Resource International, Inc.

FRA-70-12.68 PROJECT 4R
FRA-70-1282R
I-70 EB AND RAMP C5
OVER SOUDER AVENUE
PID NO. 105523
FRANKLIN COUNTY, OHIO

STRUCTURE FOUNDATION EXPLORATION REPORT

Prepared For:
GPD GROUP
1801 Watermark Drive, Suite 150
Columbus, OH 43215

Prepared By:
Resource International, Inc.
6350 Presidential Gateway
Columbus, Ohio 43231

Rii Project No. W-13-045

June 2018

Planning, Engineering, Construction Management, Technology
6350 Presidential Gateway, Columbus, Ohio 43231
P 614.823.4949 F 614.823.4990

RESOURCE INTERNATIONAL, INC.
ISO 9001:2008 Certified QMS
An ISO 9001:2008 QMS Certified Firm

Planning
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Technology

March 15, 2015 (Revised June 28, 2018)

Mr. Christopher W. Luzier, P.E.
Project Manager
GPD GROUP
1801 Watermark Drive, Suite 210
Columbus, OH 43215

Re: Structure Foundation Exploration Report
FRA-70-12.68 Project 4R
FRA-70-1282R – I-70 EB and Ramp C5 over Souder Avenue
PID No. 105523
Rii Project No. W-13-045

Mr. Luzier:

Resource International, Inc. (Rii) is pleased to submit this structure foundation exploration report for the above referenced project. Engineering logs have been prepared and are attached to this report along with the results of laboratory testing. This report includes foundation recommendations for the design and construction of the proposed FRA-70-1282R bridge structure carrying I-70 eastbound and Ramp C5 over Souder Avenue in Columbus, Ohio.

We sincerely appreciate the opportunity to be of service to you on this project. If you have any questions regarding the structure foundation exploration or this report, please contact us.

Sincerely,

RESOURCE INTERNATIONAL, INC.

Brian R. Trenner, P.E.
Director – Geotechnical Programming

Jonathan P. Sterenberg, P.E.
Director – Geotechnical Planning

Enclosure: Structure Foundation Exploration Report

6350 Presidential Gateway
Columbus, Ohio 43231
Phone: 614.823.4949
Fax: 614.823.4990

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APPENDICIES

EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a structure foundation exploration for the design and construction of the proposed FRA-70-1282R bridge structure carrying I-70 eastbound and Ramp C5 over Souder Avenue, as shown on the vicinity map and boring plan presented in Appendix II of the full report. The existing structure is a single-span bridge that consists of a reinforced concrete deck on prestressed concrete I-beams with supported with full height, wall-type abutments supported on spread foundations and has a total length of approximately 64 feet. Based on information provided by Burgess and Niple, it is understood that the existing superstructure will be removed and replaced and that the structure will widened approximately 40 feet to the south to accommodate the proposed Ramp C5 alignment. It is also understood that the existing substructure units will be remain in place to support the new superstructure where I-70 eastbound crosses Souder Avenue. The proposed widened portion of the structure, which will support Ramp C5, will consist of a single-span prestressed concrete I-beam superstructure with a composite reinforced concrete deck and full height, wall-type semi-integral abutments. The roadway profile grade along I-70 will match the existing roadway profile grade, and the widened portion of the structure will be situated along the existing embankment slope.

Exploration and Findings

Between January 29 and February 27, 2015, two (2) structural borings, designated as B-013-1-15 and B-013-2-15, were advanced to a completion depth of 35.0 to 66.5 feet, respectively, below the existing ground surface. In addition to the borings performed by Rii as part of the current exploration, two (2) borings, designated as B-109-0-09 and B-122-0-09, were advanced to a completion depth of 50.0 and 79.1 feet below the existing ground surface, respectively by DLZ as part of the FRA-70-8.93 preliminary exploration. The current project boring locations are shown on the boring plan provided in Appendix II of the full report.

Boring B-013-1-15 was performed in the paved median between I-70 eastbound and westbound, just west of the existing bridge structure, and encountered 7.0 inches of asphalt overlying 5.0 inches of aggregate base at the ground surface. Borings B-013-2-15 and B-109-0-09 were performed in the grass just south of the I-70 embankment and encountered 6.0 and 5.0 inches of topsoil, respectively, at the ground surface, as identified by the significant presence of vegetation and organic material. Boring B-122-0-09 was performed in the grass just north of the I-70 embankment and encountered 2.0 inches of topsoil at the ground surface.

Beneath the pavement materials in boring B-013-1-15, existing embankment fill consisting of brown gravel and sand (ODOT A-1-b) and brown to gray silt and clay (ODOT A-6a) were encountered extending to a depth of 18.0 feet below existing grade. Beneath the topsoil in borings B-013-2-15, B-109-0-09 and B-122-0-09, material identified as existing fill or possible fill was encountered extending to depths ranging from 3.5 to 8.0 feet below existing grade. The fill materials consisted of brown and gray gravel and sand, gravel with sand, silt and clay, sandy silt, silt and clay and clay (ODOT A-1-b, A-2-6, A-4a, A-6a, A-7-6). The fill material encountered at boring B-013-2-15 contained cinders and root fibers throughout.

Underlying the surficial materials and existing fill, natural granular soils were encountered in the upper 25 to 37 feet of the soil profile overlying cohesive soils. The granular soils were generally described as brown, gray and black gravel, gravel and sand, fine sand, coarse and fine sand and sandy silt (ODOT A-1-a, A-1-b, A-3, A-3a, A-4a). The cohesive soils were generally described as gray and brownish gray sandy silt and silt and clay (ODOT A-4a, A-6a). It should be noted that cobbles and boulders were encountered within the dense granular soil deposits at depths ranging from 20.0 to 50.0 feet below the ground surface, which corresponds to elevations ranging from approximately 655 to 685 feet msl.

Top of bedrock was encountered in borings B-013-2-15 and B-122-0-09 at an elevation of 647.0 and 642.1 feet msl, respectively. The upper portion of the bedrock consists of weathered limestone which was able to be augered to competent (cored) limestone bedrock, which was encountered at an elevation of 646.0 and 632.0 feet msl, respectively.

In addition to the borings performed as part of the preliminary engineering and current explorations, four (4) historic borings performed in 1968 by the Department of Highways as part of the original FRA-70-12.31S project for the existing structure, designated as B-001-S-68 through B-004-S-68, were extended to depths ranging from 45 to 50.8 feet below the existing grade of Souder Avenue. In general, the historic borings encountered medium dense to very dense granular soils overlying hard cohesive soils. The granular soils were generally described as brown and gray gravel, gravel and sand, gravel with sand and silt, sandy silt and silt (ODOT A-1-a, A-1-b, A-2-4, A-4a, A-4b), and the cohesive soils were generally described as gray sandy silt and silt (ODOT A-4a, A-4b). Bedrock was not encountered in the historic borings prior to the termination depths. The historic boring locations are also shown on the boring plan provided in Appendix II of the full report.

Analyses and Recommendations

Design details of the structure proposed were provided by Burgess and Niple. Based on information provided by Burgess and Niple, it is understood that the existing superstructure will be removed and replaced and that the structure will widened approximately 40 feet to the south to accommodate the proposed Ramp C5 alignment. It is also understood that the existing substructure units will be remain in place to support the new superstructure where I-70 eastbound crosses Souder Avenue. The proposed widened structure will consist of a single-span prestressed concrete I-beam superstructure with a composite reinforced concrete deck and full height, wall-type semi-integral abutments. It is understood that the proposed substructure units for the widened portion of the structure will match the geometry of the existing abutments. The roadway profile grade along I-70 will match the existing roadway profile grade, and the widened portion of the structure will be situated along the existing embankment slope.

Shallow Foundation Recommendations

Based on a review of the historic construction records for this structure, the existing abutments consist of full height, cast-in-place (CIP) reinforced concrete wall-type abutments that were designed for a maximum bearing pressure of 2.5 tons per square foot (5.0 ksf). The structure foundation exploration report for the existing structure was not able to be located during a review of the available historic records; consequently, the maximum allowable bearing capacity recommended for the existing spread foundations could not be determined. Therefore, it is recommended that the maximum design bearing pressure for the portion of the new structure that will be supported on the existing spread foundations not exceed the maximum design bearing pressure for the existing structure of 2.5 tsf.

Consideration was given to use of shallow spread foundations for support of the proposed widened portion of the bridge, but given the potential for excessive differential settlement between the existing and widened portions of the structure, this foundation option was eliminated. Therefore, it is recommended that the widened portion of the structure be supported on a deep foundation system.

Driven Pile Recommendations

Per Section 202.2.3.2 of the 2004 ODOT BDM, cast-in-place (CIP) pipe piles shall be utilized where piles are not extended to bedrock, and steel H-piles shall be utilized where piles are driven to bear on bedrock. Given the depth to bedrock encountered at the site as well as the proposed loading, either steel CIP pipe piles (ODOT Item 507.06) driven to the required frictional capacity based on the design load or steel H-piles (ODOT Item 507.07) driven to refusal on bedrock can employed for foundation support. Based on the soil encountered at this site, it has been determined that a CIP pile foundation will not be a feasible foundation type due to the dense granular soils encountered in the upper 25 feet of the soil profile below the foundation elevation. The pile analysis considered 12, 14 and 16-inch CIP piles and the results indicated that the piles could not be extended to the minimum required embedment depth of 15.0 feet below the bottom of the CIP walls without potentially overstressing the piles. Therefore, this pile type is not considered suitable for support of the proposed structure widening.

It is recommended to support the proposed structure on steel H-piles driven to refusal on bedrock. Refusal on bedrock during driving can be considered achieved when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. Table 8 provides recommended pile lengths and the corresponding ultimate bearing value (UBV) of the CIP pipe piles and steel H-piles and associated factor-of-safety (FS).

Table 1. FRA-70-1282R Driven Pile Recommendations

Substructure Reference	Ground Elevation [1]	Pile Size	Pile Elevation (feet msl)		Pile Length [3] (feet)	Ultimate Bearing Value (tons/pile)	FS [4]
			Top [2]	Tip			
Rear / Forward Abutment (B-013-2-15)	705.5	HP 10x42 [5]	699.4	647.0	55	150	2.0

1. *Ground elevation listed is the ground elevation at the boring location.*
2. *The top of pile elevation corresponds to the pile cutoff elevation, which is assumed to be 1.0-foot above the proposed bottom of footing elevation.*
3. *Per Section 202.3.2 of the 2004 ODOT BDM, the estimated pile length was determined as the pile cutoff elevation (top) minus the pile tip elevation, rounded up to the nearest 5.0 feet.*
4. *A factor-of-safety of 2.0 should be considered in determining the design load per pile per Section 202.3.2 of the 2004 ODOT BDM.*
5. *A steel pile point is recommended to protect the tips of the H-piles during pile installation.*

The existing spread foundations are bearing on dense to very dense granular soils consisting of gravel, gravel and sand and gravel with sand and silt (ODOT A-1-a, A-1-b, A-2-4). Given the granular nature of the bearing soils, there may be a risk for additional or differential settlement of the existing spread footing foundations due to vibrations from the pile driving operations given the close proximity of the piles to the existing foundations. Therefore, it is recommended that the existing foundations be closely monitored during installation of the new piles for the widened portion of the proposed structure to ensure that additional settlement of the existing structure does not occur.

Please note that this executive summary does not contain all the information presented in the report. The unabridged subsurface exploration report should be read in its entirety to obtain a more complete understanding of the information presented.

1.0 INTRODUCTION

The overall purpose of this project is to provide detailed subsurface information and recommendations for the design and construction of the FRA-70-12.68/13.11/14.05C (Project 4R/4H/4A) projects in Columbus, Ohio. The projects represent the central portion of FRA-70-8.93 (PID 77369) I-70/71 south innerbelt improvements project. The FRA-70-12.68 (Project 4R) phase will consist of all work associated with the construction of Ramp C5, starting at the bridge over Souder Avenue and extending east to Front Street. The proposed Ramp C5 will be a two-lane to four-lane ramp that will collect and direct traffic from I-71 northbound and SR-315 southbound as well as I-70 eastbound to exit in downtown at the intersection of Front Street and W. Fulton Avenue. This project includes the construction of six (6) new bridge structures for the proposed Ramp C5 alignment and replacement of three (3) bridge structures, two along I-70 and the Front Street Structure over I-70, as well as the construction of fourteen (14) new retaining walls and a culvert structure to accommodate the new configuration.

This report is a presentation of the structure foundation exploration performed for the design and construction of the proposed FRA-70-1282R bridge structure carrying I-70 eastbound and Ramp C5 over Souder Avenue, as shown on the vicinity map and boring plan presented in Appendix II. The existing structure is a single-span bridge that consists of a reinforced concrete deck on prestressed concrete I-beams with supported with full height, wall-type abutments supported on spread foundations and has a total length of approximately 64 feet. Based on information provided by Burgess and Niple, it is understood that the existing superstructure will be removed and replaced and that the structure will widened approximately 40 feet to the south to accommodate the proposed Ramp C5 alignment. It is also understood that the existing substructure units will be remain in place to support the new superstructure where I-70 eastbound crosses Souder Avenue. The proposed widened portion of the structure, which will support Ramp C5, will consist of a single-span prestressed concrete I-beam superstructure with a composite reinforced concrete deck and full height, wall-type semi-integral abutments. The roadway profile grade along I-70 will match the existing roadway profile grade, and the widened portion of the structure will be situated along the existing embankment slope.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 Site Geology

Both the Illinoian and Wisconsinan glaciers advanced over two-thirds of the State of Ohio, leaving behind glacial features such as moraines, kame deposits, lacustrine deposits and outwash terraces. The glacial and non-glacial regions comprise five physiographic sections based on geological age, depositional process and geomorphic occurrence (physical features or landforms). The project area lies within the Columbus Lowland District of the Till Plains Section. This area is characterized by flat to gently rolling ground moraine deposits from the Late Wisconsinan age. The site topography exhibits moderate to high relief. The ground moraine deposits are composed primarily of silty loam till (Darby, Bellefontaine, Centerburg, Grand Lake, Arcanum, Knightstown Tills), with smaller alluvium and outwash deposits bordering the Scioto River, its tributaries and floodplain areas. A ground moraine is the sheet of debris left after the steady retreat of glacial ice. The debris left behind ranges in composition from clay size particles to boulders (including silt, sand, and gravel). Outwash deposits consist of undifferentiated sand and gravel deposited by meltwater in front of glacial ice, and often occurs as valley terraces or low plains. Alluvium and alluvial terrace deposits range in composition from silty clay size particles to cobbles, usually deposited in present and former floodplain areas.

According to the bedrock geology and topography maps obtained from the Ohio Department of Natural Resources (ODNR), the underlying bedrock consists predominantly of the Middle to Lower Devonian-aged Columbus Limestone. This formation is further subdivided into two members in the central portion of the state, known as the Delhi and Bellepoint Members. The Delhi Member consists of light gray, finely to coarsely crystalline, irregularly bedded, fossiliferous limestone. The Bellepoint Member consists of variable brown, finely crystalline, massively bedded limy dolomite. Both of these members contain chert nodules. Just east of High Street, the underlying bedrock consists of the Upper Devonian Ohio Shale Formation overlying the Middle Devonian-aged Delaware Limestone Formation. The Ohio Shale formation consists of brownish black to greenish gray, thinly bedded, fissile, carbonaceous shale. The Delaware Limestone consists of bluish gray, thin to medium bedded dolomitic limestone with nodules and layers of chert. Regionally, the bedrock surface forms a broad valley aligned roughly north-to-south beneath the Scioto River. According to bedrock topography mapping, the elevation of the bedrock surface ranges from approximately 600 feet mean sea level (msl) in the valley to approximately 625 feet msl near the project limits. In the borings performed for this structure, limestone bedrock was encountered at elevations ranging from 642.1 to 647.0 feet msl.

2.2 Existing Conditions

The proposed FRA-70-1282R structure is located at the existing I-70 over Souder Avenue overpass, approximately 2,500 feet west of the Scioto River. The existing I-70 eastbound in the vicinity of the structure is a four-lane, asphalt paved roadway that is aligned east-to-west. The southernmost lane becomes the ramp from I-70 eastbound to I-71 southbound. The existing I-70 roadway profile grade is elevated approximately 20 feet above surrounding terrain on engineered embankments, which are grass covered with patches of dense vegetation. The existing Souder Avenue is four-lane, asphalt paved roadway that is aligned north-to-south. Mound Street is aligned parallel to I-70 along the south side of the existing embankment and intersects with Souder Avenue just south of the existing structure. The terrain along I-70 slopes down gently to the west and the surrounding area is relatively flat-lying.

3.0 EXPLORATION

Between January 29 and February 27, 2015, two (2) structural borings, designated as B-013-1-15 and B-013-2-15, were advanced to a completion depth of 35.0 to 66.5 feet, respectively, below the existing ground surface. Boring B-013-1-15 was performed in the median between I-70 eastbound and westbound for determination of the subsurface conditions within the existing embankment fill to aid in the design of the temporary shoring that will be required for the construction of the widened portion of the proposed structure. Boring B-013-2-15 was performed at the toe of the existing embankment along the west side of Souder Avenue to determine the subsurface conditions and depth to bedrock within the widened portion of the proposed structure. In addition to the borings performed by Rii as part of the current exploration, two (2) borings, designated as B-109-0-09 and B-122-0-09, were performed DLZ in the vicinity of the bridge structure as part of the FRA-70-8.93 preliminary exploration and their findings were published in a report dated March 18, 2010. The borings were advanced to a completion depth of 50.0 and 79.1 feet below the existing ground surface, respectively. The current project boring locations are shown on the boring plan provided in Appendix II of this report and summarized in Table 2 below.

Table 2. Test Boring Summary

Boring Number	Reference Alignment	Station	Offset	Latitude	Longitude	Ground Elevation (feet msl)	Boring Depth (feet)
B-013-1-15	BL I-70 EB	127+00.32	45.0' Lt.	39.950158148	-83.021287305	725.9	35.0
B-013-2-15	BL I-70 EB	127+19.67	80.0' Rt.	39.949827253	-83.021150673	705.5	66.5
B-109-0-09	BL Ramp C5	5032+97.77	44.7' Rt.	39.949836696	-83.020667264	704.9	50.0
B-122-0-09	BL I-70 WB	127+17.91	134.2' Lt.	39.950614109	-83.021366100	705.6	79.1

The locations for the current exploration borings performed by Rii were determined and located in the field by Rii representatives. Rii utilized a handheld GPS unit to obtain northing and easting coordinates of the boring locations. Ground surface elevations at the boring locations were interpolated using topographic mapping information provided by GPD GROUP.

The borings performed by Rii for the current exploration were drilled using an all-terrain vehicle (ATV) mounted rotary drilling machine, utilizing a 4.5-inch outside diameter, solid flight auger or 4.25-inch inside diameter, hollow-stem auger to advance the holes. Standard penetration test (SPT) and split spoon sampling were performed in borings B-013-1-15 and B-013-2-15 at 2.5-foot increments of depth to 20.0 and 30.0 feet, respectively, and at 5.0-foot increments thereafter to the boring termination depth or top of bedrock. The SPT, per the American Society for Testing and Materials (ASTM) designation D1586, is conducted using a 140-pound hammer falling 30.0 inches to drive a 2.0-inch outside diameter split spoon sampler 18.0 inches. Rii utilized a calibrated automatic drop hammer to generate consistent energy transfer to the sampler. Driving resistance is recorded on the boring logs in terms of blow per 6.0-inch interval of the driving distance. The second and third intervals are added to obtain the number of blows per foot (N). Standard penetration blow counts aid in determining soil properties applicable in foundation system design. Measured blow count (N) values are corrected to an equivalent (60%) energy ratio, N_{60}, by the following equation. Both values are represented on boring logs in Appendix IV.

$$N_{60} = N_m*(ER/60)$$

Where:
N_m = measured N value
ER = drill rod energy ratio, expressed as a percent, for the system used

The hammer for the Mobile B-53 drill rig used by Rii for boring B-013-1-15 was calibrated on April 26, 2013, and has a drill rod energy ratio of 77.7 percent. The hammer for the CME 55 drill rig used by Rii for boring B-013-2-15 was calibrated on October 20, 2-14, and has a drill rod energy ratio of 92.0 percent.

