Report of Geohazard Exploration

FINAL REPORT
HAM-275-5.28 Slide Repair
PID No. 92075
Hamilton County, Ohio
Project No. N1115271
December 4, 2012

Prepared for:
Ohio Department of Transportation- District 8
Lebanon, Ohio

Prepared by:

Terracon Consultants, Inc.
Cincinnati, Ohio

December 4, 2012

Terracon

Ohio Department of Transportation- District 8
505 South SR 741
Lebanon, Ohio 45036-9518

Attn: Mr. Joe Smithson, P.E.
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Re: Geohazard Exploration – FINAL REPORT
HAM-275-5.28 Slide Repair / PID No. 92075
Hamilton County, Ohio
HCN/Terracon Project Number: N1115271

Dear Mr. Smithson:

Terracon Consultants, Inc. (Terracon) has completed the geological site evaluation for the above referenced project. This study was performed in general accordance with our proposal Number PN1100891, dated October 7, 2011. This report presents the findings of the subsurface exploration and provides geotechnical related recommendations concerning the landslide repair. This report supersedes our draft report submitted October 9, 2012 and has addressed ODOT's review comments of the earlier draft report.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Jeffrey D. Dunlap, P.E.
Senior Geotechnical Engineer

Swaminathan Srinivasan, P.E.
Senior V.P.- Division Manager

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APPENDIX

GEOHAZARD EXPLORATION
HAM-275-5.28 SLIDE REPAIR, PID NO. 75890
HAMILTON COUNTY, OHIO
Terracon Project No. N1115271
December 4, 2012

EXECUTIVE SUMMARY

A geotechnical study has been performed for landslide repair at HAM-275-5.28 in Hamilton County, Ohio. Existing roadway distress is occurring along the outer roadway shoulder, in an embankment section of the highway. The existing shoulder appears to have been recently repaired, but a crack has redeveloped in the existing pavement shoulder.

A total of two (2) test borings were performed for this landslide study, and these borings were supplemented with three (3) test borings performed for an emergency culvert replacement. All the borings were performed in October, 2011. Generally, the encountered subsurface conditions consisted of existing embankment fill underlain by residual or colluvial soils then shale and limestone bedrock beginning at a depth of 25 feet below grade near the shoulder of I-275. Beyond the toe of the existing embankment, the encountered soils transitioned to alluvial and outwash granular soils underlain by residual soil then shale and limestone bedrock beginning at a depth of 15 feet In most cases, a layer of very soft brown and gray weathered shale occurred first, before transitioning to gray unweathered shale with limestone.

The following key geotechnical-related items were identified:

- The existing area downslope of the roadway is sloping at approximately 2.2H:1V to 2.5H:1V and the toe of the embankment is near the right-of-way line. The Dry Fork Creek is located beyond the right-of-way line.

- Due to limited work space and on-going traffic conditions, the preferred remedial option is a cantilevered drilled shaft retaining wall. To reduce construction time, traffic disruption, and additional disturbance to the slope, closely spaced cantilevered piers with plug piers is considered the most feasible solution, since the soil below the cantilevered drilled pier wall can continue to translate downslope.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOHAZARD EXPLORATION
HAM-275-5.28 SLIDE REPAIR, PID NO. 75890
HAMILTON COUNTY, OHIO
Terracon Project No. N1115271
December 4, 2012

1.0 INTRODUCTION

The purpose of this study has been to explore the subsurface conditions along the western edge of existing I-275, about 1 mile north of its intersection with Kilby Road (see plan sheets in the appendix). This landslide area is just north of a recently replaced culvert passing beneath the westbound lanes of I-275. Landslide activity has caused cracking within the western shoulder and has caused the guardrail to settle. Between October 2011 and August 2012, the west shoulder was patched, but a crescent shaped crack has reappeared in the repaired shoulder area indicating continued landslide movement.

2.0 RECONNAISSANCE

Terracon personnel visited the site October 5, 2011 and again on August 25, 2012. a crescent shaped crack was observed in the west shoulder of the pavement between approximately stations 281+90 to 282+45 in October 2011. In August 2012, an asphalt patch was observed in the area of the crack, and the crescent shaped crack has reappeared through the existing pavement patch. The top elevation of the guardrail has settled. Some trees were observed to be leaning toward the toe of the embankment within the landslide area. No defined toe bulge was observed during either site visit. Based on some topographic features indicated on the topographic survey, the bowl shaped landslide appears to extend from approximately Station 281+60 to 282+90.

The land usage around the project consists of the wooded areas between the interstate and Dry Fork Creek. The land use to the wet of Dry Fork Creek is commercial and is used as a sand and gravel pit mining operation. Grades within the landslide area slope from east to west and consist of the existing highway embankment. The existing embankment sideslope ranges in steepness from approximately 2.2H:1V to 2.5H:1V and has a slope height of between 20 to 25 feet in the landslide area. Beyond the toe of the existing highway embankment, the grades flatten to approximately 6H:1V to nearly level. Near station 281+00 beyond the toe of the existing highway embankment, an east-west oriented drainage way was observed.

3.0 GEOLOGY

The site is located on the western side of the uplands between the Whitewater and Great Miami Rivers, where the uplands meet the Whitewater River flood plain. Dry Fork Creek is located just west of the landslide site. Embankment construction for the existing westbound lanes of I-275 has impacted the soil conditions in the landslide area.

Deep to moderately deep alluvial and outwash soils are present within the flood plain to the underlying Ordovician Age shale and limestone bedrock. Relatively shallow glacial and residual soils are present to the underlying Ordovician Age shale and limestone bedrock in the upland area. Embankment fill soils are present overlying the natural soils, where embankment construction was performed for the existing I-275 construction. Review of 1971 construction plans indicate there was a previous east-west oriented drainage way located near station 281+00.

Review of well data in the area, indicates that no water producing wells are present in the upland glacial areas. Several water wells are located to the west of the site with the flood plain of the Whitewater River. Available well logs indicate that granular soils are frequently encountered at depths of 3 to 5 feet below existing grades. Groundwater was typically encountered at depths greater than 20 feet below existing grades and the wells were generally capable of producing up to 25 gallons per minute during testing.

4.0 EXPLORATION

The boring locations were laid out on the site by ODOT and Terracon personnel based on site features on the project plans. The surveyed stationing and ground surface elevations at test boring locations were provided by ODOT.

A total of 5 test borings, designated as B-001-0-11 to B-005-0-11, were performed for the landslide and adjacent culvert replacement project between October 18 to 26, 2011. The test borings were drilled using a track-mounted drill rig. The drill rig utilized hollow stem augers to permit split-spoon sampling. Samples were obtained at 2.5 to 5 feet intervals for the full depth of the soil portion of the borings. Drilling and sampling procedures were performed in general accordance with AASHTO T206, and undisturbed samples were obtained at the depths shown on the soil profile in general accordance with AASTO T207. The hammer systems used were most recently calibrated on September 8, 2010. The average drill rod energy ratio (ER) for the drill rig used to perform the test borings was 83.7 percent. Borings B-003-0-11 to B-005-0-11 were advanced into bedrock and sampled (AASHTO T225) using NQ size coring equipment.

Slope inclinometers were installed in Test Borings B-004-0-11 and B-005-0-11 to depths of 35 feet and 25 feet below existing grades, respectively. The slope inclinometers were read five times by Terracon engineering personnel between November 4, 2011 and August 25, 2012, including the initial reading.

5.0 FINDINGS

The test borings drilled for this project generally encountered topsoil at the existing ground surface. Existing embankment fill soils were encountered below the surficial materials at the test borings. Natural interbedded granular and cohesive soils of glacial, residual, alluvial and outwash origin were encountered below the existing embankment fill or surficial soils. Ordovician Age shale and limestone bedrock was encountered at three test borings at depths ranging from 10 to 25 feet below existing ground surface.

Existing embankment fill was encountered below the surficial materials at test borings B-001-0-11, B-002-0-11 and B-005-0-11. The fine-grained existing fill soils were classified as silty clay (A-6b) or clay (A-7-6). The existing embankment soils contained shale and limestone pieces or fragments with some limestone floaters.

At Boring B-005-0-11 underlying the surficial soils, granular alluvial and outwash soils were encountered to a depth of 12.5 feet below existing ground surface. These granular soils were classified as coarse and fine sand (A-3a) and gravel and/or stone fragments with sand, silt and clay (A-2-6 or A-2-7).

Underlying the existing fill or surficial materials in B-001-0-11 to B-004-0-11 and underlying the natural granular soils in B-005-0-11, natural fine-grained soils were encountered of glacial or residual origin. The encountered natural fine-grained soils were classified as silty clay (A-6b) or clay (A-7-6).

Bedrock consisting of shale and interbedded limestone was encountered at varying elevations in Borings B-003-0-11 to B-005-0-11. The shale varied from highly weathered to moderately weathered and was described as very weak to weak. The limestone varied from slightly to moderately weathered and was described as moderately strong.

Groundwater during drilling was reported at each test boring location. Groundwater was encountered during drilling operations only in borings B-004-0-11 and B-005-0-11. No long-term water levels were recorded.

Slope inclinometer readings indicate that the downslope movement is occurring in Test Boring B-004-0-11 at depth of between 23 to 25 feet below existing grade. This depth closely corresponds to the depth of weathered shale and limestone bedrock encountered in Boring B-004-0-11. No movement was recorded in the inclinometer installed in Boring B-005-0-11. The surface of the inclinometer showed some upslope movement, which is likely attributed to the reclamation activities performed around the inclinometer location by Terracon personnel and the contractor who replaced the culvert to the south of the landslide area. Plots of the inclinometer data are included in the Appendix.

6.0 ANALYSES AND RECOMMENDATIONS

6.1 General Assessment

The slope movements are most likely attributed to the sloping bedrock surface in a direction perpendicular to the roadway and possibly increased pore pressures in the soil from heavy precipitation that occurred throughout 2011. Also, surface water backing up from the previous failed culvert may have also introduced water into the slide area.

It appears that the most feasible repair option would be to install a single row of drilled piers just outside of the downslope or western roadway shoulder. The drilled piers would be socketed into brown and gray shale bedrock. The analyses described below were performed with this repair option in mind. Cantilevered piers have been assumed here, without the use of tieback anchors. Plug piers should be considered between the structural piers, since the slope below the drilled piers could continue to translate downslope, after the piers are installed.

6.2 Lateral Earth Pressure Analyses

The slope and drilled pier retaining wall for remedial measures were analyzed in general accordance with ODOT Geotechnical Bulletin 7, Drilled Shaft Landslide Stabilization Design. A back analysis of the existing failed slope was performed using the PCSTABL5M software developed by Purdue University and the UA Slope 2.1 software developed by the University of Akron at Station 282+10 using soil conditions represented in test borings B-004-0-11 and B-005-0-11 and the recorded inclinometer data. A groundwater surface was assumed to exist along the top of the encountered granular soils at the toe of the existing embankment and then approximately 5 feet above the bedrock surface beneath the embankment in our analyses. The angle of internal friction of the fine-grained soil between the assumed groundwater surface and the top of bedrock was adjusted until a factor of safety of approximately 1.0 was achieved. A friction angle of 12 degrees was assumed for the soil layer above the bedrock, which represents a residual strength of the soil after the initial shear failure of the soil. The results of the analysis are attached to this report.

Using the same cross section (Station 282+10) and the UA Slope 2.1 software, an analyses of slope stabilization using drilled shafts was performed. The slope was evaluated with a single row of drilled shafts located at various offsets from existing road centerline. An offset of 86 feet left of centerline was selected based upon constructability and the required safety factor of 1.3. It should be noted that offsets further than 86 feet from the road centerline resulted in higher safety factors but were considered impractical due to construction difficulties that would be caused by the steep nature of the existing slope. Several drilled shaft diameters and shaft center-to-center spacings along the drilled shaft retaining wall were evaluated. The final configuration consisted of 36-inch diameter drilled shafts spaced at 6 feet center-to-center spacing. A force applied to each drilled shaft was calculated using the UA Slope 2.1 software.

The LPILE 6.0 software package was to used to evaluate the deflection at the top of the dilled shafts using Service I loads. The LPILE 6.0 software was also used to evaluate the induced moments and shear distributions using Strength I loads. The loading used in the LPILE evaluations were determined from the UA Slope 2.1 software analyses. The earth pressure loads were multiplied by a load factor of 1.5, and the vehicular live loads were multiplied by a load factor of 1.75 for the Strength I case. W24x176 steel sections were used to reinforce the drilled shafts. The acceptable lateral drilled shaft head deflection is considered less than 2 inches per ODOT GB7, since the drilled shafts are located within 10 feet of the edge of pavement. The composite concrete drilled shaft and W24x176 steel section was analyzed as an equivalent steel pipe having a diameter of 22.617 inches with a wall thickness of 1.34 inches, which is equivalent to the flange width of the W24x176.

Based on the analyses, a single row of 36-inch diameter drilled shafts spaced at 6 feet centers located at 86 feet right of the road centerline is recommended to resist the calculated driving forces with an estimated head deflection of 2 inch or less. The analyses assumed ODOT Class S concrete (4500 psi compressive strength) with 50 ksi yield strength for the steel sections. Results of the analyses are included in the Appendix of this report.

6.3 Conclusions and Recommendations

A landslide has occurred along the left side of I-275 in Hamilton County, Ohio near mile point 5.28. The length of the landslide is approximately 150 feet. The installed inclinometers indicate that the soil movement is occurring at the soil/rock interface or just above the soil/rock interface at Boring B-004-0-11. The total lateral soil movement recorded in the inclinometer is approximately 0.75 inches. The inclinometer at Boring B-005-0-11 indicates no lateral downslope soil movement. The depth and shape of the failure surface has been estimated based upon the observed head scarp location, other field observations and data from the test borings. The failure surface appears to be located within the soil layer above the bedrock surface, which is located approximately 25 feet below the road surface grade.

- It is recommended that the remedial measures consist of a single row of 36-inch diameter drilled shafts spaced at 6 feet center-to-center located 86 feet left of the I-275 centerline. The drilled shafts should be embedded a minimum of 20 feet into the weathered and unweathered shale and limestone bedrock. The maximum depth to bedrock assumed in the analyses is 25 feet. The drilled shafts need to be reinforced with W24X176, 50 ksi steel sections for the full length of the drilled shafts. ODOT Type S concrete should be used in the drilled shafts. This analysis is for preliminary cost analysis. Detailed structural design will need to be performed by the structural engineer.

- The drilled shafts should be installed beginning at approximately Station 281+50 to approximately Station 283+00.

- The top of the shafts should extend to the approximate existing pavement grade. This will require the use of sonotubes to form the top portion of the drilled shafts. The area between the pavement and the drilled shafts should be backfilled with structural backfill. Compaction should be performed with lightweight compaction equipment to avoid overstressing the drilled shafts and causing additional lateral deflection.

- Plug piers should be installed on the upslope side of and between the structural piers, since the soil downslope of the drilled shafts could continue to move. It is anticipated that the plug piers could consist of 42-inch diameter piers installed to the top of bedrock, since the failure surface extends to the top of bedrock.

- The drilled shafts should be designed to resist a maximum factored moment of 12,411 inch-kips and a maximum factored shear of 213.6 kips.

- Using the presented recommendations, a factor of safety greater than 1.3 for the slope above the drilled shaft wall is anticipated.

- A sketch showing the location of the proposed shaft locations and embedment into bedrock is attached in the Appendix of this report.

7.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX

PROJECT DESCRIPTION

EXPLORATION OF A LANDSLIDE ON I-275 IN HAMILTON COUNTY.

HISTORIC RECORDS

NO HISTORIC BORING RECORDS WERE FOUND WITHIN THE LANDSLIDE AREA.

GEOLOGY

THE SITE IS LOCATED ON THE WESTERN SIDE OF THE UPLANDS BETWEEN THE WHITEWATER AND GREAT MIAMI RIVERS, WHERE THE UPLANDS MEET THE WHITEWATER RIVER FLOOD PLAIN. DRY FORK CREEK IS LOCATED JUST WEST OF THE LANDSLIDE SITE. EMBANKMENT CONSTRUCTION FOR THE EXISTING WESTBOUND LANES OF I-275 HAVE IMPACTED THE SOIL CONDITIONS IN THE LANDSLIDE AREA.

DEEP TO MODERATELY DEEP ALLUVIAL AND OUTWASH SOILS ARE PRESENT WITHIN THE FLOOD PLAIN TO THE UNDERLYING ORDOVICIAN AGE SHALE AND LIMESTONE BEDROCK. RELATIVELY SHALLOW GLACIAL AND RESIDUAL SOILS ARE PRESENT TO THE UNDERLYING ORDOVICIAN AGE SHALE AND LIMESTONE BEDROCK IN THE UPLAND AREA. EMBANKMENT FILL SOILS ARE PRESENT OVERLYING THE NATURAL SOILS, WHERE EMBANKMENT CONSTRUCTION WAS PERFORMED FOR THE EXISTING I-275 CONSTRUCTION.

REVIEW OF 1971 CONSTRUCTION PLANS INDICATE THERE WAS A PREVIOUS EAST-WEST ORIENTED DRAINAGE WAY LOCATED NEAR STATION 281+00.

RECONNAISSANCE

HCN PERSONNEL VISITED THE SITE ON OCTOBER 5, 2011 AND AGAIN ON AUGUST 25, 2012. A CRESCENT SHAPED CRACK WAS OBSERVED IN THE WEST SHOULDER OF THE PAVEMENT BETWEEN APPROXIMATELY STATIONS 281+90 TO 282+45 IN OCTOBER 2011. IN AUGUST 2012, AN ASPHALT PATCH WAS OBSERVED IN THE AREA OF THE CRACK, AND THE CRESCENT SHAPED CRACK HAS REAPPEARED THROUGH THE EXISTING PAVEMENT PATCH. THE TOP ELEVATION OF THE GUARDRAIL WAS OBSERVED TO HAVE SETTLED DURING BOTH SITE VISITS. SOME TREES WERE OBSERVED TO BE LEANING TOWARD THE TOE OF THE EMBANKMENT SIDESLOPE WITHIN THE LANDSLIDE AREA. NO DEFINED TOE BULGE WAS OBSERVED DURING EITHER SITE VISIT.

THE LAND USAGE AROUND THE PROJECT CONSISTS OF THE WOODED AREAS BETWEEN THE INTERSTATE AND DRY FORK CREEK. THE LAND USE TO THE WET OF DRY FORK CREEK IS COMMERCIAL AND IS USED AS A SAND AND GRAVEL PIT MINING OPERATION. GRADES WITHIN THE LANDSLIDE AREA SLOPE FROM EAST TO WEST AND CONSIST OF THE EXISITNG HIGHWAY EMBANKMENT. THE EXISTING EMBANKMENT SIDESLOPE RANGES IN STEEPNESS FROM APPROXIMATLEY 2.2H:1V TO 2.5H:1V AND HAS A SLOPE HEIGHT OF BETWEEN 20 TO 25 FEET IN THE LANDSLIDE AREA. BEYOND THE TOE OF THE EXISTING HIGHWAY EMBANKMENT, THE GRADES FLATTEN TO APPROXIMATELY 6H:1V TO NEARLY LEVEL. NEAR STATION 281+00 BEYOND THE TOE OF THE EXISTING HIGHWAY EMBANKMENT, AN EAST-WEST ORIENTED DRAINAGE WAY WAS OBSERVED.

SUBSURFACE EXPLORATION

A TOTAL OF 5 TEST BORINGS, DESIGNATED AS B-001-0-11 TO B-005-0-11, WERE PERFORMED FOR THE LANDSLIDE AND ADJACENT CULVERT REPLACEMENT PROJECT BETWEEN OCTOBER 18 TO 26, 2011. THE TEST BORINGS WERE DRILLED USING A TRACK-MOUNTED DRILL RIG. THE DRILL RIG UTILIZED HOLLOW STEM AUGERS TO PERMIT SPLIT-SPOON SAMPLING. SAMPLES WERE OBTAINED AT 2.5 TO 5 FEET INTERVALS FOR THE FULL DEPTH OF THE SOIL PORTION OF THE BORINGS. DRILLING AND SAMPLING PROCEDURES WERE PERFORMED IN GENERAL ACCORDANCE WITH AASHTO T206, AND UNDISTURBED SAMPLES WERE OBTAINED AT THE DEPTHS SHOWN ON THE SOIL PROFILE IN GENERAL ACCORDANCE WITH AASTO T207. THE HAMMER SYSTEMS USED WERE MOST RECENTLY CALIBRATED ON SEPTEMBER 8, 2010. THE AVERAGE DRILL ROD ENERGY RATIO (ER) FOR THE DRILL RIG USED TO PERFORM THE TEST BORINGS WAS 83.7 PERCENT. BORINGS B-003-0-11 TO B-005-0-11 WERE ADVANCED INTO BEDROCK AND SAMPLED (AASHTO T225) USING NQ SIZE CORING EQUIPMENT.

EXPLORATION FINDINGS

THE TEST BORINGS DRILLED FOR THIS PROJECT GENERALLY ENCOUNTERED TOPSOIL AT THE EXISTING GROUND SURFACE. EXISTING EMBANKMENT FILL SOILS WERE ENCOUNTERED BELOW THE SURFICIAL MATERIALS AT THE TEST BORINGS. NATURAL INTERBEDDED GRANULAR AND COHESIVE SOILS OF GLACIAL, RESIDUAL, ALLUVIAL AND OUTWASH ORIGIN WERE ENCOUNTERED BELOW THE EXISTING EMBANKMENT FILL OR SURFICIAL SOILS. ORDOVICIAN AGE SHALE AND LIMESTONE BEDROCK WAS ENCOUNTERED AT THREE TEST BORINGS AT DEPTHS RANGING FROM 10 TO 25 FEET BELOW EXISTING GROUND SURFACE.

EXISTING EMBANKMENT FILL WAS ENCOUNTERED BELOW THE SURFICIAL MATERIALS AT TEST BORINGS B-001-0-11, B-002-0-11 AND B-005-0-11. THE FINE-GRAINED EXISTING FILL SOILS WERE CLASSIFIED AS SILTY CLAY (A-6B) OR CLAY (A-7-6). THE EXISTING EMBANKMENT SOILS CONTAINED SHALE AND LIMESTONE PIECES OR FRAGMENTS WITH SOME LIMESTONE FLOATERS.

AT BORING B-005-0-11 UNDERLYING THE SURFICIAL SOILS, GRANULAR ALLUVIAL AND OUTWASH SOILS WERE ENCOUNTERED TO A DEPTH OF 12.5 FEET BELOW EXISTING GROUND SURFACE. THESE GRANULAR SOILS WERE CLASSIFIED AS COARSE AND FINE SAND (A-3A) AND GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT AND CLAY (A-2-6 OR A-2-7).

UNDERLYING THE EXISTING FILL OR SURFICIAL MATERIALS IN B-001-0-11 TO B-004-0-11 AND UNDERLYING THE NATURAL GRANULAR SOILS IN B-005-0-11, NATURAL FINE-GRAINED SOILS WERE ENCOUNTERED OF GLACIAL OR RESIDUAL ORIGIN. THE ENCOUNTERED NATURAL FINE-GRAINED SOILS WERE CLASSIFIED AS SILTY CLAY (A-6B) OR CLAY (A-7-6).

BEDROCK CONSISTING OF SHALE AND INTERBEDDED LIMESTONE WAS ENCOUNTERED AT VARYING ELEVATIONS IN BORINGS B-003-0-11 TO B-005-0-11. THE SHALE VARIED FROM HIGHLY WEATHERED TO MODERATELY WEATHERED AND WAS DESCRIBED AS VERY WEAK TO WEAK. THE LIMESTONE VARIED FROM SLIGHTLY TO MODERATELY WEATHERED AND WAS DESCRIBED AS MODERATELY STRONG.

GROUNDWATER DURING DRILLING WAS REPORTED AT EACH TEST BORING LOCATION. GROUNDWATER WAS ENCOUNTERED DURING DRILLING OPERATIONS ONLY IN BORINGS B-004-0-11 AND B-005-0-11. NO LONG-TERM WATER LEVELS WERE RECORDED.

LEGEND

DESCRIPTION	ODOT CLASS	CLASSIFIED MECH.	CLASSIFIED VISUAL
GRAVEL/STONE FRAGMENTS W/ SAND & SILT	A-2-6	1	-
GRAVEL/STONE FRAGMENTS W/ SAND, SILT & CLAY	A-2-7	2	-
COARSE & FINE SAND	A-3a	1	-
SILTY CLAY	A-6b	3	3
CLAY	A-7-6	17	10
	TOTAL	24	13
INTERBEDDED SHALE & LIMESTONE	VISUAL		
INTERBEDDED SHALE & LIMESTONE WEATHERED	VISUAL		

BORING LOCATION - PLAN VIEW.

INSTRUMENTAL BORING LOCATION - PLAN VIEW.

DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.

WC INDICATES WATER CONTENT IN PERCENT.

N_{60} INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.

X/Y/Z NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X= NUMBER OF BLOWS FOR FIRST 6 INCHES.
Y= NUMBER OF BLOWS FOR SECOND 6 INCHES.
Z= NUMBER OF BLOWS FOR THIRD 6 INCHES.

W— INDICATES FREE WATER ELEVATION.

▼ INDICATES FREE WATER ELEVATION.

SS INDICATES A SPLIT SPOON SAMPLE.

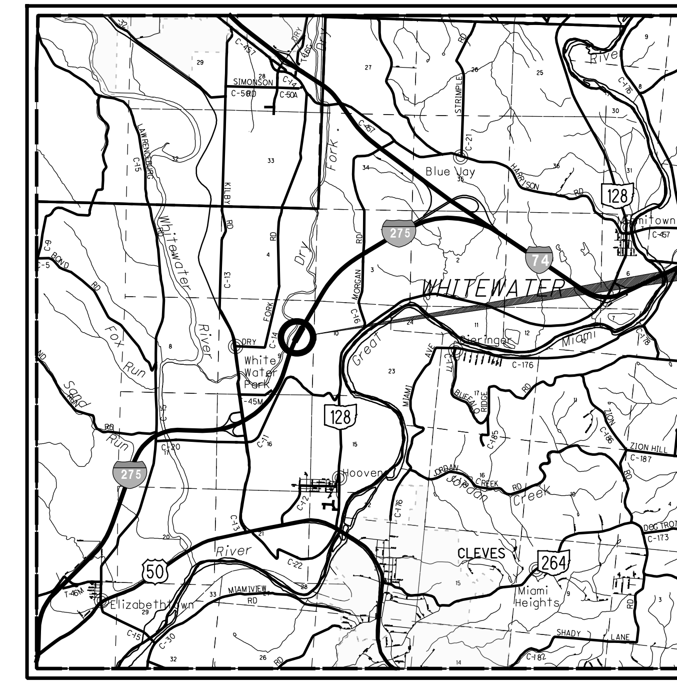
ST INDICATES A SHELBY TUBE SAMPLE.

