Resource International, Inc.

FRA-70-12.68 PROJECT 4R
FRA-70-1301A
RAMP C5 OVER SR-315
PID NO. 105523
FRANKLIN COUNTY, OHIO

STRUCTURE FOUNDATION EXPLORATION REPORT

Prepared For:
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Rii Project No. W-13-045

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December 24, 2014 (Revised January 30, 2019)

Mr. Christopher W. Luzier, P.E.
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Re: Structure Foundation Exploration Report
FRA-70-12.68 Project 4R
FRA-70-1301A – Ramp C5 over SR-315
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 recommendations for the design and construction of the proposed FRA-70-1301A bridge structure carrying Ramp C5 over SR-315 as part of the FRA-70-12.68 Project 4R in Columbus, Ohio.

We sincerely appreciate the opportunity to be of service to you on this project. If you have any questions regarding the preliminary 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

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EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a structure foundation exploration for the design and construction of the proposed FRA-70-1301A bridge structure carrying the proposed Ramp C5 over SR-315. Based on information provided by Burgess and Niple, it is understood that the proposed structure will be an eight-span prestressed concrete I-beam with composite reinforced concrete deck structure with reinforced concrete substructures and will have a total length of approximately 966 feet and width of approximately 31 feet. This structure will be connected to the proposed FRA-70-1321A bridge structure at the east end of the alignment.

Exploration and Findings

Between June 10 and July 30, 2013, six (6) borings, designated as B-015-1-13, B-015-2-13 and B-015-4-13 through B-015-7-13, were drilled along the proposed bridge alignment at the locations shown on the boring plan provided in Appendix I of the full report. The borings were advanced to completion depths ranging from 68.5 to 95.7 feet below the existing ground surface at the respective boring location. Boring B-015-3-13 was also planned near the proposed footprint of Pier 4, but due to the presence of dense underground utilities in the vicinity of the proposed boring location, this boring was eliminated from the program. In addition, boring B-108-5-13, which was performed as part of the FRA-70-13.10 Project 6A for the proposed FRA-71-1503L bridge structure, was also utilized for subsurface evaluation and foundation analysis for this structure. The boring was performed on June 30 and July 1, 2014, and was advanced to a depth of 63.0 feet below existing grade.

Borings B-015-1-13 and B-015-4-13 were drilled through the existing shoulder of I-70 eastbound and the I-70 eastbound ramp to SR-315 northbound, respectively, and encountered 9.0 and 4.0 inches of asphalt overlying 6.0 and 12.0 inches of aggregate base, respectively. Boring B-015-6-13 was performed in the existing access drive to the pump station located within the infield of the I-70 eastbound to SR-315 northbound loop ramp and encountered 2.0 inches of asphalt at the ground surface. The remaining borings were drilled in the grass infield areas between the various roadways and interchange ramps and encountered 4.0 to 8.0 inches of topsoil at the ground surface.

Beneath the surface materials in borings B-015-1-13, B-015-4-13, B-015-5-13 and B-015-6-13, material identified as existing fill was encountered extending to depths ranging from 15.5 to 37.0 feet below the ground surface. The fill material consisted of dark brown, dark gray, gray, brown and brownish gray gravel, gravel and sand, gravel with sand and silt, gravel with sand, silt and clay, sandy silt, silt and clay and silty clay (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-4a, A-6a, A-6b) and contained brick, concrete or coal fragments and root fibers throughout.

Underlying the surficial materials and existing fill, where encountered, natural soils were encountered consisting of both granular and cohesive material. The granular soils were generally described as brown, gray, brownish gray and dark gray gravel, gravel and sand, gravel with sand and silt, gravel with sand, silt and clay, coarse and fine sand and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-3a, A-4a). The cohesive soils were described as gray, brown, dark gray and dark brown sandy silt, silt, silt and clay, silty clay and clay (ODOT A-4a, A-4b, A-6a, A-6b, A-7-6).

With the exception of boring B-015-1-13, bedrock was encountered in the remaining borings at depths ranging from 58.5 to 70.5 feet below the ground surface, which corresponds to elevations ranging from 641.9 to 657.6 feet msl. The cored bedrock consisted of limestone in all of the borings where bedrock was encountered with the exception of boring B-015-7-13, which encountered dolomite.

Analyses and Recommendations

Design details of the proposed structure were provided by Burgess and Niple and GPD GROUP. Based on the information provided, it is understood that the proposed structure will consist of an eight-span prestressed concrete I-beam with composite reinforced concrete deck structure with reinforced concrete substructures supported on deep foundations consisting of driven piles or drilled shafts. This structure will be connected to the proposed FRA-70-1321A bridge structure at the east end of the alignment. Foundation recommendations for the combined Pier A (Pier 8) are provided in the FRA-70-1321A Structure Foundation Exploration report. Therefore, recommendations for this substructure unit are not provided in this report.

Driven Pile Recommendations

It is understood that driven piles will be utilized at the rear abutment and Pier 1 through Pier 5 substructure units. Given the depth of bedrock encountered and the anticipated loading at the abutments, it is recommended that steel H-piles (ODOT Item 507.06) driven to refusal on bedrock be employed for foundation support. Friction bearing piles will not be a feasible foundation option as the maximum factored load per pile exceeds the maximum factored resistance allowed per Section 202.2.3.2.b of the 2007 ODOT BDM for all pile types and sizes. Per Section 202.2.3.2a of the 2007 ODOT Bridge Design Manual, refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. The following table shows the recommended pile lengths and the corresponding factored structural axial resistance ($R_{R\ max}$) of steel H-piles.

H-Pile Recommendations

Substructure Reference	Ground Elevation [1]	Pile Size [2]	Pile Elevation		Pile Length [4] (feet)	$R_{R\ max}$ [5] (kips/pile)	φ [6]
			Top [3]	Tip			
Rear Abutment (B-015-1-13 / B-003-E-68)	746.7 / 719.0	HP 10x42	731.5	649.5	85	310	N/A
Pier 1 (B-015-2-13)	700.4	HP 14x73	695.5	641.9	55	530	N/A
Pier 2 (B-001-B-68)	702.0	HP 14x73	698.1	641.9	60	530	N/A
Pier 3 (B-108-5-13)	705.0	HP 14x73	694.9	645.8	50	530	N/A
Pier 4 (B-108-5-13 / B-015-4-13)	734.2	HP 14x73	705.1	646.7	60	530	N/A
Pier 5 (B-015-4-13)	734.2	HP 14x73	731.9	647.5	85	530	N/A

1. *Ground elevation listed is the ground elevation at the respective boring location.*
2. *A steel pile point is recommended to protect the tips of the piles during pile installation.*
3. *The top of pile elevation corresponds to the pile cutoff elevation, which is 1.0-foot above the proposed bottom of footing elevation.*
4. *Per ODOT BDM Section 202.3.2, 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.*
5. *The factored structural axial resistance for H-piles is based on the structural limit state of the steel H-pile section per Section 202.2.3.2.a of the 2007 ODOT BDM.*
6. *For H-piles driven to refusal on bedrock, no geotechnical resistance factor should be applied to the factored structural axial resistance values presented, as the values presented account for the structural resistance factor, φ_c = 0.50, for H-piles subject to damage due to severe driving conditions.*

Based on discussions with Burgess and Niple, it is understood that HP 12x74 piles are being recommended in the Stage 2 design plans, which have been successfully utilized on other ODOT projects which have been designed by Burgess and Niple. Calculations were performed by Burgess and Niple to determine the maximum factored structural resistance per pile in accordance with Section 202.2.3.2.a of the 2007 ODOT BDM, which was determined to be 545 kips per pile. Therefore, the piles will be an acceptable alternative for the recommended HP 14x73 pile sections for Pier 1 through Pier 5.

Drilled Shaft Recommendations

Given the proposed loading per shaft at each of the pier locations, friction bearing drilled shafts within the overburden soils are not economically feasible foundation options due to the size and number of shafts that would be required to support the proposed loading. Therefore, it is recommended that the drilled shafts be extended through the surficial soils to bear on or within the underlying limestone bedrock at Pier 6 and Pier 7.

Using equation 10.8.3.5.4c-1 of the AASHTO LRFD BDS, the nominal end bearing resistance for drilled shafts socketed a minimum of $1.5B_{RS}$ into intact rock is 2.5 times the unconfined compressive strength of the bedrock unit that the shaft tip is bearing on or within. Based on unconfined compression tests performed on limestone rock cores obtained from the borings performed at the subject piers, the unconfined compressive strength ranges from 5,771 to 12,661 psi. Using equation 10.8.3.5.4c-1 and the limiting unconfined compressive strength from the given range for the limestone bedrock, it is recommended that drilled shaft foundations socketed a minimum of $1.5B_{RS}$ into the bedrock to bear on or within the competent limestone bedrock be proportioned for a nominal end bearing resistance of 2,078 ksf at the strength limit state.

Where lateral load demands do not require a rock socket length of $1.5B_{RS}$, the socket length can be reduced or the shaft can bear on the bedrock surface with no rock socket. If the rock socket is reduced to a length less than $1.5B_{RS}$, a reduced nominal end bearing resistance should be utilized based on equations 10.8.3.5.4c-2 and 10.8.3.5.4c-3 of the AASHTO LRFD BDS. Using the limiting unconfined compressive strength from the given range for the limestone bedrock, it is recommended that drilled shaft foundations bearing on or within the competent limestone bedrock with a socket length less than $1.5B_{RS}$ into the bedrock be proportioned for a nominal end bearing resistance of 899 ksf at the strength limit state.

The following table lists the estimated elevation of the top of bedrock as well as the proposed rock sock diameter and length from the design plans and, corresponding nominal end bearing resistance to be utilized for the design of the drilled shaft foundations. A resistance factor of $\varphi_{qp} = 0.5$ at the strength limit state should be utilized for design.

Drilled Shaft Recommendations

Substructure Unit (Boring)	Top of Bedrock Elevation (feet msl)	Rock Socket Diameter [1] (feet)	Proposed Socket Length [1] (feet)	Nominal End Bearing Resistance [2] (ksf)
Pier 6 (B-015-5-13)	657.6	4.0	4.0	899
Pier 7 (B-015-6-13)	655.5	4.0	4.0	899

1. *Proposed rock socket diameter and length at each substructure unit determined from proposed plan information provided by Burgess and Niple.*
2. *Nominal end bearing resistance provided is the value that should be utilized in the determination of the end bearing resistance per drilled shaft based on the proposed rock socket length and diameter.*

Settlement Analysis

A settlement analysis was performed at the rear abutment to predict the long term consolidation settlement that will result after the embankment fill has been placed. Based on soil profile and cross section information provided by Burgess and Niple and GPD GROUP, a fill height of approximately 35 feet is anticipated near the rear abutment of the proposed structure. Results of the settlement analysis indicate that a total settlement of 4.42 inches is anticipated near the rear abutment due to the weight of the new embankment fill. Due to the presence of thick granular soil layers present elevations ranging from 674.7 to 694.7 feet msl, it is anticipated that a portion of the settlement of the natural soils will occur during construction of the proposed embankment. Long term settlement of the natural cohesive soils and embankment fill following the completion of construction is expected to be on the order of approximately 3.6 inches. Results of the settlement analysis indicate that approximately 90 percent of the primary consolidation of the cohesive layers will be complete within 55 days following the placement of the surcharge load. Therefore, if a 55 day waiting period is specified following completion of construction of the embankment surcharge, downdrag forces along the piles will be eliminated.

Slope Stability Analysis

A slope stability analysis was performed at the proposed rear abutment to evaluate the stability of the embankment slope at the substructure location. For slopes that are integrated with or supporting structural foundations or elements global stability is satisfied when a minimum factor of safety of 1.5 is obtained. The resulting factor of safety under drained (long-term stability) conditions for the proposed embankment slope at the rear abutment is 1.50, and the stability of the slope under undrained (short-term stability) conditions is 1.86. Based on the results of the analyses, the stability of the proposed embankment slopes will be within acceptable limits.

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-70-1301A bridge structure carrying the proposed Ramp C5 over SR-315, as shown on the vicinity map and boring plan presented in Appendix I. Based on information provided by Burgess and Niple, it is understood that the proposed structure will be an eight-span prestressed concrete I-beam with composite reinforced concrete deck structure with reinforced concrete substructures and will have a total length of approximately 966 feet and width of approximately 31 feet. This structure will be connected to the proposed FRA-70-1321A bridge structure at the east end of the alignment.

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 Formation. 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 Scioto River, the Upper Devonian Ohio Shale Formation overlies the Columbus Limestone Formation. The Ohio Shale formation consists of brownish black to greenish gray, thinly bedded, fissile, carbonaceous shale. 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. Limestone and dolomite bedrock was encountered at elevations ranging from 641.9 to 657.6 feet msl along the structure alignment.

2.2 Existing Conditions

The proposed FRA-70-1301A structure will be situated along the south side of the existing I-70 eastbound structure that crosses over SR-315. The west end of the structure will be located along the slope of the existing infield between I-70 eastbound, the I-70 eastbound ramp to I-71 southbound and SR-315 southbound roadways. The proposed structure will then span over the existing SR-315 northbound and southbound roadways as well as several interchange ramps between I-70, I-71 and SR-315. There is also an existing pump station situated within the infield of the loop ramp from I-70 eastbound to SR-315 northbound. The terrain along SR-315 is lowered from the surrounding terrain, and the existing infields between the roadways are generally grass covered, with some patches of dense vegetation along the slope west of SR-315 northbound. The Scioto River flows along the east side of I-71 and SR-315 northbound.

3.0 EXPLORATION

Between June 10 and July 30, 2013, six (6) borings, designated as B-015-1-13, B-015-2-13 and B-015-4-13 through B-015-7-13, were drilled along the proposed bridge alignment at the locations shown on the boring plan provided in Appendix I of this report and summarized in Table 1. The borings were advanced to completion depths ranging from 68.5 to 95.7 feet below the existing ground surface at the respective boring location. Boring B-015-3-13 was also planned near the proposed footprint of Pier 4, but due to the presence of dense underground utilities in the vicinity of the proposed boring location, this boring was eliminated from the program. In addition, boring B-108-5-13, which was performed as part of the FRA-70-13.10 Project 6A for the proposed

FRA-71-1503L bridge structure, was also utilized for subsurface evaluation and foundation analysis for this structure. The boring was performed on June 30 and July 1, 2014, and was advanced to a depth of 63.0 feet below existing grade.

Table 1. Test Boring Summary

Boring Number	Reference Alignment	Station [1]	Offset [1]	Latitude	Longitude	Ground Elevation (feet msl)	Boring Depth (feet)
B-015-1-13	BL Ramp C5	5041+24.30	73.2' Lt.	39.949844277	-83.017516074	746.7	95.0
B-015-2-13	BL Ramp C5	5042+88.86	2.6' Rt.	39.950018890	-83.017141752	700.4	68.5
B-015-4-13	BL Ramp C5	5048+23.41	12.5' Rt.	39.950291772	-83.015266056	734.2	95.7
B-015-5-13	BL Ramp C5	5049+08.12	37.6' Rt.	39.950498754	-83.015042527	723.6	76.0
B-015-6-13	BL Ramp C5	5050+28.85	20.8' Lt.	39.950578918	-83.014626080	723.0	77.5
B-015-7-13	BL Ramp C5	5051+29.66	9.8' Rt.	39.950618516	-83.014254653	721.8	80.5
B-105-8-13	BL I-71 SB	239+69.30	18.7' Rt.	39.950225756	-83.016078985	700.3	63.0

The boring locations 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 were drilled using a truck or all-terrain vehicle (ATV) mounted rotary drilling machine, utilizing either a 3.25-inch, 3.75-inch or 4.25-inch inside diameter, continuous hollow-stem auger to advance the holes. Standard penetration testing (SPT) and split spoon sampling were performed in the borings at 2.5-foot increments of depth to 30.0 feet and at 5.0-foot increments thereafter to the boring termination depth. 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

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

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, CME 750 and CME 750X drill rigs used were calibrated on April 26, 2013, and have drill rod energy ratios of 77.7, 82.6 and 86.8 percent, respectively. No calibration factor was applied to the blow counts presented on the historic boring logs, as these were performed using a manual hammer.

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.

During drilling, Rii personnel prepared field logs 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 2.

Table 2. Laboratory Test Schedule

Laboratory Test	Test Designation	Number of Tests Performed
Natural Moisture Content	ASTM D 2216	140
Plastic and Liquid Limits	AASHTO T89, T90	44
Gradation – Sieve/Hydrometer	AASHTO T88	44
Unconfined Compressive Strength of Intact Rock	ASTM D7012	8

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 III. A description of the soil terms used throughout this report is presented in Appendix II.

The depth to bedrock was determined by 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.

Where borings were extended into the bedrock (after encountering auger refusal), an NQ or HQ-sized double-tube diamond bit core barrel (utilizing wire line equipment) was used to core the bedrock. Coring produced 1.85 and 2.45 inch diameter cores, from which the type of rock and its 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:

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

Rii has included a plan showing the soil borings performed in the project area in Appendix I.

At the completion of drilling, the borings were backfilled with a mixture of bentonite chips and soil cuttings or sealed with a cement-bentonite grout mix, and any pavement surfaces were patched with an equivalent thickness of cold patch asphalt or quick set concrete to match the surrounding pavement thickness and type.

In addition to the borings performed for the current exploration, historic borings performed in 1968 by the Department of Highways as part of the original FRA-70-12.31S project were obtained from the construction documents on record. Three (3) borings, designated as B-001-B-68, B-003-E-68 and B-012-E-68, were obtained near the abutments of the existing bridge structure in the area. The borings were extended to a depth of 63.5, 75.0 and 60.0 feet, respectively, below the ground surface at the time the borings were obtained.

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 and what is represented on the boring logs.

4.1 Surface Materials

Borings B-015-1-13 and B-015-4-13 were drilled through the existing shoulder of I-70 eastbound and the I-70 eastbound ramp to SR-315 northbound, respectively, and encountered 9.0 and 4.0 inches of asphalt overlying 6.0 and 12.0 inches of aggregate base, respectively. Boring B-015-6-13 was performed in the existing access drive to the pump station located within the infield of the I-70 eastbound to SR-315 northbound loop ramp and encountered 2.0 inches of asphalt at the ground surface. The remaining borings were drilled in the grass infield areas between the various roadways and interchange ramps and encountered 4.0 to 8.0 inches of topsoil at the ground surface.

4.2 Subsurface Soils

Beneath the surface materials in borings B-015-1-13, B-015-4-13, B-015-5-13 and B-015-6-13, material identified as existing fill was encountered extending to depths ranging from 15.5 to 37.0 feet below the ground surface. The fill material consisted of dark brown, dark gray, gray, brown and brownish gray gravel, gravel and sand, gravel with sand and silt, gravel with sand, silt and clay, sandy silt, silt and clay and silty clay (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-4a, A-6a, A-6b) and contained brick, concrete or coal fragments and root fibers throughout.

Underlying the surficial materials and existing fill, where encountered, natural soils were encountered consisting of both granular and cohesive material. The granular soils were generally described as brown, gray, brownish gray and dark gray gravel, gravel and sand, gravel with sand and silt, gravel with sand, silt and clay, coarse and fine sand and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-3a, A-4a). The cohesive soils were described as gray, brown, dark gray and dark brown sandy silt, silt, silt and clay, silty clay and clay (ODOT A-4a, A-4b, A-6a, A-6b, A-7-6).

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 ($5 \leq N_{60} \leq 10$ blows per foot [bpf]) to very dense ($N_{60} > 50$ bpf). Overall blow counts recorded from the SPT sampling ranged from 5 bpf to split spoon sampler refusal. Split spoon sampler refusal is defined as exceeding 50 blows from the hammer with less than 6.0 inches of penetration by the split spoon sampler. The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soil encountered ranged from soft ($0.25 < HP \leq 0.5$ tsf) to hard ($HP > 4.0$ tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, ranged from 0.5 to over 4.5 tsf (limit of instrument).

Natural moisture contents of the soil samples tested ranged from 5 to 31 percent. The natural moisture content of the cohesive soil samples tested for plasticity index ranged from 10 percent below to 9 percent above their corresponding plastic limits. In general, the soil exhibited natural moisture contents considered to be significantly below to significantly above optimum moisture levels.

4.3 Bedrock

Bedrock was encountered in the borings as presented in Table 3.

Table 3. Top of Bedrock Elevations

Boring Number	Ground Surface Elevation (feet msl)	Top of Bedrock (Auger Refusal)	
		Depth (feet)	Elevation (feet msl)
B-015-1-13	746.7	N/A	N/A
B-015-2-13	700.4	58.5	641.9
B-015-4-13	734.2	86.7	647.5
B-015-5-13	723.6	66.0	657.6
B-015-6-13	723.0	67.5	655.5
B-015-7-13	721.8	70.5	651.3
B-108-5-13	700.3	54.5	645.8

With the exception of boring B-015-1-13, bedrock was encountered in the remaining borings at depths ranging from 54.5 to 70.5 feet below the ground surface, which corresponds to elevations ranging from 641.9 to 657.6 feet msl. The cored bedrock consisted of limestone in all of the borings where bedrock was encountered, with the exception of boring B-015-7-13, which encountered dolomite. The limestone bedrock was described as gray and brown, slightly weathered to unweathered, moderately strong to very strong and slightly to highly fractured. The dolomite bedrock was described as brown and gray, slightly weathered, strong and moderately fractured to fractured.

The percent recovery, RQD values and unconfined compressive strengths of the bedrock core runs are summarized in Table 4.

Table 4. Rock Core Summary

Boring	Core No.	Elevation (feet msl)	Recovery (%)	RQD (%)	Unconfined Compressive Strength
B-015-2-13	RC-1	641.9 to 640.9	100	54	N/A
	RC-2	640.9 to 635.9	87	63	N/A
	RC-3	635.9 to 631.9	96	78	q_u @ 67.6' = 5,771 psi
B-015-4-13	RC-1	647.5 to 642.5	98	87	q_u @ 87.1' = 7,935 psi
	RC-2	642.5 to 638.5	98	88	q_u @ 35.2' = 8,024 psi
B-015-5-13	RC-1	657.6 to 652.6	88	63	q_u @ 66.8' = 10,927 psi
	RC-2	652.6 to 647.6	100	88	N/A
B-015-6-13	RC-1	655.5 to 651.5	51	51	q_u @ 68.3' = 9,274 psi
	RC-2	651.5 to 646.5	98	88	N/A
	RC-3	646.5 to 645.5	100	67	q_u @ 66.8' = 12,661 psi
B-015-7-13	RC-1	651.3 to 646.3	97	58	q_u @ 72.1' = 12,300 psi
	RC-2	646.3 to 641.3	95	58	N/A
B-108-5-13	RC-1	645.8 to 640.8	100	79	q_u @ 56.8' = 11,933 psi
	RC-2	640.8 to 637.3	87	79	N/A

It should be noted that bedrock naturally 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 bedrock, according to the RQD value, was fair (50% < RQD ≤ 75%) to excellent (90% < RQD ≤ 100%).

4.4 Groundwater

Groundwater was encountered in the borings as presented in Table 5.

Table 5. Groundwater

Boring Number	Ground Elevation (feet msl)	Initial Groundwater		Upon Completion	
		Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-015-1-13	746.7	68.5	678.2	N/A [1]	-
B-015-2-13	700.4	11.0	689.4	N/A [1]	-
B-015-4-13	734.2	55.0	679.2	N/A [1]	-
B-015-5-13	723.6	40.0	683.6	N/A [1]	-
B-015-6-13	723.0	33.5	689.5	N/A [1]	-
B-015-7-13	721.8	30.0	691.8	N/A [1]	-
B-108-5-13	700.3	11.5	688.8	N/A [1]	-

1. *The groundwater level at completion could not be obtained due to the addition of mud or water as a drilling fluid.*

Groundwater was encountered initially during drilling in all seven borings performed for the current exploration at depths ranging from 11.0 to 68.5 feet below the existing ground surface, corresponding to elevations ranging from 678.2 to 691.8 feet msl. The groundwater level at the completion of drilling could not be measured due to the addition of mud in boring B-015-1-13 to counteract heaving sands or water as a circulating fluid during the rock coring process in the remaining borings.

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 III.

4.5 Historic Borings

In general, the historic borings encountered cohesive and granular soils overlying limestone bedrock. The cohesive soils were generally described as gray and brown sandy silt and clay (ODOT A-4a, A-7-6), and the granular soils were generally described as brown and gray gravel, gravel and sand, gravel with sand and silt, coarse and fine sand and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-3a, A-4a). Limestone bedrock was encountered in borings B-001-B-68, B-003-E-68 and B-012-E-68 at an elevation of 641.9, 648.4 and 646.4 feet msl, respectively. 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 proposed structure were provided by Burgess and Niple. Based on the information provided, it is understood that the proposed structure will consist of an eight-span prestressed concrete I-beam with composite reinforced concrete deck structure with reinforced concrete substructures supported on deep foundations consisting of driven piles or drilled shafts. This structure will be connected to the proposed FRA-70-1321A bridge structure at the east end of the alignment. Foundation recommendations for the combined Pier A (Pier 8) are provided in the FRA-70-1321A Structure Foundation Exploration report. Therefore, recommendations for this substructure unit are not provided in this report.

Proposed structural data was obtained from design details provided by Burgess and Niple and are included in Table 6.

Table 6. Structure and Bridge Design Elevations

Substructure Reference	Structure Component	Elevation [1] (feet msl)	Design Maximum Factored Load
Rear Abutment (B-015-1-13 / B-003-E-68)	Bottom of Footing	730.5	215 kips/pile
Pier 1 (B-015-2-13)	Bottom of Footing	694.5	490 kips/pile
Pier 2 (B-001-B-68)	Bottom of Footing	697.1	515 kips/pile
Pier 3 (B-108-5-13)	Bottom of Footing	693.9	515 kips/pile
Pier 4 (B-108-5-13 / B-015-4-13)	Bottom of Footing	704.1	440 kips/pile
Pier 5 (B-015-4-13)	Bottom of Footing	730.9	490 kips/pile
Pier 6 (B-015-5-13)	Top of Shaft	722.1	2,030 kips/shaft
Pier 7 (B-015-6-13)	Top of Shaft	723.6	2,280 kips/shaft

1. *Proposed bottom of footing elevations and structural loading based on structure information provided by Burgess and Niple and GPD Group.*

5.1 Driven Pile Recommendations

It is understood that driven piles will be utilized at the rear abutment and Pier 1 through Pier 5 substructure units. Given the depth of bedrock encountered and the anticipated loading at the abutments, it is recommended that steel H-piles (ODOT Item 507.06) driven to refusal on bedrock be employed for foundation support. Friction bearing piles will not be a feasible foundation option as the maximum factored load per pile exceeds the maximum factored resistance allowed per Section 202.2.3.2.b of the 2007 ODOT BDM for all pile types and sizes. Per Section 202.2.3.2a of the 2007 ODOT Bridge Design Manual, refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. Table 7 shows the recommended pile lengths and the corresponding factored structural axial resistance ($R_{R\,max}$) of steel H-piles. For H-piles driven to refusal on bedrock, no geotechnical resistance factor should be applied to the factored structural axial resistance values presented, as the values presented account for the structural resistance factor, φ_c = 0.50, for H-piles subject to damage due to severe driving conditions.

Table 7. H-Pile Recommendations

Substructure Reference	Ground Elevation [1]	Pile Size [2]	Pile Elevation		Pile Length [4] (feet)	$R_{R\,max}$ [5] (kips/pile)	φ [6]
			Top [3]	Tip			
Rear Abutment (B-015-1-13 / B-003-E-68)	746.7 / 719.0	HP 10x42	731.5	649.5	85	310	N/A
Pier 1 (B-015-2-13)	700.4	HP 14x73	695.5	641.9	55	530	N/A
Pier 2 (B-001-B-68)	702.0	HP 14x73	698.1	641.9	60	530	N/A
Pier 3 (B-108-5-13)	705.0	HP 14x73	694.9	645.8	50	530	N/A
Pier 4 (B-108-5-13 / B-015-4-13)	734.2	HP 14x73	705.1	646.7	60	530	N/A
Pier 5 (B-015-4-13)	734.2	HP 14x73	731.9	647.5	85	530	N/A

1. *Ground elevation listed is the ground elevation at the respective boring location.*
2. *A steel pile point is recommended to protect the tips of the piles during pile installation.*
3. *The top of pile elevation corresponds to the pile cutoff elevation, which is 1.0-foot above the proposed bottom of footing elevation.*
4. *Per ODOT BDM Section 202.3.2, 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.*
5. *The factored structural axial resistance for H-piles is based on the structural limit state of the steel H-pile section per Section 202.2.3.2.a of the 2007 ODOT BDM.*
6. *For H-piles driven to refusal on bedrock, no geotechnical resistance factor should be applied to the factored structural axial resistance values presented, as the values presented account for the structural resistance factor, φ_c = 0.50, for H-piles subject to damage due to severe driving conditions.*

Based on discussions with Burgess and Niple, it is understood that HP 12x74 piles are being recommended in the Stage 2 design plans for Pier 1 through Pier 5, which have been successfully utilized on other ODOT projects which have been designed by Burgess and Niple. Calculations were performed by Burgess and Niple to determine the maximum factored structural resistance per pile in accordance with Section 202.2.3.2.a of the 2007 ODOT BDM, which was determined to be 545 kips per pile. Therefore, the piles will be an acceptable alternative for the recommended HP 14x73 pile sections for Pier 1 through Pier 5.

Based on the Stage 2 design plans, it is understood that the front two rows of piles will be battered to provide resistance to the anticipated lateral loads. However, given the amount of new fill being placed in this area, which the piles will be driven through, downdrag loading due to settlement of the new embankment may effect the stability of the battered piles. Downdrag movement could result in adverse effects such as, but not limited to, severe bending created in the piles, additional lateral load introduced into the pile cap, undesirable deformation in the pile system, and loss-of-ground below inclined pile elements. Consideration should be given to the use of vertical piles only at the rear abutment. Lateral stability of the pile system should be performed to verify that all serviceability requirements are being satisfied. Lateral design considerations are discussed in Section 5.3, and a boring-by-boring tabulation of lateral design parameters are provided in Appendix VIII.

Per Section 202.2.3.2.a of the 2007 ODOT BDM, the factored resistance of H-piles driven to refusal on bedrock is typically governed by the structural resistance of the pile element. The factored structural axial resistances listed in Table 7 consider an axially loaded pile with negligible moment, no appreciable loss of section due to deterioration throughout the life of the structure, a steel yield strength of 50 ksi, a structural resistance factor for H-piles subject to damage due to severe driving conditions (LRFD 6.5.4.2: $\varphi_c = 0.50$) and a pile fully braced along its length. **The factored structural axial resistance should not be used for piles that are subjected to bending moments or are not supported by soil for their entire length.** Static or dynamic load testing is not required for H-piles driven to refusal on bedrock. It is anticipated that the piles will be able to be driven a short distance into the surficial bedrock before satisfying the driving conditions that meet the refusal criterion. It is estimated that refusal will be met within the upper 6.0 inches of the surficial bedrock. Settlement is estimated to be less than 1.0 inch for H-piles driven to refusal on bedrock.

5.1.1 Driveability

A drivability analysis was performed in accordance with Section 10.7.8 of the 2018 AASHTO LRFD Bridge Design Specifications (BDS) using the GRLWEAP software program, and the results are provided in Appendix VI. In the driveability analysis, a Delmag 19-42 hammer with a rated energy of approximately 43,000 ft-lbs was used in conjunction with H-pile sections. 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 depths provided in Table 7. Care should be taken during pile driving operations when approaching the bedrock elevations noted above, 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 2007 ODOT BDM, steel pile points should be used when the piles are driven to bear on strong bedrock (limestone or dolomite).

It should be noted that a boulder zone was encountered in boring B-001-B-68 at an elevation of approximately 666.0 feet msl and extended to an approximate elevation of 656.0 feet msl. Given the presence of boulders in the area, the pile driving operations should be closely monitored to verify that the piles extend to the limestone bedrock. It is not acceptable to terminate pile driving with the pile tip bearing on a boulder. If an obstruction is present and the pile cannot displace it, then the pile will need to be relocated to miss the obstruction and extended to bear on the limestone bedrock.

5.2 Drilled Shaft Recommendations

Given the proposed loading per shaft at each of the pier locations, friction bearing drilled shafts within the overburden soils are not economically feasible foundation options due to the size and number of shafts that would be required to support the proposed loading. Therefore, it is recommended that the drilled shafts be extended through the surficial soils to bear on or within the underlying limestone bedrock at Pier 6 and Pier 7.

Per Section 10.8.3.5.4c of the 2018 AASHTO LRDF Bridge Design Specifications (BDS), a minimum rock socket length of 1.5 times the diameter of the drilled shaft within the rock socket (1.5B_{RS}) is required to utilize the full end bearing resistance within the bedrock unit that the shafts are end bearing in/on. However, based on discussions with the ODOT Office of Geotechnical Engineering (OGE), a reduced tip resistance can be utilized for shafts not extended to the required minimum socket length of 1.5B_{RS}.

Using equation 10.8.3.5.4c-1 of the AASHTO LRFD BDS, the nominal end bearing resistance for drilled shafts socketed a minimum of 1.5B_{RS} into intact rock is 2.5 times the unconfined compressive strength of the bedrock unit that the shaft tip is bearing on or within. Based on unconfined compression tests performed on limestone rock cores obtained from the borings performed at the subject piers, the unconfined compressive strength ranges from 5,771 to 12,661 psi. Using equation 10.8.3.5.4c-1 and the limiting unconfined compressive strength from the given range for the limestone bedrock, it is recommended that drilled shaft foundations socketed a minimum of 1.5B_{RS} into the bedrock to bear on or within the competent limestone bedrock be proportioned for a nominal end bearing resistance of 2,078 ksf at the strength limit state. A resistance factor of φ_{qp} = 0.5 at the strength limit state should be utilized for design.

Where lateral load demands do not require a rock socket length of $1.5B_{RS}$, the socket length can be reduced or the shaft can bear on the bedrock surface with no rock socket. If the rock socket is reduced to a length less than $1.5B_{RS}$, a reduced nominal end bearing resistance should be utilized based on equations 10.8.3.5.4c-2 and 10.8.3.5.4c-3 of the AASHTO LRFD BDS, which is as follows:

$$q_p = A + q_u\left[m_b\left(\frac{A}{q_u}\right) + s\right]^a$$

In which:

$$A = \sigma'_{vb} + q_u\left[m_b\left(\frac{\sigma'_{vb}}{q_u}\right) + s\right]^a$$

Where:
σ'_{vb} = vertical effective stress at the socket bearing (tip) elevation (ksf)
s, a and m_b = Hoek-Brown strength parameters for fractured rock mass determined from GSI in accordance with Section 10.4.6.4 of the AASHTO LRFD BDS
q_u = unconfined compressive strength of intact rock (ksf)

Based on discussions with ODOT OGE, the condition of the rock mass for the determination of the GSI rating should consider the limestone to have a "closed" joint condition, a "blocky" structure and a "good" joint surface condition. Using this description for the structure and surface conditions of the rock mass, a GSI rating of 70 was determined from Figure 10.4.6.4-1 of the AASHTO LRFD BDS, and the Hoek-Brown strength parameters s, a and m_b were calculated as 0.036, 0.50 and 3.08, respectively. The vertical effective stress was estimated considering 65 feet of soil overburden with a buoyant unit weight of 57.6 pcf. Using the above noted equations and the limiting unconfined compressive strength from the given range for the limestone bedrock, it is recommended that drilled shaft foundations bearing on or within the competent limestone bedrock with a socket length less than $1.5B_{RS}$ into the bedrock be proportioned for a nominal end bearing resistance of 899 ksf at the strength limit state. A resistance factor of $\varphi_{qp} = 0.5$ at the strength limit state should be utilized for design.

Based on the plan information provided by Burgess and Niple, the proposed shaft diameter at Pier 6 and Pier 7 will be 4.5 feet within the overburden soils and 4.0 feet within the bedrock socket. Table 8 lists the estimated elevation of the top of bedrock as well as the proposed rock sock diameter and length from the design plans and, corresponding nominal end bearing resistance to be utilized for the design of the drilled shaft foundations.

Table 8. Drilled Shaft Recommendations

Substructure Unit (Boring)	Top of Bedrock Elevation (feet msl)	Rock Socket Diameter [1] (feet)	Proposed Socket Length [1] (feet)	Nominal End Bearing Resistance [2] (ksf)
Pier 6 (B-015-5-13)	657.6	4.0	4.0	899
Pier 7 (B-015-6-13)	655.5	4.0	4.0	899

1. *Proposed rock socket diameter and length at each substructure unit determined from proposed plan information provided by Burgess and Niple.*
2. *Nominal end bearing resistance provided is the value that should be utilized in the determination of the end bearing resistance per drilled shaft based on the proposed rock socket length and diameter.*

If lateral analysis of the drilled shafts foundations indicates that the rock socket length can be reduced based on the lateral load demands, then the rock socket length may be reduced from those shown in the current design plans. If the rock socket is reduced to a length less than 1.5BRS, then the reduced bearing resistance of 899 ksf should be utilized for design.

Given the factored end bearing resistances noted above for drilled shafts extended to bear on or within the limestone bedrock, it is anticipated that the axial resistance will be governed by structural resistance of the drilled shaft. The factored resistance per shaft provided in the design sheets should be the limiting value between the factored geotechnical resistance and the factored axial compressive resistance of the shaft.

Drilled shafts designed in accordance with the requirements presented above should experience a maximum settlement estimated to be less than 0.5 inches. Group settlement of the shafts, socketed into bedrock, is considered negligible for a minimum spacing of 2.0 shaft diameters center-to-center. Drilled shaft calculations are provided in Appendix VII.

5.3 Lateral Design

If lateral loads or moments are expected to be applied on the foundation elements, they should be analyzed to verify the shaft or 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 VII. 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 (for drilled shafts) 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 VII.

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)

5.4 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
Soft 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
Soft to Stiff Cohesive Soil	115	0	24°	0.37	0.59	3.97
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	28°	0.32	0.53	5.07
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.

5.5 Settlement Considerations

5.5.1 Compressibility Parameters

The compressibility parameters utilized in the settlement analysis of the proposed embankment are provided in Table 13.

Table 12. Compressibility Parameters Utilized in Settlement Analysis

Material Type	γ (pcf)	C_c (1)	C_r (2)	e_o (3)	C_v (4) (ft²/yr)	N_{60}	C' (5)
Item 203 Embankment	120	N/A	N/A	N/A	N/A	N/A	N/A
Medium Dense to Very Dense Gravel and Sand (ODOT A-1-b)	130 to 135	N/A	N/A	N/A	N/A	30 to 49	82 to 161
Stiff to Hard Sandy Silt (ODOT A-4a)	115 to 120	0.099 to 0.144	0.010 to 0.014	0.436 to 0.475	1,000	N/A	N/A
Limestone Bedrock	145	N/A	N/A	N/A	N/A	N/A	N/A

1. *Per Table 6-9, Section 6.14.1 of FHWA GEC 5.*
2. *Estimated at 10% of C_c per Section 8.11 of Holtz and Kovacs (1981).*
3. *Per Table 8-2 of Holtz and Kovacs (1981).*
4. *Per Figure 6-37, Section 6.14.2 of FHWA GEC 5.*
5. *Per Figure 10.6.2.4.2-1 of 2018 AASHTO LRFD BDS.*

At the time of this report, the type of fill material being considered for the earthen embankment is unknown. For the analysis, it is considered that the earthen embankment will consist of cohesive material comprised of sandy silt and silt and clay (ODOT A-4a, A-6a). The compressibility parameters for the natural cohesive soils were determined based on correlations with the liquid limit of cohesive soils. Settlement of granular soils was determined using the Hough method as outlined in Section 10.6.2.4.2 of the 2018 AASHTO LRFD BDS.

5.5.2 Settlement Analysis

A settlement analysis was performed at the rear abutment to predict the long term consolidation settlement that will result after the embankment fill has been placed. Based on soil profile and cross section information provided by Burgess and Niple and GPD GROUP, a fill height of approximately 35 feet is anticipated near the rear abutment of the proposed structure. Results of the settlement analysis indicate that a total settlement of 4.42 inches is anticipated near the rear abutment due to the weight of the new embankment fill. Results of the settlement analysis are provided in Appendix IX. Some settlement of the embankment fill itself will also take place during construction of the embankment. This settlement is unable to be accurately quantified at this time, due to the unknown nature or origin of the fill to be placed. However, provided the embankment fill is placed and compacted in accordance with ODOT Item 203, the settlement of the embankment fill is expected to be minimal.

Due to the presence of thick granular soil layers present elevations ranging from 674.7 to 694.7 feet msl, it is anticipated that a portion of the settlement of the natural soils will occur during construction of the proposed embankment. Long term settlement of the natural cohesive soils and embankment fill following the completion of construction is expected to be on the order of approximately 3.6 inches. Given the anticipated amount of settlement following construction of the embankment, downdrag loads may be induced on the pile elements if installed to the final tip elevation prior to placement of the embankment fill. In order to consolidate the underlying soil to the required settlement, consideration should be given to the placement of a surcharge load in order to preload the site under the full weight of the embankment fill. Therefore, it is recommended that the embankment soil be placed within the footprint of the proposed foundation footing at the rear abutment to the profile grade of the roadway and left in place until 90 percent of consolidation of the subsurface soils has occurred to prevent downdrag loads from developing along the pile elements. Results of the settlement analysis indicate that approximately 90 percent of the primary consolidation of the cohesive layers will be complete within 55 days following the placement of the surcharge load. Therefore, if a 55 day waiting period is specified following completion of construction of the embankment surcharge, downdrag forces along the piles will be eliminated.

Settlement platforms should be installed prior to construction of the embankment and surcharge to monitor the settlement of the embankment over time. A shorter or longer hold period than specified may be required based on the settlement platform readings as directed by the geotechnical engineer. The required hold period may be considered complete when survey monitoring of the settlement platforms indicate that the above noted settlement has occurred for the hold period or until the survey shows less than ⅛-inch of total movement per week over a two week period **following placement of the final lifts of surcharge loading.**

5.6 Slope Stability Considerations

5.6.1 Strength Parameters

The shear strength parameters utilized in the slope stability analysis for the placement of the embankment fill to bring the site to the final grade are provided in Table 13.

