DICKINSON WRIGHT PLLC

150 E. GAY STREET, 24TH FLOOR
COLUMBUS, OH 43215-3192
TELEPHONE: (614) 591-5461
FACSIMILE: (844) 670-6009
http://www.dickinsonwright.com

CHRISTINE M.T. PIRIK
CPirik@dickinsonwright.com

August 24, 2020

Ms. Tanowa Troupe, Secretary
Ohio Power Siting Board
Docketing Division
180 East Broad Street, 11th Floor
Columbus, Ohio 43215-3797

Re: **Case No. 20-1321-EL-BGA -** In the Matter of the Application of Hardin Solar II LLC for a Boundary Amendment to its Certificate Issued in Case No. 18-1360-EL-BGN.

Supplement to Application – Road Condition Report and Updated Sound Analysis

Dear Ms. Troupe:

On July 31, 2020, Hardin Solar II LLC ("Applicant") filed an application with the Ohio Power Siting Board ("Board") for a boundary amendment to its certificate issued in Case No. 18-1360-EL-BGN ("Application").

The purpose of this Supplement to the Application is to submit the Road Condition Report (Attachment 1) and the Updated Pre-Construction Noise Analysis (Attachment 2). Both documents were referenced in the Application filed on July 31, 2020.

We are available, at your convenience, to answer any questions you may have.

Respectfully submitted,

*/s/ Christine M.T. Pirik*____
Christine M.T. Pirik (0029759)
William V. Vorys (0093479)
DICKINSON WRIGHT PLLC
150 East Gay Street, Suite 2400
Columbus, Ohio 43215
(614) 591-5461
cpirik@dickinsonwright.com
wvorys@dickinsonwright.com

Attorneys for Hardin Solar II LLC

Cc: James O'Dell
Jonathan Pawley

CERTIFICATE OF SERVICE

The Ohio Power Siting Board's e-filing system will electronically serve notice of the filing of this document on the parties referenced in the service list of the docket card who have electronically subscribed to these cases. In addition, the undersigned certifies that a copy of the foregoing document is also being served upon the persons below this 24th day of August, 2020.

/s/ Christine M.T. Pirik
Christine M.T. Pirik (0029759)

Counsel/Intervenors:

jodi.bair@ohioattorneygeneral.gov
robert.eubanks@ohioattorneygeneral.gov

Administrative Law Judge:

dan.fullin@puco.ohio.gov

4833-2530-5032 v1 [39579-24]

Attachment 1

Road Condition Report

.

/s/ Christine M.T. Pirik
Christine M.T. Pirik (0029759)
William Vorys (0093479)
DICKINSON WRIGHT PLLC
150 East Gay Street, Suite 2400
Columbus, Ohio 43215
(614) 591-5461
cpirik@dickinsonwright.com
wvorys@dickinsonwright.com
(Counsel is willing to accept service via email.)

Attorneys for Hardin Solar II LLC

Hardin Solar II Energy Center

Road Condition Report

Prepared for
Invenergy, LLC

August 2020

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
952.832.2600
www.barr.com

Road Condition Report

August 2020

Contents

List of Tables

List of Figures

List of Appendices

Certifications

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly licensed Professional Engineer under the laws of the State of Ohio.

08/19/2020

Matthew B. Johnson
E-74181

Date

Acronyms

Acronym	Description
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
CBR	California Bearing Ratio testing
CR	County Road
DCP	Dynamic Cone Penetrometer
EALF	Equivalent Axle Load Factors
ESAL	Equivalent Single Axle Loads
ODOT	Ohio Department of Transportation
OH	Ohio State Highway
TR	Township Road
USGA	United States Geological Survey

1.0 Executive Summary

Several studies were performed for the Hardin Solar II Energy Center (Hardin Solar II), a proposed solar power development located in Hardin County, OH. This report is intended to supplement the Road Survey Report prepared by Barr Engineering Co. in October 2018.

A road survey consisting of a video survey, a pavement visual assessment, and identification of areas of concern from visual inspection was performed for Hardin Solar II.

Hardin Solar II roads were divided into sections and each section was inspected with at least two sample units. The existing pavement visual assessments using ASTM Pavement Condition Index (PCI) survey are generally as follows:

- County Road 110 – good condition.
- Township Road 120 – good condition.
- Highway 195 – good condition.
- County Road 126 – good condition.
- County Road 130 – fair to good condition.
- Township Road 130 – good condition.
- Township Road 65 – satisfactory condition.
- County Road 65 – good condition.
- County Road 75 – satisfactory condition.

1.1 Recommendations

The results of the capacity study show an acceptable capacity reduction for all roads. Per Ohio Department of Transportation (ODOT) the reliability level for local rural roads is defined as 80%. The projects construction traffic will consume less than 20% of the road capacity, thus, there is no need for mitigation measures for these roads.

2.0 Introduction

Invenergy, LLC (Invenergy) is planning to construct the Hardin Solar II Energy Center, a proposed solar power development located in Hardin County, Ohio. Invenergy has requested a road study and drainage study for the roads indicated in Figure 1 (See Appendix A).

The road study consists of a video survey with identification of areas of concern from visual inspection. It also includes a capacity study to determine the load capacity of the existing roads and improvements required to accommodate any increased traffic by the proposed improvements.

The drainage study consists of site identification of drains, waterways, culverts, and any drainage related structure. The study reviews the existing drainage and notes any areas of concern near and around the requested roads.

The studies described in this report were performed at different times and represent the road conditions at the time of the survey. Portions of CR-110 were completed in November 2016, CR-75 and roads leading to substation were completed in August 2017, and the remainder of the roads were completed in December 2017 with supplemental studies performed in June 2020.

This report combines all phases and describes the findings from the road and drainage studies including the geotechnical exploration performed for the different sections as part of the capacity study. The following sections provide narrative of the analysis of the conditions of the roads at the time of inspection, and the impact of construction activities to the existing infrastructure. Boring logs, photographs and supporting documents are also provided as part of this report (See Appendix C).

3.0 Project information

The project site is located near the town of Alger, OH. The project consists of construction of a solar farm. The vehicles expected for construction include module delivery trucks, ready-mix trucks, lowboy semitrailers carrying construction equipment (backhoe excavator, bulldozer, etc.), electrical equipment delivery trucks, and dump trucks for aggregate delivery. Detailed loads are shown in Section 5.0.

Roads inspected and analyzed as part of this report are as follows:

1.- County Road 110 (CR-110) from Highway 235 to Highway 195.
2.- Township Road 120 (TR-120) from Highway 235 to Highway 195.
3.- Highway 195 (OH-195) from TR-120 to CR-110.
4.- County Road 126 (CR-126) from approximately 1500′ west of Highway 235 to Highway 235.
5.- County Road 130 (CR-130) from CR-75 to Highway 235.
6.- Township Road 130 (TR-130) from approximately 2500′ west of Highway 235 to Highway 235.
7.- Township Road 65 (TR-65) from CR-130 to approximately 4500′ south of point where TR-65 turns south.
8.- County Road 65 (CR-65) from CR-130 to Highway 195.
9.- County Road 75 (CR-75) from Highway 67 to CR-110.

See Appendix A – Figure 2 for analyzed roads.

4.0 Road Study

The conditions of existing pavement were assessed visually and rated using ASTM D 6433 Road and Parking Lots Pavement Condition Index Surveys (See Appendix B). This method divides the pavement into branches that are divided into sections. Each section is then divided into sample units. The units are inspected, and the severity of the distress is assessed visually. The quantity of each distress is estimated to calculate the pavement condition index (PCI). The PCI of the inspected section is determined based on the PCI of the units inspected within the section. Once the PCI of the section is determined, the PCI is used to rate the road using Table 4-1.

In addition to the PCI rating, a video survey was performed for each one of the roads to document the current conditions of the roads. These videos are provided separately and are not part of this report, however, the distresses described in this document can be used to confirm these observations.

Table 4-1 Standard PCI Rating Scale

PCI RANGE	RATING
85 - 100	GOOD
70 - 85	SATISFACTORY
55 - 70	FAIR
40 – 55	POOR
25 – 40	VERY POOR
10 – 25	SERIOUS
0 - 10	FAILED

It is important to note that the PCI does not measure structural capacity, it only provides an objective and rational basis for determining maintenance and repair needs.

Sample units within a section were randomly selected depending on the homogeneity of the pavement section. For roads where more distresses were observed, the more sections were selected for measurement. Barr did not find necessary to run a statistical analysis for determining the minimal number of sample units, due to the homogeneity on the number and types of distresses observed.

4.1 County Road 110

CR-110 was inspected from the intersection with OH-235 to the intersection with OH-195. It was divided into two sections for the inspection.

Section 1 from OH-235 to approximately 2 miles east of OH-235was generally in good condition. Minimal distresses such as shoulder drop-off, sags and bumps were observed, specifically on the bridge at the intersection with CR-35 and at the irrigation ditch crossings by the Van Deurzen Dairy site. Heavy traffic from harvesting activities was observed coming in and out of the Van Deurzen Dairy site and travelling east on CR-110 to the adjacent fields. During the site visit no significant distresses were observed in this section of road product of the heavy traffic. Two sample units were selected within the section.

Table 4-2 CR-110 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	97	GOOD
2	97	GOOD

Figure 4-1 CR-110 Section 1

Section 2 from approximately 2 miles east of OH-235 to OH-195 was observed in good condition. No signs of distresses other than shoulder drop-offs and a slight depression cause by traffic at a field entrance. Two sample units were selected within the section.

Table 4-3 CR-110 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	88	GOOD
2	77	SATISFACTORY

Figure 4-2 CR-110 Section 2

4.2 Township Road 120

TR-120 was inspected from the intersection with OH-235 to intersection with OH-195. TR-120 was divided into two sections for the inspection.

Section 1 from OH-235 to CR-35 was observed generally in good condition. The pavement has minimal distresses such as bleeding. Two sample units were selected within the section.

Table 4-4 TR-120 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	97	GOOD
2	97	GOOD

Figure 4-3 TR-120 Section 1

Section 2 from CR-35 to OH-195 was observed generally in good condition, with a localized area, approximately 1 mile west of the east end (intersection with Scioto River) that was rated as fair (See Figure 4-5).

Table 4-5 CR-150 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	90	GOOD
2	68	FAIR

Figure 4-4 TR-120 Section 2 – Sample 1

Figure 4-5 TR-120 Section 2 – Sample 2

4.3 Highway 195

Highway 195 (OH-195) was inspected from the intersection with TR-120 to the intersection with CR-110. OH-195 was divided into two sections for inspection.

Section 1 from TR-120 to CR-65 was observed generally in good condition. The pavement has minimal distresses such as longitudinal and transverse cracking, shoulder drop off, and edge cracking. Two sample units were selected within this section.

Table 4-6 OH-195 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	78	SATISFACTORY
2	85	GOOD

Figure 4-6 OH-195 Section 1

Section 2 form CR-65 to CR-110 was observed generally in good condition. The pavement has minimal distresses such as longitudinal and transverse cracking, shoulder drop off, and edge cracking. Four sample units were selected within this section.

Table 4-7 OH-195 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	78	SATISFACTORY
2	86	GOOD
3	91	GOOD
4	78	SATISFACTORY

Figure 4-7 OH-195 Section 2

4.4 County Road 126

CR-126 was inspected from the OH-235 to approximately 1500' west. CR-126 was observed generally in good conditions. The pavement has minimal distresses such as bleeding, shoulder drop off and edge cracking. Two sample units were selected along CR-126.

Table 4-8 CR-130 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	82	SATISFACTORY
2	85	GOOD

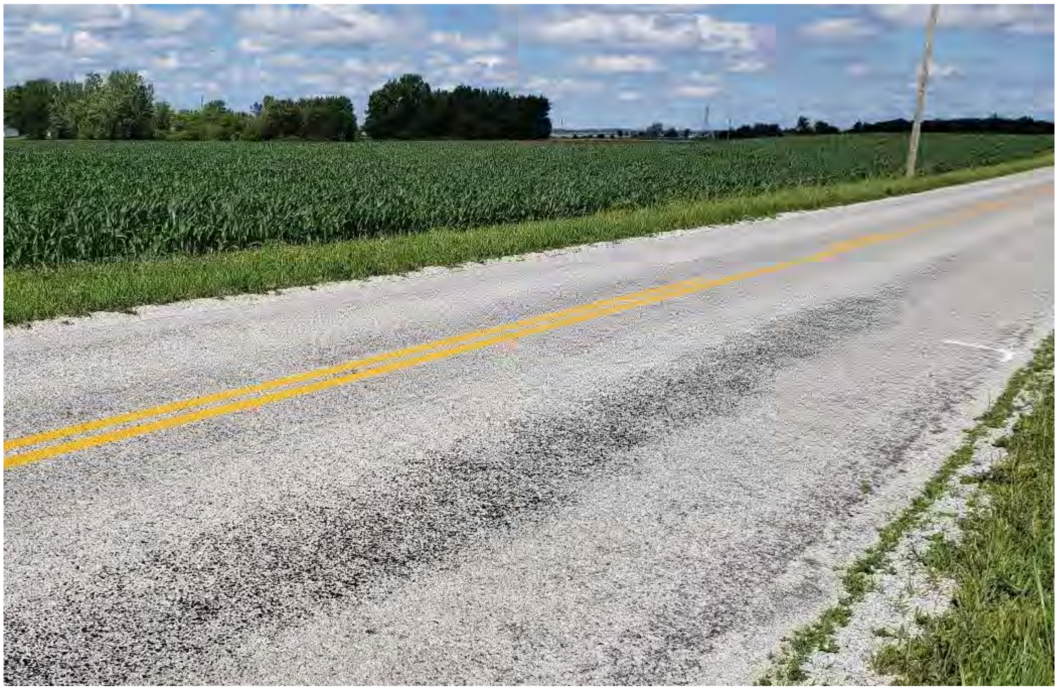


Figure 4-8 CR-126

4.5 County Road 130

CR-130 was inspected from the intersection with OH-235 to CR-75. CR-130 was divided into four sections for the inspection.

Section 1 from OH-235 to TR-55 conditions were generally good with one fair section due to potholes. Such distresses were mainly classified as low.

Table 4-9 CR-130 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	86	GOOD
2	64	FAIR
3	88	GOOD
4	93	GOOD

Figure 4-9 CR-130 Section 1

Section 2 from TR-55 to CR-65 conditions varied along its length from fair to good with the majority of the distresses at the intersections with other roads, bridges or at farm entrances. Such distresses were mainly classified as low, with few areas where the severity was deemed as medium.

Table 4-10 CR-130 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	76	SATISFACTORY
2	89	GOOD
3	87	GOOD
4	72	SATISFACTORY
5	67	FAIR
6	70	SATISFACTORY
7	64	FAIR
8	68	FAIR

Figure 4-10 CR-130 Section 2

Section 3 from CR-65 to TR-65 was observed generally in good condition. The pavement has minimal distresses such as bleeding. The road differs from previous sections with a width of 17 feet compared to 20 feet. Two sample units were selected within the section.

Table 4-11 CR-130 Section 3 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	90	GOOD
2	93	GOOD

Figure 4-11 CR-130 Section 3

Section 4 from TR-65 to CR-75 was observed generally in good condition. The pavement has minimal distresses such as edge cracking. Three sample units were selected within the section.

Table 4-12 CR-130 Section 4– PCI Summary

SAMPLE UNIT	PCI	RATING
1	79	SATISFACTORY
2	92	GOOD
3	92	GOOD

Figure 4-12 CR-130 Section 4

4.6 Township Road 130

TR-130 was inspected from OH-235 to approximately 2500′ west. TR-130 was observed generally in good condition. The pavement has minimal distresses such as bleeding, shoulder drop off, edge cracking, and weathering. Two sample units were selected along TR-130.

Table 4-13 TR-130 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	89	GOOD
2	82	SATISFACTORY

Figure 4-13 TR-130

4.7 Township Road 65

TR-65 was inspected from CR-130 to approximately 4500′ south of point where TR-65 turns south. TR-65 was divided in three sections.

Section 1 from CR-130 to the road's 90º bend was observed generally in satisfactory condition. The pavement has minimal distresses such as bleeding and edge cracking. Some areas had small potholes and corrugation resulting in lower rating. Five sample units were selected within the section.

Table 4-14 TR-65 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	69	FAIR
2	69	FAIR
3	84	SATISFACTORY
4	92	GOOD
5	92	GOOD

Figure 4-14 TR-65 Section 1

Section 2 from the bend to the intersection with access road to the substation was observed generally in satisfactory condition, except for the curve section, where fair conditions were observed due to a depression at the internal lane, and therefore the ride quality was noticeably affected. The rest of the inspected section had low distresses such as bleeding and edge cracking. Three sample units were selected within the section.

Table 4-15 TR-65 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	59	FAIR
2	84	SATISFACTORY
3	82	SATISFACTORY

Figure 4-15 TR-65 Section 2

Section 3 from the intersection with the access road to the substation to approximately 4500′ to the south of the road's 90º bend was observed generally in fair condition. The pavement has minimal to moderate distresses such as bleeding, edge cracking, shoulder drop off, alligator cracking, and rutting. Three sample units were selected within the section.

Table 4-16 TR-65 Section 3 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	68	FAIR
2	59	FAIR
3	72	SATISFACTORY

Figure 4-16 TR-65 Section 3

4.8 County Road 65

CR-65 was inspected from OH-195 to CR-130 and was divided into two sections.

Section 1 from OH-195 to approximately 4500′ south of OH-195 was observed generally in good condition. The pavement has minimal distresses such as shoulder drop off. Three sample units were selected in this section.

Table 4-17 CR-65 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	86	GOOD
2	86	GOOD
3	86	GOOD

Figure 4-17 CR-65 Section 1

Section 2 from approximately 4500' south of OH-195 to CR-130 was observed generally in good condition. Low severity distresses such as shoulder drop-off and patching were observed, especially near the intersection with CR-130. Three sample units were selected in this section.

Table 4-18 CR-65 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	87	GOOD
2	87	GOOD
3	86	GOOD

Figure 4-18 CR-65 Section 2

4.9 County Road 75

CR-75 was divided into sections of approximately half mile to under one mile each. Each section was inspected with at least four sample units.

Section 1 from OH-67 to approximately 3350 feet to the north was observed generally in satisfactory condition. The pavement has minimal distresses such as edge cracking. Six sample units were selected within the section.

Table 4-19 CR-75 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	78	SATISFACTORY
2	86	GOOD
3	91	GOOD
4	78	SATISFACTORY
5	78	SATISFACTORY
6	80	SATISFACTORY

Figure 4-19 CR-75 Section 1

Section 2 from approximately 3350 feet to the north of OH-67 to TR-154 was observed generally in satisfactory condition. The pavement has minimal distresses such as edge cracking. There are small areas with longitudinal and transverse cracking as well as patching. Four sample units were selected within the section.

Table 4-20 CR-75 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	79	SATISFACTORY
2	80	SATISFACTORY
3	78	SATISFACTORY
4	88	GOOD

Figure 4-20 CR-75 Section 2

Section 3 from TR-154 to the north intersection with CR-150 was observed generally in satisfactory condition. The pavement has minimal distresses such as bleeding and edge cracking. One sample unit had potholes, bleeding and edge cracking and seemed only in "fair" condition. Six sample units were selected within the section.

Table 4-21 CR-75 Section 3 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	60	FAIR
2	80	SATISFACTORY
3	88	GOOD
4	86	GOOD
5	78	SATISFACTORY
6	77	SATISFACTORY

Figure 4-21 CR-75 Section 3

Section 4 from the north intersection with CR-150 to CR-130 was observed generally in satisfactory condition. The pavement has minimal distresses such as longitudinal cracking, transverse cracking and edge cracking. There were a couple of areas with patching that resulted in a “fair” rating for one sample unit. Six sample units were selected within the section.

Table 4-22 CR-75 Section 4 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	70	SATISFACTORY
2	67	FAIR
3	75	SATISFACTORY
4	88	GOOD
5	84	SATISFACTORY
6	93	GOOD

Figure 4-22 CR-75 Section 4

Section 5 from CR-130 to TR-120 was observed generally in satisfactory condition. The pavement has minimal distresses such as longitudinal cracking, bleeding, shoulder drop off and edge cracking. Some moderate edge cracking and shoulder drop off was also observed. Four sample units were selected within the section.

Table 4-23 CR-75 Section 5 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	72	SATISFACTORY
2	69	FAIR
3	71	SATISFACTORY
4	71	SATISFACTORY

Figure 4-23 CR-75 Section 5 – Sample 1

Figure 4-24 CR-75 Section 5 – Sample 4

Section 6 from TR-120 to CR-110 was observed generally in satisfactory condition. The pavement has minimal distresses such as bleeding, shoulder drop off and edge cracking. Some moderate edge cracking and was also observed. Patching was observed in the southbound lane between CR-110 and approximately 500' south, giving Sample Unit 1 a fair rating. Four sample units were selected within the section.

Table 4-24 CR-75 Section 6 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	59	FAIR
2	78	SATISFACTORY
3	85	GOOD
4	80	SATISFACTORY

Figure 4-25 CR-75 Section 6 – Sample 1

Figure 4-26 CR-75 Section 6 – Sample 3

5.0 Geotechnical Evaluation

Soil borings were completed along existing public roads at intervals of approximately 0.25 miles of roadway. Each soil boring extended to a depth of 5 feet. Soil samples were collected at 2 ½ foot intervals by driving a split spoon sampler.

Other bulk samples were also obtained during drilling. Samples were used for soils characterization and tests. Additionally, selected samples were sent to laboratory for Proctor and California Bearing Ratio testing (CBR). Dynamic Cone Penetrometer (DCP) tests were performed parallel to soil borings to determine in situ soil strength and to correlate to other parameters such as CBR values. Further information on the evaluations and results are presented in Appendix C.

6.0 Capacity Study

This section will focus on determining the load capacity of the existing roads and improvements required to accommodate any increased traffic by the proposed construction activities.

6.1 Existing pavement structure

Table 6-1 Existing pavement structure

Road	Average Asphalt Thickness	Average Gravel Thickness
1A - CR 110 - 235 to TR 44	11.6	0.0
1B - CR 110 - TR 44 to OH195	7.2	8.4
2A - TR 120 - 235 to CR 35	10.3	0.0
2B - TR 120 - CR 35 to TR 44	6.0	14.0
2C - TR 120 - TR 44 to OH195	5.7	9.0
3 - OH-195 - TR 120 to CR 110	7.3	11.4
4 - CR-126 - 235 to West	5.5	7.2
5A - CR 130 - 235 to OH195	6.4	10.0
5B - CR 130 - TR 65 to CR 65	6.0	12.0
5C - CR 130 - CR 75 to TR 65	6.0	7.6
6 - TR-130 - 235 to West	5.2	5.3
7 - TR 65 - CR 130 to South	5.8	7.9
8 - CR 65 - CR 130 to North	8.7	8.3
9A - CR 75 - OH 67 to CR 130	8.2	7.6
9B - CR 75 - CR 130 to North	8.0	5.9

Asphalt thicknesses at boring locations ranged from 5 to 12 inches and gravel thickness where present ranged from 5 to 14 inches with an average of approximately 8 inches. There was no base course underlying the asphalt at several locations (see Appendix C). The average existing pavement structure for each road will be used for the capacity study.

6.2 Subsurface Conditions

Subsurface conditions were determined by borings with the geotechnical evaluation. The resulting boring logs are located in Appendix C. Existing conditions consist of a surficial layer of asphalt sometimes underlain by a base course of either silty sand with gravel, silty gravel, or poorly graded gravel with silt and/or sand followed by native lean to fat clay. There were no base or sub-base courses identified beneath the asphalt for some portions; in these locations the bituminous materials appear to be placed directly on the existing soil/fill materials.

6.3 Roadway analysis

The roadway analysis is based on the AASHTO/ODOT pavement design equations. This pavement design method is based around the concept of serviceability or the ability of pavement to serve traffic.

This empirical equation is widely used and has the following form:

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Where;	W_{18}	=	number of 18 kip equivalent single axle loads (ESAL)
	Z_R	=	standard normal deviate (function of the design reliability level)
	S_0	=	overall standard deviation (function of overall design uncertainty)
	ΔPSI	=	allowable serviceability loss at end of design life
	M_R	=	subgrade resilient modulus
	SN	=	structural number (a measure of required structural capacity)

6.3.1 Serviceability

The initial serviceability for flexible pavements is 4.5 and the terminal serviceability is 2.5 in accordance to ODOT recommendations. This results in a design serviceability loss of 2.0.

6.3.2 Traffic

For design purposes, truck traffic is converted to loading which is normalized by the concept of an equivalent single axle load (ESAL) of 18,000 lb. (80 kN). The Asphalt Institute's Equivalent Axle Load Factors were used to convert the loads. Table 6-2 shows the conversions.

Table 6-2 Equivalent Axle Load Factors

LOADED VEHICLES

Aggregate		**EALF**
12,000	Load on Steer Axle (Single Axle)	0.189
34,000	Load on Drive Axle (Tandem Axle)	1.095
	ESALs per Aggregate Truck	**1.28**
Concrete		
12,000	Load on Steer Axle (Single Axle)	0.189
50,000	Load on Drum Axle (Tandem Axle)	4.859
	ESALs per Concrete Truck	**5.05**
Deliveries-Semi		
12,000	Load on Steer Axle (Single Axle)	0.189
34,000	Load on Drive Axle (Tandem Axle)	1.095
34,000	Load on Trailer Axle (Tandem Axle)	1.095
	ESALs per Other Truck	**2.38**

EMPTY VEHICLES

Aggregate

12,000	Load on Steer Axle (Single Axle)	0.189
10,000	Load on Drum Axle (Tandem Axle)	0.0065
	ESALs per Aggregate Truck	**0.20**

Concrete

12,000	Load on Steer Axle (Single Axle)	0.189
10,000	Load on Drum Axle (Tandem Axle)	0.0065
	ESALs per Concrete Truck	**0.20**

Deliveries-Semi

12,000	Load on Steer Axle (Single Axle)	0.189
12,000	Load on Drive Axle (Tandem Axle)	0.013
10,000	Load on Trailer Axle (Tandem Axle)	0.0065
	ESALs per Other Truck	**0.21**

The total delivery vehicles expected for the site are 6,450 over approximately 115 power blocks. Distribution of vehicles is based on power blocks. The ESAL calculated for vehicles per power block are shown on Table 6-3.

Table 6-3 Total ESAL per power block

Load type	Approx. # of trucks	Type of truck	Estimated truck per power block	ESAL per load type	Total ESAL per block
Module Deliveries	750	semi-trucks	6.5	2.59	16.8
Inverter/Transformer Pads	150	concrete trucks	1.3	5.25	6.8
Module Racking	2250	semi-trucks	19.6	2.59	50.8
Electrical misc.	1500	semi-trucks	13.0	2.59	33.7
Access Roads	1800	dump trucks	15.7	1.48	23.2
				Total ESAL per power block	**131.3**

6.3.3 Subgrade Resilient Modulus

ODOT has adopted a standard relationship between modulus of resilience (M_r) and the California bearing ratio (CBR). The units for resilient modulus are pounds per square inch (psi).

$$M_r = 1200 * CBR$$

6.3.4 California Bearing Ratio

The California bearing ratio (CBR) is a value representing a soil's saturated resistance to shearing under a standard load, compared to the resistance of crushed stone subjected to the same load. The CBR results for the site can be found in Appendix C.

ODOT's pavement design procedure uses a statistical reliability factor to account for variability in subgrade stiffness. Because of this, the average CBR is to be used for pavement design thus avoiding unnecessarily thick and wasteful design.

An average CBR @ 95% of standard Proctor density of 2.7 will be used for the evaluation of road capacity (see Appendix C).

6.3.5 Reliability

AASHTO defines reliability as the probability that the load applications a pavement can withstand in reaching a specified minimum serviceability level is not exceeded by the number of load applications that are actually applied to the pavement. ODOT's reliability level for local rural roads is 80%.

6.3.6 Overall Standard Deviation

The overall standard deviation is a measure of the spread of the probability distribution for ESAL vs. Serviceability. ODOT's standard deviation for flexible pavements is 0.49.

6.3.7 AASHTO Drainage Coefficient

The AASHTO pavement design equations attempt to consider the effects of drainage on pavement performance. ODOT's drainage coefficient pavement design is 1.

6.3.8 Structural coefficient

Structural coefficients from ODOT are 0.14 for aggregate base, 0.23 for existing asphalt concrete, and 0.43 for new surface courses.

6.3.9 Structural Number

Existing structural number (SN) is determined by multiplying the existing structure thickness by its structural coefficient. Table 6-4 shows the calculated structural number for the existing road sections.

Table 6-4 Existing Road Structural Number

Road	Asphals Thickness (in)	Asphalt Structural coefficient	Gravel Thickness (in)	Gravel Structural coefficient	Structural number
1A - CR 110 - 235 to TR 44	11.6	0.23	0.0	0.14	2.67
1B - CR 110 - TR 44 to OH195	7.2	0.23	8.4	0.14	2.83
2A - TR 120 - 235 to CR 35	10.3	0.23	0.0	0.14	2.37
2B - TR 120 - CR 35 to TR 44	6	0.23	14.0	0.14	3.34

2C - TR 120 - TR 44 to OH195	5.7	0.23	9.0	0.14	2.57
3 - OH-195 - TR 120 to CR 110	7.3	0.23	11.4	0.14	3.28
4 - CR-126 - 235 to West	5.5	0.23	7.2	0.14	2.27
5A - CR 130 - 235 to OH195	6.4	0.23	10.0	0.14	2.87
5B - CR 130 - TR 65 to CR 65	6	0.23	12.0	0.14	3.06
5C - CR 130 - CR 75 to TR 65	6	0.23	7.6	0.14	2.44
6 - TR-130 - 235 to West	5.2	0.23	5.3	0.14	1.94
7 - TR 65 - CR 130 to South	5.8	0.23	7.9	0.14	2.44
8 - CR 65 - CR 130 to North	8.7	0.23	8.3	0.14	3.16
9A - CR 75 - OH 67 to CR 130	8.2	0.23	7.6	0.14	2.95
9B - CR 75 - CR 130 to North	8	0.23	5.9	0.14	2.67

6.4 Analysis and Recommendations

Having all the parameters from the previous section we can calculate the existing pavement capacity using the empirical equation. The result will show the theoretical total number of ESAL the existing pavement is expected to support. Table 6-5 shows the results for existing road capacity.

Table 6-5 Existing Road Capacity

Road	Z_R	S_0	SN	ΔPSI	M_R	W_{18}
1A - CR 110 - 235 to TR 44	-0.841	0.49	2.67	2	3240	46578
1B - CR 110 - TR 44 to OH195	-0.841	0.49	2.83	2	3240	67893
2A - TR 120 - 235 to CR 35	-0.841	0.49	2.37	2	3240	22157
2B - TR 120 - CR 35 to TR 44	-0.841	0.49	3.34	2	3240	195105
2C - TR 120 - TR 44 to OH195	-0.841	0.49	2.57	2	3240	36909
3 - OH-195 - TR 120 to CR 110	-0.841	0.49	3.28	2	3240	171842
4 - CR-126 - 235 to West	-0.841	0.49	2.27	2	3240	17157
5A - CR 130 - 235 to OH195	-0.841	0.49	2.87	2	3240	74208
5B - CR 130 - TR 65 to CR 65	-0.841	0.49	3.06	2	3240	111125
5C - CR 130 - CR 75 to TR 65	-0.841	0.49	2.44	2	3240	26893
6 - TR-130 - 235 to West	-0.841	0.49	1.94	2	3240	6519
7 - TR 65 - CR 130 to South	-0.841	0.49	2.44	2	3240	26620
8 - CR 65 - CR 130 to North	-0.841	0.49	3.16	2	3240	137372
9A - CR 75 - OH 67 to CR 130	-0.841	0.49	2.95	2	3240	87985
9B - CR 75 - CR 130 to North	-0.841	0.49	2.67	2	3240	46359

The existing road capacity lets us determine the pavement capacity that will be consumed by the projects construction traffic. Table 6-6 shows the pavement capacity and the estimated percentage that will be used by the projects construction traffic.

Table 6-6 Road Analysis Results

Road	Number of Power Blocks	Section ESALs	Pavement Capacity	% capacity used
1A - CR 110 - 235 to TR 44	16.6	193**	46578	0.41%
1B - CR 110 - TR 44 to OH195	16.6	193**	67893	0.28%
2A - TR 120 - 235 to CR 35	16.6	2180	22157	9.84%
2B - TR 120 - CR 35 to TR 44	16.6	2180	195105	1.12%
2C - TR 120 - TR 44 to OH195	16.6	193**	36909	0.52%
3 - OH-195 - TR 120 to CR 110	16.6	193**	171842	0.11%
4 - CR-126 - 235 to West	1.7	223	17157	1.30%
5A - CR 130 - 235 to OH195	38.8	5096	74208	6.87%
5B - CR 130 - TR 65 to CR 65	14.65	1924	111125	1.73%
5C - CR 130 - CR 75 to TR 65	38.65	5070	26893	18.85%
6 - TR-130 - 235 to West	4.7	617	6519	9.46%
7 - TR 65 - CR 130 to South	29.7	3901	26620	14.65%
8 - CR 65 - CR 130 to North	2.4	315	137372	0.23%
9A - CR 75 - OH 67 to CR 130	50	6567	87985	7.46%
9B - CR 75 - CR 130 to North	8.95	1175	46359	2.53%

** ESALs represent empty vehicles for this section.

The reliability level for local rural roads is 80%. If the analysis shows the projects construction traffic will consume less than 20% of the road capacity, there is no need for mitigation for the area. The results show no mitigation required for all the roads analyzed.

The analysis and recommendations presented are based on standard pavement design equations using average thicknesses and CBR values. The actual damage to existing roads can potentially exceed what has been predicted at localized locations.

The results of the capacity analysis of the roads and any proposed mitigation area are provided in Figure 3 (Appendix A).

7.0 Drainage Study

Drainage patterns were identified during the site visit for all roads. Generally, the site's runoff is directed to the Scioto River (See Appendix A – Figure 4). To the north of OH-309, the farm fields drained towards one of the multiple drainage swales and direct flows to the south. South of OH-309, the fields generally drain to roadway ditches that discharge into the irrigation channels connected to the Scioto River.

Barr used the 2006 USGA Lidar survey, along with the data collected during the site visit, to develop drainage patterns. Dry conditions in the area, during site visit, did not allow for flow observation.

The following sections outline specific drainage features found for each of the roads analyzed.

7.1 County Road 110

CR-110 was observed significantly higher that the surrounding ground (2-4 feet). Ditches were not observed well defined, except for areas near properties where ditches were installed to convey water to the east and west. Culverts were observed on the south side of the road, under driveways and fields prior to reaching the intersection with CR-35. This drainage system discharged into irrigation ditch D-1 at the intersection with CR-35.

The road near the intersection with CR-35 was approximately 3-4 feet higher than the south field. Side slopes were approximately 4H:1V. Between the road and the corn field to the south, that channelized runoff collected upstream, towards irrigation ditch D-1.

From approximate 4000' east of CR-35 to D-4, roadway ditches on both sides of the road were observed. Both ditches directed water to the east to irrigation ditches D-4 and D-5, and that direct water to the north and east respectively.

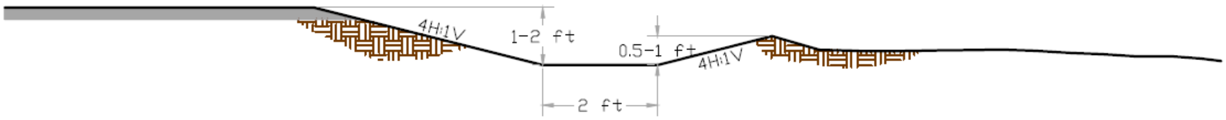


Figure 7-1 CR-110 – Roadway Ditch

Irrigation ditch D-5 continues along the north side of the road up and transitions to the south and continued to the east along the road. Well-maintained ditches were observed on the south side of the road, at Van Deurzen Dairy. Water is directed to the east until discharged into drainage ditch D-5.

Figure 7-2 CR-110 – South Ditch

Approximately 1,600 feet west of the intersection with TR-55 (Planned Road), a concrete catch basin was observed that collects water from the north side of the road and directs it to the south drainage ditch. At the intersection with OH-195, a pump station also transfers water from the north to D-5. D-5 discharges into the Scioto River, approximately ½ mile east.

Figure 7-3 CR-110 – Catch Basin

Figure 7-4 CR-110 – Pump Station

7.2 Township Road 120

TR-120 was observed above the surrounding fields. Approximately 2500′ east of OH-235 and along the south side of TR-120 a damaged corrugated metal culvert was found adjacent to the parking lot to the east. This culvert appeared to convey water from the east side towards the west and will need to be replaced or repaired for proper drainage under the access road.

The ditch on the south side of the road becomes gradually deeper, approximately ¾ mile east of the intersection with OH-235, until it reaches a depth of 4-5 feet. Approximately 1 mile west of the east end of the inspected road, a concrete manhole collects water from the north side of the road and directs it through a pump to the south side, where D-12 is located along the south side of the road, and that discharges at the Scioto River. A second structure with similar setup was observed about ½ mile west of the east end of the road.

Figure 7-5 TR-120 – West Pump Station

Figure 7-6 TR-120 – East Pump Station

7.3 Highway 195

OH-195 was observed higher than the surrounding areas. Fields to the west of OH-195 were approximately 3-4' lower than the road surface. The Scioto River border OH-195 on its east side until OH-195 turns north just south of CR-110. A concrete structure like that observed on CR-110 was observed on the west side of OH-195. It appears that drainage from the north and south is collected here and pumped east into the Scioto River. Ditches along the east side of OH-195 were less defined where OH-195 turns north as it appears that drainage flows east into the Scioto River.

Figure 7-7 OH-195 – Pump Station

7.4 County Road 126

Shallow ditches are present along CR-126, though it appears that drainage generally flows away from the roadway. Drainage on the north side of the roadway flows out into the fields and to the northeast, while drainage to the south flows to the south and east. It appears that the latter makes its way to D-12.

Figure 7-8 CR-126 Shallow Ditches

7.5 County Road 130

Drainage from the fields along CR-130 is directed the east through roadway ditches. The presence of roadway ditches varied based on the topography, with depths ranging from 1-4 feet.

The north fields' direct water towards Elder Creek or to Dunlap Creek, both discharge into the Scioto River. The south fields drain similarly to the north, with the only interference being the road itself. Culverts were observed on low points along the road, in addition to this, it is known that most agricultural fields in this area have drain tile systems interconnected with the drainage ditches.

Figure 7-9 CR-130 – Elder Creek Bridge

Figure 7-10 CR-130 – Scioto River Bridge

Drainage along CR-130 between CR-65 and TR-65 is generally divided by the road. The west side flows north and north-west while the east side of the road flows to the east. There is a low point on the east side of the road that collects water approximately 550 feet north of TR-65.

Ditches on both sides of the road were observed for the area between TR-65 and CR-75. The ditches are approximately 2-3 feet deep and have side-slopes of approximately 3:1 with the flow line of the ditches approximately 6 feet from the edge of the roadway. The ditches are relatively flat directing flow to the west. There is a low spot 700 feet east of TR-65 in the south side of the road with standing water.

Figure 7-11 CR-130 – Standing Water

On the north side of the road there is a culvert that appears to go beneath the road and discharges water south of CR-130.

Figure 7-12 CR-130 – Culvert

7.6 Township Road 130

A shallow ditch was observed along the north side of TR-130, but no defined ditch was observed on the south side. Drainage flows generally to the east. Culverts were observed on the north and south sides of the road at OH-235, allowing flow from west to east underneath the highway.

Figure 7-13 TR-130 – Ditches

7.7 Township Road 65

TR-65 between CR-130 and the 90º bend has ditches present on both sides of the road directing flow generally towards the west. The first 1,200 feet closest to CR-130 has relatively flat slope but the slope of the ditches increases as they get closer to the 90º bend. A culvert near the bend allows water to cross from the south side to the north where it flows towards the Scioto River.

Figure 7-14 TR-65 – Ditch

South of the 90º bend the road is elevated and drainage is directed away from the road. The adjacent fields to the observed area drain in their majority to the north, on the east side, and to the north-west, on the west side of the road. Culverts were not observed along this section of the road.

Figure 7-15 TR-65 – Road

7.8 County Road 65

CR-65 is an elevated road without defined ditches on its sides. Drainage of the adjacent fields is generally directed towards the Scioto River, on the west side of the road, and to the north on the east side of the road. A sump was observed south of the intersection with TR-67. This sump appears to collect runoff from the SE and direct water to the drain tile system that discharges into the Scioto River.

Figure 7-16 CR-65 – Elevated Road

7.9 County Road 75

Drainage on CR-75 was variable throughout its entire length. Several high points were observed that divided the site's drainage towards any of the multiple waterways. The road had ditches on both sides but in an intermittent fashion. These ditches varied on depth and side slopes but generally between 1 and 2 feet wide at the bottom and between 6 inches and 3 feet deep. The flow lines of the ditches varied from approximately 10-15 feet from the edge of the roadway. Several culverts were seen under driveways.

Figure 7-17 CR-75 – Culverts under driveway

Approximately 2,550 feet north of OH-67 there is a catch basin in the ditch on the east side of the road. It was not clear if there were more streams captured by the catch basin and where the catch basin outlet was.

Figure 7-18 CR-75 – Catch Basin

North of TR-154, there is a stream on the east side of the road with a crossing 570 feet south of the intersection with CR-150. The ditch featured a riprap inlet from a field to the east crossing a swale. Water was stagnant at the time of the survey but appeared to be flowing north upon review of the contours.

Figure 7-19 CR-75 – Stream

The stream crossing featured a 60-inch culvert. The crossing was diagonal and also had 3 pipe outlets near it – two downstream and one upstream. One of the pipes had visible water flowing out of it. The pipes are likely to be outlets from field drain tiles or catch basins.

Figure 7-20 CR-75 – 60" RCP Culvert Crossing

North of the stream crossing, ditches are present on the east and the west sides of the road. The ditches have varying depths and definitions and are not as deep as the ditches to the south ranging from 0-2 feet deep.

Along the ditches, there are 4 culverts of varying sizes from 8-15 inches. The culverts direct water below driveways along CR-130.

Approximately 1,100 feet south of CR-130 there is bridge/box culvert crossing under CR-130 for the same stream as the 60" RCP crossing.

Figure 7-21 CR-75 – Box Culvert Crossing

After the box culvert, there are shallow ditches on both sides of the road. The ground is relatively flat but flows gradually south towards the stream. There is an exposed culvert in that stretch.

Figure 7-22 CR-75 – Exposed Culvert

North of CR-130, shallow ditches continue along both sides of the road. Approximately 3200′ south of TR-120, a bridge crosses the same stream crossed by the box culvert and 60″ RCP. From this point north, a stream borders CR-75 on the west side. It appears that drainage on the east side of CR-75 flows towards D-10. It is unknown if there are any culverts or structures allowing water to flow from the east side of the roadway into the adjacent stream on the west.

Figure 7-23 CR-75 – Bridge

Appendix A

Figures

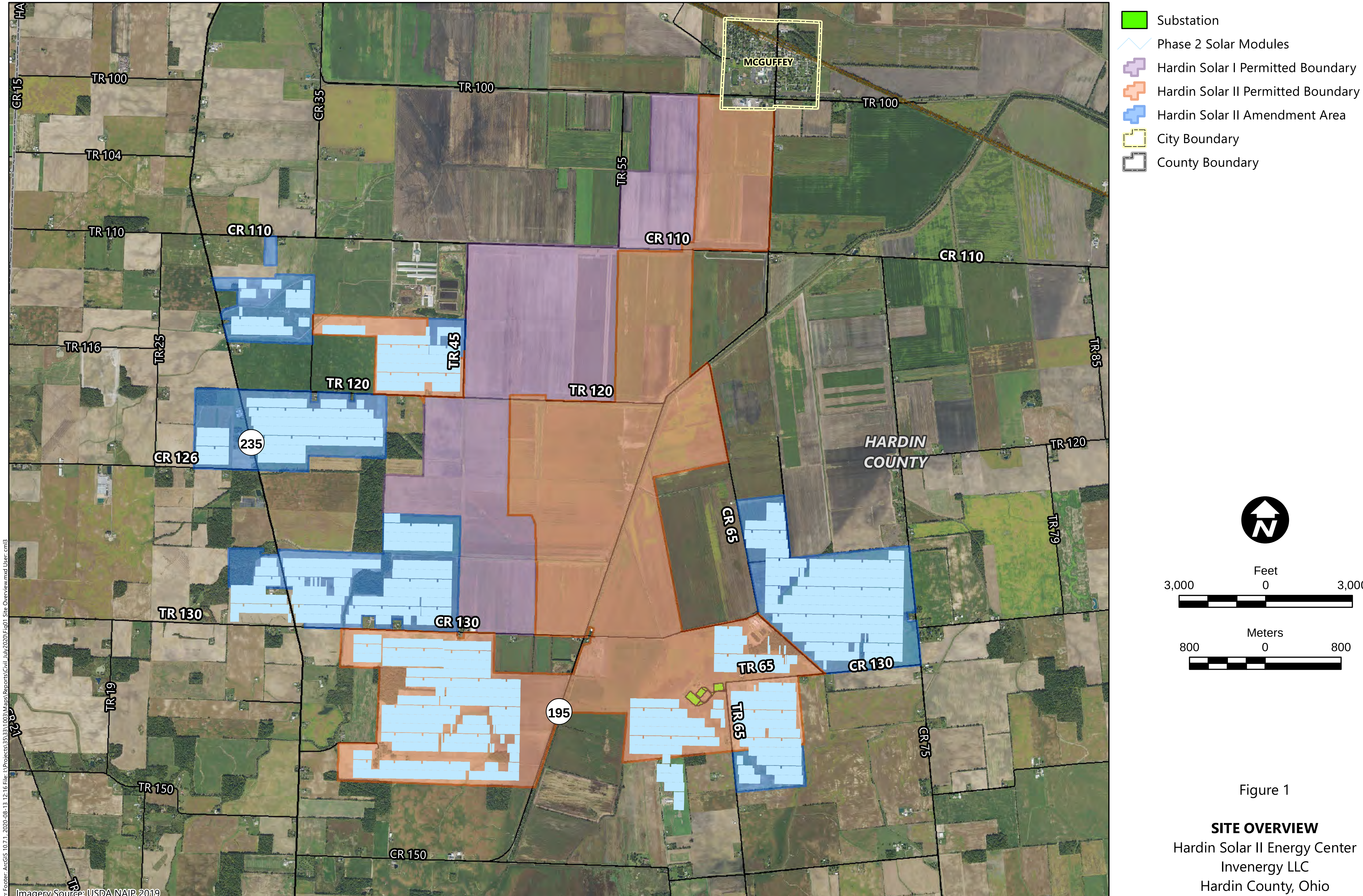


Figure 1

SITE OVERVIEW
Hardin Solar II Energy Center
Invenergy LLC
Hardin County, Ohio

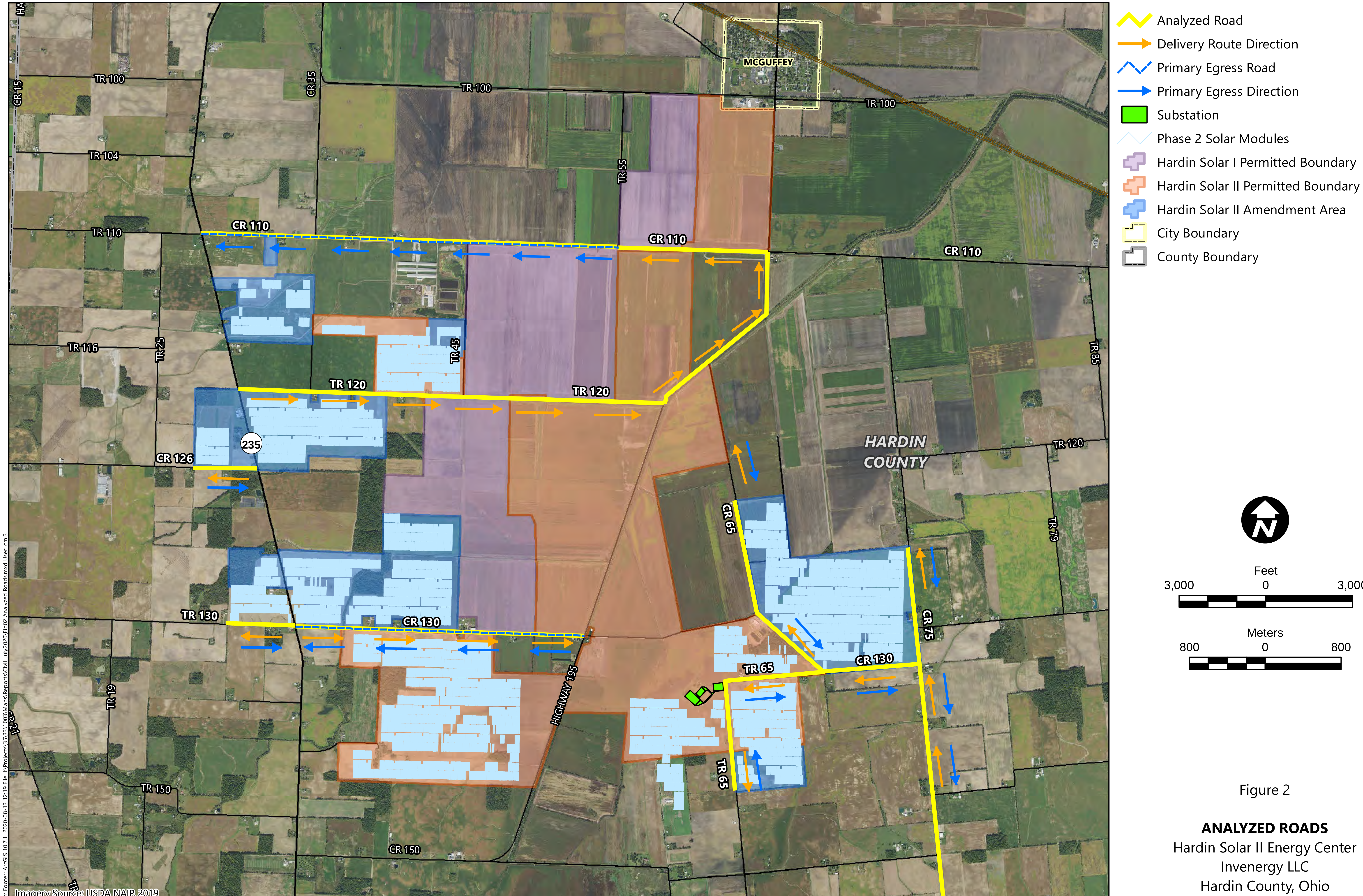
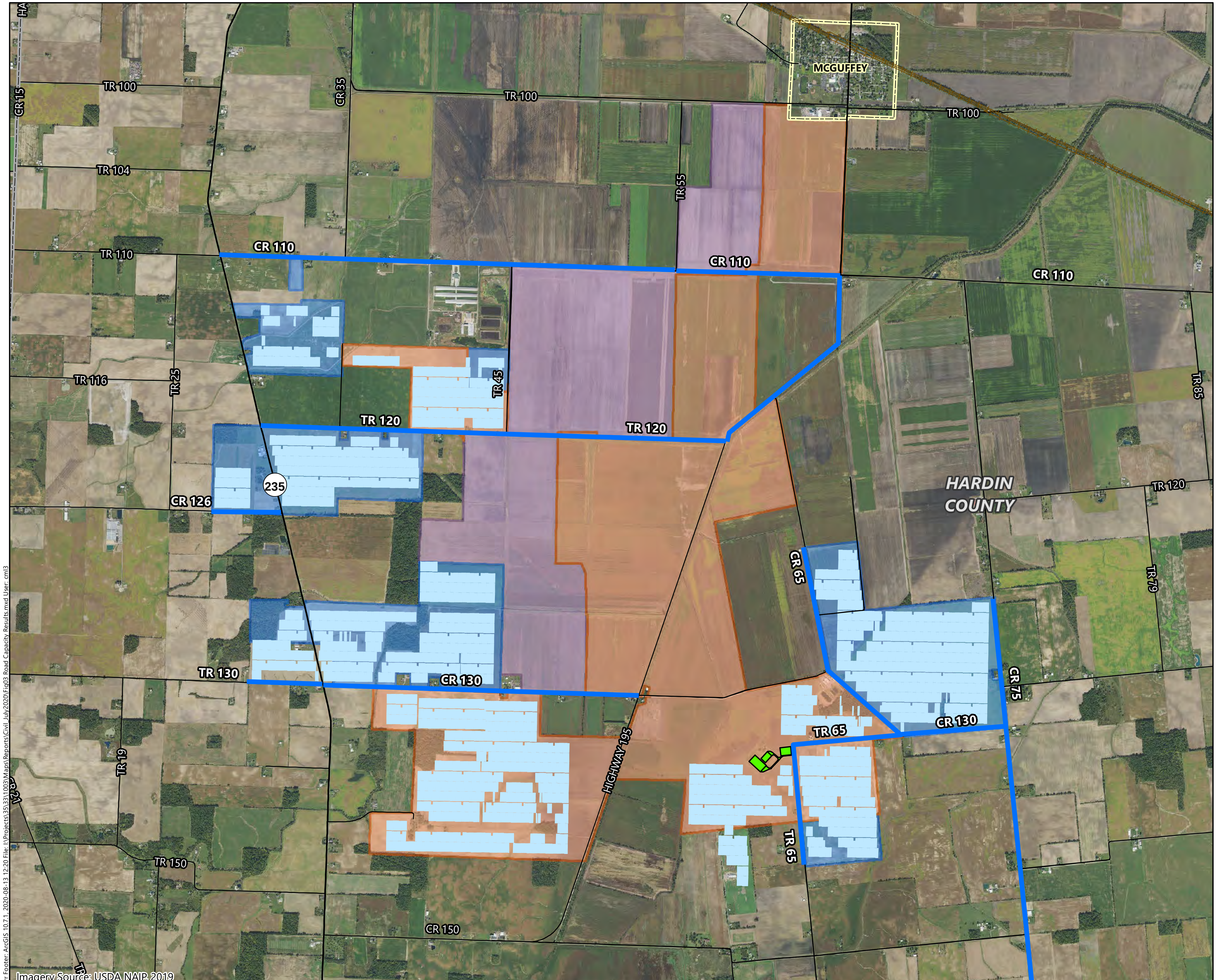


Figure 2

ANALYZED ROADS
Hardin Solar II Energy Center
Invenergy LLC
Hardin County, Ohio



Substation
Phase 2 Solar Modules
Hardin Solar I Permitted Boundary
Hardin Solar II Permitted Boundary
Hardin Solar II Amendment Area
City Boundary
County Boundary

Road Capacity Results

Acceptable

Feet
3,000 0 3,000

Meters
800 0 800

Figure 3

ROAD CAPACITY RESULTS
Hardin Solar II Energy Center
Invenergy LLC
Hardin County, Ohio

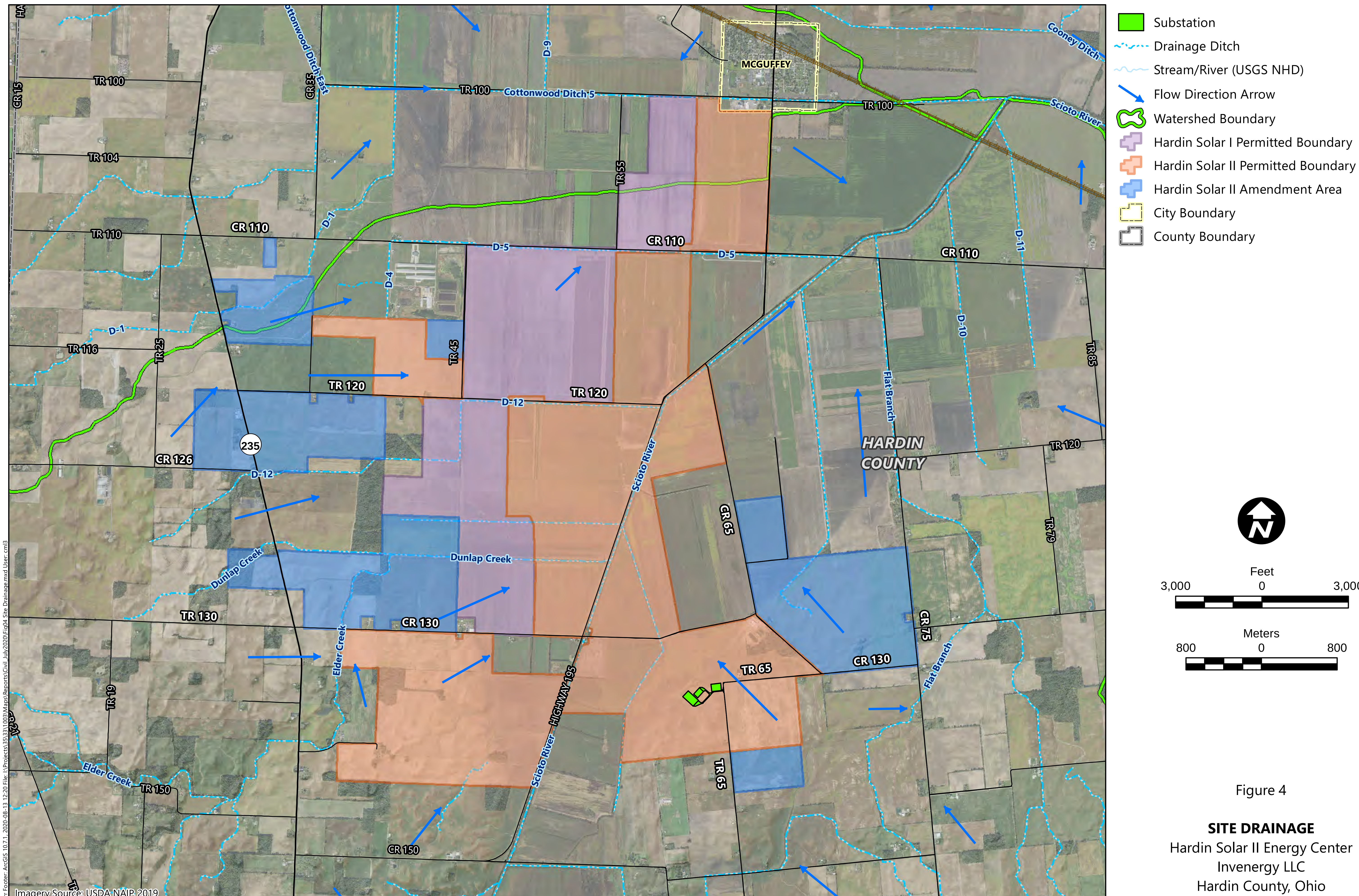


Figure 4

SITE DRAINAGE
Hardin Solar II Energy Center
Invenergy LLC
Hardin County, Ohio

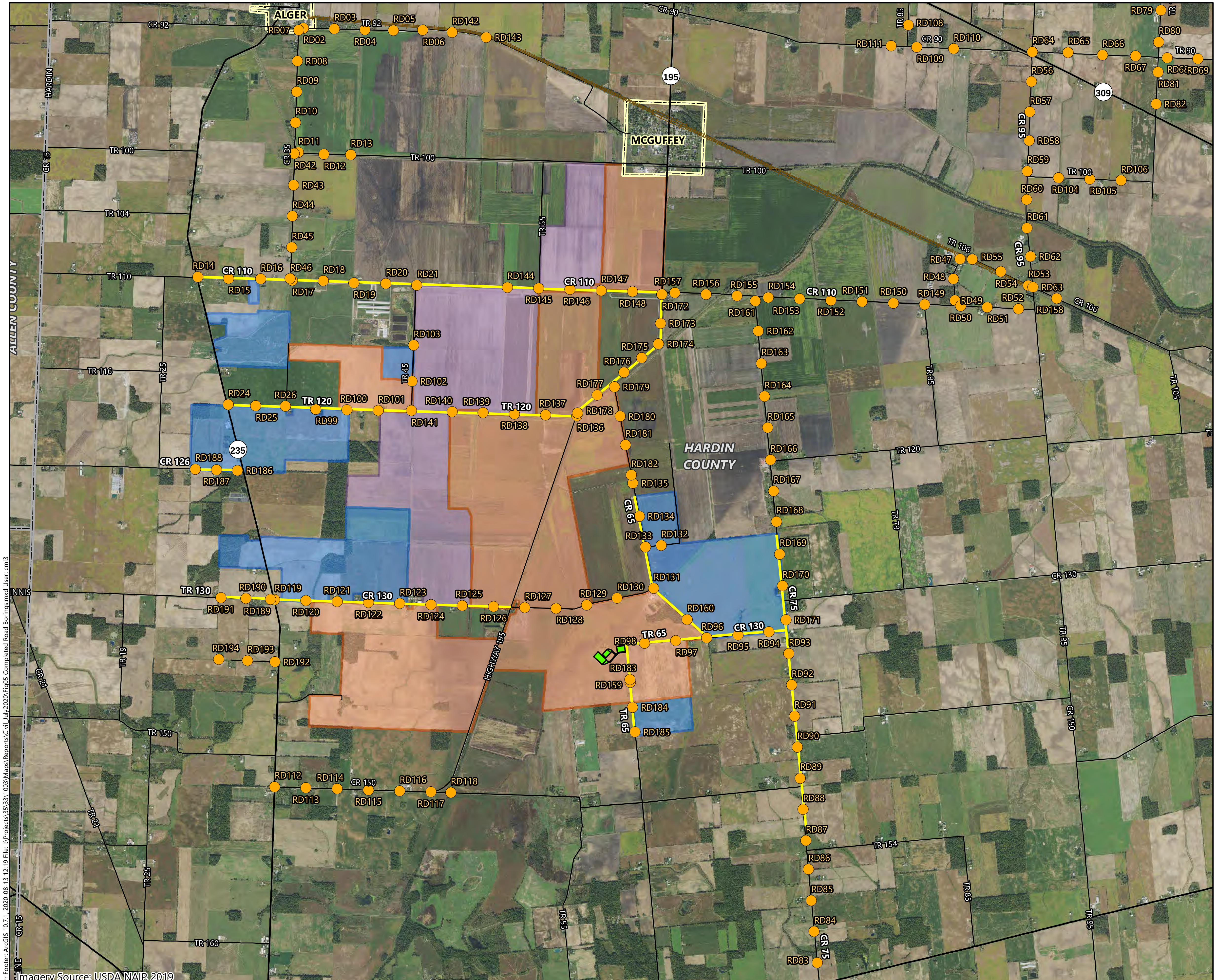


Figure 5

COMPLETED ROAD BORINGS
Hardin Solar II Energy Center
Invenergy LLC
Hardin County, Ohio

Appendix B

ASTM D 6433-07

Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys

Designation: D 6433 – 07

Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys[1]

This standard is issued under the fixed designation D 6433; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the determination of roads and parking lots pavement condition through visual surveys using the Pavement Condition Index (PCI) method of quantifying pavement condition.

1.2 The PCI for roads and parking lots was developed by the U.S. Army Corps of Engineers **(1, 2)**.[2] It is further verified and adopted by DOD and APWA.

1.3 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 6.

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *additional sample*—a sample unit inspected in addition to the random sample units to include nonrepresentative sample units in the determination of the pavement condition. This includes very poor or excellent samples that are not typical of the section and sample units, which contain an unusual distress such as a utility cut. If a sample unit containing an unusual distress is chosen at random it should be counted as an additional sample unit and another random sample unit should be chosen. If every sample unit is surveyed, then there are no additional sample units.

2.1.2 *asphalt concrete (AC) surface*—aggregate mixture with an asphalt cement binder. This term also refers to surfaces constructed of coal tars and natural tars for purposes of this practice.

2.1.3 *pavement branch*—a branch is an identifiable part of the pavement network that is a single entity and has a distinct function. For example, each roadway or parking area is a separate branch.