SPECIFICATIONS

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS, DATED MAY 2010.

AVAILABLE INFORMATION

ALL AVAILABLE SOIL AND BEDROCK INFORMATION THAT CAN BE CONVENIENTLY SHOWN ON THE GEOTECHNICAL EXPLORATION SHEETS HAS BEEN SO REPORTED. ADDITIONAL EXPLORATIONS MAY HAVE BEEN MADE TO STUDY SOME SPECIAL ASPECT OF THE PROJECT. COPIES OF THIS DATA, IF ANY, MAY BE INSPECTED IN THE DISTRICT DEPUTY DIRECTOR'S OFFICE, THE OFFICE OF GEOTECHNICAL ENGINEERING AT 1600 WEST BROAD STREET OR THE OFFICE OF STRUCTURAL ENGINEERING AT 1980 WEST BROAD STREET IN COLUMBUS, OHIO.



PROJECT LOCATION

LOCATION MAP

SCALE IN MILES

0 1 2 3 4

N

PARTICLE SIZE DEFINITIONS

	12"		3"		2.0 mm		0.42 mm		0.074 mm		0.005 mm	
BOULDERS		COBBLES		GRAVEL		COARSE SAND		FINE SAND		SILT		CLAY
					No. 10 SIEVE		No. 40 SIEVE		No. 200 SIEVE			

RECON. - JDD 10/5/2011 JWW 8/25/2012

DRILLING - CJB 10/8/2011-10/26/2011

DRAWN - KJM 9/14/2012-9/17/2012

REVIEWED - JDD 9/18/2012

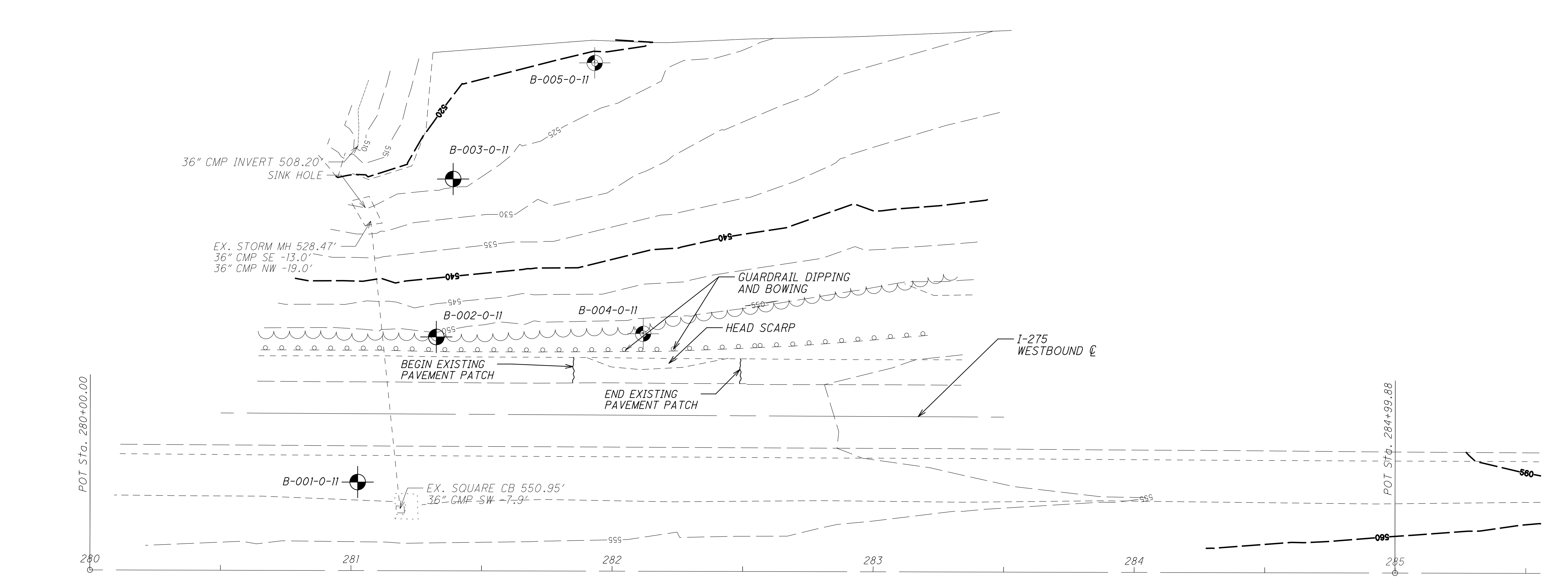
DESIGN AGENCY

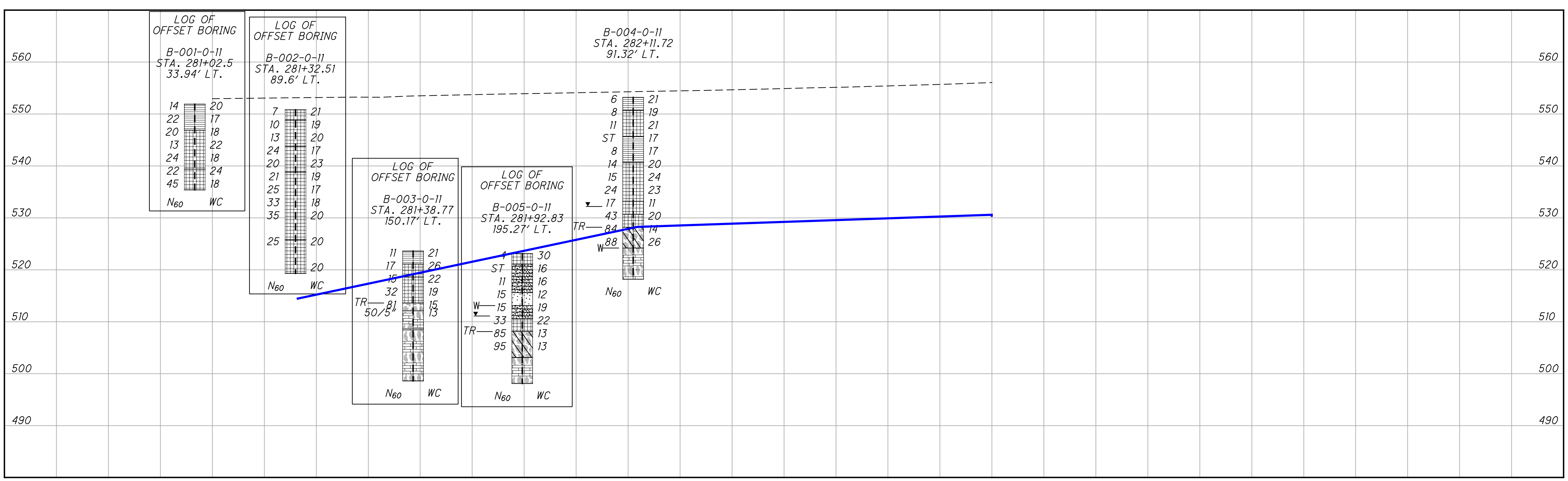
Terracon
Consulting Engineers and Scientists

PID NO. 92075

LANDSLIDE EXPLORATION

HAM-275-5.28





HORIZONTAL SCALE IN FEET

0 10 20 40

DRAWN KJM

CHECKED JDD

LANDSLIDE EXPLORATION STA. 280+50 TO STA. 283+50

HAM-275-5.28

2/9

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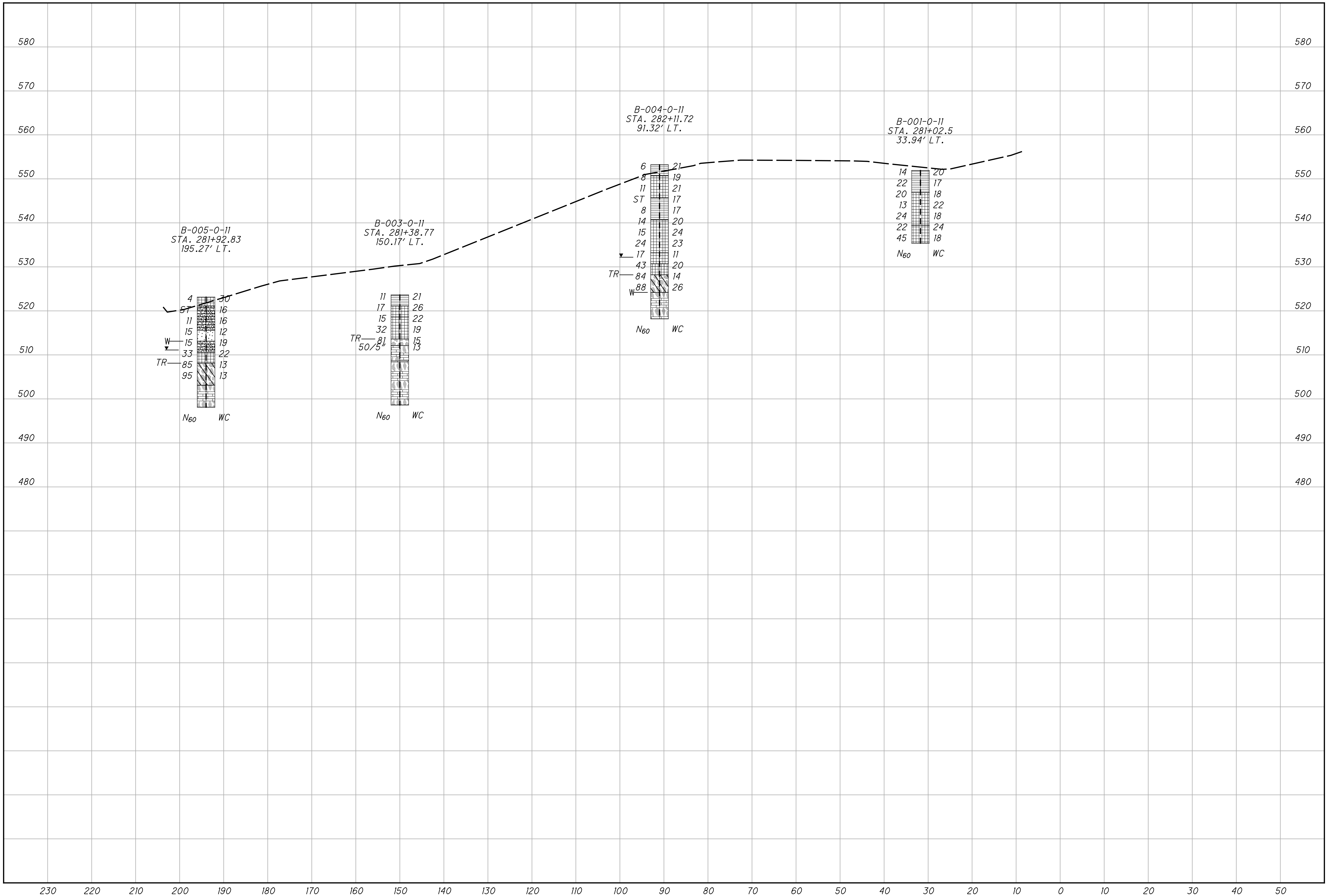

HORIZONTAL SCALE IN FEET

0 5 10 20

DRAWN KJM

CHECKED JDD

LANDSLIDE EXPLORATION CROSS SECTION STA. 282+10

HAM-275-5.28

3 / 9

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PROJECT: HAM-275-5.28 TYPE: CULVERT REPLACEMENT PID: 92075 BR ID: START: 10/24/11 END: 10/24/11	DRILLING FIRM / OPERATOR: HCN / CJB SAMPLING FIRM / LOGGER: HCN / JDD DRILLING METHOD: 3.25" HSA SAMPLING METHOD: SPT	DRILL RIG: DIEDRICH D50 TRACK HAMMER: DIEDRICH AUTOMATIC CALIBRATION DATE: 9/8/10 ENERGY RATIO (%): 83.7	STATION / OFFSET: 281+02.5, 33.94 LT ALIGNMENT: I-275 ELEVATION: 551.9 (MSL) EOB: 16.5 ft. COORD: 445926.127 N, 1326405.286 E

EXPLORATION ID: B-001-0-11 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 551.9	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
VERY STIFF, BROWN, SOME GRAY, **SILTY CLAY**, LITTLE SHALE PIECES, TRACE LIMESTONE PIECES, TO FRAGMENTS, FINE ROOTS AND GRAVEL, (EMBANKMENT FILL), DAMP		1	1 4 6	14	78	SS-1	3.75	3	4	3	42	48	39	20	19	20	A-6b (12)	
		3	9 8 8	22	78	SS-2	4.00	-	-	-	-	-	-	-	-	17	A-6b (V)	
	546.9																	
STIFF TO VERY STIFF, BROWN, LITTLE GRAY, **CLAY**, LITTLE SHALE PIECES, TRACE LIMESTONE PIECES, (EMBANKMENT FILL), DAMP		6	4 6 8	20	100	SS-3	4.25	4	7	3	34	52	44	21	23	18	A-7-6 (14)	
		8	3 3 6	13	89	SS-4	1.50	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
		11	4 7 10	24	100	SS-5	4.00	1	3	2	38	56	45	23	22	18	A-7-6 (14)	
	539.4																	
VERY STIFF, BROWN AND GRAY, TRACE DARK BROWN, **CLAY**, TRACE SHALE PIECES, SAND, SMALL LIMESTONE FRAGMENTS AND FINE GRAVEL, DAMP		13	6 6 10	22	100	SS-6	3.00	-	-	-	-	-	-	-	-	24	A-7-6 (V)	
	535.4	16 (EOB)	11 14 18	45	100	SS-7	4.00	3	3	5	40	49	45	20	25	18	A-7-6 (15)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL CUTTINGS

CULVERT REPLACEMENT
BORING LOG B-001-0-11

DRAWN KJM CHECKED JDD

PROJECT: HAM-275-5.28	DRILLING FIRM / OPERATOR: HCN / CJB	DRILL RIG: DIEDRICH D50 TRACK	STATION / OFFSET: 281+32.51, 89.6 LT
TYPE: CULVERT REPLACEMENT	SAMPLING FIRM / LOGGER: HCN / JDD	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: I-275
PID: 92075 BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 9/8/10	ELEVATION: 550.8 (MSL) EOB: 31.5 ft.
START: 10/18/11 END: 10/18/11	SAMPLING METHOD: SPT	ENERGY RATIO (%): 83.7	COORD: 445980.032 N, 1326372.228 E

EXPLORATION ID B-002-0-11 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 550.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
STIFF TO VERY STIFF, GRAY AND BROWN, **CLAY**, LITTLE TO SOME SHALE PIECES, LITTLE TO TRACE LIMESTONE PIECES TO FLOATERS (EMBANKMENT FILL), MOIST	548.8	1	1 2 3	7	67	SS-1	2.00	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
VERY STIFF, BROWN TRACE GRAY, **CLAY**, TRACE GRAVEL, SHALE PIECES AND LIMESTONE PIECES, (EMBANKMENT FILL), MOIST		3	3 3 4	10	89	SS-2	3.00	0	5	3	40	52	43	21	22	19	A-7-6 (13)	
	543.8	6	19 4 5	13	67	SS-3	3.00	-	-	-	-	-	-	-	-	20	A-7-6 (V)	
VERY STIFF, BROWN AND GRAY, **CLAY**, LITTLE SHALE PIECES, TRACE TO LITTLE LIMESTONE PIECES, TRACE GRAVEL (EMBANKMENT FILL), MOIST		8	24 9 8	24	78	SS-4	3.50	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
	538.8	11	4 7 7	20	100	SS-5	4.00	1	5	2	45	47	43	23	20	23	A-7-6 (13)	
VERY STIFF, BROWN, GRAY, AND DARK BROWN, **CLAY**, LITTLE SHALE PIECES, TRACE SMALL LIMESTONE PIECES, AND GRAVEL (EMBANKMENT FILL), MOIST		13	7 6 9	21	100	SS-6	4.00	-	-	-	-	-	-	-	-	19	A-7-6 (V)	
		16	4 6 12	25	89	SS-7	3.00	4	10	3	37	46	41	19	22	17	A-7-6 (13)	
		18	8 12 12	33	67	SS-8	3.25	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
	525.8	21	8 11 14	35	100	SS-9	4.25	-	-	-	-	-	-	-	-	20	A-7-6 (V)	
VERY STIFF, BROWN, LITTLE GRAY, **CLAY**, TRACE TO LITTLE ROCK PIECES, GRAVEL, AND SAND (EMBANKMENT FILL), MOIST		26	8 9 9	25	78	SS-10	3.50	3	6	4	39	48	41	19	22	20	A-7-6 (13)	
	519.3	31 EOB			-	SS-11	4.00	-	-	-	-	-	-	-	-	20	A-7-6 (V)	

NOTES: AREA CUT APPROX. 1 FT. FOR ACCESS.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL CUTTINGS

HAM-275-5.28

CULVERT REPLACEMENT
BORING LOG B-002-0-11

DRAWN KJM
CHECKED JDD

PROJECT: HAM-275-5.28	DRILLING FIRM / OPERATOR: HCN / CJB	DRILL RIG: DIEDRICH D50 TRACK	STATION / OFFSET: 281+38.77, 150.17 LT
TYPE: CULVERT REPLACEMENT	SAMPLING FIRM / LOGGER: HCN / JDD	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: I-275
PID: 92075 BR ID:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 9/8/10	ELEVATION: 523.6 (MSL) EOB: 25.0 ft.
START: 10/18/11 END: 10/18/11	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 83.7	COORD: 446015.857 N, 1326322.986 E

EXPLORATION ID B-003-0-11 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 523.6	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
VERY STIFF, MOTTLED BROWN, LITTLE GRAY, **SILTY CLAY**, TRACE SAND, FINE GRAVEL AND FINE ROOTS, MOIST	521.1	1–2	4 5 3	11	67	SS-1	3.00	-	-	-	-	-	-	-	-	21	A-6b (V)	
VERY STIFF, BROWN, **CLAY**, LITTLE SAND AND FINE GRAVEL, TRACE ROOT HAIRS, MOIST	518.6	3–4	4 6 6	17	100	SS-2	3.00	10	13	10	20	47	54	20	34	26	A-7-6 (17)	
VERY STIFF, OLIVE-BROWN TO GRAYISH-BROWN, **CLAY**, TRACE INTERBEDDED SHALE SEAMS AND PIECES, MOIST		5–7	5 5 6	15	100	SS-3	3.50	0	2	2	33	63	51	23	28	22	A-7-6 (17)	
	513.6	8–9	7 10 13	32	100	SS-4	4.00	-	-	-	-	-	-	-	-	19	A-7-6 (V)	
SHALE, BROWN, TRACE GRAY, HIGHLY WEATHERED, VERY WEAK, LAMINATED.	512.1	TR 10–11	13 22 36	81	100	SS-5	-	-	-	-	-	-	-	-	-	15		
INTERBEDDED SHALE (50%) AND LIMESTONE (50%); **SHALE**, GRAY, MODERATELY WEATHERED, WEAK, LAMINATED; **LIMESTONE**, LIGHT GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, THIN BEDDED.	508.6	12–14	50/5"	-	100	SS-6	-	-	-	-	-	-	-	-	-	13		
INTERBEDDED SHALE (90%) AND LIMESTONE (10%); **SHALE**, GRAY, MODERATELY WEATHERED, WEAK, LAMINATED, CALCAREOUS; **LIMESTONE**, LIGHT GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, THIN BEDDED, TRACE FRACTURES.		15–17			58	NQ2-1	-	-	-	-	-	-	-	-	-	-		
		18–21			40	NQ2-2	-	-	-	-	-	-	-	-	-	-		
	498.6	22–24, EOB 25			61	NQ2-3	-	-	-	-	-	-	-	-	-	-		

NOTES: AREA CUT 6" FOR ACCESS.
ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (11 X 17) - OH DOT.GDT - 9/5/12 12:55 - N:\PROJECTS\2011\N1115271\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\N1115271 TEST BORING LOGS.GPJ

CULVERT REPLACEMENT
BORING LOG B-003-0-11

DRAWN KJM CHECKED JDD

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PROJECT: HAM-275-5.28	DRILLING FIRM / OPERATOR: HCN / CJB	DRILL RIG: DIEDRICH D50 TRACK	STATION / OFFSET: 282+11.72, 91.32 LT	EXPLORATION ID B-004-0-11
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HCN / JDD	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: I-275	
PID: 92075 BR ID:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 9/8/10	ELEVATION: 553.2 (MSL) EOB: 35.0 ft.	PAGE 1 OF 1
START: 10/26/11 END: 10/26/11	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 83.7	COORD: 446049.397 N, 1326410.501 E	

MATERIAL DESCRIPTION AND NOTES	ELEV.
VERY STIFF, GRAY, LITTLE BROWN, **SILTY CLAY**, LITTLE SHALE PIECES AND FRAGMENTS, TRACE SAND AND LIMESTONE PIECES, (FILL), DAMP	553.2 – 550.7
VERY STIFF, GRAY, LITTLE BROWN, **CLAY**, LITTLE SHALE PIECES AND FRAGMENTS, TRACE SAND AND LIMESTONE PIECES, (FILL), DAMP	550.7 – 545.7
STIFF, BROWN AND GRAY, **SILTY CLAY**, TRACE SAND, SHALE AND LIMESTONE PIECES, (FILL), DAMP	545.7 – 540.7
VERY STIFF, BROWN AND GRAY, **CLAY**, LITTLE SHALE AND LIMESTONE PIECES, TRACE SAND, (FILL), MOIST	540.7 – 533.2
STIFF, OLIVE-BROWN TRACE GRAY, **CLAY**, TRACE SHALE SEAMS AND PIECES, TRACE LIMESTONE PIECES, DAMP	533.2 – 530.7
VERY STIFF TO HARD, OLIVE-BROWN, **CLAY**, LITTLE SHALE SEAMS, DAMP	530.7 – 528.2
SHALE, BROWN TRACE GRAY, HIGHLY WEATHERED, VERY WEAK, LAMINATED, FISSILE, TRACE LIMESTONE AND CLAY SEAMS BELOW 27.5'.	528.2 – 524.2
INTERBEDDED SHALE (95%) AND LIMESTONE (5%); **SHALE**, GRAY, MODERATELY WEATHERED, VERY WEAK TO WEAK, LAMINATED, FISSILE, TRACE CLAY SEAMS; **LIMESTONE**, LIGHT GRAY, LITTLE BROWN, MODERATELY WEATHERED, MODERATELY STRONG, THIN BEDDED, FRACTURED, FRACTURES IRON STAINED.	524.2 – 518.2

DEPTHS: TR at 25; W at 29; EOB at 35

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 – 1.5	2 2 2	6	100	SS-1	2.50	1	3	3	43	50	40	21	19	21	A-6b (12)	
2.5 – 4	3 3 3	8	100	SS-2	2.50	6	2	3	44	45	41	21	20	19	A-7-6 (12)	
5 – 6.5	3 3 5	11	67	SS-3	2.75	26	3	2	32	37	44	21	23	21	A-7-6 (13)	
7.5 – 9.5			75	ST-4	2.50	2	1	2	44	51	40	21	19	17	A-6b (12)	
10 – 11.5	4 2 4	8	11	SS-5	3.00	-	-	-	-	-	-	-	-	17	A-6b (V)	
12.5 – 14	4 4 6	14	89	SS-6	2.75	6	4	6	38	46	42	19	23	20	A-7-6 (14)	
15 – 16.5	3 4 7	15	56	SS-7	3.00	7	4	3	34	52	45	21	24	24	A-7-6 (15)	
17.5 – 19	4 4 13	24	78	SS-8	3.25	2	2	3	42	51	41	20	21	23	A-7-6 (13)	
20 – 21.5	2 4 8	17	89	SS-9	2.00	1	1	1	39	58	46	21	25	11	A-7-6 (15)	
22.5 – 24	5 13 18	43	78	SS-10	4.25	1	1	3	36	59	47	23	24	20	A-7-6 (15)	
25 – 26.5	12 23 37	84	100	SS-11	-	-	-	-	-	-	-	-	-	14	Rock (V)	
27.5 – 29	14 27 36	88	-	SS-12	-	-	-	-	-	-	-	-	-	26	Rock (V)	
29 – 30			33	NQ2-1	-	-	-	-	-	-	-	-	-	-		
30 – 35			66	NQ2-2	-	-	-	-	-	-	-	-	-	-		

NOTES: INCLINOMETER SET UPON COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 2 BAGS BENTONITE CHIPS; BACKFILLED WITH 3 BAGS CEMENT

STANDARD ODOT SOIL BORING LOG (11 X 17) - OH DOT.GDT - 9/17/12 08:42 - N:\PROJECTS\2011\N1115271\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\N1115271 LANDSLIDE LOGS.GPJ

7 / 9	HAM-275-5.28	CULVERT REPLACEMENT BORING LOG B-004-0-11	DRAWN KJM CHECKED JDD

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PROJECT: HAM-275-5.28 TYPE: LANDSLIDE PID: 92075 BR ID: START: 10/24/11 END: 10/25/11	DRILLING FIRM / OPERATOR: HCN / CJB SAMPLING FIRM / LOGGER: HCN / JDD DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT / NQ2	DRILL RIG: DIEDRICH D50 TRACK HAMMER: DIEDRICH AUTOMATIC CALIBRATION DATE: 9/8/10 ENERGY RATIO (%): 83.7	STATION / OFFSET: 281+92.83, 195.27 LT ALIGNMENT: I-275 ELEVATION: 523.1 (MSL) EOB: 25.0 ft. COORD: 446085.254 N, 1326311.127 E

EXPLORATION ID: B-005-0-11 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 523.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY SOFT, DARK BROWN, TRACE DARK GRAY, **CLAY**, LITTLE TO SOME ORGANICS, TRACE ROOTS, (TOPSOIL), MOIST	521.1	1–2	2 1 2	4	56	SS-1	0.25	5	3	7	51	34	50	27	23	30	A-7-6 (15)	
STIFF, REDDISH-BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, MOIST	518.1	3–4			-	ST-2	-	20	32	16	13	19	42	18	24	16	A-2-7 (2)	
LOOSE, REDDISH-BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, MOIST	515.6	5–7	4 4 4	11	89	SS-3	-	10	25	37	10	18	36	15	21	16	A-2-6 (1)	
MEDIUM DENSE, REDDISH-BROWN, **COARSE AND FINE SAND**, TRACE SILT AND CLAY, MOIST	513.1	8–10 (W at 10)	3 4 7	15	89	SS-4	-	1	15	63	7	14	NP	NP	NP	12	A-3a (0)	
MEDIUM DENSE, REDDISH-BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, WET	510.6	11–12 (▼ at 12)	7 7 4	15	89	SS-5	-	23	29	15	10	23	52	21	31	19	A-2-7 (4)	
VERY STIFF, OLIVE-BROWN, **CLAY**, LITTLE SHALE SEAMS AND PIECES, TRACE LIMESTONE PIECES, (RESIDUUM), DAMP	508.1	13–15 (TR at 15)	12 12 12	33	78	SS-6	4.00	8	4	5	35	48	48	24	24	22	A-7-6 (15)	
SHALE, GRAY TRACE OLIVE-BROWN, MODERATELY WEATHERED, WEAK, LAMINATED, FISSILE.		15–17	11 23 38	85	100	SS-7	-	-	-	-	-	-	-	-	-	13	Rock (V)	
	503.1	18–20	18 32 36	95	100	SS-8	-	-	-	-	-	-	-	-	-	13	Rock (V)	
INTERBEDDED SHALE (95%) AND LIMESTONE (5%); **SHALE**, GRAY, MODERATELY WEATHERED, WEAK, LAMINATED, CALCAREOUS; **LIMESTONE**, LIGHT GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, VERY THIN BEDDED, LOSS 12%.	498.1	20–25 (EOB at 25)	80		88	NQ2-1											CORE	

STANDARD ODOT SOIL BORING LOG (11 X 17) - OH DOT.GDT - 9/17/12 08:42 - N:\PROJECTS\2011\N1115271\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\N1115271 LANDSLIDE LOGS.GPJ

NOTES: INCLINOMETER SET UPON COMPLETION.

