than or equal to 3000 will be highlighted in light salmon background. Every sample that has a Sulfate Content greater than or equal to 8000 will be highlighted in darker salmon background. Note the revised sulfate criteria in GB1 issued July 20, 2018.

d. Unsuitable/Unstable:

i. Unsuitable samples that are within 3 feet of the top of subgrade will be highlighted with salmon background and the class will be showing in this field.

ii. Unstable Samples that are within 3 feet of top of subgrade will be highlighted with salmon background and text to indicate the problem as follows:

Criterion	Stabilization Need Check	Text displayed in the field
A-1-a, A-1-b, A-3, or A-3a Soil Class	No Stabilization is needed	
HP ≥ 1.875	No Stabilization is needed	
N_{60} ≥ 15	No Stabilization is needed	
1.875 ≥ HP ≥ 1.5 and M_c≥ Opt. M_c+3	Unstable Subgrade	HP & Mc
15 ≥ N_{60} ≥ 12 and M_c≥ Opt. M_c+3	Unstable Subgrade	N_{60} & Mc
HP ≤ 1.5	Unstable Subgrade	HP
N_{60} ≤ 12	Unstable Subgrade	N_{60}

iii. The field is formulated to check for HP first and check for N_{60} second.

e. Excavate and Replace (Item 204) is going to be calculated based on the subgrade depth for each sample indicating an unsuitable or unstable problem.

f. Recommendation:

i. Geotextile Option is calculated and rounded to a multiple of 3 inches based on the subgrade depth for every sample indicating an unsuitable or unstable problem.

ii. GEOGRID Option is only offered in case of unstable subgrade problem and if the geotextile option indicates the need to excavate greater than 12 inches.

PLEASE NOTE: The Problem, Excavate & Replace, and Recommendation Fields are the responsibility of the Designer. These fields are being enhanced to attempt to capture the ODOT philosophy regarding the GB1 stabilization chart, but are considered still under development. If there are discrepancies between the spreadsheet output and the GB1 chart - the chart governs in conjunction with engineering judgement. Please contact Steve Taliaferro at stephen.taliaferro@dot.ohio.gov if you have any questions.

PLEASE NOTE: It is the Designer's responsibility to identify the most representative data when samples have been separated into multiple specimen (say 1.5 to 2.3 feet and 2.3 to 3.0 feet). The spreadsheet is not capable at this time of addressing this issue within a direct data export from gINT.

4. Results Summary:
All fields in this sheet are password protected and are either calculated or read from the other worksheets.

5. Graph Worksheet:
This worksheet is designed to read the average N_{60L} and the average HP from the Cover Sheet and plot a blue line for Average HP and orange line for Average N_{60L} on GB1 Figure B – Subgrade Stabilization. The Override Table can be used to enter HP and/or N_{60L} values that are different than the calculated averages. The Override values will change the global undercut recommendation in the Results Summary.

APPENDIX I

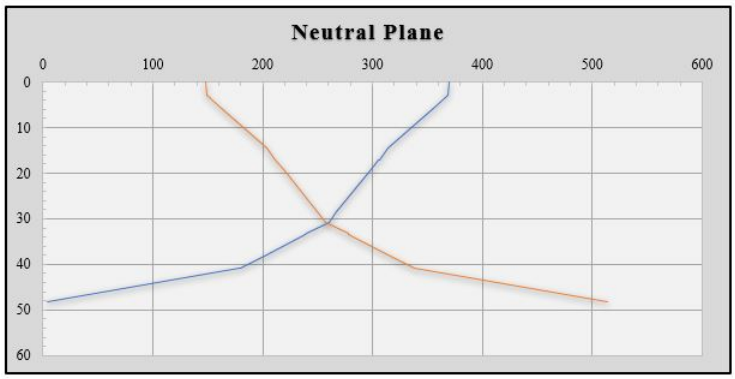
DOWNDRAG ANALYSIS

Objective: **To evaluate structural capacity of cast-in-place (CIP) closed-ended pipe piles at the Structural Strength Limit State considering downdrag loading, as well as to determine the elastic compression of the pile above the neutral plane for evaluation at the Service Limit State.**