During drilling for the borings performed by Rii, field logs were prepared by Rii personnel showing the encountered subsurface conditions. Soil samples obtained from the drilling operation were preserved and sealed in glass jars and delivered to the soil laboratory. In the laboratory, the soil samples were visually classified and select samples were tested, as noted in Table 3.

Table 3. Laboratory Test Schedule

Laboratory Test	Test Designation	Number of Tests Performed
Natural Moisture Content	ASTM D 2216	29
Plastic and Liquid Limits	AASHTO T89, T90	9
Gradation – Sieve/Hydrometer	AASHTO T88	9

The tests performed are necessary to classify existing soil according to the Ohio Department of Transportation (ODOT) classification system and to estimate engineering properties of importance in determining foundation design and construction recommendations. Results of the laboratory testing are presented on the boring logs in Appendix IV. A description of the soil terms used throughout this report is presented in Appendix III.

Hand penetrometer readings, which provide a rough estimate of the unconfined compressive strength of the soil, were reported on the boring logs in units of tons per square foot (tsf) and were utilized to classify the consistency of the cohesive soil in each layer. An indirect estimate of the unconfined compressive strength of the cohesive split spoon samples can also be made from a correlation with the blow counts (N_{60}). Please note that split spoon samples are considered to be disturbed and the laboratory determination of their shear strengths may vary from undisturbed conditions.

The depth to bedrock in boring B-013-2-15 was determined by visual inspection of the limestone fragments obtained within the split spoon samples and based on the blow counts obtained from the SPT testing. Split spoon sampler refusal is defined as exceeding 50 blows with less than 6.0 inches of penetration by the split spoon sampler. The boring was then extended to competent bedrock, which was defined by encountering auger refusal. Auger refusal is defined as no or insignificant observable advancement of the augers with the weight of the drill rig driving the augers.

The competent bedrock encountered in boring B-013-2-15 was cored using an HQ-sized double-tube diamond bit core barrel (utilizing wire line equipment). Coring produced 2.5-inch diameter cores, from which the type of rock and geological characteristics were determined.

Rock cores were logged in the field and visually classified in the laboratory. They were analyzed to identify the type of rock, color, mineral content, bedding planes and other geological and mechanical features of interest in this project. The Rock Quality Designation (RQD) for each rock core run was calculated according to the following equation:

$$RQD = \frac{\sum \text{segments equal to or longer than 4.0 inches}}{\text{core run length}} \times 100$$

In addition to the borings performed as part of the preliminary engineering and current explorations, historic borings performed in 1968 by the Department of Highways as part of the original FRA-70-12.31S project for the existing structure were also obtained from the construction documents on record. Four (4) borings, designated as B-001-S-68 through B-004-S-68, were obtained along the entire width of the existing bridge alignment. Based on the elevations provided on the boring logs, it is anticipated that these borings were performed from the then-existing ground surface and that the profile for the then-proposed I-70 was raised to cross over Souder Avenue. The borings were extended to depths ranging from 45 to 50.8 feet below the existing grade of Souder Avenue. The historic boring locations are shown on the boring plan provided in Appendix II of this report and the historic boring logs are provided in Appendix V.

4.0 FINDINGS

Interpreted engineering logs have been prepared based on the field logs, visual examination of samples and laboratory test results. Classification follows the respective version of the ODOT Specifications for Geotechnical Explorations (SGE) at the time the exploration borings were performed. The following is a summary of what was found in the test borings performed as part of the preliminary engineering phase and current exploration and what is represented on the boring logs.

4.1 Surface Materials

Boring B-013-1-15 was performed in the paved median between I-70 eastbound and westbound, just west of the existing bridge structure, and encountered 7.0 inches of asphalt overlying 5.0 inches of aggregate base at the ground surface. Borings B-013-2-15 and B-109-0-09 were performed in the grass just south of the I-70 embankment and encountered 6.0 and 5.0 inches of topsoil, respectively, at the ground surface, as identified by the significant presence of vegetation and organic material. Boring B-122-0-09 was performed in the grass just north of the I-70 embankment and encountered 2.0 inches of topsoil at the ground surface.

4.2 Subsurface Soils

Beneath the pavement materials in boring B-013-1-15, existing embankment fill consisting of brown gravel and sand (ODOT A-1-b) and brown to gray silt and clay (ODOT A-6a) were encountered extending to a depth of 18.0 feet below existing grade. Beneath the topsoil in borings B-013-2-15, B-109-0-09 and B-122-0-09, material identified as existing fill or possible fill was encountered extending to depths ranging from 3.5 to 8.0 feet below existing grade. The fill materials consisted of brown and gray gravel and sand, gravel with sand, silt and clay, sandy silt, silt and clay and clay (ODOT A-1-b, A-2-6, A-4a, A-6a, A-7-6). The fill material encountered at boring B-013-2-15 contained cinders and root fibers throughout.

Underlying the surficial materials and existing fill, natural granular soils were encountered in the upper 25 to 37 feet of the soil profile overlying cohesive soils. The granular soils were generally described as brown, gray and black gravel, gravel and sand, fine sand, coarse and fine sand and sandy silt (ODOT A-1-a, A-1-b, A-3, A-3a, A-4a). The cohesive soils were generally described as gray and brownish gray sandy silt and silt and clay (ODOT A-4a, A-6a). It should be noted that cobbles and boulders were encountered within the dense granular soil deposits at depths ranging from 20.0 to 50.0 feet below the ground surface, which corresponds to elevations ranging from approximately 655 to 685 feet msl.

The relative density of granular soils is primarily derived from SPT blow counts (N_{60}). Based on the SPT blow counts obtained, the granular soil encountered ranged from loose (5 ≤ N_{60} ≤ 10 blows per foot [bpf]) to very dense (N_{60} > 50 bpf). Overall blow counts recorded from the SPT sampling ranged from 8 bpf to split spoon sampler refusal. The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soil encountered ranged from medium stiff (0.5 ≤ HP ≤ 1.0 tsf) to hard (HP > 4.0 tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, ranged from 0.75 to over 4.5 tsf (limit of instrument).

Natural moisture contents of the soil samples tested ranged from 2 to 31 percent. The natural moisture content of the cohesive soil samples tested for plasticity index ranged from 6 percent below to at their corresponding plastic limits. In general, the soil exhibited natural moisture contents considered to be moderately below to at optimum moisture levels.

4.3 Bedrock

Bedrock was encountered in borings B-013-2-15 and B-122-0-09 as presented in Table 4.

Table 4. Top of Bedrock Elevations

Boring Number	Ground Surface Elevation (feet msl)	Top of Bedrock		Top of Bedrock Core	
		Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-013-2-15	705.5	58.5	647.0	59.5	646.0
B-122-0-09	705.6	63.5	642.1	73.6	632.0

Top of bedrock was encountered in borings B-013-2-15 and B-122-0-09 at an elevation of 647.0 and 642.1 feet msl, respectively. The upper portion of the bedrock consists of weathered limestone which was able to be augered to competent (cored) limestone bedrock, which was encountered at an elevation of 646.0 and 632.0 feet msl, respectively. The limestone is described as gray and white, unweathered to moderately weathered, moderately strong to strong, medium to thick bedded, fossiliferous, petroliferous, cherty, pyritic, dolomitic and slightly to highly fractured with open, slightly rough apertures.

The percent recovery and RQD values from the bedrock core runs are summarized in Table 5.

Table 5. Rock Core Summary

Boring	Core No.	Depth (feet)	Recovery (%)	RQD (%)
B-013-2-15	RC-1	59.5 to 61.5	92	25
	RC-2	61.5 to 66.5	100	71
B-122-0-09	RC-1	73.6 to 79.1	100	77

It should be noted that bedrock experiences mechanical breaks during the drilling and coring processes. Rii attempted to account for fresh, manmade breaks during tabulation of the RQD analysis. The quality of the cored, according to the RQD values, was very poor (RQD ≤ 25%) to good (75 < RQD ≤ 90%).

4.4 Groundwater

Groundwater was encountered in the borings as presented in Table 6.

Table 6. Groundwater Levels

Boring Number	Ground Surface Elevation (feet msl)	Initial Groundwater		Upon Completion	
		Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-013-1-15	725.9	Dry	Dry	Dry	Dry
B-013-2-15	705.5	18.5	687.0	N/A [1]	N/A
B-109-0-09	704.9	13.5	691.4	N/A [1]	N/A
B-122-0-09	705.6	13.5	692.1	15.7 [2]	689.9

1. *The groundwater level at completion could not be obtained due to the addition of mud as a drilling fluid.*
2. *The groundwater level at completion was measured prior to adding water for the rock coring process.*

Groundwater was not encountered during or at the completion of drilling in boring B-013-1-15. Groundwater was encountered initially during the drilling process in borings B-013-2-15, B-109-0-09 and B-122-0-09 at depths ranging from 13.5 18.5 feet below the existing ground surface, which corresponds to elevations ranging from 687.0 to 692.1 feet msl. The groundwater levels at the completion of drilling in borings B-013-2-15 and B-109-0-09 could not be measured due to the addition of mud to counteract heaving sands as well as water as a circulating fluid during the rock coring process. The groundwater level at the completion of drilling in boring B-122-0-08 was 15.7 feet below existing grade prior to adding water for the rock coring process.

Please note that short-term water level readings, especially in cohesive soils, are not necessarily an accurate indication of the actual groundwater level. In addition, groundwater levels or the presence of groundwater are considered to be dependent on seasonal fluctuations in precipitation.

A more comprehensive description of what was encountered during the drilling process may be found on the boring logs in Appendix IV.

4.5 Historic Borings

In general, the historic borings encountered medium dense to very dense granular soils overlying hard cohesive soils. The granular soils were generally described as brown and gray gravel, gravel and sand, gravel with sand and silt, sandy silt and silt (ODOT A-1-a, A-1-b, A-2-4, A-4a, A-4b), and the cohesive soils were generally described as gray sandy silt and silt (ODOT A-4a, A-4b). Bedrock was not encountered in the historic borings prior to the termination depths. Groundwater levels were not noted in the borings performed during the 1968 investigation. In general, the subsurface conditions encountered in the historic borings matched relatively closely with the subsurface conditions encountered in the current exploration borings.

5.0 ANALYSES AND RECOMMENDATIONS

Data obtained from the review of existing geotechnical information have been used to determine the foundation support capabilities and the settlement potential for the soil encountered at the site. These parameters have been used to provide guidelines for the design of foundation systems for the subject bridge, as well as the construction specifications related to the placement of foundation systems and general earthwork recommendations, which are discussed in the following paragraphs.

Design details of the structure proposed were provided by Burgess and Niple. Based on information provided by Burgess and Niple, it is understood that the existing superstructure will be removed and replaced and that the structure will widened approximately 40 feet to the south to accommodate the proposed Ramp C5 alignment. It is also understood that the existing substructure units will be remain in place to support the new superstructure where I-70 eastbound crosses Souder Avenue. The proposed widened structure will consist of a single-span prestressed concrete I-beam superstructure with a composite reinforced concrete deck and full height, wall-type semi-integral abutments. It is understood that the proposed substructure units for the widened portion of the structure will match the geometry of the existing abutments. The roadway profile grade along I-70 will match the existing roadway profile grade, and the widened portion of the structure will be situated along the existing embankment slope. Proposed structural data for the widened was obtained from design details provided by Burgess and Niple and are included in Table 7.

Table 7. Structure and Bridge Design Elevations

Substructure Unit	Structure Component [1]	Elevation [1] (feet msl)	Maximum Design Load
Rear / Forward Abutment (B-013-2-15)	Bottom of Footing	698.4	74 tons/pile

1. *Proposed foundation elevations and structural loading based on structure information provided by Burgess and Niple.*

As the design includes the reuse of portions of the existing structure, it is understood that the proposed design will be performed using Load Factor Design (LFD) specifications in accordance with the 2004 Bridge Design Manual (BDM). Therefore, all recommendations will be presented using allowable bearing values with the appropriate factor-of-safety.

5.1 Shallow Foundation Recommendations

Based on a review of the historic construction records for this structure, the existing abutments consist of full height, cast-in-place (CIP) reinforced concrete wall-type abutments that were designed for a maximum bearing pressure of 2.5 tons per square foot (5.0 ksf). The structure foundation exploration report for the existing structure was not able to be located during a review of the available historic records; consequently, the maximum allowable bearing capacity recommended for the existing spread foundations could not be determined. Therefore, it is recommended that the maximum design bearing pressure for the portion of the new structure that will be supported on the existing spread foundations not exceed the maximum design bearing pressure for the existing structure of 2.5 tsf.

Consideration was given to use of shallow spread foundations for support of the proposed widened portion of the bridge, but given the potential for excessive differential settlement between the existing and widened portions of the structure, this foundation option was eliminated. Therefore, it is recommended that the widened portion of the structure be supported on a deep foundation system.

5.2 Driven Pile Recommendations

Per Section 202.2.3.2 of the 2004 ODOT BDM, cast-in-place (CIP) pipe piles shall be utilized where piles are not extended to bedrock, and steel H-piles shall be utilized where piles are driven to bear on bedrock. Given the depth to bedrock encountered at the site as well as the proposed loading, either steel CIP pipe piles (ODOT Item 507.06) driven to the required frictional capacity based on the design load provided in Table 7 or steel H-piles (ODOT Item 507.07) driven to refusal on bedrock can employed for foundation support. Based on the soil encountered at this site, it has been determined that a CIP pile foundation will not be a feasible foundation type due to the dense granular soils encountered in the upper 25 feet of the soil profile below the foundation elevation. The pile analysis considered 12, 14 and 16-inch CIP piles and the results indicated that the piles could not be extended to the minimum required embedment depth of 15.0 feet below the bottom of the CIP walls without potentially overstressing the piles. Therefore, this pile type is not considered suitable for support of the proposed structure widening.

It is recommended to support the proposed structure on steel H-piles driven to refusal on bedrock. Refusal on bedrock during driving can be considered achieved when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. Table 8 provides recommended pile lengths and the corresponding ultimate bearing value (UBV) of the CIP pipe piles and steel H-piles and associated factor-of-safety (FS).

Table 8. FRA-70-1282R Driven Pile Recommendations

Substructure Reference	Ground Elevation [1]	Pile Size	Pile Elevation (feet msl)		Pile Length [3] (feet)	Ultimate Bearing Value (tons/pile)	FS [4]
			Top [2]	Tip			
Rear / Forward Abutment (B-013-2-15)	705.5	HP 10x42 [5]	699.4	647.0	55	150	2.0

1. *Ground elevation listed is the ground elevation at the boring location.*
2. *The top of pile elevation corresponds to the pile cutoff elevation, which is assumed to be 1.0-foot above the proposed bottom of footing elevation.*
3. *Per Section 202.3.2 of the 2004 ODOT BDM, the estimated pile length was determined as the pile cutoff elevation (top) minus the pile tip elevation, rounded up to the nearest 5.0 feet.*
4. *A factor-of-safety of 2.0 should be considered in determining the design load per pile per Section 202.3.2 of the 2004 ODOT BDM.*
5. *A steel pile point is recommended to protect the tips of the H-piles during pile installation.*

The CIP pipe piles were analyzed utilizing the DRIVEN software program, and the results are provided in Appendix VI.

Static or dynamic load testing is not required for H-piles driven to refusal on bedrock. Further installation considerations are presented in Section 5.2.2.

5.2.1 Driveability

A drivability analysis was performed in accordance with Section 10.7.8 of the 2017 AASHTO LRFD BDS using the GRLWEAP software program, and the results are provided in Appendix VII. In the driveability analysis, a Delmag 19-42 hammer with a rated energy of approximately 43,000 ft-lbs was used in conjunction with the H-pile section. Based on the results of this analysis, driving stresses induced on the H-piles **would not exceed** 90 percent of the yield stress of the steel (f_y = 50 ksi, 0.9f_y = 45 ksi) if driven through the overburden soils to the bedrock elevation provided in Table 8. Care should be taken during pile driving operations when approaching the bedrock elevation noted in Table 8, and when extending the piles into the surficial bedrock material, to ensure that the driving stresses induced on the pile elements do not exceed the maximum allowable value of 90 percent of the yield stress of the steel, subsequently damaging the pile elements. Pile driving should be terminated upon achieving the required 20 blows from the pile hammer with an inch or less of penetration to reduce the possibility of damaging the pile element.

Per Section 202.2.3.2.a of the 2004 ODOT BDM, a steel pile point should be used during the pile installation to protect the tips of the H-piles when the piles are being driven to bear on strong bedrock, such as the limestone bedrock encountered at this structure location.

5.2.2 Driven Pile Considerations

Proper pile installation is as important as pile design in order to obtain a cost effective and safe product. Driven piles must be installed to develop adequate soil resistance without structural damage. Because piles cannot be visually inspected after installation, direct quality control of the finished product is impossible. Consequently, substantial control must be exercised over peripheral operations leading to the pile placement within the foundation. It is essential that installation be considered during the design stage to insure that piles shown on the plans can be installed. Construction monitoring should be employed in (1) pile materials, (2) installation equipment, and (3) the estimation of the static load capacity.

It is recommended that the contractor submit a wave equation analysis (bearing graph) of his driving equipment, or the necessary pile driving and equipment data to perform the wave equation analysis, for hammer approval. A constant capacity wave equation analysis (inspector’s chart) should also be performed to assist field personnel during inspection in accordance with the 2004 ODOT BDM.

The existing spread foundations are bearing on dense to very dense granular soils consisting of gravel, gravel and sand and gravel with sand and silt (ODOT A-1-a, A-1-b, A-2-4). Given the granular nature of the bearing soils, there may be a risk for additional or differential settlement of the existing spread footing foundations due to vibrations from the pile driving operations given the close proximity of the piles to the existing foundations. Therefore, it is recommended that the existing foundations be closely monitored during installation of the new piles for the widened portion of the proposed structure to ensure that additional settlement of the existing structure does not occur.

5.2.3 *Lateral Design*

If lateral load or moments are expected to be applied on the foundation elements, they should be analyzed to verify the pile has enough lateral and bending resistance against these loads. A boring-by-boring tabulation of parameters that should be used for lateral loading design is provided in Appendix VIII. In order to evaluate the lateral capacity, it is recommended that a derivation of COM624, such as LPILE, be utilized to determine the proper embedment depth and cross section required to resist the lateral load for a given end condition and deflection. Table 9 lists the eleven different soil types internal to the LPILE program. These strata were utilized to define the soil strata in the soil profile for each boring provided in Appendix VIII.

Table 9. Subsurface Strata Description

Strata	Description
1	Soft Clay
2	Stiff Clay with Water
3	Stiff Clay without Free Water
4	Sand (Reese)
5	User Defined
6	Vuggy Limestone (Strong Rock)
7	Silt (with cohesion and internal friction angle)
8	API Sand
9	Weak Rock
10	Liquefiable Sand (Rollins)
11	Stiff Clay without free water with a specified initial K (Brown)

5.3 Lateral Earth Pressure

For the soil types encountered in the borings, the "in-situ" unit weight (γ), cohesion (c), effective angle of friction (φ'), and lateral earth pressure coefficients for at-rest conditions (k_o), active conditions (k_a), and passive conditions (k_p) have been estimated and are provided in Table 10 and Table 11.