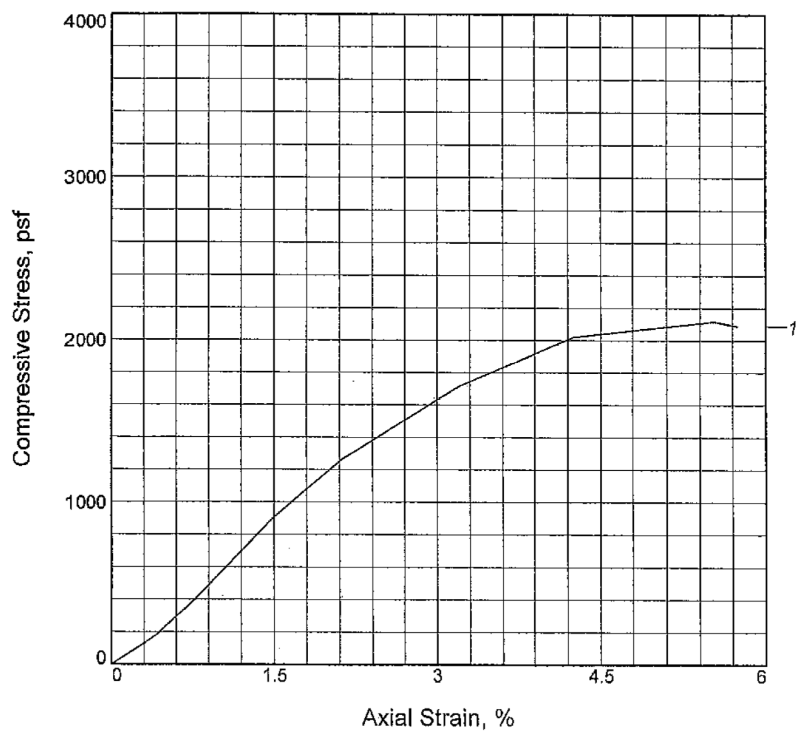
ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 1 BAG BENTONITE CHIPS; BACKFILLED WITH 2 BAGS CEMENT

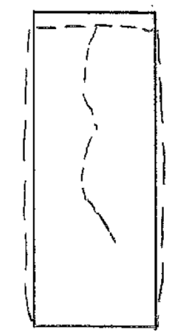
HAM-275-5.28

CULVERT REPLACEMENT
BORING LOG B-005-0-11

DRAWN KJM
CHECKED JDD

UNCONFINED COMPRESSION TEST





Sample No.	1			
Unconfined strength, psf	2118.8			
Undrained shear strength, psf	1059.4			
Failure strain, %	5.5			
Strain rate, in./min.	0.047			
Water content, %	16.6			
Wet density, pcf	131.2			
Dry density, pcf	112.6			
Saturation, %	89.9			
Void ratio	0.4972			
Specimen diameter, in.	2.820			
Specimen height, in.	4.700			
Height/diameter ratio	1.67			

Description: LIGHT BROWN SILTY CLAY

LL = 40 | **PL =** 21 | **PI =** 19 | **Assumed GS=** 2.70 | **Type:** ST

Project No.: N1115271
Date Sampled: 11-11-11
Remarks:
Lab No. 8799

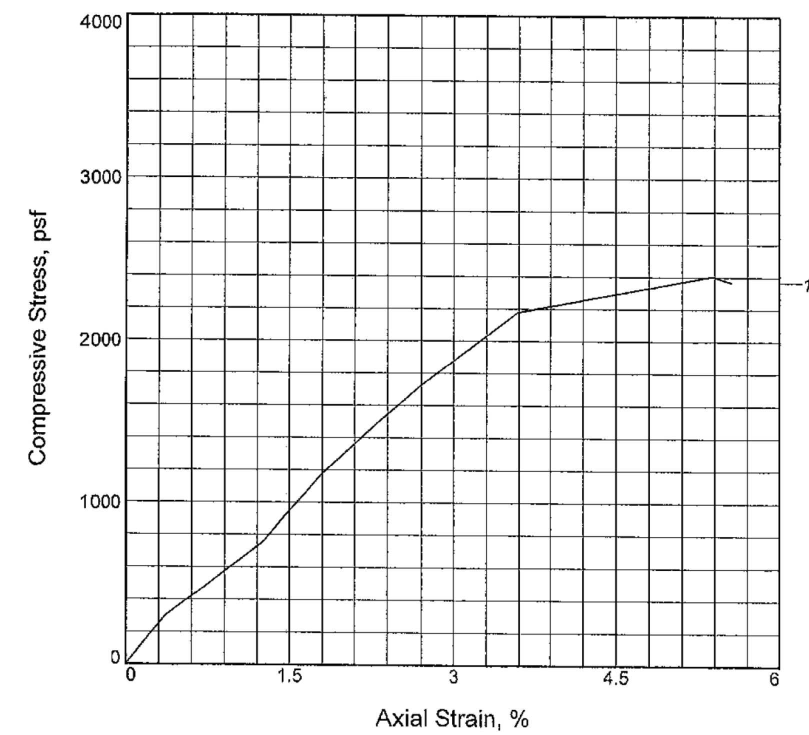
Figure ________

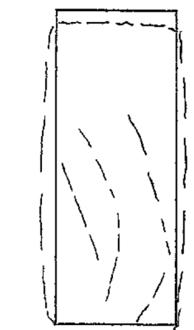
Client: OHIO DEPARTMENT OFTRANSPORTATION DISTRICT 8
Project: HAM-275-5.28 - TASK ORDER M - PID 92075
Source of Sample: B-004-0-11 **Depth:** 7.5-9.5'
Sample Number: 4/ST

UNCONFINED COMPRESSION TEST
H.C. Nutting
A Terracon Company

Tested By: SV **Checked By:** GS

UNCONFINED COMPRESSION TEST





Sample No.	1			
Unconfined strength, psf	2403.8			
Undrained shear strength, psf	1201.9			
Failure strain, %	5.4			
Strain rate, in./min.	0.055			
Water content, %	16.2			
Wet density, pcf	134.4			
Dry density, pcf	115.7			
Saturation, %	95.7			
Void ratio	0.4566			
Specimen diameter, in.	2.850			
Specimen height, in.	5.580			
Height/diameter ratio	1.96			

Description: BROWN GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT & CLAY

LL = 42 | **PL =** 18 | **PI =** 24 | **Assumed GS=** 2.70 | **Type:** ST

Project No.: N1115271
Date Sampled: 11-11-11
Remarks:
Lab No. 8789

Figure ________

Client: OHIO DEPARTMENT OFTRANSPORTATION DISTRICT 8
Project: HAM-275-5.28 - TASK ORDER M - PID 92075
Source of Sample: B-005-0-11 **Depth:** 2.5-4'
Sample Number: 2/ST

UNCONFINED COMPRESSION TEST
H.C. Nutting
A Terracon Company

Tested By: SV **Checked By:** GS

DRAWN KJM CHECKED JDD

LANDSLIDE EXPLORATION
COMPRESSIVE STRENGTH TEST RESULTS

HAM-275-5.28

9/9

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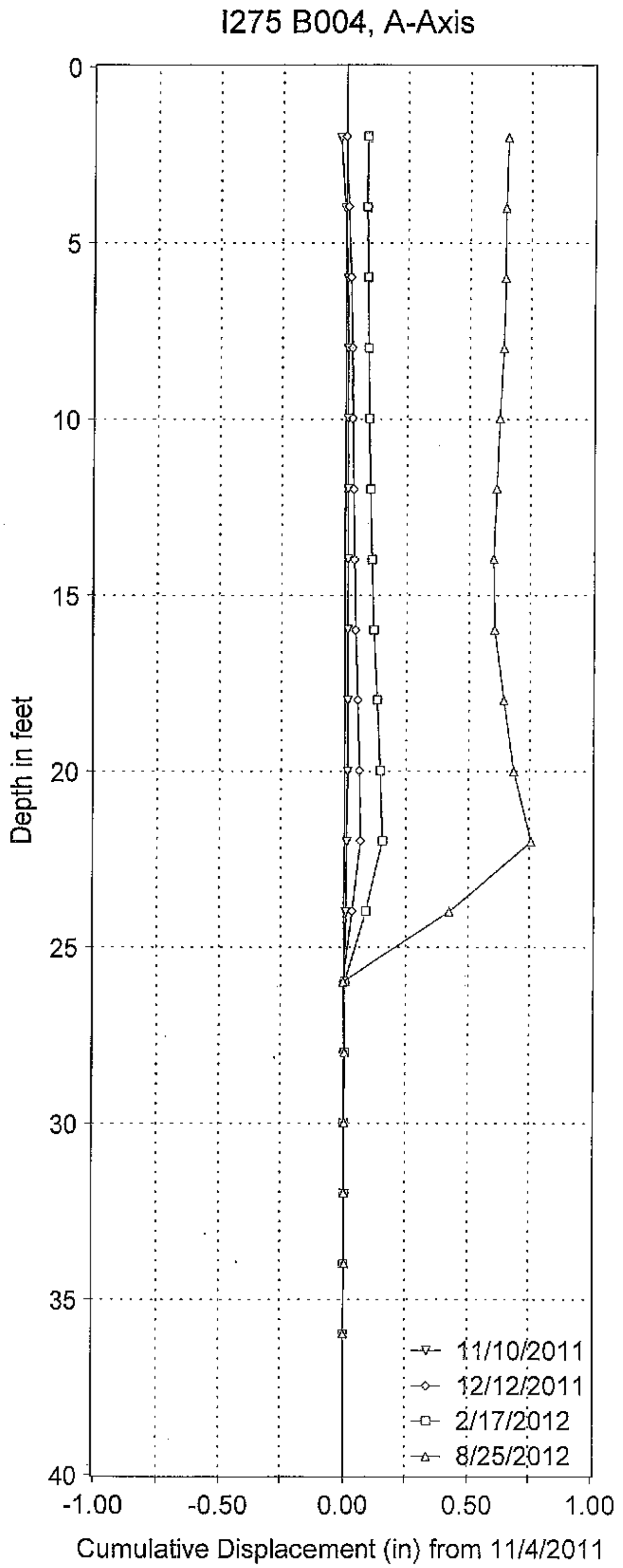
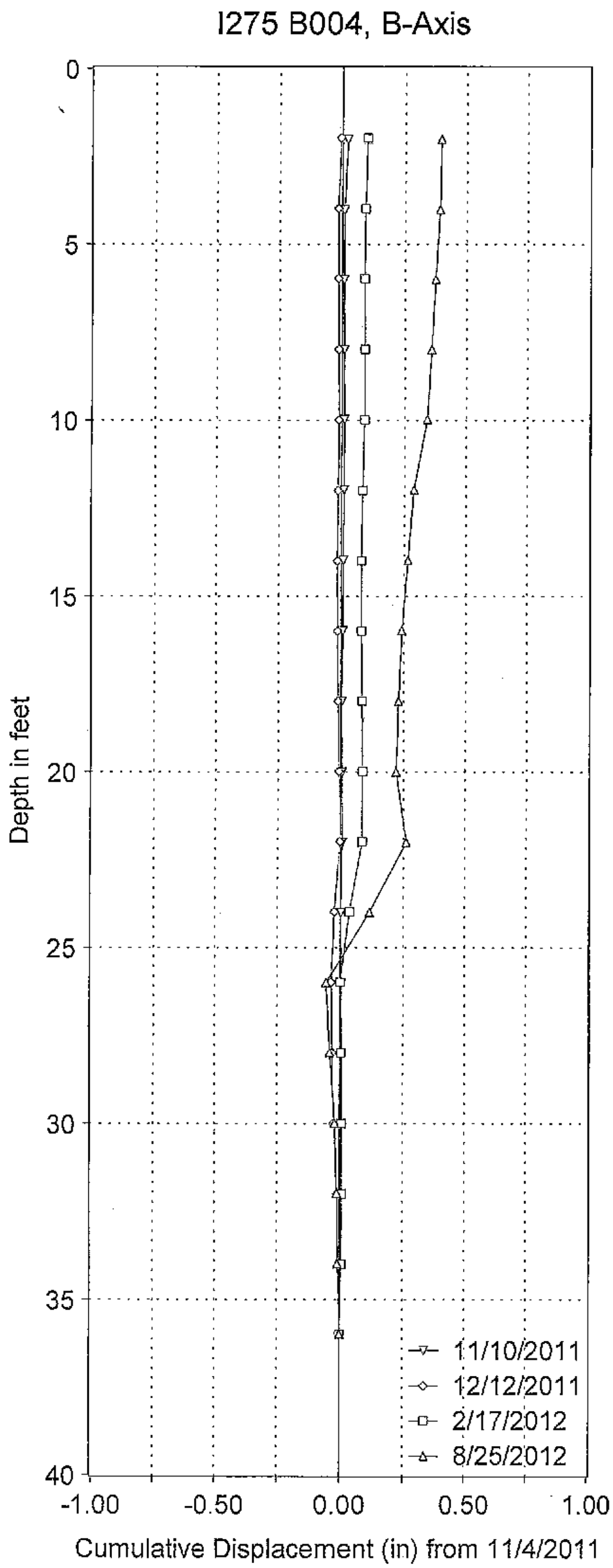
BORING NO.: B-003-0-11
CORE BOX NO.: 1 OF 1
DEPTH (ft.): 10.0-25.0

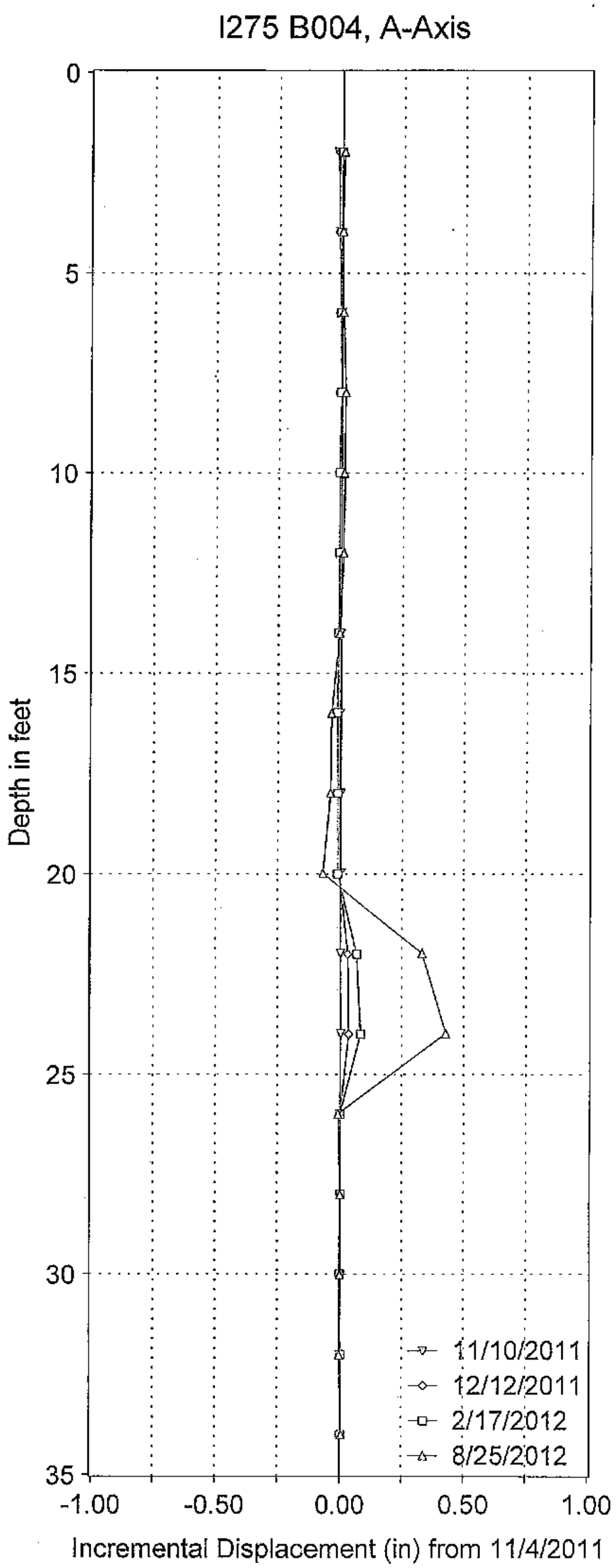
BORING NO.: B-004-0-11
CORE BOX NO.: 1 OF 1
DEPTH (ft.): 25.0-35.0

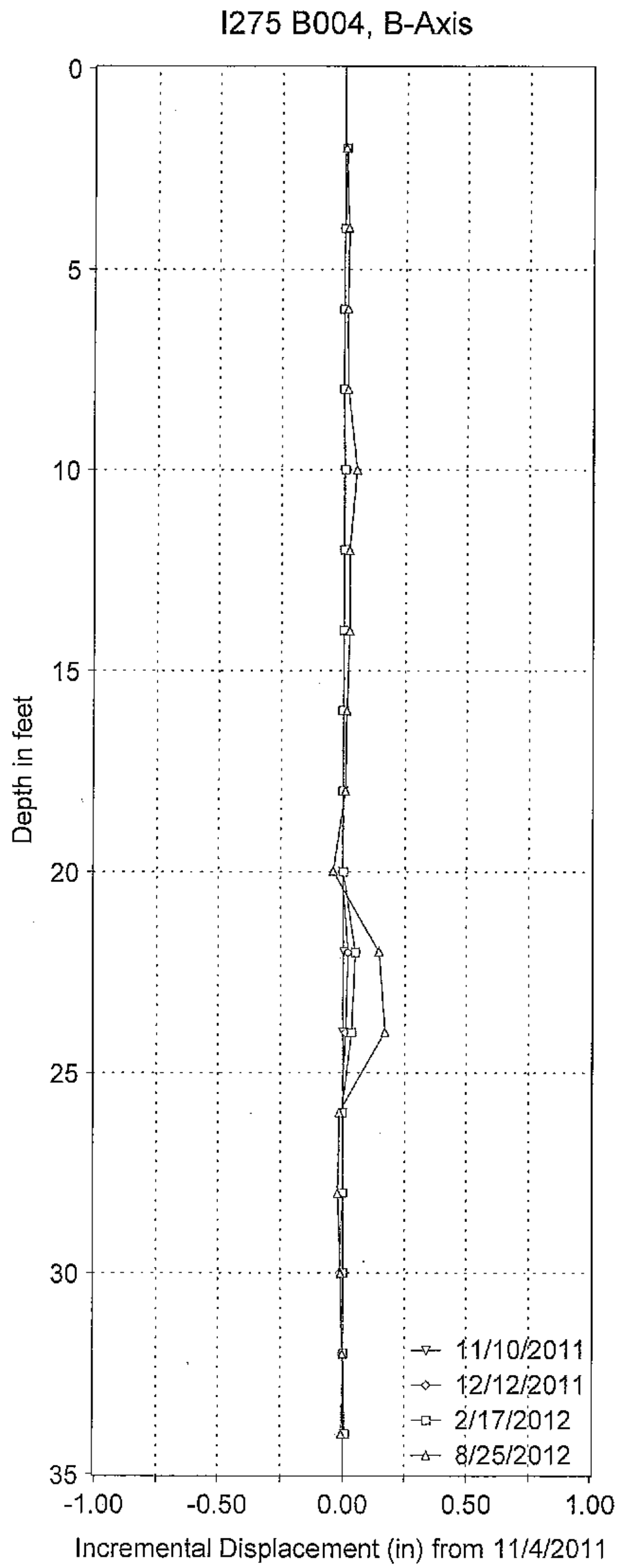
BORING NO.: B-005-0-11
CORE BOX NO.: 1 OF 2
DEPTH (ft.): 15.0-25.0

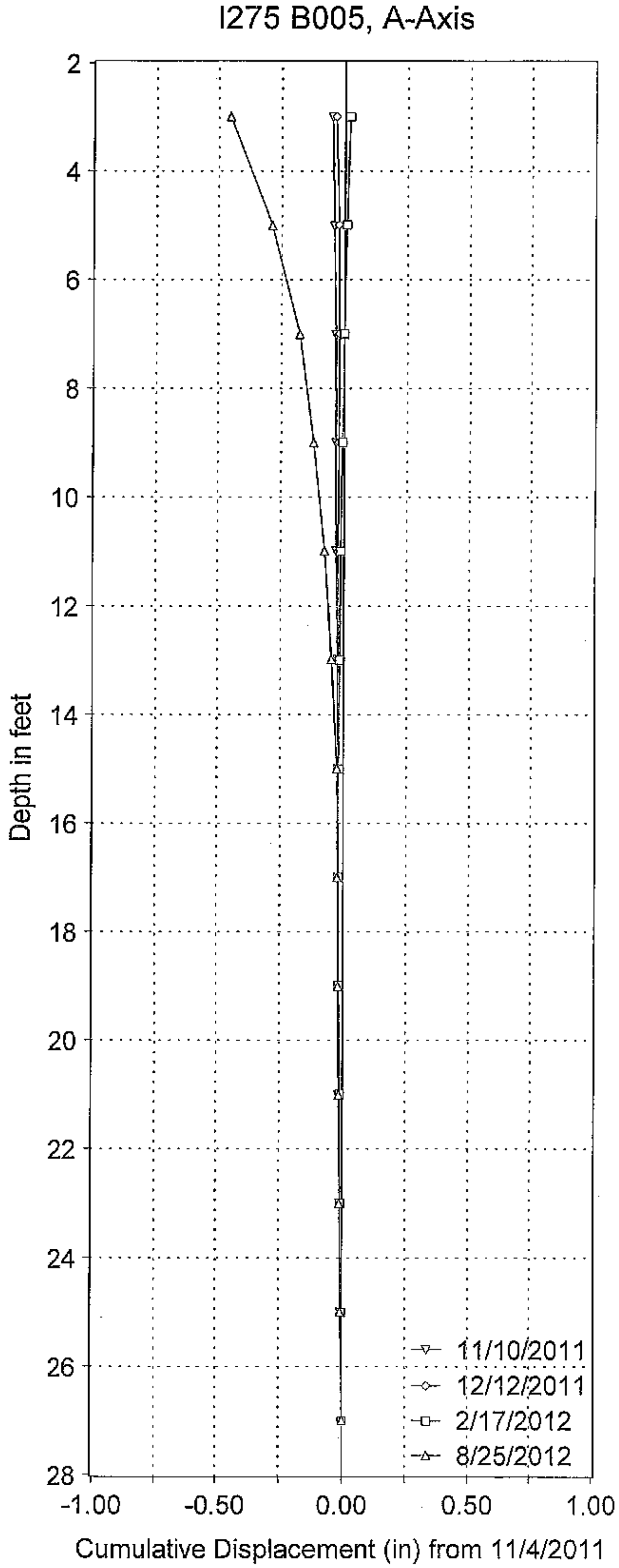
Project Mgr.: JDD	PN. N1115271	Terracon	ROCK CORE PHOTOGRAPHS	SHEET
Drawn By: TCF	Scale: As Shown	611 LUNKEN PARK DRIVE	HAM-275-5.28 SLIDE REPAIR	10
Chkd By: JDD	File No. Core A	CINCINNATI, OHIO 45226	OHIO DEPARTMENT OF TRANSPORTATION – DIST. 8	
Approved By: SS	Date: 10-5-12		HAMILTON COUNTY, CINCINNATI, OHIO	

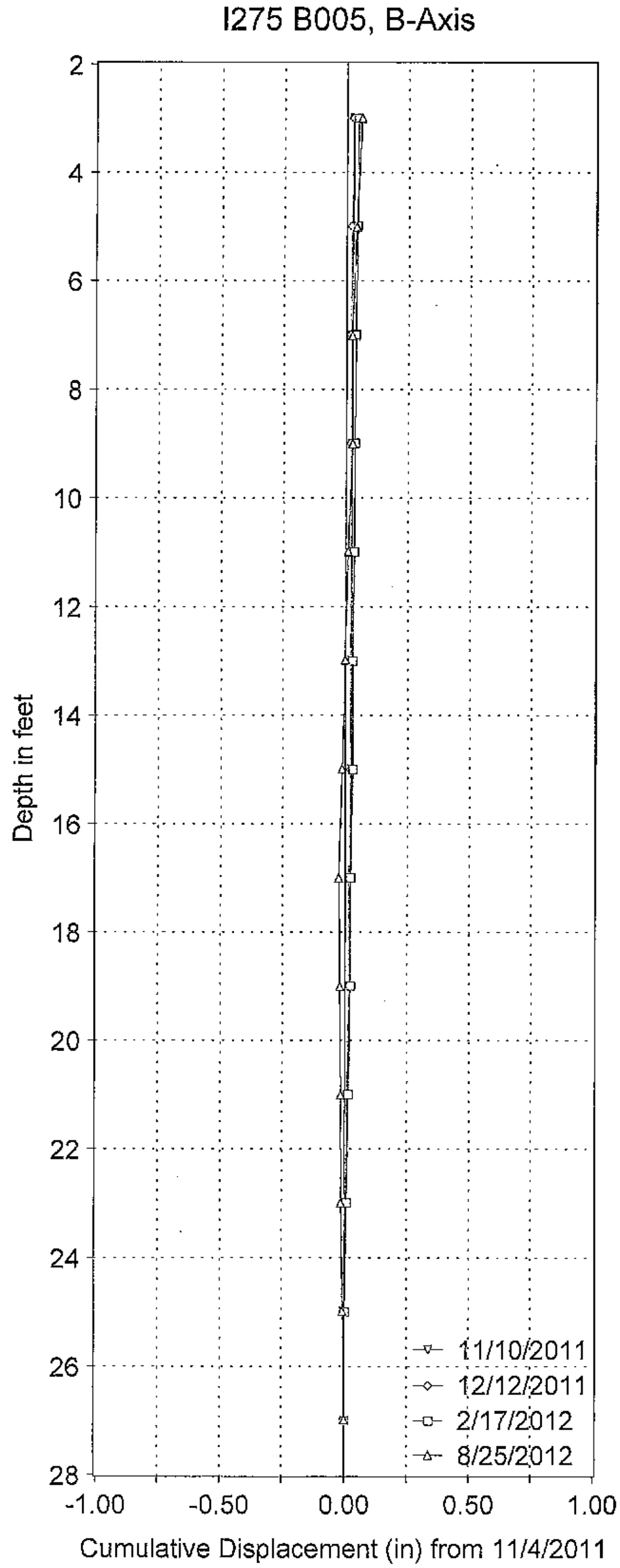

I275 B004, A-Axis
Depth in feet
Cumulative Displacement (in) from 11/4/2011
11/10/2011
12/12/2011
2/17/2012
8/25/2012

