REPORT
STRUCTURE FOUNDATION EXPLORATION
BRIDGE HAM-LMST TO ELSTUN (OVER CLOUGH CREEK)
HAM-LMST EXT TO ELSTUN
HAMILTON COUNTY, OHIO
PID#: 113602

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NEAS PROJECT 22-0029

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National Engineering & Architectural Services Inc.

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1. INTRODUCTION

1.1. General

National Engineering & Architectural Services, Inc. (NEAS) presents our Structure Foundation Exploration Report for the Little Miami Scenic Trail extension project (HAM-LMST Extension to Elstun, PID 113602). The newly proposed bridge structure (Bridge HAM-LMST to Elstun) is planned to carry the LMST over Clough Creek immediately south of the State Route 32 (SR-32) and SR-125/Beechmont Avenue (Ave) interchange within the city of Cincinnati, Hamilton County, Ohio. The purpose of the project is to project connectivity between Elstun Road (Rd) and the LMST at this location. This report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge foundation design and construction in accordance with Load and Resistance Factors Design (LRFD) method as set forth in AASHTO's Publication *LRFD Bridge Design Specifications, 9th Edition* (AASHTO, 2020) and *ODOT's Bridge Design Manual 2020 Edition* (BDM) (ODOT [1], 2021).

The exploration was conducted in general accordance with Barr Engineering, Inc. DBA National Engineering & Architectural Services, Inc.'s (NEAS) proposal to Stantec dated November 23, 2021, subsequent proposal to Stantec dated January 3, 2022 and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT, 2022).

The scope of work performed by NEAS as part of the referenced project included: a review of published geotechnical information; performing 4 total test borings; laboratory testing of soil samples in accordance with the SGE; performing geotechnical engineering analyses to assess foundation design and construction considerations; and development of this summary report.

1.2. Proposed Construction

It is our understanding that ODOT and the local Eastern Corridor Implementation Partners are planning to extend the LMST within the project limits to provide connectivity with the nearby Elstun Rd. As part of the planned extension, a new structure is proposed to carry the LMST extension over Clough Creek between Elstun Rd and the existing/proposed LMST. Based on the HAM-LMST Ext to Elstun structure type study developed by Stantec and dated June 28, 2022, the proposed structure will likely consist of a two-span, prefabricated simple span truss bridge with a concrete deck which is approximately 253 ft in length (abutment to abutment) and 12 ft in width (railing to railing). The proposed bridge is to be supported on stub type abutments and a wall type pier. The proposed substructures will utilize a deep foundation system consisting of "HP10X42 steel "H" piles driven to refusal on bedrock at the abutments and drilled shafts socketed into bedrock at the pier.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Outer Bluegrass physiographic region, part of the Bluegrass Section (ODGS, 1998). This is an area of moderately high relief, dissected plateau of carbonate rocks with caves and other karst features to the east and thin, early drift caps and narrow ridges to the west. The geology within this region consists of Odovician- and Silurian-age dolomites, limestones, and calcareous shales with the presence of silt-loam colluvium and thin pre-Wisconsinan drift on ridges in the west.

The geology at the project site is mapped as an average of 20 ft of Holocene-age alluvium followed by an average of 50 ft of interlayered medium-fine to fine grained materials then an average of 50 ft of interlayered very fine grained materials followed by an average of 40 ft of Wisconsinan-age sand and gravel all atop Ordovician-age limestone and shale bedrock as well as bedrock-derived colluvium. The alluvium in this region is described as a non-compact soil comprised of a wide variety of textual classes from silt to boulders that is found within floodplains of modern streams. The unit described as interlayered medium-fine to fine grained materials is described as predominantly fine sand that includes clay, silt and thin gravel interbeds. These soils are deposited in variable thickness and sequence of lithologies as lacustrine and deltaic facies as well as overbank sediments. The unit described as interlayered very fine-grained materials is described as being similar to the previously mentioned unit except finer grained soils such as clay and silt predominate with interbeds of fine sand and possible occurrences of till. Lastly, the Wisconsinan-age sand and gravel in this region is described as intermixed and interbedded sand and gravel with thin, discontinuous layers of silt, clay and till and are deposited fluvially in low-level terraces and in buried valleys (Pavey, et al., 2013).

Based on the Bedrock Geologic Units Map of Ohio (USGS & ODGS, 2005), bedrock within the project area, consists of both the Point Pleasant and Kope formations. The Point Pleasant formation is mapped over the majority of the site with the Kope formation generally located south of Clough Creek below Elstun Rd. The Point Pleasant is comprised of interbedded limestone (60 percent) and shale (40 percent) that is thin to medium bedded. The bedrock in this formation is described as gray to bluish gray in color weathering to light gray and is planar to lenticular. The Kope formation is also comprised of interbedded shale (75 percent) and limestone (25 percent) that is thin to thick bedded. The bedrock in the Kope formation is described as gray to bluish gray in color weathering to light gray to yellowish gray and generally planar. Based on the ODNR bedrock topography map of Ohio, bedrock elevation at the bridge site can be expected to be between about 450 and 550 ft above mean sea level (amsl), putting bedrock at a depth ranging from 50 ft below ground surface (bgs) to outcropping (above the ground surface) in locations (ODGS, 2003).

The soils at the project site have been mapped (Web Soil Survey) by the Natural Resources Conservation Service (USDA, 2015) as Urban land in the northern portion, Jules silt loam in the central portion of the site, and Huntington silt loam and Pate silty clay loam in the southern portion of the project. Soils classified as Urban Land are soils that have been disturbed by cutting and filling and as such are not classified according to the AASHTO method of soil classification. Soils in the Jules series are characterized as deep, well drained to moderately well drained soils formed in calcareous, stratified silty alluvium on alluvial fans or flood plains. The Jules series is comprised of both coarse- and fine-grained soils and classifies as A-4 type soils according to the AASHTO method of soil classification. Soils in the Huntington series are characterized as very deep, well drained soils formed in alluvium derived from shale, sandstone, and limestone on river valley flood plains. The Huntington series is comprised of primarily fine-grained soils and classifies as A-6, and A-7 type soils according to the AASHTO method of soil classification. Soils in the Pate series are characterized as deep, well drained to moderately drained, very slowly permeable soils formed dominantly in residuum weathered from interbedded limestone and shale with the upper part having considerable mixing of colluvium. The Pate series is comprised of primarily fine-grained soils and classifies as A-6, and A-7 type soils according to the AASHTO method of soil classification.

2.2. Hydrology/Hydrogeology

Groundwater at the project site can be expected at an elevation consistent with that of the nearby Little Miami River and Clough Creek as they are the most dominant hydraulic influence in the vicinity of the project's boundaries. The water level of the river and creek may be generally representative of the local groundwater table. However, it should be noted that perched groundwater systems may be existent in areas due to the presence of fine-grained soils making it difficult for groundwater to permeate to the phreatic surface.

The Central portion of project site near the Clough Creek is located within a regulatory floodway (Zone AE), while the northern and southern portions of the site are located within a special flood hazard area (Zone AE) based on available mapping by the Federal Emergency Management Agency's (FEMA) National Flood Hazard mapping program (FEMA, 2016).

2.3. Mining and Oil/Gas Production

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

No abandoned oil or gas wells are noted on ODNR's Oil and Gas Well Locator in the vicinity of the project site (ODNR [1], 2020).

2.4. Historical Records and Previous Phases of Project Exploration

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

- Project Boring Logs, and Structural Foundation Investigation Sheets for project HAM-125-1.50, dated October 22, 1982.

Historical soil borings associated with the above plans were reviewed, however, they were not utilized for our analysis, and therefore, are not referenced within this report nor within the project developed Structure Foundation Exploration Sheets.

2.5. Site Reconnaissance

A field reconnaissance visit for the overall project area was conducted on June 10, 2022, along the site of the proposed LMST extension near Clough Creek and the SR-32 and SR-125 interchange. Site conditions were noted and photographed during the visit.

During our field reconnaissance, no geohazards were observed within the immediate vicinity of the bridge site. Land use of the project area generally consists of a combination of woodland as well as tree-cleared grass lands containing high voltage electrical lines and associated electric poles. Land uses of the areas surrounding the project are identified as: 1) woodland; 2) commercial properties; and, 3) residential properties.

In general, the land located along the proposed LMST extension and bridge site consisted of property that was either a utility easement that is tree-cleared grassland or moderately vegetated woodlands (Photographs 1 and 2). The woodland is generally located to both the east and west of the referenced utility easement. With respect to topography, the property appears to gradually slope downward towards Clough Creek from both the north and south. Although the refenced area appeared to drain towards Clough Creek, standing surface water was observed throughout the project area particularly on the south side of Clough Creek. Markers for what appeared to be a large gas main were observed just west of the project area while a drainage ditch was observed to run through the site starting at an existing culvert located near the base of the SR-32 and SR-125 interchange ramp embankment slope and extending southwest to Clough Creek. Some minor erosion of the both the drainage ditch and banks of Clough Creek were observed (Photograph 3). It was also noted that a large concrete structure was observed along the Clough Creek bank, near the southwest portion of the project site (Photograph 4).

In general, the existing SR-32 southbound (SB) to SR-125 eastbound (EB) ramp pavement was observed to be in good condition with some signs of weathering and surface wear. Moderate severity longitudinal cracking was common along this ramp as well as moderate severity raveling and crack sealing deficiencies.

The indicated ramp is located in the northeastern limits of the project area and sits atop a 2H:1V (2 Horizontal to 1 Vertical (2H:1V) embankment slope with vegetation that varied from heavy to light (Photograph 6). No apparent signs of instability were noted along the existing slope during our site visit. The ramp pavement in this area appeared to be generally well-drained with no signs of standing water observed during our reconnaissance.

Photograph 1: Overall view of project area south of Clough Creek

Photograph 2: Overall view of project area north of Clough Creek

Photograph 3: Erosion of the banks of Clough Creek

Photograph 4: Large concrete structure in southwestern portion of project site

Photograph 5: Southwestern embankment slope of ramp from SR-32 SB to SR-125 EB

3. GEOTECHNICAL EXPLORATION

3.1. Field Exploration Program

The exploration for the bridge was conducted by NEAS between July 6, 2022 and August 11, 2022 and included 3 borings drilled to depths between 33.3 and 41.0 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. Borings were typically located at/near proposed substructures 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 prior to drilling operations utilizing a hand-held GPS unit. 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. Coordinates, elevations and depths of the borings are shown in Table 1 below and boring locations are depicted on the Boring Location Plan provided in Appendix A.

Table 1: Project Boring Summary

Boring Number	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)	Structure
B-001-0-20	39.106434	-84.400284	499.5	36.5	Rear Abutment / Embankment Stability
B-002-0-20	39.106323	-84.400483	477.6	41.0	Rear Abutment
B-003-0-20	39.105798	-84.400302	470.0	33.3	Pier
B-004-0-20	39.105605	-84.400275	477.7	41.0	Forward Abutment

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 and NQ2 coring equipment. Soil samples were generally recovered using a split spoon sampler (AASHTO T-206 “Standard Method for Penetration Test and Split Barrel Sampling of Soils.”) at intervals of 2.5-ft to depths between 25 and 35 ft bgs and at 5-ft intervals thereafter until refusal was encountered. Continuous sampling was performed within boring B-003-0-20 at depths estimated to be representative of existing streambed soils for further grain-size testing described in Section 3.2.3. of this report. 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 CME auto hammers that have been calibrated to be 79% efficient with the most recent calibration date of January 24, 2022 as indicated on the boring logs. When bedrock was encountered the samples were collected in 10.0-ft runs using NQ2, triple tube, core barrel, with water as the circulating fluid.

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.

3.2. Laboratory Testing Program

The laboratory testing program consisted of classification testing, moisture content determinations, grain-size distribution testing, unconfined compressive strength of soil testing, one-dimensional

consolidation testing and unconfined compressive strength of rock cores. The individual laboratory data sheets and results are included in Appendix B. Additionally, data from the laboratory testing program was incorporated onto the final borings 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 38% 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 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 and 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. Streambed Grain Size Distribution

At the approximate streambed elevation in borings B-003-0-20 continuous SPT sampling was performed within the upper approximate 7.5 ft to obtain representative samples of potential streambed soils. Grain size distribution testing was performed on the obtained streambed samples to develop D_{50} values (i.e., the diameter in the particle-size distribution curve corresponding to 50% finer). The calculated D_{50} values are shown in Table 2 below and the developed particle-size distribution curve are included with the associated boring log within Appendix B.

Table 2: Streambed Grain Size Analysis Results

Boring ID	Sample Depth (ft)	Sample Elevation (ft)	ODOT Classification	D_{50} (mm)
B-003-0-20	0.0 - 1.5	470.0 - 468.5	Silt and Clay (A-6a)	0.013
B-003-0-20	1.5 - 3.0	468.5 - 467.0	Gravel with Sand (A-1-b)	0.530
B-003-0-20	3.0 - 4.5	467.0 - 465.5	Gravel with Sand and Silt (A-2-4)	0.380
B-003-0-20	4.5 - 6.0	465.5 - 464.0	Gravel and Stone Fragments with Sand (A-1-b)	1.488
B-003-0-20	6.0 - 7.5	464.0 - 462.5	Gravel and Stone Fragments with Sand (A-1-b)	0.886

3.2.4. Unconfined Compressive Strength of Soil

Unconfined compressive strength testing was performed in accordance with AASHTO T-208 "Standard Method of Test for Unconfined Compressive Strength of Cohesive Soil" on one (1) relatively undisturbed

(Shelby Tube), cohesive sample obtained during the exploration program. The sample was obtained from borings B-002-0-20 from a depth of 7.9 to 8.4 ft bgs (approximate elevations 469.7 to 469.2 ft amsl). The sample tested classified as Silty Clay (A-6b). A summary of the Unconfined Compressive Strength of Cohesive Soil test is shown in Table 3 below, while the laboratory testing report is included with the associated boring log within Appendix B.

Table 3: Unconfined Compressive Strength of Cohesive Soil Test Results

Boring Number	Depth of Specimen Tested (ft bgs)	Estimated Elevation (ft amsl)	Unconfined Compressive Strength (psf)	Undrained Shear Strength (psf)	Strain at Failure (%)
B-002-0-20	7.9 - 8.4	469.7 - 469.2	2271	1135.5	15.0
Notes: *1. Laboratory test report attached with boring log.*					

3.2.5. Consolidation Testing

One (1) consolidation test was performed in accordance with ASTM D 2435-04 “Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading” on a relatively undisturbed cohesive soil sample collected from boring B-002-0-20. The sample was collected at a depth of 8.4 to 8.5 ft bgs (approximate elevations 469.2 to 469.1 ft amsl) and was classified as Silty Clay (A-6b). The results of the consolidation test are presented in Table 4 below, while the laboratory testing reports are included with the associated boring log within Appendix B.

Table 4: Consolidation Test Results

Boring Number	Depth (ft)	Elevation (ft)	Compression Index (Cc)	Recompression Index (Cr)	Preconsolidation Pressure (psf)	Void Ratio
B-002-0-20	8.4 - 8.5	469.2 - 469.1	0.102	0.012	3,500	0.448

3.2.6. Unconfined Compressive Strength of Bedrock

Unconfined Compressive Strength of a Rock Core Tests were conducted in accordance with ASTM D 7012 "Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures" on a 10-ft rock core run obtained during the exploration program. Two rock core specimens were obtained and tested from the 10-ft continuous core run performed within boring B-003-0-20. In general, the rock is classified as unweathered, gray limestone. The Unconfined Compressive Strength of a Rock Core Test results are shown in Table 5 below and provided in Appendix B.

Table 5: Unconfined Compressive Strength of Bedrock Test Results

Boring Number	Depth of Test Specimen (ft)	Rock Description	Moisture Content (%)	Dry Unit Weight (pcf)	Unconfined Compressive Strength (psi)	Strain (%)
B-003-0-20	23.7 - 24.1	Gray Limestone	0.5	167.2	5,634	0.5
B-003-0-20	32.8 - 33.2	Gray Limestone	1.4	164.1	7,935	0.7

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, results of historical explorations, and consideration of the geological history of the site.

4.1. Subsurface Conditions

4.1.1. Overburden Soil

At the proposed bridge site, three different materials were encountered below the existing pavement section or ground surface. In general, the three different overburden materials consisted of either: 1) embankment "man-made" fill soils; 2) natural alluvial soils; or, 3) natural interlayered medium-fine to very-fine grained material. These materials and the general profile is further described below.

Fill soils were encountered in one of the four borings (B-001-0-20) performed for the project with these soils being encountered at the ground surface and extended to a depth of 22 ft bgs (approximate elevation 477.5 ft amsl). Based on laboratory testing results and a visual review of the soil samples obtained, the fill at the site is comprised of fine-grained cohesive material and is classified on the boring logs as Silty Clay (A-6b). With respect to the soil strength of the fill, these soils can be described as having a consistency of medium stiff to hard correlating to converted SPT-N values (N_{60}) between 7 and 29 blows per foot (bpf) and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 2.5 and 4.5 tons per square foot (tsf). Natural moisture contents of the fill ranged from 14 to 21 percent. Based on Atterberg Limits tests performed on representative samples of the cohesive fill material, the liquid and plastic limits ranged from35 to 39 percent and from 19 to 21 percent, respectively.

The strata encountered either below the fill soils (B-001-0-20) or at the ground surface (B-002-0-20, B-003-0-20 and B-004-0-20) consisted of natural alluvial soils comprised of an upper fine-grained cohesive stratum followed by a lower stratum of granular non-cohesive soils. The cohesive alluvial material extends to depths between 1.5 and 36.5 ft bgs (approximate elevations 468.5 and 463.0 ft amsl) followed by the granular alluvial material that extends to depths between 11.3 and 19.5 ft bgs (approximate elevations 463.8 and 458.2 ft amsl). It should be noted, the cohesive alluvial soils extended to borehole termination depth in boring B-001-0-21 and therefore the granular non-cohesive alluvial soils were not encountered within the referenced boring. Based on laboratory testing results and a visual review of the soil samples obtained within this stratum, the upper soils are comprised of cohesive material classified on the boring logs as Silt and Clay (A-6a), Silty Clay (A-6b) and Clay (A-7-6) while the granular alluvium is classified as Stone Fragments (A-1-a), Gravel and/or Stone Fragments with Sand (A-1-b) and Gravel with Sand and Silt (A-2-4). With respect to the soil strength of the fine-grained alluvium encountered, these soils can be described as having a consistency of medium stiff to hard correlating to N_{60} between 8 and 20 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between 2.0 and 4.5 tsf. Natural moisture contents of the cohesive soils ranged from 13 to 25 percent. Based on Atterberg Limits tests performed on representative samples of the cohesive alluvial material, the liquid and plastic limits ranged from 34 to 46 percent and from 20 to 25 percent, respectively. With respect to the soil strength of the granular alluvium, these soils can be described as having a relative compactness of very loose to dense

correlating to converted N_{60} values between 3 and 42 bpf. Natural moisture contents of the granular alluvium ranged from 2 to 14 percent.

The soil stratum encountered immediately beneath the granular alluvial soils in three of the four borings performed (B-002-0-20, B-003-0-20 and B-004-0-20) consisted of natural overburden soils generally comprised of medium- to very-fine grained cohesive material. These soils extended to bedrock encountered at depths ranging between 23.3 and 31.0 ft bgs (approximate elevations 446.7 to 446.6 ft amsl) and are classified on the borings logs as cohesive Sandy Silt (A-4a), Silt and Clay (A-6a) and Clay (A-7-6). The exception being interbedded layers of non-cohesive granular material which was encountered in borings B-002-0-20 and B-003-0-20. The interbedded granular layers ranged in thickness from 1.8 to 3.8 ft bgs and were encountered at depths between 14.5 and 24.5 ft bgs (approximate elevations 456.6 and 450.5 ft amsl). With respect to the soil strength of the cohesive material encountered in this stratum, these soils can be described as having a consistency of medium stiff to hard correlating to N_{60} values between 5 and 43 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between 0.5 and 4.5 tsf. Natural moisture contents of the natural cohesive soils ranged from 9 to 31 percent. Based on Atterberg Limits tests performed on representative samples of the cohesive material, the liquid and plastic limits ranged from 29 to 42 percent and from 17 to 21 percent, respectively. The layers of granular material encountered within borings B-002-0-20 and B-003-0-20 were classified on the logs as Stone Fragments with Sand and Silt A-2-4 and Coarse and Fine Sand (A-3a). With respect to the soil strength, the granular material can be described as having a relative compactness of loose to dense correlating to converted N_{60} values between 9 and 37 bpf. Natural moisture contents of the granular layers ranged from 9 to 19 percent.

4.1.2. Groundwater

Groundwater measurements were taken during the boring drilling procedures at each borehole location. Groundwater was encountered during drilling in three of the four project borings performed at the proposed bridge site (B-002-0-20, B-003-0-20 and B-004-0-20) at depths ranging from 9.0 to 17.5 ft bgs (elevations 465.1 to 460.2 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. The specific groundwater readings are included on the boring logs provided in Appendix B.

4.1.3. Bedrock

Bedrock was encountered in each boring performed at the project site, with the exception of boring B-001-0-20. In general, bedrock was encountered at depths between approximately 23.3 and 31.0 feet bgs (approximate elevations 446.7 and 446.6 ft amsl). Bedrock encountered at the proposed bridge site can generally characterized as interbedded limestone and shale containing ⅛- to ½-inch clay seams throughout. The limestone encountered within the project borings performed is described as unweathered to slightly weathered with a relative strength ranging from moderately strong to strong. The interbedded shale encountered within the project borings is described as highly to severely weathered with a relative strength ranging from very weak to weak. Based on the project borings performed at the site, the estimated bedrock surface appears to be relatively level across the site.

Rock coring was performed at each bridge boring location at which bedrock was encountered once auger refusal was encountered. Recovery of the bedrock core samples ranged from 90 to 96 percent while rock quality designation (RQD) values ranged from 24 to 33 percent. A summary of the bedrock data is presented below in Table 6.

Table 6: Bedrock Summary

Boring Number	Depth to Bedrock (ft)	Depth to Top of Core Sample (ft)	Elevation of Top of Core Sample (ft)	Bedrock Recovery (%)	Bedrock RQD (%)
B-002-0-20	30.8	31.0	446.6	90	24
B-003-0-20	23.3	23.3	446.7	96	33
B-004-0-20	30.8	31.0	446.7	94	24

5. ANALYSES AND RECOMMENDATIONS

5.1. Soil Profile for Analysis

For analysis purposes, each boring drilled for Bridge HAM-LMST to Elstun was reviewed, and a generalized material profile was developed. Utilizing the generalized soil profile, engineering properties for each soil stratum were estimated based on their field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory test (i.e., Atterberg Limits, grain size, etc.) results using correlations provided in published engineering manuals, research reports and guidance documents. Engineering soil properties were estimated for each individual classified layer per boring location. The developed soil profiles and estimated engineering soil properties for use in analysis of Bridge HAM-LMST to Elstun (with cited correlation/reference material) are summarized within Tables 7 through 10 below.

Table 7: Soil Profile and Estimated Engineering Properties - At Boring B-001-0-20

Bridge HAM-LMST to Elstun: Embankment Stability, B-001-0-20				
Soil Description	Unit Weight[1] (pcf)	Undrained Shear Strength[2] (psf)	Effective Cohesion[3] (psf)	Effective Friction Angle[3] (degrees)
Silty Clay Elevation (499.5 ft - 463 ft)	125	2100	200	24

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 8: Soil Profile and Estimated Engineering Properties - At Boring B-002-0-20

Bridge HAM-LMST to Elstun: Rear Abutment, B-002-0-20					
Soil Description	Unit Weight[1] (pcf)	Undrained Shear Strength[2] (psf)	Effective Cohesion[3] (psf)	Effective Friction Angle[3] (degrees)	Setup Factor (f_{su})
Silt and Clay Elevation (477.6 ft - 473.1 ft)	125	1100	250	25	1.5
Silty Clay Elevation (473.1 ft - 468.4 ft)	108	1000	100	22	1.75
Gravel with Sand Elevation (468.4 ft - 465.6 ft)	125	-	-	36	1.0
Gravel Elevation (465.6 ft - 463.8 ft)	128	-	-	37	1.0
Silt and Clay Elevation (463.8 ft - 456.6 ft)	118	1100	100	22	1.5
Coarse and Fine Sand Elevation (456.6 ft - 454.8 ft)	122	-	-	30	1.0
Silt and Clay Elevation (454.8 ft - 453.1 ft)	122	2100	200	24	1.5
Gravel with Sand and Silt Elevation (453.1 ft - 449.3 ft)	130	-	-	38	1.2
Silt and Clay Elevation (449.3 ft - 446.6 ft)	135	5500	400	27	1.5

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 9: Soil Profile and Estimated Engineering Properties - At Boring B-003-0-20

Bridge HAM-LMST to Elstun: Pier, B-003-0-20					
Soil Description	**Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**	**Setup Factor (f_{su})**
Silt and Clay Elevation (470 ft - 468.5 ft)	108	1000	100	22	1.5
Gravel with Sand Elevation (468.5 ft - 467 ft)	112	-	-	33	1.0
Gravel with Sand and Silt Elevation (467 ft - 465.5 ft)	108	-	-	29	1.2
Gravel with Sand Elevation (465.5 ft - 461 ft)	125	-	-	37	1.0
Gravel with Sand Elevation (461 ft - 458.7 ft)	120	-	-	31	1.0
Silt and Clay Elevation (458.7 ft - 455.5 ft)	115	600	75	21	1.5
Gravel with Sand and Silt Elevation (455.5 ft - 453 ft)	128	-	-	38	1.2
Silt and Clay Elevation (453 ft - 450.5 ft)	125	2750	250	25	1.5
Gravel with Sand and Silt Elevation (450.5 ft - 446.7 ft)	128	-	-	38	1.2

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 10: Soil Profile and Estimated Engineering Properties - At Boring B-004-0-20

Bridge HAM-LMST to Elstun: Forward Abutment, B-004-0-20					
Soil Description	**Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**	**Setup Factor (f_{su})**
Silt and Clay Elevation (477.7 ft - 473.2 ft)	110	1350	150	23	1.5
Clay Elevation (473.2 ft - 466.5 ft)	110	1450	150	22	2.0
Gravel Elevation (466.5 ft - 463.2 ft)	130	-	-	41	1.0
Gravel with Sand Elevation (463.2 ft - 458.2 ft)	125	-	-	34	1.0
Clay Elevation (458.2 ft - 455.7 ft)	115	600	75	20	2.0
Clay Elevation (455.7 ft - 449.4 ft)	128	4400	300	26	2.0
Silt and Clay Elevation (449.4 ft - 446.7 ft)	125	2600	250	25	1.5

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

For settlement analysis purposes at the proposed rear and forward abutment locations, NEAS reviewed borings B-002-0-20 and B-004-0-20 and developed a generalized material profile. To develop the generalized material profile, 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). Engineering properties and settlement parameters for each Soil Type were estimated based on weighted average values of their field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory test results (i.e., Atterberg Limits, consolidation, etc.) using correlations provided in published engineering manuals, research reports and guidance documents. The developed soil profiles, settlement parameters and estimated engineering soil properties for use in settlement analysis at the proposed rear and forward abutment locations (with cited correlation/reference material) are summarized within Tables 11 and 12, respectively.

Table 11: Soil Profile and Parameters for Settlement Analysis – At Boring B-002-0-20

HAM-LMST to Elstun: Settlement Analysis at Rear Abutment, B-002-0-20								
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 - Cohesive[6] Elevation (477.6 ft - 468.4 ft)	130	946000	0.40	0.448	0.10	0.012	5.8	0.20
Soil Type 2 - Granular Elevation (468.4 ft - 463.8 ft)	125	492000	0.25	-	-	-	-	-
Soil Type 1 - Cohesive[6] Elevation (463.8 ft - 456.6 ft)	130	946000	0.40	0.448	0.10	0.012	1.8	0.20
Soil Type 2 - Granular Elevation (456.6 ft - 454.8 ft)	125	427000	0.25	-	-	-	-	-
Soil Type 1 - Cohesive[6] Elevation (454.8 ft - 453.1 ft)	130	946000	0.40	0.448	0.102	0.012	1.50	0.20
Soil Type 2 - Granular Elevation (453.1 ft - 449.3 ft)	125	409000	0.25	-	-	-	-	-
Soil Type 1 - Cohesive[6] Elevation (449.3 ft - 446.6 ft)	130	946000	0.40	0.448	0.10	0.012	1.3	0.20

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 from boring B-002-0-20.*

Table 12: Soil Profile and Parameters for Settlement Analysis – At Boring B-004-0-20

HAM-LMST to Elstun: Settlement Analysis at Forward Abutment, B-004-0-20								
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 - Cohesive[6] Elevation (477.6 ft - 466.5 ft)	130	946000	0.40	0.448	0.10	0.012	3.7	0.20
Soil Type 2 - Granular Elevation (466.5 ft - 458.2 ft)	125	492000	0.25	-	-	-	-	-
Soil Type 1 - Cohesive[6] Elevation (458.2 ft - 446.7 ft)	130	946000	0.40	0.448	0.10	0.012	1.8	0.20

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 from boring B-002-0-20.*

5.2. Bridge Foundation Analysis and Recommendations

5.2.1. Pile 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 whether HP10x42 steel “H” piles would achieve the maximum UBV in friction per Section 202.2.3.2 of the ODOT BDM, prior to reaching the estimated bedrock elevation (*Driven* results are provided in Appendix C). 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 (pile cap bearing elevation) to the geotechnical pile tip elevation where the required UBV is obtained.

Based on our analysis, it was determined that HP10x42 steel “H” would not obtain the maximum UBV in friction within the overburden soil and therefore, should be driven be driven to refusal in bedrock. Subsequently, the estimated geotechnical pile tip elevation for steel "H" piles driven to refusal on bedrock is assumed to be the elevation at which rock coring operations began. Based on the results of our analysis, the estimated geotechnical pile length and respective pile UBV per substructure location for HP10x42 steel “H” piles driven to refusal in bedrock are given in Table 13 (*Driven* results are provided in Appendix C).

Table 13: Deep Foundation Analysis Summary

Pile Type	Geotechnical Pile Length[1] (ft)	Ultimate Side Resistance[2] (kips)	Ultimate Point Resistance[2] (kips)	Ultimate Bearing Value[2] (kips)
Bridge HAM-LMST to Elstun: Rear Abutment, B-002-0-20				
HP10x42	46.9	-	310.0	310.0
Bridge HAM-LMST to Elstun: Forward Abutment, B-004-0-20				
HP10x42	46.8	-	310.0	310.0

Notes:
1. *The length of pile from bottom of pile cap (pile cap bearing elevation) to the depth at which refusal in bedrock is estimated.*
2. *Equal to the total factored structural resistance of the pile.*

5.2.2. Pile Driveability

NEAS's pile drivability evaluation estimated a Delmag D19-42 diesel hammer to determine if HP10x42 steel “H” piles 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. For this analysis, NEAS developed a representative subsurface model utilizing the computer program *GRLWEAP* developed by GRL Engineers, Inc (*GRLWEAP* results are provided in Appendix D).

The results of the evaluation indicated that the referenced steel “H” pile size would not be overstressed during the pile installation process based on: 1) the referenced hammer and steel section; and, 2) the provided Soil Profile and Estimated Engineering Properties presented in a Section 5.1 of this report. It should be noted; however, that driveability can be difficult to assess quantitatively; therefore, the contractor should provide an analysis to demonstrate that the equipment planned for use is capable of pile installation without over-stressing the piles.

5.2.3. Pile Foundation Recommendations

We recommend that a driven pile foundation be used for support for the proposed bridge abutments, with the piles consisting of HP10x42 steel "H" piles driven to bedrock refusal. Refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. The factored resistance for piles driven to refusal on bedrock is typically governed by structural resistance as opposed to driving resistance for friction piles; therefore, the total factored load for any single HP10x42 steel “H” pile is equal to 310 kips (maximum factored structural resistance) (ODOT, 2021). This total factored load (single pile) for an HP10x42 may be used to support the abutment foundations under the following conditions: 1) piles are installed in accordance with Sections 507 and 523 of the CMS; 2) the piles are axially loaded pile with negligible moment; 3) steel piles have a yield strength of 50 kips per square inch (ksi); 4) assumed no appreciable loss of section due to deterioration throughout the life of the structure; 5) steel "H" piles are assumed to be subject to damage due to severe driving conditions equating to a structural resistance factor of 0.5; and, 6) the piles are fully braced along their length.