Table 10. Estimated Undrained (Short-term) Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ	k_a	k_o	k_p
Medium Stiff to Stiff Cohesive Soil	115	1,000	0°	N/A	N/A	N/A
Very Stiff to Hard Cohesive Soil	125	3,000	0°	N/A	N/A	N/A
Loose Granular Soil	120	0	28°	0.32	0.53	5.07
Medium Dense to Dense Granular Soil	130	0	32°	0.27	0.47	6.82
Very Dense Granular Soil	135	0	35°	0.24	0.43	8.56
Compacted Cohesive Engineered Fill	120	2,000	0°	N/A	N/A	N/A
Compacted Granular Engineered Fill	130	0	33°	0.26	0.46	7.41

1. *When below groundwater table, use effective unit weight, $\gamma' = \gamma$ - 62.4 pcf and add hydrostatic water pressure.*

Table 11. Estimated Drained (Long-term) Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ'	k_a	k_o	k_p
Medium Stiff to Stiff Cohesive Soil	115	0	26°	0.35	0.56	4.53
Very Stiff to Hard Cohesive Soil	125	100	28°	0.32	0.53	5.07
Loose Granular Soil	120	0	28°	0.32	0.53	5.07
Medium Dense to Dense Granular Soil	130	0	32°	0.27	0.47	6.82
Very Dense Granular Soil	135	0	35°	0.24	0.43	8.56
Compacted Cohesive Engineered Fill	120	0	30°	0.30	0.50	5.58
Compacted Granular Engineered Fill	130	0	33°	0.26	0.46	7.41

1. *When below groundwater table, use effective unit weight, $\gamma' = \gamma$ - 62.4 pcf and add hydrostatic water pressure.*

These parameters are considered appropriate for the design of all subsurface structures and any excavation support systems. Subsurface structures (where the top of the structure is restrained from movement) should be designed based on at-rest conditions (k_o). For proposed temporary retaining structures (where the top of the structure is allowed to move), earth pressure distributions should be based on active (k_a) and passive (k_p) conditions. The values in this table have been estimated from correlation charts based on minimum standards specified for compacted engineered fill materials. These recommendations do not take into consideration the effect of any surcharge loading or a sloped ground surface (a flat surface is considered). Earth pressures on excavation support systems will be dependent on the type of sheeting and method of bracing or anchorage.

5.4 Construction Considerations

All site work shall conform to local codes and to the latest ODOT Construction and Materials Specifications (CMS), including that all excavation and embankment preparation and construction should follow ODOT Item 200 (Earthwork).

As noted in Section 5.2.2, given the granular nature of the bearing soils, there may be a risk for additional or differential settlement of the existing spread footing foundations due to vibrations from the pile driving operations given the close proximity of the piles to the existing foundations. Therefore, it is recommended that the existing foundations be closely monitored during installation of the new piles for the widened portion of the proposed structure to ensure that additional settlement of the existing structure does not occur.

5.4.1 Excavation Considerations

All excavations should be shored / braced or laid back at a safe angle in accordance to Occupational Safety and Health Administration (OSHA) guidelines. During excavation, if slopes cannot be laid back to OSHA Standards due to adjacent structures or other obstructions, sheeting boxes may be required. The following table should be utilized as a general guide for implementing OSHA guidelines when estimating excavation back slopes at the various boring locations. Actual excavation back slopes must be field verified by qualified personnel at the time of excavation in strict accordance with OSHA guidelines.

Table 12. Excavation Back Slopes

Soil	Maximum Back Slope	Notes
Soft to Medium Stiff Cohesive	1.5 : 1.0	Above Ground Water Table and No Seepage
Stiff Cohesive	1.0 : 1.0	Above Ground Water Table and No Seepage
Very Stiff to Hard Cohesive	0.75 : 1.0	Above Ground Water Table and No Seepage
All Granular & Cohesive Soil Below Ground Water Table or with Seepage	1.5 : 1.0	None
Rock to 3.0' +/- below Auger Refusal	0.75 : 1.0	Above Ground Water Table and No Seepage
Stable Rock	Vertical	Above Ground Water Table and No Seepage

5.4.2 Groundwater Considerations

Based on the groundwater observations made during drilling, groundwater is not anticipated to be encountered during construction of the proposed structure. However, if groundwater is encountered, proper groundwater control should be employed and maintained to prevent disturbance to excavation bottoms consisting of cohesive soil, and to prevent the possible development of a quick or "boiling" condition where soft silts and/or fine sands are encountered. It is preferable that the groundwater level, if encountered, be maintained at least 36 inches below the deepest excavation. Any seepage or groundwater encountered at this site should be able to be controlled by pumping from temporary sumps. Additional measures may be required depending on seasonal fluctuations of the groundwater level. Note that determining and maintaining actual groundwater levels during construction is the responsibility of the contractor.

6.0 LIMITATIONS OF STUDY

The above recommendations are predicated upon construction inspection by a qualified soil technician under the direct supervision of a professional geotechnical engineer. Adequate testing and inspection during construction are considered necessary to assure an adequate foundation system and are part of these recommendations.

The recommendations for this project were developed utilizing soil and bedrock information obtained from the test borings that were made at the proposed site for the current investigation. Resource International is not responsible for the data, conclusions, opinions or recommendations made by others during previous investigations at this site. At this time we would like to point out that soil borings only depict the soil and bedrock conditions at the specific locations and time at which they were made. The conditions at other locations on the site may differ from those occurring at the boring locations.

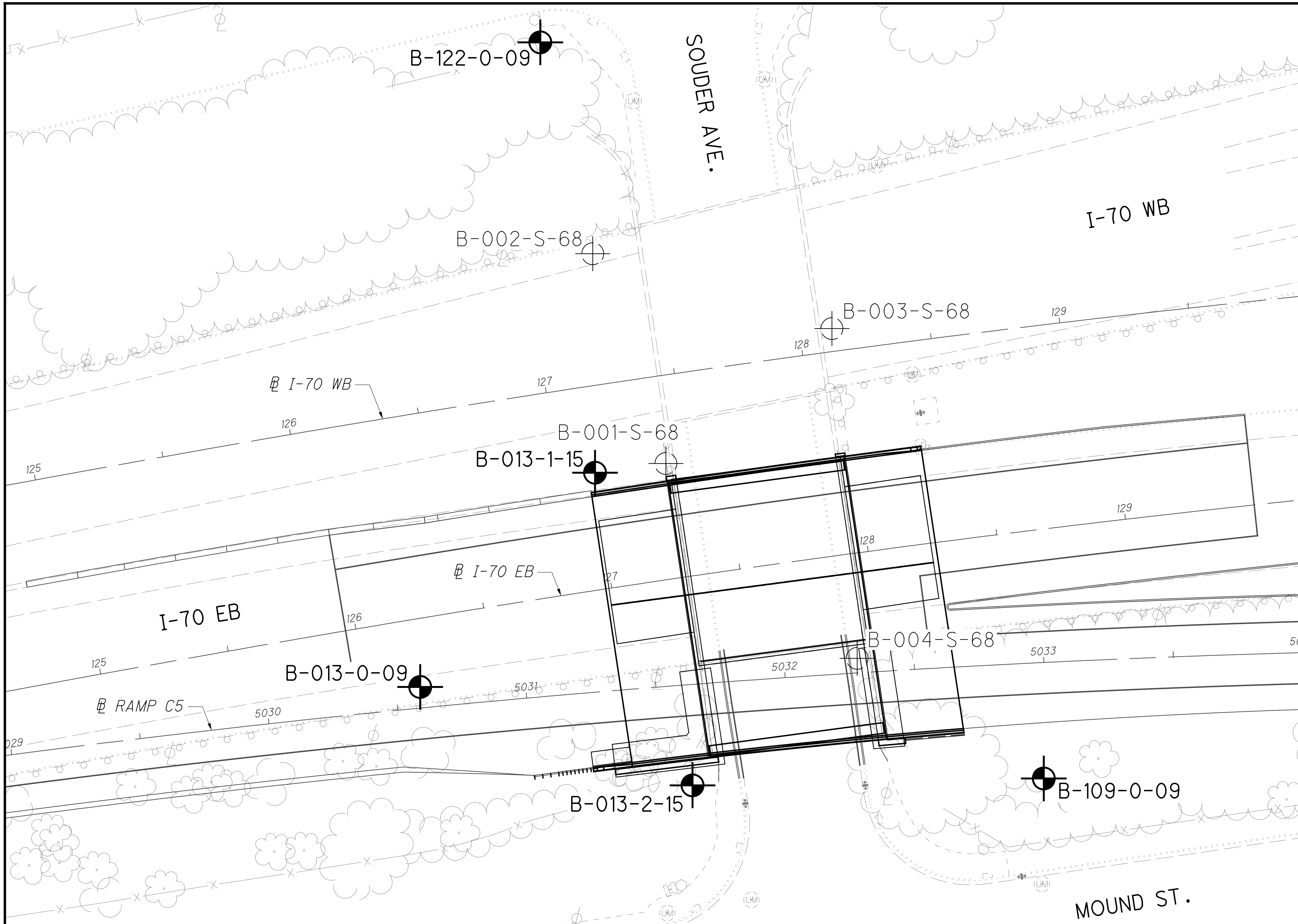
The conclusions and recommendations herein have been based upon the available soil and bedrock information and the design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be brought to the attention of the geotechnical engineer to determine whether any changes in the foundation or earthwork recommendations are necessary. If deviations from the noted subsurface conditions are encountered during construction, they should also be brought to the attention of the geotechnical engineer.

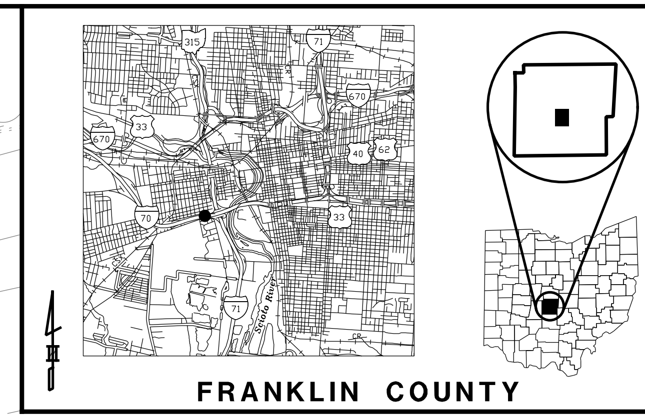
The scope of our services does not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater or surface water within or beyond the site studied. Any statements in this report or on the test boring logs regarding odors, staining of soils or other unusual conditions observed are strictly for the information of our client.

Our professional services have been performed, our findings obtained and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. Resource International is not responsible for the conclusions, opinions or recommendations made by others based upon the data included.

APPENDIX I

VICINITY MAP AND BORING PLAN





VICINITY MAP

BORING PLAN

FRA-70-1282R

FRANKLIN COUNTY, OHIO

RII PROJECT NO. W-13-045		DRAWN RRM
SCALE: 1"=40' 0 20 40	N	REVIEWED BRT
		DATE 7-11-18

RESOURCE INTERNATIONAL, INC.

APPENDIX II

DESCRIPTION OF SOIL TERMS

DESCRIPTION OF SOIL TERMS

The following terminology was used to describe soils throughout this report and is generally adapted from ASTM 2487/2488 and ODOT Specifications for Geotechnical Explorations.

Granular Soils – ODOT A-1, A-2, A-3, A-4 (non-plastic)
The relative compactness of granular soils is described as:

Description	Blows per foot – SPT (N_{60})		
Very Loose	Below		5
Loose	5	-	10
Medium Dense	11	-	30
Dense	31	-	50
Very Dense	Over		50

Cohesive Soils – ODOT A-4, A-5, A-6, A-7, A-8
The relative consistency of cohesive soils is described as:

Description	Unconfined Compression (tsf)		
Very Soft	Less than		0.25
Soft	0.25	-	0.5
Medium Stiff	0.5	-	1.0
Stiff	1.0	-	2.0
Very Stiff	2.0	-	4.0
Hard	Over		4.0

Gradation - The following size-related denominations are used to describe soils:

Soil Fraction		Size
Boulders		Larger than 12”
Cobbles		12” to 3”
Gravel	coarse	3” to ¾“
	fine	¾” to 2.0 mm (¾” to #10 Sieve)
Sand	coarse	2.0 mm to 0.42 mm (#10 to #40 Sieve)
	fine	0.42 mm to 0.074 mm (#40 to #200 Sieve)
Silt		0.074 mm to 0.005 mm (#200 to 0.005 mm)
Clay		Smaller than 0.005 mm

Modifiers of Components - The following modifiers indicate the range of percentages of the minor soil components:

Term	Range		
Trace	0%	-	10%
Little	10%	-	20%
Some	20%	-	35%
And	35%	-	50%

Moisture Table - The following moisture-related denominations are used to describe cohesive soils:

Term	Range - ODOT
Dry	Well below Plastic Limit
Damp	Below Plastic Limit
Moist	Above PL to 3% below LL
Wet	3% below LL to above LL

Organic Content – The following terms are used to describe organic soils:

Term	Organic Content (%)
Slightly organic	2-4
Moderately organic	4-10
Highly organic	>10

Bedrock – The following terms are used to describe the relative strength of bedrock:

Description	Field Parameter
Very Weak	Can be carved with knife and scratched by fingernail. Pieces 1 in. thick can be broken by finger pressure.
Weak	Can be grooved or gouged with knife readily. Small, thin pieces can be broken by finger pressure.
Slightly Strong	Can be grooved or gouged 0.05 in deep with knife. 1 in. size pieces from hard blows of geologist hammer.
Moderately Strong	Can be scratched with knife or pick. 1/4 in. size grooves or gouges from blows of geologist hammer.
Strong	Can be scratched with knife or pick with difficulty. Hard hammer blows to detach hand specimen.
Very Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to detach hand specimen.
Extremely Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to chip hand specimen.

CLASSIFICATION OF SOILS

Ohio Department of Transportation

(The classification of a soil is found by proceeding from top to bottom of the chart. The first classification that the test data fits is the correct classification.)

SYMBOL	DESCRIPTION	Classifcation AASHTO	OHIO	LL_O/LL × 100*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
	Gravel and/or Stone Fragments	A-1-a			30 Max.	15 Max.		6 Max.	0	Min. of 50% combined gravel, cobble and boulder sizes
	Gravel and/or Stone Fragments with Sand	A-1-b			50 Max.	25 Max.		6 Max.	0	
	Fine Sand	A-3			51 Min.	10 Max.	NON-PLASTIC		0	
	Coarse and Fine Sand	--	A-3a			35 Max.		6 Max.	0	Min. of 50% combined coarse and fine sand sizes
	Gravel and/or Stone Fragments with Sand and Silt	A-2-4				35 Max.	40 Max.	10 Max.	0	
		A-2-5					41 Min.			
	Gravel and/or Stone Fragments with Sand, Silt and Clay	A-2-6				35 Max.	40 Max.	11 Min.	4	
		A-2-7					41 Min.			
	Sandy Silt	A-4	A-4a	76 Min.		36 Min.	40 Max.	10 Max.	8	Less than 50% silt sizes
	Silt	A-4	A-4b	76 Min.		50 Min.	40 Max.	10 Max.	8	50% or more silt sizes
	Elastic Silt and Clay	A-5		76 Min.		36 Min.	41 Min.	10 Max.	12	
	Silt and Clay	A-6	A-6a	76 Min.		36 Min.	40 Max.	11 - 15	10	
	Silty Clay	A-6	A-6b	76 Min.		36 Min.	40 Max.	16 Min.	16	
	Elastic Clay	A-7-5		76 Min.		36 Min.	41 Min.	≤LL-30	20	
	Clay	A-7-6		76 Min.		36 Min.	41 Min.	>LL-30	20	
	Organic Silt	A-8	A-8a	75 Max.		36 Min.				W/o organics would classify as A-4a or A-4b
	Organic Clay	A-8	A-8b	75 Max.		36 Min.				W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6

MATERIAL CLASSIFIED BY VISUAL INSPECTION

- Sod and Topsoil
- Pavement or Base
- Uncontrolled Fill (Describe)
- Bouldery Zone
- P Peat

* Only perform the oven-dried liquid limit test and this calculation if organic material is present in the sample.

DESCRIPTION OF ROCK TERMS

The following terminology was used to describe the rock throughout this report and is generally adapted from ASTM D5878 and the ODOT Specifications for Geotechnical Explorations.

Weathering – Describes the degree of weathering of the rock mass:

Description	Field Parameter
Unweathered	No evidence of any chemical or mechanical alteration of the rock mass. Mineral crystals have a right appearance with no discoloration. Fractures show little or not staining on surfaces.
Slightly Weathered	Slight discoloration of the rock surface with minor alterations along discontinuities. Less than 10% of the rock volume presents alteration.
Moderately Weathered	Portions of the rock mass are discolored as evident by a dull appearance. Surfaces may have a pitted appearance with weathering "halos" evident. Isolated zones of varying rock strengths due to alteration may be present. 10 to 15% of the rock volume presents alterations.
Highly Weathered	Entire rock mass appears discolored and dull. Some pockets of slightly to moderately weathered rock may be present and some areas of severely weathered materials may be present.
Severely Weathered	Majority of the rock mass reduced to a soil-like state with relic rock structure discernable. Zones of more resistant rock may be present but the material can generally be molded and crumbled by hand pressures.

Strength of Bedrock – The following terms are used to describe the relative strength of bedrock:

Description	Field Parameter
Very Weak	Can be carved with knife and scratched by fingernail. Pieces 1 in. thick can be broken by finger pressure.
Weak	Can be grooved or gouged with knife readily. Small, thin pieces can be broken by finger pressure.
Slightly Strong	Can be grooved or gouged 0.05 in deep with knife. 1 in. size pieces from hard blows of geologist hammer.
Moderately Strong	Can be scratched with knife or pick. 1/4 in. size grooves or gouges from blows of geologist hammer.
Strong	Can be scratched with knife or pick with difficulty. Hard hammer blows to detach hand specimen.
Very Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to detach hand specimen.
Extremely Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to chip hand specimen.