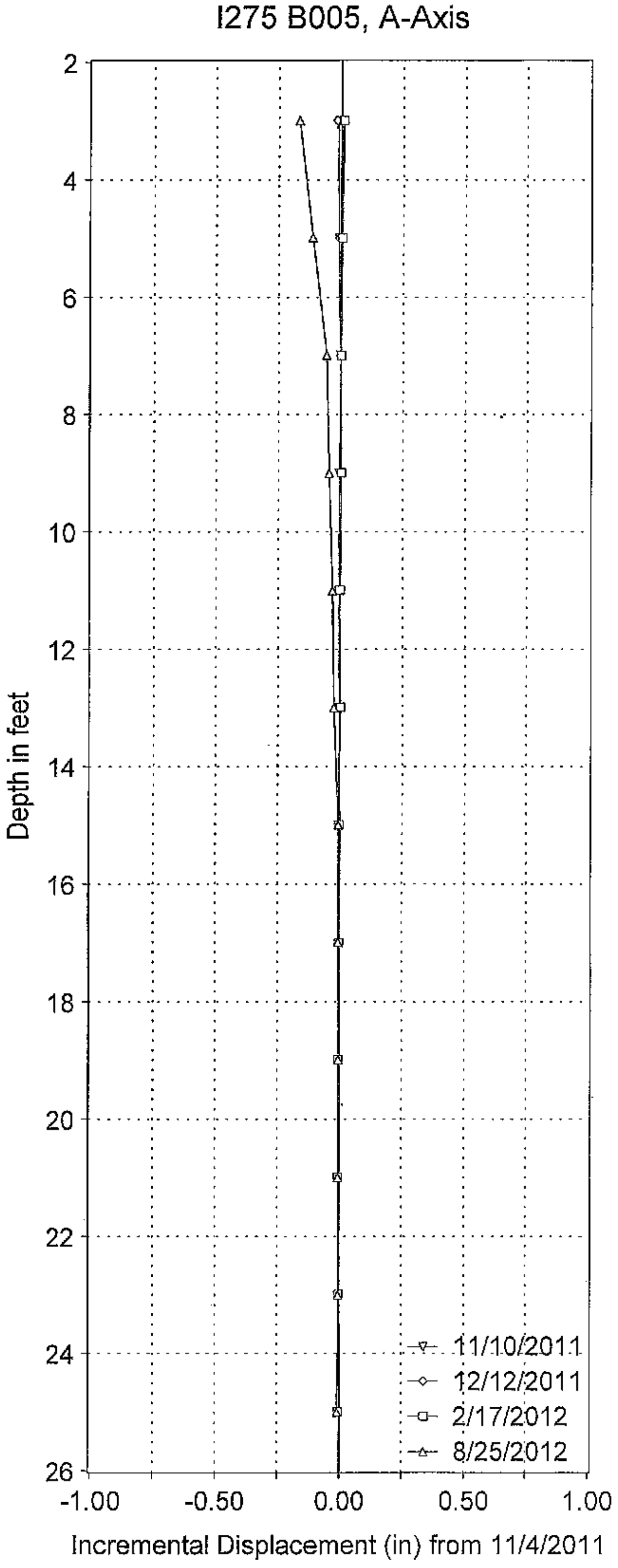

I275 B004, B-Axis
Depth in feet
Cumulative Displacement (in) from 11/4/2011
11/10/2011
12/12/2011
2/17/2012
8/25/2012

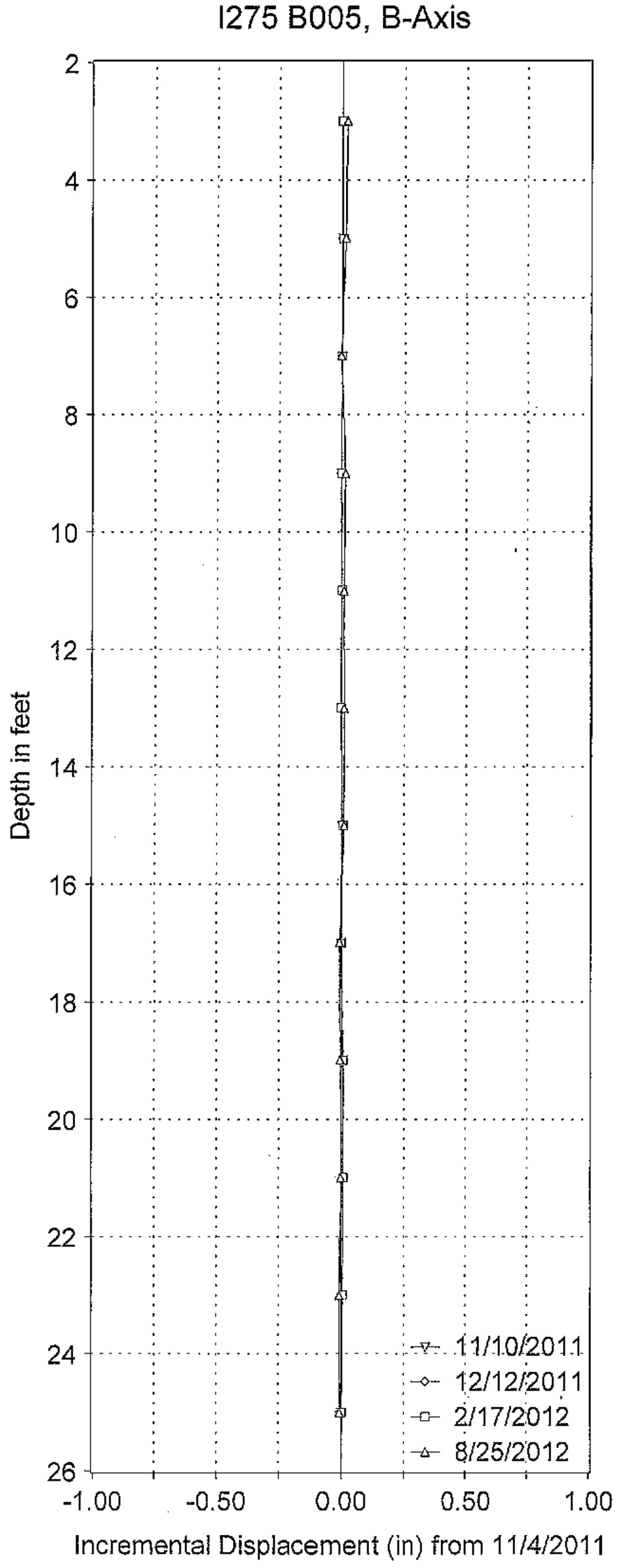

I275 B004, A-Axis
Depth in feet
0
5
10
15
20
25
30
35
-1.00
-0.50
0.00
0.50
1.00
Incremental Displacement (in) from 11/4/2011
11/10/2011
12/12/2011
2/17/2012
8/25/2012


I275 B004, B-Axis
Depth in feet
0
5
10
15
20
25
30
35
-1.00
-0.50
0.00
0.50
1.00
Incremental Displacement (in) from 11/4/2011
11/10/2011
12/12/2011
2/17/2012
8/25/2012


I275 B005, A-Axis
Depth in feet
2
4
6
8
10
12
14
16
18
20
22
24
26
28
-1.00
-0.50
0.00
0.50
1.00
Cumulative Displacement (in) from 11/4/2011
11/10/2011
12/12/2011
2/17/2012
8/25/2012


I275 B005, B-Axis
Depth in feet
2
4
6
8
10
12
14
16
18
20
22
24
26
28
-1.00
-0.50
0.00
0.50
1.00
Cumulative Displacement (in) from 11/4/2011
11/10/2011
12/12/2011
2/17/2012
8/25/2012


I275 B005, A-Axis
Depth in feet
Incremental Displacement (in) from 11/4/2011
11/10/2011
12/12/2011
2/17/2012
8/25/2012

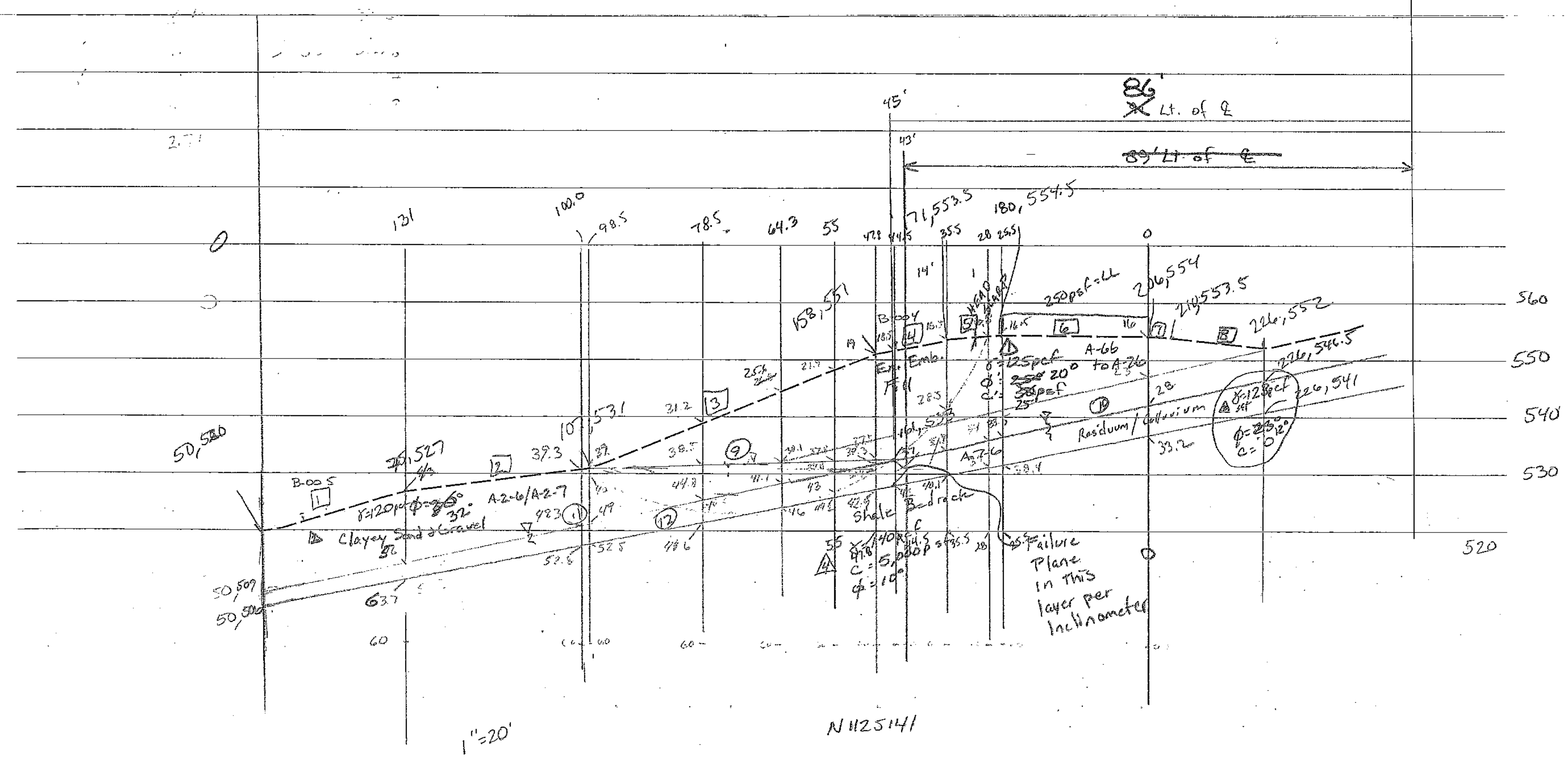

I275 B005, B-Axis
Depth in feet
Incremental Displacement (in) from 11/4/2011
11/10/2011
12/12/2011
2/17/2012
8/25/2012

Per GB-6
Max A-7-6 Fill Params
c'= 400 psf ϕ'= 22° (Too High)

Soils
1 Emb. Fill
2 A-2-6/A-2-7
3 A-7-6
4 Shale Bedrock

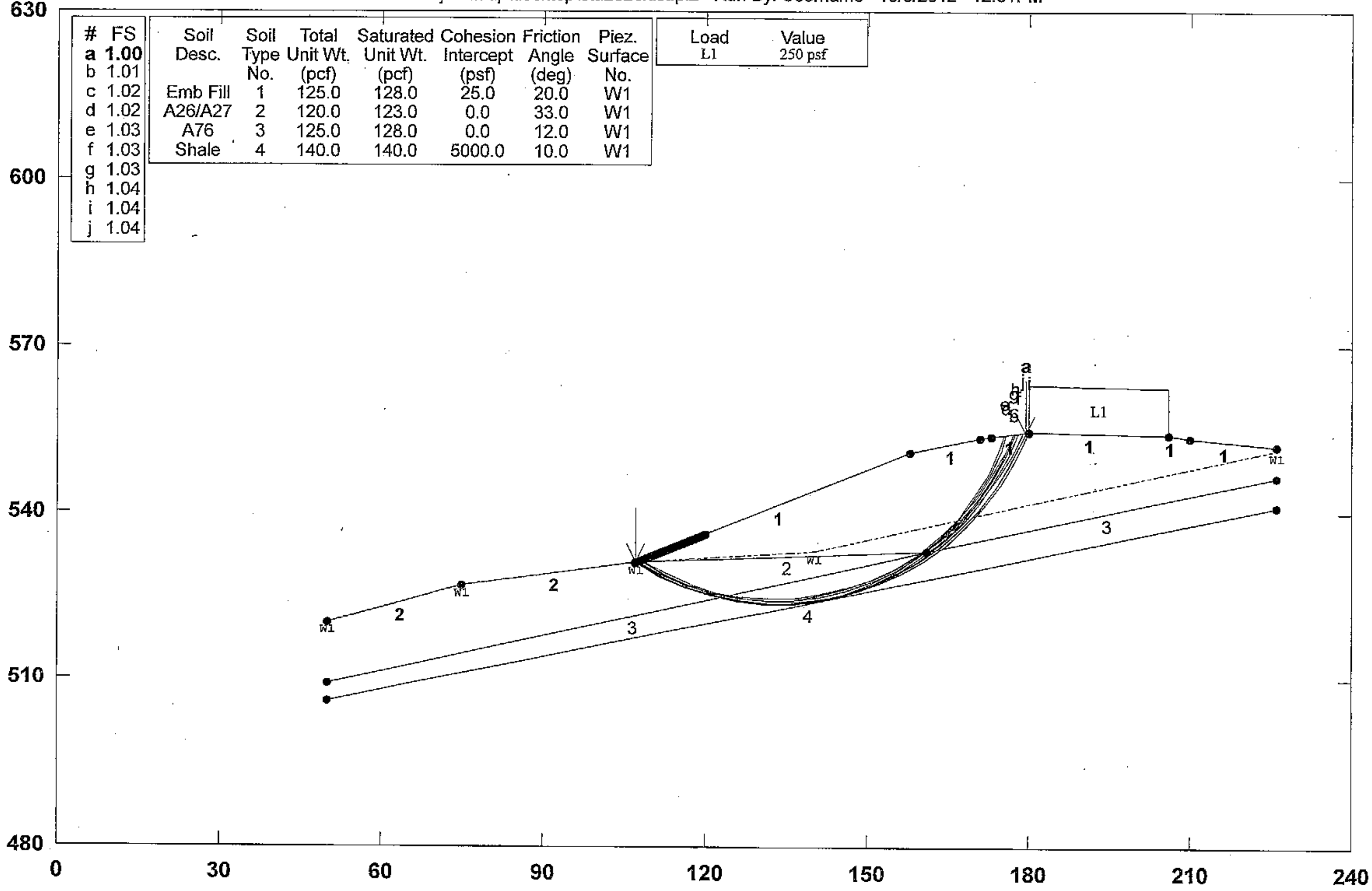
Global Stability
Using PCSTABL5M + UA SLOPE 2.1
Use Conditions from B-004 + B-005
Plus Inclinometer data

XCL 275
282+10.00 / 1



HAM-275-5.28 PID92075 STA 282+10 Left Existing

c:\users\jddunlap\desktop\sta282exist.pl2 Run By: Username 10/3/2012 12:01PM



#	FS
a	**1.00**
b	1.01
c	1.02
d	1.02
e	1.03
f	1.03
g	1.03
h	1.04
i	1.04
j	1.04

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Emb Fill	1	125.0	128.0	25.0	20.0	W1
A26/A27	2	120.0	123.0	0.0	33.0	W1
A76	3	125.0	128.0	0.0	12.0	W1
Shale	4	140.0	140.0	5000.0	10.0	W1

Load	Value
L1	250 psf

PCSTABL5M/si FSmin=1.00

Safety Factors Are Calculated By The Modified Bishop Method

STED

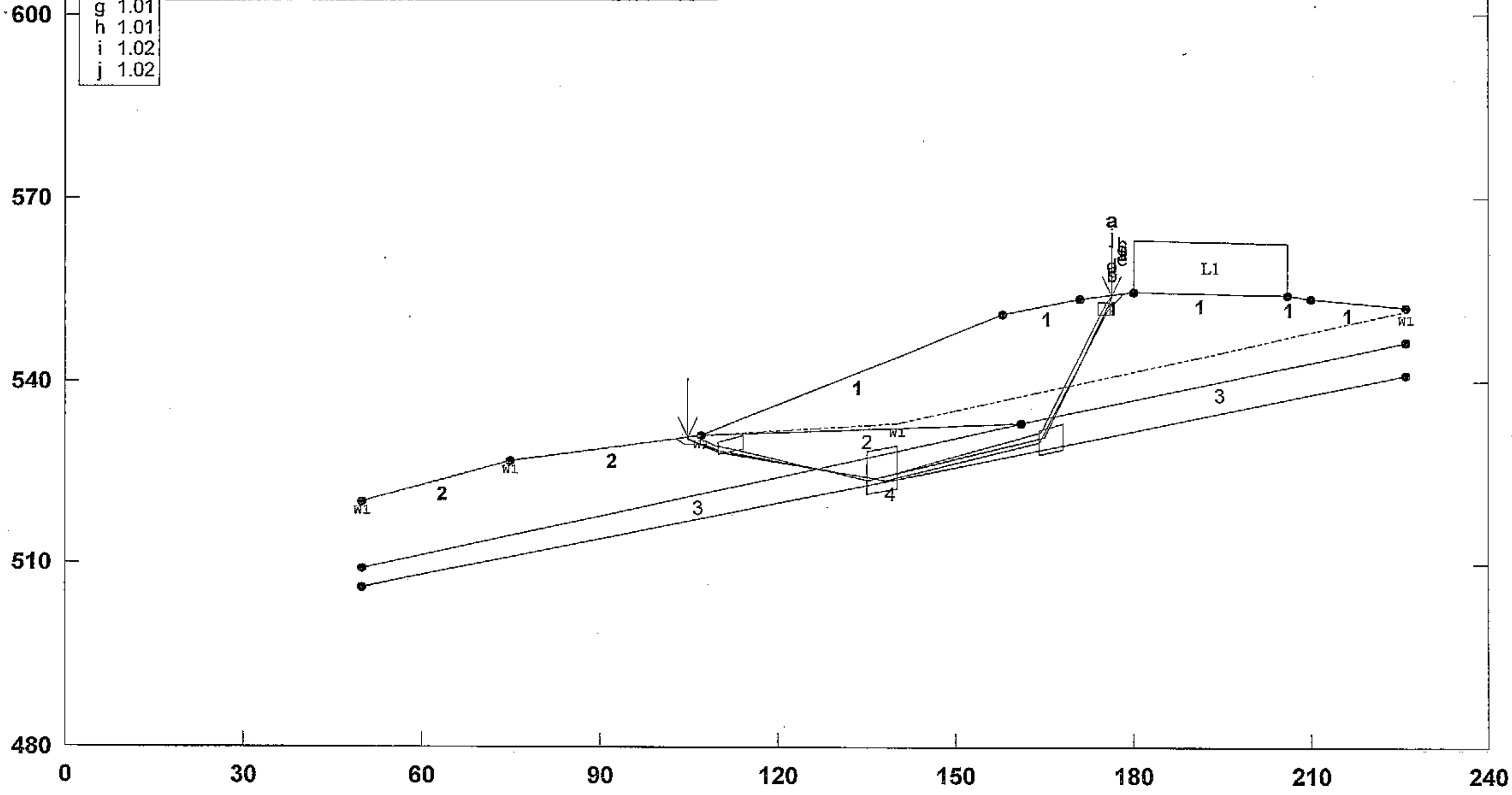
HAM-275-5.28 PID92075 STA 282+10 Left Existing Block

c:\users\jddunlap\desktop\sta282existbl.pl2 Run By: Username 10/3/2012 12:02PM

#	FS
a	**1.01**
b	1.01
c	1.01
d	1.01
e	1.01
f	1.01
g	1.01
h	1.01
i	1.02
j	1.02

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Emb Fill	1	125.0	128.0	25.0	20.0	W1
A26/A27	2	120.0	123.0	0.0	33.0	W1
A76	3	125.0	128.0	0.0	13.0	W1
Shale	4	140.0	140.0	5000.0	10.0	W1

Load	Value
L1	250 psf



PCSTABL5M/si FSmin=1.01

Safety Factors Are Calculated By The Modified Janbu Method

STED

UA Slope Program Version 2.1 - C:\Users\jddunlap\Desktop\HAM-275-528\NoPiers28200.uas*

File Run Options Help

Calculated Results

Factor of Safety: 1.009

Force per Shaft: N/A lb

Acting Point X: N/A ft Y: N/A ft

Analysis Unit System

(•) English ( ) Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num: 12 Soil Layer Num: 4

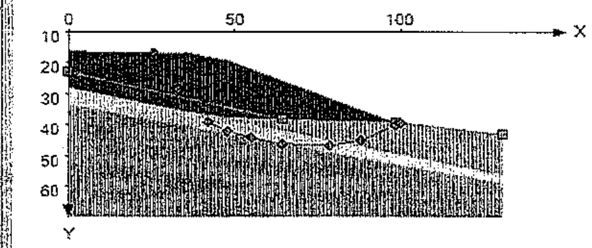
Analysis Method

( ) Total Stress (•) Effective Stress

Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	20.0	125.0
Layer2	0.1	32.0	123.0
Layer3	0.1	12.0	128.0
Layer4	5000.0	10.0	140.0

Chart (Double-Click for More Options)



Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Secti
X (ft)	0.00	25.50	28.00	35.50	44.50	47.80	55.00	64.30	78.50	98.50	100.00	131.0
Y1 (ft)	16.00	16.50	16.80	16.50	18.50	19.00	21.90	25.60	31.20	39.00	39.30	43.00
Y2 (ft)	28.00	33.50	34.00	35.70	37.00	37.50	37.80	38.10	38.50	39.00	39.30	43.00
Y3 (ft)	28.00	33.50	34.00	35.70	37.00	38.30	39.80	41.70	44.80	49.00	49.30	56.00
Y4 (ft)	33.20	38.40	39.00	40.10	42.00	42.90	44.20	46.00	48.60	52.50	52.80	58.70
Y5 (ft)	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00

Coordinates of Crest X: 47.80 ft Y: 19.00 ft Coordinates of Toe X: 98.50 ft Y: 39.00 ft

Drilled Shaft Information

(•) Calculate without Drilled Shaft

( ) Automatically Determine Contribution via Soil Arching Stabilization Mechanism

( ) Manually Defined Load Transfer Factor

0.000000

Diameter: 1.00 ft

Clear Spacing: 0.00 ft

X Coordinate: 25.50 ft

Run

Pore Water Pressure

Pore Pressure Options: ( ) No Pore Pressure ( ) Constant Ratio (•) Specified phreatic surface

	Point 1	Point 2	Point 3	Point 4
X (ft)	0.00	64.30	98.50	131.00
Y (ft)	23.00	38.10	39.00	43.00

Slip Surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10
X (ft)	25.50	33.00	42.00	47.80	55.00	64.30	78.50	88.00	98.50	100.00
Y (ft)	16.50	28.50	39.00	42.00	44.00	46.00	46.50	45.00	40.00	39.30

Start | Inbox - Mailbox - Dun... | W RE100912.docx - Mic... | N:\Projects\2011\W... | UA Slope Program ...