2.1.4 *pavement condition index (PCI)*—a numerical rating of the pavement condition that ranges from 0 to 100 with 0 being the worst possible condition and 100 being the best possible condition.

2.1.5 *pavement condition rating*—a verbal description of pavement condition as a function of the PCI value that varies from "failed" to "excellent" as shown in Fig. 1.

2.1.6 *pavement distress*—external indicators of pavement deterioration caused by loading, environmental factors, construction deficiencies, or a combination thereof. Typical distresses are cracks, rutting, and weathering of the pavement surface. Distress types and severity levels detailed in Appendix X1 for AC, and Appendix X2 for PCC pavements must be used to obtain an accurate PCI value.

2.1.7 *pavement sample unit*—a subdivision of a pavement section that has a standard size range: 20 contiguous slabs (± 8 slabs if the total number of slabs in the section is not evenly divided by 20 or to accommodate specific field condition) for PCC pavement, and 2500 contiguous square feet, $\pm$ 1000 ft^2 (225 $\pm$ 90 m^2), if the pavement is not evenly divided by 2500 or to accommodate specific field condition, for AC pavement.

2.1.8 *pavement section*—a contiguous pavement area having uniform construction, maintenance, usage history, and condition. A section should have the same traffic volume and load intensity.

2.1.9 *portland cement concrete (PCC) pavement*—aggregate mixture with portland cement binder including nonreinforced and reinforced jointed pavement.

2.1.10 *random sample*—a sample unit of the pavement section selected for inspection by random sampling techniques, such as a random number table or systematic random procedure.

3. Summary of Practice

3.1 The pavement is divided into branches that are divided into sections. Each section is divided into sample units. The type and severity of pavement distress is assessed by visual

---

[1] This practice is under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and is the direct responsibility of Subcommittee E17.41 on Pavement Testing, Evaluation, and Management Methods.

Current edition approved Dec. 1, 2007. Published January 2008. Originally approved in 1999. Last previous edition approved in 2003 as D 6433 – 03.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

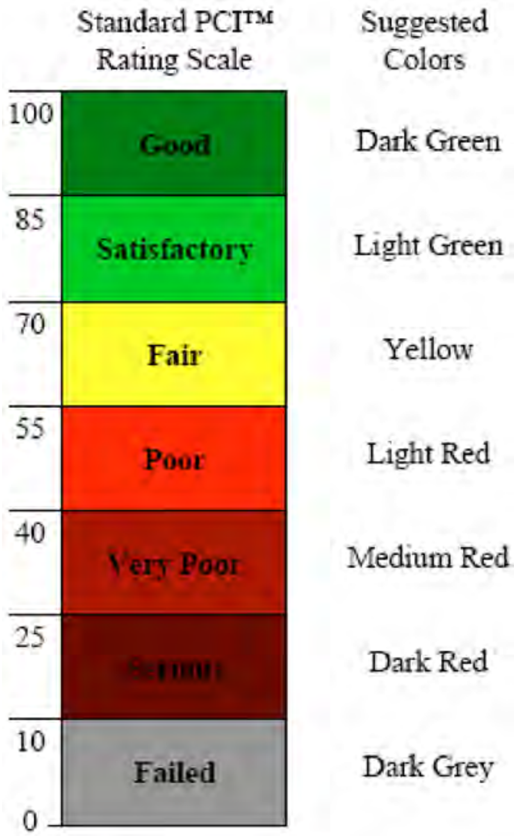


FIG. 1 Pavement Condition Index (PCI), Rating Scale, and Suggested Colors

inspection of the pavement sample units. The quantity of the distress is measured as described in Appendix X1 and Appendix X2. The distress data are used to calculate the PCI for each sample unit. The PCI of the pavement section is determined based on the PCI of the inspected sample units within the section.

4. Significance and Use

4.1 The PCI is a numerical indicator that rates the surface condition of the pavement. The PCI provides a measure of the present condition of the pavement based on the distress observed on the surface of the pavement, which also indicates the structural integrity and surface operational condition (localized roughness and safety). The PCI cannot measure structural capacity nor does it provide direct measurement of skid resistance or roughness. It provides an objective and rational basis for determining maintenance and repair needs and priorities. Continuous monitoring of the PCI is used to establish the rate of pavement deterioration, which permits early identification of major rehabilitation needs. The PCI provides feedback on pavement performance for validation or improvement of current pavement design and maintenance procedures.

5. Apparatus

5.1 *Data Sheets*, or other field recording instruments that record at a minimum the following information: date, location, branch, section, sample unit size, slab number and size, distress types, severity levels, quantities, and names of surveyors. Example data sheets for AC and PCC pavements are shown in Figs. 2 and 3.

5.2 *Hand Odometer Wheel*, that reads to the nearest 0.1 ft (30 mm).

5.3 *Straightedge or String Line*, (AC only), 10 ft (3 m).

5.4 *Scale*, 12 in. (300 mm) that reads to ⅛ in. (3 mm) or better. Additional 12-in. (300 mm) ruler or straightedge is needed to measure faulting in PCC pavements.

5.5 *Layout Plan*, for network to be inspected.

6. Hazards

6.1 Traffic is a hazard as inspectors may walk on the pavement to perform the condition survey.

7. Sampling and Sample Units

7.1 Identify branches of the pavement with different uses such as roadways and parking on the network layout plan.

7.2 Divide each branch into sections based on the pavements design, construction history, traffic, and condition.

7.3 Divide the pavement sections into sample units. If the pavement slabs in PCC have joint spacing greater than 25 ft (8 m) subdivide each slab into imaginary slabs. The imaginary slabs all should be less than or equal to 25 ft (8 m) in length, and the imaginary joints dividing the slabs are assumed to be in perfect condition. This is needed because the deduct values developed for jointed concrete slabs are less than or equal to 25 ft (8 m).

7.4 Individual sample units to be inspected should be marked or identified in a manner to allow inspectors and quality control personnel to easily locate them on the pavement surface. Paint marks along the edge and sketches with locations connected to physical pavement features are acceptable. It is necessary to be able to accurately relocate the sample units to allow verification of current distress data, to examine changes in condition with time of a particular sample unit, and to enable future inspections of the same sample unit if desired.

7.5 Select the sample units to be inspected. The number of sample units to be inspected may vary from the following: all of the sample units in the section, a number of sample units that provides a 95 % confidence level, or a lesser number.

7.5.1 All sample units in the section may be inspected to determine the average PCI of the section. This is usually precluded for routine management purposes by available manpower, funds, and time. Total sampling, however, is desirable for project analysis to help estimate maintenance and repair quantities.

7.5.2 The minimum number of sample units (n) that must be surveyed within a given section to obtain a statistically adequate estimate (95 % confidence) of the PCI of the section

ASPHALT SURFACED ROADS AND PARKING LOTS CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT	SKETCH:
BRANCH ____________ SECTION _________ SAMPLE UNIT _________ SURVEYED BY ___________ DATE _________ SAMPLE AREA _________	

1. Alligator Cracking	6. Depression	11. Patching & Util Cut Patching	16. Shoving
2. Bleeding	7. Edge Cracking	12. Polished Aggregate	17. Slippage Cracking
3. Block Cracking	8. Jt. Reflection Cracking	13. Potholes	18. Swell
4. Bumps and Sags	9. Lane/Shoulder Drop Off	14. Railroad Crossing	19. Weathering/Raveling
5. Corrugation	10. Long & Trans Cracking	15. Rutting	

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE

FIG. 2 Flexible Pavement Condition Survey Data Sheet for Sample Unit

CONCRETE SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH____________ SECTION____________ SAMPLE UNIT____________
SURVEYED BY__________ DATE____________ SAMPLE AREA____________

Distress Types

21. Blow up/Buckling
22. Corner Break
23. Divided Slab
24. Durability Crack
25. Faulting
26. Joint Seal
27. Lane/Shoulder
28. Linear Cracking
29. Patching (Large)
30. Patching (Small)
31. Polished Aggregate
32. Popouts
33. Pumping
34. Punchout
35. Railroad Crossing
36. Scaling
37. Shrinkage
38. Spalling Corner
39. Spalling Joint

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE

SKETCH:

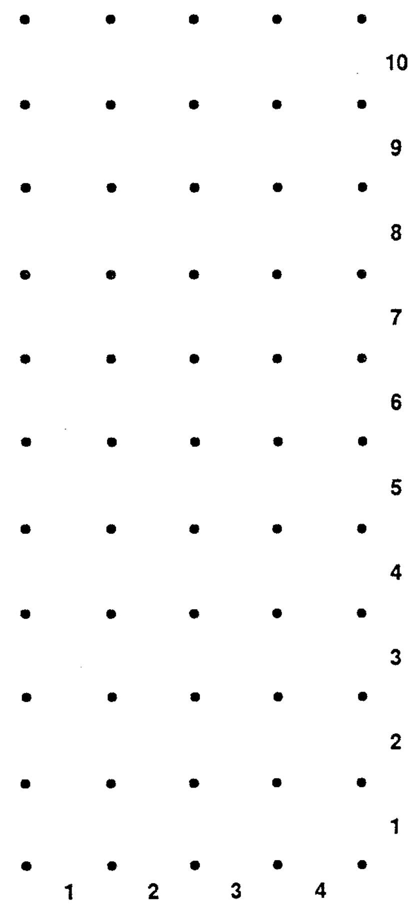


FIG. 3 Joint Rigid Pavement Condition Survey Data Sheet for Sample Unit

is calculated using the following formula and rounding n to the next highest whole number (see Eq 1).

$$n = Ns^2/((e^2/4)(N-1) + s^2) \quad (1)$$

where:

e = acceptable error in estimating the section PCI; commonly, $e = \pm 5$ PCI points;
s = standard deviation of the PCI from one sample unit to another within the section. When performing the initial inspection the standard deviation is assumed to be ten for AC pavements and 15 for PCC pavements. This assumption should be checked as described below after PCI values are determined. For subsequent inspections, the standard deviation from the preceding inspection should be used to determine n; and,
N = total number of sample units in the section.

7.5.2.1 If obtaining the 95 % confidence level is critical, the adequacy of the number of sample units surveyed must be confirmed. The number of sample units was estimated based on an assumed standard deviation. Calculate the actual standard deviation (s) as follows (see Eq 2):

$$s = \left(\sum_{i=1}^{n}(PCI_i - PCI_s)^2/(n-1)\right)^{1/2} \quad (2)$$

where:

PCI_i = PCI of surveyed sample units i,
PCI_s = PCI of section (mean PCI of surveyed sample units), and
n = total number of sample units surveyed.

7.5.2.2 Calculate the revised minimum number of sample units (Eq 1) to be surveyed using the calculated standard deviation (Eq 2). If the revised number of sample units to be surveyed is greater than the number of sample units already surveyed, select and survey additional random sample units. These sample units should be spaced evenly across the section. Repeat the process of checking the revised number of sample units and surveying additional random sample units until the total number of sample units surveyed equals or exceeds the minimum required sample units (*n*) in Eq 1, using the actual total sample standard deviation.

7.5.3 Once the number of sample units to be inspected has been determined, compute the spacing interval of the units using systematic random sampling. Samples are spaced equally throughout the section with the first sample selected at random. The spacing interval (*i*) of the units to be sampled is calculated by the following formula rounded to the next lowest whole number:

$$i = N/n \tag{3}$$

where:
N = total number of sample units in the section, and
n = number of sample units to be inspected.

The first sample unit to be inspected is selected at random from sample units 1 through *i*. The sample units within a section that are successive increments of the interval *i* after the first randomly selected unit also are inspected.

7.6 A lessor sampling rate than the above mentioned 95 % confidence level can be used based on the condition survey objective. As an example, one agency uses the following table for selecting the number of sample units to be inspected for other than project analysis:

Given	Survey
1 to 5 sample units	1 sample unit
6 to 10 sample units	2 sample units
11 to 15 sample units	3 sample units
16 to 40 sample units	4 sample units
over 40 sample units	10 %

7.7 Additional sample units only are to be inspected when nonrepresentative distresses are observed as defined in 2.1.1. These sample units are selected by the user.

8. Inspection Procedure

8.1 The definitions and guidelines for quantifying distresses for PCI determination are given in Appendix X1 for AC pavements. Using this test method, inspectors should identify distress types accurately 95 % of the time. Linear measurements should be considered accurate when they are within 10 % if remeasured, and area measurements should be considered accurate when they are within 20 % if remeasured. Distress severities that one determines based on ride quality are considered subjective.

8.2 *Asphalt Concrete (AC) Surfaced Pavement*—Individually inspect each sample unit chosen. Sketch the sample unit, including orientation. Record the branch and section number and the number and type of the sample unit (random or additional). Record the sample unit size measured with the hand odometer. Conduct the distress inspection by walking over the sidewalk/shoulder of the sample unit being surveyed, measuring the quantity of each severity level of every distress type present, and recording the data. Each distress must correspond in type and severity to that described in Appendix X1. The method of measurement is included with each distress description. Repeat this procedure for each sample unit to be inspected. A copy of a Blank Flexible Pavement Condition Survey Data Sheet for Sample Unit is included in Fig. 2.

8.3 *PCC Pavements*—Individually inspect each sample unit chosen. Sketch the sample unit showing the location of the slabs. Record the sample unit size, branch and section number, and number and type of the sample unit (random or additional), the number of slabs in the sample unit and the slab size measured with the hand odometer. Perform the inspection by walking over the sidewalk/shoulder of the sample unit being surveyed and recording all distress existing in the slab along with their severity level. Each distress type and severity must correspond with that described in Appendix X2. Summarize the distress types, their severity levels and the number of slabs in the sample unit containing each type and severity level. Repeat this procedure for each sample unit to be inspected. A copy of a Blank Jointed Rigid Pavement Condition Survey Data Sheet for Sample Unit is included in Fig. 3.

9. Calculation of PCI for Asphalt Concrete (AC) Pavement

9.1 Add up the total quantity of each distress type at each severity level, and record them in the "Total Severities" section. For example, Fig. 4 shows five entries for the Distress Type 1, "Alligator Cracking": 5L, 4L, 4L, 8H, and 6H. The distress at each severity level is summed and entered in the "Total Severity" section as 13 ft^2 (1.2 m^2) of low severity and 14 ft^2 (1.3 m^2) of medium severity. The units for the quantities may be either in square feet (square meters), linear feet (meters), or number of occurrences, depending on the distress type.

9.2 Divide the total quantity of each distress type at each severity level from 9.1 by the total area of the sample unit and multiply by 100 to obtain the percent density of each distress type and severity.

9.3 Determine the deduct value (DV) for each distress type and severity level combination from the distress deduct value curves in Appendix X3.

9.4 Determine the maximum corrected deduct value (CDV). The procedure for determining maximum CDV from individual DVs is identical for both AC and PCC pavement types.

9.5 The following procedure must be used to determine the maximum CDV.

9.5.1 If none or only one individual deduct value is greater than two, the total value is used in place of the maximum CDV in determining the PCI; otherwise, maximum CDV must be determined using the procedure described in 9.5.2-9.5.5.

9.5.2 List the individual deduct values in descending order. For example, in Fig. 4 this will be 25.1, 23.4, 17.9, 11.2, 7.9, 7.5, 6.9, and 5.3.

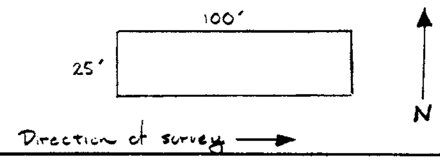
9.5.3 Determine the allowable number of deducts, *m*, from Fig. 5, or using the following formula (see Eq 4):

$$m = 1 + (9/98)(100–HDV) \leq 10 \tag{4}$$

ASPHALT SURFACED ROADS AND PARKING LOTS CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH SPRINGFIELD **SECTION** 001 **SAMPLE UNIT** 1
SURVEYED BY KAK **DATE** 10 Jul 93 **SAMPLE AREA** 2500 sf

SKETCH:



1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Bumps and Sags
5. Corrugation
6. Depression
7. Edge Cracking
8. Jt. Reflection Cracking
9. Lane/Shoulder Drop Off
10. Long & Trans Cracking
11. Patching & Util Cut Patching
12. Polished Aggregate
13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage Cracking
18. Swell
19. Weathering/Raveling

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE
1 L	1×5	1×4	1×4							13	0.52	7.9
1 H	1×8	1×6								14	0.56	23.4
7 L	32	15	18	24	41					130	5.20	7.5
8 M	20	15	35	27	23	10	13			143	5.72	25.1
11 H	3×4	2×5								22	0.88	17.9
13 L	1									1	0.04	11.2
15 L	4	9	8							21	0.84	6.9
19 L	250									250	10.0	5.3

FIG. 4 Example of a Flexible Pavement Condition Survey Data Sheet

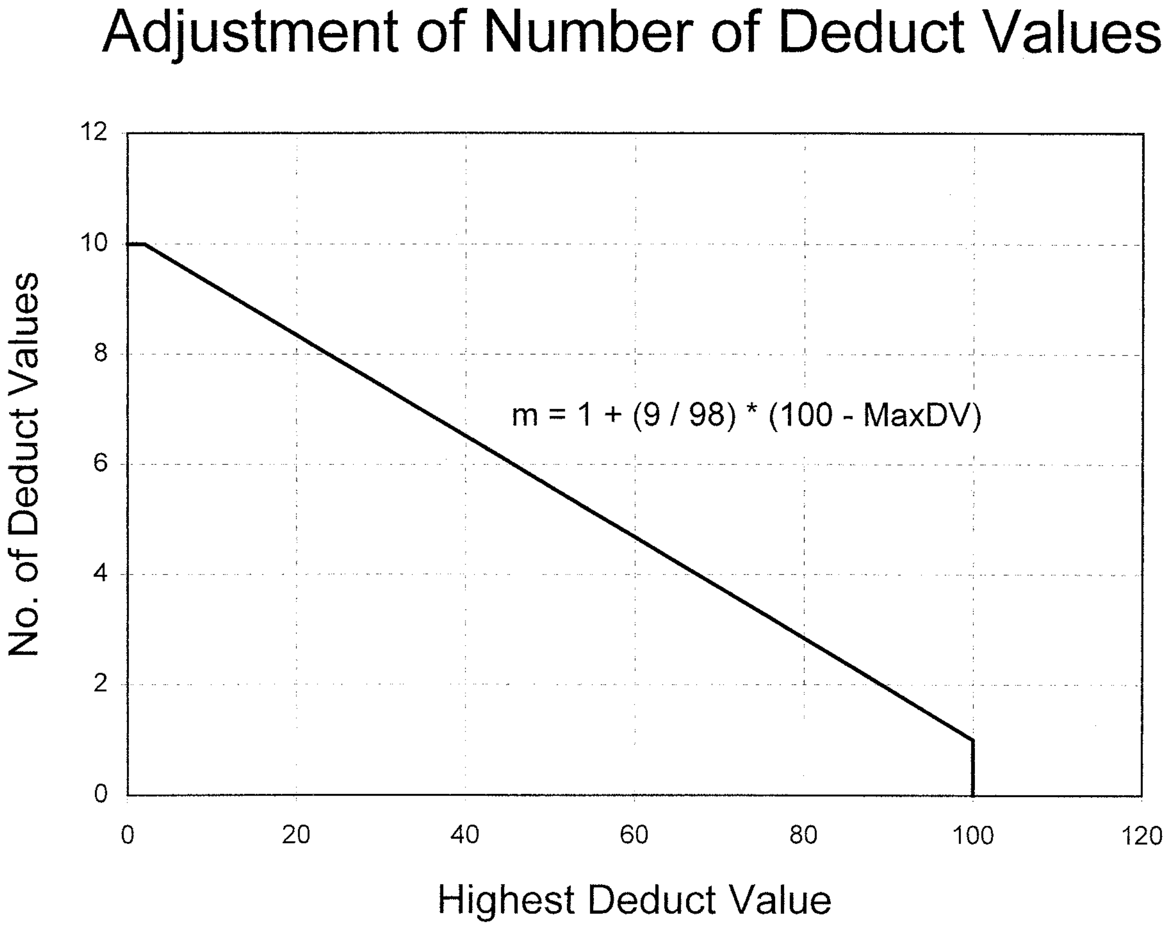


FIG. 5 Adjustment of Number of Deduct Values

where:

m = allowable number of deducts including fractions (must be less than or equal to ten), and

HDV = highest individual deduct value.

(For the example in Fig. 4, m = 1 + (9/98)(100-25.1) = 7.9).

9.5.4 The number of individual deduct values is reduced to the m largest deduct values, including the fractional part. For the example in Fig. 6, the values are 25.1, 23.4, 17.9, 11.2, 7.9, 7.5, 6.9, and 4.8 (the 4.8 is obtained by multiplying 5.3 by (7.9 – 7 = 0.9)). If less than m deduct values are available, all of the deduct values are used.

9.5.5 Determine maximum CDV iteratively, as shown in Fig. 6.

9.5.5.1 Determine total deduct value by summing individual deduct values. The total deduct value is obtained by adding the individual deduct values in 9.5.4, that is, 104.7.

9.5.5.2 Determine q as the number of deducts with a value greater than 2.0. For example, in Fig. 6, q = 8.

9.5.5.3 Determine the CDV from total deduct value and q by looking up the appropriate correction curve for AC pavements in Fig. X4.15 in Appendix X3.

9.5.5.4 Reduce the smallest individual deduct value greater than 2.0 to 2.0 and repeat 9.5.5.1-9.5.5.3 until q = 1.

9.5.5.5 Maximum CDV is the largest of the CDVs.

9.6 Calculate PCI by subtracting the maximum CDV from 100: PCI = 100-max CDV.

9.7 Fig. 6 shows a summary of PCI calculation for the example AC pavement data in Fig. 4. A blank PCI calculation form is included in Fig. 2.

10. Calculation of PCI for Portland Cement Concrete (PCC) Pavement

10.1 For each unique combination of distress type and severity level, add up the total number of slabs in which they occur. For the example in Fig. 7, there are two slabs containing low-severity corner break (Distress 22L).

10.2 Divide the number of slabs from 10.1 by the total number of slabs in the sample unit and multiply by 100 to obtain the percent density of each distress type and severity combination.

10.3 Determine the deduct values for each distress type severity level combination using the corresponding deduct curve in Appendix X4.

10.4 Determine PCI by following the procedures in 9.5 and 9.6, using the correction curve for PCC pavements (see Fig. X4.20 in Appendix X4) in place of the correction curve for AC pavements.

m = 1 + (9/98) (100 - 25.1) = 7.9 < 8

Use highest 7 deducts and 0.9 of eighth deduct.

0.9 x 5.3 = 4.8

#	Deduct Values										Total	q	CDV
1	25.1	23.4	17.9	11.2	7.9	7.5	6.9	4.8			104.7	8	51.0
2	25.1	23.4	17.9	11.2	7.9	7.5	6.9	2			101.9	7	50.0
3	25.1	23.4	17.9	11.2	7.9	7.5	2	2			96.0	6	46.0
4	25.1	23.4	17.9	11.2	7.9	2	2	2			90.5	5	47.0
5	25.1	23.4	17.9	11.2	2	2	2	2			84.6	4	48.0
6	25.1	23.4	17.9	2	2	2	2	2			75.4	3	48.0
7	25.1	23.4	2	2	2	2	2	2			59.5	2	44.0
8	25.1	2	2	2	2	2	2	2			38.1	1	38.0
9													
10													

Max CDV = 51

PCI = 100 - Max CDV = 49

Rating = FAIR

FIG. 6 Calculation of Corrected PCI Value—Flexible Pavement

10.5 Fig. 7 shows a summary of PCI calculation for the example PCC pavement distress data in Fig. 8.

11. Determination of Section PCI

11.1 If all surveyed sample units are selected randomly, then the PCI of the section (PCI_s) is calculated as the area weighted PCI of the randomly surveyed sample units ($\overline{PCI_r}$) using equation 5:

$$PCI_S = \overline{PCI_r} = \frac{\sum_{i=1}^{n} (PCI_{ri} \cdot A_{ri})}{\sum_{i=1}^{n} A_{ri}} \tag{5}$$

CONCRETE SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH SECOND SECTION 001 SAMPLE UNIT 1
SURVEYED BY KAK DATE 10 JUL 93 SAMPLE AREA 20 slabs

Distress Types

21. Blow up/Buckling
22. Corner Break
23. Divided Slab
24. Durability Crack
25. Faulting
26. Joint Seal
27. Lane/Shoulder
28. Linear Cracking
29. Patching (Large)
30. Patching (Small)
31. Polished Aggregate
32. Popouts
33. Pumping
34. Punchout
35. Railroad Crossing
36. Scaling
37. Shrinkage
38. Spalling Corner
39. Spalling Joint

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE
26	H	—	100	8.0
22	L	3	15	12.6
22	M	1	5	7.7
23	M	3	15	30.5
30	M	4	20	4.4
34	M	2	10	25.1
38	L	6	30	5.8
39	H	1	5	9.0

SKETCH:

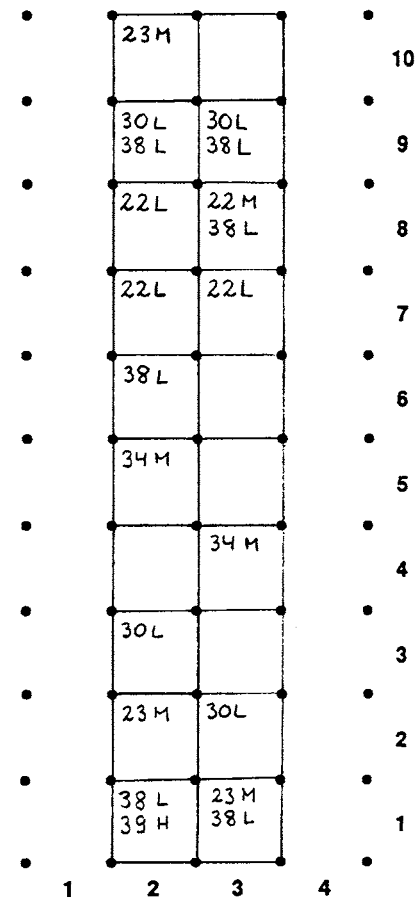


FIG. 7 Example of a Jointed Rigid Pavement Condition Survey Data Sheet

where:

$\overline{PCI_r}$ = area weighted PCI of randomly surveyed sample units,
PCI_{ri} = PCI of random sample unit i,
A_{ri} = area of random sample unit i,
n = number of random sample units surveyed.

If additional sample units, as defined in 2.1.1, are surveyed, the area weighted PCI of the surveyed additional units ($\overline{PCI_a}$) is calculated using equation 6. The PCI of the pavement section is calculated using equation 7.

$$\overline{PCI_a} = \frac{\sum_{i=1}^{m} (PCI_{ai} \cdot A_{ai})}{\sum_{i=1}^{m} A_{ai}} \tag{6}$$

$$PCI_s = \frac{\overline{PCI_r}(A - \sum_{i=1}^{m} A_{ai}) + \overline{PCI_a}(\sum_{i=1}^{m} A_{ai})}{A} \tag{7}$$

m = 1 + (9/98) (100 - 30.5) = 7.4 < 8

Use highest 7 deducts and 0.4 of eighth deduct.

0.4 x 4.4 = 1.76

#	Deduct Values										Total	q	CDV
1	30.5	25.1	12.6	9.0	8.0	7.7	5.8	1.76			100.5	7	50.0
2	30.5	25.1	12.6	9.0	8.0	7.7	2	1.76			96.7	6	49.5
3	30.5	25.1	12.6	9.0	8.0	2	2	1.76			91.0	5	51.0
4	30.5	25.1	12.6	9.0	2	2	2	1.76			85.0	4	49.0
5	30.5	25.1	12.6	2	2	2	2	1.76			78.0	3	50.0
6	30.5	25.1	2	2	2	2	2	1.76			67.4	2	50.0
7	30.5	2	2	2	2	2	2	1.76			44.3	1	44.3
8													
9													
10													

Max CDV = 51

PCI = 100 - Max CDV = 49

Rating = FAIR

FIG. 8 Calculation of Corrected PCI Value—Jointed Rigid Pavement

$\overline{PCI_a}$ = area weighted PCI of additional sample units,
PCI_{ai} = PCI of additional sample unit i,
A_{ai} = area of additional sample unit i,
A = area of section,
m = number of additional sample units surveyed, and
PCI_s = area weighted PCI of the pavement section.

11.2 Determine the overall condition rating of the section by using the section PCI and the condition rating scale in Fig. 1.

12. Report

12.1 Develop a summary report for each section. The summary lists section location, size, total number of sample units, the sample units inspected, the PCIs obtained, the average PCI for the section, and the section condition rating.

APPENDIXES

(Nonmandatory Information)

X1. Distress in Asphalt Pavements

X1.1 During the field condition surveys and validation of the PCI, several questions are commonly asked about the identification and measurement of some of the distresses. The answers to these questions for each distress are included under the heading "How to Measure." For convenience, however, the most frequently raised issues are addressed below:

X1.1.1 If alligator cracking and rutting occur in the same area, each is recorded separately at its respective severity level.

X1.1.2 If bleeding is counted, polished aggregate is not counted in the same area.

X1.1.3 Spalling as used herein is the further breaking of pavement or loss of materials around cracks or joints.

X1.1.4 If a crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. If, however, the different levels of severity in a portion of a crack cannot be easily divided, that portion should be rated at the highest severity level present.

X1.1.5 If any distress, including cracking and potholes, is found in a patched area, it is not recorded; its effect on the patch, however, is considered in determining the severity level of the patch.

X1.1.6 A significant amount of polished aggregate should be present before it is counted.

X1.1.7 A distress is said to be raveled if the area surrounding the distress is broken (sometimes to the extent that pieces are removed).

X1.2 The reader should note that the items above are general issues and do not stand alone as inspection criteria. To properly measure each distress type, the inspector must be familiar with its individual measurement criteria.

X1.3 Nineteen distress types for asphalt-surfaced pavements are listed alphabetically in this manual.

RIDE QUALITY

X1.4 Ride quality must be evaluated in order to establish a severity level for the following distress types:

X1.4.1 Bumps.

X1.4.2 Corrugation.

X1.4.3 Railroad crossings.

X1.4.4 Shoving.

X1.4.5 Swells.

X1.4.6 To determine the effect these distresses have on ride quality, the inspector should drive at the normal operating speed and use the following severity-level definitions of ride quality:

X1.4.6.1 **L**—Low. Vehicle vibrations, for example, from corrugation, are noticeable, but no reduction in speed is necessary for comfort or safety. Individual bumps or settlements, or both, cause the vehicle to bounce slightly, but create little discomfort.

X1.4.6.2 **M**—Medium. Vehicle vibrations are significant and some reduction in speed is necessary for safety and comfort. Individual bumps or settlements, or both, cause the vehicle to bounce significantly, creating some discomfort.

X1.4.6.3 **H**—High. Vehicle vibrations are so excessive that speed must be reduced considerably for safety and comfort. Individual bumps or settlements, or both, cause the vehicle to bounce excessively, creating substantial discomfort, safety hazard, or high potential vehicle damage.

X1.4.7 The inspector should drive at the posted speed in a sedan that is representative of cars typically seen in local traffic. Pavement sections near stop signs should be rated at a deceleration speed appropriate for the intersection.

ALLIGATOR CRACKING (FATIGUE)

X1.5 *Description*—Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading. Cracking begins at the bottom of the asphalt surface, or stabilized base, where tensile stress and strain are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel longitudinal cracks. After repeated traffic loading, the cracks connect, forming many sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are generally less than 0.5 m (1.5 ft) on the longest side. Alligator cracking occurs only in areas subjected to repeated traffic loading, such as wheel paths. Pattern-type cracking that occurs over an entire area not subjected to loading is called "block cracking," which is not a load-associated distress.

X1.5.1 *Severity Levels*:

X1.5.1.1 **L**—Fine, longitudinal hairline cracks running parallel to each other with no, or only a few interconnecting cracks. The cracks are not spalled (Fig. X1.1).

FIG. X1.1 Low-Severity Alligator Cracking

X1.5.1.2 **M**—Further development of light alligator cracks into a pattern or network of cracks that may be lightly spalled (Fig. X1.2).

X1.5.1.3 **H**—Network or pattern cracking has progressed so that the pieces are well defined and spalled at the edges. Some of the pieces may rock under traffic (Fig. X1.3).

X1.5.2 *How to Measure*—Alligator cracking is measured in square meters (square feet) of surface area. The major difficulty in measuring this type of distress is that two or three levels of severity often exist within one distressed area. If these portions can be easily distinguished from each other, they should be measured and recorded separately; however, if the different levels of severity cannot be divided easily, the entire area should be rated at the highest severity present. If alligator cracking and rutting occur in the same area, each is recorded separately as its respective severity level.

BLEEDING

X1.6 *Description*—Bleeding is a film of bituminous material on the pavement surface that creates a shiny, glasslike, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphaltic cement or tars in the mix, excess application of a bituminous sealant, or low air void content, or a combination thereof. It occurs when asphalt fills the voids of the mix during hot weather and then expands onto the pavement surface. Since the bleeding process in not reversible during cold weather, asphalt or tar will accumulate on the surface.

X1.6.1 *Severity Levels*:

X1.6.1.1 **L**—Bleeding only has occurred to a very slight degree and is noticeable only during a few days of the year. Asphalt does not stick to shoes or vehicles (Fig. X1.4).

X1.6.1.2 **M**—Bleeding has occurred to the extent that asphalt sticks to shoes and vehicles during only a few weeks of the year (Fig. X1.5).

X1.6.1.3 **H**—Bleeding has occurred extensively and considerable asphalt sticks to shoes and vehicles during at least several weeks of the year (Fig. X1.6).

X1.6.2 *How to Measure*—Bleeding is measured in square meters (square feet) of surface area. If bleeding is counted, polished aggregate should not be counted.

FIG. X1.2 Medium-Severity Alligator Cracking

FIG. X1.3 High-Severity Alligator Cracking

FIG. X1.4 Low-Severity Bleeding

FIG. X1.5 Medium-Severity Bleeding

BLOCK CRACKING

X1.7 *Description*—Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 0.3 by 0.3 m (1 by 1 ft) to 3 by 3 m (10 by 10 ft). Block cracking is caused mainly by shrinkage of the asphalt concrete and daily

FIG. X1.6 High-Severity Bleeding

temperature cycling, which results in daily stress/strain cycling. It is not load-associated. Block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large portion of the pavement area, but sometimes will occur only in nontraffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, many-sided pieces with sharp angles. Also, unlike block, alligator cracks are caused by repeated traffic loadings, and therefore, are found only in traffic areas, that is, wheel paths.

X1.7.1 *Severity Levels*:

X1.7.1.1 **L**—Blocks are defined by low-severity[3] cracks (Fig. X1.7).

X1.7.1.2 **M**—Blocks are defined by medium-severity[3] cracks (Fig. X1.8).

X1.7.1.3 **H**—Blocks are defined by high-severity[3] cracks (Fig. X1.9).

X1.7.2 *How to Measure*—Block cracking is measured in m^2 (ft^2) of surface area. It usually occurs at one severity level in a given pavement section; however, if areas of different severity levels can be distinguished easily from one another, they should be measured and recorded separately.

BUMPS AND SAGS

X1.8 *Description*:

X1.8.1 Bumps are small, localized, upward displacements of the pavement surface. They are different from shoves in that shoves are caused by unstable pavement. Bumps, on the other hand, can be caused by several factors, including:

X1.8.1.1 Buckling or bulging of underlying PCC slabs in AC overlay over PCC pavement.

X1.8.1.2 Frost heave (ice, lens growth).

X1.8.1.3 Infiltration and buildup of material in a crack in combination with traffic loading (sometimes called “tenting”).

X1.8.1.4 Sags are small, abrupt, downward displacements of the pavement surface. If bumps appear in a pattern perpendicular to traffic flow and are spaced at less than 3 m (10 ft), the distress is called corrugation. Distortion and displacement that occur over large areas of the pavement surface, causing large or long dips, or both, in the pavement should be recorded as“ swelling.”

X1.8.2 *Severity Levels*:

X1.8.2.1 **L**—Bump or sag causes low-severity ride quality (Fig. X1.10).

X1.8.2.2 **M**—Bump or sag causes medium-severity ride quality (Fig. X1.11).

X1.8.2.3 **H**—Bump or sag causes high-severity ride quality (Fig. X1.12).

X1.8.3 *How to Measure*—Bumps or sags are measured in linear meters (feet). If the bump occurs in combination with a crack, the crack also is recorded.

[3] See definitions of longitudinal transverse cracking within Appendix X2.10.

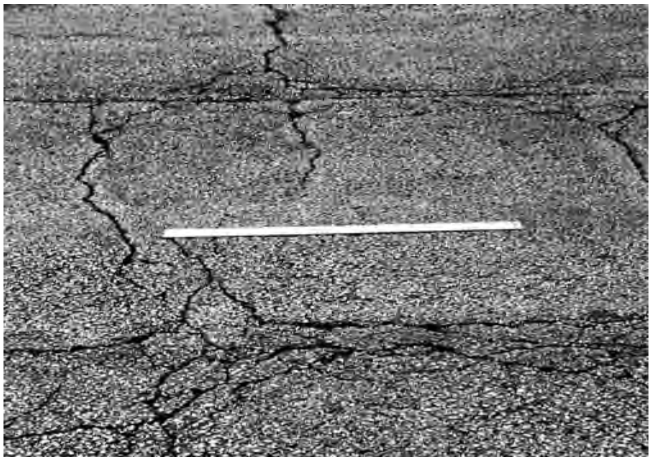


FIG. X1.7 Low-Severity Block Cracking

FIG. X1.8 Medium-Severity Block Cracking

FIG. X1.9 High-Severity Block Cracking

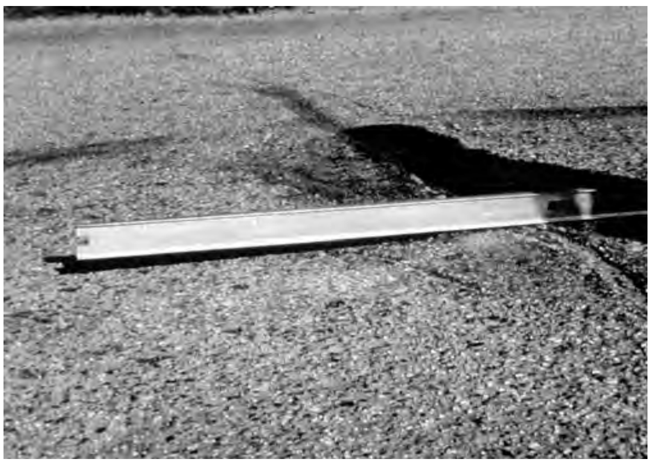


FIG. X1.10 Low-Severity Bumps and Sags

FIG. X1.11 Medium-Severity Bumps and Sags

CORRUGATION

X1.9 *Description*—Corrugation, also known as "washboarding", is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals, usually less than 3 m (10 ft) along the pavement. The ridges are perpendicular to

FIG. X1.12 High-Severity Bumps and Sags

the traffic direction. This type of distress usually is caused by traffic action combined with an unstable pavement surface or base.

X1.9.1 *Severity Levels*:

X1.9.1.1 **L**—Corrugation produces low-severity ride quality (Fig. X1.13).

X1.9.1.2 **M**—Corrugation produces medium-severity ride quality (Fig. X1.14).

X1.9.1.3 **H**—Corrugation produces high-severity ride quality (Fig. X1.15).

X1.9.2 *How to Measure*—Corrugation is measured in square meters (square feet) of surface area.

DEPRESSION

X1.10 *Description*—Depressions are localized pavement surface areas with elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponding water creates a "birdbath" area; on dry pavement, depressions can be spotted by looking for stains caused by ponding water. Depressions are created by settlement of the foundation soil or are a result of

FIG. X1.13 Low-Severity Corrugation

FIG. X1.14 Medium-Severity Corrugation

FIG. X1.15 High-Severity Corrugation

improper construction. Depressions cause some roughness, and when deep enough or filled with water, can cause hydroplaning.

X1.10.1 *Severity Levels (Maximum Depth of Depression)*:

X1.10.1.1 **L**–13 to 25 mm (½ to 1 in.) (Fig. X1.16).

X1.10.1.2 **M**–25 to 50 mm (1 to 2 in.) (Fig. X1.17).

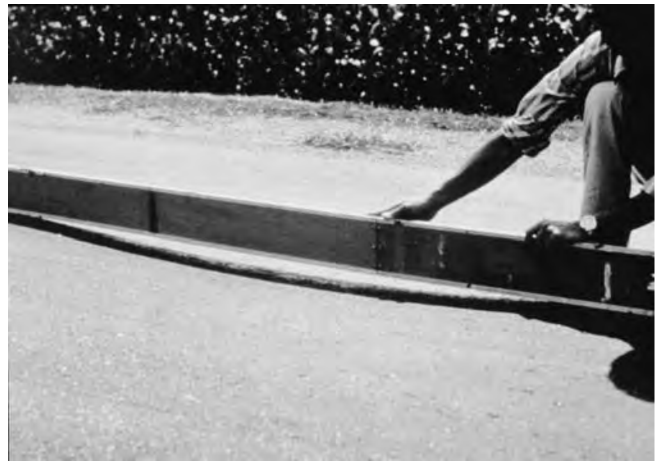


FIG. X1.17 Medium-Severity Depression

X1.10.1.3 **H**—More than 50 mm (2 in.) (Fig. X1.18).

X1.10.2 *How to Measure*—Depressions are measured in square meters (square feet) of surface area.

EDGE CRACKING

X1.11 *Description*—Edge cracks are parallel to and usually within 0.3 to 0.5 m (1 to 1.5 ft) of the outer edge of the pavement. This distress is accelerated by traffic loading and can be caused by frost-weakened base or subgrade near the edge of the pavement. The area between the crack and pavement edge is classified as raveled if it is broken up (sometimes to the extent that pieces are removed).

X1.11.1 *Severity Levels*:

X1.11.1.1 **L**—Low or medium cracking with no breakup or raveling (Fig. X1.19).

X1.11.1.2 **M**—Medium cracks with some breakup and raveling (Fig. X1.20).

X1.11.1.3 **H**—Considerable breakup or raveling along the edge (Fig. X1.21).

X1.11.2 *How to Measure*—Edge cracking is measure in linear meters (feet).

FIG. X1.16 Low-Severity Depression

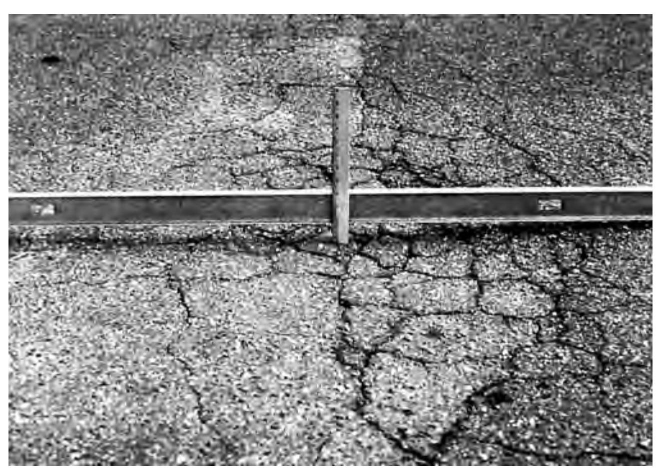


FIG. X1.18 High-Severity Depression

FIG. X1.19 Low-Severity Edge Cracking

FIG. X1.20 Medium-Severity Edge Cracking

FIG. X1.21 High-Severity Edge Cracking

JOINT REFLECTION CRACKING (From Longitudinal and Transverse PCC Slabs)

X1.12 *Description*—This distress occurs only on asphalt-surfaced pavements that have been laid over a PCC slab. It does not include reflection cracks from any other type of base, that is, cement- or lime-stabilized; these cracks are caused mainly by thermal- or moisture-induced movement of the PCC slab beneath the AC surface. This distress is not load-related; however, traffic loading may cause a breakdown of the AC surface near the crack. If the pavement is fragmented along a crack, the crack is said to be spalled. A knowledge of slab dimension beneath the AC surface will help to identify these distresses.

X1.12.1 *Severity Levels*:

X1.12.1.1 **L**—One of the following conditions exists (Fig. X1.22): Nonfilled crack width is less than 10 mm (3⁄8 in.), or filled crack of any width (filler in satisfactory condition).

X1.12.1.2 **M**—One of the following conditions exists (Fig. X1.23): Nonfilled crack width is greater than or equal to 10 mm (3⁄8 in.) and less than 75 mm (3 in.); nonfilled crack less than or equal to 75 mm (3 in.) surrounded by light secondary cracking; or, filled crack of any width surrounded by light secondary cracking.

X1.12.1.3 **H**—One of the following conditions exists (Fig. X1.24): Any crack filled or nonfilled surrounded by medium- or high-severity secondary cracking; nonfilled cracks greater than 75 mm (3 in.); or, a crack of any width where approximately 100 mm (4 in.) of pavement around the crack are severely raveled or broken.

X1.12.2 *How to Measure*—Joint reflection cracking is measured in linear meters (feet). The length and severity level of each crack should be identified and recorded separately. For example, a crack that is 15 m (50 ft) long may have 3 m (10 ft) of high severity cracks, which are all recorded separately. If a bump occurs at the reflection crack, it is recorded also.

LANE/SHOULDER DROP-OFF

X1.13 *Description*—Lane/shoulder drop-off is a difference in elevation between the pavement edge and the shoulder. This distress is caused by shoulder erosion, shoulder settlement, or by building up the roadway without adjusting the shoulder level.

X1.13.1 *Severity Levels*:

X1.13.1.1 **L**—The difference in elevation between the pavement edge and shoulder is > 25 mm (1 in.) and< 50 mm (2 in.) (Fig. X1.25).

FIG. X1.22 Low-Severity Joint Reflection Cracking

FIG. X1.23 Medium-Severity Joint Reflection Cracking

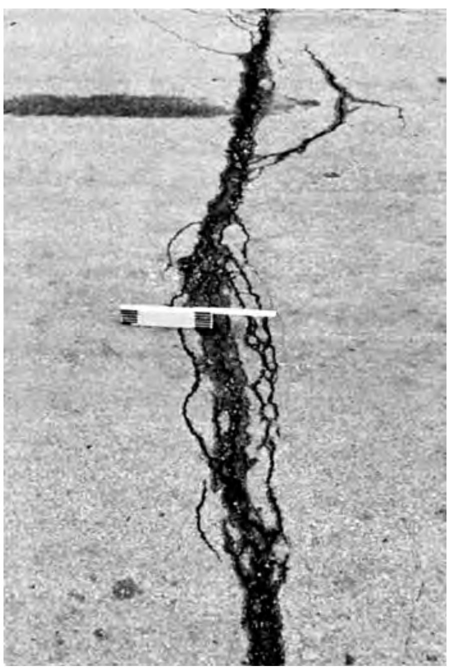


FIG. X1.24 High-Severity Joint Reflection Cracking

X1.13.1.2 **M**—The difference in elevation is > 50 mm (2 in.) and < 100 mm (4 in.) (Fig. X1.26).

X1.13.1.3 **H**—The difference in elevation is > 100 mm (4 in.) (Fig. X1.27).

X1.13.2 *How to Measure*—Lane/shoulder drop-off is measured in linear meters (feet).

LONGITUDINAL AND TRANSVERSE CRACKING (Non-PCC Slab Joint Reflective)

X1.14 *Description*:

FIG. X1.25 Low-Severity Lane/Shoulder Drop-Off

FIG. X1.26 Medium-Severity Lane/Shoulder Drop-Off

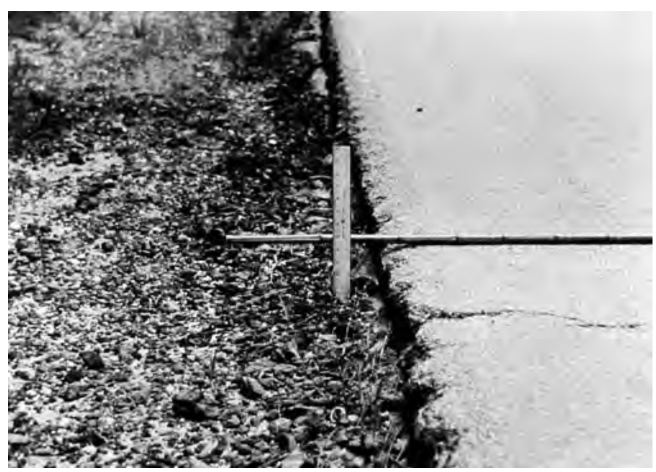


FIG. X1.27 High-Severity Lane/Shoulder Drop-Off

X1.14.1 Longitudinal cracks are parallel to the pavement's centerline or laydown direction. They may be caused by:

X1.14.1.1 A poorly constructed paving lane joint.

X1.14.1.2 Shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or daily temperature cycling, or both.

X1.14.1.3 A reflective crack caused by cracking beneath the surface course, including cracks in PCC slabs, but not PCC joints.

X1.14.1.4 Transverse cracks extend across the pavement at approximately right angles to the pavement centerline or direction of laydown. These types of cracks are not usually load-associated.

X1.14.2 *Severity Levels*:

X1.14.2.1 **L**—One of the following conditions exists (Fig. X1.28): nonfilled crack width is less than 10 mm (3⁄8 in.), or filled crack of any width (filler in satisfactory condition).

X1.14.2.2 **M**—One of the following conditions exists (Fig. X1.29): nonfilled crack width is greater than or equal to 10 mm and less than 75 mm (3⁄8 to 3 in.); nonfilled crack is less than or equal to 75 mm (3 in.) surrounded by light and random cracking; or, filled crack is of any width surrounded by light random cracking.

X1.14.2.3 **H**—One of the following conditions exists (Fig. X1.30): any crack filled or nonfilled surrounded by medium- or high-severity random cracking; nonfilled crack greater than 75 m (3 in.); or, a crack of any width where approximately 100 mm (4 in.) of pavement around the crack is severely broken.

X1.14.3 *How to Measure*—Longitudinal and transverse cracks are measured in linear meters (feet). The length and severity of each crack should be recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately.

FIG. X1.29 Medium-Severity Longitudinal and Transverse Cracking

FIG. X1.30 High-Severity Longitudinal and Transverse Cracking

PATCHING AND UTILITY CUT PATCHING

X1.15 *Description*—A patch is an area of pavement that has been replaced with new material to repair the existing pavement. A patch is considered a defect no matter how well it is performing (a patched area or adjacent area usually does not perform as well as an original pavement section). Generally, some roughness is associated with this distress.

X1.15.1 *Severity Levels*:

X1.15.1.1 **L**—Patch is in good condition and satisfactory. Ride quality is rated as low severity or better (Fig. X1.31).

X1.15.1.2 **M**—Patch is moderately deteriorated, or ride quality is rated as medium severity, or both (Fig. X1.32).

FIG. X1.28 Low-Severity Longitudinal and Transverse Cracking

FIG. X1.31 Low-Severity Patching and Utility Cut Patching

X1.15.1.3 **H**—Patch is badly deteriorated, or ride quality is rated as high severity, or both; needs replacement soon (Fig. X1.33).

X1.15.2 *How to Measure*—Patching is rated in ft^2 of surface area; however, if a single patch has areas of differing

FIG. X1.32 Medium-Severity Patching and Utility Cut Patching

FIG. X1.33 High-Severity Patching and Utility Cut Patching

severity, these areas should be measured and recorded separately. For example, a 2.5 m^2 (27.0 ft^2) patch may have 1 m^2 (11 ft^2) of medium severity and 1.5 m^2 (16 ft^2) of low severity. These areas would be recorded separately. Any distress found in a patched area will not be recorded; however, its effect on the patch will be considered when determining the patch's severity level. No other distresses, for example, are recorded within a patch. Even if the patch material is shoving or cracking, the area is rated only as a patch. If a large amount of pavement has been replaced, it should not be recorded as a patch but considered as new pavement, for example, replacement of a complete intersection.

POLISHED AGGREGATE

X1.16 *Description*—This distress is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance. When the aggregate in the surface becomes smooth to the touch, adhesion with vehicle tires is considerably reduced. When the portion of aggregate extending above the surface is small, the pavement texture does not significantly contribute to reducing vehicle speed. Polished aggregate should be counted when close examination reveals that the aggregate extending above the asphalt is negligible, and the surface aggregate is smooth to the touch. This type of distress is indicated when the number on a skid resistance test is low or has dropped significantly from a previous rating.

X1.16.1 *Severity Levels*—No degrees of severity are defined; however, the degree of polishing should be clearly evident in the sample unit in that the aggregate surface should be smooth to the touch (Fig. X1.34).

X1.16.2 *How to Measure*—Polished aggregate is measured in square meters (square feet) of surface area. If bleeding is counted, polished aggregate should not be counted.

POTHOLES

X1.17 *Description*—Potholes are small—usually less than 750 mm (30 in.) in diameter—bowl-shaped depressions in the pavement surface. They generally have sharp edges and vertical sides near the top of the hole. When holes are created by high-severity alligator cracking, they should be identified as potholes, not as weathering.

X1.17.1 *Severity Levels*:

X1.17.1.1 The levels of severity for potholes less than 750 mm (30 in.) in diameter are based on both the diameter and the depth of the pothole, according to Table X1.1.

X1.17.1.2 If the pothole is more than 750 mm (30 in.) in diameter, the area should be determined in square feet and divided by 0.5 m^2 (5.5 ft^2) find the equivalent number of holes. If the depth is 25 mm (1 in.) or less, the holes are considered medium-severity. If the depth is more than 25 mm (1 in.), they are considered high-severity (Figs. X1.35-X1.37).

X1.17.2 *How to Measure*—Potholes are measured by counting the number that are low-, medium-, and high-severity and recording them separately.

RAILROAD CROSSING

X1.18 *Description*—Railroad crossing defects are depressions or bumps around, or between tracks, or both.

X1.18.1 *Severity Levels*:

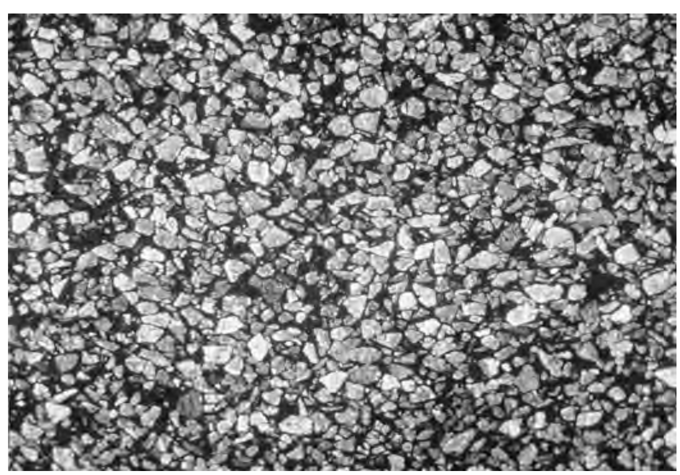


FIG. X1.34 Polished Aggregate

TABLE X1.1 Levels of Severity for Potholes

		Average Diameter (mm) (in.)	
Maximum Depth of Pothole	100 to 200 mm (4 to 8 in.)	200 to 450 mm (8 to 18 in.)	450 to 750 mm (18 to 30 in.)
13 to ≤25 mm (½ to 1 in.)	**L**	**L**	**M**
>25 and ≤50 mm (1 to 2 in.)	**L**	**M**	**H**
>50 mm (2 in.)	**M**	**M**	**H**

FIG. X1.35 Low-Severity Pothole

FIG. X1.36 Medium-Severity Pothole

X1.18.1.1 **L**—Railroad crossing causes low-severity ride quality (Fig. X1.38).

X1.18.1.2 **M**—Railroad crossing causes medium-severity ride quality (Fig. X1.39).

X1.18.1.3 **H**—Railroad crossing causes high-severity ride quality (Fig. X1.40).

X1.18.2 *How to Measure*—The area of the crossing is measured in square meters (square feet) of surface area. If the crossing does not affect ride quality, it should not be counted. Any large bump created by the tracks should be counted as part of the crossing.

FIG. X1.37 High-Severity Pothole

FIG. X1.38 Low-Severity Railroad Crossing

FIG. X1.39 Medium-Severity Railroad Crossing

RUTTING

X1.19 *Description*—A rut is a surface depression in the wheel paths. Pavement uplift may occur along the sides of the rut, but, in many instances, ruts are noticeable only after a

FIG. X1.40 High-Severity Railroad Crossing

FIG. X1.42 Medium-Severity Rutting

rainfall when the paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrades, usually caused by consolidated or lateral movement of the materials due to traffic load.

X1.19.1 *Severity Levels (Mean Rut Depth)*:

X1.19.1.1 **L**—6 to 13 mm (¼ to ½ in.) (Fig. X1.41).

X1.19.1.2 **M**—>13 to 25 mm (>½ to 1 in.) (Fig. X1.42).

X1.19.1.3 **H**—>25 mm (>1 in.) (Fig. X1.43).

X1.19.2 *How to Measure*—Rutting is measured in square meters (square feet) of surface area, and its severity is determined by the mean depth of the rut (see X1.19.1.1-X1.19.1.3). The mean rut depth is calculated by laying a straight edge across the rut, measuring its depth, then using measurements taken along the length of the rut to compute its mean depth in millimeters.

FIG. X1.43 High-Severity Rutting

SHOVING

X1.20 *Description*:

X1.20.1 Shoving is a permanent, longitudinal displacement of a localized area of the pavement surface caused by traffic loading. When traffic pushes against the pavement, it produces a short, abrupt wave in the pavement surface. This distress normally occurs only in unstable liquid asphalt mix (cutback or emulsion) pavements.

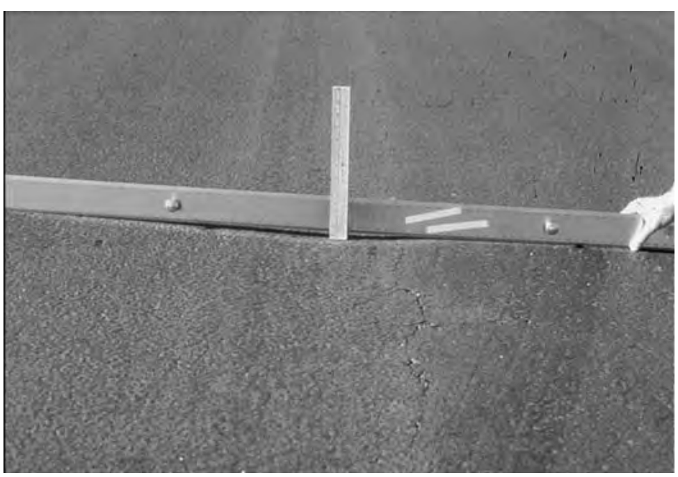


FIG. X1.41 Low-Severity Rutting

X1.20.2 Shoves also occur where asphalt pavements abut PCC pavements. The PCC pavements increase in length and push the asphalt pavement, causing the shoving.

X1.20.3 *Severity Levels*:

X1.20.3.1 **L**—Shove causes low-severity ride quality (Fig. X1.44).

X1.20.3.2 **M**—Shove causes medium-severity ride quality (Fig. X1.45).

X1.20.3.3 **H**—Shove causes high-severity ride quality (Fig. X1.46).

X1.20.4 *How to Measure*—Shoves are measured in square meters (feet) of surface area. Shoves occurring in patches are considered in rating the patch, not as a separate distress.

SLIPPAGE CRACKING

X1.21 *Description*—Slippage cracks are crescent or half-moon shaped cracks, usually transverse to the direction of travel. They are produced when braking or turning wheels cause the pavement surface to slide or deform. This distress usually occurs in overlaps when there is a poor bond between the surface and the next layer of the pavement structure.

FIG. X1.44 Low-Severity Shoving

FIG. X1.45 Medium-Severity Shoving

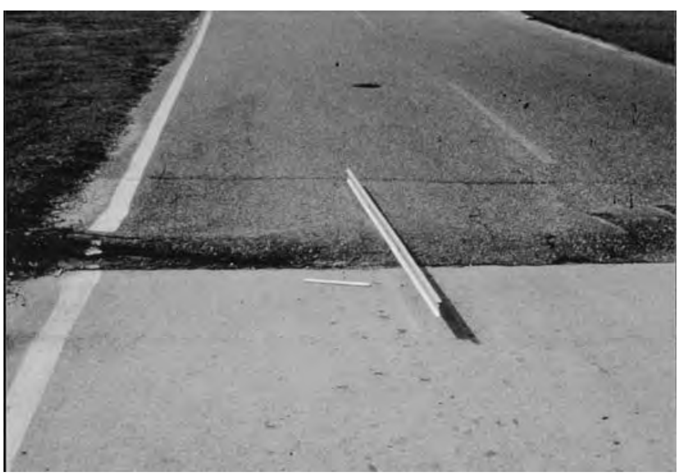


FIG. X1.46 High-Severity Shoving

X1.21.1 *Severity Level*:

X1.21.1.1 **L**—Average crack width is < 10 mm (⅜ in.) (Fig. X1.47).

X1.21.1.2 **M**—One of the following conditions exists (Fig. X1.48): average crack width is ≥ 10 and < 40 mm (≥ ⅜ and< 1-½ in.); or the area around the crack is moderately spalled, or surrounded with secondary cracks.

X1.21.1.3 **H**—One of the following conditions exists (Fig. X1.49): the average crack width is > 40 mm (1-½ in.) or the area around the crack is broken into easily removed pieces.

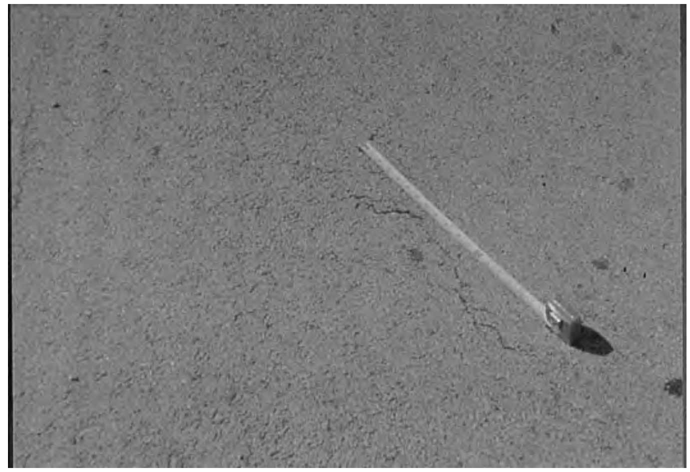


FIG. X1.47 Low-Severity Slippage Cracking

FIG. X1.48 Medium-Severity Slippage Cracking

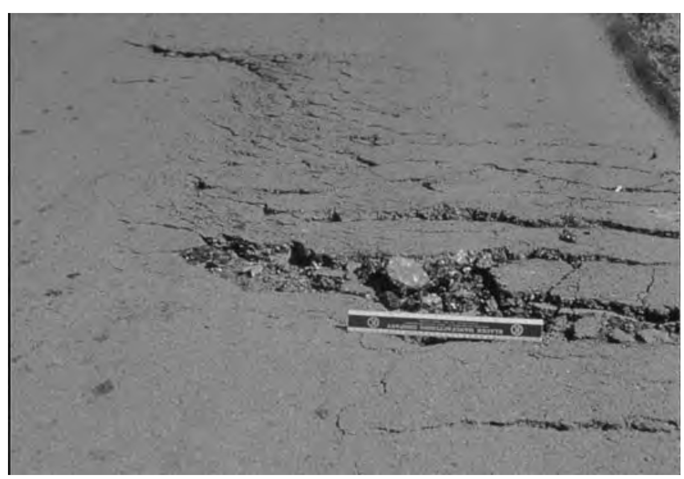


FIG. X1.49 High-Severity Slippage Cracking

X1.21.2 *How to Measure*—The area associated with a given slippage crack is measured in square meters (square feet) and rated according to the highest level of severity in the area.

SWELL

X1.22 *Description*—Swell is characterized by an upward bulge in the pavement's surface, a long, gradual wave more than 3 m (10 ft) long (Fig. X1.50). Swelling can be accompanied by surface cracking. This distress usually is caused by frost action in the subgrade or by swelling soil.