Driven to bedrock refusal, pile tip elevations are estimated to range from 446.6 to 446.7 ft amsl across the proposed bridge site. Pile lengths based on: 1) our Deep Foundation Analysis (presented in Section 5.2.11 of this report); and, 2) the "Estimated Length" and "Order Length" definitions and formulas presented in Section 303.4.2 "Pile Foundations" of the BDM, are shown in Table 14.

Table 14: Estimated Pile Lengths

Pile Type	Bottom of Pile Cap Elevation (ft amsl)	Geotechnical Pile Length (ft)	Geotechnical Pile Tip Elevation (ft amsl)	Estimated Pile Length[(1)] (ft)	Order Length[(1)] (ft)
Bridge HAM-LMST to Elstun: Rear Abutment, B-002-0-20					
HP10x42	493.5	46.9	446.6	50	55
Bridge HAM-LMST to Elstun: Forward Abutment, B-004-0-20					
HP10x42	493.5	46.8	446.7	50	55

Notes:
1. Based on definitions and formulas presented in Section 305.3.5.2 of the 2020 BDM.

5.2.4. Drilled Shaft Analysis and Recommendations

A drilled shaft foundation analysis was performed at the proposed bridge pier location in accordance with the LRFD BDS. Specifically, procedures in Section 10.8.3.5.4 of the LRFD BDS were used to calculate the nominal and factored unit tip (LRFD BDS Section 10.8.3.5.4c) and unit side (LRFD BDS Section 10.8.3.5.4b) resistance in rock for drilled shaft foundations at the proposed pier location. Per ODOT's Geotechnical Design Manual (GDM) Section 1306.4.2, as clay filled seams were identified throughout the bedrock cores obtained of the site bedrock LRFD BDS Equation 10.8.3.5.4c-2 was utilized for drilled shaft tip resistance calculation. The side and tip resistance were computed based on: 1) bedrock properties presented in Table 17 of this report; 2) a 2.5-ft diameter rock socket; and, 3) proposed rock socket length of at least 1.5 times the diameter of the shaft rock socket. The nominal and factored unit tip resistance of a drilled shaft foundation socketed in rock are summarized in Table 15 below. Unit side resistances are not provided in the table below and are not recommended for inclusion on the plans. Per the ODOT GDM Section 1306.4.2, the design of a rock-socketed drilled shaft should "typically utilize only the tip resistance or side resistance, but not both". Therefore, only the tip resistance is provided in Table 15 below as it is usually adequate to support the drilled shaft loads except in the weakest of rocks. In accordance with LRFD BDS Table 10.5.5.2.4-1, nominal tip resistance was multiplied by a resistance factors of 0.50 to obtain factored unit tip resistance. Drilled shaft resistance calculations for the proposed pier are provided in Appendix E. For bridge piers that are to be supported by a single (non-redundant) drilled shaft foundation, the resistance factor indicated should be reduced by 20 percent.

Table 15: Drilled Shaft Rock Socket Resistance Summary

Substructure	Nominal Unit Tip Resistance (ksf)	Factored Unit Tip Resistance (ksf)
Pier 1	106.9	53.4

Notes:
1. Geotechnical tip resistance provided is not limited by the structural strength of the concrete.

It should be noted that if the utilization of both shaft tip and side resistance is required to support the proposed bridge pier design loads, further analysis must be performed to incorporate the provisions within ODOT GDM Section 1306.3. Furthermore, if both shaft tip and side resistance are to be utilized, each drilled shaft shall be socketed a minimum depth of 1.5 times the shaft diameter within the bedrock at the site and the top 2 feet of rock socket should be neglected in the calculation of the total factored side resistance in accordance with ODOT BDM Section 305.4.2.

As it is anticipated that the proposed pier will be supported by two (2) drilled shafts, in accordance with Section 305.4.5 of the BDM, NEAS recommends that Thermal Integrity Profiler (TIP) testing be performed on each shaft and BDM plan note 606.8-6 "ITEM 894 - THERMAL INTEGRITY PROFILER (T.I.P.) TEST" be included in the plans.

5.2.5. 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 lateral load capacity can be obtained by increasing the diameter or the embedment depth of the foundation element. The generalized soil and rock parameters, including recommended lateral soil/rock modulus, and soil/rock strain to be used to analyze the laterally loaded shaft by the p-y curve method are presented in Tables 16 and 17 below. Furthermore, a resistance factor of 1.0 should be used when estimating the lateral geotechnical resistance of a single shaft/pile or shaft/pile group in accordance with LRFD BDS Tables 10.5.5.2.3-1 and 10.5.5.2.4-1.

Table 16: Generalized Soil Parameters for Lateral Load Analysis

LPILE Parameters For Soil and Highly Weathered Bedrock							
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-003-0-20	Stiff Clay w/o Water	471.0 - 468.5	108	22	1,000	220	0.0095
	Sand (Reese)	468.5 - 467.0	112	33	-	105	-
	Sand (Reese)	467.0 - 465.5	108	29	-	30	-
	Sand (Reese)	465.5 - 461.0	125	37	-	145	-
	Sand (Reese)	461.0 - 458.7	57.6	31	-	40	-
	Soft Clay	458.7 - 455.5	52.6	21	600	85	0.0132
	Sand (Reese)	455.5 - 453.0	65.6	38	-	160	-
	Stiff Clay w/o Water	453.0 - 450.5	62.6	25	2,750	915	0.0053
	Sand (Reese)	450.5 - 446.7	65.6	38	-	160	-

Table 17: Generalized Bedrock Parameters for Lateral Load Analysis

LPILE Parameters For Bedrock (p-y Modeled as Weak Rock)							
Boring Number	**Elevation (ft amsl)**	**Effective Unit Weight (pcf)**	**Rock Quality Designation (%)**	**Uniaxial Compressive Strength[(2)] (psi)**	**Modulus of Intact Rock (ksi)**	**Modulus of Rock Mass (ksi)**	**Strain Factor, k_{rm}**
B-003-0-20	446.7 - 436.7	97.6	33	4,216	380	26.6	0.00005

Notes:
1. *Based on RQD value recorded for the 10 ft core run from boring B-003-0-20.*
2. *UNC strength composite of average of limestone UNC tests and shale relative strength description and UNCs from ODOT GDM Table 400-6.*

5.2.6. Drilled Shaft Lateral Load Analysis

The lateral load analysis of the project drilled shaft foundations has been performed by Stantec. These calculations will be provided to ODOT as part of a separate submission.

5.2.7. Settlement Analysis

In order to estimate the maximum total and differential settlement that could result within the subsurface soils supporting the proposed LMST embankment soils at the proposed Bridge HAM-LMST to Elstun rear and forward abutment locations, NEAS reviewed: 1) HAM-LMST Ext to Elstun structure type study developed by Stantec and dated June 28, 2022; 2) Service Limit State loading conditions; and, 3) the generalized subsurface profile and Settlement Parameters for Analysis provided in the 'Soil Profile for Analysis' section 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 provided in Appendix F.

Based on our analyses, the estimated maximum total settlement associated with the loads induced by the proposed new embankment at the rear and forward abutment locations is about 3.4 inches. 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. Of the total settlement, about 0.7 inches is expected to be elastic (immediate) and take place during construction. The remaining 2.7 inches of settlement is anticipated to be long-term with the majority (i.e., 90 percent) of long-term settlement anticipated to take place in the first 70 days following construction at the rear abutment and 170 days following construction at the forward abutment.

5.2.8. Bridge Foundation Settlement Considerations and Recommendations

Based on our settlement analysis, it is our opinion that the total long-term (consolidation) settlement magnitudes anticipated at the rear and forward abutment locations will likely exceed 0.4-inches and consequently, may induce downdrag loading on the proposed "H" pile foundations. Per Section 305.3.2.2 "Downdrag and Drag Load" of the ODOT BDM, if 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 greater than or equal to the combined effect of the factored downdrag load and the sum of factored loads (highest loaded pile at each substructure). Furthermore, per Section 305.3.5.8 of the ODOT BDM, specifying battered piles is restricted when downdrag loading is anticipated. However, provided that the project schedule can tolerate a delay between substantial completion of the site earthwork in this area and the commencement of pile installation, postponing abutment construction and allowing the potentially damaging settlements to take place is an alternative to prevent the potential downdrag loads.

Based on our discussions with the design team and our understanding that the project can tolerate a delay between substantial completion of the site earthwork and pile installation, NEAS recommends that site earthwork be performed at both the rear and forward abutments and that a settlement monitoring program be implemented at these locations. The monitoring program should be designed and implemented to verify that the settlements have dissipated to a level acceptable by the Geotechnical Engineer as well as to determine the time when pile installation/abutment construction may begin. Therefore, NEAS recommends BDM Plan Note 605.1-1 for Foundation on Piles in New Embankments be incorporated into the plans. For plan development purposes, the anticipated waiting period for the damaging settlements to take place can be assumed to be the time in which approximately 90 percent of the long-term settlements takes place (i.e., 70 days and 170 days at the rear and forward abutments, respectively, as presented in Section 5.2.7. of this report). If it is later determined that the referenced waiting periods are not feasible, considerations for installing wick drains prior to embankment construction should be made to accelerate the time required for the damaging settlements to take place.

With respect to the settlement monitoring plan, it is recommended that settlement platforms be furnished and constructed per plan notes and details found on ODOT's Office of Geotechnical Engineering (OGE) website. See ODOT's Special Provision "ITEM SPECIAL–SETTLEMENT PLATFORMS" at www.dot.state.oh.us/geotechnical/Pages/plan-notes.aspx. It is recommended that settlement platforms be placed in an area of maximum fill height but out of the way of construction traffic to avoid being damaged, such as near the crest of the embankment. Therefore, we recommend a total of two (2) settlement platforms be constructed, one behind each abutment where the largest amount of fill is proposed. The elevation of each settlement platform shall be recorded on a weekly basis until settlement is considered acceptable by the Geotechnical Engineer. It is our opinion that settlement can be considered acceptable upon three (3)

consecutive readings which indicate less than a 1/8-inch difference between each reading. Written documentation of the settlement monitoring, including the settlement measurements plots, shall be provided to the Geotechnical Engineer at the conclusion of each monitoring period.

5.3. Embankment Analysis and Recommendations

5.3.1. Embankment Stability Analysis

For purposes of evaluating stability of the planned Little Miami Scenic Trail embankments proposed as part of the project, NEAS reviewed cross-sections along the length of the project trail segments to identify sections that were interpreted to represent conditions that posed the greatest potential for slope instability as a result of the planned construction. Specifically, the segment of the proposed trail that will be constructed on a side-hill section that is to be tied into the existing SR-32 and SR-125/Beechmont Ave interchange ramp. In general, cross-sections along the referenced segment of the proposed trail alignment were reviewed 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 alignment and the associated soil properties, one cross-section was estimated to be most "critical" for the project and was analyzed for global stability. The cross-section selected to be evaluated is the proposed cross-section at approximate STA. 76+50 (LMST alignment).

For the cross-section, NEAS developed a representative cross-sectional 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) HAM-LMST Ext to Elstun structure type study developed by Stantec and dated June 28, 2022; 2) a live load surcharge of 250 pounds per square foot (psf) to account for traffic induced loads; 3) a live load surcharge of 100 psf to account for bike trail/construction induced loads; and, 4) test borings and laboratory data developed as part of this report.

For analysis purposes, borings performed along or adjacent to the indicated proposed embankment section were reviewed and a generalized material profile was developed for analysis to represent worse case conditions at the cross-section location. The generalized material profile and estimated engineering soil properties determined for Borings B-001-0-20 and B-002-0-20, summarized within Tables 7 and 8 of this report, were utilized in the development of the indicated cross-sectional model.

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 1.33 which equates to an AASHTO resistance factor less than 0.75 (per AASHTO's LRFD BDS the specified resistance factors are essentially the inverse of the FOS that should be targeted in slope stability programs). For this 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 analyses for the above referenced embankment section, the minimum slope stability safety factor is about 1.56 (0.64 resistance factor). The graphical output of the slope stability program (cross-sectional model, calculated safety factor, and critical failure plane) for the analyzed section is presented in Appendix G.

5.3.2. Embankment Construction Recommendations

As indicated above, the embankment cross-section analyzed for slope stability was determined to be stable (i.e., FOS greater than about 1.33) as proposed in the HAM-LMST Ext to Elstun structure type study developed by Stantec and dated June 28, 2022. Therefore, the proposed embankment slopes can be constructed in accordance with Item 203 "Roadway Excavation and Embankment" of the ODOT CMS.

In areas where additional embankment material is proposed along existing slopes that are steeper than 8 Horizontal to 1 Vertical (8H:1V) but flatter than 4H:1V, it is recommended that the proposed embankment be benched into the existing slopes in accordance with Item 203.05 "Embankment Construction Methods" of the ODOT CMS. For areas where additional embankment material is proposed along existing slopes that are steeper than 4H:1V, it is recommended that the proposed embankment be designed and constructed in accordance with GB2. For sidehill fills planned on existing slopes steeper than 4H:1V, ODOT's GB2 recommends that *the embankment slopes be constructed utilizing special benching in order to blend the new embankment with the existing slope to prevent the development of a weak shear plane at the interface between the proposed fill and existing slope material* (ODOT [2], 2017). As the project embankment fill slopes were determined to be stable as-proposed based on our embankment stability analysis, a special benching scheme similar to that shown in Figure 1 of the ODOT GB2 can be used in areas where special benching is recommended. The height and width dimensions of the special benching scheme shown in Figure 1 should be arranged to minimize the required cut and fill quantities, though the height of a single bench shall not exceed 20 ft without a stability analysis and design per OSHA requirements. Additionally, it may be appropriate to adjust the bench slope shown from a 1H:1V to a 1.75H:1V slope if the existing slope is made up of primarily granular materials. The benched material should be replaced with compacted engineered fill per Item 203 of the ODOT CMS, while proper lift thicknesses and material density should be maintained in the proposed fill per Item 203.06 of the ODOT CMS. In situations where it is not practical to extend the final bench through the existing roadway due to maintenance of traffic concerns, a benching scheme similar to that shown in Figure 1a of the ODOT GB2 can be used in order to avoid impacting the existing roadway, guardrail or shoulder. This scheme results in the placement of a temporary over-steepened fill that can later be "shaved-off" to bring the slope to the final proposed grade.

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 Bridge HAM-LMST to Elstun carrying the Little Miami Scenic Trail over Clough Creek. This report has been prepared for Stantec, 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 test results 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 project 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.

Structure Foundation Exploration
Bridge HAM-LST to Elstun Over Clough Creek
HAM-LMST Extension to Elstun
Hamilton County, Ohio
PID: 113602

It has been a pleasure to be of service to Stantec in performing this geotechnical exploration for the HAM-LMST Extension to Elstun project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

Brendan P. Andrews, P.E.
Senior Geotechnical Engineer

Kevin C. Arens, P.E.
Geotechnical Engineer

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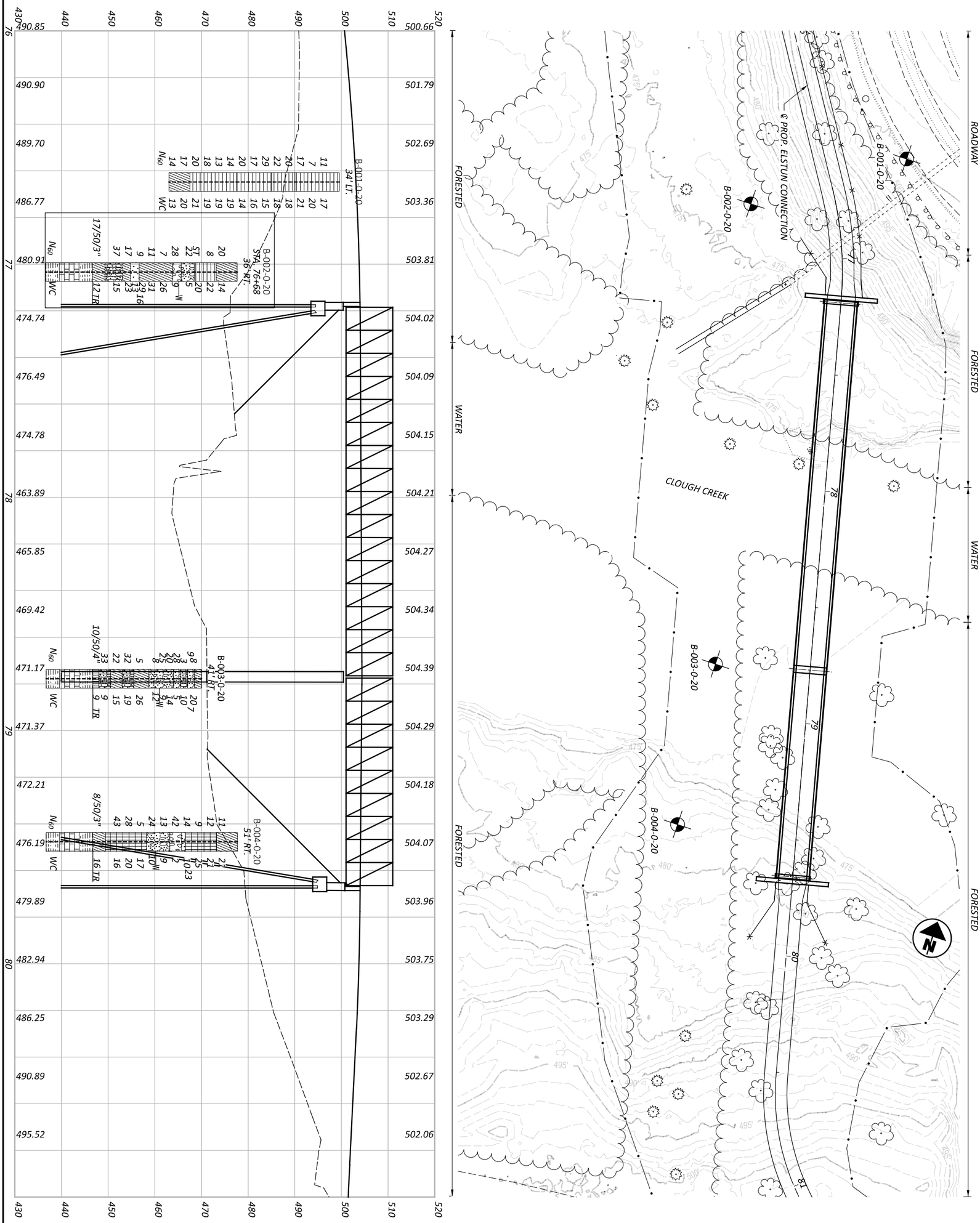
APPENDIX A

BORING LOCATION PLAN

HAM-LMST EXTENSION TO ELSTUN PHASE 2

MODEL: 113602_IP001 PAPERSIZE: 17x11 (in.) DATE: 12/15/2022 TIME: 12:18:26 PM USER: mjasiewicz
P:\OHDOT_v2\WorkSets\113602\400-Engineering\Geotechnical\Sheets\113602_ZP001.dgn



GEOTECHNICAL PROFILE - BRIDGE
BRIDGE HAM-LMST TO ELSTUN

HORIZONTAL SCALE IN FEET
0 20
10 40

DESIGN AGENCY
2800 CORPORATE EXCHANGE DR. SUITE 240
COLUMBUS, OH. 43231
TELEPHONE 614.898.7400
WWW.MEANSINC.COM

DESIGNER MWJ
REVIEWER BPA 12/15/22
PROJECT ID 113602
SUBSET 3 TOTAL 12
SHEET P.0 TOTAL 0

APPENDIX B

BORING LOGS AND LABORATORY TESTING RESULTS

PROJECT: HAM-LMST EXT
TYPE: BRIDGE
PID: 113602 SFN:
START: 8/11/22 END: 8/11/22

DRILLING FIRM / OPERATOR: NEAS / J. HODGES
SAMPLING FIRM / LOGGER: NEAS / J. HODGES
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 55X
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 1/24/22
ENERGY RATIO (%): 79

STATION / OFFSET: 76+65, 34' LT.
ALIGNMENT: ELSTUN CONNECTION
ELEVATION: 499.5 (MSL) EOB: 36.5 ft.
LAT / LONG: 39.106434, -84.400284

EXPLORATION ID B-001-0-20

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
VERY STIFF, BROWN AND LIGHT BROWN, **SILTY CLAY**, LITTLE SAND, TRACE TO LITTLE GRAVEL, DAMP TO MOIST	499.5		2 3 5	11	56	SS-1	3.25	13	7	10	35	35	39	21	18	17	A-6b (10)	
			2 3 2	7	39	SS-2	3.00	5	5	13	39	38	39	20	19	20	A-6b (12)	
			2 4 9	17	33	SS-3	2.50	-	-	-	-	-	-	-	-	21	A-6b (V)	
HARD, GRAYISH BROWN, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, DAMP	490.0		3 6 9	20	100	SS-4	4.25	-	-	-	-	-	-	-	-	18	A-6b (V)	
			3 6 11	22	67	SS-5	4.25	-	-	-	-	-	-	-	-	18	A-6b (V)	
HARD, GRAYISH BROWN AND BROWN, **SILTY CLAY**, SOME GRAVEL AND STONE FRAGMENTS, SOME SAND, DAMP	485.0		3 14 8	29	100	SS-6	4.25	24	14	9	30	23	35	19	16	15	A-6b (6)	
			5 6 7	17	44	SS-7	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
			7 7 8	20	28	SS-8	4.25	-	-	-	-	-	-	-	-	14	A-6b (V)	
HARD, BROWN AND BROWNISH GRAY, **SILTY CLAY**, TRACE TO LITTLE SAND, TRACE GRAVEL, DAMP	477.5		5 5 6	14	39	SS-9	4.25	-	-	-	-	-	-	-	-	19	A-6b (V)	
			3 4 6	13	56	SS-10	4.25	4	6	8	44	38	39	21	18	19	A-6b (11)	
			4 6 8	18	28	SS-11	4.25	-	-	-	-	-	-	-	-	19	A-6b (V)	

PID: 113602	SFN:	PROJECT: HAM-LMST EXT	STATION / OFFSET: 76+65, 34' LT.	START: 8/11/22	END: 8/11/22	PG 2 OF 2	B-001-0-20

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 AND BROWNISH GRAY, **SILTY CLAY**, TRACE TO LITTLE SAND, TRACE GRAVEL, DAMP *(continued)*	469.5	31	5 7 8	20	50	SS-12	4.25	-	-	-	-	-	-	-	-	21	A-6b (V)	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	467.5	32																
		33	4 6 7	17	44	SS-13	4.25	4	5	10	49	32	35	20	15	20	A-6a (10)	
		34																
		35	4 5 6	14	39	SS-14	4.00	-	-	-	-	-	-	-	-	13	A-6a (V)	
	463.0	36 EOB																

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

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 50 GAL. BENTONITE GROUT; SHOVELED SOIL CUTTINGS

PROJECT: HAM-LMST EXT	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 76+68, 36' RT.	EXPLORATION ID B-002-0-20	
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: ELSTUN CONNECTION		
PID: 113602 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/24/22	ELEVATION: 477.6 (MSL) EOB: 41.0 ft.	PAGE 1 OF 2	
START: 7/7/22 END: 7/8/22	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 79	LAT / LONG: 39.106323, -84.400483		

MATERIAL DESCRIPTION AND NOTES	ELEV. 477.6	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
HARD, BROWN, **SILT AND CLAY**, SOME GRAVEL, LITTLE SAND, CONTAINS ROOTS, DAMP	473.1		3 7 8	20	61	SS-1	4.50	24	11	9	36	20	34	20	14	14	A-6a (6)	
STIFF TO VERY STIFF, BROWN AND BROWNISH GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, CONTAINS IRON STAINING, MOIST TO DAMP			2 3 3	8	100	SS-2	3.25	-	-	-	-	-	-	-	-	22	A-6b (V)	
@7.9' TO 8.4'; Qu = 2271 PSF @ 15.0%	468.4				83	ST-1	2.00	9	6	9	41	35	38	20	18	20	A-6b (11)	
MEDIUM DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, DAMP	465.6		10 8 9	22	50	SS-3	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
MEDIUM DENSE, GRAY, **STONE FRAGMENTS**, LITTLE SAND, TRACE SILT, TRACE CLAY, ENCOUNTER WITH COBBLE, MOIST	463.8	W 465.1	4 9 12	28	44	SS-4	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
SOFT TO STIFF, GRAY, **SILT AND CLAY**, TRACE TO LITTLE SAND, TRACE GRAVEL, MOIST TO WET			1 2 3	7	100	SS-5	1.75	3	2	6	56	33	32	20	12	26	A-6a (9)	
			3 4 4	11	39	SS-6	0.75	-	-	-	-	-	-	-	-	31	A-6a (V)	
	456.6		4 4 3	9	100	SS-7A	0.50	-	-	-	-	-	-	-	-	29	A-6a (V)	
LOOSE TO MEDIUM DENSE, GRAY, **COARSE AND FINE SAND**, SOME GRAVEL, TRACE SILT, TRACE CLAY, WET	454.8					SS-7B	-	-	-	-	-	-	-	-	-	16	A-3a (V)	
STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	453.1		3 5 8	17	100	SS-8A	-	-	-	-	-	-	-	-	-	13	A-3a (V)	
						SS-8B	1.50	-	-	-	-	-	-	-	-	23	A-6a (V)	
DENSE, GRAY, **STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, WET	449.3		7 10 18	37	44	SS-9	-	-	-	-	-	-	-	-	-	15	A-2-4 (V)	
VERY STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, RELIC ROCK STRUCTURE, DAMP																		

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 12/15/22 11:49 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\HAM LMST EXT\GINT FILES\HAM-LMST EXT.GPJ

PID: 113602	SFN:	PROJECT: HAM-LMST EXT	STATION / OFFSET: 76+68, 36' RT.	START: 7/7/22	END: 7/8/22	PG 2 OF 2	B-002-0-20

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
	447.6																	
	446.6	TR 31	17 50/3"	-	89	SS-10	3.50	-	-	-	-	-	-	-	-	12	A-6a (V)	
INTERBEDDED LIMESTONE (51%) AND SHALE (49%), CONTAINS MANY INTERBEDDED 1/8" - 1/2" CLAY SEAMS, BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH TO VERY ROUGH, BLOCKY/DISTURBED/SEAMY, GOOD TO FAIR SURFACE CONDITION, RQD 24%, REC. 90%; **LIMESTONE**, GRAY AND LIGHT GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, FINE TO COARSE GRAINED, LAMINATED TO THIN BEDDED, FOSSILIFEROUS, STYLOLITIC; **SHALE**, GRAY, SEVERELY TO HIGHLY WEATHERED, VERY WEAK TO WEAK, FISSILE.		32 33 34 35 36 37 38 39 40	24		90	NQ2-1										CORE	
	436.6	EOB 41																

NOTES: GROUNDWATER ENCOUNTERED AT 12.5' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 100 GAL. BENTONITE GROUT

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: HAM-LMST Ext, Boring Location: B-002-0-20, ST-1, Depth: 7.9 - 8.4ft)

Tested Date: 7/11/2022

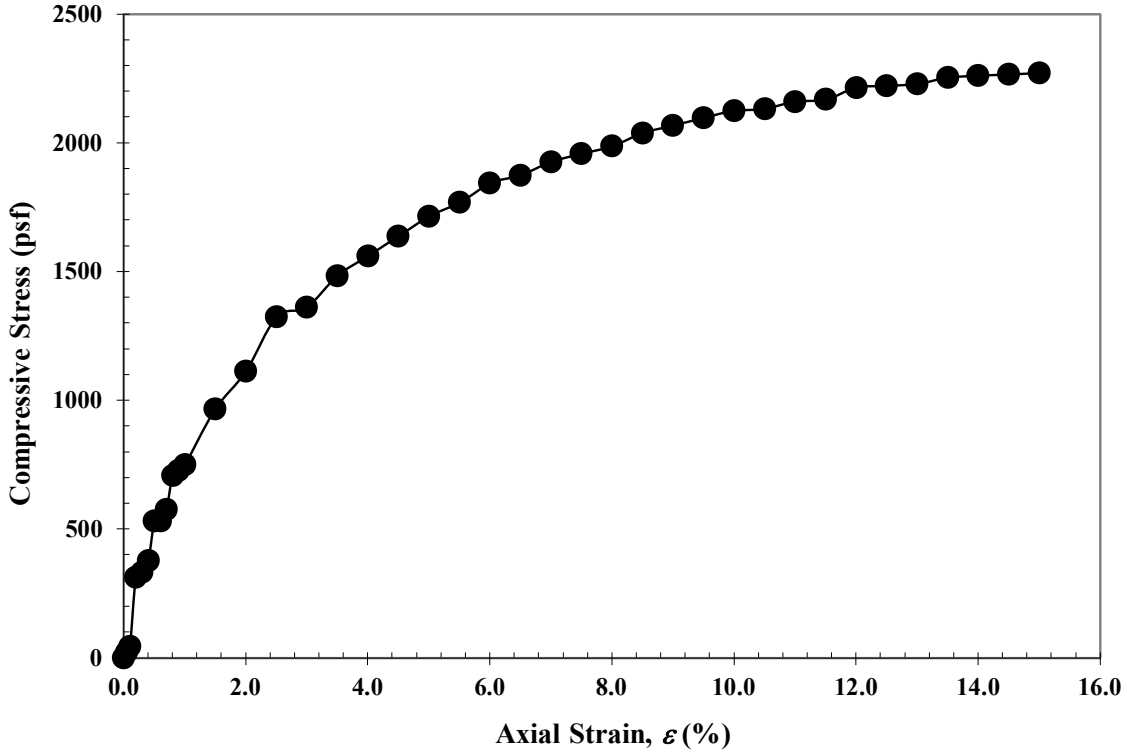
Specimen Properties

Average Dia., D_{avg} (in):	2.87
Average Height, H_{avg} (in):	5.75
Area, A (in^2):	6.47
Volume, V (in^3):	37.21
Wet Mass of Specimen (lb):	2.8
Moisture Content (%):	21.9
Dry Mass of Specimen (lb):	2.3
Wet Unit Weight, γ (lb/ft^3):	129.1
Dry Unit Weight, γ_d (lb/ft^3):	105.9

Final Specimen Figure

Results

Unconfined Compressive Strength (psf):	**2271**
Strain (%):	**15.0**



Notes: Stiff, brownish gray, SILTY CLAY, little sand, trace gravel, damp. Specimen contains gravel >1/6 specimen diameter. Results reported may differ from a specimen that meets the maximum particle size allowance of D2166. Specimen exceeded strain limitations of 15.0%.

National Engineering & Architectural Services Inc.