No Piers

UA Slope Program Version 2.1 - C:\Users\jddunlap\Desktop\HAM-275-528\Pier1-28200.uas*

File Run Options Help

Calculated Results

Factor of Safety: 1.375

Force per Shaft: 49800.033 lb

Acting Point X: 40.000 ft Y: 30.342 ft

Analysis Unit System

English / Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num: 12 Soil Layer Num: 4

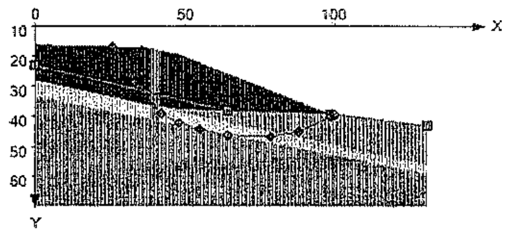
Analysis Method

Total Stress / Effective Stress

Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	20.0	125.0
Layer2	0.1	32.0	123.0
Layer3	0.1	12.0	128.0
Layer4	5000.0	10.0	140.0

Chart (Double-Click for More Options)



Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Sect
X (ft)	0.00	25.50	28.00	35.50	44.50	47.80	55.00	64.30	78.50	98.50	100.00	131.0
Y1 (ft)	16.00	16.50	16.80	16.50	18.50	19.00	21.90	25.60	31.20	39.00	39.30	43.00
Y2 (ft)	28.00	33.50	34.00	35.70	37.00	37.50	37.80	38.10	38.50	39.00	39.30	43.00
Y3 (ft)	28.00	33.50	34.00	35.70	37.00	38.30	39.80	41.70	44.80	49.00	49.30	56.00
Y4 (ft)	33.20	38.40	39.00	40.10	42.00	42.90	44.20	46.00	48.60	52.50	52.80	58.70
Y5 (ft)	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00

Coordinates of Crest X: 47.80 ft Y: 19.00 ft Coordinates of Toe X: 98.50 ft Y: 39.00 ft

Drilled Shaft Information

Calculate without Drilled Shaft

Automatically Determine Contribution via Soil Arching Stabilization Mechanism

Manually Defined Load Transfer Factor

0.202029

Diameter: 3.00 ft

Clear Spacing: 3.00 ft

X Coordinate: 40.00 ft

Run

Pore Water Pressure

Pore Pressure Options: No Pore Pressure / Constant Ratio / Specified phreatic surface

	Point 1	Point 2	Point 3	Point 4
X (ft)	0.00	64.30	98.50	131.00
Y (ft)	23.00	38.10	39.00	43.00

Slip Surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10
X (ft)	25.50	33.00	42.00	47.80	55.00	64.30	78.50	88.00	98.50	100.00
Y (ft)	16.50	28.50	39.00	42.00	44.00	46.00	46.50	45.00	40.00	39.30

Start Inbox - Mailbox ... RP100912.doc UANoPiers.doc N:\Projects\20... UA Slope Pro... 2011 12:07 PM

86' Lt. of I-275 ℄

3' ϕ Piers 6ft. C-C

Terracon

PROJECT: HAM-275-5.28 UASLOPE RESULTS Page ______ of ______

JOB NO. N1115271 Date ______ Comp. By JDD CHECKED BY: ______

S/D = 2 D = 36"

	S	D	CS	FS	P(kips)	Y
37	6'	3'	3'	1.203	29.341	27.78
40				1.375	49.800	30.342 ←
43				1.656	77.880	32.472
46				2.043	90.908	33.696
50				2.942	117.780	35.112
60				9.999	172.950	38.084
70				9.999	187.233	40.144
80				9.999	185.726	41.485
90				3.404	117.540	41.288

Note Add 46' to get I-275 ℄

S/D = 2 D = 42"

37	7'	3.5	3.5	1.191	32.459	27.78
40				1.352	55.464	30.342 ←
43				1.612	87.234	32.472
46				1.966	102.170	33.696
50				2.763	132.929	35.112
60				9.999	199.028	38.084
70				9.999	216.265	40.144
80				9.999	214.210	41.485
90				2.738	121.647	41.288

S/D = 1 D = 42"

37	3.5	3.5	0	1.287	22.705	27.78
40				1.547	37.448	30.342 ←
43				2.019	57.043	32.472
46				2.76	65.733	33.696
50				5.193	83.614	35.112
60				9.99	109.332	38.084
70				9.99	115.906	40.144
80				9.999	115.935	41.485
90				9.999	97.389	41.288

Terracon

PROJECT: ______ Page ____ of ____

JOB NO. ______ Date ______ Comp. By ______ CHECKED BY: ______

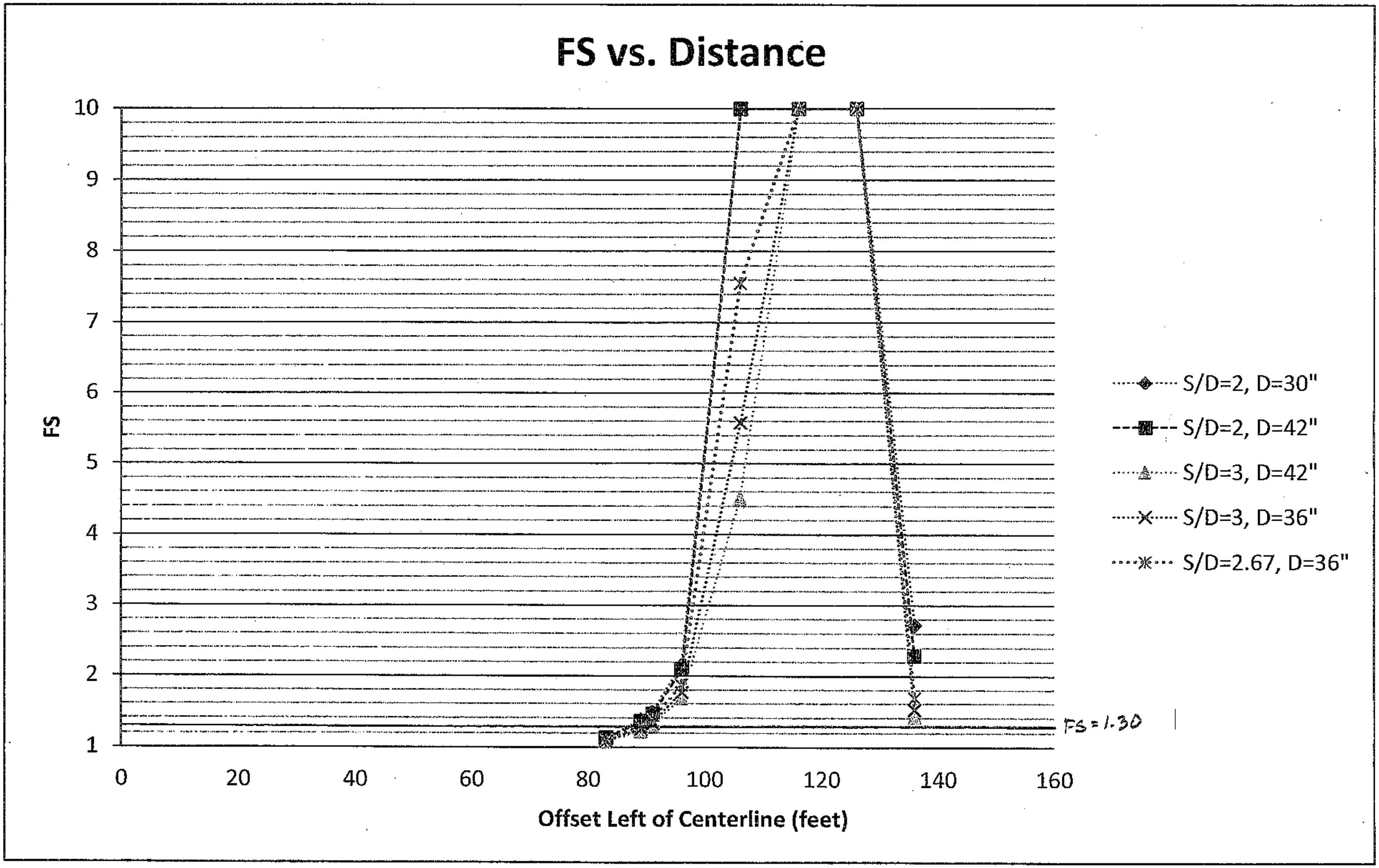
S/D = 2.33   D = 36"

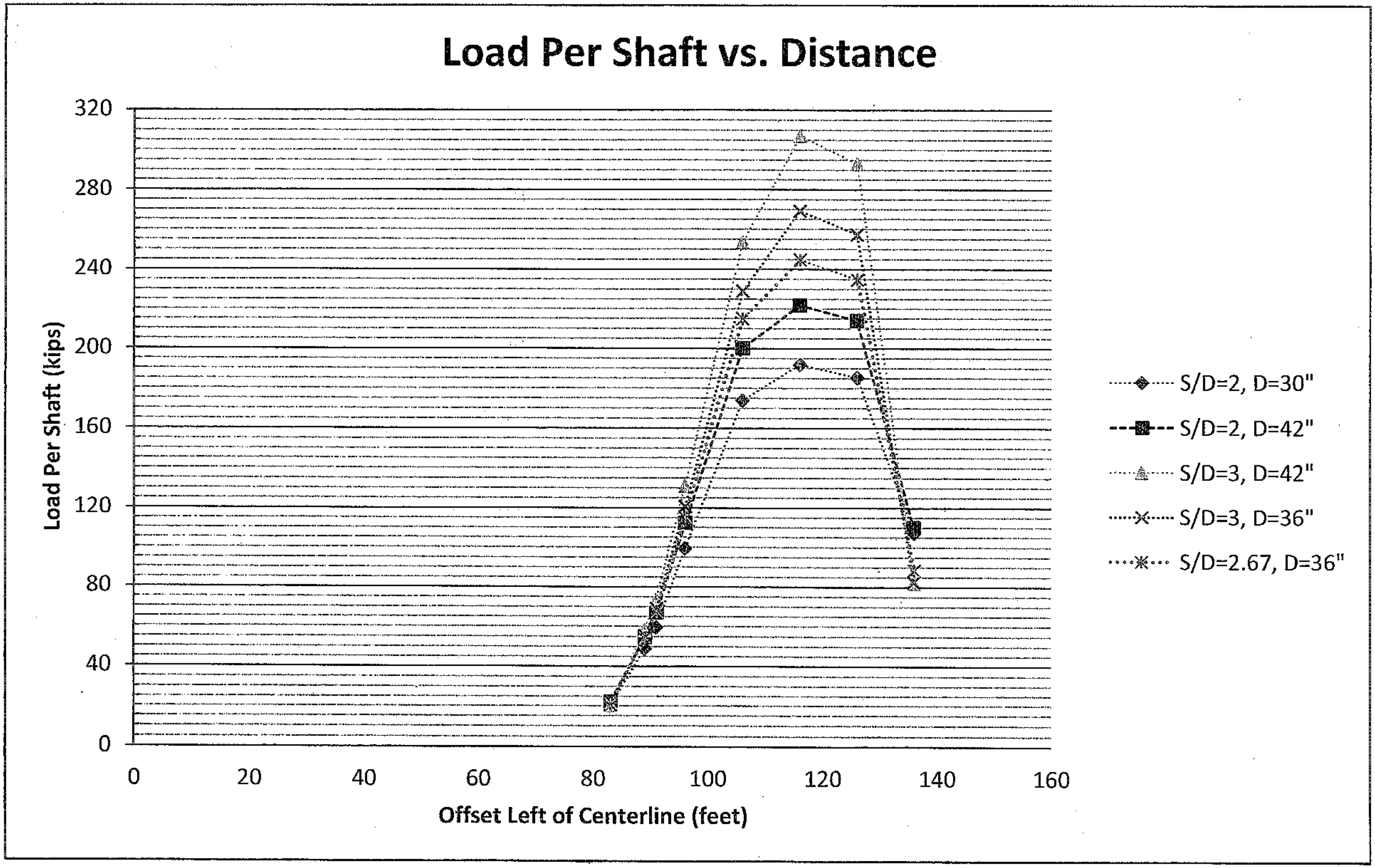
	S =	D	CS	FS	P(kip)	Y
37	7	3	4	1.177	30.446	27.78
40				1.326	52.434	30.342
43				1.565	83.086	32.472
46				1.885	97.738	33.696
50				2.586	127.860	35.112
60				9.999	195.847	38.084
70				9.999	213.746	40.144
80				9.999	211.349	41.485
90				2.308	107.335	41.288

S/D = 1   D = 36"

	S	D	CS			
37	3	3	0	1.287	19.461	27.78
40				1.547	32.099	30.342
43				2.019	48.894	32.472
46				2.760	56.343	33.696
50				5.193	71.669	35.112
60				9.999	93.714	38.084
70				9.999	99.348	40.144
80				9.999	99.373	41.485
90				9.999	83.477	41.288

Form 112—5-93


FS vs. Distance
FS
10
9
8
7
6
5
4
3
2
1
0
20
40
60
80
100
120
140
160
Offset Left of Centerline (feet)
FS = 1.30
S/D=2, D=30"
S/D=2, D=42"
S/D=3, D=42"
S/D=3, D=36"
S/D=2.67, D=36"

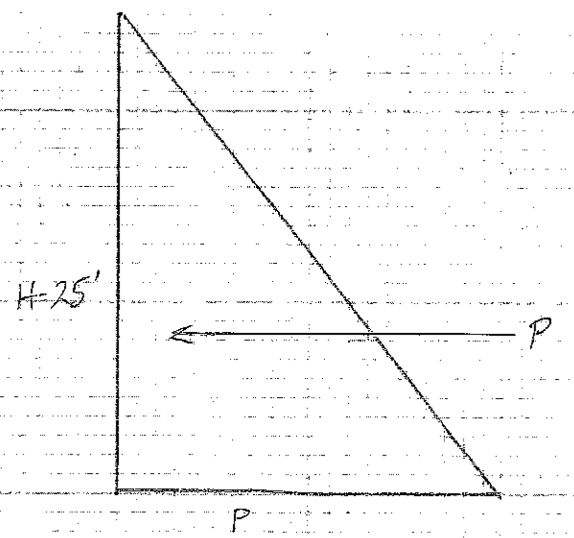


Load Per Shaft vs. Distance
Load Per Shaft (kips)
320
280
240
200
160
120
80
40
0
0
20
40
60
80
100
120
140
160
Offset Left of Centerline (feet)
S/D=2, D=30"
S/D=2, D=42"
S/D=3, D=42"
S/D=3, D=36"
S/D=2.67, D=36"

PROJECT: HAM-275-5.28 Page ____ of ____

JOB NO. N1115271 Date ________ Comp. By ________ CHECKED BY: ________

Assume Failure occurring on top of Weathered Rock @ 25' Depth



Try $S/D = 2$, $D = 36''$, $S = 6'$

$P = 49{,}800$ lbs

$P = \frac{1}{2} \gamma K_a H^2$

$p = \frac{P}{\frac{1}{2} H}$

$p = \frac{P = 49{,}800}{\frac{1}{2} 25} = 3{,}984$ lb/ft $= 332$ lb/in   Strength $= 332 \times 1.5 = 498$ lb/in

For Traffic Use $K_a = .333 (\phi = 30°)$

$q = 250$ psf $250 \times 0.33 \times \frac{6\text{ ft}}{12\text{ in}} = 41.25$ lb/in   Strength $= 41.25 \times 1.75 = 73$ lb/in

Try W 24x176

$f'_c = 4{,}500$ psi

$\phi = 36''$

Form 112—5-93

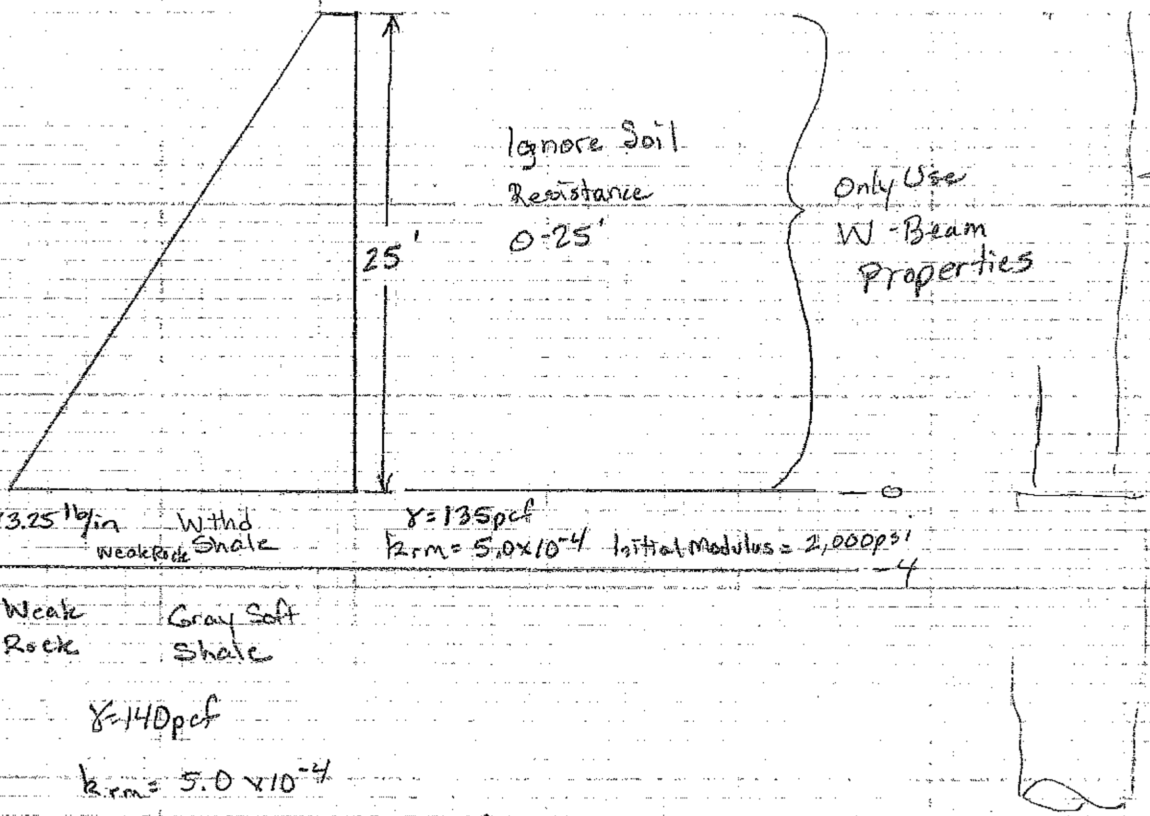
Terracon

PROJECT: ______ Page ____ of ____

JOB NO. ______ Date ______ Comp. By ______ CHECKED BY: ______

Service

41.25 lb/in (Strength = 73 lb/in)



(Strength = 57 lb/in) 373.25 lb/in Wthd Shale weak Rock

$\gamma = 135$ pcf

$k_{rm} = 5.0 \times 10^{-4}$ Initial Modulus = 2,000 psi

Weak Rock Gray Soft Shale

$\gamma = 140$ pcf

$k_{rm} = 5.0 \times 10^{-4}$

Initial Modulus = 3,000 psi

$$B_a = 0.64\,(S/D)^{0.35} = 0.82$$

Moment capacity

For W 24 X 176

Factored M = 12410.938 kips in

Flexure factor, $f_f = 1.0$; $f_y = 50$ ksi

$$S_x = \frac{\text{Factored } M}{f_f \times f_y} = \frac{12410.938}{1 \times 50} = 248.219 < 450 \text{ in}^3$$

O.K.

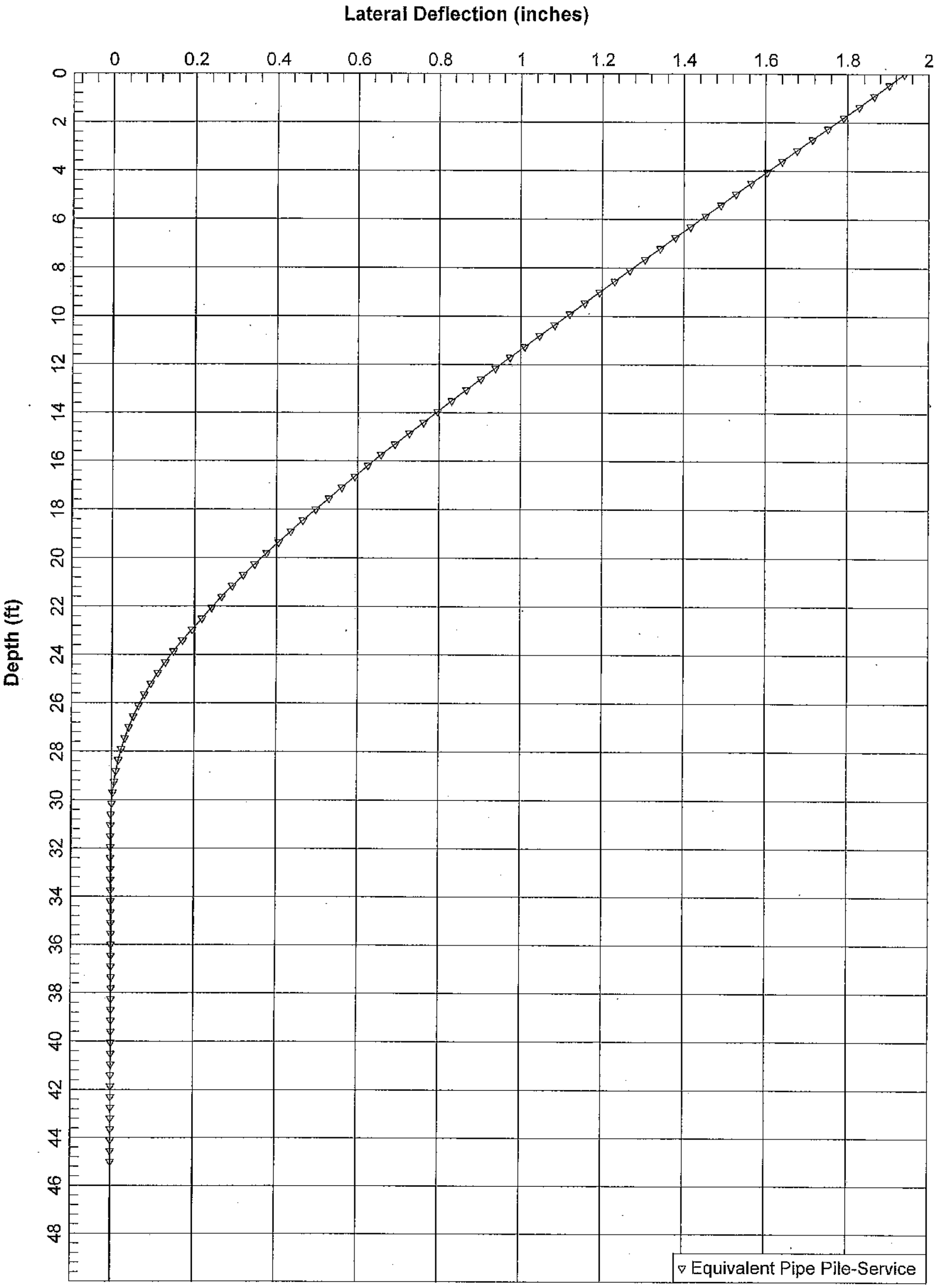
Shear Capacity

Factored V = 213.6 Kips

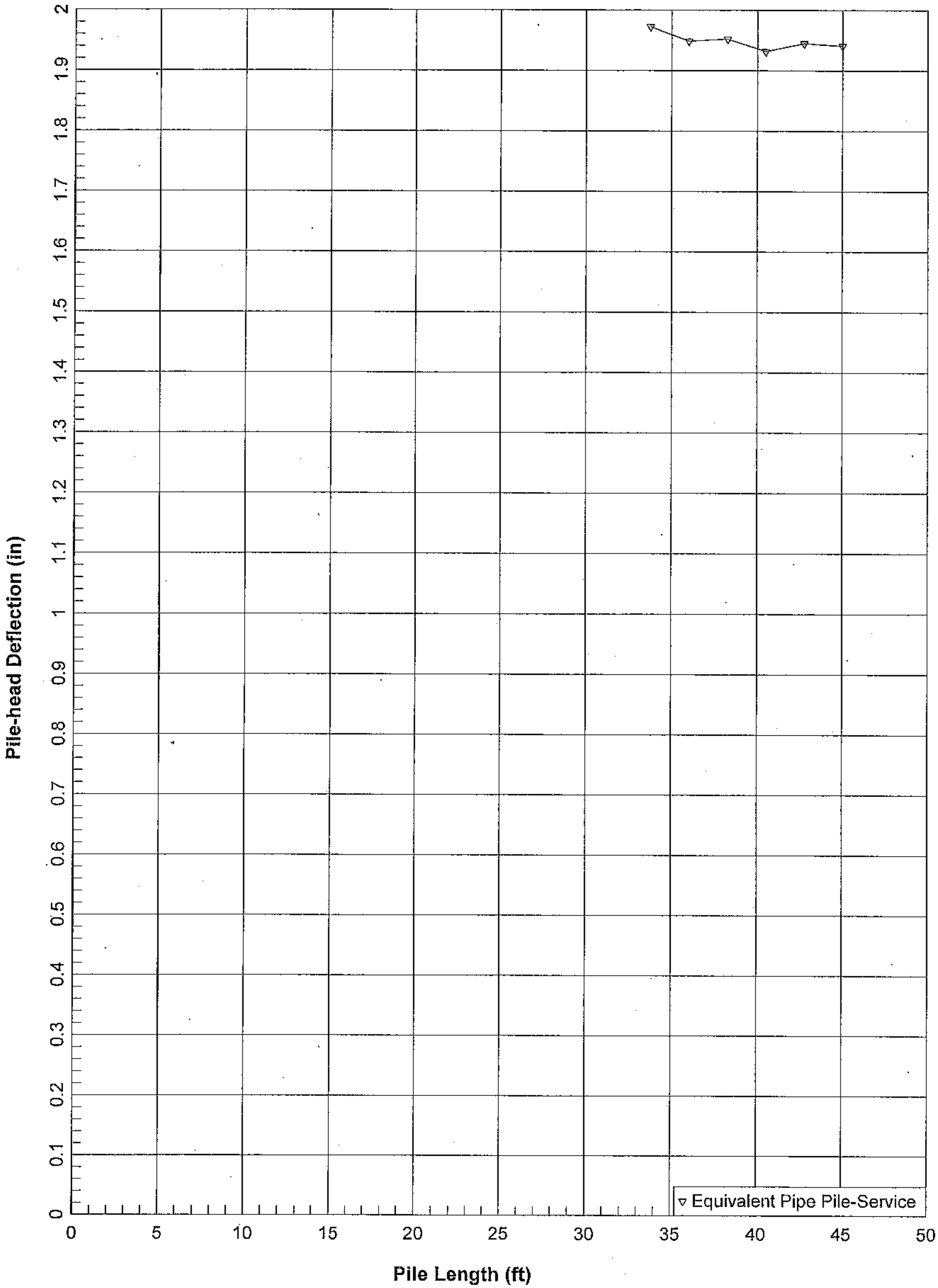
Shear factor, $f_v = 1.0$; $f_y = 50$ ksi

$$D_w t_w = \frac{\text{Factored } V}{f_v \times (0.58 f_y)} = \frac{213.6}{1 \times (0.58 \times 50)} = 7.36 \text{ in}^2 < 16.92 \text{ in}^2 \quad \text{O.K.}$$