X1.22.1 *Severity Level*:

X1.22.1.1 **L**—Swell causes low-severity ride quality. Low-severity swells are not always easy to see but can be detected by driving at the speed limit over the pavement section. An upward motion will occur at the swell if it is present.

X1.22.1.2 **M**—Swell causes medium-severity ride quality.

X1.22.1.3 **H**—Swell causes high-severity ride quality.

X1.22.2 *How to Measure*—The surface area of the swell is measured in square meters (square feet).

WEATHERING AND RAVELING

X1.23 *Description*—Weathering and raveling are the wearing away of the pavement surface due to a loss of asphalt or tar binder and dislodged aggregate particles. These distresses indicate that either the asphalt binder has hardened appreciably or that a poor-quality mixture is present. In addition, raveling may be caused by certain types of traffic, for example, tracked vehicles. Softening of the surface and dislodging of the aggregates due to oil spillage also are included under raveling.

X1.23.1 *Severity Levels*:

X1.23.1.1 **L**—Aggregate or binder has started to wear away. In some areas, the surface is starting to pit (Fig. X1.51). In the case of oil spillage, the oil stain can be seen, but the surface is hard and cannot be penetrated with a coin.

X1.23.1.2 **M**—Aggregate or binder has worn away. The surface texture is moderately rough and pitted (Fig. X1.52). In the case of oil spillage, the surface is soft and can be penetrated with a coin.

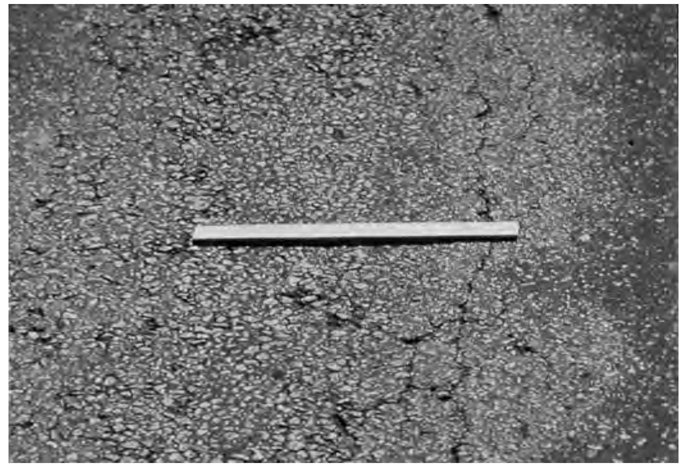


FIG. X1.51 Low-Severity Weathering and Raveling

FIG. X1.52 Medium-Severity Weathering and Raveling

X1.23.1.3 **H**—Aggregate or binder has been worn away considerably. The surface texture is very rough and severely pitted. The pitted areas are less than 10 mm (4 in.) in diameter and less than 13 mm (½ in.) deep (Fig. X1.53); pitted areas larger than this are counted as potholes. In the case of oil

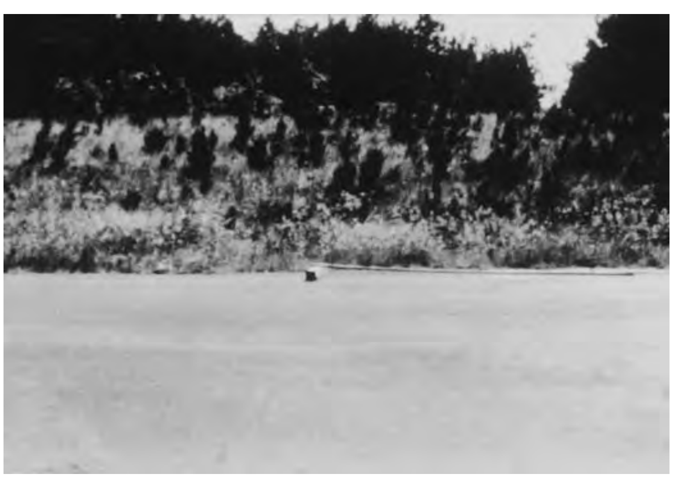


FIG. X1.50 Example Swell. Severity level is based on ride quality criteria.

FIG. X1.53 High-Severity Weathering and Raveling spillage, the asphalt binder has lost its binding effect and the aggregate has become loose.

X1.23.2 *How to Measure*—Weathering and raveling are measured in square meters (square feet) of surface area.

X2. DISTRESS IN JOINTED CONCRETE PAVEMENTS

X2.1 This Appendix lists alphabetically 19 distress types for jointed concrete pavements. Distress definitions apply to both plain and reinforced jointed concrete pavements, with the exception of linear cracking distress, which is defined separately for plain and reinforced jointed concrete.

X2.1.1 During the field condition surveys and validation of the PCI, several questions often are asked about the identification and counted method of some of the distresses. Answers to these questions are included under the heading "How to Count." For convenience, however, the most frequently raised issues are addressed below.

X2.1.1.1 Faulting is counted only at joints. Faulting associated with cracks is not counted separately since it is incorporated into the severity-level definitions of cracks. Crack definitions are also used in defining corner breaks and divided slabs.

X2.1.1.2 Joint seal damage is not counted on a slab-by-slab basis. Instead, a severity level is assigned based on the overall condition of the joint seal in the area.

X2.1.1.3 Cracks in reinforced concrete slabs that are less than ⅛ in. wide are counted as shrinkage cracks. Shrinkage cracks should not be counted to determine if the slab is broken into four or more pieces.

X2.1.1.4 Low-severity scaling, that is, crazing, should only be counted if there is evidence that future scaling is likely to occur.

X2.1.2 The user should note that the items above are general issues and do not stand alone as inspection criteria. To measure each distress type properly, the inspector must be familiar with the individual distress criteria.

X2.2 *Ride Quality*:

X2.2.1 Ride quality must be evaluated in order to establish a severity level for the following distress types:

X2.2.1.1 Blowup/buckling.

X2.2.1.2 Railroad crossings.

X2.2.2 To determine the effect these distresses have on ride quality, the inspector should drive at the normal operating speed and use the following severity-level definitions of ride quality:

X2.2.2.1 **L**—Low. Vehicle vibrations, for example, from corrugation, are noticeable, but no reduction in speed is necessary for comfort or safety, or individual bumps or settlements, or both, cause the vehicle to bounce slightly but create little discomfort.

X2.2.2.2 **M**—Medium. Vehicle vibrations are significant and some reduction in speed is necessary for safety and comfort, or individual bumps or settlements cause the vehicle to bounce significantly, or both, creating some discomfort.

X2.2.2.3 **H**—High. Vehicle vibrations are so excessive that speed must be reduced considerably for safety and comfort, or individual bumps or settlements, or both, cause the vehicle to bounce excessively, creating substantial discomfort, a safety hazard, or high potential vehicle damage, or a combination thereof.

X2.2.3 The inspector should drive at the posted speed in a sedan that is representative of cars typically seen in local traffic. Pavement sections near stop signs should be rated at a deceleration speed appropriate for the intersection.

BLOWUP/BUCKLING

X2.3 *Description*—Blowups or buckles occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit slab expansion. The insufficient width usually is caused by infiltration of incompressible materials into the joint space. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups also can occur at utility cuts and drainage inlets.

X2.3.1 *Severity Levels*:

X2.3.1.1 **L**—Buckling or shattering causes low-severity ride quality (Fig. X2.1).

X2.3.1.2 **M**—Buckling or shattering causes medium-severity ride quality (Fig. X2.2).

X2.3.1.3 **H**—Buckling or shattering causes high-severity ride quality (Fig. X2.3).

X2.3.2 *How to Count*—At a crack, a blowup is counted as being in one slab; however, if the blowup occurs at a joint and affects two slabs, the distress should be recorded as occurring in two slabs. When a blowup renders the pavement impassable, it should be repaired immediately.

CORNER BREAK

X2.4 *Description*—A corner break is a crack that intersects the joints at a distance less than or equal to one-half the slab length on both sides, measured from the corner of the slab. For

FIG. X2.1 Low Severity Blowup/Buckling

FIG. X2.2 Medium Severity Blowup/Buckling

FIG. X2.3 High-Severity Blowup/Buckling

example, a slab measuring 3.5 by 6.0 m (11.5 by 20.0 ft) that has a crack 1.5 m (5 ft) on one side and 3.5 m (11.5 ft) on the other side is not considered a corner break; it is a diagonal crack. However, a crack that intersects 0.5 m (4 ft) on one side and 2.5 m (8 ft) on the other is considered a corner break. A corner break differs from a corner spall in that the crack extends vertically through the entire slab thickness, whereas a corner spall intersects the joint at an angle. Load repetition combined with loss of support and curling stresses usually cause corner breaks.

X2.4.1 *Severity Levels*—

X2.4.1.1 **L**—Break is defined by a low-severity[4] crack. A low severity crack is < 13 mm (½ in.), cracks of any width with satisfactory filler; no faulting. The area between the break and the joints is not cracked or may be lightly cracked (Fig. X2.4).

X2.4.1.2 **M**—Break is defined by a medium-severity[4] crack, or the area between the break and the joints, or both, has a medium crack. A medium severity crack is a nonfilled crack > 13 mm and < 50 mm (>½ in. and < 2 in.), a nonfilled crack < 50 mm (2 in.) with faulting < 10 mm (⅜ in.), or a any filled crack with faulting < 10 mm (⅜ in.) (Fig. X2.5).

FIG. X2.4 Low-Severity Corner Break

X2.4.1.3 **H**—Break is defined by a high-severity[4] crack, or the area between the break and the joints, or both, is highly cracked. A high severity crack is a nonfilled crack >50 mm (2 in.) wide, or any filled or nonfilled crack with faulting >10 mm (⅜ in.) (Fig. X2.6).

X2.4.2 *How to Count*—Distressed slab is recorded as one slab if it:

X2.4.2.1 A single corner break.

X2.4.2.2 More than one break of a particular severity.

X2.4.2.3 Two or more breaks of different severities. For two or more breaks, the highest level of severity should be recorded. For example, a slab containing both low- and medium-severity corner breaks should be counted as one slab with a medium corner break.

FIG. X2.5 Medium-Severity Corner Break

[4] The above crack severity definitions are for nonreinforced slabs. For reinforced slabs, see *linear cracking*.

FIG. X2.6 High-Severity Corner Break

FIG. X2.7 Low-Severity Divided Slab

DIVIDED SLAB

X2.5 *Description*—Slab is divided by cracks into four or more pieces due to overloading, or inadequate support, or both. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break.

X2.5.1 *Severity Levels*—Table X2.1 lists severity levels for divided slabs. Examples are shown in Figs. X2.7-X2.9.

X2.5.2 *How to Count*—If the divided slab is medium- or high-severity, no other distress is counted for that slab.

DURABILITY ("D") CRACKING

X2.6 *Description*—"D" cracking is caused by freeze-thaw expansion of the large aggregate, which, over time, gradually breaks down the concrete. This distress usually appears as a pattern of cracks running parallel and close to a joint or linear crack. Since the concrete becomes saturated near joints and cracks, a dark-colored deposit can usually be found around fine" D" cracks. This type of distress may eventually lead to disintegration of the entire slab.

X2.6.1 *Severity Levels*:

X2.6.1.1 *L*—"D" cracks cover less than 15 % of slab area. Most of the cracks are tight, but a few pieces may be loose and or missing (Fig. X2.10).

X2.6.1.2 **M**—One of the following conditions exists (Fig. X2.11): "D" cracks cover less than 15 % of the area and most of the pieces are loose and or missing, or "D" cracks cover more than 15 % of the area. Most of the cracks are tight, but a few pieces may be loose and or missing.

X2.6.1.3 *H*—"D" cracks cover more than 15 % of the area and most of the pieces have come out or could be removed easily (Fig. X2.12).

TABLE X2.1 Levels of Severity for Faulting

Severity Level	Difference of Elevation
L	>3 and <10 mm (>1⁄8 and <3⁄8 in.)
M	>10 and <20 mm (>3⁄8 and <3⁄4 in.)
H	>20 mm (>3⁄4 in.)

FIG. X2.8 Medium-Severity Divided Slab

FIG. X2.9 High-Severity Divided Slab

X2.6.2 *How to Count*—When the distress is located and rated at one severity, it is counted as one slab. If more than one severity level exists, the slab is counted as having the higher severity distress. For example, if low and medium "D" cracking are on the same slab, the slab is counted as medium-severity cracking only.

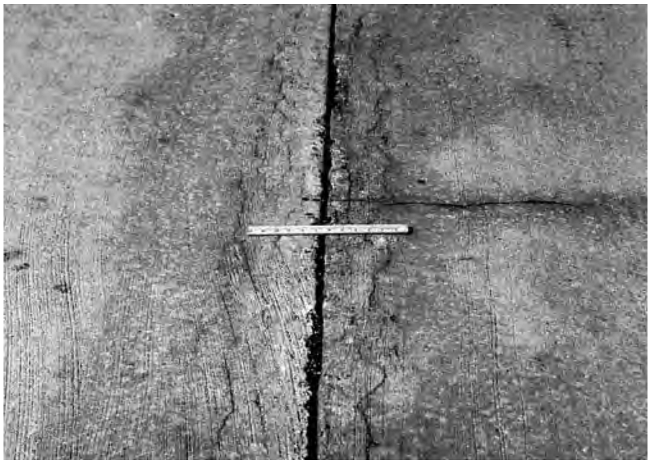


FIG. X2.10 Low-Severity Durability Cracking

FIG. X2.11 Medium-Severity Durability Cracking

FIG. X2.12 High-Severity Durability Cracking

FAULTING

X2.7 *Description*:

X2.7.1 Faulting is the difference in elevation across a joint. Some common causes of faulting are as follows:

X2.7.1.1 Settlement because of soft foundation.

X2.7.1.2 Pumping or eroding of material from under the slab.

X2.7.1.3 Curling of the slab edges due to temperature and moisture changes.

X2.7.2 *Severity Levels*—Severity levels are defined by the difference in elevation across the joint as indicated in Table X2.2. Figs. X2.13-X2.15 show examples of the different severity levels.

X2.7.3 *How to Count*—Faulting across a joint is counted as one slab. Only affected slabs are counted. Faults across a crack are not counted as distress but are considered when defining crack severity.

JOINT SEAL DAMAGE

X2.8 *Description*:

X2.8.1 Joint seal damage is any condition that enables soil or rocks to accumulate in the joints or allows significant water infiltration. Accumulation of incompressible materials prevents the slab from expanding and may result in buckling, shattering, or spalling. A pliable joint filler bonded to the edges of the slabs protects the joints from material accumulation and prevents water from seeping down and softening the foundation supporting the slab. Typical types of joint seal damage are as follows:

X2.8.1.1 Stripping of joint sealant.

X2.8.1.2 Extrusion of joint sealant.

X2.8.1.3 Weed growth.

X2.8.1.4 Hardening of the filler (oxidation).

X2.8.1.5 Loss of bond to the slab edges.

X2.8.1.6 Lack or absence of sealant in the joint.

X2.8.2 *Severity Levels*:

X2.8.2.1 **L**—Joint sealant is in generally good condition throughout section (Fig. X2.16). Sealant is performing well, with only minor damage (see X2.8.1.1-X2.8.1.6). Joint seal damage is at low severity if a few of the joints have sealer, which has debonded from, but is still in contact with, the joint edge. This condition exists if a knife blade can be inserted between sealer and joint face without resistance.

X2.8.2.2 **M**—Joint sealant is in generally fair condition over the entire section, with one or more of the above types of damage occurring to a moderate degree. Sealant needs replacement within two years (Fig. X2.17). Joint seal damage is at medium severity if a few of the joints have any of the following conditions: joint sealer is in place, but water access is possible through visible openings no more than 3 mm (⅛ in.) wide. If a knife blade cannot be inserted easily between sealer and joint face, this condition does not exist; pumping debris are evident at the joint; joint sealer is oxidized and "lifeless" but pliable (like a rope), and generally fills the joint opening; or, vegetation in the joint is obvious but does not obscure the joint opening.

TABLE X2.2 Levels of Severity for Punchouts

Severity of the Majority of Cracks	Number of Pieces 2 to 3	4 to 5	>5
L	**L**	**L**	**M**
M	**L**	**M**	**H**
H	**M**	**H**	**H**

FIG. X2.13 Low-Severity Faulting

FIG. X2.14 Medium-Severity Faulting

FIG. X2.15 High-Severity Faulting

FIG. X2.16 Low-Severity Joint Seal Damage

FIG. X2.17 Medium-Severity Joint Seal Damage

FIG. X2.18 High-Severity Joint Seal Damage

X2.8.2.3 **H**—Joint sealant is in generally poor condition over the entire section, with one or more of the above types of damage occurring to a severe degree. Sealant needs immediate replacement (Fig. X2.18). Joint seal damage is at high severity if 10 % or more of the joint sealer exceeds limiting criteria listed above or if 10 % or more of sealer is missing.

X2.8.3 *How to Count*—Joint seal damage is not counted on a slab-by-slab basis but is rated based on the overall condition of the sealant over the entire area.

LANE/SHOULDER DROP-OFF

X2.9 *Description*—Lane/shoulder drop-off is the difference between the settlement or erosion of the shoulder and the pavement travel-lane edge. The elevation difference can be a safety hazard, and it also can cause increased water infiltration.

X2.9.1 *Severity Levels*:

X2.9.1.1 **L**—The difference between the pavement edge and shoulder is >25 and ≤50 mm (>1 and ≤2 in.) (Fig. X2.19).

X2.9.1.2 **M**—The difference in elevation is >50 and ≤100 mm (>2 and ≤4 in.) (Fig. X2.20).

X2.9.1.3 **H**—The difference in elevation is >100 mm (>4 in.) (Fig. X2.21).

X2.9.2 *How to Count*—The mean lane/shoulder drop-off is computed by averaging the maximum and minimum drop along the slab. Each slab exhibiting distress is measured separately and counted as one slab with the appropriate severity level.

LINEAR CRACKING
(Longitudinal, Transverse, and Diagonal Cracks)

X2.10 *Description*—These cracks, which divide the slab into two or three pieces, usually are caused by a combination of repeated traffic loading, thermal gradient curling, and repeated moisture loading. (Slabs divided into four or more pieces are counted as divided slabs.) Hairline cracks that are only a few feet long and do not extend across the entire slab, are counted as shrinkage cracks.

X2.10.1 *Severity Levels (Nonreinforced Slabs)*:

X2.10.1.1 **L**—Nonfilled[4] cracks ≤ 13 mm (≤ ½ in.) or filled cracks of any width with the filler in satisfactory condition. No faulting exists (Fig. X2.22).

X2.10.1.2 **M**—One of the following conditions exists: nonfilled crack with a width >13 and ≤50 mm (>½ and ≤ 2 in.); nonfilled crack of any width ≤ 50 mm (2 in.) with faulting of <10 mm (⅜ in.), or filled crack of any width with faulting <10 mm (⅜ in.) (Fig. X2.23).

X2.10.1.3 **H**—One of the following conditions exists: nonfilled crack with a width >50 mm (2 in.), or filled or nonfilled crack of any width with faulting >10 mm (⅜ in.) (Fig. X2.24).

X2.10.2 *Reinforced Slabs*:

X2.10.2.1 **L**—Nonfilled cracks ≥ 3 and < 25 mm (≥ ⅛ to < 1 in.) wide; filled crack of any width with the filler in satisfactory condition. No faulting exists.

FIG. X2.19 Low-Severity Lane/Shoulder Drop-Off

FIG. X2.20 Medium-Severity Lane/Shoulder Drop-Off

FIG. X2.21 High-Severity Lane/Shoulder Drop-Off

X2.10.2.2 **M**—One of the following conditions exists: nonfilled cracks with a width ≥ 25 and < 75 mm (≥ 1 and < 3 in.) and no faulting; nonfilled crack of any width ≤ 75 mm (3 in.) with ≤ 10 mm (⅜ in.) of faulting, or filled crack of any width with ≤ 10 mm (⅜ in.) faulting.

X2.10.2.3 **H**—Once of the following conditions exists: nonfilled crack >75 mm (3 in.) wide, or filled or nonfilled crack of any width with faulting >10 mm (⅜ in.).

X2.10.3 *How to Count*—One the severity has been identified, the distress is recorded as one slab. If two medium severity cracks are within one slab, the slab is counted as

FIG. X2.22 Low-Severity Linear Cracking

FIG. X2.23 Medium-Severity Linear Cracking

having one high-severity crack. Slabs divided into four or more pieces are counted as divided slabs. In reinforced slabs, cracks <3 mm (⅛ in.) wide are counted as shrinkage cracks. Slabs longer than 9 m (29.5 ft) are divided into approximately equal length“ slabs” having imaginary joints assumed to be in perfect condition.

PATCHING, LARGE (MORE THAN 0.5 M^2 [5.5 FT^2]) AND UTILITY CUTS

X2.11 *Description*—A patch is an area where the original pavement has been removed and replaced by filler material. A utility cut is a patch that has replaced the original pavement to allow the installation or maintenance of underground utilities. The severity levels of a utility cut are assessed according to the same criteria as large patching.

X2.11.1 *Severity Levels*:

FIG. X2.24 High-Severity Linear Cracking

X2.11.1.1 **L**—Patch is functioning well, with little or no deterioration (Fig. X2.25).

X2.11.1.2 **M**—Patch is moderately deteriorated, or moderate spalling can be seen around the edges, or both. Patch material can be dislodged with considerable effort (Fig. X2.26).

X2.11.1.3 **H**—Patch is badly deteriorated. The extent of the deterioration warrants replacement (Fig. X2.27).

X2.11.2 *How to Count*—If a single slab has one or more patches with the same severity level, it is counted as one slab containing that distress. If a single slab has more than one severity level, it is counted as one slab with the higher severity level.

PATCHING, SMALL (LESS THAN 0.5 M^2 [5.5 FT^2])

X2.12 *Description*—A patch is an area where the original pavement has been removed and replaced by a filler material.

X2.12.1 *Severity Levels*:

X2.12.1.1 **L**—Patch is functioning well with little or no deterioration (Fig. X2.28).

X2.12.1.2 **M**—Patch is moderately deteriorated. Patch material can be dislodged with considerable effort (Fig. X2.29).

FIG. X2.25 Low-Severity Patching, Large and Utility Cuts

FIG. X2.26 Medium-Severity Patching, Large and Utility Cuts

FIG. X2.27 High-Severity Patching, Large and Utility Cuts

FIG. X2.28 Low-Severity Patching, Small

X2.12.1.3 **H**—Patch is badly deteriorated. The extent of deterioration warrants replacement (Fig. X2.30).

X2.12.2 *How to Count*—If a single slab has one or more patches with the same severity level, it is counted as one slab containing that distress. If a single slab has more than one severity level, it is counted as one slab with the higher severity level.

FIG. X2.29 Medium-Severity Patching, Small

FIG. X2.30 High-Severity Patching, Small

POLISHED AGGREGATE

X2.13 *Description*—This distress is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance.

X2.13.1 *Severity Levels*—No degrees of severity are defined; however, the degree of polishing should be significant before it is included in the condition survey and rated as a defect (Fig. X2.31).

X2.13.2 *How to Count*—A slab with polished aggregate is counted as one slab.

POPOUTS

X2.14 *Description*—A popout is a small piece of pavement that breaks loose from the surface due to freeze-thaw action, combined with expansive aggregates. Popouts usually range in diameter from approximately 25 to 100 mm (1 to 4 in.) and in depth from 13 to 50 mm (½ to 2 in.).

X2.14.1 *Severity Levels*—No degrees of severity are defined for popouts; however, popouts must be extensive before

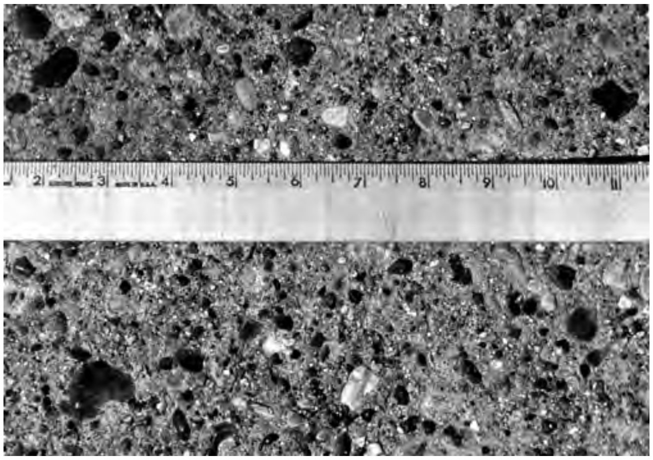


FIG. X2.31 Polished Aggregate

they are counted as a distress. Average popout density must exceed approximately three popouts/m^2 over the entire slab area (Fig. X2.32).

X2.14.2 *How to Count*—The density of the distress must be measured. If there is any doubt that the average is greater than three popouts per square yard, at least three random 1 m^2 (11 ft^2) areas should be checked. When the average is greater than this density, the slab should be counted.

PUMPING

X2.15 *Description*—Pumping is the ejection of material from the slab foundation through joints or cracks. This is caused by deflection of the slab with passing loads. As a load moves across the joint between the slabs, water is first forced under the leading slab, and then forced back under the trailing slab. This action erodes and eventually removes soil particles resulting in progressive loss of pavement support. Pumping can be identified by surface stains and evidence of base or subgrade material on the pavement close to joints or cracks. Pumping near joints is caused by poor joint sealer and indicates loss of support; repeated loading eventually will produce cracks. Pumping also can occur along the slab edge causing loss of support.

FIG. X2.32 Popouts

X2.15.1 *Severity Levels*—No degrees of severity are defined. It is enough to indicate that pumping exists (Fig. X2.33 and Fig. X2.34).

X2.15.2 *How to Count*—One pumping joint between two slabs is counted as two slabs; however, if the remaining joints around the slab are also pumping, one slab is added per additional pumping joint.

PUNCHOUT

X2.16 *Description*—This distress is a localized area of the slab that is broken into pieces. The punchout can take many different shapes and forms, but it is usually defined by a crack and a joint. The distance between the join and the crack or two closely spaced cracks is ≤ 1.5 m (5 ft) wide. This distress is caused by heavy repeated loads, inadequate slab thickness, loss of foundation support, or a localized concrete construction deficiency, for example, honeycombing.

X2.16.1 *Severity Levels*—Table X2.2 lists the severity levels for punchouts, and Figs. X2.35-X2.37 show examples.

X2.16.2 *How to Count*—If a slab contains more than one punchout or a punchout and a crack, it is counted as shattered.

RAILROAD CROSSING

X2.17 *Description*—Railroad crossing distress is characterized by depressions or bumps around the tracks.

X2.17.1 *Severity Levels*:

X2.17.1.1 **L**—Railroad crossing causes low-severity ride quality (Fig. X2.38).

X2.17.1.2 **M**—Railroad crossing causes medium-severity ride quality (Fig. X2.39).

X2.17.1.3 **H**—Railroad crossing causes high-severity ride quality (Fig. X2.40).

FIG. X2.33 Pumping

FIG. X2.34 Pumping

FIG. X2.35 Low-Severity Punchout

X2.17.2 *How to Count*—The number of slabs crossed by the railroad tracks is counted. Any large bump created by the tracks should be counted as part of the crossing.

SCALING, MAP CRACKING, AND CRAZING

X2.18 *Description*—Map cracking or crazing refers to a network of shallow, fine, or hairline cracks that extend only through the upper surface of the concrete. The cracks tend to intersect at angles of 120°. Map cracking or crazing usually is caused by concrete over-finishing and may lead to surface scaling, which is the breakdown of the slab surface to a depth of approximately 6 to 13 mm (¼ to ½ in.). Scaling also may be caused by deicing salts, improper construction, freeze-thaw cycles and poor aggregate. The type of scaling defined here is not caused by "D" cracking. If scaling is caused by "D" cracking, it should be counted under that distress only.

X2.18.1 *Severity Levels*:

FIG. X2.36 Medium-Severity Punchout

FIG. X2.37 High-Severity Punchout

FIG. X2.38 Low-Severity Railroad Crossing

X2.18.1.1 **L**—Crazing or map cracking exists over most of the slab area; the surface is in good condition, with only minor scaling present (Fig. X2.41).

X2.18.1.2 **M**—Slab is scaled but less than 15 % of the slab is affected (Fig. X2.42).

X2.18.1.3 **H**—Slab is scaled over more than 15 % of its area (Fig. X2.43).

FIG. X2.39 Medium-Severity Railroad Crossing

FIG. X2.40 High-Severity Railroad Crossing

FIG. X2.41 Low-Severity Scaling, Map Cracking, and Crazing

X2.18.2 *How to Count*—A scaled slab is counted as one slab. Low-severity crazing only should be counted if the potential for scaling appears to be imminent or a few small pieces come out.

SHRINKAGE CRACKS

X2.19 *Description*—Shrinkage cracks are hairline cracks that usually are less than 2-m long and do not extend across the entire slab. They are formed during the setting and curing of the concrete and usually do not extend through the depth of the slab.

X2.19.1 *Severity Levels*—No degrees of severity are defined. It is enough to indicate that shrinkage cracks are present (Fig. X2.44).

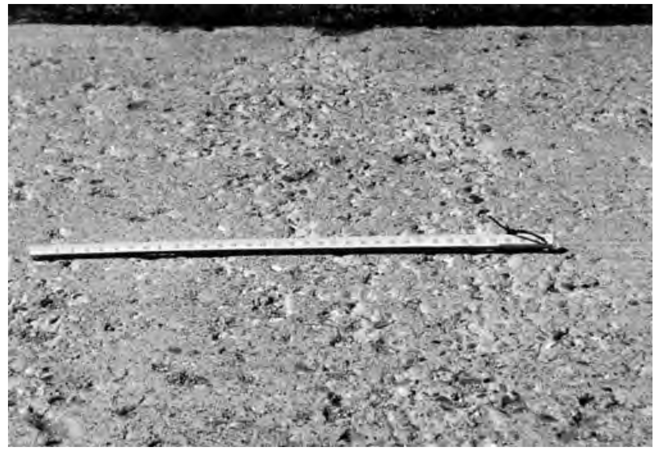


FIG. X2.42 Medium-Severity Scaling, Map Cracking, and Crazing

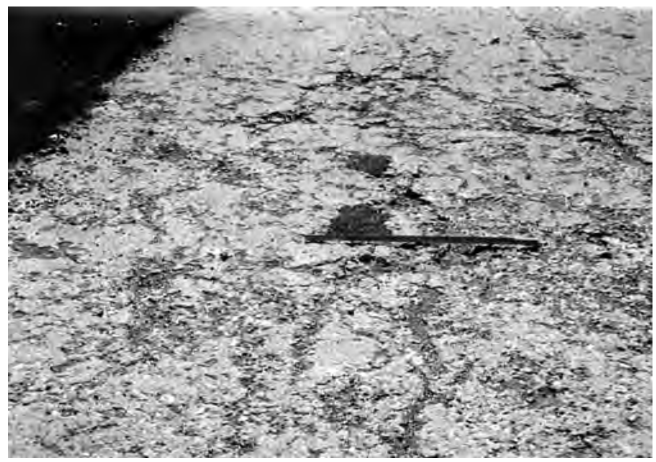


FIG. X2.43 High-Severity Scaling, Map Cracking, and Crazing

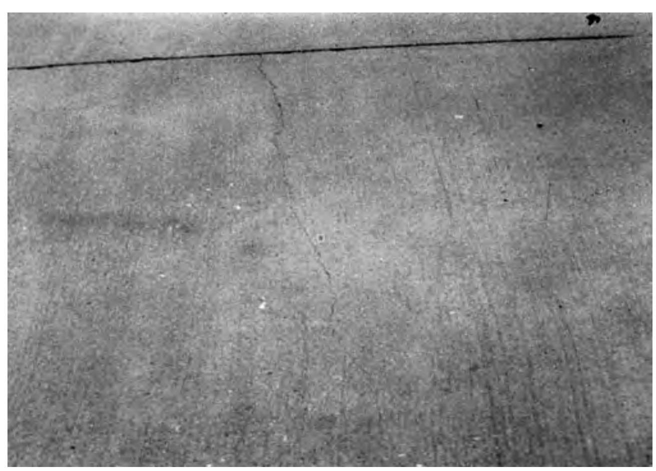


FIG. X2.44 Shrinkage Cracks

X2.19.2 *How to Count*—If any shrinkage cracks exist on a particular slab, the slab is counted as one slab with shrinkage cracks.

SPALLING, CORNER

X2.20 *Description*—Corner spalling is the breakdown of the slab within approximately 0.5 m (1.5 ft) of the corner. A corner spall differs from a corner break in that the spall usually angles downward to intersect the joint, whereas a break extends vertically through the slab corner. Spalls less than 130 mm (5 in.) from the crack to the corner on both sides should not be counted.

X2.20.1 *Severity Levels*—Table X2.3 lists the levels of severity for corner spalling. Figs. X2.45-X2.47 show examples. Corner spalling with an area of less than 650 cm (10 in.^{2}) from the crack to the corner on both sides should not be counted.

X2.20.2 *How to Count*—If one or more corner spalls with the same severity level are in a slab, the slab is counted as one slab with corner spalling. If more than one severity level occurs, it is counted as one slab with the higher severity level.

SPALLING, JOINT

X2.21 *Description*:

X2.21.1 Joint spalling is the breakdown of the slab edges within 0.5 m (1.5 ft) of the joint. A joint spall usually does not extend vertically through the slab, but intersects the joint at an angle. Spalling results from:

X2.21.1.1 Excessive stresses at the joint caused by traffic loading or by infiltration of incompressible materials.

X2.21.1.2 Weak concrete at the joint caused by overworking.

X2.21.1.3 Water accumulation in the joint and freeze-thaw action.

X2.21.2 *Severity Levels*—Table X2.4 and Figs. X2.48-X2.50 show the severity levels of joint spalling. A frayed joint where the concrete has been worn away along the entire joint is rated as low severity.

X2.21.3 *How to Count*—If spall is along the edge of one slab, it is counted as one slab with joint spalling. If spalling is on more than one edge of the same slab, the edge having the highest severity is counted and recorded as one slab. Joint spalling also can occur along the edges of two adjacent slabs. If this is the case, each slab is counted as having joint spalling.

TABLE X2.3 Levels of Severity for Corner Spalling

Depth of Spall	Dimensions of Sides of Spall 130 × 130 mm to 300 × 300 mm (5 × 5 in.) to (12 × 12 in.)	300 × 300 mm (>12 × 12 in.)
<25 mm (1 in.)	L	L
>25 to 50 mm (1 to 2 in.)	L	M
>50 mm (2 in.)	M	H

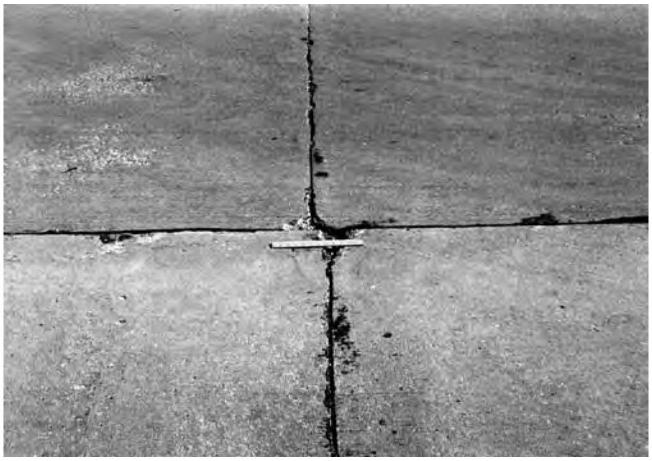


FIG. X2.45 Low-Severity Spalling, Corner

FIG. X2.46 Medium-Severity Spalling, Corner

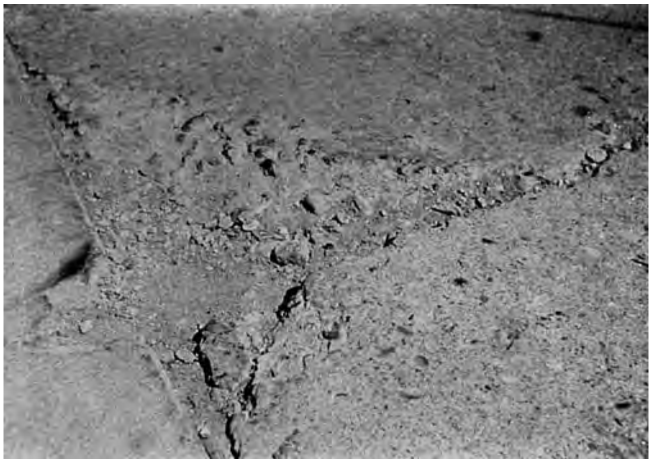


FIG. X2.47 High-Severity Spalling, Corner

TABLE X2.4 Levels of Severity for Joint Spalling

Spall Pieces	Width of Spall	Length of Spall <0.5 m (1.5 ft)	Length of Spall >0.5 m (1.5 ft)
Tight—cannot be removed easily (maybe a few pieces missing.	<100 mm (4 in.)	**L**	**L**
	>100 mm	**L**	**L**
Loose—can be removed and some pieces are missing; if most or all pieces are missing, spall is shallow, less than 25 mm (1 in.).	<100 mm	**L**	**M**
	>100 mm	**L**	**M**
Missing—most or all pieces have been removed.	<100 mm	**L**	**M**
	>100 mm	**M**	**H**

FIG. X2.48 Low-Severity Spalling, Joint

FIG. X2.49 Medium-Severity Spalling, Joint

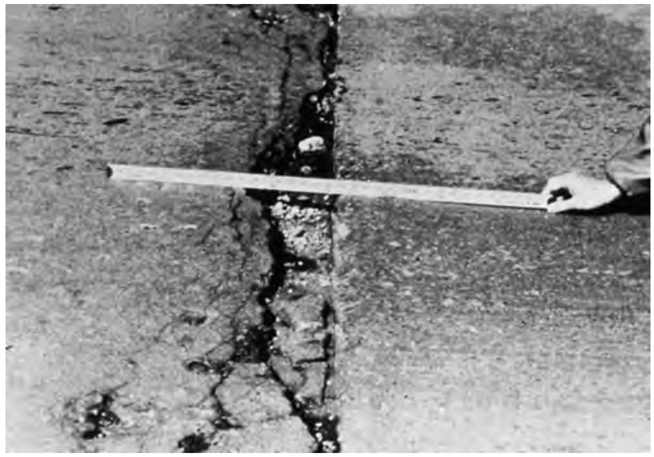


FIG. X2.50 High-Severity Spalling, Joint

X3. DEDUCT VALUE CURVES FOR ASPHALT

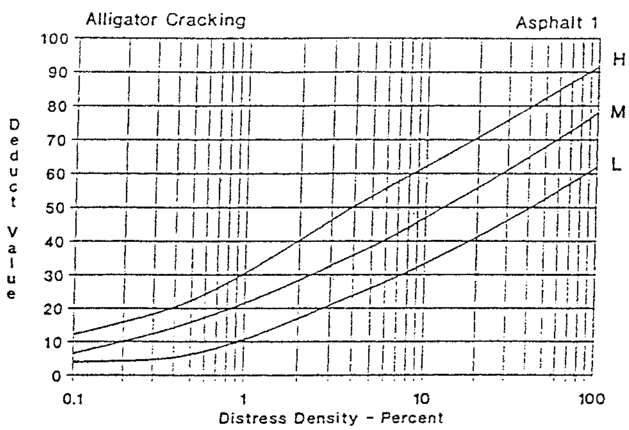


FIG. X3.1 Alligator Cracking

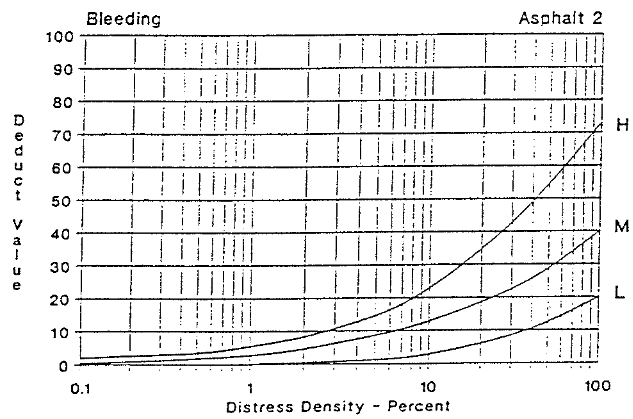


FIG. X3.2 Bleeding

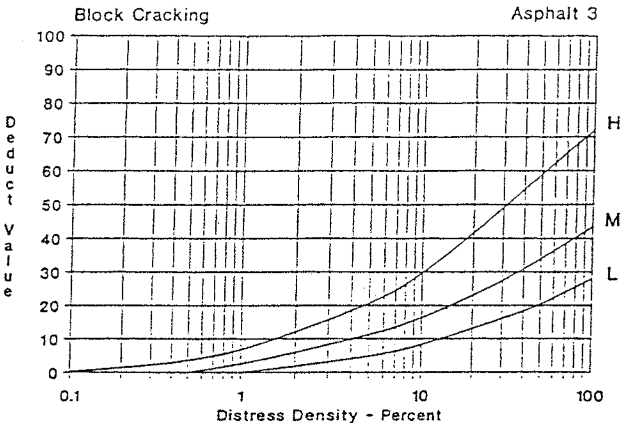


FIG. X3.3 Block Cracking

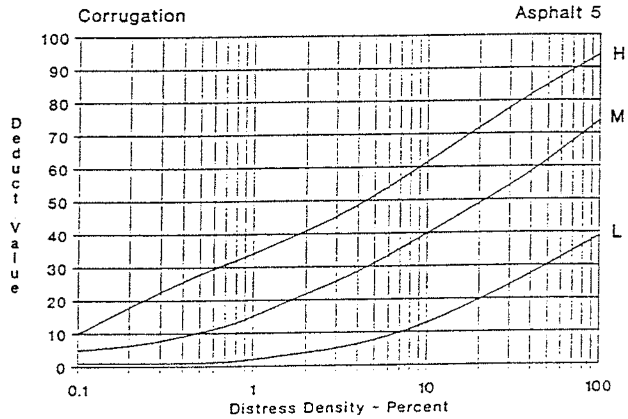


FIG. X3.6 Corrugation

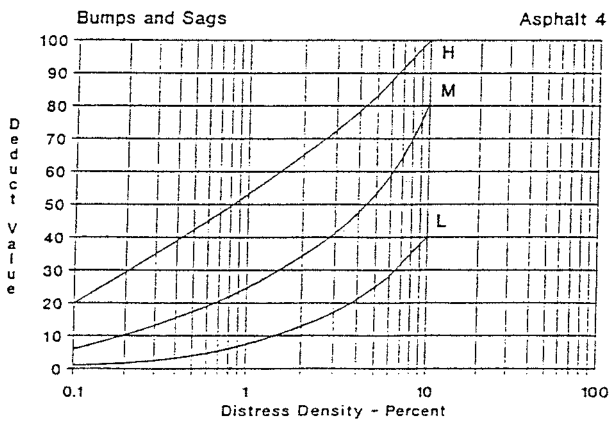


FIG. X3.4 Bumps and Sags

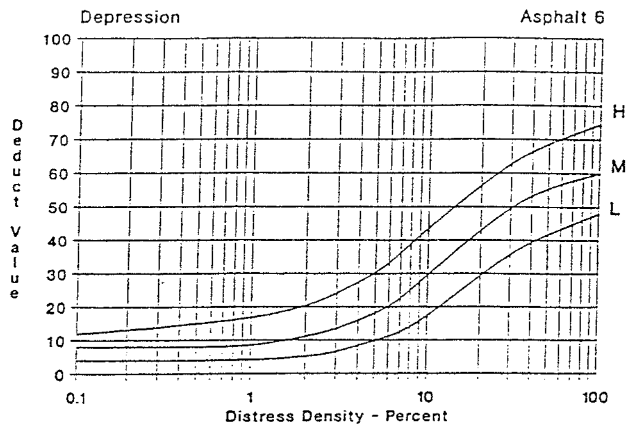


FIG. X3.7 Depression

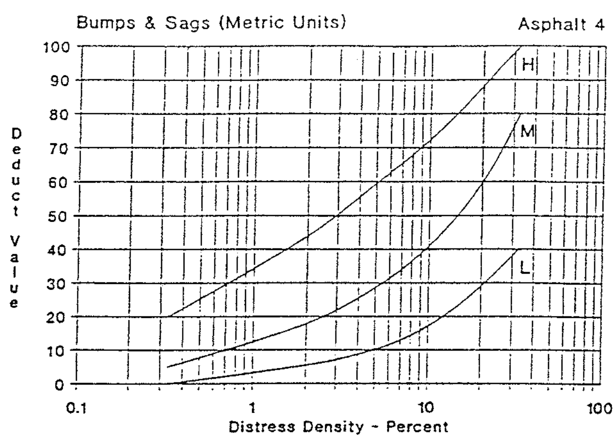


FIG. X3.5 Bumps and Sags (Metric units)

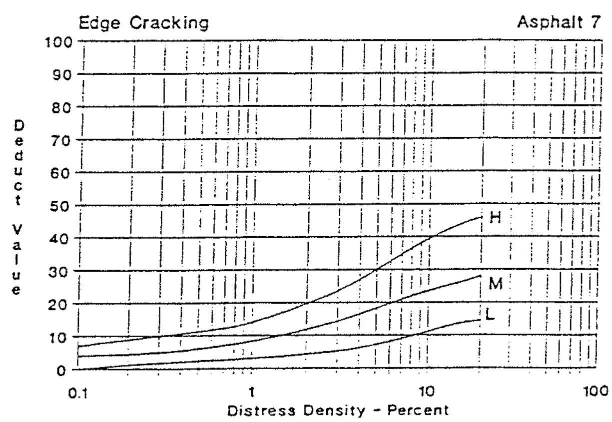


FIG. X3.8 Edge Cracking

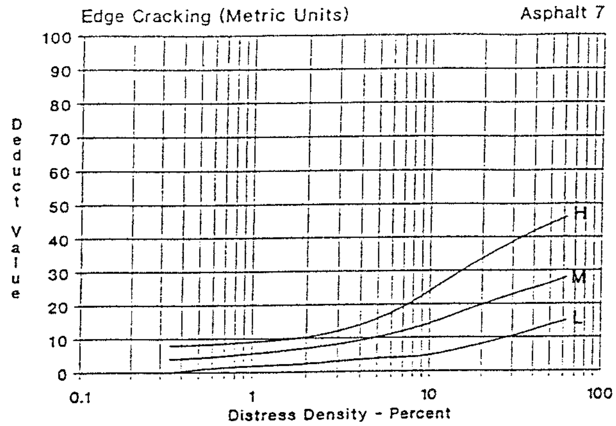


FIG. X3.9 Edge Cracking (metric units)

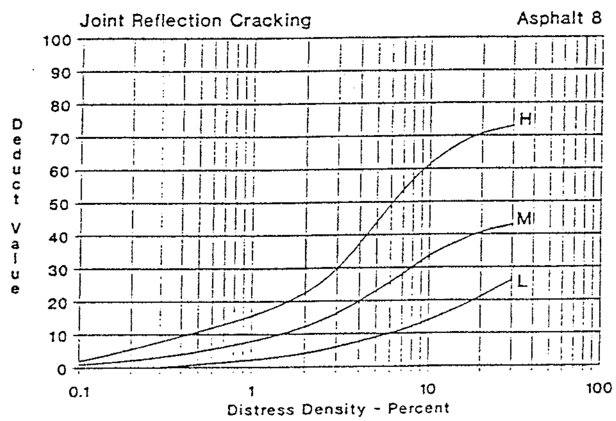


FIG. X3.10 Joint Reflection Cracking

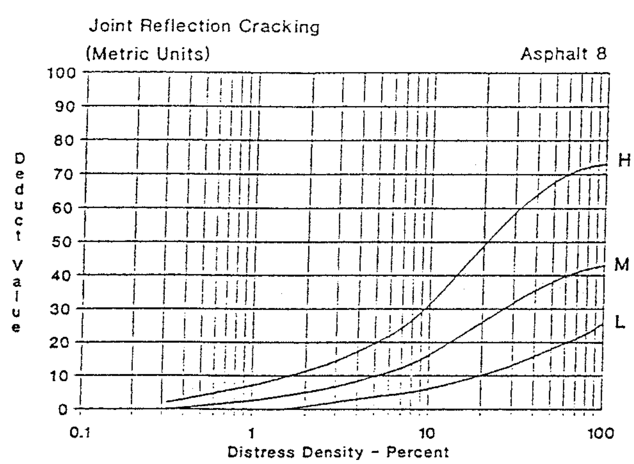


FIG. X3.11 Joint Reflection Cracking (metric units)

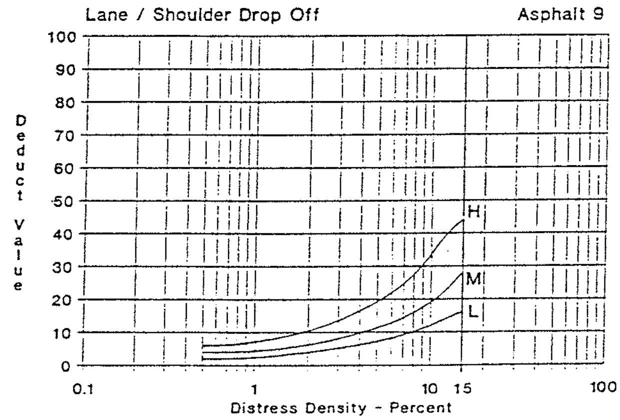


FIG. X3.12 Lane/Shoulder Drop-Off

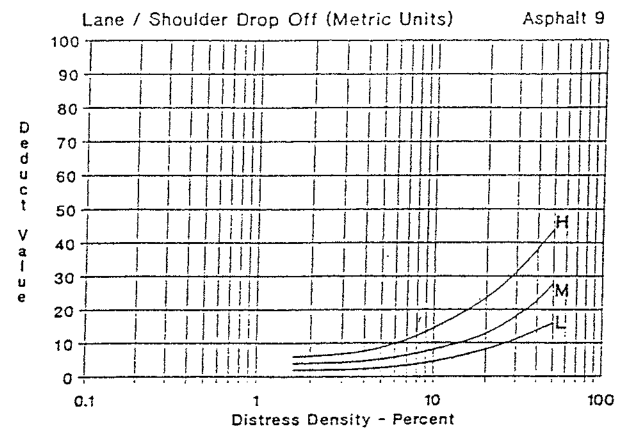


FIG. X3.13 Lane/Shoulder Drop-Off (metric units)

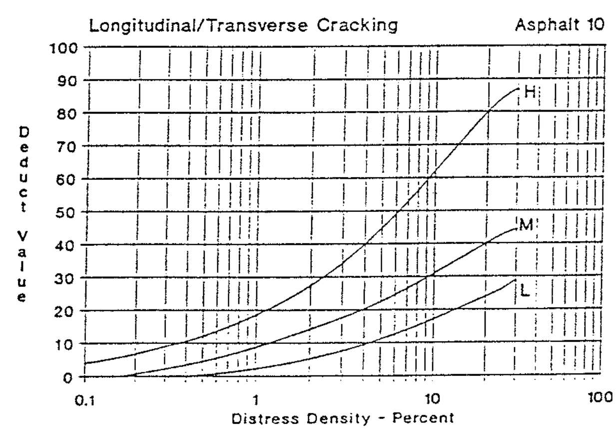


FIG. X3.14 Longitudinal/Transverse Cracking

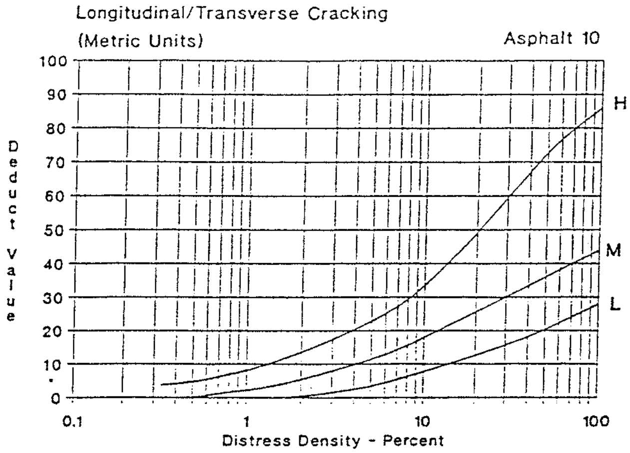


FIG. X3.15 Longitudinal/Transverse Cracking (metric units)

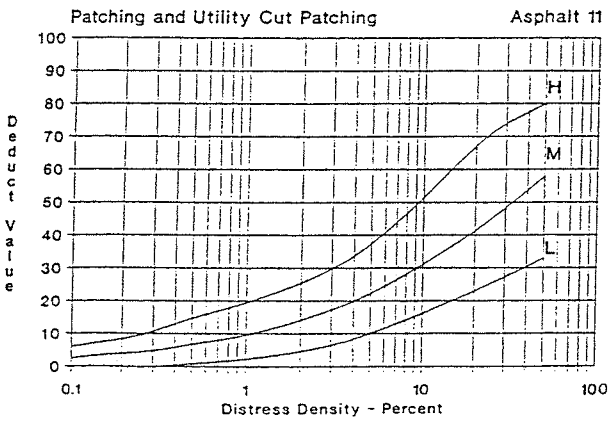


FIG. X3.16 Patching and Utility Cut Patching

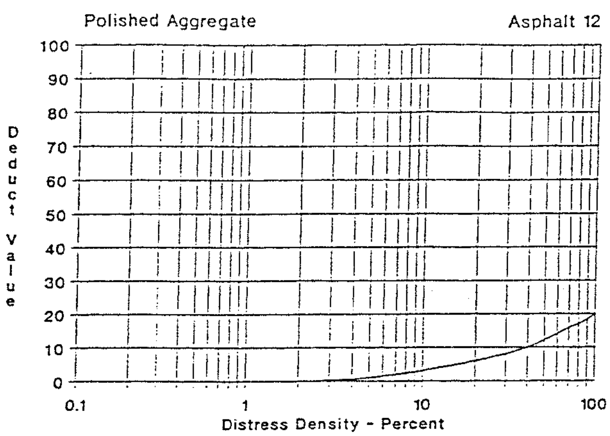


FIG. X3.17 Polished Aggregate

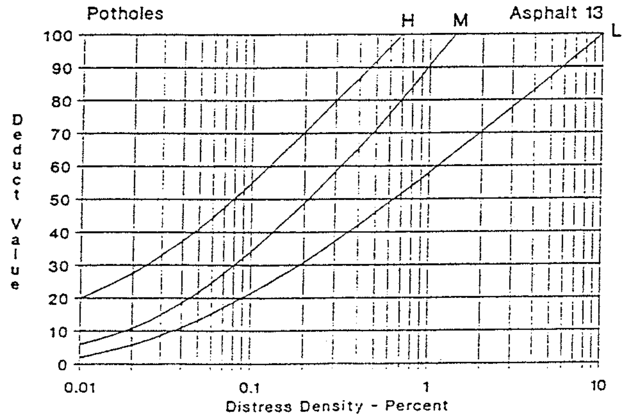


FIG. X3.18 Potholes

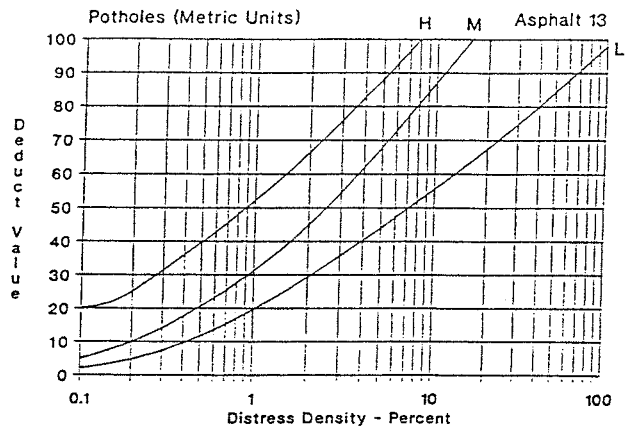


FIG. X3.19 Potholes (metric units)

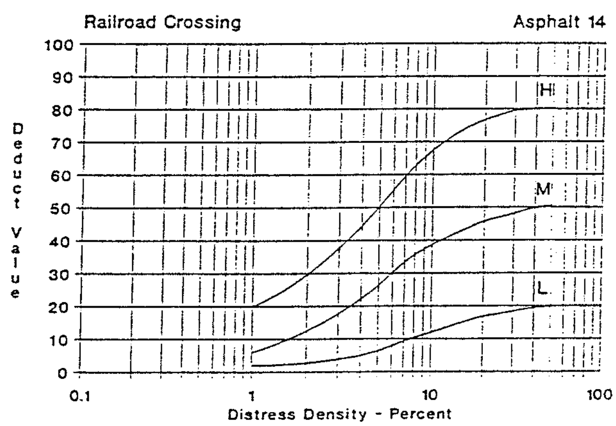


FIG. X3.20 Railroad Crossing

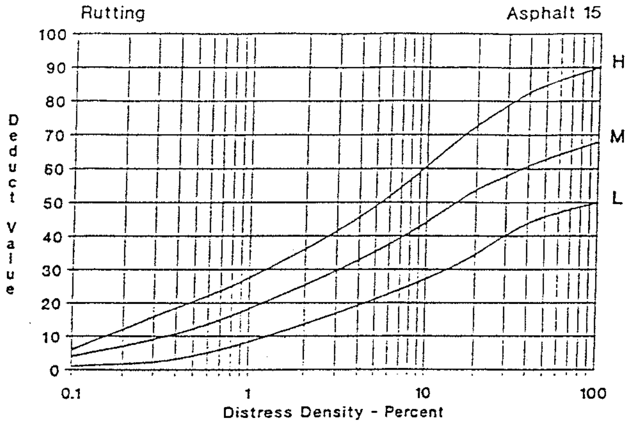


FIG. X3.21 Rutting

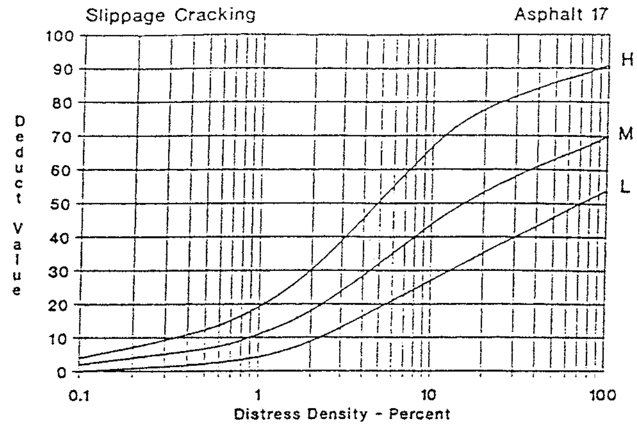


FIG. X3.23 Slippage Cracking

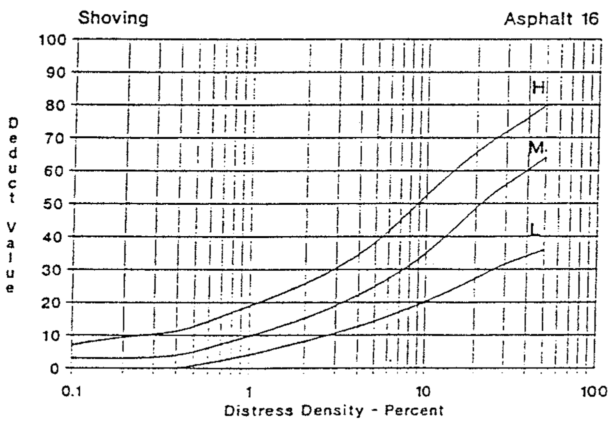


FIG. X3.22 Shoving

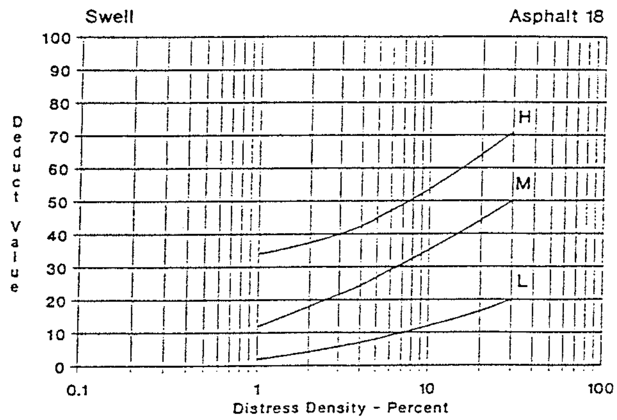


FIG. X3.24 Swell

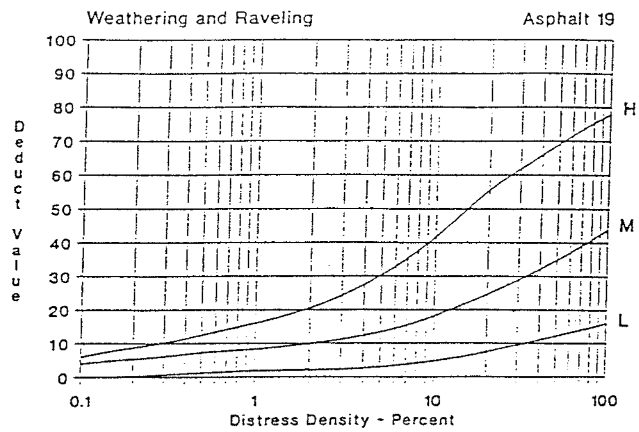


FIG. X3.25 Weathering and Raveling

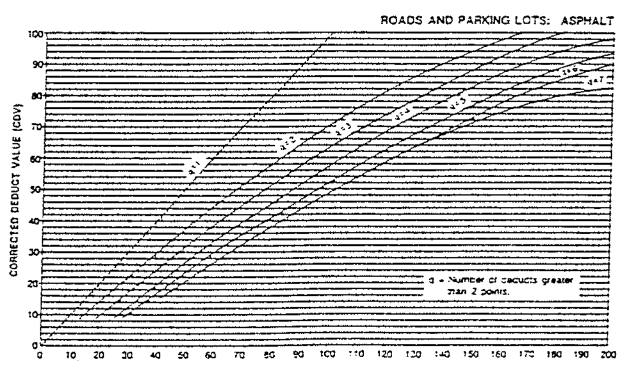


FIG. X3.26 Total Deduct Value

X4. DEDUCT VALUE CURVES FOR CONCRETE

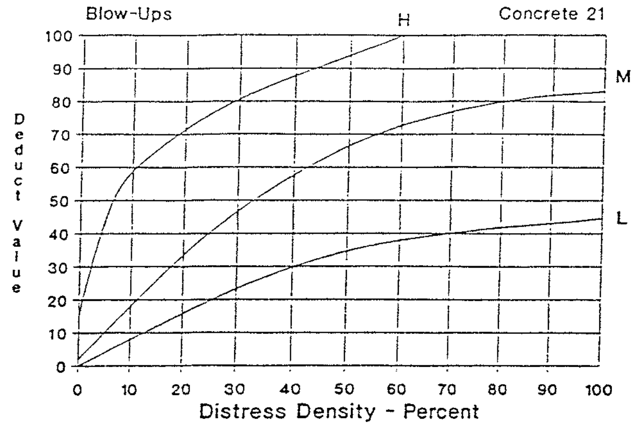


FIG. X4.1 Blowups

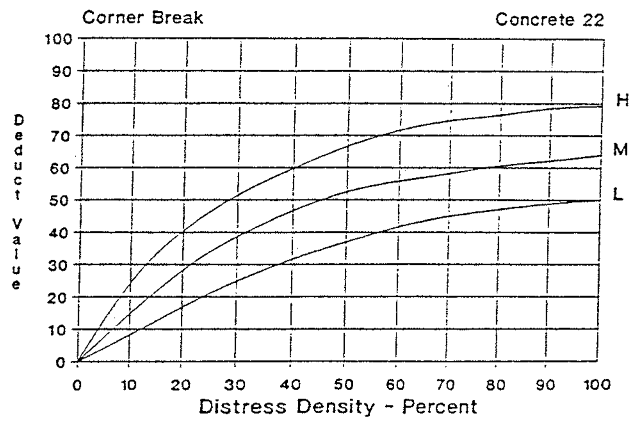


FIG. X4.2 Corner Break

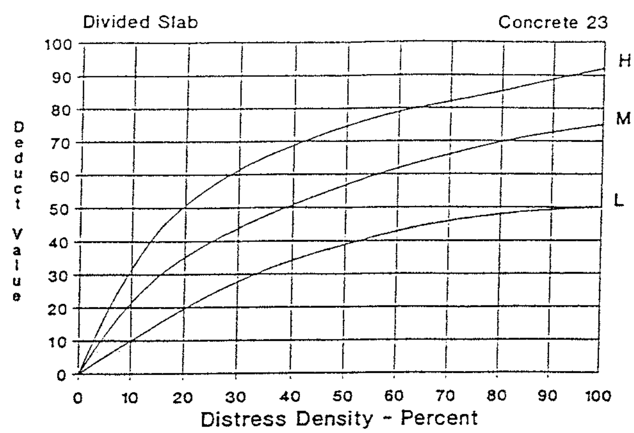


FIG. X4.3 Divided Slab

REFERENCES

(1) *PAVER Asphalt Distress Manual*, US Army Construction Engineering Laboratories, TR 97/104, June 1997.