Table 13. Shear Strength Parameters Utilized in Slope Stability Analysis

Material Type	γ (pcf)	φ' (1) (°)	c' (2) (psf)	S_u (3) (psf)
Item 203 Embankment	120	30	200	2,000
Medium Dense to Very Dense Gravel and Sand (ODOT A-1-b)	130 to 135	36 to 39	0	N/A
Very Stiff Silt and Clay, Silty Clay (ODOT A-6a, A-6b)	120	28	0	2,375 to 3,125
Stiff to Hard Sandy Silt (ODOT A-4a)	115 to 120	29 to 30	0	1,875 to 2,875
Limestone Bedrock	165	45	5,000	N/A

1. *Per Figure 7-45, Section 7.6.9 of FHWA GEC 5 for cohesive soils and Table 10.4.6.2.4-1 of the 2018 AASHTO LRFS BDS for granular soils.*
2. *Estimated based on overconsolidated nature of soil.*
3. *$S_u = 125(N_{60})$, Terzaghi and Peck (1967).*

Shear strength parameters for new embankment fill were determined using ODOT Geotechnical Bulletin 6 (GB-6) as a guide. The shear strength parameters for the embankment fill listed in Table 13 above are the limiting values based on the assumption that the embankment fill utilized will consist of sandy silt, silt and clay or silty clay (ODOT A-4a, A-6a, A-6b). If granular embankment is utilized, it should be tested to ensure that it has a minimum friction angle of 33 degrees.

The shear strength parameters for the natural soils were assigned using correlations provided in FHWA Geotechnical Engineering Circular (GEC) No. 5 (FHWA-NHI-16-072) Evaluation of Soil and Rock Properties and based on past experience in the vicinity of the site with projects performed in similar subsurface profiles.

5.6.2 Slope Stability Analysis

A slope stability analysis was performed at the proposed rear abutment to evaluate the stability of the embankment slope at the substructure location. The slope geometry was determined using proposed plan and profile information provided by Burgess and Niple and GPD GROUP. Soil parameters utilized in the slope stability analysis are presented in Table 13. Per Section 11.6.2.3 of the 2018 AASHTO LRFD BDS, overall (global) stability embankment slopes that are integrated with or supporting structural foundations or elements is satisfied if the product of the factor of safety from the slope stability output multiplied by the resistance factor φ=0.65 is greater than 1.0. Therefore, global stability is satisfied when a minimum factor of safety of 1.5 is obtained.

The resulting factor of safety under drained (long-term stability) conditions for the proposed embankment slope at the rear abutment is 1.50, and the stability of the slope under undrained (short-term stability) conditions is 1.86. Based on the results of the analyses, the stability of the proposed embankment slopes will be within acceptable limits. Calculations for slope stability of the proposed embankment slope are provided in Appendix X.

5.7 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).

5.7.1 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 14. 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

5.7.2 Groundwater Considerations

Based on the groundwater observations made during drilling, groundwater may be encountered during construction of the drilled shafts. Where 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. In the case of drilled shafts, the utilization of casing will be required below the water table to maintain an open hole and prevent the sidewalls from collapse. In addition, concrete placed below the water table should be placed by tremie method using a rigid tremie pipe. 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.

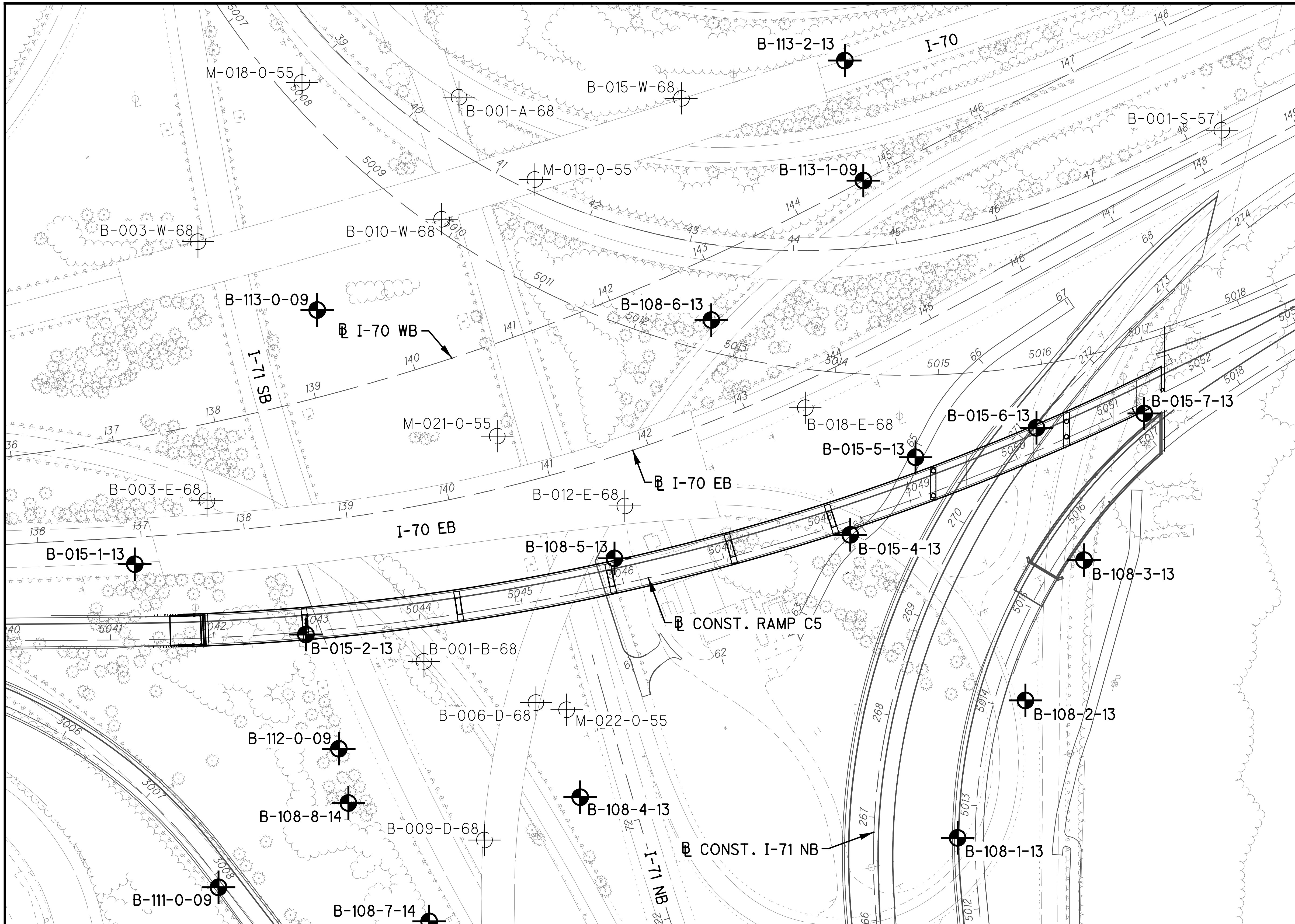
The conclusions and recommendations herein have been based upon the available soil and bedrock information and the design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be 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.

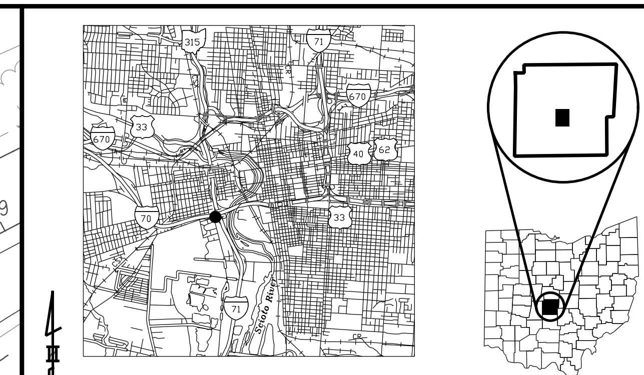
The scope of our services does not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater or surface water within or beyond the site studied. Any statements in this report or on the test boring logs regarding odors, staining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





FRANKLIN COUNTY

VICINITY MAP

BORING PLAN

FRA-70-1301A

FRANKLIN COUNTY, OHIO

RII PROJECT NO.
W-13-045

SCALE: 1"=100'
0 50 100

DRAWN
RRM

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	Classifcation OHIO	$LL_O/LL \times 100$*	% 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	
F S	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
- 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-015-1-13, B-015-2-13, B-015-4-13 through B-015-7-13, and B-108-5-13

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

<u>Classification Test Data</u>

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.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 5041+24.30 / 73.2' LT	EXPLORATION ID B-015-1-13
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT: BL RAMP C5	
PID: 77372 BR ID: FRA-70-1301A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 4/26/13	ELEVATION: 746.7 (MSL) EOB: 95.0 ft.	PAGE 1 OF 4
START: 7/25/13 END: 7/30/13	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.7	LAT / LONG: 39.949844277, -83.017516074	

MATERIAL DESCRIPTION AND NOTES	ELEV. 746.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
0.8' - ASPHALT (9.0")	745.9																	
0.5' - AGGREGATE BASE (6.0")	745.4	1																
FILL: VERY STIFF, GRAYISH BROWN TO GRAY **SILT AND CLAY**, LITTLE TO SOME COARSE TO FINE SAND, TRACE TO LITTLE FINE GRAVEL, DAMP. -STONE FRAGMENTS PRESENT IN SS-1		2 – 3	6 13 19	41	67	SS-1	4.00	-	-	-	-	-	-	-	-	9	A-6a (V)	
		4 – 5	3 6 11	22	67	SS-2	3.50	-	-	-	-	-	-	-	-	13	A-6a (V)	
		6 – 7	3 4 7	14	83	SS-3	4.00	-	-	-	-	-	-	-	-	12	A-6a (V)	
		8 – 10	4 4 4	10	33	SS-4	3.50	13	6	14	41	26	29	16	13	10	A-6a (8)	
		11 – 12	4 4 7	14	67	SS-5	4.00	-	-	-	-	-	-	-	-	14	A-6a (V)	
		13 – 15	2 2 6	10	67	SS-6	4.00	-	-	-	-	-	-	-	-	12	A-6a (V)	
		16 – 17	3 13 13	34	33	SS-7	4.00	-	-	-	-	-	-	-	-	13	A-6a (V)	
		18 – 20	5 7 13	26	61	SS-8	3.25	3	8	16	46	27	27	16	11	10	A-6a (8)	
		21 – 22	3 6 9	19	78	SS-9	3.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
	721.2	23 – 25	6 13 9	28	61	SS-10	4.00	-	-	-	-	-	-	-	-	14	A-6a (V)	
STIFF, GRAY **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP.	718.7	26 – 27	2 6 7	17	78	SS-11	-	23	24	16	25	12	29	19	10	12	A-4a (0)	
VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST.		28 – 29	21 28 25	69	83	SS-12	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5041+24.30 / 73.2 LT	START: 7/25/13	END: 7/30/13	PG 2 OF 4	B-015-1-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 716.7
VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST. *(same as above)*	714.7
VERY STIFF, DARK BROWN **SILTY CLAY**, SOME FINE GRAVEL, LITTLE COARSE TO FINE SAND, DAMP.	709.7
STIFF TO HARD, DARK GRAY TO BROWN **SANDY SILT**, "AND" GRAVEL, TRACE CLAY, DAMP.	694.7
MEDIUM DENSE TO DENSE, BROWNISH GRAY TO GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST. -COBBLES PRESENT @ 52.0'	

W (water level at approx. 58.5)

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
34–35	10 6 9	19	83	SS-13	2.50	30	13	7	28	22	37	18	19	17	A-6b (6)	
39–40	8 11 7	23	33	SS-14	4.50	-	-	-	-	-	-	-	-	12	A-4a (V)	
44–45	7 6 7	17	33	SS-15	4.50	-	-	-	-	-	-	-	-	11	A-4a (V)	
49–50	8 9 13	28	61	SS-16	2.00	44	9	9	29	9	26	20	6	14	A-4a (1)	
54–55	6 16 22	49	78	SS-17	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
59–60	2 20 5	32	50	SS-18	-	-	-	-	-	-	-	-	-	18	A-1-b (V)	

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5041+24.30 / 73.2 LT	START: 7/25/13	END: 7/30/13	PG 3 OF 4	B-015-1-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 684.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM DENSE TO DENSE, BROWNISH GRAY TO GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST. *(same as above)*		63																
-HEAVING SANDS ENCOUNTERED @ 63.5'		64–65	1 1 26	35	33	SS-19	-	47	29	10	11	3	22	19	3	13	A-1-b (0)	
		66																
		67																
		68 W																
		69–70	5 10 8	23	100	SS-20	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
		71																
	674.7	72																
STIFF TO VERY STIFF, GRAY **SANDY SILT**, LITTLE CLAY, LITTLE FINE GRAVEL, DAMP.		73																
		74–75	8 10 8	23	100	SS-21	2.50	-	-	-	-	-	-	-	-	13	A-4a (V)	
		76																
		77																
-SWITCHED TO ROTARY DRILLING TECHNIQUES WITH MUD @ 76.0'		78																
		79–80	9 5 6	14	50	SS-22	2.00	-	-	-	-	-	-	-	-	12	A-4a (V)	
		81																
		82																
		83																
		84–85	WOH 5 9	18	100	SS-23	2.00	17	13	17	35	18	21	15	6	7	A-4a (4)	
		86																
		87																
		88																
		89–90	2 4 4	10	100	SS-24	1.25	-	-	-	-	-	-	-	-	11	A-4a (V)	
		91																
		92																
		93																
		94	2															

MATERIAL DESCRIPTION AND NOTES	ELEV. 652.4	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
	651.7	EOB 95	4 6	13	72	SS-25	1.50	-	-	-	-	-	-	-	-	11	A-4a (V)	

NOTES: SEEPAGE ENCOUNTERED @ 58.5'; GROUNDWATER ENCOUNTERED INITIALLY @ 68.5'.

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

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / S.M.	DRILL RIG: CME-750 (SN 98048)	STATION / OFFSET: 5042+88.86 / 2.6' RT	EXPLORATION ID **B-015-2-13**
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / S.B.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5	
PID: 77372 BR ID: FRA-70-1301A	DRILLING METHOD: 3.75" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 700.4 (MSL) EOB: 68.5 ft.	PAGE 1 OF 3
START: 6/27/13 END: 6/28/13	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 82.6	LAT / LONG: 39.950018890, -83.017141752	

MATERIAL DESCRIPTION AND NOTES	ELEV. 700.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
0.4' - TOPSOIL (4.0")	700.0																	
MEDIUM DENSE TO DENSE, BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP TO MOIST. -TRACE ROOT FIBERS PRESENT IN SS-1		1–2	10 17 17	47	72	SS-1	-	-	-	-	-	-	-	-	-	5	A-2-4 (V)	
-COBBLES PRESENT @ 5.0'	694.9	4–5	6 6 6	17	56	SS-2	-	40	18	12	22	8	25	18	7	11	A-2-4 (0)	
DENSE TO VERY DENSE, GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP.		6–7	6 18 22	55	56	SS-3	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
	689.9	9–10 (W)	18 19 10	40	56	SS-4	-	59	15	7	16	3	18	17	1	6	A-1-b (0)	
LOOSE TO MEDIUM DENSE, GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST TO WET.		(W) 11–12	8 4 6	14	33	SS-5	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	
		14–15	2 3 4	10	33	SS-6	-	-	-	-	-	-	-	-	-	15	A-1-b (V)	
		16–17	3 6 4	14	33	SS-7	-	-	-	-	-	-	-	-	-	14	A-1-b (V)	
-HEAVING SANDS ENCOUNTERED @ 20.0'		19–20	17 12 9	29	33	SS-8	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
-INTRODUCED MUD @ 20.0'	677.4	21–22	16 13 8	29	33	SS-9	-	-	-	-	-	-	-	-	-	24	A-1-b (V)	
MEDIUM DENSE TO VERY DENSE, GRAY **GRAVEL**, SOME FINE TO COARSE SAND, TRACE SILT, TRACE CLAY, MOIST.		24–25	2 7 16	32	33	SS-10	-	-	-	-	-	-	-	-	-	13	A-1-a (V)	
		26–27	11 19 21	55	50	SS-11	-	72	18	4	5	1	NP	NP	NP	10	A-1-a (0)	
		29	6 6 10	22	28	SS-12	-	-	-	-	-	-	-	-	-	12	A-1-a (V)	

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5042+88.86 / 2.6 RT	START: 6/27/13	END: 6/28/13	PG 2 OF 3	B-015-2-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 670.4	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
MEDIUM DENSE TO VERY DENSE, GRAY **GRAVEL**, SOME FINE TO COARSE SAND, TRACE SILT, TRACE CLAY, MOIST. *(same as above)*	668.4	31–32																
VERY STIFF TO HARD, GRAY **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP TO MOIST.		33																
		34–35	3 14 21	48	50	SS-13	4.50	-	-	-	-	-	-	-	-	12	A-4a (V)	
		39–40	11 15 16	43	72	SS-14	4.50	-	-	-	-	-	-	-	-	11	A-4a (V)	
		44–45	8 10 16	36	89	SS-15	4.50	23	13	15	32	17	20	12	8	11	A-4a (3)	
		49–50	4 9 12	29	89	SS-16	4.50	-	-	-	-	-	-	-	-	10	A-4a (V)	
		54–55	4 10 12	30	72	SS-17	4.00	-	-	-	-	-	-	-	-	10	A-4a (V)	
AUGER REFUSAL @ 58.5'	641.9	TR																
LIMESTONE : DARK AND LIGHT GRAY, SLIGHTLY WEATHERED, STRONG, VERY THIN TO THIN BEDDED, CHERTY, DOLOMITIC, FOSSILIFEROUS, STYOLITIC, HIGHLY FRACTURED, OPEN APERTURE, VERY ROUGH; RQD 68%, REC 92%.		59–61	54		100	RC-1											CORE	

MATERIAL DESCRIPTION AND NOTES	ELEV. 638.3	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 : DARK AND LIGHT GRAY, SLIGHTLY WEATHERED, STRONG, VERY THIN TO THIN BEDDED, CHERTY, DOLOMITIC, FOSSILIFEROUS, STYOLITIC, HIGHLY FRACTURED, OPEN APERTURE, VERY ROUGH; RQD 68%, REC 92%. *(same as above)*		63 – 64	63		87	RC-2											CORE	
-RC-3: VUGGY, TRACE PETROLEUM RESIDUE PRESENT -QU @ 67.6' = 5,771 PSI	631.9	65 – 68, EOB	78		96	RC-3											CORE	

NOTES: SEEPAGE ENCOUNTERED @ 10.0'; GROUNDWATER INITIALLY ENCOUNTERED @ 11.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 141 LBS PORTLAND CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER

B-015-2-13 – RC-1, RC-2, and RC-3 – Depth from 58.5 to 68.5 feet

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / J.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 5048+23.41 / 12.5' RT
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / R.B.	HAMMER: AUTOMATIC	ALIGNMENT: BL RAMP C5
PID: 77372 BR ID: FRA-70-1301A	DRILLING METHOD: 4.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 734.2 (MSL) EOB: 95.7 ft.
START: 7/22/13 END: 7/24/13	SAMPLING METHOD: SPT / HQ	ENERGY RATIO (%): 77.7	LAT / LONG: 39.950291772, -83.015266056

EXPLORATION ID **B-015-4-13**

MATERIAL DESCRIPTION AND NOTES	ELEV. 734.2
0.5' - ASPHALT (6.0")	733.7
1.0' - AGGREGATE BASE (12.0")	732.7
FILL: MEDIUM DENSE, DARK BROWNISH GRAY **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, MOIST. -ASPHALT AND CONCRETE FRAGMENTS PRESENT IN SS-1	731.2
FILL: VERY STIFF, DARK BROWN **SILT AND CLAY**, LITTLE TO SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP. -BRICK FRAGMENTS, ROOT AND GRASS FIBERS PRESENT IN SS-2	728.7
FILL: MEDIUM DENSE, DARK BROWNISH GRAY AND BLACK **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, MOIST. -COAL, CINDERS AND STONE FRAGMENTS PRESENT IN SS-3	726.2
FILL: VERY STIFF, GRAY TO DARK BROWNISH GRAY **SILTY CLAY**, SOME FINE TO COARSE SAND, SOME FINE GRAVEL, DAMP. -STONE FRAGMENTS PRESENT IN SS-7	716.2
FILL: VERY DENSE, BROWN **GRAVEL**, SOME FINE TO COARSE SAND, TRACE SILT, TRACE CLAY, DAMP. -COBBLES PRESENT FROM 19.0' TO 22.0'	711.7
FILL: VERY STIFF, BROWN **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP.	708.7
FILL: LOOSE, DARK BROWNISH GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST. -CONCRETE FRAGMENTS PRESENT IN SS-11	706.2
FILL: STIFF, BROWN **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -CLAY TILE AND BRICK FRAGMENTS PRESENT IN SS-12	

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
3 10 10	26	78	SS-1	-	-	-	-	-	-	-	-	-	13	A-2-4 (V)
4 6 7	17	67	SS-2	2.50	-	-	-	-	-	-	-	-	17	A-6a (V)
13 9 13	28	67	SS-3	-	-	-	-	-	-	-	-	-	13	A-2-4 (V)
7 7 6	17	56	SS-4	2.50	-	-	-	-	-	-	-	-	16	A-6b (V)
6 5 7	16	67	SS-5	2.50	27	15	8	28	22	37	21	16	15	A-6b (5)
5 7 7	18	61	SS-6	2.75	-	-	-	-	-	-	-	-	18	A-6b (V)
6 7 8	19	50	SS-7	3.00	-	-	-	-	-	-	-	-	17	A-6b (V)
27 25 20	58	67	SS-8	-	64	18	6	10	2	25	23	2	7	A-1-a (0)
50/4"	-	50	SS-9	-	-	-	-	-	-	-	-	-	5	A-1-a (V)
13 8 5	17	67	SS-10	-	26	18	16	26	14	30	20	10	13	A-4a (1)
6 3 3	8	67	SS-11	-	-	-	-	-	-	-	-	-	10	A-1-b (V)
2 3 5	10	50	SS-12	1.25	-	-	-	-	-	-	-	-	16	A-6a (V)

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5048+23.41 / 12.5 RT	START: 7/22/13	END: 7/24/13	PG 2 OF 4	B-015-4-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 704.2	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
FILL: STIFF, BROWN **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. *(same as above)*	702.2	31–32																
MEDIUM DENSE, BROWN **GRAVEL AND SAND**, TRACE SILT, MOIST.		34–35	10 6 5	14	56	SS-13	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
	697.2																	
STIFF TO VERY STIFF, DARK BROWN **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, MOIST.		39–40 (W)	12 12 12	31	33	SS-14	3.00	-	-	-	-	-	-	-	-	12	A-4a (V)	
		44–45	3 4 4	10	61	SS-15	-	29	20	14	23	14	25	18	7	15	A-4a (0)	
	687.2																	
SOFT TO MEDIUM STIFF, GRAY **CLAY**, "AND" SILT, MOIST.		49–50	1 2 2	5	61	SS-16	0.50	-	-	-	-	-	-	-	-	28	A-7-6 (V)	
-QU @ 54.8' = 2,207 PSF		54–55 (W)			88	ST-17	1.00	0	0	0	61	39	46	24	22	31	A-7-6 (14)	
	677.2																	
MEDIUM DENSE, BROWNISH GRAY **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, WET.		59–60	1 5 6	14	33	SS-18	-	-	-	-	-	-	-	-	-	29	A-4a (V)	
		61																

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5048+23.41 / 12.5 RT	START: 7/22/13	END: 7/24/13	PG 3 OF 4	B-015-4-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 672.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM DENSE, BROWNISH GRAY **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, WET. *(same as above)*		63 – 65	3 4 5	12	33	SS-19	-	-	-	-	-	-	-	-	-	24	A-4a (V)	
	667.2	67																
HARD, DARK GRAYISH BROWN **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, MOIST.		68 – 70	14 22 8	39	67	SS-20	-	31	12	9	30	18	28	19	9	21	A-4a (3)	
	662.2	72																
LOOSE, DARK GRAY **GRAVEL AND SAND**, TRACE SILT, MOIST. -COBBLES PRESENT @ 72.0'		73 – 75	7 4 4	10	44	SS-21	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
	657.2	77																
MEDIUM STIFF TO STIFF, DARK GRAY **SANDY SILT**, LITTLE CLAY, TRACE FINE GRAVEL, DAMP.		78 – 80	3 3 6	12	61	SS-22	1.00	-	-	-	-	-	-	-	-	11	A-4a (V)	
		83 – 85	2 4 6	13	67	SS-23	1.50	10	13	18	39	20	20	14	6	11	A-4a (5)	
AUGER REFUSAL @ 86.7'	647.5	TR																
LIMESTONE : GRAY, UNWEATHERED, MODERATELY STRONG TO STRONG, THIN BEDDED TO LAMINATED, CALCAREOUS, FOSSILIFEROUS, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH; RQD 87%, REC 98%. -QU @ 87.1' = 7,935 PSI		87 – 92	87		98	RC-1											CORE	
-QU @ 92.4' = 8,024 PSI -CHERT NODULES PRESENT IN RC-2		92 – 94	88		98	RC-2											CORE	

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5048+23.41 / 12.5 RT	START: 7/22/13	END: 7/24/13	PG 4 OF 4	B-015-4-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 639.9	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
	638.5	95 EOB																

NOTES: SEEPAGE ENCOUNTERED @ 39.5'; GROUNDWATER ENCOUNTERED INITIALLY @ 55.0'

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

B-015-4-13 – RC-1 and RC-2 – Depth from 86.7 to 95.7 feet

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / S.M.	DRILL RIG: CME-750 (SN 98048)	STATION / OFFSET: 5049+08.12 / 37.6' RT
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / K.S.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5
PID: 77372 BR ID: FRA-70-1301A	DRILLING METHOD: 3.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 723.6 (MSL) EOB: 76.0 ft.
START: 6/25/13 END: 6/26/13	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 82.6	LAT / LONG: 39.950498754, -83.015042527

EXPLORATION ID **B-015-5-13**

MATERIAL DESCRIPTION AND NOTES	ELEV. 723.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
0.7' - TOPSOIL (8.0")	722.9																	
FILL: VERY STIFF, BROWN **SILTY CLAY**, SOME FINE TO COARSE SAND, SOME FINE GRAVEL, DAMP TO MOIST.		1–2	5 9 9	25	44	SS-1	3.50	30	13	12	29	16	35	15	20	10	A-6b (5)	
-ROOT FIBERS PRESENT IN SS-1 AND SS-2		4–5	3 4 3	10	33	SS-2	3.50	-	-	-	-	-	-	-	-	19	A-6b (V)	
-COBBLES PRESENT THROUGHOUT	715.6	6–7	9 9 16	34	39	SS-3	2.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
FILL: VERY STIFF, DARK GRAY **SILT AND CLAY**, SOME FINE TO COARSE SAND, SOME FINE GRAVEL, DAMP. -CLAY TILE AND BRICK FRAGMENTS PRESENT IN SS-4		9–10	9 13 14	37	78	SS-4	4.00	26	16	14	30	14	30	16	14	11	A-6a (3)	
	710.6	11–12	7 9 8	23	56	SS-5	4.00	-	-	-	-	-	-	-	-	13	A-6a (V)	
FILL: MEDIUM DENSE, BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, MOIST.	708.1	14–15	7 6 4	14	44	SS-6	-	-	-	-	-	-	-	-	-	16	A-2-4 (V)	
FILL: MEDIUM STIFF TO VERY STIFF, BROWNISH GRAY TO DARK GRAY **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE TO LITTLE FINE GRAVEL, MOIST.		16–17	WOH 13 8	29	50	SS-7	3.50	-	-	-	-	-	-	-	-	18	A-6b (V)	
-WOOD FRAGMENTS PRESENT IN SS-8		19–20	3 3 4	10	61	SS-8	1.50	14	8	13	38	27	37	16	21	22	A-6b (10)	
-COBBLES PRESENT @ 22.0'		21–23			58	ST-9	2.75	-	-	-	-	-	-	-	-	21	A-6b (V)	
		24–25	2 4 4	11	72	SS-10	2.00	-	-	-	-	-	-	-	-	22	A-6b (V)	
		26–27	6 5 6	15	89	SS-11	1.75	-	-	-	-	-	-	-	-	20	A-6b (V)	
-WOOD FRAGMENTS PRESENT IN SS-12		29	WOH 3 3	8	67	SS-12	0.50	7	8	13	40	32	38	16	22	25	A-6b (12)	

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5049+08.12 / 37.6 RT	START: 6/25/13	END: 6/26/13	PG 2 OF 3	B-015-5-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 693.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
FILL: MEDIUM STIFF TO VERY STIFF, BROWNISH GRAY TO DARK GRAY **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE TO LITTLE FINE GRAVEL, MOIST. *(same as above)*		31–33																
		34	1 2 3	7	78	SS-13	0.50	-	-	-	-	-	-	-	-	28	A-6b (V)	
-COBBLES PRESENT @ 35.0'	686.6	35–37																
LOOSE, DARK GRAY **GRAVEL WITH SAND, SILT, AND CLAY**, WET.		38																
		39	1 1 3	6	33	SS-14	-	-	-	-	-	-	-	-	-	19	A-2-6 (V)	
	681.6	W 40–42																
HARD, DARK GRAY **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP TO MOIST.		43																
		44	5 15 38	73	67	SS-15	4.5+	26	12	15	30	17	21	11	10	9	A-4a (2)	
		45–48																
		49	3 6 11	23	67	SS-16	4.50	-	-	-	-	-	-	-	-	12	A-4a (V)	
	671.6	50–52																
MEDIUM DENSE, DARK GRAY **GRAVEL WITH SAND, SILT, AND CLAY**, WET. -COBBLES PRESENT @ 53.0'		53																
		54	7 10 10	28	33	SS-17	-	-	-	-	-	-	-	-	-	28	A-2-6 (V)	
	666.6	55–57																
STIFF TO VERY STIFF, DARK GRAY **SANDY SILT**, LITTLE CLAY, LITTLE FINE GRAVEL, DAMP TO MOIST.		58																
		59	2 6 8	19	61	SS-18	2.00	15	14	17	38	16	20	13	7	12	A-4a (4)	
		60–61																

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5049+08.12 / 37.6 RT	START: 6/25/13	END: 6/26/13	PG 3 OF 3	B-015-5-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 661.5	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
STIFF TO VERY STIFF, DARK GRAY **SANDY SILT**, LITTLE CLAY, LITTLE FINE GRAVEL, DAMP TO MOIST. *(same as above)*		63 – 65	WOH 7 16	32	44	SS-19	2.75	-	-	-	-	-	-	-	-	13	A-4a (V)	
AUGER REFUSAL @ 66.0'	657.6	TR 66																
LIMESTONE : VARIGATED GRAY AND BROWN, UNWEATHERED, STRONG TO VERY STRONG, VERY THIN TO THIN BEDDED, CHERTY, DOLOMITIC, FOSSILIFEROUS, PYRITIC, FRACTURED TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY TO VERY ROUGH; RQD 75%, REC 94%. -QU @ 66.8' = 10,927 PSI		66 – 71	63		88	RC-1											CORE	
		71 – 76	88		100	RC-2											CORE	
	647.6	EOB 76																

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 40.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 141 LBS PORTLAND CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER

B-015-5-13 – RC-1 and RC-2 – Depth from 66.0 to 76.0 feet

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / S.M.	DRILL RIG: CME-750 (SN 98048)	STATION / OFFSET: 5050+28.85 / 20.8' LT	EXPLORATION ID B-015-6-13
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5	
PID: 77372 BR ID: FRA-70-1301A	DRILLING METHOD: 3.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 723.0 (MSL) EOB: 77.5 ft.	PAGE
START: 6/13/13 END: 6/24/13	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 82.6	LAT / LONG: 39.950578918, -83.014626080	1 OF 3

MATERIAL DESCRIPTION AND NOTES	ELEV. 723.0
0.2' - ASPHALT (2.0")	722.8
FILL: MEDIUM DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP.	720.0
FILL: MEDIUM DENSE TO DENSE, DARK BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST. -PETROLEUM ODOR PRESENT IN SS-3	715.0
FILL: STIFF, BROWN **SILT AND CLAY**, "AND" COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	712.5
FILL: MEDIUM DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST.	710.0
FILL: MEDIUM DENSE, BLACK **SANDY SILT**, SOME FINE GRAVEL, TRACE CLAY, WET. -COBBLES PRESENT @ 13.0'	707.5
MEDIUM DENSE, BROWN **SANDY SILT**, SOME FINE GRAVEL, TRACE CLAY, WET.	705.0
VERY DENSE, BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, MOIST.	702.5
VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP. -INTRODUCED WATER @ 22.5'	

DEPTHS	SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1–2	6 8 6	19	78	SS-1	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
3.5–5	3 5 9	19	39	SS-2	-	57	9	8	7	19	33	17	16	16	A-2-6 (1)	
6–7.5	6 11 13	33	22	SS-3	-	-	-	-	-	-	-	-	-	15	A-2-6 (V)	
8.5–10	2 2 2	6	33	SS-4	1.50	4	17	36	16	27	29	16	13	17	A-6a (2)	
11–12.5	3 5 5	14	28	SS-5	-	-	-	-	-	-	-	-	-	15	A-2-6 (V)	
13.5–15	9 6 5	15	56	SS-6	-	26	17	18	36	3	NP	NP	NP	26	A-4a (1)	
16–17.5	5 6 12	25	39	SS-7	-	-	-	-	-	-	-	-	-	23	A-4a (V)	
18.5–20	13 25 22	65	17	SS-8	-	-	-	-	-	-	-	-	-	12	A-2-4 (V)	
21–22.5	14 21 22	59	67	SS-9	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
23.5–25	8 18 21	54	72	SS-10	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	
26–27.5	16 19 24	59	78	SS-11	-	51	15	17	15	2	NP	NP	NP	9	A-1-b (0)	
28.5–30	8 30 19	67	67	SS-12	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	

MATERIAL DESCRIPTION AND NOTES	ELEV. 693.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP. *(same as above)*		W (33.5)																
		34	15 50/5"	-	73	SS-13	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	
	686.0	37																
HARD, BROWNISH GRAY TO GRAY **SILT**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DRY TO MOIST.		39	21 22 26	66	67	SS-14	4.50	-	-	-	-	-	-	-	-	9	A-4b (V)	
		44	16 29 30	81	72	SS-15	4.50	12	9	14	53	12	20	14	6	12	A-4b (6)	
		49	16 22 26	66	72	SS-16	4.50	-	-	-	-	-	-	-	-	15	A-4b (V)	
		54	17 24 28	72	78	SS-17	4.50	-	-	-	-	-	-	-	-	16	A-4b (V)	
	666.0	57																
VERY DENSE, GRAY **GRAVEL WITH SAND AND SILT**, TRACE CLAY, MOIST TO WET.		59	27 35 50	117	83	SS-18	-	-	-	-	-	-	-	-	-	18	A-2-4 (V)	

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5050+28.85 / 20.8 LT	START: 6/13/13	END: 6/24/13	PG 3 OF 3	B-015-6-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 660.9	DEPTHS	SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
VERY DENSE, GRAY **GRAVEL WITH SAND AND SILT**, TRACE CLAY, MOIST TO WET. *(same as above)*		63																
		64	25 47 50/1"	-	100	SS-19	-	33	21	15	23	8	NP	NP	NP	21	A-2-4 (0)	
		65–66																
AUGER REFUSAL @ 67.5'	655.5	67 TR	50/5"	-	10	SS-20	-	-	-	-	-	-	-	-	-	15	A-2-4 (V)	
LIMESTONE : VARIGATED GRAY AND BROWN, SLIGHTLY WEATHERED TO UNWEATHERED, STRONG TO VERY STRONG, VERY THIN TO THIN BEDDED, CHERTY, DOLOMITIC, PYRITIC, HIGHLY TO MODERATELY FRACTURED, OPEN TO NARROW APERTURE, VERY ROUGH TO SLIGHTLY ROUGH; RQD 71%, REC 87%. -QU @ 68.3' = 9,274 PSI		68–71	51		51	RC-1											CORE	
-QU @ 76.9' = 12,661 PSI		72–76	88		98	RC-2											CORE	
	645.5	77 EOB	67		100	RC-3											CORE	

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 33.5'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 141 LBS PORTLAND CEMENT / 25 LBS BENTONITE POWDER / 40 GAL WATER

B-015-6-13 – RC-1, RC-2, and RC-3 – Depth from 67.3 to 77.5 feet

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / S.M.	DRILL RIG: CME-750 (SN 98048)	STATION / OFFSET: 5051+29.66 / 9.8' RT	EXPLORATION ID **B-015-7-13**
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5	PAGE
PID: 77372 BR ID: FRA-70-1301A	DRILLING METHOD: 3.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 721.8 (MSL) EOB: 80.5 ft.	1 OF 3
START: 6/10/13 END: 6/13/13	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 82.6	LAT / LONG: 39.950618516, -83.014254653	

MATERIAL DESCRIPTION AND NOTES	ELEV. 721.8
0.4' - TOPSOIL (5.0")	721.4
HARD, BROWN **CLAY**, SOME FINE GRAVEL, SOME FINE TO COARSE SAND, LITTLE SILT, DRY.	718.8
DENSE, GRAY **GRAVEL**, LITTLE FINE TO COARSE SAND, TRACE SILT, TRACE CLAY, DAMP.	716.3
STIFF TO VERY STIFF, DARK BROWN TO BROWNISH GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, SOME FINE GRAVEL, DAMP TO MOIST.	708.8
LOOSE TO DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, DAMP.	703.8
DENSE TO VERY DENSE, GRAY **GRAVEL AND SAND**, LITTLE TO SOME SILT, TRACE CLAY, DAMP TO MOIST.	