5710 Westbourne Avenue
Columbus, OH 43213
614.892.0162

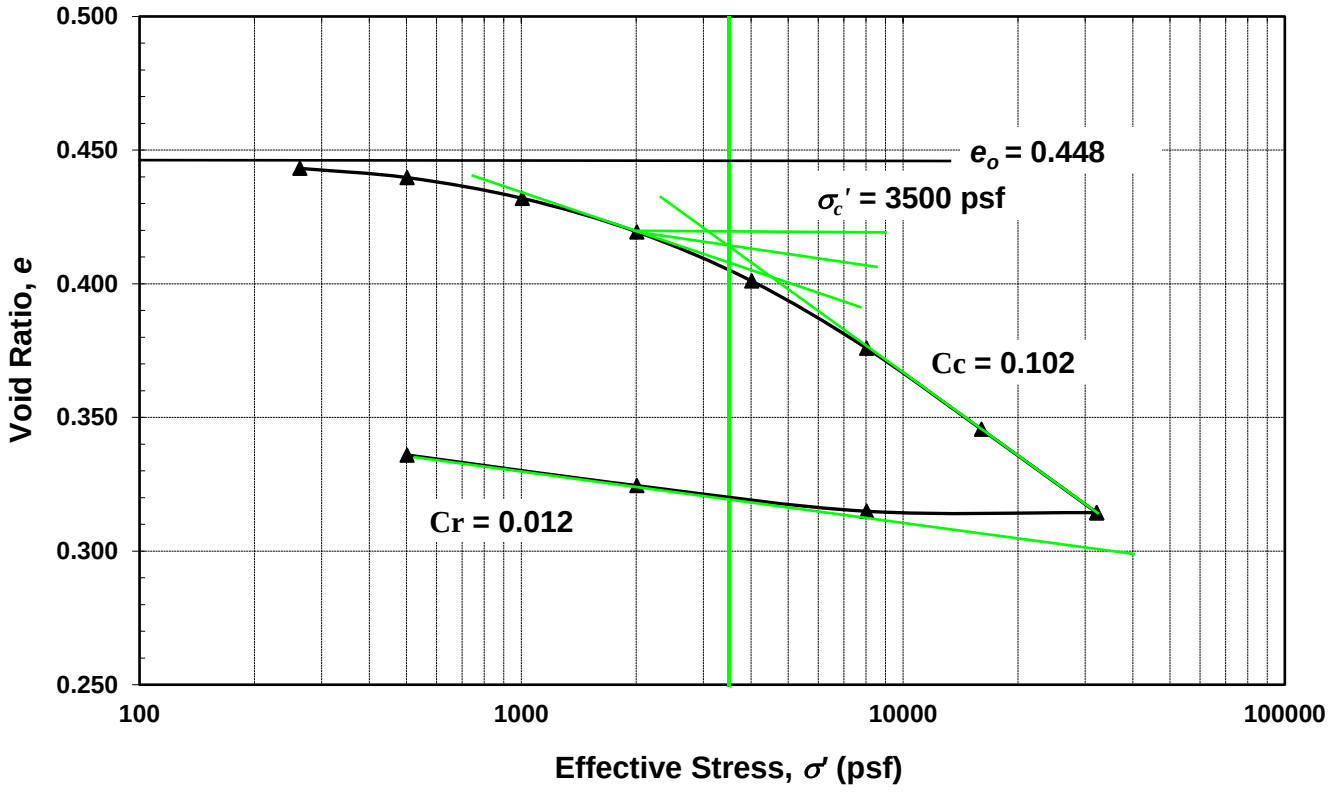
Consolidation Test

Project Name: HAM-LMST Ext
Prepared by: LR
Source: B-002-0-20 ST-1 (8.4' - 8.5')
Checked by: ZM
Description: Stiff to very stiff, gray, SILTY CLAY, little sand, trace gravel, damp.
After testing, a 7/16" gravel piece was found within the specimen.
Date: 7/29/2022
Test Specification: ASTM D 2435
Initial Void Ratio: 0.448
Initial Bulk Unit Weight (lb/ft^3): 135
In-situ Vertical Effective Stress (psf): 1100
Dry Unit Weight (lb/ft^3): 116

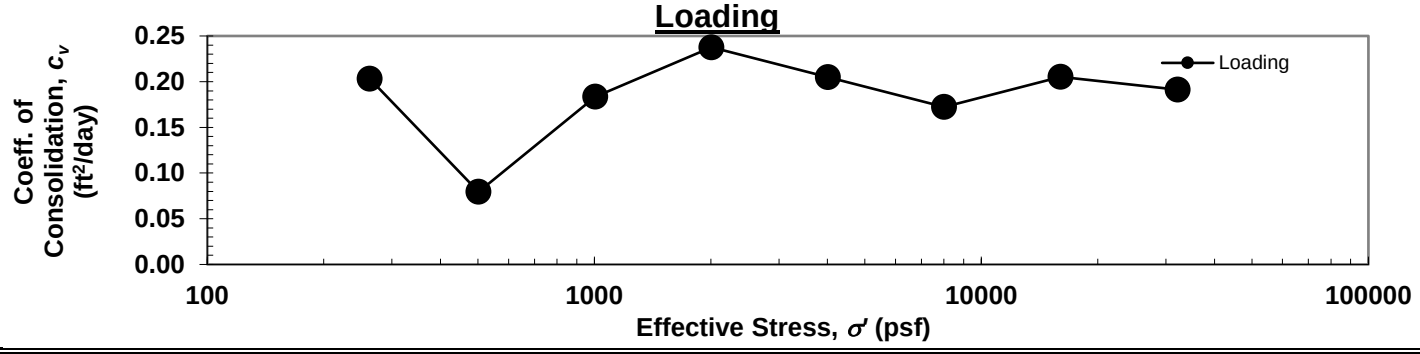
Compression and Swelling Index

Compression Index (*Cc*): 0.102
Preconsolidation Pressure (σ_c')(psf): **3500**
Recompression Index (*Cr*): 0.012
Over-Consolidation Ratio (*OCR*): **3.18**

Consolidation Curve



Loading



OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-002-0-20

Run #:	Depth		Recovery		RQD	
NQ2-1	31.0'	41.0'	108"/120"	90%	28.5"/120"	24%

HAM-LMST Extension to Ranchvale (PID #113602)

PROJECT: HAM-LMST EXT	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 78+78, 41' RT.
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: ELSTUN CONNECTION
PID: 113602 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/24/22	ELEVATION: 470.0 (MSL) EOB: 33.3 ft.
START: 7/6/22 END: 7/6/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 79	LAT / LONG: 39.105798, -84.400302

EXPLORATION ID B-003-0-20

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
MEDIUM STIFF, BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS NO INTACT SOIL FOR HP READINGS, DAMP	470.0		3 3 3	8	22	SS-1	-	1	0	6	65	28	40	25	15	20	A-6a (10)	
LOOSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP	468.5		2 4 3	9	100	SS-2	-	16	39	30	11	4	NP	NP	NP	7	A-1-b (0)	
VERY LOOSE, BROWN, **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP	467.0		1 1 1	3	28	SS-3	-	21	28	20	22	9	NP	NP	NP	10	A-2-4 (0)	
MEDIUM DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, ENCOUNTER WITH COBBLE, LARGE STONE FRAGMENTS, DAMP	465.5		3 11 10	28	100	SS-4	-	46	23	14	12	5	NP	NP	NP	5	A-1-b (0)	
LOOSE TO MEDIUM DENSE, ORANGISH BROWN AND GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, CONTAINS IRON STAINING, WET TO MOIST	464.0	W 461.0	8 8 7	20	89	SS-5	-	33	32	20	11	4	NP	NP	NP	14	A-1-b (0)	
			3 10 9	25	39	SS-6	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
			3 4 2	8	28	SS-7	-	-	-	-	-	-	-	-	-	12	A-1-b (V)	
	458.7																	
STIFF, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, MOIST	455.5		2 2 2	5	100	SS-8	1.50	1	2	31	33	33	31	18	13	26	A-6a (7)	
DENSE, GRAY, **STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, WET	453.0		7 12 12	32	100	SS-9	-	-	-	-	-	-	-	-	-	19	A-2-4 (V)	
VERY STIFF, GRAY, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL AND STONE FRAGMENTS, DAMP	450.5		5 10 7	22	100	SS-10	2.75	16	18	20	22	24	29	17	12	15	A-6a (3)	
DENSE, GRAY, **STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP	448.0		6 8 17	33	100	SS-11	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, LITTLE STONE FRAGMENTS, RELIC ROCK STRUCTURE, DAMP	446.7	TR	10 50/4"	-	60	SS-12	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
@23.7'-24.1'; Qu = 5634 PSI @ 0.5%			33		96	NQ2-1											CORE	

PID: 113602	SFN:	PROJECT: HAM-LMST EXT	STATION / OFFSET: 78+78, 41' RT.	START: 7/6/22	END: 7/6/22	PG 2 OF 2	B-003-0-20

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
INTERBEDDED LIMESTONE (61%) AND SHALE (39%), CONTAINS MANY INTERBEDDED 1/8" - 1/2" CLAY SEAMS, BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH TO VERY ROUGH, BLOCKY/DISTURBED/SEAMY, GOOD TO FAIR SURFACE CONDITION, RQD 33%, REC. 96%; **LIMESTONE**, GRAY AND LIGHT GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, FINE TO COARSE GRAINED, LAMINATED TO THIN BEDDED, FOSSILIFEROUS, STYLOLITIC; **SHALE**, GRAY, SEVERELY WEATHERED, VERY WEAK, FISSILE. *(continued)* @32.8'-33.2'; Qu = 7935 PSI @ 0.7%	440.0 436.7	31 32 33 EOB																

NOTES: GROUNDWATER ENCOUNTERED AT 9.0' DURING DRILLING. HOLE DID NOT CAVE.

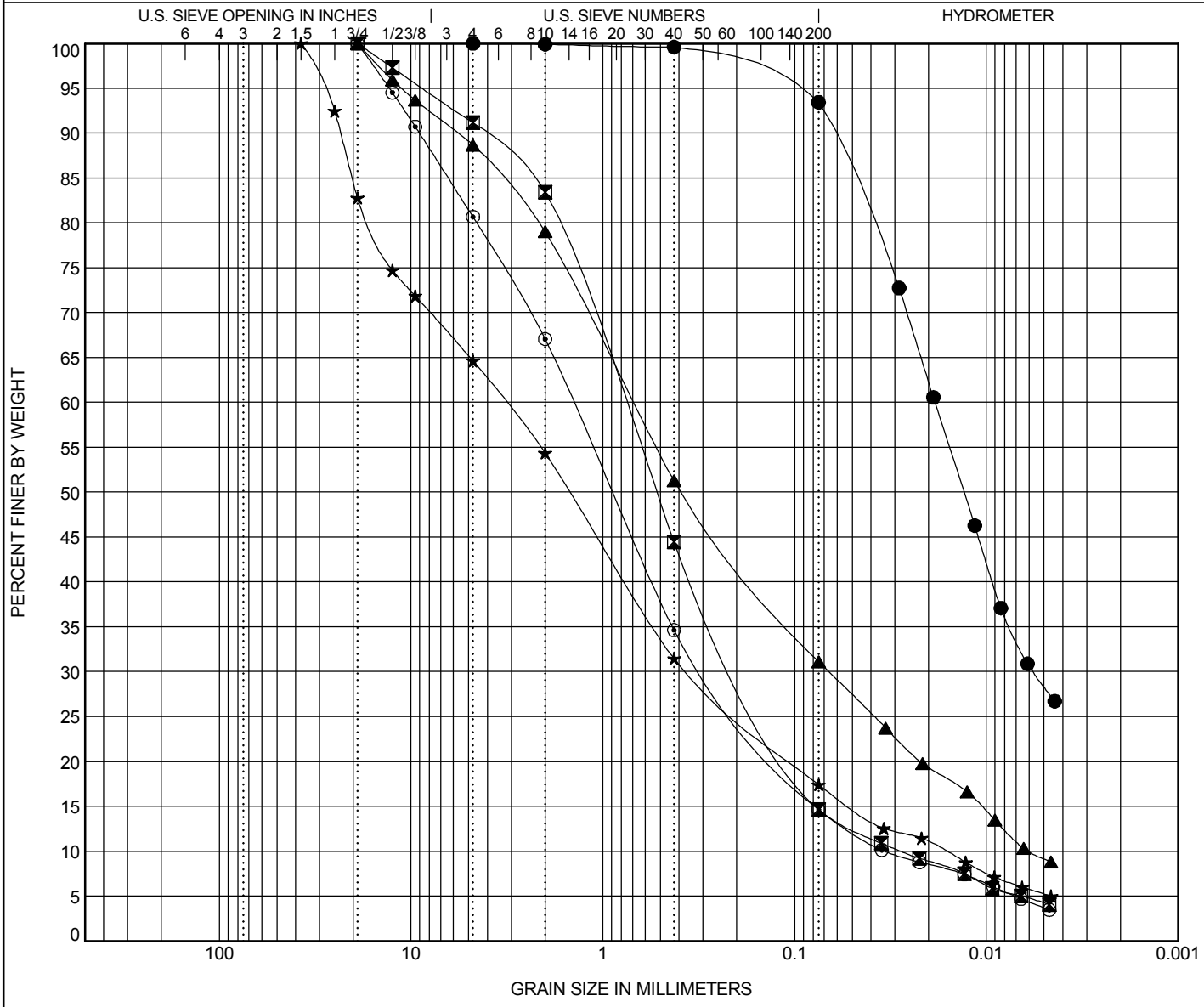
ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 100 GAL. BENTONITE GROUT

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT HAM-LMST EXT **PID** 113602

OGE NUMBER 0 **PROJECT TYPE**



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-003-0-20	0.0	A-6a ~ LEAN CLAY(CL)	40	25	15
⊠	B-003-0-20	1.5	A-1-b ~ SILTY SAND(SM)	NP	NP	NP
▲	B-003-0-20	3.0	A-2-4 ~ SILTY SAND(SM)	NP	NP	NP
★	B-003-0-20	4.5	A-1-b ~ SILTY SAND with GRAVEL(SM)	NP	NP	NP
⊙	B-003-0-20	6.0	A-1-b ~ SILTY SAND with GRAVEL(SM)	NP	NP	NP

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-003-0-20	0.0	0.064	0.013	0.006		1	0	6	65	28		
⊠	B-003-0-20	1.5	4.165	0.53	0.183	0.028	16	39	30	11	4	1.53	28.29
▲	B-003-0-20	3.0	5.705	0.38	0.067	0.006	21	28	20	22	9	1.07	115.61
★	B-003-0-20	4.5	23.308	1.488	0.355	0.016	46	23	14	12	5	2.39	196.07
⊙	B-003-0-20	6.0	9.042	0.886	0.285	0.034	33	32	20	11	4	1.68	42.22

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: HAM-LMST Extension, Boring Location: B-003-0-20, NQ2-1, Depth: 23.7 - 24.1ft)

Tested Date: 7/14/2022

Specimen Properties

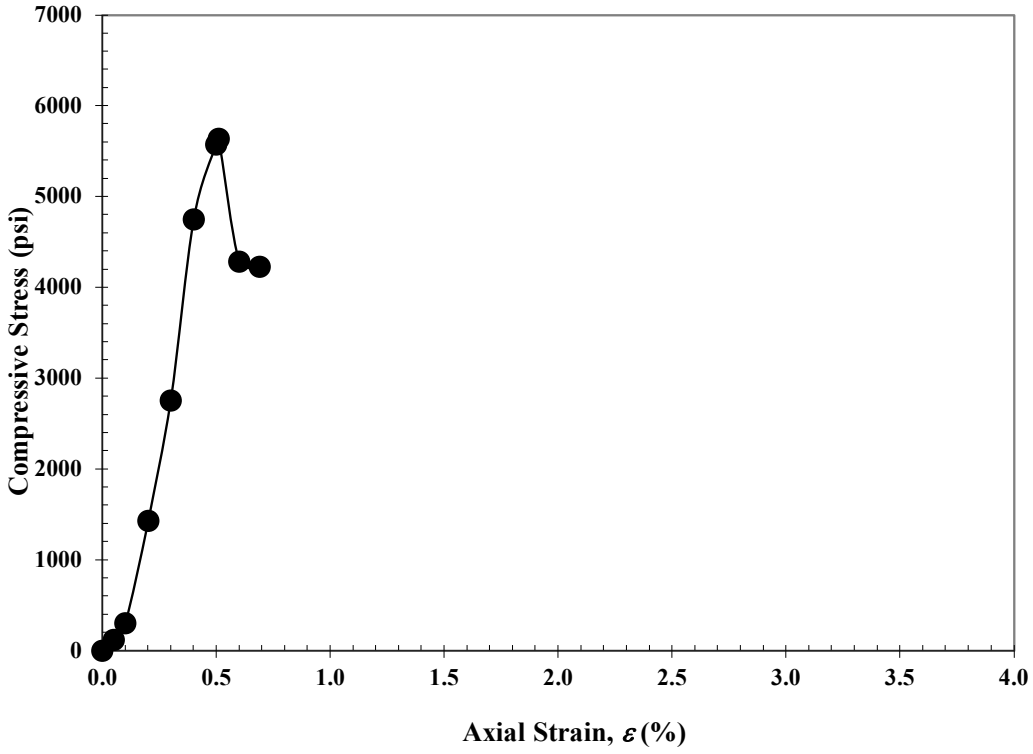
Average Dia., D_{avg} (in):	1.97
Average Height, H_{avg} (in):	4.50
Length to Diameter Ratio:	2.28
Area, A (in^2):	3.06
Volume, V (in^3):	13.75
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	0.5
Dry Mass of Specimen (lb):	1.3
Wet Unit Weight, γ (lb/ft^3):	168.1
Dry Unit Weight, γ_d (lb/ft^3):	167.2

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **5634** **39** (MPa)

Strain (%): **0.5**



Notes: Limestone, gray, unweathered, fine to coarse grained, moderately strong, fossiliferous.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

NEAS
National Engineering & Architectural Services Inc.

5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: HAM-LMST Extension, Boring Location: B-003-0-20, NQ2-1, Depth: 32.8 - 33.2ft)

Tested Date: 7/14/2022

Specimen Properties

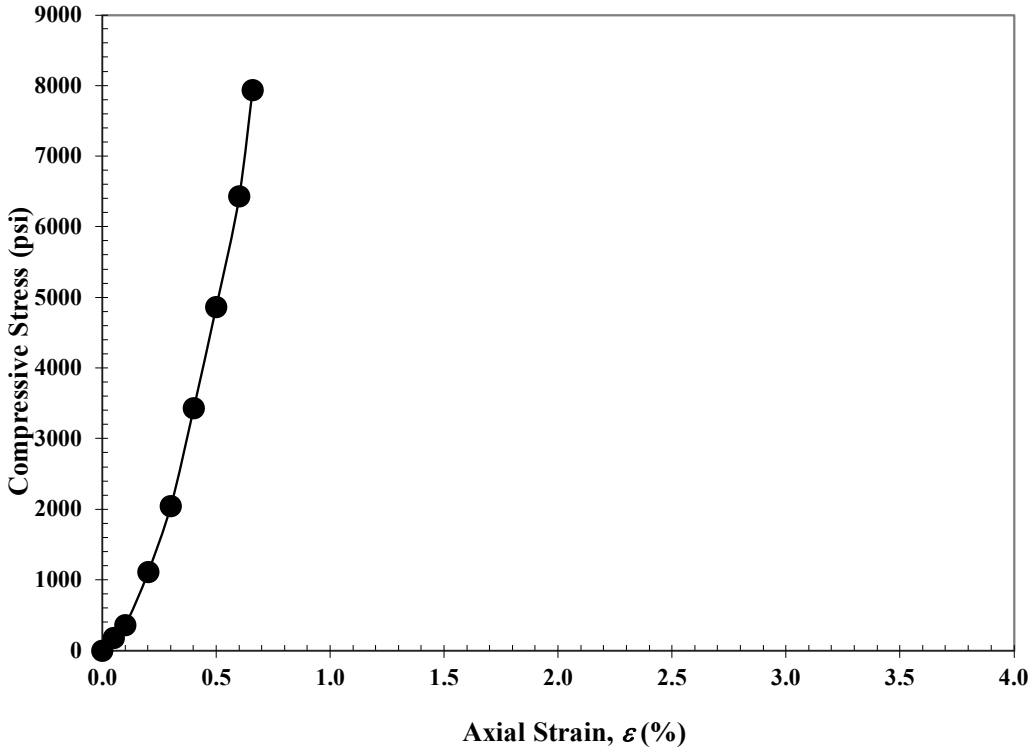
Average Dia., D_{avg} (in):	1.97
Average Height, H_{avg} (in):	4.41
Length to Diameter Ratio:	2.24
Area, A (in^2):	3.04
Volume, V (in^3):	13.41
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	1.4
Dry Mass of Specimen (lb):	1.3
Wet Unit Weight, γ (lb/ft^3):	166.4
Dry Unit Weight, γ_d (lb/ft^3):	164.1

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **7935** **55** (MPa)

Strain (%): **0.7**



Notes: Limestone, gray, unweathered, fine to medium grained, strong, slightly fossiliferous, slightly argillaceous.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-003-0-20

Run #:	Depth		Recovery		RQD	
NQ2-1	23.3’	33.3’	115”/120”	96%	39.25”/120”	33%
HAM-LMST Extension to Ranchvale (PID #113602)						

PROJECT: HAM-LMST EXT	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 79+48, 51' RT.
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: ELSTUN CONNECTION
PID: 113602 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/24/22	ELEVATION: 477.7 (MSL) EOB: 41.0 ft.
START: 7/7/22 END: 7/7/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 79	LAT / LONG: 39.105605, -84.400275

EXPLORATION ID B-004-0-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 477.7	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
HARD, BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, DAMP	473.2	1–4	4 4 4	11	83	SS-1	4.25	1	1	3	63	32	36	22	14	21	A-6a (10)	
VERY STIFF TO HARD, BROWN, **CLAY**, "AND" SILT, TRACE SAND, TRACE GRAVEL, DAMP	466.5	5–6	2 4 5	12	100	SS-2	4.25	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
		8–9	3 3 4	9	100	SS-3	3.00	0	1	9	55	35	46	25	21	25	A-7-6 (14)	
		10–11	3 4 7	14	100	SS-4A	2.75	-	-	-	-	-	-	-	-	23	A-7-6 (V)	
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP	465.7					SS-4B	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
DENSE, GRAY, **STONE FRAGMENTS**, LITTLE SAND, TRACE SILT, TRACE CLAY, ENCOUNTER WITH COBBLE, DAMP	463.2	13–14	38 13 19	42	67	SS-5	-	-	-	-	-	-	-	-	-	2	A-1-a (V)	
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP		15–16	8 6 4	13	100	SS-6	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
SS-7 BECOMES ORANGISH BROWN, CONTAINS IRON STAINING, WET	458.2	W 460.2 18–19	7 10 8	24	78	SS-7	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
MEDIUM STIFF TO VERY STIFF, GREENISH GRAY, **CLAY**, SOME SILT, TRACE TO LITTLE SAND, TRACE GRAVEL, SS-8 CONTAINS NO INTACT SOIL FOR HP READINGS, DAMP		20–21	2 2 2	5	22	SS-8	-	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
		23–24	6 6 15	28	100	SS-9	3.50	5	6	6	34	49	42	21	21	20	A-7-6 (13)	
		25–26	5 20 13	43	100	SS-10	3.25	-	-	-	-	-	-	-	-	16	A-7-6 (V)	
	449.4																	
HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, RELIC ROCK STRUCTURE, CONTAINS NO INTACT SOIL FOR HP READINGS, DAMP																		

PID: 113602	SFN:	PROJECT: HAM-LMST EXT	STATION / OFFSET: 79+48, 51' RT.	START: 7/7/22	END: 7/7/22	PG 2 OF 2	B-004-0-20

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
	447.7																	
	446.7	TR 31	8 50/3"	-	67	SS-11	-	-	-	-	-	-	-	-	-	16	A-6a (V)	
INTERBEDDED LIMESTONE (57%) AND SHALE (43%), CONTAINS MANY INTERBEDDED 1/8" - 1/2" CLAY SEAMS, BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH TO VERY ROUGH, BLOCKY/DISTURBED/SEAMY, GOOD TO FAIR SURFACE CONDITION, RQD 24%, REC. 94%; **LIMESTONE**, GRAY AND LIGHT GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, FINE TO COARSE GRAINED, LAMINATED TO THIN BEDDED, FOSSILIFEROUS, STYLOLITIC; **SHALE**, GRAY, SEVERELY TO HIGHLY WEATHERED, VERY WEAK, FISSILE.		32 33 34 35 36 37 38 39 40	24		94	NQ2-1											CORE	
	436.7	EOB 41																

NOTES: GROUNDWATER ENCOUNTERED AT 17.5' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 100 GAL. BENTONITE GROUT

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

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B-004-0-20

Run #:	Depth		Recovery		RQD	
NQ2-1	31.0'	41.0'	112.75"/120"	94%	28.5"/120"	24%
HAM-LMST Extension to Ranchvale (PID #113602)						

APPENDIX C

DRIVEN ANALYSIS

REAR ABUTMENT

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename:
Project Name: HAM-LMST Ext Ranchvale
Project Date: 07/18/2022
Project Client: Stantec
Computed By: KCA
Project Manager: BPA

PILE INFORMATION

Pile Type: H Pile - HP10X42
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Pile Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	10.60 ft
	- Driving/Restrike	10.60 ft
	- Ultimate:	10.60 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	2.60 ft	33.00%	125.00 pcf	1100.00 psf	T-80 Same
2	Cohesive	4.70 ft	43.00%	108.00 pcf	1000.00 psf	T-80 Same
3	Cohesionless	2.80 ft	0.00%	125.00 pcf	36.0/36.0	Nordlund
4	Cohesionless	1.80 ft	0.00%	128.00 pcf	37.0/37.0	Nordlund
5	Cohesive	7.20 ft	33.00%	118.00 pcf	1100.00 psf	T-80 Sand
6	Cohesionless	1.80 ft	0.00%	122.00 pcf	30.0/30.0	Nordlund
7	Cohesive	1.70 ft	33.00%	122.00 pcf	2100.00 psf	T-80 Same
8	Cohesionless	3.80 ft	17.00%	130.00 pcf	38.0/38.0	Nordlund
9	Cohesive	2.70 ft	33.00%	135.00 pcf	5500.00 psf	T-80 Same

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	997.39 psf	0.02 Kips
2.59 ft	Cohesive	N/A	N/A	997.39 psf	5.70 Kips
2.61 ft	Cohesive	N/A	N/A	923.00 psf	5.74 Kips
7.29 ft	Cohesive	N/A	N/A	923.00 psf	13.86 Kips
7.31 ft	Cohesionless	833.23 psf	26.39	N/A	13.90 Kips
10.09 ft	Cohesionless	1006.97 psf	26.39	N/A	18.32 Kips
10.11 ft	Cohesionless	1183.24 psf	27.13	N/A	18.36 Kips
10.59 ft	Cohesionless	1213.96 psf	27.13	N/A	19.38 Kips
10.61 ft	Cohesionless	1246.93 psf	27.13	N/A	19.42 Kips
11.89 ft	Cohesionless	1288.91 psf	27.13	N/A	22.30 Kips
11.91 ft	Cohesive	N/A	N/A	1100.00 psf	22.34 Kips
19.09 ft	Cohesive	N/A	N/A	1100.00 psf	39.78 Kips
19.11 ft	Cohesionless	1732.50 psf	21.99	N/A	39.83 Kips
20.89 ft	Cohesionless	1785.54 psf	21.99	N/A	42.83 Kips
20.91 ft	Cohesive	N/A	N/A	1350.61 psf	42.87 Kips
22.59 ft	Cohesive	N/A	N/A	1350.61 psf	47.88 Kips
22.61 ft	Cohesionless	1941.14 psf	27.86	N/A	47.95 Kips
26.39 ft	Cohesionless	2068.90 psf	27.86	N/A	60.38 Kips
26.41 ft	Cohesive	N/A	N/A	1309.00 psf	60.43 Kips
29.09 ft	Cohesive	N/A	N/A	1309.00 psf	68.18 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	0.85 Kips
2.59 ft	Cohesive	N/A	N/A	N/A	0.85 Kips
2.61 ft	Cohesive	N/A	N/A	N/A	0.77 Kips
7.29 ft	Cohesive	N/A	N/A	N/A	0.77 Kips
7.31 ft	Cohesionless	833.85 psf	77.60	13.05 Kips	3.86 Kips
10.09 ft	Cohesionless	1181.35 psf	77.60	13.05 Kips	5.47 Kips
10.11 ft	Cohesionless	1183.88 psf	91.20	17.74 Kips	6.58 Kips
10.59 ft	Cohesionless	1245.32 psf	91.20	17.74 Kips	6.92 Kips
10.61 ft	Cohesionless	1247.26 psf	91.20	17.74 Kips	6.93 Kips
11.89 ft	Cohesionless	1331.22 psf	91.20	17.74 Kips	7.40 Kips
11.91 ft	Cohesive	N/A	N/A	N/A	0.85 Kips
19.09 ft	Cohesive	N/A	N/A	N/A	0.85 Kips
19.11 ft	Cohesionless	1732.80 psf	30.00	1.15 Kips	1.15 Kips
20.89 ft	Cohesionless	1838.88 psf	30.00	1.15 Kips	1.15 Kips
20.91 ft	Cohesive	N/A	N/A	N/A	1.63 Kips
22.59 ft	Cohesive	N/A	N/A	N/A	1.63 Kips
22.61 ft	Cohesionless	1941.48 psf	110.40	23.13 Kips	13.33 Kips
26.39 ft	Cohesionless	2197.00 psf	110.40	23.13 Kips	15.08 Kips
26.41 ft	Cohesive	N/A	N/A	N/A	4.26 Kips
29.09 ft	Cohesive	N/A	N/A	N/A	4.26 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.02 Kips	0.85 Kips	0.87 Kips
2.59 ft	5.70 Kips	0.85 Kips	6.56 Kips
2.61 ft	5.74 Kips	0.77 Kips	6.52 Kips
7.29 ft	13.86 Kips	0.77 Kips	14.63 Kips
7.31 ft	13.90 Kips	3.86 Kips	17.76 Kips
10.09 ft	18.32 Kips	5.47 Kips	23.79 Kips
10.11 ft	18.36 Kips	6.58 Kips	24.94 Kips
10.59 ft	19.38 Kips	6.92 Kips	26.29 Kips
10.61 ft	19.42 Kips	6.93 Kips	26.35 Kips
11.89 ft	22.30 Kips	7.40 Kips	29.69 Kips
11.91 ft	22.34 Kips	0.85 Kips	23.19 Kips
19.09 ft	39.78 Kips	0.85 Kips	40.63 Kips
19.11 ft	39.83 Kips	1.15 Kips	40.98 Kips
20.89 ft	42.83 Kips	1.15 Kips	43.98 Kips
20.91 ft	42.87 Kips	1.63 Kips	44.50 Kips
22.59 ft	47.88 Kips	1.63 Kips	49.51 Kips
22.61 ft	47.95 Kips	13.33 Kips	61.28 Kips
26.39 ft	60.38 Kips	15.08 Kips	75.46 Kips
26.41 ft	60.43 Kips	4.26 Kips	64.70 Kips
29.09 ft	68.18 Kips	4.26 Kips	72.44 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	997.39 psf	0.03 Kips
2.59 ft	Cohesive	N/A	N/A	997.39 psf	8.51 Kips
2.61 ft	Cohesive	N/A	N/A	923.00 psf	8.58 Kips
7.29 ft	Cohesive	N/A	N/A	923.00 psf	22.81 Kips
7.31 ft	Cohesionless	833.23 psf	26.39	N/A	22.86 Kips
10.09 ft	Cohesionless	1006.97 psf	26.39	N/A	27.28 Kips
10.11 ft	Cohesionless	1183.24 psf	27.13	N/A	27.32 Kips
10.59 ft	Cohesionless	1213.96 psf	27.13	N/A	28.33 Kips
10.61 ft	Cohesionless	1246.93 psf	27.13	N/A	28.38 Kips
11.89 ft	Cohesionless	1288.91 psf	27.13	N/A	31.26 Kips
11.91 ft	Cohesive	N/A	N/A	1100.00 psf	31.32 Kips
19.09 ft	Cohesive	N/A	N/A	1100.00 psf	57.35 Kips
19.11 ft	Cohesionless	1732.50 psf	21.99	N/A	57.40 Kips
20.89 ft	Cohesionless	1785.54 psf	21.99	N/A	60.40 Kips
20.91 ft	Cohesive	N/A	N/A	1350.61 psf	60.46 Kips
22.59 ft	Cohesive	N/A	N/A	1350.61 psf	67.94 Kips
22.61 ft	Cohesionless	1941.14 psf	27.86	N/A	68.02 Kips
26.39 ft	Cohesionless	2068.90 psf	27.86	N/A	82.99 Kips
26.41 ft	Cohesive	N/A	N/A	1309.00 psf	83.08 Kips
29.09 ft	Cohesive	N/A	N/A	1309.00 psf	94.64 Kips