(2) *PAVER Asphalt Distress Manual*, US Army Construction Engineering Laboratories, TR 97/105, June 1997.

(3) Carey, W.N., Jr. and Irick, P.E., "The Pavement Serviceability-Performance Concept," *HRB Bulletin 250*, 1960.

(4) Sayers, M. W., Gillespie, T. D., and Queiroz, C. A. V., "The International Road Roughness Experiment: Establishing Correlation and a Calibration Standard for Measurements," World Bank Technical Paper No. 45, the International Bank for Reconstruction and Development/the World Bank, Washington, DC, 1986.

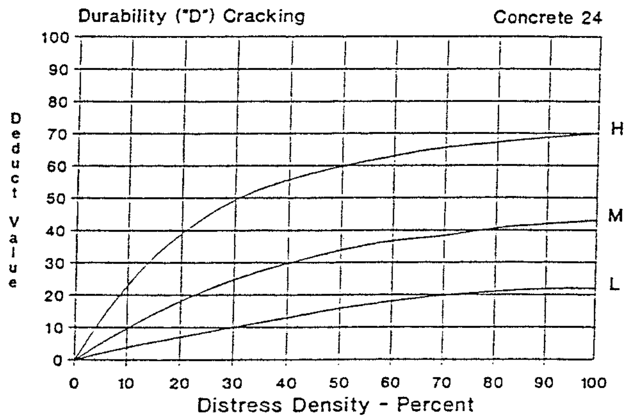


FIG. X4.4 Durability ("D") Cracking

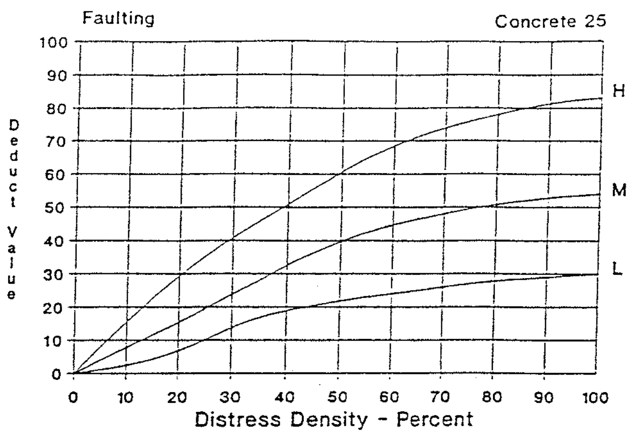


FIG. X4.5 Faulting

Joint Seal Damage   Concrete 26

Joint seal damage is not rated by density. The severity of the distress is determined by the sealant's overall condition for a particular sample unit.

The deduct values for the three levels of severity are:

LOW	2 points
MEDIUM	4 points
HIGH	8 points

FIG. X4.6 Rigid Pavement Deduct Values, Distress 26, joint seal damage

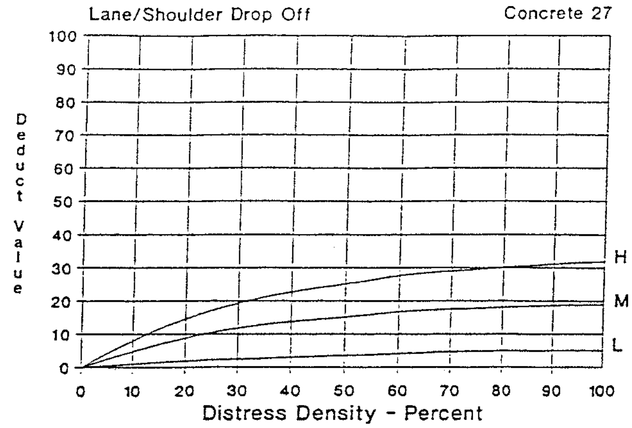


FIG. X4.7 Lane/Shoulder Drop-Off

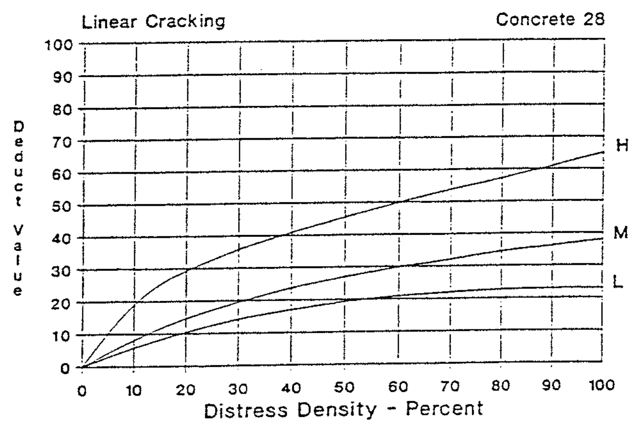


FIG. X4.8 Linear Cracking

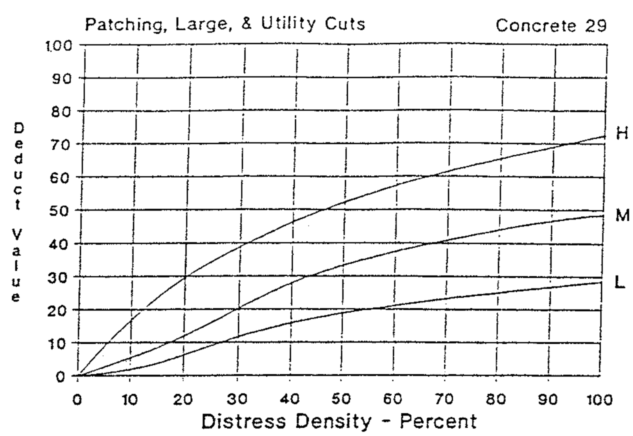


FIG. X4.9 Patching, Large, and Utility Cuts

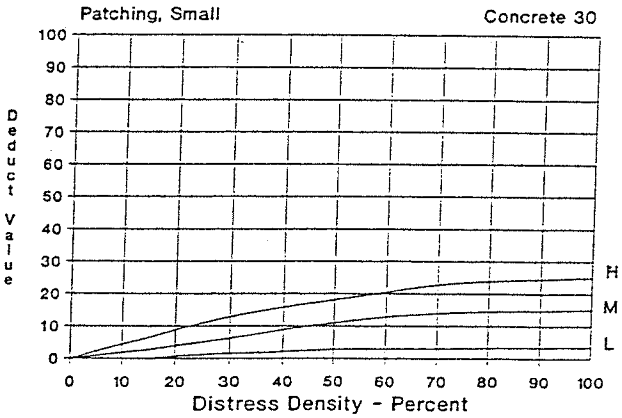


FIG. X4.10 Patching, Small

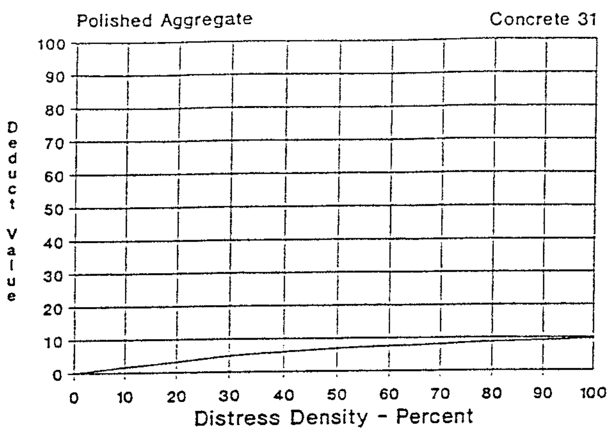


FIG. X4.11 Polished Aggregate

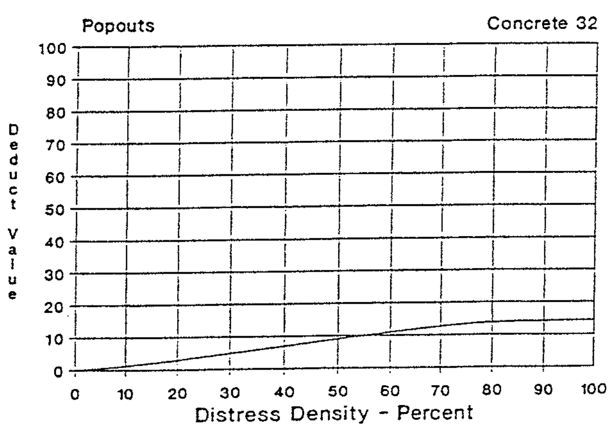


FIG. X4.12 Popouts

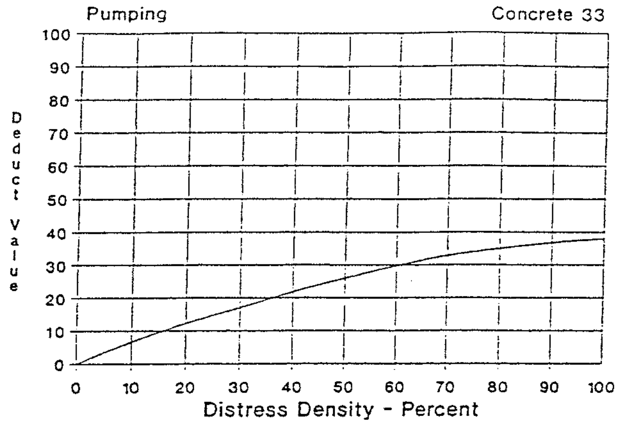


FIG. X4.13 Pumping

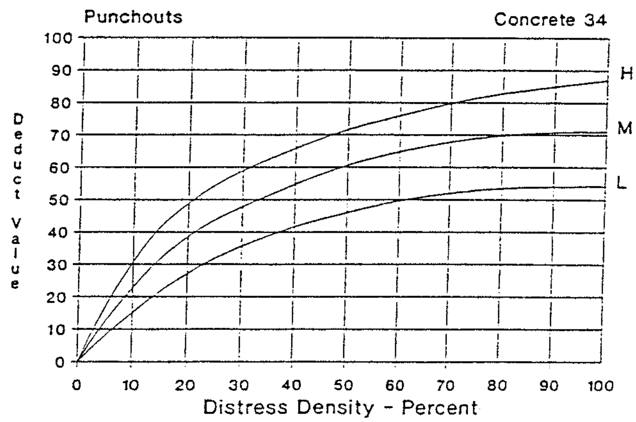


FIG. X4.14 Punchouts

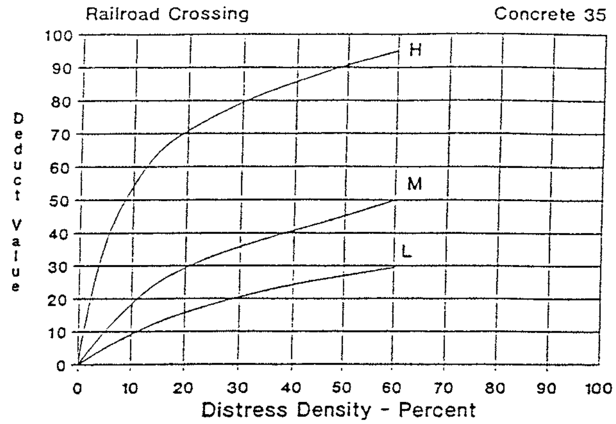


FIG. X4.15 Railroad Crossing

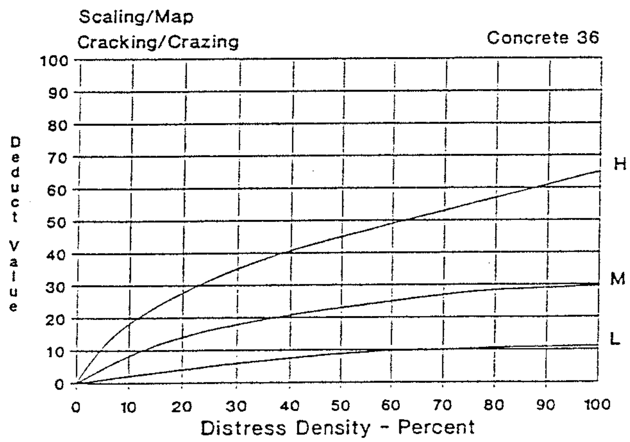


FIG. X4.16 Scaling/Map Cracking/Crazing

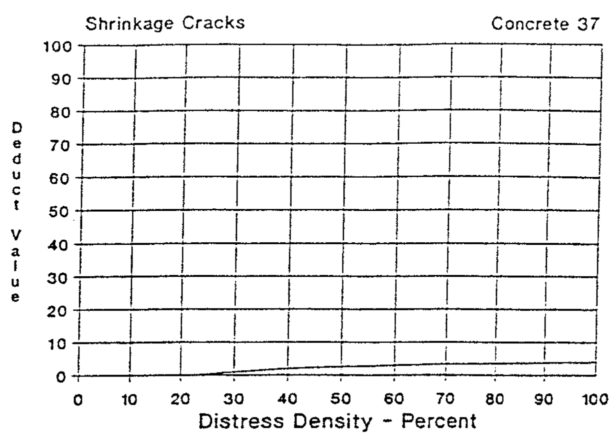


FIG. X4.17 Shrinkage Cracks

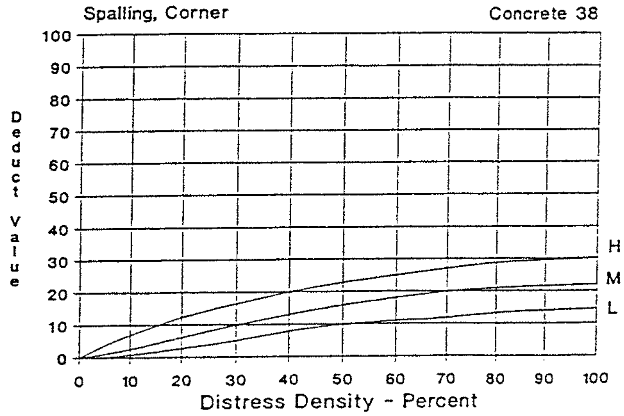


FIG. X4.18 Spalling, Corner

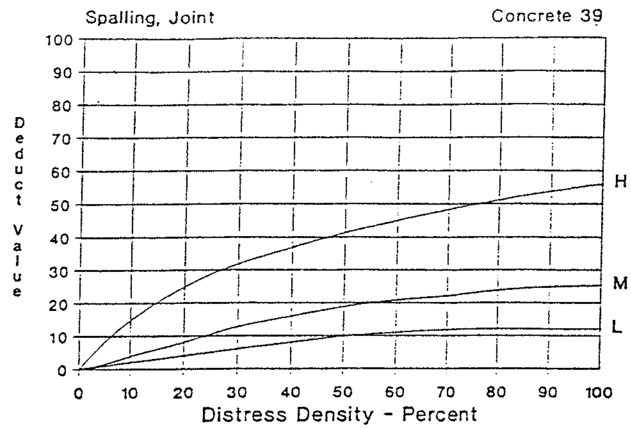
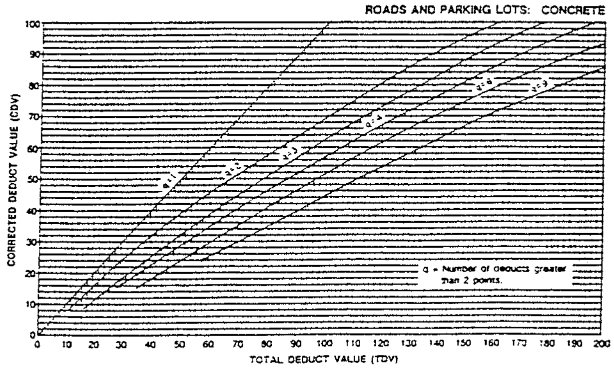


FIG. X4.19 Spalling, Joint



Corrected deduct values for jointed concrete pavement.

FIG. X4.20 Corrected Deduct Values for Jointed Concrete Pavement

Appendix C

Geotechnical Investigation

Geotechnical Investigation – Alger area

1.1 Geotechnical Investigation

Barr Engineering Co. (Barr), under authorization and contract with Invenergy, LLC (Invenergy), has completed a geotechnical investigation of roads around the Hardin Wind Project in Hardin County, Ohio. As part of this geotechnical investigation, Barr completed 23 geotechnical borings along road alignments near the proposed wind turbine location.

This letter report and its attachments provide geotechnical findings from the investigation. Barr previously completed a geotechnical investigation of the overall project area and prepared a comprehensive geotechnical report with recommendations for foundation design of turbines, original substation location, O&M building, overhead collector, and met towers.

1.1.1 Field Work

Under subcontract to Barr, Olsson Associates of Lincoln, Nebraska, completed a 28 shallow borings along existing county road alignments using a truck mounted drill rig to depths of five feet in two mobilizations between September 16th and October 17th, 2016. Standard penetration tests were performed and split-spoon samples were collected at 2.5-ft intervals to a depth of 5 ft. Drilling was advanced using solid-stem augers (SSA).

The coordinates of the borings are included in the Table 1 below and shown on Figure 1 attached.

Table 1 Testing Conditions and Coordinates

Geotechnical Boring ID	UTM NAD83 Z17N		Latitude [deg.]	Longitude [deg.]	Boring	CBR
	Easting [m]	Northing [m]				
RD-02	259954.9	4509774.5	40.70393	-83.84138	X	
RD-03	260351.1	4509766.4	40.70397	-83.83669	X	
RD-04	260747.5	4509750.7	40.70394	-83.83200	X	X
RD-05	261113.5	4509744.9	40.70400	-83.82767	X	
RD-06	261489.3	4509746.6	40.70412	-83.82322	X	
RD-07	259892.2	4509747.8	40.70367	-83.84211	X	
RD-08	259876.7	4509351.7	40.70010	-83.84214	X	
RD-09	259868.8	4508955.5	40.69653	-83.84208	X	
RD-10	259851.8	4508559.3	40.69296	-83.84213	X	
RD-11	259888.1	4508174.9	40.68952	-83.84155	X	
RD-12	260219.0	4508150.8	40.68940	-83.83763	X	X
RD-13	260565.8	4508143.9	40.68943	-83.83353	X	
RD-14	258598.1	4506568.9	40.67469	-83.85619	X	
RD-15	258992.6	4506551.5	40.67465	-83.85152	X	
RD-16	259404.3	4506544.7	40.67471	-83.84665	X	
RD-17	259812.8	4506527.3	40.67467	-83.84181	X	X
RD-18	260210.7	4506520.3	40.67472	-83.83711	X	
RD-19	260602.9	4506494.8	40.67461	-83.83246	X	
RD-20	261015.8	4506482.8	40.67462	-83.82758	X	
RD-21	261415.7	4506464.6	40.67457	-83.82285	X	
RD-24	258987.6	4504926.8	40.66003	-83.85095	X	X
RD-25	259343.0	4504913.7	40.66001	-83.84675	X	
RD-26	259723.8	4504905.9	40.66006	-83.84225	X	

RD-42	259836.8	4508157.4	40.68934	-83.84215	X	
RD-43	259830.0	4507753.1	40.68570	-83.84208	X	
RD-44	259811.8	4507353.9	40.68211	-83.84214	X	
RD-45	259805.0	4506952.0	40.67849	-83.84207	X	
RD-46	259784.2	4506548.3	40.67485	-83.84216	X	

1.1.2 Bulk Soil Sampling

Bulk samples of representative material from the site were collected for the purpose of laboratory testing. A total of four bulk soil samples (5-gallon buckets) were collected across the project site in support of California Bearing Ratio (CBR) testing. Sampling locations were selected to provide representative soil samples across the project area.

1.2 Subsurface Conditions

The results of the geotechnical borings and laboratory tests were compiled to obtain an understanding of the lithology of the study areas.

The typical stratigraphy, as determined from the field data collected at the road boring locations, consists of a surficial layer of asphalt or gravel underlain by primarily lean clay. Silty sand with various amounts of gravel was identified in three of the road borings beneath the asphalt. There were no base or sub-base courses identified beneath the asphalt; the bituminous materials appear to be placed directly on the existing soil/fill materials.

1.2.1 Asphalt

Asphalt was encountered in 26 of the 28 road boring locations. Asphalt thicknesses at boring locations ranged from 6 to 20.5 inches. The average asphalt thickness as approximately 12 inches.

1.2.2 Gravel

Surficial gravel was encountered in five of the 28 road boring locations. It was classified as a poorly graded gravel with sand. The thickness of the surficial gravel ranged from three to five inches.

1.2.3 Lean Clay to Fat Clay

Lean to fat clay was encountered in 27 of the 28 road boring locations in thicknesses ranging from approximately 1.5 feet to 4.7 feet. N-values from Standard Penetration Testing (SPT) conducted in the clays ranged from 4 to 22 blows per foot (bpf) with an average of 10 bpf. These results indicate that the clays typically have consistencies ranging from soft or very stiff.

1.2.4 Silty Sand

Silty sand with various amounts of gravel was encountered in three of the 28 road boring locations in thicknesses ranging from approximately 1.8 feet to 4.1 feet. N-values from SPT's conducted in the silty sand ranged from 7 to 27 blows per foot (bpf) with an average of approximately 14 bpf. These results indicate that the silty sands typically have relative densities ranging from loose to medium dense.

1.3 Groundwater Conditions

No evidence of groundwater was observed during the course of the geotechnical field investigation, however the road borings did not extend greater than 5 feet below existing grade. As a result, groundwater is not anticipated to be a significant factor in the current road construction.

1.4 Shear Strength

1.4.1 Approximate Undrained Shear Strength

The results of the geotechnical investigation indicate that most of roads bear directly on clayey soils with no base or sub-base courses present under the asphalt or gravel.

A number of pocket penetrometer tests were conducted on split spoon samples collected during drilling. The pocket penetrometer values in clay soils at each road boring location ranged from 1.0 tsf to greater than 4.5 tsf. The average results indicated an estimated unconfined compressive strength of 3.0 tons per square foot (tsf), which corresponds to an undrained shear strength of approximately 1,500 psf.

1.4.2 Approximate Drained Shear Strength

Granular soils were encountered in three road borings completed at all proposed turbine locations. The shear strength of these soils was estimated from correlations to SPT results collected at 2.5-foot intervals during sampling in the boreholes. The SPT value can be correlated to the soil friction angle (Das, 2007). The lowest average SPT value obtained for a cohesionless soil interval between a depth of one and five feet was SPT = 7 at road boring RD-19. An SPT value of 7 in silty sand correlates to a friction angle of approximately 30 degrees.

1.5 Laboratory Testing

Laboratory testing was performed on selected samples as described below.

1.5.1 California Bearing Ratio Testing

Design for roads and general working areas is based in part on the strength of the subgrade that can be reasonably achieved. California Bearing Ratio (CBR) tests were completed on soil samples collected from the selected locations across the site to determine the field strength of the subgrade.

A total of four samples of the shallow subgrade soils were collected adjacent to the road borings in the shoulders (Figure 1). The bulk samples were collected from soil immediately topsoil or fill materials, which typically corresponded to a depth of approximately 6 to 20 inches below the surface. The soil samples were prepared to approximate 95 percent of the standard Proctor maximum dry density at the optimum moisture content. The results of the CBR testing are presented in Table 2.

In general, the CBR samples were classified as fat clay with various amount of sand and gravel. Results from the testing conducted on the subgrade samples indicate that CBR values at 0.1 inch of deflection under a surcharge of 50 psf range from 2.0 to 3.6 percent, when compacted to 95 percent of the standard Proctor density at optimum moisture. The results indicate that the soils at the site are fairly consistent in their ability to support roads.

Table 2 CBR Testing Results

Geotechnical Boring ID	USCS	California Bearing Ratio Value (Optimum Moisture Content)*
		95% Compaction
RD-04	CH	2.2
RD-12	CH	3.0
RD-17	CH	3.6
RD-24	CH	2.0

1.6 DCP Field Testing

Dynamic Cone Pentrometer (DCP) tests were completed during investigation as a means of quantifying the subgrade strength of the soils in the road borings.

DCP tests were conducted in accordance with ASTM standard D6951 "Standard Test Method for use of the Dynamic Cone Penetrometer in Shallow Pavement Applications". The DCP was model K-100, manufactured by Kessler Soils Engineering Products, Inc. All tests were conducted utilizing a 17.6 pound hammer.

DCP tests were completed in all 28 road boring locations. The approximate location of each DCP test is provided in Table 3. Each test was conducted to a depth of 12 inches below existing grade. The results of the DCP testing are provided in Table 3.

The DCP rate of penetration can be correlated to California Bearing Ratio (CBR) values for the road subgrade. The following equation shows the relationship between measured DCP values in the field and approximate CBR values.

where:

CBR = California Bearing Ratio

PR = DCP rate of penetration [mm]

Table 3 shows the CBR value obtained at each of the four locations tested. It should be noted that several DCP values were higher than what would be expected given the material encountered in the borings. These locations tend to coincide with borings where silty sand was encountered. Any CBR correlations yielding values above 7 should be treated as anomalous as the DCP may have struck gravel causing an artificially high Dynamic Cone Penetration Index (DPI). Reading higher than 7 are not anticipated with clayey soils. Specifically regarding RD-17, because the CBR samples were collected in the right of way adjacent to the boring rather than in the exact location of the road boring, it is likely that the material tested was not similar to the material the DCP was completed in. Based on the lab results, an average CBR value of 2.7 is recommended for road design based on the results obtained from testing at this time.

Table 3 DCP Testing Results and CBR Correlation

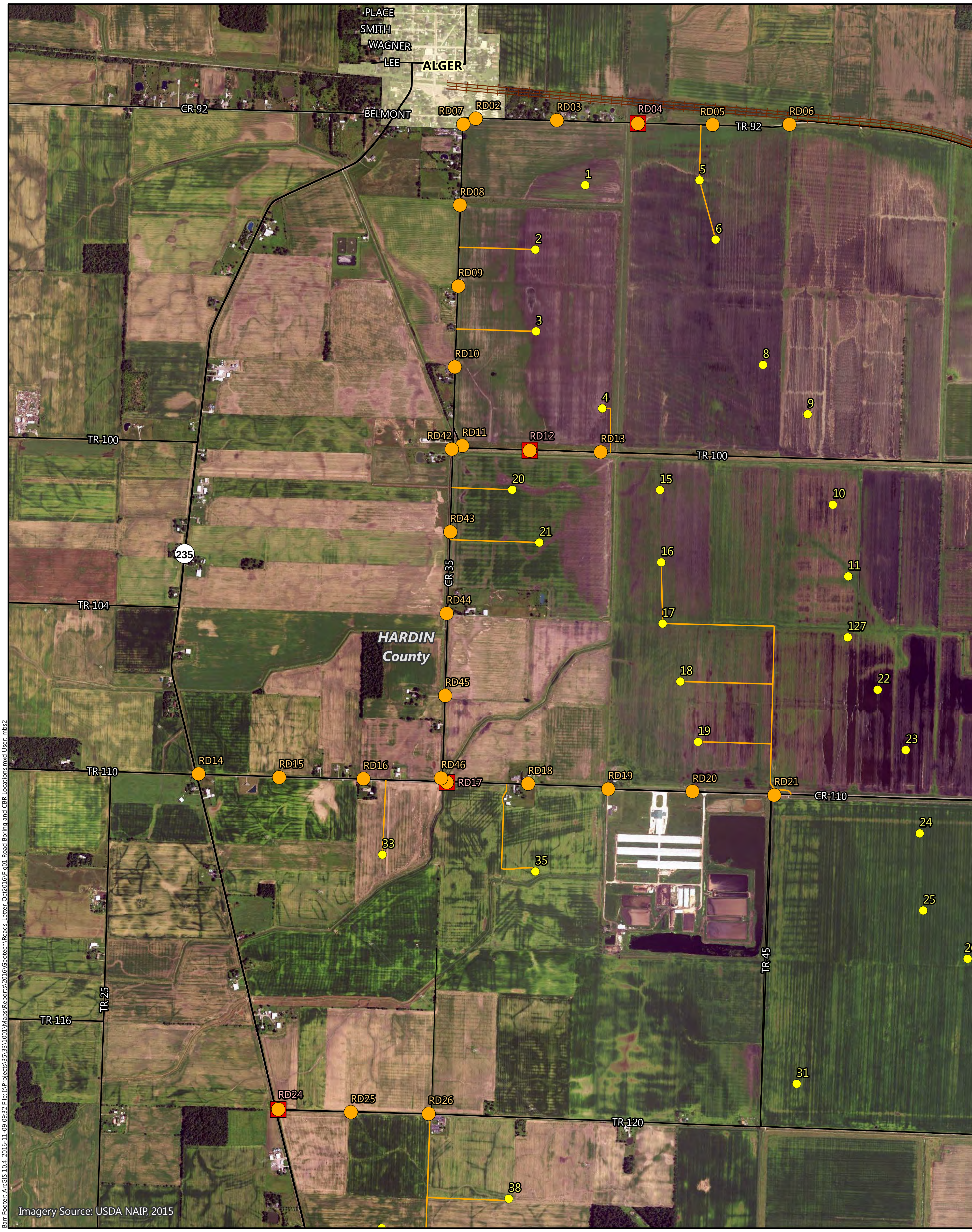
Location ID	Bituminous Thickness (inches)	DCP Blows per Foot	DPI	log (CBR)	Correlated CBR Value	95% Tested CBR Value
RD-02	12.5	7	43.5	0.62	4.2	--
RD-03	12	7	43.5	0.62	4.2	--
RD-04	14.5	7	43.5	0.62	4.2	2.2
RD-05	13.5	7	43.5	0.62	4.2	--
RD-06	19	36	8.5	1.42	26.4	--
RD-07	10.5	7	43.5	0.62	4.2	--
RD-08	10	7	43.5	0.62	4.2	--
RD-09	11	6	50.8	0.55	3.5	--
RD-10	12.5	5	61.0	0.46	2.9	--
RD-11	6	17	17.9	1.06	11.4	--
RD-12	4 (gravel)	6	50.8	0.55	3.5	3.0
RD-13	5 (gravel)	10	30.5	0.80	6.3	--
RD-14	11	9	33.9	0.75	5.6	--
RD-15	11.5	16	19.1	1.03	10.6	--
RD-16	11.5	9	33.9	0.75	5.6	--
RD-17	11.5	41	7.4	1.48	30.5	3.6
RD-18	12	8	38.1	0.69	4.9	--
RD-19	11.5	72	4.2	1.76	57.3	--
RD-20	12	18	16.9	1.08	12.1	--
RD-21	12	12	25.4	0.89	7.7	--
RD-24	8	8	38.1	0.69	4.9	2.0
RD-25	11	11	27.7	0.84	7.0	--
RD-26	12	7	43.5	0.62	4.2	--
RD-42	15	8	38.1	0.69	4.9	--
RD-43	13	7	43.5	0.62	4.2	--
RD-44	13	6	50.8	0.55	3.5	--
RD-45	13	7	43.5	0.62	4.2	--
RD-46	12	6	50.8	0.55	3.5	--

CBR Computations referenced from Salgado, 2003.

Used Kesler DCP (smaller DCP) under asphalt/gravel fill

1. Kessler Soils Engineering Products, Inc., *K-100 Models with quick connect pin User's Manual*, Springfield, Virginia, October 2007.

2. Giroud, J.P. and Han, J. "Design Method for Geogrid-Reinforced Unpaved Roads, II. Calibration and Applications" Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 130(8): 787-797.



Turbine Location (8/5/2016)

Road Boring Location

Road Boring and CBR Location

Transportation Route

Access Road

Feet

Meters

Figure 1

SOIL BORING AND CBR LOCATIONS

Hardin Wind Project
Invenergy LLC
Hardin County, Ohio

California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	**10557**
Client:	Barr Engineering Company	Date:	10/5/16

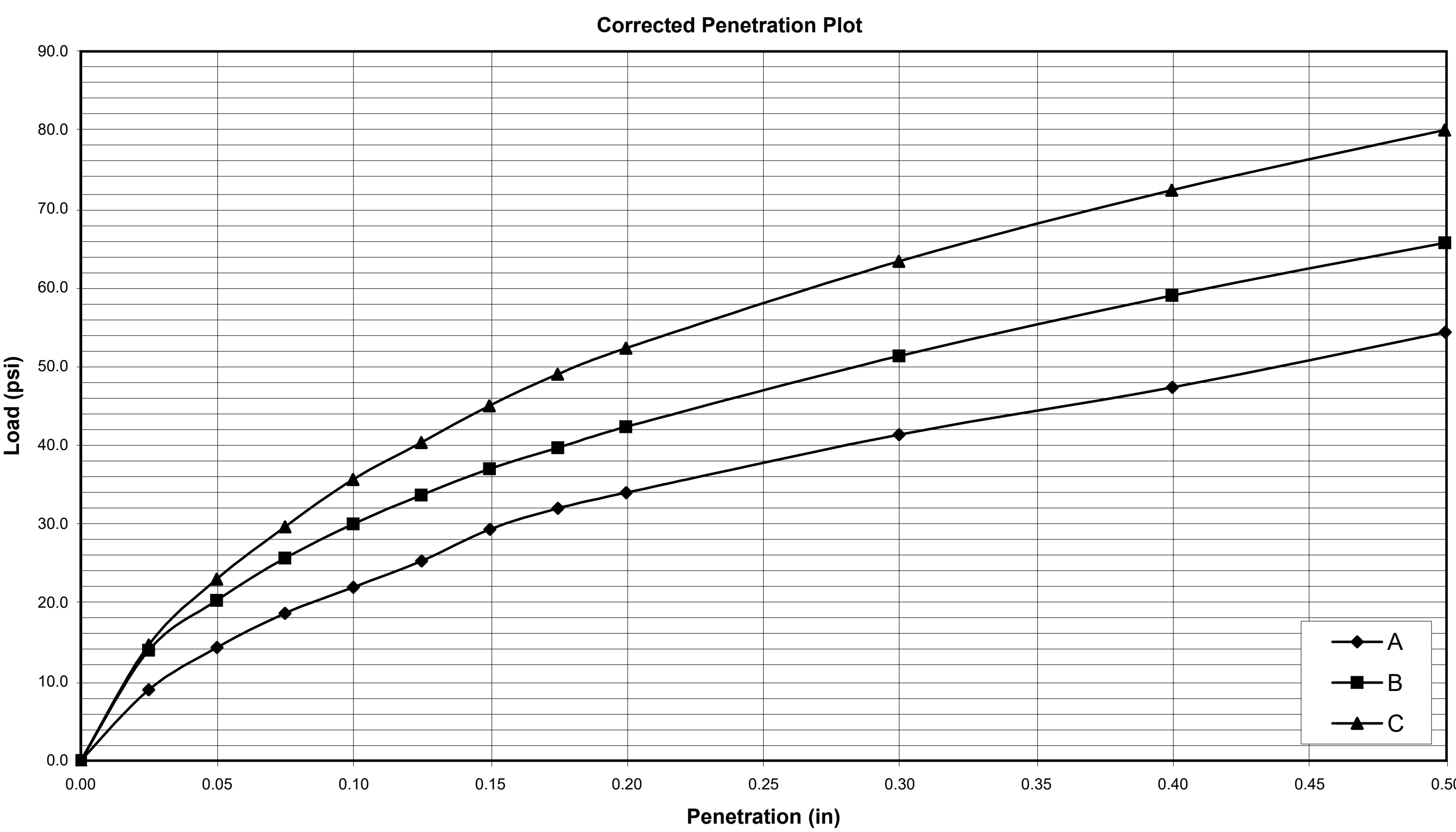
Boring #: RD-04, RD-12, RD-17		Procedural Method:
Sample:		Specimens compacted to approximately 95% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft):	Type: Bulk	
Location:		

Classification: Fat Clay with a little gravel (CH), Fat Clay with a trace of organic material (CH), Fat Clay (CH)

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	92.5, 84.3, 98	PL:	Organic Content:
Optimum Water Content:	25.3%, 31.5%, 23.3%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	25.3%	31.5%	23.3%
Initial Dry Density (PCF)	87.8	80.4	93.1
Relative Compaction	94.9%	95.4%	94.9%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.6%	1.9%	1.2%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**2.2%**	**3.0%**	**3.6%**
at 0.2 inch (%)	2.3%	2.8%	3.5%
Moisture Content After Penetration			
Top 1" of Specimen:	29.5%	35.1%	25.5%
Average of specimen:	28.4%	33.9%	25.0%

Stress vs. Penetration Graph



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

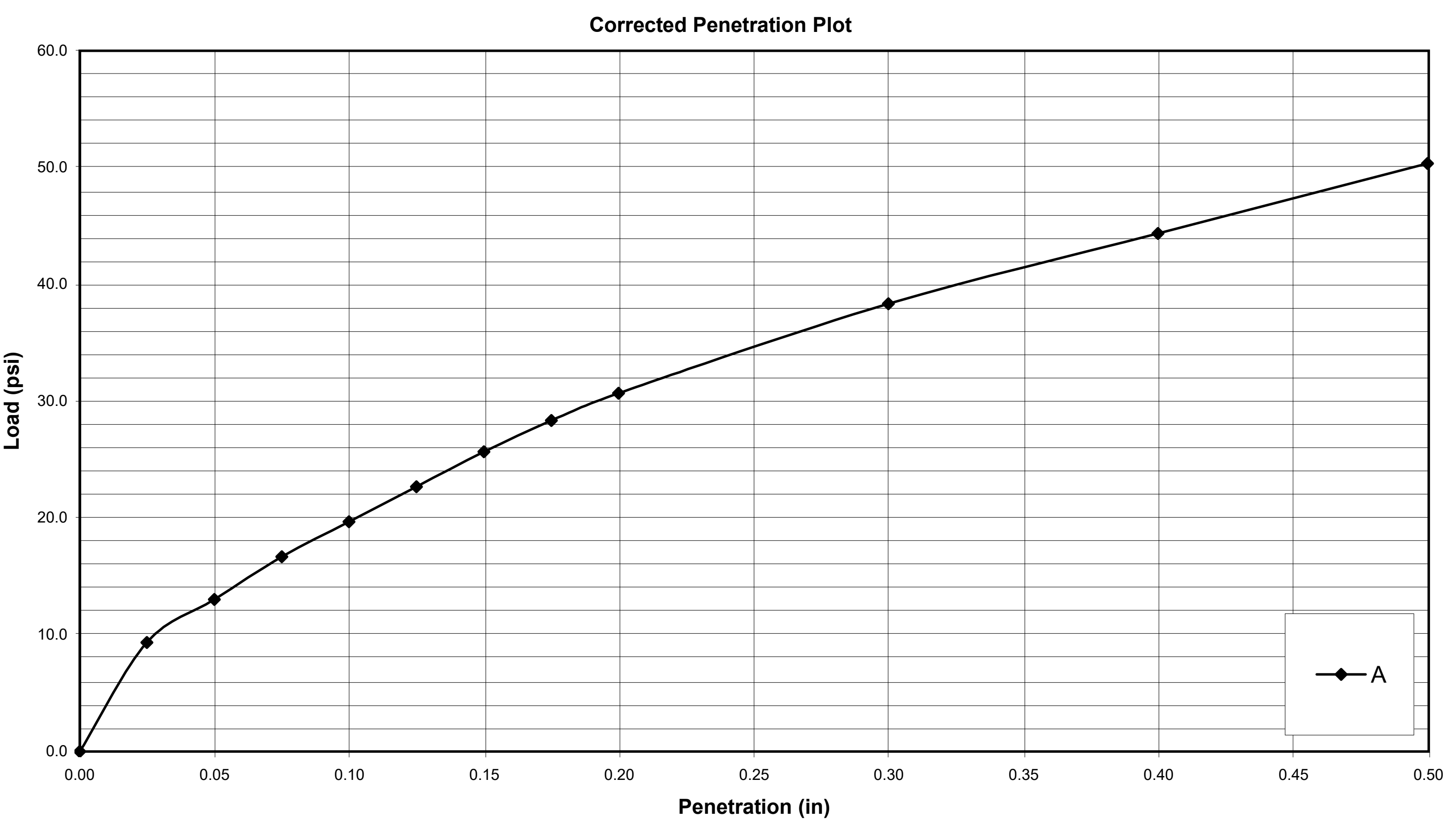
Project:	Hardin Wind	Job:	**10557**
Client:	Barr Engineering Company	Date:	10/5/16

Boring #: RD-24		Procedural Method:
Sample:		Specimens compacted to approximately 95% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft):	Type: Bulk	
Location:		
Classification: Fat Clay with a little gravel (CH)		

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	91.3	PL:	Organic Content:
Optimum Water Content:	26.7%	PI:	pH:

Initial Molding Conditions			
Specimen	A		
Compaction Hammer:	5 lb		
Number of Layers:	3		
Blows per Layer:	NA		
Initial Moisture Content:	26.7%		
Initial Dry Density (PCF)	86.6		
Relative Compaction	94.9%		
Soaking Phase			
Days Soaked	4		
Surcharge (psf)	50		
Total Swell (%)	2.0%		
Penetration Phase			
Surcharge (psf)	50		
Corrected CBR Values			
at 0.1 inch (%)	**2.0%**		
at 0.2 inch (%)	2.1%		
Moisture Content After Penetration			
Top 1" of Specimen:	32.1%		
Average of specimen:	30.9%		

Stress vs. Penetration Graph



Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-02

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)		Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA (N in blows/ft)	WATER CONTENT %	SIEVE ANALYSIS	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	Surface Elev.:													
	0.0	ASPHALT: 12.5 inches thick.													
	1.1	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	1.1		Split Spoon	8 (at 2.0)							2		
	2.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; stiff.	2.5		Split Spoon	12 (at 4.0)							2		
	5.0	Bottom of Boring at 5.0 feet	5.0												

Completion Depth: 5.0
Date Boring Started: 9/17/16
Date Boring Completed: 9/17/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:239955m, E:4509775m
Datum: NAD83

Remarks:

SAMPLE TYPES	WATER LEVELS (ft)	LEGEND
Split Spoon	After Drilling: Dry; At Time of Drilling: Dry	MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

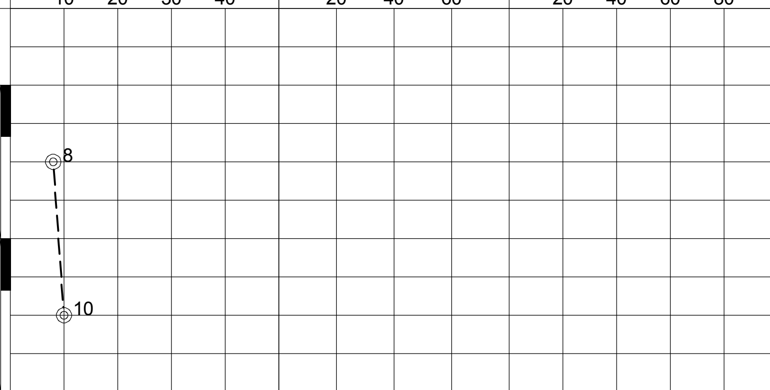
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-03

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488) Surface Elev.:		Sample Type & Rec.	SPT N in blows/ft	Qp tsf
	0.0	ASPHALT: 12 inches thick.				
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	1.0	Split Spoon	8 (at 2.0)	2.5 (at 2.0)
	3.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; stiff.	3.5	Split Spoon	10 (at 4.0)	1.5 (at 4.0)
	5.0	Bottom of Boring at 5.0 feet	5.0			



Physical Properties: WC %, γ pcf, ϕ °, Qu tsf, Qp tsf, Gs, RQD %

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260352m, E:4509766m
Datum:	NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
After Drilling Dry
At Time of Drilling Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Qu Unconfined Compression
Qp Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-04

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	Material Description (ASTM D2488)	Layer Bottom Depth	SPT N (blows/ft)	Q_p (tsf)
0.0	ASPHALT: 14.5 inches thick.	1.3		
1.3	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	4.0	8 (at 2.0)	3.5 (at 2.0)
			12 (at 4.0)	1 (at 4.0)
4.0	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; medium stiff.	5.0		
5.0	Bottom of Boring at 5.0 feet			

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260747m, E:4509752m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): After Drilling Dry; At Time of Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-05

Project: Hardin County Wind Project
Location: Hardin County, Ohio
Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488) Surface Elev.:	Depth	Standard Penetration Test Data (N in blows/ft)	Qp tsf
	0.0	ASPHALT: 13.5 inches thick.			
	1.3	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.	1.3	13 (at 2.0)	2.5
	3.0	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; medium stiff.	3.0	7 (at 4.0)	
	5.0	Bottom of Boring at 5.0 feet	5.0		

Column headings: Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA (N in blows/ft; 10 20 30 40); WATER CONTENT % (PL, LL; 20 40 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES; 20 40 60 80); Physical Properties: WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %

Completion Depth: 5.0
Date Boring Started: 9/17/16
Date Boring Completed: 9/17/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:260113m, E:4709746m
Datum: NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
After Drilling: Dry
At Time of Drilling: Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-06

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)		Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA (N in blows/ft)	WATER CONTENT %	SIEVE ANALYSIS	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	Surface Elev.:													
	0.0	ASPHALT: 19 inches thick.													
	1.7	SILTY SAND WITH GRAVEL (SM): fine to coarse grained; brown; moist; medium dense.	1.7		Split Spoon	13									
	3.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; soft.	3.5		Split Spoon	4							0.5		
	5.0	Bottom of Boring at 5.0 feet	5.0												

Completion Depth: 5.0
Date Boring Started: 9/17/16
Date Boring Completed: 9/17/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:261488m, E:4509749m
Datum: NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
After Drilling: Dry
At Time of Drilling: Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-07

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Depth	Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA (N in blows/ft)	WATER CONTENT %	SIEVE ANALYSIS	WC %	γ pcf	φ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	Surface Elev.:													
	0.0	ASPHALT: 10.5 inches thick.													
	0.9	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.	0.9		Split Spoon										
	2.0	LEAN TO FAT CLAY (CL/CH): greenish gray; moist; stiff.	2.0		Split Spoon	10							2		
	4.0				Split Spoon	11							2		
	5.0	Bottom of Boring at 5.0 feet	5.0												

Completion Depth: 5.0
Date Boring Started: 9/16/16
Date Boring Completed: 9/16/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:259591m, E:4509747m
Datum: NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
After Drilling
Dry
At Time of Drilling
Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
φ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-08

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Bottom depth	Standard Penetration Test Data (N in blows/ft)	Q_p tsf
0.0	ASPHALT: 10 inches thick.	0.9		
0.9	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	3.0	8 (at 2.0 ft)	2.5
3.0	LEAN TO FAT CLAY (CL/CH): gray to brown; moist; stiff.	5.0	10 (at 4.0 ft)	2
5.0	Bottom of Boring at 5.0 feet			

Column headings: Elevation, feet; Depth, feet; Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA (N in blows/ft: 10, 20, 30, 40); WATER CONTENT % (PL, LL: 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES: 20, 40, 60, 80); Physical Properties: WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259877m, E:4509351m
Datum:	NAD83

Remarks:

SAMPLE TYPES

Split Spoon

WATER LEVELS (ft)

After Drilling
Dry
At Time of Drilling
Dry

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-09

Sheet 1 of 1

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Bottom depth	Standard Penetration Test Data (N in blows/ft)	Q_p (tsf)
0.0	ASPHALT: 11 inches thick.	0.9		
0.9	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	2.0	8 (at 2.0 ft)	1.5
2.0	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; stiff.	5.0	11 (at 4.0 ft)	2
5.0	Bottom of Boring at 5.0 feet			

Column headings: Elevation, feet; Depth, feet; Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA (N in blows/ft; 10, 20, 30, 40); WATER CONTENT % (PL, LL; 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES; 20, 40, 60, 80); Physical Properties: WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259868m, E:4508955m
Datum:	NAD83

Remarks:

SAMPLE TYPES	WATER LEVELS (ft)	LEGEND
Split Spoon	After Drilling: Dry	MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle
	At Time of Drilling: Dry	Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-10

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488) Surface Elev.:	Strata depth	Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA N in blows/ft	WATER CONTENT %	SIEVE ANALYSIS	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	ASPHALT: 12.5 inches thick.													
	1.1	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	1.1		Split Spoon										
	2.0					7							1.5		
	3.5	LEAN TO FAT CLAY (CL/CH): greenish gray; moist; stiff.	3.5		Split Spoon										
	4.0					10							1		
	5.0	Bottom of Boring at 5.0 feet	5.0												

Completion Depth: 5.0
Date Boring Started: 9/17/16
Date Boring Completed: 9/17/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:259851m, E:4508560m
Datum: NAD83

Remarks:

SAMPLE TYPES

Split Spoon

WATER LEVELS (ft)

At Time of Drilling: Dry
After Drilling: Dry

LEGEND

MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

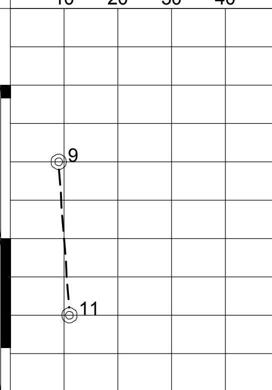
LOG OF BORING RD-11

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Bottom depth	N (blows/ft)	Qp (tsf)
0.0	ASPHALT: 6 inches thick.	0.5		
0.5	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff; trace gravel.	3.0	9 (at 2.0)	2
3.0	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff.	5.0	11 (at 4.0)	2.5
5.0	Bottom of Boring at 5.0 feet			



Physical Properties: WC %, γ pcf, ϕ °, Qu tsf, Qp tsf, Gs, RQD %

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259886m, E:4508175m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling: Dry; After Drilling: Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-12

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Layer bottom depth	Sample Type	SPT N (blows/ft)	Q_p tsf
	0.0	Surface Elev.:				
	0.0–0.3	GRAVEL WITH SAND (GP): brown and gray; moist; 6 inches thick; [fill].	0.3			
	0.3–3.0	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; medium stiff.		Split Spoon (1.0–3.0)	7 (at 2.0)	2.5 (at 2.0)
	3.0–5.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	3.0	Split Spoon (3.0–5.0)	8 (at 4.0)	2.5 (at 4.0)
	5.0	Bottom of Boring at 5.0 feet	5.0			

Column headings: Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA, N in blows/ft (10, 20, 30, 40); WATER CONTENT % (PL, LL; 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES; 20, 40, 60, 80); Physical Properties: WC %, γ pcf, φ °, Q_u tsf, Q_p tsf, Gs, RQD %.

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260219m, E:4508152m
Datum:	NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
At Time of Drilling
Dry
After Drilling
Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
φ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-13

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	Material Description (ASTM D2488)	Bottom depth	Sample Type & Rec.	SPT N (blows/ft)	Q_p (tsf)
0.0	GRAVEL WITH SAND (GP): brown and gray; moist; 5 inches thick; [fill].	0.4			
0.4	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff.	2.5	Split Spoon (1.0–3.0)	14 (at 2.0)	2.5
2.5	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.	5.0	Split Spoon (3.0–5.0)	9 (at 4.0)	2
5.0	Bottom of Boring at 5.0 feet	5.0			

Column headings: Elevation, feet; Depth, feet; MATERIAL DESCRIPTION (ASTM D2488); Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA, N in blows/ft (10, 20, 30, 40); WATER CONTENT % (PL, LL; 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES; 20, 40, 60, 80); Physical Properties: WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %

Depth scale: 0.0 to 10.0 ft in 0.5 ft increments.

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260560m, E:4508144m
Datum:	NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
At Time of Drilling: Dry
After Drilling: Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-14

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	Material Description (ASTM D2488)	Layer bottom depth	Sample Type & Rec.	SPT N (blows/ft)	Q_p (tsf)
0.0	ASPHALT: 11 inches thick.	0.9			
0.9	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	3.0	Split Spoon	8	3
3.0	LEAN TO FAT CLAY (CL/CH): brown and gray; moist; stiff.	5.0	Split Spoon	14	2
5.0	Bottom of Boring at 5.0 feet				

Completion Depth: 5.0
Date Boring Started: 9/16/16
Date Boring Completed: 9/16/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:258597m, E:4506570m
Datum: NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling: Dry; After Drilling: Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-15

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Depth	SPT N (blows/ft)	Qp (tsf)
0.0	ASPHALT: 11.5 inches thick.			
0.9	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff to very stiff.	0.9		
2.0			8	2
4.0			16	2
5.0	Bottom of Boring at 5.0 feet	5.0		

Column headings: Elevation, feet; Depth, feet; Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA (N in blows/ft: 10, 20, 30, 40); WATER CONTENT % (PL, LL: 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES: 20, 40, 60, 80); Physical Properties: WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:258992m, E:4506558m
Datum:	NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
At Time of Drilling: Dry
After Drilling: Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

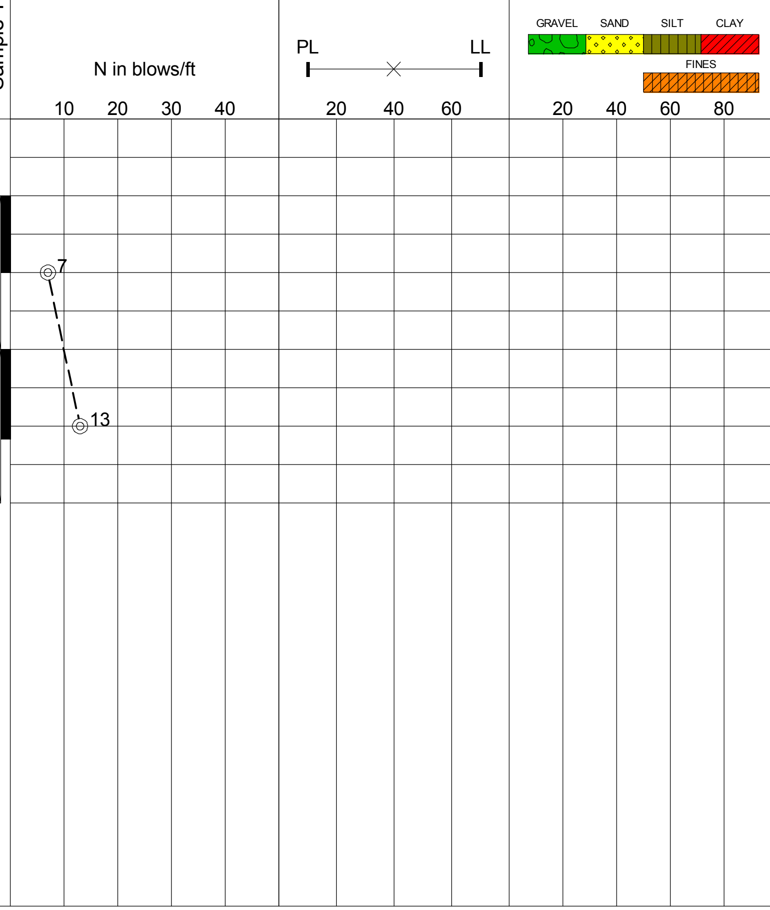
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-16

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)		Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA (N in blows/ft)	WATER CONTENT %	SIEVE ANALYSIS	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
		Surface Elev.:													
	0.0	ASPHALT: 11.5 inches thick.													
	0.9	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	0.9			7							2		
	3.0	LEAN TO FAT CLAY (CL/CH): gray to brown; moist; stiff.	3.0			13							1.5		
	5.0	Bottom of Boring at 5.0 feet	5.0												



Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259405m, E:4506544m
Datum:	NAD83

Remarks:

SAMPLE TYPES
☒ Split Spoon

WATER LEVELS (ft)
At Time of Drilling Dry
After Drilling Dry

LEGEND
- MC Moisture Content
- γ Dry Unit Weight
- ϕ Friction Angle
- Q_u Unconfined Compression
- Q_p Hand Penetrometer UC
- Gs Specific Gravity
- RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-17

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Depth	Sample Type & Rec.	SPT N in blows/ft	Qp tsf
	0.0	Surface Elev.:				
	0.0	ASPHALT: 11.5 inches thick.				
	0.9	SILTY SAND (SM): fine to coarse grained; brown; moist; loose; [fill].	0.9	Split Spoon	8 (at 2.0)	
	3.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	3.0	Split Spoon	8 (at 4.0)	1
	5.0	Bottom of Boring at 5.0 feet	5.0			

Column headings: Graphic Log; STANDARD PENETRATION TEST DATA (N in blows/ft; 10, 20, 30, 40); WATER CONTENT % (PL, LL; 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES; 20, 40, 60, 80); Physical Properties: WC %, γ pcf, ϕ °, Qu tsf, Qp tsf, Gs, RQD %

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259813m, E:4506531m
Datum:	NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
At Time of Drilling: Dry
After Drilling: Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-18

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Strata Depth	Graphic Log	Sample Type & Rec.	SPT N (blows/ft)	Water Content %	Sieve Analysis	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	ASPHALT: 12 inches thick.													
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	1.0		Split Spoon										
	2.0					7							2.5		
	2.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; stiff.	2.5												
	3.0				Split Spoon										
	4.0					11							3		
	5.0	Bottom of Boring at 5.0 feet	5.0												

Completion Depth: 5.0
Date Boring Started: 9/16/16
Date Boring Completed: 9/16/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:260210m, E:4506521m
Datum: NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
At Time of Drilling: Dry
After Drilling: Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-19

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)		Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA (N in blows/ft)	WATER CONTENT % (PL — LL)	SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES)	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
		Surface Elev.:													
	0.0	ASPHALT: 11.5 inches thick.													
	0.9	SILTY SAND WITH GRAVEL (SM): fine to coarse grained; brown; moist; loose to medium dense.	0.9		Split Spoon	27 (at 2.0 ft)									
					Split Spoon	7 (at 4.0 ft)									
	5.0	Bottom of Boring at 5.0 feet	5.0												

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0

SPT scale: 10, 20, 30, 40 | Water content scale: 20, 40, 60 | Sieve scale: 20, 40, 60, 80

Physical Properties

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260603m, E:4506499m
Datum:	NAD83

Remarks:

SAMPLE TYPES

Split Spoon

WATER LEVELS (ft)

At Time of Drilling
Dry
After Drilling
Dry

LEGEND

MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-20

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488) Surface Elev.:	Depth	Graphic Log	Sample Type & Rec.	SPT N in blows/ft	Water Content %	Sieve Analysis	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	ASPHALT: 12 inches thick.													
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff; trace gravel.	1.0		Split Spoon										
	2.0					11							3.5		
	4.0				Split Spoon	12							3		
	4.5	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.	4.5												
	5.0	Bottom of Boring at 5.0 feet	5.0												

Completion Depth: 5.0
Date Boring Started: 9/16/16
Date Boring Completed: 9/16/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:260989m, E:4506483m
Datum: NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
At Time of Drilling Dry
After Drilling Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-21

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488) Surface Elev.:		Graphic Log	Sample Type & Rec.	Standard Penetration Test Data (N in blows/ft)	Water Content %	Sieve Analysis	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	ASPHALT: 12 inches thick.													
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; trace gravel.	1.0		Split Spoon										
	2.0					6							2.5		
	4.0					9							3		
	4.5	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.	4.5												
	5.0	Bottom of Boring at 5.0 feet	5.0												

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:261399m, E:4506465m
Datum:	NAD83

Remarks:

SAMPLE TYPES
Split Spoon

WATER LEVELS (ft)
At Time of Drilling: Dry
After Drilling: Dry

LEGEND
MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-24

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Bottom depth	Sample Type	N in blows/ft	Qp tsf
0.0	ASPHALT: 8 inches thick.				
0.7	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	0.7	Split Spoon		
2.0				8	3
3.0	LEAN TO FAT CLAY (CL/CH): gray; moist; very stiff; some gravel.	3.0	Split Spoon		
4.0				20	4.5
5.0	Bottom of Boring at 5.0 feet	5.0			

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:258987m, E:4504928m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-25

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Bottom depth	Sample	SPT N (blows/ft)	Q_p (tsf)
0.0	ASPHALT: 11 inches thick.	0.9			
0.9	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; trace gravel.	3.0	Split Spoon	8 (at 2.0)	2.5
3.0	LEAN TO FAT CLAY (CL/CH): brown and gray; moist; very stiff; trace gravel.	5.0	Split Spoon	22 (at 4.0)	4.5
5.0	Bottom of Boring at 5.0 feet				

Column headings: Elevation, feet; Depth, feet; Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA (N in blows/ft: 10, 20, 30, 40); WATER CONTENT % (PL, LL: 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES: 20, 40, 60, 80); Physical Properties: WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %.