DEPTHS: 1 – 29 (W)

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
4 15 12	37	50	SS-1	4.5+	24	14	13	15	34	43	19	24	9	A-7-6 (8)
9 11 12	32	17	SS-2	-	-	-	-	-	-	-	-	-	6	A-1-a (V)
3 4 2	8	61	SS-3	2.00	-	-	-	-	-	-	-	-	15	A-6a (V)
2 4 4	11	67	SS-4	2.50	26	15	15	16	28	32	17	15	13	A-6a (3)
3 6 5	15	56	SS-5	2.00	-	-	-	-	-	-	-	-	20	A-6a (V)
2 3 3	8	72	SS-6	-	-	-	-	-	-	-	-	-	17	A-2-6 (V)
3 9 5	19	44	SS-7	-	30	20	15	11	24	30	18	12	17	A-2-6 (0)
		0	ST-8	-	-	-	-	-	-	-	-	-	-	
5 18 18	50	72	SS-9	-	-	-	-	-	-	-	-	-	7	A-1-b (V)
11 21 19	55	67	SS-10	-	49	18	9	23	1	NP	NP	NP	7	A-1-b (0)
12 27 22	67	83	SS-11	-	-	-	-	-	-	-	-	-	8	A-1-b (V)
8 13 17	41	11	SS-12	-	-	-	-	-	-	-	-	-	10	A-1-b (V)

PID: 77372 | BR ID: FRA-70-1301A | PROJECT: FRA-70-12.68 - PHASE 4A | STATION / OFFSET: 5051+29.66 / 9.8 RT | START: 6/10/13 | END: 6/13/13 | | B-015-7-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 691.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
DENSE TO VERY DENSE, GRAY **GRAVEL AND SAND**, LITTLE TO SOME SILT, TRACE CLAY, DAMP TO MOIST. *(same as above)*		31 – 33																
-HEAVING SANDS ENCOUNTERED @ 33.5'		34	21 50/1"	-	100	SS-13	-	34	30	16	19	1	NP	NP	NP	15	A-1-b (0)	
-INTRODUCED MUD @ 33.5'		35 – 38																
		39	20 36 38	102	56	SS-14	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
		40 – 43																
		44	13 14 24	52	72	SS-15	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
	674.8	45 – 47																
HARD, GRAY **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.		48																
		49	16 19 25	61	83	SS-16	4.50	7	7	15	46	25	30	14	16	19	A-6b (10)	
	669.8	50 – 52																
VERY DENSE, GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST TO WET.		53																
		54	20 50/1"	-	171	SS-17	-	-	-	-	-	-	-	-	-	17	A-1-b (V)	
		55 – 58																
		59	30 50/1"	-	100	SS-18	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	
		60 – 61																

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

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5051+29.66 / 9.8 RT	START: 6/10/13	END: 6/13/13	PG 3 OF 3	B-015-7-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 659.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
VERY DENSE, GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST TO WET. *(same as above)*		63																
		64	42 50/4"	-	100	SS-19	-	54	17	10	16	3	22	17	5	10	A-1-b (0)	
		65 – 68																
		69	50/5"	-	20	SS-20	-	-	-	-	-	-	-	-	-	24	A-1-b (V)	
	651.3	70 TR																
DOLOMITE : BROWN AND GRAY, SLIGHTLY WEATHERED, STRONG, VERY THIN TO MEDIUM BEDDED, CHERTY, CRYSTALLINE,, SILICEOUS, CALCITE/PYRITE DEPOSITS, CHERT NODULES AND LENSES, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURE, SLIGHTLY ROUGH TO ROUGH; RQD 58%, REC 96%. -CHERT NODULE @ 71.1' -QU @ 72.1' = 12,300 PSI		71 – 75	58		97	RC-1											CORE	
		76 – 80	58		95	RC-2											CORE	
	641.3	EOB																

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 30.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BNTONITE POWDER / 50 GAL WATER

B-015-7-13 – RC-1 – Depth from 70.5 to 75.5 feet

B-015-7-13 – RC-2 – Depth from 75.5 to 80.5 feet

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-13.10 - PHASE 6A	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 239+69.30 / 18.7' RT	EXPLORATION ID **B-108-5-13**
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / S.B.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL I-71 SB	
PID: 89464 BR ID: FRA-71-1503L	DRILLING METHOD: 4.25" HSA / HQ	CALIBRATION DATE: 4/26/13	ELEVATION: 700.3 (MSL) EOB: 63.0 ft.	PAGE 1 OF 3
START: 6/30/14 END: 7/1/14	SAMPLING METHOD: SPT / RC	ENERGY RATIO (%): 86.8	LAT / LONG: 39.950225756, -83.016078985	

MATERIAL DESCRIPTION AND NOTES	ELEV. 700.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
0.5' - TOPSOIL (6.0")	699.8																	
MEDIUM DENSE, BROWN AND GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP.	697.3		3 5 12	25	33	SS-1	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	
STIFF, DARK BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST. -ROCK FRAGMENTS AND ORGANICS PRESENT IN SS-2	694.8		6 4 4	12	33	SS-2	2.00	20	16	15	30	19	30	17	13	18	A-6a (4)	
MEDIUM DENSE, BROWN TO DARK BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST. -COBBLES PRESENT THROUGHOUT -ROCK FRAGMENTS PRESENT IN 3S-4A	689.8		2 5 6	16	0	SS-3	-	-	-	-	-	-	-	-	-	-		
			5	-	100	3S-3A	-	-	-	-	-	-	-	-	-	13	A-2-6 (V)	
			3 5 9	20	0	SS-4	-	-	-	-	-	-	-	-	-	-		
			9	-	100	3S-4A	-	43	17	10	17	13	30	18	12	15	A-2-6 (0)	
MEDIUM DENSE TO DENSE, BROWN **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST. -COBBLES PRESENT THROUGHOUT	682.3	W	8 7 7	20	39	SS-5	-	-	-	-	-	-	-	-	-	6	A-1-a (V)	
			20 20 8	41	33	SS-6	-	-	-	-	-	-	-	-	-	12	A-1-a (V)	
			11 9 10	27	100	SS-7	-	67	17	7	6	3	NP	NP	NP	13	A-1-a (0)	
MEDIUM DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, WET. -ROCK FRAGMENTS PRESENT IN SS-9	677.3		3 5 6	16	100	SS-8	-	3	61	20	11	5	NP	NP	NP	24	A-1-b (0)	
			3 6 9	22	78	SS-9	-	-	-	-	-	-	-	-	-	23	A-1-b (V)	
DENSE TO VERY DENSE, GRAY TO BROWN **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, DAMP TO MOIST. -COBBLES PRESENT THROUGHOUT			9 12 13	36	67	SS-10	-	-	-	-	-	-	-	-	-	6	A-1-a (V)	
			11 14 15	42	89	SS-11	-	67	15	7	8	3	17	14	3	10	A-1-a (0)	
			50/3"	-	100	SS-12	-	-	-	-	-	-	-	-	-	11	A-1-a (V)	

PID: 89464	BR ID: FRA-71-1503L	PROJECT: FRA-70-13.10 - PHASE 6A	STATION / OFFSET: 239+69.30 / 18.7 RT	START: 6/30/14	END: 7/1/14	PG 2 OF 3	B-108-5-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 670.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DENSE TO VERY DENSE, GRAY TO BROWN **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, DAMP TO MOIST. *(same as above)*	668.3	31																
DENSE, BROWN AND BLACK **GRAVEL AND SAND**, TRACE SILT, TRACE CLAY, MOIST.		32–33																
-ROCK FRAGMENTS PRESENT IN SS-13		34–35	7 10 13	33	61	SS-13	-	43	43	8	4	2	NP	NP	NP	12	A-1-b (0)	
	663.3	36–37																
VERY STIFF TO HARD, GRAY **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP.		38																
		39–40	19 9 12	30	67	SS-14	4.00	-	-	-	-	-	-	-	-	11	A-4a (V)	
		41–43																
		44–45	11 9 12	30	83	SS-15	4.50	-	-	-	-	-	-	-	-	10	A-4a (V)	
		46–48																
		49–50	8 9 10	27	67	SS-16	4.00	21	12	16	32	19	20	12	8	11	A-4a (3)	
		51–53																
-ROCK FRAGMENTS PRESENT IN SS-17 AUGER REFUSAL @ 54.5 FEET	645.8	54 TR	22 50/5"	-	100	SS-17	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)	
LIMESTONE : BLUISH GRAY TO LIGHT BROWN AND GRAY, UNWEATHERED, VERY STRONG, VERY THICK BEDDED, CALCAREOUS, SILICEOUS, FOSSILIFEROUS, VUGGY, SLIGHTLY FRACTURED TO FRACTURED, TIGHT TO OPEN APERTURES, SLIGHTLY TO VERY ROUGH; RQD 79%, REC 95%. -QU @ 56.8' = 11,933 PSI		55–59	79		100	RC-1											CORE	
-DOLOMITIC AND SLIGHTLY TO HIGHLY FRACTURED FROM 59.5' TO 63.0'		60–61	79		87	RC-2											CORE	

PID: 89464	BR ID: FRA-71-1503L	PROJECT: FRA-70-13.10 - PHASE 6A	STATION / OFFSET: 239+69.30 / 18.7 RT	START: 6/30/14	END: 7/1/14	PG 3 OF 3	B-108-5-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 638.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
	637.3	EOB 63																

NOTES: GROUNDWATER ENCOUNTERED INITIALLY @ 11.5'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER

2014 ODOT BORING LOG-RII NE BRIDGE ID - OH DOT.GDT - 4/21/15 08:37 - U:\GI8\PROJECTS\2013\W-13-072.GPJ

B-108-5-13 – RC-1 and RC-2 – Depth from 54.5 to 63.0 feet

APPENDIX IV

HISTORIC BORING LOGS:

B-001-B-68, B-003-E-68 and B-012-E-68

B-001-B-68

LOG OF BORING

Date Started 7-23-68
Date Completed 7-25-68
Boring No B-1

Sampler Type SS Dia 1 3/8"
Casing Length 40' Dia 3 1/2"
Station & Offset 58+39, 06' Lt. (Rear Abutment)

Water Elev ______
Surface Elev 701.0'

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.
701.0	0														
	2														
	4														
696.0	6	5/5			Brown Gravelly Sandy Silt	1	16	26	18	15	25	27	9	24	A-4a
693.5	8	4/12			Brown Silty Sandy Gravel and Boulders	2	35	15	15	19	16	NP	NP	12	A-2-4
691.0	10	30/34			Brown Silty Sandy Gravel	3	48	20	11	10	11	NP	NP	9	A-1-b
	12														
	14														
686.0	16	6/10			Brown Silty Gravelly Sand	4	27	29	13	15	16	NP	NP	11	A-3a
	18														
681.0	20	16/22			Brownish-Gray Silty Sandy Gravel	5	44	13	14	17	12	NP	NP	7	A-2-4
	22														
	24														
676.0	26	12/18			Gray Silty Sand	6	6	52	27	-15	-	NP	NP	18	A-1-b
	28														
671.0	30	8/10			Brownish-Gray Clayey Silt	7	0	2	7	39	52	27	9	28	A-4a
	32														
	34														
666.0	36				No Sample Recovered - Boulders (Driller's Des.)		V	I		S	U		A	L	
	38														
661.0	40				No Sample Recovered - Boulders(Driller's Des.)		V	I		S	U		A	L	
	42														
	44														
656.0	46	50* (0.6')			Gray Silty Gravelly Sand	10	29	17	15	20	19	14	PL	7	-
	48														
651.0	50	20/29			Gray Sandy Gravelly Silt	11	29	12	13	24	22	20	5	10	A-4a
	52														
	54														
646.0	56	12/14			Gray Sandy Silt	12	7	8	16	40	29	19	5	13	A-4a
642.5	58				TOP OF ROCK										
	60														
	62		4.7	0.3	Limestone, gray, hard, dense, badly broken in part, jointed. Core Loss 6%.										
637.5	64				BOTTOM OF BORING										

*Refusal

B-003-E-68

LOG OF BORING

Date Started 7-15-68
Date Completed 7-17-68
Boring No B-3

Sampler Typ. SS Dia 1 3/8"
Casing Length 55' Dia 3 1/2"
Station & Offset 494+81, 19' Lt. (First Pier)

Wat. Elev ________
Surface Elev 719.0'

Elev.	Depth	Std Pen (N)	Rec ft.	Loss ft.	Description	Sample No	% Agg	% CS	% FS	% Silt	% Clay	L L	P I	W C	SHTL Class.
719.0	0														
	2														
	4														
714.0															
	6	11/14			Brownish-Gray Sandy Gravelly Silt	1	40	9	8	18	25	28	9	22	A-4a
	8														
709.0	10														
		14/16			Brown Gravelly Sand (Wash Sample)	2	37	53	4	- 6	-	NP	NP	22	A-1-b
	12														
	14														
704.0															
	16	10/12			Gray Silt and Clay, Slightly Organic	3	0	5	11	36	48	44	16	22	A-7-6
	18														
699.0	20														
		50* (0.7')			Brown Silty Sandy Gravel	4	66	12	7	-15	-	NP	NP	14	A-1-a
	22														
	24														
694.0															
	26	50*/ (0.4')			Brown Silty Sandy Gravel	5	65	16	7	-12	-	NP	NP	9	A-1-a
	28														
689.0	30														
		50* (0.7')			Gray Gravel	6	90	6	2	- 2	-	NP	NP	29	A-1-a
	32														
	34														
684.0															
	36	9/4			Brown Gravel	7	81	7	4	- 8	-	NP	NP	9	A-1-a
	38														
679.0	40														
		11/17			Brown Silty Sandy Gravel	8	72	9	7	-12	-	NP	NP	4	A-1-a
	42														
	44														
674.0															
	46	27/27			Gray Sandy Gravel	9	72	14	6	- 8	-	NP	NP	10	A-1-a
	48														
669.0	50														
		12/14			Gray Silty Sand	10	12	56	19	-13	-	NP	NP	20	A-1-b
	52														
	54														
664.0															
	56	10/15			Brown Gravelly Sandy Silt	11	24	13	16	24	23	19	6	10	A-4a
	58														
659.0	60														
		15/16			Gray Gravelly Sandy Silt	12	22	16	17	24	21	20	7	10	A-4a
	62														
	64														
654.0															
	66	11/13			Gray Gravelly Sandy Silt	13	16	13	17	23	31	21	9	14	A-4a
	68														
649.0	70														
		50/*			TOP OF ROCK										
	72														
			4.5	0.0	Limestone, light-gray, hard, dense, crystalline, few fossils, few chert seams. No Core Loss.										
	74														
644.0															

BOTTOM OF BORING
*Refusal

B-012-E-68

LOG OF BORING

Date Started 7-11-68
Date Completed 7-17-68
Boring No B-12

Sampler Type SS Dia 1 3/8"
Casing Length 58' Dia 3 1/2"
Station & Offset 498+62, 65' Rt. (5th Pier)

Water Elev ______
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														
702.5	2														
	4				No Sample Recovered (Hole Caved in)		V	I		S	U		A	L	
700.0	6	9/9			Brown Sandy Gravel	1	51	43	3	- 3	-	NP	NP	13	A-1-a
697.5	8				No Sample Recovered (Hole Caved in)		V	I		S	U		A	L	
695.0	10	6/3			Brown Silty Sandy Gravel	2	49	27	9	-15	-	NP	NP	18	A-1-b
	12														
	14														
690.0	16	3/1			Brown Sandy Gravel	3	67	24	3	- 6	-	NP	NP	10	A-1-a
	18														
685.0	20	23/24			Brown Silty Sandy Gravel	4	68	12	8	-12	-	NP	NP	8	A-1-a
	22														
	24														
680.0	26	15/12			Brown Sandy Gravel	5	70	16	6	- 8	-	NP	NP	12	A-1-a
	28														
675.0	30														
	32	50*/ (0.4')			Gray Gravel	6	90	8	1	- 1	-	NP	NP	4	A-1-a
	34														
670.0	36	50* (0.9')			Gray Silty Sandy Gravel	7	38	23	11	17	11	16	4	14	A-2-4
	38														
665.0	40	11/15			Gray Sandy Gravelly Silt	8	35	9	13	23	20	NP	NP	12	A-4a
	42														
	44														
660.0	46	50* (0.6')			Gray Gravelly Sandy Silt	9	25	17	16	19	23	19	6	15	A-4a
	48														
655.0	50	11/12			Gray Silty Sandy Gravel	10	44	11	12	15	18	-	-	10	A-2-4
	52														
	54														
650.0	56	23/27			Gray Silty Sandy Gravel	11	52	15	13	-20	-	NP	NP	10	A-1-b
647.0	58				TOP OF ROCK										
645.0	60		2.0	0.0	Limestone, light-gray, hard, dense, crystalline, few small fossils. No Core Loss.										

BOTTOM OF BORING

*Refusal

APPENDIX V

UNCONFINED COMPRESSIVE STRENGTH TEST RESULTS

RESOURCE INTERNATIONAL, INC.

Engineering Consultants

Unconfined Compressive Strength of Intact Rock Core Specimens (ASTM D 7012-04)

6350 Presidential Gatew.
Columbus, OH 43231
Phone (614) 823-4949

9885 Rockside Road
Cleveland, OH 44125
Phone (216) 573-0955

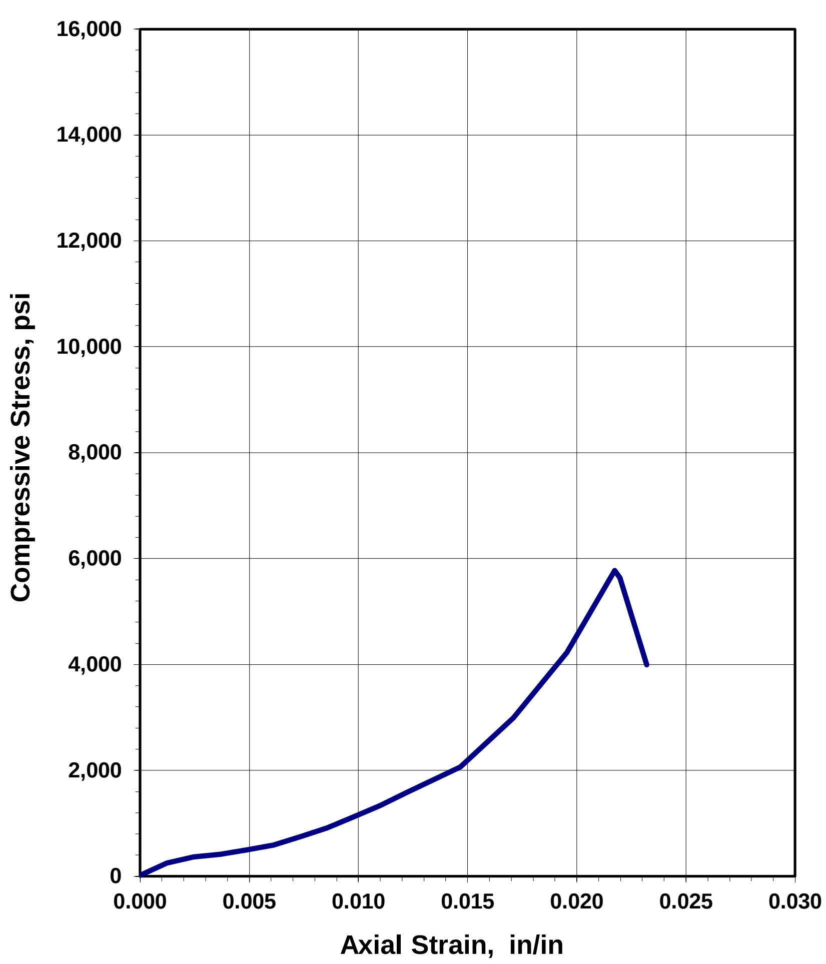
4480 Lake Forest Drive
Cincinnati, Ohio 45242
Phone (513) 769-6998

Project: FRA-70-12.68
Project No.: W-13-045
Date of Testing: 7/12/2013
Test Performed by: JJH/TK

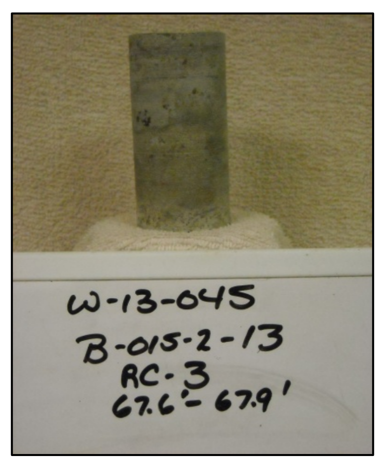
Rock Description: LIMESTONE: Light gray, slightly weathered, strong.

Boring No.:	B-015-2-13	Average Length:	4.094 in
Station / Offset:	5042+88.86, 2.6' Rt.	Average Diameter:	1.872 in
Sample No. / Depth:	RC-3 / 67.6 ft.	Length to diameter ratio:	2.187
Moisture condition:	As received	Cross Sectional Area:	2.751 in^2
		Failure Load:	15,880 lbs
Rate of Loading:	79.4 lbs/sec	Axial Strain at Failure:	0.0217 in/in
Testing Time:	200 sec	Stress:	5,771 psi
	(Rate 2-15 minutes to failure)		

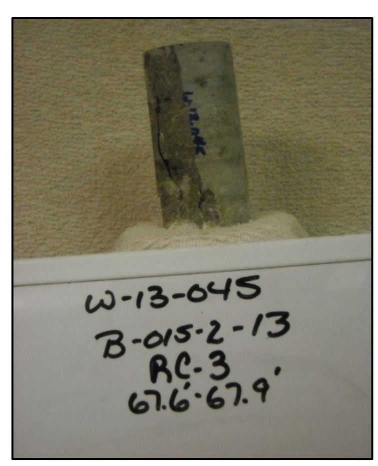
Unconfined Compression Test



Before Testing



After Failure



REMARKS:

RESOURCE INTERNATIONAL, INC.
Engineering Consultants

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Columbus, OH 43231
Phone (614) 823-4949

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Cleveland, OH 44125
Phone (216) 573-0955

4480 Lake Forest Drive
Cincinnati, Ohio 45242
Phone (513) 769-6998

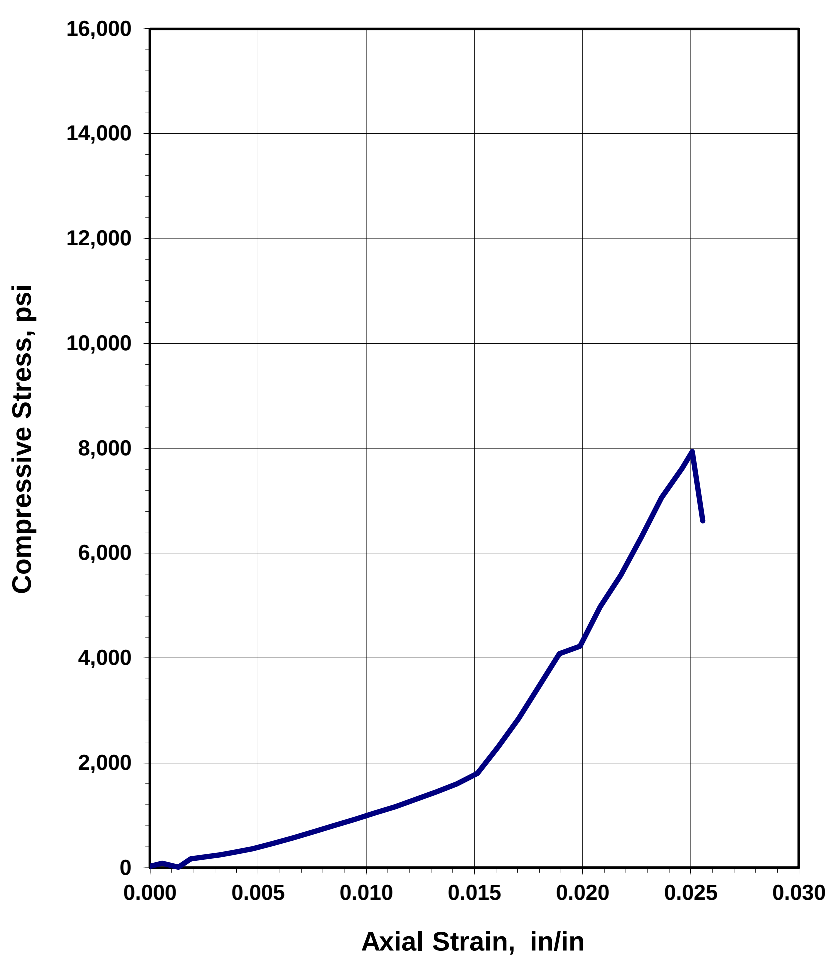
Unconfined Compressive Strength of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68
Project No.: W-13-045
Date of Testing: 8/2/2013
Test Performed by: JH/TK

Rock Description: LIMESTONE: Gray, unweathered, moderately strong to strong.

Boring No.:	B-015-4-13	Average Length:	5.284 in
Station / Offset:	5048+23.41, 12.5' Rt.	Average Diameter:	2.389 in
Sample No. / Depth:	RC-1 / 87.1 ft.	Length to diameter ratio:	2.212
Moisture condition:	As received	Cross Sectional Area:	4.480 in^2
		Failure Load:	35,560 lbs
Rate of Loading:	70.7 lbs/sec	Axial Strain at Failure:	0.0251 in/in
Testing Time:	503 sec	Stress:	7,935 psi
	(Rate 2-15 minutes to failure)		

Unconfined Compression Test



Before Testing

After Failure

REMARKS:

RESOURCE INTERNATIONAL, INC.

Engineering Consultants

Unconfined Compressive Strength of Intact Rock Core Specimens (ASTM D 7012-04)

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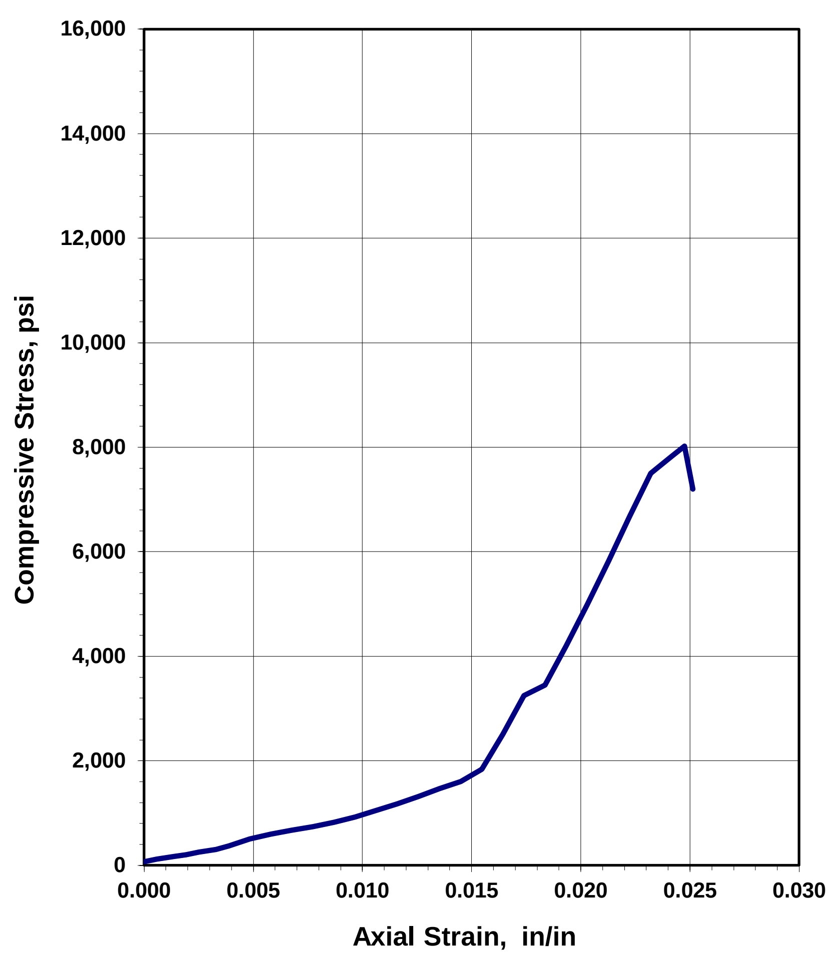
4480 Lake Forest Drive
Cincinnati, Ohio 45242
Phone (513) 769-6998

Project: FRA-70-12.68
Project No.: W-13-045
Date of Testing: 8/2/2013
Test Performed by: JH/TK

Rock Description: LIMESTONE: Gray, unweathered, moderately strong to strong.

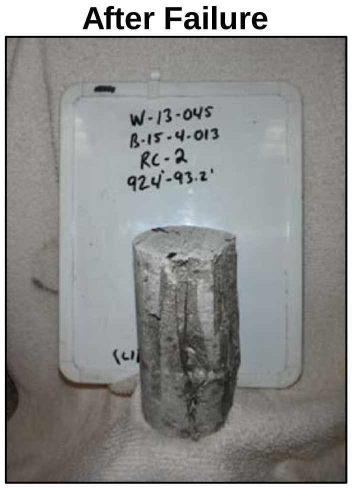
Boring No.:	B-015-4-13	Average Length:	5.173 in
Station / Offset:	5048+23.41, 12.5' Rt.	Average Diameter:	2.386 in
Sample No. / Depth:	RC-2 / 92.4 ft.	Length to diameter ratio:	2.168
Moisture condition:	As received	Cross Sectional Area:	4.469 in^2
		Failure Load:	35,870 lbs
Rate of Loading:	84.0 lbs/sec	Axial Strain at Failure:	0.0247 in/in
Testing Time:	427 sec	Stress:	8,024 psi
	(Rate 2-15 minutes to failure)		

Unconfined Compression Test



Before Testing

After Failure



REMARKS: ______

RESOURCE INTERNATIONAL, INC.

Engineering Consultants

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9885 Rockside Road
Cleveland, OH 44125
Phone (216) 573-0955

4480 Lake Forest Drive
Cincinnati, Ohio 45242
Phone (513) 769-6998

Unconfined Compressive Strength of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68

Project No.: W-13-045

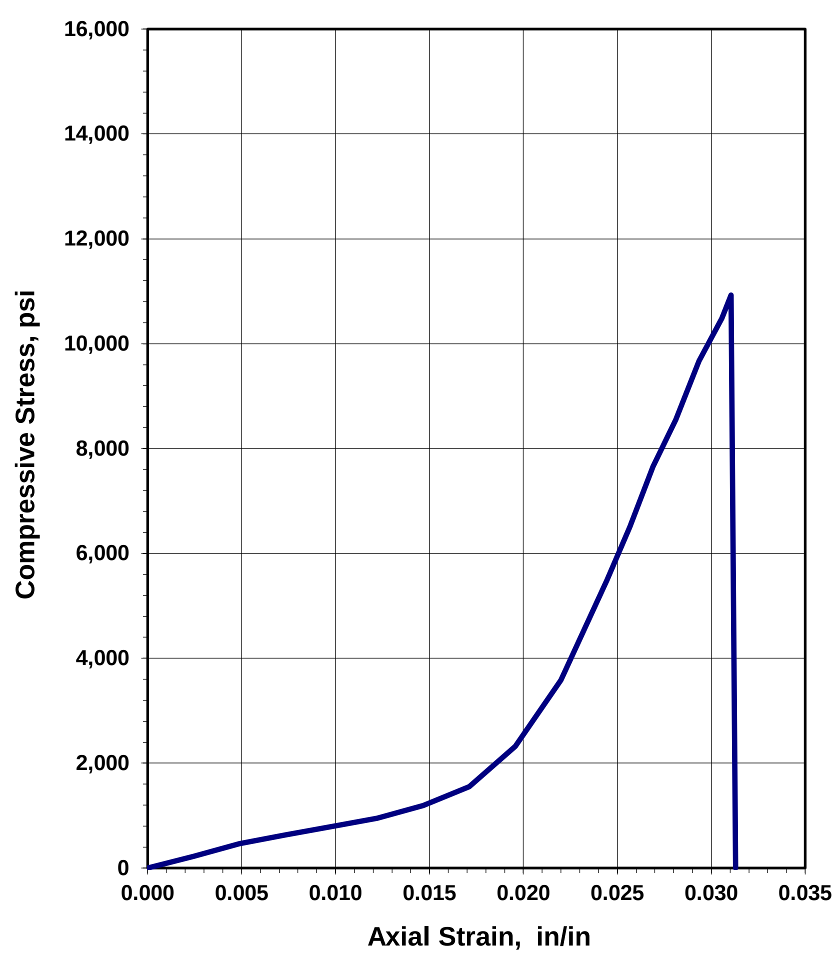
Date of Testing: 7/12/2013

Test Performed by: JJH/TK

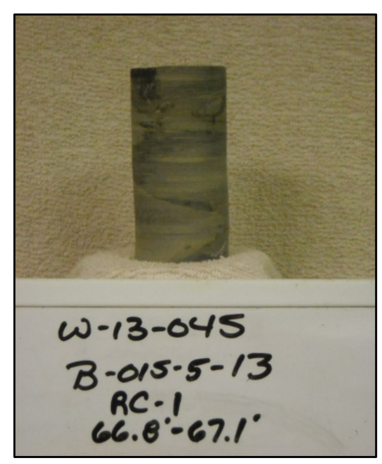
Rock Description: LIMESTONE: Brown and gray, unweathered, strong to very strong.

Boring No.:	B-015-5-13	Average Length:	4.09 in
Station / Offset:	5049+08.12, 37.6' Rt.	Average Diameter:	1.868 in
Sample No. / Depth:	RC-1 / 66.8 ft.	Length to diameter ratio:	2.190
Moisture condition:	As received	Cross Sectional Area:	2.739 in^2
		Failure Load:	29,940 lbs
Rate of Loading:	80.2 lbs/sec	Axial Strain at Failure:	0.0311 in/in
Testing Time:	373 sec	Stress:	10,927 psi
	(Rate 2-15 minutes to failure)		

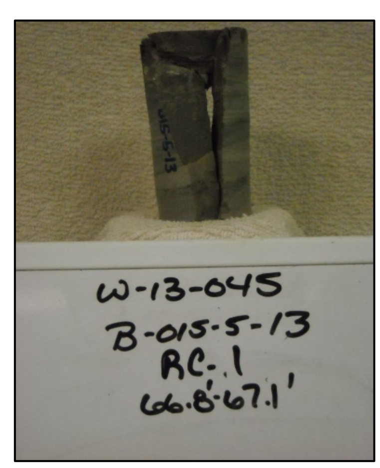
Unconfined Compression Test



Before Testing



After Failure



REMARKS:

RESOURCE INTERNATIONAL, INC.
Engineering Consultants

Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

6350 Presidential Gatew.
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Phone (614) 823-4949

9885 Rockside Road
Cleveland, OH 44125
Phone (216) 573-0955

4480 Lake Forest Drive
Cincinnati, Ohio 45242
Phone (513) 769-6998

Project: FRA-70-12.68
Project No.: W-13-045
Date of Testing: 7/12/2013
Test Performed by: JJH/TK

Rock Description: LIMESTONE: Gray and brown, slightly weathered to unweathered, strong to very strong.

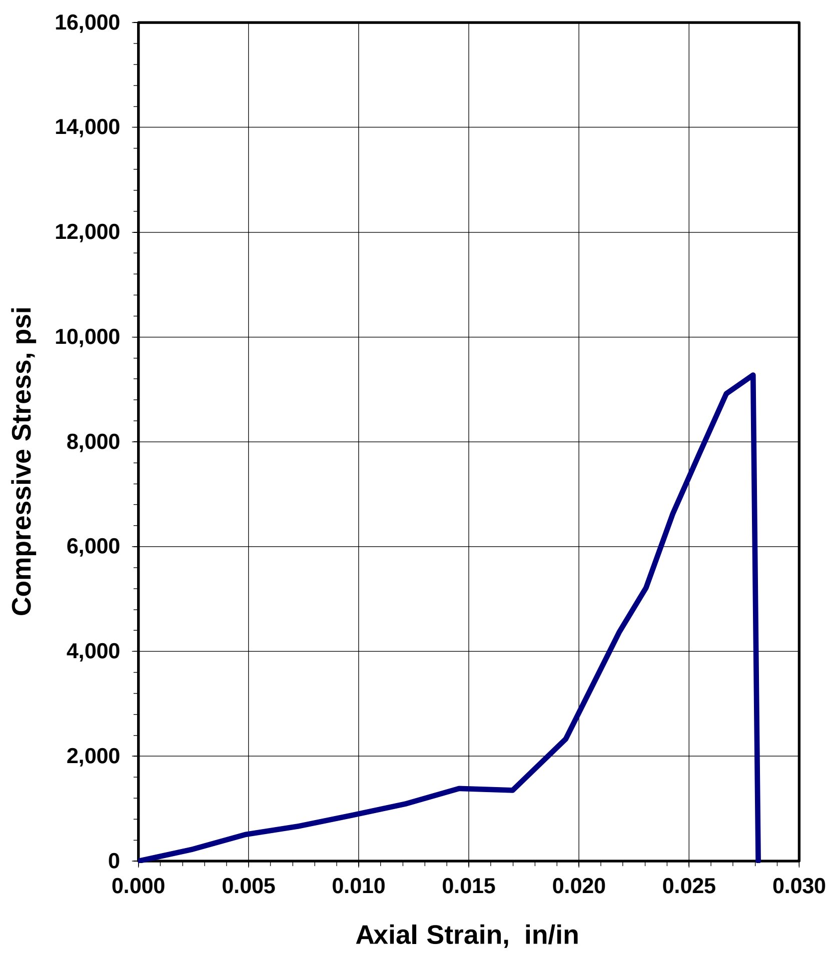
Boring No.: B-015-6-13
Station / Offset: 5050+28.85, 20.8' Lt.
Sample No. / Depth: RC-1 / 68.3 ft.
Moisture condition: As received

Rate of Loading: 74.6 lbs/sec
Testing Time: 342 sec
(Rate 2-15 minutes to failure)

Average Length: 4.122 in
Average Diameter: 1.872 in
Length to diameter ratio: 2.202
Cross Sectional Area: 2.751 in^2

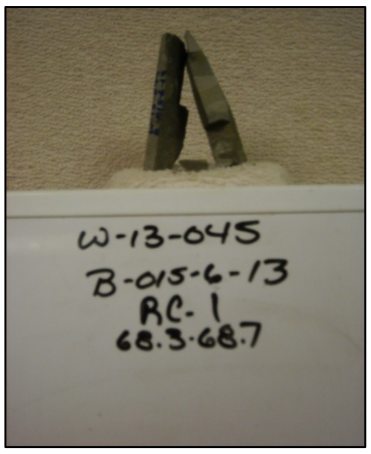
Failure Load: 25,520 lbs
Axial Strain at Failure: 0.0279 in/in
Stress: 9,274 psi

Unconfined Compression Test



Before Testing

After Failure



REMARKS:

RESOURCE INTERNATIONAL, INC.
Engineering Consultants

Unconfined Compressive Strength of Intact Rock Core Specimens (ASTM D 7012-04)

6350 Presidential Gatew.
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Phone (614) 823-4949

9885 Rockside Road
Cleveland, OH 44125
Phone (216) 573-0955

4480 Lake Forest Drive
Cincinnati, Ohio 45242
Phone (513) 769-6998

Project: FRA-70-12.68
Project No.: W-13-045
Date of Testing: 7/12/2013
Test Performed by: JJH/TK

Rock Description: LIMESTONE: Gray and brown, slightly weathered to unweathered, strong to very strong.

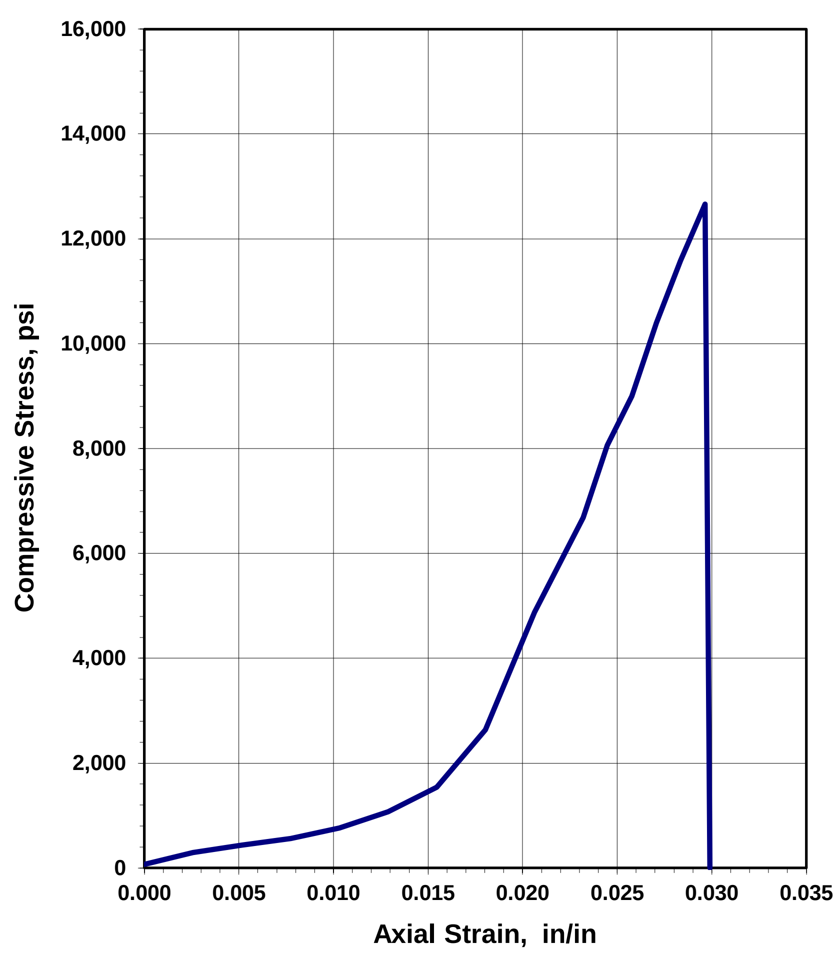
Boring No.: B-015-6-13
Station / Offset: 5050+28.85, 20.8' Lt.
Sample No. / Depth: RC-3 / 76.9 ft.
Moisture condition: As received

Average Length: 3.88 in
Average Diameter: 1.872 in
Length to diameter ratio: 2.073
Cross Sectional Area: 2.751 in^2

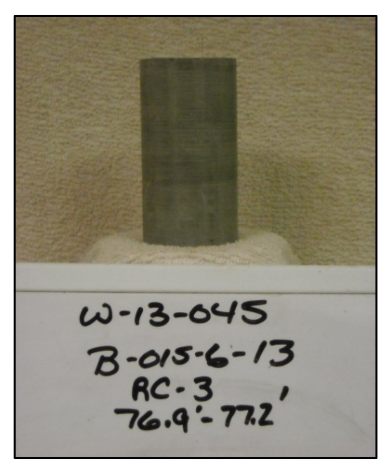
Failure Load: 34,840 lbs
Axial Strain at Failure: 0.0296 in/in
Stress: 12,661 psi

Rate of Loading: 75.9 lbs/sec
Testing Time: 459 sec
(Rate 2-15 minutes to failure)

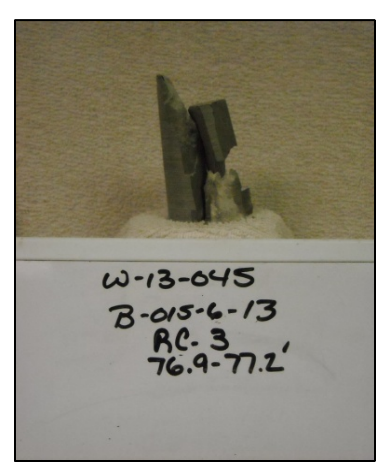
Unconfined Compression Test



Before Testing



After Failure



REMARKS: ______

RESOURCE INTERNATIONAL, INC.
Engineering Consultants

6350 Presidential Gatew.	9885 Rockside Road	4480 Lake Forest Drive
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Phone (614) 823-4949	Phone (216) 573-0955	Phone (513) 769-6998

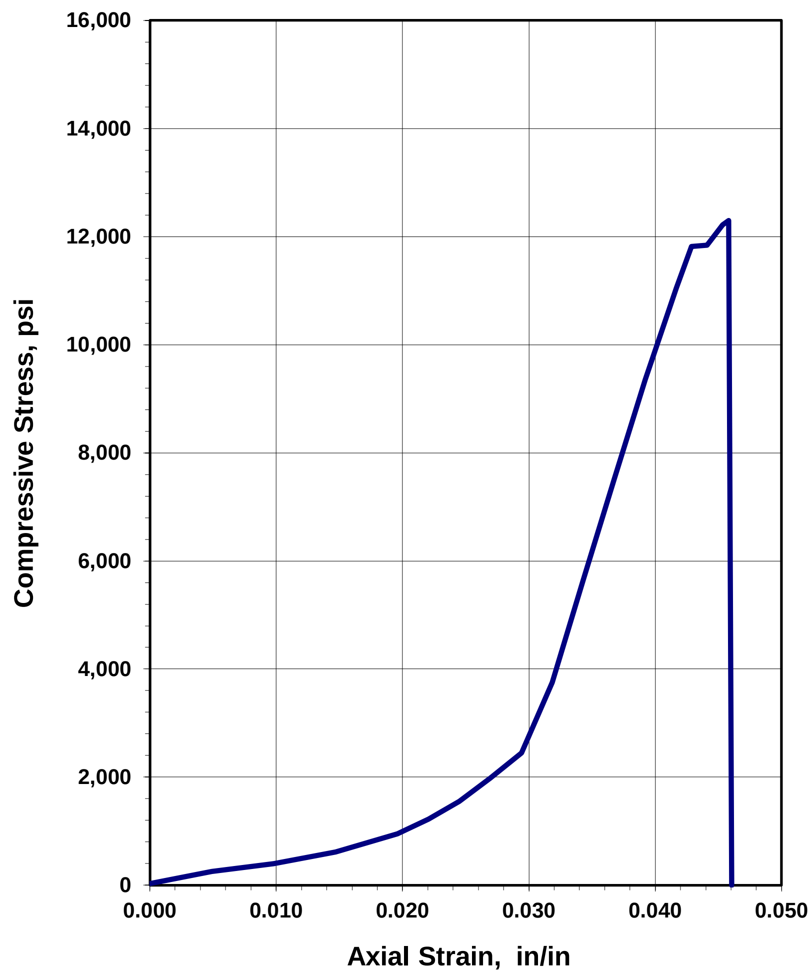
Unconfined Compressive Strength of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68
Project No.: W-13-045
Date of Testing: 7/12/2013
Test Performed by: JJH/TK

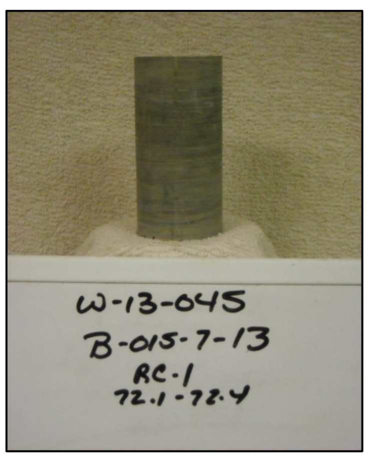
Rock Description: DOLOMITE: Gray and brown, slightly weathered, strong.