Bedding Thickness – Description of bedding thickness as the average perpendicular distances between bedding surfaces:

Description	Thickness
Very Thick	Greater than 36 inches
Thick	18 to 36 inches
Medium	10 to 18 inches
Thin	2 to 10 inches
Very Thin	0.4 to 2 inches
Laminated	0.1 to 0.4 inches
Thinly Laminated	Less than 0.1 inches

Fracturing – Describes the degree and condition of fracturing (fault, joint, or shear):

Degree of Fracturing

Description	Spacing
Unfractured	Greater than 10 feet
Intact	3 to 10 feet
Slightly Fractured	1 to 3 feet
Moderately Fractured	

Aperture Width

Description	Width
Open	Greater than 0.2 inches
Narrow	0.05 to 0.2 inches
Tight	Less than 0.05 inches

Surface Roughness

Description	Criteria
Very Rough	Near vertical steps and ridges occur on surface
Slightly Rough	Asperities on the surfaces distinguishable
Slickensided	Surface has smooth, glassy finish, evidence of Striations

RQD – Rock Quality Designation (calculation shown in report) and Rock Quality (ODOT, GB 3, January 13, 2006):

RQD %	Rock Index Property Classification (based on RQD, not slake durability index)
0 – 25%	Very Poor
26 – 50%	Poor
51 – 70%	Fair
71 – 85%	Good
86 – 100%	Very Good

APPENDIX III

PROJECT BORING LOGS:

B-013-1-13, B-013-2-13, B-109-0-09
and B-122-0-09

BORING LOGS

Definitions of Abbreviations

AS	=	Auger sample
GI	=	Group index as determined from the Ohio Department of Transportation classification system
HP	=	Unconfined compressive strength as determined by a hand penetrometer (tons per square foot)
LL_o	=	Oven-dried liquid limit as determined by ASTM D4318. Per ASTM D2487, if LL_o/LL is less than 75 percent, soil is classified as “organic”.
LOI	=	Percent organic content (by weight) as determined by ASTM D2974 (loss on ignition test)
PID	=	Photo-ionization detector reading (parts per million)
QR	=	Unconfined compressive strength of intact rock core sample as determined by ASTM D2938 (pounds per square inch)
QU	=	Unconfined compressive strength of soil sample as determined by ASTM D2166 (pounds per square foot)
RC	=	Rock core sample
REC	=	Ratio of total length of recovered soil or rock to the total sample length, expressed as a percentage
RQD	=	Rock quality designation – estimate of the degree of jointing or fracture in a rock mass, expressed as a percentage:

$$\frac{\sum \text{segments equal to or longer than 4.0 inches}}{\text{core run length}} \times 100$$

S	=	Sulfate content (parts per million)
SPT	=	Standard penetration test blow counts, per ASTM D1586. Driving resistance recorded in terms of blows per 6-inch interval while letting a 140-pound hammer free fall 30 inches to drive a 2-inch outer diameter (O.D.) split spoon sampler a total of 18 inches. The second and third intervals are added to obtain the number of blows per foot (N_m).
N_{60}	=	Measured blow counts corrected to an equivalent (60 percent) energy ratio (ER) by the following equation: $N_{60} = N_m*(ER/60)$
SS	=	Split spoon sample
2S	=	For instances of no recovery from standard SS interval, a 2.5 inch O.D. split spoon is driven the full length of the standard SS interval plus an additional 6.0 inches to obtain a representative sample. Only the final 6.0 inches of sample is retained. Blow counts from 2S sampling are not correlated with N_{60} values.
3S	=	Same as 2S, but using a 3.0 inch O.D. split spoon sampler.
TR	=	Top of rock
W	=	Initial water level measured during drilling
▼	=	Water level measured at completion of drilling

Classification Test Data

Gradation (as defined on Description of Soil Terms):

GR	=	% Gravel
SA	=	% Sand
SI	=	% Silt
CL	=	% Clay

Atterberg Limits:

LL	=	Liquid limit
PL	=	Plastic limit
PI	=	Plasticity Index
WC	=	Water content (%)

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / J.K./S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 127+00.32 / 45.0' LT
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / C.D./N.A.	HAMMER: AUTOMATIC	ALIGNMENT: BL I-70 EB
PID: 77372 BR ID: FRA-70-1282R	DRILLING METHOD: 4.5" CFA / 3.25" HSA	CALIBRATION DATE: 4/26/13	ELEVATION: 725.9 (MSL) EOB: 35.0 ft.
START: 2/26/15 END: 2/27/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.7	LAT / LONG: 39.950158148, -83.021287305

EXPLORATION ID **B-013-1-15**

MATERIAL DESCRIPTION AND NOTES	ELEV. 725.9
0.6' - ASPHALT (7.0")	725.3
0.4' - AGGREGATE BASE (5.0")	724.9
FILL: HARD, BROWN **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.	722.9
FILL: DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST.	715.4
FILL: HARD, BROWN TO GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DRY TO DAMP.	707.9
DENSE TO VERY DENSE, GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST.	698.9
DENSE, GRAY **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, DAMP. -ROCK FRAGMENTS PRESENT IN SS-10	

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
40 16 13	38	67	SS-1	4.5+	-	-	-	-	-	-	-	-	8	A-6a (V)
11 15 16	40	100	SS-2	-	34	30	17	12	7	NP	NP	NP	7	A-1-b (0)
14 12 14	34	100	SS-3	-	-	-	-	-	-	-	-	-	7	A-1-b (V)
19 17 14	40	100	SS-4	-	-	-	-	-	-	-	-	-	8	A-1-b (V)
15 9 11	26	100	SS-5	4.5+	-	-	-	-	-	-	-	-	9	A-6a (V)
8 8 14	28	100	SS-6	4.5+	20	13	11	36	20	28	17	11	14	A-6a (5)
14 22 21	56	100	SS-7	4.5+	-	-	-	-	-	-	-	-	9	A-6a (V)
8 11 14	32	100	SS-8	-	52	19	7	14	8	NP	NP	NP	12	A-1-b (0)
17 15 25	52	100	SS-9	-	-	-	-	-	-	-	-	-	9	A-1-b (V)
12 12 18	39	100	SS-10	-	-	-	-	-	-	-	-	-	5	A-1-a (V)

PID: 77372	BR ID: FRA-70-1282R	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 127+00.32 / 45.0 LT	START: 2/26/15	END: 2/27/15	PG 2 OF 2	B-013-1-15

MATERIAL DESCRIPTION AND NOTES	ELEV. 695.9	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
DENSE, GRAY **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, DAMP. *(same as above)*	693.9	31, 32																
MEDIUM DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP.		33																
-ROCK FRAGMENTS PRESENT IN SS-11	690.9	34, EOB 35	9 9 10	25	100	SS-11	-	61	14	5	13	7	NP	NP	NP	6	A-1-b (0)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

2014 ODOT BORING LOG-RII NE BRIDGE ID - OH DOT.GDT - 3/14/15 17:33 - U:\GI8\PROJECTS\2013\W-13-045.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / J.K.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: 127+19.67 / 80.0' RT
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL I-70 EB
PID: 77372 BR ID: FRA-70-1282R	DRILLING METHOD: 4.25" HSA / RC	CALIBRATION DATE: 10/20/14	ELEVATION: 705.5 (MSL) EOB: 66.5 ft.
START: 1/29/15 END: 2/25/15	SAMPLING METHOD: SPT / HQ	ENERGY RATIO (%): 92	LAT / LONG: 39.949827253, -83.021150673

EXPLORATION ID **B-013-2-15**

MATERIAL DESCRIPTION AND NOTES	ELEV. 705.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
0.5' - TOPSOIL (6.0")	705.0																	
FILL: MEDIUM DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST. -CINDERS AND STONE FRAGMENTS PRESENT IN SS-1		1–2	5 6 9	23	100	SS-1	-	-	-	-	-	-	-	-	-	11	A-2-6 (V)	
	702.5	3																
POSSIBLE FILL: DENSE TO VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP. -ROOT FIBERS PRESENT IN SS-2		4–5	24 20 15	54	56	SS-2	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	
		6–7	10 14 12	40	67	SS-3	-	63	12	8	13	4	NP	NP	NP	6	A-1-b (0)	
	697.5	8																
MEDIUM DENSE TO VERY DENSE, BROWN **GRAVEL**, LITTLE TO SOME COARSE TO FINE SAND, TRACE TO LITTLE SILT, TRACE CLAY, DAMP TO MOIST.		9–10	16 18 23	63	100	SS-4	-	-	-	-	-	-	-	-	-	5	A-1-a (V)	
-COBBLES ENCOUNTERED @ 11.0'		11–12	14 13 14	41	50	SS-5	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	
		14–15	16 20 17	57	72	SS-6	-	71	12	5	9	3	NP	NP	NP	5	A-1-a (0)	
		W 17	7 15 21	55	89	SS-7	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
		W 18–19	13 29 50/2"	-	93	SS-8	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
		21–22	7 8 9	26	94	SS-9	-	-	-	-	-	-	-	-	-	10	A-1-a (V)	
-ROCK FRAGMENTS PRESENT IN SS-10		24–25	6 25 11	55	100	SS-10	-	53	25	7	12	3	NP	NP	NP	12	A-1-a (0)	
-HEAVING SANDS ENCOUNTERED @ 26.0'		26–27	5 12 16	43	100	SS-11	-	-	-	-	-	-	-	-	-	12	A-1-a (V)	
-INTRODUCED MUD @ 28.5'		29	19 16 20	55	100	SS-12	-	61	24	7	7	1	NP	NP	NP	10	A-1-a (0)	

PID: 77372	BR ID: FRA-70-1282R	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 127+19.67 / 80.0 RT	START: 1/29/15	END: 2/25/15	PG 2 OF 3	B-013-2-15

MATERIAL DESCRIPTION AND NOTES	ELEV. 675.5	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
MEDIUM DENSE TO VERY DENSE, BROWN **GRAVEL**, LITTLE TO SOME COARSE TO FINE SAND, TRACE TO LITTLE SILT, TRACE CLAY, DAMP TO MOIST. *(same as above)*	673.5	31 – 32																
HARD, GRAY **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP.		34 – 35	10 28 44	110	100	SS-13	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)	
		39 – 40	7 27 36	97	72	SS-14	4.5+	24	11	17	34	14	20	14	6	8	A-4a (3)	
	663.5																	
DENSE, BLACK **FINE SAND**, TRACE SILT, WET.		44 – 45	14 10 18	43	100	SS-15	-	-	-	-	-	-	-	-	-	19	A-3 (V)	
	658.5																	
HARD, DARK GRAY **SANDY SILT**, SOME CLAY, SOME FINE GRAVEL, DAMP.		48.5	50/4"	-	25	SS-16	-	-	-	-	-	-	-	-	-	11	A-4a (V)	
-BOULDER ENCOUNTERED @ 51.0-52.5'																		
-ROCK FRAGMENTS PRESENT IN SS-16 AND SS-17		53.5	50/3"	-	33	SS-17	-	-	-	-	-	-	-	-	-	12	A-4a (V)	
	647.0	TR																
LIMESTONE FRAGMENTS AUGER REFUSAL @ 59.5'	646.0	58.5 – 59	50/1"	-	100	SS-18	-	-	-	-	-	-	-	-	-	2	Rock (V)	
GRANITE BOULDER	645.5	60 – 61	25		92	RC-1											CORE	

2014 ODOT BORING LOG-RII NE BRIDGE ID - OH DOT.GDT - 3/27/15 18:31 - U:\GI8\PROJECTS\2013W-13-045.GPJ

PID: 77372	BR ID: FRA-70-1282R	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 127+19.67 / 80.0 RT	START: 1/29/15	END: 2/25/15	PG 3 OF 3	B-013-2-15

MATERIAL DESCRIPTION AND NOTES	ELEV. 643.4	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
LIMESTONE : GRAY AND WHITE, MODERATELY WEATHERED TO UNWEATHERED, MODERATELY STRONG TO STRONG, MEDIUM TO THICK BEDDED, CHERTY, DOLOMITIC, FOSSILIFEROUS, PYRITIC, SLIGHTLY TO HIGHLY FRACTURED, OPEN APERTURES, SLIGHTLY ROUGH.; RQD 58%, REC 98%. *(same as above)* -STYLOLITES PRESENT IN RC-2	639.0	63 64 65 66 EOB	71		100	RC-2											CORE	

NOTES: SEEPAGE ENCOUNTERED @ 17.0'; GROUNDWATER ENCOUNTERED INITIALLY @ 18.5'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 100 LBS BENTONITE CHIPS AND SOIL CUTTINGS

B-013-2-13 – RC-1 – Depth from 59.5 to 61.5 feet

B-013-2-13 – RC-2 – Depth from 61.5 to 66.5 feet

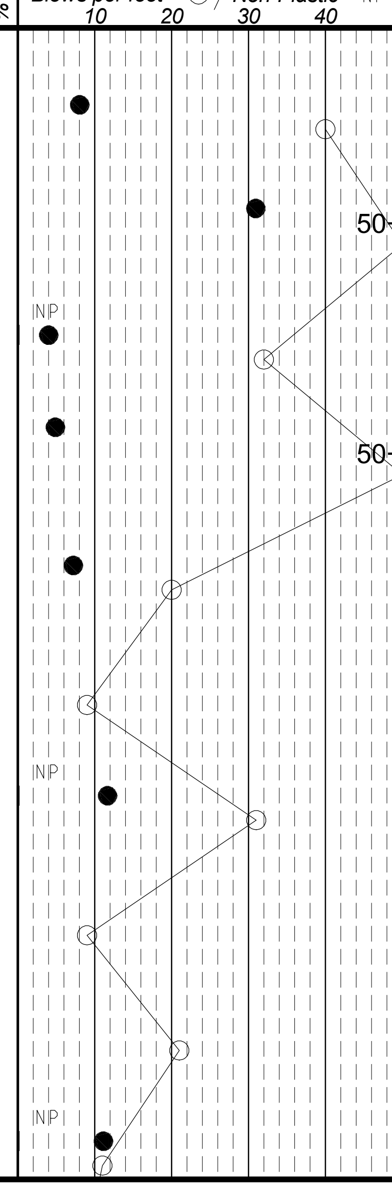
DLZ Ohio, Inc. * 6121 Huntley Road, Columbus, Ohio 43229 * (614) 888-0040

Client: ms consultants	Project: FRA-70-8.93	Job No. 0221-1004.01
LOG OF: Boring B-109-0-09	Location: Sta. 5032+97.77, 44.7' RT., BL RAMP C5	Date Drilled: 9/11/2009

WATER OBSERVATIONS:
Water seepage at: 13.5', 42.0'
Water level at completion: 12.5' (includes drilling water)
FIELD NOTES:

Depth (ft)	Elev. (ft) 704.9	Blows per 6"	Recovery	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
1.0	703.9						Topsoil - 5"						
		6 18 21	6	1			FILL: Very dense brown SANDY SILT (A-4a), some fine to coarse sand, some gravel; damp.						
3.5	701.4	10 50/1	2	2		-	POSSIBLE FILL: Hard brown SANDY SILT (A-4a), little clay, trace to little fine to coarse gravel; damp.						
6.0	698.9	15 15 16	12	3			Dense to very dense brown GRAVEL (A-1-a), little to some fine to coarse sand, trace silt; damp.	75	13	---	4	--8--	
		50/5	5	4									
		26 10 9	2	5			@ 11.0'-12.5'; contains sandstone fragments. @ 11.0'-15.0', loose to medium dense.						
		6 6 3	3	6			@ 13.5', becomes wet.						
		8 12 18	6	7				68	18	---	6	--8--	
		2 5 4	5	8			@ 18.5'-25.0', loose to medium dense.						
		5 8 12	2	9									
25	679.9	5 5 6	6	10			@ 23.5'-25.0', trace fine to coarse sand.	83	6	---	2	--9--	

STANDARD PENETRATION (N60)
Natural Moisture Content, % - ●
PL ⊢—⊣ LL
Blows per foot - ○ / Non-Plastic - NP

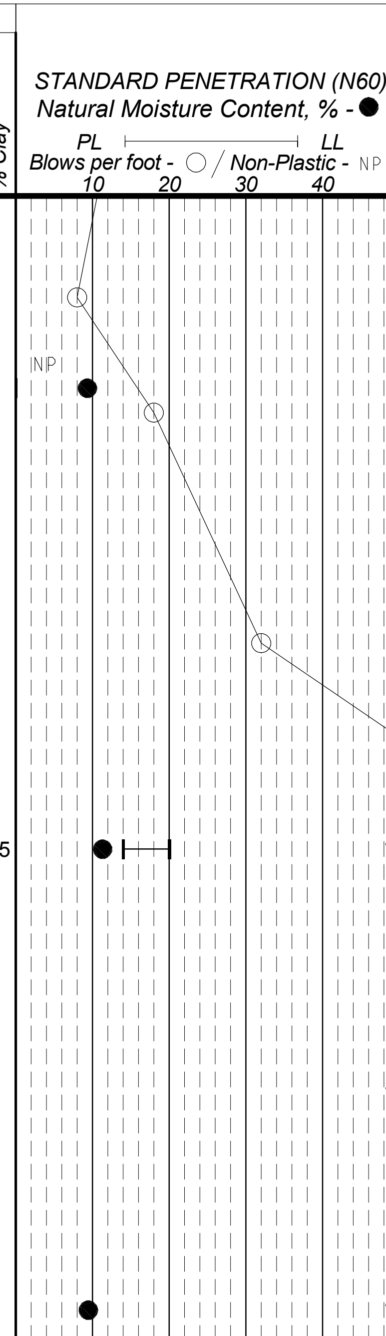


Client: ms consultants	Project: FRA-70-8.93	Job No. 0221-1004.01
LOG OF: Boring B-109-0-09	Location: Sta. 5032+97.77, 44.7' RT., BL RAMP C5	Date Drilled: 9/11/2009

WATER OBSERVATIONS:
Water seepage at: 13.5', 42.0'
Water level at completion: 12.5' (includes drilling water)

FIELD NOTES:

Depth (ft)	Elev. (ft) 679.9	Blows per 6"	Recovery	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
							Loose to medium dense brown GRAVEL WITH SAND (A-1-b), little fine to coarse sand, trace silt; damp.						
		3 3 5	3	11									
30		5 8 9	7	12				83	9	---	2	--6--	
35		15 14 17	1	13			@ 33.5'-35.0', dense.						
37.0	667.9						Hard gray SANDY SILT (A-4a), some fine to coarse sand, some gravel; damp.						
40		27 36 38	18	14		4.5+		21	16	---	17	31	15
42.0	662.9						Very dense gray COARSE AND FINE SAND (A-3a), little fine to coarse gravel, trace silt; wet.						
45		25 26 23	18	15									
47.0	657.9						Hard brown SANDY SILT (A-4a), trace to little gravel; moist.						
50.0	654.9	24 36 35	12	16		4.5+	Bottom of Boring - 50.0'						



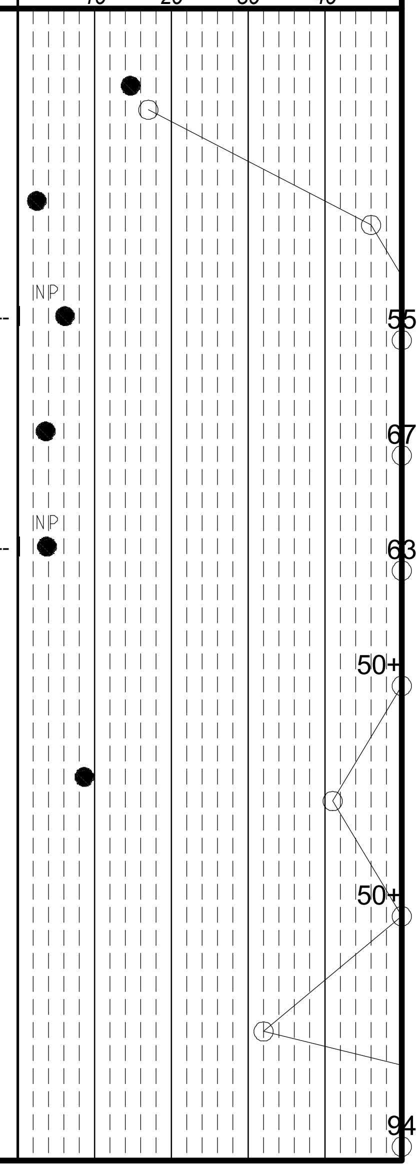
Client: ms consultants | *Project:* FRA-70-8.93 | *Job No.* 0221-1004.01

LOG OF: Boring B-122-0-09 | *Location:* Sta. 127+17.91, 134.2' LT., BL I-70 WB | *Date Drilled:* 8/18/2009 to 8/20/2009

WATER OBSERVATIONS:
Water seepage at: 13.5'
Water level at completion: 15.7' (prior to adding water)
FIELD NOTES:

Depth (ft)	Elev. (ft) 705.6	Blows per 6"	Recovery	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0.2	705.4						Topsoil - 2"						
		5 7 9	7	1		4.5+	POSSIBLE FILL: Hard brown CLAY (A-7-6), little fine to coarse sand, little gravel; damp.						
3.5	702.1	11 19 25	15	2			Dense to very dense brown GRAVEL (A-1-a), little fine to coarse sand, little silt; damp.						
5													
		11 23 29	14	3				69	14	---	6	--11--	
10		19 31 33	14	4									
		31 31 29	16	5				73	11	---	5	--11--	
		14 50/5	6	6			@ 13.5', becomes wet.						
15													
		5 17 22	11	7									
		23 50/6	10	8			@ 18.5'-23.5', 0.5 to 6.0 feet sand heave.						
20							@ 19.5', auger refusal; used tricone to advance hole to 21.0'.						
		26 16 14	9	9									
25	680.6	18 39 50	8	10									