Method: **In accordance with ODOT Bridge Design Manual, 2020 [Sect. 305.3.2.2], FHWA-NHI-16-009/010, Geotechnical Engineering Circular 12 (GEC 12), [Sect. 7.3.5, Sect. 7.3.6.1, and Sect. 11.6.3], and LRFD Bridge Design Specifications, 8th Ed., 2018, [Sect. 6.15.3.1]**

Givens:

DD Load Factor	UBV (kips)	Factored Permanent Load (kips)	Unfactored Permanent Load (kips)
1.4	369.7	190.4	148.0
Depth (ft)	**Side Resistance, Rs (kips)**	**Nominal Resistance - Side Resistance (Rn - Rs) (kips)**	**Unfactored Permanent Load + Side Resistance (Q + Rs) (kips)**
0.01	0	369.70	148.00
2.99	1.02	368.68	149.02
3.01	1.08	368.62	149.08
5.49	13.35	356.35	161.35
5.51	13.45	356.25	161.45
14.49	55.83	313.87	203.83
14.51	55.91	313.79	203.91
16.99	63.79	305.91	211.79
17.01	63.85	305.85	211.85
19.49	72.18	297.52	220.18
19.51	72.25	297.45	220.25
28.51	102.19	267.51	250.19
30.69	109.44	260.26	257.44
30.71	109.56	260.14	257.56
33.29	130.36	239.34	278.36
33.31	130.51	239.19	278.51
38.29	167.86	201.84	315.86
38.31	168.03	201.67	316.03
40.69	190.15	179.55	338.15
40.71	190.48	179.22	338.48
48.29	365.51	4.19	513.51
48.31	365.85	3.85	513.85



	Depth	Rs	Rn-Rs	Q+Rs
Lower Bound	30.71	109.56	260.44	257.56
Upper Bound	33.29	130.36	239.64	278.36

Depth of Neutral Plane (ft)	30.9
Q+DD @ Neutral Plane (kips)	259.0
DD @ Neutral Plane (kips)	111.0
Qp @ Neutral Plane (kips)	345.8

Rs = Nominal Side Resistance
Rn = Nominal Geotechnical Resistance (Side & End Bearing)
Q = Permanent Unfactored Load (Exclude Transient)
Qp = Total Factored Load (Permanent & Downdrag)
DD = Nominal Drag Load Per Pile

Pile Loading and Parameters:

Total Unfactored Axial Load (for the highest loaded pile at the substructure):

$Q_1 = \Sigma Q_i$ $\quad Q_1 := 200.3\ kip$ Permanent and transient loads

$Q_2 = \Sigma Q_i + DD$ $\quad Q_2 := 259\ kip$ Permanent and downdrag (DD) loads

$Q := \max(Q_1, Q_2)$ $\quad Q = 259\ kip$ Factored Axial Load to use in Structural Strength Limit State per **ODOT BDM [Sect. 305.3.2.2]**

Total Factored Axial Load (for the highest loaded pile at the substructure):

$Q_{P1} = \Sigma \eta_i \gamma_i Q_i$ $\quad Q_{P1} := 258.8\ kip$ Permanent and transient loads **ODOT BDM [Eq. C305.3.2-5]**

$Q_{P2} = \Sigma \eta_i \gamma_i Q_i + \eta_i \gamma_p DD$ $\quad Q_{P2} := 345.8\ kip$ Permanent and downdrag (DD) loads **ODOT BDM [Eq. C305.3.2.2-1]**

$Q_P := \max(Q_{P1}, Q_{P2})$ $\quad Q_P = 345.8\ kip$ Factored Axial Load to use in Structural Strength Limit State per **ODOT BDM [Sect. 305.3.2.2]**

Pile Parameters:

$D_o := 14\ in$ Pile Outside Diameter (ODOT Preferred: 12-in, 14-in & 16-in)

$t_w := 0.5\ in$ Pile Wall Thickness (minimum = UBV/900 kips)

$D_i := D_o - 2 \cdot t_w$ $\quad D_i = 13\ in$ Pile Inside Diameter

$f'_c := 4\ ksi$ 28-day compressive strength of concrete assumed to be 4 ksi per **ODOT BDM [Sect. C305.3.3]**

$F_y := 35\ ksi$ Yield strength of structural steel assumed to be 35 ksi per **ODOT BDM [Sect. C305.3.3]**

Calculations

Assumptions:

The factored axial structural resistance of the pile calculated below are calculated in accordance with **LRFD BDS [Sect. 6.9.5.1]** assuming an axially loaded pile with negligible moment; no appreciable loss of section due to deterioration throughout the life of the structure; a steel yield strength of 35-ksi; a 28-day compressive strength of concrete. 4-ksi, a structural resistance factor for pipe piles subject to damage due to severe driving conditions (φ_c = 0.60); and a pile fully braced along its length (l = 0-in). If a pile is not anticipated to be fully braced along its length (i.e., capped column type piers) see **LRFD BDS [Sect. 6.9.5.1].**

Piles under combined axial compression and flexure, should check structural Strength Limit State by determining factored structural resistance in accordance with LRFD BDS [Sect. 6.9.2.2]

Cross-sectional area of concrete

$A_c := \frac{\pi}{4} \cdot D_i^2$ $A_c = 132.7\ in^2$

Cross-sectional area of steel

$A_s := \frac{\pi}{4} \cdot \left(D_o^2 - D_i^2\right)$ $A_s = 21.2\ in^2$

Nominal Compressive Resistance of Composite Members:

$F_e := F_y + 0.85 \cdot f'_c \cdot \left(\frac{A_c}{A_s}\right)$ $F_e = 56.3\ ksi$ **LRFD BDS [Eq. 6.9.5.1-4]**

Factored Structural Resistance of Pile:

$\varphi_c := 0.6$ Structural Resistance Factor per **LRFD BDS [Sect. 6.5.4.2]** for severe driving conditions

$P_r := \varphi_c \cdot F_e \cdot A_s$ $P_r = 716.1\ kip$

Structural Strength Limit State Check:

$\text{Check} := \text{if}\left(P_r \geq Q_P, \text{“GOOD”}, \text{“FAIL”}\right)$

$\text{Check} = \text{“GOOD”}$

If Check = "FAIL", consideration should be given to increased pile wall thickness or decreased load on pile (i.e., more piles, reduce downdrag effect, etc.)

Axial Compression of Pile Above the Neutral Plane:

$C_3 := 0.4$ Composite Column Constant per **LRFD BDS [Table 6.9.5.1-1]**

$E := 29000\ ksi$ Elastic Modulus of Steel

$L := 30.9\ ft$ Length of pile (above neutral plane if downdrag controls)

$A := \frac{\pi}{4} \cdot D_o^2 = 153.9\ in^2$ Total Area of the Pile

$E_c := \left(2500\ f'^{0.33}_c\right)\ ksi = 3950.2\ ksi$ Elastic Modulus of Concrete per **LRFD BDS [Eq. C5.4.2.4-1]**

$n := \frac{E}{E_c} = 7.3$ Modular Ratio on the Concrete per **LRFD BDS [Eq. C5.4.2.4-1]**

$E_e := E \cdot \left(1 + \left(\frac{C_3}{n}\right) \cdot \left(\frac{A_c}{A_s}\right)\right) = 38890.1\ ksi$ Elastic Modulus of Composite Column per **LRFD BDS [Eq. 6.9.5.1-5]**

$\Delta := \frac{Q \cdot L}{A \cdot E_e} = 0.02\ in$ Elastic Compression of the Pile per **GEC 12 [Eq. 7-48]**