Boring No.:	B-015-7-13	Average Length:	4.081 in
Station / Offset:	5051+29.66, 9.8' Rt.	Average Diameter:	1.855 in
Sample No. / Depth:	RC-1 / 72.1 ft.	Length to diameter ratio:	2.200
Moisture condition:	As received	Cross Sectional Area:	2.701 in^2
Rate of Loading:	63.9 lbs/sec	Failure Load:	33,240 lbs
Testing Time:	520 sec	Axial Strain at Failure:	0.0458 in/in
(Rate 2-15 minutes to failure)		Stress:	12,300 psi

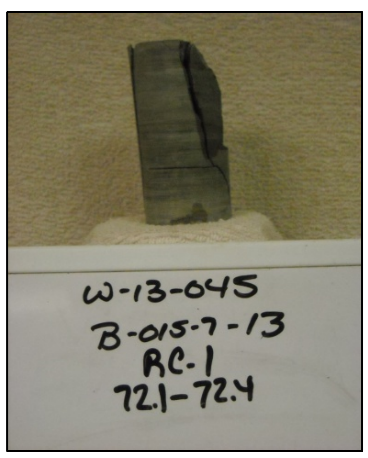
Unconfined Compression Test



Before Testing



After Failure



REMARKS:

RESOURCE INTERNATIONAL, INC.

Engineering Consultants

Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

6350 Presidential Gatew.	9885 Rockside Road	4480 Lake Forest Drive
Columbus, OH 43231	Cleveland, OH 44125	Cincinnati, Ohio 45242
Phone (614) 823-4949	Phone (216) 573-0955	Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

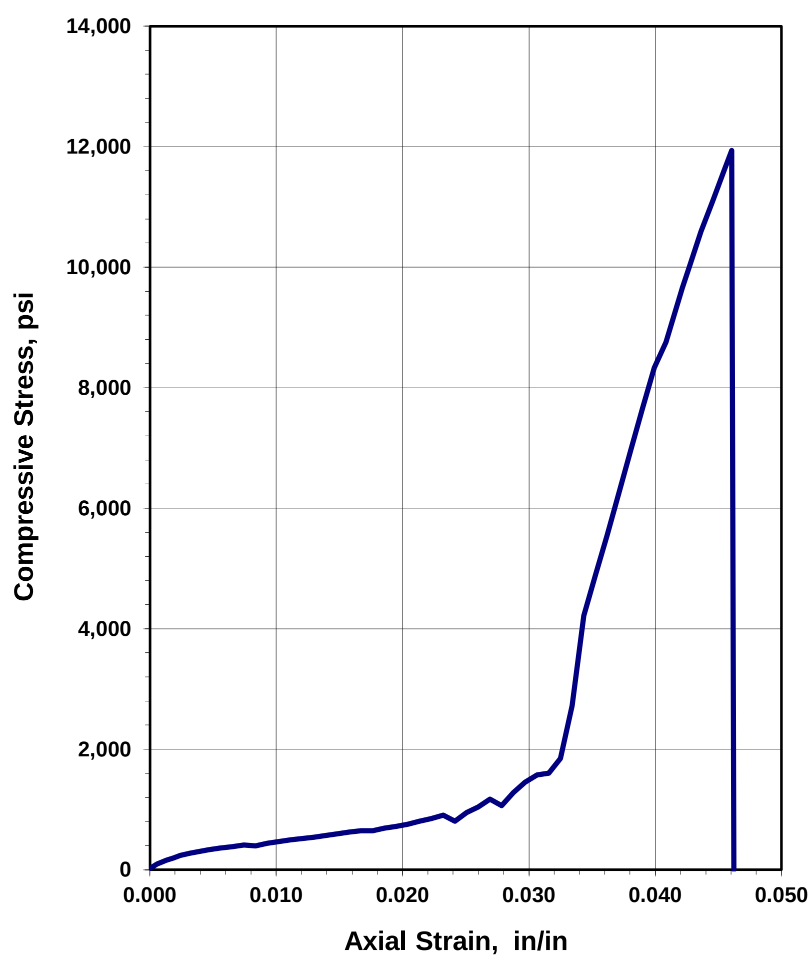
Date of Testing: 7/3/2014

Test Performed by: K.R./T.K.

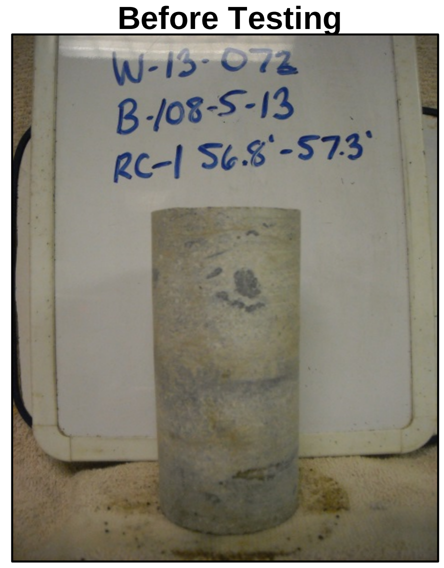
Rock Description: Dolomitic Limestone

Boring No.:	B-108-5-13	Average Length:	5.386 in
Station / Offset:	239+69.30, 18.7' Rt.	Average Diameter:	2.408 in
Sample No. / Depth:	RC-1 / 56.8 ft	Length to diameter ratio:	2.237
Moisture condition:	As received	Cross Sectional Area:	4.552 in^2
Rate of Loading:	72.6 lbs/sec	Failure Load:	54,340 lbs
Testing Time:	749 sec	Axial Strain at Failure:	0.0460 in/in
	(Rate 2-15 minutes to failure)	Stress:	11,933 psi

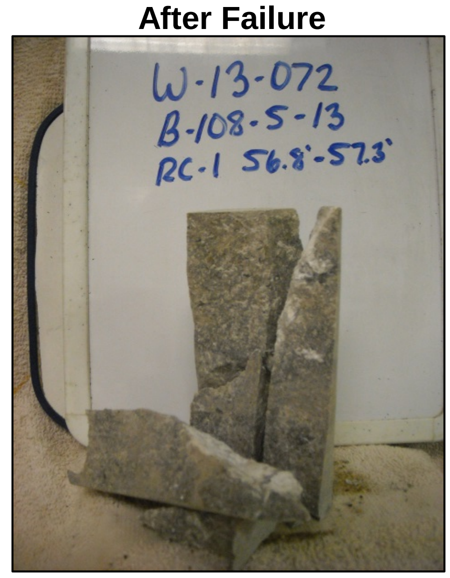
Unconfined Compression Test



Before Testing



After Failure



REMARKS: ____________________

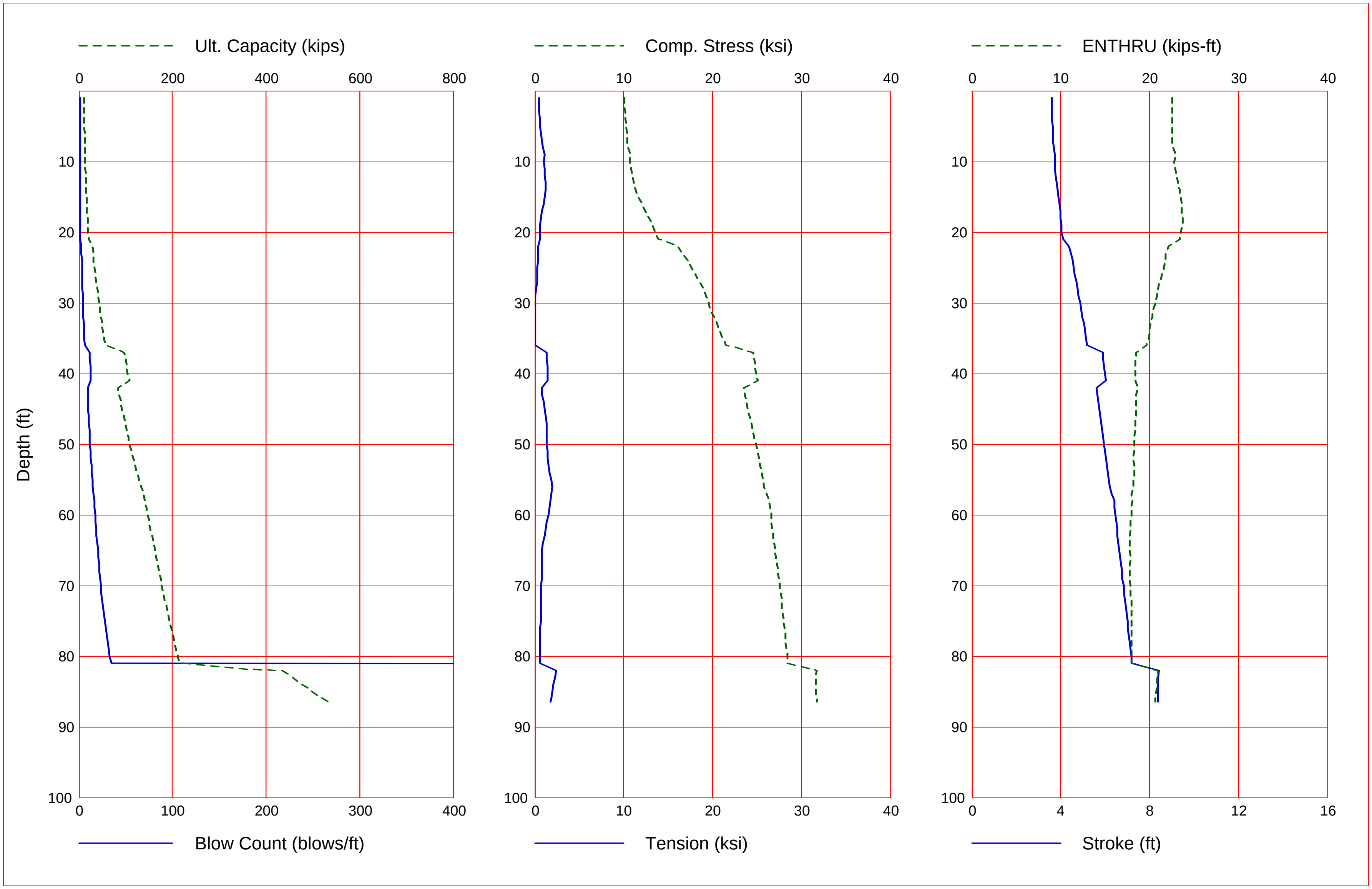
APPENDIX VI

GRLWEAP DRIVEABILITY ANALYSIS OUTPUTS

Resource International Inc
FRA-70-1301A-B-015-3-13-R. Abut-HP10x42

Dec 23 2014
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.500 / 1.000



Gain/Loss 1 at Shaft and Toe 0.500 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
1.0	11.5	0.0	11.5	1.3	10.055	-0.483	3.60	22.6
2.0	11.6	0.1	11.5	1.3	10.079	-0.481	3.60	22.6
3.0	11.7	0.2	11.5	1.3	10.156	-0.485	3.61	22.6
4.0	11.8	0.3	11.5	1.3	10.205	-0.563	3.62	22.6
5.0	12.0	0.5	11.5	1.3	10.253	-0.630	3.63	22.6
6.0	12.3	0.8	11.5	1.4	10.353	-0.742	3.64	22.6
7.0	12.5	1.1	11.5	1.4	10.426	-0.833	3.66	22.6
8.0	12.9	1.4	11.5	1.4	10.538	-0.951	3.68	22.7
9.0	13.2	1.8	11.5	1.4	10.711	-1.130	3.74	22.9
10.0	13.6	2.2	11.5	1.4	10.732	-1.056	3.72	22.8
11.0	14.1	2.6	11.5	1.5	10.866	-1.120	3.75	22.9
12.0	14.6	3.1	11.5	1.5	10.984	-1.158	3.77	23.0
13.0	15.1	3.7	11.5	1.5	11.166	-1.199	3.81	23.2
14.0	15.7	4.2	11.5	1.6	11.342	-1.212	3.88	23.4
15.0	16.3	4.9	11.5	1.6	11.654	-1.090	3.91	23.5
16.0	17.0	5.5	11.5	1.6	12.093	-0.962	3.94	23.6
17.0	17.7	6.2	11.5	1.7	12.478	-0.836	3.97	23.6
18.0	18.5	7.0	11.5	1.7	12.877	-0.705	4.01	23.7
19.0	19.3	7.8	11.5	1.8	13.315	-0.622	4.05	23.7
20.0	20.1	8.6	11.5	1.8	13.490	-0.592	4.05	23.5
21.0	21.0	9.5	11.5	1.9	13.949	-0.542	4.10	23.4
22.0	29.0	10.3	18.6	2.7	16.213	-0.357	4.38	22.1
23.0	30.6	11.1	19.5	2.9	16.633	-0.346	4.44	21.8
24.0	32.3	12.0	20.3	3.1	17.228	-0.324	4.53	21.8
25.0	34.1	12.9	21.2	3.3	17.681	-0.312	4.60	21.6
26.0	35.9	13.8	22.0	3.5	18.105	-0.288	4.65	21.4
27.0	37.7	14.8	22.9	3.7	18.530	-0.225	4.71	21.2
28.0	39.5	15.8	23.7	4.0	18.895	-0.122	4.77	21.0
29.0	41.4	16.9	24.6	4.2	19.224	-0.021	4.82	20.8
30.0	43.3	17.9	25.4	4.5	19.539	0.000	4.88	20.6
31.0	45.3	19.1	26.3	4.7	19.837	0.000	4.93	20.4
32.0	47.3	20.2	27.1	5.0	20.188	0.000	4.98	20.3
33.0	49.3	21.4	27.9	5.2	20.514	0.000	5.04	20.1
34.0	51.4	22.6	28.8	5.5	20.827	0.000	5.09	20.0
35.0	53.5	23.9	29.6	5.8	21.152	0.000	5.14	19.9
36.0	55.7	25.2	30.5	6.1	21.444	0.000	5.20	19.7
37.0	97.1	27.6	69.4	11.8	24.594	-1.327	5.90	18.5
38.0	99.6	30.2	69.4	12.0	24.713	-1.371	5.93	18.4
39.0	102.2	32.8	69.4	12.3	24.803	-1.415	5.96	18.4
40.0	104.9	35.5	69.4	12.6	24.957	-1.451	6.00	18.4
41.0	107.7	38.3	69.4	12.9	25.080	-1.479	6.03	18.4
42.0	83.6	41.1	42.5	9.2	23.469	-0.780	5.61	18.7
43.0	86.6	44.0	42.5	9.5	23.627	-0.848	5.65	18.5
44.0	89.6	47.0	42.5	9.8	23.833	-1.013	5.69	18.5
45.0	92.7	50.1	42.5	10.1	23.982	-1.094	5.73	18.5
46.0	95.8	53.3	42.5	10.4	24.144	-1.279	5.77	18.5
47.0	99.1	56.5	42.5	10.9	24.357	-1.370	5.82	18.4

Gain/Loss 1 at Shaft and Toe 0.500 / 1.000 (Continued)

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
48.0	102.4	59.8	42.5	11.3	24.510	-1.354	5.87	18.4
49.0	105.8	63.2	42.5	11.7	24.686	-1.324	5.91	18.3
50.0	109.2	66.7	42.5	12.1	24.881	-1.309	5.96	18.3
51.0	112.8	70.3	42.5	12.6	25.037	-1.398	6.01	18.3
52.0	116.4	73.9	42.5	13.0	25.184	-1.451	6.05	18.2
53.0	120.1	77.6	42.5	13.4	25.349	-1.506	6.10	18.3
54.0	123.9	81.4	42.5	13.9	25.515	-1.668	6.14	18.3
55.0	127.8	85.3	42.5	14.4	25.653	-1.849	6.18	18.2
56.0	131.7	89.2	42.5	14.8	25.789	-1.976	6.22	18.2
57.0	138.8	91.3	47.5	16.1	26.093	-1.879	6.31	18.0
58.0	141.6	93.4	48.3	16.6	26.386	-1.785	6.41	18.1
59.0	144.5	95.5	49.0	17.1	26.471	-1.697	6.43	18.0
60.0	147.3	97.6	49.7	17.6	26.583	-1.551	6.47	18.0
61.0	150.2	99.8	50.4	18.2	26.638	-1.383	6.49	17.9
62.0	153.2	102.0	51.1	18.7	26.765	-1.238	6.53	17.9
63.0	156.1	104.3	51.8	19.2	26.847	-1.097	6.56	17.8
64.0	159.1	106.6	52.5	19.8	26.942	-0.932	6.60	17.8
65.0	162.1	108.9	53.3	20.3	27.058	-0.812	6.63	17.8
66.0	165.2	111.2	54.0	20.8	27.150	-0.816	6.66	17.9
67.0	168.3	113.6	54.7	21.5	27.282	-0.834	6.71	17.8
68.0	171.4	116.0	55.4	22.2	27.368	-0.827	6.75	17.8
69.0	174.6	118.4	56.1	22.7	27.459	-0.783	6.78	17.8
70.0	177.7	120.9	56.8	23.5	27.571	-0.703	6.83	17.9
71.0	181.0	123.4	57.5	24.3	27.654	-0.673	6.86	17.9
72.0	184.2	125.9	58.3	25.0	27.747	-0.695	6.89	18.0
73.0	187.5	128.5	59.0	25.8	27.836	-0.702	6.93	18.0
74.0	190.8	131.1	59.7	26.7	27.942	-0.690	6.97	18.0
75.0	194.1	133.7	60.4	27.7	28.007	-0.666	7.00	18.0
76.0	197.5	136.4	61.1	28.6	28.106	-0.635	7.03	18.0
77.0	200.9	139.1	61.8	29.7	28.165	-0.622	7.07	18.0
78.0	204.3	141.8	62.5	30.8	28.265	-0.625	7.11	18.0
79.0	207.8	144.5	63.3	31.9	28.327	-0.627	7.13	18.0
80.0	211.3	147.3	64.0	33.2	28.419	-0.620	7.17	18.0
81.0	214.8	150.1	64.7	34.7	28.478	-0.584	7.20	18.0
82.0	434.0	162.5	271.4	9999.0	31.683	-2.375	8.41	21.0
83.0	455.9	184.5	271.4	9999.0	31.611	-2.261	8.40	20.9
84.0	477.9	206.5	271.4	9999.0	31.614	-2.112	8.40	20.9
85.0	499.9	228.4	271.4	9999.0	31.621	-1.972	8.39	20.7
86.0	521.8	250.4	271.4	9999.0	31.685	-1.851	8.39	20.6
86.5	532.8	261.4	271.4	9999.0	31.723	-1.759	8.39	20.6

Refusal occurred; no driving time output possible

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-70-1301A\DRIVEABILITY\B-015-1-13\B-015-0-13
-REAR ABUTMENT.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
 Hammer File Version:  2003 (2/22/2013)

                      Input File Contents
    FRA-70-1301A-B-015-3-13-R. Abut-HP10x42
 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   1   0  0   0   0   0   0   0  0   0   0   0   0   0   0.000
   Pile g  Hammer g  Toe Area Pile Size          Pile Type
   32.170    32.170    97.720    10.070             H Pile
     W Cp      A Cp      E Cp      T Cp       CoR      ROut      StCp
    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
   86.500     12.40   30000.0   492.000     3.295         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
0.100	0.167	0.105	0.150	0.000	0.000	0.000	0.000

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

0.000	0.000	0.000	0.000

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

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	11.48	0.10	0.17	0.20	0.15	2.00	6.56	168.0
21.00	0.55	11.48	0.10	0.17	0.20	0.15	2.00	6.56	168.0
21.00	0.35	17.79	0.10	0.17	0.20	0.15	1.50	6.56	84.0
36.00	0.60	30.49	0.10	0.17	0.20	0.15	1.50	6.56	84.0
36.00	0.73	69.45	0.10	0.17	0.05	0.15	1.00	6.56	1.0
41.00	0.86	69.45	0.10	0.17	0.05	0.15	1.00	6.56	1.0
41.00	0.85	42.52	0.10	0.17	0.05	0.15	1.00	6.56	1.0
56.00	1.21	42.52	0.10	0.17	0.05	0.15	1.00	6.56	1.0
56.00	0.93	46.83	0.10	0.17	0.20	0.15	1.50	6.56	84.0
81.50	1.29	65.04	0.10	0.17	0.20	0.15	1.50	6.56	84.0
81.50	10.00	271.44	0.10	0.10	0.05	0.15	0.00	6.56	0.0
86.50	10.00	271.44	0.10	0.10	0.05	0.15	0.00	6.56	0.0

Gain/Loss factors: shaft and toe

0.50000	0.00000	0.00000	0.00000	0.00000
1.00000	0.00000	0.00000	0.00000	0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
1.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
2.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
3.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
4.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
5.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
7.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
8.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
9.00	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
11.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
13.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
14.00	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
16.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
17.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
18.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
19.00	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
21.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
22.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
23.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
24.00	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
26.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
27.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
28.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
29.00	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
31.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
32.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
33.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
34.00	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
36.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
37.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
38.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
39.00	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
41.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
42.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
43.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
44.00	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
46.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
47.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
48.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
49.00	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
52.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
53.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
54.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
56.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
57.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
58.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
59.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
61.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
62.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
63.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
64.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
65.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
66.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
67.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
68.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
69.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
70.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
71.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
72.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
73.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
74.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
75.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
76.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
77.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
78.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
79.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
80.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
81.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
82.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
83.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
84.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
85.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
86.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
86.50	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-70-1301A-B-015-3-13-R. Abut-HP10x42

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		9317.9			

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

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 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-70-1301A-B-015-3-13-R. Abut-HP10x42                            12/23/2014
Resource International Inc                               GRLWEAP Version 2010

 Depth                 (ft)       1.0
 Shaft Gain/Loss Factor         0.500  Toe Gain/Loss Factor          1.000

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

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
       ft      in2      ksi   lb/ft3      ft             ft/s    k/ft/s
      0.0    12.40   30000.    492.0      3.3       0    16807.     22.1
     86.5    12.40   30000.    492.0      3.3       0    16807.     22.1

 Wave Travel Time 2L/c (ms)    10.293

       Pile and Soil Model           Total Capacity Rut  (kips)      11.5
No. Weight   Stiffn C-Slk T-Slk  CoR  Soil-S  Soil-D Quake  LbTop Perim    Area
      kips     k/in    ft    ft        kips    s/ft  inch     ft    ft     in2
  1  0.141     9318 0.010 0.000 0.85     0.0   0.000 0.100   3.33   3.3    12.4
  2  0.141     9318 0.000 0.000 1.00     0.0   0.000 0.100   6.65   3.3    12.4
 26  0.141     9318 0.000 0.000 1.00     0.0   0.200 0.100  86.50   3.3    12.4
Toe                                     11.5   0.150 0.167

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

 PILE, SOIL, ANALYSIS OPTIONS:
 Uniform pile                          Pile Segments: Automatic
 No. of Slacks/Splices              0  Pile Damping           (%)         1
                                       Pile Damping Fact.(k/ft/s)     0.443
 Driveability Analysis
 Soil Damping Option            Smith
 Max No Analysis Iterations         0  Time Increment/Critical         160
 Output Time Interval               1  Analysis Time-Input   (ms)        0
 Output Level: Normal
 Gravity Mass, Pile, Hammer:   32.170    32.170    32.170
 Output Segment Generation: Automatic

    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
     1.00     10.81      1.00     0.800

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    Rut   Bl Ct   Stroke (ft) Ten Str   i   t Comp Str   i   t ENTHRU   Bl Rt
   kips    b/ft   down     up     ksi            ksi          kip-ft   b/min
   11.5     1.3   3.60   3.61   -0.48   7  33    10.06   1   7   22.6    62.3
          1           0   10.81000       11.86000

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 Depth                 (ft)       2.0
 Shaft Gain/Loss Factor         0.500  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)    97.720  Pile Type                    H Pile
 Pile Size          (inch)    10.070
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B-015-0-13 -REAR ABUTMENT

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
86.5	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 10.293

Pile and Soil Model Total Capacity Rut (kips) 11.6

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	0.141	9318	0.010	0.000	0.85	0.0	0.000	0.100	3.33	3.3	12.4
2	0.141	9318	0.000	0.000	1.00	0.0	0.000	0.100	6.65	3.3	12.4
26	0.141	9318	0.000	0.000	1.00	0.1	0.200	0.100	86.50	3.3	12.4
Toe						11.5	0.150	0.167			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
2.00	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
11.6	1.3	3.60	3.61	-0.48	7	33	10.08	1	7	22.6	62.3

1 0 10.81000 11.86000

Depth (ft) 3.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

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

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
86.5	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 10.293

Pile and Soil Model Total Capacity Rut (kips) 11.7

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	0.141	9318	0.010	0.000	0.85	0.0	0.000	0.100	3.33	3.3	12.4
2	0.141	9318	0.000	0.000	1.00	0.0	0.000	0.100	6.65	3.3	12.4
26	0.141	9318	0.000	0.000	1.00	0.2	0.200	0.100	86.50	3.3	12.4
Toe						11.5	0.150	0.167			

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

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
3.00	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
11.7	1.3	3.61	3.62	-0.48	10	16	10.16	1	7	22.6	62.2

1 0 10.81000 11.86000

8	0.141	9318	0.000	0.000	1.00	3.0	0.200	0.100	26.62	3.3	12.4
9	0.141	9318	0.000	0.000	1.00	3.4	0.200	0.100	29.94	3.3	12.4
10	0.141	9318	0.000	0.000	1.00	3.8	0.200	0.100	33.27	3.3	12.4
11	0.141	9318	0.000	0.000	1.00	4.9	0.167	0.100	36.60	3.3	12.4
12	0.141	9318	0.000	0.000	1.00	8.6	0.050	0.100	39.92	3.3	12.4
13	0.141	9318	0.000	0.000	1.00	9.5	0.050	0.100	43.25	3.3	12.4
14	0.141	9318	0.000	0.000	1.00	10.4	0.050	0.100	46.58	3.3	12.4
15	0.141	9318	0.000	0.000	1.00	11.2	0.050	0.100	49.90	3.3	12.4
16	0.141	9318	0.000	0.000	1.00	12.1	0.050	0.100	53.23	3.3	12.4
17	0.141	9318	0.000	0.000	1.00	11.9	0.071	0.100	56.56	3.3	12.4
18	0.141	9318	0.000	0.000	1.00	7.0	0.200	0.100	59.88	3.3	12.4
19	0.141	9318	0.000	0.000	1.00	7.4	0.200	0.100	63.21	3.3	12.4
20	0.141	9318	0.000	0.000	1.00	7.7	0.200	0.100	66.54	3.3	12.4
21	0.141	9318	0.000	0.000	1.00	8.1	0.200	0.100	69.87	3.3	12.4
22	0.141	9318	0.000	0.000	1.00	8.4	0.200	0.100	73.19	3.3	12.4
23	0.141	9318	0.000	0.000	1.00	8.8	0.200	0.100	76.52	3.3	12.4
24	0.141	9318	0.000	0.000	1.00	9.1	0.200	0.100	79.85	3.3	12.4
25	0.141	9318	0.000	0.000	1.00	41.4	0.067	0.100	83.17	3.3	12.4
26	0.141	9318	0.000	0.000	1.00	73.1	0.050	0.100	86.50	3.3	12.4
Toe						271.4	0.150	0.100			

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
86.50	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
532.8	9999.0	8.39	8.36	-1.76	10	25	31.72	2	2	20.6	40.8

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SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.500 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
1.0	11.5	0.0	11.5	1.3	10.055	-0.483	3.60	22.6
2.0	11.6	0.1	11.5	1.3	10.079	-0.481	3.60	22.6
3.0	11.7	0.2	11.5	1.3	10.156	-0.485	3.61	22.6
4.0	11.8	0.3	11.5	1.3	10.205	-0.563	3.62	22.6
5.0	12.0	0.5	11.5	1.3	10.253	-0.630	3.63	22.6
6.0	12.3	0.8	11.5	1.4	10.353	-0.742	3.64	22.6
7.0	12.5	1.1	11.5	1.4	10.426	-0.833	3.66	22.6
8.0	12.9	1.4	11.5	1.4	10.538	-0.951	3.68	22.7
9.0	13.2	1.8	11.5	1.4	10.711	-1.130	3.74	22.9
10.0	13.6	2.2	11.5	1.4	10.732	-1.056	3.72	22.8
11.0	14.1	2.6	11.5	1.5	10.866	-1.120	3.75	22.9
12.0	14.6	3.1	11.5	1.5	10.984	-1.158	3.77	23.0
13.0	15.1	3.7	11.5	1.5	11.166	-1.199	3.81	23.2
14.0	15.7	4.2	11.5	1.6	11.342	-1.212	3.88	23.4
15.0	16.3	4.9	11.5	1.6	11.654	-1.090	3.91	23.5
16.0	17.0	5.5	11.5	1.6	12.093	-0.962	3.94	23.6
17.0	17.7	6.2	11.5	1.7	12.478	-0.836	3.97	23.6
18.0	18.5	7.0	11.5	1.7	12.877	-0.705	4.01	23.7
19.0	19.3	7.8	11.5	1.8	13.315	-0.622	4.05	23.7
20.0	20.1	8.6	11.5	1.8	13.490	-0.592	4.05	23.5
21.0	21.0	9.5	11.5	1.9	13.949	-0.542	4.10	23.4
22.0	29.0	10.3	18.6	2.7	16.213	-0.357	4.38	22.1
23.0	30.6	11.1	19.5	2.9	16.633	-0.346	4.44	21.8
24.0	32.3	12.0	20.3	3.1	17.228	-0.324	4.53	21.8
25.0	34.1	12.9	21.2	3.3	17.681	-0.312	4.60	21.6
26.0	35.9	13.8	22.0	3.5	18.105	-0.288	4.65	21.4
27.0	37.7	14.8	22.9	3.7	18.530	-0.225	4.71	21.2
28.0	39.5	15.8	23.7	4.0	18.895	-0.122	4.77	21.0
29.0	41.4	16.9	24.6	4.2	19.224	-0.021	4.82	20.8
30.0	43.3	17.9	25.4	4.5	19.539	0.000	4.88	20.6
31.0	45.3	19.1	26.3	4.7	19.837	0.000	4.93	20.4

32.0	47.3	20.2	27.1	5.0	20.188	0.000	4.98	20.3
33.0	49.3	21.4	27.9	5.2	20.514	0.000	5.04	20.1
34.0	51.4	22.6	28.8	5.5	20.827	0.000	5.09	20.0
35.0	53.5	23.9	29.6	5.8	21.152	0.000	5.14	19.9
36.0	55.7	25.2	30.5	6.1	21.444	0.000	5.20	19.7
37.0	97.1	27.6	69.4	11.8	24.594	-1.327	5.90	18.5
38.0	99.6	30.2	69.4	12.0	24.713	-1.371	5.93	18.4
39.0	102.2	32.8	69.4	12.3	24.803	-1.415	5.96	18.4
40.0	104.9	35.5	69.4	12.6	24.957	-1.451	6.00	18.4
41.0	107.7	38.3	69.4	12.9	25.080	-1.479	6.03	18.4
42.0	83.6	41.1	42.5	9.2	23.469	-0.780	5.61	18.7
43.0	86.6	44.0	42.5	9.5	23.627	-0.848	5.65	18.5
44.0	89.6	47.0	42.5	9.8	23.833	-1.013	5.69	18.5
45.0	92.7	50.1	42.5	10.1	23.982	-1.094	5.73	18.5
46.0	95.8	53.3	42.5	10.4	24.144	-1.279	5.77	18.5
47.0	99.1	56.5	42.5	10.9	24.357	-1.370	5.82	18.4
48.0	102.4	59.8	42.5	11.3	24.510	-1.354	5.87	18.4
49.0	105.8	63.2	42.5	11.7	24.686	-1.324	5.91	18.3
50.0	109.2	66.7	42.5	12.1	24.881	-1.309	5.96	18.3
51.0	112.8	70.3	42.5	12.6	25.037	-1.398	6.01	18.3
52.0	116.4	73.9	42.5	13.0	25.184	-1.451	6.05	18.2
53.0	120.1	77.6	42.5	13.4	25.349	-1.506	6.10	18.3
54.0	123.9	81.4	42.5	13.9	25.515	-1.668	6.14	18.3
55.0	127.8	85.3	42.5	14.4	25.653	-1.849	6.18	18.2
56.0	131.7	89.2	42.5	14.8	25.789	-1.976	6.22	18.2
57.0	138.8	91.3	47.5	16.1	26.093	-1.879	6.31	18.0
58.0	141.6	93.4	48.3	16.6	26.386	-1.785	6.41	18.1
59.0	144.5	95.5	49.0	17.1	26.471	-1.697	6.43	18.0
60.0	147.3	97.6	49.7	17.6	26.583	-1.551	6.47	18.0
61.0	150.2	99.8	50.4	18.2	26.638	-1.383	6.49	17.9
62.0	153.2	102.0	51.1	18.7	26.765	-1.238	6.53	17.9
63.0	156.1	104.3	51.8	19.2	26.847	-1.097	6.56	17.8
64.0	159.1	106.6	52.5	19.8	26.942	-0.932	6.60	17.8
65.0	162.1	108.9	53.3	20.3	27.058	-0.812	6.63	17.8
66.0	165.2	111.2	54.0	20.8	27.150	-0.816	6.66	17.9
67.0	168.3	113.6	54.7	21.5	27.282	-0.834	6.71	17.8
68.0	171.4	116.0	55.4	22.2	27.368	-0.827	6.75	17.8
69.0	174.6	118.4	56.1	22.7	27.459	-0.783	6.78	17.8
70.0	177.7	120.9	56.8	23.5	27.571	-0.703	6.83	17.9
71.0	181.0	123.4	57.5	24.3	27.654	-0.673	6.86	17.9
72.0	184.2	125.9	58.3	25.0	27.747	-0.695	6.89	18.0
73.0	187.5	128.5	59.0	25.8	27.836	-0.702	6.93	18.0
74.0	190.8	131.1	59.7	26.7	27.942	-0.690	6.97	18.0
75.0	194.1	133.7	60.4	27.7	28.007	-0.666	7.00	18.0
76.0	197.5	136.4	61.1	28.6	28.106	-0.635	7.03	18.0
77.0	200.9	139.1	61.8	29.7	28.165	-0.622	7.07	18.0
78.0	204.3	141.8	62.5	30.8	28.265	-0.625	7.11	18.0
79.0	207.8	144.5	63.3	31.9	28.327	-0.627	7.13	18.0
80.0	211.3	147.3	64.0	33.2	28.419	-0.620	7.17	18.0
81.0	214.8	150.1	64.7	34.7	28.478	-0.584	7.20	18.0
82.0	434.0	162.5	271.4	9999.0	31.683	-2.375	8.41	21.0
83.0	455.9	184.5	271.4	9999.0	31.611	-2.261	8.40	20.9
84.0	477.9	206.5	271.4	9999.0	31.614	-2.112	8.40	20.9
85.0	499.9	228.4	271.4	9999.0	31.621	-1.972	8.39	20.7
86.0	521.8	250.4	271.4	9999.0	31.685	-1.851	8.39	20.6
86.5	532.8	261.4	271.4	9999.0	31.723	-1.759	8.39	20.6

Refusal occurred; no driving time output possible

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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
1.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
2.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
3.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
4.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
5.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
6.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
7.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00

8.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
9.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
10.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
11.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
12.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
13.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
14.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
15.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
16.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
17.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
18.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
19.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
20.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
21.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
22.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
23.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
24.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
25.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
26.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
27.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
28.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
29.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
30.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
31.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
32.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
33.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
34.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
35.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
36.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
37.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
38.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
39.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
40.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
41.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
42.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
43.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
44.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
45.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
46.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
47.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
48.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
49.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
50.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
51.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
52.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
53.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
54.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
55.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
56.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
57.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
58.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
59.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
60.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
61.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
62.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
63.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
64.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
65.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
66.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
67.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
68.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
69.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
70.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
71.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
72.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
73.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
74.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
75.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
76.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
77.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
78.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
79.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
80.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
81.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
82.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00

83.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
84.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
85.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
86.00	86.50	0.00	10.81	1.00	0.80	1.00	1.00
86.50	86.50	0.00	10.81	1.00	0.80	1.00	1.00

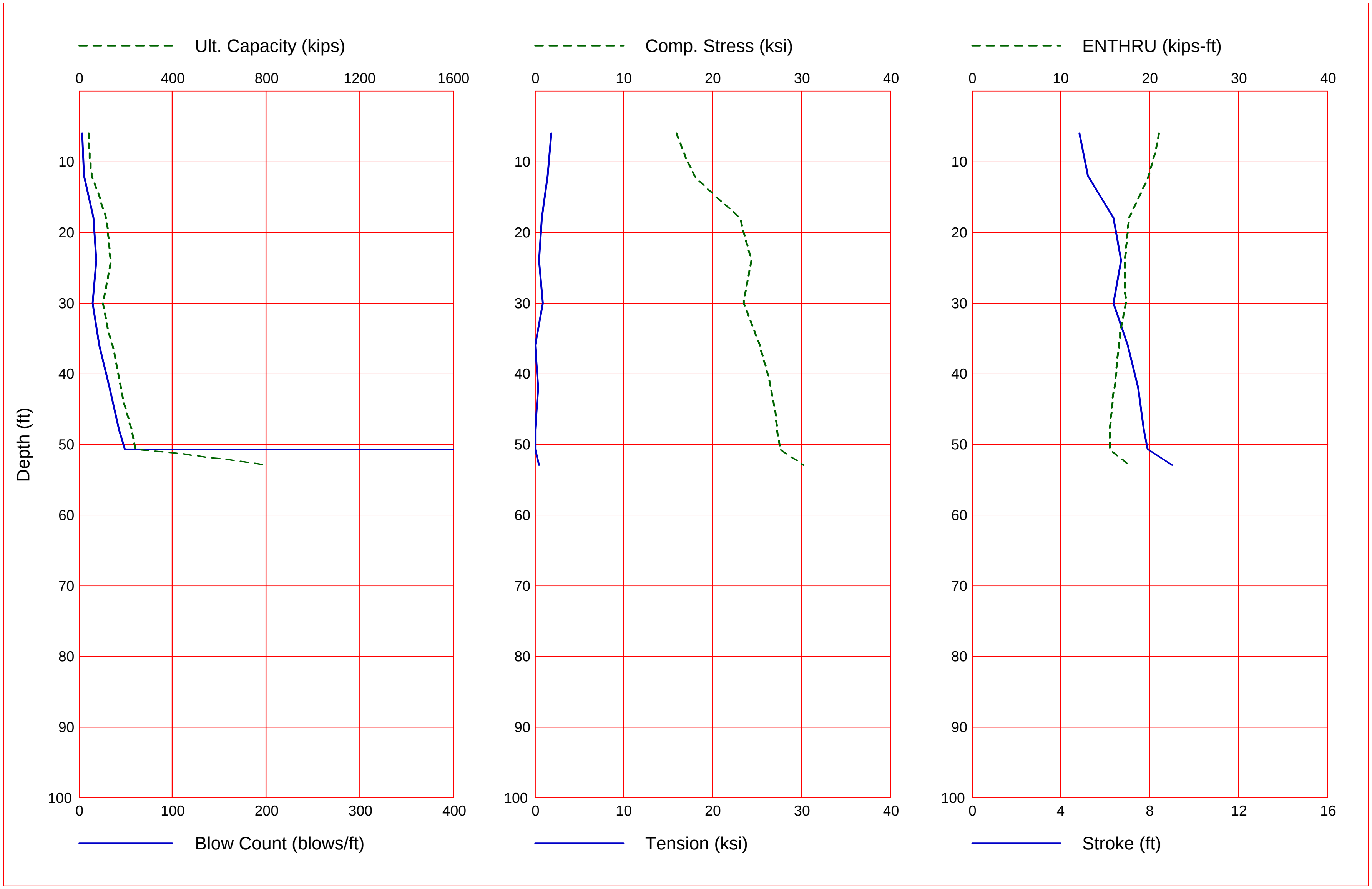
Soil Layer Resistance Values

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
0.00	0.00	11.48	0.100	0.167	0.200	0.150	1.000	6.560	168.000
21.00	0.55	11.48	0.100	0.167	0.200	0.150	1.000	6.560	168.000
21.00	0.35	17.79	0.100	0.168	0.200	0.150	0.667	6.560	84.000
36.00	0.60	30.49	0.100	0.168	0.200	0.150	0.667	6.560	84.000
36.00	0.73	69.45	0.100	0.168	0.050	0.150	0.000	6.560	1.000
41.00	0.86	69.45	0.100	0.168	0.050	0.150	0.000	6.560	1.000
41.00	0.85	42.52	0.100	0.168	0.050	0.150	0.000	6.560	1.000
56.00	1.21	42.52	0.100	0.168	0.050	0.150	0.000	6.560	1.000
56.00	0.93	46.83	0.100	0.168	0.200	0.150	0.667	6.560	84.000
81.50	1.29	65.04	0.100	0.168	0.200	0.150	0.667	6.560	84.000
81.50	10.00	271.44	0.100	0.100	0.050	0.150	0.667	6.560	84.000
86.50	10.00	271.44	0.100	0.100	0.050	0.150	0.667	6.560	84.000

Resource International Inc
FRA-70-1301A - Boring B-015-2-13

Dec 23 2014
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000



Gain/Loss 1 at Shaft and Toe 1.000 / 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
6.0	41.3	3.8	37.4	3.9	15.947	-1.895	4.84	21.1
12.0	53.5	16.0	37.4	5.6	17.958	-1.454	5.21	19.9
18.0	115.2	28.8	86.4	15.4	23.139	-0.799	6.38	17.6
24.0	133.9	47.5	86.4	19.0	24.397	-0.445	6.70	17.2
30.0	104.3	79.5	24.8	14.4	23.474	-0.861	6.39	17.3
36.0	142.3	117.5	24.8	22.0	25.294	-0.027	7.00	16.6
42.0	181.8	157.0	24.8	33.2	26.630	-0.379	7.48	16.1
48.0	222.8	198.0	24.8	43.5	27.242	-0.097	7.75	15.5
50.7	241.4	216.6	24.8	48.8	27.543	0.000	7.90	15.5
53.0	804.7	253.3	551.4	9999.0	30.201	-0.448	9.01	17.8