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259342m, E:4504917m
Datum:	NAD83

Remarks:

SAMPLE TYPES

Split Spoon

WATER LEVELS (ft)

At Time of Drilling: Dry
After Drilling: Dry

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-26

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Depth, feet	Material Description (ASTM D2488)	Sample	SPT N (blows/ft)	Qp (tsf)
0.0–1.0	ASPHALT: 12 inches thick.			
1.0–3.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	Split Spoon	7	2.5
3.0–5.0	LEAN TO FAT CLAY (CL/CH): brown and gray; moist; stiff.	Split Spoon	13	1.5
5.0	Bottom of Boring at 5.0 feet			

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259723m, E:4504907m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling: Dry; After Drilling: Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-42

Project: Hardin County Wind Project	Location: Hardin County, Ohio	Client: Invenergy, LLC

Barr Project Number: 35331001

MATERIAL DESCRIPTION (ASTM D2488)

Surface Elev.:

Depth, feet	Material Description	Bottom depth	SPT N (blows/ft)
0.0	ASPHALT: 15 inches thick.	1.3	
1.3	POORLY GRADED GRAVEL WITH SAND (GP): tan to light brown; moist.	1.4	
1.4	LEAN TO FAT CLAY (CL/CH): grayish brown to brown; moist; stiff; trace sand and gravel.	5.5	9 (at 2.0 ft); 11 (at 4.0 ft)
5.5	Bottom of Boring at 5.4 feet		

Column headings: Elevation, feet; Depth, feet; Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA (N in blows/ft: 10, 20, 30, 40); WATER CONTENT % (PL, LL: 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES: 20, 40, 60, 80); Physical Properties: WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %

Completion Depth:	5.4
Date Boring Started:	
Date Boring Completed:	
Logged By:	Carlos
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	
Datum:	NAD83

Remarks:

SAMPLE TYPES	WATER LEVELS (ft)	LEGEND
Split Spoon		MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-43

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Sample Type & Rec.	Standard Penetration Test Data (N in blows/ft)
0.0	Surface Elev.:		
0.0–1.1	ASPHALT: 13 inches thick.		
1.1–1.3	POORLY GRADED GRAVEL WITH SAND (GP): tan to light brown; moist.		
1.3–5.3	LEAN TO FAT CLAY (CL/CH): dark brown to gray; moist; stiff; trace sand and gravel.	Split Spoon (1.0–2.0)	10
		Split Spoon (3.0–4.0)	11
5.3	Bottom of Boring at 5.3 feet		

Column headings: Elevation, feet; Depth, feet; Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA (N in blows/ft: 10, 20, 30, 40); WATER CONTENT % (PL, LL: 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES: 20, 40, 60, 80); Physical Properties (WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %)

Completion Depth:	5.3
Date Boring Started:	
Date Boring Completed:	
Logged By:	Carlos
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	
Datum:	NAD83

Remarks:

SAMPLE TYPES

Split Spoon

WATER LEVELS (ft)

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-44

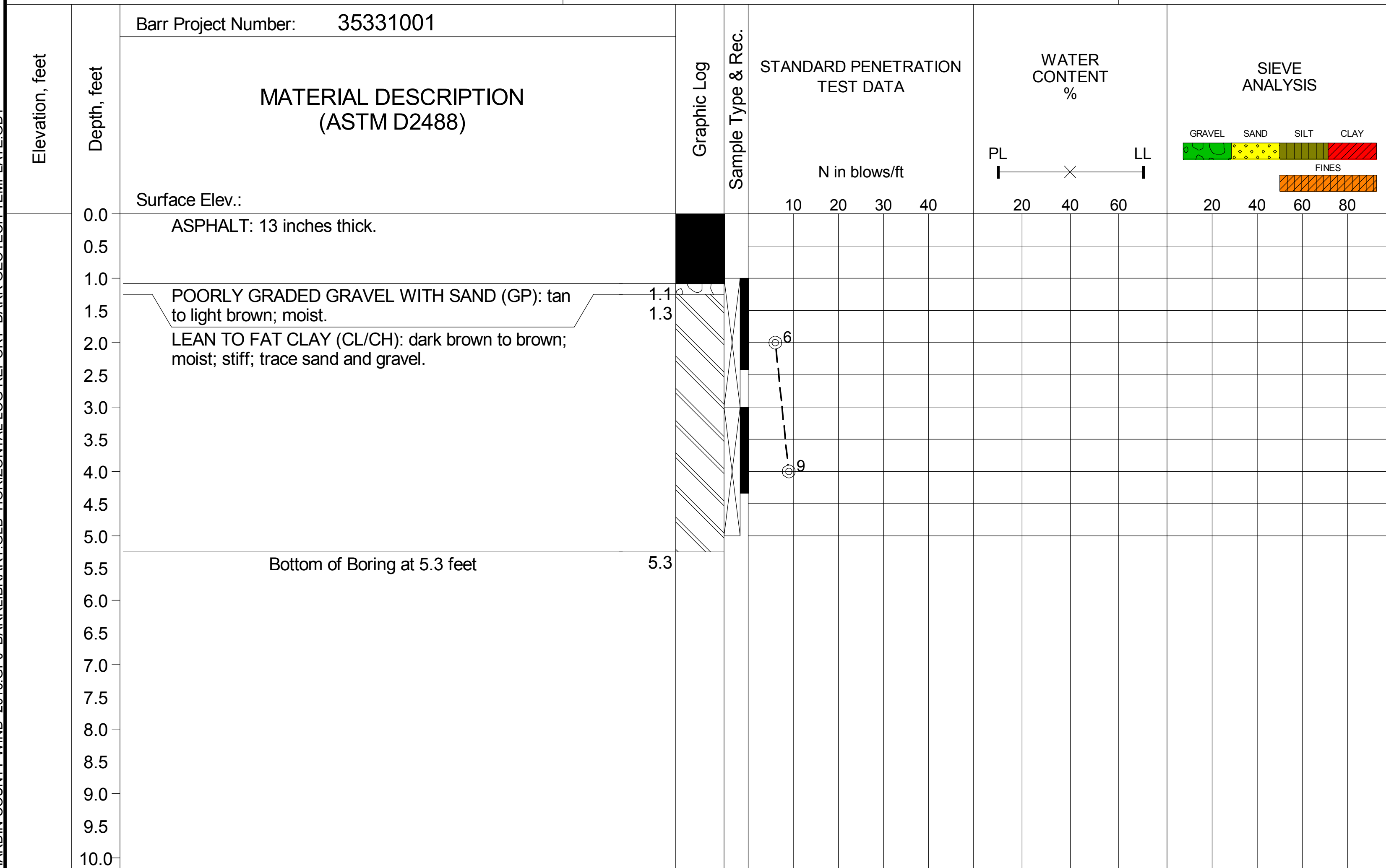
Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

MATERIAL DESCRIPTION (ASTM D2488)

Surface Elev.:

Depth, feet	Material Description	Layer bottom depth (ft)
0.0	ASPHALT: 13 inches thick.	1.1
1.1	POORLY GRADED GRAVEL WITH SAND (GP): tan to light brown; moist.	1.3
1.3	LEAN TO FAT CLAY (CL/CH): dark brown to brown; moist; stiff; trace sand and gravel.	5.3
5.3	Bottom of Boring at 5.3 feet	



Physical Properties: WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %

Completion Depth:	5.3
Date Boring Started:	
Date Boring Completed:	
Logged By:	Carlos
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft)

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-45

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Bottom depth	Sample Type & Rec.	SPT N (blows/ft)
0.0	Surface Elev.:			
0.0–1.1	ASPHALT: 13 inches thick.	1.1		
1.1–5.1	LEAN TO FAT CLAY (CL/CH): dark brown to grayish brown; moist; stiff; trace sand and gravel.	5.1	Split Spoon	9 (at 2.0), 10 (at 4.0)
5.1	Bottom of Boring at 5.1 feet			

Column headings: Elevation, feet; Depth, feet; Graphic Log; Sample Type & Rec.; STANDARD PENETRATION TEST DATA (N in blows/ft: 10, 20, 30, 40); WATER CONTENT % (PL, LL: 20, 40, 60); SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES: 20, 40, 60, 80); Physical Properties: WC %, γ pcf, ϕ °, Q_u tsf, Q_p tsf, Gs, RQD %

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0

Completion Depth:	5.1
Date Boring Started:	
Date Boring Completed:	
Logged By:	Carlos
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	
Datum:	NAD83

Remarks:

SAMPLE TYPES

Split Spoon

WATER LEVELS (ft)

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-46

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488) Surface Elev.:		Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA N in blows/ft	WATER CONTENT %	SIEVE ANALYSIS	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	ASPHALT: 12 inches thick.													
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; trace sand and gravel.	1.0		Split Spoon										
	2.0					10									
	4.0				Split Spoon	8									
	5.0	Bottom of Boring at 5.0 feet	5.0												

Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0

SPT scale: 10, 20, 30, 40. Water content: PL, LL; 20, 40, 60. Sieve analysis: GRAVEL, SAND, SILT, CLAY, FINES; 20, 40, 60, 80.

Physical Properties

Completion Depth:	5.0
Date Boring Started:	
Date Boring Completed:	
Logged By:	Carlos
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	
Datum:	NAD83

Remarks:

SAMPLE TYPES

Split Spoon

WATER LEVELS (ft)

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

Geotechnical Investigation – Substation area

1.1 Geotechnical Investigation

Barr Engineering Co. (Barr), under authorization and contract with Invenergy, LLC (Invenergy), has completed a geotechnical investigation of roads around the Hardin Wind Project in Hardin County, Ohio. As part of this geotechnical investigation, Barr completed 16 geotechnical borings along road alignments near the proposed project substation.

This letter report and its attachments provide geotechnical findings from the investigation. Barr previously completed 35 road borings with dynamic cone penetration (DCP) and California bearing ratio (CBR) testing along other travel alignments adjacent to proposed wind turbine locations. A geotechnical investigation of the overall project area and prepared a comprehensive geotechnical report with recommendations for foundation design of turbines, original substation location, O&M building, overhead collector, and met towers.

1.1.1 Field Work

Under subcontract to Barr, TTL Associates, INC of Toledo, Ohio, completed 16 shallow borings along existing county road alignments using a truck mounted drill rig to depths of approximately five feet in one mobilization on July 5, 2017. Standard penetration tests were performed and split-spoon samples were collected at approximately 2.5-ft intervals to a depth of approximately 5 ft. Drilling was advanced using hollow-stem augers (HSA).

The coordinates of the borings are included in the Table 1 below and shown on Figure 1 attached.

Table 1 Testing Conditions and Coordinates

Geotechnical Boring ID	UTM NAD83 Z17N		Latitude [deg.]	Longitude [deg.]	Boring	CBR
	Easting [m]	Northing [m]				
RD-83	268403.4319	4506799.966	40.59752	-83.75876	X	
RD-84	268318.5228	4506543.933	40.60115	-83.75936	X	
RD-85	268339.59	4506270.925	40.60465	-83.75989	X	X
RD-86	268410.4847	4506195.139	40.60833	-83.76056	X	
RD-87	268751.9301	4506181.553	40.61165	-83.76108	X	
RD-88	269153.8898	4506157.843	40.61522	-83.76163	X	
RD-89	269281.1811	4506462.284	40.61877	-83.76226	X	
RD-90	268927.5277	4506639.041	40.62237	-83.76282	X	X
RD-91	268563.3968	4506798.961	40.62601	-83.76282	X	
RD-92	269322.4737	4509083.902	40.62966	-83.76398	X	
RD-93	269300.3226	4508694.78	40.63312	-83.76453	X	
RD-94	269294.6341	4508326.876	40.63570	-83.76746	X	
RD-95	269269.9484	4507932.329	40.63524	-83.77223	X	
RD-96	269261.1113	4507564.293	40.63479	-83.77712	X	X
RD-97	269266.694	4507201.019	40.63437	-83.78170	X	
RD-98	269311.6733	4506833.856	40.63384	-83.78651	X	

1.1.2 Bulk Soil Sampling

Bulk samples of representative material from the site were collected for the purpose of laboratory testing. A total of three bulk soil samples (5-gallon buckets) were collected across the project site in support of California Bearing Ratio (CBR) testing. Sampling locations were selected to provide representative soil samples across the project area.

1.2 Subsurface Conditions

The results of the geotechnical borings and laboratory tests were compiled to obtain an understanding of the lithology of the study areas.

The typical stratigraphy, as determined from the field data collected at the road boring locations, consists of a surficial layer of asphalt underlain a base course of either silty sand with gravel, silty gravel, or poorly graded gravel with silt underlain by native lean to fat clay. Two road locations, RD-85 and RD-93, have a poorly graded sand layer underlying the base course layer. One road location, RD-92 has a thin layer of clayey sand underlying the fat clay layer.

1.2.1 Asphalt

Asphalt was encountered in all 16 of the road boring locations. Asphalt thicknesses at boring locations ranged from 5 to 11 inches. The average asphalt thickness was approximately 7 inches.

1.2.2 Base Course

Crushed stone gravel was encountered in all 16 of the road boring locations below the asphalt. It was primarily classified as a poorly graded gravel with silt and sand. The thickness of the base course ranged from 3 to 12 inches with an average of approximately 8 inches.

1.2.3 Lean Clay to Fat Clay

Lean to fat clay was encountered in all of the 16 road boring locations in thicknesses ranging from approximately 2.8 feet to 4.1 feet. N-values from Standard Penetration Testing (SPT) conducted in the clays ranged from 5 to 19 blows per foot (bpf) with an average of 8 bpf. These results indicate that the clays typically have consistencies ranging from medium stiff to very stiff.

1.3 Groundwater Conditions

No evidence of groundwater was observed during the course of the geotechnical field investigation, however the road borings did not extend greater than 5.5 feet below existing grade. As a result, groundwater is not anticipated to be a significant factor in the current road construction.

1.4 Shear Strength

1.4.1 Approximate Undrained Shear Strength

The results of the geotechnical investigation indicate that all of the roads bear on a base course.

The results of the geotechnical investigation indicate that a majority of the turbine foundations will bear predominantly on cohesive material (clay and weathered to residual shale). The undrained shear strength of these soils was estimated from SPT results.

The undrained shear strength was approximated through correlations from SPT results collected at 2.5 intervals during sampling in the boreholes. The SPT results for geotechnical borings are summarized in the boring logs at the end of this Appendix. The average SPT value obtained for a cohesive soil layer between a depth of 1 and 5.5 feet was SPT = 7. The SPT value can be correlated to the soil undrained shear strength (Das, 2007). Using a correlation developed by Barr from this and other projects completed in similar geology to that of the project area, a SPT value of 7 correlates to an undrained shear strength of approximately 850 psf.

A number of pocket penetrometer tests were conducted on split spoon samples collected. The pocket penetrometer values in clay soils at each road boring location ranged from 1. 5 tsf to greater than 4.5 tsf. The minimum results indicated an estimated unconfined compressive strength of 1.5 tons per square foot (tsf), which corresponds to an undrained shear strength of approximately 1,500 psf. Based on an analysis of the results presented, the recommended undrained shear strength design value is 1,500 psf.

1.5 .Laboratory Testing

Laboratory testing was performed on selected samples as described below.

1.5.1 Moisture Content

A total of eight moisture content tests were performed on soils at the project site. The moisture content for clayey soils ranged from 13 to 28 percent, with an average of 22 percent, indicating that soils were generally in a moist condition. The results of the moisture content testing can be found in Table 2 below.

1.5.2 Atterberg Limits

A total of four Atterberg Limits tests were performed on cohesive soils at the project site. Results of the Atterberg Limits testing indicated a Liquid Limit ranging from 33 to 60 percent, a Plastic Limit ranging from 16 to 19, and Plasticity Indices ranging from 17 to 41 percent. According to the USCS plasticity chart, these are classified as lean clay (CL) and fat clay (CH). The results of the Atterberg Limits testing can be found in Table 2 below.

Table 2 Moisture Content and Atterberg Limits Testing Results

Geotechnical Boring ID	USCS	Depth [ft]	Moisture Content [%]	Atterberg Limits		
				Liquid Limit [%]	Plastic Limit [%]	Plasticity Index
RD-83	CL	3.5-5.0	14.8	-	-	-
RD-84	CL	1.0-2.5	22.4	43.5	17.9	25.6
RD-87	CH	3.5-5.0	26.5	55.3	18.7	36.6
RD-90	CH	3.5-5.0	26.7	-	-	-
RD-94	CH	1.0-2.5	28.1	60.1	18.8	41.3
RD-95	CH	3.5-5.0	18.5	-	-	-
RD-97	CL	1.0-2.5	12.8	32.7	15.6	17.1
RD-98	CH	1.0-2.5	22.8	-	-	-

1.5.3 California Bearing Ratio Testing

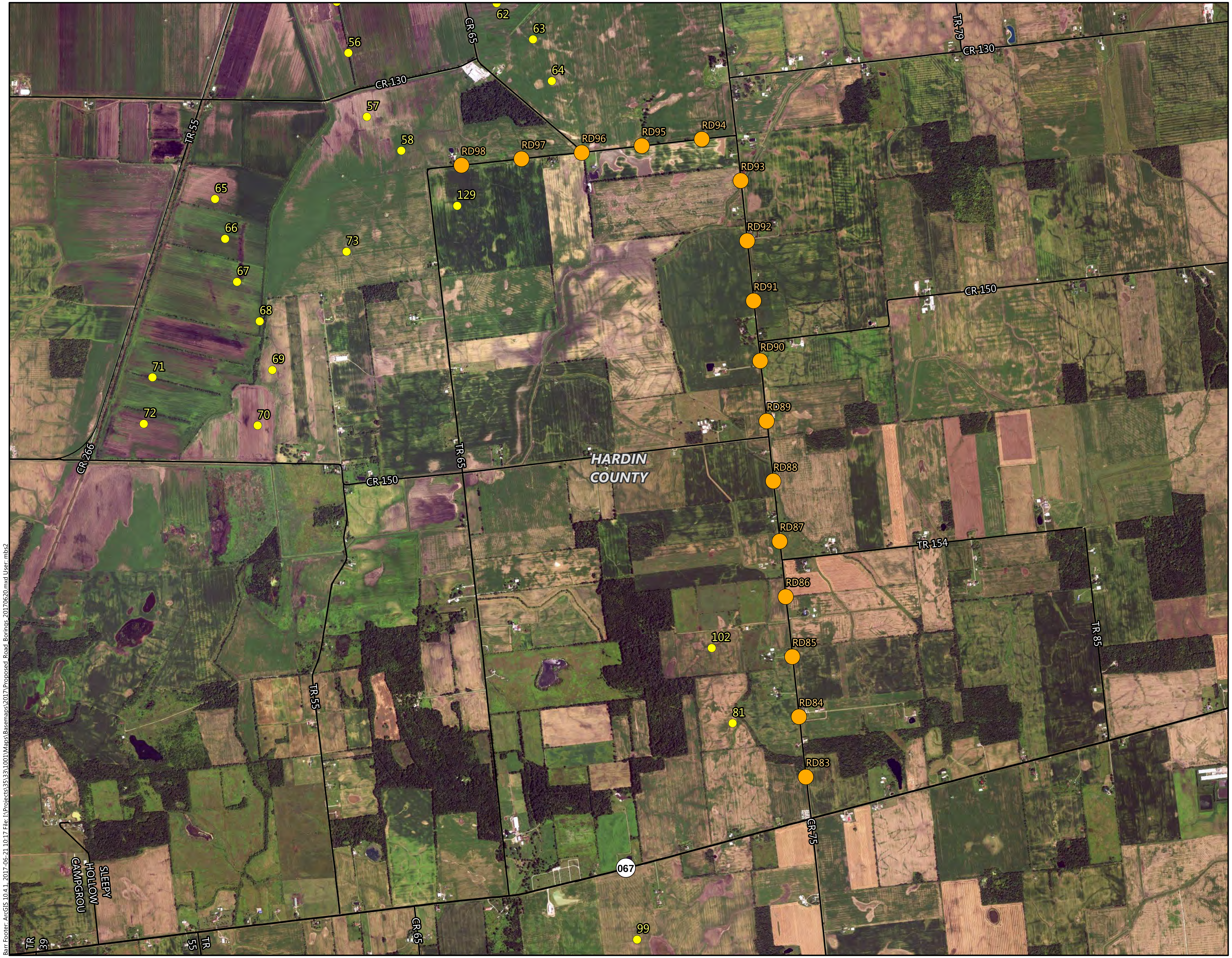
Design for roads and general working areas is based in part on the strength of the subgrade that can be reasonably achieved. California Bearing Ratio (CBR) tests were completed on soil samples collected from the selected locations across the site to determine the field strength of the subgrade.

A total of three samples of the shallow subgrade soils were collected adjacent to the road borings in the shoulders (Figure 1). The bulk samples were collected from soil immediately below topsoil or fill materials, which typically corresponded to a depth of approximately 6 to 20 inches below the surface. The soil samples were prepared to approximate 90, 95 and 98 percent of the standard Proctor maximum dry density at the optimum moisture content. The results of the CBR testing at 95% compaction are presented in Table 3.

In general, the CBR samples were classified as lean clay with various amount of sand and gravel. Results from the testing conducted on the subgrade samples indicate that CBR values at 0.1 inch of deflection under a surcharge of 50 psf range from 2.3-3.0 percent, when compacted to 95 percent of the standard Proctor density at optimum moisture. The results indicate that the soils at the site are fairly consistent in their ability to support roads.

Table 3 CBR Testing Results

Geotechnical Boring ID	USCS	California Bearing Ratio Value (Optimum Moisture Content)*
		95% Compaction
RD-85	CL	3.0
RD-90	CL	2.8
RD-96	CL/CH	2.3



Proposed Road Boring Location

Turbine Location (3/29/2017)

County Boundary

Feet

2,000 0 2,000

Meters

600 0 600

Figure 1

PROPOSED ROAD BORING LOCATIONS - 6/20/2017

Hardin Wind Project

Invenergy LLC

Hardin County, Ohio

Barr Footer: ArcGIS 10.4.1, 2017-06-21 10:17 File: I:\Projects\35\33\1001\Maps\Basemaps\2017\Proposed_Road_Borings_20170620.mxd User: mbs2

California Bearing Ratio ASTM:D1883

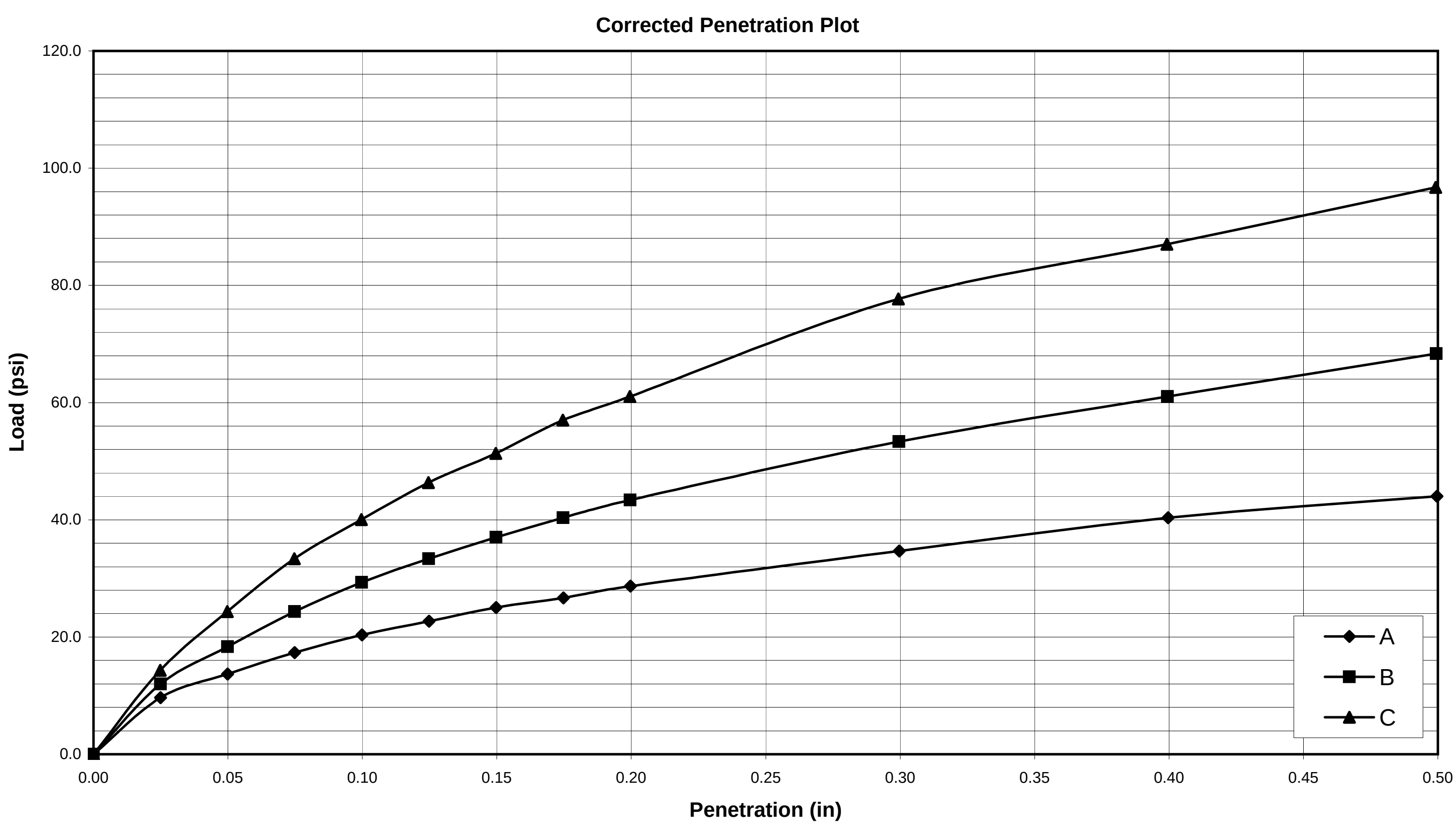
Project:	Hardin Wind	Job:	**10950**
Client:	Barr Engineering Company	Date:	7/18/17

Boring #: RD-85		Procedural Method:
Sample:		Specimens compacted to approximately 90%, 95% and 98% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft):	Type: Bulk	
Location:		
Classification: Lean Clay w/sand and a little gravel (CL)		

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	104.1	PL:	Organic Content:
Optimum Water Content:	19.7%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	19.7%	19.7%	19.7%
Initial Dry Density (PCF)	94.0	99.2	101.9
Relative Compaction	90.3%	95.3%	97.9%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.3%	1.1%	0.9%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**2.1%**	**3.0%**	**4.0%**
at 0.2 inch (%)	1.9%	2.9%	4.1%
Moisture Content After Penetration			
Top 1" of Specimen:	25.6%	24.3%	21.3%
Average of specimen:	25.2%	23.0%	21.4%

Stress vs. Penetration Graph

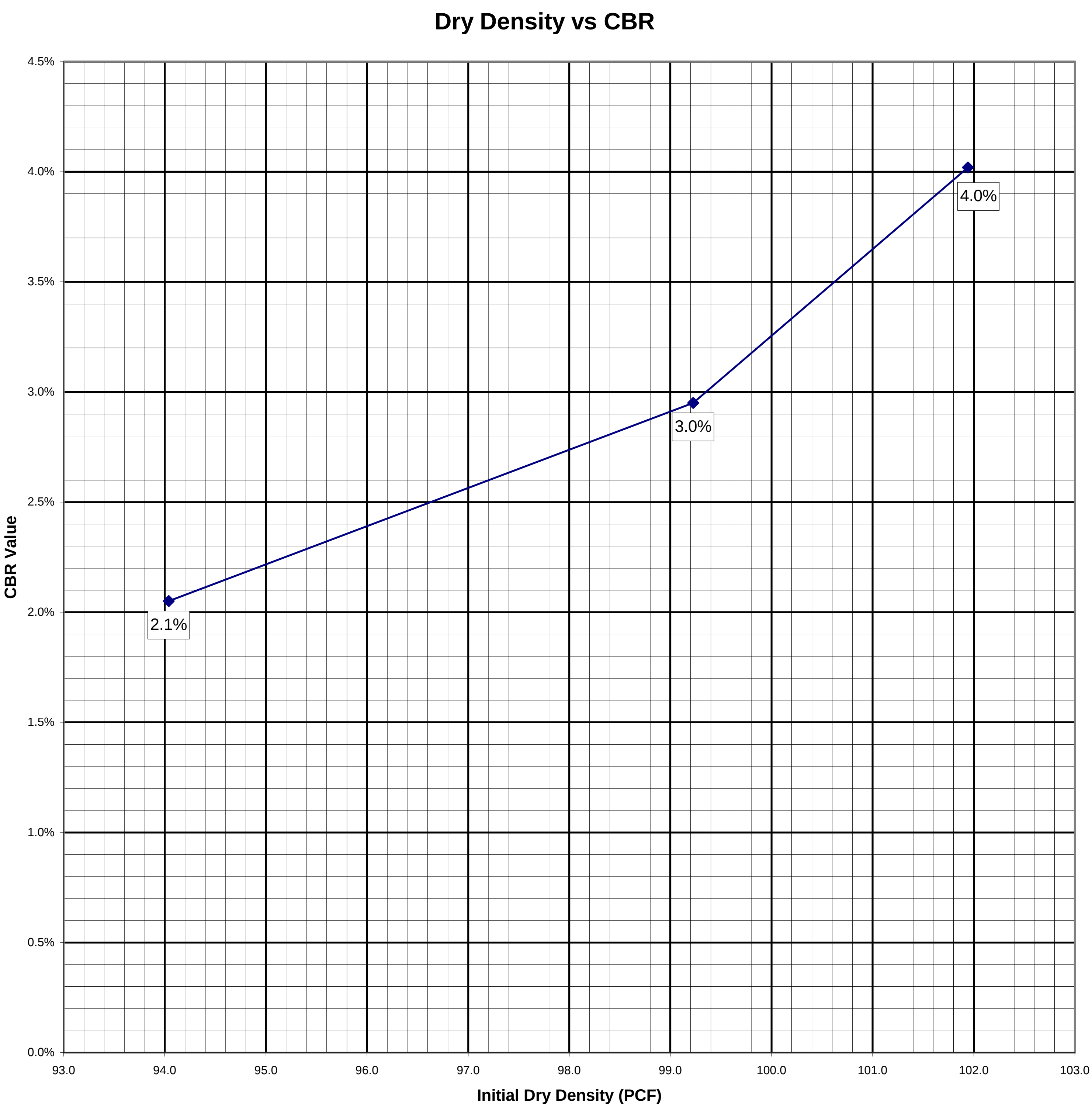


California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	10950
Client:	Barr Engineering Company	Date:	7/18/17

Boring #: RD-85		Procedural Method:
Sample:		Specimens compacted to approximately 90%, 95% and 98% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft):	Type: Bulk	
Location:		
Classification: Lean Clay w/sand and a little gravel (CL)		

Test Plot



California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	**10950**
Client:	Barr Engineering Company	Date:	7/18/17

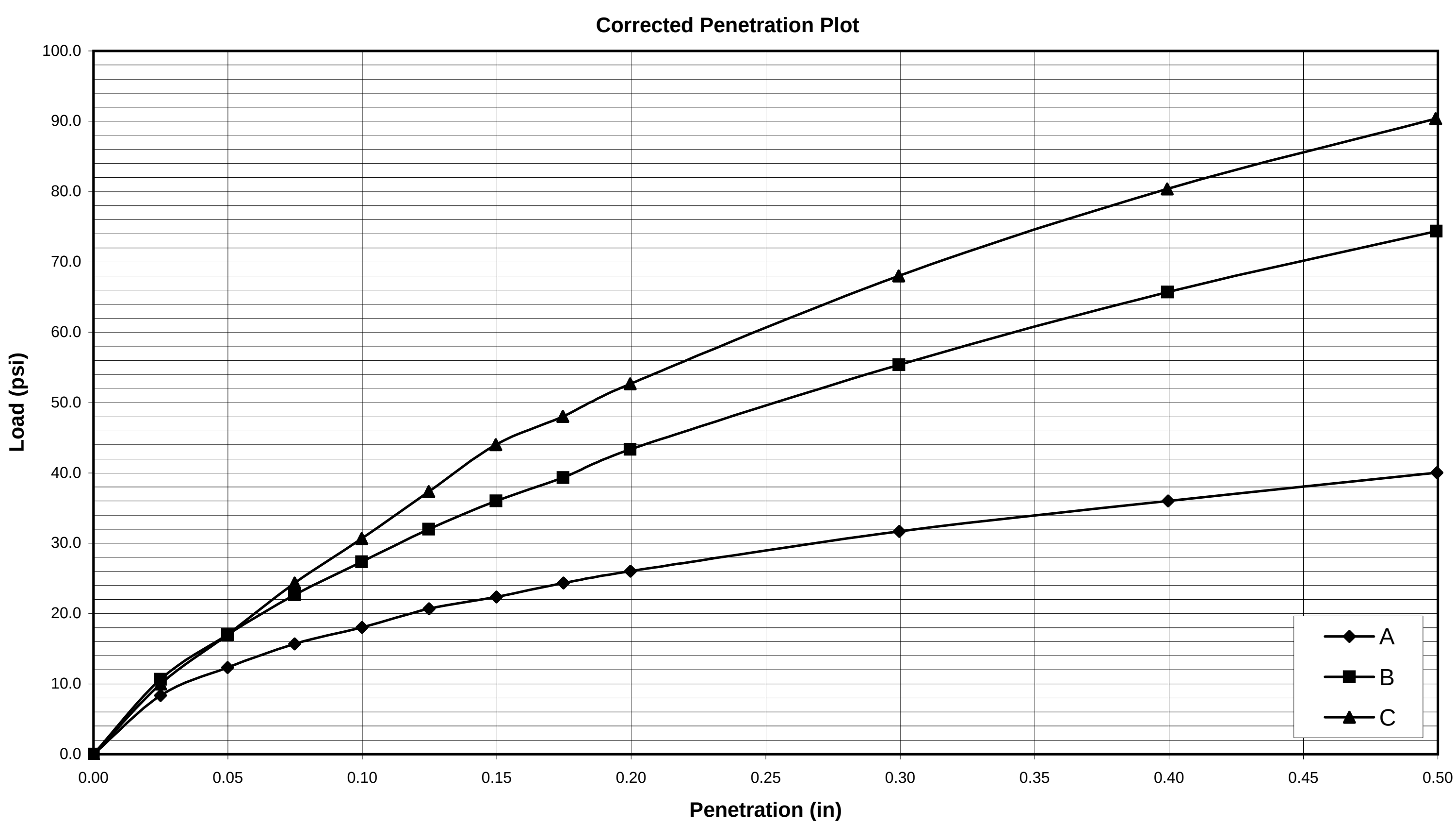
Boring #: RD-90		**Procedural Method:**
Sample:		Specimens compacted to approximately 90%, 95% and 98% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft):	Type: Bulk	
Location:		

Classification: Lean Clay w/sand and a little gravel (CL)

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	103.0	PL:	Organic Content:
Optimum Water Content:	20.4%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	20.4%	20.4%	20.4%
Initial Dry Density (PCF)	93.1	98.2	101.2
Relative Compaction	90.3%	95.4%	98.3%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.6%	1.8%	1.6%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**1.8%**	**2.8%**	**3.1%**
at 0.2 inch (%)	1.7%	2.9%	3.5%
Moisture Content After Penetration			
Top 1" of Specimen:	25.9%	23.9%	22.7%
Average of specimen:	25.7%	22.7%	21.6%

Stress vs. Penetration Graph



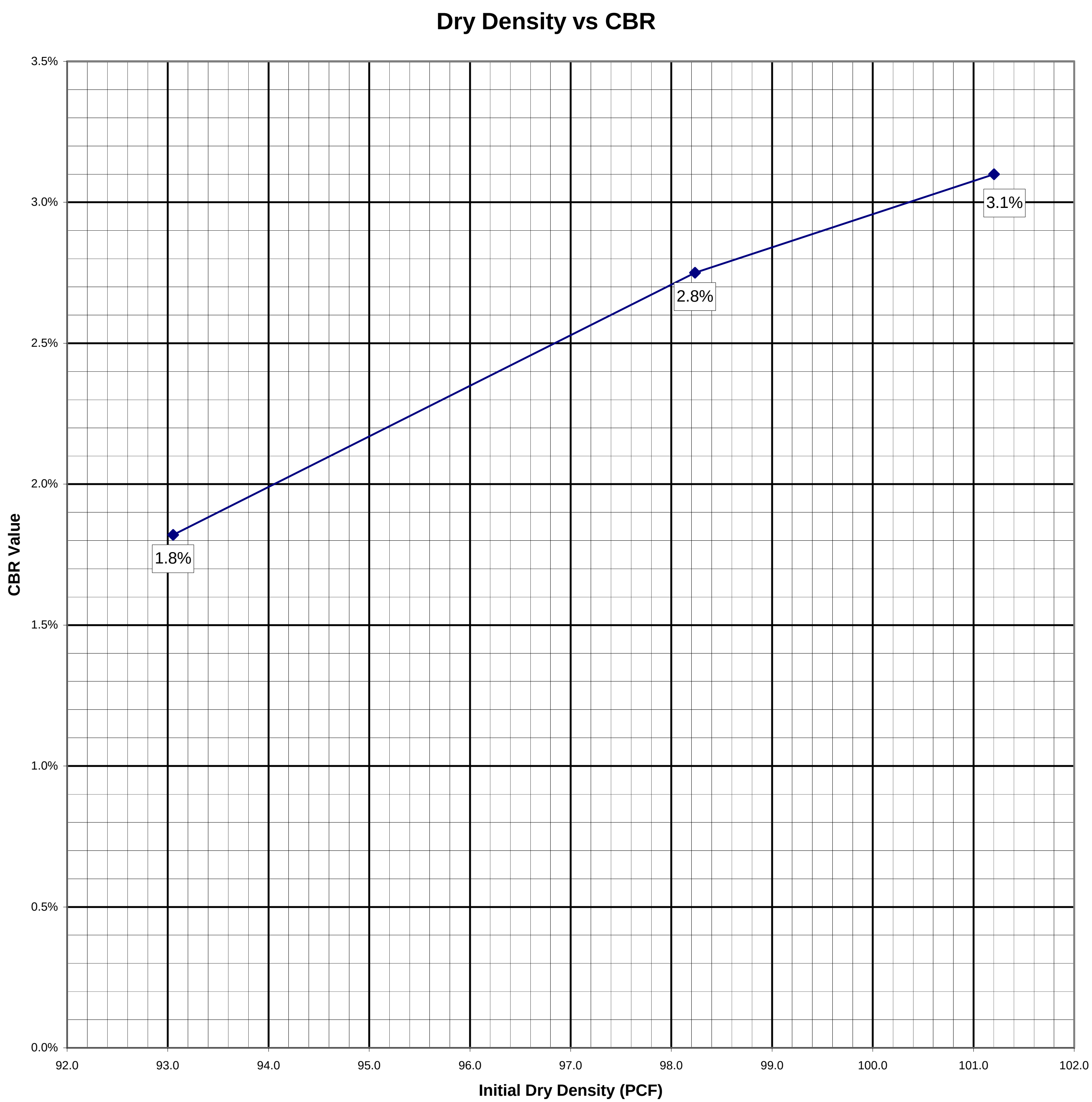
California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	10950
Client:	Barr Engineering Company	Date:	7/18/17

Boring #: RD-90		Procedural Method:
Sample:		Specimens compacted to approximately 90%, 95% and 98% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft):	Type: Bulk	
Location:		

Classification: Lean Clay w/sand and a little gravel (CL)

Test Plot



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

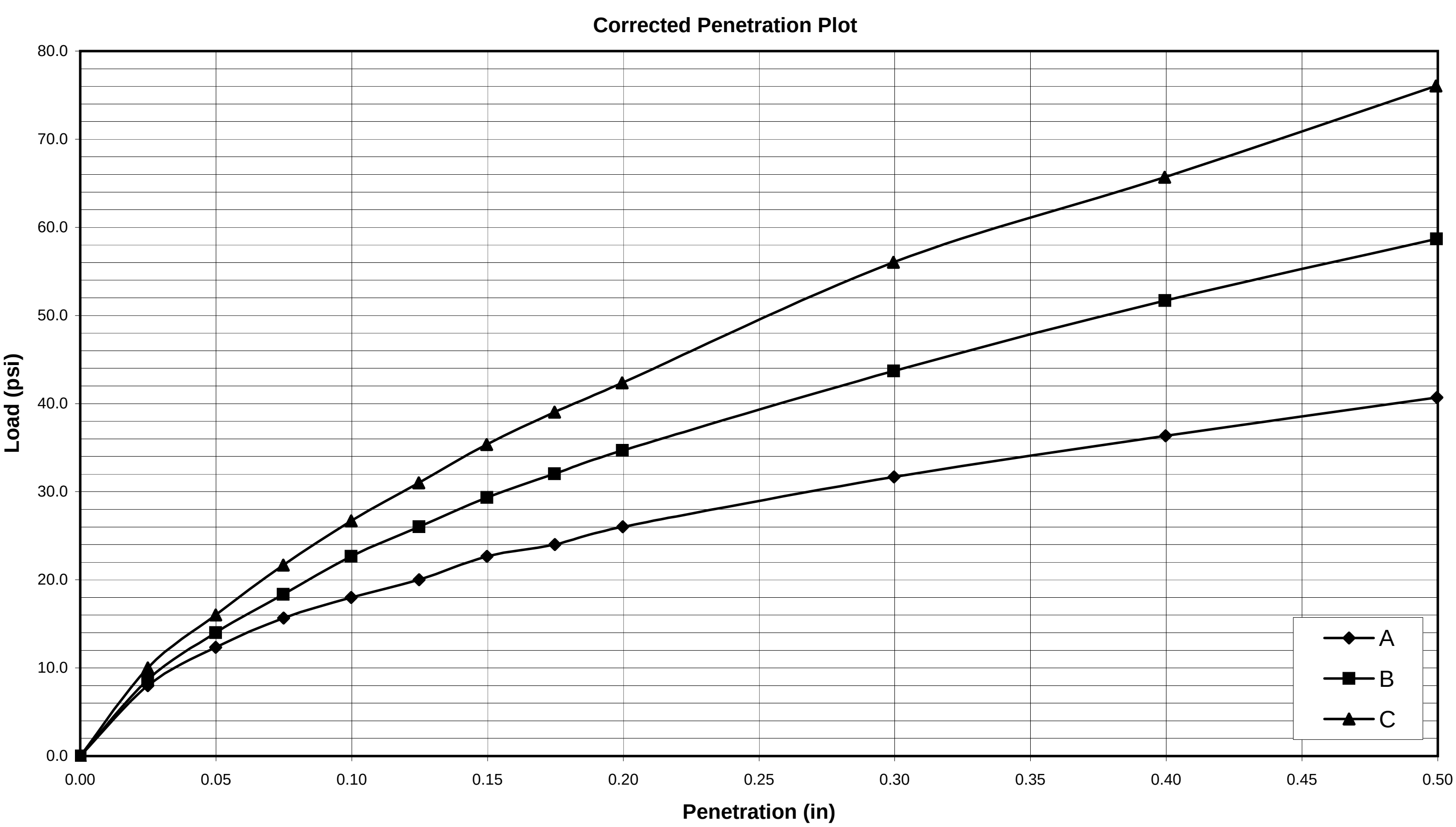
Project:	Hardin Wind	Job:	**10950**
Client:	Barr Engineering Company	Date:	7/18/17

Boring #: RD-96	Procedural Method:
Sample:	Specimens compacted to approximately 90%, 95% and 98% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): / Type: Bulk	
Location:	
Classification: Lean Clay w/sand and a trace of gravel (CL/CH)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	102.0	PL:	Organic Content:
Optimum Water Content:	21.0%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	21.0%	21.0%	21.0%
Initial Dry Density (PCF)	92.0	97.2	100.1
Relative Compaction	90.2%	95.3%	98.1%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.3%	1.2%	1.2%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**1.8%**	**2.3%**	**2.7%**
at 0.2 inch (%)	1.7%	2.3%	2.8%
Moisture Content After Penetration			
Top 1" of Specimen:	27.0%	23.6%	23.5%
Average of specimen:	25.8%	22.7%	21.9%

Stress vs. Penetration Graph



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

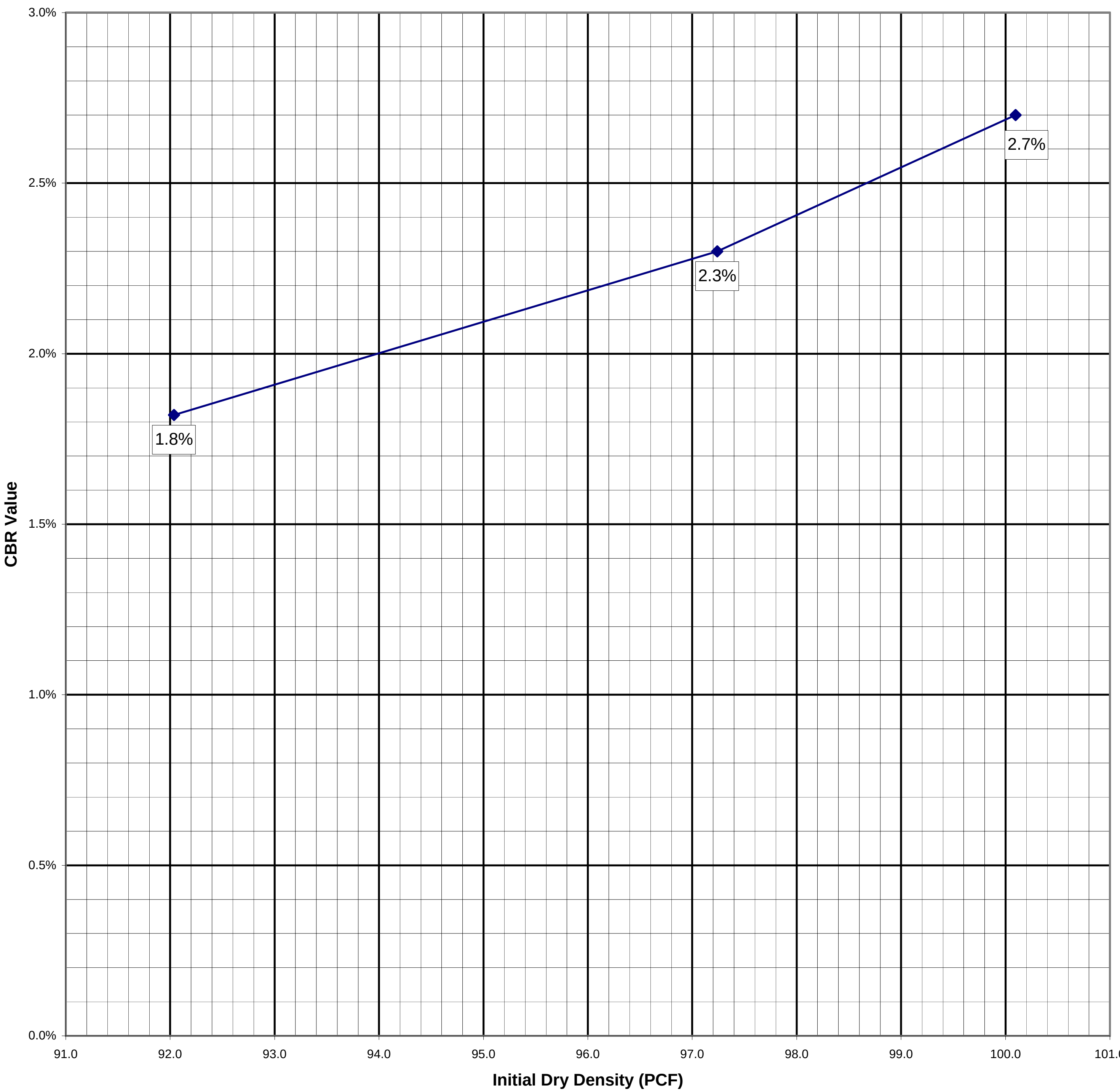
Project:	Hardin Wind	Job:	10950
Client:	Barr Engineering Company	Date:	7/18/17

Boring #: RD-96		Procedural Method:
Sample:		Specimens compacted to approximately 90%, 95% and 98% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft):	Type: Bulk	
Location:		

Classification: Lean Clay w/sand and a trace of gravel (CL/CH)

Test Plot

Dry Density vs CBR



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD83

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.59752° Long: -83.75876°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Bottom depth	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft	WATER CONTENT (%)
	0.0	ASPHALT: black.	0.8ft					
	0.8	CRUSHED STONE: [fill].	1.2ft					
	1.2	LEAN CLAY (CL): brown; moist; stiff; with gray and red mottling; trace gravel; trace fine sand.	3.0ft	1	78	11	11	
	3.0	SANDY LEAN CLAY (CL): grayish brown; moist; stiff; trace fine sand; trace gravel.	5.0ft	2	89	12	12	14.8
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

Date Boring Started:	7/5/17 4:40 pm	Water Levels (ft)	Remarks: Located ~3.5' E of shoulder
Date Boring Completed:	7/5/17 4:55 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD84

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.60115° Long: -83.75936°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Layer Depth	Sample No.	% Recovery	SPT, N value or RQD %	Water Content (%)	PL	LL
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.5ft						
	1.0	LEAN CLAY (CL): grayish brown; moist; medium stiff; with orange mottling; trace to with sand.	1.0ft	1	78	7	22.4	18	44
	3.0	LEAN TO FAT CLAY (CL/CH): dark brown; moist; medium stiff; trace sand.	3.0ft	2	67	6			
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% / RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)

NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × (20, 40, 60)

Date Boring Started:	7/5/17
Date Boring Completed:	7/5/17
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located ~4' E of shoulder

Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD85

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.60465° Long: -83.75989°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Bottom depth	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.8	CRUSHED STONE: [fill].	0.8ft			
	1.0	POORLY GRADED SAND (SP): fine grained; brown; moist; loose; with gravel; trace silt.	1.0ft			
	1.3	SANDY LEAN CLAY (CL): brown; moist; medium stiff; trace black and gray mottling.	1.3ft	1	67	6
	2.5	FAT CLAY (CH): brown; moist; trace black and orangish gray mottling; trace sand.	2.5ft	2	78	7
	5.0	Bottom of Boring at 5.0 feet	5.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)

Date Boring Started:	7/5/17 4:05 pm
Date Boring Completed:	7/5/17 4:15 pm
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located ~3' E of shoulder

Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

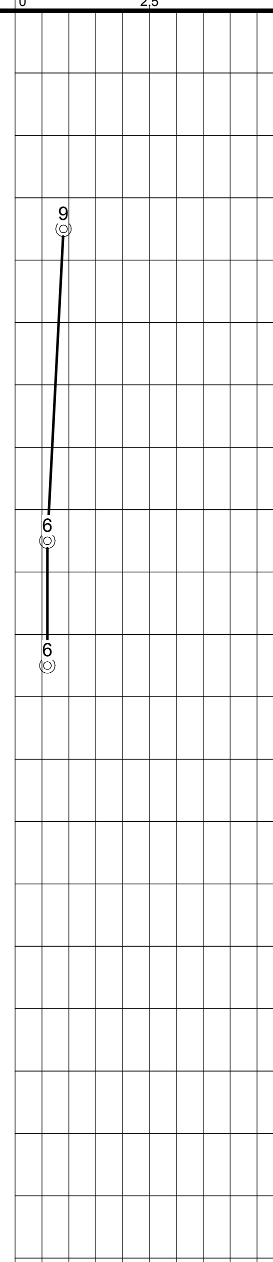
LOG OF BORING RD86

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.60833° Long: -83.76056°	Completion Depth:	5.5 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Bottom	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.	0.9ft			
	0.9	CRUSHED STONE: [fill].	1.7ft			
	1.7	LEAN TO FAT CLAY (CL/CH): dark brown; moist; stiff; trace sand; trace gravel.	3.0ft	1	67	9
	3.0	FAT CLAY (CH): grayish brown; moist; medium stiff.	5.5ft	2	6	6
				3	100	6
	5.5	Bottom of Boring at 5.5 feet	5.5ft			

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5



Date Boring Started:	7/5/17 3:40 pm	Water Levels (ft)	Remarks: Located ~3' E of shoulder
Date Boring Completed:	7/5/17 3:55 pm	At Time of Drilling Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD87

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.61165° Long: -83.76108°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎	NATURAL DRY DENSITY (pcf) ☆ / WATER CONTENT (%) × PL–LL
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]. 0.5ft							
	1.4	FAT CLAY (CH): dark brown; moist; medium stiff; trave red mottling; trace sand. 1.4ft			1	100	6	6	
	2.5	FAT CLAY (CH): brown; moist; medium stiff; with gray and red mottling; trace to with sand. 2.5ft			2	67	8	8	PL 19, LL 55, water content 26.5
	5.0	Bottom of Boring at 5.0 feet 5.0ft							

SHEAR STRENGTH, tsf: 0 – 2.5 – 5

Date Boring Started:	7/5/17 3:20 pm
Date Boring Completed:	7/5/17 3:35 pm
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located ~3.5' E of shoulder

Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

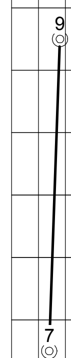
LOG OF BORING RD88

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.61522° Long: -83.76163°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill].	0.5ft				
	1.2	FAT CLAY (CH): dark brown; moist; stiff; trace red mottling; trace sand.	1.2ft	X	1	67	9
	3.0	FAT CLAY (CH): brown; moist; medium stiff to stiff; with gray and red mottling; trace sand.	3.0ft	X	2	100	7
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)



Date Boring Started:	7/5/17 3:00 pm	Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Completed:	7/5/17 3:15 pm	At Time of Drilling Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

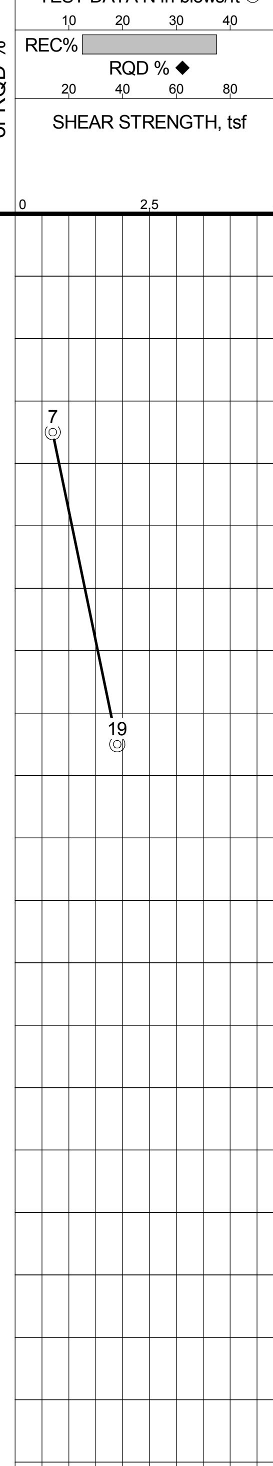
LOG OF BORING RD89

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.61877° Long: -83.76226°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.7	CRUSHED STONE: [fill].	0.7ft			
	1.4	LEAN CLAY (CL): brown; moist; medium stiff; with gray and red mottling; with sand; trace gravel.	1.4ft	1	78	7
	3.0	SANDY LEAN CLAY (CL): brown; moist; medium stiff to very stiff; trace gravel.	3.0ft			
	4.0	FAT CLAY (CH): brown; moist; very stiff; with gray mottling; trace gravel.	4.0ft	2	100	19
	5.0	Bottom of Boring at 5.0 feet	5.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft ◎
REC% / RQD % ◆
SHEAR STRENGTH, tsf



Date Boring Started:	7/5/17 2:40 pm	Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Completed:	7/5/17 2:50 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD90

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.62237° Long: -83.76282°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %	Water Content (%)
	0.0	ASPHALT: black.				
	0.7ft	CRUSHED STONE: [fill].				
	1.4ft	FAT CLAY (CH): dark brown; moist; medium stiff; trace reddish mottling; trace sand. 1.4'-3': trace organics.	1	67	7	
			2	56	6	26.7
	5.0ft	Bottom of Boring at 5.0 feet				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)

NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × PL LL (20, 40, 60)

Date Boring Started:	7/5/17 2:20 pm	Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Completed:	7/5/17 2:35 pm	At Time of Drilling Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD91

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.62601° Long: -83.76336°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / REC% / RQD % ◆ / SHEAR STRENGTH, tsf
	0.0	ASPHALT: black.						
	0.7	CRUSHED STONE: [fill]. 0.7ft						
	1.4	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; trace gray and red mottling; trace sand; trace gravel. 1.4ft			1	72	8	8
	3.5	FAT CLAY (CH): brown; moist; medium stiff; with dark brown and gray mottling; trace gravel; trace sand. 3.5ft			2	78	8	8
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:	7/5/17 2:05 pm
Date Boring Completed:	7/5/17 2:20 pm
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling
Dry

Remarks: Located ~3.5' E of shoulder. Drilled ~1.5' and hit cobbles. Moved ~1' S and drillied this hole.

Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD92

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.62966° Long: -83.76398°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Depth	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.8	CRUSHED STONE: [fill].	0.8ft				
	1.2	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; with gray and red mottling; trace fine sand; trace gravel.	1.2ft		1	78	7
	3.5	FAT CLAY (CH): brown; moist; medium stiff; with fine to medium sand.	3.5ft				
	4.0	POORLY GRADED CLAYEY SAND (SP-SC): fine to medium grained; brown; moist; loose; trace silt.	4.0ft		2	100	5
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC%
RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)

Date Boring Started:	7/5/17 1:40 pm
Date Boring Completed:	7/5/17 1:55 pm
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling
Dry

Remarks:

Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD93

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63312° Long: -83.76453°	Completion Depth:	5.0 ft
Datum:	NAD83		

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.6	CRUSHED STONE: [fill].	0.6ft			
	1.6	POORLY GRADED SAND (SP): fine grained; brown; moist; loose; trace clay; trace crushed gravel.	1.6ft	1	44	5
	2.0	LEAN TO FAT CLAY (CL/CH): dark brown; moist; medium stiff; trace fine sand.	2.0ft			
	3.5	FAT CLAY (CH): brown; moist; medium stiff; trace gray and red mottling; trace gravel; trace sand.	3.5ft	2	22	6
	5.0	Bottom of Boring at 5.0 feet	5.0ft			

Date Boring Started:	7/5/17 1:05 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	7/5/17 1:25 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD94

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63570° Long: -83.76746°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Bottom depth	Sample No.	% Recovery	SPT, N value or RQD %	Water content (%)	PL	LL
	0.0	ASPHALT: black.							
	0.4	CRUSHED STONE: [fill].	0.4ft						
	1.0	FAT CLAY (CH): drak brownish gray to brown; moist; medium stiff; with gray mottling at 1.5'; trace gravel; trace fine sand.	1.0ft	1	78	7	28.1	19	60
	3.0	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff; with gray mottling; trace gravel; trace fine sand.	3.0ft	2	67	9			
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% / RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)

NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × ; PL — LL (20, 40, 60)

Date Boring Started:	7/5/17 12:45 pm
Date Boring Completed:	7/5/17 1:00 pm
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 3' N of shoulder

Weather: Sunny, 85 F

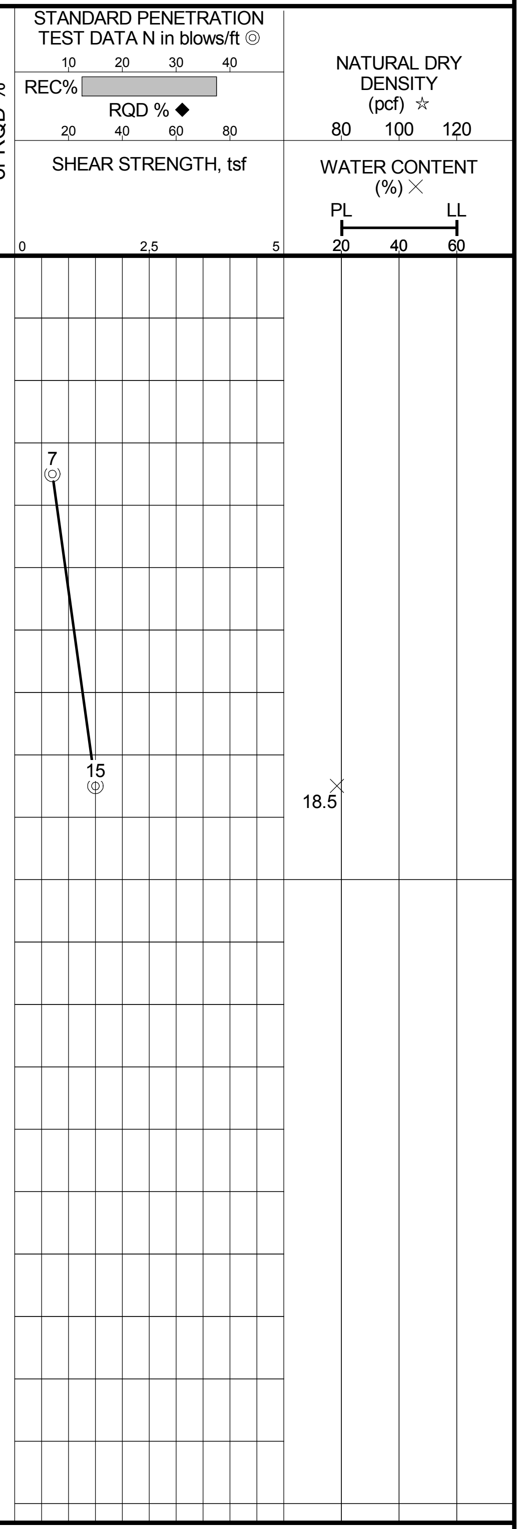
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD95

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63524° Long: -83.77223°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.4	CRUSHED STONE: [fill].	0.4ft			
	1.1	FAT CLAY (CH): dark brownish black; moist; medium stiff; trace reddish brown mottling; trace organics; trace sand.	1.1ft	1	67	7
	2.0	FAT CLAY (CH): grayish brown; moist; stiff; with reddish brown mottling; trace gravel; trace to with sand.	2.0ft	2	78	15
	5.0	Bottom of Boring at 5.0 feet	5.0ft			



Date Boring Started:	7/5/17 12:25 pm	Water Levels (ft)	Remarks: Located ~3' N of shoulder
Date Boring Completed:	7/5/17 12:40 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD96

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63479° Long: -83.77712°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft
	0.0	ASPHALT: black.						
	0.7	CRUSHED STONE: [fill]. (0.7ft)						
	1.5	FAT CLAY (CH): dark brownish black; moist; medium stiff; trace reddish brown mottling; trace fine sand. (1.5ft)			1	56	7	7
	3.3	FAT CLAY (CH): grayish brown; moist; medium stiff; trace reddish brown mottling; with gravel; trace sand. (3.3ft)			2	78	6	6
	5.0	Bottom of Boring at 5.0 feet (5.0ft)						

Date Boring Started:	7/5/17 12:05 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	7/5/17 12:20 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 80 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD97

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63437° Long: -83.78170°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Standard Penetration Test Data N in blows/ft	Water Content (%) / PL–LL
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.5ft					
	0.9	SANDY LEAN CLAY (CL): grayish brown; moist; stiff; trace gray mottling; trace sand; few gravel.	0.9ft	1	67	10	10	12.8; PL 16, LL 33
	3.0	LEAN CLAY (CL): brown; moist; stiff; trace black and red mottling.	3.0ft	2	67	9	9	
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

Date Boring Started:	7/5/17 11:40 am	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	7/5/17 11:55 am	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 80 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD98

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	HSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63384° Long: -83.78651°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Standard Penetration Test Data N in blows/ft	Water Content (%)
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.5ft					
	1.0	FAT CLAY (CH): dark brown to dark grayish brown; moist; medium stiff; trace organics; trace brown mottling.	1.0ft	1	11	6	6	22.8
	3.0	FAT CLAY (CH): grayish brown; moist; medium stiff; trace red mottling; trace gravel; trace sand at 5'.	3.0ft	2	33	5	5	
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

Chart scales: SPT N 10, 20, 30, 40; REC%; RQD % 20, 40, 60, 80; SHEAR STRENGTH, tsf 0, 2.5, 5; NATURAL DRY DENSITY (pcf) 80, 100, 120; WATER CONTENT (%) PL, LL 20, 40, 60

Date Boring Started:	7/5/17
Date Boring Completed:	7/5/17
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 2.5' N of shoulder

Weather: Sunny, 80 F

Geotechnical Investigation – Remainder of Hardin roads

1.1 Geotechnical Investigation

Barr Engineering Co. (Barr), under authorization and contract with Invenergy, LLC (Invenergy), has completed a geotechnical investigation of roads around the Hardin Wind Project in Hardin County, Ohio. As part of this geotechnical investigation, Barr completed 62 geotechnical borings along road alignments adjacent to proposed turbine locations in the project area.

This letter report and its attachments provide geotechnical findings from the investigation. Barr previously completed 51 road borings with California bearing ratio (CBR) testing along other travel alignments adjacent to proposed wind turbine locations. Barr previously completed a geotechnical investigation of the overall project area and prepared a comprehensive geotechnical report with recommendations for foundation design of turbines, original substation location, O&M building, overhead collector, and met towers.

1.1.1 Field Work

Under subcontract to Barr, TTL Associates, INC of Toledo, Ohio, completed 62 shallow borings along existing county road alignments using a truck mounted drill rig to depths of approximately five feet in one mobilization on December 6, 2017. Standard penetration tests were performed and split-spoon samples were collected at approximately 2.5- foot intervals to a depth of approximately 5 ft. Drilling was advanced using solid-stem augers (SSA). Completed borings were backfilled with cuttings and topped with cold-patch asphalt.

The coordinates of the borings are included in the Table 1 and shown on Figure 1 attached.