STANDARD PENETRATION (N60)
Natural Moisture Content, % - ●
PL ├──┤ LL
Blows per foot - ○ / Non-Plastic - NP



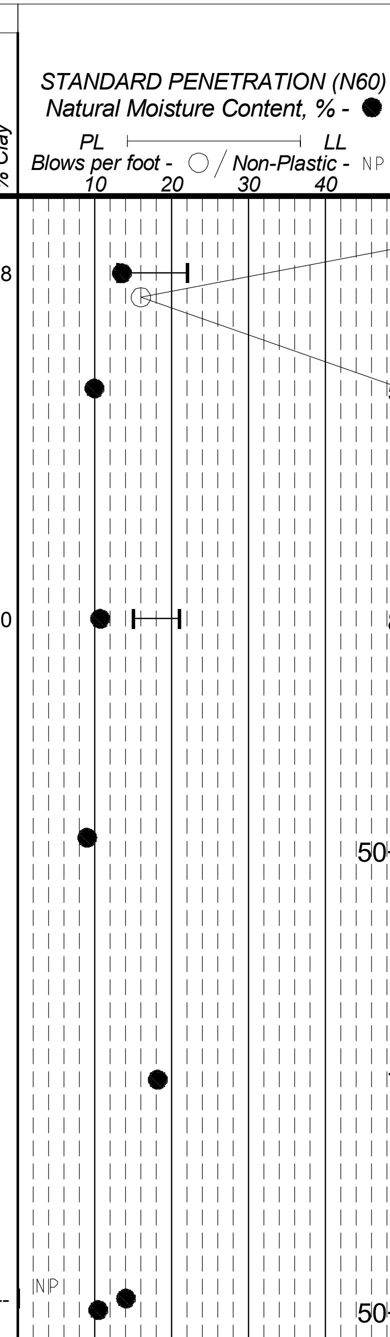
Client: ms consultants | *Project:* FRA-70-8.93 | *Job No.* 0221-1004.01

LOG OF: Boring B-122-0-09 | *Location:* Sta. 127+17.91, 134.2' LT., BL I-70 WB | *Date Drilled:* 8/18/2009 to 8/20/2009

WATER OBSERVATIONS:
Water seepage at: 13.5'
Water level at completion: 15.7' (prior to adding water)

FIELD NOTES:

Depth (ft)	Elev. (ft) 680.6	Blows per 6"	Recovery	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf)	DESCRIPTION	Graphic Log	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N60)
							Stiff to very stiff brownish gray SANDY SILT (A-4a), some fine to coarse sand, trace to little gravel; damp to moist.								
		5 7 8	11	11		1.25			15	11	---	13	33	28	
							@ 26.0', 5.0 feet sand heave.								
30		16 25 31	17	12		4.0									59
							@ 30.0', difficult drilling.								
35		21 50 34	14	13		4.0	@ 33.5'-39.5', hard, brown, contains rock fragments.		18	8	---	13	41	20	88
40		20 50/6	8	14		4.5+									50+
45		29 38 37	14	15		0.75	@ 43.5'-45.0', medium stiff; wet.								79
47.0	658.6						Very dense gray SANDY SILT (A-4a), trace gravel; contains rock fragments; wet.								
49.0	656.6	26 50/6	11	16A 16B		4.5+	Hard brownish gray SILT AND CLAY (A-6a); damp.		7	3	---	53	--37--		50+
50	655.6														



Client: ms consultants | Project: FRA-70-8.93 | Job No. 0221-1004.01

LOG OF: Boring B-122-0-09 | Location: Sta. 127+17.91, 134.2' LT., BL I-70 WB | Date Drilled: 8/18/2009 to 8/20/2009

WATER OBSERVATIONS:
Water seepage at: 13.5'
Water level at completion: 15.7' (prior to adding water)
FIELD NOTES:

Depth (ft)	Elev. (ft) 655.6	Blows per 6"	Recovery	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N60)
							Hard brownish gray SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; damp.							
53.5	652.1	46 50/6	8	17		4.5+	Hard brown SANDY SILT (A-4a), little to some gravel; moist.							50+
							@ 53.5', 4.0 feet sand heave.							
							@ 57.5',59.5', auger refusal, encountered possible boulders; offset hole 4.0 ' west and continued sampling.							
		50/5	4	18		4.5+	@ 58.5'-58.9', contains rock fragments.	31	16	---	17	22	14	50+
63.5	642.1	50/5	3	19			Weathered LIMESTONE fragments interbedded with silty clay							50+
		7 50/5		20										50+
73.6	632.0	50/1	1	21			Limestone, light gray, unweathered.							50+
75	630.6													

Client: ms consultants	Project: FRA-70-8.93	Job No. 0221-1004.01
LOG OF: Boring B-122-0-09	Location: Sta. 127+17.91, 134.2' LT., BL I-70 WB	Date Drilled: 8/18/2009 to 8/20/2009

WATER OBSERVATIONS:
Water seepage at: 13.5'
Water level at completion: 15.7' (prior to adding water)
FIELD NOTES:

Depth (ft)	Elev. (ft) 630.6	Blows per 6"	Recovery	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf)	DESCRIPTION	Graphic Log	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N60) Natural Moisture Content, % - ● PL ⊢⊣ LL Blows per foot - ○ / Non-Plastic - NP 10 20 30 40
		Core 66"	Rec 66"	RQD 77%	R1		Limestone, light gray, unweathered, strong, thick bedded, fossilferous, petroliferous, slightly to moderately fractured. @ 76.6',78.3', high angle fractures.								
79.1	626.5						Bottom of Boring - 79.1'								
80															
85															
90															
95															
100															

APPENDIX IV

HISTORIC BORING LOGS:

B-001-S-68 through B-004-S-68

B-001-S-68

LOG OF BORING

Date Started 6-26-68 | Sampler Type SS | Dia 1 3/8" | Water Elev. ______

Date Completed 6-27-68 | Casing: Length 40' | Dia 3 1/2"

Boring No. B-1 | Station & Offset 484+26, 35' Lt. (Rear Abutment) | Surface Elev 705.6'

Depth scale (ft): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46

Elev.	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Sample No.	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	SHTL Class.
705.6														
700.6	15/18			Brown Silty Sandy Gravel	1	49	13	9	21	8	19	2	9	A-2-4
695.6				Brown Silty Gravelly Sand (Wash Sample)-(Sand Heaved 5.0' in Casing)	2	25	42	16	-17	-	NP	NP	10	A-1-b
690.6	18/21			Brown Silty Sandy Gravel	3	57	14	8	14	7	NP	NP	7	A-1-b
685.6	19/21			Brown Silty Sandy Gravel	4	61	12	10	-17	-	NP	NP	3	A-1-b
680.6	18/19			Brown Silty Sandy Gravel	5	64	13	9	-14	-	NP	NP	5	A-1-a
675.6	12/13			Brown Silty Sandy Gravel	6	61	16	9	-14	-	NP	NP	9	A-1-a
670.6	50* (0.7')			Brown Gravel	7	79	7	6	- 8	-	NP	NP	8	A-1-a
665.6	50/*			Gray Sandy Gravelly Silt	8	25	9	14	28	24	20	5	10	A-4a
660.6 659.9	50* (0.7')			Gray Silty Gravelly Sand	9	20	3	44	-33	-	NP	NP	21	A-2-4

BOTTOM OF BORING

*Refusal

B-002-S-68

LOG OF BORING

Date Started 6-24-68 | Sampler Type SS | Dia 1 3/8" | Water Elev. ______

Date Completed 6-26-68 | Casing: Length 30' | Dia. 3 1/2"

Boring No. B-2 | Station & Offset 484+18, 48' Lt. (Rear Abutment) | Surface Elev 704.7'

Elev.	Depth	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Sample No.	% Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	SHTL Class.
704.7	0, 2, 4														
699.7	6, 8	32/45			Brown Silty Sandy Gravel	1	57	13	11	-20-		NP	NP	9	A-1-b
694.7	10, 12, 14	40/25			Brown Silty Sandy Gravel	2	48	19	12	-21-		NP	NP	10	A-1-b
689.7	16, 18	10/21			Brown Sandy Gravel	3	82	12	3	-3-		NP	NP	6	A-1-a
684.7	20, 22, 24	13/13			Brown Silty Sandy Gravel	4	55	13	13	-19-		NP	NP	4	A-1-b
679.7	26, 28	21/25			Brown Gravelly Silt	5	48	5	7	29	11	NP	NP	11	A-4a
674.7	30, 32, 34	50* (0.8')			Gray Sandy Gravelly Silt	6	40	7	13	21	19	NP	NP	10	A-4a
669.7	36, 38	50/*			Gray Silty Sand	7	7	20	40	8	25	NP	NP	10	A-3a
664.7	40, 42, 44	50* (0.6')			Gray Gravelly Sandy Silt	8	17	9	18	30	26	19	4	9	A-4a
659.7					Gray Silt	9	6	4	9	52	29	20	3	15	A-4b

BOTTOM OF BORING

*Refusal

B-003-S-68

LOG OF BORING

Date Started 6-27-68 | Sampler Type SS | Dia 1 3/8" | Water Elev. ______

Date Completed 6-28-68 | Casing: Length 32' | Dia 3 1/2"

Boring No. B-3 | Station & Offset 485+02, CL, (Forward Abutment) | Surface Elev. 705.0'

Elev.	Depth	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Sample No.	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	SHTL Class.
705.0	0														
	2														
	4														
700.0	6	24/30			Brown Silty Sandy Gravel	1	42	14	10	14	20	20	7	9	A-2-4
	8														
695.0	10	14/17			Brown Silty Sandy Gravel	2	65	17	7	-11	-	NP	NP	7	A-1-a
	12														
	14														
690.0	16	50* (0.8')			Brown Silty Gravel	3	66	4	5	15	10	NP	NP	9	A-1-b
	18														
685.0	20	14/15			Brown Silty Gravelly Sand	4	26	20	15	21	18	NP	NP	13	A-4a
	22														
	24														
680.0	26	16/17			Gray Silty Sandy Gravel	5	52	21	12	-15	-	NP	NP	11	A-1-a
	28														
675.0	30	13/14			Gray Silty Sandy Gravel	6	V	I	S	U	A	L	17	4	9	-
	32														
	34														
670.0	36	50* (0.6')			Gray Gravelly Sandy Silt	7	15	14	19	39	13	18	5	11	A-4a
	38														
665.0	40	50* (0.4')			Gray Sandy Silt	8	0	1	28	55	16	NP	NP	18	A-4b
	42														
	44														
660.0	46	50/*			Gray Sandy Silt	9	13	10	23	30	24	17	4	29	A-4a
	48														
655.0 / 654.2	50	50* (0.8')			Gray Gravelly Sandy Silt	10	16	11	19	30	24	22	7	9	A-4a

BOTTOM OF BORING

*Refusal

B-004-S-68

LOG OF BORING

Date Started 7-1-68 Sampler Type SS Dia 1 3/8" Water Elev. ______

Date Completed 7-3-68 Casing: Length 40' Dia 3 1/2"

Boring No. B-4 Station & Offset 484+95, 46' Rt. (Forward Abutment) Surface Elev. 706.0'

Elev.	Depth	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Sample No.	Physical Characteristics % Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	SHTL Class.
706.0	0														
	2														
	4														
701.0	6	5/6			Brown Silty Sandy Gravel	1	39	7	23	17	14	NP	NP	12	A-2-4
	8														
696.0	10														
	12	50* (0.3')			Gray Silty Sand	2	9	53	16	-22	-	NP	NP	12	A-1-b
	14														
691.0	16	50/*			Gray Gravel with Boulders	3	-	-	-	-	-	-	-	3	Visual
	18														
686.0	20	7/7			Gray Gravel with Boulders	4	88	3	2	- 7	-	NP	NP	3	A-1-a
	22														
	24														
681.0	26	8/5			Gray Silty Sand (Wash Sample)	5	0	62	18	-20	-	NP	NP	29	A-1-b
	28														
676.0	30	50* (0.4')			Brown Silty Sandy Gravel	6	67	14	3	-16	-	NP	NP	8	A-1-b
	32														
	34														
671.0	36	50* (0.4')			Gray Sandy Silt	7	9	14	32	22	23	17	4	11	A-4a
	38														
666.0	40	50* (0.8')			Gray Sandy Silt	8	11	10	19	25	35	24	9	9	A-4a
	42														
	44														
661.0	46	50* (0.4')			Gray Sandy Silt	9	7	7	23	47	16	NP	NP	11	A-4a
	48														
656.0 655.6	50	50* (0.4')			Gray Sandy Silt	10	0	3	26	46	25	18	4	11	A-4a

BOTTOM OF BORING

*Refusal

APPENDIX V

DRIVEN ANALYSIS OUTPUTS

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\LEGACY\DESKTOP\B-013-2.DVN
Project Name: FRA-70-1282R Project Date: 02/27/2015
Project Client: Burgess _Niple
Computed By: JRH
Project Manager: BRT

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 12.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	11.00 ft
	- Driving/Restrike	11.00 ft
	- Ultimate:	11.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	25.00 ft	0.00%	135.00 pcf	43.0/43.0	Nordlund
2	Cohesive	10.00 ft	17.00%	130.00 pcf	8000.00 psf	T-80 Same
3	Cohesionless	5.00 ft	17.00%	130.00 pcf	36.0/36.0	Nordlund
4	Cohesive	11.50 ft	17.00%	130.00 pcf	8000.00 psf	T-80 Same

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.68 psf	25.29	N/A	0.00 Kips
9.01 ft	Cohesionless	608.17 psf	25.29	N/A	13.39 Kips
10.99 ft	Cohesionless	741.83 psf	25.29	N/A	19.93 Kips
11.01 ft	Cohesionless	1485.36 psf	25.29	N/A	20.00 Kips
20.01 ft	Cohesionless	1812.06 psf	25.29	N/A	59.87 Kips
24.99 ft	Cohesionless	1992.84 psf	25.29	N/A	88.11 Kips
25.01 ft	Cohesive	N/A	N/A	1904.00 psf	88.23 Kips
34.01 ft	Cohesive	N/A	N/A	1904.00 psf	142.06 Kips
34.99 ft	Cohesive	N/A	N/A	1904.00 psf	147.93 Kips
35.01 ft	Cohesionless	3177.74 psf	21.17	N/A	148.04 Kips
39.99 ft	Cohesionless	3346.06 psf	21.17	N/A	174.79 Kips
40.01 ft	Cohesive	N/A	N/A	1904.00 psf	174.90 Kips
49.01 ft	Cohesive	N/A	N/A	1904.00 psf	228.74 Kips
51.49 ft	Cohesive	N/A	N/A	1928.24 psf	244.45 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.35 psf	307.00	532.19 Kips	0.26 Kips
9.01 ft	Cohesionless	1216.35 psf	307.00	532.19 Kips	229.93 Kips
10.99 ft	Cohesionless	1483.65 psf	307.00	532.19 Kips	280.46 Kips
11.01 ft	Cohesionless	1485.73 psf	307.00	532.19 Kips	280.86 Kips
20.01 ft	Cohesionless	2139.13 psf	307.00	532.19 Kips	404.37 Kips
24.99 ft	Cohesionless	2500.67 psf	307.00	532.19 Kips	472.72 Kips
25.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
34.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
34.99 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
35.01 ft	Cohesionless	3178.08 psf	77.60	119.07 Kips	119.07 Kips
39.99 ft	Cohesionless	3514.72 psf	77.60	119.07 Kips	119.07 Kips
40.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
49.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
51.49 ft	Cohesive	N/A	N/A	N/A	56.55 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.26 Kips	0.26 Kips
9.01 ft	13.39 Kips	229.93 Kips	243.33 Kips
10.99 ft	19.93 Kips	280.46 Kips	300.39 Kips
11.01 ft	20.00 Kips	280.86 Kips	300.86 Kips
20.01 ft	59.87 Kips	404.37 Kips	464.24 Kips
24.99 ft	88.11 Kips	472.72 Kips	560.83 Kips
25.01 ft	88.23 Kips	56.55 Kips	144.78 Kips
34.01 ft	142.06 Kips	56.55 Kips	198.61 Kips
34.99 ft	147.93 Kips	56.55 Kips	204.47 Kips
35.01 ft	148.04 Kips	119.07 Kips	267.10 Kips
39.99 ft	174.79 Kips	119.07 Kips	293.85 Kips
40.01 ft	174.90 Kips	56.55 Kips	231.45 Kips
49.01 ft	228.74 Kips	56.55 Kips	285.29 Kips
51.49 ft	244.45 Kips	56.55 Kips	301.00 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.68 psf	25.29	N/A	0.00 Kips
9.01 ft	Cohesionless	608.17 psf	25.29	N/A	13.39 Kips
10.99 ft	Cohesionless	741.83 psf	25.29	N/A	19.93 Kips
11.01 ft	Cohesionless	1485.36 psf	25.29	N/A	20.00 Kips
20.01 ft	Cohesionless	1812.06 psf	25.29	N/A	59.87 Kips
24.99 ft	Cohesionless	1992.84 psf	25.29	N/A	88.11 Kips
25.01 ft	Cohesive	N/A	N/A	1904.00 psf	88.21 Kips
34.01 ft	Cohesive	N/A	N/A	1904.00 psf	132.89 Kips
34.99 ft	Cohesive	N/A	N/A	1904.00 psf	137.76 Kips
35.01 ft	Cohesionless	3177.74 psf	21.17	N/A	137.85 Kips
39.99 ft	Cohesionless	3346.06 psf	21.17	N/A	160.05 Kips
40.01 ft	Cohesive	N/A	N/A	1904.00 psf	160.15 Kips
49.01 ft	Cohesive	N/A	N/A	1904.00 psf	204.83 Kips
51.49 ft	Cohesive	N/A	N/A	1928.24 psf	217.87 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.35 psf	307.00	532.19 Kips	0.26 Kips
9.01 ft	Cohesionless	1216.35 psf	307.00	532.19 Kips	229.93 Kips
10.99 ft	Cohesionless	1483.65 psf	307.00	532.19 Kips	280.46 Kips
11.01 ft	Cohesionless	1485.73 psf	307.00	532.19 Kips	280.86 Kips
20.01 ft	Cohesionless	2139.13 psf	307.00	532.19 Kips	404.37 Kips
24.99 ft	Cohesionless	2500.67 psf	307.00	532.19 Kips	472.72 Kips
25.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
34.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
34.99 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
35.01 ft	Cohesionless	3178.08 psf	77.60	119.07 Kips	119.07 Kips
39.99 ft	Cohesionless	3514.72 psf	77.60	119.07 Kips	119.07 Kips
40.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
49.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
51.49 ft	Cohesive	N/A	N/A	N/A	56.55 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.26 Kips	0.26 Kips
9.01 ft	13.39 Kips	229.93 Kips	243.33 Kips
10.99 ft	19.93 Kips	280.46 Kips	300.39 Kips
11.01 ft	20.00 Kips	280.86 Kips	300.86 Kips
20.01 ft	59.87 Kips	404.37 Kips	464.24 Kips
24.99 ft	88.11 Kips	472.72 Kips	560.83 Kips
25.01 ft	88.21 Kips	56.55 Kips	144.76 Kips
34.01 ft	132.89 Kips	56.55 Kips	189.44 Kips
34.99 ft	137.76 Kips	56.55 Kips	194.31 Kips
35.01 ft	137.85 Kips	119.07 Kips	256.92 Kips
39.99 ft	160.05 Kips	119.07 Kips	279.12 Kips
40.01 ft	160.15 Kips	56.55 Kips	216.70 Kips
49.01 ft	204.83 Kips	56.55 Kips	261.38 Kips
51.49 ft	217.87 Kips	56.55 Kips	274.42 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.68 psf	25.29	N/A	0.00 Kips
9.01 ft	Cohesionless	608.17 psf	25.29	N/A	13.39 Kips
10.99 ft	Cohesionless	741.83 psf	25.29	N/A	19.93 Kips
11.01 ft	Cohesionless	1485.36 psf	25.29	N/A	20.00 Kips
20.01 ft	Cohesionless	1812.06 psf	25.29	N/A	59.87 Kips
24.99 ft	Cohesionless	1992.84 psf	25.29	N/A	88.11 Kips
25.01 ft	Cohesive	N/A	N/A	1904.00 psf	88.23 Kips
34.01 ft	Cohesive	N/A	N/A	1904.00 psf	142.06 Kips
34.99 ft	Cohesive	N/A	N/A	1904.00 psf	147.93 Kips
35.01 ft	Cohesionless	3177.74 psf	21.17	N/A	148.04 Kips
39.99 ft	Cohesionless	3346.06 psf	21.17	N/A	174.79 Kips
40.01 ft	Cohesive	N/A	N/A	1904.00 psf	174.90 Kips
49.01 ft	Cohesive	N/A	N/A	1904.00 psf	228.74 Kips
51.49 ft	Cohesive	N/A	N/A	1928.24 psf	244.45 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.35 psf	307.00	532.19 Kips	0.26 Kips
9.01 ft	Cohesionless	1216.35 psf	307.00	532.19 Kips	229.93 Kips
10.99 ft	Cohesionless	1483.65 psf	307.00	532.19 Kips	280.46 Kips
11.01 ft	Cohesionless	1485.73 psf	307.00	532.19 Kips	280.86 Kips
20.01 ft	Cohesionless	2139.13 psf	307.00	532.19 Kips	404.37 Kips
24.99 ft	Cohesionless	2500.67 psf	307.00	532.19 Kips	472.72 Kips
25.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
34.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
34.99 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
35.01 ft	Cohesionless	3178.08 psf	77.60	119.07 Kips	119.07 Kips
39.99 ft	Cohesionless	3514.72 psf	77.60	119.07 Kips	119.07 Kips
40.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
49.01 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
51.49 ft	Cohesive	N/A	N/A	N/A	56.55 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.26 Kips	0.26 Kips
9.01 ft	13.39 Kips	229.93 Kips	243.33 Kips
10.99 ft	19.93 Kips	280.46 Kips	300.39 Kips
11.01 ft	20.00 Kips	280.86 Kips	300.86 Kips
20.01 ft	59.87 Kips	404.37 Kips	464.24 Kips
24.99 ft	88.11 Kips	472.72 Kips	560.83 Kips
25.01 ft	88.23 Kips	56.55 Kips	144.78 Kips
34.01 ft	142.06 Kips	56.55 Kips	198.61 Kips
34.99 ft	147.93 Kips	56.55 Kips	204.47 Kips
35.01 ft	148.04 Kips	119.07 Kips	267.10 Kips
39.99 ft	174.79 Kips	119.07 Kips	293.85 Kips
40.01 ft	174.90 Kips	56.55 Kips	231.45 Kips
49.01 ft	228.74 Kips	56.55 Kips	285.29 Kips
51.49 ft	244.45 Kips	56.55 Kips	301.00 Kips