Refusal occurred; no driving time output possible

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

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

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

```
 Input  File: C:\USERS\JAMESH.RIICOLUMBUS\DESKTOP\DRIVEABILITY\B-015-2-13.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
 Hammer File Version:  2003 (2/22/2013)

                       Input File Contents
     FRA-70-1301A - Boring B-015-2-13
 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   1   0  0   0   0   0   0   0  0   0   0   0   0   0   0.000
    Pile g  Hammer g  Toe Area Pile Size          Pile Type
    32.185    32.185   198.500    14.580             H Pile
      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
    53.000     21.40   30457.9   493.356     4.699         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
0.100	0.243	0.200	0.150	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac
0.000 0.000 0.000 0.000
Research Soil Model: RD-skn: m, d, toe: m, d
0.000 0.000 0.000 0.000
Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	138.19	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4.50	0.17	138.19	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4.50	0.27	37.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12.00	0.54	37.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12.00	0.35	86.37	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26.00	0.83	86.37	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26.00	1.28	24.81	0.00	0.00	0.00	0.00	0.00	0.00	0.0
52.50	1.52	24.81	0.00	0.00	0.00	0.00	0.00	0.00	0.0
52.50	10.00	551.39	0.00	0.00	0.00	0.00	0.00	0.00	0.0
53.00	10.00	551.39	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Gain/Loss factors: shaft and toe
1.00000 0.00000 0.00000 0.00000 0.00000
1.00000 0.00000 0.00000 0.00000 0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
18.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
24.00	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
36.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
42.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
48.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
50.65	0.00	0.00	0.000	0.000	0.000	0.000	0.000
53.00	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-70-1301A - Boring B-015-2-13

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	0.0098	5.8
Combined Pile Top		16397.5			

HAMMER OPTIONS:

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

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	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

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                                                             B-015-2-13
 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
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FRA-70-1301A - Boring B-015-2-13                                 12/23/2014
Resource International Inc                               GRLWEAP Version 2010

 Depth                 (ft)       6.0
 Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)    198.500  Pile Type                    H Pile
 Pile Size           (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
       ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
      0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
     53.0    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     6.268

       Pile and Soil Model           Total Capacity Rut  (kips)      41.3
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  0.243    16397 0.010 0.000 0.85     0.0   0.000 0.100   3.31   4.7    21.4
  2  0.243    16397 0.000 0.000 1.00     0.0   0.000 0.100   6.62   4.7    21.4
 15  0.243    16397 0.000 0.000 1.00     0.6   0.200 0.100  49.69   4.7    21.4
 16  0.243    16397 0.000 0.000 1.00     3.2   0.200 0.100  53.00   4.7    21.4
Toe                                     37.4   0.150 0.243

     3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
     3.888 kips total reduced pile weight   (g= 32.19 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)     0.771
 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    32.185    32.185
 Output Segment Generation: Automatic

    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
     6.00     10.81      1.00     0.800
```

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FRA-70-1301A - Boring B-015-2-13                                 12/23/2014
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
   41.3     3.9   4.84   4.82   -1.89   3   8    15.95  10   4   21.1    53.9
         1          0   10.81000       11.86000
```

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FRA-70-1301A - Boring B-015-2-13                                 12/23/2014
Resource International Inc                               GRLWEAP Version 2010

 Depth                 (ft)      12.0
 Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)    198.500  Pile Type                    H Pile
 Pile Size           (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
       ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
      0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
     53.0    21.40   30458.    493.4      4.7       0    16911.     38.5
```

Wave Travel Time 2L/c (ms) 6.268

Pile and Soil Model — Total Capacity Rut (kips) 53.5

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.243	16397	0.010	0.000	0.85	0.0	0.000	0.100	3.31	4.7	21.4
2	0.243	16397	0.000	0.000	1.00	0.0	0.000	0.100	6.62	4.7	21.4
13	0.243	16397	0.000	0.000	1.00	0.4	0.200	0.100	43.06	4.7	21.4
14	0.243	16397	0.000	0.000	1.00	2.5	0.200	0.100	46.38	4.7	21.4
15	0.243	16397	0.000	0.000	1.00	5.6	0.200	0.100	49.69	4.7	21.4
16	0.243	16397	0.000	0.000	1.00	7.5	0.200	0.100	53.00	4.7	21.4
Toe						37.4	0.150	0.243			

3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
3.888 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
12.00	10.81	1.00	0.800

FRA-70-1301A - Boring B-015-2-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft) down	Stroke (ft) up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
53.5	5.6	5.21	5.20	-1.45	3	8	17.96	9	3	19.9	51.8

1 0 10.81000 11.86000

FRA-70-1301A - Boring B-015-2-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 18.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
53.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.268

Pile and Soil Model — Total Capacity Rut (kips) 115.2

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	0.243	16397	0.010	0.000	0.85	0.0	0.000	0.100	3.31	4.7	21.4
2	0.243	16397	0.000	0.000	1.00	0.0	0.000	0.100	6.62	4.7	21.4
11	0.243	16397	0.000	0.000	1.00	0.2	0.200	0.100	36.44	4.7	21.4
12	0.243	16397	0.000	0.000	1.00	1.9	0.200	0.100	39.75	4.7	21.4
13	0.243	16397	0.000	0.000	1.00	5.3	0.200	0.100	43.06	4.7	21.4
14	0.243	16397	0.000	0.000	1.00	7.1	0.200	0.100	46.38	4.7	21.4
15	0.243	16397	0.000	0.000	1.00	6.6	0.200	0.100	49.69	4.7	21.4
16	0.243	16397	0.000	0.000	1.00	7.8	0.200	0.100	53.00	4.7	21.4
Toe						86.4	0.150	0.243			

3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
3.888 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
18.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft) down	Stroke (ft) up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
115.2	15.4	6.38	6.39	-0.80	12	40	23.14	12	4	17.6	46.6

1 0 10.81000 11.86000

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Depth (ft) 24.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
53.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.268

Pile and Soil Model Total Capacity Rut (kips) 133.9

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.243	16397	0.010	0.000	0.85	0.0	0.000	0.100	3.31	4.7	21.4
2	0.243	16397	0.000	0.000	1.00	0.0	0.000	0.100	6.62	4.7	21.4
9	0.243	16397	0.000	0.000	1.00	0.1	0.200	0.100	29.81	4.7	21.4
10	0.243	16397	0.000	0.000	1.00	1.4	0.200	0.100	33.12	4.7	21.4
11	0.243	16397	0.000	0.000	1.00	4.7	0.200	0.100	36.44	4.7	21.4
12	0.243	16397	0.000	0.000	1.00	6.8	0.200	0.100	39.75	4.7	21.4
13	0.243	16397	0.000	0.000	1.00	6.8	0.200	0.100	43.06	4.7	21.4
14	0.243	16397	0.000	0.000	1.00	7.5	0.200	0.100	46.38	4.7	21.4
15	0.243	16397	0.000	0.000	1.00	9.2	0.200	0.100	49.69	4.7	21.4
16	0.243	16397	0.000	0.000	1.00	11.0	0.200	0.100	53.00	4.7	21.4
Toe						86.4	0.150	0.243			

3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
3.888 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
24.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
133.9	19.0	6.70	6.66	-0.45	10	37	24.40	11	4	17.2	45.6

1 0 10.81000 11.86000

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

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
53.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.268

Pile and Soil Model Total Capacity Rut (kips) 104.3

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	0.243	16397	0.010	0.000	0.85	0.0	0.000	0.100	3.31	4.7	21.4
2	0.243	16397	0.000	0.000	1.00	0.0	0.000	0.100	6.62	4.7	21.4
7	0.243	16397	0.000	0.000	1.00	0.0	0.200	0.100	23.19	4.7	21.4
8	0.243	16397	0.000	0.000	1.00	1.1	0.200	0.100	26.50	4.7	21.4
9	0.243	16397	0.000	0.000	1.00	4.1	0.200	0.100	29.81	4.7	21.4
10	0.243	16397	0.000	0.000	1.00	6.4	0.200	0.100	33.12	4.7	21.4

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 11  0.243    16397 0.000 0.000 1.00     7.0   0.200 0.100  36.44   4.7    21.4
 12  0.243    16397 0.000 0.000 1.00     7.1   0.200 0.100  39.75   4.7    21.4
 13  0.243    16397 0.000 0.000 1.00     8.9   0.200 0.100  43.06   4.7    21.4
 14  0.243    16397 0.000 0.000 1.00    10.7   0.200 0.100  46.38   4.7    21.4
 15  0.243    16397 0.000 0.000 1.00    13.9   0.200 0.100  49.69   4.7    21.4
 16  0.243    16397 0.000 0.000 1.00    20.3   0.200 0.100  53.00   4.7    21.4
Toe                                     24.8   0.150 0.243

     3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
     3.888 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    30.00     10.81      1.00     0.800
```

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FRA-70-1301A - Boring B-015-2-13                                   12/23/2014
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
  104.3    14.4   6.39   6.40   -0.86   9  39    23.47   9   3   17.3    46.6
         1           0   10.81000       11.86000
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FRA-70-1301A - Boring B-015-2-13                                   12/23/2014
Resource International Inc                              GRLWEAP Version 2010

 Depth                 (ft)      36.0
 Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                   H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3      ft             ft/s    k/ft/s
      0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
     53.0    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     6.268

        Pile and Soil Model           Total Capacity Rut  (kips)     142.3
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  0.243    16397 0.010 0.000 0.85     0.0   0.000 0.100   3.31   4.7    21.4
  2  0.243    16397 0.000 0.000 1.00     0.0   0.000 0.100   6.62   4.7    21.4
  6  0.243    16397 0.000 0.000 1.00     0.7   0.200 0.100  19.88   4.7    21.4
  7  0.243    16397 0.000 0.000 1.00     3.4   0.200 0.100  23.19   4.7    21.4
  8  0.243    16397 0.000 0.000 1.00     6.1   0.200 0.100  26.50   4.7    21.4
  9  0.243    16397 0.000 0.000 1.00     7.2   0.200 0.100  29.81   4.7    21.4
 10  0.243    16397 0.000 0.000 1.00     6.8   0.200 0.100  33.12   4.7    21.4
 11  0.243    16397 0.000 0.000 1.00     8.6   0.200 0.100  36.44   4.7    21.4
 12  0.243    16397 0.000 0.000 1.00    10.3   0.200 0.100  39.75   4.7    21.4
 13  0.243    16397 0.000 0.000 1.00    12.3   0.200 0.100  43.06   4.7    21.4
 14  0.243    16397 0.000 0.000 1.00    20.2   0.200 0.100  46.38   4.7    21.4
 15  0.243    16397 0.000 0.000 1.00    20.7   0.200 0.100  49.69   4.7    21.4
 16  0.243    16397 0.000 0.000 1.00    21.2   0.200 0.100  53.00   4.7    21.4
Toe                                     24.8   0.150 0.243

     3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
     3.888 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    36.00     10.81      1.00     0.800
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FRA-70-1301A - Boring B-015-2-13                                   12/23/2014
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
  142.3    22.0   7.00   6.97   -0.03   8  34    25.29   7   3   16.6    44.6
         1           0   10.81000       11.86000
```

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FRA-70-1301A - Boring B-015-2-13                              12/23/2014
Resource International Inc                              GRLWEAP Version 2010

 Depth                (ft)      42.0
 Shaft Gain/Loss Factor        1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
    53.0    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     6.268

       Pile and Soil Model            Total Capacity Rut  (kips)     181.8
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  0.243    16397 0.010 0.000 0.85     0.0   0.000 0.100   3.31   4.7    21.4
  2  0.243    16397 0.000 0.000 1.00     0.0   0.000 0.100   6.62   4.7    21.4
  4  0.243    16397 0.000 0.000 1.00     0.4   0.200 0.100  13.25   4.7    21.4
  5  0.243    16397 0.000 0.000 1.00     2.7   0.200 0.100  16.56   4.7    21.4
  6  0.243    16397 0.000 0.000 1.00     5.7   0.200 0.100  19.88   4.7    21.4
  7  0.243    16397 0.000 0.000 1.00     7.4   0.200 0.100  23.19   4.7    21.4
  8  0.243    16397 0.000 0.000 1.00     6.5   0.200 0.100  26.50   4.7    21.4
  9  0.243    16397 0.000 0.000 1.00     8.2   0.200 0.100  29.81   4.7    21.4
 10  0.243    16397 0.000 0.000 1.00    10.0   0.200 0.100  33.12   4.7    21.4
 11  0.243    16397 0.000 0.000 1.00    11.8   0.200 0.100  36.44   4.7    21.4
 12  0.243    16397 0.000 0.000 1.00    18.9   0.200 0.100  39.75   4.7    21.4
 13  0.243    16397 0.000 0.000 1.00    20.6   0.200 0.100  43.06   4.7    21.4
 14  0.243    16397 0.000 0.000 1.00    21.1   0.200 0.100  46.38   4.7    21.4
 15  0.243    16397 0.000 0.000 1.00    21.5   0.200 0.100  49.69   4.7    21.4
 16  0.243    16397 0.000 0.000 1.00    22.0   0.200 0.100  53.00   4.7    21.4
Toe                                     24.8   0.150 0.243

     3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
     3.888 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    42.00     10.81      1.00     0.800
↑
FRA-70-1301A - Boring B-015-2-13                              12/23/2014
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
  181.8    33.2   7.48   7.47   -0.38   5  50    26.63   6   3   16.1    43.2
        1          0   10.81000       11.86000
↑
FRA-70-1301A - Boring B-015-2-13                              12/23/2014
Resource International Inc                              GRLWEAP Version 2010

 Depth                (ft)      48.0
 Shaft Gain/Loss Factor        1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
    53.0    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     6.268

       Pile and Soil Model            Total Capacity Rut  (kips)     222.8
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  0.243    16397 0.010 0.000 0.85     0.0   0.000 0.100   3.31   4.7    21.4
  2  0.243    16397 0.000 0.000 1.00     0.2   0.200 0.100   6.62   4.7    21.4
```

3	0.243	16397	0.000	0.000	1.00	2.1	0.200	0.100	9.94	4.7	21.4
4	0.243	16397	0.000	0.000	1.00	5.4	0.200	0.100	13.25	4.7	21.4
5	0.243	16397	0.000	0.000	1.00	7.3	0.200	0.100	16.56	4.7	21.4
6	0.243	16397	0.000	0.000	1.00	6.5	0.200	0.100	19.88	4.7	21.4
7	0.243	16397	0.000	0.000	1.00	7.9	0.200	0.100	23.19	4.7	21.4
8	0.243	16397	0.000	0.000	1.00	9.7	0.200	0.100	26.50	4.7	21.4
9	0.243	16397	0.000	0.000	1.00	11.5	0.200	0.100	29.81	4.7	21.4
10	0.243	16397	0.000	0.000	1.00	17.5	0.200	0.100	33.12	4.7	21.4
11	0.243	16397	0.000	0.000	1.00	20.5	0.200	0.100	36.44	4.7	21.4
12	0.243	16397	0.000	0.000	1.00	21.0	0.200	0.100	39.75	4.7	21.4
13	0.243	16397	0.000	0.000	1.00	21.5	0.200	0.100	43.06	4.7	21.4
14	0.243	16397	0.000	0.000	1.00	21.9	0.200	0.100	46.38	4.7	21.4
15	0.243	16397	0.000	0.000	1.00	22.4	0.200	0.100	49.69	4.7	21.4
16	0.243	16397	0.000	0.000	1.00	22.8	0.200	0.100	53.00	4.7	21.4
Toe						24.8	0.150	0.243			

3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
3.888 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
48.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
222.8	43.5	7.75	7.80	-0.10	3	48	27.24	4	2	15.5	42.4

1 0 10.81000 11.86000

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Depth (ft) 50.7
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
53.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.268

Pile and Soil Model Total Capacity Rut (kips) 241.4

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	0.243	16397	0.010	0.000	0.85	0.1	0.200	0.100	3.31	4.7	21.4
2	0.243	16397	0.000	0.000	1.00	1.5	0.200	0.100	6.62	4.7	21.4
3	0.243	16397	0.000	0.000	1.00	4.9	0.200	0.100	9.94	4.7	21.4
4	0.243	16397	0.000	0.000	1.00	6.9	0.200	0.100	13.25	4.7	21.4
5	0.243	16397	0.000	0.000	1.00	6.7	0.200	0.100	16.56	4.7	21.4
6	0.243	16397	0.000	0.000	1.00	7.5	0.200	0.100	19.88	4.7	21.4
7	0.243	16397	0.000	0.000	1.00	9.3	0.200	0.100	23.19	4.7	21.4
8	0.243	16397	0.000	0.000	1.00	11.1	0.200	0.100	26.50	4.7	21.4
9	0.243	16397	0.000	0.000	1.00	15.8	0.200	0.100	29.81	4.7	21.4
10	0.243	16397	0.000	0.000	1.00	20.4	0.200	0.100	33.12	4.7	21.4
11	0.243	16397	0.000	0.000	1.00	20.9	0.200	0.100	36.44	4.7	21.4
12	0.243	16397	0.000	0.000	1.00	21.4	0.200	0.100	39.75	4.7	21.4
13	0.243	16397	0.000	0.000	1.00	21.8	0.200	0.100	43.06	4.7	21.4
14	0.243	16397	0.000	0.000	1.00	22.3	0.200	0.100	46.38	4.7	21.4
15	0.243	16397	0.000	0.000	1.00	22.7	0.200	0.100	49.69	4.7	21.4
16	0.243	16397	0.000	0.000	1.00	23.2	0.200	0.100	53.00	4.7	21.4
Toe						24.8	0.150	0.243			

3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
3.888 kips total reduced pile weight (g= 32.19 ft/s2)

Depth Stroke Pressure Efficy

ft	ft	Ratio	
50.65	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
241.4	48.8	7.90	7.92	0.00	1	0	27.54	3	2	15.5	42.0

1 0 10.81000 11.86000

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Depth (ft) 53.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
53.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.268

Pile and Soil Model Total Capacity Rut (kips) 804.7

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	0.243	16397	0.010	0.000	0.85	0.9	0.200	0.100	3.31	4.7	21.4
2	0.243	16397	0.000	0.000	1.00	3.9	0.200	0.100	6.62	4.7	21.4
3	0.243	16397	0.000	0.000	1.00	6.3	0.200	0.100	9.94	4.7	21.4
4	0.243	16397	0.000	0.000	1.00	7.1	0.200	0.100	13.25	4.7	21.4
5	0.243	16397	0.000	0.000	1.00	7.0	0.200	0.100	16.56	4.7	21.4
6	0.243	16397	0.000	0.000	1.00	8.8	0.200	0.100	19.88	4.7	21.4
7	0.243	16397	0.000	0.000	1.00	10.6	0.200	0.100	23.19	4.7	21.4
8	0.243	16397	0.000	0.000	1.00	13.4	0.200	0.100	26.50	4.7	21.4
9	0.243	16397	0.000	0.000	1.00	20.3	0.200	0.100	29.81	4.7	21.4
10	0.243	16397	0.000	0.000	1.00	20.8	0.200	0.100	33.12	4.7	21.4
11	0.243	16397	0.000	0.000	1.00	21.2	0.200	0.100	36.44	4.7	21.4
12	0.243	16397	0.000	0.000	1.00	21.7	0.200	0.100	39.75	4.7	21.4
13	0.243	16397	0.000	0.000	1.00	22.1	0.200	0.100	43.06	4.7	21.4
14	0.243	16397	0.000	0.000	1.00	22.6	0.200	0.100	46.38	4.7	21.4
15	0.243	16397	0.000	0.000	1.00	23.1	0.200	0.100	49.69	4.7	21.4
16	0.243	16397	0.000	0.000	1.00	43.4	0.200	0.100	53.00	4.7	21.4
Toe						551.4	0.150	0.243			

3.886 kips total unreduced pile weight (g= 32.17 ft/s2)
3.888 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
53.00	10.81	1.00	0.800

FRA-70-1301A - Boring B-015-2-13 12/23/2014
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
804.7	9999.0	9.01	9.00	-0.45	3	31	30.20	2	2	17.8	39.5

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Resource International Inc GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 1.000 1.000

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
6.0	41.3	3.8	37.4	3.9	15.947	-1.895	4.84	21.1
12.0	53.5	16.0	37.4	5.6	17.958	-1.454	5.21	19.9
18.0	115.2	28.8	86.4	15.4	23.139	-0.799	6.38	17.6

B-015-2-13

24.0	133.9	47.5	86.4	19.0	24.397	-0.445	6.70	17.2
30.0	104.3	79.5	24.8	14.4	23.474	-0.861	6.39	17.3
36.0	142.3	117.5	24.8	22.0	25.294	-0.027	7.00	16.6
42.0	181.8	157.0	24.8	33.2	26.630	-0.379	7.48	16.1
48.0	222.8	198.0	24.8	43.5	27.242	-0.097	7.75	15.5
50.7	241.4	216.6	24.8	48.8	27.543	0.000	7.90	15.5
53.0	804.7	253.3	551.4	9999.0	30.201	-0.448	9.01	17.8

Refusal occurred; no driving time output possible

FRA-70-1301A - Boring B-015-2-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
6.00	53.00	0.00	10.81	1.00	0.80	1.00	1.00
12.00	53.00	0.00	10.81	1.00	0.80	1.00	1.00
18.00	53.00	0.00	10.81	1.00	0.80	1.00	1.00
24.00	53.00	0.00	10.81	1.00	0.80	1.00	1.00
30.00	53.00	0.00	10.81	1.00	0.80	1.00	1.00
36.00	53.00	0.00	10.81	1.00	0.80	1.00	1.00
42.00	53.00	0.00	10.81	1.00	0.80	1.00	1.00
48.00	53.00	0.00	10.81	1.00	0.80	1.00	1.00
50.65	53.00	0.00	10.81	1.00	0.80	1.00	1.00
53.00	53.00	0.00	10.81	1.00	0.80	1.00	1.00

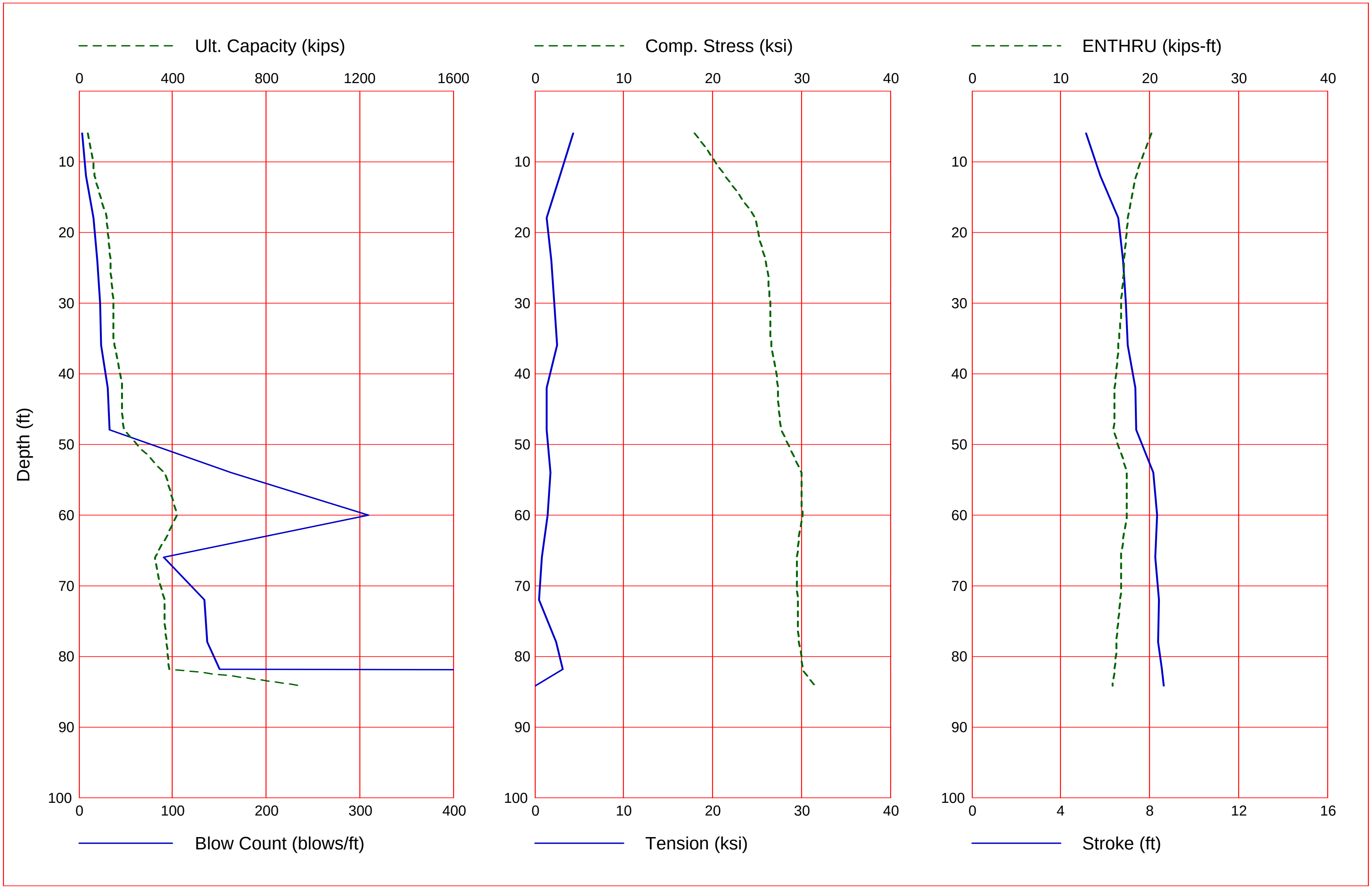
Soil Layer Resistance Values

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
0.00	0.00	138.19	0.100	0.243	0.200	0.150	1.000	0.000	0.000
4.50	0.17	138.19	0.100	0.243	0.200	0.150	1.000	0.000	0.000
4.50	0.27	37.43	0.100	0.243	0.200	0.150	1.000	0.000	0.000
12.00	0.54	37.43	0.100	0.243	0.200	0.150	1.000	0.000	0.000
12.00	0.35	86.37	0.100	0.243	0.200	0.150	1.000	0.000	0.000
26.00	0.83	86.37	0.100	0.243	0.200	0.150	1.000	0.000	0.000
26.00	1.28	24.81	0.100	0.243	0.200	0.150	1.000	0.000	0.000
52.50	1.52	24.81	0.100	0.243	0.200	0.150	1.000	0.000	0.000
52.50	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000
53.00	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000

Resource International Inc
FRA-70-1301A - Boring B-015-4-13

Dec 23 2014
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000



Gain/Loss 1 at Shaft and Toe 1.000 / 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
6.0	39.9	24.4	15.5	3.9	17.944	-4.347	5.15	20.2
12.0	65.3	49.8	15.5	7.6	21.346	-2.845	5.76	18.5
18.0	119.2	70.3	48.9	16.1	24.832	-1.320	6.58	17.5
24.0	137.6	88.7	48.9	20.0	25.966	-1.820	6.80	17.1
30.0	146.3	106.0	40.3	22.3	26.482	-2.190	6.92	16.8
36.0	150.9	132.3	18.6	23.8	26.615	-2.460	7.03	16.5
42.0	185.4	166.8	18.6	31.0	27.314	-1.379	7.34	16.1
48.0	194.0	187.8	6.2	33.1	27.686	-1.356	7.42	15.9
54.0	367.4	211.8	155.6	162.5	30.040	-1.752	8.19	17.4
60.0	420.9	255.0	165.9	309.3	30.104	-1.444	8.33	17.4
66.0	325.6	300.8	24.8	90.3	29.481	-0.787	8.26	16.8
72.0	368.4	339.6	28.8	134.1	29.651	-0.500	8.42	16.7
78.0	374.2	364.9	9.3	137.0	29.691	-2.354	8.40	16.3
81.8	387.1	377.8	9.3	150.1	30.117	-3.126	8.54	16.1
84.2	958.9	407.5	551.4	9999.0	31.518	0.000	8.63	15.8

Refusal occurred; no driving time output possible

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

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

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

```
 Input  File: C:\USERS\JAMESH.RIICOLUMBUS\DESKTOP\DRIVEABILITY\B-015-4-13.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
 Hammer File Version:  2003 (2/22/2013)

                       Input File Contents
     FRA-70-1301A - Boring B-015-4-13
 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   1   0  0   0   0   0   0   0  0   0   0   0   0   0   0.000
    Pile g  Hammer g  Toe Area Pile Size          Pile Type
    32.185    32.185   198.500    14.580             H Pile
      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
    84.200     21.40   30457.9   493.356     4.699         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
0.100	0.243	0.200	0.150	0.000	0.000	0.000	0.000

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

0.000	0.000	0.000	0.000

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

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.85	15.51	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15.00	0.94	15.51	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15.00	0.49	48.94	0.00	0.00	0.00	0.00	0.00	0.00	0.0
25.00	0.76	48.94	0.00	0.00	0.00	0.00	0.00	0.00	0.0
25.00	0.54	7.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
29.00	0.55	7.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
29.00	0.74	40.31	0.00	0.00	0.00	0.00	0.00	0.00	0.0
34.00	0.84	40.31	0.00	0.00	0.00	0.00	0.00	0.00	0.0
34.00	1.19	18.61	0.00	0.00	0.00	0.00	0.00	0.00	0.0
44.00	1.26	18.61	0.00	0.00	0.00	0.00	0.00	0.00	0.0
44.00	0.49	6.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
51.66	0.50	6.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
51.66	1.38	151.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
64.00	1.74	172.74	0.00	0.00	0.00	0.00	0.00	0.00	0.0
64.00	1.52	24.81	0.00	0.00	0.00	0.00	0.00	0.00	0.0
69.00	1.52	24.81	0.00	0.00	0.00	0.00	0.00	0.00	0.0
69.00	1.21	28.79	0.00	0.00	0.00	0.00	0.00	0.00	0.0
74.00	1.27	28.79	0.00	0.00	0.00	0.00	0.00	0.00	0.0
74.00	0.71	9.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
83.70	0.71	9.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
83.70	10.00	551.39	0.00	0.00	0.00	0.00	0.00	0.00	0.0
84.20	10.00	551.39	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Gain/Loss factors: shaft and toe

1.00000	0.00000	0.00000	0.00000	0.00000
1.00000	0.00000	0.00000	0.00000	0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
18.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
24.00	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
36.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
42.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
48.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
54.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
66.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
72.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
78.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
81.85	0.00	0.00	0.000	0.000	0.000	0.000	0.000
84.20	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-70-1301A - Boring B-015-4-13

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	0.0098	5.8
Combined Pile Top		16127.3			

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-70-1301A - Boring B-015-4-13                                 12/23/2014
Resource International Inc                               GRLWEAP Version 2010

  Depth                 (ft)       6.0
  Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor           1.000

  PILE PROFILE:
  Toe Area            (in2)    198.500  Pile Type                     H Pile
  Pile Size          (inch)     14.580

   L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
        ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
       0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
      84.2    21.40   30458.    493.4      4.7       0    16911.     38.5

  Wave Travel Time 2L/c (ms)     9.958

         Pile and Soil Model            Total Capacity Rut  (kips)      39.9
 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  0.247    16127 0.010 0.000 0.85     0.0   0.000 0.100   3.37   4.7    21.4
   2  0.247    16127 0.000 0.000 1.00     0.0   0.000 0.100   6.74   4.7    21.4
  24  0.247    16127 0.000 0.000 1.00    10.6   0.200 0.100  80.83   4.7    21.4
  25  0.247    16127 0.000 0.000 1.00    13.8   0.200 0.100  84.20   4.7    21.4
 Toe                                     15.5   0.150 0.243

      6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
      6.176 kips total reduced pile weight   (g= 32.19 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)     0.771
  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    32.185    32.185
  Output Segment Generation: Automatic

     Depth    Stroke  Pressure    Efficy
        ft        ft     Ratio
      6.00     10.81      1.00     0.800
```

```
FRA-70-1301A - Boring B-015-4-13                                 12/23/2014
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
```

```
   39.9     3.9   5.15   5.20   -4.35   6  11    17.94  10   4   20.2    52.1
          1           0   10.81000       11.86000
```

FRA-70-1301A - Boring B-015-4-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

```
 Depth                  (ft)      12.0
 Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft              ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7        0    16911.     38.5
    84.2    21.40   30458.    493.4      4.7        0    16911.     38.5

 Wave Travel Time 2L/c (ms)     9.958

        Pile and Soil Model            Total Capacity Rut  (kips)      65.3
No. Weight   Stiffn C-Slk T-Slk  CoR  Soil-S  Soil-D Quake  LbTop Perim    Area
      kips     k/in    ft    ft        kips    s/ft  inch     ft    ft     in2
  1  0.247    16127 0.010 0.000 0.85     0.0   0.000 0.100   3.37   4.7    21.4
  2  0.247    16127 0.000 0.000 1.00     0.0   0.000 0.100   6.74   4.7    21.4
 22  0.247    16127 0.000 0.000 1.00     7.6   0.200 0.100  74.10   4.7    21.4
 23  0.247    16127 0.000 0.000 1.00    13.8   0.200 0.100  77.46   4.7    21.4
 24  0.247    16127 0.000 0.000 1.00    14.1   0.200 0.100  80.83   4.7    21.4
 25  0.247    16127 0.000 0.000 1.00    14.4   0.200 0.100  84.20   4.7    21.4
Toe                                     15.5   0.150 0.243

     6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
     6.176 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    12.00     10.81      1.00     0.800
```

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```
    Rut   Bl Ct   Stroke (ft) Ten Str   i   t Comp Str   i   t ENTHRU   Bl Rt
   kips    b/ft   down     up     ksi             ksi          kip-ft   b/min
   65.3     7.6   5.76   5.78   -2.85   6  11    21.35  22   6   18.5    49.1
          1           0   10.81000       11.86000
```

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```
 Depth                  (ft)      18.0
 Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft              ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7        0    16911.     38.5
    84.2    21.40   30458.    493.4      4.7        0    16911.     38.5

 Wave Travel Time 2L/c (ms)     9.958

        Pile and Soil Model            Total Capacity Rut  (kips)     119.2
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  0.247    16127 0.010 0.000 0.85     0.0   0.000 0.100   3.37   4.7    21.4
  2  0.247    16127 0.000 0.000 1.00     0.0   0.000 0.100   6.74   4.7    21.4
 20  0.247    16127 0.000 0.000 1.00     4.6   0.200 0.100  67.36   4.7    21.4
 21  0.247    16127 0.000 0.000 1.00    13.7   0.200 0.100  70.73   4.7    21.4
 22  0.247    16127 0.000 0.000 1.00    14.0   0.200 0.100  74.10   4.7    21.4
 23  0.247    16127 0.000 0.000 1.00    14.3   0.200 0.100  77.46   4.7    21.4
 24  0.247    16127 0.000 0.000 1.00    14.6   0.200 0.100  80.83   4.7    21.4
 25  0.247    16127 0.000 0.000 1.00     9.0   0.200 0.100  84.20   4.7    21.4
```

```
Toe                                   48.9   0.150 0.243

     6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
     6.176 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    18.00     10.81      1.00     0.800

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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
  119.2    16.1   6.58   6.53   -1.32  18  44    24.83  20   6   17.5    46.0
          1           0   10.81000       11.86000

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Resource International Inc                              GRLWEAP Version 2010

 Depth                 (ft)      24.0
 Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                     H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7        0    16911.     38.5
    84.2    21.40   30458.    493.4      4.7        0    16911.     38.5

 Wave Travel Time 2L/c (ms)     9.958

       Pile and Soil Model           Total Capacity Rut  (kips)     137.6
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  0.247    16127 0.010 0.000 0.85     0.0   0.000 0.100   3.37   4.7    21.4
  2  0.247    16127 0.000 0.000 1.00     0.0   0.000 0.100   6.74   4.7    21.4
 18  0.247    16127 0.000 0.000 1.00     1.7   0.200 0.100  60.62   4.7    21.4
 19  0.247    16127 0.000 0.000 1.00    13.6   0.200 0.100  63.99   4.7    21.4
 20  0.247    16127 0.000 0.000 1.00    13.9   0.200 0.100  67.36   4.7    21.4
 21  0.247    16127 0.000 0.000 1.00    14.2   0.200 0.100  70.73   4.7    21.4
 22  0.247    16127 0.000 0.000 1.00    14.5   0.200 0.100  74.10   4.7    21.4
 23  0.247    16127 0.000 0.000 1.00    10.3   0.200 0.100  77.46   4.7    21.4
 24  0.247    16127 0.000 0.000 1.00     9.4   0.200 0.100  80.83   4.7    21.4
 25  0.247    16127 0.000 0.000 1.00    10.9   0.200 0.100  84.20   4.7    21.4
Toe                                   48.9   0.150 0.243

     6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
     6.176 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    24.00     10.81      1.00     0.800

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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
  137.6    20.0   6.80   6.77   -1.82  19  38    25.97  19   6   17.1    45.3
          1           0   10.81000       11.86000

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Resource International Inc                              GRLWEAP Version 2010

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

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                     H Pile
 Pile Size          (inch)    14.580
```

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
84.2	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 9.958

Pile and Soil Model — Total Capacity Rut (kips) 146.3

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.247	16127	0.010	0.000	0.85	0.0	0.000	0.100	3.37	4.7	21.4
2	0.247	16127	0.000	0.000	1.00	0.0	0.000	0.100	6.74	4.7	21.4
17	0.247	16127	0.000	0.000	1.00	12.3	0.200	0.100	57.26	4.7	21.4
18	0.247	16127	0.000	0.000	1.00	13.9	0.200	0.100	60.62	4.7	21.4
19	0.247	16127	0.000	0.000	1.00	14.2	0.200	0.100	63.99	4.7	21.4
20	0.247	16127	0.000	0.000	1.00	14.5	0.200	0.100	67.36	4.7	21.4
21	0.247	16127	0.000	0.000	1.00	11.7	0.200	0.100	70.73	4.7	21.4
22	0.247	16127	0.000	0.000	1.00	9.1	0.200	0.100	74.10	4.7	21.4
23	0.247	16127	0.000	0.000	1.00	10.6	0.200	0.100	77.46	4.7	21.4
24	0.247	16127	0.000	0.000	1.00	10.2	0.200	0.100	80.83	4.7	21.4
25	0.247	16127	0.000	0.000	1.00	9.7	0.200	0.100	84.20	4.7	21.4
Toe						40.3	0.150	0.243			

6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
6.176 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	10.81	1.00	0.800

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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
146.3	22.3	6.92	6.91	-2.19	10	37	26.48	17	5	16.8	44.9

1 0 10.81000 11.86000

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Depth (ft) 36.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
84.2	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 9.958

Pile and Soil Model — Total Capacity Rut (kips) 150.9

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	0.247	16127	0.010	0.000	0.85	0.0	0.000	0.100	3.37	4.7	21.4
2	0.247	16127	0.000	0.000	1.00	0.0	0.000	0.100	6.74	4.7	21.4
15	0.247	16127	0.000	0.000	1.00	9.3	0.200	0.100	50.52	4.7	21.4
16	0.247	16127	0.000	0.000	1.00	13.8	0.200	0.100	53.89	4.7	21.4
17	0.247	16127	0.000	0.000	1.00	14.1	0.200	0.100	57.26	4.7	21.4
18	0.247	16127	0.000	0.000	1.00	14.4	0.200	0.100	60.62	4.7	21.4
19	0.247	16127	0.000	0.000	1.00	13.1	0.200	0.100	63.99	4.7	21.4
20	0.247	16127	0.000	0.000	1.00	8.8	0.200	0.100	67.36	4.7	21.4
21	0.247	16127	0.000	0.000	1.00	10.2	0.200	0.100	70.73	4.7	21.4
22	0.247	16127	0.000	0.000	1.00	10.7	0.200	0.100	74.10	4.7	21.4
23	0.247	16127	0.000	0.000	1.00	8.9	0.200	0.100	77.46	4.7	21.4
24	0.247	16127	0.000	0.000	1.00	12.4	0.200	0.100	80.83	4.7	21.4
25	0.247	16127	0.000	0.000	1.00	16.6	0.200	0.100	84.20	4.7	21.4
Toe						18.6	0.150	0.243			

6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
6.176 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
36.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
150.9	23.8	7.03	7.03	-2.46	10	37	26.61	15	5	16.5	44.5

1 0 10.81000 11.86000

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Resource International Inc GRLWEAP Version 2010

Depth (ft) 42.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
84.2	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 9.958

Pile and Soil Model Total Capacity Rut (kips) 185.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	16127	0.010	0.000	0.85	0.0	0.000	0.100	3.37	4.7	21.4
2	0.247	16127	0.000	0.000	1.00	0.0	0.000	0.100	6.74	4.7	21.4
13	0.247	16127	0.000	0.000	1.00	6.4	0.200	0.100	43.78	4.7	21.4
14	0.247	16127	0.000	0.000	1.00	13.7	0.200	0.100	47.15	4.7	21.4
15	0.247	16127	0.000	0.000	1.00	14.0	0.200	0.100	50.52	4.7	21.4
16	0.247	16127	0.000	0.000	1.00	14.3	0.200	0.100	53.89	4.7	21.4
17	0.247	16127	0.000	0.000	1.00	14.5	0.200	0.100	57.26	4.7	21.4
18	0.247	16127	0.000	0.000	1.00	8.4	0.200	0.100	60.62	4.7	21.4
19	0.247	16127	0.000	0.000	1.00	9.9	0.200	0.100	63.99	4.7	21.4
20	0.247	16127	0.000	0.000	1.00	11.2	0.200	0.100	67.36	4.7	21.4
21	0.247	16127	0.000	0.000	1.00	8.6	0.200	0.100	70.73	4.7	21.4
22	0.247	16127	0.000	0.000	1.00	11.7	0.200	0.100	74.10	4.7	21.4
23	0.247	16127	0.000	0.000	1.00	15.2	0.200	0.100	77.46	4.7	21.4
24	0.247	16127	0.000	0.000	1.00	19.1	0.200	0.100	80.83	4.7	21.4
25	0.247	16127	0.000	0.000	1.00	19.5	0.200	0.100	84.20	4.7	21.4
Toe						18.6	0.150	0.243			

6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
6.176 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
42.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
185.4	31.0	7.34	7.34	-1.38	9	36	27.31	13	4	16.1	43.5

1 0 10.81000 11.86000

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Depth (ft) 48.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

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 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
       ft      in2      ksi   lb/ft3       ft              ft/s    k/ft/s
      0.0    21.40   30458.    493.4      4.7        0    16911.     38.5
     84.2    21.40   30458.    493.4      4.7        0    16911.     38.5

 Wave Travel Time 2L/c (ms)     9.958

        Pile and Soil Model            Total Capacity Rut  (kips)     194.0
No. Weight   Stiffn C-Slk T-Slk  CoR  Soil-S  Soil-D Quake  LbTop Perim    Area
      kips     k/in    ft    ft         kips    s/ft  inch     ft    ft     in2
  1  0.247    16127 0.010 0.000 0.85     0.0   0.000 0.100   3.37   4.7    21.4
  2  0.247    16127 0.000 0.000 1.00     0.0   0.000 0.100   6.74   4.7    21.4
 11  0.247    16127 0.000 0.000 1.00     3.4   0.200 0.100  37.05   4.7    21.4
 12  0.247    16127 0.000 0.000 1.00    13.7   0.200 0.100  40.42   4.7    21.4
 13  0.247    16127 0.000 0.000 1.00    14.0   0.200 0.100  43.78   4.7    21.4
 14  0.247    16127 0.000 0.000 1.00    14.3   0.200 0.100  47.15   4.7    21.4
 15  0.247    16127 0.000 0.000 1.00    14.6   0.200 0.100  50.52   4.7    21.4
 16  0.247    16127 0.000 0.000 1.00     9.6   0.200 0.100  53.89   4.7    21.4
 17  0.247    16127 0.000 0.000 1.00     9.6   0.200 0.100  57.26   4.7    21.4
 18  0.247    16127 0.000 0.000 1.00    11.1   0.200 0.100  60.62   4.7    21.4
 19  0.247    16127 0.000 0.000 1.00     9.2   0.200 0.100  63.99   4.7    21.4
 20  0.247    16127 0.000 0.000 1.00    10.9   0.200 0.100  67.36   4.7    21.4
 21  0.247    16127 0.000 0.000 1.00    13.8   0.200 0.100  70.73   4.7    21.4
 22  0.247    16127 0.000 0.000 1.00    19.1   0.200 0.100  74.10   4.7    21.4
 23  0.247    16127 0.000 0.000 1.00    19.4   0.200 0.100  77.46   4.7    21.4
 24  0.247    16127 0.000 0.000 1.00    17.5   0.200 0.100  80.83   4.7    21.4
 25  0.247    16127 0.000 0.000 1.00     7.8   0.200 0.100  84.20   4.7    21.4
Toe                                      6.2   0.150 0.243

     6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
     6.176 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    48.00     10.81      1.00     0.800
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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
  194.0    33.1   7.42   7.47   -1.36  24   8    27.69  12   4   15.9    43.3
          1           0   10.81000       11.86000
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FRA-70-1301A - Boring B-015-4-13                                  12/23/2014
Resource International Inc                              GRLWEAP Version 2010

 Depth                 (ft)      54.0
 Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
       ft      in2      ksi   lb/ft3       ft              ft/s    k/ft/s
      0.0    21.40   30458.    493.4      4.7        0    16911.     38.5
     84.2    21.40   30458.    493.4      4.7        0    16911.     38.5

 Wave Travel Time 2L/c (ms)     9.958

        Pile and Soil Model            Total Capacity Rut  (kips)     367.4
No. Weight   Stiffn C-Slk T-Slk  CoR  Soil-S  Soil-D Quake  LbTop Perim    Area
      kips     k/in    ft    ft         kips    s/ft  inch     ft    ft     in2
  1  0.247    16127 0.010 0.000 0.85     0.0   0.000 0.100   3.37   4.7    21.4
  2  0.247    16127 0.000 0.000 1.00     0.0   0.000 0.100   6.74   4.7    21.4
  9  0.247    16127 0.000 0.000 1.00     0.4   0.200 0.100  30.31   4.7    21.4
 10  0.247    16127 0.000 0.000 1.00    13.6   0.200 0.100  33.68   4.7    21.4
 11  0.247    16127 0.000 0.000 1.00    13.9   0.200 0.100  37.05   4.7    21.4
 12  0.247    16127 0.000 0.000 1.00    14.2   0.200 0.100  40.42   4.7    21.4
```