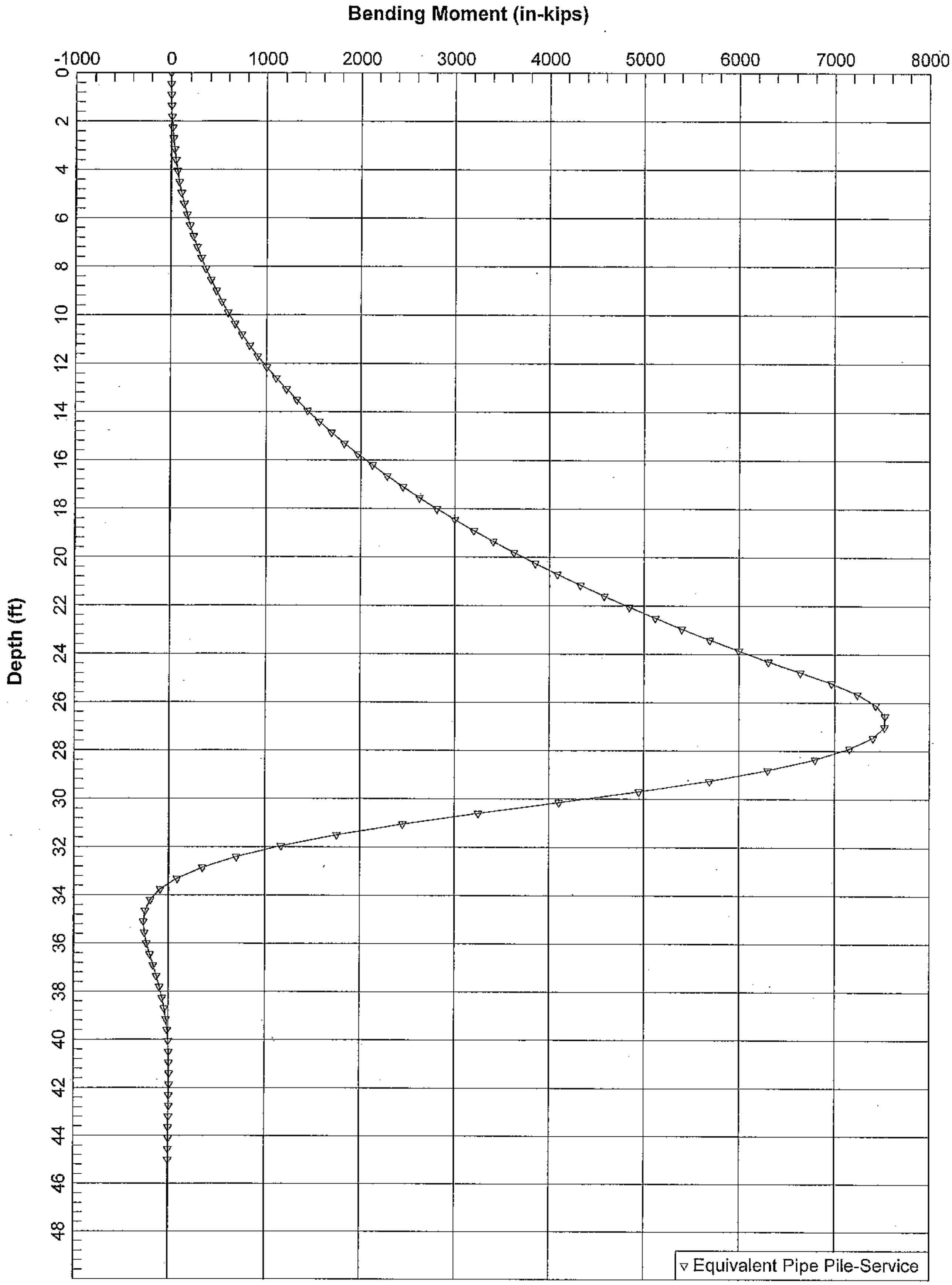
$\{25.24 - (2 \times 1.34)\}\{0.75\} =$

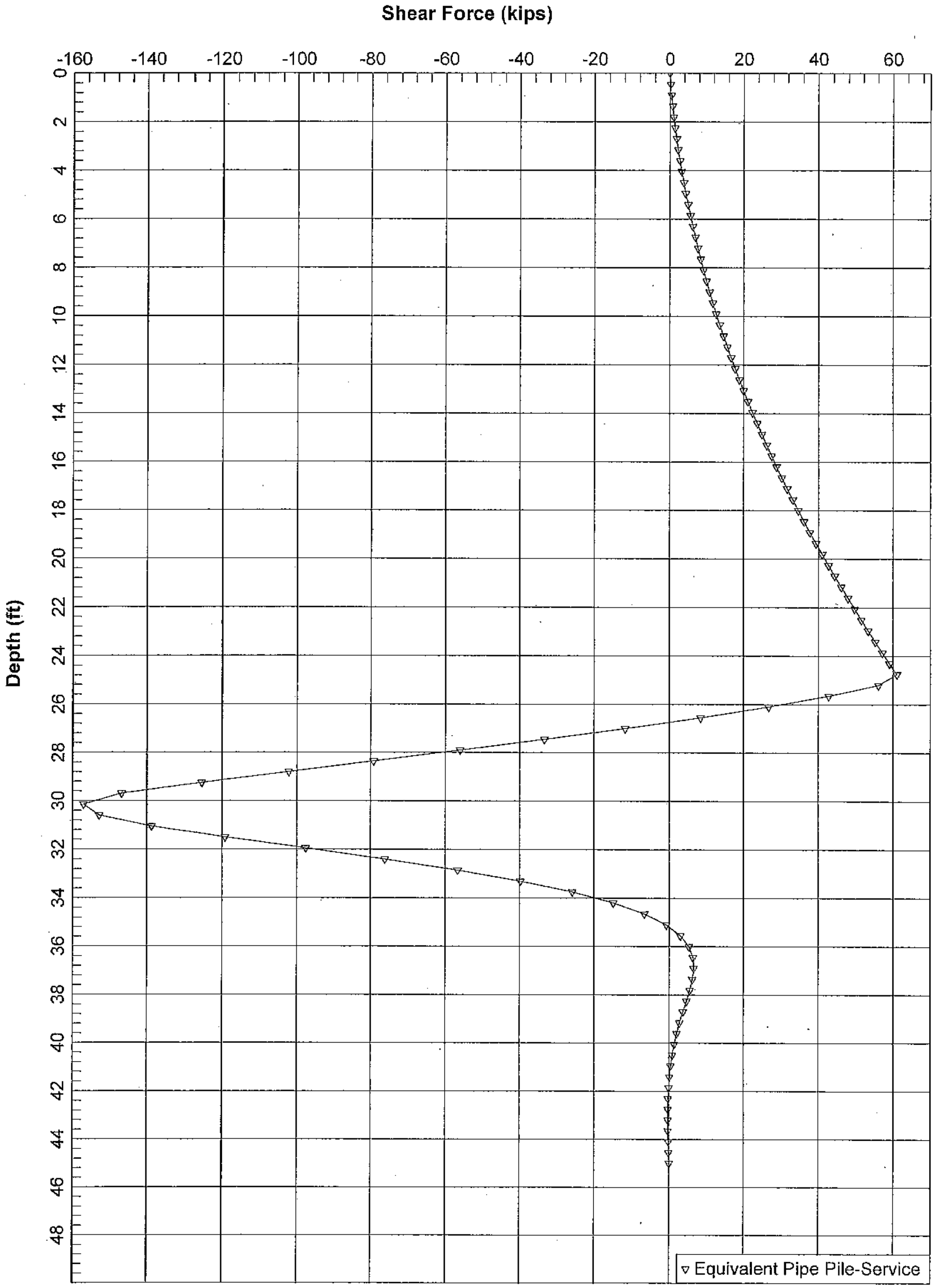


Lateral Deflection (inches)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Equivalent Pipe Pile-Service



Pile-head Deflection (in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
0
5
10
15
20
25
30
35
40
45
50
Pile Length (ft)
▿ Equivalent Pipe Pile-Service


Bending Moment (in-kips)
-1000
0
1000
2000
3000
4000
5000
6000
7000
8000
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Equivalent Pipe Pile-Service



Shear Force (kips)
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Equivalent Pipe Pile-Service

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LPile Plus for Windows, Version 6 (6.0.22)

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

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This program is licensed to:

Terracon
Cincinnati, OH

Files Used for Analysis

```
Path to file locations:        N:\Projects\2011\N1115271\Working
Files\Calculations-Analyses\
Name of input data file:       LPile (USCS units)-Service Case-Pipe Pile.lp6d
Name of output report file:    LPile (USCS units)-Service Case-Pipe Pile.lp6o
Name of plot output file:      LPile (USCS units)-Service Case-Pipe Pile.lp6p
Name of runtime messeage file: LPile (USCS units)-Service Case-Pipe Pile.lp6r
```

Date and Time of Analysis

Date: September 20, 2012   Time: 13:09:47

Problem Title

Project Name:

Job Number: N1125141

Client:

Engineer:

Description:

Program Options

Engineering units are US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes nonlinear bending stiffness and nominal moment capacity with pile response computed using nonlinear EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output pile response for full length of pile
- Analysis assumes no soil movements acting on pile
- No p-y curves to be computed and output for user-specified depths

Solution Control Parameters:

- Number of pile increments	=	100	
- Maximum number of iterations allowed	=	100	
- Deflection tolerance for convergence	=	1.0000E-05	in
- Maximum allowable deflection	=	100.0000	in

Pile Response Output Options:
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1

Pile Structural Properties and Geometry

Total Number of Sections	=	1
Total Pile Length	=	45.00 ft
Depth of ground surface below top of pile	=	25.00 ft
Slope angle of ground surface	=	0.00 deg.

Pile dimensions used for p-y curve computations defined using 2 points. p-y curves are computed using values of pile diameter interpolated over the length of the pile.

Point	Depth X ft	Pile Diameter in
1	0.00000	22.6170000
2	45.000000	22.6170000

Input Structural Properties:

Pile Section No. 1:

Section Type = Steel Pipe Pile

Section Length	=	45.000 ft
Pile Diameter	=	22.617 in

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                   =        0.000 degrees
                                                     =        0.000 radians

Pile Batter Angle                                    =        0.000 degrees
                                                     =        0.000 radians
```

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

```
Distance from top of pile to top of layer            =       25.000 ft
Distance from top of pile to bottom of layer         =       29.000 ft
Initial modulus of rock at top of layer              =   2.0000E+03 lbs/in**2
Initial modulus of rock at bottom of layer           =   2.0000E+03 lbs/in**2
```

Layer 2 is weak rock, p-y criteria by Reese, 1997

```
Distance from top of pile to top of layer            =       29.000 ft
Distance from top of pile to bottom of layer         =       60.000 ft
Initial modulus of rock at top of layer              =   3.0000E+03 lbs/in**2
Initial modulus of rock at bottom of layer           =   3.0000E+03 lbs/in**2
```

(Depth of lowest layer extends   15.00 ft below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 4 points

Point No.	Depth X ft	Eff. Unit Weight pcf
1	25.00	135.00000
2	29.00	135.00000
3	29.00	140.00000
4	60.00	140.00000

**** Warning - POSSIBLE INPUT DATA ERROR ****

Values entered for effective unit weights of soil were outside
the limits of 0.011574 pci (20 pcf) or 0.0810019 pci (140 pcf)
This data may be erroneous. Please check your data.

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Depth ft	Eff. Unit Wt., pcf	Cohesion psf	Friction Ang., deg.	qu psi	RQD percent	Epsilon 50	kpy pci	Rock Emass psi	krm	Test Type	Test Prop.	Elas. Subgr. pci
1	Weak Rock	25.000	135.000	--	--	100.000	0.00	--	--	2000.000	5.00E-04	--	--	--
		29.000	135.000	--	--	100.000	0.00	--	--	2000.000	5.00E-04	--	--	--
2	Weak Rock	29.000	140.000	--	--	110.000	0.00	--	--	3000.000	5.00E-04	--	--	--
		60.000	140.000	--	--	110.000	0.00	--	--	3000.000	5.00E-04	--	--	--

Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading

Distributed lateral load intensity defined using 2 points

Point No.	Depth X in	Dist. Load lbs/in
1	0.000	41.250
2	300.000	373.250

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs
1	1	V = 0.000 lbs	M = 0.000 in-lbs	0.000

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head

y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust is assumed to be acting axially

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

Length of Section	=	45.00000000 ft
Outer Diameter of Pipe	=	22.61700000 in
Pipe Wall Thickness	=	1.34000000 in
Yield Stress of Pipe	=	36.00000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	89.57051363 sq. in.
Moment of Inertia	=	5088.79566726 in^4
Elastic Bending Stiffness	=	147575074. lb-in^2
Plastic Modulus, Z	=	607.43441153 in^3
Plastic Moment Capacity = Fy Z	=	21868. in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	3224.538 kips
Nominal Axial Tensile Capacity	=	-3224.538 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.000002333	344.2740587	147586235.	11.3085000	0.7573500	
0.000004665	688.5481174	147586235.	11.3085000	1.5147001	
0.000006998	1032.8221761	147586235.	11.3085000	2.2720501	
0.000009331	1377.0962348	147586235.	11.3085000	3.0294001	
0.0000117	1721.3702935	147586235.	11.3085000	3.7867501	

0.0000140	2065.6443522	147586235.	11.3085000	4.5441002	
0.0000163	2409.9184110	147586235.	11.3085000	5.3014502	
0.0000187	2754.1924697	147586235.	11.3085000	6.0588002	
0.0000210	3098.4665284	147586235.	11.3085000	6.8161503	
0.0000233	3442.7405871	147586235.	11.3085000	7.5735003	
0.0000257	3787.0146458	147586235.	11.3085000	8.3308503	
0.0000280	4131.2887045	147586235.	11.3085000	9.0882003	
0.0000303	4475.5627632	147586235.	11.3085000	9.8455504	
0.0000327	4819.8368219	147586235.	11.3085000	10.6029004	
0.0000350	5164.1108806	147586235.	11.3085000	11.3602504	
0.0000373	5508.3849393	147586235.	11.3085000	12.1176004	
0.0000397	5852.6589980	147586235.	11.3085000	12.8749505	
0.0000420	6196.9330567	147586235.	11.3085000	13.6323005	
0.0000443	6541.2071155	147586235.	11.3085000	14.3896505	
0.0000467	6885.4811742	147586235.	11.3085000	15.1470006	
0.0000490	7229.7552329	147586235.	11.3085000	15.9043506	
0.0000513	7574.0292916	147586235.	11.3085000	16.6617006	
0.0000537	7918.3033503	147586235.	11.3085000	17.4190506	
0.0000560	8262.5774090	147586235.	11.3085000	18.1764007	
0.0000583	8606.8514677	147586235.	11.3085000	18.9337507	
0.0000607	8951.1255264	147586235.	11.3085000	19.6911007	
0.0000630	9295.3995851	147586235.	11.3085000	20.4484508	
0.0000653	9639.6736438	147586235.	11.3085000	21.2058008	
0.0000676	9983.9477025	147586235.	11.3085000	21.9631508	
0.0000700	10328.	147586235.	11.3085000	22.7205008	
0.0000723	10672.	147586235.	11.3085000	23.4778509	
0.0000746	11017.	147586235.	11.3085000	24.2352009	
0.0000770	11361.	147586235.	11.3085000	24.9925509	
0.0000793	11705.	147586235.	11.3085000	25.7499010	
0.0000816	12050.	147586235.	11.3085000	26.5072510	
0.0000840	12394.	147586235.	11.3085000	27.2646010	
0.0000863	12738.	147586235.	11.3085000	28.0219510	
0.0000886	13082.	147586235.	11.3085000	28.7793011	
0.0000910	13427.	147586235.	11.3085000	29.5366511	
0.0000956	14115.	147586235.	11.3085000	31.0513511	
0.0001003	14804.	147586235.	11.3085000	32.5660512	
0.0001050	15492.	147586235.	11.3085000	34.0807513	
0.0001096	16181.	147586235.	11.3085000	35.5954513	
0.0001143	16843.	147352745.	11.3085000	36.0000000	Y
0.0001190	17420.	146428607.	11.3085000	36.0000000	Y
0.0001236	17896.	144754119.	11.3085000	36.0000000	Y
0.0001283	18270.	142399054.	11.3085000	36.0000000	Y
0.0001330	18581.	139745635.	11.3085000	36.0000000	Y
0.0001376	18846.	136935022.	11.3085000	36.0000000	Y
0.0001423	19079.	134078261.	11.3085000	36.0000000	Y
0.0001470	19281.	131197662.	11.3085000	36.0000000	Y
0.0001516	19460.	128340791.	11.3085000	36.0000000	Y
0.0001563	19620.	125533437.	11.3085000	36.0000000	Y
0.0001610	19763.	122787676.	11.3085000	36.0000000	Y
0.0001656	19893.	120112017.	11.3085000	36.0000000	Y
0.0001703	20011.	117512295.	11.3085000	36.0000000	Y
0.0001750	20118.	114992309.	11.3085000	36.0000000	Y
0.0001796	20216.	112550128.	11.3085000	36.0000000	Y
0.0001843	20304.	110179885.	11.3085000	36.0000000	Y
0.0001889	20386.	107891921.	11.3085000	36.0000000	Y
0.0001936	20462.	105685996.	11.3085000	36.0000000	Y
0.0001983	20532.	103550131.	11.3085000	36.0000000	Y
0.0002029	20596.	101484703.	11.3085000	36.0000000	Y
0.0002076	20657.	99497903.	11.3085000	36.0000000	Y
0.0002123	20711.	97568321.	11.3085000	36.0000000	Y
0.0002169	20764.	95710828.	11.3085000	36.0000000	Y
0.0002216	20812.	93912886.	11.3085000	36.0000000	Y
0.0002263	20857.	92176537.	11.3085000	36.0000000	Y

0.0002309	20899.	90497066.	11.3085000	36.0000000	Y
0.0002356	20939.	88874169.	11.3085000	36.0000000	Y
0.0002403	20976.	87301762.	11.3085000	36.0000000	Y
0.0002449	21012.	85785058.	11.3085000	36.0000000	Y
0.0002496	21044.	84309779.	11.3085000	36.0000000	Y
0.0002543	21076.	82888639.	11.3085000	36.0000000	Y
0.0002589	21104.	81505559.	11.3085000	36.0000000	Y
0.0002636	21132.	80167803.	11.3085000	36.0000000	Y
0.0002683	21159.	78874953.	11.3085000	36.0000000	Y
0.0002729	21183.	77613538.	11.3085000	36.0000000	Y
0.0002776	21206.	76394523.	11.3085000	36.0000000	Y
0.0002963	21290.	71864895.	11.3085000	36.0000000	Y
0.0003149	21358.	67821679.	11.3085000	36.0000000	Y
0.0003336	21415.	64197587.	11.3085000	36.0000000	Y
0.0003522	21462.	60931173.	11.3085000	36.0000000	Y
0.0003709	21502.	57972734.	11.3085000	36.0000000	Y
0.0003896	21537.	55284283.	11.3085000	36.0000000	Y
0.0004082	21568.	52832816.	11.3085000	36.0000000	Y
0.0004269	21593.	50582048.	11.3085000	36.0000000	Y
0.0004455	21616.	48515607.	11.3085000	36.0000000	Y
0.0004642	21636.	46607642.	11.3085000	36.0000000	Y
0.0004829	21654.	44844313.	11.3085000	36.0000000	Y
0.0005015	21669.	43205815.	11.3085000	36.0000000	Y
0.0005202	21684.	41684877.	11.3085000	36.0000000	Y
0.0005389	21696.	40263200.	11.3085000	36.0000000	Y
0.0005575	21707.	38935771.	11.3085000	36.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip
1	0.000	21707.3

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Horizontal shear force at pile head = 0.000 lbs
Applied moment at pile head = 0.000 in-lbs
Axial thrust load on pile head = 0.000 lbs

Depth Deflect. Bending Shear Slope Total Bending Soil
Res. Soil Spr. Distrib.

X	y	Moment	Force	S	Stress	Stiffness	p	Es*h	Lat. Load
inches	inches	in-lbs	lbs	radians	psi*	lb-in^2	lb/in	lb/inch	lb/inch
0.00	1.9408	-6.743E-06	0.000	-0.006938	1.498E-08	1.476E+11	0.000	0.000	21.3720
5.400	1.9033	311.6037	185.2146	-0.006938	0.6925	1.476E+11	0.000	0.000	47.2260
10.800	1.8659	2000.3176	456.3702	-0.006938	4.4452	1.476E+11	0.000	0.000	53.2020
16.200	1.8284	5240.4019	759.7962	-0.006938	11.6454	1.476E+11	0.000	0.000	59.1780
21.600	1.7909	10206.	1095.4926	-0.006938	22.6804	1.476E+11	0.000	0.000	65.1540
27.000	1.7535	17072.	1463.4594	-0.006937	37.9374	1.476E+11	0.000	0.000	71.1300
32.400	1.7160	26011.	1863.6966	-0.006936	57.8036	1.476E+11	0.000	0.000	77.1060
37.800	1.6785	37200.	2296.2042	-0.006935	82.6664	1.476E+11	0.000	0.000	83.0820
43.200	1.6411	50810.	2760.9822	-0.006934	112.9128	1.476E+11	0.000	0.000	89.0580
48.600	1.6037	67018.	3258.0306	-0.006931	148.9303	1.476E+11	0.000	0.000	95.0340
54.000	1.5662	85997.	3787.3494	-0.006929	191.1060	1.476E+11	0.000	0.000	101.0100
59.400	1.5288	107922.	4348.9386	-0.006925	239.8272	1.476E+11	0.000	0.000	106.9860
64.800	1.4915	132966.	4942.7982	-0.006921	295.4811	1.476E+11	0.000	0.000	112.9620
70.200	1.4541	161304.	5568.9282	-0.006915	358.4551	1.476E+11	0.000	0.000	118.9380
75.600	1.4168	193110.	6227.3286	-0.006909	429.1362	1.476E+11	0.000	0.000	124.9140
81.000	1.3795	228559.	6917.9994	-0.006901	507.9118	1.476E+11	0.000	0.000	130.8900
86.400	1.3422	267825.	7640.9406	-0.006892	595.1691	1.476E+11	0.000	0.000	136.8660
91.800	1.3050	311081.	8396.1522	-0.006881	691.2954	1.476E+11	0.000	0.000	142.8420
97.200	1.2679	358503.	9183.6342	-0.006869	796.6780	1.476E+11	0.000	0.000	148.8180
102.600	1.2309	410264.	10003.	-0.006855	911.7039	1.476E+11	0.000	0.000	154.7940
108.000	1.1939	466540.	10855.	-0.006839	1036.7606	1.476E+11	0.000	0.000	160.7700
113.400	1.1570	527503.	11740.	-0.006821	1172.2353	1.476E+11	0.000	0.000	166.7460
118.800	1.1202	593328.	12656.	-0.006800	1318.5151	1.476E+11	0.000	0.000	172.7220
124.200	1.0835	664191.	13605.	-0.006777	1475.9874	1.476E+11	0.000	0.000	178.6980
129.600	1.0470	740263.	14586.	-0.006752	1645.0394	1.476E+11	0.000	0.000	184.6740
135.000	1.0106	821722.	15600.	-0.006723	1826.0583	1.476E+11	0.000	0.000	190.6500
140.400	0.9744	908739.	16645.	-0.006691	2019.4315	1.476E+11	0.000	0.000	196.6260
145.800	0.9384	1001490.	17723.	-0.006657	2225.5460	1.476E+11	0.000	0.000	202.6020
151.200	0.9025	1100149.	18833.	-0.006618	2444.7893	1.476E+11			

0.000	0.000	208.5780				
156.600	0.8669	1204890.	19976.	-0.006576	2677.5485	1.476E+11
0.000	0.000	214.5540				
162.000	0.8315	1315887.	21151.	-0.006530	2924.2108	1.476E+11
0.000	0.000	220.5300				
167.400	0.7964	1433315.	22358.	-0.006480	3185.1636	1.476E+11
0.000	0.000	226.5060				
172.800	0.7615	1557348.	23597.	-0.006425	3460.7941	1.476E+11
0.000	0.000	232.4820				
178.200	0.7270	1688161.	24868.	-0.006365	3751.4894	1.476E+11
0.000	0.000	238.4580				
183.600	0.6928	1825926.	26172.	-0.006301	4057.6370	1.476E+11
0.000	0.000	244.4340				
189.000	0.6589	1970819.	27508.	-0.006232	4379.6240	1.476E+11
0.000	0.000	250.4100				
194.400	0.6255	2123015.	28877.	-0.006157	4717.8376	1.476E+11
0.000	0.000	256.3860				
199.800	0.5924	2282686.	30277.	-0.006076	5072.6651	1.476E+11
0.000	0.000	262.3620				
205.200	0.5598	2450008.	31710.	-0.005990	5444.4938	1.476E+11
0.000	0.000	268.3380				
210.600	0.5277	2625155.	33175.	-0.005897	5833.7109	1.476E+11
0.000	0.000	274.3140				
216.000	0.4962	2808300.	34673.	-0.005797	6240.7037	1.476E+11
0.000	0.000	280.2900				
221.400	0.4651	2999619.	36202.	-0.005691	6665.8593	1.476E+11
0.000	0.000	286.2660				
226.800	0.4347	3199286.	37764.	-0.005578	7109.5651	1.476E+11
0.000	0.000	292.2420				
232.200	0.4049	3407474.	39359.	-0.005457	7572.2082	1.476E+11
0.000	0.000	298.2180				
237.600	0.3758	3624358.	40985.	-0.005328	8054.1761	1.476E+11
0.000	0.000	304.1940				
243.000	0.3473	3850113.	42644.	-0.005191	8555.8558	1.476E+11
0.000	0.000	310.1700				
248.400	0.3197	4084912.	44335.	-0.005046	9077.6346	1.476E+11
0.000	0.000	316.1460				
253.800	0.2928	4328930.	46058.	-0.004892	9619.8998	1.476E+11
0.000	0.000	322.1220				
259.200	0.2669	4582341.	47814.	-0.004729	10183.	1.476E+11
0.000	0.000	328.0980				
264.600	0.2418	4845319.	49602.	-0.004557	10767.	1.476E+11
0.000	0.000	334.0740				
270.000	0.2176	5118039.	51422.	-0.004375	11373.	1.476E+11
0.000	0.000	340.0500				
275.400	0.1945	5400675.	53274.	-0.004182	12002.	1.476E+11
0.000	0.000	346.0260				
280.800	0.1725	5693401.	55159.	-0.003979	12652.	1.476E+11
0.000	0.000	352.0020				
286.200	0.1515	5996391.	57076.	-0.003765	13325.	1.476E+11
0.000	0.000	357.9780				
291.600	0.1318	6309820.	59025.	-0.003540	14022.	1.476E+11
0.000	0.000	363.9540				
297.000	0.1133	6633862.	61007.	-0.003303	14742.	1.476E+11
0.000	0.000	369.9300				
302.400	0.0961	6968691.	56073.	-0.003055	15486.	1.476E+11
-2217.7858	124580.	20.7269				
307.800	0.0803	7239454.	42750.	-0.002795	16088.	1.476E+11
-2737.4807	184032.	0.000				
313.200	0.0659	7430392.	26737.	-0.002526	16512.	1.476E+11
-3193.2005	261462.	0.000				
318.600	0.0530	7528216.	8448.9206	-0.002253	16729.	1.476E+11
-3580.2419	364493.	0.000				

324.000	0.0416	7521640.	-11729.	-0.001977	16715.	1.476E+11	-3893.2179	505110.	0.000
329.400	0.0317	7401538.	-33380.	-0.001704	16448.	1.476E+11	-4125.6840	703083.	0.000
334.800	0.0232	7161131.	-56047.	-0.001438	15914.	1.476E+11	-4269.4160	993086.	0.000
340.200	0.0162	6796228.	-79219.	-0.001183	15103.	1.476E+11	-4312.8907	1441326.	0.000
345.600	0.0104	6305561.	-102306.	-0.000943	14012.	1.476E+11	-4237.6566	2190980.	0.000
351.000	0.005976	5691324.	-125651.	-0.000723	12647.	1.476E+11	-4408.6301	3983648.	0.000
356.400	0.002632	4948531.	-146776.	-0.000529	10997.	1.476E+11	-3415.3625	7006391.	0.000
361.800	0.000266	4106147.	-156999.	-0.000363	9124.8227	1.476E+11	-370.8921	7522109.	0.000
367.200	-0.001289	3252947.	-152822.	-0.000228	7228.8119	1.476E+11	1917.9153	8037827.	0.000
372.600	-0.002201	2455673.	-138731.	-0.000124	5457.0829	1.476E+11	3300.8141	8100000.	0.000
378.000	-0.002627	1754651.	-119178.	-4.695E-05	3899.2478	1.476E+11	3941.0920	8100000.	0.000
383.400	-0.002708	1168552.	-97571.	6.532E-06	2596.7969	1.476E+11	4061.3456	8100000.	0.000
388.800	-0.002557	700881.	-76250.	4.073E-05	1557.5228	1.476E+11	3835.2764	8100000.	0.000
394.200	-0.002268	345047.	-56711.	5.987E-05	766.7760	1.476E+11	3401.4878	8100000.	0.000
399.600	-0.001910	88401.	-39790.	6.780E-05	196.4468	1.476E+11	2865.4378	8100000.	0.000
405.000	-0.001535	-84690.	-25835.	6.786E-05	188.2009	1.476E+11	2303.1886	8100000.	0.000
410.400	-0.001177	-190619.	-14848.	6.283E-05	423.6011	1.476E+11	1766.0389	8100000.	0.000
415.800	-0.000857	-245051.	-6609.4270	5.486E-05	544.5613	1.476E+11	1285.3828	8100000.	0.000
421.200	-0.000585	-262001.	-770.0419	4.558E-05	582.2282	1.476E+11	877.3524	8100000.	0.000
426.600	-0.000365	-253368.	3075.6314	3.615E-05	563.0424	1.476E+11	546.9710	8100000.	0.000
432.000	-0.000194	-228784.	5339.9890	2.733E-05	508.4126	1.476E+11	291.6800	8100000.	0.000
437.400	-6.946E-05	-195696.	6408.8475	1.957E-05	434.8819	1.476E+11	104.1935	8100000.	0.000
442.800	1.686E-05	-159569.	6621.8744	1.307E-05	354.5994	1.476E+11	-25.2947	8100000.	0.000
448.200	7.166E-05	-124179.	6263.3510	7.876E-06	275.9560	1.476E+11	-107.4917	8100000.	0.000
453.600	0.000102	-91925.	5560.3319	3.922E-06	204.2781	1.476E+11	-152.8857	8100000.	0.000
459.000	0.000114	-64128.	4685.7428	1.068E-06	142.5073	1.476E+11	-171.0361	8100000.	0.000
464.400	0.000113	-41319.	3764.4564	-8.615E-07	91.8196	1.476E+11	-170.1810	8100000.	0.000
469.800	0.000105	-23472.	2880.8507	-2.047E-06	52.1598	1.476E+11	-157.0804	8100000.	0.000
475.200	9.135E-05	-10205.	2086.7707	-2.663E-06	22.6788	1.476E+11	-137.0234	8100000.	0.000
480.600	7.596E-05	-934.6534	1409.1647	-2.867E-06	2.0770	1.476E+11	-113.9418	8100000.	0.000
486.000	6.039E-05	5013.5644	856.9470	-2.792E-06	11.1413	1.476E+11	-90.5833	8100000.	0.000
491.400	4.581E-05	8320.3746	426.8537	-2.548E-06	18.4898	1.476E+11			