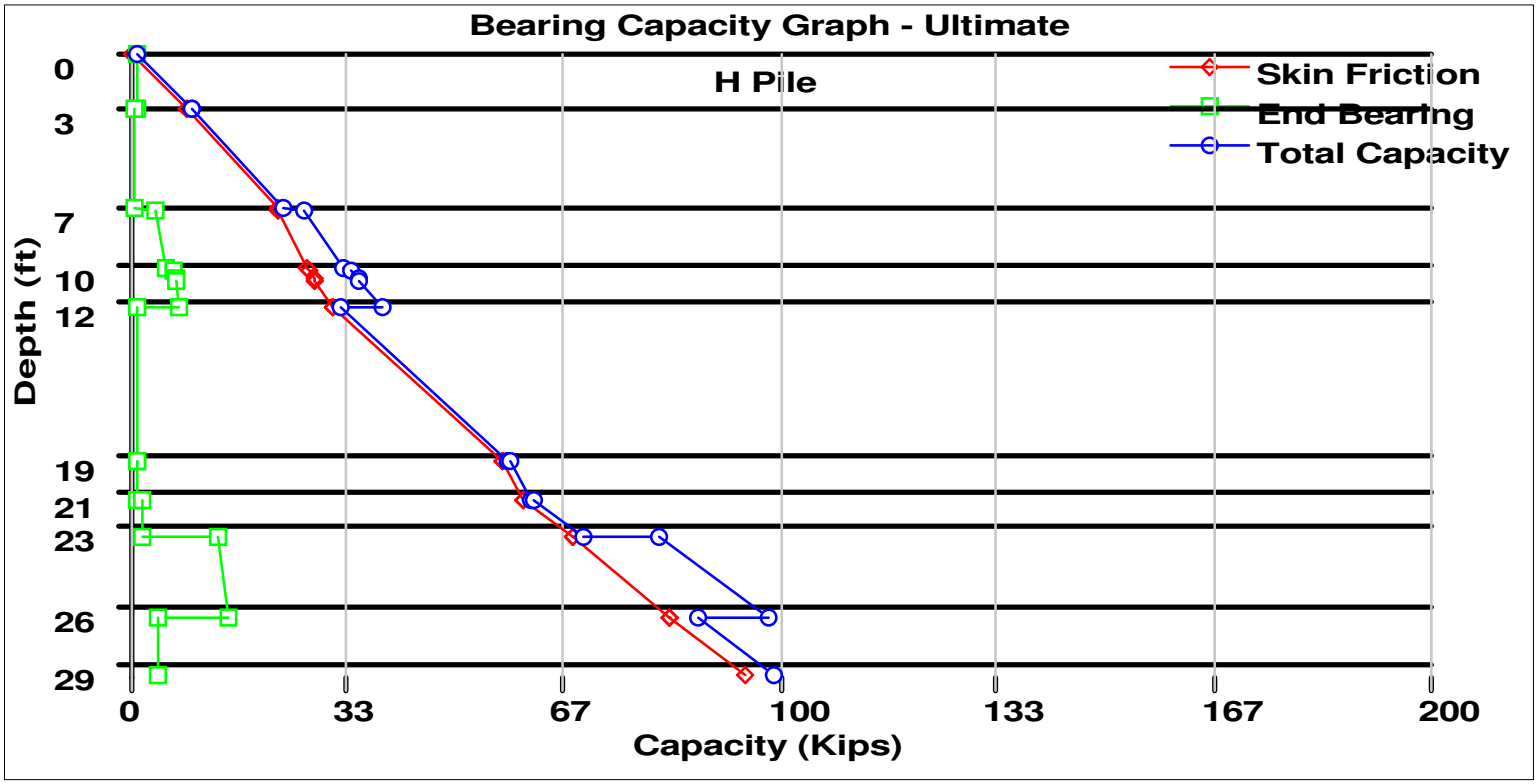
ULTIMATE - END BEARING

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	0.85 Kips
2.59 ft	Cohesive	N/A	N/A	N/A	0.85 Kips
2.61 ft	Cohesive	N/A	N/A	N/A	0.77 Kips
7.29 ft	Cohesive	N/A	N/A	N/A	0.77 Kips
7.31 ft	Cohesionless	833.85 psf	77.60	13.05 Kips	3.86 Kips
10.09 ft	Cohesionless	1181.35 psf	77.60	13.05 Kips	5.47 Kips
10.11 ft	Cohesionless	1183.88 psf	91.20	17.74 Kips	6.58 Kips
10.59 ft	Cohesionless	1245.32 psf	91.20	17.74 Kips	6.92 Kips
10.61 ft	Cohesionless	1247.26 psf	91.20	17.74 Kips	6.93 Kips
11.89 ft	Cohesionless	1331.22 psf	91.20	17.74 Kips	7.40 Kips
11.91 ft	Cohesive	N/A	N/A	N/A	0.85 Kips
19.09 ft	Cohesive	N/A	N/A	N/A	0.85 Kips
19.11 ft	Cohesionless	1732.80 psf	30.00	1.15 Kips	1.15 Kips
20.89 ft	Cohesionless	1838.88 psf	30.00	1.15 Kips	1.15 Kips
20.91 ft	Cohesive	N/A	N/A	N/A	1.63 Kips
22.59 ft	Cohesive	N/A	N/A	N/A	1.63 Kips
22.61 ft	Cohesionless	1941.48 psf	110.40	23.13 Kips	13.33 Kips
26.39 ft	Cohesionless	2197.00 psf	110.40	23.13 Kips	15.08 Kips
26.41 ft	Cohesive	N/A	N/A	N/A	4.26 Kips
29.09 ft	Cohesive	N/A	N/A	N/A	4.26 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.03 Kips	0.85 Kips	0.89 Kips
2.59 ft	8.51 Kips	0.85 Kips	9.37 Kips
2.61 ft	8.58 Kips	0.77 Kips	9.35 Kips
7.29 ft	22.81 Kips	0.77 Kips	23.59 Kips
7.31 ft	22.86 Kips	3.86 Kips	26.72 Kips
10.09 ft	27.28 Kips	5.47 Kips	32.75 Kips
10.11 ft	27.32 Kips	6.58 Kips	33.89 Kips
10.59 ft	28.33 Kips	6.92 Kips	35.25 Kips
10.61 ft	28.38 Kips	6.93 Kips	35.31 Kips
11.89 ft	31.26 Kips	7.40 Kips	38.65 Kips
11.91 ft	31.32 Kips	0.85 Kips	32.17 Kips
19.09 ft	57.35 Kips	0.85 Kips	58.20 Kips
19.11 ft	57.40 Kips	1.15 Kips	58.55 Kips
20.89 ft	60.40 Kips	1.15 Kips	61.55 Kips
20.91 ft	60.46 Kips	1.63 Kips	62.09 Kips
22.59 ft	67.94 Kips	1.63 Kips	69.57 Kips
22.61 ft	68.02 Kips	13.33 Kips	81.35 Kips
26.39 ft	82.99 Kips	15.08 Kips	98.07 Kips
26.41 ft	83.08 Kips	4.26 Kips	87.34 Kips
29.09 ft	94.64 Kips	4.26 Kips	98.90 Kips

Filename:


Bearing Capacity Graph - Ultimate
H Pile
Skin Friction
End Bearing
Total Capacity
Depth (ft)
0
3
7
10
12
19
21
23
26
29
0
33
67
100
133
167
200
Capacity (Kips)

FORWARD ABUTMENT

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\XPMUSER\DESKTOP\HAM-LMST\FA10X42.DVN
Project Name: HAM-LMST Ext Ranchvale Project Date: 07/18/2022
Project Client: Stantec
Computed By: KCA
Project Manager: BPA

PILE INFORMATION

Pile Type: H Pile - HP10X42
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Pile Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	18.80 ft
	- Driving/Restrike	18.80 ft
	- Ultimate:	18.80 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	5.80 ft	33.00%	110.00 pcf	1350.00 psf	T-80 Same
2	Cohesive	6.70 ft	50.00%	110.00 pcf	1450.00 psf	T-80 Same
3	Cohesionless	3.30 ft	0.00%	130.00 pcf	41.0/41.0	Nordlund
4	Cohesionless	5.00 ft	0.00%	125.00 pcf	34.0/34.0	Nordlund
5	Cohesive	2.50 ft	50.00%	115.00 pcf	600.00 psf	T-80 Sand
6	Cohesive	6.30 ft	50.00%	128.00 pcf	4400.00 psf	T-80 Clay
7	Cohesive	2.70 ft	33.00%	125.00 pcf	2600.00 psf	T-80 Same

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1166.25 psf	0.03 Kips
5.79 ft	Cohesive	N/A	N/A	1166.25 psf	14.91 Kips
5.81 ft	Cohesive	N/A	N/A	1218.57 psf	14.95 Kips
12.49 ft	Cohesive	N/A	N/A	1218.57 psf	28.36 Kips
12.51 ft	Cohesionless	1375.65 psf	30.06	N/A	28.44 Kips
15.79 ft	Cohesionless	1588.85 psf	30.06	N/A	40.28 Kips
15.81 ft	Cohesionless	1804.62 psf	24.93	N/A	40.35 Kips
18.79 ft	Cohesionless	1990.88 psf	24.93	N/A	48.16 Kips
18.81 ft	Cohesionless	2179.31 psf	24.93	N/A	48.22 Kips
20.79 ft	Cohesionless	2241.29 psf	24.93	N/A	54.07 Kips
20.81 ft	Cohesive	N/A	N/A	600.00 psf	54.09 Kips
23.29 ft	Cohesive	N/A	N/A	600.00 psf	56.54 Kips
23.31 ft	Cohesive	N/A	N/A	836.06 psf	56.57 Kips
29.59 ft	Cohesive	N/A	N/A	836.06 psf	65.22 Kips
29.61 ft	Cohesive	N/A	N/A	1050.60 psf	65.26 Kips
32.29 ft	Cohesive	N/A	N/A	1050.60 psf	71.48 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	1.05 Kips
5.79 ft	Cohesive	N/A	N/A	N/A	1.05 Kips
5.81 ft	Cohesive	N/A	N/A	N/A	1.12 Kips
12.49 ft	Cohesive	N/A	N/A	N/A	1.12 Kips
12.51 ft	Cohesionless	1376.30 psf	202.00	43.36 Kips	18.24 Kips
15.79 ft	Cohesionless	1802.70 psf	202.00	43.36 Kips	23.89 Kips
15.81 ft	Cohesionless	1805.25 psf	55.60	6.33 Kips	5.73 Kips
18.79 ft	Cohesionless	2177.75 psf	55.60	6.33 Kips	6.33 Kips
18.81 ft	Cohesionless	2179.63 psf	55.60	6.33 Kips	6.33 Kips
20.79 ft	Cohesionless	2303.57 psf	55.60	6.33 Kips	6.33 Kips
20.81 ft	Cohesive	N/A	N/A	N/A	0.46 Kips
23.29 ft	Cohesive	N/A	N/A	N/A	0.46 Kips
23.31 ft	Cohesive	N/A	N/A	N/A	3.41 Kips
29.59 ft	Cohesive	N/A	N/A	N/A	3.41 Kips
29.61 ft	Cohesive	N/A	N/A	N/A	2.01 Kips
32.29 ft	Cohesive	N/A	N/A	N/A	2.01 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.03 Kips	1.05 Kips	1.07 Kips
5.79 ft	14.91 Kips	1.05 Kips	15.96 Kips
5.81 ft	14.95 Kips	1.12 Kips	16.07 Kips
12.49 ft	28.36 Kips	1.12 Kips	29.49 Kips
12.51 ft	28.44 Kips	18.24 Kips	46.68 Kips
15.79 ft	40.28 Kips	23.89 Kips	64.18 Kips
15.81 ft	40.35 Kips	5.73 Kips	46.08 Kips
18.79 ft	48.16 Kips	6.33 Kips	54.50 Kips
18.81 ft	48.22 Kips	6.33 Kips	54.55 Kips
20.79 ft	54.07 Kips	6.33 Kips	60.40 Kips
20.81 ft	54.09 Kips	0.46 Kips	54.56 Kips
23.29 ft	56.54 Kips	0.46 Kips	57.01 Kips
23.31 ft	56.57 Kips	3.41 Kips	59.98 Kips
29.59 ft	65.22 Kips	3.41 Kips	68.63 Kips
29.61 ft	65.26 Kips	2.01 Kips	67.28 Kips
32.29 ft	71.48 Kips	2.01 Kips	73.49 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	1166.25 psf	0.04 Kips
5.79 ft	Cohesive	N/A	N/A	1166.25 psf	22.26 Kips
5.81 ft	Cohesive	N/A	N/A	1218.57 psf	22.33 Kips
12.49 ft	Cohesive	N/A	N/A	1218.57 psf	49.16 Kips
12.51 ft	Cohesionless	1375.65 psf	30.06	N/A	49.23 Kips
15.79 ft	Cohesionless	1588.85 psf	30.06	N/A	61.08 Kips
15.81 ft	Cohesionless	1804.62 psf	24.93	N/A	61.15 Kips
18.79 ft	Cohesionless	1990.88 psf	24.93	N/A	68.96 Kips
18.81 ft	Cohesionless	2179.31 psf	24.93	N/A	69.02 Kips
20.79 ft	Cohesionless	2241.29 psf	24.93	N/A	74.86 Kips
20.81 ft	Cohesive	N/A	N/A	600.00 psf	74.91 Kips
23.29 ft	Cohesive	N/A	N/A	600.00 psf	79.82 Kips
23.31 ft	Cohesive	N/A	N/A	836.06 psf	79.87 Kips
29.59 ft	Cohesive	N/A	N/A	836.06 psf	97.17 Kips
29.61 ft	Cohesive	N/A	N/A	1050.60 psf	97.23 Kips
32.29 ft	Cohesive	N/A	N/A	1050.60 psf	106.51 Kips

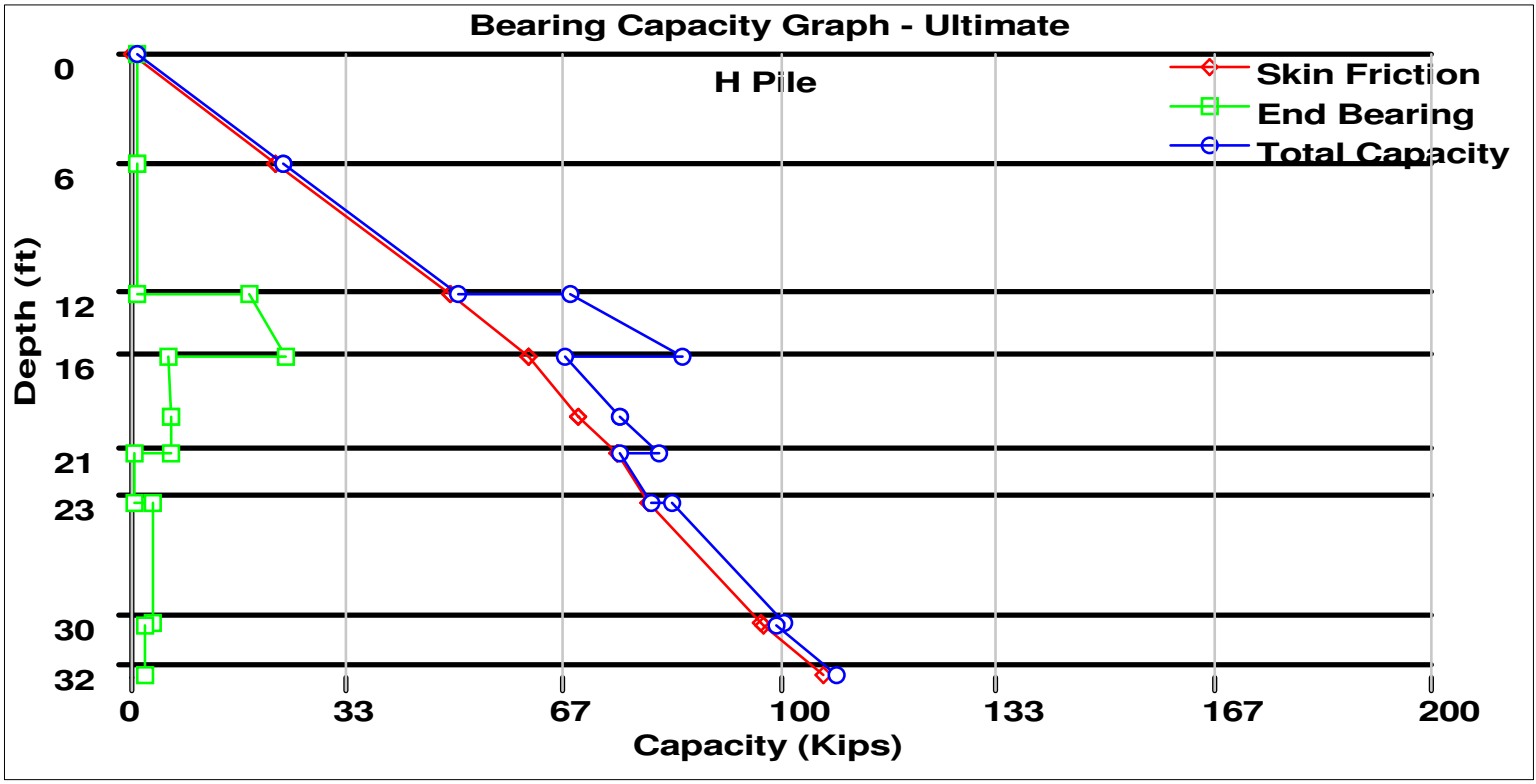
ULTIMATE - END BEARING

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	1.05 Kips
5.79 ft	Cohesive	N/A	N/A	N/A	1.05 Kips
5.81 ft	Cohesive	N/A	N/A	N/A	1.12 Kips
12.49 ft	Cohesive	N/A	N/A	N/A	1.12 Kips
12.51 ft	Cohesionless	1376.30 psf	202.00	43.36 Kips	18.24 Kips
15.79 ft	Cohesionless	1802.70 psf	202.00	43.36 Kips	23.89 Kips
15.81 ft	Cohesionless	1805.25 psf	55.60	6.33 Kips	5.73 Kips
18.79 ft	Cohesionless	2177.75 psf	55.60	6.33 Kips	6.33 Kips
18.81 ft	Cohesionless	2179.63 psf	55.60	6.33 Kips	6.33 Kips
20.79 ft	Cohesionless	2303.57 psf	55.60	6.33 Kips	6.33 Kips
20.81 ft	Cohesive	N/A	N/A	N/A	0.46 Kips
23.29 ft	Cohesive	N/A	N/A	N/A	0.46 Kips
23.31 ft	Cohesive	N/A	N/A	N/A	3.41 Kips
29.59 ft	Cohesive	N/A	N/A	N/A	3.41 Kips
29.61 ft	Cohesive	N/A	N/A	N/A	2.01 Kips
32.29 ft	Cohesive	N/A	N/A	N/A	2.01 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.04 Kips	1.05 Kips	1.08 Kips
5.79 ft	22.26 Kips	1.05 Kips	23.30 Kips
5.81 ft	22.33 Kips	1.12 Kips	23.46 Kips
12.49 ft	49.16 Kips	1.12 Kips	50.29 Kips
12.51 ft	49.23 Kips	18.24 Kips	67.48 Kips
15.79 ft	61.08 Kips	23.89 Kips	84.98 Kips
15.81 ft	61.15 Kips	5.73 Kips	66.88 Kips
18.79 ft	68.96 Kips	6.33 Kips	75.29 Kips
18.81 ft	69.02 Kips	6.33 Kips	75.35 Kips
20.79 ft	74.86 Kips	6.33 Kips	81.20 Kips
20.81 ft	74.91 Kips	0.46 Kips	75.38 Kips
23.29 ft	79.82 Kips	0.46 Kips	80.28 Kips
23.31 ft	79.87 Kips	3.41 Kips	83.28 Kips
29.59 ft	97.17 Kips	3.41 Kips	100.58 Kips
29.61 ft	97.23 Kips	2.01 Kips	99.25 Kips
32.29 ft	106.51 Kips	2.01 Kips	108.53 Kips

Filename: C:\DOCUME~1\XPMUSER\DESKTOP\HAM-LMST\FA10X42.DVN



APPENDIX D

PILE DRIVABILITY ANALYSIS

REAR ABUTMENT

Gain/Loss 3 at Shaft and Toe 0.570 / 1.000

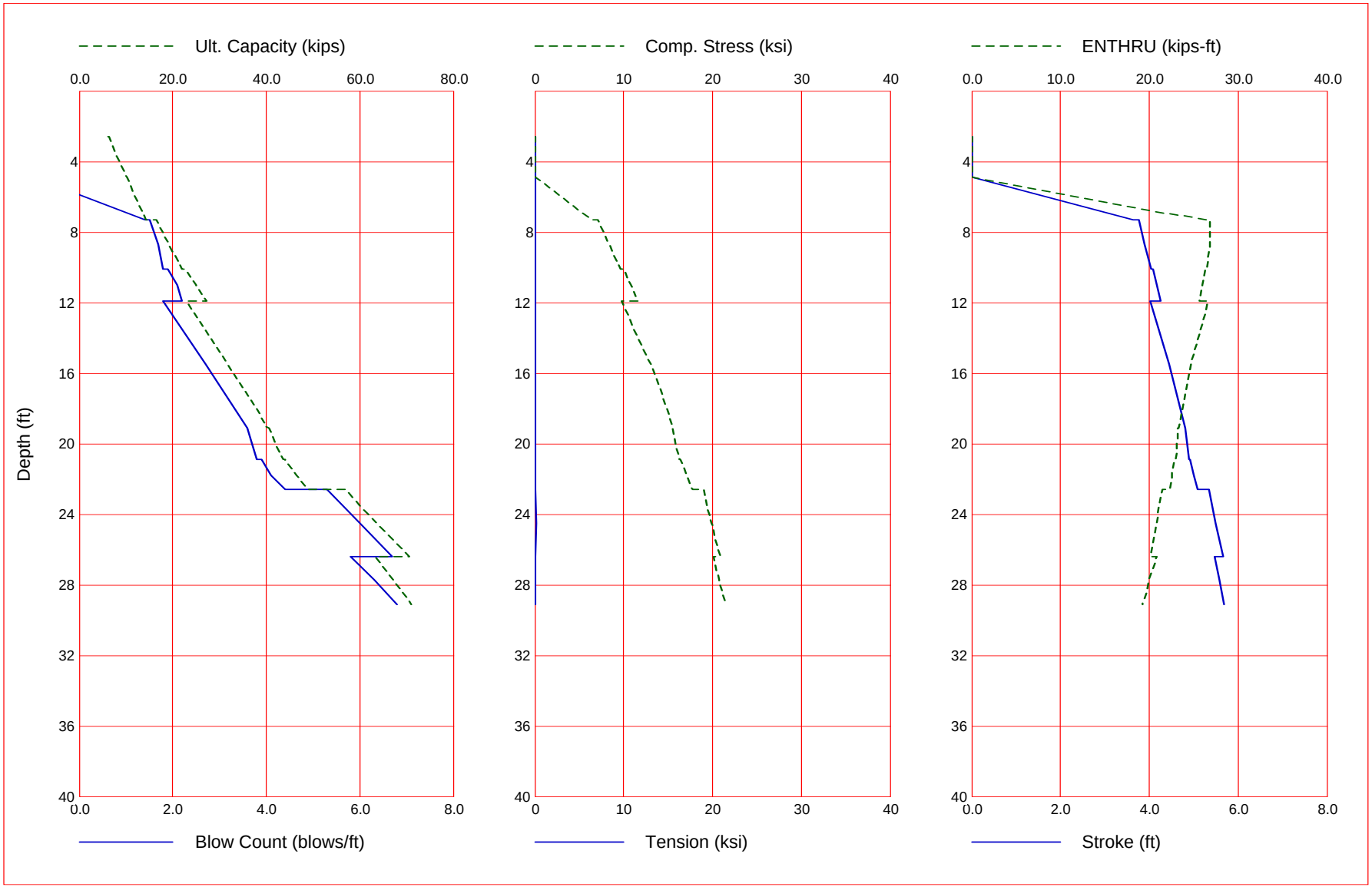
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
2.6	6.2	5.7	0.6	-1.0	0.000	0.000	0.00	0.0
2.6	6.3	5.7	0.5	-1.0	0.000	0.000	0.00	0.0
4.9	10.3	9.8	0.5	-1.0	0.000	0.000	0.00	0.0
7.3	14.3	13.8	0.5	1.4	6.298	0.000	3.64	26.6
7.3	16.5	13.9	2.6	1.5	7.063	0.000	3.77	26.8
8.7	19.1	15.9	3.2	1.7	8.405	0.000	3.90	26.8
10.1	22.0	18.3	3.7	1.8	9.706	0.000	4.04	26.5
10.1	22.8	18.4	4.5	1.9	10.039	0.000	4.08	26.3
11.0	25.0	20.2	4.8	2.1	10.861	0.000	4.16	26.0
11.9	27.3	22.2	5.0	2.2	11.620	0.000	4.26	25.6
11.9	22.9	22.3	0.6	1.8	9.798	0.000	4.03	26.6
15.5	31.6	31.0	0.6	2.7	13.064	0.000	4.45	24.7
19.1	40.3	39.7	0.6	3.6	15.514	0.000	4.81	23.3
19.1	40.6	39.8	0.8	3.6	15.539	0.000	4.82	23.2
20.0	42.1	41.3	0.8	3.7	15.868	0.000	4.86	23.1
20.9	43.6	42.8	0.8	3.8	16.260	0.000	4.90	23.0
20.9	44.0	42.9	1.1	3.9	16.359	0.000	4.91	22.9
21.8	46.5	45.3	1.1	4.1	17.090	0.000	5.00	22.6
22.6	48.9	47.8	1.1	4.4	17.776	0.000	5.09	22.3
22.6	57.0	47.9	9.1	5.3	19.051	0.000	5.34	21.5
24.5	63.6	53.9	9.6	6.0	19.902	-0.115	5.50	20.9
26.4	70.5	60.3	10.2	6.7	20.898	-0.089	5.66	20.2
26.4	63.3	60.4	2.9	5.8	20.117	-0.072	5.47	20.8
27.7	67.1	64.2	2.9	6.3	20.773	0.000	5.58	20.0
29.1	71.0	68.1	2.9	6.8	21.463	0.000	5.69	19.3

Total Continuous Driving Time 2.00 minutes; Total Number of Blows 82 (starting at penetration 2.6 ft)

National Engineering & Architectural Ser
HAM-LMST Ext Ranchvale : 07/18/2022 : KC

Jul 18 2022
GRLWEAP Version 2010

Gain/Loss 3 at Shaft and Toe 0.570 / 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.

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Input File: C:\USERS\KARENS\DESKTOP\GRL FILES\RA10X42.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (10/17/2016)

Input File Contents

HAM-LMST Ext Ranchvale : 07/18/2022 : KC

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	97.720	10.070	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
2.700	12.400	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
29.080	12.40	29000.0	492.000	3.295	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
0.000	0.000	0.000	0.000	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	1.00	0.58	0.10	0.10	0.15	0.15	1.49	6.00	168.000
2.59	1.00	0.58	0.10	0.10	0.15	0.15	1.49	6.00	168.000
2.61	0.92	0.52	0.10	0.12	0.20	0.15	1.75	6.00	168.000
7.29	0.92	0.52	0.10	0.12	0.20	0.15	1.75	6.00	168.000
7.31	0.40	2.62	0.10	0.11	0.05	0.15	1.00	6.00	1.000
10.09	0.57	3.71	0.10	0.11	0.05	0.15	1.00	6.00	1.000
10.11	0.63	4.47	0.10	0.10	0.05	0.15	1.00	6.00	1.000
10.59	0.66	4.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
10.61	0.66	4.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
11.89	0.70	5.02	0.10	0.10	0.05	0.15	1.00	6.00	1.000
11.91	1.10	0.58	0.10	0.12	0.15	0.15	1.49	6.00	168.000
19.09	1.10	0.58	0.10	0.12	0.15	0.15	1.49	6.00	168.000
19.11	0.50	0.78	0.10	0.15	0.05	0.15	1.00	6.00	1.000
20.89	0.53	0.78	0.10	0.15	0.05	0.15	1.00	6.00	1.000
20.91	1.35	1.11	0.10	0.10	0.15	0.15	1.49	6.00	24.000
22.59	1.35	1.11	0.10	0.10	0.15	0.15	1.49	6.00	24.000
22.61	1.13	9.05	0.10	0.10	0.10	0.15	1.21	6.00	24.000
26.39	1.28	10.23	0.10	0.10	0.10	0.15	1.21	6.00	24.000
26.41	1.31	2.89	0.10	0.08	0.15	0.15	1.49	6.00	168.000
29.08	1.31	2.89	0.10	0.08	0.15	0.15	1.49	6.00	168.000

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
2.58	0.00	0.00	0.000	0.0	0.000	0.000	0.000
2.62	0.00	0.00	0.000	0.0	0.000	0.000	0.000
4.95	0.00	0.00	0.000	0.0	0.000	0.000	0.000
7.28	0.00	0.00	0.000	0.0	0.000	0.000	0.000
7.32	0.00	0.00	0.000	0.0	0.000	0.000	0.000
8.70	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.08	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.12	0.00	0.00	0.000	0.0	0.000	0.000	0.000
11.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
11.88	0.00	0.00	0.000	0.0	0.000	0.000	0.000
11.92	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
19.08	0.00	0.00	0.000	0.0	0.000	0.000	0.000
19.12	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.88	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.92	0.00	0.00	0.000	0.0	0.000	0.000	0.000

21.75	0.00	0.00	0.000	0.0	0.000	0.000	0.000
22.58	0.00	0.00	0.000	0.0	0.000	0.000	0.000
22.62	0.00	0.00	0.000	0.0	0.000	0.000	0.000
24.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
26.38	0.00	0.00	0.000	0.0	0.000	0.000	0.000
26.42	0.00	0.00	0.000	0.0	0.000	0.000	0.000
27.73	0.00	0.00	0.000	0.0	0.000	0.000	0.000
29.08	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

HAM-LMST Ext Ranchvale : 07/18/2022 : KC

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	2.700	3286.0	0.800	0.0100	5.8
Combined Pile Top		9274.4			

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)	12.40	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)	3286.0	Stiffness	(kips/in)	0.0

♀

Depth	(ft)	2.6	Standard Soil Setup		
Shaft Gain/Loss Factor		0.484	Toe Gain/Loss Factor		1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 5.7

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	5.1	0.150	0.100	29.08	3.3	12.4
Toe						0.6	0.150	0.100			

1.232 kips total unreduced pile weight (g= 32.17 ft/s2)
1.232 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) 0.435
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
2.58	10.81	1.00	0.800

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
5.7	Hammer did not run										
6.0	Hammer did not run										
6.2	Hammer did not run										
6.5	Hammer did not run										
6.8	Hammer did not run										

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 2.6 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8

29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 5.7

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	5.2	0.150	0.100	29.08	3.3	12.4
Toe						0.5	0.150	0.120			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
2.62	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
5.7	Hammer did not run										
6.0	Hammer did not run										
6.3	Hammer did not run										
6.5	Hammer did not run										
6.8	Hammer did not run										

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 4.9 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 9.1

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	3.4	0.150	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	5.2	0.186	0.100	29.08	3.3	12.4
Toe						0.5	0.150	0.120			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy

4.95	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
9.1	Hammer did not run										
9.7	Hammer did not run										
10.3	Hammer did not run										
10.9	Hammer did not run										
11.5	Hammer did not run										

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth	(ft)	7.3	Standard Soil Setup
Shaft Gain/Loss Factor		0.484	Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area	(in2)	97.720	Pile Type H Pile
Pile Size	(inch)	10.070	

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	12.40	29000.	492.0	3.3	0	16524.	21.8
	29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 12.6

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	1.6	0.150	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	5.7	0.171	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	29.08	3.3	12.4
Toe						0.5	0.150	0.120			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
7.28	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
12.6	Hammer did not run										
13.4	1.4	3.58	3.60	0.00	1	0	6.76	1	7	26.4	62.3
14.3	1.4	3.64	3.66	0.00	1	0	6.30	1	8	26.6	61.8
15.2	1.5	3.70	3.72	0.00	1	0	6.37	1	5	26.8	61.4
16.1	1.5	3.76	3.78	0.00	1	0	6.89	1	5	26.8	60.9

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth	(ft)	7.3	Standard Soil Setup

Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 14.7

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	1.7	0.150	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	5.6	0.172	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	4.8	0.199	0.100	29.08	3.3	12.4
Toe						2.6	0.150	0.110			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
7.32	10.81	1.00	0.800

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
14.7	1.4	3.65	3.68	0.00	1	0	6.23	1	8	26.6	61.8
15.6	1.5	3.72	3.74	0.00	1	0	6.50	1	5	26.8	61.3
16.5	1.5	3.77	3.79	0.00	1	0	7.06	1	5	26.8	60.8
17.4	1.6	3.83	3.85	0.00	1	0	7.69	1	5	26.9	60.4
18.3	1.7	3.89	3.90	0.00	1	0	8.21	1	5	26.8	60.0

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 8.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 17.3

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4

2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	4.4	0.150	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	4.9	0.194	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	4.7	0.160	0.100	29.08	3.3	12.4
Toe						3.2	0.150	0.110			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
8.70	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
17.3	1.6	3.79	3.82	0.00	1	0	7.35	1	5	26.8	60.7
18.2	1.6	3.85	3.87	0.00	1	0	7.89	1	5	26.8	60.3
19.1	1.7	3.90	3.92	0.00	1	0	8.40	1	5	26.8	59.8
20.0	1.7	3.99	3.96	0.00	1	0	9.01	1	5	26.8	59.4
20.8	1.8	4.03	4.01	0.00	1	0	9.45	1	5	26.6	59.0