13	0.247	16127	0.000	0.000	1.00	14.5	0.200	0.100	43.78	4.7	21.4
14	0.247	16127	0.000	0.000	1.00	10.9	0.200	0.100	47.15	4.7	21.4
15	0.247	16127	0.000	0.000	1.00	9.3	0.200	0.100	50.52	4.7	21.4
16	0.247	16127	0.000	0.000	1.00	10.7	0.200	0.100	53.89	4.7	21.4
17	0.247	16127	0.000	0.000	1.00	9.8	0.200	0.100	57.26	4.7	21.4
18	0.247	16127	0.000	0.000	1.00	10.1	0.200	0.100	60.62	4.7	21.4
19	0.247	16127	0.000	0.000	1.00	12.8	0.200	0.100	63.99	4.7	21.4
20	0.247	16127	0.000	0.000	1.00	18.6	0.200	0.100	67.36	4.7	21.4
21	0.247	16127	0.000	0.000	1.00	19.3	0.200	0.100	70.73	4.7	21.4
22	0.247	16127	0.000	0.000	1.00	19.7	0.200	0.100	74.10	4.7	21.4
23	0.247	16127	0.000	0.000	1.00	8.1	0.200	0.100	77.46	4.7	21.4
24	0.247	16127	0.000	0.000	1.00	7.8	0.200	0.100	80.83	4.7	21.4
25	0.247	16127	0.000	0.000	1.00	17.9	0.200	0.100	84.20	4.7	21.4
Toe						155.6	0.150	0.243			

6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
6.176 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
54.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
367.4	162.5	8.19	8.19	-1.75	10	21	30.04	10	4	17.4	41.3

1 0 10.81000 11.86000

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Depth (ft) 60.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
84.2	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 9.958

Pile and Soil Model Total Capacity Rut (kips) 420.9

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	0.247	16127	0.010	0.000	0.85	0.0	0.000	0.100	3.37	4.7	21.4
2	0.247	16127	0.000	0.000	1.00	0.0	0.000	0.100	6.74	4.7	21.4
8	0.247	16127	0.000	0.000	1.00	11.0	0.200	0.100	26.94	4.7	21.4
9	0.247	16127	0.000	0.000	1.00	13.8	0.200	0.100	30.31	4.7	21.4
10	0.247	16127	0.000	0.000	1.00	14.1	0.200	0.100	33.68	4.7	21.4
11	0.247	16127	0.000	0.000	1.00	14.4	0.200	0.100	37.05	4.7	21.4
12	0.247	16127	0.000	0.000	1.00	12.3	0.200	0.100	40.42	4.7	21.4
13	0.247	16127	0.000	0.000	1.00	8.9	0.200	0.100	43.78	4.7	21.4
14	0.247	16127	0.000	0.000	1.00	10.4	0.200	0.100	47.15	4.7	21.4
15	0.247	16127	0.000	0.000	1.00	10.4	0.200	0.100	50.52	4.7	21.4
16	0.247	16127	0.000	0.000	1.00	9.3	0.200	0.100	53.89	4.7	21.4
17	0.247	16127	0.000	0.000	1.00	12.5	0.200	0.100	57.26	4.7	21.4
18	0.247	16127	0.000	0.000	1.00	17.3	0.200	0.100	60.62	4.7	21.4
19	0.247	16127	0.000	0.000	1.00	19.3	0.200	0.100	63.99	4.7	21.4
20	0.247	16127	0.000	0.000	1.00	19.6	0.200	0.100	67.36	4.7	21.4
21	0.247	16127	0.000	0.000	1.00	10.8	0.200	0.100	70.73	4.7	21.4
22	0.247	16127	0.000	0.000	1.00	7.8	0.200	0.100	74.10	4.7	21.4
23	0.247	16127	0.000	0.000	1.00	14.7	0.200	0.100	77.46	4.7	21.4
24	0.247	16127	0.000	0.000	1.00	23.3	0.200	0.100	80.83	4.7	21.4
25	0.247	16127	0.000	0.000	1.00	24.8	0.200	0.100	84.20	4.7	21.4
Toe						165.9	0.150	0.243			

6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
6.176 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
60.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
420.9	309.3	8.33	8.33	-1.44	8	21	30.10	8	3	17.4	40.9

1 0 10.81000 11.86000

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Depth (ft) 66.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
84.2	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 9.958

Pile and Soil Model Total Capacity Rut (kips) 325.6

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	16127	0.010	0.000	0.85	0.0	0.000	0.100	3.37	4.7	21.4
2	0.247	16127	0.000	0.000	1.00	0.0	0.000	0.100	6.74	4.7	21.4
6	0.247	16127	0.000	0.000	1.00	8.1	0.200	0.100	20.21	4.7	21.4
7	0.247	16127	0.000	0.000	1.00	13.8	0.200	0.100	23.58	4.7	21.4
8	0.247	16127	0.000	0.000	1.00	14.1	0.200	0.100	26.94	4.7	21.4
9	0.247	16127	0.000	0.000	1.00	14.4	0.200	0.100	30.31	4.7	21.4
10	0.247	16127	0.000	0.000	1.00	13.7	0.200	0.100	33.68	4.7	21.4
11	0.247	16127	0.000	0.000	1.00	8.6	0.200	0.100	37.05	4.7	21.4
12	0.247	16127	0.000	0.000	1.00	10.1	0.200	0.100	40.42	4.7	21.4
13	0.247	16127	0.000	0.000	1.00	11.0	0.200	0.100	43.78	4.7	21.4
14	0.247	16127	0.000	0.000	1.00	8.7	0.200	0.100	47.15	4.7	21.4
15	0.247	16127	0.000	0.000	1.00	12.2	0.200	0.100	50.52	4.7	21.4
16	0.247	16127	0.000	0.000	1.00	16.0	0.200	0.100	53.89	4.7	21.4
17	0.247	16127	0.000	0.000	1.00	19.2	0.200	0.100	57.26	4.7	21.4
18	0.247	16127	0.000	0.000	1.00	19.5	0.200	0.100	60.62	4.7	21.4
19	0.247	16127	0.000	0.000	1.00	13.4	0.200	0.100	63.99	4.7	21.4
20	0.247	16127	0.000	0.000	1.00	7.8	0.200	0.100	67.36	4.7	21.4
21	0.247	16127	0.000	0.000	1.00	11.5	0.200	0.100	70.73	4.7	21.4
22	0.247	16127	0.000	0.000	1.00	22.9	0.200	0.100	74.10	4.7	21.4
23	0.247	16127	0.000	0.000	1.00	24.5	0.200	0.100	77.46	4.7	21.4
24	0.247	16127	0.000	0.000	1.00	26.1	0.200	0.100	80.83	4.7	21.4
25	0.247	16127	0.000	0.000	1.00	25.3	0.200	0.100	84.20	4.7	21.4
Toe						24.8	0.150	0.243			

6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
6.176 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
66.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
325.6	90.3	8.26	8.21	-0.79	6	41	29.48	6	3	16.8	41.2

1 0 10.81000 11.86000

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Depth (ft) 72.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
84.2	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 9.958

Pile and Soil Model Total Capacity Rut (kips) 368.4

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.247	16127	0.010	0.000	0.85	0.0	0.000	0.100	3.37	4.7	21.4
2	0.247	16127	0.000	0.000	1.00	0.0	0.000	0.100	6.74	4.7	21.4
4	0.247	16127	0.000	0.000	1.00	5.1	0.200	0.100	13.47	4.7	21.4
5	0.247	16127	0.000	0.000	1.00	13.7	0.200	0.100	16.84	4.7	21.4
6	0.247	16127	0.000	0.000	1.00	14.0	0.200	0.100	20.21	4.7	21.4
7	0.247	16127	0.000	0.000	1.00	14.3	0.200	0.100	23.58	4.7	21.4
8	0.247	16127	0.000	0.000	1.00	14.6	0.200	0.100	26.94	4.7	21.4
9	0.247	16127	0.000	0.000	1.00	8.8	0.200	0.100	30.31	4.7	21.4
10	0.247	16127	0.000	0.000	1.00	9.8	0.200	0.100	33.68	4.7	21.4
11	0.247	16127	0.000	0.000	1.00	11.3	0.200	0.100	37.05	4.7	21.4
12	0.247	16127	0.000	0.000	1.00	8.8	0.200	0.100	40.42	4.7	21.4
13	0.247	16127	0.000	0.000	1.00	11.4	0.200	0.100	43.78	4.7	21.4
14	0.247	16127	0.000	0.000	1.00	14.6	0.200	0.100	47.15	4.7	21.4
15	0.247	16127	0.000	0.000	1.00	19.1	0.200	0.100	50.52	4.7	21.4
16	0.247	16127	0.000	0.000	1.00	19.5	0.200	0.100	53.89	4.7	21.4
17	0.247	16127	0.000	0.000	1.00	16.0	0.200	0.100	57.26	4.7	21.4
18	0.247	16127	0.000	0.000	1.00	7.8	0.200	0.100	60.62	4.7	21.4
19	0.247	16127	0.000	0.000	1.00	8.4	0.200	0.100	63.99	4.7	21.4
20	0.247	16127	0.000	0.000	1.00	22.6	0.200	0.100	67.36	4.7	21.4
21	0.247	16127	0.000	0.000	1.00	24.2	0.200	0.100	70.73	4.7	21.4
22	0.247	16127	0.000	0.000	1.00	25.7	0.200	0.100	74.10	4.7	21.4
23	0.247	16127	0.000	0.000	1.00	25.9	0.200	0.100	77.46	4.7	21.4
24	0.247	16127	0.000	0.000	1.00	24.1	0.200	0.100	80.83	4.7	21.4
25	0.247	16127	0.000	0.000	1.00	20.0	0.200	0.100	84.20	4.7	21.4
Toe						28.8	0.150	0.243			

6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
6.176 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
72.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
368.4	134.1	8.42	8.34	-0.50	4	38	29.65	5	3	16.7	40.9

1 0 10.81000 11.86000

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Depth (ft) 78.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
84.2	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 9.958

Pile and Soil Model — Total Capacity Rut (kips) 374.2

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	16127	0.010	0.000	0.85	0.0	0.000	0.100	3.37	4.7	21.4
2	0.247	16127	0.000	0.000	1.00	2.1	0.200	0.100	6.74	4.7	21.4
3	0.247	16127	0.000	0.000	1.00	13.6	0.200	0.100	10.10	4.7	21.4
4	0.247	16127	0.000	0.000	1.00	13.9	0.200	0.100	13.47	4.7	21.4
5	0.247	16127	0.000	0.000	1.00	14.2	0.200	0.100	16.84	4.7	21.4
6	0.247	16127	0.000	0.000	1.00	14.6	0.200	0.100	20.21	4.7	21.4
7	0.247	16127	0.000	0.000	1.00	10.1	0.200	0.100	23.58	4.7	21.4
8	0.247	16127	0.000	0.000	1.00	9.5	0.200	0.100	26.94	4.7	21.4
9	0.247	16127	0.000	0.000	1.00	10.9	0.200	0.100	30.31	4.7	21.4
10	0.247	16127	0.000	0.000	1.00	9.5	0.200	0.100	33.68	4.7	21.4
11	0.247	16127	0.000	0.000	1.00	10.5	0.200	0.100	37.05	4.7	21.4
12	0.247	16127	0.000	0.000	1.00	13.2	0.200	0.100	40.42	4.7	21.4
13	0.247	16127	0.000	0.000	1.00	19.0	0.200	0.100	43.78	4.7	21.4
14	0.247	16127	0.000	0.000	1.00	19.4	0.200	0.100	47.15	4.7	21.4
15	0.247	16127	0.000	0.000	1.00	18.6	0.200	0.100	50.52	4.7	21.4
16	0.247	16127	0.000	0.000	1.00	7.8	0.200	0.100	53.89	4.7	21.4
17	0.247	16127	0.000	0.000	1.00	7.9	0.200	0.100	57.26	4.7	21.4
18	0.247	16127	0.000	0.000	1.00	19.8	0.200	0.100	60.62	4.7	21.4
19	0.247	16127	0.000	0.000	1.00	23.8	0.200	0.100	63.99	4.7	21.4
20	0.247	16127	0.000	0.000	1.00	25.4	0.200	0.100	67.36	4.7	21.4
21	0.247	16127	0.000	0.000	1.00	26.4	0.200	0.100	70.73	4.7	21.4
22	0.247	16127	0.000	0.000	1.00	24.1	0.200	0.100	74.10	4.7	21.4
23	0.247	16127	0.000	0.000	1.00	20.9	0.200	0.100	77.46	4.7	21.4
24	0.247	16127	0.000	0.000	1.00	18.2	0.200	0.100	80.83	4.7	21.4
25	0.247	16127	0.000	0.000	1.00	11.3	0.200	0.100	84.20	4.7	21.4
Toe						9.3	0.150	0.243			

6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
6.176 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
78.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
374.2	137.0	8.40	8.40	-2.35	24	7	29.69	3	2	16.3	40.8

1 0 10.81000 11.86000

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Depth (ft) 81.8
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
84.2	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 9.958

Pile and Soil Model — Total Capacity Rut (kips) 387.1

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.247	16127	0.010	0.000	0.85	4.1	0.200	0.100	3.37	4.7	21.4
2	0.247	16127	0.000	0.000	1.00	13.7	0.200	0.100	6.74	4.7	21.4
3	0.247	16127	0.000	0.000	1.00	14.0	0.200	0.100	10.10	4.7	21.4
4	0.247	16127	0.000	0.000	1.00	14.3	0.200	0.100	13.47	4.7	21.4
5	0.247	16127	0.000	0.000	1.00	14.6	0.200	0.100	16.84	4.7	21.4
6	0.247	16127	0.000	0.000	1.00	9.3	0.200	0.100	20.21	4.7	21.4

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  7  0.247    16127 0.000 0.000 1.00     9.7   0.200 0.100  23.58   4.7    21.4
  8  0.247    16127 0.000 0.000 1.00    11.1   0.200 0.100  26.94   4.7    21.4
  9  0.247    16127 0.000 0.000 1.00     9.0   0.200 0.100  30.31   4.7    21.4
 10  0.247    16127 0.000 0.000 1.00    11.1   0.200 0.100  33.68   4.7    21.4
 11  0.247    16127 0.000 0.000 1.00    14.2   0.200 0.100  37.05   4.7    21.4
 12  0.247    16127 0.000 0.000 1.00    19.1   0.200 0.100  40.42   4.7    21.4
 13  0.247    16127 0.000 0.000 1.00    19.4   0.200 0.100  43.78   4.7    21.4
 14  0.247    16127 0.000 0.000 1.00    16.9   0.200 0.100  47.15   4.7    21.4
 15  0.247    16127 0.000 0.000 1.00     7.8   0.200 0.100  50.52   4.7    21.4
 16  0.247    16127 0.000 0.000 1.00     7.9   0.200 0.100  53.89   4.7    21.4
 17  0.247    16127 0.000 0.000 1.00    22.0   0.200 0.100  57.26   4.7    21.4
 18  0.247    16127 0.000 0.000 1.00    24.0   0.200 0.100  60.62   4.7    21.4
 19  0.247    16127 0.000 0.000 1.00    25.6   0.200 0.100  63.99   4.7    21.4
 20  0.247    16127 0.000 0.000 1.00    26.1   0.200 0.100  67.36   4.7    21.4
 21  0.247    16127 0.000 0.000 1.00    24.1   0.200 0.100  70.73   4.7    21.4
 22  0.247    16127 0.000 0.000 1.00    20.3   0.200 0.100  74.10   4.7    21.4
 23  0.247    16127 0.000 0.000 1.00    17.1   0.200 0.100  77.46   4.7    21.4
 24  0.247    16127 0.000 0.000 1.00    11.3   0.200 0.100  80.83   4.7    21.4
 25  0.247    16127 0.000 0.000 1.00    11.3   0.200 0.100  84.20   4.7    21.4
Toe                                      9.3   0.150 0.243

     6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
     6.176 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    81.85     10.81      1.00     0.800
↑
FRA-70-1301A - Boring B-015-4-13                                    12/23/2014
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
  387.1   150.1   8.54   8.46   -3.13  24   7    30.12   2   2   16.1    40.6
          1          0   10.81000       11.86000
↑
FRA-70-1301A - Boring B-015-4-13                                    12/23/2014
Resource International Inc                               GRLWEAP Version 2010

 Depth                (ft)      84.2
 Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                     H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7        0    16911.     38.5
    84.2    21.40   30458.    493.4      4.7        0    16911.     38.5

 Wave Travel Time 2L/c (ms)     9.958

       Pile and Soil Model            Total Capacity Rut  (kips)     958.9
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  0.247    16127 0.010 0.000 0.85    13.6   0.200 0.100   3.37   4.7    21.4
  2  0.247    16127 0.000 0.000 1.00    13.9   0.200 0.100   6.74   4.7    21.4
  3  0.247    16127 0.000 0.000 1.00    14.2   0.200 0.100  10.10   4.7    21.4
  4  0.247    16127 0.000 0.000 1.00    14.5   0.200 0.100  13.47   4.7    21.4
  5  0.247    16127 0.000 0.000 1.00    11.1   0.200 0.100  16.84   4.7    21.4
  6  0.247    16127 0.000 0.000 1.00     9.2   0.200 0.100  20.21   4.7    21.4
  7  0.247    16127 0.000 0.000 1.00    10.7   0.200 0.100  23.58   4.7    21.4
  8  0.247    16127 0.000 0.000 1.00     9.9   0.200 0.100  26.94   4.7    21.4
  9  0.247    16127 0.000 0.000 1.00    10.0   0.200 0.100  30.31   4.7    21.4
 10  0.247    16127 0.000 0.000 1.00    12.7   0.200 0.100  33.68   4.7    21.4
 11  0.247    16127 0.000 0.000 1.00    18.4   0.200 0.100  37.05   4.7    21.4
 12  0.247    16127 0.000 0.000 1.00    19.3   0.200 0.100  40.42   4.7    21.4
 13  0.247    16127 0.000 0.000 1.00    19.7   0.200 0.100  43.78   4.7    21.4
 14  0.247    16127 0.000 0.000 1.00     8.5   0.200 0.100  47.15   4.7    21.4
 15  0.247    16127 0.000 0.000 1.00     7.8   0.200 0.100  50.52   4.7    21.4
 16  0.247    16127 0.000 0.000 1.00    17.4   0.200 0.100  53.89   4.7    21.4
 17  0.247    16127 0.000 0.000 1.00    23.6   0.200 0.100  57.26   4.7    21.4
 18  0.247    16127 0.000 0.000 1.00    25.1   0.200 0.100  60.62   4.7    21.4
```

19	0.247	16127	0.000	0.000	1.00	26.7	0.200	0.100	63.99	4.7	21.4
20	0.247	16127	0.000	0.000	1.00	24.1	0.200	0.100	67.36	4.7	21.4
21	0.247	16127	0.000	0.000	1.00	21.7	0.200	0.100	70.73	4.7	21.4
22	0.247	16127	0.000	0.000	1.00	19.6	0.200	0.100	74.10	4.7	21.4
23	0.247	16127	0.000	0.000	1.00	11.3	0.200	0.100	77.46	4.7	21.4
25	0.247	16127	0.000	0.000	1.00	33.1	0.200	0.100	84.20	4.7	21.4
Toe						551.4	0.150	0.243			

6.173 kips total unreduced pile weight (g= 32.17 ft/s2)
6.176 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
84.20	10.81	1.00	0.800

↑

FRA-70-1301A - Boring B-015-4-13 12/23/2014
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
958.9	9999.0	8.63	8.62	0.00	1	0	31.52	1	2	15.8	40.3

↑

FRA-70-1301A - Boring B-015-4-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 1.000 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
6.0	39.9	24.4	15.5	3.9	17.944	-4.347	5.15	20.2
12.0	65.3	49.8	15.5	7.6	21.346	-2.845	5.76	18.5
18.0	119.2	70.3	48.9	16.1	24.832	-1.320	6.58	17.5
24.0	137.6	88.7	48.9	20.0	25.966	-1.820	6.80	17.1
30.0	146.3	106.0	40.3	22.3	26.482	-2.190	6.92	16.8
36.0	150.9	132.3	18.6	23.8	26.615	-2.460	7.03	16.5
42.0	185.4	166.8	18.6	31.0	27.314	-1.379	7.34	16.1
48.0	194.0	187.8	6.2	33.1	27.686	-1.356	7.42	15.9
54.0	367.4	211.8	155.6	162.5	30.040	-1.752	8.19	17.4
60.0	420.9	255.0	165.9	309.3	30.104	-1.444	8.33	17.4
66.0	325.6	300.8	24.8	90.3	29.481	-0.787	8.26	16.8
72.0	368.4	339.6	28.8	134.1	29.651	-0.500	8.42	16.7
78.0	374.2	364.9	9.3	137.0	29.691	-2.354	8.40	16.3
81.8	387.1	377.8	9.3	150.1	30.117	-3.126	8.54	16.1
84.2	958.9	407.5	551.4	9999.0	31.518	0.000	8.63	15.8

Refusal occurred; no driving time output possible

↑

FRA-70-1301A - Boring B-015-4-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
6.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
12.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
18.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
24.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
30.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
36.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
42.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
48.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
54.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
60.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
66.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
72.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
78.00	84.20	0.00	10.81	1.00	0.80	1.00	1.00
81.85	84.20	0.00	10.81	1.00	0.80	1.00	1.00
84.20	84.20	0.00	10.81	1.00	0.80	1.00	1.00

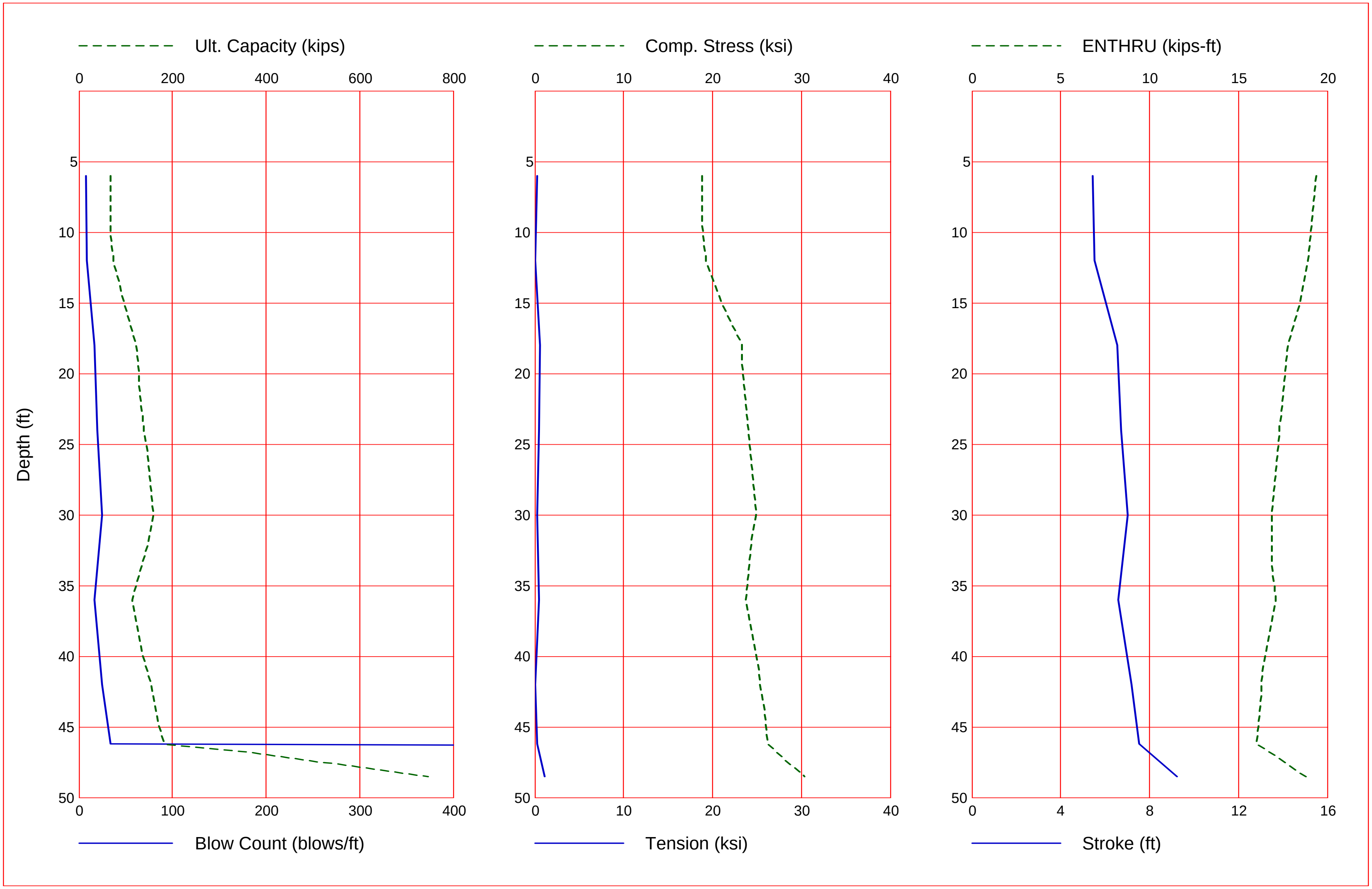
Soil Layer Resistance Values

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
0.00	0.85	15.51	0.100	0.243	0.200	0.150	1.000	0.000	0.000
15.00	0.94	15.51	0.100	0.243	0.200	0.150	1.000	0.000	0.000
15.00	0.49	48.94	0.100	0.243	0.200	0.150	1.000	0.000	0.000
25.00	0.76	48.94	0.100	0.243	0.200	0.150	1.000	0.000	0.000
25.00	0.54	7.75	0.100	0.243	0.200	0.150	1.000	0.000	0.000
29.00	0.55	7.75	0.100	0.243	0.200	0.150	1.000	0.000	0.000
29.00	0.74	40.31	0.100	0.243	0.200	0.150	1.000	0.000	0.000
34.00	0.84	40.31	0.100	0.243	0.200	0.150	1.000	0.000	0.000
34.00	1.19	18.61	0.100	0.243	0.200	0.150	1.000	0.000	0.000
44.00	1.26	18.61	0.100	0.243	0.200	0.150	1.000	0.000	0.000
44.00	0.49	6.20	0.100	0.243	0.200	0.150	1.000	0.000	0.000
51.66	0.50	6.20	0.100	0.243	0.200	0.150	1.000	0.000	0.000
51.66	1.38	151.59	0.100	0.243	0.200	0.150	1.000	0.000	0.000
64.00	1.74	172.74	0.100	0.243	0.200	0.150	1.000	0.000	0.000
64.00	1.52	24.81	0.100	0.243	0.200	0.150	1.000	0.000	0.000
69.00	1.52	24.81	0.100	0.243	0.200	0.150	1.000	0.000	0.000
69.00	1.21	28.79	0.100	0.243	0.200	0.150	1.000	0.000	0.000
74.00	1.27	28.79	0.100	0.243	0.200	0.150	1.000	0.000	0.000
74.00	0.71	9.30	0.100	0.243	0.200	0.150	1.000	0.000	0.000
83.70	0.71	9.30	0.100	0.243	0.200	0.150	1.000	0.000	0.000
83.70	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000
84.20	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000

Resource International Inc
FRA-71-1503L - Boring B-108-5-13

Dec 23 2014
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000



Gain/Loss 1 at Shaft and Toe 1.000 / 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
6.0	68.0	1.8	66.2	7.2	18.814	-0.255	5.45	19.4
12.0	73.5	7.3	66.2	8.2	19.296	-0.067	5.54	18.9
18.0	123.4	16.9	106.5	16.6	23.274	-0.630	6.53	17.8
24.0	139.0	32.4	106.5	19.8	24.068	-0.483	6.74	17.3
30.0	159.4	52.9	106.5	24.8	24.959	-0.239	7.02	16.9
36.0	114.8	89.9	24.8	16.3	23.729	-0.520	6.61	17.1
42.0	154.8	130.0	24.8	25.3	25.355	0.000	7.18	16.3
46.2	183.6	158.8	24.8	34.1	26.229	-0.240	7.52	16.0
48.5	746.8	195.4	551.4	9999.0	30.356	-1.137	9.22	18.8

Refusal occurred; no driving time output possible

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

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

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

```
 Input  File: C:\USERS\JAMESH.RIICOLUMBUS\DESKTOP\DRIVEABILITY\B-108-5-13.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
 Hammer File Version:  2003 (2/22/2013)

                       Input File Contents
     FRA-71-1503L - Boring B-108-5-13
 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   1   0  0   0   0   0   0   0  0   0   0   0   0   0   0.000
    Pile g  Hammer g  Toe Area Pile Size          Pile Type
    32.185    32.185   198.500    14.580             H Pile
      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
    48.500     21.40   30457.9   493.356     4.699         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
0.100	0.243	0.200	0.150	0.000	0.000	0.000	0.000

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

0.000 0.000 0.000 0.000

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

0.000 0.000 0.000 0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	66.22	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16.50	0.35	66.22	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16.50	0.42	106.52	0.00	0.00	0.00	0.00	0.00	0.00	0.0
30.50	0.82	106.52	0.00	0.00	0.00	0.00	0.00	0.00	0.0
30.50	1.33	24.81	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.00	1.52	24.81	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.00	10.00	551.39	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.50	10.00	551.39	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Gain/Loss factors: shaft and toe

1.00000 0.00000 0.00000 0.00000 0.00000
1.00000 0.00000 0.00000 0.00000 0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
18.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
24.00	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
36.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
42.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
46.15	0.00	0.00	0.000	0.000	0.000	0.000	0.000
48.50	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-71-1503L - Boring B-108-5-13

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	0.0098	5.8
Combined Pile Top		16798.9			

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-71-1503L - Boring B-108-5-13                                   12/23/2014
Resource International Inc                                GRLWEAP Version 2010

 Depth                (ft)       6.0
 Shaft Gain/Loss Factor        1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
       ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
      0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
     48.5    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     5.736

        Pile and Soil Model           Total Capacity Rut  (kips)      68.0
No. Weight   Stiffn C-Slk T-Slk  CoR  Soil-S  Soil-D Quake  LbTop Perim    Area
      kips     k/in    ft    ft         kips    s/ft  inch     ft    ft     in2
  1  0.237    16799 0.010 0.000 0.85     0.0   0.000 0.100   3.23   4.7    21.4
  2  0.237    16799 0.000 0.000 1.00     0.0   0.000 0.100   6.47   4.7    21.4
 14  0.237    16799 0.000 0.000 1.00     0.4   0.200 0.100  45.27   4.7    21.4
 15  0.237    16799 0.000 0.000 1.00     1.4   0.200 0.100  48.50   4.7    21.4
Toe                                     66.2   0.150 0.243

     3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
     3.558 kips total reduced pile weight   (g= 32.19 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)     0.771
 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    32.185    32.185
 Output Segment Generation: Automatic

    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
     6.00     10.81      1.00     0.800
↑
FRA-71-1503L - Boring B-108-5-13                                   12/23/2014
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
   68.0     7.2   5.45   5.44   -0.25   2   8    18.81  10   4   19.4    50.5
        1          0   10.81000       11.86000
↑
FRA-71-1503L - Boring B-108-5-13                                   12/23/2014
Resource International Inc                                GRLWEAP Version 2010

 Depth                (ft)      12.0
 Shaft Gain/Loss Factor        1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
       ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
      0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
     48.5    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     5.736
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Pile and Soil Model					Total Capacity Rut (kips)			73.5		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	0.3	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	1.3	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	2.3	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	3.4	0.200	0.100	48.50	4.7	21.4
Toe						66.2	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
12.00	10.81	1.00	0.800

FRA-71-1503L - Boring B-108-5-13 12/23/2014
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
73.5	8.2	5.54	5.59	-0.07	12	50	19.30	11	4	18.9	49.9

1 0 10.81000 11.86000

FRA-71-1503L - Boring B-108-5-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 18.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model					Total Capacity Rut (kips)			123.4		
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	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	0.2	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	1.1	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	2.2	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	3.2	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	4.3	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	5.9	0.200	0.100	48.50	4.7	21.4
Toe						106.5	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
18.00	10.81	1.00	0.800

FRA-71-1503L - Boring B-108-5-13 12/23/2014
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
123.4	16.6	6.53	6.47	-0.63	11	41	23.27	11	4	17.8	46.2

1 0 10.81000 11.86000

FRA-71-1503L - Boring B-108-5-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 24.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model Total Capacity Rut (kips) 139.0

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	0.1	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	1.0	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	2.0	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	3.1	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	4.1	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	5.5	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	7.6	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	9.0	0.200	0.100	48.50	4.7	21.4
Toe						106.5	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
24.00	10.81	1.00	0.800

↑
FRA-71-1503L - Boring B-108-5-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft) down	Stroke (ft) up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft			ksi			ksi			kip-ft	b/min
139.0	19.8	6.74	6.69	-0.48	9	36	24.07	10	4	17.3	45.5

1 0 10.81000 11.86000

↑
FRA-71-1503L - Boring B-108-5-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

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

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model Total Capacity Rut (kips) 159.4

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	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
6	0.237	16799	0.000	0.000	1.00	0.0	0.200	0.100	19.40	4.7	21.4
7	0.237	16799	0.000	0.000	1.00	0.8	0.200	0.100	22.63	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	1.9	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	2.9	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	4.0	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	5.2	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	7.4	0.200	0.100	38.80	4.7	21.4

13	0.237	16799	0.000	0.000	1.00	8.8	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	10.2	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	11.6	0.200	0.100	48.50	4.7	21.4
Toe						106.5	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
30.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
159.4	24.8	7.02	6.99	-0.24	8	32	24.96	8	3	16.9	44.5

1 0 10.81000 11.86000

FRA-71-1503L - Boring B-108-5-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 36.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model Total Capacity Rut (kips) 114.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
4	0.237	16799	0.000	0.000	1.00	0.0	0.200	0.100	12.93	4.7	21.4
5	0.237	16799	0.000	0.000	1.00	0.7	0.200	0.100	16.17	4.7	21.4
6	0.237	16799	0.000	0.000	1.00	1.7	0.200	0.100	19.40	4.7	21.4
7	0.237	16799	0.000	0.000	1.00	2.8	0.200	0.100	22.63	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	3.8	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	4.9	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	7.2	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	8.6	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	10.0	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	11.4	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	18.0	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	20.9	0.200	0.100	48.50	4.7	21.4
Toe						24.8	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
36.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
114.8	16.3	6.61	6.55	-0.52	7	36	23.73	7	3	17.1	46.0

1 0 10.81000 11.86000

FRA-71-1503L - Boring B-108-5-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

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 Depth                (ft)      42.0
 Shaft Gain/Loss Factor        1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                   H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
    48.5    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     5.736

       Pile and Soil Model            Total Capacity Rut  (kips)     154.8
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  0.237    16799 0.010 0.000 0.85     0.0   0.000 0.100   3.23   4.7    21.4
  2  0.237    16799 0.000 0.000 1.00     0.0   0.000 0.100   6.47   4.7    21.4
  3  0.237    16799 0.000 0.000 1.00     0.5   0.200 0.100   9.70   4.7    21.4
  4  0.237    16799 0.000 0.000 1.00     1.6   0.200 0.100  12.93   4.7    21.4
  5  0.237    16799 0.000 0.000 1.00     2.6   0.200 0.100  16.17   4.7    21.4
  6  0.237    16799 0.000 0.000 1.00     3.7   0.200 0.100  19.40   4.7    21.4
  7  0.237    16799 0.000 0.000 1.00     4.7   0.200 0.100  22.63   4.7    21.4
  8  0.237    16799 0.000 0.000 1.00     6.9   0.200 0.100  25.87   4.7    21.4
  9  0.237    16799 0.000 0.000 1.00     8.4   0.200 0.100  29.10   4.7    21.4
 10  0.237    16799 0.000 0.000 1.00     9.8   0.200 0.100  32.33   4.7    21.4
 11  0.237    16799 0.000 0.000 1.00    11.2   0.200 0.100  35.57   4.7    21.4
 12  0.237    16799 0.000 0.000 1.00    16.8   0.200 0.100  38.80   4.7    21.4
 13  0.237    16799 0.000 0.000 1.00    20.8   0.200 0.100  42.03   4.7    21.4
 14  0.237    16799 0.000 0.000 1.00    21.3   0.200 0.100  45.27   4.7    21.4
 15  0.237    16799 0.000 0.000 1.00    21.8   0.200 0.100  48.50   4.7    21.4
Toe                                     24.8   0.150 0.243

     3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
     3.558 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    42.00     10.81      1.00     0.800
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FRA-71-1503L - Boring B-108-5-13                                  12/23/2014
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
  154.8    25.3   7.18   7.16    0.00   1   0    25.35   5   3   16.3    44.1
          1          0   10.81000       11.86000
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FRA-71-1503L - Boring B-108-5-13                                  12/23/2014
Resource International Inc                               GRLWEAP Version 2010

 Depth                (ft)      46.2
 Shaft Gain/Loss Factor        1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                   H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
    48.5    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     5.736

       Pile and Soil Model            Total Capacity Rut  (kips)     183.6
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  0.237    16799 0.010 0.000 0.85     0.0   0.200 0.100   3.23   4.7    21.4
  2  0.237    16799 0.000 0.000 1.00     0.8   0.200 0.100   6.47   4.7    21.4
  3  0.237    16799 0.000 0.000 1.00     1.9   0.200 0.100   9.70   4.7    21.4
  4  0.237    16799 0.000 0.000 1.00     2.9   0.200 0.100  12.93   4.7    21.4
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5	0.237	16799	0.000	0.000	1.00	4.0	0.200	0.100	16.17	4.7	21.4
6	0.237	16799	0.000	0.000	1.00	5.2	0.200	0.100	19.40	4.7	21.4
7	0.237	16799	0.000	0.000	1.00	7.4	0.200	0.100	22.63	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	8.8	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	10.2	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	11.6	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	19.2	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	20.9	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	21.4	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	22.0	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	22.5	0.200	0.100	48.50	4.7	21.4
Toe						24.8	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
46.15	10.81	1.00	0.800