Table 1 Testing Conditions and Coordinates

Geotechnical Boring ID	Latitude [deg.]	Longitude [deg.]	Boring	CBR
RD99	40.65983	-83.83762	X	
RD100	40.65987	-83.83287	X	
RD101	40.65991	-83.82811	X	
RD102	40.66342	-83.82312	X	
RD103	40.66761	-83.82306	X	
RD104	40.68935	-83.72577	X	
RD105	40.68931	-83.72101	X	
RD106	40.68927	-83.71625	X	
RD107	40.71004	-83.74908	X	
RD108	40.70649	-83.74939	X	X
RD109	40.70398	-83.74796	X	
RD110	40.70392	-83.74233	X	
RD111	40.70402	-83.75185	X	
RD112	40.61594	-83.84203	X	
RD113	40.61594	-83.83727	X	
RD114	40.61593	-83.83252	X	
RD115	40.61593	-83.82777	X	X

RD116	40.61592	-83.82301	X	
RD117	40.61592	-83.81826	X	
RD118	40.61591	-83.81520	X	
RD119	40.63763	-83.84292	X	
RD120	40.63763	-83.83817	X	
RD121	40.63763	-83.83341	X	
RD122	40.63763	-83.82866	X	
RD123	40.63763	-83.82390	X	
RD124	40.63763	-83.81915	X	X
RD125	40.63763	-83.81440	X	
RD126	40.63763	-83.80964	X	X
RD127	40.63764	-83.80489	X	
RD128	40.63764	-83.80013	X	
RD129	40.63817	-83.79549	X	
RD130	40.63907	-83.79089	X	
RD131	40.64033	-83.78539	X	
RD132	40.64534	-83.78446	X	
RD133	40.64510	-83.78683	X	
RD134	40.64863	-83.78789	X	
RD135	40.65244	-83.78905	X	
RD136	40.66003	-83.79787	X	
RD137	40.66003	-83.80263	X	
RD138	40.66003	-83.80739	X	
RD139	40.66002	-83.81214	X	
RD140	40.66002	-83.81690	X	X
RD141	40.66002	-83.82309	X	
RD142	40.70398	-83.81874	X	
RD143	40.70353	-83.81349	X	
RD144	40.67466	-83.80907	X	
RD145	40.67466	-83.80431	X	
RD146	40.67465	-83.79956	X	
RD147	40.67464	-83.79480	X	
RD148	40.67463	-83.79004	X	X
RD149	40.67420	-83.74556	X	
RD150	40.67425	-83.75031	X	
RD151	40.67430	-83.75507	X	
RD152	40.67435	-83.75983	X	
RD153	40.67440	-83.76458	X	
RD154	40.67445	-83.76934	X	
RD155	40.67451	-83.77410	X	
RD156	40.67458	-83.77885	X	
RD157	40.67465	-83.78361	X	
RD158	40.67538	-83.72550	X	
RD159	40.62935	-83.78847	X	

RD160	40.63686	-83.78014	X	

1.1.2 Bulk Soil Sampling

Bulk samples of representative material from the site were collected for the purpose of laboratory testing. A total of six bulk soil samples (5-gallon buckets) were collected across the project site in support of California Bearing Ratio (CBR) testing. Sampling locations were selected to provide a representative sampling of soils present across the project area.

1.2 Subsurface Conditions

The results of the geotechnical borings and laboratory tests were compiled to obtain an understanding of the lithology of the study areas.

The typical stratigraphy, as determined from the field data collected at the road boring locations, consists of a surficial layer of asphalt underlain a base course of either poorly graded gravel with sand and silt or poorly graded sand with silt underlain by native lean to fat clay. Organic clay to organic silt was encountered in 17 of the road borings. Two road locations, RD-102 and RD-103 were completed in a dirt field access road with no asphalt or gravel surficial cover. Native silty to clayey sand was encountered in five boring locations at RD-118, RD-128, RD-133, RD-134, and RD-153.

1.2.1 Asphalt

Asphalt was encountered in 60 of the 62 road boring locations. Asphalt thicknesses at boring locations where asphalt was present ranged from 1 to 12 inches. The average asphalt thickness was approximately 7 inches.

1.2.2 Base Course

Crushed stone gravel with various amounts of silt and sand was encountered in 60 of the 62 road boring locations below the asphalt. Two borings (RD-102 and RD-103) were completed on an undeveloped dirt access road. It was primarily classified as a poorly graded gravel with silt and sand. The thickness of the base course where present ranged from 4 to 33 inches with an average of approximately 9 inches.

1.2.3 Lean Clay to Fat Clay

Lean to fat clay was encountered in 61 of the 62 road boring locations in thicknesses ranging from approximately 1 feet to 4.1 feet. N-values from Standard Penetration Testing (SPT) conducted in the clays ranged from 1 to 58 blows per foot (bpf) with an average of 10 bpf. These results indicate that the clays typically have consistencies ranging from very soft to hard.

1.2.4 Organic Clay

Organic clay was encountered in 17 of the road boring locations in thicknesses ranging from approximately 0.5 feet to 4.7 feet. N-values from Standard Penetration Testing (SPT) conducted in the organic clays ranged from 1 to 12 blows per foot (bpf) with an average of approximately 6 bpf. These results indicate that the clays typically have consistencies ranging from very soft to stiff.

1.3 Groundwater Conditions

No evidence of groundwater was observed during the course of the geotechnical field investigation, however the road borings did not extend greater than five feet below existing grade. As a result, groundwater is not anticipated to be a significant factor in the current road construction.

1.4 Laboratory Testing

Laboratory testing was performed on selected samples as described below.

1.4.1 Moisture Content

A total of five moisture content tests were performed on soils at the project site. The moisture content for clayey soils ranged from 15 to 72 percent, with an average of 22 percent, indicating that soils were generally in a moist condition. The results of the moisture content testing can be found in Table 2 below and attached.

1.4.2 Atterberg Limits

A total of five Atterberg Limits tests were performed on cohesive soils at the project site. Four test were performed on lean to fat clay. Atterberg Limits testing of these samples indicated a Liquid Limit ranging from 34 to 62 percent, a Plastic Limit ranging from 17 to 21, and Plasticity Indices ranging from 17 to 43 percent. According to the USCS plasticity chart, these are classified as lean clay (CL) and fat clay (CH). One sample of organic clay was tested for Atterberg Limits and this sample indicated a Liquid Limit of 113 percent, a Plastic Limit of 80, and Plasticity Index of 33 percent. The results of the Atterberg Limits testing can be found in Table 2 below and attached.

1.4.3 Organic Content

A test of organic content tests was performed on one sample from the project site. The organic content was found to be 31.5 percent. The results of the organic content testing can be found in Table 2 below.

Table 2 Moisture Content and Atterberg Limits Testing Results

Geotechnical Boring ID	USCS	Depth [ft]	Moisture Content [%]	Organic Content [%]	Atterberg Limits		
					Liquid Limit [%]	Plastic Limit [%]	Plasticity Index
RD-109	CH	3.5-5.0	28.3	--	62	19	43
RD-127	CL	5-6.5	31.9	--	43	20	23
RD-134	OH	1.5-3.0	72.1	31.5	113	80	33
RD-151	CH	3.5-5.0	27.7	--	57	21	36
RD-156	CL	1.5-3	14.8	--	34	17	17

1.4.4 California Bearing Ratio Testing

Design for roads and general working areas is based in part on the strength of the subgrade that can be reasonably achieved. California Bearing Ratio (CBR) tests were completed on soil samples collected from the selected locations across the site to determine the field strength of the subgrade.

A total of six samples of the shallow subgrade soils were collected either adjacent to the road borings in the shoulders or directly beneath the gravel base in the road borings (Figure 1). The bulk samples were collected from soil immediately below topsoil or fill materials, which typically corresponded to a depth of approximately 3 to 15 inches below the surface, though one sample was composited from material collected Add comment from 2 to 6 feet. The soil samples were prepared to approximate 95, 98 and 100 percent of the standard Proctor maximum dry density at the optimum moisture content. The results of the CBR testing at 95% compaction are presented in Table 3 as well as being attached to this letter report.

In general, the CBR samples were classified as lean clay with various amount of sand and gravel though one sample of organic clay was obtained and tested. Results from the testing conducted on the subgrade samples indicate that CBR values at 0.1 inch of deflection under a surcharge of 50 psf range from 2.5 -4.7 percent, when compacted to 95 percent of the standard Proctor density at optimum moisture and. 2.9-6.2 percent, when compacted to 98 percent of the standard Proctor density at optimum moisture. There was little to no apparent gain when looking at the results of samples compacted to 100 percent of the standard Proctor density at optimum moisture. This is likely due to the effects of the soil actually breaking down or being overworked in the process of applying the comp active effort required to allow the sample to reach 100 percent. The results indicate that the soils at the site are fairly consistent in their ability to support roads.

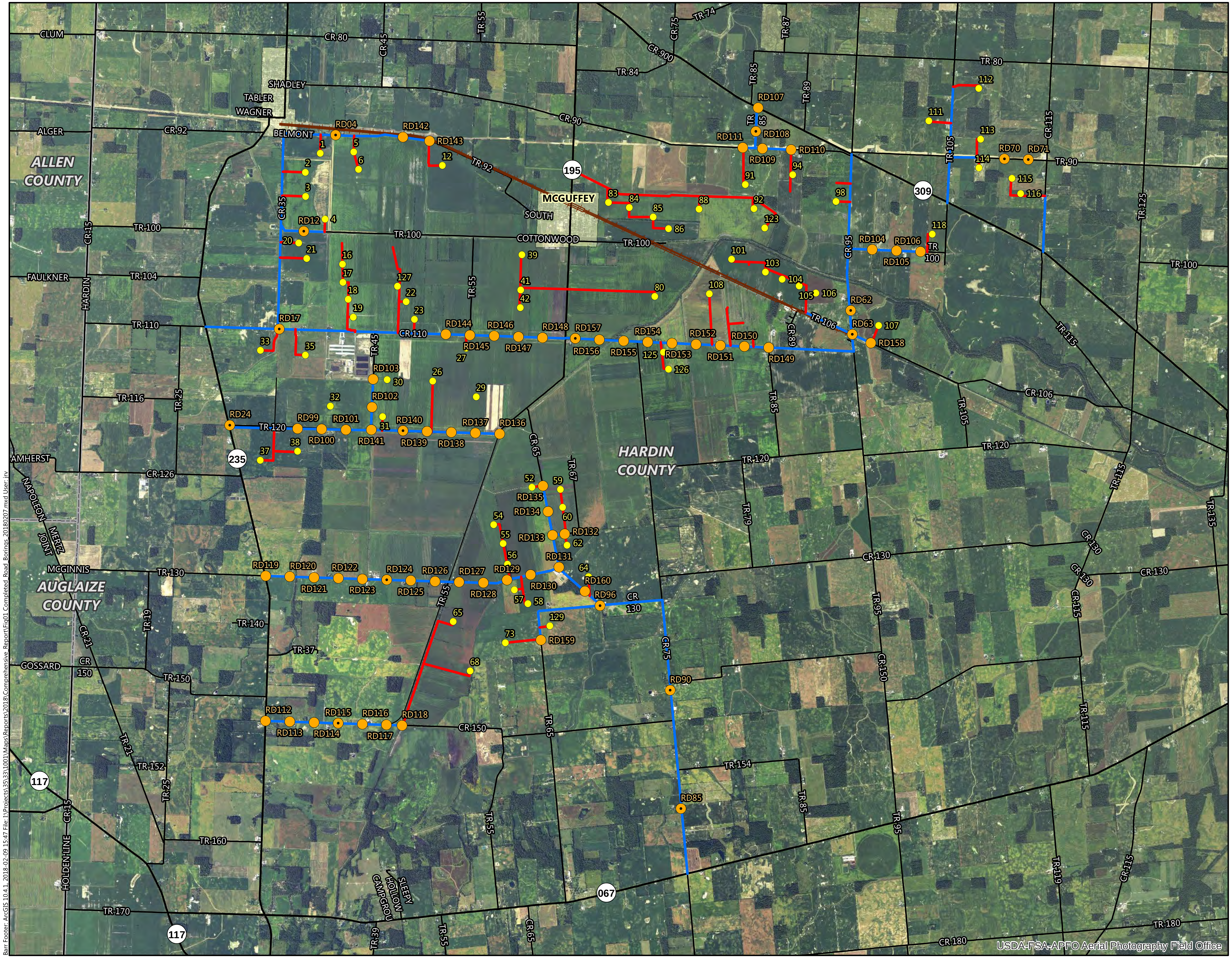
Table 3 CBR Testing Results

Geotechnical Boring ID	USCS	California Bearing Ratio Value (Optimum Moisture Content)*		
		95% Compaction	98% Compaction	100% Compaction
RD-108	CH	2.8	3.6	3.6
RD-115	CL	4.7	5.9	5.9
RD-124	CL/OL	3.4	4.6	4.9
RD-126	OH	2.5	2.9	2.6
RD-140	OL	4.4	6.2	5.9
RD-148	CL	4.1	5	4.9

Attachments:

Boring Logs

Laboratory Test Results



- Turbine Location (11/17/2017)
- Access Road (11/17/2017)
- Transportation Route (11/17/2017)
- Completed Road Boring
- Completed Road Boring and CBR Location
- City Boundary
- County Boundary

Feet
5,000 0 5,000

Meters
1,600 0 1,600

Figure 1

COMPLETED ROAD BORINGS LOCATIONS - 2/9/2018

Hardin Wind Project
Invenergy LLC
Hardin County, Ohio

California Bearing Ratio ASTM:D1883

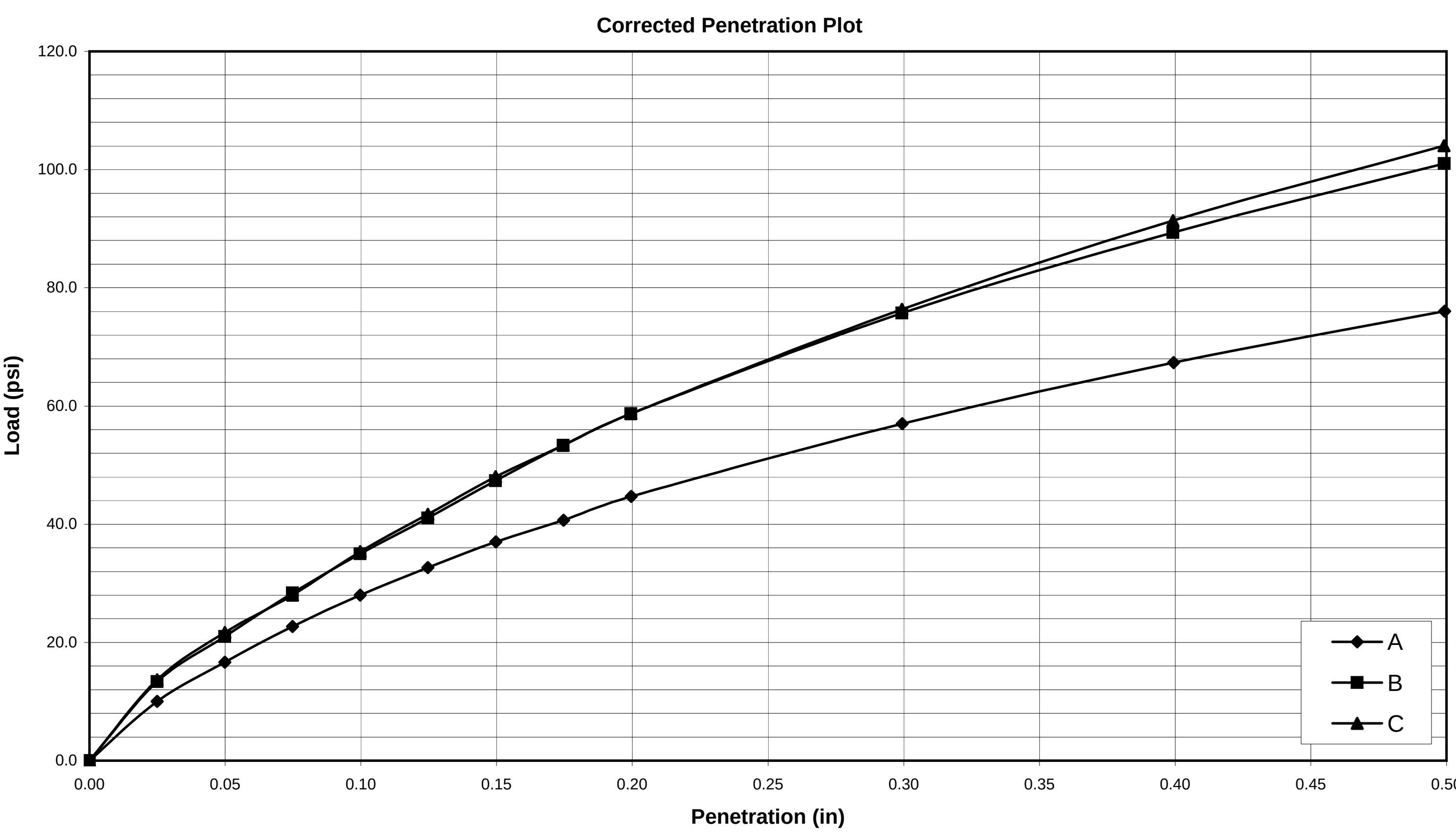
Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-108		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 7"-18"	Type: Bulk	
Location:		
Classification: Fat Clay w/a trace of gravel (CH)		

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	95.6	PL:	Organic Content:
Optimum Water Content:	24.6%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	24.6%	24.6%	24.6%
Initial Dry Density (PCF)	90.9	93.8	95.5
Relative Compaction	95.0%	98.1%	99.9%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.4%	1.3%	1.3%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**2.8%**	**3.6%**	**3.6%**
at 0.2 inch (%)	3.0%	3.9%	3.9%
Moisture Content After Penetration			
Top 1" of Specimen:	28.4%	25.9%	27.5%
Average of specimen:	27.7%	25.7%	25.6%

Stress vs. Penetration Graph

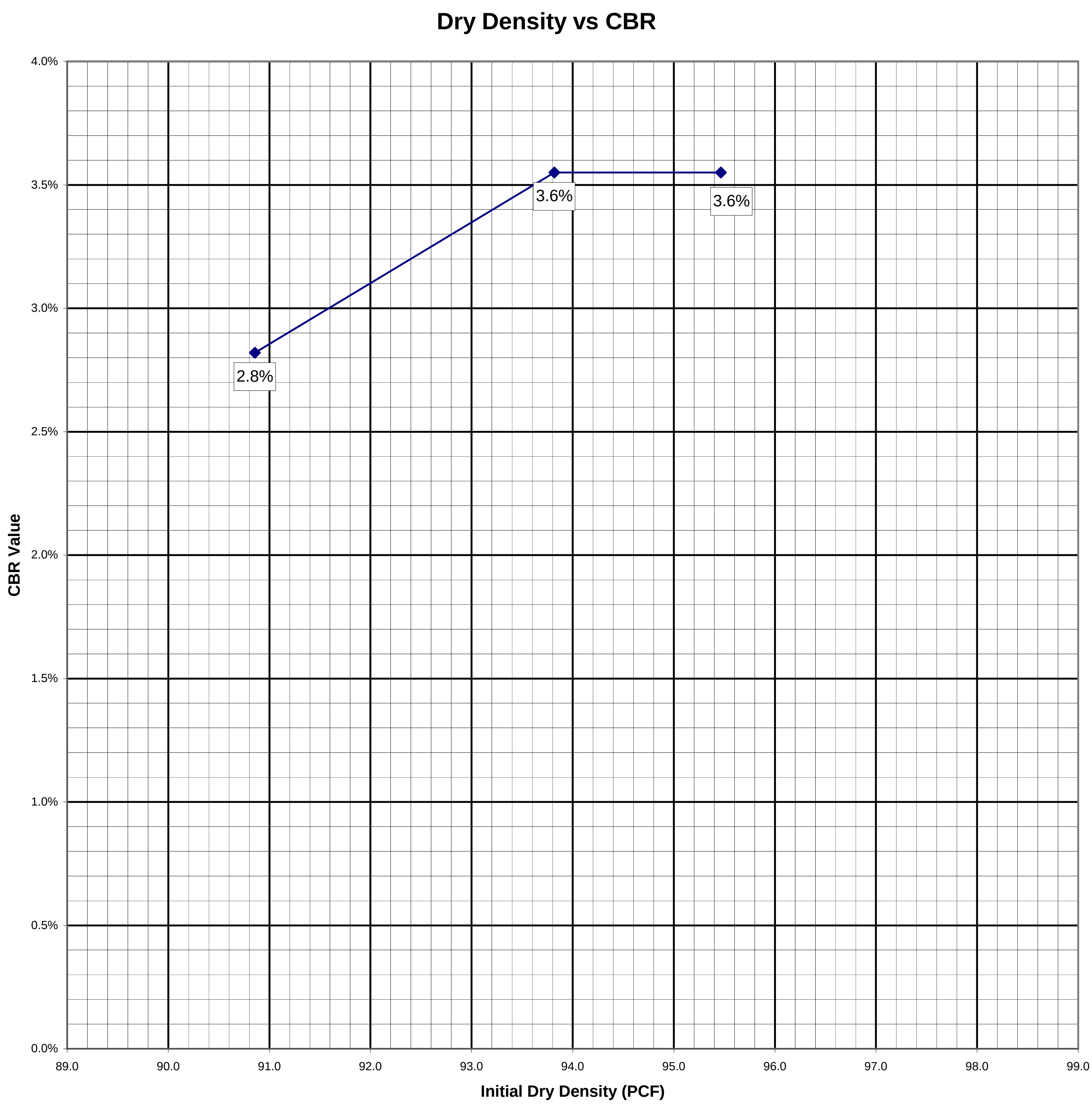


California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-108	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 7"-18" Type: Bulk	
Location:	
Classification: Fat Clay w/a trace of gravel (CH)	

Test Plot



9530 James Ave South
SOIL ENGINEERING TESTING, INC.
Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

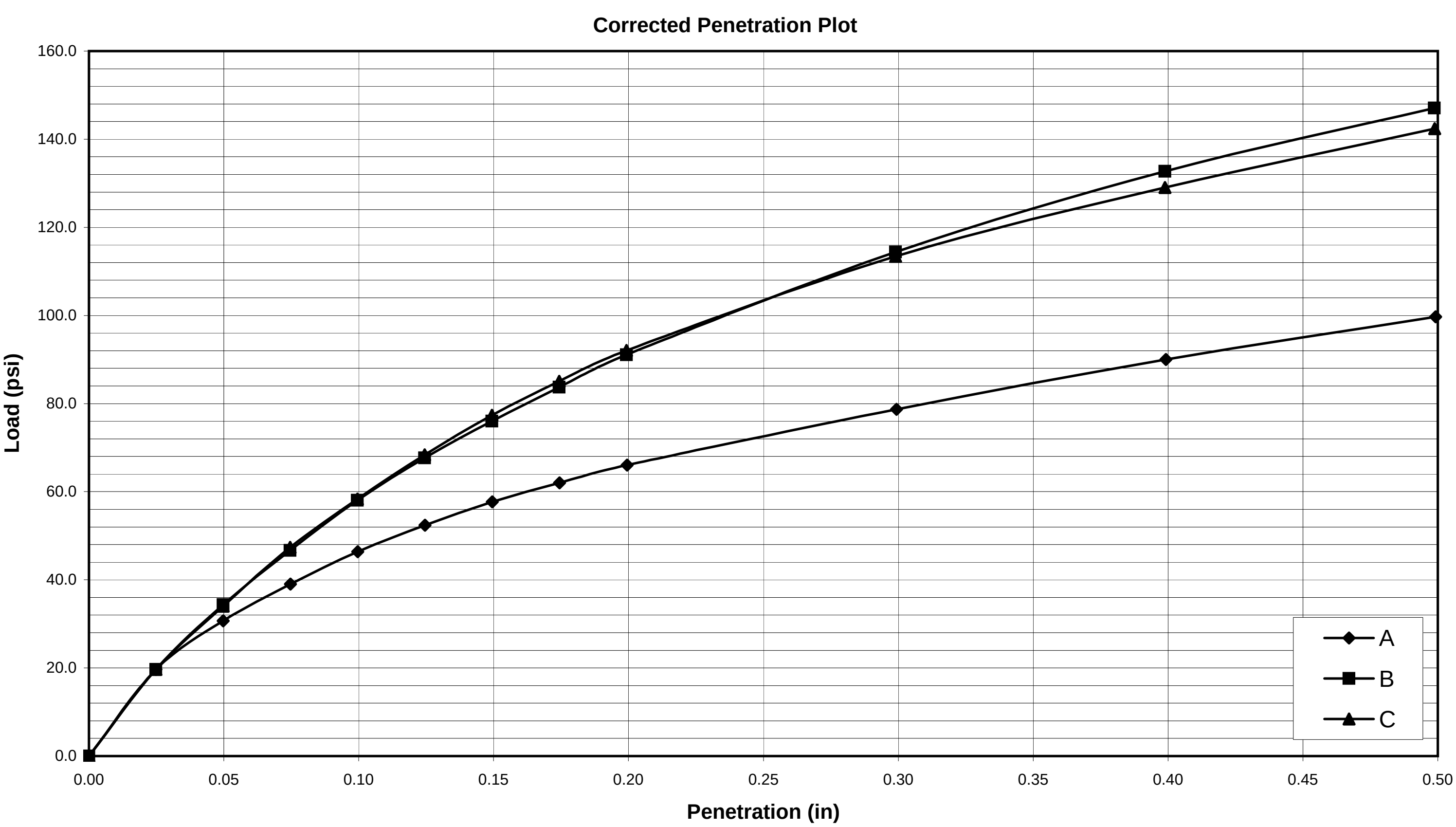
Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-115		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 3"-15"	Type: Bulk	
Location:		
Classification: Lean Clay with sand and a little gravel (CL)		

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	113.3	PL:	Organic Content:
Optimum Water Content:	14.7%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	14.7%	14.7%	14.7%
Initial Dry Density (PCF)	107.8	111.1	113.3
Relative Compaction	95.2%	98.1%	100.0%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	0.8%	0.7%	0.8%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**4.7%**	**5.9%**	**5.9%**
at 0.2 inch (%)	4.4%	6.1%	6.2%
Moisture Content After Penetration			
Top 1" of Specimen:	18.3%	17.8%	19.8%
Average of specimen:	17.5%	17.5%	19.0%

Stress vs. Penetration Graph



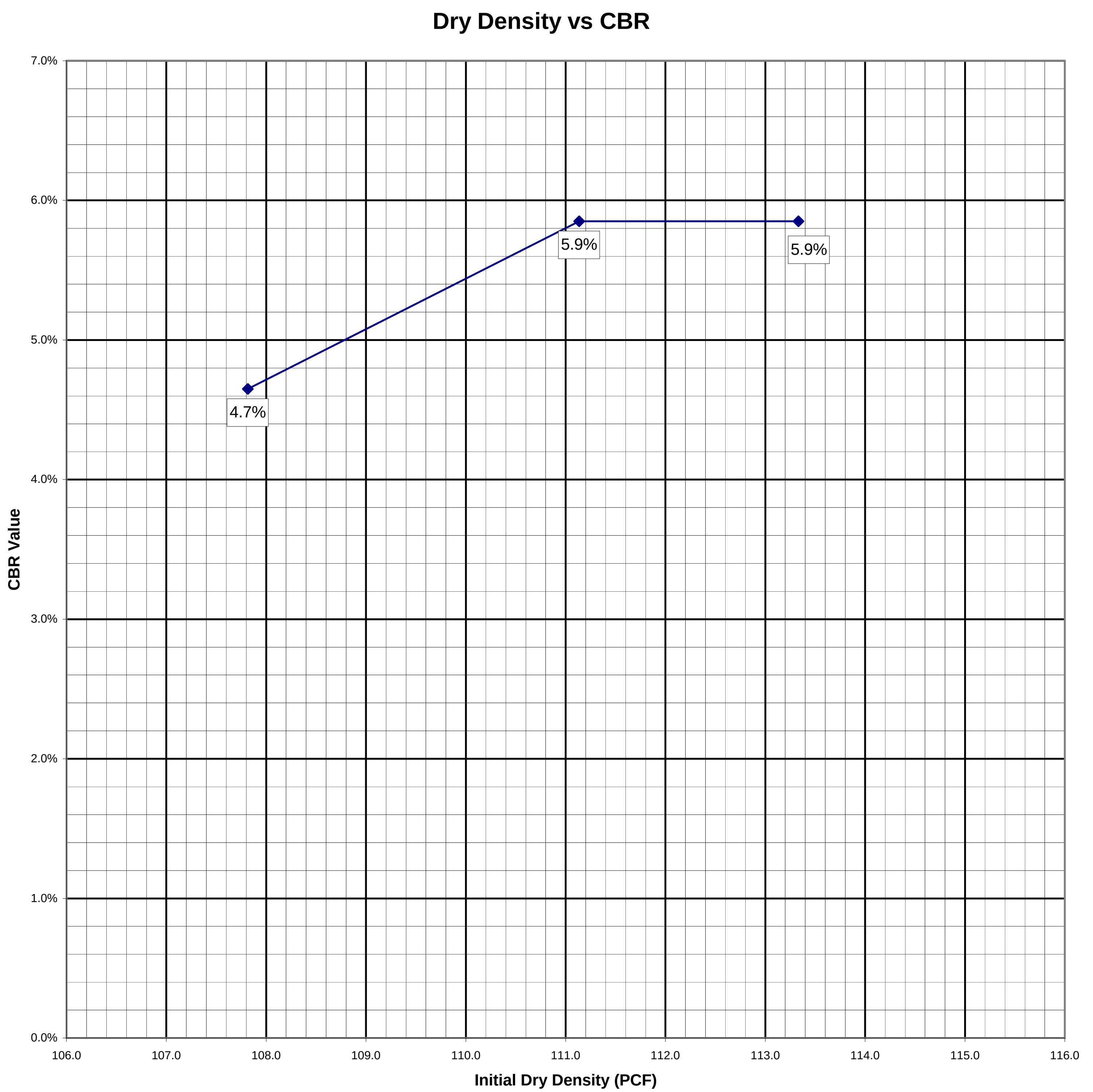
California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-115		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 3"-15"	Type: Bulk	
Location:		

Classification: Lean Clay with sand and a little gravel (CL)

Test Plot



California Bearing Ratio ASTM:D1883

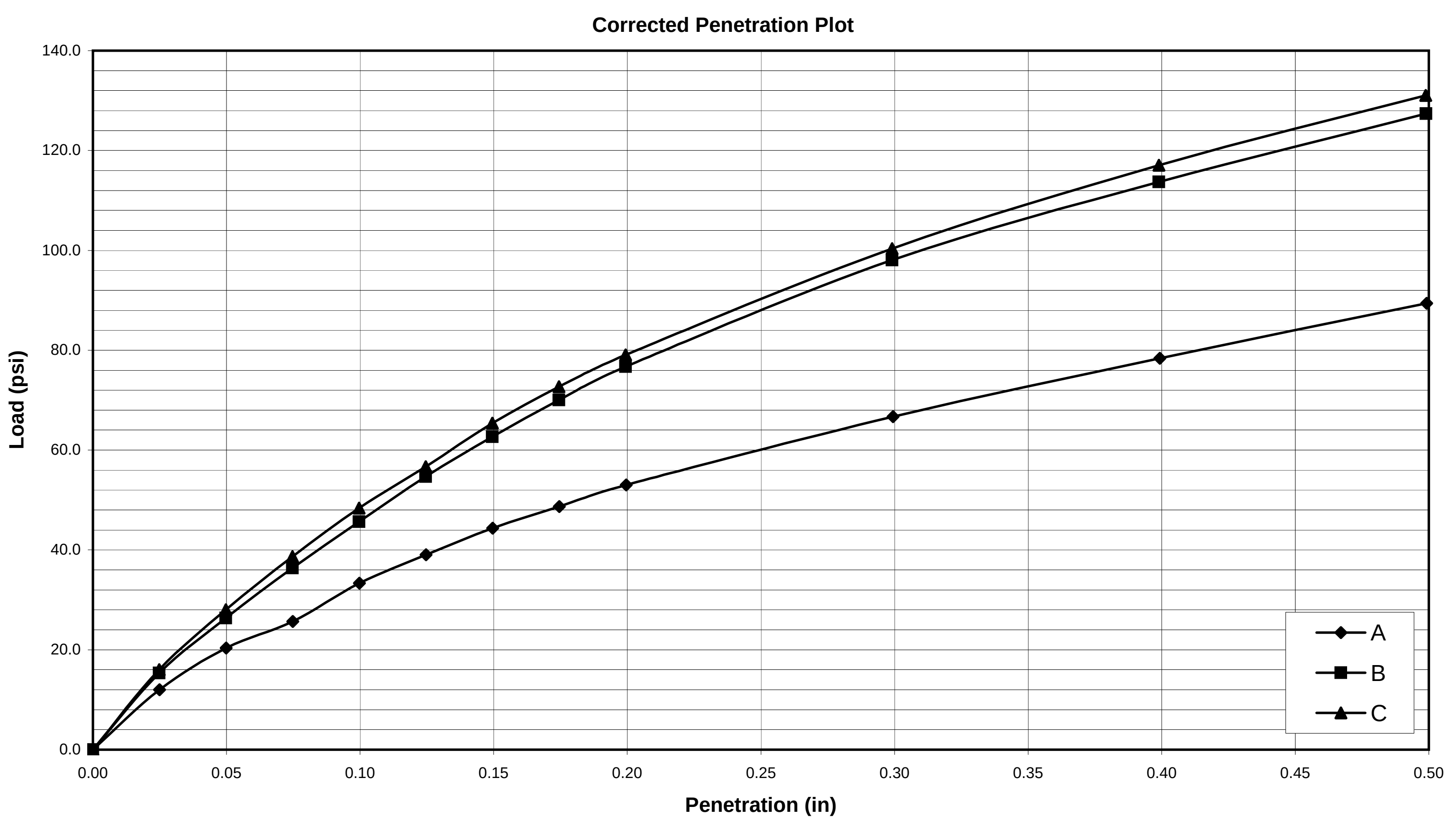
Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-124	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 5"-17" Type: Bulk	
Location:	
Classification: Lean Clay with organic fines (CL/OL)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	98.0	PL:	Organic Content:
Optimum Water Content:	22.8%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	22.8%	22.8%	22.8%
Initial Dry Density (PCF)	93.2	96.1	97.9
Relative Compaction	95.1%	98.0%	99.9%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	0.8%	0.7%	0.7%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**3.4%**	**4.6%**	**4.9%**
at 0.2 inch (%)	3.6%	5.1%	5.3%
Moisture Content After Penetration			
Top 1" of Specimen:	28.1%	23.6%	24.6%
Average of specimen:	27.0%	23.0%	23.7%

Stress vs. Penetration Graph



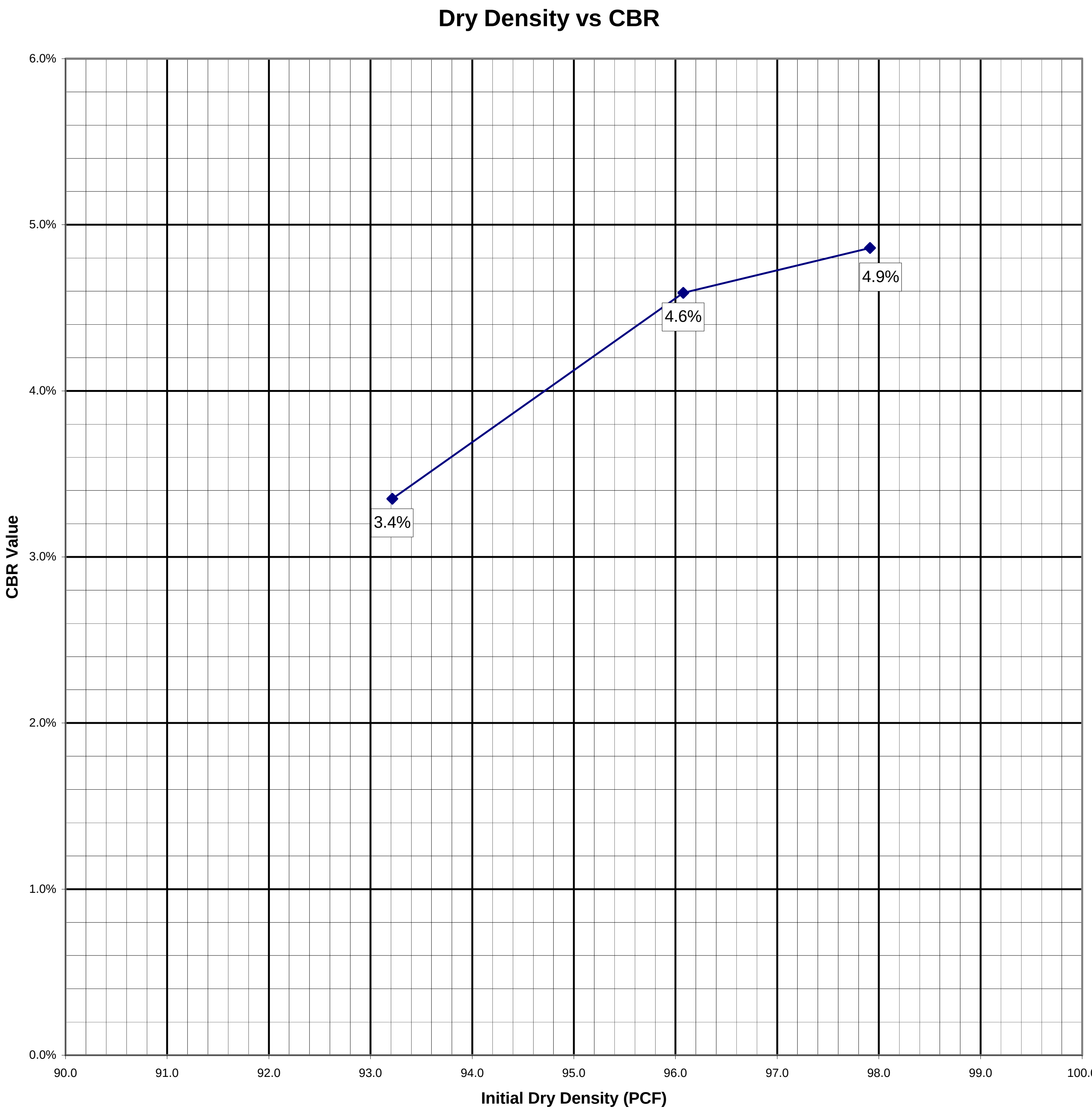
California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-124		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 5"-17"	Type: Bulk	
Location:		

Classification: Lean Clay with organic fines (CL/OL)

Test Plot



California Bearing Ratio ASTM:D1883

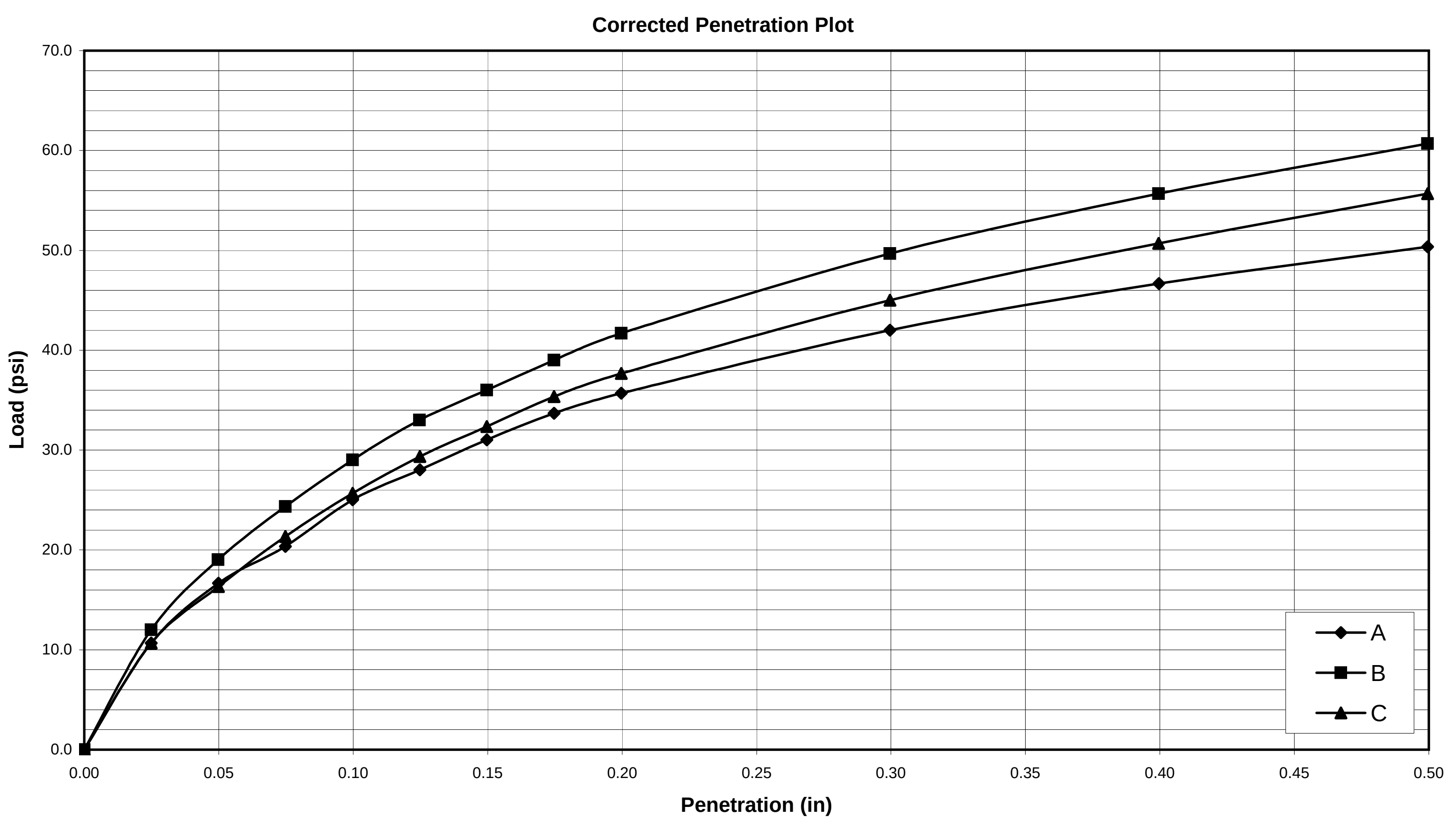
Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-126		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 2-6	Type: Bulk	
Location:		
Classification: Organic Clay (OH)		

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	42.0	PL:	Organic Content:
Optimum Water Content:	90.0%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	90.0%	90.0%	90.0%
Initial Dry Density (PCF)	40.2	41.2	42.0
Relative Compaction	95.7%	98.1%	100.1%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.6%	1.6%	1.7%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**2.5%**	**2.9%**	**2.6%**
at 0.2 inch (%)	2.4%	2.8%	2.5%
Moisture Content After Penetration			
Top 1" of Specimen:	95.7%	95.3%	94.6%
Average of specimen:	100.7%	96.8%	93.1%

Stress vs. Penetration Graph

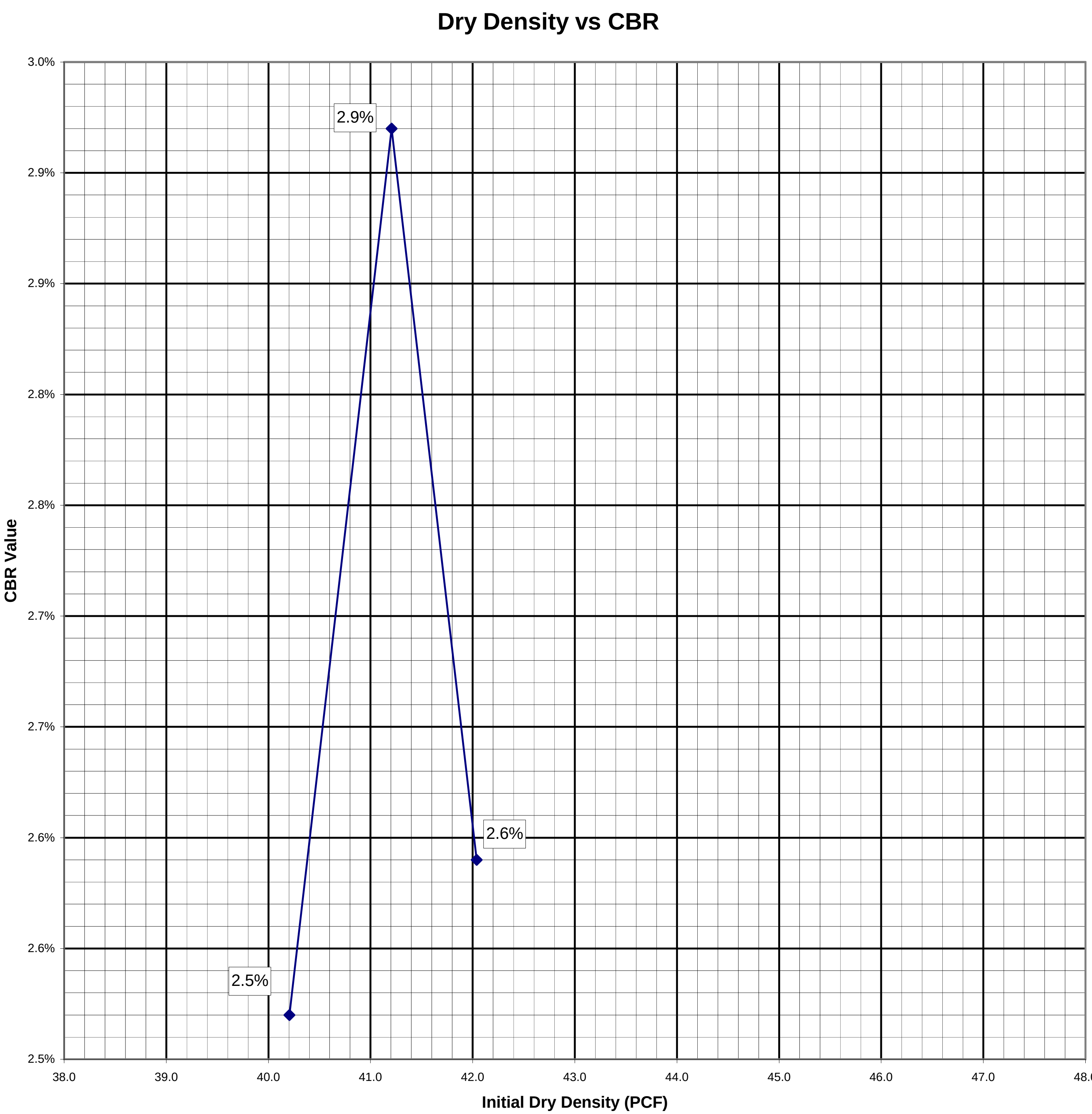


California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-126	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 2-6 / Type: Bulk	
Location:	
Classification: Organic Clay (OH)	

Test Plot



California Bearing Ratio ASTM:D1883

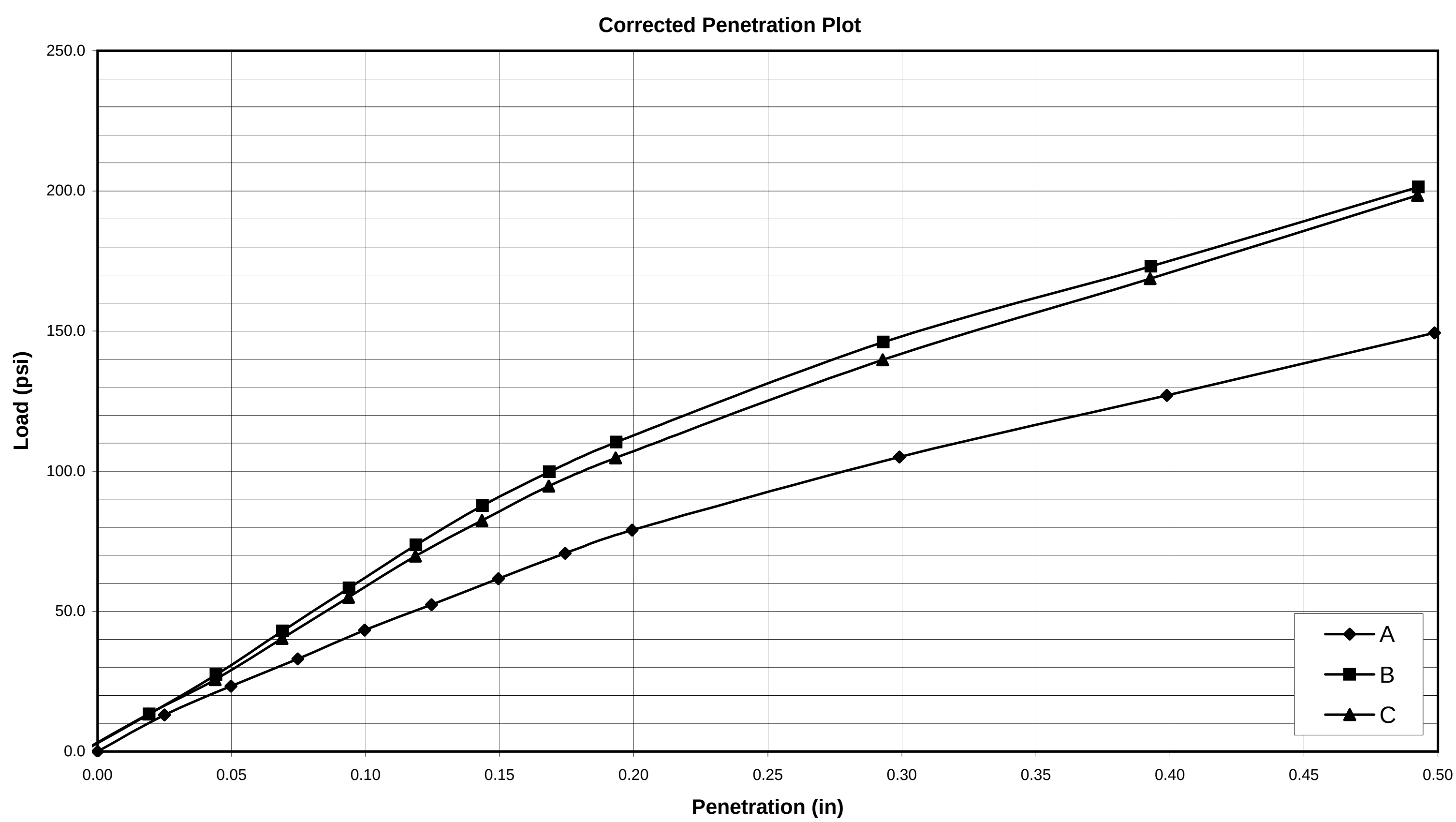
Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-140		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 7"-20"	Type: Bulk	
Location:		
Classification: Organic Clay w/gravel (OL)		

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	100.7	PL:	Organic Content:
Optimum Water Content:	19.8%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	19.8%	19.8%	19.8%
Initial Dry Density (PCF)	95.7	98.8	100.9
Relative Compaction	95.1%	98.1%	100.2%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.0%	1.0%	1.0%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**4.4%**	**6.2%**	**5.9%**
at 0.2 inch (%)	5.3%	7.6%	7.1%
Moisture Content After Penetration			
Top 1" of Specimen:	25.5%	22.8%	22.4%
Average of specimen:	25.0%	22.9%	21.4%

Stress vs. Penetration Graph

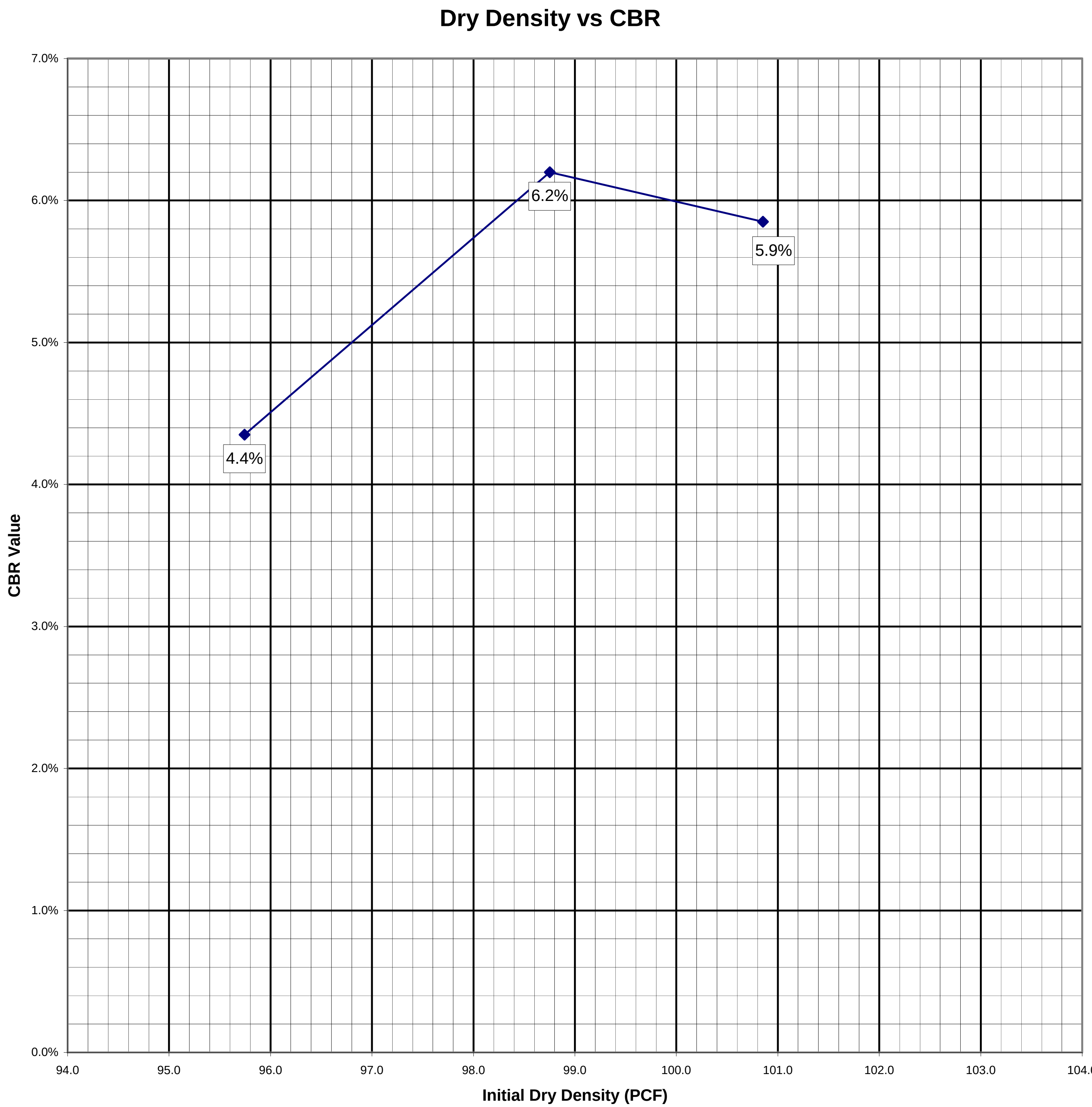


California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-140		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 7"-20"	Type: Bulk	
Location:		
Classification: Organic Clay w/gravel (OL)		

Test Plot



California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

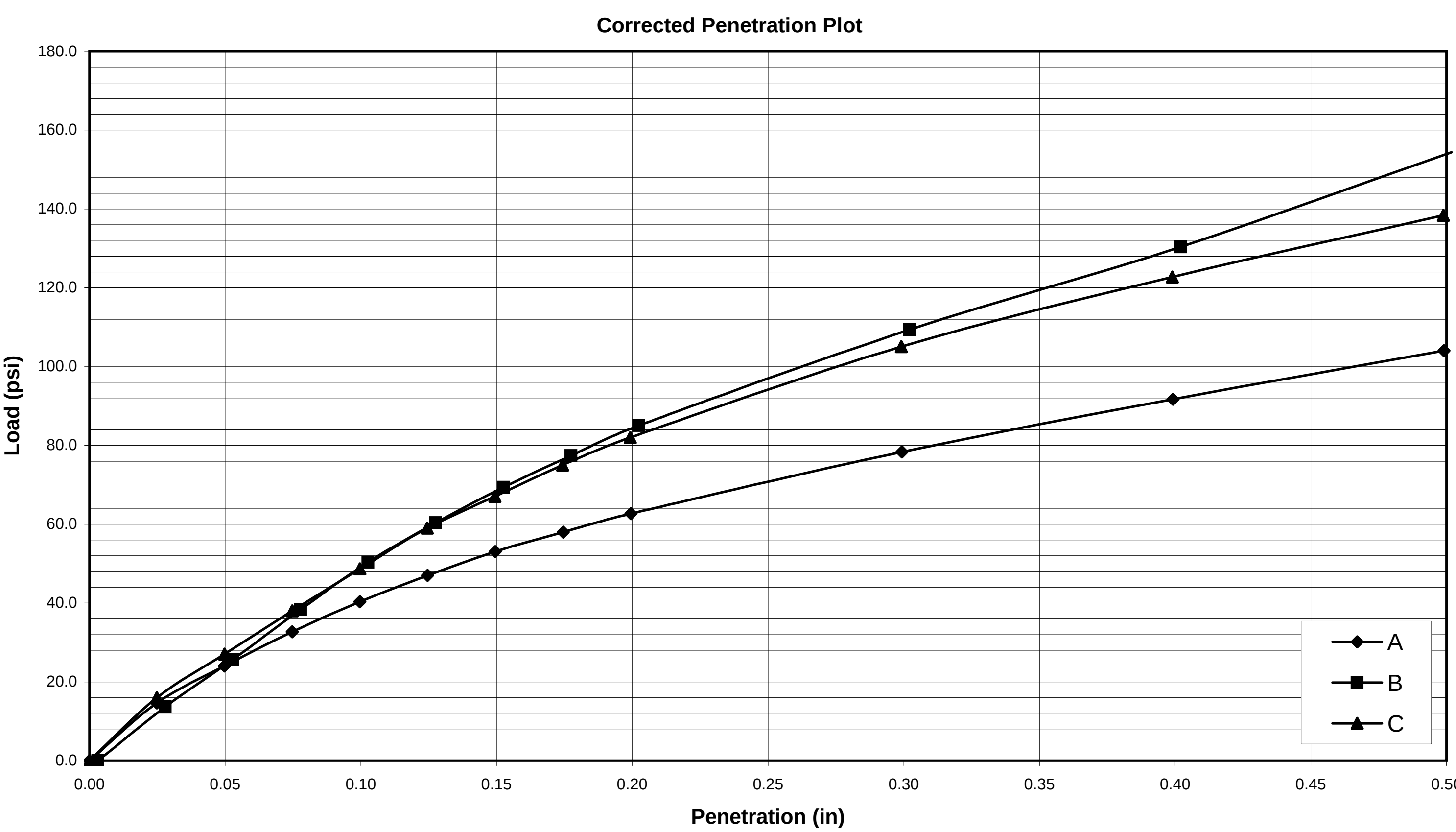
Boring #: RD-148		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 2"-14"	Type: Bulk	
Location:		

Classification: Lean Clay with gravel and organic fines (CL)

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	105.0	PL:	Organic Content:
Optimum Water Content:	18.2%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	18.2%	18.2%	18.2%
Initial Dry Density (PCF)	100.0	103.2	105.3
Relative Compaction	95.3%	98.2%	100.3%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.1%	1.0%	1.2%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**4.1%**	**5.0%**	**4.9%**
at 0.2 inch (%)	4.2%	5.6%	5.5%
Moisture Content After Penetration			
Top 1" of Specimen:	22.1%	20.4%	21.6%
Average of specimen:	21.7%	21.5%	20.4%

Stress vs. Penetration Graph

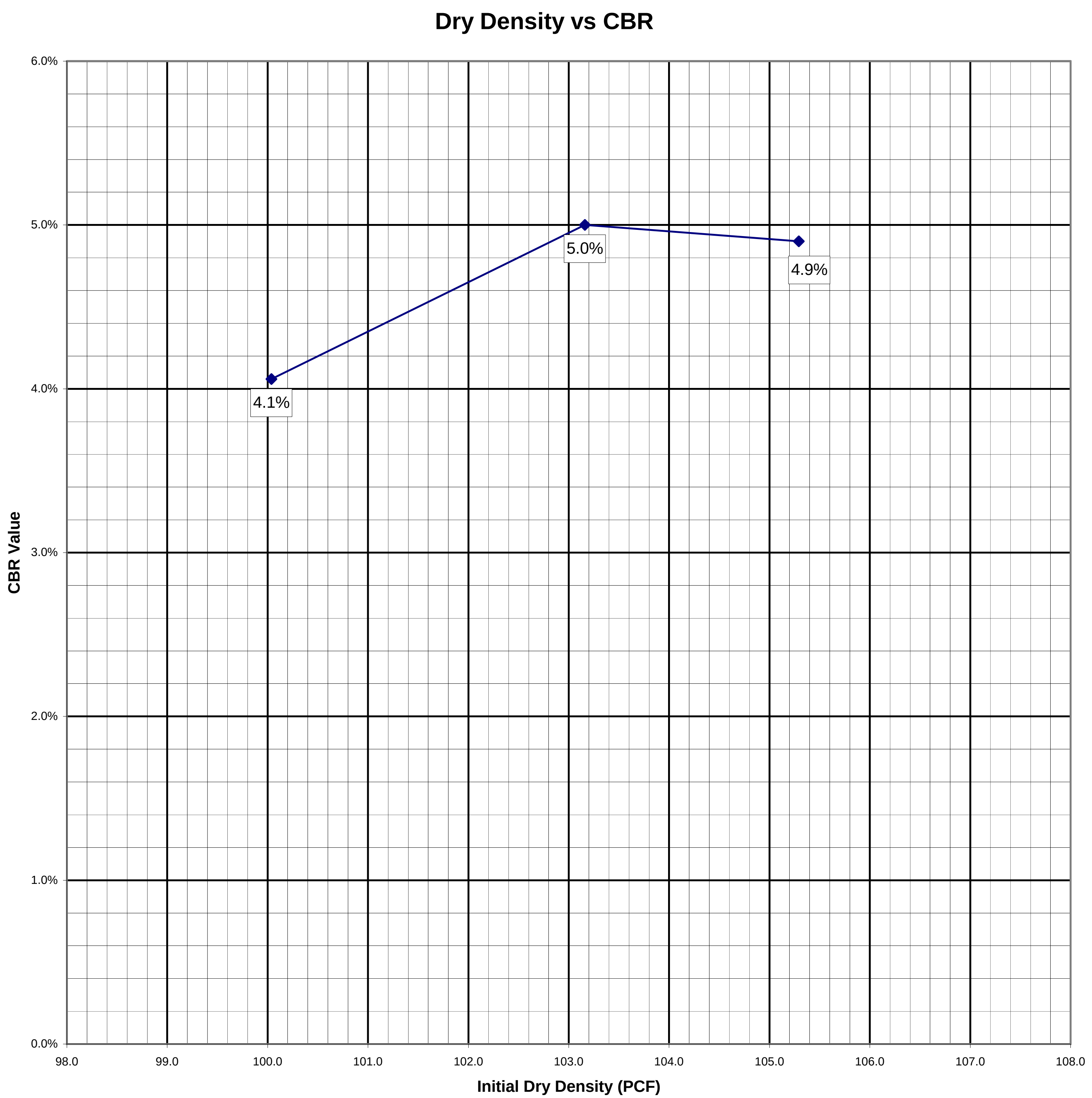


California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-148	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 2"-14" — Type: Bulk	
Location:	
Classification: Lean Clay with gravel and organic fines (CL)	

Test Plot



Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD083

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.59752° Long: -83.75876°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Depth, feet	Material Description	Sample No.	% Recovery	SPT, N value or RQD %	Water Content (%)
0.0	ASPHALT: black.				
0.8ft	CRUSHED STONE: [fill].				
1.2ft	LEAN CLAY (CL): brown; moist; stiff; with gray and red mottling; trace gravel; trace fine sand.	1	78	11	
3.0ft	SANDY LEAN CLAY (CL): grayish brown; moist; stiff; trace fine sand; trace gravel.	2	89	12	14.8
5.0ft	Bottom of Boring at 5.0 feet				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5); NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × ; PL, LL (20, 40, 60)

Date Boring Started:	7/5/17 4:40 pm	Water Levels (ft)	Remarks: Located ~3.5' E of shoulder
Date Boring Completed:	7/5/17 4:55 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD084

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.60115° Long: -83.75936°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft	WATER CONTENT (%) PL / LL
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.5ft					
	1.0	LEAN CLAY (CL): grayish brown; moist; medium stiff; with orange mottling; trace to with sand.	1.0ft	1	78	7	7	PL 18, LL 44, WC 22.4
	3.0	LEAN TO FAT CLAY (CL/CH): dark brown; moist; medium stiff; trace sand.	3.0ft	2	67	6	6	
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

Chart scales: Standard Penetration Test Data N in blows/ft 10, 20, 30, 40; REC%; RQD % ◆ 20, 40, 60, 80; Shear Strength, tsf 0, 2.5, 5; Natural Dry Density (pcf) ☆ 80, 100, 120; Water Content (%) × PL LL 20, 40, 60.

		Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Started:	7/5/17 4:20 pm	At Time of Drilling: Dry	
Date Boring Completed:	7/5/17 4:40 pm		
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD085

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.60465° Long: -83.75989°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.8	CRUSHED STONE: [fill]. 0.8ft					
	1.0	POORLY GRADED SAND (SP): fine grained; brown; moist; loose; with gravel; trace silt. 1.0ft					
	1.3	SANDY LEAN CLAY (CL): brown; moist; medium stiff; trace black and gray mottling. 1.3ft			1	67	6
	2.5	FAT CLAY (CH): brown; moist; trace black and orangish gray mottling; trace sand. 2.5ft			2	78	7
	5.0	Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)

Date Boring Started:	7/5/17 4:05 pm	Water Levels (ft)	Remarks: Located ~3' E of shoulder
Date Boring Completed:	7/5/17 4:15 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD086

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.60833° Long: -83.76056°	Completion Depth:	5.5 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Layer Depth	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft
	0.0	ASPHALT: black.					
	0.9	CRUSHED STONE: [fill].	0.9ft				
	1.7	LEAN TO FAT CLAY (CL/CH): dark brown; moist; stiff; trace sand; trace gravel.	1.7ft	1	67	9	9
	3.0	FAT CLAY (CH): grayish brown; moist; medium stiff.	3.0ft	2	6	6	6
				3	100	6	6
	5.5	Bottom of Boring at 5.5 feet	5.5ft				

Date Boring Started:	7/5/17 3:40 pm	Water Levels (ft)	Remarks: Located ~3' E of shoulder
Date Boring Completed:	7/5/17 3:55 pm	At Time of Drilling Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

M:\GINT\PROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD087

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.61165° Long: -83.76108°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft	NATURAL DRY DENSITY (pcf) / WATER CONTENT (%) PL–LL
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]. 0.5ft							
	1.5	FAT CLAY (CH): dark brown; moist; medium stiff; trave red mottling; trace sand. 1.4ft			1	100	6	6	
	2.5	FAT CLAY (CH): brown; moist; medium stiff; with gray and red mottling; trace to with sand. 2.5ft			2	67	8	8	PL 19, LL 55, water content 26.5
	5.0	Bottom of Boring at 5.0 feet 5.0ft							

Date Boring Started:	7/5/17 3:20 pm
Date Boring Completed:	7/5/17 3:35 pm
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling
Dry

Remarks: Located ~3.5' E of shoulder

Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

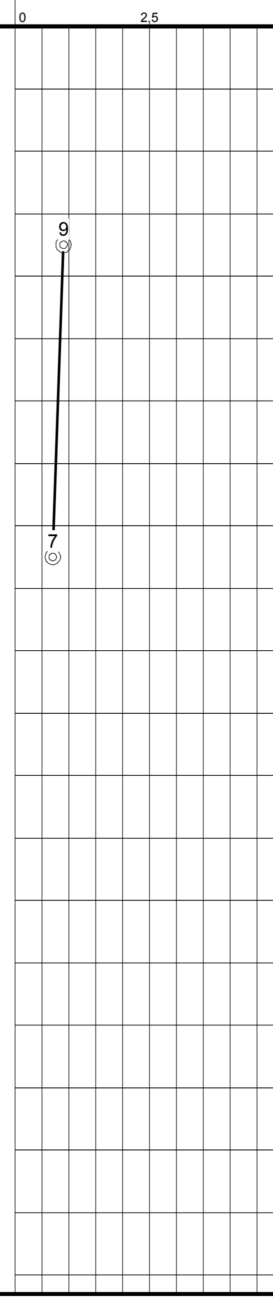
LOG OF BORING RD088

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.61522° Long: -83.76163°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Depth	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill].	0.5ft				
	1.2	FAT CLAY (CH): dark brown; moist; stiff; trace red mottling; trace sand.	1.2ft	X	1	67	9
	3.0	FAT CLAY (CH): brown; moist; medium stiff to stiff; with gray and red mottling; trace sand.	3.0ft	X	2	100	7
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC% RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf



Date Boring Started:	7/5/17 3:00 pm	Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Completed:	7/5/17 3:15 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD089

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.61877° Long: -83.76226°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft
	0.0	ASPHALT: black.							
	0.7	CRUSHED STONE: [fill].	0.7ft						
	1.4	LEAN CLAY (CL): brown; moist; medium stiff; with gray and red mottling; with sand; trace gravel.	1.4ft			1	78	7	7
	3.0	SANDY LEAN CLAY (CL): brown; moist; medium stiff to very stiff; trace gravel.	3.0ft						
	4.0	FAT CLAY (CH): brown; moist; very stiff; with gray mottling; trace gravel.	4.0ft			2	100	19	19
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Chart scales: STANDARD PENETRATION TEST DATA N in blows/ft ◎ 10 20 30 40; REC% ; RQD % ◆ 20 40 60 80; SHEAR STRENGTH, tsf 0 2.5 5

Date Boring Started:	7/5/17 2:40 pm	Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Completed:	7/5/17 2:50 pm	At Time of Drilling Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD090

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.62237° Long: -83.76282°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Water Content (%)
	0.0	ASPHALT: black.					
	0.7	CRUSHED STONE: [fill].	0.7ft				
	1.4	FAT CLAY (CH): dark brown; moist; medium stiff; trace reddish mottling; trace sand. 1.4'-3': trace organics.	1.4ft	1	67	7	
	4.0–4.5			2	56	6	26.7
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft (10, 20, 30, 40); REC%; RQD % (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)

NATURAL DRY DENSITY (pcf) (80, 100, 120); WATER CONTENT (%); PL, LL (20, 40, 60)

Date Boring Started:	7/5/17 2:20 pm
Date Boring Completed:	7/5/17 2:35 pm
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located ~4' E of shoulder

Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD091

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.62601° Long: -83.76336°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Depth of change	Sample No.	% Recovery	SPT, N value or RQD %	Standard Penetration Test Data N in blows/ft
	0.0	ASPHALT: black.					
	0.7	CRUSHED STONE: [fill].	0.7ft				
	1.4	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; trace gray and red mottling; trace sand; trace gravel.	1.4ft	1	72	8	8
	3.5	FAT CLAY (CH): brown; moist; medium stiff; with dark brown and gray mottling; trace gravel; trace sand.	3.5ft	2	78	8	8
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

Date Boring Started:	7/5/17 2:05 pm
Date Boring Completed:	7/5/17 2:20 pm
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located ~3.5' E of shoulder. Drilled ~1.5' and hit cobbles. Moved ~1' S and drillied this hole.

Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD092

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.62966° Long: -83.76398°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.8	CRUSHED STONE: [fill].	0.8ft				
	1.2	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; with gray and red mottling; trace fine sand; trace gravel.	1.2ft	Split spoon	1	78	7
	3.5	FAT CLAY (CH): brown; moist; medium stiff; with fine to medium sand.	3.5ft	Split spoon	2	100	5
	4.0	POORLY GRADED CLAYEY SAND (SP-SC): fine to medium grained; brown; moist; loose; trace silt.	4.0ft				
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)

Date Boring Started:	7/5/17 1:40 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	7/5/17 1:55 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD093

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63312° Long: -83.76453°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.6	CRUSHED STONE: [fill].	0.6ft			
	1.6	POORLY GRADED SAND (SP): fine grained; brown; moist; loose; trace clay; trace crushed gravel.	1.6ft	1	44	5
	2.0	LEAN TO FAT CLAY (CL/CH): dark brown; moist; medium stiff; trace fine sand.	2.0ft			
	3.5	FAT CLAY (CH): brown; moist; medium stiff; trace gray and red mottling; trace gravel; trace sand.	3.5ft	2	22	6
	5.0	Bottom of Boring at 5.0 feet	5.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)

Date Boring Started:	7/5/17 1:05 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	7/5/17 1:25 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD094

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63570° Long: -83.76746°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	SPT N (blows/ft)	PL	Water Content (%)	LL
	0.0	ASPHALT: black.								
	0.4	CRUSHED STONE: [fill].	0.4ft							
	1.0	FAT CLAY (CH): drak brownish gray to brown; moist; medium stiff; with gray mottling at 1.5'; trace gravel; trace fine sand.	1.0ft	1	78	7	7	19	28.1	60
	3.0	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff; with gray mottling; trace gravel; trace fine sand.	3.0ft	2	67	9	9			
	5.0	Bottom of Boring at 5.0 feet	5.0ft							

Chart headings: STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5); NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × ; PL, LL (20, 40, 60)

Date Boring Started:	7/5/17 12:45 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	7/5/17 1:00 pm	At Time of Drilling Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD095

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63524° Long: -83.77223°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (Surface Elev.: Unknown)		Samples	Sample No.	% Recovery	SPT, N value or RQD %	Natural Dry Density (pcf)	Water Content (%)
	0.0	ASPHALT: black.							
	0.4	CRUSHED STONE: [fill].	0.4ft						
	1.1	FAT CLAY (CH): dark brownish black; moist; medium stiff; trace reddish brown mottling; trace organics; trace sand.	1.1ft	SS	1	67	7		
	2.0	FAT CLAY (CH): grayish brown; moist; stiff; with reddish brown mottling; trace gravel; trace to with sand.	2.0ft	SS	2	78	15		18.5
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Standard Penetration Test Data N in blows/ft: 7 (sample 1), 15 (sample 2)

Date Boring Started:	7/5/17 12:25 pm	Water Levels (ft)	Remarks: Located ~3' N of shoulder
Date Boring Completed:	7/5/17 12:40 pm	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

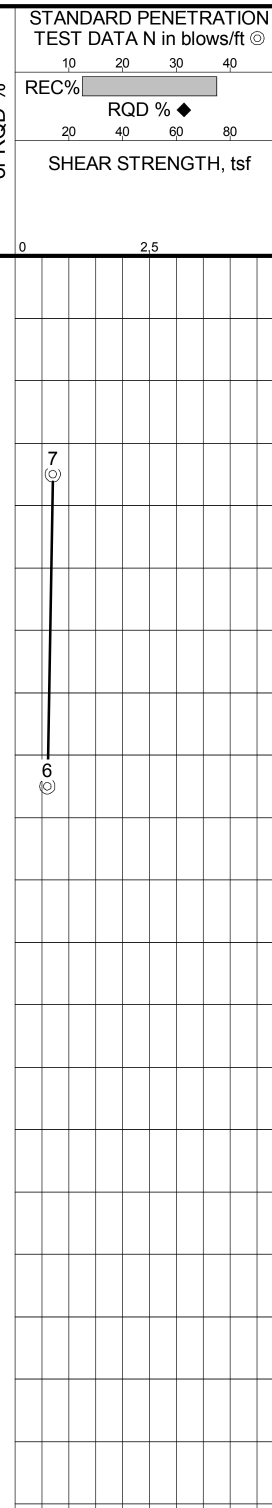
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD096

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63479° Long: -83.77712°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.7	CRUSHED STONE: [fill]. 0.7ft					
	1.5	FAT CLAY (CH): dark brownish black; moist; medium stiff; trace reddish brown mottling; trace fine sand. 1.5ft			1	56	7
	3.3	FAT CLAY (CH): grayish brown; moist; medium stiff; trace reddish brown mottling; with gravel; trace sand. 3.3ft			2	78	6
	5.0	Bottom of Boring at 5.0 feet 5.0ft					



Date Boring Started:	7/5/17 12:05 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	7/5/17 12:20 pm	At Time of Drilling Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 80 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD097

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63437° Long: -83.78170°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	SPT N (blows/ft)	Water content / PL / LL (%)
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.5ft					
	0.9	SANDY LEAN CLAY (CL): grayish brown; moist; stiff; trace gray mottling; trace sand; few gravel.	0.9ft	1	67	10	10	12.8 / 16 / 33
	3.0	LEAN CLAY (CL): brown; moist; stiff; trace black and red mottling.	3.0ft	2	67	9	9	
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

Chart headings: STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5); NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × ; PL — LL (20, 40, 60)

Date Boring Started:	7/5/17 11:40 am	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	7/5/17 11:55 am	At Time of Drilling: Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 80 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD098

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63384° Long: -83.78651°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft	NATURAL DRY DENSITY (pcf) / WATER CONTENT (%)
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]. 0.5ft							
	1.0	FAT CLAY (CH): dark brown to dark grayish brown; moist; medium stiff; trace organics; trace brown mottling. 1.0ft			1	11	6	6	22.8
	3.0	FAT CLAY (CH): grayish brown; moist; medium stiff; trace red mottling; trace gravel; trace sand at 5'. 3.0ft			2	33	5	5	
	5.0	Bottom of Boring at 5.0 feet 5.0ft							

Date Boring Started:	7/5/17 11:20 am
Date Boring Completed:	7/5/17 11:40 am
Logged By:	AMS3
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling
Dry

Remarks: Located 2.5' N of shoulder

Weather: Sunny, 80 F

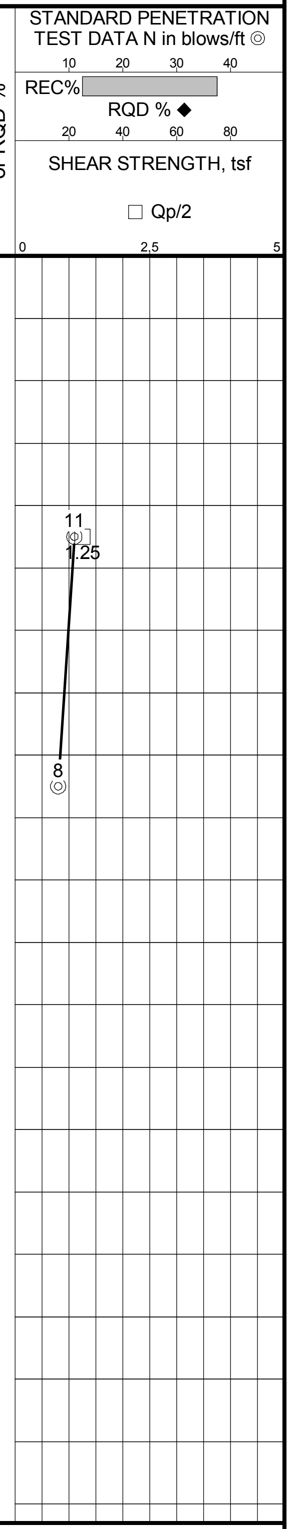
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD099

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.5	CRUSHED STONE: [fill].	0.5ft			
	1.7	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel.	1.7ft	1	44	11
				2	64	8
	5.0	Bottom of Boring at 5.0 feet	5.0ft			



Date Boring Started:	12/8/17 10:00 am	Water Levels (ft)
Date Boring Completed:	12/8/17 10:20 am	At Time of Drilling: Dry
Logged By:	MAN2	
Drilling Contractor:	TTL Associates	
Drill Rig:		

Remarks: Located 2.5' N of shoulder

Weather: Sunny, 20 F

M:\GINT\PROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

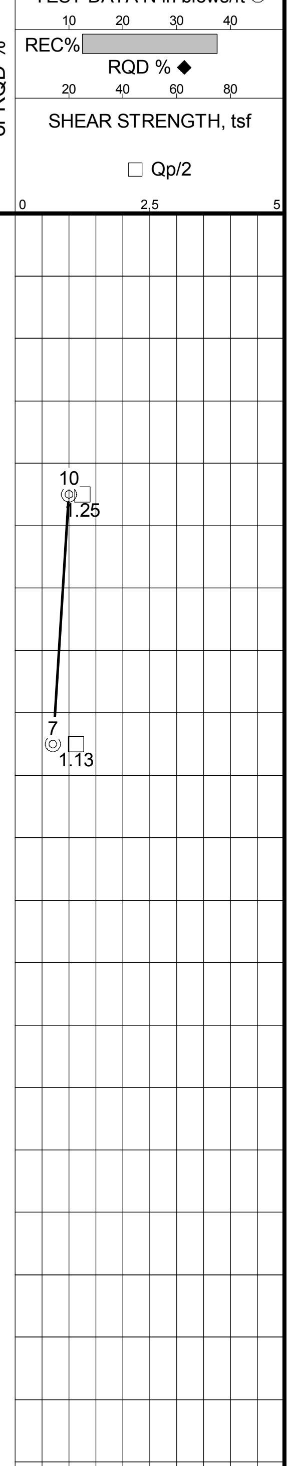
LOG OF BORING RD100

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill]. 0.5ft					
	1.7	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel; trace orange mottling. 1.7ft			1	39	10
					2	61	7
	5.0	Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
REC% ▭ RQD % ◆
SHEAR STRENGTH, tsf
☐ Qp/2



Date Boring Started:	12/8/17 9:40 am	Water Levels (ft)	Remarks: Located 2' N of shoulder
Date Boring Completed:	12/8/17 9:55 am	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 18 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD101

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.			
	0.5	CRUSHED STONE: [fill]. (0.5ft)			
	1.7	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel; trace orange mottling. (1.7ft)	1	28	9
			2	67	7
	5.0	Bottom of Boring at 5.0 feet (5.0ft)			

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf; ☐ Qp/2 (0, 2.5, 5)

Plotted values: 9, 1 (at sample 1); 7, 0.875 (at sample 2)

Date Boring Started:	12/8/17 9:25 am
Date Boring Completed:	12/8/17 9:35 am
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 3.5' N of shoulder

Weather: Sunny, 18 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD102

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	Standard Penetration Test Data N in blows/ft / Shear Strength, tsf (Qp/2)
	0.0	TOPSOIL: dark brown to black; moist.						
	1.5	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel. 1.5ft						
	2.3				1	56	7	N = 7; 0.75
	4.3				2	78	10	N = 10; 1.13
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:	12/8/17 10:30 am	Water Levels (ft)	Remarks: Located 5' W of tilled field on field access road
Date Boring Completed:	12/8/17 10:50 am	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 20 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

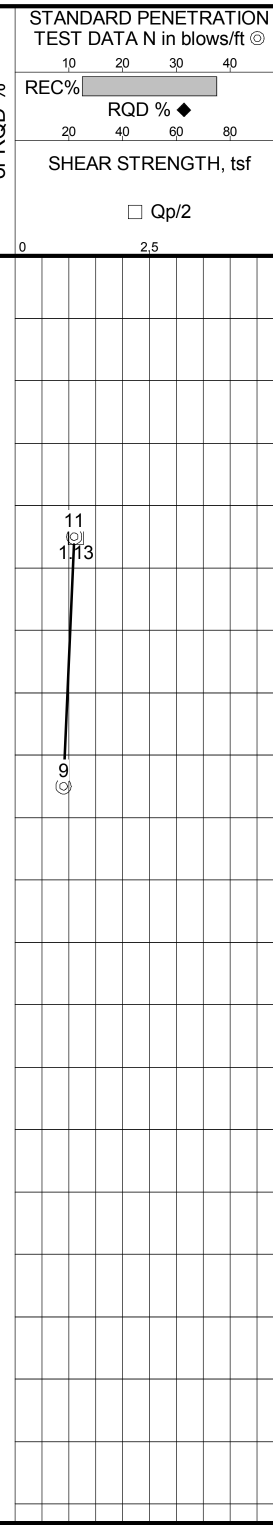
LOG OF BORING RD103

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft
	0.0	TOPSOIL: dark brown to black; moist.							
	2.0	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel.	2.0ft			1	47	11	11
						2	78	9	9
	5.0	Bottom of Boring at 5.0 feet	5.0ft						



Date Boring Started:	12/8/17 11:00 am	Water Levels (ft)	Remarks: Located 6' W of tilled field on field access road
Date Boring Completed:	12/8/17 11:20 am	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 20 F

M:\GINT\PROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD104

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	SPT N (blows/ft) / Qp/2 (tsf)
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill].	0.5ft				
	1.0	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.0ft				
	2.0–2.5			1	50	14	14 / 1.63
	4.0–4.5			2	67	10	10 / 1.38
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	12/6/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

M:\GINT\PROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD105

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft / REC% / RQD % / SHEAR STRENGTH, tsf (Qp/2)
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill]. 0.5ft						
	1.0	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling. 1.1ft						
	2.0–2.5				1	50	11	11 / 1.13
	4.0–4.5				2	78	12	12 / 1.38
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/6/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD106

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	SHEAR STRENGTH, tsf (Qp/2)
	0.0	ASPHALT: black.					
	0.7	CRUSHED STONE: [fill].	0.7ft				
	1.1	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff; trace organics; trace sand and gravel; trace orange mottling.	1.1ft				
	2.0–3.0			1	25	8	1.25
	3.5–5.0			2	92	7	0.875
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% ; RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Date Boring Started:	12/6/17
Date Boring Completed:	12/6/17
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling
Dry

Remarks: Located 3' N of shoulder

Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD107

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (tsf)
	0.0	ASPHALT: black.					
	0.7	CRUSHED STONE: very loose; [fill].	0.7ft				
	1.8	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.8ft	1	44	9	2.25
				2	67	18	1.75
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5) ☐ Qp/2

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3.5' NE of shoulder
Date Boring Completed:	12/6/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

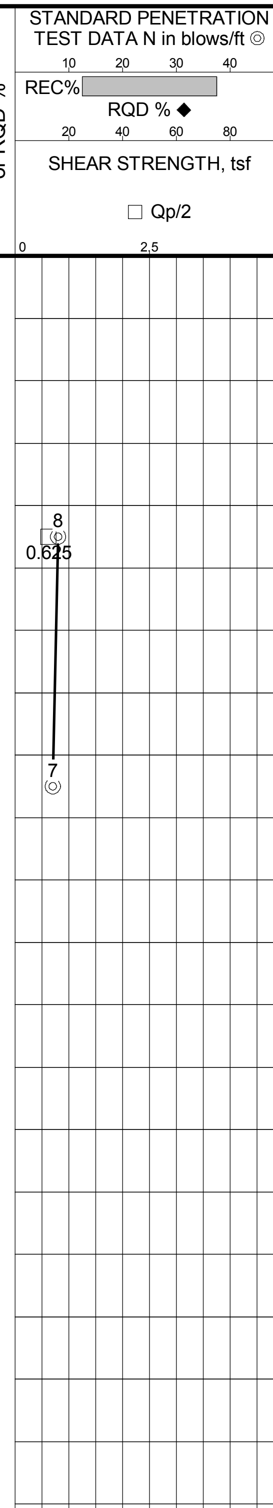
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD108

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.			
	0.5	CRUSHED STONE: [fill]. 0.5ft			
	0.9	LEAN TO FAT CLAY (CL-CH): brown; moist to wet; stiff; trace organics; trace sand and gravel; trace orange mottling. 0.9ft			
			1	61	8
			2	61	7
	5.0	Bottom of Boring at 5.0 feet 5.0ft			



Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 2' E of shoulder
Date Boring Completed:	12/6/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD109

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf
	0.0	ASPHALT: black.					
	1.0	CRUSHED STONE: [fill].	1.0ft				
	1.8	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.8ft	1	44	11	1.5
				2	50	9	0.625
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/6/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

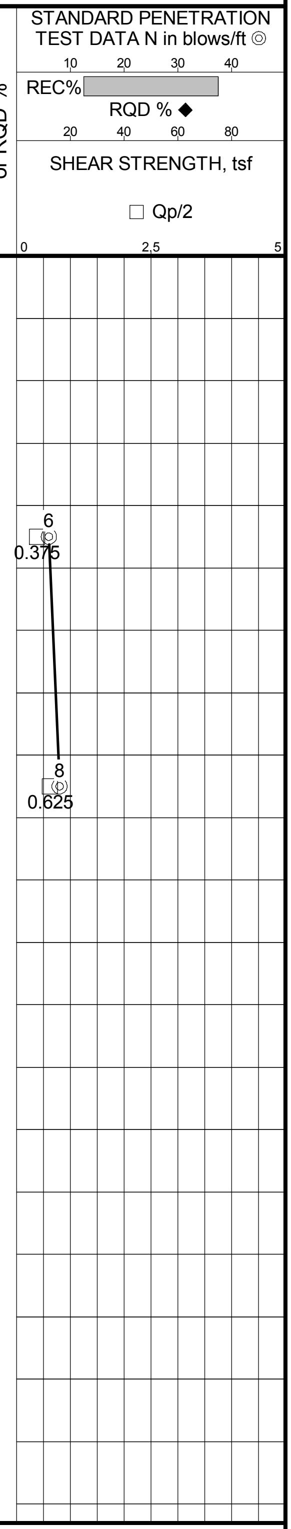
LOG OF BORING RD110

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.5ft					
	1.0	POORLY GRADED SAND WITH SILT (SP-SM): fine to coarse grained; brown; moist; [fill]; with gravel.	1.0ft					
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.8ft					
	2.0–2.5					1	28	6
	4.0–4.5					2	83	8
	5.0	Bottom of Boring at 5.0 feet	5.0ft					



		Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Started:	12/6/17	At Time of Drilling: Dry	
Date Boring Completed:	12/6/17		
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

M:\GINT\PROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD111

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill].	0.5ft				
	1.0	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; stiff to very stiff; trace organics; trace sand and gravel; trace orange mottling.	1.0ft				
	2.0–2.5			1	50	9	1.13
	4.0–4.5			2	83	19	2.25
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/6/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD112

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.						
	0.7	CRUSHED STONE: [fill].	0.7ft					
	1.3	POORLY GRADED SAND WITH SILT (SP-SM): fine to coarse grained; brown; moist; [fill]; with gravel.	1.3ft					
	1.7	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.7ft					
	2.25					1	56	14
	4.25					2	61	10
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎

10 20 30 40

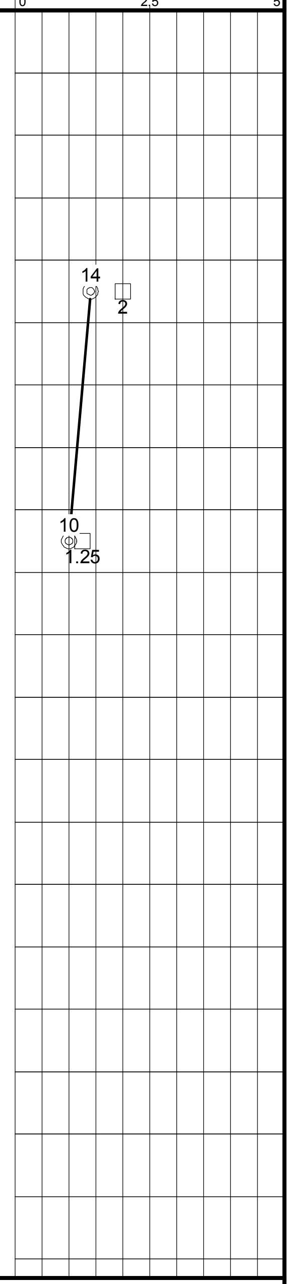
REC% RQD % ◆

20 40 60 80

SHEAR STRENGTH, tsf

☐ Qp/2

0 2.5 5



Date Boring Started:	12/7/17 12:50 pm	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/7/17 1:05 pm	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 25 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD113

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf
	0.0	ASPHALT: black.					
	0.7	CRUSHED STONE: [fill].	0.7ft				
	1.4	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff to very stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.4ft	1	67	11	1.75
				2	83	21	2.25
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

Date Boring Started:	12/7/17 1:15 pm	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/7/17 1:30 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 20 F

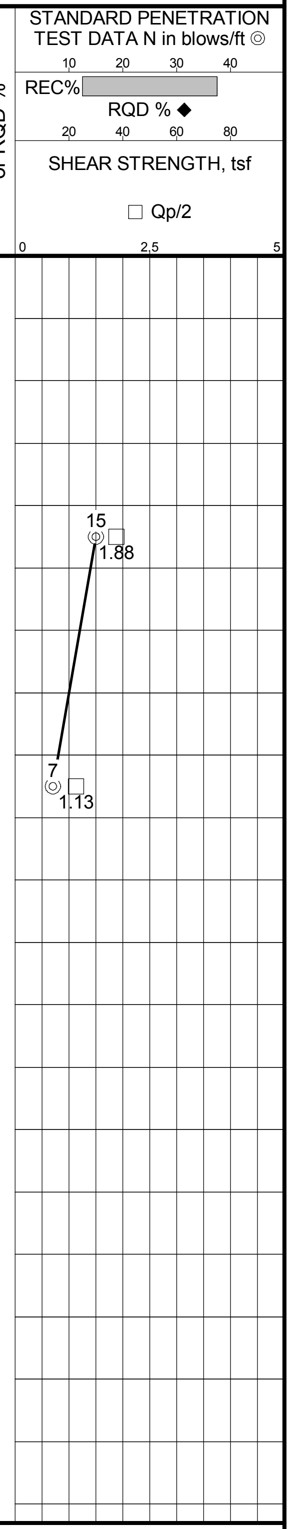
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD114

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (Surface Elev.: Unknown)		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.						
	0.7	CRUSHED STONE: [fill].	0.7ft					
	1.4	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff to stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.4ft			1	61	15
						2	44	7
	5.0	Bottom of Boring at 5.0 feet	5.0ft					



Date Boring Started:	12/7/17 1:30 pm	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/7/17 1:45 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 20 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD115

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft / SHEAR STRENGTH, tsf Qp/2
	0.0	ASPHALT: black.					
	0.8	CRUSHED STONE: [fill].	0.8ft				
	1.4	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff to stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.4ft				
	2.3			1	28	10	N = 10; Qp/2 = 0.5
	4.3			2	67	10	N = 10; Qp/2 = 1.75
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

Date Boring Started:	12/7/17 1:50 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/7/17 2:15 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 20 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD116

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft / SHEAR STRENGTH, tsf (Qp/2)
	0.0	ASPHALT: black.					
	0.8	CRUSHED STONE: [fill].	0.8ft				
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.5ft	1	56	10	10
				2	78	10	10; Qp/2 0.375
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

Date Boring Started:	12/7/17 2:20 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/7/17 2:35 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 20 F

M:\GINT\PROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD117

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft / REC% / RQD % / SHEAR STRENGTH, tsf (Qp/2)
	0.0	ASPHALT: black.						
	0.7	CRUSHED STONE: [fill]. 0.7ft						
	1.4	LEAN TO FAT CLAY (CL-CH): brown; moist; very stiff; trace organics; trace to with sand; trace gravel; trace orange mottling. 1.4ft			1	72	17	17; 2.25
					2	89	22	22; 2.25
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:	12/7/17 2:45 pm	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/7/17 3:00 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 20 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD118

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.			
	0.8	CRUSHED STONE: brown and black; moist; dense; [fill]; mix of natural stone and recycled asphalt. 0.8ft			
	2.3		1	72	34
	3.5	SILTY SAND (SM): brown; moist; medium dense; with gravel. 3.5ft			
	4.3		2	56	16
	5.0	Bottom of Boring at 5.0 feet 5.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft: 34, 16

Date Boring Started:	12/7/17 3:05 pm
Date Boring Completed:	12/7/17 3:20 pm
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 5' N of shoulder

Weather: Overcast, 20 F

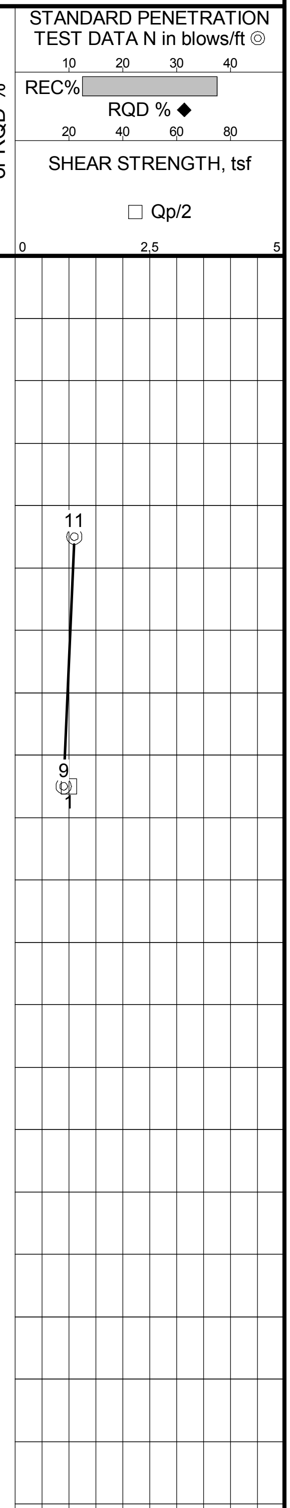
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD119

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.6ft					
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.3ft					
	2.0–3.0					1	33	11
	3.5–5.0					2	67	9
	5.0	Bottom of Boring at 5.0 feet	5.0ft					



Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' E of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD120

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft / REC% / RQD % / SHEAR STRENGTH, tsf (Qp/2)
	0.0	ASPHALT: black.						
	0.6	CRUSHED STONE: [fill]. 0.6ft						
	2.0	LEAN TO FAT CLAY (CL-CH): gray to brown to bluish gray; moist; medium stiff; trace organics; trace to with sand; trace gravel; trace orange mottling. 2.0ft			1	67	8	N = 8; Qp/2 = 1.63
	4.25				2	39	6	N = 6; Qp/2 = 0.25
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD121

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Bottom depth	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.6	CRUSHED STONE: [fill].	0.6ft			
	1.5	POORLY GRADED SAND WITH SILT (SP-SM): fine grained; brown; moist; with gravel.	1.5ft			
	2.0	LEAN TO FAT CLAY (CL-CH): gray to brown to bluish gray; moist; medium stiff to very stiff; trace to with sand; trace gravel; trace orange mottling.	2.0ft	1	56	8
				2	94	28
	5.0	Bottom of Boring at 5.0 feet	5.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft (10, 20, 30, 40): 8, 28
REC% / RQD % (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)

Date Boring Started:	12/5/17
Date Boring Completed:	12/5/17
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 3' N of shoulder

Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD122

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf
	0.0	ASPHALT: black.						
	0.7ft	CRUSHED STONE: [fill].						
	1.2ft	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff to very stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.						
					1	72	12	1.38
					2	83	17	1.13
	5.0ft	Bottom of Boring at 5.0 feet						

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% / RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Date Boring Started:	12/5/17
Date Boring Completed:	12/5/17
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 3' N of shoulder

Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD123

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black. 0.1ft					
		CRUSHED STONE: [fill]. 1.2ft					
	1.2	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff; trace organics; trace to with sand; trace gravel; trace orange mottling. 5.0ft			1	50	9
					2	83	11
	5.0	Bottom of Boring at 5.0 feet					

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Sample 1: N = 9, Qp/2 = 1.38
Sample 2: N = 11, Qp/2 = 2.25

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

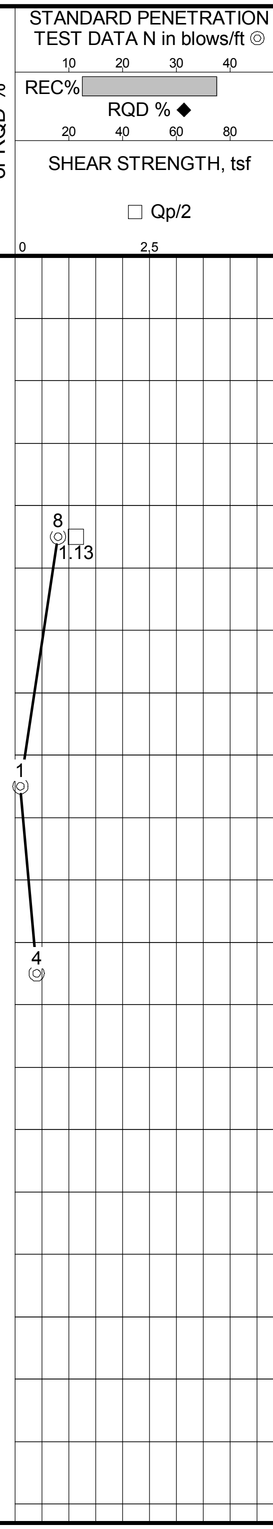
LOG OF BORING RD124

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.8ft	CRUSHED STONE: [fill].					
	1.4ft	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; medium stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.			1	28	8
	2.7ft	ORGANIC CLAY (OH): black to dark gray; moist; loose; trace gravel.					
	3.5ft				2	22	1
	5.0	Bottom of Boring at 5.0 feet			3	28	4



Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD125

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft; REC%; RQD %; SHEAR STRENGTH, tsf
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.4ft						
	1.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; medium stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.0ft						
	2.0–2.5					1	28	9	9
	2.5	ORGANIC CLAY (OH): black to dark gray; moist; loose; trace gravel.	2.6ft						
	3.5		3.5ft						
	4.0–4.5					2	22	3	3
	5.0	Bottom of Boring at 5.0 feet							

Chart scales: N in blows/ft 10, 20, 30, 40; RQD % 20, 40, 60, 80; Shear strength 0, 2.5, 5.

Date Boring Started:	12/5/17
Date Boring Completed:	12/5/17
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 3.5' N of shoulder

Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD126

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft
	0.0	ASPHALT: black.						
	0.6	CRUSHED STONE: [fill]. 0.6ft						
	1.3	ORGANIC CLAY (OH): black to dark gray; moist; very loose to loose; trace gravel. 1.3ft						
					1	17	5	5
					2	11	3	3
	6.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; trace to with sand; trace gravel; trace orange mottling. 6.0ft						
	7.0	Bottom of Boring at 7.0 feet 7.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

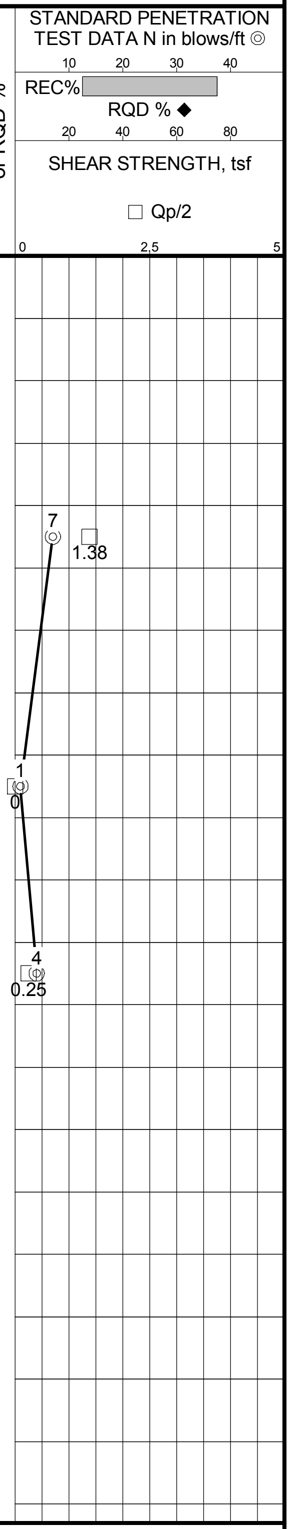
LOG OF BORING RD127

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	6.5 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.						
	1.0	CRUSHED STONE: [fill].	1.0ft					
	1.5	LEAN TO FAT CLAY (CL-CH): blueish gray; moist; medium stiff; trace sand; trace gravel.	1.5ft			1	22	7
	3.5	ORGANIC CLAY (OH): black to dark gray; moist; trace gravel and sand.	3.5ft					
	4.0	LEAN TO FAT CLAY (CL-CH): blueish gray; moist; very soft to soft; trace sand; trace gravel.	4.0ft			2, 3	50	1
						4	100	4
	6.5	Bottom of Boring at 6.5 feet	6.5ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎



Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

M:\GINTPROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD128

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	6.5 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / REC% / RQD % ◆ / SHEAR STRENGTH, tsf
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.4ft						
	2.0	CLAYEY SAND (SC): medium to coarse grained; brown; moist; very loose to loose; trace gravel.	2.0ft			1	28	8	8
						2	8	1	1
	5.0	LEAN TO FAT CLAY (CL-CH): blueish gray; moist; very loose; trace sand; trace gravel.	5.0ft			3	67	4	4
	6.5	Bottom of Boring at 6.5 feet	6.5ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD129

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength, tsf (Qp/2)
	0.0	ASPHALT: black.				
	0.3	CRUSHED STONE: [fill].				
	1.0	POORLY GRADED SAND (SP-SM): medium to coarse grained; [fill]; with gravel.				
	1.5	LEAN TO FAT CLAY (CL-CH): light brown to greenish gray; moist; medium stiff; trace gravel.				
	2.3	ORGANIC CLAY (OH): black; moist.	1	22	7	1.25
	3.5	SANDY LEAN CLAY (CL): greenish gray; moist; medium stiff; trace organics; trace gravel.	2	22	5	
	5.0	Bottom of Boring at 5.0 feet				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

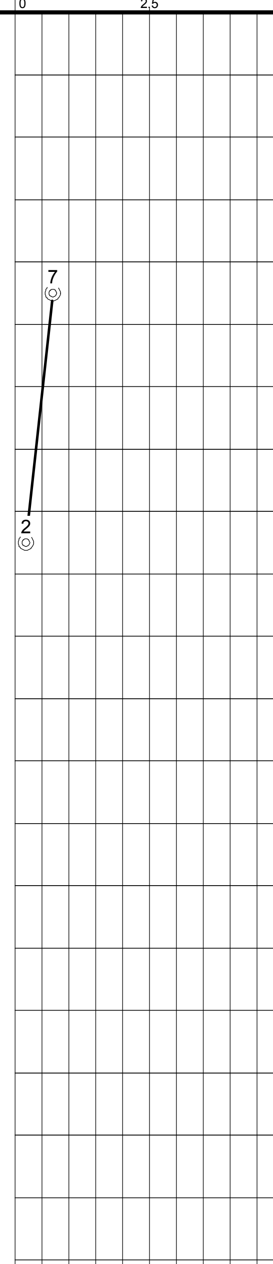
LOG OF BORING RD130

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.4	CRUSHED STONE: [fill]; with sand.				
	1.1	OGANIC SILT (OH): very dark brown; moist; very loose to medium dense; trace sand and gravel.				
	1.5–3.0		Split spoon	1	44	7
	3.5–5.0		Split spoon	2	11	2
	5.0	Bottom of Boring at 5.0 feet				

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC% RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5



Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD131

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (Surface Elev.: Unknown)		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf (0 2.5 5)
	0.0	ASPHALT: black.							
	0.6	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.3	ORGANIC CLAY (OH): very dark brown; moist; very loose to medium dense; trace sand.	1.3ft			1	50	11	11
						2	0	3	3
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Boring in intersection approximately 12 ft E and 12 ft W of each shoulder
Date Boring Completed:	12/5/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

M:\GINTPROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD132

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft
	0.0	ASPHALT: black.							
		CRUSHED STONE: [fill]; with sand.	0.3ft						
	0.5	ORGANIC CLAY (OH): very dark brown; moist; loose.	0.6ft						
	1.5–3.0					1	17	5	5
	3.5	LEAN TO FAT CLAY (CL-CH): blueish gray; moist; medium stiff; trace sand; trace gravel.	3.5ft			2	50	7	7
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/7/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

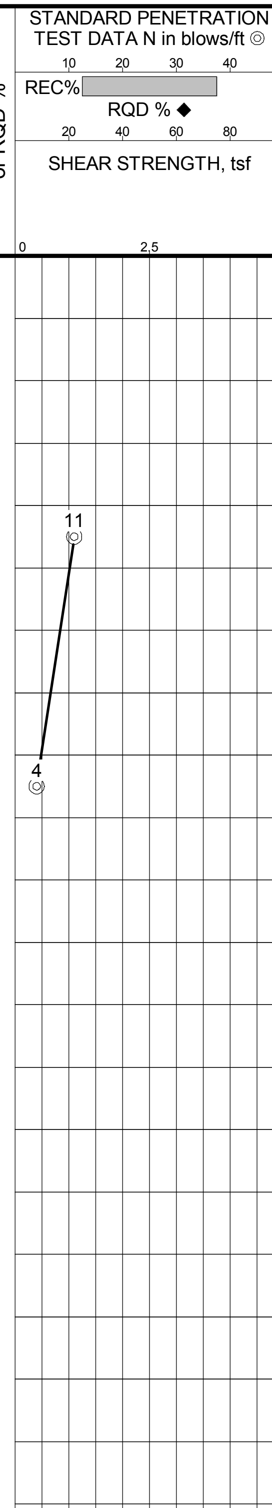
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD133

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.7	CRUSHED STONE: [fill]; with sand.	0.7ft			
	1.3	CLAYEY SAND (SC): fine to medium grained; brown; moist; medium dense; with gravel.	1.3ft	1	56	11
	2.8	ORGANIC CLAY (OH): very dark brown; moist; soft; trace sand.	2.8ft	2	44	4
	4.5	LEAN TO FAT CLAY (CL-CH): gray; moist; trace sand; trace gravel.	4.5ft			
	5.0	Bottom of Boring at 5.0 feet	5.0ft			



Date Boring Started:	12/7/17 4:25 pm
Date Boring Completed:	12/7/17 4:40 pm
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 4' N of shoulder

Weather: Overcast, 25 F

M:\GINT\PROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD134

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Bottom depth	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.8	CRUSHED STONE: [fill]; with sand.	0.8ft				
	1.4	CLAYEY SAND (SC): fine to medium grained; brown; moist; with gravel.	1.4ft				
	1.7	ORGANIC CLAY (OH): very dark brown; moist; medium stiff; trace sand.	1.7ft	Split spoon	1	22	8
	3.7	LEAN TO FAT CLAY (CL-CH): gray; moist; soft; trace sand; trace gravel.	3.7ft	Split spoon	2	58	4
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)

Date Boring Started:	12/7/17 4:45 pm
Date Boring Completed:	12/7/17 4:55 pm
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 4' N of shoulder

Weather: Overcast, 25 F

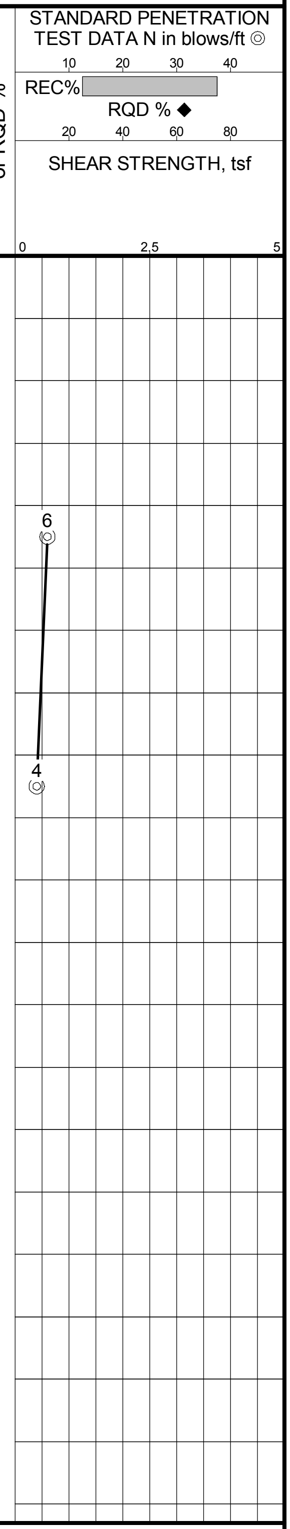
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD135

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Depth	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.8	CRUSHED STONE: [fill]; with sand.	0.8ft			
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff; trace sand; trace gravel.	1.5ft			
	2.2	ORGANIC CLAY (OH): very dark brown; moist; soft; trace sand.	2.2ft	1	11	6
	4.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; trace sand; trace gravel.	4.0ft	2	56	4
	5.0	Bottom of Boring at 5.0 feet	5.0ft			



Date Boring Started:	12/7/17 5:00 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/7/17 5:15 pm	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD136

Sheet 1 of 1

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft / REC% / RQD % / SHEAR STRENGTH, tsf (Qp/2)
	0.0	ASPHALT: black.						
	0.4	CRUSHED STONE: [fill]; with sand. (0.4ft)						
	1.0	LEAN TO FAT CLAY (CL-CH): brown; moist; very stiff; trace sand; trace gravel. (1.0ft)						
	1.5–2.5				1	67	17	N = 17; Qp/2 = 1.63
	2.5	ORGANIC CLAY (OH): very dark brown; moist; trace sand. (2.5ft)						
	3.5	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff; trace sand; trace gravel. (3.5ft)						
	3.5–5.0				2	50	12	N = 12; Qp/2 = 1.88
	5.0	Bottom of Boring at 5.0 feet (5.0ft)						

Date Boring Started:	12/7/17 10:20 am	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/7/17 10:40 am	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

M:\GINT\PROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

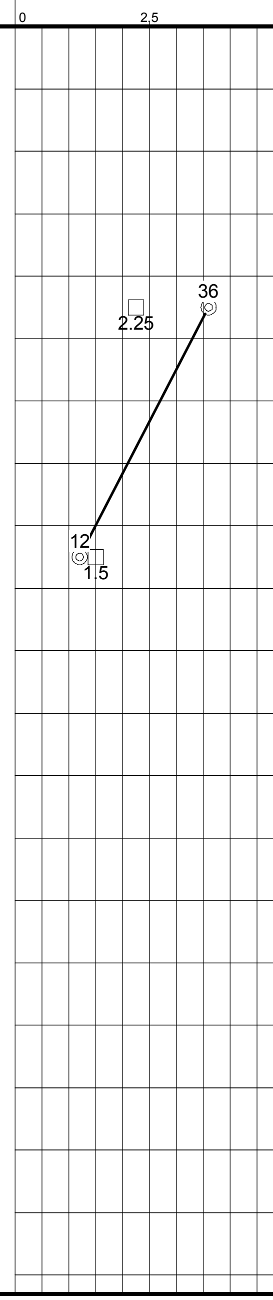
LOG OF BORING RD137

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill]; with sand. 0.4ft					
	1.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff to hard; trace sand; trace gravel. 1.3ft					
	2.5				1	72	36
	4.5				2	83	12
	5.0	Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
☐ Qp/2



Date Boring Started:	12/7/17 10:45 am	Water Levels (ft)	Remarks: Located 4' S of shoulder
Date Boring Completed:	12/7/17 11:05 am	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

BARR

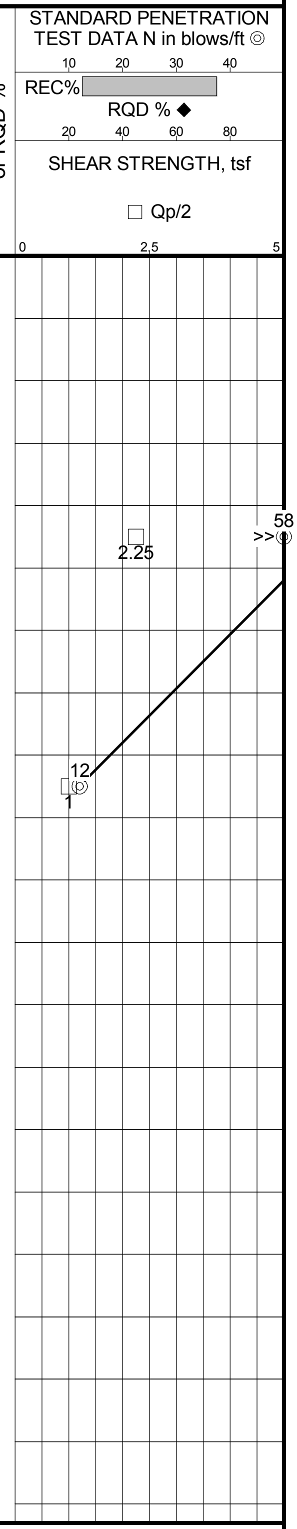
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD138

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill]; with sand. 0.5ft					
	1.3	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff to hard; trace sand; trace gravel. 1.3ft					
	2.3				1	61	58
	4.3				2	86	12
	5.0	Bottom of Boring at 5.0 feet 5.0ft					



Date Boring Started:	12/7/17 11:45 am	Water Levels (ft)	Remarks: Located 4' S of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD139

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (Surface Elev.: Unknown)		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft						
	1.3	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	1.3ft			1	28	6	6
	4.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; medium stiff; trace sand; trace gravel.	4.0ft			2	28	5	5
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

STANDARD PENETRATION TEST DATA N in blows/ft: 10, 20, 30, 40
REC%
RQD %: 20, 40, 60, 80
SHEAR STRENGTH, tsf: 0, 2.5, 5

Date Boring Started:	12/8/17 8:00 am
Date Boring Completed:	12/8/17 8:15 am
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 2.5' N of shoulder

Weather: Sunny, 16 F

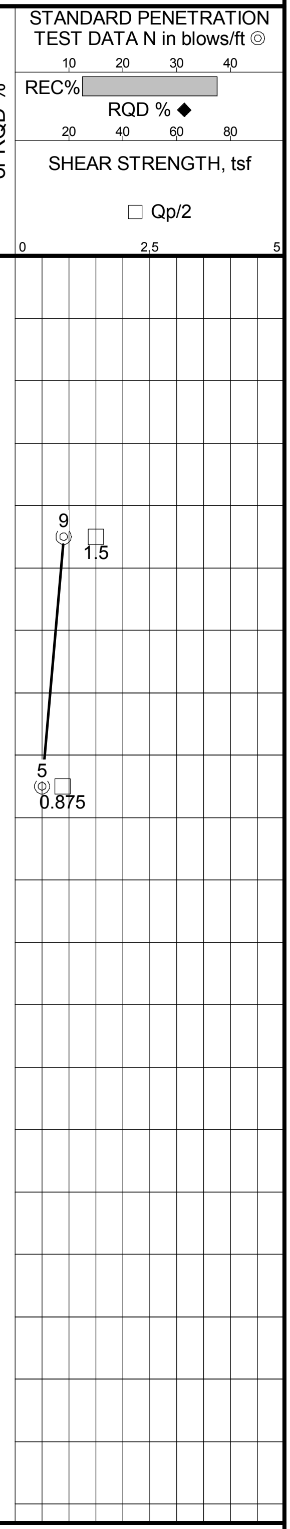
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD140

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Bottom depth	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft			
	1.3	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; trace sand; trace gravel.	1.3ft			
	1.8	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	1.8ft	1	33	9
	3.7	LEAN TO FAT CLAY (CL-CH): gray; moist; medium stiff; trace sand; trace gravel.	3.7ft	2	72	5
	5.0	Bottom of Boring at 5.0 feet	5.0ft			



Date Boring Started:	12/8/17 8:30 am	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/8/17 8:45 am	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 16 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD141

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft / SHEAR STRENGTH, tsf
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft				
	1.2	ORGANIC CLAY (OH): very dark brown; moist; stiff; trace sand; trace gravel.	1.2ft	1	17	12	12
	3.5	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff; trace sand; trace gravel.	3.5ft	2	75	12	12; 1.25
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

Chart scales: N 10, 20, 30, 40; REC%; RQD % ◆ 20, 40, 60, 80; SHEAR STRENGTH, tsf 0, 2.5, 5; ☐ Qp/2

Date Boring Started:	12/8/17 8:55 am
Date Boring Completed:	12/8/17 9:15 am
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 2' N of shoulder

Weather: Sunny, 16 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD142

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Layer bottom	Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (shear strength, tsf)
	0.0	ASPHALT: black.					
		CRUSHED STONE: [fill]; with sand.	0.7ft				
		LEAN TO FAT CLAY (CL-CH): gray to brown; moist; medium stiff to stiff; trace sand; trace gravel.	1.4ft	1	44	9	1.5
				2	44	5	0.75
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft (10, 20, 30, 40); REC%; RQD % (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5); Qp/2

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/6/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD143

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft; REC%; RQD %; SHEAR STRENGTH, tsf (Qp/2)
	0.0	ASPHALT: black.						
	0.6	CRUSHED STONE: [fill]; with sand. 0.6ft						
	1.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff; trace sand; trace gravel. 1.0ft						
					1	50	11	11; 1.63
					2	72	9	9; 1.88
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 2' N of shoulder
Date Boring Completed:	12/6/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

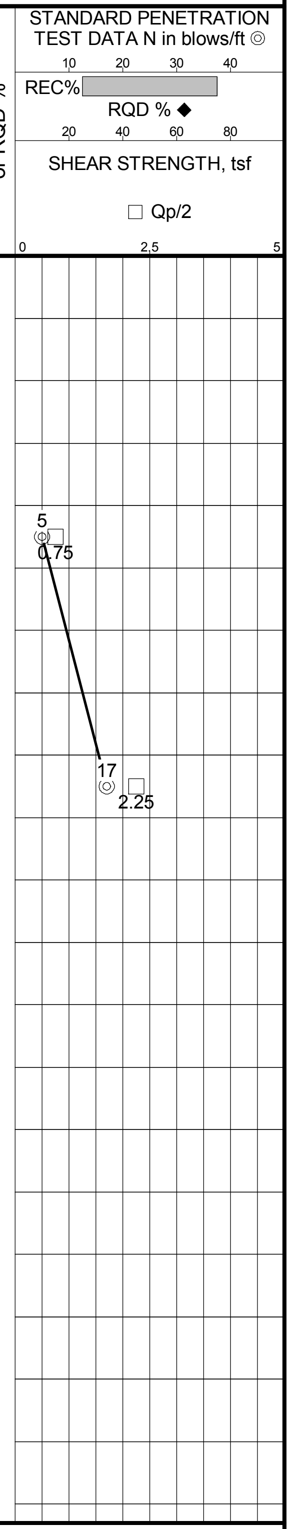
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD144

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf
	0.0	ASPHALT: black.				
	0.7	CRUSHED STONE: [fill]; with sand.				
	1.3	LEAN TO FAT CLAY (CL-CH): brown to dark brown; moist; medium stiff to very stiff; trace to with sand; trace gravel; trace orange mottling.				
	~2.3		1	28	5	0.75
	~4.3		2	72	17	2.25
	5.0	Bottom of Boring at 5.0 feet				



Date Boring Started:	12/7/17 9:30 am
Date Boring Completed:	12/7/17 9:45 am
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 4' S of shoulder

Weather: Overcast, 25 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD145

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft; REC%; RQD %; SHEAR STRENGTH, tsf (Qp/2)
	0.0	ASPHALT: black.						
	0.6	CRUSHED STONE: [fill]; with sand. 0.6ft						
	1.3	LEAN TO FAT CLAY (CL-CH): brown to dark brown; moist; medium stiff to stiff; trace to with sand; trace gravel; trace orange mottling. 1.3ft			1	50	11	11; 1.75
					2	44	7	7; 1.25
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:	12/7/17 9:10 am	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	12/7/17 9:25 am	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 25 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD146

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf
	0.0	ASPHALT: black.					
	0.6	CRUSHED STONE: [fill]; with sand.	0.6ft				
	1.3	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff to very stiff; trace to with sand; trace gravel.	1.3ft				
				1	72	16	2.25
				2	50	15	2.25
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

Date Boring Started:	12/7/17 8:50 am
Date Boring Completed:	12/7/17 9:05 am
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 2.5' N of shoulder

Weather: Sunny, 25 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD147

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (tsf)
	0.0	ASPHALT: black.				
	0.6ft	CRUSHED STONE: [fill]; with sand.				
	1.3ft	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff to very stiff; trace to with sand; trace gravel.				
			1	56	16	2.25
			2	83	8	1.75
	5.0ft	Bottom of Boring at 5.0 feet				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Date Boring Started:	12/7/17 8:30 am
Date Boring Completed:	12/7/17 8:45 am
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 3' S of shoulder

Weather: Sunny, 25 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

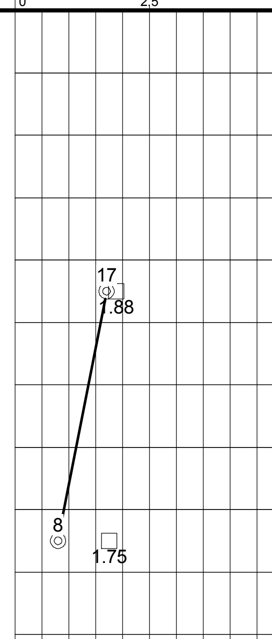
LOG OF BORING RD148

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.						
	0.6	CRUSHED STONE: [fill]; with sand.	0.6ft					
	1.3	LEAN TO FAT CLAY (CL-CH): brown to dark brown; moist; medium stiff to very stiff; trace to with sand; trace gravel.	1.3ft					
						1	64	17
						2	61	8
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
REC% RQD % ◆
SHEAR STRENGTH, tsf
☐ Qp/2



		Water Levels (ft)	
Date Boring Started:	12/7/17 7:50 am	At Time of Drilling: Dry	Remarks: Located 1.5' S of shoulder
Date Boring Completed:	12/7/17 8:10 am		
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 25 F

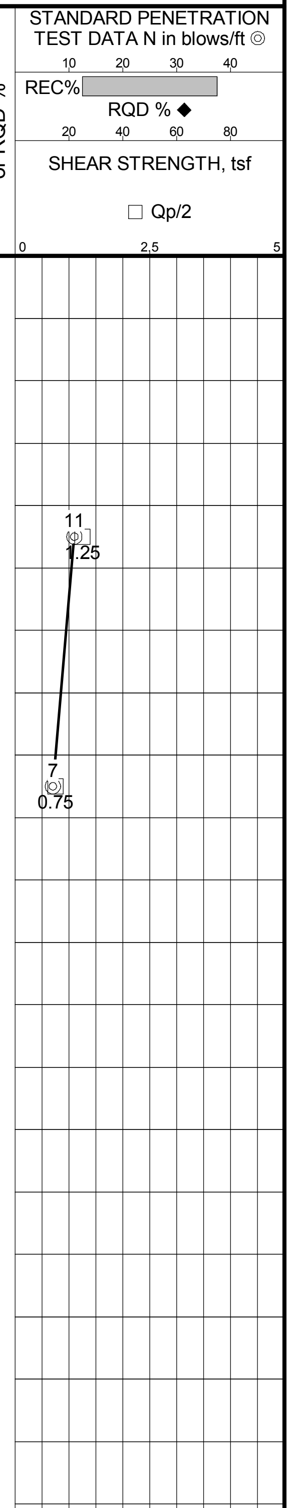
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD149

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.			
	0.8ft	CRUSHED STONE: [fill]; with sand.			
	1.7ft	LEAN TO FAT CLAY (CL-CH): brown to dark brown with gray; moist; medium stiff to stiff; trace to with sand; trace gravel; trace orange mottling.	1	22	11
			2	47	7
	5.0ft	Bottom of Boring at 5.0 feet			



Date Boring Started:	12/6/17 2:00 pm	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/6/17 2:15 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD150

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.						
	0.8	CRUSHED STONE: [fill]; with sand.	0.8ft					
	1.2	LEAN TO FAT CLAY (CL-CH): brown to dark brown with gray; moist; medium stiff to stiff; trace to with sand; trace gravel; trace orange mottling.	1.2ft					
						1	14	9
						2	83	9
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Plotted values: 9; 9; 1

Date Boring Started:	12/6/17 2:15 pm	Water Levels (ft)	Remarks: Located 2' S of shoulder
Date Boring Completed:	12/6/17 2:30 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD151

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft; REC%; RQD %; SHEAR STRENGTH, tsf; Qp/2
	0.0	ASPHALT: black.						
	0.8	CRUSHED STONE: [fill]; with sand. (0.8ft)						
	1.2	LEAN TO FAT CLAY (CL-CH): brown to dark brown with gray; moist; stiff; trace to with sand; trace gravel; trace orange mottling; trace organics. (1.2ft)						
	2.4				1	14	9	9; Qp/2 0.5
	4.2				2	83	9	9; Qp/2 0.875
	5.0	Bottom of Boring at 5.0 feet (5.0ft)						

Date Boring Started:	12/6/17 2:35 pm	Water Levels (ft)	Remarks: Located 2' S of shoulder
Date Boring Completed:	12/6/17 2:50 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD152

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Bottom depth	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.	0.7ft			
	0.7	CRUSHED STONE: [fill]; with sand.	1.4ft			
	1.4	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; medium stiff; trace sand.	2.3ft	1	22	7
	2.3	ORGANIC CLAY (OH): very dark brown; moist; trace sand; trace gravel.	3.5ft			
	3.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff; trace sand; trace gravel.	5.0ft	2	100	9
	5.0	Bottom of Boring at 5.0 feet	5.0ft			

Date Boring Started:	12/6/17 3:00 pm	Water Levels (ft)	Remarks: Located 2' S of shoulder
Date Boring Completed:	12/6/17 3:15 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD153

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft				
	1.5	ORGANIC CLAY (OH): very dark brown; moist; medium dense; trace sand; trace gravel.	1.5ft		1	22	7
	3.0	CLAYEY SAND (SC): fine to coarse grained; brown; moist; loose; trace gravel; orange mottling.	3.0ft		2	67	7
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)

Date Boring Started:	12/6/17 3:25 pm
Date Boring Completed:	12/6/17 3:45 pm
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling
Dry

Remarks: Located 5' S of shoulder

Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD154

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.6	CRUSHED STONE: [fill]; with sand.	0.6ft			
	1.3	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	1.3ft	1	11	7
	4.0	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; medium stiff; trace sand; trace gravel.	4.0ft	2	36	7
	5.0	Bottom of Boring at 5.0 feet	5.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)
☐ Qp/2

Plotted values: N = 7 at sample 1; N = 7 at sample 2; Qp/2 = 0.5 at sample 2.