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 10.1 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 20.2

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	0.8	0.150	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	5.9	0.165	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	5.1	0.085	0.100	29.08	3.3	12.4
Toe						3.7	0.150	0.110			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
10.08	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
20.2	1.7	3.91	3.93	0.00	1	0	8.64	1	5	26.7	59.8
21.1	1.8	4.00	3.96	0.00	1	0	9.29	1	5	26.8	59.3
22.0	1.8	4.04	4.02	0.00	1	0	9.71	1	5	26.5	59.0
22.9	1.9	4.09	4.07	0.00	1	0	10.12	1	5	26.3	58.6
23.8	2.0	4.11	4.13	0.00	1	0	10.41	1	5	25.9	58.3

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 10.1 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
	29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 21.0

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	0.8	0.150	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	5.9	0.166	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	5.1	0.082	0.100	29.08	3.3	12.4
Toe						4.5	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
10.12	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
21.0	1.7	4.00	3.96	0.00	1	0	9.25	1	5	26.8	59.4
21.9	1.8	4.04	4.01	0.00	1	0	9.66	1	5	26.6	59.0
22.8	1.9	4.08	4.06	0.00	1	0	10.04	1	5	26.3	58.7
23.7	2.0	4.10	4.12	0.00	1	0	10.34	1	4	26.0	58.4
24.6	2.1	4.16	4.17	0.00	1	0	10.79	1	4	25.8	58.0

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 11.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 23.3

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	2.6	0.150	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	5.4	0.179	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	4.7	0.189	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	5.8	0.050	0.100	29.08	3.3	12.4
Toe						4.8	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
11.00	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
23.3	1.9	4.07	4.04	0.00	1	0	10.03	1	5	26.5	58.8
24.2	2.0	4.07	4.11	0.00	1	0	10.26	1	5	26.0	58.5
25.0	2.1	4.16	4.14	0.00	1	0	10.86	1	5	26.0	58.1
25.9	2.2	4.16	4.20	0.00	1	0	11.03	1	4	25.5	57.9
26.8	2.2	4.27	4.23	0.00	1	0	11.64	1	5	25.6	57.5

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 11.9 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 25.5

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	4.3	0.150	0.100	19.39	3.3	12.4

7	0.137	9274	0.000	0.000	1.00	5.0	0.193	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	4.7	0.162	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	6.4	0.050	0.100	29.08	3.3	12.4
Toe						5.0	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
11.88	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
25.5	2.0	4.16	4.13	0.00	1	0	10.90	1	4	26.0	58.1
26.4	2.1	4.16	4.19	0.00	1	0	11.07	1	4	25.6	57.9
27.3	2.2	4.26	4.22	0.00	1	0	11.62	1	4	25.6	57.5
28.2	2.3	4.26	4.28	-0.08	6	89	11.79	1	4	25.2	57.3
29.1	2.4	4.30	4.33	0.00	1	0	12.02	1	4	25.0	57.0

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 11.9 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 21.1

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	4.4	0.150	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	4.9	0.194	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	4.7	0.160	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	6.5	0.051	0.100	29.08	3.3	12.4
Toe						0.6	0.150	0.120			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
11.92	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
21.1	1.7	3.90	3.92	0.00	1	0	8.76	1	5	26.8	59.9
22.0	1.7	3.99	3.96	0.00	1	0	9.43	1	5	26.8	59.4
22.9	1.8	4.03	4.01	0.00	1	0	9.80	1	5	26.6	59.0
23.8	1.9	4.08	4.06	0.00	1	0	10.20	1	5	26.3	58.7
24.7	2.0	4.09	4.12	0.00	1	0	10.52	1	4	26.0	58.4

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 15.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 29.0

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	5.1	0.150	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	4.8	0.145	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	6.7	0.069	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	29.08	3.3	12.4
Toe						0.6	0.150	0.120			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
15.50	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
29.0	2.4	4.29	4.32	0.00	5	86	12.16	1	4	25.1	57.0
30.3	2.5	4.35	4.38	0.00	1	0	12.52	1	4	24.7	56.7
31.6	2.7	4.45	4.43	0.00	1	0	13.06	1	4	24.7	56.2
32.9	2.8	4.51	4.49	0.00	1	0	13.40	1	4	24.4	55.8
34.3	2.9	4.57	4.54	0.00	1	0	13.77	1	4	24.2	55.5

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 19.1 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 36.8

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	5.6	0.155	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	4.9	0.128	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	6.8	0.083	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	29.08	3.3	12.4
Toe						0.6	0.150	0.120			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
19.08	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
36.8	3.2	4.67	4.64	0.00	1	0	14.54	1	4	23.8	54.9
38.5	3.4	4.74	4.71	0.00	1	0	15.03	1	4	23.5	54.5
40.3	3.6	4.81	4.78	0.00	1	0	15.51	1	4	23.3	54.1
42.1	3.8	4.88	4.84	0.00	1	0	15.98	1	4	23.0	53.7
43.8	4.0	4.94	4.91	0.00	1	0	16.42	1	4	22.8	53.3

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 19.1 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 37.1

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4

2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	5.7	0.156	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	4.9	0.126	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	6.9	0.085	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	29.08	3.3	12.4
Toe						0.8	0.150	0.150			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
19.12	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
37.1	3.2	4.68	4.65	0.00	1	0	14.62	1	4	23.8	54.8
38.8	3.4	4.75	4.72	0.00	1	0	15.08	1	4	23.5	54.4
40.6	3.6	4.82	4.79	0.00	1	0	15.54	1	4	23.2	54.0
42.3	3.8	4.89	4.85	0.00	1	0	16.01	1	4	23.0	53.6
44.1	4.0	4.95	4.91	0.00	1	0	16.50	1	4	22.8	53.3

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 20.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
	29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 38.5

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	1.2	0.150	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	5.8	0.168	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	5.2	0.068	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	7.1	0.112	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	6.6	0.135	0.100	29.08	3.3	12.4
Toe						0.8	0.150	0.150			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
20.00	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
38.5	3.3	4.72	4.69	0.00	1	0	14.94	1	4	23.6	54.6
40.3	3.5	4.79	4.76	0.00	1	0	15.40	1	4	23.3	54.2
42.1	3.7	4.86	4.82	0.00	1	0	15.87	1	4	23.1	53.8
43.8	3.9	4.92	4.89	0.00	1	0	16.37	1	4	22.9	53.5
45.6	4.1	4.99	4.95	0.00	1	0	16.84	1	4	22.6	53.1

♀

Depth (ft) 20.9 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 40.0

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	3.0	0.150	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	5.3	0.182	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	4.7	0.184	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	5.9	0.050	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	7.1	0.135	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	6.2	0.114	0.100	29.08	3.3	12.4
Toe						0.8	0.150	0.150			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
20.88	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
40.0	3.4	4.76	4.73	0.00	1	0	15.31	1	4	23.5	54.4
41.8	3.6	4.83	4.79	0.00	1	0	15.77	1	4	23.2	54.0
43.6	3.8	4.90	4.86	0.00	1	0	16.26	1	4	23.0	53.6
45.3	4.0	4.96	4.92	0.00	1	0	16.72	1	4	22.7	53.2

47.1	4.2	5.03	4.98	0.00	1	0	17.22	1	4	22.5	52.9

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 20.9 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
	29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 40.5

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	3.0	0.150	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	5.3	0.183	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	4.7	0.183	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	5.9	0.050	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	7.1	0.136	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	6.2	0.113	0.100	29.08	3.3	12.4
Toe						1.1	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
20.92	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
40.5	3.5	4.78	4.75	0.00	1	0	15.39	1	4	23.4	54.2
42.2	3.7	4.85	4.81	0.00	1	0	15.91	1	4	23.1	53.9
44.0	3.9	4.91	4.88	0.00	1	0	16.36	1	4	22.9	53.5
45.7	4.1	4.98	4.94	0.00	1	0	16.88	1	4	22.7	53.2
47.5	4.3	5.04	5.00	0.00	1	0	17.36	1	4	22.5	52.8

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 21.8 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 42.7

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	4.7	0.150	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	4.9	0.196	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	4.7	0.155	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	6.5	0.058	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	22.62	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	6.6	0.116	0.100	29.08	3.3	12.4
Toe						1.1	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
21.75	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
42.7	3.7	4.87	4.83	0.00	1	0	16.04	1	4	23.1	53.8
44.6	3.9	4.93	4.90	0.00	1	0	16.55	1	4	22.8	53.4
46.5	4.1	5.00	4.96	0.00	1	0	17.09	1	4	22.6	53.0
48.3	4.3	5.07	5.03	0.00	1	0	17.59	1	4	22.4	52.6
50.2	4.6	5.13	5.09	0.00	1	0	18.00	1	4	22.1	52.3

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 22.6 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 44.9

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	6.0	0.159	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	4.9	0.113	0.100	16.16	3.3	12.4

6	0.137	9274	0.000	0.000	1.00	7.0	0.093	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	6.9	0.146	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	7.1	0.124	0.100	29.08	3.3	12.4
Toe						1.1	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
22.58	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
44.9	4.0	4.96	4.92	0.00	1	0	16.68	1	4	22.7	53.3
46.9	4.2	5.03	4.99	0.00	1	0	17.23	1	4	22.5	52.9
48.9	4.4	5.09	5.05	0.00	1	0	17.78	1	4	22.3	52.5
50.9	4.6	5.16	5.12	0.00	1	0	18.23	1	4	22.1	52.2
52.9	4.9	5.23	5.18	0.00	1	0	18.61	1	4	21.9	51.8

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 22.6 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 53.0

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	0.0	0.150	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	6.1	0.159	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	4.9	0.111	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	7.0	0.094	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	6.9	0.146	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	7.2	0.124	0.100	29.08	3.3	12.4
Toe						9.1	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
22.62	10.81	1.00	0.800

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
53.0	4.9	5.22	5.18	0.00	1	0	18.35	1	4	21.9	51.8
55.0	5.1	5.28	5.25	0.00	1	0	18.68	1	4	21.6	51.5
57.0	5.3	5.34	5.31	0.00	1	0	19.05	1	4	21.5	51.2
59.0	5.6	5.40	5.37	-0.06	3	50	19.34	1	4	21.2	50.9
61.0	5.8	5.46	5.43	-0.22	3	50	19.66	1	4	21.1	50.6

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 24.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model — Total Capacity Rut (kips) 59.3

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	0.137	9274	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	3.7	0.150	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	5.1	0.188	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	4.7	0.173	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	6.2	0.050	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	7.1	0.143	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	6.4	0.114	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	9.4	0.122	0.100	29.08	3.3	12.4
Toe						9.6	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
24.50	10.81	1.00	0.800

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
59.3	5.5	5.38	5.34	0.00	1	0	19.24	1	4	21.3	51.0
61.4	5.7	5.44	5.41	-0.11	2	50	19.62	1	4	21.1	50.7
63.6	6.0	5.50	5.47	-0.11	2	49	19.90	1	4	20.9	50.4
65.7	6.2	5.56	5.53	-0.12	2	47	20.26	1	4	20.7	50.1
67.8	6.5	5.62	5.60	-0.12	2	46	20.57	1	4	20.6	49.8

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022

Depth (ft) 26.4 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
	29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 66.0

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	0.137	9274	0.010	0.000	0.85	1.0	0.150	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	5.8	0.167	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	5.2	0.075	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	7.1	0.110	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	6.6	0.136	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	7.9	0.126	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	10.3	0.100	0.100	29.08	3.3	12.4
Toe						10.2	0.150	0.100			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
26.38	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
66.0	6.2	5.54	5.52	-0.08	2	47	20.20	1	4	20.6	50.1
68.3	6.4	5.60	5.58	-0.09	2	46	20.57	1	4	20.4	49.9
70.5	6.7	5.66	5.64	-0.09	2	45	20.90	1	4	20.2	49.6
72.8	7.0	5.72	5.70	-0.09	2	45	21.23	1	4	20.1	49.3
75.1	7.3	5.78	5.77	-0.10	2	44	21.55	1	4	19.9	49.1

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 26.4 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
	29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model					Total Capacity Rut (kips)			58.8		
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	0.137	9274	0.010	0.000	0.85	1.1	0.150	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	5.8	0.168	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	5.2	0.071	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	7.1	0.111	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	6.6	0.136	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	7.9	0.126	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	10.3	0.100	0.100	29.08	3.3	12.4
Toe						2.9	0.150	0.080			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
26.42	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
58.8	5.3	5.34	5.30	0.00	1	0	19.36	1	4	21.2	51.2
61.1	5.6	5.41	5.37	-0.07	2	50	19.77	1	4	21.0	50.8
63.3	5.8	5.47	5.44	-0.07	2	49	20.12	1	4	20.8	50.5
65.6	6.1	5.53	5.51	-0.07	2	48	20.49	1	4	20.6	50.2
67.9	6.4	5.60	5.57	-0.08	2	47	20.86	1	4	20.4	49.9

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 27.7 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model					Total Capacity Rut (kips)			62.2		
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	0.137	9274	0.010	0.000	0.85	3.7	0.150	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	5.1	0.188	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	4.7	0.173	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	6.2	0.050	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	7.1	0.143	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	6.4	0.114	0.100	22.62	3.3	12.4

8	0.137	9274	0.000	0.000	1.00	9.4	0.122	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	9.6	0.121	0.100	29.08	3.3	12.4
Toe						2.9	0.150	0.080			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
27.73	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
62.2	5.7	5.44	5.41	0.00	2	49	19.97	1	4	20.4	50.7
64.7	6.0	5.51	5.48	0.00	1	0	20.35	1	4	20.2	50.3
67.1	6.3	5.58	5.55	0.00	1	0	20.77	1	4	20.0	50.0
69.6	6.6	5.64	5.62	0.00	1	0	21.15	1	4	19.8	49.7
72.0	6.9	5.71	5.69	0.00	1	0	21.54	1	4	19.6	49.4

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 29.1 Standard Soil Setup
Shaft Gain/Loss Factor 0.484 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	29000.	492.0	3.3	0	16524.	21.8	
29.1	12.40	29000.	492.0	3.3	0	16524.	21.8	

Wave Travel Time 2L/c (ms) 3.520

Pile and Soil Model Total Capacity Rut (kips) 65.7

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	0.137	9274	0.010	0.000	0.85	6.1	0.159	0.100	3.23	3.3	12.4
2	0.137	9274	0.000	0.000	1.00	4.8	0.200	0.100	6.46	3.3	12.4
3	0.137	9274	0.000	0.000	1.00	4.9	0.111	0.100	9.69	3.3	12.4
4	0.137	9274	0.000	0.000	1.00	7.0	0.094	0.100	12.92	3.3	12.4
5	0.137	9274	0.000	0.000	1.00	7.1	0.150	0.100	16.16	3.3	12.4
6	0.137	9274	0.000	0.000	1.00	6.9	0.146	0.100	19.39	3.3	12.4
7	0.137	9274	0.000	0.000	1.00	7.2	0.124	0.100	22.62	3.3	12.4
8	0.137	9274	0.000	0.000	1.00	10.1	0.100	0.100	25.85	3.3	12.4
9	0.137	9274	0.000	0.000	1.00	8.8	0.142	0.100	29.08	3.3	12.4
Toe						2.9	0.150	0.080			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
29.08	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022

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
65.7	6.2	5.55	5.52	0.00	1	0	20.65	1	4	19.7	50.2
68.4	6.5	5.62	5.59	0.00	1	0	21.07	1	4	19.5	49.8
71.0	6.8	5.69	5.67	0.00	1	0	21.46	1	4	19.3	49.5
73.6	7.1	5.76	5.74	0.00	1	0	21.85	1	4	19.1	49.2
76.3	7.4	5.83	5.81	0.00	1	0	22.23	1	4	18.9	48.9

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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
2.6	5.7	5.1	0.6	Hammer did not run				
2.6	5.7	5.2	0.5	Hammer did not run				
4.9	9.1	8.6	0.5	Hammer did not run				
7.3	12.6	12.0	0.5	Hammer did not run				
7.3	14.7	12.1	2.6	1.4	6.229	0.000	3.65	26.6
8.7	17.3	14.1	3.2	1.6	7.353	0.000	3.79	26.8
10.1	20.2	16.5	3.7	1.7	8.636	0.000	3.91	26.7
10.1	21.0	16.6	4.5	1.7	9.249	0.000	4.00	26.8
11.0	23.3	18.5	4.8	1.9	10.034	0.000	4.07	26.5
11.9	25.5	20.5	5.0	2.0	10.902	0.000	4.16	26.0
11.9	21.1	20.5	0.6	1.7	8.759	0.000	3.90	26.8
15.5	29.0	28.4	0.6	2.4	12.159	-0.003	4.29	25.1
19.1	36.8	36.2	0.6	3.2	14.538	0.000	4.67	23.8
19.1	37.1	36.3	0.8	3.2	14.620	0.000	4.68	23.8
20.0	38.5	37.8	0.8	3.3	14.940	0.000	4.72	23.6
20.9	40.0	39.3	0.8	3.4	15.311	0.000	4.76	23.5
20.9	40.5	39.4	1.1	3.5	15.388	0.000	4.78	23.4
21.8	42.7	41.6	1.1	3.7	16.041	0.000	4.87	23.1
22.6	44.9	43.8	1.1	4.0	16.679	0.000	4.96	22.7
22.6	53.0	43.9	9.1	4.9	18.350	0.000	5.22	21.9
24.5	59.3	49.7	9.6	5.5	19.237	0.000	5.38	21.3
26.4	66.0	55.8	10.2	6.2	20.200	-0.083	5.54	20.6
26.4	58.8	55.9	2.9	5.3	19.361	0.000	5.34	21.2
27.7	62.2	59.3	2.9	5.7	19.967	0.000	5.44	20.4
29.1	65.7	62.8	2.9	6.2	20.648	0.000	5.55	19.7

Total Driving Time 1 minutes; Total No. of Blows 73
Starting at penetration 2.6 ft

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
2.6	6.0	5.4	0.6	Hammer did not run				
2.6	6.0	5.5	0.5	Hammer did not run				
4.9	9.7	9.2	0.5	Hammer did not run				
7.3	13.4	12.9	0.5	1.4	6.760	0.000	3.58	26.4
7.3	15.6	13.0	2.6	1.5	6.497	0.000	3.72	26.8
8.7	18.2	15.0	3.2	1.6	7.894	0.000	3.85	26.8
10.1	21.1	17.4	3.7	1.8	9.289	0.000	4.00	26.8
10.1	21.9	17.5	4.5	1.8	9.660	0.000	4.04	26.6
11.0	24.2	19.4	4.8	2.0	10.260	0.000	4.07	26.0
11.9	26.4	21.4	5.0	2.1	11.066	0.000	4.16	25.6
11.9	22.0	21.4	0.6	1.7	9.429	0.000	3.99	26.8
15.5	30.3	29.7	0.6	2.5	12.520	0.000	4.35	24.7
19.1	38.5	38.0	0.6	3.4	15.034	0.000	4.74	23.5

19.1	38.8	38.1	0.8	3.4	15.077	0.000	4.75	23.5
20.0	40.3	39.5	0.8	3.5	15.405	0.000	4.79	23.3
20.9	41.8	41.0	0.8	3.6	15.771	0.000	4.83	23.2
20.9	42.2	41.1	1.1	3.7	15.912	0.000	4.85	23.1
21.8	44.6	43.5	1.1	3.9	16.553	0.000	4.93	22.8
22.6	46.9	45.8	1.1	4.2	17.230	0.000	5.03	22.5
22.6	55.0	45.9	9.1	5.1	18.679	0.000	5.28	21.6
24.5	61.4	51.8	9.6	5.7	19.625	-0.115	5.44	21.1
26.4	68.3	58.0	10.2	6.4	20.569	-0.089	5.60	20.4
26.4	61.1	58.2	2.9	5.6	19.766	-0.071	5.41	21.0
27.7	64.7	61.8	2.9	6.0	20.355	0.000	5.51	20.2
29.1	68.4	65.5	2.9	6.5	21.069	0.000	5.62	19.5

Total Driving Time 1 minutes; Total No. of Blows 78
Starting at penetration 2.6 ft

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

SUMMARY OVER DEPTHS

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
2.6	6.2	5.7	0.6	Hammer did not run				
2.6	6.3	5.7	0.5	Hammer did not run				
4.9	10.3	9.8	0.5	Hammer did not run				
7.3	14.3	13.8	0.5	1.4	6.298	0.000	3.64	26.6
7.3	16.5	13.9	2.6	1.5	7.063	0.000	3.77	26.8
8.7	19.1	15.9	3.2	1.7	8.405	0.000	3.90	26.8
10.1	22.0	18.3	3.7	1.8	9.706	0.000	4.04	26.5
10.1	22.8	18.4	4.5	1.9	10.039	0.000	4.08	26.3
11.0	25.0	20.2	4.8	2.1	10.861	0.000	4.16	26.0
11.9	27.3	22.2	5.0	2.2	11.620	0.000	4.26	25.6
11.9	22.9	22.3	0.6	1.8	9.798	0.000	4.03	26.6
15.5	31.6	31.0	0.6	2.7	13.064	0.000	4.45	24.7
19.1	40.3	39.7	0.6	3.6	15.514	0.000	4.81	23.3
19.1	40.6	39.8	0.8	3.6	15.539	0.000	4.82	23.2
20.0	42.1	41.3	0.8	3.7	15.868	0.000	4.86	23.1
20.9	43.6	42.8	0.8	3.8	16.260	0.000	4.90	23.0
20.9	44.0	42.9	1.1	3.9	16.359	0.000	4.91	22.9
21.8	46.5	45.3	1.1	4.1	17.090	0.000	5.00	22.6
22.6	48.9	47.8	1.1	4.4	17.776	0.000	5.09	22.3
22.6	57.0	47.9	9.1	5.3	19.051	0.000	5.34	21.5
24.5	63.6	53.9	9.6	6.0	19.902	-0.115	5.50	20.9
26.4	70.5	60.3	10.2	6.7	20.898	-0.089	5.66	20.2
26.4	63.3	60.4	2.9	5.8	20.117	-0.072	5.47	20.8
27.7	67.1	64.2	2.9	6.3	20.773	0.000	5.58	20.0
29.1	71.0	68.1	2.9	6.8	21.463	0.000	5.69	19.3

Total Driving Time 2 minutes; Total No. of Blows 82
Starting at penetration 2.6 ft

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
2.6	6.5	5.9	0.6	Hammer did not run				
2.6	6.5	6.0	0.5	Hammer did not run				
4.9	10.9	10.4	0.5	Hammer did not run				
7.3	15.2	14.7	0.5	1.5	6.374	0.000	3.70	26.8
7.3	17.4	14.8	2.6	1.6	7.686	0.000	3.83	26.9
8.7	20.0	16.8	3.2	1.7	9.009	0.000	3.99	26.8
10.1	22.9	19.2	3.7	1.9	10.119	0.000	4.09	26.3

10.1	23.7	19.2	4.5	2.0	10.345	0.000	4.10	26.0
11.0	25.9	21.1	4.8	2.2	11.035	0.000	4.16	25.5
11.9	28.2	23.1	5.0	2.3	11.787	-0.075	4.26	25.2
11.9	23.8	23.2	0.6	1.9	10.201	0.000	4.08	26.3
15.5	32.9	32.4	0.6	2.8	13.398	0.000	4.51	24.4
19.1	42.1	41.5	0.6	3.8	15.982	0.000	4.88	23.0
19.1	42.3	41.6	0.8	3.8	16.011	0.000	4.89	23.0
20.0	43.8	43.0	0.8	3.9	16.368	0.000	4.92	22.9
20.9	45.3	44.5	0.8	4.0	16.718	0.000	4.96	22.7
20.9	45.7	44.6	1.1	4.1	16.884	0.000	4.98	22.7
21.8	48.3	47.2	1.1	4.3	17.591	0.000	5.07	22.4
22.6	50.9	49.8	1.1	4.6	18.229	0.000	5.16	22.1
22.6	59.0	50.0	9.1	5.6	19.337	-0.062	5.40	21.2
24.5	65.7	56.1	9.6	6.2	20.263	-0.117	5.56	20.7
26.4	72.8	62.6	10.2	7.0	21.225	-0.091	5.72	20.1
26.4	65.6	62.7	2.9	6.1	20.491	-0.068	5.53	20.6
27.7	69.6	66.7	2.9	6.6	21.153	0.000	5.64	19.8
29.1	73.6	70.8	2.9	7.1	21.854	0.000	5.76	19.1

Total Driving Time 2 minutes; Total No. of Blows 84
Starting at penetration 2.6 ft

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.656 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
2.6	6.8	6.2	0.6	Hammer did not run				
2.6	6.8	6.3	0.5	Hammer did not run				
4.9	11.5	11.0	0.5	Hammer did not run				
7.3	16.1	15.6	0.5	1.5	6.888	0.000	3.76	26.8
7.3	18.3	15.7	2.6	1.7	8.210	0.000	3.89	26.8
8.7	20.8	17.7	3.2	1.8	9.449	0.000	4.03	26.6
10.1	23.8	20.1	3.7	2.0	10.409	0.000	4.11	25.9
10.1	24.6	20.1	4.5	2.1	10.789	0.000	4.16	25.8
11.0	26.8	22.0	4.8	2.2	11.644	0.000	4.27	25.6
11.9	29.1	24.0	5.0	2.4	12.019	0.000	4.30	25.0
11.9	24.7	24.1	0.6	2.0	10.515	0.000	4.09	26.0
15.5	34.3	33.7	0.6	2.9	13.768	0.000	4.57	24.2
19.1	43.8	43.2	0.6	4.0	16.417	0.000	4.94	22.8
19.1	44.1	43.3	0.8	4.0	16.499	0.000	4.95	22.8
20.0	45.6	44.8	0.8	4.1	16.839	0.000	4.99	22.6
20.9	47.1	46.3	0.8	4.2	17.223	0.000	5.03	22.5
20.9	47.5	46.4	1.1	4.3	17.358	0.000	5.04	22.5
21.8	50.2	49.1	1.1	4.6	18.003	0.000	5.13	22.1
22.6	52.9	51.8	1.1	4.9	18.610	0.000	5.23	21.9
22.6	61.0	52.0	9.1	5.8	19.662	-0.221	5.46	21.1
24.5	67.8	58.2	9.6	6.5	20.568	-0.123	5.62	20.6
26.4	75.1	64.8	10.2	7.3	21.545	-0.095	5.78	19.9
26.4	67.9	65.0	2.9	6.4	20.865	-0.075	5.60	20.4
27.7	72.0	69.1	2.9	6.9	21.536	0.000	5.71	19.6
29.1	76.3	73.4	2.9	7.4	22.232	0.000	5.83	18.9

Total Driving Time 2 minutes; Total No. of Blows 92
Starting at penetration 2.6 ft

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
2.58	29.08	0.00	10.81	1.00	0.80	1.00	1.00
2.62	29.08	0.00	10.81	1.00	0.80	1.00	1.00
4.95	29.08	0.00	10.81	1.00	0.80	1.00	1.00
7.28	29.08	0.00	10.81	1.00	0.80	1.00	1.00
7.32	29.08	0.00	10.81	1.00	0.80	1.00	1.00
8.70	29.08	0.00	10.81	1.00	0.80	1.00	1.00
10.08	29.08	0.00	10.81	1.00	0.80	1.00	1.00
10.12	29.08	0.00	10.81	1.00	0.80	1.00	1.00
11.00	29.08	0.00	10.81	1.00	0.80	1.00	1.00
11.88	29.08	0.00	10.81	1.00	0.80	1.00	1.00
11.92	29.08	0.00	10.81	1.00	0.80	1.00	1.00
15.50	29.08	0.00	10.81	1.00	0.80	1.00	1.00
19.08	29.08	0.00	10.81	1.00	0.80	1.00	1.00
19.12	29.08	0.00	10.81	1.00	0.80	1.00	1.00
20.00	29.08	0.00	10.81	1.00	0.80	1.00	1.00
20.88	29.08	0.00	10.81	1.00	0.80	1.00	1.00
20.92	29.08	0.00	10.81	1.00	0.80	1.00	1.00
21.75	29.08	0.00	10.81	1.00	0.80	1.00	1.00
22.58	29.08	0.00	10.81	1.00	0.80	1.00	1.00
22.62	29.08	0.00	10.81	1.00	0.80	1.00	1.00
24.50	29.08	0.00	10.81	1.00	0.80	1.00	1.00
26.38	29.08	0.00	10.81	1.00	0.80	1.00	1.00
26.42	29.08	0.00	10.81	1.00	0.80	1.00	1.00
27.73	29.08	0.00	10.81	1.00	0.80	1.00	1.00
29.08	29.08	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	1.00	0.58	0.100	0.100	0.150	0.150	0.768	6.000	168.000
2.59	1.00	0.58	0.100	0.100	0.150	0.150	0.768	6.000	168.000
2.61	0.92	0.52	0.100	0.120	0.200	0.150	1.000	6.000	168.000
7.29	0.92	0.52	0.100	0.120	0.200	0.150	1.000	6.000	168.000
7.31	0.40	2.62	0.100	0.110	0.050	0.150	0.000	6.000	1.000
10.09	0.57	3.71	0.100	0.110	0.050	0.150	0.000	6.000	1.000
10.11	0.63	4.47	0.100	0.100	0.050	0.150	0.000	6.000	1.000
10.59	0.66	4.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000
10.61	0.66	4.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000
11.89	0.70	5.02	0.100	0.100	0.050	0.150	0.000	6.000	1.000
11.91	1.10	0.58	0.100	0.120	0.150	0.150	0.768	6.000	168.000
19.09	1.10	0.58	0.100	0.120	0.150	0.150	0.768	6.000	168.000
19.11	0.50	0.78	0.100	0.150	0.050	0.150	0.000	6.000	1.000
20.89	0.53	0.78	0.100	0.150	0.050	0.150	0.000	6.000	1.000
20.91	1.35	1.11	0.100	0.100	0.150	0.150	0.768	6.000	24.000
22.59	1.35	1.11	0.100	0.100	0.150	0.150	0.768	6.000	24.000
22.61	1.13	9.05	0.100	0.100	0.100	0.150	0.396	6.000	24.000
26.39	1.28	10.23	0.100	0.100	0.100	0.150	0.396	6.000	24.000
26.41	1.31	2.89	0.100	0.080	0.150	0.150	0.768	6.000	168.000
29.08	1.31	2.89	0.100	0.080	0.150	0.150	0.768	6.000	168.000

FORWARD ABUTMENT

Gain/Loss 3 at Shaft and Toe 0.500 / 1.000

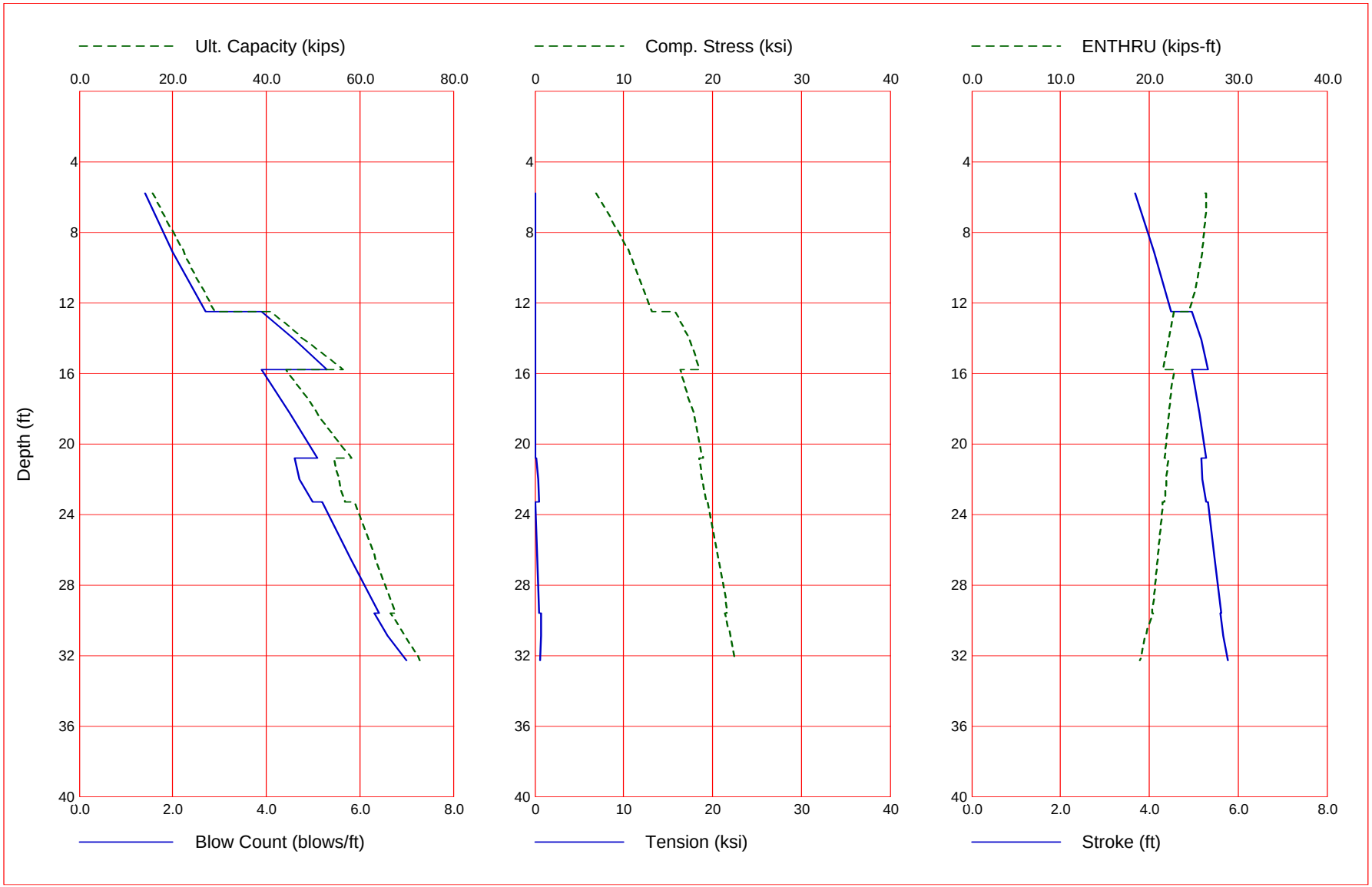
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.8	15.6	14.9	0.7	1.4	6.829	0.000	3.68	26.3
5.8	15.7	15.0	0.8	1.4	6.921	0.000	3.69	26.4
9.1	22.4	21.6	0.8	2.0	10.566	0.000	4.11	26.0
12.5	29.1	28.3	0.8	2.7	13.214	0.000	4.50	24.5
12.5	40.8	28.4	12.4	3.9	15.887	0.000	4.95	22.8
14.1	48.2	33.9	14.3	4.6	17.457	0.000	5.17	22.1
15.8	56.4	40.2	16.2	5.3	18.549	0.000	5.33	21.5
15.8	44.2	40.3	3.9	3.9	16.344	0.000	4.95	22.8
18.3	51.0	46.7	4.2	4.5	17.814	0.000	5.12	22.2
20.8	58.3	54.0	4.3	5.1	18.973	0.000	5.29	21.7
20.8	54.4	54.1	0.3	4.6	18.475	-0.124	5.17	22.1
22.0	55.6	55.3	0.3	4.7	18.824	-0.356	5.20	21.9
23.3	56.8	56.5	0.3	5.0	19.232	-0.514	5.27	21.7
23.3	58.9	56.5	2.3	5.2	19.480	-0.102	5.33	21.5
26.5	63.2	60.9	2.3	5.8	20.612	-0.303	5.48	21.0
29.6	67.5	65.2	2.3	6.4	21.564	-0.530	5.62	20.3
29.6	66.6	65.2	1.4	6.3	21.423	-0.710	5.60	20.4
30.9	69.6	68.3	1.4	6.6	21.975	-0.711	5.67	19.6
32.3	72.8	71.4	1.4	7.0	22.487	-0.591	5.76	18.9

Total Continuous Driving Time 2.00 minutes; Total Number of Blows 116 (starting at penetration 5.8 ft)

National Engineering & Architectural Ser
HAM-LMST Ext Ranchvale : 07/18/2022 : KC

Jul 18 2022
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.