↑
FRA-71-1503L - Boring B-108-5-13 12/23/2014
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
183.6	34.1	7.52	7.51	-0.24	4	49	26.23	4	2	16.0	43.1

1 0 10.81000 11.86000

↑
FRA-71-1503L - Boring B-108-5-13 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 48.5
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model — Total Capacity Rut (kips) 746.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.237	16799	0.010	0.000	0.85	0.5	0.200	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	1.6	0.200	0.100	6.47	4.7	21.4
3	0.237	16799	0.000	0.000	1.00	2.6	0.200	0.100	9.70	4.7	21.4
4	0.237	16799	0.000	0.000	1.00	3.7	0.200	0.100	12.93	4.7	21.4
5	0.237	16799	0.000	0.000	1.00	4.7	0.200	0.100	16.17	4.7	21.4
6	0.237	16799	0.000	0.000	1.00	6.9	0.200	0.100	19.40	4.7	21.4
7	0.237	16799	0.000	0.000	1.00	8.4	0.200	0.100	22.63	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	9.8	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	11.2	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	16.8	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	20.8	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	21.3	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	21.8	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	22.3	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	42.8	0.200	0.100	48.50	4.7	21.4
Toe						551.4	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
48.50	10.81	1.00	0.800

↑
FRA-71-1503L - Boring B-108-5-13 12/23/2014

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
746.8	9999.0	9.22	9.19	-1.14	6	33	30.36	4	2	18.8	39.0

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 1.000 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
6.0	68.0	1.8	66.2	7.2	18.814	-0.255	5.45	19.4
12.0	73.5	7.3	66.2	8.2	19.296	-0.067	5.54	18.9
18.0	123.4	16.9	106.5	16.6	23.274	-0.630	6.53	17.8
24.0	139.0	32.4	106.5	19.8	24.068	-0.483	6.74	17.3
30.0	159.4	52.9	106.5	24.8	24.959	-0.239	7.02	16.9
36.0	114.8	89.9	24.8	16.3	23.729	-0.520	6.61	17.1
42.0	154.8	130.0	24.8	25.3	25.355	0.000	7.18	16.3
46.2	183.6	158.8	24.8	34.1	26.229	-0.240	7.52	16.0
48.5	746.8	195.4	551.4	9999.0	30.356	-1.137	9.22	18.8

Refusal occurred; no driving time output possible

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
6.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
12.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
18.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
24.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
30.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
36.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
42.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
46.15	48.50	0.00	10.81	1.00	0.80	1.00	1.00
48.50	48.50	0.00	10.81	1.00	0.80	1.00	1.00

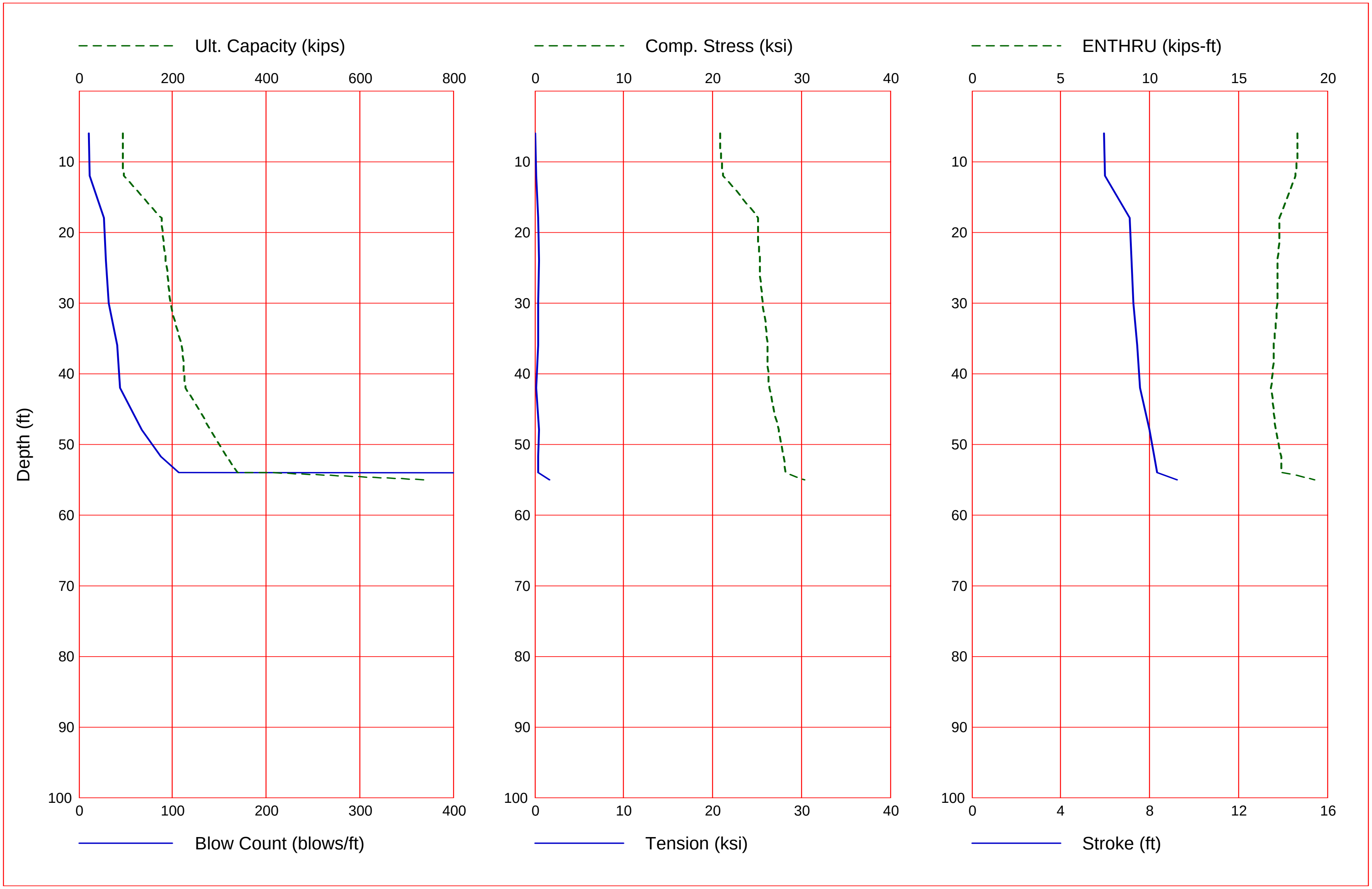
Soil Layer Resistance Values

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
0.00	0.00	66.22	0.100	0.243	0.200	0.150	1.000	0.000	0.000
16.50	0.35	66.22	0.100	0.243	0.200	0.150	1.000	0.000	0.000
16.50	0.42	106.52	0.100	0.243	0.200	0.150	1.000	0.000	0.000
30.50	0.82	106.52	0.100	0.243	0.200	0.150	1.000	0.000	0.000
30.50	1.33	24.81	0.100	0.243	0.200	0.150	1.000	0.000	0.000
48.00	1.52	24.81	0.100	0.243	0.200	0.150	1.000	0.000	0.000
48.00	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000
48.50	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000

Resource International Inc
FRA-70-1301A - Historic Boring B-1

Dec 23 2014
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000



Gain/Loss 1 at Shaft and Toe 1.000 / 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
6.0	93.3	1.1	92.1	10.9	20.846	-0.083	5.94	18.3
12.0	96.7	4.6	92.1	11.6	21.192	-0.195	6.01	18.2
18.0	177.1	10.1	167.0	27.0	25.156	-0.376	7.11	17.3
24.0	184.8	17.8	167.0	29.2	25.371	-0.504	7.17	17.2
30.0	194.9	27.9	167.0	32.4	25.694	-0.341	7.28	17.2
36.0	220.5	47.8	172.7	40.7	26.169	-0.356	7.45	17.0
42.0	227.0	73.9	153.1	44.4	26.389	-0.152	7.56	16.8
48.0	279.6	117.1	162.5	67.4	27.469	-0.474	8.00	17.1
51.7	314.9	146.6	168.3	87.4	27.965	-0.395	8.23	17.4
54.0	338.9	166.9	172.0	106.8	28.197	-0.352	8.35	17.4
55.0	746.2	194.9	551.4	9999.0	30.318	-1.687	9.24	19.3

Refusal occurred; no driving time output possible

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

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 Input  File: C:\USERS\JAMESH.RIICOLUMBUS\DESKTOP\DRIVEABILITY\B-1.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
 Hammer File Version:  2003 (2/22/2013)

                        Input File Contents
     FRA-70-1301A - Historic Boring B-1
 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   1   0  0   0   0   0   0   0  0   0   0   0   0   0   0.000
    Pile g  Hammer g  Toe Area Pile Size           Pile Type
    32.185    32.185   198.500    14.580             H Pile
      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
    55.000     21.40   30457.9   493.356     4.699         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
```

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                                                               B-1
      Qs        Qt        Js        Jt        Qx        Jx      Rati      Dept
   0.100     0.243     0.200     0.150     0.000     0.000     0.000     0.000
 Research Soil Model: Atoe, Plug,  Gap, Q-fac
   0.000     0.000     0.000     0.000
 Research Soil Model: RD-skn: m, d, toe: m, d
   0.000     0.000     0.000     0.000
 Res. Distribution
   Dpth    Rskn      Rtoe      Qs      Qt      Js      Jt    SU F    LimD   SU T
   0.00    0.00     92.13    0.00    0.00    0.00    0.00   0.00    0.00    0.0
  16.00    0.22     92.13    0.00    0.00    0.00    0.00   0.00    0.00    0.0
  16.00    0.20    166.98    0.00    0.00    0.00    0.00   0.00    0.00    0.0
  30.00    0.40    166.98    0.00    0.00    0.00    0.00   0.00    0.00    0.0
  30.00    0.64    172.74    0.00    0.00    0.00    0.00   0.00    0.00    0.0
  41.00    0.89    172.74    0.00    0.00    0.00    0.00   0.00    0.00    0.0
  41.00    1.37    151.53    0.00    0.00    0.00    0.00   0.00    0.00    0.0
  54.50    1.90    172.74    0.00    0.00    0.00    0.00   0.00    0.00    0.0
  54.50   10.00    551.39    0.00    0.00    0.00    0.00   0.00    0.00    0.0
  55.00   10.00    551.39    0.00    0.00    0.00    0.00   0.00    0.00    0.0
 Gain/Loss factors: shaft and toe
  1.00000   0.00000   0.00000   0.00000   0.00000
  1.00000   0.00000   0.00000   0.00000   0.00000
     Dpth         L      Wait      Strk      Pmx%      Eff.      Stff       CoR
     6.00      0.00      0.00     0.000     0.000     0.000     0.000     0.000
    12.00      0.00      0.00     0.000     0.000     0.000     0.000     0.000
    18.00      0.00      0.00     0.000     0.000     0.000     0.000     0.000
    24.00      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
    36.00      0.00      0.00     0.000     0.000     0.000     0.000     0.000
    42.00      0.00      0.00     0.000     0.000     0.000     0.000     0.000
    48.00      0.00      0.00     0.000     0.000     0.000     0.000     0.000
    51.65      0.00      0.00     0.000     0.000     0.000     0.000     0.000
    54.00      0.00      0.00     0.000     0.000     0.000     0.000     0.000
    55.00      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
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           GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
                             Version 2010
                            English Units

                FRA-70-1301A - Historic Boring B-1
                ________________________________________

         Hammer Model:   D 19-42             Made by:      DELMAG

         No.    Weight    Stiffn       CoR     C-Slk     Dampg
                  kips    k/inch                  ft    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    0.0098       5.8
     Combined Pile Top     16788.8

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
         ____________________________________________________________
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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
```

↑
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FRA-70-1301A - Historic Boring B-1                             12/23/2014
Resource International Inc                            GRLWEAP Version 2010

 Depth                (ft)       6.0
 Shaft Gain/Loss Factor        1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
    55.0    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     6.505

       Pile and Soil Model            Total Capacity Rut  (kips)      93.3
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  0.237    16789 0.010 0.000 0.85     0.0   0.000 0.100   3.24   4.7    21.4
  2  0.237    16789 0.000 0.000 1.00     0.0   0.000 0.100   6.47   4.7    21.4
 16  0.237    16789 0.000 0.000 1.00     0.2   0.200 0.100  51.76   4.7    21.4
 17  0.237    16789 0.000 0.000 1.00     0.9   0.200 0.100  55.00   4.7    21.4
Toe                                     92.1   0.150 0.243

     4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
     4.034 kips total reduced pile weight   (g= 32.19 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)     0.771
 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    32.185    32.185
 Output Segment Generation: Automatic

    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
     6.00     10.81      1.00     0.800
```

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FRA-70-1301A - Historic Boring B-1                             12/23/2014
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
   93.3    10.9   5.94   5.96   -0.08   6  50    20.85  12   4   18.3    48.3
          1          0   10.81000       11.86000
```

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FRA-70-1301A - Historic Boring B-1                             12/23/2014
Resource International Inc                            GRLWEAP Version 2010

 Depth                (ft)      12.0
 Shaft Gain/Loss Factor        1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
```

55.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms)   6.505

Pile and Soil Model   Total Capacity Rut (kips)   96.7

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	0.237	16789	0.010	0.000	0.85	0.0	0.000	0.100	3.24	4.7	21.4
2	0.237	16789	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
14	0.237	16789	0.000	0.000	1.00	0.2	0.200	0.100	45.29	4.7	21.4
15	0.237	16789	0.000	0.000	1.00	0.8	0.200	0.100	48.53	4.7	21.4
16	0.237	16789	0.000	0.000	1.00	1.5	0.200	0.100	51.76	4.7	21.4
17	0.237	16789	0.000	0.000	1.00	2.1	0.200	0.100	55.00	4.7	21.4
Toe						92.1	0.150	0.243			

4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
4.034 kips total reduced pile weight   (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
12.00	10.81	1.00	0.800

FRA-70-1301A - Historic Boring B-1   12/23/2014
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
96.7	11.6	6.01	6.03	-0.20	15	45	21.19	13	4	18.2	48.0

1   0   10.81000   11.86000

FRA-70-1301A - Historic Boring B-1   12/23/2014
Resource International Inc   GRLWEAP Version 2010

Depth   (ft)   18.0
Shaft Gain/Loss Factor   1.000 Toe Gain/Loss Factor   1.000

PILE PROFILE:
Toe Area   (in2)   198.500 Pile Type   H Pile
Pile Size   (inch)   14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
55.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms)   6.505

Pile and Soil Model   Total Capacity Rut (kips)   177.1

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.237	16789	0.010	0.000	0.85	0.0	0.000	0.100	3.24	4.7	21.4
2	0.237	16789	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
12	0.237	16789	0.000	0.000	1.00	0.1	0.200	0.100	38.82	4.7	21.4
13	0.237	16789	0.000	0.000	1.00	0.7	0.200	0.100	42.06	4.7	21.4
14	0.237	16789	0.000	0.000	1.00	1.4	0.200	0.100	45.29	4.7	21.4
15	0.237	16789	0.000	0.000	1.00	2.0	0.200	0.100	48.53	4.7	21.4
16	0.237	16789	0.000	0.000	1.00	2.7	0.200	0.100	51.76	4.7	21.4
17	0.237	16789	0.000	0.000	1.00	3.2	0.200	0.100	55.00	4.7	21.4
Toe						167.0	0.150	0.243			

4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
4.034 kips total reduced pile weight   (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
18.00	10.81	1.00	0.800

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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			ksi			ksi			kip-ft	b/min
177.1	27.0	7.11	7.09	-0.38	14	35	25.16	13	4	17.3	44.3

1 0 10.81000 11.86000

FRA-70-1301A - Historic Boring B-1 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 24.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
55.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.505

Pile and Soil Model Total Capacity Rut (kips) 184.8

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	0.237	16789	0.010	0.000	0.85	0.0	0.000	0.100	3.24	4.7	21.4
2	0.237	16789	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
10	0.237	16789	0.000	0.000	1.00	0.1	0.200	0.100	32.35	4.7	21.4
11	0.237	16789	0.000	0.000	1.00	0.6	0.200	0.100	35.59	4.7	21.4
12	0.237	16789	0.000	0.000	1.00	1.3	0.200	0.100	38.82	4.7	21.4
13	0.237	16789	0.000	0.000	1.00	1.9	0.200	0.100	42.06	4.7	21.4
14	0.237	16789	0.000	0.000	1.00	2.6	0.200	0.100	45.29	4.7	21.4
15	0.237	16789	0.000	0.000	1.00	3.2	0.200	0.100	48.53	4.7	21.4
16	0.237	16789	0.000	0.000	1.00	3.7	0.200	0.100	51.76	4.7	21.4
17	0.237	16789	0.000	0.000	1.00	4.4	0.200	0.100	55.00	4.7	21.4
Toe						167.0	0.150	0.243			

4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
4.034 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
24.00	10.81	1.00	0.800

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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
184.8	29.2	7.17	7.16	-0.50	13	35	25.37	12	4	17.2	44.1

1 0 10.81000 11.86000

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Resource International Inc GRLWEAP Version 2010

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

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
55.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.505

Pile and Soil Model Total Capacity Rut (kips) 194.9

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	0.237	16789	0.010	0.000	0.85	0.0	0.000	0.100	3.24	4.7	21.4
2	0.237	16789	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
8	0.237	16789	0.000	0.000	1.00	0.0	0.200	0.100	25.88	4.7	21.4
9	0.237	16789	0.000	0.000	1.00	0.5	0.200	0.100	29.12	4.7	21.4
10	0.237	16789	0.000	0.000	1.00	1.2	0.200	0.100	32.35	4.7	21.4

```
 11  0.237    16789 0.000 0.000 1.00     1.8   0.200 0.100  35.59   4.7    21.4
 12  0.237    16789 0.000 0.000 1.00     2.5   0.200 0.100  38.82   4.7    21.4
 13  0.237    16789 0.000 0.000 1.00     3.1   0.200 0.100  42.06   4.7    21.4
 14  0.237    16789 0.000 0.000 1.00     3.6   0.200 0.100  45.29   4.7    21.4
 15  0.237    16789 0.000 0.000 1.00     4.3   0.200 0.100  48.53   4.7    21.4
 16  0.237    16789 0.000 0.000 1.00     5.0   0.200 0.100  51.76   4.7    21.4
 17  0.237    16789 0.000 0.000 1.00     5.8   0.200 0.100  55.00   4.7    21.4
Toe                                    167.0   0.150 0.243

     4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
     4.034 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    30.00     10.81      1.00     0.800
↑
FRA-70-1301A - Historic Boring B-1                                12/23/2014
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
  194.9    32.4   7.28   7.28   -0.34  11  30    25.69  11   4   17.2    43.7
        1           0   10.81000       11.86000
↑
FRA-70-1301A - Historic Boring B-1                                12/23/2014
Resource International Inc                              GRLWEAP Version 2010

 Depth                 (ft)      36.0
 Shaft Gain/Loss Factor         1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
      ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
     0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
    55.0    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     6.505

        Pile and Soil Model            Total Capacity Rut  (kips)     220.5
No. Weight   Stiffn C-Slk T-Slk  CoR  Soil-S  Soil-D Quake  LbTop Perim     Area
      kips     k/in    ft    ft         kips    s/ft  inch     ft    ft      in2
  1  0.237    16789 0.010 0.000 0.85     0.0   0.000 0.100   3.24   4.7    21.4
  2  0.237    16789 0.000 0.000 1.00     0.0   0.000 0.100   6.47   4.7    21.4
  6  0.237    16789 0.000 0.000 1.00     0.0   0.200 0.100  19.41   4.7    21.4
  7  0.237    16789 0.000 0.000 1.00     0.4   0.200 0.100  22.65   4.7    21.4
  8  0.237    16789 0.000 0.000 1.00     1.1   0.200 0.100  25.88   4.7    21.4
  9  0.237    16789 0.000 0.000 1.00     1.7   0.200 0.100  29.12   4.7    21.4
 10  0.237    16789 0.000 0.000 1.00     2.4   0.200 0.100  32.35   4.7    21.4
 11  0.237    16789 0.000 0.000 1.00     3.0   0.200 0.100  35.59   4.7    21.4
 12  0.237    16789 0.000 0.000 1.00     3.5   0.200 0.100  38.82   4.7    21.4
 13  0.237    16789 0.000 0.000 1.00     4.2   0.200 0.100  42.06   4.7    21.4
 14  0.237    16789 0.000 0.000 1.00     4.9   0.200 0.100  45.29   4.7    21.4
 15  0.237    16789 0.000 0.000 1.00     5.7   0.200 0.100  48.53   4.7    21.4
 16  0.237    16789 0.000 0.000 1.00     9.6   0.200 0.100  51.76   4.7    21.4
 17  0.237    16789 0.000 0.000 1.00    11.2   0.200 0.100  55.00   4.7    21.4
Toe                                    172.7   0.150 0.243

     4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
     4.034 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    36.00     10.81      1.00     0.800
↑
FRA-70-1301A - Historic Boring B-1                                12/23/2014
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
  220.5    40.7   7.45   7.52   -0.36  10  29    26.17   9   3   17.0    43.1
```

1 0 10.81000 11.86000

FRA-70-1301A - Historic Boring B-1 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 42.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
55.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.505

Pile and Soil Model Total Capacity Rut (kips) 227.0

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.237	16789	0.010	0.000	0.85	0.0	0.000	0.100	3.24	4.7	21.4
2	0.237	16789	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
5	0.237	16789	0.000	0.000	1.00	0.3	0.200	0.100	16.18	4.7	21.4
6	0.237	16789	0.000	0.000	1.00	1.0	0.200	0.100	19.41	4.7	21.4
7	0.237	16789	0.000	0.000	1.00	1.6	0.200	0.100	22.65	4.7	21.4
8	0.237	16789	0.000	0.000	1.00	2.3	0.200	0.100	25.88	4.7	21.4
9	0.237	16789	0.000	0.000	1.00	3.0	0.200	0.100	29.12	4.7	21.4
10	0.237	16789	0.000	0.000	1.00	3.4	0.200	0.100	32.35	4.7	21.4
11	0.237	16789	0.000	0.000	1.00	4.1	0.200	0.100	35.59	4.7	21.4
12	0.237	16789	0.000	0.000	1.00	4.8	0.200	0.100	38.82	4.7	21.4
13	0.237	16789	0.000	0.000	1.00	5.6	0.200	0.100	42.06	4.7	21.4
14	0.237	16789	0.000	0.000	1.00	8.9	0.200	0.100	45.29	4.7	21.4
15	0.237	16789	0.000	0.000	1.00	11.0	0.200	0.100	48.53	4.7	21.4
16	0.237	16789	0.000	0.000	1.00	12.2	0.200	0.100	51.76	4.7	21.4
17	0.237	16789	0.000	0.000	1.00	15.6	0.200	0.100	55.00	4.7	21.4
Toe						153.1	0.150	0.243			

4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
4.034 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
42.00	10.81	1.00	0.800

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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
227.0	44.4	7.56	7.61	-0.15	7	27	26.39	8	3	16.8	42.9

1 0 10.81000 11.86000

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Resource International Inc GRLWEAP Version 2010

Depth (ft) 48.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
55.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.505

Pile and Soil Model Total Capacity Rut (kips) 279.6

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

B-1

1	0.237	16789	0.010	0.000	0.85	0.0	0.000	0.100	3.24	4.7	21.4
2	0.237	16789	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
3	0.237	16789	0.000	0.000	1.00	0.2	0.200	0.100	9.71	4.7	21.4
4	0.237	16789	0.000	0.000	1.00	0.9	0.200	0.100	12.94	4.7	21.4
5	0.237	16789	0.000	0.000	1.00	1.6	0.200	0.100	16.18	4.7	21.4
6	0.237	16789	0.000	0.000	1.00	2.2	0.200	0.100	19.41	4.7	21.4
7	0.237	16789	0.000	0.000	1.00	2.9	0.200	0.100	22.65	4.7	21.4
8	0.237	16789	0.000	0.000	1.00	3.3	0.200	0.100	25.88	4.7	21.4
9	0.237	16789	0.000	0.000	1.00	4.0	0.200	0.100	29.12	4.7	21.4
10	0.237	16789	0.000	0.000	1.00	4.7	0.200	0.100	32.35	4.7	21.4
11	0.237	16789	0.000	0.000	1.00	5.4	0.200	0.100	35.59	4.7	21.4
12	0.237	16789	0.000	0.000	1.00	8.2	0.200	0.100	38.82	4.7	21.4
13	0.237	16789	0.000	0.000	1.00	10.9	0.200	0.100	42.06	4.7	21.4
14	0.237	16789	0.000	0.000	1.00	12.0	0.200	0.100	45.29	4.7	21.4
15	0.237	16789	0.000	0.000	1.00	14.4	0.200	0.100	48.53	4.7	21.4
16	0.237	16789	0.000	0.000	1.00	22.2	0.200	0.100	51.76	4.7	21.4
17	0.237	16789	0.000	0.000	1.00	24.1	0.200	0.100	55.00	4.7	21.4
Toe						162.5	0.150	0.243			

4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
4.034 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
48.00	10.81	1.00	0.800

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FRA-70-1301A - Historic Boring B-1 12/23/2014
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
279.6	67.4	8.00	7.99	-0.47	6	46	27.47	6	3	17.1	41.8

1 0 10.81000 11.86000

↑
FRA-70-1301A - Historic Boring B-1 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 51.7
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
55.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.505

Pile and Soil Model Total Capacity Rut (kips) 314.9

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	0.237	16789	0.010	0.000	0.85	0.0	0.000	0.100	3.24	4.7	21.4
2	0.237	16789	0.000	0.000	1.00	0.3	0.200	0.100	6.47	4.7	21.4
3	0.237	16789	0.000	0.000	1.00	1.0	0.200	0.100	9.71	4.7	21.4
4	0.237	16789	0.000	0.000	1.00	1.6	0.200	0.100	12.94	4.7	21.4
5	0.237	16789	0.000	0.000	1.00	2.3	0.200	0.100	16.18	4.7	21.4
6	0.237	16789	0.000	0.000	1.00	3.0	0.200	0.100	19.41	4.7	21.4
7	0.237	16789	0.000	0.000	1.00	3.4	0.200	0.100	22.65	4.7	21.4
8	0.237	16789	0.000	0.000	1.00	4.1	0.200	0.100	25.88	4.7	21.4
9	0.237	16789	0.000	0.000	1.00	4.8	0.200	0.100	29.12	4.7	21.4
10	0.237	16789	0.000	0.000	1.00	5.5	0.200	0.100	32.35	4.7	21.4
11	0.237	16789	0.000	0.000	1.00	8.8	0.200	0.100	35.59	4.7	21.4
12	0.237	16789	0.000	0.000	1.00	11.0	0.200	0.100	38.82	4.7	21.4
13	0.237	16789	0.000	0.000	1.00	12.2	0.200	0.100	42.06	4.7	21.4
14	0.237	16789	0.000	0.000	1.00	15.5	0.200	0.100	45.29	4.7	21.4
15	0.237	16789	0.000	0.000	1.00	22.4	0.200	0.100	48.53	4.7	21.4
16	0.237	16789	0.000	0.000	1.00	24.4	0.200	0.100	51.76	4.7	21.4
17	0.237	16789	0.000	0.000	1.00	26.3	0.200	0.100	55.00	4.7	21.4
Toe						168.3	0.150	0.243			

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

4.034 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
51.65	10.81	1.00	0.800

↑

FRA-70-1301A - Historic Boring B-1 12/23/2014
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
314.9	87.4	8.23	8.18	-0.39	6	42	27.96	5	3	17.4	41.3

1 0 10.81000 11.86000

↑

FRA-70-1301A - Historic Boring B-1 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 54.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
55.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.505

Pile and Soil Model Total Capacity Rut (kips) 338.9

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	0.237	16789	0.010	0.000	0.85	0.2	0.200	0.100	3.24	4.7	21.4
2	0.237	16789	0.000	0.000	1.00	0.8	0.200	0.100	6.47	4.7	21.4
3	0.237	16789	0.000	0.000	1.00	1.5	0.200	0.100	9.71	4.7	21.4
4	0.237	16789	0.000	0.000	1.00	2.1	0.200	0.100	12.94	4.7	21.4
5	0.237	16789	0.000	0.000	1.00	2.8	0.200	0.100	16.18	4.7	21.4
6	0.237	16789	0.000	0.000	1.00	3.3	0.200	0.100	19.41	4.7	21.4
7	0.237	16789	0.000	0.000	1.00	3.9	0.200	0.100	22.65	4.7	21.4
8	0.237	16789	0.000	0.000	1.00	4.6	0.200	0.100	25.88	4.7	21.4
9	0.237	16789	0.000	0.000	1.00	5.3	0.200	0.100	29.12	4.7	21.4
10	0.237	16789	0.000	0.000	1.00	7.6	0.200	0.100	32.35	4.7	21.4
11	0.237	16789	0.000	0.000	1.00	10.7	0.200	0.100	35.59	4.7	21.4
12	0.237	16789	0.000	0.000	1.00	11.8	0.200	0.100	38.82	4.7	21.4
13	0.237	16789	0.000	0.000	1.00	13.1	0.200	0.100	42.06	4.7	21.4
14	0.237	16789	0.000	0.000	1.00	21.9	0.200	0.100	45.29	4.7	21.4
15	0.237	16789	0.000	0.000	1.00	23.8	0.200	0.100	48.53	4.7	21.4
16	0.237	16789	0.000	0.000	1.00	25.8	0.200	0.100	51.76	4.7	21.4
17	0.237	16789	0.000	0.000	1.00	27.7	0.200	0.100	55.00	4.7	21.4
Toe						172.0	0.150	0.243			

4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
4.034 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
54.00	10.81	1.00	0.800

↑

FRA-70-1301A - Historic Boring B-1 12/23/2014
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
338.9	106.8	8.35	8.30	-0.35	5	40	28.20	5	3	17.4	41.0

1 0 10.81000 11.86000

↑

FRA-70-1301A - Historic Boring B-1 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 55.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area	(in2)	198.500	Pile Type	H Pile
Pile Size	(inch)	14.580		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
55.0	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 6.505

Pile and Soil Model — Total Capacity Rut (kips) 746.2

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.237	16789	0.010	0.000	0.85	0.3	0.200	0.100	3.24	4.7	21.4
2	0.237	16789	0.000	0.000	1.00	1.0	0.200	0.100	6.47	4.7	21.4
3	0.237	16789	0.000	0.000	1.00	1.7	0.200	0.100	9.71	4.7	21.4
4	0.237	16789	0.000	0.000	1.00	2.3	0.200	0.100	12.94	4.7	21.4
5	0.237	16789	0.000	0.000	1.00	3.0	0.200	0.100	16.18	4.7	21.4
6	0.237	16789	0.000	0.000	1.00	3.4	0.200	0.100	19.41	4.7	21.4
7	0.237	16789	0.000	0.000	1.00	4.1	0.200	0.100	22.65	4.7	21.4
8	0.237	16789	0.000	0.000	1.00	4.9	0.200	0.100	25.88	4.7	21.4
9	0.237	16789	0.000	0.000	1.00	5.6	0.200	0.100	29.12	4.7	21.4
10	0.237	16789	0.000	0.000	1.00	9.0	0.200	0.100	32.35	4.7	21.4
11	0.237	16789	0.000	0.000	1.00	11.1	0.200	0.100	35.59	4.7	21.4
12	0.237	16789	0.000	0.000	1.00	12.2	0.200	0.100	38.82	4.7	21.4
13	0.237	16789	0.000	0.000	1.00	15.8	0.200	0.100	42.06	4.7	21.4
14	0.237	16789	0.000	0.000	1.00	22.5	0.200	0.100	45.29	4.7	21.4
15	0.237	16789	0.000	0.000	1.00	24.4	0.200	0.100	48.53	4.7	21.4
16	0.237	16789	0.000	0.000	1.00	26.4	0.200	0.100	51.76	4.7	21.4
17	0.237	16789	0.000	0.000	1.00	47.3	0.200	0.100	55.00	4.7	21.4
Toe						551.4	0.150	0.243			

4.033 kips total unreduced pile weight (g= 32.17 ft/s2)
4.034 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
55.00	10.81	1.00	0.800

FRA-70-1301A - Historic Boring B-1 12/23/2014
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
746.2	9999.0	9.24	9.21	-1.69	10	18	30.32	5	2	19.3	39.0

FRA-70-1301A - Historic Boring B-1 12/23/2014
Resource International Inc GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 1.000 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
6.0	93.3	1.1	92.1	10.9	20.846	-0.083	5.94	18.3
12.0	96.7	4.6	92.1	11.6	21.192	-0.195	6.01	18.2
18.0	177.1	10.1	167.0	27.0	25.156	-0.376	7.11	17.3
24.0	184.8	17.8	167.0	29.2	25.371	-0.504	7.17	17.2
30.0	194.9	27.9	167.0	32.4	25.694	-0.341	7.28	17.2
36.0	220.5	47.8	172.7	40.7	26.169	-0.356	7.45	17.0
42.0	227.0	73.9	153.1	44.4	26.389	-0.152	7.56	16.8
48.0	279.6	117.1	162.5	67.4	27.469	-0.474	8.00	17.1
51.7	314.9	146.6	168.3	87.4	27.965	-0.395	8.23	17.4
54.0	338.9	166.9	172.0	106.8	28.197	-0.352	8.35	17.4
55.0	746.2	194.9	551.4	9999.0	30.318	-1.687	9.24	19.3

Refusal occurred; no driving time output possible

FRA-70-1301A - Historic Boring B-1 12/23/2014
Resource International Inc GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
6.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00
12.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00
18.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00
24.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00
30.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00
36.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00
42.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00
48.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00
51.65	55.00	0.00	10.81	1.00	0.80	1.00	1.00
54.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00
55.00	55.00	0.00	10.81	1.00	0.80	1.00	1.00

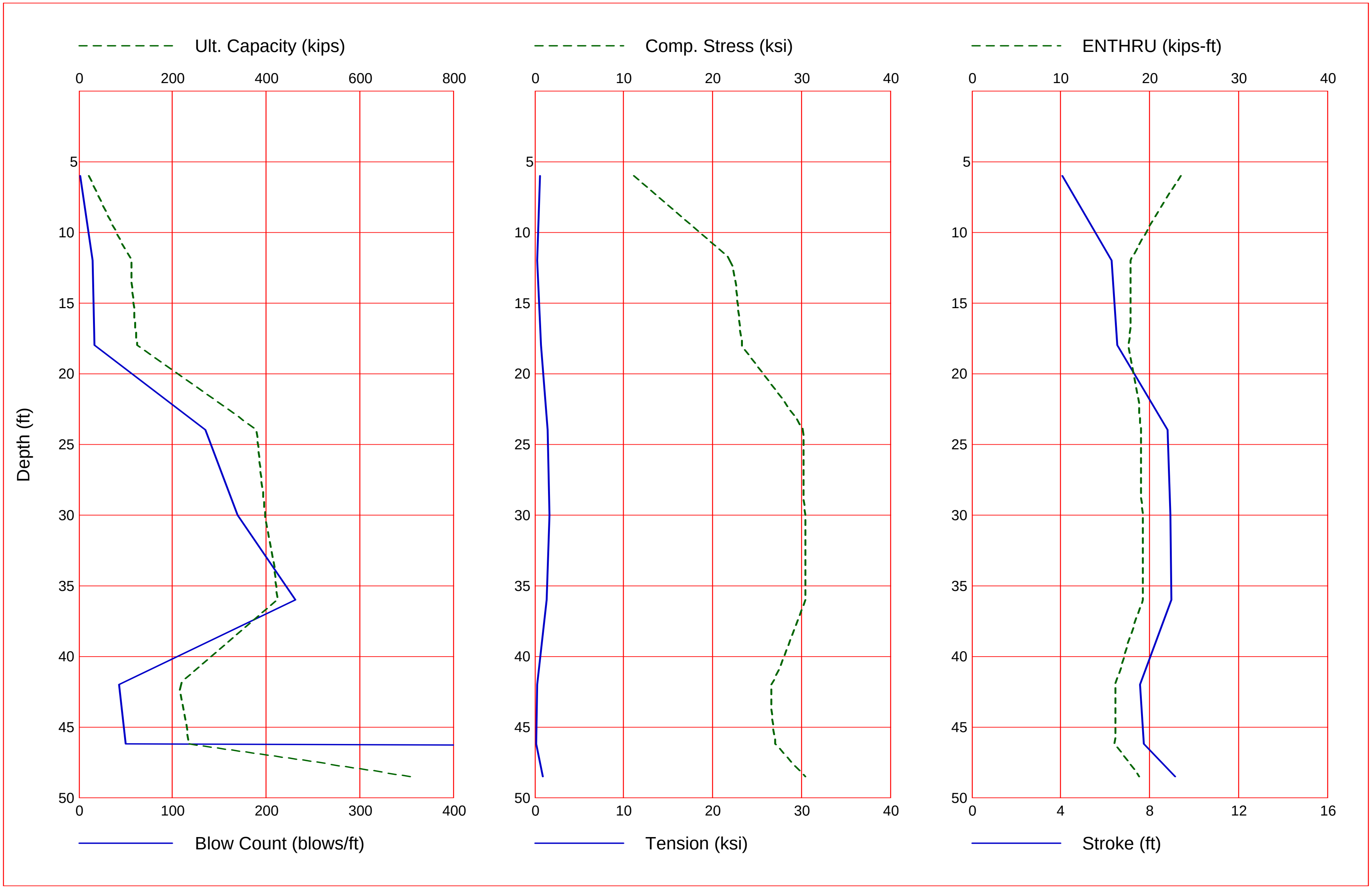
Soil Layer Resistance Values

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
0.00	0.00	92.13	0.100	0.243	0.200	0.150	1.000	0.000	0.000
16.00	0.22	92.13	0.100	0.243	0.200	0.150	1.000	0.000	0.000
16.00	0.20	166.98	0.100	0.243	0.200	0.150	1.000	0.000	0.000
30.00	0.40	166.98	0.100	0.243	0.200	0.150	1.000	0.000	0.000
30.00	0.64	172.74	0.100	0.243	0.200	0.150	1.000	0.000	0.000
41.00	0.89	172.74	0.100	0.243	0.200	0.150	1.000	0.000	0.000
41.00	1.37	151.53	0.100	0.243	0.200	0.150	1.000	0.000	0.000
54.50	1.90	172.74	0.100	0.243	0.200	0.150	1.000	0.000	0.000
54.50	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000
55.00	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000

Resource International Inc
FRA-70-1301A - Historic Boring B-12

Dec 23 2014
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000



Gain/Loss 1 at Shaft and Toe 1.000 / 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
6.0	21.3	1.2	20.1	1.8	11.127	-0.607	4.07	23.5
12.0	112.1	5.6	106.5	14.3	22.161	-0.292	6.28	17.9
18.0	124.6	18.1	106.5	16.9	23.277	-0.669	6.55	17.7
24.0	378.9	33.4	345.5	134.7	30.265	-1.422	8.83	19.0
30.0	398.3	52.8	345.5	169.6	30.496	-1.695	8.92	19.2
36.0	424.0	78.5	345.5	231.7	30.454	-1.382	8.98	19.2
42.0	214.1	107.6	106.5	42.9	26.619	-0.282	7.57	16.2
46.2	233.1	126.6	106.5	50.0	27.032	-0.172	7.75	16.1
48.5	710.5	159.2	551.4	9999.0	30.466	-0.951	9.16	18.8

Refusal occurred; no driving time output possible

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

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

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

```
 Input  File: C:\USERS\JAMESH.RIICOLUMBUS\DESKTOP\DRIVEABILITY\B-12.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
 Hammer File Version:  2003 (2/22/2013)
```

Input File Contents

```
     FRA-70-1301A - Historic Boring B-12
 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   1   0  0   0   0   0   0   0  0   0   0   0   0   0   0.000
    Pile g  Hammer g  Toe Area Pile Size           Pile Type
    32.185    32.185   198.500    14.580              H Pile
      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
    48.500     21.40   30457.9   493.356     4.699         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
0.100	0.243	0.200	0.150	0.000	0.000	0.000	0.000

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

0.000	0.000	0.000	0.000

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

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	20.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10.00	0.14	20.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10.00	0.20	106.52	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20.00	0.68	106.52	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20.00	0.43	345.48	0.00	0.00	0.00	0.00	0.00	0.00	0.0
40.00	1.17	345.48	0.00	0.00	0.00	0.00	0.00	0.00	0.0
40.00	0.88	106.52	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.00	1.06	106.52	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.00	10.00	551.39	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.50	10.00	551.39	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Gain/Loss factors: shaft and toe

1.00000	0.00000	0.00000	0.00000	0.00000
1.00000	0.00000	0.00000	0.00000	0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
18.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
24.00	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
36.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
42.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
46.15	0.00	0.00	0.000	0.000	0.000	0.000	0.000
48.50	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-70-1301A - Historic Boring B-12

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	0.0098	5.8
Combined Pile Top		16798.9			

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-70-1301A - Historic Boring B-12 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 6.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model Total Capacity Rut (kips) 21.3

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	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	0.2	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	0.9	0.200	0.100	48.50	4.7	21.4
Toe						20.1	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 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) 0.771
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 32.185 32.185
Output Segment Generation: Automatic

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
6.00	10.81	1.00	0.800

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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
21.3	1.8	4.07	4.09	-0.61	6	7	11.13	1	2	23.5	58.7

1 0 10.81000 11.86000

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Resource International Inc GRLWEAP Version 2010