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\LEGACY\DESKTOP\B-013-2.DVN
Project Name: FRA-70-1282R　　Project Date: 02/27/2015
Project Client: Burgess _Niple
Computed By: JRH
Project Manager: BRT

PILE INFORMATION

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

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	11.00 ft
	- Driving/Restrike	11.00 ft
	- Ultimate:	11.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	25.00 ft	0.00%	135.00 pcf	43.0/43.0	Nordlund
2	Cohesive	10.00 ft	17.00%	130.00 pcf	8000.00 psf	T-80 Same
3	Cohesionless	5.00 ft	17.00%	130.00 pcf	36.0/36.0	Nordlund
4	Cohesive	11.50 ft	17.00%	130.00 pcf	8000.00 psf	T-80 Same

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.68 psf	28.66	N/A	0.00 Kips
9.01 ft	Cohesionless	608.17 psf	28.66	N/A	21.00 Kips
10.99 ft	Cohesionless	741.83 psf	28.66	N/A	31.24 Kips
11.01 ft	Cohesionless	1485.36 psf	28.66	N/A	31.35 Kips
20.01 ft	Cohesionless	1812.06 psf	28.66	N/A	93.85 Kips
24.99 ft	Cohesionless	1992.84 psf	28.66	N/A	138.12 Kips
25.01 ft	Cohesive	N/A	N/A	1904.00 psf	138.29 Kips
34.01 ft	Cohesive	N/A	N/A	1904.00 psf	201.10 Kips
34.99 ft	Cohesive	N/A	N/A	1904.00 psf	207.93 Kips
35.01 ft	Cohesionless	3177.74 psf	23.99	N/A	208.08 Kips
39.99 ft	Cohesionless	3346.06 psf	23.99	N/A	248.24 Kips
40.01 ft	Cohesive	N/A	N/A	1904.00 psf	248.39 Kips
49.01 ft	Cohesive	N/A	N/A	1904.00 psf	311.20 Kips
51.49 ft	Cohesive	N/A	N/A	1904.00 psf	328.51 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.35 psf	307.00	724.36 Kips	0.35 Kips
9.01 ft	Cohesionless	1216.35 psf	307.00	724.36 Kips	312.97 Kips
10.99 ft	Cohesionless	1483.65 psf	307.00	724.36 Kips	381.74 Kips
11.01 ft	Cohesionless	1485.73 psf	307.00	724.36 Kips	382.28 Kips
20.01 ft	Cohesionless	2139.13 psf	307.00	724.36 Kips	550.39 Kips
24.99 ft	Cohesionless	2500.67 psf	307.00	724.36 Kips	643.42 Kips
25.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
34.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
34.99 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
35.01 ft	Cohesionless	3178.08 psf	77.60	162.06 Kips	162.06 Kips
39.99 ft	Cohesionless	3514.72 psf	77.60	162.06 Kips	162.06 Kips
40.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
49.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
51.49 ft	Cohesive	N/A	N/A	N/A	76.97 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.35 Kips	0.35 Kips
9.01 ft	21.00 Kips	312.97 Kips	333.96 Kips
10.99 ft	31.24 Kips	381.74 Kips	412.98 Kips
11.01 ft	31.35 Kips	382.28 Kips	413.63 Kips
20.01 ft	93.85 Kips	550.39 Kips	644.25 Kips
24.99 ft	138.12 Kips	643.42 Kips	781.54 Kips
25.01 ft	138.29 Kips	76.97 Kips	215.26 Kips
34.01 ft	201.10 Kips	76.97 Kips	278.06 Kips
34.99 ft	207.93 Kips	76.97 Kips	284.90 Kips
35.01 ft	208.08 Kips	162.06 Kips	370.14 Kips
39.99 ft	248.24 Kips	162.06 Kips	410.30 Kips
40.01 ft	248.39 Kips	76.97 Kips	325.36 Kips
49.01 ft	311.20 Kips	76.97 Kips	388.17 Kips
51.49 ft	328.51 Kips	76.97 Kips	405.48 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.68 psf	28.66	N/A	0.00 Kips
9.01 ft	Cohesionless	608.17 psf	28.66	N/A	21.00 Kips
10.99 ft	Cohesionless	741.83 psf	28.66	N/A	31.24 Kips
11.01 ft	Cohesionless	1485.36 psf	28.66	N/A	31.35 Kips
20.01 ft	Cohesionless	1812.06 psf	28.66	N/A	93.85 Kips
24.99 ft	Cohesionless	1992.84 psf	28.66	N/A	138.12 Kips
25.01 ft	Cohesive	N/A	N/A	1904.00 psf	138.26 Kips
34.01 ft	Cohesive	N/A	N/A	1904.00 psf	190.39 Kips
34.99 ft	Cohesive	N/A	N/A	1904.00 psf	196.07 Kips
35.01 ft	Cohesionless	3177.74 psf	23.99	N/A	196.19 Kips
39.99 ft	Cohesionless	3346.06 psf	23.99	N/A	229.52 Kips
40.01 ft	Cohesive	N/A	N/A	1904.00 psf	229.65 Kips
49.01 ft	Cohesive	N/A	N/A	1904.00 psf	281.78 Kips
51.49 ft	Cohesive	N/A	N/A	1904.00 psf	296.14 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.35 psf	307.00	724.36 Kips	0.35 Kips
9.01 ft	Cohesionless	1216.35 psf	307.00	724.36 Kips	312.97 Kips
10.99 ft	Cohesionless	1483.65 psf	307.00	724.36 Kips	381.74 Kips
11.01 ft	Cohesionless	1485.73 psf	307.00	724.36 Kips	382.28 Kips
20.01 ft	Cohesionless	2139.13 psf	307.00	724.36 Kips	550.39 Kips
24.99 ft	Cohesionless	2500.67 psf	307.00	724.36 Kips	643.42 Kips
25.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
34.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
34.99 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
35.01 ft	Cohesionless	3178.08 psf	77.60	162.06 Kips	162.06 Kips
39.99 ft	Cohesionless	3514.72 psf	77.60	162.06 Kips	162.06 Kips
40.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
49.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
51.49 ft	Cohesive	N/A	N/A	N/A	76.97 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.35 Kips	0.35 Kips
9.01 ft	21.00 Kips	312.97 Kips	333.96 Kips
10.99 ft	31.24 Kips	381.74 Kips	412.98 Kips
11.01 ft	31.35 Kips	382.28 Kips	413.63 Kips
20.01 ft	93.85 Kips	550.39 Kips	644.25 Kips
24.99 ft	138.12 Kips	643.42 Kips	781.54 Kips
25.01 ft	138.26 Kips	76.97 Kips	215.23 Kips
34.01 ft	190.39 Kips	76.97 Kips	267.36 Kips
34.99 ft	196.07 Kips	76.97 Kips	273.04 Kips
35.01 ft	196.19 Kips	162.06 Kips	358.25 Kips
39.99 ft	229.52 Kips	162.06 Kips	391.58 Kips
40.01 ft	229.65 Kips	76.97 Kips	306.62 Kips
49.01 ft	281.78 Kips	76.97 Kips	358.75 Kips
51.49 ft	296.14 Kips	76.97 Kips	373.11 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.68 psf	28.66	N/A	0.00 Kips
9.01 ft	Cohesionless	608.17 psf	28.66	N/A	21.00 Kips
10.99 ft	Cohesionless	741.83 psf	28.66	N/A	31.24 Kips
11.01 ft	Cohesionless	1485.36 psf	28.66	N/A	31.35 Kips
20.01 ft	Cohesionless	1812.06 psf	28.66	N/A	93.85 Kips
24.99 ft	Cohesionless	1992.84 psf	28.66	N/A	138.12 Kips
25.01 ft	Cohesive	N/A	N/A	1904.00 psf	138.29 Kips
34.01 ft	Cohesive	N/A	N/A	1904.00 psf	201.10 Kips
34.99 ft	Cohesive	N/A	N/A	1904.00 psf	207.93 Kips
35.01 ft	Cohesionless	3177.74 psf	23.99	N/A	208.08 Kips
39.99 ft	Cohesionless	3346.06 psf	23.99	N/A	248.24 Kips
40.01 ft	Cohesive	N/A	N/A	1904.00 psf	248.39 Kips
49.01 ft	Cohesive	N/A	N/A	1904.00 psf	311.20 Kips
51.49 ft	Cohesive	N/A	N/A	1904.00 psf	328.51 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.35 psf	307.00	724.36 Kips	0.35 Kips
9.01 ft	Cohesionless	1216.35 psf	307.00	724.36 Kips	312.97 Kips
10.99 ft	Cohesionless	1483.65 psf	307.00	724.36 Kips	381.74 Kips
11.01 ft	Cohesionless	1485.73 psf	307.00	724.36 Kips	382.28 Kips
20.01 ft	Cohesionless	2139.13 psf	307.00	724.36 Kips	550.39 Kips
24.99 ft	Cohesionless	2500.67 psf	307.00	724.36 Kips	643.42 Kips
25.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
34.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
34.99 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
35.01 ft	Cohesionless	3178.08 psf	77.60	162.06 Kips	162.06 Kips
39.99 ft	Cohesionless	3514.72 psf	77.60	162.06 Kips	162.06 Kips
40.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
49.01 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
51.49 ft	Cohesive	N/A	N/A	N/A	76.97 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.35 Kips	0.35 Kips
9.01 ft	21.00 Kips	312.97 Kips	333.96 Kips
10.99 ft	31.24 Kips	381.74 Kips	412.98 Kips
11.01 ft	31.35 Kips	382.28 Kips	413.63 Kips
20.01 ft	93.85 Kips	550.39 Kips	644.25 Kips
24.99 ft	138.12 Kips	643.42 Kips	781.54 Kips
25.01 ft	138.29 Kips	76.97 Kips	215.26 Kips
34.01 ft	201.10 Kips	76.97 Kips	278.06 Kips
34.99 ft	207.93 Kips	76.97 Kips	284.90 Kips
35.01 ft	208.08 Kips	162.06 Kips	370.14 Kips
39.99 ft	248.24 Kips	162.06 Kips	410.30 Kips
40.01 ft	248.39 Kips	76.97 Kips	325.36 Kips
49.01 ft	311.20 Kips	76.97 Kips	388.17 Kips
51.49 ft	328.51 Kips	76.97 Kips	405.48 Kips

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\LEGACY\DESKTOP\B-013-2.DVN
Project Name: FRA-70-1282R Project Date: 02/27/2015
Project Client: Burgess _Niple
Computed By: JRH
Project Manager: BRT

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 16.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	11.00 ft
	- Driving/Restrike	11.00 ft
	- Ultimate:	11.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	25.00 ft	0.00%	135.00 pcf	43.0/43.0	Nordlund
2	Cohesive	10.00 ft	17.00%	130.00 pcf	8000.00 psf	T-80 Same
3	Cohesionless	5.00 ft	17.00%	130.00 pcf	36.0/36.0	Nordlund
4	Cohesive	11.50 ft	17.00%	130.00 pcf	8000.00 psf	T-80 Same

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.68 psf	31.49	N/A	0.00 Kips
9.01 ft	Cohesionless	608.17 psf	31.49	N/A	30.12 Kips
10.99 ft	Cohesionless	741.83 psf	31.49	N/A	44.82 Kips
11.01 ft	Cohesionless	1485.36 psf	31.49	N/A	44.98 Kips
20.01 ft	Cohesionless	1812.06 psf	31.49	N/A	134.65 Kips
24.99 ft	Cohesionless	1992.84 psf	31.49	N/A	198.16 Kips
25.01 ft	Cohesive	N/A	N/A	1904.00 psf	198.38 Kips
34.01 ft	Cohesive	N/A	N/A	1904.00 psf	270.15 Kips
34.99 ft	Cohesive	N/A	N/A	1904.00 psf	277.97 Kips
35.01 ft	Cohesionless	3177.74 psf	26.37	N/A	278.16 Kips
39.99 ft	Cohesionless	3346.06 psf	26.37	N/A	333.96 Kips
40.01 ft	Cohesive	N/A	N/A	1904.00 psf	334.16 Kips
49.01 ft	Cohesive	N/A	N/A	1904.00 psf	405.94 Kips
51.49 ft	Cohesive	N/A	N/A	1904.00 psf	425.72 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.35 psf	307.00	946.11 Kips	0.45 Kips
9.01 ft	Cohesionless	1216.35 psf	307.00	946.11 Kips	408.77 Kips
10.99 ft	Cohesionless	1483.65 psf	307.00	946.11 Kips	498.60 Kips
11.01 ft	Cohesionless	1485.73 psf	307.00	946.11 Kips	499.30 Kips
20.01 ft	Cohesionless	2139.13 psf	307.00	946.11 Kips	718.88 Kips
24.99 ft	Cohesionless	2500.67 psf	307.00	946.11 Kips	840.39 Kips
25.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
34.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
34.99 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
35.01 ft	Cohesionless	3178.08 psf	77.60	211.67 Kips	211.67 Kips
39.99 ft	Cohesionless	3514.72 psf	77.60	211.67 Kips	211.67 Kips
40.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
49.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
51.49 ft	Cohesive	N/A	N/A	N/A	100.53 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.45 Kips	0.45 Kips
9.01 ft	30.12 Kips	408.77 Kips	438.89 Kips
10.99 ft	44.82 Kips	498.60 Kips	543.42 Kips
11.01 ft	44.98 Kips	499.30 Kips	544.28 Kips
20.01 ft	134.65 Kips	718.88 Kips	853.53 Kips
24.99 ft	198.16 Kips	840.39 Kips	1038.54 Kips
25.01 ft	198.38 Kips	100.53 Kips	298.91 Kips
34.01 ft	270.15 Kips	100.53 Kips	370.69 Kips
34.99 ft	277.97 Kips	100.53 Kips	378.50 Kips
35.01 ft	278.16 Kips	211.67 Kips	489.83 Kips
39.99 ft	333.96 Kips	211.67 Kips	545.64 Kips
40.01 ft	334.16 Kips	100.53 Kips	434.69 Kips
49.01 ft	405.94 Kips	100.53 Kips	506.47 Kips
51.49 ft	425.72 Kips	100.53 Kips	526.25 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.68 psf	31.49	N/A	0.00 Kips
9.01 ft	Cohesionless	608.17 psf	31.49	N/A	30.12 Kips
10.99 ft	Cohesionless	741.83 psf	31.49	N/A	44.82 Kips
11.01 ft	Cohesionless	1485.36 psf	31.49	N/A	44.98 Kips
20.01 ft	Cohesionless	1812.06 psf	31.49	N/A	134.65 Kips
24.99 ft	Cohesionless	1992.84 psf	31.49	N/A	198.16 Kips
25.01 ft	Cohesive	N/A	N/A	1904.00 psf	198.34 Kips
34.01 ft	Cohesive	N/A	N/A	1904.00 psf	257.92 Kips
34.99 ft	Cohesive	N/A	N/A	1904.00 psf	264.40 Kips
35.01 ft	Cohesionless	3177.74 psf	26.37	N/A	264.56 Kips
39.99 ft	Cohesionless	3346.06 psf	26.37	N/A	310.88 Kips
40.01 ft	Cohesive	N/A	N/A	1904.00 psf	311.04 Kips
49.01 ft	Cohesive	N/A	N/A	1904.00 psf	370.62 Kips
51.49 ft	Cohesive	N/A	N/A	1904.00 psf	387.03 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.35 psf	307.00	946.11 Kips	0.45 Kips
9.01 ft	Cohesionless	1216.35 psf	307.00	946.11 Kips	408.77 Kips
10.99 ft	Cohesionless	1483.65 psf	307.00	946.11 Kips	498.60 Kips
11.01 ft	Cohesionless	1485.73 psf	307.00	946.11 Kips	499.30 Kips
20.01 ft	Cohesionless	2139.13 psf	307.00	946.11 Kips	718.88 Kips
24.99 ft	Cohesionless	2500.67 psf	307.00	946.11 Kips	840.39 Kips
25.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
34.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
34.99 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
35.01 ft	Cohesionless	3178.08 psf	77.60	211.67 Kips	211.67 Kips
39.99 ft	Cohesionless	3514.72 psf	77.60	211.67 Kips	211.67 Kips
40.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
49.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
51.49 ft	Cohesive	N/A	N/A	N/A	100.53 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.45 Kips	0.45 Kips
9.01 ft	30.12 Kips	408.77 Kips	438.89 Kips
10.99 ft	44.82 Kips	498.60 Kips	543.42 Kips
11.01 ft	44.98 Kips	499.30 Kips	544.28 Kips
20.01 ft	134.65 Kips	718.88 Kips	853.53 Kips
24.99 ft	198.16 Kips	840.39 Kips	1038.54 Kips
25.01 ft	198.34 Kips	100.53 Kips	298.87 Kips
34.01 ft	257.92 Kips	100.53 Kips	358.45 Kips
34.99 ft	264.40 Kips	100.53 Kips	364.93 Kips
35.01 ft	264.56 Kips	211.67 Kips	476.23 Kips
39.99 ft	310.88 Kips	211.67 Kips	522.55 Kips
40.01 ft	311.04 Kips	100.53 Kips	411.57 Kips
49.01 ft	370.62 Kips	100.53 Kips	471.15 Kips
51.49 ft	387.03 Kips	100.53 Kips	487.56 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.68 psf	31.49	N/A	0.00 Kips
9.01 ft	Cohesionless	608.17 psf	31.49	N/A	30.12 Kips
10.99 ft	Cohesionless	741.83 psf	31.49	N/A	44.82 Kips
11.01 ft	Cohesionless	1485.36 psf	31.49	N/A	44.98 Kips
20.01 ft	Cohesionless	1812.06 psf	31.49	N/A	134.65 Kips
24.99 ft	Cohesionless	1992.84 psf	31.49	N/A	198.16 Kips
25.01 ft	Cohesive	N/A	N/A	1904.00 psf	198.38 Kips
34.01 ft	Cohesive	N/A	N/A	1904.00 psf	270.15 Kips
34.99 ft	Cohesive	N/A	N/A	1904.00 psf	277.97 Kips
35.01 ft	Cohesionless	3177.74 psf	26.37	N/A	278.16 Kips
39.99 ft	Cohesionless	3346.06 psf	26.37	N/A	333.96 Kips
40.01 ft	Cohesive	N/A	N/A	1904.00 psf	334.16 Kips
49.01 ft	Cohesive	N/A	N/A	1904.00 psf	405.94 Kips
51.49 ft	Cohesive	N/A	N/A	1904.00 psf	425.72 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.35 psf	307.00	946.11 Kips	0.45 Kips
9.01 ft	Cohesionless	1216.35 psf	307.00	946.11 Kips	408.77 Kips
10.99 ft	Cohesionless	1483.65 psf	307.00	946.11 Kips	498.60 Kips
11.01 ft	Cohesionless	1485.73 psf	307.00	946.11 Kips	499.30 Kips
20.01 ft	Cohesionless	2139.13 psf	307.00	946.11 Kips	718.88 Kips
24.99 ft	Cohesionless	2500.67 psf	307.00	946.11 Kips	840.39 Kips
25.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
34.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
34.99 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
35.01 ft	Cohesionless	3178.08 psf	77.60	211.67 Kips	211.67 Kips
39.99 ft	Cohesionless	3514.72 psf	77.60	211.67 Kips	211.67 Kips
40.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
49.01 ft	Cohesive	N/A	N/A	N/A	100.53 Kips
51.49 ft	Cohesive	N/A	N/A	N/A	100.53 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.45 Kips	0.45 Kips
9.01 ft	30.12 Kips	408.77 Kips	438.89 Kips
10.99 ft	44.82 Kips	498.60 Kips	543.42 Kips
11.01 ft	44.98 Kips	499.30 Kips	544.28 Kips
20.01 ft	134.65 Kips	718.88 Kips	853.53 Kips
24.99 ft	198.16 Kips	840.39 Kips	1038.54 Kips
25.01 ft	198.38 Kips	100.53 Kips	298.91 Kips
34.01 ft	270.15 Kips	100.53 Kips	370.69 Kips
34.99 ft	277.97 Kips	100.53 Kips	378.50 Kips
35.01 ft	278.16 Kips	211.67 Kips	489.83 Kips
39.99 ft	333.96 Kips	211.67 Kips	545.64 Kips
40.01 ft	334.16 Kips	100.53 Kips	434.69 Kips
49.01 ft	405.94 Kips	100.53 Kips	506.47 Kips
51.49 ft	425.72 Kips	100.53 Kips	526.25 Kips