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Input File: C:\USERS\KARENS\DESKTOP\GRL FILES\FA10X42.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (10/17/2016)

Input File Contents

HAM-LMST Ext Ranchvale : 07/18/2022 : KC

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	97.720	10.070	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
2.700	12.400	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
32.280	12.40	30000.0	492.000	3.295	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
0.000	0.000	0.000	0.000	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	1.17	0.71	0.10	0.11	0.15	0.15	1.49	6.00	168.000
5.79	1.17	0.71	0.10	0.11	0.15	0.15	1.49	6.00	168.000
5.81	1.22	0.76	0.10	0.11	0.20	0.15	2.00	6.00	168.000
12.49	1.22	0.76	0.10	0.11	0.20	0.15	2.00	6.00	168.000
12.51	0.95	12.38	0.10	0.09	0.05	0.15	1.00	6.00	1.000
15.79	1.24	16.21	0.10	0.09	0.05	0.15	1.00	6.00	1.000
15.81	0.72	3.89	0.10	0.12	0.05	0.15	1.00	6.00	1.000
18.79	0.87	4.30	0.10	0.12	0.05	0.15	1.00	6.00	1.000
18.81	0.87	4.30	0.10	0.12	0.05	0.15	1.00	6.00	1.000
20.79	0.92	4.30	0.10	0.12	0.05	0.15	1.00	6.00	1.000
20.81	0.60	0.31	0.10	0.13	0.20	0.15	2.00	6.00	168.000
23.29	0.60	0.31	0.10	0.13	0.20	0.15	2.00	6.00	168.000
23.31	0.84	2.31	0.10	0.08	0.20	0.15	2.00	6.00	168.000
29.59	0.84	2.31	0.10	0.08	0.20	0.15	2.00	6.00	168.000
29.61	1.05	1.36	0.10	0.10	0.15	0.15	1.49	6.00	168.000
32.28	1.05	1.36	0.10	0.10	0.15	0.15	1.49	6.00	168.000

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
5.78	0.00	0.00	0.000	0.0	0.000	0.000	0.000
5.82	0.00	0.00	0.000	0.0	0.000	0.000	0.000
9.15	0.00	0.00	0.000	0.0	0.000	0.000	0.000
12.48	0.00	0.00	0.000	0.0	0.000	0.000	0.000
12.52	0.00	0.00	0.000	0.0	0.000	0.000	0.000
14.15	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.78	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.82	0.00	0.00	0.000	0.0	0.000	0.000	0.000
18.30	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.78	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.82	0.00	0.00	0.000	0.0	0.000	0.000	0.000
22.05	0.00	0.00	0.000	0.0	0.000	0.000	0.000
23.28	0.00	0.00	0.000	0.0	0.000	0.000	0.000
23.32	0.00	0.00	0.000	0.0	0.000	0.000	0.000
26.45	0.00	0.00	0.000	0.0	0.000	0.000	0.000
29.58	0.00	0.00	0.000	0.0	0.000	0.000	0.000
29.62	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.93	0.00	0.00	0.000	0.0	0.000	0.000	0.000
32.28	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

HAM-LMST Ext Ranchvale : 07/18/2022 : KC

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	2.700	3286.0	0.800	0.0100	5.8
Combined Pile Top		9603.5			

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)	12.40	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)	3286.0	Stiffness	(kips/in)	0.0

Depth	(ft)	5.8	Standard Soil Setup	
Shaft Gain/Loss Factor		0.400	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	97.720	Pile Type	H Pile
Pile Size	(inch)	10.070		

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	12.40	30000.	492.0	3.3	0	16807.	22.1
32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 14.1

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	5.9	0.150	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	32.28	3.3	12.4
Toe						0.7	0.150	0.110			

1.368 kips total unreduced pile weight (g= 32.17 ft/s2)
1.368 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) 0.443
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
5.78	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC — 07/18/2022
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
14.1	1.3	3.59	3.61	0.00	1	0	6.97	1	6	25.9	62.3
14.8	1.4	3.64	3.66	0.00	1	0	6.71	1	6	26.1	61.9
15.6	1.4	3.68	3.70	0.00	1	0	6.83	1	6	26.3	61.5
16.3	1.5	3.72	3.75	0.00	1	0	7.23	1	6	26.5	61.2
17.0	1.5	3.77	3.79	0.00	1	0	7.62	1	5	26.6	60.9

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC — 07/18/2022
National Engineering & Architectural Ser — GRLWEAP Version 2010

Depth (ft) 5.8 — Standard Soil Setup
Shaft Gain/Loss Factor 0.400 — Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 — Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
	32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 14.2

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4

9	0.137	9603	0.000	0.000	1.00	6.0	0.150	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	32.28	3.3	12.4
Toe						0.8	0.150	0.110			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
5.82	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
14.2	1.3	3.60	3.62	0.00	1	0	6.90	1	6	26.0	62.2
15.0	1.4	3.64	3.67	0.00	1	0	6.75	1	6	26.2	61.8
15.7	1.4	3.69	3.71	0.00	1	0	6.92	1	6	26.4	61.5
16.5	1.5	3.74	3.76	0.00	1	0	7.31	1	6	26.5	61.1
17.2	1.5	3.78	3.80	0.00	1	0	7.78	1	5	26.7	60.8

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 9.1 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
	32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 19.6

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	6.2	0.150	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	7.4	0.152	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	32.28	3.3	12.4
Toe						0.8	0.150	0.110			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
9.15	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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

19.6	1.7	3.99	3.96	0.00	1	0	9.44	1	5	26.8	59.4
21.0	1.8	4.06	4.04	0.00	1	0	10.07	1	5	26.5	58.8
22.4	2.0	4.11	4.13	0.00	1	0	10.57	1	5	26.0	58.3
23.8	2.1	4.21	4.19	0.00	1	0	11.32	1	5	25.8	57.7
25.2	2.3	4.26	4.28	0.00	1	0	11.74	1	5	25.3	57.3

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 12.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
	32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 24.9

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	6.5	0.150	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	7.3	0.154	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	32.28	3.3	12.4
Toe						0.8	0.150	0.110			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
12.48	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
24.9	2.3	4.26	4.28	0.00	1	0	11.88	1	5	25.3	57.3
27.0	2.5	4.36	4.39	0.00	1	0	12.49	1	5	24.8	56.6
29.1	2.7	4.50	4.48	0.00	1	0	13.21	1	5	24.5	55.9
31.2	2.9	4.59	4.57	0.00	1	0	13.76	1	5	24.1	55.3
33.2	3.2	4.69	4.66	0.00	1	0	14.28	1	5	23.8	54.8

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 12.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L ft	b Top in2	Area ksi	E-Mod lb/ft3	Spec Wt ft	Perim	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	30000.	492.0	3.3		0	16807.	22.1
32.3	12.40	30000.	492.0	3.3		0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 36.7

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	6.6	0.150	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	7.3	0.154	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	5.2	0.199	0.100	32.28	3.3	12.4
Toe						12.4	0.150	0.090			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
12.52	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
36.7	3.4	4.79	4.76	0.00	1	0	14.87	1	4	23.4	54.2
38.7	3.7	4.87	4.84	0.00	1	0	15.38	1	4	23.1	53.7
40.8	3.9	4.95	4.92	0.00	1	0	15.89	1	4	22.8	53.3
42.9	4.2	5.03	5.00	0.00	1	0	16.35	1	4	22.5	52.8
45.0	4.4	5.11	5.07	0.00	1	0	16.84	1	4	22.2	52.4

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 14.1 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L ft	b Top in2	Area ksi	E-Mod lb/ft3	Spec Wt ft	Perim	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	30000.	492.0	3.3		0	16807.	22.1
32.3	12.40	30000.	492.0	3.3		0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 44.1

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	2.9	0.150	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	6.1	0.180	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	29.05	3.3	12.4

10	0.137	9603	0.000	0.000	1.00	8.1	0.130	0.100	32.28	3.3	12.4
Toe						14.3	0.150	0.090			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
14.15	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
44.1	4.1	5.02	4.99	0.00	1	0	16.52	1	4	22.6	52.9
46.1	4.4	5.10	5.06	0.00	1	0	16.99	1	4	22.3	52.5
48.2	4.6	5.17	5.13	0.00	1	0	17.46	1	4	22.1	52.1
50.3	4.9	5.24	5.20	0.00	1	0	17.81	1	4	21.8	51.7
52.4	5.1	5.30	5.27	0.00	1	0	18.16	2	4	21.6	51.4

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 15.8 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model Total Capacity Rut (kips) 52.2

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	6.6	0.150	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	7.3	0.155	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	5.3	0.198	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	11.7	0.050	0.100	32.28	3.3	12.4
Toe						16.2	0.150	0.090			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
15.78	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
52.2	4.7	5.19	5.15	0.00	1	0	17.88	1	4	22.0	51.9
54.3	5.0	5.27	5.22	0.00	1	0	18.22	1	4	21.8	51.6
56.4	5.3	5.33	5.29	0.00	1	0	18.55	2	4	21.5	51.2
58.5	5.5	5.39	5.36	0.00	1	0	18.84	2	4	21.3	50.9
60.6	5.8	5.46	5.43	-0.22	6	50	19.16	2	4	21.1	50.6

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 15.8 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
	32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model Total Capacity Rut (kips) 40.1

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	6.7	0.150	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	7.2	0.155	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	5.3	0.197	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	11.7	0.050	0.100	32.28	3.3	12.4
Toe						3.9	0.150	0.120			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.82	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
40.1	3.4	4.78	4.74	0.00	1	0	15.30	1	4	23.5	54.3
42.1	3.7	4.86	4.83	0.00	1	0	15.83	1	4	23.1	53.8
44.2	3.9	4.95	4.91	0.00	1	0	16.34	1	4	22.8	53.3
46.3	4.1	5.02	4.98	0.00	1	0	16.89	1	4	22.6	52.9
48.4	4.4	5.10	5.06	0.00	1	0	17.37	1	4	22.3	52.5

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 18.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile

Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
	32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 46.8

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	5.0	0.150	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	5.5	0.194	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	10.1	0.084	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	9.4	0.050	0.100	32.28	3.3	12.4
Toe						4.2	0.150	0.120			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
18.30	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
46.8	4.0	4.97	4.93	0.00	1	0	16.82	1	4	22.8	53.2
48.9	4.2	5.05	5.00	0.00	1	0	17.37	1	4	22.5	52.8
51.0	4.5	5.12	5.08	0.00	1	0	17.81	1	4	22.2	52.4
53.1	4.7	5.19	5.15	0.00	1	0	18.21	1	4	22.0	52.0
55.1	5.0	5.26	5.22	0.00	1	0	18.58	2	4	21.8	51.6

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 20.8 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
	32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 54.1

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4

4	0.137	9603	0.000	0.000	1.00	3.3	0.150	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	6.0	0.183	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	8.4	0.121	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	10.1	0.050	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	9.3	0.050	0.100	32.28	3.3	12.4
Toe						4.3	0.150	0.120			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
20.78	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
54.1	4.6	5.15	5.10	0.00	1	0	18.21	1	4	22.1	52.2
56.2	4.8	5.22	5.17	0.00	1	0	18.65	1	4	21.9	51.9
58.3	5.1	5.29	5.24	0.00	1	0	18.97	2	4	21.7	51.5
60.4	5.3	5.35	5.31	0.00	1	0	19.36	2	4	21.5	51.1
62.5	5.6	5.42	5.38	-0.29	4	50	19.74	2	4	21.3	50.8

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 20.8 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L ft	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		12.40	30000.	492.0	3.3	0	16807.	22.1
32.3		12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model Total Capacity Rut (kips) 50.2

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
4	0.137	9603	0.000	0.000	1.00	3.4	0.150	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	6.0	0.183	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	8.5	0.119	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	10.1	0.050	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	9.3	0.051	0.100	32.28	3.3	12.4
Toe						0.3	0.150	0.130			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
20.82	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
50.2	4.1	5.02	4.98	-0.04	10	8	17.65	1	4	22.6	53.0
52.3	4.4	5.09	5.05	-0.09	10	8	18.10	1	4	22.3	52.5
54.4	4.6	5.17	5.12	-0.12	10	8	18.48	1	4	22.1	52.1
56.5	4.9	5.24	5.19	-0.17	9	8	18.90	1	4	21.9	51.7
58.5	5.1	5.30	5.26	-0.19	9	8	19.27	2	4	21.6	51.4

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 22.0 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
	32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 51.2

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
4	0.137	9603	0.000	0.000	1.00	6.2	0.150	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	7.4	0.152	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	19.37	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	11.3	0.057	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	8.8	0.050	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	6.8	0.095	0.100	32.28	3.3	12.4
Toe						0.3	0.150	0.130			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
22.05	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
51.2	4.2	5.05	5.01	-0.23	9	8	17.88	1	4	22.5	52.8
53.4	4.5	5.13	5.08	-0.31	9	8	18.38	1	4	22.2	52.3
55.6	4.7	5.20	5.16	-0.36	9	8	18.82	1	4	21.9	51.9
57.8	5.0	5.28	5.24	-0.37	9	8	19.25	1	4	21.7	51.5
60.0	5.3	5.35	5.31	-0.35	9	8	19.64	2	4	21.4	51.1

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 23.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
	32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model Total Capacity Rut (kips) 52.2

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
3	0.137	9603	0.000	0.000	1.00	1.6	0.150	0.100	9.68	3.3	12.4
4	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	6.5	0.171	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	7.0	0.156	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	10.8	0.050	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	9.0	0.050	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	4.2	0.153	0.100	32.28	3.3	12.4
Toe						0.3	0.150	0.130			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
23.28	10.81	1.00	0.800

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
52.2	4.4	5.11	5.07	-0.49	9	8	18.30	1	4	22.3	52.4
54.5	4.7	5.19	5.14	-0.53	9	8	18.80	1	4	22.0	52.0
56.8	5.0	5.27	5.23	-0.51	9	8	19.23	1	4	21.7	51.6
59.1	5.3	5.34	5.30	-0.47	9	8	19.62	2	4	21.4	51.2
61.5	5.5	5.41	5.38	-0.43	9	8	20.06	2	4	21.2	50.8

♀
HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 23.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 54.2

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	0.0	0.000	0.100	6.46	3.3	12.4
3	0.137	9603	0.000	0.000	1.00	1.7	0.150	0.100	9.68	3.3	12.4
4	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	6.5	0.172	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	7.1	0.154	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	10.8	0.050	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	9.0	0.050	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	4.1	0.155	0.100	32.28	3.3	12.4
Toe						2.3	0.150	0.080			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
23.32	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
54.2	4.6	5.18	5.13	-0.15	9	8	18.66	1	4	22.0	52.1
56.5	4.9	5.26	5.21	-0.13	9	8	19.08	1	4	21.8	51.7
58.9	5.2	5.33	5.29	-0.10	9	8	19.48	2	4	21.5	51.3
61.2	5.5	5.40	5.37	-0.12	4	50	19.98	2	4	21.3	50.9
63.5	5.8	5.47	5.44	-0.29	4	50	20.38	2	4	21.0	50.5

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 26.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 57.6

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	0.137	9603	0.010	0.000	0.85	0.0	0.000	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	1.4	0.150	0.100	6.46	3.3	12.4
3	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	9.68	3.3	12.4

4	0.137	9603	0.000	0.000	1.00	6.6	0.170	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	6.9	0.158	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	10.9	0.050	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	9.0	0.050	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	4.3	0.150	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	3.5	0.200	0.100	32.28	3.3	12.4
Toe						2.3	0.150	0.080			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
26.45	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
57.6	5.1	5.31	5.26	-0.51	8	8	19.53	1	4	21.6	51.4
60.4	5.4	5.39	5.36	-0.41	8	8	20.08	2	4	21.3	50.9
63.2	5.8	5.48	5.45	-0.30	8	8	20.61	2	4	21.0	50.5
65.9	6.1	5.56	5.54	-0.18	8	8	21.09	2	4	20.7	50.1
68.7	6.5	5.64	5.62	-0.20	3	47	21.58	2	4	20.5	49.7

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 29.6 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L ft	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		12.40	30000.	492.0	3.3	0	16807.	22.1
32.3		12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model Total Capacity Rut (kips) 61.1

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	0.137	9603	0.010	0.000	0.85	1.2	0.150	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	6.46	3.3	12.4
3	0.137	9603	0.000	0.000	1.00	6.6	0.169	0.100	9.68	3.3	12.4
4	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	6.7	0.162	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	11.0	0.050	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	8.9	0.050	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	4.5	0.144	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	3.5	0.200	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	3.6	0.200	0.100	32.28	3.3	12.4
Toe						2.3	0.150	0.080			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
29.58	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
61.1	5.6	5.43	5.39	-0.94	8	8	20.45	1	4	20.9	50.8
64.3	6.0	5.52	5.50	-0.73	8	8	21.00	1	4	20.6	50.3
67.5	6.4	5.62	5.60	-0.53	8	8	21.56	1	4	20.3	49.8
70.7	6.8	5.71	5.69	-0.32	8	8	22.11	1	4	20.0	49.4
73.9	7.2	5.80	5.78	-0.12	8	8	22.65	1	4	19.8	49.0

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 29.6 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model Total Capacity Rut (kips) 60.2

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	0.137	9603	0.010	0.000	0.85	1.3	0.150	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	6.46	3.3	12.4
3	0.137	9603	0.000	0.000	1.00	6.6	0.169	0.100	9.68	3.3	12.4
4	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	6.8	0.161	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	10.9	0.050	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	9.0	0.050	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	4.5	0.147	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	3.5	0.200	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	3.6	0.200	0.100	32.28	3.3	12.4
Toe						1.4	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
29.62	10.81	1.00	0.800

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
60.2	5.5	5.40	5.37	-1.13	8	8	20.28	1	4	21.0	50.9
63.4	5.9	5.50	5.47	-0.92	8	8	20.86	1	4	20.6	50.4

66.6	6.3	5.60	5.57	-0.71	8	8	21.42	1	4	20.4	49.9
69.8	6.7	5.69	5.67	-0.50	8	8	21.98	1	4	20.1	49.5
73.0	7.1	5.78	5.76	-0.30	8	8	22.52	1	4	19.8	49.1

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

Depth (ft) 30.9 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model Total Capacity Rut (kips) 62.9

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	0.137	9603	0.010	0.000	0.85	4.3	0.150	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	7.5	0.150	0.100	6.46	3.3	12.4
3	0.137	9603	0.000	0.000	1.00	5.7	0.190	0.100	9.68	3.3	12.4
4	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	9.4	0.098	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	9.7	0.050	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	8.4	0.065	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	2.9	0.200	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	3.6	0.200	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	4.9	0.177	0.100	32.28	3.3	12.4
Toe						1.4	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
30.93	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
62.9	5.8	5.48	5.45	-1.16	8	8	20.76	1	4	20.2	50.5
66.3	6.2	5.58	5.55	-0.94	8	8	21.38	1	4	19.9	50.0
69.6	6.6	5.67	5.65	-0.71	8	8	21.97	1	4	19.6	49.6
73.0	7.1	5.77	5.75	-0.48	8	8	22.52	1	4	19.3	49.1
76.3	7.5	5.87	5.85	-0.26	8	8	23.08	1	4	19.1	48.7

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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Depth (ft) 32.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.400 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile

Pile Size (inch) 10.070

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	12.40	30000.	492.0	3.3	0	16807.	22.1
32.3	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 3.841

Pile and Soil Model — Total Capacity Rut (kips) 65.8

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	0.137	9603	0.010	0.000	0.85	7.5	0.150	0.100	3.23	3.3	12.4
2	0.137	9603	0.000	0.000	1.00	7.0	0.161	0.100	6.46	3.3	12.4
3	0.137	9603	0.000	0.000	1.00	5.2	0.200	0.100	9.68	3.3	12.4
4	0.137	9603	0.000	0.000	1.00	5.8	0.184	0.100	12.91	3.3	12.4
5	0.137	9603	0.000	0.000	1.00	11.4	0.050	0.100	16.14	3.3	12.4
6	0.137	9603	0.000	0.000	1.00	8.7	0.050	0.100	19.37	3.3	12.4
7	0.137	9603	0.000	0.000	1.00	5.7	0.118	0.100	22.60	3.3	12.4
8	0.137	9603	0.000	0.000	1.00	3.3	0.200	0.100	25.82	3.3	12.4
9	0.137	9603	0.000	0.000	1.00	3.6	0.200	0.100	29.05	3.3	12.4
10	0.137	9603	0.000	0.000	1.00	6.2	0.157	0.100	32.28	3.3	12.4
Toe						1.4	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
32.28	10.81	1.00	0.800

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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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
65.8	6.1	5.55	5.53	-1.05	7	8	21.24	1	4	19.5	50.1
69.3	6.5	5.66	5.63	-0.82	7	8	21.88	1	4	19.2	49.7
72.8	7.0	5.76	5.74	-0.59	7	8	22.49	1	4	18.9	49.2
76.3	7.5	5.86	5.84	-0.35	7	8	23.07	1	4	18.6	48.8
79.8	8.0	5.90	5.96	-0.07	7	8	23.48	1	4	18.2	48.4

♀

HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

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
5.8	14.1	13.4	0.7	1.3	6.972	0.000	3.59	25.9
5.8	14.2	13.5	0.8	1.3	6.896	0.000	3.60	26.0
9.1	19.6	18.8	0.8	1.7	9.438	0.000	3.99	26.8
12.5	24.9	24.2	0.8	2.3	11.884	0.000	4.26	25.3
12.5	36.7	24.3	12.4	3.4	14.865	0.000	4.79	23.4
14.1	44.1	29.8	14.3	4.1	16.516	0.000	5.02	22.6
15.8	52.2	36.0	16.2	4.7	17.875	0.000	5.19	22.0
15.8	40.1	36.2	3.9	3.4	15.304	0.000	4.78	23.5
18.3	46.8	42.6	4.2	4.0	16.820	0.000	4.97	22.8
20.8	54.1	49.8	4.3	4.6	18.206	0.000	5.15	22.1
20.8	50.2	49.9	0.3	4.1	17.645	-0.043	5.02	22.6
22.0	51.2	50.9	0.3	4.2	17.880	-0.231	5.05	22.5

23.3	52.2	51.8	0.3	4.4	18.301	-0.491	5.11	22.3
23.3	54.2	51.9	2.3	4.6	18.658	-0.152	5.18	22.0
26.5	57.6	55.3	2.3	5.1	19.531	-0.509	5.31	21.6
29.6	61.1	58.8	2.3	5.6	20.451	-0.937	5.43	20.9
29.6	60.2	58.8	1.4	5.5	20.282	-1.129	5.40	21.0
30.9	62.9	61.6	1.4	5.8	20.760	-1.161	5.48	20.2
32.3	65.8	64.4	1.4	6.1	21.237	-1.047	5.55	19.5

Total Driving Time 2 minutes; Total No. of Blows 102
Starting at penetration 5.8 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
5.8	14.8	14.1	0.7	1.4	6.707	0.000	3.64	26.1
5.8	15.0	14.2	0.8	1.4	6.751	0.000	3.64	26.2
9.1	21.0	20.2	0.8	1.8	10.075	0.000	4.06	26.5
12.5	27.0	26.3	0.8	2.5	12.490	0.000	4.36	24.8
12.5	38.7	26.4	12.4	3.7	15.381	0.000	4.87	23.1
14.1	46.1	31.8	14.3	4.4	16.993	0.000	5.10	22.3
15.8	54.3	38.1	16.2	5.0	18.221	0.000	5.27	21.8
15.8	42.1	38.3	3.9	3.7	15.828	0.000	4.86	23.1
18.3	48.9	44.7	4.2	4.2	17.371	0.000	5.05	22.5
20.8	56.2	51.9	4.3	4.8	18.654	0.000	5.22	21.9
20.8	52.3	52.0	0.3	4.4	18.105	-0.090	5.09	22.3
22.0	53.4	53.1	0.3	4.5	18.377	-0.308	5.13	22.2
23.3	54.5	54.2	0.3	4.7	18.799	-0.527	5.19	22.0
23.3	56.5	54.2	2.3	4.9	19.075	-0.133	5.26	21.8
26.5	60.4	58.1	2.3	5.4	20.083	-0.413	5.39	21.3
29.6	64.3	62.0	2.3	6.0	20.999	-0.732	5.52	20.6
29.6	63.4	62.0	1.4	5.9	20.862	-0.922	5.50	20.6
30.9	66.3	64.9	1.4	6.2	21.378	-0.939	5.58	19.9
32.3	69.3	67.9	1.4	6.5	21.876	-0.822	5.66	19.2

Total Driving Time 2 minutes; Total No. of Blows 110
Starting at penetration 5.8 ft

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
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
5.8	15.6	14.9	0.7	1.4	6.829	0.000	3.68	26.3
5.8	15.7	15.0	0.8	1.4	6.921	0.000	3.69	26.4
9.1	22.4	21.6	0.8	2.0	10.566	0.000	4.11	26.0
12.5	29.1	28.3	0.8	2.7	13.214	0.000	4.50	24.5
12.5	40.8	28.4	12.4	3.9	15.887	0.000	4.95	22.8
14.1	48.2	33.9	14.3	4.6	17.457	0.000	5.17	22.1
15.8	56.4	40.2	16.2	5.3	18.549	0.000	5.33	21.5
15.8	44.2	40.3	3.9	3.9	16.344	0.000	4.95	22.8
18.3	51.0	46.7	4.2	4.5	17.814	0.000	5.12	22.2
20.8	58.3	54.0	4.3	5.1	18.973	0.000	5.29	21.7
20.8	54.4	54.1	0.3	4.6	18.475	-0.124	5.17	22.1
22.0	55.6	55.3	0.3	4.7	18.824	-0.356	5.20	21.9
23.3	56.8	56.5	0.3	5.0	19.232	-0.514	5.27	21.7
23.3	58.9	56.5	2.3	5.2	19.480	-0.102	5.33	21.5
26.5	63.2	60.9	2.3	5.8	20.612	-0.303	5.48	21.0
29.6	67.5	65.2	2.3	6.4	21.564	-0.530	5.62	20.3
29.6	66.6	65.2	1.4	6.3	21.423	-0.710	5.60	20.4
30.9	69.6	68.3	1.4	6.6	21.975	-0.711	5.67	19.6

32.3	72.8	71.4	1.4	7.0	22.487	-0.591	5.76	18.9

Total Driving Time 2 minutes; Total No. of Blows 116
Starting at penetration 5.8 ft

G/L at Shaft and Toe: 0.550 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
5.8	16.3	15.6	0.7	1.5	7.225	0.000	3.72	26.5
5.8	16.5	15.7	0.8	1.5	7.314	0.000	3.74	26.5
9.1	23.8	23.0	0.8	2.1	11.324	0.000	4.21	25.8
12.5	31.2	30.4	0.8	2.9	13.764	0.000	4.59	24.1
12.5	42.9	30.5	12.4	4.2	16.351	0.000	5.03	22.5
14.1	50.3	36.0	14.3	4.9	17.813	0.000	5.24	21.8
15.8	58.5	42.3	16.2	5.5	18.841	0.000	5.39	21.3
15.8	46.3	42.4	3.9	4.1	16.888	0.000	5.02	22.6
18.3	53.1	48.8	4.2	4.7	18.207	0.000	5.19	22.0
20.8	60.4	56.1	4.3	5.3	19.362	0.000	5.35	21.5
20.8	56.5	56.2	0.3	4.9	18.903	-0.173	5.24	21.9
22.0	57.8	57.5	0.3	5.0	19.246	-0.370	5.28	21.7
23.3	59.1	58.8	0.3	5.3	19.619	-0.472	5.34	21.4
23.3	61.2	58.9	2.3	5.5	19.978	-0.121	5.40	21.3
26.5	65.9	63.6	2.3	6.1	21.094	-0.179	5.56	20.7
29.6	70.7	68.4	2.3	6.8	22.110	-0.324	5.71	20.0
29.6	69.8	68.4	1.4	6.7	21.977	-0.501	5.69	20.1
30.9	73.0	71.6	1.4	7.1	22.518	-0.479	5.77	19.3
32.3	76.3	74.9	1.4	7.5	23.069	-0.350	5.86	18.6

Total Driving Time 2 minutes; Total No. of Blows 121
Starting at penetration 5.8 ft