```
-68.7106   8100000.       0.000
   496.800  3.287E-05  9623.5849   108.2151 -2.220E-06    21.3859  1.476E+11
-49.3038   8100000.       0.000
   502.200  2.183E-05  9489.0973  -113.3277 -1.870E-06    21.0870  1.476E+11
-32.7491   8100000.       0.000
   507.600  1.267E-05  8399.6457  -253.0685 -1.543E-06    18.6660  1.476E+11
-19.0067   8100000.       0.000
   513.000  5.169E-06  6755.9578  -325.3218 -1.266E-06    15.0133  1.476E+11
-7.7537   8100000.      0.000
   518.400 -9.980E-07  4886.1707  -342.2150 -1.053E-06    10.8582  1.476E+11
1.4970    8100000.      0.000
   523.800 -6.200E-06  3060.0359  -313.0642 -9.073E-07     6.8001  1.476E+11
9.2996    8100000.      0.000
   529.200 -1.080E-05  1505.0775  -244.2279 -8.238E-07     3.3446  1.476E+11
16.1953   8100000.      0.000
   534.600 -1.510E-05   422.3749  -139.3590 -7.885E-07     0.9386  1.476E+11
22.6450   8100000.      0.000
   540.000 -1.931E-05     0.000       0.000 -7.808E-07     0.000  1.476E+11
28.9695   4050000.      0.000
```

* This analysis makes computations of pile response using nonlinear moment-curvature relationships.
The above values of total stress are computed for combined axial stress and do not equal the
actual stresses in concrete and steel in the range of nonlinear bending.

Output Verification: Computed forces and moments are within specified convergence limits.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =      1.9407878 inches
Computed slope at pile head      =     -0.0069382 radians
Maximum bending moment           =       7528216. inch-lbs
Maximum shear force              =       -156999. lbs
Depth of maximum bending moment  =    318.6000000 inches below pile head
Depth of maximum shear force     =    361.8000000 inches below pile head
Number of iterations             =             14
Number of zero deflection points =              3
```

Summary of Pile Response(s)

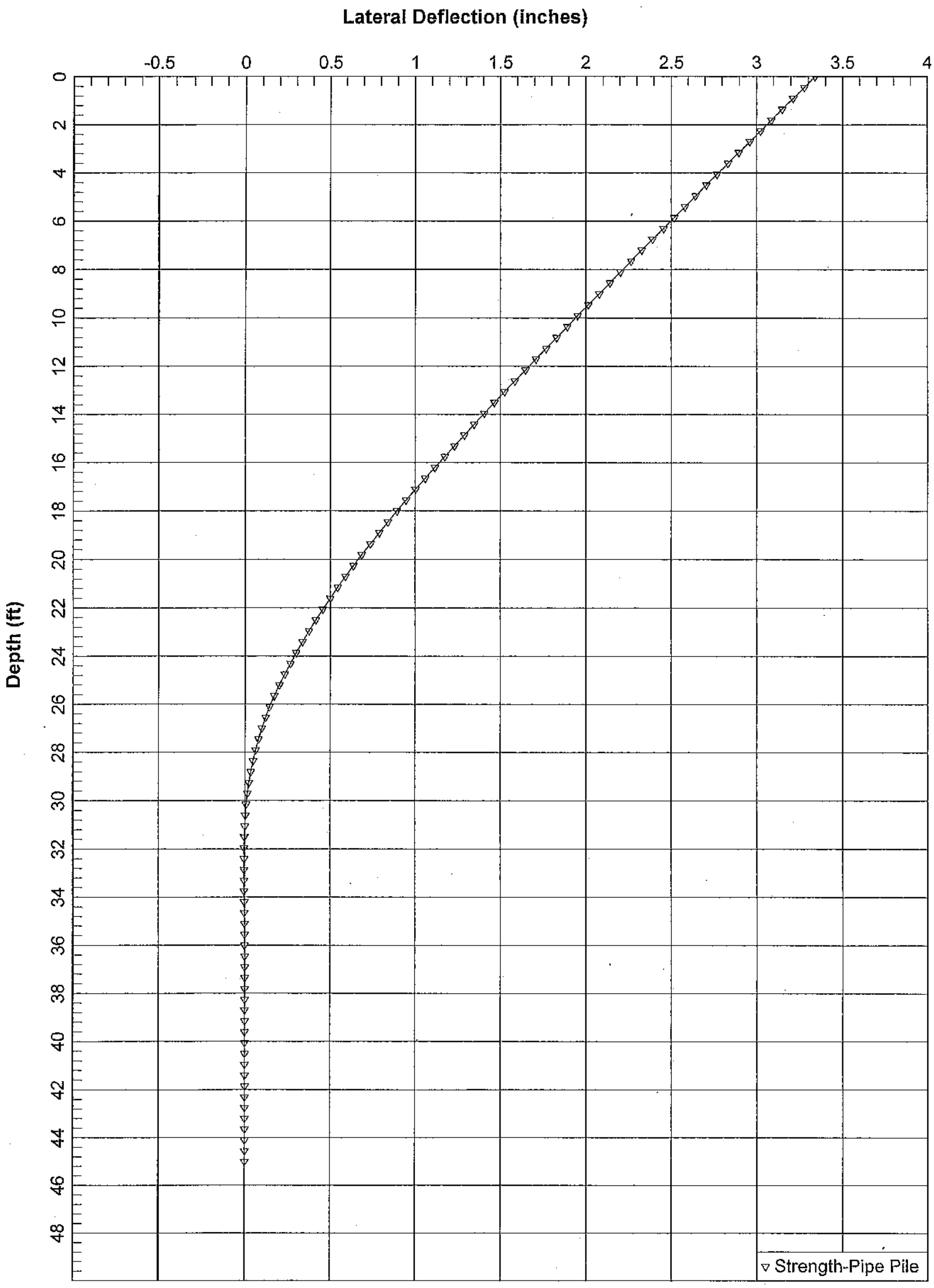
Definitions of Pile-head Loading Conditions:

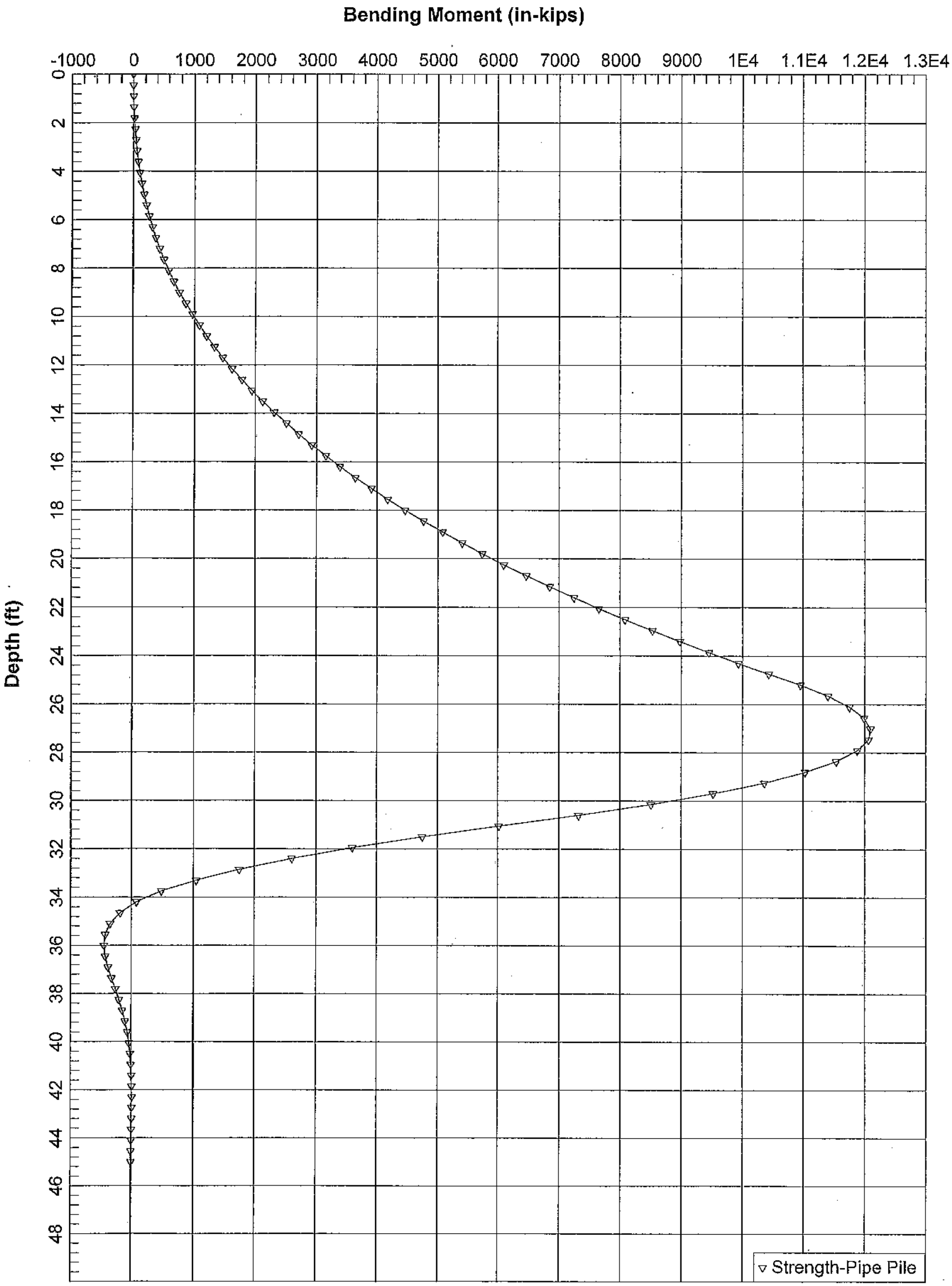
```
Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians
```

```
                 Pile-head       Pile-head
Load  Load     Condition 1    Condition 2        Axial         Pile-head        Maximum
      Maximum         Pile-head
Case  Type     V(lbs) or      in-lb, rad.,       Loading       Deflection       Moment
```

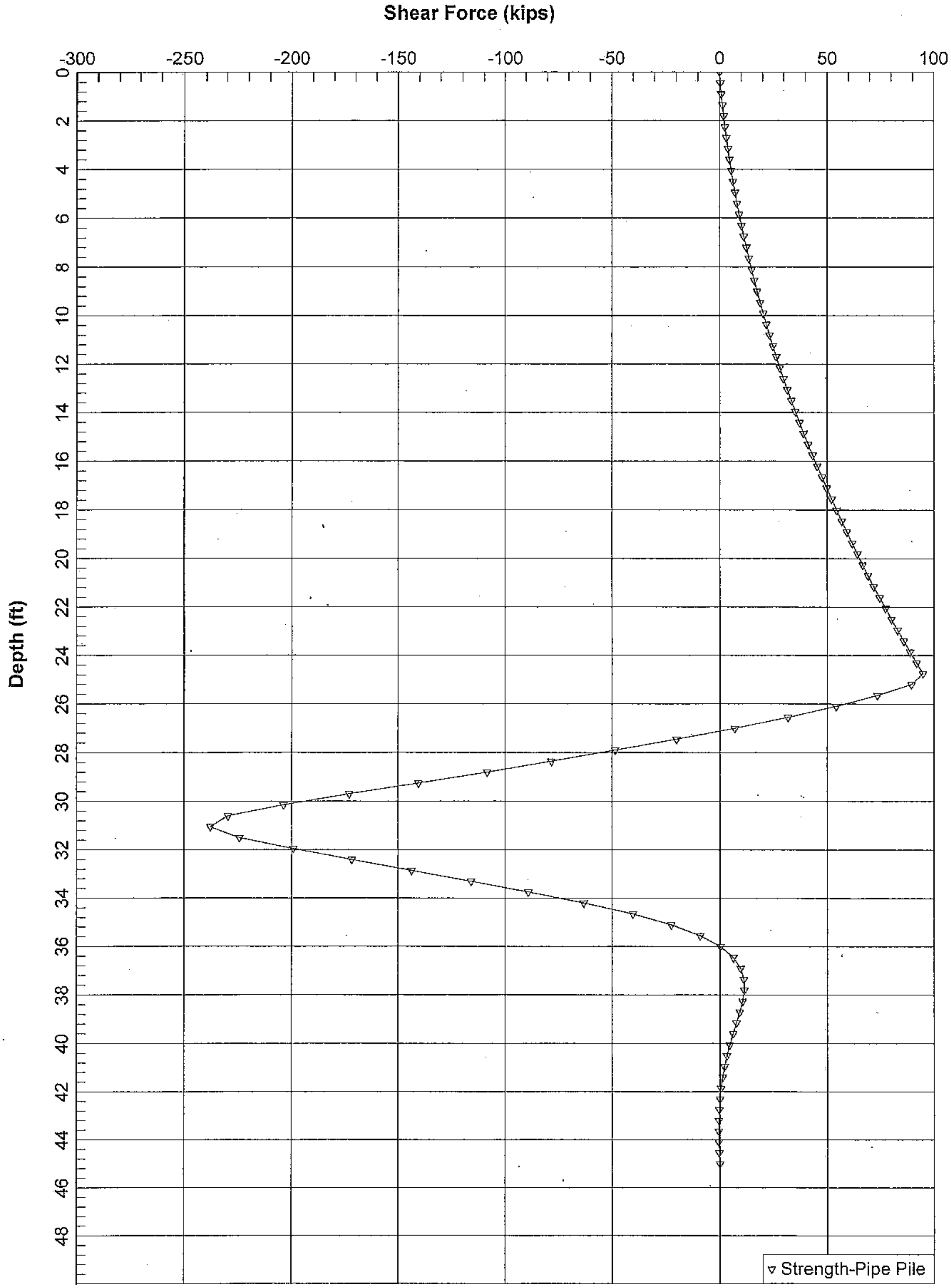
```
       Shear           Rotation
 No.   No.   y(inches)      or in-lb/rad.        lbs           inches            in-lbs
        lbs             radians
----  ----  --------------  --------------  -------------  -------------
-------------  -------------  -------------
  1     1   V =        0.000  M =       0.000      0.0000000      1.94078780
7528216.        -156999.    -0.00693816
```

The analysis ended normally.

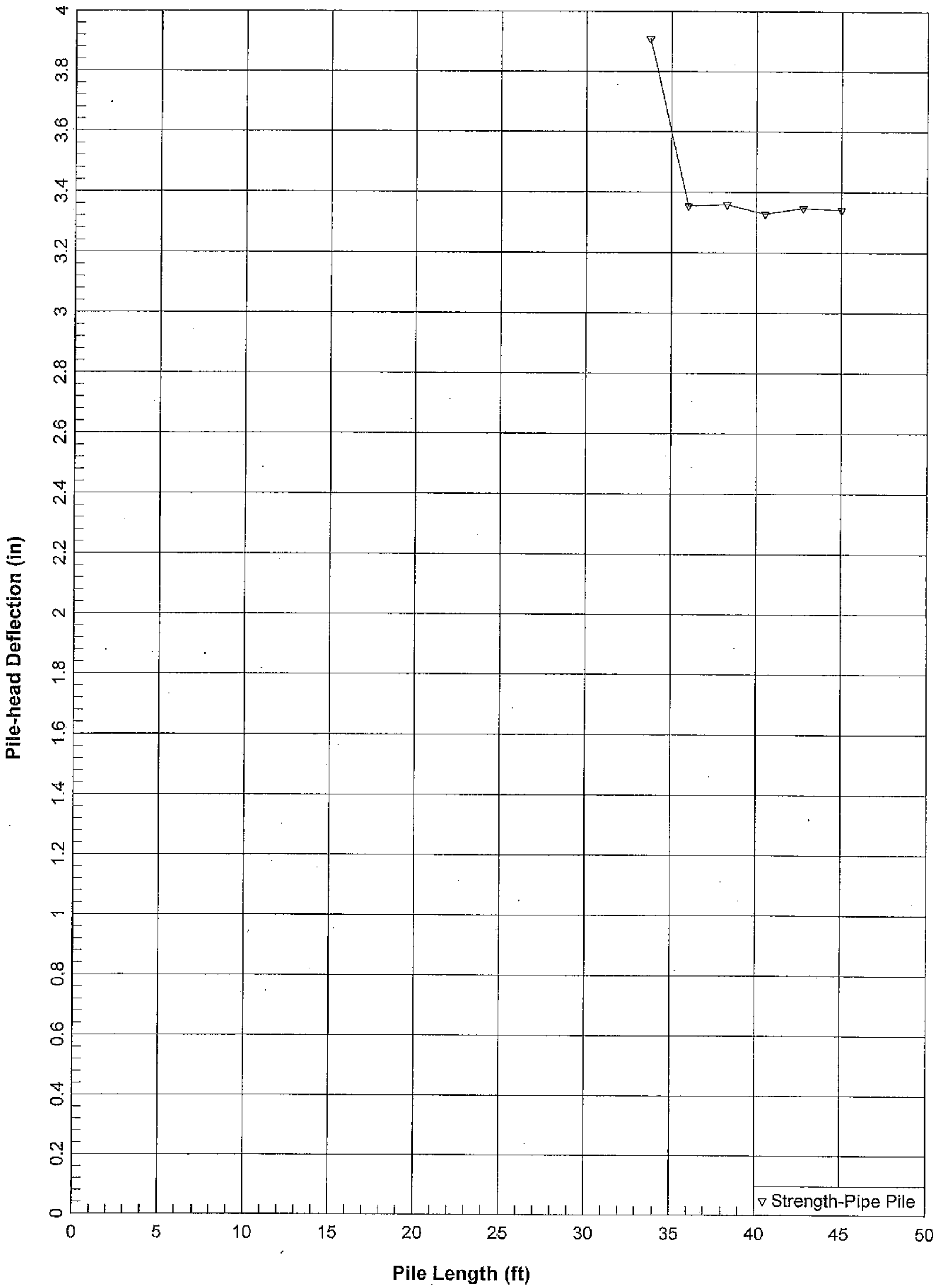

Lateral Deflection (inches)
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Strength-Pipe Pile



Bending Moment (in-kips)
-1000
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
1E4
1.1E4
1.2E4
1.3E4
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Strength-Pipe Pile



Shear Force (kips)
-300
-250
-200
-150
-100
-50
0
50
100
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Strength-Pipe Pile



Pile-head Deflection (in)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
0
5
10
15
20
25
30
35
40
45
50
Pile Length (ft)
Strength-Pipe Pile

===

LPile Plus for Windows, Version 6 (6.0.22)

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

===

This program is licensed to:

Terracon
Cincinnati, OH

Files Used for Analysis

```
Path to file locations:       N:\Projects\2011\N1115271\Working
Files\Calculations-Analyses\
Name of input data file:      LPile (USCS units)-Strength Case-Pipe Pile.lp6d
Name of output report file:   LPile (USCS units)-Strength Case-Pipe Pile.lp6o
Name of plot output file:     LPile (USCS units)-Strength Case-Pipe Pile.lp6p
Name of runtime messeage file: LPile (USCS units)-Strength Case-Pipe Pile.lp6r
```

Date and Time of Analysis

Date: September 20, 2012   Time: 14:08:34

Problem Title

Project Name:

Job Number: N1125141

Client:

Engineer:

Description:

Program Options

Engineering units are US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes nonlinear bending stiffness and nominal moment capacity with pile response computed using nonlinear EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output pile response for full length of pile
- Analysis assumes no soil movements acting on pile
- No p-y curves to be computed and output for user-specified depths

Solution Control Parameters:

- Number of pile increments	=	100	
- Maximum number of iterations allowed	=	100	
- Deflection tolerance for convergence	=	1.0000E-05	in
- Maximum allowable deflection	=	100.0000	in

Pile Response Output Options:
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1

Pile Structural Properties and Geometry

Total Number of Sections	=	1
Total Pile Length	=	45.00 ft
Depth of ground surface below top of pile	=	25.00 ft
Slope angle of ground surface	=	0.00 deg.

Pile dimensions used for p-y curve computations defined using 2 points. p-y curves are computed using values of pile diameter interpolated over the length of the pile.