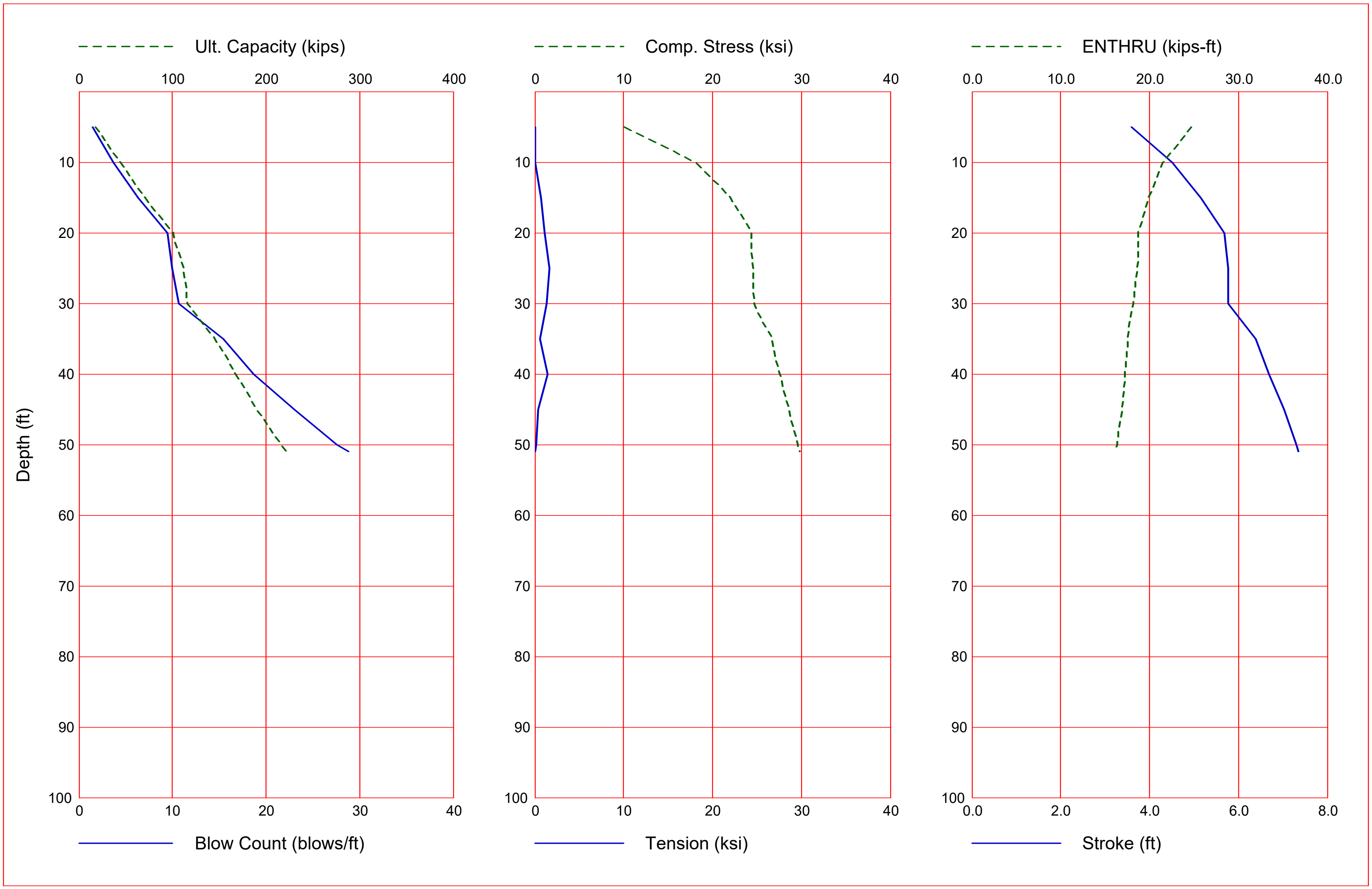
APPENDIX VI

GRLWEAP DRIVEABILITY ANALYSIS OUTPUTS

Resource International Inc
FRA-70-1282R - HP 10x42

Jun 28 2018
GRLWEAP Version 2010

Gain/Loss 3 at Shaft and Toe 0.830 / 1.000



Gain/Loss 3 at Shaft and Toe 0.830 / 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
5.0	17.9	3.9	14.0	1.5	10.077	0.000	3.60	24.7
10.0	43.6	15.6	28.0	3.7	18.084	0.000	4.52	21.5
15.0	70.8	34.0	36.8	6.3	22.047	-0.650	5.15	19.9
20.0	100.9	56.6	44.3	9.5	24.402	-1.078	5.68	18.7
25.0	112.4	83.4	29.0	10.0	24.631	-1.633	5.76	18.6
30.0	115.8	109.6	6.2	10.7	24.645	-1.384	5.77	18.2
35.0	145.4	135.8	9.6	15.4	26.706	-0.594	6.38	17.5
40.0	167.4	157.7	9.6	18.7	27.587	-1.488	6.68	17.2
45.0	190.1	183.9	6.2	23.0	28.604	-0.374	7.02	16.9
50.0	216.3	210.1	6.2	27.6	29.551	-0.136	7.30	16.4
51.0	221.6	215.4	6.2	28.8	29.774	-0.058	7.34	16.2