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HAM-LMST Ext Ranchvale : 07/18/2022 : KC 07/18/2022
National Engineering & Architectural Ser GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.600 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
5.8	17.0	16.3	0.7	1.5	7.624	0.000	3.77	26.6
5.8	17.2	16.4	0.8	1.5	7.781	0.000	3.78	26.7
9.1	25.2	24.5	0.8	2.3	11.738	0.000	4.26	25.3
12.5	33.2	32.5	0.8	3.2	14.285	0.000	4.69	23.8
12.5	45.0	32.6	12.4	4.4	16.837	0.000	5.11	22.2
14.1	52.4	38.1	14.3	5.1	18.162	0.000	5.30	21.6
15.8	60.6	44.4	16.2	5.8	19.163	-0.223	5.46	21.1
15.8	48.4	44.5	3.9	4.4	17.374	0.000	5.10	22.3
18.3	55.1	50.9	4.2	5.0	18.576	0.000	5.26	21.8
20.8	62.5	58.2	4.3	5.6	19.738	-0.293	5.42	21.3
20.8	58.5	58.2	0.3	5.1	19.273	-0.192	5.30	21.6
22.0	60.0	59.7	0.3	5.3	19.637	-0.354	5.35	21.4
23.3	61.5	61.2	0.3	5.5	20.059	-0.434	5.41	21.2
23.3	63.5	61.2	2.3	5.8	20.385	-0.287	5.47	21.0
26.5	68.7	66.4	2.3	6.5	21.585	-0.200	5.64	20.5
29.6	73.9	71.6	2.3	7.2	22.651	-0.120	5.80	19.8
29.6	73.0	71.6	1.4	7.1	22.521	-0.298	5.78	19.8
30.9	76.3	75.0	1.4	7.5	23.078	-0.258	5.87	19.1
32.3	79.8	78.4	1.4	8.0	23.483	-0.066	5.90	18.2

Total Driving Time 3 minutes; Total No. of Blows 131
Starting at penetration 5.8 ft

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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
5.78	32.28	0.00	10.81	1.00	0.80	1.00	1.00
5.82	32.28	0.00	10.81	1.00	0.80	1.00	1.00
9.15	32.28	0.00	10.81	1.00	0.80	1.00	1.00
12.48	32.28	0.00	10.81	1.00	0.80	1.00	1.00
12.52	32.28	0.00	10.81	1.00	0.80	1.00	1.00
14.15	32.28	0.00	10.81	1.00	0.80	1.00	1.00
15.78	32.28	0.00	10.81	1.00	0.80	1.00	1.00
15.82	32.28	0.00	10.81	1.00	0.80	1.00	1.00
18.30	32.28	0.00	10.81	1.00	0.80	1.00	1.00
20.78	32.28	0.00	10.81	1.00	0.80	1.00	1.00
20.82	32.28	0.00	10.81	1.00	0.80	1.00	1.00
22.05	32.28	0.00	10.81	1.00	0.80	1.00	1.00
23.28	32.28	0.00	10.81	1.00	0.80	1.00	1.00
23.32	32.28	0.00	10.81	1.00	0.80	1.00	1.00
26.45	32.28	0.00	10.81	1.00	0.80	1.00	1.00
29.58	32.28	0.00	10.81	1.00	0.80	1.00	1.00
29.62	32.28	0.00	10.81	1.00	0.80	1.00	1.00
30.93	32.28	0.00	10.81	1.00	0.80	1.00	1.00
32.28	32.28	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	1.17	0.71	0.100	0.110	0.150	0.150	0.660	6.000	168.000
5.79	1.17	0.71	0.100	0.110	0.150	0.150	0.660	6.000	168.000
5.81	1.22	0.76	0.100	0.110	0.200	0.150	1.000	6.000	168.000
12.49	1.22	0.76	0.100	0.110	0.200	0.150	1.000	6.000	168.000
12.51	0.95	12.38	0.100	0.090	0.050	0.150	0.000	6.000	1.000
15.79	1.24	16.21	0.100	0.090	0.050	0.150	0.000	6.000	1.000
15.81	0.72	3.89	0.100	0.120	0.050	0.150	0.000	6.000	1.000
18.79	0.87	4.30	0.100	0.120	0.050	0.150	0.000	6.000	1.000
18.81	0.87	4.30	0.100	0.120	0.050	0.150	0.000	6.000	1.000
20.79	0.92	4.30	0.100	0.120	0.050	0.150	0.000	6.000	1.000
20.81	0.60	0.31	0.100	0.130	0.200	0.150	1.000	6.000	168.000
23.29	0.60	0.31	0.100	0.130	0.200	0.150	1.000	6.000	168.000
23.31	0.84	2.31	0.100	0.080	0.200	0.150	1.000	6.000	168.000
29.59	0.84	2.31	0.100	0.080	0.200	0.150	1.000	6.000	168.000
29.61	1.05	1.36	0.100	0.100	0.150	0.150	0.660	6.000	168.000
32.28	1.05	1.36	0.100	0.100	0.150	0.150	0.660	6.000	168.000

APPENDIX E

DRILLED SHAFT ANALYSIS

PIER 1

Objective: **To estimate Drilled Shaft Resistance in Rock per direction of ODOT.**
Method: **In accordance with AASHTO LRFD Bridge Design Specifications, 9th Ed., November 2020, [Sect. 10.8.3.5.4] and ODOT Geotechnical Design Manual Section 1306.4.2.**

Givens:

Tip Resistance Rock Parameters:

$q_u := 6784\ psi \cdot 0.5 + 200\ psi \cdot 0.5$

$q_u = 3492\ psi$

Uniaxial Compressive Strength of Rock Core.
Note: Per ODOT BDM [Sect. 305.4.2], if shafts are socketed into interbedded rock, use a composite unconfined compressive strength (i.e., weighted average) of the interbedded rock types. If no laboratory UNC tests were performed, use the relative strength descriptions in conjunction with Table 400-6 of ODOT's GDM.

$RQD := 33$ Rock Quality Designation, Unit: Percentage

$GSI := 28.5$ Geological Strength Index (GSI)

$D := 0$ Disturbance Factor, D
0 If typical coring techniques are to be used, 1 if blasting techniques are to be used, and an intermediate value if down hole hammer is to be used, LRFD BDS [Sect. C10.4.6.4]

$\sigma'_{vb} := 3.51\ ksf$ Effective overburden stress at a socket tip elevations

$m_i := 6$ Rock constant, **LRFD BDS Table 10.4.6.4-1**

$$m_b := m_i \cdot e^{\left(\frac{GSI - 100}{28 - 14\,D}\right)} = 0.47$$

$$s := e^{\left(\frac{GSI - 100}{9 - 3\,D}\right)} = 0.00035$$

$$a := \frac{1}{2} + \frac{1}{6} \cdot \left(e^{\frac{-GSI}{15}} - e^{\frac{-20}{3}}\right) = 0.52$$

$$A := \sigma'_{vb} + q_u \cdot \left(m_b \cdot \frac{\sigma'_{vb}}{q_u} + s\right)^a = 29.81\ ksf$$

Other Parameters:

$p_a := 14.7\ psi$ Atmospheric Pressure

Unit Tip Resistance Calculation

$Condition := 2$

Per **ODOT GDM [Sect. 1306.4.2],** use 'Condition=1' unless:

- A rock socket length of less than 1.5 times the shaft diameter is proposed;
- Voids, karst and/or clay filled seams have been identified within 2 times the shaft diameter below the bottom of the rock socket; OR,
- Bedrock of adverse jointing has been identified, such that the structure of the joints will control the mode of bearing failure (If **ODOT GDM Figure 1300-14-b** applies).

$q_{p1} := 2.5 \cdot q_u$

$q_{p1} = 1257.1\ ksf$

Condition 1 - Nominal Unit Tip Resistance, **LRFD [Sect. 10.8.3.5.4c-1]**

$q_{p2} := A + q_u \cdot \left(\langle m_b \rangle \left(\frac{A}{q_u} \right) + s \right)^a$

$q_{p2} = 106.9\ ksf$

Condition 2 - Nominal Unit Tip Resistance, **LRFD [Sect. 10.8.3.5.4c-2]**

$q_p := \text{if}\left(Condition = 1, q_{p1}, q_{p2}\right)$

$q_p = 106.9\ ksf$

Nominal Unit Tip Resistance for Design, **ODOT GDM [Sect. 1306.4.2]**

$\phi_{qp} := 0.50$

Tip Resistance Factor in Rock, **LRFD BDS [Sect. 10.5.5.2.4-1]**

$q_{b\_F} := \phi_{qp} \cdot q_p$ $q_{b\_F} = 53.4\ ksf$

Factored Unit Tip Resistance

Shaft Dimensions/Properties

$D := 3\ ft$

Diameter of Drill Shaft

$D_R := D - 6\ in = 2.5\ ft$

Diameter of Rock Socket (assuming 6 in smaller than Diameter of Drilled Shaft), **ODOT BDM [Sect. 305.4.4.2]**

$A_p := \pi \cdot \left(\frac{D_R}{2} \right)^2$ $A_p = 4.9\ ft^2$

Area of Shaft Tip

Shaft Tip Resistance

$R_p := q_p \cdot A_p$ $R_p = 524.7\ kip$

Nominal Shaft Tip Resistance

$\phi_{qp} \cdot R_p = 262.3\ kip$

Factored Shaft Tip Resistance

Note:

2. Geotechnical resistances of rock-socketed drilled shafts are not limited by the structural strength of the concrete. If the concrete strength limits resistance structurally, the drilled shafts can be modified in construction to use a higher strength concrete to take advantage of more of the geotechnical resistance.

APPENDIX F

SETTLEMENT ANALYSIS

REAR ABUTMENT

HAM-LMST Ext to Elstun

PROJECT IDENTIFICATION

Title: HAM-LMST Ext to Elstun
Project Number: PID 113602 -
Client: Stantec
Designer: KCA
Station Number:

Description:
Settlement Analysis at Rear Abutment

Company's information:

Name: NEAS Inc.
Street: 2800 Corporate Exchange Drive
Suite 240
Columbus, OH 43231
Telephone #: 614-354-7558
Fax #:
E-Mail: brendan.andrews@neasinc.com

Original file path and name: C:\Users\karens\Desktop\FoSSA1_RearAbutment080422.2ST
Original date and time of creating this file: Thu Aug 04 10:12:37 2022

GEOMETRY: Analysis of a 2D geometry

INPUT DATA – FOUNDATION LAYERS – 8 layers

	Wet Unit Weight, γ [lb/ft³]	Poisson's Ratio μ	Description of Soil
1	130.00	0.40	Layer 1 - Cohesive
2	125.00	0.25	Layer 2 - Granular
3	130.00	0.40	Layer 3 - Cohesive
4	125.00	0.25	Layer 4 - Granular
5	130.00	0.40	Layer 5 - Cohesive
6	125.00	0.25	Layer 6 - Granular
7	130.00	0.40	Layer 7 - Cohesive
8	160.00	0.20	Bedrock

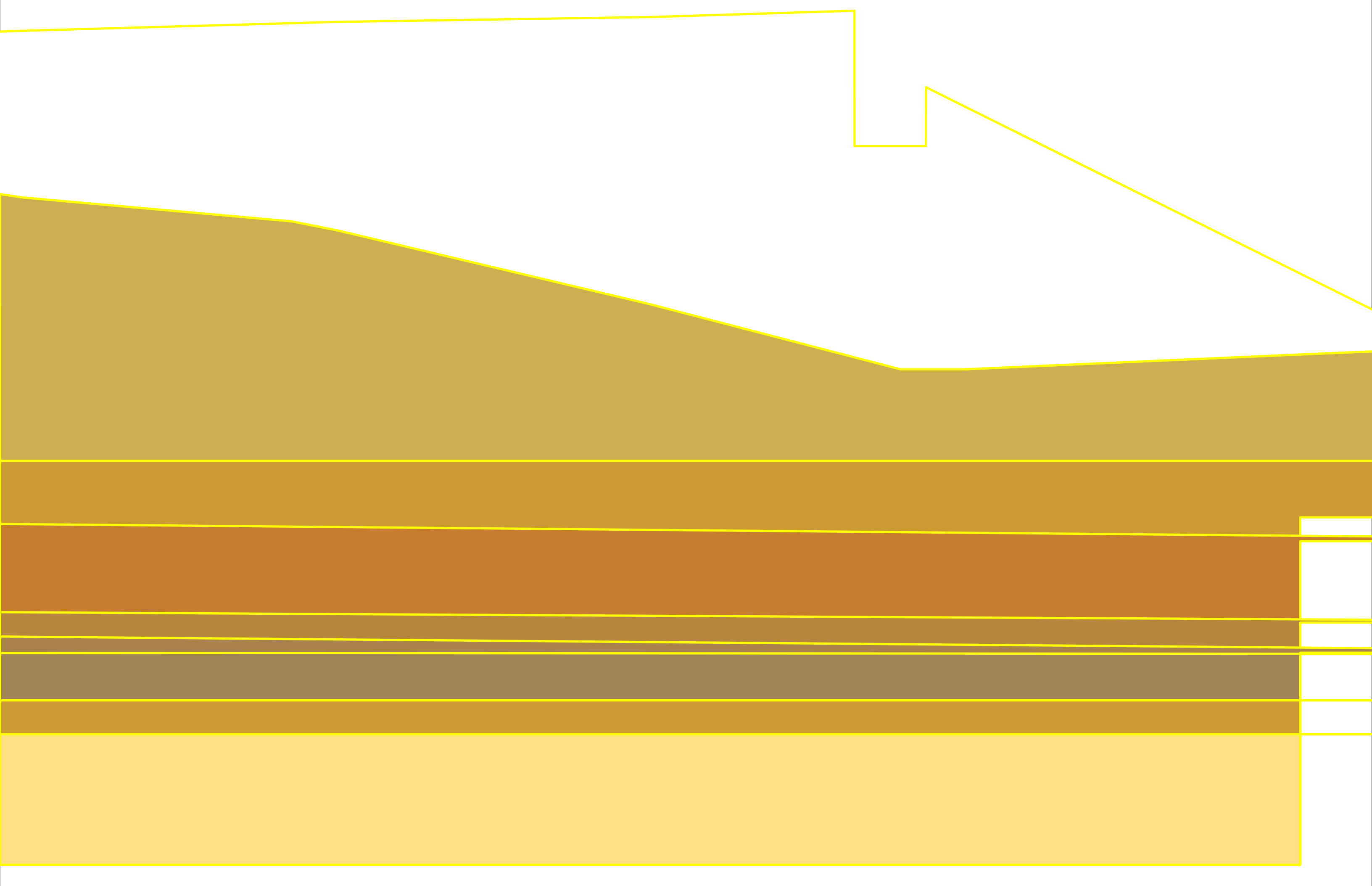
INPUT DATA – EMBANKMENT LAYERS -- 1 layers

	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	465.10
2	200.00	465.10

DRAWING OF SPECIFIED GEOMETRY



INPUT DATA FOR CONSOLIDATION –– α = 1/2

Layer #	Underging Consolidation [Yes/No]	OCR = Pc / Po	Cc	Cr	e0	Cv [ft ²/day]	Drains at :
1	Yes	5.80	0.102	0.012	0.448	0.2000	Top & Bot.
2	No	N/A	N/A	N/A	N/A	N/A	N/A
3	Yes	1.80	0.102	0.012	0.448	0.2000	Top & Bot.
4	No	N/A	N/A	N/A	N/A	N/A	N/A
5	Yes	1.50	0.102	0.012	0.448	0.2000	Top & Bot.
6	No	N/A	N/A	N/A	N/A	N/A	N/A
7	Yes	1.30	0.102	0.012	0.448	0.2000	Top & Bot.
8	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	0.00	0.00	1	946000	0.4000	0.0039	491.70	491.69	0.01
			2	492000	0.2500	0.0036			
			3	946000	0.4000	0.0013			
			4	492000	0.2500	0.0015			
			5	946000	0.4000	0.0004			
			6	492000	0.2500	0.0032			
			7	946000	0.4000	0.0007			
			8	1000000000(	0.2000	0.0000			
2	5.00	0.00	1	946000	0.4000	0.0094	491.70	491.68	0.02
			2	492000	0.2500	0.0049			
			3	946000	0.4000	0.0021			
			4	492000	0.2500	0.0020			
			5	946000	0.4000	0.0006			
			6	492000	0.2500	0.0040			
			7	946000	0.4000	0.0009			
			8	1000000000(	0.2000	0.0000			
3	10.00	0.00	1	946000	0.4000	0.0110	491.70	491.67	0.03
			2	492000	0.2500	0.0061			
			3	946000	0.4000	0.0028			
			4	492000	0.2500	0.0024			
			5	946000	0.4000	0.0007			
			6	492000	0.2500	0.0048			
			7	946000	0.4000	0.0012			
			8	1000000000(	0.2000	0.0000			
4	15.00	0.00	1	946000	0.4000	0.0116	491.70	491.67	0.03
			2	492000	0.2500	0.0071			
			3	946000	0.4000	0.0034			
			4	492000	0.2500	0.0027			
			5	946000	0.4000	0.0008			
			6	492000	0.2500	0.0055			
			7	946000	0.4000	0.0014			
			8	1000000000(	0.2000	0.0000			
5	20.00	0.00	1	946000	0.4000	0.0119	491.70	491.66	0.04
			2	492000	0.2500	0.0079			
			3	946000	0.4000	0.0039			
			4	492000	0.2500	0.0031			
			5	946000	0.4000	0.0009			
			6	492000	0.2500	0.0062			
			7	946000	0.4000	0.0017			
			8	1000000000(	0.2000	0.0000			
6	25.00	0.00	1	946000	0.4000	0.0120	491.70	491.66	0.04
			2	492000	0.2500	0.0085			
			3	946000	0.4000	0.0043			
			4	492000	0.2500	0.0034			
			5	946000	0.4000	0.0010			
			6	492000	0.2500	0.0068			
			7	946000	0.4000	0.0019			
			8	1000000000(	0.2000	0.0000			

*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.]
7	30.00	0.00	1	946000	0.4000	0.0120	491.57	491.53	0.04
			2	492000	0.2500	0.0090			
			3	946000	0.4000	0.0047			
			4	492000	0.2500	0.0036			
			5	946000	0.4000	0.0011			
			6	492000	0.2500	0.0074			
			7	946000	0.4000	0.0021			
			8	1000000000(	0.2000	0.0000			
8	35.00	0.00	1	946000	0.4000	0.0124	491.43	491.39	0.04
			2	492000	0.2500	0.0096			
			3	946000	0.4000	0.0050			
			4	492000	0.2500	0.0039			
			5	946000	0.4000	0.0012			
			6	492000	0.2500	0.0079			
			7	946000	0.4000	0.0023			
			8	1000000000(	0.2000	0.0000			
9	40.00	0.00	1	946000	0.4000	0.0128	490.86	490.81	0.05
			2	492000	0.2500	0.0109			
			3	946000	0.4000	0.0054			
			4	492000	0.2500	0.0042			
			5	946000	0.4000	0.0013			
			6	492000	0.2500	0.0085			
			7	946000	0.4000	0.0024			
			8	1000000000(	0.2000	0.0000			
10	45.00	0.00	1	946000	0.4000	0.0135	490.13	490.08	0.05
			2	492000	0.2500	0.0115			
			3	946000	0.4000	0.0058			
			4	492000	0.2500	0.0045			
			5	946000	0.4000	0.0014			
			6	492000	0.2500	0.0091			
			7	946000	0.4000	0.0026			
			8	1000000000(	0.2000	0.0000			
11	50.00	0.00	1	946000	0.4000	0.0139	489.40	489.35	0.05
			2	492000	0.2500	0.0122			
			3	946000	0.4000	0.0062			
			4	492000	0.2500	0.0047			
			5	946000	0.4000	0.0012			
			6	492000	0.2500	0.0096			
			7	946000	0.4000	0.0028			
			8	1000000000(	0.2000	0.0000			
12	55.00	0.00	1	946000	0.4000	0.0145	488.96	488.90	0.05
			2	492000	0.2500	0.0130			
			3	946000	0.4000	0.0066			
			4	492000	0.2500	0.0050			
			5	946000	0.4000	0.0013			
			6	492000	0.2500	0.0102			
			7	946000	0.4000	0.0030			
			8	1000000000(	0.2000	0.0000			

*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.]
13	60.00	0.00	1	946000	0.4000	0.0150	488.51	488.45	0.06
			2	492000	0.2500	0.0137			
			3	946000	0.4000	0.0071			
			4	492000	0.2500	0.0062			
			5	946000	0.4000	0.0014			
			6	492000	0.2500	0.0108			
			7	946000	0.4000	0.0032			
			8	1000000000(	0.2000	0.0000			
14	65.00	0.00	1	946000	0.4000	0.0153	488.07	488.01	0.06
			2	492000	0.2500	0.0145			
			3	946000	0.4000	0.0076			
			4	492000	0.2500	0.0066			
			5	946000	0.4000	0.0015			
			6	492000	0.2500	0.0114			
			7	946000	0.4000	0.0034			
			8	1000000000(	0.2000	0.0000			
15	70.00	0.00	1	946000	0.4000	0.0161	487.62	487.56	0.06
			2	492000	0.2500	0.0154			
			3	946000	0.4000	0.0081			
			4	492000	0.2500	0.0069			
			5	946000	0.4000	0.0016			
			6	492000	0.2500	0.0120			
			7	946000	0.4000	0.0036			
			8	1000000000(	0.2000	0.0000			
16	75.00	0.00	1	946000	0.4000	0.0170	486.80	486.73	0.07
			2	492000	0.2500	0.0174			
			3	946000	0.4000	0.0087			
			4	492000	0.2500	0.0073			
			5	946000	0.4000	0.0017			
			6	492000	0.2500	0.0125			
			7	946000	0.4000	0.0038			
			8	1000000000(	0.2000	0.0000			
17	80.00	0.00	1	946000	0.4000	0.0175	485.62	485.55	0.07
			2	492000	0.2500	0.0184			
			3	946000	0.4000	0.0093			
			4	492000	0.2500	0.0077			
			5	946000	0.4000	0.0018			
			6	492000	0.2500	0.0131			
			7	946000	0.4000	0.0040			
			8	1000000000(	0.2000	0.0000			
18	85.00	0.00	1	946000	0.4000	0.0179	484.44	484.36	0.08
			2	492000	0.2500	0.0195			
			3	946000	0.4000	0.0099			
			4	492000	0.2500	0.0080			
			5	946000	0.4000	0.0019			
			6	492000	0.2500	0.0137			
			7	946000	0.4000	0.0042			
			8	1000000000(	0.2000	0.0000			

*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.]
19	90.00	0.00	1	946000	0.4000	0.0187	483.26	483.18	0.08
			2	492000	0.2500	0.0206			
			3	946000	0.4000	0.0100			
			4	492000	0.2500	0.0083			
			5	946000	0.4000	0.0015			
			6	492000	0.2500	0.0141			
			7	946000	0.4000	0.0044			
			8	1000000000(	0.2000	0.0000			
20	95.00	0.00	1	946000	0.4000	0.0187	482.08	482.00	0.08
			2	492000	0.2500	0.0215			
			3	946000	0.4000	0.0105			
			4	492000	0.2500	0.0085			
			5	946000	0.4000	0.0016			
			6	492000	0.2500	0.0145			
			7	946000	0.4000	0.0045			
			8	1000000000(	0.2000	0.0000			
21	100.00	0.00	1	946000	0.4000	0.0188	480.90	480.82	0.08
			2	492000	0.2500	0.0222			
			3	946000	0.4000	0.0108			
			4	492000	0.2500	0.0087			
			5	946000	0.4000	0.0016			
			6	492000	0.2500	0.0147			
			7	946000	0.4000	0.0046			
			8	1000000000(	0.2000	0.0000			
22	105.00	0.00	1	946000	0.4000	0.0178	479.60	479.52	0.08
			2	492000	0.2500	0.0225			
			3	946000	0.4000	0.0110			
			4	492000	0.2500	0.0087			
			5	946000	0.4000	0.0016			
			6	492000	0.2500	0.0146			
			7	946000	0.4000	0.0046			
			8	1000000000(	0.2000	0.0000			
23	110.00	0.00	1	946000	0.4000	0.0159	478.30	478.22	0.08
			2	492000	0.2500	0.0237			
			3	946000	0.4000	0.0109			
			4	492000	0.2500	0.0086			
			5	946000	0.4000	0.0016			
			6	492000	0.2500	0.0144			
			7	946000	0.4000	0.0045			
			8	1000000000(	0.2000	0.0000			
24	115.00	0.00	1	946000	0.4000	0.0133	477.00	476.93	0.07
			2	492000	0.2500	0.0229			
			3	946000	0.4000	0.0105			
			4	492000	0.2500	0.0083			
			5	946000	0.4000	0.0015			
			6	492000	0.2500	0.0139			
			7	946000	0.4000	0.0043			
			8	1000000000(	0.2000	0.0000			

*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.]
25	120.00	0.00	1	946000	0.4000	0.0106	475.70	475.63	0.07
			2	492000	0.2500	0.0216			
			3	946000	0.4000	0.0099			
			4	492000	0.2500	0.0079			
			5	946000	0.4000	0.0014			
			6	492000	0.2500	0.0133			
			7	946000	0.4000	0.0041			
			8	1000000000(	0.2000	0.0000			
26	125.00	0.00	1	946000	0.4000	0.0096	475.70	475.64	0.06
			2	492000	0.2500	0.0199			
			3	946000	0.4000	0.0090			
			4	492000	0.2500	0.0073			
			5	946000	0.4000	0.0013			
			6	492000	0.2500	0.0123			
			7	946000	0.4000	0.0038			
			8	1000000000(	0.2000	0.0000			
27	130.00	0.00	1	946000	0.4000	0.0084	475.92	475.86	0.06
			2	492000	0.2500	0.0179			
			3	946000	0.4000	0.0080			
			4	492000	0.2500	0.0066			
			5	946000	0.4000	0.0012			
			6	492000	0.2500	0.0113			
			7	946000	0.4000	0.0034			
			8	1000000000(	0.2000	0.0000			
28	135.00	0.00	1	946000	0.4000	0.0074	476.14	476.09	0.05
			2	492000	0.2500	0.0157			
			3	946000	0.4000	0.0069			
			4	492000	0.2500	0.0059			
			5	946000	0.4000	0.0007			
			6	492000	0.2500	0.0101			
			7	946000	0.4000	0.0030			
			8	1000000000(	0.2000	0.0000			
29	140.00	0.00	1	946000	0.4000	0.0060	476.36	476.32	0.04
			2	492000	0.2500	0.0132			
			3	946000	0.4000	0.0057			
			4	492000	0.2500	0.0051			
			5	946000	0.4000	0.0006			
			6	492000	0.2500	0.0088			
			7	946000	0.4000	0.0026			
			8	1000000000(	0.2000	0.0000			
30	145.00	0.00	1	946000	0.4000	0.0043	476.58	476.55	0.03
			2	492000	0.2500	0.0106			
			3	946000	0.4000	0.0044			
			4	492000	0.2500	0.0043			
			5	946000	0.4000	0.0005			
			6	492000	0.2500	0.0074			
			7	946000	0.4000	0.0021			
			8	1000000000(	0.2000	0.0000			

*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.]
31	150.00	0.00	1	946000	0.4000	0.0027	476.80	476.77	0.03
			2	492000	0.2500	0.0085			
			3	946000	0.4000	0.0032			
			4	492000	0.2500	0.0035			
			5	946000	0.4000	0.0004			
			6	492000	0.2500	0.0061			
			7	946000	0.4000	0.0017			
			8	1000000000(	0.2000	0.0000			
32	155.00	0.00	1	946000	0.4000	0.0011	477.02	477.00	0.02
			2	492000	0.2500	0.0061			
			3	946000	0.4000	0.0020			
			4	492000	0.2500	0.0027			
			5	946000	0.4000	0.0003			
			6	492000	0.2500	0.0049			
			7	946000	0.4000	0.0012			
			8	1000000000(	0.2000	0.0000			
33	160.00	0.00	1	946000	0.4000	-0.0003	477.23	477.22	0.01
			2	492000	0.2500	0.0039			
			3	946000	0.4000	0.0010			
			4	492000	0.2500	0.0020			
			5	946000	0.4000	0.0002			
			6	492000	0.2500	0.0038			
			7	946000	0.4000	0.0008			
			8	1000000000(	0.2000	0.0000			
34	165.00	0.00	1	946000	0.4000	-0.0013	477.42	477.42	0.01
			2	492000	0.2500	0.0022			
			3	946000	0.4000	0.0002			
			4	492000	0.2500	0.0014			
			5	946000	0.4000	0.0001			
			6	492000	0.2500	0.0028			
			7	946000	0.4000	0.0005			
			8	1000000000(	0.2000	0.0000			
35	170.00	0.00	1	946000	0.4000	-0.0019	477.51	477.51	0.00
			2	492000	0.2500	0.0009			
			3	946000	0.4000	-0.0004			
			4	492000	0.2500	0.0011			
			5	946000	0.4000	0.0000			
			6	492000	0.2500	0.0019			
			7	946000	0.4000	0.0002			
			8	1000000000(	0.2000	0.0000			

*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	0.00	0.00	491.70	0.05	491.65
2	5.00	0.00	491.70	0.07	491.63
3	10.00	0.00	491.70	0.08	491.62
4	15.00	0.00	491.70	0.08	491.62
5	20.00	0.00	491.70	0.08	491.62
6	25.00	0.00	491.70	0.09	491.61
7	30.00	0.00	491.57	0.09	491.47
8	35.00	0.00	491.43	0.10	491.34
9	40.00	0.00	490.86	0.11	490.75
10	45.00	0.00	490.13	0.12	490.01
11	50.00	0.00	489.40	0.12	489.28
12	55.00	0.00	488.96	0.13	488.82
13	60.00	0.00	488.51	0.14	488.37
14	65.00	0.00	488.07	0.14	487.92
15	70.00	0.00	487.62	0.15	487.47
16	75.00	0.00	486.80	0.16	486.64
17	80.00	0.00	485.62	0.17	485.45
18	85.00	0.00	484.44	0.18	484.26
19	90.00	0.00	483.26	0.19	483.07
20	95.00	0.00	482.08	0.20	481.88
21	100.00	0.00	480.90	0.21	480.69
22	105.00	0.00	479.60	0.22	479.38
23	110.00	0.00	478.30	0.22	478.08
24	115.00	0.00	477.00	0.22	476.78
25	120.00	0.00	475.70	0.21	475.49

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

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
26	125.00	0.00	475.70	0.19	475.51
27	130.00	0.00	475.92	0.17	475.75
28	135.00	0.00	476.14	0.14	476.00
29	140.00	0.00	476.36	0.11	476.25
30	145.00	0.00	476.58	0.08	476.50
31	150.00	0.00	476.80	0.06	476.74
32	155.00	0.00	477.02	0.04	476.97
33	160.00	0.00	477.23	0.03	477.20
34	165.00	0.00	477.42	0.03	477.40
35	170.00	0.00	477.51	0.02	477.49

*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.]	D E S C R I P T I O N
1	1	0.00	491.70	Layer 1 - Cohesive
	2	25.00	491.70	
	3	36.30	491.40	
	4	50.00	489.40	
	5	71.40	487.50	
	6	75.00	486.80	
	7	100.00	480.90	
	8	120.00	475.70	
	9	125.00	475.70	
	10	150.00	476.80	
	11	163.80	477.40	
	12	175.00	477.60	
	13	181.60	475.90	
	14	185.00	468.41	
	15	186.40	465.51	
	16	200.00	463.91	
2	1	0.00	468.40	Layer 2 - Granular
	2	185.00	468.40	
	3	186.40	465.50	
	4	200.00	463.90	
3	1	0.00	463.80	Layer 3 - Cohesive
	2	200.00	462.00	
4	1	0.00	456.60	Layer 4 - Granular
	2	200.00	455.50	
5	1	0.00	454.80	Layer 5 - Cohesive
	2	200.00	453.10	
6	1	0.00	453.10	Layer 6 - Granular
	2	200.00	453.00	
7	1	0.00	449.30	Layer 7 - Cohesive
	2	200.00	449.30	
8	1	0.00	446.60	Bedrock
	2	200.00	446.60	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #		Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	X1 = 0.00 [ft]	1	0.00	500.70	Proposed Embankment
	X2 = 163.80 [ft]	2	25.00	501.80	
		3	50.00	502.70	
		4	75.00	503.40	
		5	100.00	503.80	
		6	116.30	504.30	
		7	116.31	493.50	
		8	122.00	493.50	
		9	122.01	498.20	
		10	163.80	477.40	

FORWARD ABUTMENT

HAM-LMST Ext to Elstun

PROJECT IDENTIFICATION

Title: HAM-LMST Ext to Elstun
Project Number: PID 113602 -
Client: Stantec
Designer: KCA
Station Number:

Description:
Settlement Analysis at Rear Abutment

Company's information:

Name: NEAS Inc.
Street: 2800 Corporate Exchange Drive
Suite 240
Columbus, OH 43231
Telephone #: 614-354-7558
Fax #:
E-Mail: brendan.andrews@neasinc.com

Original file path and name: C:\Users\karens\Desktop\FoSSA1_ForwardAbutment080422.2ST
Original date and time of creating this file: Thu Aug 04 10:12:37 2022

GEOMETRY: Analysis of a 2D geometry

INPUT DATA – FOUNDATION LAYERS – 4 layers

	Wet Unit Weight, γ [lb/ft³]	Poisson's Ratio μ	Description of Soil
1	130.00	0.40	Layer 1 - Cohesive
2	125.00	0.25	Layer 2 - Granular
3	130.00	0.40	Layer 3 - Cohesive
4	160.00	0.20	Bedrock

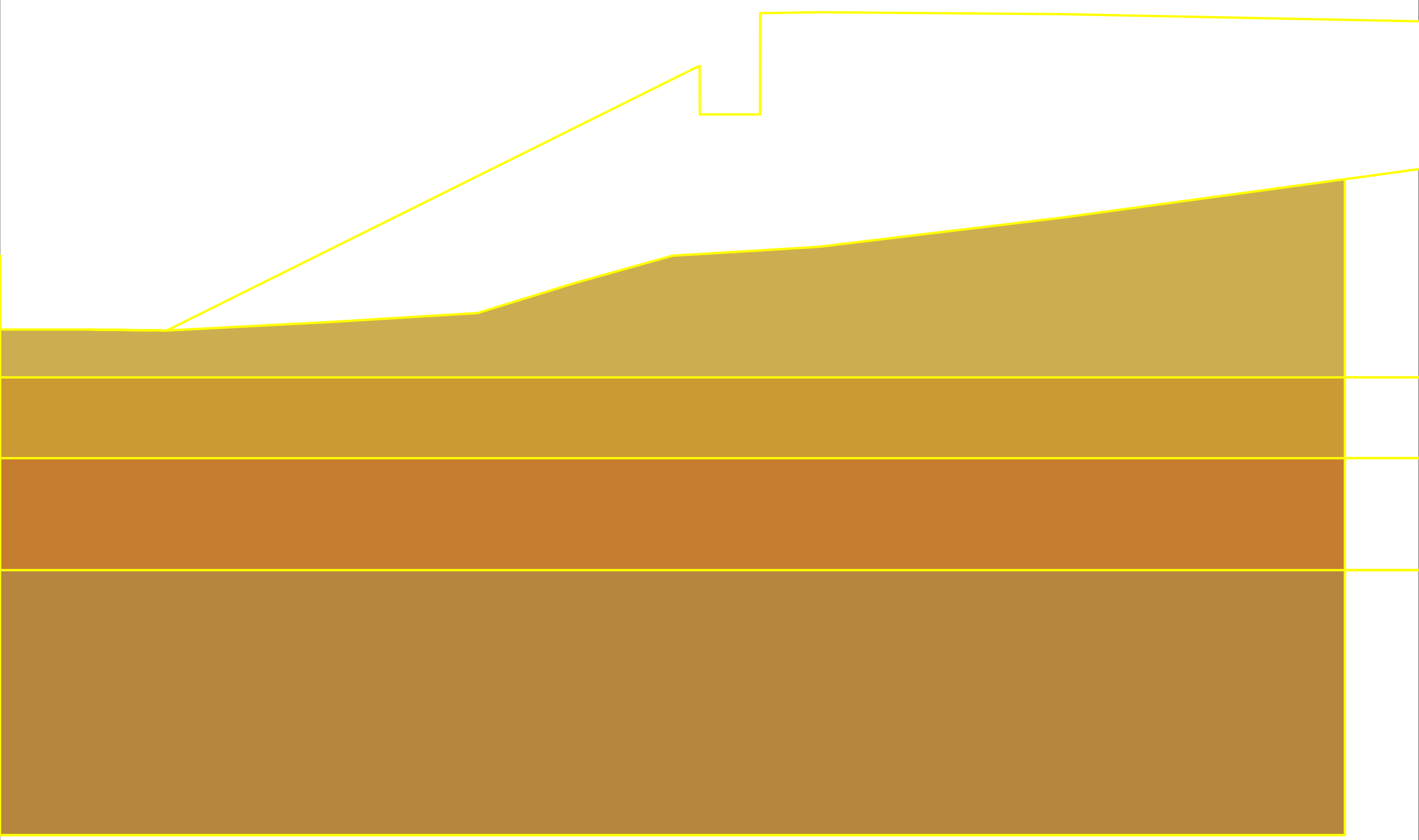
INPUT DATA – EMBANKMENT LAYERS -- 1 layers

	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	461.00
2	200.00	461.00

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	Yes	3.70	0.102	0.012	0.448	0.2000	Top & Bot.
2	No	N/A	N/A	N/A	N/A	N/A	N/A
3	Yes	1.80	0.102	0.012	0.448	0.2000	Top & Bot.
4	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	0.00	0.00	1	946000	0.4000	-0.0001	471.40	471.40	-0.00
			2	492000	0.2500	-0.0012			
			3	946000	0.4000	-0.0023			
			4	1000000000(	0.2000	0.0000			
2	5.00	0.00	1	946000	0.4000	-0.0002	471.34	471.34	-0.00
			2	492000	0.2500	-0.0009			
			3	946000	0.4000	-0.0019			
			4	1000000000(	0.2000	0.0000			
3	10.00	0.00	1	946000	0.4000	-0.0001	471.40	471.40	-0.00
			2	492000	0.2500	0.0006			
			3	946000	0.4000	-0.0010			
			4	1000000000(	0.2000	0.0000			
4	15.00	0.00	1	946000	0.4000	0.0006	471.67	471.66	0.00
			2	492000	0.2500	0.0034			
			3	946000	0.4000	0.0003			
			4	1000000000(	0.2000	0.0000			
5	20.00	0.00	1	946000	0.4000	0.0013	471.93	471.92	0.01
			2	492000	0.2500	0.0067			
			3	946000	0.4000	0.0020			
			4	1000000000(	0.2000	0.0000			
6	25.00	0.00	1	946000	0.4000	0.0020	472.20	472.18	0.02
			2	492000	0.2500	0.0101			
			3	946000	0.4000	0.0039			
			4	1000000000(	0.2000	0.0000			
7	30.00	0.00	1	946000	0.4000	0.0028	472.50	472.48	0.02
			2	492000	0.2500	0.0135			
			3	946000	0.4000	0.0058			
			4	1000000000(	0.2000	0.0000			
8	35.00	0.00	1	946000	0.4000	0.0036	472.80	472.77	0.03
			2	492000	0.2500	0.0167			
			3	946000	0.4000	0.0075			
			4	1000000000(	0.2000	0.0000			
9	40.00	0.00	1	946000	0.4000	0.0045	473.10	473.07	0.03
			2	492000	0.2500	0.0195			
			3	946000	0.4000	0.0091			
			4	1000000000(	0.2000	0.0000			
10	45.00	0.00	1	946000	0.4000	0.0057	474.65	474.61	0.04
			2	492000	0.2500	0.0214			
			3	946000	0.4000	0.0103			
			4	1000000000(	0.2000	0.0000			
11	50.00	0.00	1	946000	0.4000	0.0072	476.20	476.16	0.04
			2	492000	0.2500	0.0229			
			3	946000	0.4000	0.0113			
			4	1000000000(	0.2000	0.0000			
12	55.00	0.00	1	946000	0.4000	0.0088	477.60	477.55	0.05
			2	492000	0.2500	0.0242			
			3	946000	0.4000	0.0122			
			4	1000000000(	0.2000	0.0000			

*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.]
13	60.00	0.00	1	946000	0.4000	0.0106	479.00	478.95	0.05
			2	492000	0.2500	0.0247			
			3	946000	0.4000	0.0129			
			4	1000000000(	0.2000	0.0000			
14	65.00	0.00	1	946000	0.4000	0.0072	479.30	479.25	0.05
			2	492000	0.2500	0.0247			
			3	946000	0.4000	0.0139			
			4	1000000000(	0.2000	0.0000			
15	70.00	0.00	1	946000	0.4000	0.0142	479.60	479.54	0.06
			2	492000	0.2500	0.0296			
			3	946000	0.4000	0.0154			
			4	1000000000(	0.2000	0.0000			
16	75.00	0.00	1	946000	0.4000	0.0162	479.90	479.83	0.07
			2	492000	0.2500	0.0336			
			3	946000	0.4000	0.0167			
			4	1000000000(	0.2000	0.0000			
17	80.00	0.00	1	946000	0.4000	0.0163	480.50	480.43	0.07
			2	492000	0.2500	0.0341			
			3	946000	0.4000	0.0174			
			4	1000000000(	0.2000	0.0000			
18	85.00	0.00	1	946000	0.4000	0.0164	481.10	481.03	0.07
			2	492000	0.2500	0.0334			
			3	946000	0.4000	0.0175			
			4	1000000000(	0.2000	0.0000			
19	90.00	0.00	1	946000	0.4000	0.0165	481.70	481.63	0.07
			2	492000	0.2500	0.0324			
			3	946000	0.4000	0.0171			
			4	1000000000(	0.2000	0.0000			
20	95.00	0.00	1	946000	0.4000	0.0167	482.30	482.24	0.06
			2	492000	0.2500	0.0314			
			3	946000	0.4000	0.0166			
			4	1000000000(	0.2000	0.0000			
21	100.00	0.00	1	946000	0.4000	0.0165	482.90	482.84	0.06
			2	492000	0.2500	0.0303			
			3	946000	0.4000	0.0160			
			4	1000000000(	0.2000	0.0000			
22	105.00	0.00	1	946000	0.4000	0.0169	483.58	483.52	0.06
			2	492000	0.2500	0.0291			
			3	946000	0.4000	0.0153			
			4	1000000000(	0.2000	0.0000			
23	110.00	0.00	1	946000	0.4000	0.0169	484.26	484.20	0.06
			2	492000	0.2500	0.0280			
			3	946000	0.4000	0.0147			
			4	1000000000(	0.2000	0.0000			
24	115.00	0.00	1	946000	0.4000	0.0169	484.94	484.88	0.06
			2	492000	0.2500	0.0268			
			3	946000	0.4000	0.0140			
			4	1000000000(	0.2000	0.0000			

*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.]
25	120.00	0.00	1	946000	0.4000	0.0170	485.62	485.56	0.06
			2	492000	0.2500	0.0257			
			3	946000	0.4000	0.0133			
			4	1000000000(	0.2000	0.0000			
26	125.00	0.00	1	946000	0.4000	0.0171	486.30	486.25	0.05
			2	492000	0.2500	0.0247			
			3	946000	0.4000	0.0126			
			4	1000000000(	0.2000	0.0000			
27	130.00	0.00	1	946000	0.4000	0.0172	486.98	486.93	0.05
			2	492000	0.2500	0.0236			
			3	946000	0.4000	0.0118			
			4	1000000000(	0.2000	0.0000			
28	135.00	0.00	1	946000	0.4000	0.0172	487.66	487.61	0.05
			2	492000	0.2500	0.0224			
			3	946000	0.4000	0.0107			
			4	1000000000(	0.2000	0.0000			
29	140.00	0.00	1	946000	0.4000	0.0169	488.34	488.29	0.05
			2	492000	0.2500	0.0208			
			3	946000	0.4000	0.0091			
			4	1000000000(	0.2000	0.0000			
30	145.00	0.00	1	946000	0.4000	0.0152	489.02	488.98	0.04
			2	492000	0.2500	0.0174			
			3	946000	0.4000	0.0067			
			4	1000000000(	0.2000	0.0000			
31	150.00	0.00	1	946000	0.4000	0.0060	489.70	489.68	0.02
			2	492000	0.2500	0.0090			
			3	946000	0.4000	0.0035			
			4	1000000000(	0.2000	0.0000			

*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	0.00	0.00	471.40	0.00	471.40
2	5.00	0.00	471.34	0.00	471.33
3	10.00	0.00	471.40	0.01	471.39
4	15.00	0.00	471.67	0.03	471.64
5	20.00	0.00	471.93	0.04	471.89
6	25.00	0.00	472.20	0.07	472.13
7	30.00	0.00	472.50	0.10	472.40
8	35.00	0.00	472.80	0.12	472.68
9	40.00	0.00	473.10	0.14	472.96
10	45.00	0.00	474.65	0.16	474.49
11	50.00	0.00	476.20	0.17	476.03
12	55.00	0.00	477.60	0.19	477.41
13	60.00	0.00	479.00	0.20	478.80
14	65.00	0.00	479.30	0.19	479.11
15	70.00	0.00	479.60	0.24	479.36
16	75.00	0.00	479.90	0.26	479.64
17	80.00	0.00	480.50	0.27	480.23
18	85.00	0.00	481.10	0.26	480.84
19	90.00	0.00	481.70	0.25	481.45
20	95.00	0.00	482.30	0.25	482.05
21	100.00	0.00	482.90	0.24	482.66
22	105.00	0.00	483.58	0.23	483.35
23	110.00	0.00	484.26	0.23	484.03
24	115.00	0.00	484.94	0.22	484.72
25	120.00	0.00	485.62	0.21	485.41

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

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
26	125.00	0.00	486.30	0.20	486.10
27	130.00	0.00	486.98	0.19	486.79
28	135.00	0.00	487.66	0.18	487.48
29	140.00	0.00	488.34	0.16	488.18
30	145.00	0.00	489.02	0.13	488.89
31	150.00	0.00	489.70	0.09	489.61

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

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

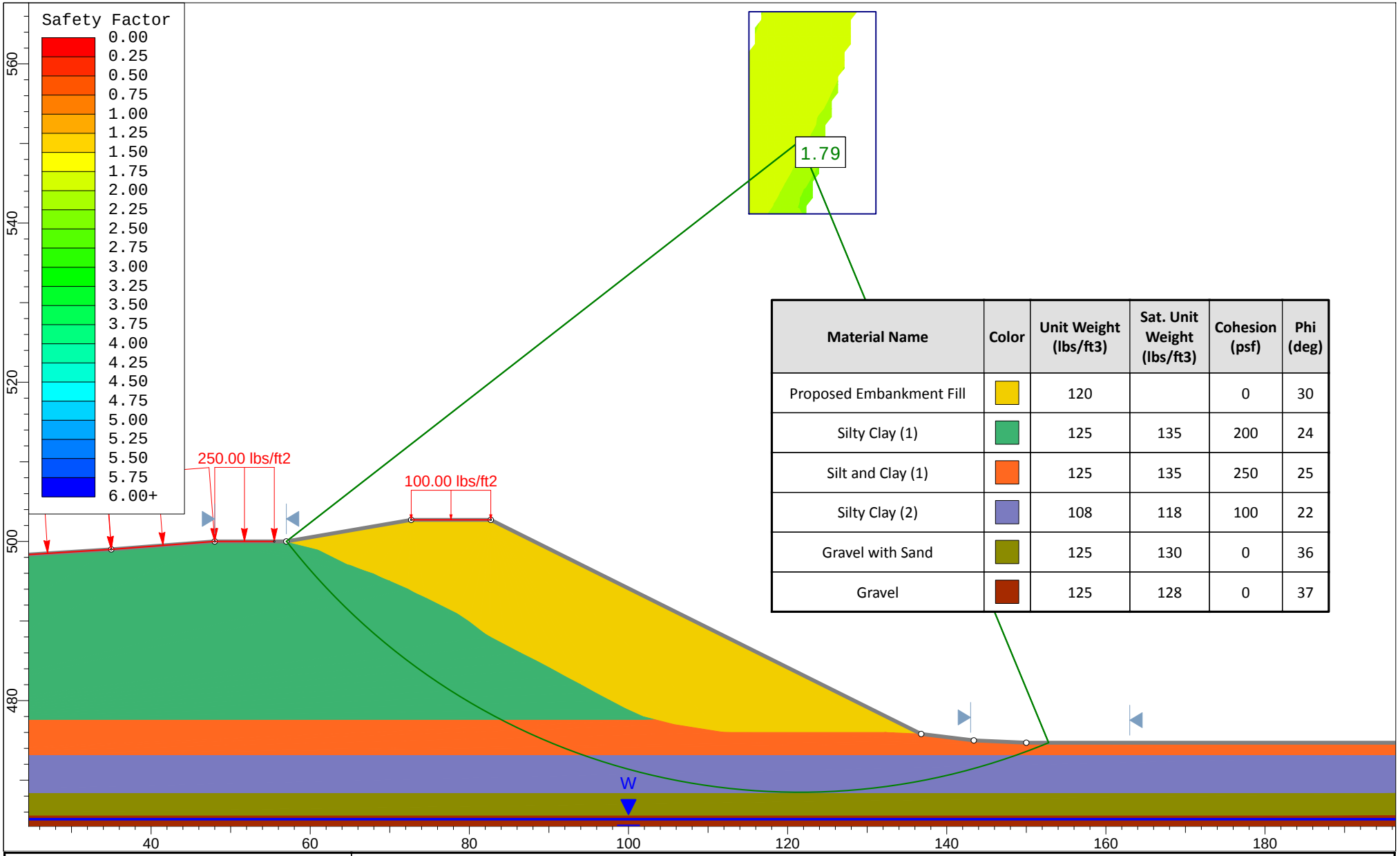
Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	1	0.00	471.40	Layer 1 - Cohesive
	2	8.10	471.30	
	3	25.00	472.20	
	4	40.00	473.10	
	5	50.00	476.20	
	6	60.00	479.00	
	7	75.00	479.90	
	8	100.00	482.90	
	9	125.00	486.30	
	10	150.00	489.70	
2	1	0.00	466.50	Layer 2 - Granular
	2	150.00	466.50	
3	1	0.00	458.20	Layer 3 - Cohesive
	2	150.00	458.20	
4	1	0.00	446.70	Bedrock
	2	150.00	446.70	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #		Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	X1 = 0.00 [ft]	1	8.10	471.30	Proposed Embankment
	X2 = 150.00 [ft]	2	62.80	498.50	
		3	62.81	493.50	
		4	69.00	493.50	
		5	69.01	503.90	
		6	75.00	504.00	
		7	100.00	503.80	
		8	125.00	503.30	
		9	150.00	502.80	

APPENDIX G

EMBANKMENT STABILITY ANALYSIS



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Proposed Embankment Fill		120		0	30
Silty Clay (1)		125	135	200	24
Silt and Clay (1)		125	135	250	25
Silty Clay (2)		108	118	100	22
Gravel with Sand		125	130	0	36
Gravel		125	128	0	37

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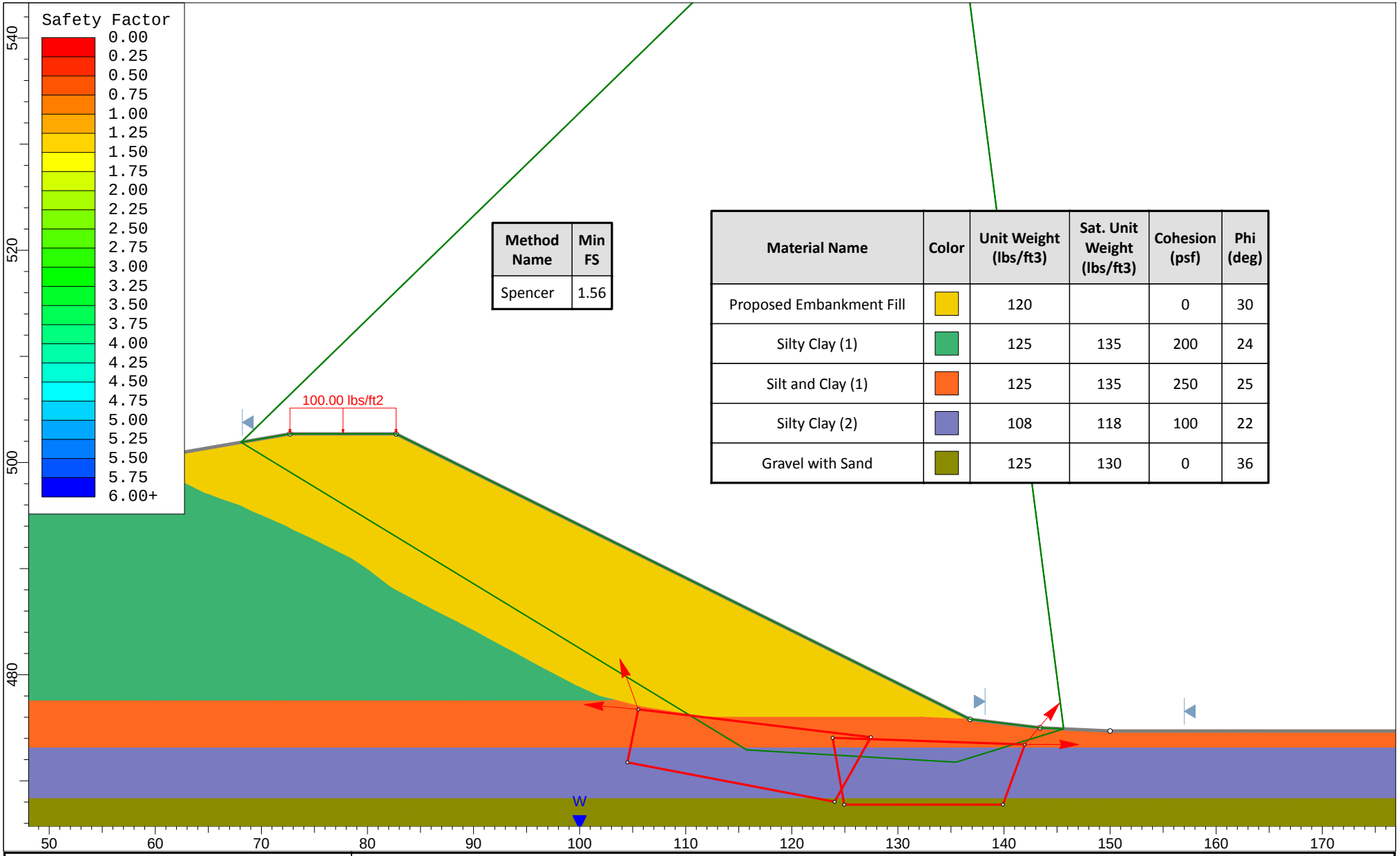
SLIDEINTERPRET 7.038

Project	HAM-Little Miami Scenic Trail to Elstun		
Analysis Description	Embankment Stability Analysis - Near STA. 76+50 (LMST) Side Hill Fill - Effective Stress - Circular Failure		
Drawn By	KCA	Scale	1:200
Company	NEAS Inc.		
Date	11/4/2022, 11:59:09 AM	File Name	LMST-SideHillFill_EffCircular110422.slim



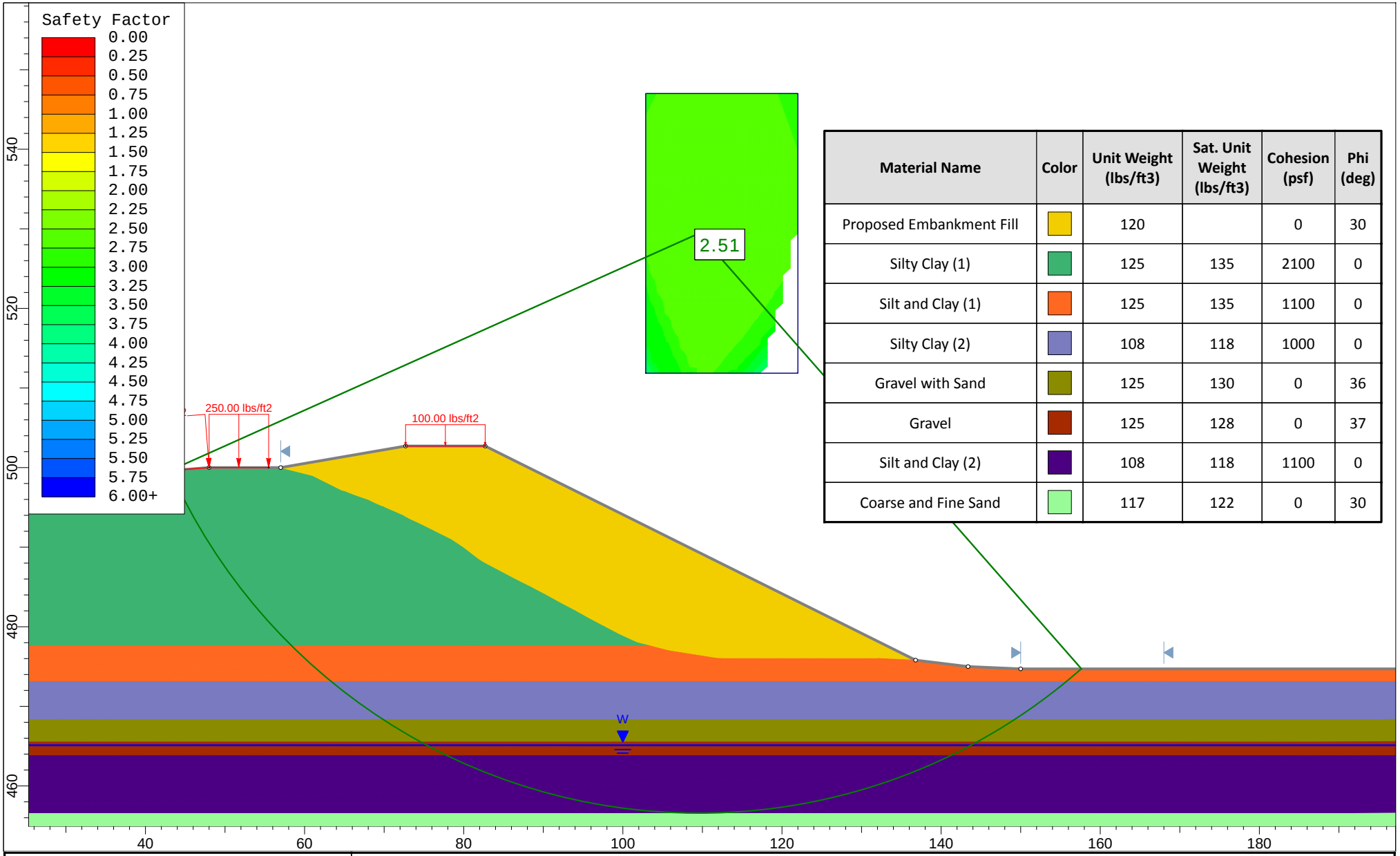
Method Name	Min FS
Spencer	1.56

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Proposed Embankment Fill		120		0	30
Silty Clay (1)		125	135	200	24
Silt and Clay (1)		125	135	250	25
Silty Clay (2)		108	118	100	22
Gravel with Sand		125	130	0	36

rocscience

SLIDEINTERPRET 7.038

Project	HAM-Little Miami Scenic Trail to Elstun		
Analysis Description	Embankment Stability Analysis - Near STA. 76+50 (LMST) Side Hill Fill - Effective Stress - Block Failure		
Drawn By	KCA	Scale 1:150	Company NEAS Inc.
Date	11/4/2022, 11:59:09 AM		File Name LMST-SideHillFill_EffBlock110422.slim



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Proposed Embankment Fill		120		0	30
Silty Clay (1)		125	135	2100	0
Silt and Clay (1)		125	135	1100	0
Silty Clay (2)		108	118	1000	0
Gravel with Sand		125	130	0	36
Gravel		125	128	0	37
Silt and Clay (2)		108	118	1100	0
Coarse and Fine Sand		117	122	0	30

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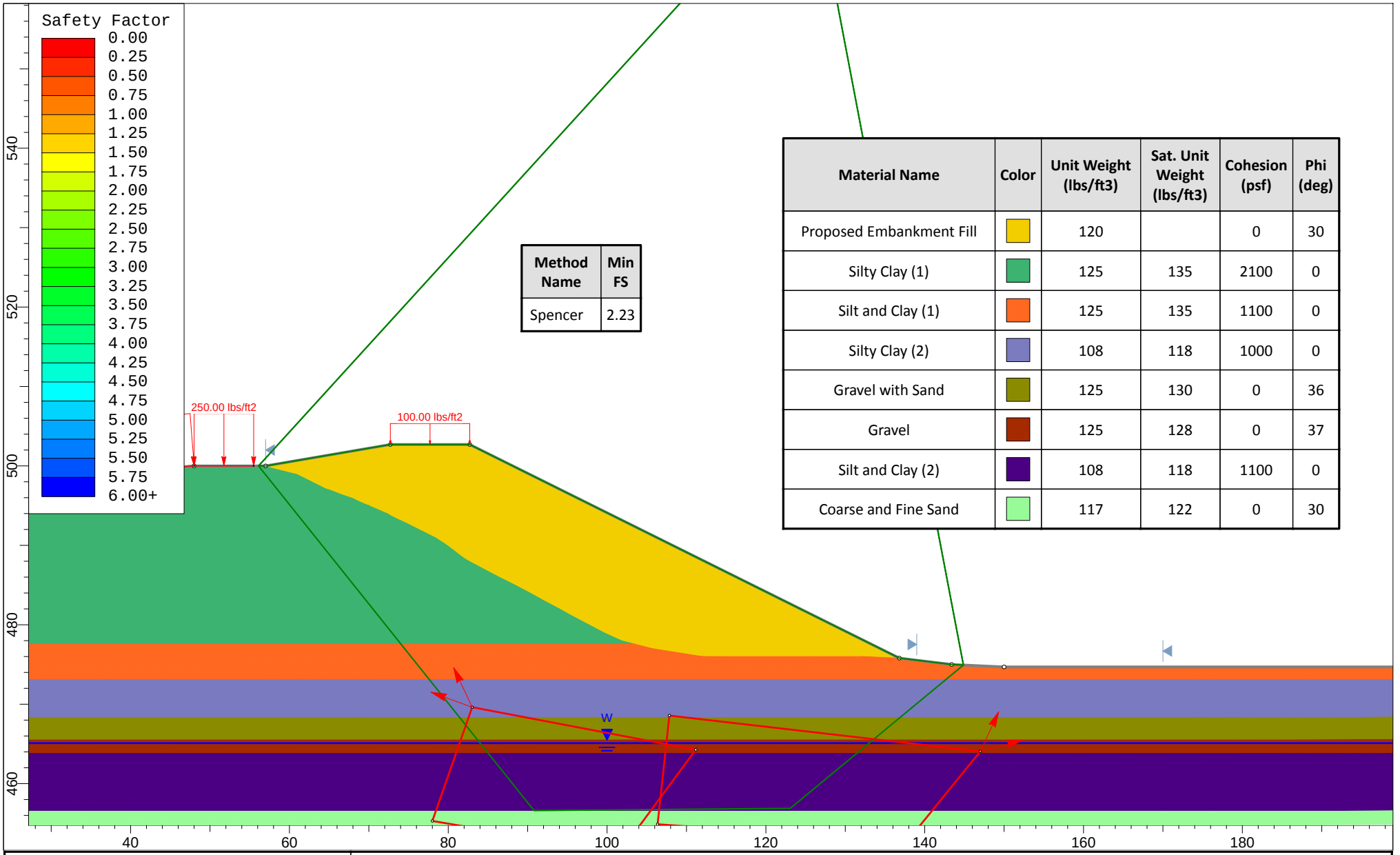
SLIDEINTERPRET 7.038

Project	HAM-Little Miami Scenic Trail to Elstun		
Analysis Description	Embankment Stability Analysis - Near STA. 76+50 (LMST) Side Hill Fill - Total Stress - Circular Failure		
Drawn By	KCA	Scale 1:200	Company NEAS Inc.
Date	11/4/2022, 11:59:09 AM		File Name LMST-SideHillFill_TotCircular110422.slim



Method Name	Min FS
Spencer	2.23

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Proposed Embankment Fill		120		0	30
Silty Clay (1)		125	135	2100	0
Silt and Clay (1)		125	135	1100	0
Silty Clay (2)		108	118	1000	0
Gravel with Sand		125	130	0	36
Gravel		125	128	0	37
Silt and Clay (2)		108	118	1100	0
Coarse and Fine Sand		117	122	0	30

rocscience

SLIDEINTERPRET 7.038

Project	HAM-Little Miami Scenic Trail to Elstun		
Analysis Description	Embankment Stability Analysis - Near STA. 76+50 (LMST) Side Hill Fill - Total Stress - Block Failure		
Drawn By	KCA	Scale 1:200	Company NEAS Inc.
Date	11/4/2022, 11:59:09 AM		File Name LMST-SideHillFill_TotBlock110422.slim