Point	Depth X ft	Pile Diameter in
1	0.00000	22.6170000
2	45.000000	22.6170000

Input Structural Properties:

Pile Section No. 1:

Section Type = Steel Pipe Pile

Section Length	=	45.000 ft
Pile Diameter	=	22.617 in

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                 =        0.000 degrees
                                                   =        0.000 radians

Pile Batter Angle                                  =        0.000 degrees
                                                   =        0.000 radians
```

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

```
Distance from top of pile to top of layer          =       25.000 ft
Distance from top of pile to bottom of layer       =       29.000 ft
Initial modulus of rock at top of layer            =   2.0000E+03 lbs/in**2
Initial modulus of rock at bottom of layer         =   2.0000E+03 lbs/in**2
```

Layer 2 is weak rock, p-y criteria by Reese, 1997

```
Distance from top of pile to top of layer          =       29.000 ft
Distance from top of pile to bottom of layer       =       60.000 ft
Initial modulus of rock at top of layer            =   3.0000E+03 lbs/in**2
Initial modulus of rock at bottom of layer         =   3.0000E+03 lbs/in**2
```

(Depth of lowest layer extends 15.00 ft below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 4 points

Point No.	Depth X ft	Eff. Unit Weight pcf
1	25.00	135.00000
2	29.00	135.00000
3	29.00	140.00000
4	60.00	140.00000

**** Warning - POSSIBLE INPUT DATA ERROR ****

Values entered for effective unit weights of soil were outside the limits of 0.011574 pci (20 pcf) or 0.0810019 pci (140 pcf) This data may be erroneous. Please check your data.

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Depth ft	Eff. Unit Wt., pcf	Cohesion psf	Friction Ang., deg.	qu psi	RQD percent	Epsilon 50	kpy pci	Rock Emass psi	krm	Test Type	Test Prop.	Elas. Subgr. pci
1	Weak Rock	25.000	135.000	--	--	100.000	0.00	--	--	2000.000	5.00E-04	--	--	--
		29.000	135.000	--	--	100.000	0.00	--	--	2000.000	5.00E-04	--	--	--
2	Weak Rock	29.000	140.000	--	--	110.000	0.00	--	--	3000.000	5.00E-04	--	--	--
		60.000	140.000	--	--	110.000	0.00	--	--	3000.000	5.00E-04	--	--	--

Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading

Distributed lateral load intensity defined using 2 points

Point No.	Depth X in	Dist. Load lbs/in
1	0.000	73.000
2	300.000	571.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1		Condition 2		Axial Thrust Force, lbs
1	1	V =	0.000 lbs	M =	0.000 in-lbs	0.000

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head

y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust is assumed to be acting axially

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel Pipe Pile:

Length of Section	=	45.00000000	ft
Outer Diameter of Pipe	=	22.61700000	in
Pipe Wall Thickness	=	1.34000000	in
Yield Stress of Pipe	=	36.00000000	ksi
Elastic Modulus	=	29000.	ksi
Cross-sectional Area	=	89.57051363	sq. in.
Moment of Inertia	=	5088.79566726	in^4
Elastic Bending Stiffness	=	147575074.	lb-in^2
Plastic Modulus, Z	=	607.43441153	in^3
Plastic Moment Capacity = Fy Z	=	21868.	in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	3224.538	kips
Nominal Axial Tensile Capacity	=	-3224.538	kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.000002333	344.2740587	147586235.	11.3085000	0.7573500	
0.000004665	688.5481174	147586235.	11.3085000	1.5147001	
0.000006998	1032.8221761	147586235.	11.3085000	2.2720501	
0.000009331	1377.0962348	147586235.	11.3085000	3.0294001	
0.0000117	1721.3702935	147586235.	11.3085000	3.7867501	

0.0000140	2065.6443522	147586235.	11.3085000	4.5441002	
0.0000163	2409.9184110	147586235.	11.3085000	5.3014502	
0.0000187	2754.1924697	147586235.	11.3085000	6.0588002	
0.0000210	3098.4665284	147586235.	11.3085000	6.8161503	
0.0000233	3442.7405871	147586235.	11.3085000	7.5735003	
0.0000257	3787.0146458	147586235.	11.3085000	8.3308503	
0.0000280	4131.2887045	147586235.	11.3085000	9.0882003	
0.0000303	4475.5627632	147586235.	11.3085000	9.8455504	
0.0000327	4819.8368219	147586235.	11.3085000	10.6029004	
0.0000350	5164.1108806	147586235.	11.3085000	11.3602504	
0.0000373	5508.3849393	147586235.	11.3085000	12.1176004	
0.0000397	5852.6589980	147586235.	11.3085000	12.8749505	
0.0000420	6196.9330567	147586235.	11.3085000	13.6323005	
0.0000443	6541.2071155	147586235.	11.3085000	14.3896505	
0.0000467	6885.4811742	147586235.	11.3085000	15.1470006	
0.0000490	7229.7552329	147586235.	11.3085000	15.9043506	
0.0000513	7574.0292916	147586235.	11.3085000	16.6617006	
0.0000537	7918.3033503	147586235.	11.3085000	17.4190506	
0.0000560	8262.5774090	147586235.	11.3085000	18.1764007	
0.0000583	8606.8514677	147586235.	11.3085000	18.9337507	
0.0000607	8951.1255264	147586235.	11.3085000	19.6911007	
0.0000630	9295.3995851	147586235.	11.3085000	20.4484508	
0.0000653	9639.6736438	147586235.	11.3085000	21.2058008	
0.0000676	9983.9477025	147586235.	11.3085000	21.9631508	
0.0000700	10328.	147586235.	11.3085000	22.7205008	
0.0000723	10672.	147586235.	11.3085000	23.4778509	
0.0000746	11017.	147586235.	11.3085000	24.2352009	
0.0000770	11361.	147586235.	11.3085000	24.9925509	
0.0000793	11705.	147586235.	11.3085000	25.7499010	
0.0000816	12050.	147586235.	11.3085000	26.5072510	
0.0000840	12394.	147586235.	11.3085000	27.2646010	
0.0000863	12738.	147586235.	11.3085000	28.0219510	
0.0000886	13082.	147586235.	11.3085000	28.7793011	
0.0000910	13427.	147586235.	11.3085000	29.5366511	
0.0000956	14115.	147586235.	11.3085000	31.0513511	
0.0001003	14804.	147586235.	11.3085000	32.5660512	
0.0001050	15492.	147586235.	11.3085000	34.0807513	
0.0001096	16181.	147586235.	11.3085000	35.5954513	
0.0001143	16843.	147352745.	11.3085000	36.0000000	Y
0.0001190	17420.	146428607.	11.3085000	36.0000000	Y
0.0001236	17896.	144754119.	11.3085000	36.0000000	Y
0.0001283	18270.	142399054.	11.3085000	36.0000000	Y
0.0001330	18581.	139745635.	11.3085000	36.0000000	Y
0.0001376	18846.	136935022.	11.3085000	36.0000000	Y
0.0001423	19079.	134078261.	11.3085000	36.0000000	Y
0.0001470	19281.	131197662.	11.3085000	36.0000000	Y
0.0001516	19460.	128340791.	11.3085000	36.0000000	Y
0.0001563	19620.	125533437.	11.3085000	36.0000000	Y
0.0001610	19763.	122787676.	11.3085000	36.0000000	Y
0.0001656	19893.	120112017.	11.3085000	36.0000000	Y
0.0001703	20011.	117512295.	11.3085000	36.0000000	Y
0.0001750	20118.	114992309.	11.3085000	36.0000000	Y
0.0001796	20216.	112550128.	11.3085000	36.0000000	Y
0.0001843	20304.	110179885.	11.3085000	36.0000000	Y
0.0001889	20386.	107891921.	11.3085000	36.0000000	Y
0.0001936	20462.	105685996.	11.3085000	36.0000000	Y
0.0001983	20532.	103550131.	11.3085000	36.0000000	Y
0.0002029	20596.	101484703.	11.3085000	36.0000000	Y
0.0002076	20657.	99497903.	11.3085000	36.0000000	Y
0.0002123	20711.	97568321.	11.3085000	36.0000000	Y
0.0002169	20764.	95710828.	11.3085000	36.0000000	Y
0.0002216	20812.	93912886.	11.3085000	36.0000000	Y
0.0002263	20857.	92176537.	11.3085000	36.0000000	Y

0.0002309	20899.	90497066.	11.3085000	36.0000000	Y
0.0002356	20939.	88874169.	11.3085000	36.0000000	Y
0.0002403	20976.	87301762.	11.3085000	36.0000000	Y
0.0002449	21012.	85785058.	11.3085000	36.0000000	Y
0.0002496	21044.	84309779.	11.3085000	36.0000000	Y
0.0002543	21076.	82888639.	11.3085000	36.0000000	Y
0.0002589	21104.	81505559.	11.3085000	36.0000000	Y
0.0002636	21132.	80167803.	11.3085000	36.0000000	Y
0.0002683	21159.	78874953.	11.3085000	36.0000000	Y
0.0002729	21183.	77613538.	11.3085000	36.0000000	Y
0.0002776	21206.	76394523.	11.3085000	36.0000000	Y
0.0002963	21290.	71864895.	11.3085000	36.0000000	Y
0.0003149	21358.	67821679.	11.3085000	36.0000000	Y
0.0003336	21415.	64197587.	11.3085000	36.0000000	Y
0.0003522	21462.	60931173.	11.3085000	36.0000000	Y
0.0003709	21502.	57972734.	11.3085000	36.0000000	Y
0.0003896	21537.	55284283.	11.3085000	36.0000000	Y
0.0004082	21568.	52832816.	11.3085000	36.0000000	Y
0.0004269	21593.	50582048.	11.3085000	36.0000000	Y
0.0004455	21616.	48515607.	11.3085000	36.0000000	Y
0.0004642	21636.	46607642.	11.3085000	36.0000000	Y
0.0004829	21654.	44844313.	11.3085000	36.0000000	Y
0.0005015	21669.	43205815.	11.3085000	36.0000000	Y
0.0005202	21684.	41684877.	11.3085000	36.0000000	Y
0.0005389	21696.	40263200.	11.3085000	36.0000000	Y
0.0005575	21707.	38935771.	11.3085000	36.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip
1	0.000	21707.3

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Horizontal shear force at pile head = 0.000 lbs
Applied moment at pile head = 0.000 in-lbs
Axial thrust load on pile head = 0.000 lbs

Depth Deflect. Bending Shear Slope Total Bending Soil
Res. Soil Spr. Distrib.

X inches	y inches	Moment in-lbs	Force lbs	S radians	Stress psi*	Stiffness lb-in^2	p lb/in	Es*h lb/inch	Lat. Load lb/inch
0.00	3.3410	-8.991E-06	-2.081E-07	-0.0117	1.998E-08	1.476E+11	0.000	0.000	37.6205
5.400	3.2776	548.5069	322.8782	-0.0117	1.2189	1.476E+11	0.000	0.000	81.9640
10.800	3.2143	3487.0841	789.6865	-0.0117	7.7491	1.476E+11	0.000	0.000	90.9280
16.200	3.1509	9077.1217	1304.9005	-0.0117	20.1715	1.476E+11	0.000	0.000	99.8920
21.600	3.0876	17580.	1868.5201	-0.0117	39.0669	1.476E+11	0.000	0.000	108.8560
27.000	3.0242	29257.	2480.5454	-0.0117	65.0162	1.476E+11	0.000	0.000	117.8200
32.400	2.9609	44370.	3140.9762	-0.0117	98.6003	1.476E+11	0.000	0.000	126.7840
37.800	2.8976	63180.	3849.8126	-0.0117	140.4001	1.476E+11	0.000	0.000	135.7480
43.200	2.8342	85948.	4607.0546	-0.0117	190.9964	1.476E+11	0.000	0.000	144.7120
48.600	2.7709	112936.	5412.7022	-0.0117	250.9700	1.476E+11	0.000	0.000	153.6760
54.000	2.7077	144405.	6266.7554	-0.0117	320.9020	1.476E+11	0.000	0.000	162.6400
59.400	2.6444	180617.	7169.2142	-0.0117	401.3730	1.476E+11	0.000	0.000	171.6040
64.800	2.5812	221833.	8120.0786	-0.0117	492.9641	1.476E+11	0.000	0.000	180.5680
70.200	2.5180	268314.	9119.3486	-0.0117	596.2561	1.476E+11	0.000	0.000	189.5320
75.600	2.4549	320322.	10167.	-0.0117	711.8297	1.476E+11	0.000	0.000	198.4960
81.000	2.3919	378118.	11263.	-0.0117	840.2660	1.476E+11	0.000	0.000	207.4600
86.400	2.3289	441963.	12408.	-0.0117	982.1458	1.476E+11	0.000	0.000	216.4240
91.800	2.2660	512120.	13600.	-0.0116	1138.0500	1.476E+11	0.000	0.000	225.3880
97.200	2.2032	588848.	14842.	-0.0116	1308.5593	1.476E+11	0.000	0.000	234.3520
102.600	2.1405	672411.	16131.	-0.0116	1494.2548	1.476E+11	0.000	0.000	243.3160
108.000	2.0780	763068.	17470.	-0.0116	1695.7172	1.476E+11	0.000	0.000	252.2800
113.400	2.0156	861082.	18856.	-0.0115	1913.5275	1.476E+11	0.000	0.000	261.2440
118.800	1.9534	966714.	20291.	-0.0115	2148.2665	1.476E+11	0.000	0.000	270.2080
124.200	1.8914	1080226.	21774.	-0.0115	2400.5150	1.476E+11	0.000	0.000	279.1720
129.600	1.8296	1201877.	23306.	-0.0114	2670.8541	1.476E+11	0.000	0.000	288.1360
135.000	1.7680	1331931.	24886.	-0.0114	2959.8644	1.476E+11	0.000	0.000	297.1000
140.400	1.7067	1470649.	26515.	-0.0113	3268.1269	1.476E+11	0.000	0.000	306.0640
145.800	1.6456	1618291.	28192.	-0.0113	3596.2225	1.476E+11	0.000	0.000	315.0280
151.200	1.5849	1775119.	29917.	-0.0112	3944.7320	1.476E+11			

```
0.000       0.000   323.9920
   156.600     1.5246   1941395.       31691.     -0.0111  4314.2363  1.476E+11
0.000       0.000   332.9560
   162.000     1.4646   2117380.       33513.     -0.0111  4705.3163  1.476E+11
0.000       0.000   341.9200
   167.400     1.4051   2303336.       35384.     -0.0110  5118.5528  1.476E+11
0.000       0.000   350.8840
   172.800     1.3460   2499523.       37303.     -0.0109  5554.5268  1.476E+11
0.000       0.000   359.8480
   178.200     1.2874   2706203.       39270.     -0.0108  6013.8190  1.476E+11
0.000       0.000   368.8120
   183.600     1.2293   2923638.       41286.     -0.0107  6497.0104  1.476E+11
0.000       0.000   377.7760
   189.000     1.1718   3152089.       43350.     -0.0106  7004.6818  1.476E+11
0.000       0.000   386.7400
   194.400     1.1149   3391817.       45463.     -0.0105  7537.4141  1.476E+11
0.000       0.000   395.7040
   199.800     1.0587   3643084.       47624.     -0.0103  8095.7882  1.476E+11
0.000       0.000   404.6680
   205.200     1.0033   3906151.       49833.     -0.0102  8680.3849  1.476E+11
0.000       0.000   413.6320
   210.600     0.9486   4181279.       52091.     -0.0101  9291.7852  1.476E+11
0.000       0.000   422.5960
   216.000     0.8947   4468731.       54397.   -0.009896  9930.5698  1.476E+11
0.000       0.000   431.5600
   221.400     0.8417   4768766.       56752.   -0.009727     10597.   1.476E+11
0.000       0.000   440.5240
   226.800     0.7896   5081648.       59155.   -0.009547     11293.   1.476E+11
0.000       0.000   449.4880
   232.200     0.7386   5407636.       61606.   -0.009355     12017.   1.476E+11
0.000       0.000   458.4520
   237.600     0.6886   5746993.       64106.   -0.009151     12771.   1.476E+11
0.000       0.000   467.4160
   243.000     0.6397   6099980.       66654.   -0.008934     13556.   1.476E+11
0.000       0.000   476.3800
   248.400     0.5921   6466858.       69251.   -0.008704     14371.   1.476E+11
0.000       0.000   485.3440
   253.800     0.5457   6847888.       71896.   -0.008461     15218.   1.476E+11
0.000       0.000   494.3080
   259.200     0.5007   7243333.       74589.   -0.008203     16096.   1.476E+11
0.000       0.000   503.2720
   264.600     0.4572   7653453.       77331.   -0.007930     17008.   1.476E+11
0.000       0.000   512.2360
   270.000     0.4151   8078510.       80121.   -0.007642     17952.   1.476E+11
0.000       0.000   521.2000
   275.400     0.3746   8518765.       82960.   -0.007339     18931.   1.476E+11
0.000       0.000   530.1640
   280.800     0.3358   8974480.       85847.   -0.007019     19943.   1.476E+11
0.000       0.000   539.1280
   286.200     0.2988   9445915.       88783.   -0.006682     20991.   1.476E+11
0.000       0.000   548.0920
   291.600     0.2637   9933333.       91767.   -0.006327     22074.   1.476E+11
0.000       0.000   557.0560
   297.000     0.2305  10436995.       94799.   -0.005955     23193.   1.476E+11
0.000       0.000   566.0200
   302.400     0.1994  10957162.       89399.   -0.005563     24349.   1.476E+11
-2597.7173      70365.    31.7084
   307.800     0.1704  11402504.       73551.   -0.005154     25339.   1.476E+11
-3303.7860     104698.      0.000
   313.200     0.1437  11751508.       54155.   -0.004730     26115.   1.476E+11
-3879.6313     145797.      0.000
   318.600     0.1193  11987381.       31842.   -0.004296     26639.   1.476E+11
-4384.6565     198452.      0.000
```

324.000	0.0973	12095398.	7005.1996	-0.003856	26879.	1.476E+11	-4814.0567	267189.	0.000
329.400	0.0777	12063037.	-19931.	-0.003414	26807.	1.476E+11	-5162.3541	358918.	0.000
334.800	0.0604	11880142.	-48512.	-0.002976	26400.	1.476E+11	-5423.0624	484630.	0.000
340.200	0.0455	11539111.	-78242.	-0.002547	25643.	1.476E+11	-5588.0791	662737.	0.000
345.600	0.0329	11035131.	-108575.	-0.002134	24523.	1.476E+11	-5646.4967	926304.	0.000
351.000	0.0225	10366499.	-140399.	-0.001743	23037.	1.476E+11	-6140.2312	1474812.	0.000
356.400	0.0141	9518818.	-172917.	-0.001379	21153.	1.476E+11	-5903.2193	2261453.	0.000
361.800	0.007590	8498999.	-203525.	-0.001049	18887.	1.476E+11	-5433.2601	3865399.	0.000
367.200	0.002764	7320746.	-229303.	-0.000760	16268.	1.476E+11	-4114.0101	8037827.	0.000
372.600	-0.000616	6022529.	-237915.	-0.000516	13383.	1.476E+11	924.1676	8100000.	0.000
378.000	-0.002806	4751261.	-224055.	-0.000319	10558.	1.476E+11	4209.2758	8100000.	0.000
383.400	-0.004058	3602735.	-199173.	-0.000166	8006.1228	1.476E+11	5006.2170	6662610.	0.000
388.800	-0.004597	2600190.	-171711.	-5.234E-05	5778.2327	1.476E+11	5164.9512	6067161.	0.000
394.200	-0.004623	1748255.	-143801.	2.721E-05	3885.0334	1.476E+11	5172.1878	6041818.	0.000
399.600	-0.004303	1047141.	-116119.	7.835E-05	2326.9938	1.476E+11	5080.3684	6375428.	0.000
405.000	-0.003777	494171.	-89125.	0.000107	1098.1639	1.476E+11	4917.2713	7031146.	0.000
410.400	-0.003152	84588.	-63158.	0.000117	187.9751	1.476E+11	4700.1274	8051431.	0.000
415.800	-0.002511	-187939.	-40297.	0.000115	417.6437	1.476E+11	3767.1110	8100000.	0.000
421.200	-0.001908	-350617.	-22400.	0.000105	779.1524	1.476E+11	2861.4410	8100000.	0.000
426.600	-0.001373	-429855.	-9112.6208	9.112E-05	955.2386	1.476E+11	2059.6829	8100000.	0.000
432.000	-0.000924	-449033.	188.8883	7.504E-05	997.8565	1.476E+11	1385.3205	8100000.	0.000
437.400	-0.000563	-427815.	6208.1550	5.900E-05	950.7052	1.476E+11	844.0376	8100000.	0.000
442.800	-0.000286	-381985.	9646.8300	4.418E-05	848.8599	1.476E+11	429.5458	8100000.	0.000
448.200	-8.551E-05	-323629.	11153.	3.127E-05	719.1800	1.476E+11	128.2624	8100000.	0.000
453.600	5.140E-05	-261533.	11291.	2.057E-05	581.1885	1.476E+11	-77.1072	8100000.	0.000
459.000	0.000137	-201686.	10529.	1.210E-05	448.1936	1.476E+11	-204.9665	8100000.	0.000
464.400	0.000182	-147815.	9238.7813	5.701E-06	328.4807	1.476E+11	-273.0523	8100000.	0.000
469.800	0.000198	-101907.	7698.7490	1.133E-06	226.4616	1.476E+11	-297.3301	8100000.	0.000
475.200	0.000194	-64669.	6109.1621	-1.914E-06	143.7096	1.476E+11	-291.4058	8100000.	0.000
480.600	0.000178	-35928.	4603.3143	-3.755E-06	79.8409	1.476E+11	-266.3156	8100000.	0.000
486.000	0.000154	-14953.	3261.7030	-4.686E-06	33.2295	1.476E+11	-230.5774	8100000.	0.000
491.400	0.000127	-701.7978	2125.0435	-4.972E-06	1.5596	1.476E+11			

```
-190.4076    8100000.      0.000
   496.800   0.000100  7997.2945  1205.8627 -4.839E-06    17.7719  1.476E+11
-150.0297    8100000.      0.000
   502.200  7.468E-05     12322.   498.3228 -4.467E-06    27.3813  1.476E+11
-112.0221    8100000.      0.000
   507.600  5.178E-05     13379.   -13.8352 -3.997E-06    29.7317  1.476E+11
-77.6661    8100000.      0.000
   513.000  3.152E-05     12172.  -351.1770 -3.529E-06    27.0493  1.476E+11
-47.2753    8100000.      0.000
   518.400  1.366E-05  9586.4688  -534.1486 -3.131E-06    21.3034  1.476E+11
-20.4919    8100000.      0.000
   523.800 -2.300E-06  6403.2938  -580.1611 -2.839E-06    14.2296  1.476E+11
3.4503    8100000.      0.000
   529.200 -1.700E-05  3320.7288  -502.0095 -2.661E-06     7.3794  1.476E+11
25.4948    8100000.      0.000
   534.600 -3.104E-05   981.5912  -307.4749 -2.582E-06     2.1813  1.476E+11
46.5551    8100000.      0.000
   540.000 -4.488E-05      0.000      0.000 -2.564E-06      0.000  1.476E+11
67.3245    4050000.      0.000
```

* This analysis makes computations of pile response using nonlinear moment-curvature relationships.
  The above values of total stress are computed for combined axial stress and do not equal the
  actual stresses in concrete and steel in the range of nonlinear bending.

Output Verification: Computed forces and moments are within specified convergence limits.

Output Summary for Load Case No. 1:

```
Pile-head deflection               =      3.3409665 inches
Computed slope at pile head        =     -0.0117313 radians
Maximum bending moment             =      12095398. inch-lbs
Maximum shear force                =       -237915. lbs
Depth of maximum bending moment    =    324.0000000 inches below pile head
Depth of maximum shear force       =    372.6000000 inches below pile head
Number of iterations               =             17
Number of zero deflection points   =              3
```

Summary of Pile Response(s)

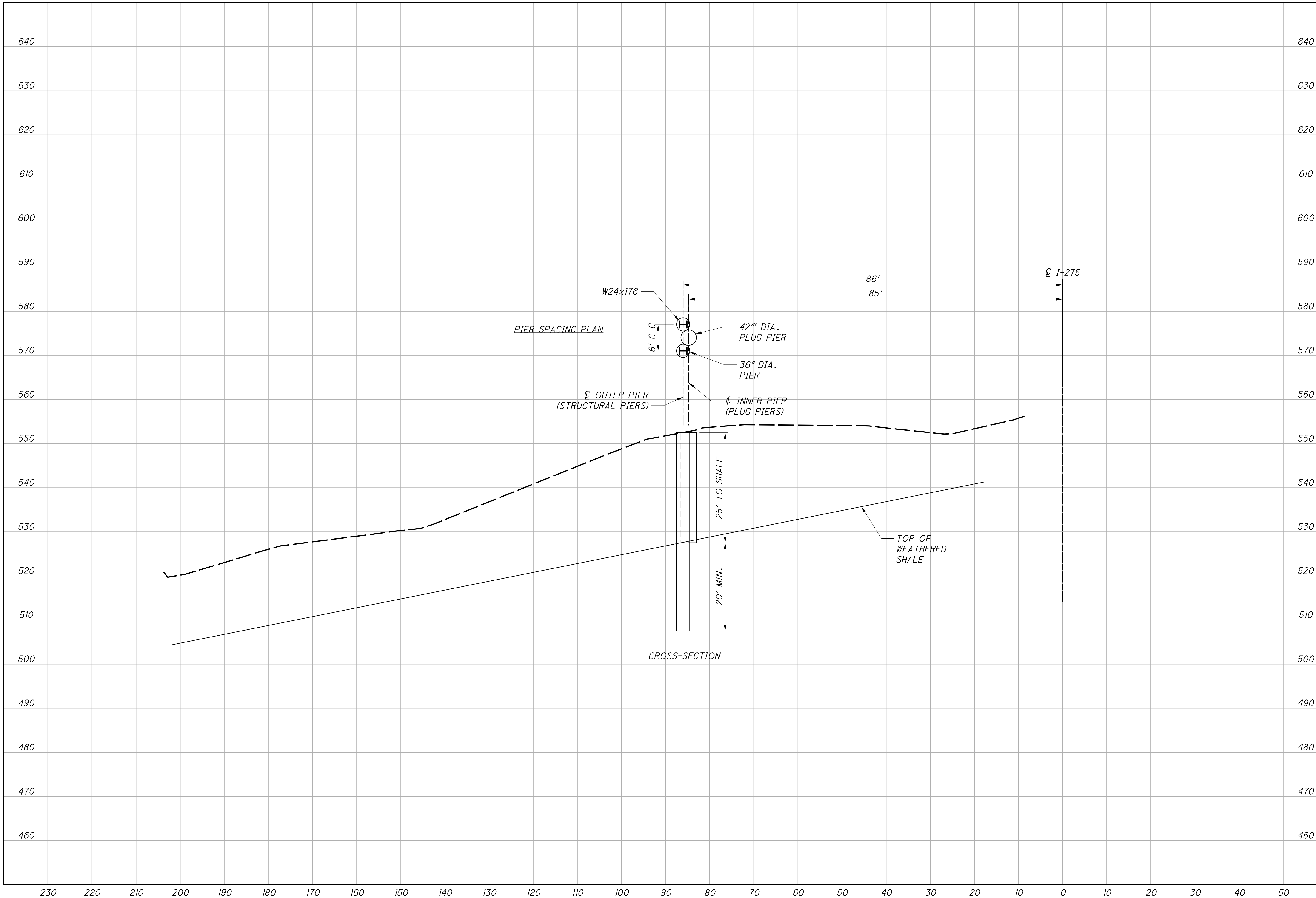
Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

```
                Pile-head        Pile-head
Load  Load     Condition 1     Condition 2          Axial         Pile-head         Maximum
         Maximum         Pile-head
Case  Type     V(lbs) or      in-lb, rad.,         Loading        Deflection        Moment
```

```
         Shear          Rotation
 No.    No.    y(inches)      or in-lb/rad.         lbs            inches          in-lbs
         lbs            radians
 ----  ----  --------------  --------------  -------------  -------------
-------------  -------------  -------------
  1      1   V =        0.000  M =        0.000      0.0000000      3.34096647
12095398.         -237915.    -0.01173135
```

The analysis ended normally.



HORIZONTAL SCALE IN FEET

DRAWN KJM

CHECKED JDD

TYPICAL DRILLED SHAFT WALL CROSS SECTION AND PIER SPACING PLAN

HAM-275-5.28

1/1

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