Total Continuous Driving Time 13.00 minutes; Total Number of Blows 592

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

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

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

```
 Input  File: J:\GEOTECH\PROJECTS\2013\W-13-045 FRA-70-13.54 PROJECT 4A\ANALYSIS\FRA-70-1282R\DRIVEABILITY\B-013-2-15.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
 Hammer File Version:  2003 (2/22/2013)

                       Input File Contents
     FRA-70-1282R - HP 10x42
 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   144.000    10.000            Unknown
      W Cp      A Cp      E Cp      T Cp       CoR      ROut      StCp
     1.900   227.000     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
    51.000     12.40   29000.0   492.000     3.300         0     0.850     0.010
 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     0.002     0.002     1.250      0.00      0.00
     P atm        P1        P2        P3        P4        P5
     14.70   1520.00   1368.00   1231.00   1108.00      0.00
    Stroke    Effic.  Pressure  R-Weight   T-Delay Exp-Coeff   Eps-Str  Total-AW
   10.8100    0.8000 1520.0000    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	LimD	SU T
0.01	0.00	0.03	0.10	0.08	0.05	0.15	1.00	0.00	0.0
9.01	0.85	25.21	0.10	0.08	0.05	0.15	1.00	0.00	0.0
10.99	1.04	30.75	0.10	0.08	0.05	0.15	1.00	0.00	0.0
11.01	1.04	30.79	0.10	0.08	0.05	0.15	1.00	0.00	0.0
20.01	1.50	44.34	0.10	0.08	0.05	0.15	1.00	0.00	0.0
24.99	1.75	51.83	0.10	0.08	0.05	0.15	1.00	0.00	0.0
25.01	1.90	6.20	0.10	0.08	0.15	0.15	1.21	0.00	0.0
34.01	1.92	6.20	0.10	0.08	0.15	0.15	1.21	0.00	0.0
34.99	1.93	6.20	0.10	0.08	0.15	0.15	1.21	0.00	0.0
35.01	1.52	13.05	0.10	0.08	0.05	0.15	1.21	0.00	0.0
39.99	1.68	13.05	0.10	0.08	0.05	0.15	1.21	0.00	0.0
40.01	1.90	6.20	0.10	0.08	0.15	0.15	1.21	0.00	0.0
49.01	1.92	6.20	0.10	0.08	0.15	0.15	1.21	0.00	0.0
51.00	1.96	6.20	0.10	0.08	0.15	0.15	1.21	0.00	0.0

Gain/Loss factors: shaft and toe
0.79600 0.81300 0.83000 0.84700 0.86400
1.00000 1.00000 1.00000 1.00000 1.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
5.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
51.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000

1 0 10.81000 11.86000

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

FRA-70-1282R - HP 10x42

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	140046.7	1.000	0.0100	
3	0.800	140046.7	1.000	0.0100	
4	0.800	140046.7	1.000	0.0100	
5	0.800	140046.7	1.000	0.0100	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		8813.7			

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)	1520.00	Actual Pressure	(psi)	1520.00
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)	227.00	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)	60155.0	Stiffness	(kips/in)	0.0

↑
FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	5.0			
Shaft Gain/Loss Factor		0.796	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model — Total Capacity Rut (kips) 17.9

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.144	8814	0.010	0.000	0.85	0.0	0.000	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	0.0	0.000	0.100	6.80	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	0.4	0.050	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	3.5	0.050	0.100	51.00	3.3	12.4
Toe						14.0	0.150	0.083			

2.161 kips total unreduced pile weight (g= 32.17 ft/s2)
2.161 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	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	10.81	1.00	0.800

↑
FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc 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
17.9	1.5	3.60	3.57	0.00	1	0	10.08	1	7	24.7	62.5
17.9	1.5	3.60	3.57	0.00	1	0	10.08	1	7	24.7	62.5
17.9	1.5	3.60	3.57	0.00	1	0	10.08	1	7	24.7	62.5
17.9	1.5	3.60	3.57	0.00	1	0	10.08	1	7	24.7	62.5
17.9	1.5	3.60	3.57	0.00	1	0	10.08	1	7	24.7	62.5

1 0 10.81000 11.86000

↑
FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	10.0			
Shaft Gain/Loss Factor		0.796	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type		Unknown
Pile Size	(inch)	10.000			

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model — Total Capacity Rut (kips) 43.6

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	0.144	8814	0.010	0.000	0.85	0.0	0.000	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	0.0	0.000	0.100	6.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	1.6	0.050	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	5.2	0.050	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	8.8	0.050	0.100	51.00	3.3	12.4
Toe						28.0	0.150	0.083			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	10.81	1.00	0.800

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft) down	up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft			ksi			ksi			kip-ft	b/min
43.6	3.7	4.52	4.50	0.00	1	0	18.08	6	3	21.5	55.7
43.6	3.7	4.52	4.50	0.00	1	0	18.08	6	3	21.5	55.7
43.6	3.7	4.52	4.50	0.00	1	0	18.08	6	3	21.5	55.7
43.6	3.7	4.52	4.50	0.00	1	0	18.08	6	3	21.5	55.7
43.6	3.7	4.52	4.50	0.00	1	0	18.08	6	3	21.5	55.7

1 0 10.81000 11.86000

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	15.0		
Shaft Gain/Loss Factor		0.796	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type		Unknown
Pile Size	(inch)	10.000			

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model — Total Capacity Rut (kips) 70.8

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	0.144	8814	0.010	0.000	0.85	0.0	0.000	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	0.0	0.000	0.100	6.80	3.3	12.4
11	0.144	8814	0.000	0.000	1.00	0.3	0.050	0.100	37.40	3.3	12.4
12	0.144	8814	0.000	0.000	1.00	3.3	0.050	0.100	40.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	6.9	0.050	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	10.5	0.050	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	13.0	0.050	0.100	51.00	3.3	12.4
Toe						36.8	0.150	0.083			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
15.00	10.81	1.00	0.800

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
70.8	6.3	5.15	5.11	-0.65	12	50	22.05	12	4	19.9	52.0
70.8	6.3	5.15	5.11	-0.65	12	50	22.05	12	4	19.9	52.0
70.8	6.3	5.15	5.11	-0.65	12	50	22.05	12	4	19.9	52.0
70.8	6.3	5.15	5.11	-0.65	12	50	22.05	12	4	19.9	52.0
70.8	6.3	5.15	5.11	-0.65	12	50	22.05	12	4	19.9	52.0

1 0 10.81000 11.86000

Depth (ft) 20.0
Shaft Gain/Loss Factor 0.796 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 144.000 Pile Type Unknown
Pile Size (inch) 10.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model — Total Capacity Rut (kips) 100.9

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	0.144	8814	0.010	0.000	0.85	0.0	0.000	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	0.0	0.000	0.100	6.80	3.3	12.4
10	0.144	8814	0.000	0.000	1.00	1.4	0.050	0.100	34.00	3.3	12.4
11	0.144	8814	0.000	0.000	1.00	5.0	0.050	0.100	37.40	3.3	12.4
12	0.144	8814	0.000	0.000	1.00	8.6	0.050	0.100	40.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	11.9	0.050	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	13.9	0.050	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	15.9	0.050	0.100	51.00	3.3	12.4
Toe						44.3	0.150	0.083			

2.161 kips total unreduced pile weight (g= 32.17 ft/s2)
2.161 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

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
100.9	9.5	5.68	5.67	-1.08	11	42	24.40	11	4	18.7	49.4
100.9	9.5	5.68	5.67	-1.08	11	42	24.40	11	4	18.7	49.4
100.9	9.5	5.68	5.67	-1.08	11	42	24.40	11	4	18.7	49.4
100.9	9.5	5.68	5.67	-1.08	11	42	24.40	11	4	18.7	49.4
100.9	9.5	5.68	5.67	-1.08	11	42	24.40	11	4	18.7	49.4

1 0 10.81000 11.86000

Depth (ft) 25.0
Shaft Gain/Loss Factor 0.796 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 144.000 Pile Type Unknown
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model — Total Capacity Rut (kips) 112.4

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.144	8814	0.010	0.000	0.85	0.0	0.000	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	0.0	0.000	0.100	6.80	3.3	12.4
8	0.144	8814	0.000	0.000	1.00	0.2	0.050	0.100	27.20	3.3	12.4
9	0.144	8814	0.000	0.000	1.00	3.1	0.050	0.100	30.60	3.3	12.4
10	0.144	8814	0.000	0.000	1.00	6.7	0.050	0.100	34.00	3.3	12.4
11	0.144	8814	0.000	0.000	1.00	10.3	0.050	0.100	37.40	3.3	12.4
12	0.144	8814	0.000	0.000	1.00	12.9	0.050	0.100	40.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	14.8	0.050	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	16.8	0.050	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	18.7	0.050	0.100	51.00	3.3	12.4
Toe						29.0	0.150	0.083			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	10.81	1.00	0.800

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft) down	up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
112.4	10.0	5.75	5.73	-1.63	9	38	24.63	10	4	18.6	49.1
112.4	10.1	5.70	5.75	-1.63	9	38	24.43	10	4	18.4	49.2
112.4	10.0	5.76	5.74	-1.63	9	38	24.63	10	4	18.6	49.1
112.4	10.1	5.69	5.75	-1.63	9	38	24.43	10	4	18.4	49.2
112.4	10.1	5.70	5.75	-1.63	9	38	24.43	10	4	18.4	49.2

1 0 10.81000 11.86000

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Depth (ft) 30.0
Shaft Gain/Loss Factor 0.796 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 144.000 Pile Type Unknown
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model — Total Capacity Rut (kips) 114.7

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.144	8814	0.010	0.000	0.85	0.0	0.000	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	0.0	0.000	0.100	6.80	3.3	12.4
7	0.144	8814	0.000	0.000	1.00	1.2	0.050	0.100	23.80	3.3	12.4
8	0.144	8814	0.000	0.000	1.00	4.8	0.050	0.100	27.20	3.3	12.4
9	0.144	8814	0.000	0.000	1.00	8.4	0.050	0.100	30.60	3.3	12.4
10	0.144	8814	0.000	0.000	1.00	11.7	0.050	0.100	34.00	3.3	12.4
11	0.144	8814	0.000	0.000	1.00	13.8	0.050	0.100	37.40	3.3	12.4
12	0.144	8814	0.000	0.000	1.00	15.7	0.050	0.100	40.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	17.7	0.050	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	18.2	0.100	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	17.0	0.150	0.100	51.00	3.3	12.4
Toe						6.2	0.150	0.083			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	10.81	1.00	0.800

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc 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
114.7	10.5	5.75	5.80	-1.48	8	37	24.56	8	3	18.2	48.9
115.2	10.6	5.76	5.81	-1.43	8	37	24.61	8	3	18.2	48.9
115.8	10.7	5.77	5.82	-1.38	8	37	24.65	8	3	18.2	48.9
116.3	10.8	5.78	5.84	-1.34	8	37	24.69	8	3	18.1	48.8
116.8	10.8	5.79	5.84	-1.29	8	37	24.72	8	3	18.1	48.8

1 0 10.81000 11.86000

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Depth (ft) 35.0
Shaft Gain/Loss Factor 0.796 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 144.000 Pile Type Unknown
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model Total Capacity Rut (kips) 143.3

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.144	8814	0.010	0.000	0.85	0.0	0.000	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	0.0	0.000	0.100	6.80	3.3	12.4
5	0.144	8814	0.000	0.000	1.00	0.2	0.050	0.100	17.00	3.3	12.4
6	0.144	8814	0.000	0.000	1.00	2.9	0.050	0.100	20.40	3.3	12.4
7	0.144	8814	0.000	0.000	1.00	6.5	0.050	0.100	23.80	3.3	12.4
8	0.144	8814	0.000	0.000	1.00	10.1	0.050	0.100	27.20	3.3	12.4
9	0.144	8814	0.000	0.000	1.00	12.8	0.050	0.100	30.60	3.3	12.4
10	0.144	8814	0.000	0.000	1.00	14.7	0.050	0.100	34.00	3.3	12.4
11	0.144	8814	0.000	0.000	1.00	16.7	0.050	0.100	37.40	3.3	12.4
12	0.144	8814	0.000	0.000	1.00	18.6	0.050	0.100	40.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	17.2	0.145	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	51.00	3.3	12.4
Toe						9.6	0.150	0.083			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
35.00	10.81	1.00	0.800

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc 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
143.3	15.0	6.34	6.36	-0.64	6	32	26.57	7	3	17.5	46.7
144.4	15.2	6.36	6.38	-0.61	6	32	26.64	7	3	17.5	46.7
145.4	15.4	6.38	6.40	-0.59	6	32	26.71	7	3	17.5	46.6
146.5	15.6	6.40	6.42	-0.62	6	29	26.76	7	3	17.4	46.5
147.6	15.8	6.42	6.44	-0.69	6	29	26.81	7	3	17.5	46.4

1 0 10.81000 11.86000

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Depth (ft) 40.0
Shaft Gain/Loss Factor 0.796 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 144.000 Pile Type Unknown
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model Total Capacity Rut (kips) 164.3

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.144	8814	0.010	0.000	0.85	0.0	0.000	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	0.0	0.000	0.100	6.80	3.3	12.4
4	0.144	8814	0.000	0.000	1.00	1.0	0.050	0.100	13.60	3.3	12.4
5	0.144	8814	0.000	0.000	1.00	4.6	0.050	0.100	17.00	3.3	12.4
6	0.144	8814	0.000	0.000	1.00	8.2	0.050	0.100	20.40	3.3	12.4
7	0.144	8814	0.000	0.000	1.00	11.6	0.050	0.100	23.80	3.3	12.4
8	0.144	8814	0.000	0.000	1.00	13.7	0.050	0.100	27.20	3.3	12.4
9	0.144	8814	0.000	0.000	1.00	15.6	0.050	0.100	30.60	3.3	12.4
10	0.144	8814	0.000	0.000	1.00	17.6	0.050	0.100	34.00	3.3	12.4
11	0.144	8814	0.000	0.000	1.00	18.2	0.094	0.100	37.40	3.3	12.4
12	0.144	8814	0.000	0.000	1.00	17.0	0.150	0.100	40.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	15.6	0.108	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	14.5	0.050	0.100	51.00	3.3	12.4
Toe						9.6	0.150	0.083			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	10.81	1.00	0.800

FRA-70-1282R - HP 10x42 06/28/2018
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Rut	Bl Ct	Stroke (ft) down	up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
164.3	18.2	6.63	6.64	-1.56	5	29	27.42	6	3	17.2	45.7
165.8	18.5	6.66	6.67	-1.53	5	29	27.53	6	3	17.2	45.6
167.4	18.7	6.68	6.68	-1.49	5	29	27.59	6	3	17.2	45.6
168.9	19.0	6.70	6.71	-1.47	5	28	27.64	6	3	17.1	45.5
170.4	19.3	6.72	6.73	-1.44	5	28	27.70	6	3	17.1	45.4

1 0 10.81000 11.86000

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Depth (ft) 45.0
Shaft Gain/Loss Factor 0.796 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 144.000 Pile Type Unknown
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model Total Capacity Rut (kips) 186.0

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	0.144	8814	0.010	0.000	0.85	0.0	0.000	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	0.1	0.050	0.100	6.80	3.3	12.4
3	0.144	8814	0.000	0.000	1.00	2.6	0.050	0.100	10.20	3.3	12.4
4	0.144	8814	0.000	0.000	1.00	6.3	0.050	0.100	13.60	3.3	12.4
5	0.144	8814	0.000	0.000	1.00	9.9	0.050	0.100	17.00	3.3	12.4
6	0.144	8814	0.000	0.000	1.00	12.6	0.050	0.100	20.40	3.3	12.4
7	0.144	8814	0.000	0.000	1.00	14.6	0.050	0.100	23.80	3.3	12.4
8	0.144	8814	0.000	0.000	1.00	16.5	0.050	0.100	27.20	3.3	12.4
9	0.144	8814	0.000	0.000	1.00	18.5	0.050	0.100	30.60	3.3	12.4
10	0.144	8814	0.000	0.000	1.00	17.3	0.139	0.100	34.00	3.3	12.4
11	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	37.40	3.3	12.4
12	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	40.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	14.2	0.057	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	15.8	0.101	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	17.0	0.150	0.100	51.00	3.3	12.4
Toe						6.2	0.150	0.083			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
45.00	10.81	1.00	0.800

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc 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
186.0	22.4	6.98	6.95	-0.39	3	47	28.46	4	3	16.9	44.7
188.0	22.7	7.00	6.97	-0.39	3	47	28.53	4	3	16.9	44.6
190.1	23.0	7.02	6.99	-0.37	3	47	28.60	4	3	16.9	44.5
192.1	23.3	7.04	7.01	-0.38	3	46	28.65	4	3	16.8	44.5
194.2	23.8	7.06	7.04	-0.40	3	45	28.71	4	3	16.7	44.4

1 0 10.81000 11.86000

FRA-70-1282R - HP 10x42 06/28/2018
Resource International Inc GRLWEAP Version 2010

Depth (ft) 50.0
Shaft Gain/Loss Factor 0.796 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 144.000 Pile Type Unknown
Pile Size (inch) 10.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model Total Capacity Rut (kips) 211.1

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	0.144	8814	0.010	0.000	0.85	0.9	0.050	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	4.3	0.050	0.100	6.80	3.3	12.4
3	0.144	8814	0.000	0.000	1.00	8.0	0.050	0.100	10.20	3.3	12.4
4	0.144	8814	0.000	0.000	1.00	11.4	0.050	0.100	13.60	3.3	12.4
5	0.144	8814	0.000	0.000	1.00	13.6	0.050	0.100	17.00	3.3	12.4
6	0.144	8814	0.000	0.000	1.00	15.5	0.050	0.100	20.40	3.3	12.4
7	0.144	8814	0.000	0.000	1.00	17.5	0.050	0.100	23.80	3.3	12.4
8	0.144	8814	0.000	0.000	1.00	18.3	0.088	0.100	27.20	3.3	12.4
9	0.144	8814	0.000	0.000	1.00	17.0	0.150	0.100	30.60	3.3	12.4
10	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	34.00	3.3	12.4
11	0.144	8814	0.000	0.000	1.00	15.8	0.114	0.100	37.40	3.3	12.4
12	0.144	8814	0.000	0.000	1.00	14.5	0.050	0.100	40.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	16.9	0.145	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	51.00	3.3	12.4
Toe						6.2	0.150	0.083			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
50.00	10.81	1.00	0.800

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
211.1	26.8	7.26	7.23	-0.07	2	42	29.43	2	2	16.4	43.8
213.7	27.2	7.27	7.25	-0.11	2	42	29.47	2	2	16.4	43.8
216.3	27.6	7.30	7.28	-0.14	2	41	29.55	2	2	16.4	43.7
218.9	28.2	7.32	7.30	-0.15	2	41	29.61	2	2	16.3	43.6
221.5	28.6	7.34	7.33	-0.15	2	41	29.67	2	2	16.4	43.6

1 0 10.81000 11.86000

Depth (ft) 51.0
Shaft Gain/Loss Factor 0.796 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 144.000 Pile Type Unknown
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
51.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 6.173

Pile and Soil Model Total Capacity Rut (kips) 216.2

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	0.144	8814	0.010	0.000	0.85	1.8	0.050	0.100	3.40	3.3	12.4
2	0.144	8814	0.000	0.000	1.00	5.4	0.050	0.100	6.80	3.3	12.4
3	0.144	8814	0.000	0.000	1.00	9.0	0.050	0.100	10.20	3.3	12.4
4	0.144	8814	0.000	0.000	1.00	12.1	0.050	0.100	13.60	3.3	12.4
5	0.144	8814	0.000	0.000	1.00	14.1	0.050	0.100	17.00	3.3	12.4
6	0.144	8814	0.000	0.000	1.00	16.1	0.050	0.100	20.40	3.3	12.4
7	0.144	8814	0.000	0.000	1.00	18.0	0.050	0.100	23.80	3.3	12.4
8	0.144	8814	0.000	0.000	1.00	17.8	0.117	0.100	27.20	3.3	12.4
9	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	30.60	3.3	12.4
10	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	34.00	3.3	12.4
11	0.144	8814	0.000	0.000	1.00	14.9	0.084	0.100	37.40	3.3	12.4
12	0.144	8814	0.000	0.000	1.00	15.2	0.076	0.100	40.80	3.3	12.4
13	0.144	8814	0.000	0.000	1.00	17.0	0.150	0.100	44.20	3.3	12.4
14	0.144	8814	0.000	0.000	1.00	17.1	0.150	0.100	47.60	3.3	12.4
15	0.144	8814	0.000	0.000	1.00	17.2	0.150	0.100	51.00	3.3	12.4
Toe						6.2	0.150	0.083			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
51.00	10.81	1.00	0.800

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
216.2	27.7	7.31	7.28	-0.05	2	41	29.68	2	2	16.3	43.7
218.9	28.1	7.33	7.30	-0.07	2	41	29.75	2	2	16.3	43.6
221.6	28.8	7.34	7.33	-0.06	2	41	29.77	2	2	16.2	43.6
224.3	29.2	7.36	7.35	-0.04	2	40	29.84	2	2	16.3	43.5

227.0	29.6	7.39	7.37	-0.04	2	40	29.92	2	2	16.4	43.5

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.796 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
5.0	17.9	3.9	14.0	1.5	10.077	0.000	3.60	24.7
10.0	43.6	15.6	28.0	3.7	18.084	0.000	4.52	21.5
15.0	70.8	34.0	36.8	6.3	22.047	-0.650	5.15	19.9
20.0	100.9	56.6	44.3	9.5	24.402	-1.078	5.68	18.7
25.0	112.4	83.4	29.0	10.0	24.630	-1.633	5.75	18.6
30.0	114.7	108.5	6.2	10.5	24.563	-1.476	5.75	18.2
35.0	143.3	133.7	9.6	15.0	26.572	-0.641	6.34	17.5
40.0	164.3	154.7	9.6	18.2	27.421	-1.561	6.63	17.2
45.0	186.0	179.8	6.2	22.4	28.455	-0.390	6.98	16.9
50.0	211.1	204.9	6.2	26.8	29.431	-0.068	7.26	16.4
51.0	216.2	210.0	6.2	27.7	29.680	-0.055	7.31	16.3

Total Driving Time 12 minutes; Total No. of Blows 580

G/L at Shaft and Toe: 0.813 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
5.0	17.9	3.9	14.0	1.5	10.077	0.000	3.60	24.7
10.0	43.6	15.6	28.0	3.7	18.084	0.000	4.52	21.5
15.0	70.8	34.0	36.8	6.3	22.047	-0.650	5.15	19.9
20.0	100.9	56.6	44.3	9.5	24.402	-1.078	5.68	18.7
25.0	112.4	83.4	29.0	10.1	24.434	-1.626	5.70	18.4
30.0	115.2	109.0	6.2	10.6	24.609	-1.431	5.76	18.2
35.0	144.4	134.7	9.6	15.2	26.641	-0.614	6.36	17.5
40.0	165.8	156.2	9.6	18.5	27.526	-1.527	6.66	17.2
45.0	188.0	181.8	6.2	22.7	28.529	-0.385	7.00	16.9
50.0	213.7	207.5	6.2	27.2	29.473	-0.107	7.27	16.4
51.0	218.9	212.7	6.2	28.1	29.754	-0.068	7.33	16.3

Total Driving Time 13 minutes; Total No. of Blows 587

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.830 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
5.0	17.9	3.9	14.0	1.5	10.077	0.000	3.60	24.7
10.0	43.6	15.6	28.0	3.7	18.084	0.000	4.52	21.5
15.0	70.8	34.0	36.8	6.3	22.047	-0.650	5.15	19.9
20.0	100.9	56.6	44.3	9.5	24.402	-1.078	5.68	18.7
25.0	112.4	83.4	29.0	10.0	24.631	-1.633	5.76	18.6
30.0	115.8	109.6	6.2	10.7	24.645	-1.384	5.77	18.2
35.0	145.4	135.8	9.6	15.4	26.706	-0.594	6.38	17.5
40.0	167.4	157.7	9.6	18.7	27.587	-1.488	6.68	17.2
45.0	190.1	183.9	6.2	23.0	28.604	-0.374	7.02	16.9
50.0	216.3	210.1	6.2	27.6	29.551	-0.136	7.30	16.4
51.0	221.6	215.4	6.2	28.8	29.774	-0.058	7.34	16.2

Total Driving Time 13 minutes; Total No. of Blows 592

G/L at Shaft and Toe: 0.847 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
5.0	17.9	3.9	14.0	1.5	10.077	0.000	3.60	24.7
10.0	43.6	15.6	28.0	3.7	18.084	0.000	4.52	21.5
15.0	70.8	34.0	36.8	6.3	22.047	-0.650	5.15	19.9
20.0	100.9	56.6	44.3	9.5	24.402	-1.078	5.68	18.7
25.0	112.4	83.4	29.0	10.1	24.434	-1.626	5.69	18.4
30.0	116.3	110.1	6.2	10.8	24.692	-1.341	5.78	18.1
35.0	146.5	136.9	9.6	15.6	26.758	-0.621	6.40	17.4
40.0	168.9	159.3	9.6	19.0	27.639	-1.467	6.70	17.1
45.0	192.1	185.9	6.2	23.3	28.647	-0.382	7.04	16.8

50.0	218.9	212.7	6.2	28.2	29.608	-0.154	7.32	16.3
51.0	224.3	218.1	6.2	29.2	29.841	-0.039	7.36	16.3

Total Driving Time 13 minutes; Total No. of Blows 600

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SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.864 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
5.0	17.9	3.9	14.0	1.5	10.077	0.000	3.60	24.7
10.0	43.6	15.6	28.0	3.7	18.084	0.000	4.52	21.5
15.0	70.8	34.0	36.8	6.3	22.047	-0.650	5.15	19.9
20.0	100.9	56.6	44.3	9.5	24.402	-1.078	5.68	18.7
25.0	112.4	83.4	29.0	10.1	24.434	-1.626	5.70	18.4
30.0	116.8	110.6	6.2	10.8	24.718	-1.292	5.79	18.1
35.0	147.6	137.9	9.6	15.8	26.812	-0.690	6.42	17.5
40.0	170.4	160.8	9.6	19.3	27.704	-1.444	6.72	17.1
45.0	194.2	188.0	6.2	23.8	28.711	-0.404	7.06	16.7
50.0	221.5	215.3	6.2	28.6	29.669	-0.155	7.34	16.4
51.0	227.0	220.8	6.2	29.6	29.919	-0.039	7.39	16.4

Total Driving Time 13 minutes; Total No. of Blows 606

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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
5.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
10.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
15.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
20.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
25.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
30.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
35.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
40.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
45.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
50.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00
51.00	51.00	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft2	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.01	0.00	0.03	0.100	0.083	0.050	0.150	0.000	0.000	0.000
9.01	0.85	25.21	0.100	0.083	0.050	0.150	0.000	0.000	0.000
10.99	1.04	30.75	0.100	0.083	0.050	0.150	0.000	0.000	0.000
11.01	1.04	30.79	0.100	0.083	0.050	0.150	0.000	0.000	0.000
20.01	1.50	44.34	0.100	0.083	0.050	0.150	0.000	0.000	0.000
24.99	1.75	51.83	0.100	0.083	0.050	0.150	0.000	0.000	0.000
25.01	1.90	6.20	0.100	0.083	0.150	0.150	1.000	0.000	0.000
34.01	1.92	6.20	0.100	0.083	0.150	0.150	1.000	0.000	0.000
34.99	1.93	6.20	0.100	0.083	0.150	0.150	1.000	0.000	0.000
35.01	1.52	13.05	0.100	0.083	0.050	0.150	1.000	0.000	0.000
39.99	1.68	13.05	0.100	0.083	0.050	0.150	1.000	0.000	0.000
40.01	1.90	6.20	0.100	0.083	0.150	0.150	1.000	0.000	0.000
49.01	1.92	6.20	0.100	0.083	0.150	0.150	1.000	0.000	0.000
51.00	1.96	6.20	0.100	0.083	0.150	0.150	1.000	0.000	0.000

APPENDIX VII

LATERAL DESIGN PARAMETERS

Boring No.	Elevation (feet msl)	Soil Class.	Soil Type	Strata	N_{60}	$N1_{60}$	γ (pcf)	γ' (pcf)	Strength Parameter	k (soil) k_{rm} (rock)	ε_{50} (soil) E_r (rock)	RQD (rock)
B-013-2-15	705.5 to 702.5	A-2-4	G	4	23	41	125 psf	125 psf	φ = 40°	280 pci	-	-
	702.5 to 697.5	A-1-b	G	4	47	64	130 psf	130 psf	φ = 42°	355 pci	-	-
	697.5 to 673.5	A-1-a	G	4	57	52	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	673.5 to 663.5	A-4a	C	2	105	105	130 psf	67.6 psf	Su = 8,000 psf	2,665 pci	0.0033	-
	663.5 to 658.5	A-3	G	4	43	32	130 psf	67.6 psf	φ = 36°	95 pci	-	-
	658.5 to 647.0	A-4a	C	2	120	120	130 psf	67.6 psf	Su = 8,000 psf	2,665 pci	0.0033	-
B-109-0-09	704.9 to 698.9	A-4a	C	3	45	45	130 psf	130 psf	Su = 5,625 psf	1,875 pci	0.0041	-
	698.9 to 694.9	A-1-a	G	4	50	61	130 psf	130 psf	φ = 43°	395 pci	-	-
	694.9 to 672.9	A-1-a	G	4	16	16	125 psf	62.6 psf	φ = 37°	110 pci	-	-
	672.9 to 667.9	A-1-a	G	4	31	27	130 psf	67.6 psf	φ = 40°	155 pci	-	-
	667.9 to 662.9	A-4a	C	2	76	76	130 psf	67.6 psf	Su = 8,000 psf	2,665 pci	0.0033	-
	662.9 to 657.9	A-3a	G	4	51	40	135 psf	72.6 psf	φ = 38°	125 pci	-	-