Depth (ft) 12.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

```
 Wave Travel Time 2L/c (ms)     5.736

       Pile and Soil Model           Total Capacity Rut  (kips)     112.1
No. Weight   Stiffn C-Slk T-Slk  CoR  Soil-S  Soil-D Quake  LbTop Perim    Area
      kips     k/in    ft    ft         kips    s/ft  inch     ft    ft     in2
  1  0.237    16799 0.010 0.000 0.85     0.0   0.000 0.100   3.23   4.7    21.4
  2  0.237    16799 0.000 0.000 1.00     0.0   0.000 0.100   6.47   4.7    21.4
 12  0.237    16799 0.000 0.000 1.00     0.2   0.200 0.100  38.80   4.7    21.4
 13  0.237    16799 0.000 0.000 1.00     0.8   0.200 0.100  42.03   4.7    21.4
 14  0.237    16799 0.000 0.000 1.00     1.5   0.200 0.100  45.27   4.7    21.4
 15  0.237    16799 0.000 0.000 1.00     3.1   0.200 0.100  48.50   4.7    21.4
Toe                                    106.5   0.150 0.243

     3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
     3.558 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    12.00     10.81      1.00     0.800
↑
FRA-70-1301A - Historic Boring B-12                               12/23/2014
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
  112.1    14.3   6.28   6.29   -0.29  13  46    22.16  11   4   17.9    47.0
        1          0   10.81000       11.86000
↑
FRA-70-1301A - Historic Boring B-12                               12/23/2014
Resource International Inc                                 GRLWEAP Version 2010

 Depth                (ft)      18.0
 Shaft Gain/Loss Factor        1.000  Toe Gain/Loss Factor          1.000

 PILE PROFILE:
 Toe Area            (in2)   198.500  Pile Type                    H Pile
 Pile Size          (inch)    14.580

  L b Top     Area    E-Mod  Spec Wt    Perim  C Index  Wave Sp      EA/c
       ft      in2      ksi   lb/ft3       ft             ft/s    k/ft/s
      0.0    21.40   30458.    493.4      4.7       0    16911.     38.5
     48.5    21.40   30458.    493.4      4.7       0    16911.     38.5

 Wave Travel Time 2L/c (ms)     5.736

       Pile and Soil Model           Total Capacity Rut  (kips)     124.6
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  0.237    16799 0.010 0.000 0.85     0.0   0.000 0.100   3.23   4.7    21.4
  2  0.237    16799 0.000 0.000 1.00     0.0   0.000 0.100   6.47   4.7    21.4
 10  0.237    16799 0.000 0.000 1.00     0.1   0.200 0.100  32.33   4.7    21.4
 11  0.237    16799 0.000 0.000 1.00     0.7   0.200 0.100  35.57   4.7    21.4
 12  0.237    16799 0.000 0.000 1.00     1.4   0.200 0.100  38.80   4.7    21.4
 13  0.237    16799 0.000 0.000 1.00     2.7   0.200 0.100  42.03   4.7    21.4
 14  0.237    16799 0.000 0.000 1.00     5.4   0.200 0.100  45.27   4.7    21.4
 15  0.237    16799 0.000 0.000 1.00     7.7   0.200 0.100  48.50   4.7    21.4
Toe                                    106.5   0.150 0.243

     3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
     3.558 kips total reduced pile weight   (g= 32.19 ft/s2)


    Depth    Stroke  Pressure    Efficy
       ft        ft     Ratio
    18.00     10.81      1.00     0.800
↑
FRA-70-1301A - Historic Boring B-12                               12/23/2014
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
  124.6    16.9   6.55   6.49   -0.67  12  41    23.28  11   4   17.7    46.2
        1          0   10.81000       11.86000
↑
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FRA-70-1301A - Historic Boring B-12 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 24.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model Total Capacity Rut (kips) 378.9

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	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	0.1	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	0.6	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	1.3	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	2.4	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	5.0	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	7.4	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	8.8	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	7.8	0.200	0.100	48.50	4.7	21.4
Toe						345.5	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
24.00	10.81	1.00	0.800

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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
378.9	134.7	8.83	8.80	-1.42	11	46	30.26	11	4	19.0	39.8

1 0 10.81000 11.86000

FRA-70-1301A - Historic Boring B-12 12/23/2014
Resource International Inc GRLWEAP Version 2010

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

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model Total Capacity Rut (kips) 398.3

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	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
6	0.237	16799	0.000	0.000	1.00	0.0	0.200	0.100	19.40	4.7	21.4
7	0.237	16799	0.000	0.000	1.00	0.5	0.200	0.100	22.63	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	1.2	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	2.1	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	4.7	0.200	0.100	32.33	4.7	21.4

11	0.237	16799	0.000	0.000	1.00	7.1	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	9.1	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	7.5	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	9.4	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	11.2	0.200	0.100	48.50	4.7	21.4
Toe						345.5	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
398.3	169.6	8.92	8.84	-1.70	10	43	30.50	10	3	19.2	39.7

1 0 10.81000 11.86000

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Depth (ft) 36.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model Total Capacity Rut (kips) 424.0

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
4	0.237	16799	0.000	0.000	1.00	0.0	0.200	0.100	12.93	4.7	21.4
5	0.237	16799	0.000	0.000	1.00	0.4	0.200	0.100	16.17	4.7	21.4
6	0.237	16799	0.000	0.000	1.00	1.1	0.200	0.100	19.40	4.7	21.4
7	0.237	16799	0.000	0.000	1.00	1.8	0.200	0.100	22.63	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	4.4	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	6.7	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	9.1	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	7.5	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	9.1	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	11.0	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	12.8	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	14.6	0.200	0.100	48.50	4.7	21.4
Toe						345.5	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
36.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)		Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
424.0	231.7	8.98	8.90	-1.38	8	41	30.45	8	3	19.2	39.6

1 0 10.81000 11.86000

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Depth (ft) 42.0
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model Total Capacity Rut (kips) 214.1

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.237	16799	0.010	0.000	0.85	0.0	0.000	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.0	0.000	0.100	6.47	4.7	21.4
3	0.237	16799	0.000	0.000	1.00	0.3	0.200	0.100	9.70	4.7	21.4
4	0.237	16799	0.000	0.000	1.00	1.0	0.200	0.100	12.93	4.7	21.4
5	0.237	16799	0.000	0.000	1.00	1.7	0.200	0.100	16.17	4.7	21.4
6	0.237	16799	0.000	0.000	1.00	3.9	0.200	0.100	19.40	4.7	21.4
7	0.237	16799	0.000	0.000	1.00	6.4	0.200	0.100	22.63	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	8.7	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	7.8	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	8.9	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	10.7	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	12.5	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	14.4	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	16.2	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	15.2	0.200	0.100	48.50	4.7	21.4
Toe						106.5	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
42.00	10.81	1.00	0.800

↑
FRA-70-1301A - Historic Boring B-12 12/23/2014
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
214.1	42.9	7.57	7.63	-0.28	5	48	26.62	6	3	16.2	42.8

1 0 10.81000 11.86000

↑
FRA-70-1301A - Historic Boring B-12 12/23/2014
Resource International Inc GRLWEAP Version 2010

Depth (ft) 46.2
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model Total Capacity Rut (kips) 233.1

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.237	16799	0.010	0.000	0.85	0.0	0.200	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	0.5	0.200	0.100	6.47	4.7	21.4

3	0.237	16799	0.000	0.000	1.00	1.2	0.200	0.100	9.70	4.7	21.4
4	0.237	16799	0.000	0.000	1.00	2.1	0.200	0.100	12.93	4.7	21.4
5	0.237	16799	0.000	0.000	1.00	4.7	0.200	0.100	16.17	4.7	21.4
6	0.237	16799	0.000	0.000	1.00	7.0	0.200	0.100	19.40	4.7	21.4
7	0.237	16799	0.000	0.000	1.00	9.1	0.200	0.100	22.63	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	7.5	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	9.4	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	11.2	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	13.0	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	14.9	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	16.7	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	14.3	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	15.0	0.200	0.100	48.50	4.7	21.4
Toe						106.5	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
46.15	10.81	1.00	0.800

↑
FRA-70-1301A - Historic Boring B-12 12/23/2014
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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
233.1	50.0	7.75	7.78	-0.17	4	45	27.03	5	3	16.1	42.4
	1	0	10.81000			11.86000					

↑
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Depth (ft) 48.5
Shaft Gain/Loss Factor 1.000 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 198.500 Pile Type H Pile
Pile Size (inch) 14.580

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	30458.	493.4	4.7	0	16911.	38.5
48.5	21.40	30458.	493.4	4.7	0	16911.	38.5

Wave Travel Time 2L/c (ms) 5.736

Pile and Soil Model — Total Capacity Rut (kips) 710.5

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.237	16799	0.010	0.000	0.85	0.3	0.200	0.100	3.23	4.7	21.4
2	0.237	16799	0.000	0.000	1.00	1.0	0.200	0.100	6.47	4.7	21.4
3	0.237	16799	0.000	0.000	1.00	1.7	0.200	0.100	9.70	4.7	21.4
4	0.237	16799	0.000	0.000	1.00	3.9	0.200	0.100	12.93	4.7	21.4
5	0.237	16799	0.000	0.000	1.00	6.4	0.200	0.100	16.17	4.7	21.4
6	0.237	16799	0.000	0.000	1.00	8.8	0.200	0.100	19.40	4.7	21.4
7	0.237	16799	0.000	0.000	1.00	7.8	0.200	0.100	22.63	4.7	21.4
8	0.237	16799	0.000	0.000	1.00	8.9	0.200	0.100	25.87	4.7	21.4
9	0.237	16799	0.000	0.000	1.00	10.7	0.200	0.100	29.10	4.7	21.4
10	0.237	16799	0.000	0.000	1.00	12.5	0.200	0.100	32.33	4.7	21.4
11	0.237	16799	0.000	0.000	1.00	14.4	0.200	0.100	35.57	4.7	21.4
12	0.237	16799	0.000	0.000	1.00	16.2	0.200	0.100	38.80	4.7	21.4
13	0.237	16799	0.000	0.000	1.00	15.1	0.200	0.100	42.03	4.7	21.4
14	0.237	16799	0.000	0.000	1.00	14.6	0.200	0.100	45.27	4.7	21.4
15	0.237	16799	0.000	0.000	1.00	36.7	0.200	0.100	48.50	4.7	21.4
Toe						551.4	0.150	0.243			

3.556 kips total unreduced pile weight (g= 32.17 ft/s2)
3.558 kips total reduced pile weight (g= 32.19 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
48.50	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
710.5	9999.0	9.16	9.14	-0.95	5	34	30.47	5	2	18.8	39.1

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SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 1.000 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
6.0	21.3	1.2	20.1	1.8	11.127	-0.607	4.07	23.5
12.0	112.1	5.6	106.5	14.3	22.161	-0.292	6.28	17.9
18.0	124.6	18.1	106.5	16.9	23.277	-0.669	6.55	17.7
24.0	378.9	33.4	345.5	134.7	30.265	-1.422	8.83	19.0
30.0	398.3	52.8	345.5	169.6	30.496	-1.695	8.92	19.2
36.0	424.0	78.5	345.5	231.7	30.454	-1.382	8.98	19.2
42.0	214.1	107.6	106.5	42.9	26.619	-0.282	7.57	16.2
46.2	233.1	126.6	106.5	50.0	27.032	-0.172	7.75	16.1
48.5	710.5	159.2	551.4	9999.0	30.466	-0.951	9.16	18.8

Refusal occurred; no driving time output possible

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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
6.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
12.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
18.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
24.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
30.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
36.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
42.00	48.50	0.00	10.81	1.00	0.80	1.00	1.00
46.15	48.50	0.00	10.81	1.00	0.80	1.00	1.00
48.50	48.50	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
0.00	0.00	20.15	0.100	0.243	0.200	0.150	1.000	0.000	0.000
10.00	0.14	20.15	0.100	0.243	0.200	0.150	1.000	0.000	0.000
10.00	0.20	106.52	0.100	0.243	0.200	0.150	1.000	0.000	0.000
20.00	0.68	106.52	0.100	0.243	0.200	0.150	1.000	0.000	0.000
20.00	0.43	345.48	0.100	0.243	0.200	0.150	1.000	0.000	0.000
40.00	1.17	345.48	0.100	0.243	0.200	0.150	1.000	0.000	0.000
40.00	0.88	106.52	0.100	0.243	0.200	0.150	1.000	0.000	0.000
48.00	1.06	106.52	0.100	0.243	0.200	0.150	1.000	0.000	0.000
48.00	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000
48.50	10.00	551.39	0.100	0.243	0.200	0.150	1.000	0.000	0.000

APPENDIX VII

DRILLED SHAFT CALCULATIONS

W-13-045 FRA-70-12.68 - FRA-70-1301A
Drilled Shaft Calculations

End Bearing Resistance in Bedrock: Limestone and Dolomite

Intact Rock (Minimum Rock Socket Length ≥ 1.5B):

$q_p = 2.5q_u$ Equation 10.8.3.5.4c-1

q_u =	831	ksf
q_p =	2,078	ksf

Jointed Rock (or Shafts with Rock Socket Length < 1.5B):

$$q_p = A + q_u\left[m_b\left(\frac{A}{q_u}\right) + s\right]^a$$ Equation 10.8.3.5.4c-2:

$$A = \sigma'_{vb} + q_u\left[m_b\frac{\sigma'_{vb}}{q_u} + s\right]^a$$ Equation 10.8.3.5.4c-3

q_u =	831	ksf	
GSI =	70	Per Figure 10.4.6.4-1	
D =	0.0	Per Section 10.4.6.4 for undisturbed foundation excavation	
m_i =	9	Per Table 10.4.6.4-1	
s =	0.036	Per Equation 10.4.6.4-2	
a =	0.50	Per Equation 10.4.6.4-3	
m_b =	3.08	Per Equation 10.4.6.4-4	
σ'_{vb} =	3.74	ksf	Considering overburden depth of 65 feet and bouyant unit weight of overburden of 57.6 pcf
A =	188	ksf	Per Equation 10.8.3.5.4c-3
q_p =	899	ksf	

Side Resistance in Bedrock (Minimum Rock Socket Length ≥ 1.0B): Limestone and Dolomite

$$q_s = C(p_a)\sqrt{\frac{q_u}{p_a}}$$ Equation 10.8.3.5.4b-1:

q_u =	831	ksf
p_a =	2.12	ksf
C =	1.00	
q_s =	42.0	ksf

APPENDIX VIII

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-015-1-13	746.7 to 741.2	A-6a	C	3	32	32	125 psf	125 psf	Su = 4,000 psf	1,335 pci	0.0047	-
	741.2 to 731.2	A-6a	C	3	12	12	115 psf	115 psf	Su = 1,500 psf	500 pci	0.0070	-
	731.2 to 718.7	A-6a	C	3	25	25	120 psf	120 psf	Su = 3,125 psf	1,040 pci	0.0050	-
	718.7 to 714.7	A-1-b	G	4	69	56	135 psf	135 psf	φ = 42°	355 pci	-	-
	714.7 to 709.7	A-6b	C	3	19	19	120 psf	120 psf	Su = 2,375 psf	790 pci	0.0058	-
	709.7 to 694.7	A-4a	C	3	23	23	120 psf	120 psf	Su = 2,875 psf	960 pci	0.0052	-
	694.7 to 689.7	A-1-b	G	4	49	29	135 psf	135 psf	φ = 39°	250 pci	-	-
	689.7 to 674.7	A-1-b	G	4	30	16	130 psf	130 psf	φ = 36°	160 pci	-	-
	674.7 to 651.7	A-4a	C	2	15	15	115 psf	52.6 psf	Su = 1,875 psf	625 pci	0.0065	-
B-015-2-13	700.4 to 694.9	A-2-4	G	4	32	50	130 psf	130 psf	φ = 41°	315 pci	-	-
	694.9 to 689.9	A-1-b	G	4	48	59	130 psf	130 psf	φ = 42°	355 pci	-	-
	689.9 to 682.4	A-1-b	G	4	13	14	125 psf	62.6 psf	φ = 36°	95 pci	-	-
	682.4 to 677.4	A-1-b	G	4	29	29	130 psf	67.6 psf	φ = 39°	140 pci	-	-
	677.4 to 668.4	A-1-a	G	4	36	33	130 psf	67.6 psf	φ = 41°	175 pci	-	-
	668.4 to 658.4	A-4a	C	2	45	45	130 psf	67.6 psf	Su = 5,625 psf	1,875 pci	0.0041	-
	658.4 to 641.9	A-4a	C	2	32	32	125 psf	62.6 psf	Su = 4,000 psf	1,335 pci	0.0047	-
	641.9 to 631.9	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	63
B-015-4-13	734.2 to 726.2	A-2-4	G	4	24	35	125 psf	125 psf	φ = 39°	250 pci	-	-
	726.2 to 716.2	A-6b	C	3	17	17	120 psf	120 psf	Su = 2,125 psf	710 pci	0.0062	-
	716.2 to 711.7	A-1-a	G	4	58	54	135 psf	135 psf	φ = 43°	395 pci	-	-
	711.7 to 706.2	A-4a	G	4	12	10	115 psf	115 psf	φ = 30°	45 pci	-	-
	706.2 to 702.2	A-6a	C	3	10	10	115 psf	115 psf	Su = 1,250 psf	365 pci	0.0080	-
	702.2 to 697.2	A-1-b	G	4	14	11	125 psf	125 psf	φ = 35°	135 pci	-	-
	697.2 to 687.2	A-4a	C	3	20	20	120 psf	120 psf	Su = 2,500 psf	835 pci	0.0057	-
	687.2 to 677.2	A-7-6	C	3	5	5	115 psf	115 psf	Su = 1,100 psf	285 pci	0.0086	-
	677.2 to 667.2	A-4a	G	4	13	8	125 psf	62.6 psf	φ = 30°	30 pci	-	-
	667.2 to 662.2	A-4a	C	2	39	39	125 psf	62.6 psf	Su = 4,875 psf	1,625 pci	0.0044	-
	662.2 to 657.2	A-1-b	G	4	10	5	120 psf	57.6 psf	φ = 32°	50 pci	-	-
	657.2 to 647.5	A-4a	C	2	13	13	115 psf	52.6 psf	Su = 1,625 psf	540 pci	0.0068	-
	647.5 to 638.5	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	87

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-015-5-13	723.6 to 715.6	A-6b	C	3	23	23	120 psf	120 psf	Su = 2,875 psf	960 pci	0.0052	-
	715.6 to 708.1	A-6a	C	3	25	25	120 psf	120 psf	Su = 3,125 psf	1,040 pci	0.0050	-
	708.1 to 695.6	A-6b	C	3	15	15	115 psf	115 psf	Su = 1,875 psf	625 pci	0.0065	-
	695.6 to 686.6	A-6b	C	3	8	8	115 psf	115 psf	Su = 1,000 psf	235 pci	0.0090	-
	686.6 to 681.6	A-2-6	G	4	6	4	120 psf	120 psf	φ = 30°	45 pci	-	-
	681.6 to 676.6	A-4a	C	2	73	73	130 psf	67.6 psf	Su = 8,000 psf	2,665 pci	0.0033	-
	676.6 to 671.6	A-4a	C	2	23	23	120 psf	57.6 psf	Su = 2,875 psf	960 pci	0.0052	-
	671.6 to 666.6	A-2-6	G	4	28	18	130 psf	67.6 psf	φ = 36°	95 pci	-	-
	666.6 to 657.6	A-4a	C	2	25	25	120 psf	57.6 psf	Su = 3,125 psf	1,040 pci	0.0050	-
	657.6 to 647.6	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	63
B-015-6-13	723.0 to 715.0	A-2-6	G	4	24	35	120 psf	120 psf	φ = 39°	250 pci	-	-
	715.0 to 710.0	A-6a	C	3	10	10	115 psf	115 psf	Su = 1,250 psf	365 pci	0.0080	-
	710.0 to 705.0	A-4a	G	4	20	21	125 psf	125 psf	φ = 34°	115 pci	-	-
	705.0 to 686.0	A-1-b	G	4	61	50	135 psf	135 psf	φ = 42°	355 pci	-	-
	686.0 to 666.0	A-4b	C	2	71	71	130 psf	67.6 psf	Su = 8,000 psf	2,665 pci	0.0033	-
	666.0 to 656.0	A-2-4	G	4	100	62	135 psf	72.6 psf	φ = 41°	175 pci	-	-
	656.0 to 645.5	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	51
B-015-7-13	721.8 to 718.8	A-7-6	C	3	37	37	125 psf	125 psf	Su = 4,625 psf	1,540 pci	0.0045	-
	718.8 to 716.3	A-1-a	G	4	32	46	130 psf	130 psf	φ = 42°	355 pci	-	-
	716.3 to 708.8	A-6a	C	3	11	11	115 psf	115 psf	Su = 1,375 psf	435 pci	0.0075	-
	708.8 to 703.8	A-2-6	G	4	14	14	125 psf	125 psf	φ = 35°	135 pci	-	-
	703.8 to 689.8	A-1-b	G	4	53	45	135 psf	135 psf	φ = 41°	315 pci	-	-
	689.8 to 679.8	A-1-b	G	4	100	74	135 psf	72.6 psf	φ = 42°	195 pci	-	-
	679.8 to 674.8	A-1-b	G	4	52	37	135 psf	72.6 psf	φ = 40°	155 pci	-	-
	674.8 to 669.8	A-6b	C	2	61	61	130 psf	67.6 psf	Su = 7,625 psf	2,540 pci	0.0035	-
	669.8 to 651.3	A-1-b	G	4	100	63	135 psf	72.6 psf	φ = 42°	195 pci	-	-
	651.3 to 641.3	Dolomite	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	85
B-108-5-13	700.3 to 694.8	A-6a	C	3	18	18	120 psf	120 psf	Su = 2,250 psf	750 pci	0.0060	-
	694.8 to 689.8	A-2-6	G	4	18	22	125 psf	125 psf	φ = 37°	190 pci	-	-
	689.8 to 682.3	A-1-a	G	4	29	31	130 psf	67.6 psf	φ = 40°	155 pci	-	-
	682.3 to 677.3	A-1-b	G	4	19	19	125 psf	62.6 psf	φ = 37°	110 pci	-	-
	677.3 to 663.3	A-1-a	G	4	37	34	130 psf	67.6 psf	φ = 41°	175 pci	-	-
	663.3 to 645.8	A-4a	C	2	29	29	125 psf	62.6 psf	Su = 3,625 psf	1,210 pci	0.0048	-
	645.8 to 637.3	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	79

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-001-B-68	700.4 to 693.4	A-4a	C	3	10	10	115 psf	115 psf	Su = 1,250 psf	365 pci	0.0080	-
	693.4 to 690.4	A-2-4	G	4	16	20	125 psf	125 psf	φ = 36°	160 pci	-	-
	690.4 to 687.4	A-1-b	G	4	64	73	135 psf	72.6 psf	φ = 42°	195 pci	-	-
	687.4 to 682.4	A-3a	G	4	16	17	125 psf	62.6 psf	φ = 35°	85 pci	-	-
	682.4 to 677.4	A-2-4	G	4	38	38	130 psf	67.6 psf	φ = 39°	140 pci	-	-
	677.4 to 672.4	A-1-b	G	4	30	29	130 psf	67.6 psf	φ = 39°	140 pci	-	-
	672.4 to 666.4	A-4a	C	2	18	18	120 psf	57.6 psf	Su = 2,250 psf	750 pci	0.0060	-
	666.4 to 655.4	Boulders	G	4	100	84	140 psf	77.6 psf	φ = 45°	255 pci	-	-
	655.4 to 641.9	A-4a	G	4	58	44	135 psf	72.6 psf	φ = 37°	110 pci	-	-
	641.9 to 636.9	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	85
B-003-E-68	718.4 to 710.4	A-4a	C	3	25	25	120 psf	120 psf	Su = 3,125 psf	1,040 pci	0.0050	-
	710.4 to 705.4	A-1-b	G	4	30	34	130 psf	130 psf	φ = 40°	280 pci	-	-
	705.4 to 700.4	A-7-6	C	3	22	22	125 psf	125 psf	Su = 2,750 psf	915 pci	0.0053	-
	700.4 to 685.4	A-1-a	G	4	100	84	135 psf	135 psf	φ = 43°	395 pci	-	-
	685.4 to 675.4	A-1-a	G	4	20	15	125 psf	62.6 psf	φ = 37°	110 pci	-	-
	675.4 to 670.4	A-1-a	G	4	54	38	135 psf	72.6 psf	φ = 41°	175 pci	-	-
	670.4 to 665.4	A-1-b	G	4	26	18	125 psf	62.6 psf	φ = 37°	110 pci	-	-
	665.4 to 648.4	A-4a	C	2	27	27	125 psf	62.6 psf	Su = 3,375 psf	1,125 pci	0.0049	-
	648.4 to 643.4	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	85
B-012-E-68	704.4 to 695.4	A-1-a	G	4	18	26	125 psf	125 psf	φ = 39°	250 pci	-	-
	695.4 to 684.4	A-1-b	G	4	7	7	120 psf	120 psf	φ = 33°	95 pci	-	-
	684.4 to 674.4	A-1-a	G	4	37	34	130 psf	67.6 psf	φ = 41°	175 pci	-	-
	674.4 to 664.4	A-2-4	G	4	100	85	135 psf	72.6 psf	φ = 41°	175 pci	-	-
	664.4 to 659.4	A-4a	G	4	26	21	125 psf	62.6 psf	φ = 34°	70 pci	-	-
	659.4 to 654.4	A-4a	C	2	100	100	130 psf	67.6 psf	Su = 8,000 psf	2,665 pci	0.0033	-
	654.4 to 646.4	A-2-4	G	4	37	27	130 psf	67.6 psf	φ = 38°	125 pci	-	-
	646.4 to 644.4	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	85

APPENDIX IX

SETTLEMENT CALCULATIONS

W-13-045 - FRA-70-12.68 - FRA-70-1301A

Embankment Settlement - Rear Abutment

Calculated By: BRT Date: 6/30/2018

Checked By: JPS Date: 6/30/2018

Boring B-015-1-13

H=	35.0	ft	
B=	50.0	ft	
γ_{BF} =	120	pcf	
D_w =	31.5	ft	Below Ground Surface
$\Delta\sigma$ =	4,200	psf	At Ground Surface

																				Total Embankment Settlement				
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' (1) (psf)	LL	C_c (2)	C_r (3)	e_o (4)	N_{60}	$(N1)_{60}$ (5)	C' (6)	Z_f/B	I (7)	$\Delta\sigma_v$ (8) (psf)	σ_{vf}' Midpoint (psf)	S_c (9,10) (ft)	S_c (in)
1	A-4a	C	0.0	3.0	3.0	1.5	120	360	180	180	3,180	26	0.144	0.014	0.475				0.03	1.000	4,200	4,380	0.077	0.927
	A-4a	C	3.0	6.0	3.0	4.5	120	720	540	540	3,540	26	0.144	0.014	0.475				0.09	0.998	4,190	4,730	0.061	0.729
	A-4a	C	6.0	9.0	3.0	7.5	120	1,080	900	900	3,900	26	0.144	0.014	0.475				0.15	0.990	4,157	5,057	0.052	0.620
	A-4a	C	9.0	12.0	3.0	10.5	120	1,440	1,260	1,260	4,260	26	0.144	0.014	0.475				0.21	0.974	4,091	5,351	0.045	0.534
	A-4a	C	12.0	15.0	3.0	13.5	120	1,800	1,620	1,620	4,620	26	0.144	0.014	0.475				0.27	0.951	3,994	5,614	0.038	0.457
2	A-1-b	G	15.0	20.0	5.0	17.5	135	2,475	2,138	2,138	5,138					49	48	161	0.35	0.910	3,823	5,961	0.014	0.166
	A-1-b	G	20.0	27.5	7.5	23.8	130	3,450	2,963	2,963	5,963					30	26	88	0.48	0.834	3,504	6,466	0.029	0.345
	A-1-b	G	27.5	35.0	7.5	31.3	130	4,425	3,938	3,938	6,938					30	23	82	0.63	0.740	3,108	7,046	0.023	0.279
3	A-4a	C	35.0	40.0	5.0	37.5	115	5,000	4,713	4,338	7,338	21	0.099	0.010	0.436				0.75	0.668	2,806	7,144	0.007	0.090
	A-4a	C	40.0	45.0	5.0	42.5	115	5,575	5,288	4,601	7,601	21	0.099	0.010	0.436				0.85	0.617	2,590	7,191	0.007	0.080
	A-4a	C	45.0	50.0	5.0	47.5	115	6,150	5,863	4,864	7,864	21	0.099	0.010	0.436				0.95	0.571	2,397	7,261	0.006	0.072
	A-4a	C	50.0	55.0	5.0	52.5	115	6,725	6,438	5,127	8,127	21	0.099	0.010	0.436				1.05	0.530	2,226	7,353	0.005	0.065
	A-4a	C	55.0	60.0	5.0	57.5	115	7,300	7,013	5,390	8,390	21	0.099	0.010	0.436				1.15	0.494	2,074	7,464	0.005	0.058
																				Total Settlement:				4.422 in

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 4,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. C_c = 0.009(LL-10); Ref. Table 26, FHWA GEC 5
3. C_r = 0.10(C_c); Ref. Section 5.4.2.5 of FHWA GEC 5
4. e_o = (C_c/1.15)+0.35; Ref. Table 8-2, Holtz and Kovacs 1981
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \le \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \le \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-13-045 - FRA-70-12.68 - FRA-70-1301A

Embankment Settlement - Rear Abutment

Calculated By: BRT Date: 06/30/2018

12/24/2014 JPS Date: 06/30/2018

Boring B-015-1-13

H=	35.0	ft	
B=	50.0	ft	
γ_{BF} =	120	psf	
D_w =	31.5	ft	Below Ground Surface
$\Delta\sigma$ =	4,200	psf	At Ground Surface

	A-4a (Upper)	A-4a (Lower)			
c_v =	1,000	1,000	NA	ft^2/yr	Coefficient of consolidation
t =	55	55	55	days	Time following completion of construction
H_{dr} =	12.5	25	NA	ft	Length of longest drainage path considered
T_v =	0.964	0.241	NA		Time factor
U =	92	55	NA	%	Degree of consolidation

$(S_c)_t$ = 3.997 in Settlement complete at 90% of primary consolidation

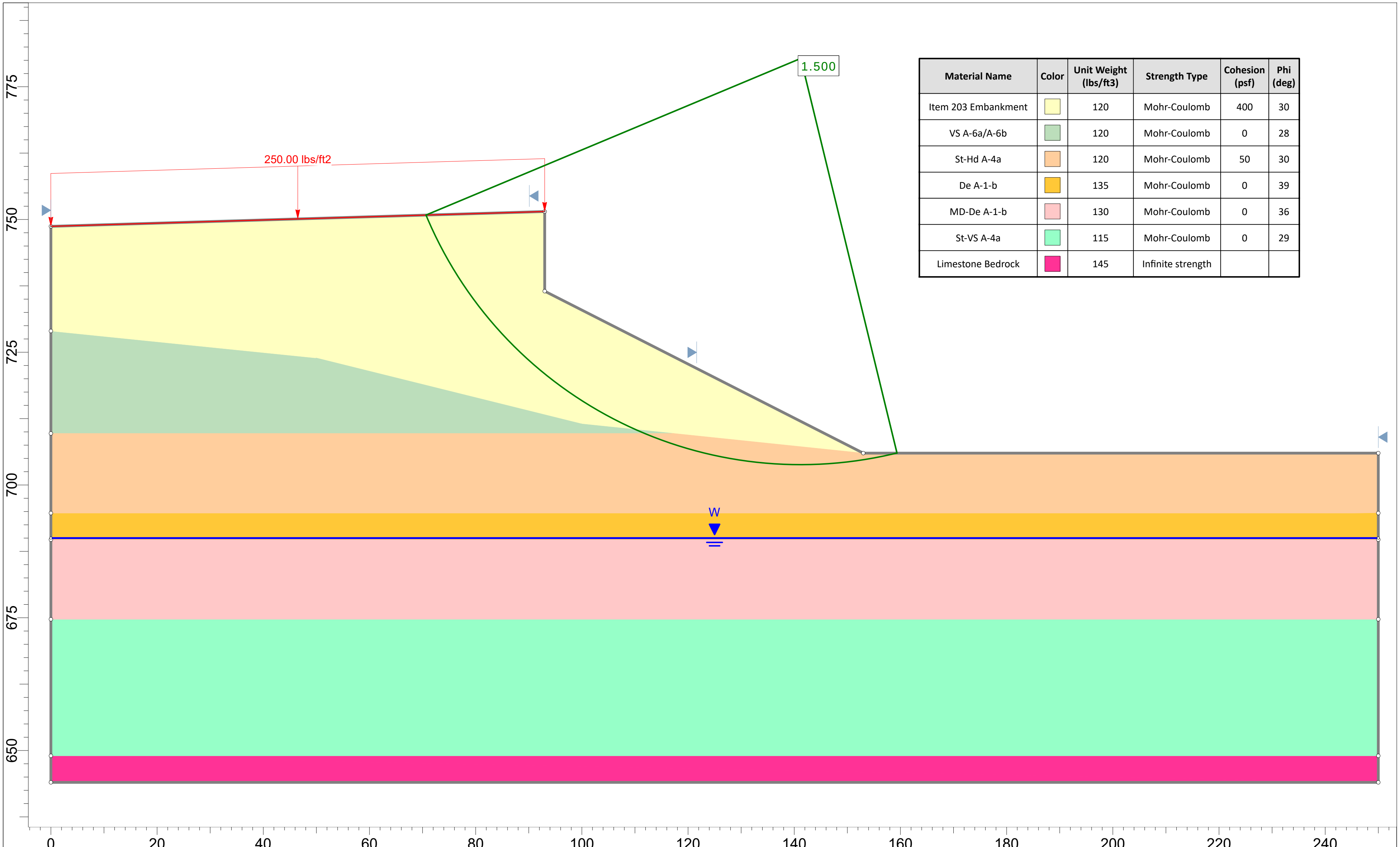
																							Total Embankment Settlement			Settlement Complete at 90% of Primary Consolidation	
Layer	Soil Type	Soil Type	Layer Depth (ft)		Layer Thickness (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' (1) (psf)	LL	C_c (2)	C_r (3)	e_o (4)	N_{60}	$(N1)_{60}$ (5)	C' (6)	Z_f/B	I (7)	$\Delta\sigma_v$ (8) (psf)	σ_{vf}' Midpoint (psf)	S_c (9,10) (ft)	S_c (in)	Layer Settlement (in)	$(S_c)_t$ (11) (in)	Layer Settlement (in)
	A-4a	C	0.0	3.0	3.0	1.5	120	360	180	180	3,180	26	0.144	0.014	0.475				0.03	1.000	4,200	4,380	0.077	0.927		0.853	
	A-4a	C	3.0	6.0	3.0	4.5	120	720	540	540	3,540	26	0.144	0.014	0.475				0.09	0.998	4,190	4,730	0.061	0.729		0.671	
1	A-4a	C	6.0	9.0	3.0	7.5	120	1,080	900	900	3,900	26	0.144	0.014	0.475				0.15	0.990	4,157	5,057	0.052	0.620	3.267	0.571	3.006
	A-4a	C	9.0	12.0	3.0	10.5	120	1,440	1,260	1,260	4,260	26	0.144	0.014	0.475				0.21	0.974	4,091	5,351	0.045	0.534		0.491	
	A-4a	C	12.0	15.0	3.0	13.5	120	1,800	1,620	1,620	4,620	26	0.144	0.014	0.475				0.27	0.951	3,994	5,614	0.038	0.457		0.421	
	A-1-b	G	15.0	20.0	5.0	17.5	135	2,475	2,138	2,138	5,138					49	48	161	0.35	0.910	3,823	5,961	0.014	0.166		0.166	
2	A-1-b	G	20.0	27.5	7.5	23.8	130	3,450	2,963	2,963	5,963					30	26	88	0.48	0.834	3,504	6,466	0.029	0.345	0.790	0.345	0.166
	A-1-b	G	27.5	35.0	7.5	31.3	130	4,425	3,938	3,938	6,938					30	23	82	0.63	0.740	3,108	7,046	0.023	0.279		0.279	
	A-4a	C	35.0	40.0	5.0	37.5	115	5,000	4,713	4,338	7,338	21	0.099	0.010	0.436				0.75	0.668	2,806	7,144	0.007	0.090		0.049	
	A-4a	C	40.0	45.0	5.0	42.5	115	5,575	5,288	4,601	7,601	21	0.099	0.010	0.436				0.85	0.617	2,590	7,191	0.007	0.080		0.044	
3	A-4a	C	45.0	50.0	5.0	47.5	115	6,150	5,863	4,864	7,864	21	0.099	0.010	0.436				0.95	0.571	2,397	7,261	0.006	0.072	0.365	0.040	0.201
	A-4a	C	50.0	55.0	5.0	52.5	115	6,725	6,438	5,127	8,127	21	0.099	0.010	0.436				1.05	0.530	2,226	7,353	0.005	0.065		0.036	
	A-4a	C	55.0	60.0	5.0	57.5	115	7,300	7,013	5,390	8,390	21	0.099	0.010	0.436				1.15	0.494	2,074	7,464	0.005	0.058		0.032	

Settlement Remaining After Hold Period: 0.426 in

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5
3. C_r = 0.10(C_c); Ref. Section 8.11, Holtz and Kovacs 1981
4. e_o = (C_c/1.15)+0.35; Ref. Table 8-2, Holtz and Kovacs 1981
5. $(N1)_{60} = C_N N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

APPENDIX X

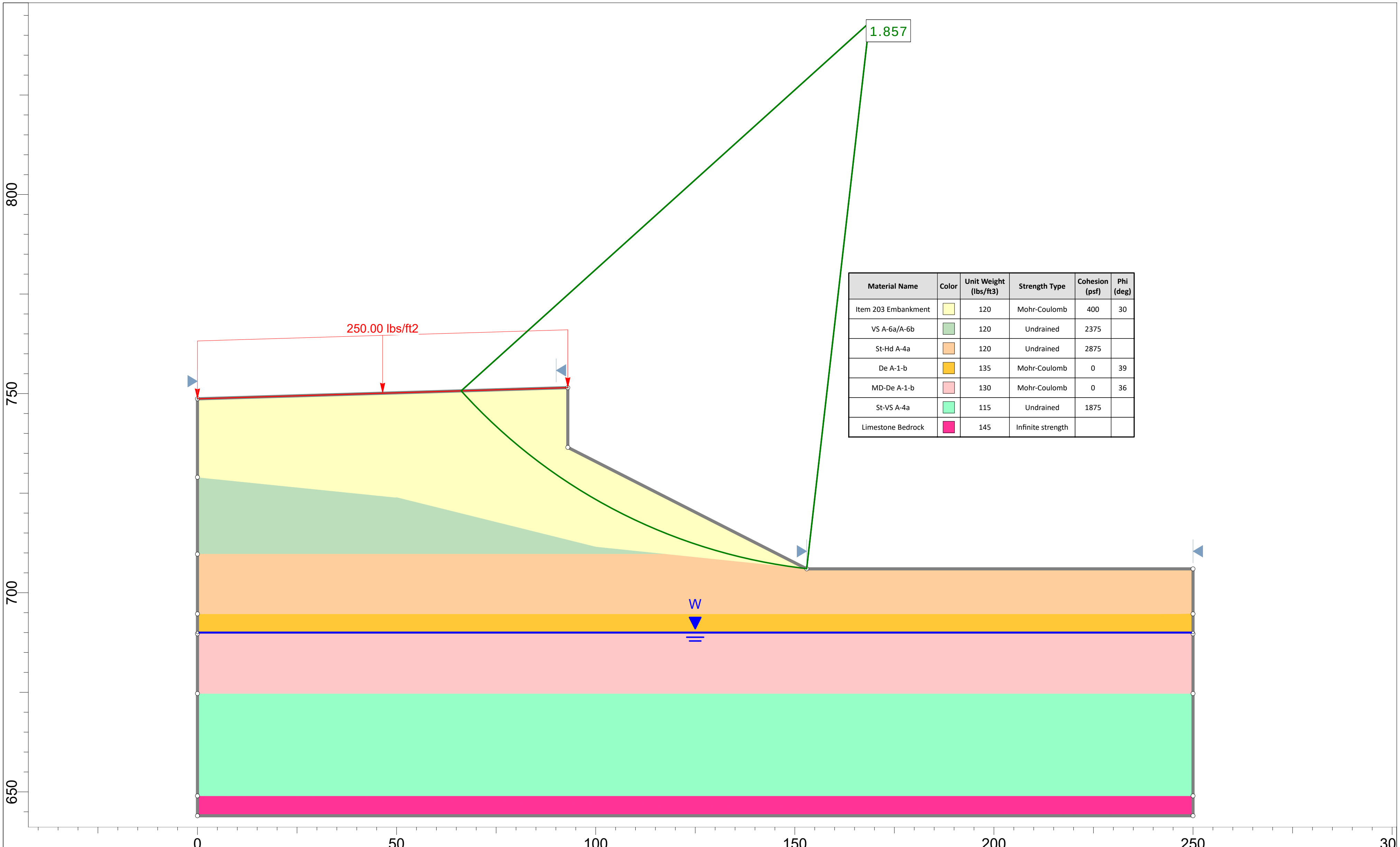
SLOPE STABILITY RESULTS



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Item 203 Embankment		120	Mohr-Coulomb	400	30
VS A-6a/A-6b		120	Mohr-Coulomb	0	28
St-Hd A-4a		120	Mohr-Coulomb	50	30
De A-1-b		135	Mohr-Coulomb	0	39
MD-De A-1-b		130	Mohr-Coulomb	0	36
St-VS A-4a		115	Mohr-Coulomb	0	29
Limestone Bedrock		145	Infinite strength		

Project	FRA-70-12.68 - FRA-70-1301A Global Stability		
Analysis Description	Embankment Global Stability - Rear Abutment - Drained - Circular - Spencer		
Drawn By BRT	*Scale* 1:300	*Company*	Resource International, Inc.
Date 6/30/2018		*File Name*	Embankment Stability - Rear Abutment - Revised.slim

SLIDEINTERPRET 7.020



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Item 203 Embankment		120	Mohr-Coulomb	400	30
VS A-6a/A-6b		120	Undrained	2375	
St-Hd A-4a		120	Undrained	2875	
De A-1-b		135	Mohr-Coulomb	0	39
MD-De A-1-b		130	Mohr-Coulomb	0	36
St-VS A-4a		115	Undrained	1875	
Limestone Bedrock		145	Infinite strength		

SLIDEINTERPRET 7.020

Project	FRA-70-12.68 - FRA-70-1301A Global Stability
Analysis Description	Embankment Global Stability - Rear Abutment - Undrained - Circular - Spencer
Drawn By	BRT
Scale	1:400
Company	Resource International, Inc.
Date	6/30/2018
File Name	Embankment Stability - Rear Abutment - Revised.slim