Date Boring Started:	12/6/17 3:50 pm	Water Levels (ft)	Remarks: Located 4' S of shoulder
Date Boring Completed:	12/6/17 4:05 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

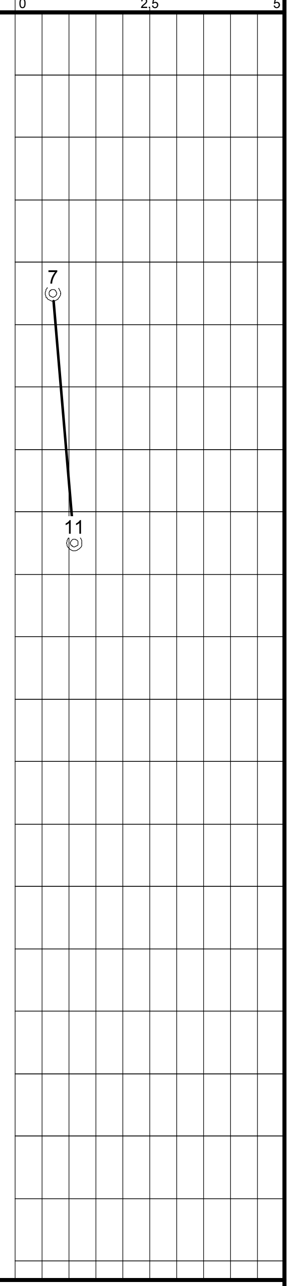
LOG OF BORING RD155

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.				
	0.6	CRUSHED STONE: [fill]; with sand.	0.6ft			
	1.3	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	1.3ft	1	11	7
	3.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff; trace sand; trace gravel.	3.5ft	2	94	11
	5.0	Bottom of Boring at 5.0 feet	5.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5)



Date Boring Started:	12/6/17 4:10 pm	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/6/17 4:25 pm	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD156

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (shear strength, tsf)
	0.0	ASPHALT: black.					
	0.6	CRUSHED STONE: [fill]; with sand.	0.6ft				
	1.3	SANDY LEAN CLAY (CL): brown to dark brown; moist; stiff; trace sand; trace gravel.	1.3ft	1	83	15	2.25
	4.2	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	4.2ft	2	56	8	0.625
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)
☐ Qp/2

Date Boring Started:	12/6/17 4:30 pm	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/6/17 4:45 pm	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD157

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (tsf)
	0.0	ASPHALT: black.					
	0.6	CRUSHED STONE: [fill]; with sand.	0.6ft				
	1.3	SANDY LEAN CLAY (CL): brown to dark brown; moist; stiff; trace sand; trace gravel.	1.3ft				
	2.0	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; trace sand; trace gravel.	2.0ft	1	56	11	2
	3.5	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	3.5ft	2	56	7	0.25
	4.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; trace sand; trace gravel.	4.5ft				
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf (0, 2.5, 5); □ Qp/2

Date Boring Started:	12/6/17 4:50 pm
Date Boring Completed:	12/6/17 5:10 pm
Logged By:	MAN2
Drilling Contractor:	TTL Associates
Drill Rig:	

Water Levels (ft)
At Time of Drilling: Dry

Remarks: Located 3' S of shoulder

Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD158

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.					
	0.8	CRUSHED STONE: [fill]; with sand.	0.8ft				
	1.5	LEAN TO FAT CLAY (CL-CH): brown to dark brown with gray; moist; medium stiff; trace to with sand; trace gravel; trace orange mottling.	1.5ft				
	2.3			X	1	22	8
	4.3			X	2	50	7
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Plotted values: N = 8 at 2.3 ft (Qp/2 = 0.75); N = 7 at 4.3 ft.

Date Boring Started:	12/6/17	Water Levels (ft)
Date Boring Completed:	12/6/17	At Time of Drilling: Dry
Logged By:	MAN2	
Drilling Contractor:	TTL Associates	
Drill Rig:		

Remarks: Located 1.5' NE of shoulder

Weather: Sunny, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD159

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Bottom depth	Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (tsf)
	0.0	ASPHALT: black.	0.5ft				
	0.5	CRUSHED STONE: [fill]; with sand.	1.0ft				
	1.0	POORLY GRADED SAND WITH SILT AND GRAVEL: [fill]; with sand.	1.5ft				
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; trace to with sand; trace gravel.	5.0ft				
	2.5			1	50	10	1.63
	4.5			2	78	15	1.13
	5.0	Bottom of Boring at 5.0 feet					

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' E of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD160

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:			
Datum:	NAD83	Completion Depth:	5.0 ft

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (tsf)
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft				
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff to stiff; trace to with sand; trace gravel.	1.5ft				
	2.2			1	50	9	0.5
	4.2			2	58	8	0.625
	5.0	Bottom of Boring at 5.0 feet	5.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 4' NE of shoulder
Date Boring Completed:	12/5/17	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Geotechnical Investigation – Supplemental area

1.1 Geotechnical Investigation

Barr Engineering Co. (Barr), under authorization and contract with Invenergy, LLC (Invenergy), has completed a geotechnical investigation of roads around the Hardin Wind Project in Hardin County, Ohio. As part of this geotechnical investigation, Barr completed 34 geotechnical borings along road alignments adjacent to proposed turbine locations in the project area.

This letter report and its attachments provide geotechnical findings from the investigation. Barr previously completed 51 road borings with California bearing ratio (CBR) testing along other travel alignments adjacent to proposed wind turbine locations. Barr previously completed a geotechnical investigation of the overall project area and prepared a comprehensive geotechnical report with recommendations for foundation design of turbines, original substation location, O&M building, overhead collector, and met towers.

1.1.1 Field Work

Under subcontract to Barr, TTL Associates, INC of Toledo, Ohio, completed 34 shallow borings along existing county road alignments using a truck mounted drill rig to depths of approximately seven feet in one mobilization beginning on June 17, 2020. Standard penetration tests were performed and split-spoon samples were collected at approximately 2-foot intervals to a depth of approximately 5 ft. Drilling was advanced using solid-stem augers (power augers). Approximate thicknesses of the existing base rock and asphalt were measured and recorded. Completed borings were backfilled with cuttings and topped with cold-patch asphalt.

The coordinates of the borings are included in the Table 1 and shown on Figure 1 attached.

Table 1 Testing Conditions and Coordinates

Geotechnical Boring ID	Latitude [deg.]	Longitude [deg.]	Boring	CBR
RD161	40.673992	-83.771295	X	X
RD162	40.670522	-83.770715	X	
RD163	40.66678	-83.770089	X	
RD164	40.662981	-83.769454	X	
RD165	40.659367	-83.76885	X	
RD166	40.655641	-83.768227	X	
RD167	40.65205	-83.767627	X	
RD168	40.64852	-83.767037	X	
RD169	40.644767	-83.76641	X	
RD170	40.641092	-83.765796	X	
RD171	40.637157	-83.765138	X	X
RD172	40.674405	-83.78555	X	
RD173	40.671052	-83.785622	X	
RD174	40.668677	-83.78583	X	
RD175	40.666983	-83.788336	X	

RD176	40.665231	-83.790926	X	
RD177	40.66252	-83.794932	X	
RD178	40.660364	-83.797786	X	X
RD179	40.663535	-83.79232	X	
RD180	40.660128	-83.791316	X	
RD181	40.656854	-83.79035	X	
RD182	40.653386	-83.789328	X	
RD183	40.629696	-83.788556	X	
RD184	40.626486	-83.788019	X	
RD185	40.623625	-83.787541	X	X
RD186	40.652448	-83.849229	X	
RD187	40.652444	-83.852396	X	
RD188	40.652439	-83.855633	X	X
RD189	40.637632	-83.843551	X	
RD190	40.637639	-83.847305	X	
RD191	40.637647	-83.851121	X	
RD192	40.630424	-83.842575	X	X
RD193	40.630453	-83.846773	X	
RD194	40.630483	-83.851122	X	

1.1.2 Bulk Soil Sampling

Bulk samples of representative material from the site were collected for the purpose of laboratory testing. A total of six bulk soil samples (5-gallon buckets) were collected across the project site in support of California Bearing Ratio (CBR) testing. Sampling locations were selected to provide a representative sampling of soils present across the project area.

1.2 Subsurface Conditions

The results of the geotechnical borings and laboratory tests were compiled to obtain an understanding of the lithology of the study areas.

The typical stratigraphy, as determined from the field data collected at the road boring locations, consists of a surficial layer of asphalt underlain with a base course of either poorly graded gravel with sand and silt or poorly graded sand with silt underlain by native lean to fat clay. Organic clay or highly organic soils were encountered in 7 of the road borings.

1.2.1 Asphalt

Asphalt was encountered in all of the road boring locations. Asphalt thicknesses at boring locations where asphalt was present ranged from 5 to 9 inches. The average asphalt thickness was approximately 7 inches.

1.2.2 Base Course

Crushed stone gravel with various amounts of silt and sand was encountered in all of the road boring locations below the asphalt. It was primarily classified as a poorly graded gravel with silt and sand. The thickness of the base course where present ranged from 5 to 14 inches with an average of approximately 8 inches.

1.2.3 Lean Clay to Fat Clay

Lean to fat clay was encountered in 61 of the 62 road boring locations in thicknesses ranging from approximately 1 feet to 4.1 feet. N-values from Standard Penetration Testing (SPT) conducted in the clays ranged from 1 to 58 blows per foot (bpf) with an average of 10 bpf. These results indicate that the clays typically have consistencies ranging from very soft to hard.

1.2.4 Organic Clay

Organic clay was encountered in five of the road boring locations in thicknesses ranging from approximately 0.2 feet to 1.2 feet. These small layers of organic soils encountered within the clays typically had slightly softer consistencies than the surrounding clays. Multiple additional boring locations had trace organics observed as shown on the boring logs.

1.3 Groundwater Conditions

No evidence of groundwater was observed during the course of the geotechnical field investigation, however the road borings did not extend greater than seven feet below existing grade. As a result, groundwater is not anticipated to be a significant factor in the current road construction.

1.4 Laboratory Testing

Laboratory testing was performed on selected samples as described below.

1.4.1 Moisture Content

A total of 25 moisture content tests were performed on soils at the project site. The moisture content for clayey soils ranged from 14 to 37.9 percent, with an exception of a clayey sand sample that tested at 6.4 percent. The average moisture was 25.2 percent, indicating that soils were generally in a moist condition, typically being dryer in the upper 1 to 3 feet. The results of the moisture content testing can be found in Table 2 below and attached.

1.4.2 Atterberg Limits

A total of nine Atterberg Limits tests were performed on cohesive soils at the project site. Seven tests were performed on lean clay with varying sand contents. Two tests were performed on fat clay. Atterberg Limits testing of these samples indicated a Liquid Limit ranging from 28 to 67 percent, a Plastic Limit ranging from 17 to 21, and Plasticity Indices ranging from 15 to 28 percent. According to the USCS plasticity chart, these are classified as lean clay (CL) and fat clay (CH). The results of the Atterberg Limits testing can be found in Table 2 below and attached.

1.4.3 Unconfined Compressive Strength

A total of 10 unconfined compressive strength tests were performed on cohesive soils at the project site. Test results ranged from 1.45 to 8.43 tons per square foot. The results of the unconfined compressive strength and other laboratory testing can be found in Table 2 below.

Table 2 Laboratory Testing Results

Geotechnical Boring ID	USCS	Depth [ft]	Moisture Content [%]	Dry Density [%]	Unconfined Compressive Strength [tsf]	Atterberg Limits		
						Liquid Limit [%]	Plastic Limit [%]	Plasticity Index
RD-162	CL	3-5	24.5			39	19	20
RD-163	CL	5-7	27.4					
RD-164	SC/GC	1-3	6.4					
	CL	5-7	27.5			28	17	11
RD-165	CL	3-5	18.9					
RD-166	CL	3-5	28.8			44	19	25
RD-167	CL	5-7	25.5	96.1	1.45			
RD-168	CL	1-3	15.8					
	CL	3-5	23.7	99.5	2.02			
RD-169	CL	3-5	16.8					
RD-170	CL	5-7	12.5	124.0	8.43			
RD-171	CH	3-5	23.5			51	19	32
RD-172	CL	5-7	25.7					
RD-173	CL	3-5	26.1					
RD-174	CL	5-7	26.7			36	17	19
RD-175	CL	5-7	19.5	109.3	1.98			
RD-176	CL	5-7	28.4					
RD-177	CL	5-7	31.5					
RD-178	CH	3-5	37.9			67	28	39
RD-179	CL	5-7	35.3					
RD-180	CL	5-7	34.9					
RD-181	CL	5-7	31.6			41	19	22
RD-182	CL	5-7	30.6					
RD-183	CL	3-5	25.8	98.1	1.71			
	CL	5-7	23.1	97.9	2.31			
RD-184	CL	5-7	14					
RD-185	CL	5-7	19.3					
RD-186	CL	3-5	25.9					
RD-187	CL	1-3	20.6	105.8	3.08			
RD-188	CL	3-5	21.3	100.6	3.25	29	15	14
RD-189	CL	5-7	27.3					
RD-190	CL	5-7	32.9					
RD-192	CL	5-7	23.6	101.8	2.72	43	22	21
RD-193	CL	1-3	19.5	108.4	4.18			
	CL	5-7	13.5					

1.4.4 Grain Size Testing

A total of two grain size analyses tests were performed on cohesive soils at the project site. The results of the grain size testing can be found in Table 2 below.

Table 3 Grain Size Testing Results

Geotechnical Boring ID	USCS	Gravel Content (%)	Sand Content (%)	Fines Content (%)
RD-167	CL	1.9	22.4	75.7
RD-175	CL	1.5	7.6	90.9

1.4.5 California Bearing Ratio and Standard Proctor Testing

Design for roads and general working areas is based in part on the strength of the subgrade that can be reasonably achieved. California Bearing Ratio (CBR) and Standard Proctor tests were completed on soil samples collected from the selected locations across the site to determine the field strength of the subgrade.

A total of six samples of the shallow subgrade soils were collected either adjacent to the road borings in the shoulders or directly beneath the gravel base in the road borings (Figure 1). The bulk samples were collected from soil immediately below topsoil or fill materials, which typically corresponded to a depth of approximately 1 foot below the surface. Two of the bulk soil samples were prepared to approximate 95 percent of the standard Proctor maximum dry density at the optimum moisture content. The results of the CBR testing are presented in Table 4 as well as being attached to this letter report.

In general, the CBR samples were classified as lean clay with various amount of sand and gravel. Results from the testing conducted on the subgrade samples indicate that CBR values at 0.1 inch of deflection under a surcharge of 50 psf ranged from 2.5 to 3.6 percent.

Table 4 CBR Testing Results

Geotechnical Boring ID	USCS	Optimum Moisture from Standard Proctor (%)	Maximum Dry Density from Standard Proctor (pcf)	California Bearing Ratio Value (Optimum Moisture Content)
RD-178	CH	23.4	98.0	3.6
RD-192	CL	15.6	114.0	2.5

Attachments:

Boring Logs

Laboratory Test Results

Turbine Location (3/28/2019)

- GE116 - 2.7
- GE127 - 2.8
- Proposed Road Boring

Feet: 2,500 0 2,500

Meters: 700 0 700

Figure 1

PROPOSED ROAD BORINGS - 6/11/2020

Hardin Wind Project

Invenergy LLC

Hardin County, Ohio

California Bearing Ratio ASTM:D1883

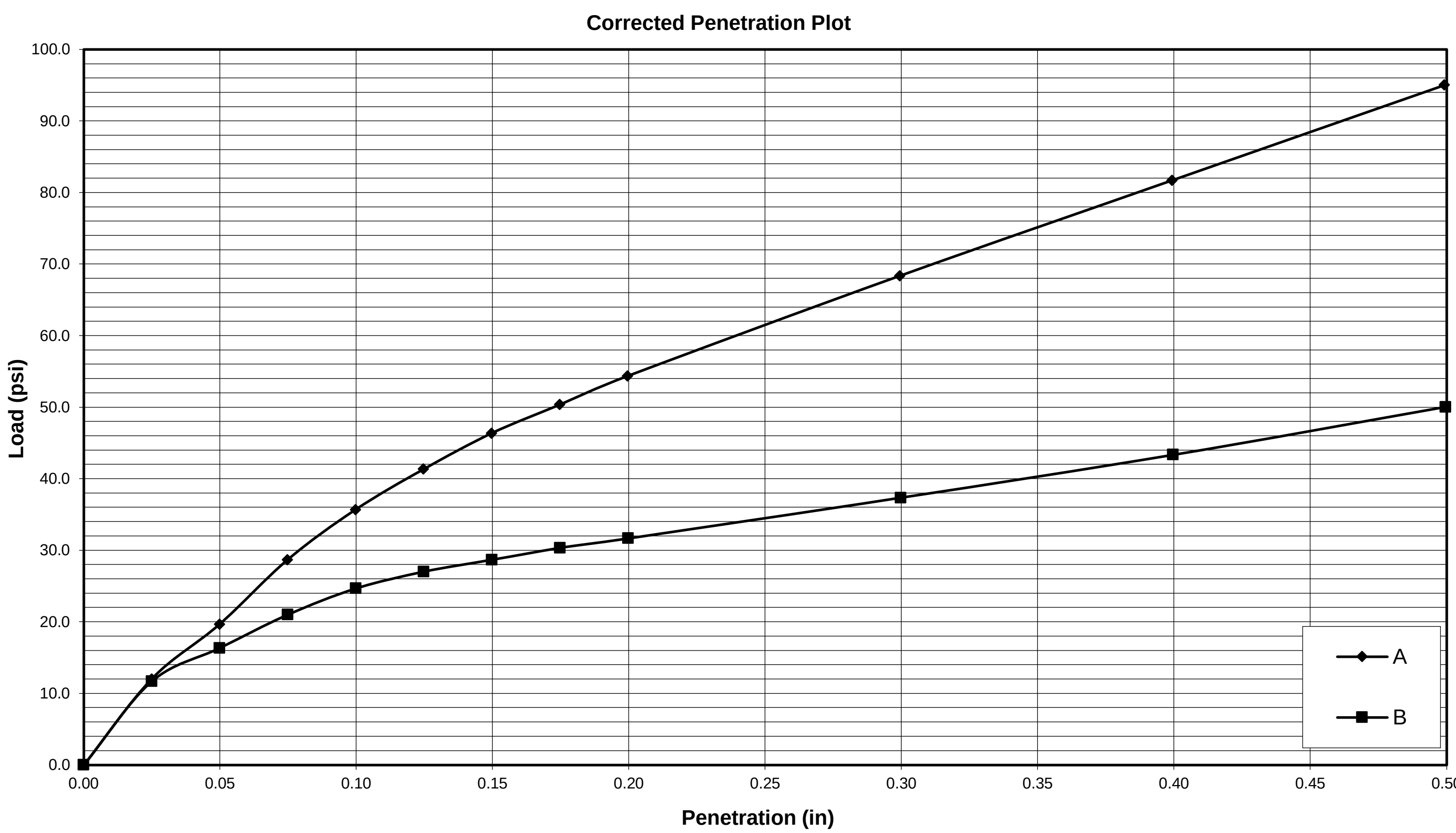
Project:	Hardin Wind	Job:	**12590**
Client:	Barr Engineering Company	Date:	7/13/20

Boring #:	RD178	RD192		Procedural Method:
Sample:				Specimens compacted to approximately 95% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft):				
Type:	Bulk	Bulk		
Classification:	Fat Clay with a trace of gravel (CH)	Sandy Lean Clay (CL)		

Laboratory Moisture-Density Values				Index Properties	
Method:	ASTM:D698 Method B			LL:	Gs:
Maximum Dry Density (PCF):	98.0	114.0		PL:	Organic Content:
Optimum Water Content:	23.4%	15.6%		PI:	pH:

Initial Molding Conditions			
Specimen	A	B	
Compaction Hammer:	5 lb	5 lb	
Number of Layers:	3	3	
Blows per Layer:	NA	NA	
Initial Moisture Content:	23.4%	15.6%	
Initial Dry Density (PCF)	93.3	108.4	
Relative Compaction	95.2%	95.1%	
Soaking Phase			
Days Soaked	4	4	
Surcharge (psf)	50	50	
Total Swell (%)	2.6%	3.6%	
Penetration Phase			
Surcharge (psf)	50	50	
Corrected CBR Values			
at 0.1 inch (%)	**3.6%**	**2.5%**	
at 0.2 inch (%)	3.6%	2.1%	
Moisture Content After Penetration			
Top 1" of Specimen:	26.1%	21.8%	
Average of specimen:	24.5%	18.7%	

Stress vs. Penetration Graph



Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD161

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS & Bulk
Coordinates:	Lat: 40.67387° Long: -83.77134°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Depth	Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (tsf)
	0.0	APPROXIMATELY 6.5 INCHES OF ASPHALT.					
	0.5	APPROXIMATELY 5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.5ft				
	1.0	FILL - SANDLY LEAN CLAY (CL): dark gray and black mottled; moist.	1.0ft				
	1.5	FILL - CLAYEY SAND (SC): gray, brown, and reddish brown; moist.	1.5ft				
	2.0			1	63	9	1.5
	3.0	FILL - LEAN CLAY (CL): black and gray; moist; trace sand and organics; friable.	3.0ft				
	4.0	LEAN CLAY (CL): gray; moist; medium stiff; trace sand and organics.	4.0ft	2	125	5	0.5
	5.5	LEAN CLAY WITH SILT (CL): gray and brown; moist; medium stiff; trace sand.	5.5ft				
	6.0			3	113	8	1.25
	7.0	Bottom of Boring at 7.0 feet	7.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)
☐ Qp/2

Date Boring Started:	6/17/20 5:20 pm
Date Boring Completed:	6/17/20 5:40 pm
Logged By:	LEB2
Drilling Contractor:	TTL
Drill Rig:	CME 75 Truck

Water Levels (ft)
After Drilling: Dry
At Time of Drilling: Dry

Remarks:

Weather: 82F, Sunny

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD162

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.67068° Long: -83.77081°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Depth, feet	Material Description	Bottom Depth	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf	Water Content (%)	PL	LL
0.0	APPROXIMATELY 7.5 INCHES OF ASPHALT.								
0.6	APPROXIMATELY 7.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.6ft							
1.2	FILL - LEAN CLAY (CL): dark gray and gray; moist; trace sand and gravel.	1.2ft							
2.0			1	25	10				
3.0	3': color change to black, trace organics.								
3.5	LEAN CLAY (CL): gray; moist; stiff; trace silt, sand, and gravel.	3.5ft							
4.0			2	58	5	0.5	24.1	19	39
5.0	5': 2-inch soft zone.								
6.0			3	100	9	0.5			
7.0	Bottom of Boring at 7.0 feet	7.0ft							

Chart legend: STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5); NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × ; PL — LL (20, 40, 60).

Date Boring Started:	6/18/20 10:10 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 10:25 am	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 74F, Partly Cloudy

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD163

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.66675° Long: -83.77020°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	Material Description	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength, tsf (Qp/2)	Water Content (%)
	0.0	APPROXIMATELY 6 INCHES OF ASPHALT.							
	0.5	APPROXIMATELY 12 INCHES OF 3/4" LIMESTONE GRAVEL BASE. 0.5ft							
	1.5	FILL - LEAN CLAY WITH GRAVEL (CL): dark gray and dark brown; moist; trace sand. 1.5ft							
	2.0				1	25	10		
	3.3	LEAN CLAY (CL): gray and brown; moist; soft to medium stiff; trace sand, silt, and organics. 3.3ft							
	4.0				2	58	4	1.25	
	6.0				3		7		27.4
	7.0	Bottom of Boring at 7.0 feet 7.0ft							

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% ; RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5)
NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120)
WATER CONTENT (%) × ; PL — LL (20, 40, 60)

Date Boring Started:	6/18/20 9:45 am
Date Boring Completed:	6/18/20 10:05 am
Logged By:	LEB2
Drilling Contractor:	TTL
Drill Rig:	CME 75 Truck

Water Levels (ft)
After Drilling: Dry
At Time of Drilling: Dry

Remarks:

Weather: 74F, Sunny

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD164

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.66335° Long: -83.76964°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Layer depth	Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (tsf)	Water Content (%)	PL	LL
	0.0	APPROXIMATELY 8.5 INCHES OF ASPHALT.								
	0.7	APPROXIMATELY 8.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.7ft							
	1.4	FILL - CLAYEY SAND WITH GRAVEL AND LEAN CLAY TRACE ORGANICS (CL): black; moist.	1.4ft							
	2.0			1	25	9		6.4		
	4.0	LEAN CLAY (CL): gray and brown; moist; soft; trace silt, organics, and sand.	4.0ft	2	58	5				
	5.0	5': moist to wet, no organics.								
	6.0			3	92	4	0.25		17	28
	7.0	Bottom of Boring at 7.0 feet	7.0ft							

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5); NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) ✕; PL —— LL (20, 40, 60)

Date Boring Started:	6/18/20 9:25 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 9:45 am	▽ After Drilling: Dry	
Logged By:	LEB2	▼ At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 72F, Sunny

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD165

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.65935° Long: -83.76897°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %	SPT N (blows/ft)	Qp/2 (tsf)	Water Content (%)
	0.0	APPROXIMATELY 9 INCHES OF ASPHALT.						
	0.8ft	APPROXIMATELY 8 INCHES OF 3/4" LIMESTONE GRAVEL BASE.						
	1.4ft	FILL - CLAYEY GRAVEL (GC): dark gray and dark brown; moist.						
	2.0		1	13	7	7		
	3.0ft	FILL - LEAN CLAY WITH GRAVEL (CL): dark gray; moist; trace sand.						
	4.0		2	25	4	4		18.9
	4.0ft	FILL - LEAN CLAY WITH SAND (CL): black; moist; trace organics and gravel.						
	5.5ft	LEAN CLAY WITH GRAVEL (CL): gray; moist to wet; medium stiff; trace gravel, sand, and silt.						
	6.0		3		6	6	0.5	
	6.5	6.5': small sand seam.						
	7.0ft	Bottom of Boring at 7.0 feet						

Date Boring Started:	6/18/20 9:05 am
Date Boring Completed:	6/18/20 9:25 am
Logged By:	LEB2
Drilling Contractor:	TTL
Drill Rig:	CME 75 Truck

Water Levels (ft)
After Drilling: Dry
At Time of Drilling: Dry

Remarks:

Weather: 71F, Sunny

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD166

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.65611° Long: -83.76843°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Water Content (%) / PL–LL
	0.0	APPROXIMATELY 9 INCHES OF ASPHALT.					
	0.8	APPROXIMATELY 12 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.8ft				
	1.8	FILL - LEAN CLAY (CL): dark gray and brown; moist; trace sand.	1.8ft	1	21	13	
	3.0	3': color change to gray and brown.					
	4.0			2	25	6	28.8 (PL 19, LL 44)
	5.3	LEAN CLAY (CL): dark gray; medium stiff; trace gravel.	5.3ft				
	6.0			3	54	6	
	7.0	Bottom of Boring at 7.0 feet	7.0ft				

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)
NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120)
WATER CONTENT (%) × ; PL, LL (20, 40, 60)

Date Boring Started:	6/18/20 8:45 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 9:00 am	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 70F, Sunny

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD167

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.65216° Long: -83.76778°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Samples / Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / SHEAR STRENGTH, tsf (▲ UC/2 □ Qp/2)	NATURAL DRY DENSITY (pcf) ☆ / WATER CONTENT (%) ×
	0.0	APPROXIMATELY 8 INCHES OF ASPHALT.					
	0.7ft	APPROXIMATELY 6 INCHES OF 3/4" LIMESTONE GRAVEL BASE.					
	1.2ft	FILL - LEAN CLAY (CL): dark gray; moist; trace sand.					
	1.5ft	FILL - LEAN CLAY WITH SAND (CL): gray, brown, and dark gray; moist; trace gravel.					
	2.0		1	46	10	10; 1.5	
	3.0ft	FILL - LEAN CLAY (CL): dark gray and brown; moist; trace sand.					
	4.0		2	42	6	6; 1.25	
	5.0ft	SANDY LEAN CLAY (CL): gray and brown; moist to wet; medium stiff; trace gravel.					
	6.0		3	88	5	5; 0.725; 0.75	25.5 ×; 96.1 ☆
	7.0ft	Bottom of Boring at 7.0 feet					

Date Boring Started:	6/18/20 8:20 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 8:40 am	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 68F, Sunny

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD168

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.64905° Long: -83.76727°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Depth, feet	Material Description	Sample No.	% Recovery	SPT, N value	Shear Strength, tsf	Water Content (%)	Natural Dry Density (pcf)
0.0–0.6	APPROXIMATELY 7.5 INCHES OF ASPHALT. (0.6ft)						
0.6–1.1	APPROXIMATELY 5.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE. (1.1ft)						
1.1–3.0	SANDY LEAN CLAY (CL): dark gray; moist; medium stiff to stiff; trace sand and organics; possible fill. (3.0ft)	1	63	7	Qp/2: 1	15.8	
3.0–7.0	SANDY LEAN CLAY (CL): brown and gray; moist; medium stiff; trace gravel.	2	83	9	UC/2: 1.01; Qp/2: 1.25	23.7	99.5
	5.5': small pocket of dark brown clayey sand with large gravel.	3	83	8	Qp/2: 0.75		
7.0	Bottom of Boring at 7.0 feet (7.0ft)						

Date Boring Started:	6/18/20 8:00 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 8:15 am	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 67F, Sunny

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD169

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.64485° Long: -83.76647°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf	Water Content (%)
	0.0	APPROXIMATELY 9 INCHES OF ASPHALT.						
	0.8	APPROXIMATELY 5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.8ft					
	1.2	LEAN CLAY (CL): dark gray; moist; medium stiff; trace sand; possible fill.	1.2ft					
	2.0			1	71	8	1.5	
	2.9	SANDY LEAN CLAY (CL): gray; moist; medium stiff to stiff; trace sand and gravel.	2.9ft					
	4.0			2	71	7	0.75	16.8
	6.0			3	92	10	2	
	7.0	Bottom of Boring at 7.0 feet	7.0ft					

Date Boring Started:	6/18/20 7:40 am
Date Boring Completed:	6/18/20 7:58 am
Logged By:	LEB2
Drilling Contractor:	TTL
Drill Rig:	CME 75 Truck

Water Levels (ft)
After Drilling: Dry
At Time of Drilling: Dry

Remarks:

Weather: 66F, Sunny

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

BARR

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD170

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.64110° Long: -83.76582°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Layer depth	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength, tsf	Natural Dry Density (pcf)	Water Content (%)
	0.0	APPROXIMATELY 8.5 INCHES OF ASPHALT.							
	0.7	APPROXIMATELY 5.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.7ft						
	1.2	FILL - LEAN CLAY (CL): dark brown, gray, and brown; moist; trace gravel, sand, and organics.	1.2ft						
	2.0			1	38	13			
	3.0	3': no organics, color change to brown and light gray.							
	4.0			2	42	28	2.25 (Qp/2)		
	5.0	5': dark gray and brown mottled, possible trace brick fragment.							
	5.5	LEAN CLAY (CL): brown; moist; very stiff; trace gravel and sand.	5.5ft						
	6.0			3	100	23	4.22 (UC/2)	124	12.6
	7.0	Bottom of Boring at 7.0 feet	7.0ft						

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf ▲ UC/2 □ Qp/2 (0, 2.5, 5); NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × PL LL (20, 40, 60)

Date Boring Started:	6/18/20 7:15 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 7:35 am	▽ After Drilling Dry	
Logged By:	LEB2	▼ At Time of Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 65F, Sunny

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD171

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS & Bulk
Coordinates:	Lat: 40.63718° Long: -83.76511°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf	Water Content (%) / PL–LL
	0.0	APPROXIMATELY 7 INCHES OF ASPHALT.						
	0.6	APPROXIMATELY 7.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.6ft					
	1.2	FAT CLAY (CH): dark gray; moist; medium stiff; trace sand, silt, and gravel.	1.2ft					
	2.0			1	42	8	1.25	
	3.5	3.5': color change to light gray and brown.						
	4.0			2	75	7	1	23.5 (PL 19, LL 51)
	5.4	5.4': small gravel layer encountered.						
	5.5	SANDY LEAN CLAY (CL): brown and gray; moist; medium stiff; trace gravel.	5.5ft					
	6.0			3	83	6	0.75	
	7.0	Bottom of Boring at 7.0 feet	7.0ft					

		Water Levels (ft)	Remarks:
Date Boring Started:	6/18/20 6:50 am	After Drilling: Dry	
Date Boring Completed:	6/18/20 7:10 am	At Time of Drilling: Dry	
Logged By:	LEB2		
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 64F, Sunny

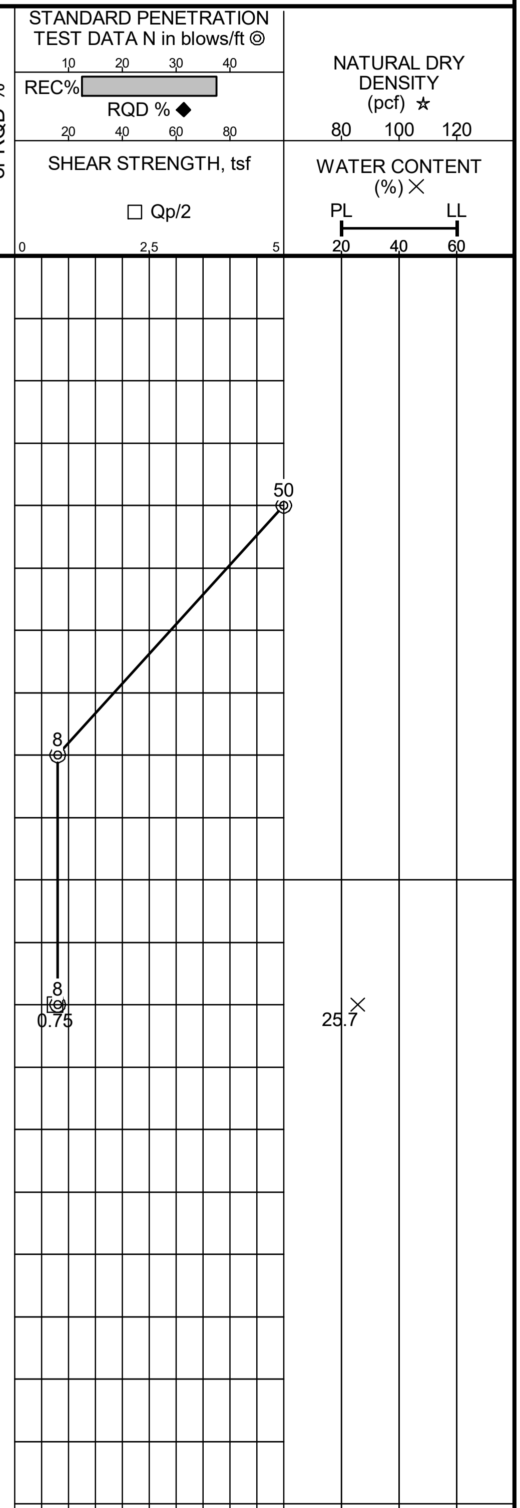
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD172

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.67410° Long: -83.78555°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
0.0	APPROXIMATELY 9 INCHES OF ASPHALT.				
0.75	APPROXIMATELY 12 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.8ft			
1.75	Drilling note: no recovery, hard sampling and drilling likely due to drilling through large cobble or boulder.	1.8ft	1	33	50
3.25	LEAN CLAY WITH ORGANICS (CL): black; moist; soft; trace sand.	3.3ft			
3.75	LEAN CLAY (CL): gray and brown; moist; medium stiff; trace sand and organics.	3.8ft	2	50	8
6.0			3	100	8
7.0	Bottom of Boring at 7.0 feet	7.0ft			



Date Boring Started:	6/18/20 10:40 am
Date Boring Completed:	6/18/20 11:45 am
Logged By:	LEB2
Drilling Contractor:	TTL
Drill Rig:	CME 75 Truck

Water Levels (ft)
After Drilling: Dry
At Time of Drilling: Dry

Remarks:

Weather: 75F, Partly Cloudy

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD173

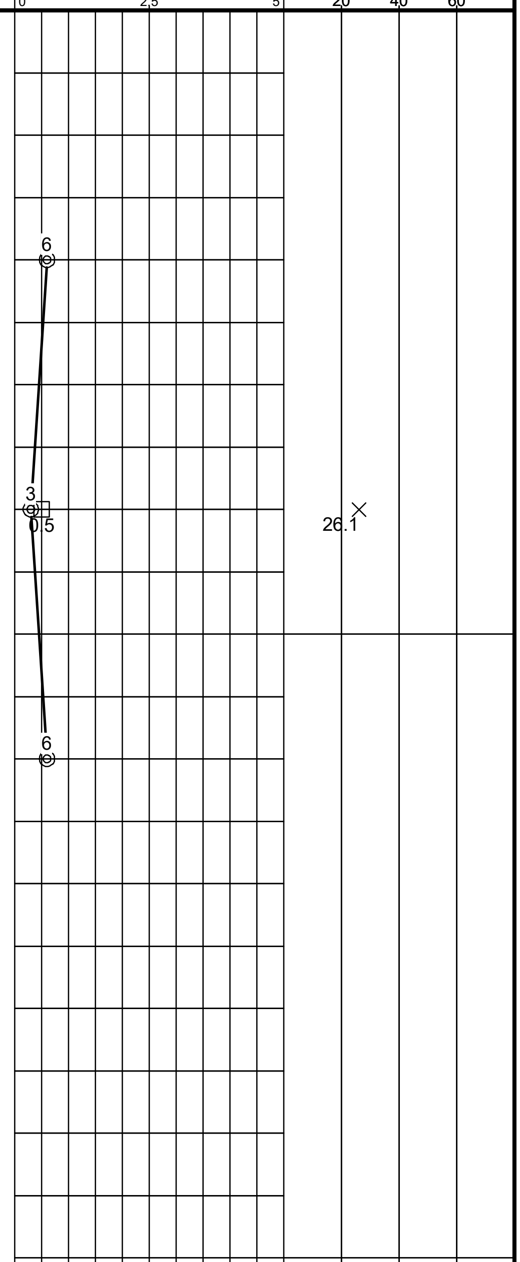
Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.67109° Long: -83.78558°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	APPROXIMATELY 7 INCHES OF ASPHALT.						
	0.6	APPROXIMATELY 13 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.6ft					
	1.7	FILL - LEAN CLAY (CL): brown; moist; trace gravel and sand.	1.7ft			1	25	6
	3.0	LEAN CLAY (CL): gray; moist; soft to medium stiff; trace sand and silt.	3.0ft			2	42	3
	5.5	5.5': color change to brown and gray.				3	100	6
	7.0	Bottom of Boring at 7.0 feet	7.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf □ Qp/2 (0, 2.5, 5)

NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × ; PL — LL (20, 40, 60)



Date Boring Started:	6/18/20 11:50 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 12:05 pm	After Drilling Dry	
Logged By:	LEB2	At Time of Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 78F, Partly Cloudy

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD174

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.66854° Long: -83.78592°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf	Water Content (%) / PL–LL
	0.0	APPROXIMATELY 8 INCHES OF ASPHALT.						
	0.7	APPROXIMATELY 11 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.7ft					
	1.6	FILL - LEAN CLAY (CL): dark gray and brown; moist; trace sand, gravel, and organics.	1.6ft					
	2.0			1	50	8	1.25	
	3.5	3.5': 3-inch black friable layer encountered.						
	4.0	LEAN CLAY (CL): gray and brown; moist; medium stiff to soft; trace sand and organics.	4.0ft	2	67	7	0.25	
	5.5	5.5': color change to gray, no silt or organics.						
	6.0			3	100	3	0.5	26.7 (PL 17, LL 36)
	7.0	Bottom of Boring at 7.0 feet	7.0ft					

Date Boring Started:	6/18/20 12:10 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 12:25 pm	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 78F, Sunny

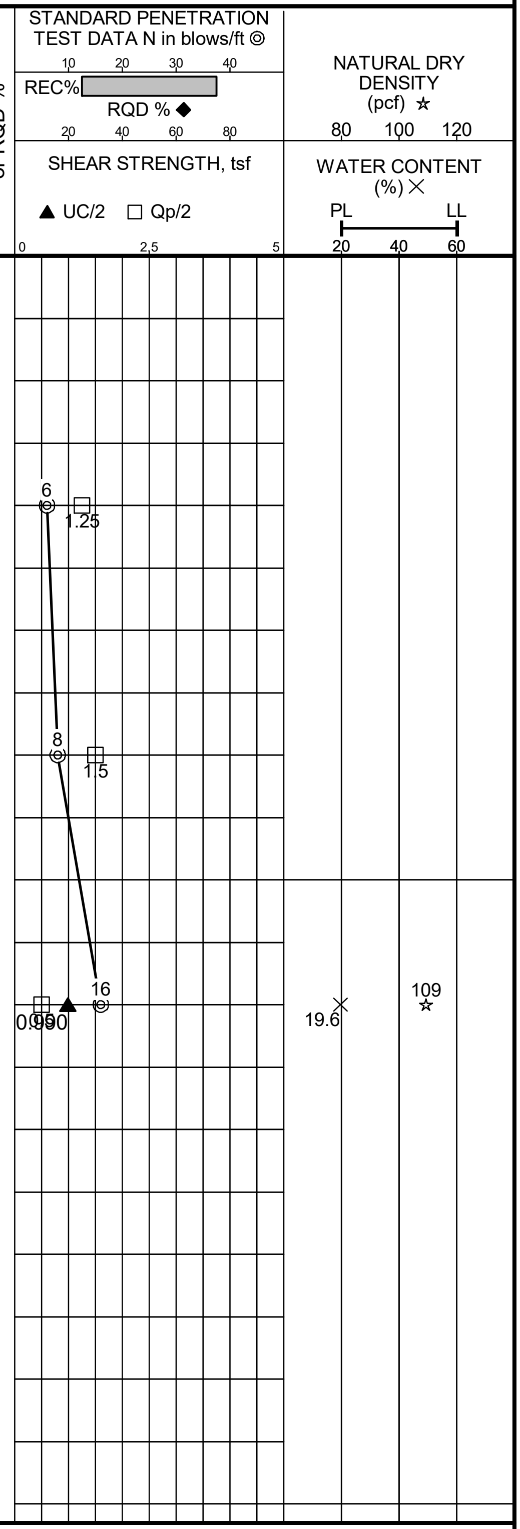
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD175

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.66700° Long: -83.78825°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	APPROXIMATELY 7 INCHES OF ASPHALT.				
	0.6	APPROXIMATELY 7 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.6ft			
	1.2	LEAN CLAY (CL): gray and brown; moist; medium stiff to very stiff; trace sand and gravel.	1.2ft			
	2.0			1	38	6
	4.0			2	88	8
	6.0			3	100	16
	7.0	Bottom of Boring at 7.0 feet	7.0ft			



Date Boring Started:	6/18/20 12:25 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 12:40 pm	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 78F, Partly Cloudy

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

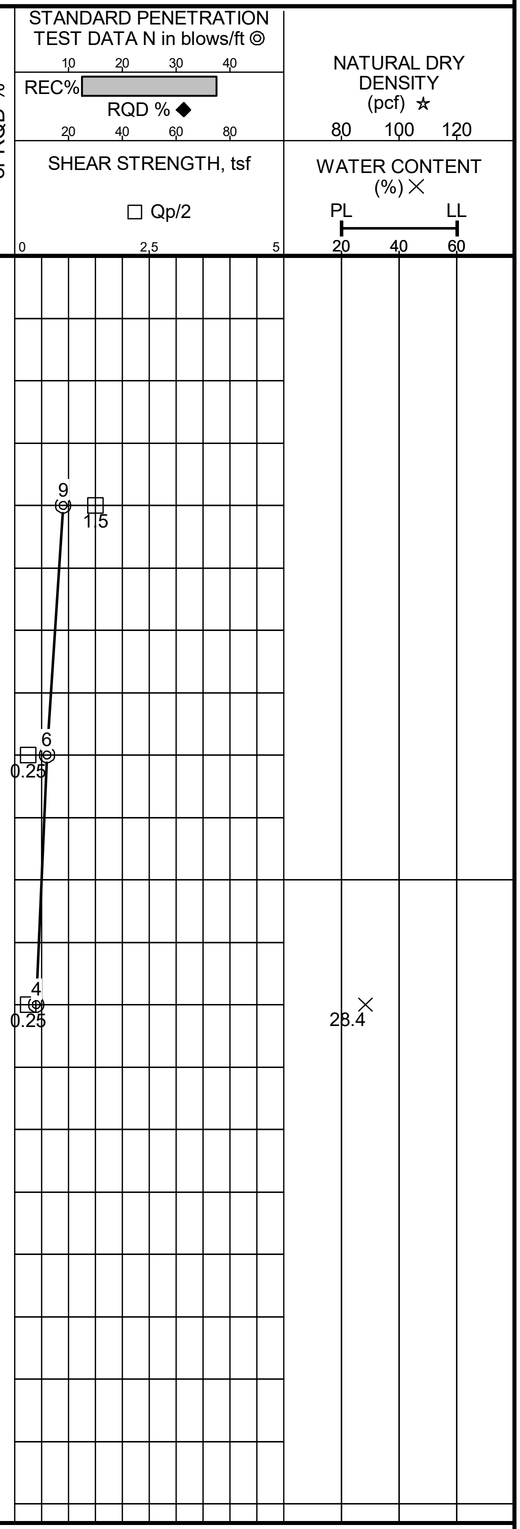
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD176

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.66525° Long: -83.79083°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	APPROXIMATELY 7 INCHES OF ASPHALT.				
	0.6	APPROXIMATELY 14 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.6ft			
	1.8	FILL - LEAN CLAY (CL): brown, gray, and dark gray mottled; moist; trace sand and gravel.	1.8ft			
	2.0			1	67	9
	4.0			2	42	6
	5.3	LEAN CLAY (CL): gray and brown; moist to wet; soft; trace organics, sand, and silt.	5.3ft			
	6.0			3	100	4
	7.0	Bottom of Boring at 7.0 feet	7.0ft			



Date Boring Started:	6/18/20 12:45 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 1:00 pm	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 78F, Partly Cloudy

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD177

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.66253° Long: -83.79488°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Layer Depth	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf	Water Content (%)
	0.0	APPROXIMATELY 8 INCHES OF ASPHALT.						
	0.7	APPROXIMATELY 13 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.7ft					
	1.8	FILL - LEAN CLAY (CL): dark gray, dark brown, and brown; moist; trace sand and gravel.	1.8ft	1	58	7	1.5	
	3.8	FILL - LEAN CLAY WITH ORGANICS (CL): black and dark gray; moist; trace sand.	3.8ft	2	33	4	0.25	
	5.0	LEAN CLAY (CL): gray; moist to wet; soft; trace sand, silt, and organics.	5.0ft	3	100	3		31.5
	7.0	Bottom of Boring at 7.0 feet	7.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% / RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5); NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × PL LL (20, 40, 60)

Date Boring Started:	6/18/20 1:05 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 1:25 pm	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 80F, Partly Cloudy

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD178

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS & Bulk
Coordinates:	Lat: 40.66045° Long: -83.79774°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Depth, feet	Material Description	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength, Qp/2 (tsf)	Water Content (%)
0.0	APPROXIMATELY 5 INCHES OF ASPHALT.					
0.4ft	APPROXIMATELY 10 INCHES OF 3/4" LIMESTONE GRAVEL BASE.					
1.3ft	FILL - LEAN TO FAT CLAY (CL-CH): gray, dark gray, and brown; moist; trace gravel and sand.					
2.0	2': trace silt.	1	54	11	0.75	
3.0	3': color change to gray and dark gray mottled.					
4.0	4': color change to gray, trace organics, soft.	2	75	6	0.25	37.9 (PL 28, LL 67)
4.8ft	ORGANIC LEAN CLAY (OL): black; soft.					
6.0ft	LEAN CLAY (CL): gray; moist to wet; soft; trace sand and silt.	3	83	4	0.25	
7.0ft	Bottom of Boring at 7.0 feet					

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% / RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf: □ Qp/2 (0, 2.5, 5)
NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120)
WATER CONTENT (%) × ; PL — LL (20, 40, 60)

Date Boring Started:	6/18/20 1:30 pm
Date Boring Completed:	6/18/20 1:50 pm
Logged By:	LEB2
Drilling Contractor:	TTL
Drill Rig:	CME 75 Truck

Water Levels (ft)
▽ After Drilling: Dry
▼ At Time of Drilling: Dry

Remarks:

Weather: 78F, Partly Cloudy

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD179

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.66332° Long: -83.79230°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf	Water Content (%)
	0.0	APPROXIMATELY 6.5 INCHES OF ASPHALT.					
	0.5	APPROXIMATELY 11.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE. (0.5ft)					
	1.5	FILL - LEAN CLAY (CL): gray, brown, and dark gray; moist; trace sand and gravel. (1.5ft)					
	2.0		1	42	5	0.75	
	3.5	LEAN CLAY (CL): gray and brown; moist to wet; soft; trace sand, silt, and organics. (3.5ft)					
	4.0		2	67	4	0.25	
	6.0		3	100	3	0.25	35.3
	7.0	Bottom of Boring at 7.0 feet (7.0ft)					

Date Boring Started:	6/18/20 2:10 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 2:25 pm	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 82F, Partly Cloudy

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD180

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.66050° Long: -83.79150°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (tsf)	Water Content (%)
	0.0	APPROXIMATELY 8.5 INCHES OF ASPHALT.					
	0.7ft	APPROXIMATELY 11.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.					
	1.7ft	FILL - LEAN CLAY (CL): dark brown; moist; trace sand and gravel.					
	2.0		1	25	7		
	3.3ft	LEAN CLAY (CL): grayish brown; moist; medium stiff to soft; trace sand, silt, and organics.					
	4.0		2	58	6	0.25	
	5.0	5': moist to wet.					
	6.0		3	100	4		34.9
	6.75	6.75': color change to brown and dark gray.					
	7.0ft	Bottom of Boring at 7.0 feet					

Date Boring Started:	6/18/20 2:25 pm
Date Boring Completed:	6/18/20 2:40 pm
Logged By:	LEB2
Drilling Contractor:	TTL
Drill Rig:	CME 75 Truck

Water Levels (ft)
After Drilling: Dry
At Time of Drilling: Dry

Remarks:

Weather: 82F, Partly Cloudy

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD181

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.65690° Long: -83.79041°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / REC% / RQD % ◆ / SHEAR STRENGTH, tsf □ Qp/2	NATURAL DRY DENSITY (pcf) ☆ / WATER CONTENT (%) ✕ PL LL
	0.0	APPROXIMATELY 6.5 INCHES OF ASPHALT.							
	0.5	APPROXIMATELY 11.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE. 0.5ft							
	1.5	FILL - CLAYEY GRAVEL (GC): dark brown; moist. 1.5ft							
	2.0				1	25	7	7	
	3.0	LEAN CLAY WITH ORGANICS (CL): black; moist; soft; trace sand. 3.0ft							
	3.5	LEAN CLAY (CL): gray and brown; moist to wet; soft; intermittent sand seams. 3.5ft							
	4.0				2	50	4	4; Qp/2 0	
	5.0	5': no sand seams, trace silt, grayish brown.							
	6.0	6': color change to gray and dark gray.			3	100	2	2; Qp/2 0.25	PL 19, LL 41, WC 31.6
	7.0	Bottom of Boring at 7.0 feet 7.0ft							

Date Boring Started:	6/18/20 2:45 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 3:05 pm	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 83F, Partly Cloudy

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD182

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.65345° Long: -83.78937°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Samples	Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength, tsf (Qp/2)	Water Content (%)
	0.0	APPROXIMATELY 7 INCHES OF ASPHALT.							
	0.6	APPROXIMATELY 8 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.6ft						
	1.3	FILL - LEAN CLAY (CL): brown; moist; trace sand.	1.3ft						
	2.0			SS	1	8	5		
	3.3	ORGANIC LEAN CLAY (OL): black; moist; soft; trace sand.	3.3ft						
	3.5	LEAN CLAY (CL): gray and brown; moist; soft; trace sand, silt, and organics.	3.5ft						
	4.0			SS	2	75	4	0.25	
	6.0			SS	3	67	3	0.25	30.6
	7.0	Bottom of Boring at 7.0 feet	7.0ft						

Date Boring Started:	6/18/20 3:10 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	6/18/20 3:25 pm	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 83F, Cloudy/Rainy

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD183

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.62976° Long: -83.78858°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft / SHEAR STRENGTH, tsf (▲ UC/2, □ Qp/2)	NATURAL DRY DENSITY (pcf) ☆ / WATER CONTENT (%) ×
	0.0	APPROXIMATELY 7 INCHES OF ASPHALT.							
	0.6ft	APPROXIMATELY 6.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.							
	1.1ft	LEAN CLAY (CL): dark gray and brown; moist; medium stiff; trace sand and gravel.							
	2.0				1	42	8	8; Qp/2 1.5	
	4.0	4': color change to gray and brown.			2	58	6	6; UC/2 0.855; Qp/2 1.25	98.1; 25.8
	6.0				3	83	7	7; 1.16	97.9; 23.1
	7.0ft	Bottom of Boring at 7.0 feet							

Date Boring Started:	6/19/20 6:55 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/19/20 7:10 am	After Drilling Dry	
Logged By:	LEB2	At Time of Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 62F, Sunny

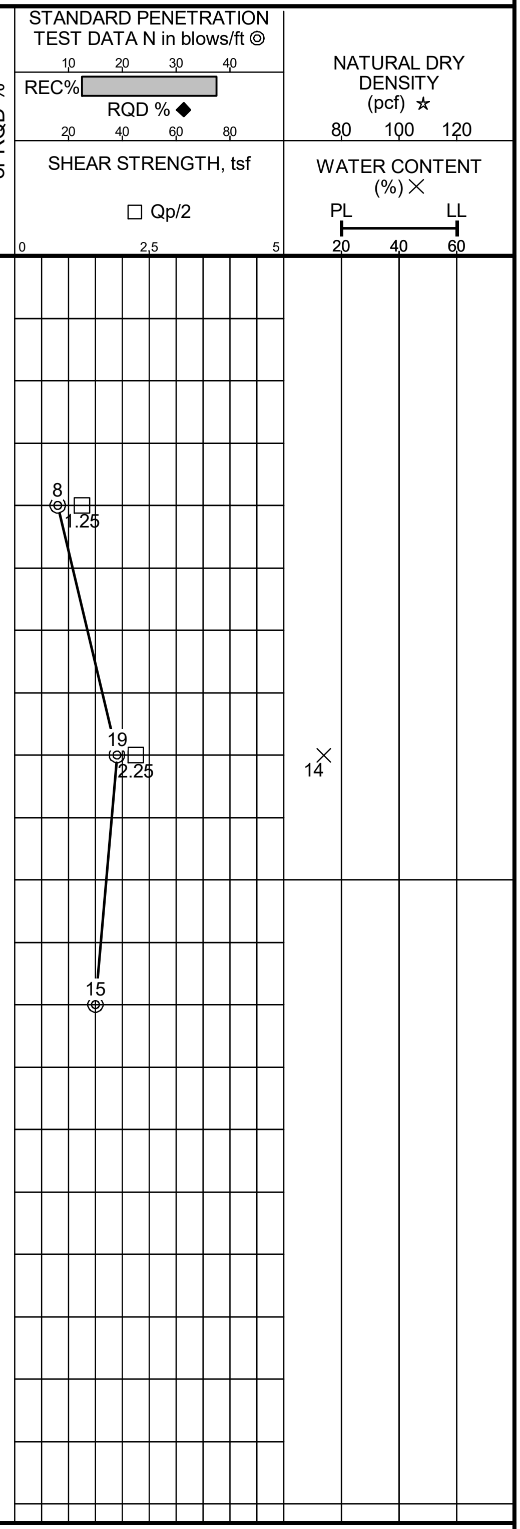
BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD184

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.62654° Long: -83.78799°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	APPROXIMATELY 5 INCHES OF ASPHALT.				
	0.5	APPROXIMATELY 6 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.4ft			
	1.0	SANDY LEAN CLAY (CL): dark gray; moist; medium stiff to very stiff; trace gravel.	0.9ft			
	2.0	2': color change to gray and brown.		1	54	8
	4.0			2	79	19
	6.0			3		15
	7.0	Bottom of Boring at 7.0 feet	7.0ft			



Date Boring Started:	6/19/20 7:15 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/19/20 7:30 am	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 62F, Sunny

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD185

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS & Bulk
Coordinates:	Lat: 40.62362° Long: -83.78750°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Shear Strength Qp/2, tsf	Water Content (%)
	0.0	APPROXIMATELY 5 INCHES OF ASPHALT.						
	0.5	APPROXIMATELY 6 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.4ft					
	1.0	SANDY LEAN CLAY (CL): dark gray; moist; medium stiff; trace gravel.	0.9ft					
	2.0	2': color change to dark gray and brown.		1	42	7	1	
	3.25	3.25': color change to gray and brown.						
	4.0	4': moist to wet.		2	71	5	0.75	
	5.0	5': color change to brown.						
	5.5	5.5': color change to brown and gray.						
	6.0			3	75	6	1.5	19.3
	7.0	Bottom of Boring at 7.0 feet	7.0ft					

Standard Penetration Test Data N in blows/ft; REC%; RQD %; Natural Dry Density (pcf); Water Content (%); PL; LL

Date Boring Started:	6/19/20 7:35 am
Date Boring Completed:	6/19/20 7:50 am
Logged By:	LEB2
Drilling Contractor:	TTL
Drill Rig:	CME 75 Truck

Water Levels (ft)
After Drilling: Dry
At Time of Drilling: Dry

Remarks:

Weather: 64F, Sunny

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

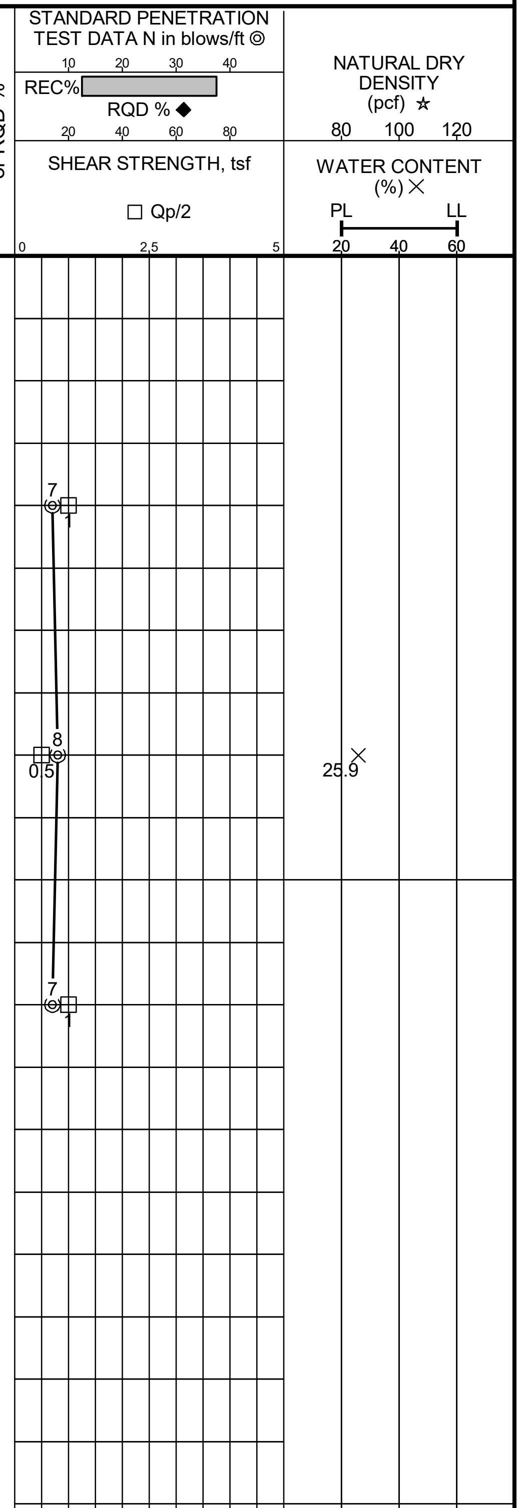
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD186

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.65242° Long: -83.84930°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	APPROXIMATELY 6 INCHES OF ASPHALT.				
	0.5	APPROXIMATELY 9 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.5ft			
	1.3	LEAN CLAY WITH SAND (CL): grayish brown; moist; medium stiff; trace gravel.	1.3ft			
	2.0			1	33	7
	3.0	3': color change to gray and brown.				
	4.0			2	54	8
	6.0			3	75	7
	7.0	Bottom of Boring at 7.0 feet	7.0ft			



Date Boring Started:	6/19/20 10:10 am	
Date Boring Completed:	6/19/20 10:25 am	
Logged By:	LEB2	
Drilling Contractor:	TTL	
Drill Rig:	CME 75 Truck	

Water Levels (ft)
After Drilling: Dry
At Time of Drilling: Dry

Remarks:

Weather: 75F, Sunny

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

BARR

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD187

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.65242° Long: -83.84930°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / SHEAR STRENGTH, tsf (▲ UC/2 □ Qp/2)	NATURAL DRY DENSITY (pcf) ☆ / WATER CONTENT (%) ×
	0.0	APPROXIMATELY 5.5 INCHES OF ASPHALT.								
	0.5	APPROXIMATELY 6.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.5ft							
	1.0	LEAN CLAY (CL): gray and brown; moist; stiff to very stiff; trace sand and gravel.	1.0ft							
	2.0					1	54	10	10; 1.54; 2	20.6; 106
	4.0	4'-5': light gray sand seams, dry to moist.				2	100	24	24; 2.25	
	6.0					3	100	21	21; 2.25	
	7.0	Bottom of Boring at 7.0 feet	7.0ft							

Chart scales: N 10, 20, 30, 40; REC% / RQD % ◆ 20, 40, 60, 80; shear strength 0, 2.5, 5; natural dry density 80, 100, 120; water content PL — LL 20, 40, 60.

		Water Levels (ft)	Remarks:
Date Boring Started:	6/19/20 10:25 am	▽ After Drilling: Dry	
Date Boring Completed:	6/19/20 10:40 am	▼ At Time of Drilling: Dry	
Logged By:	LEB2		
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 76F, Sunny

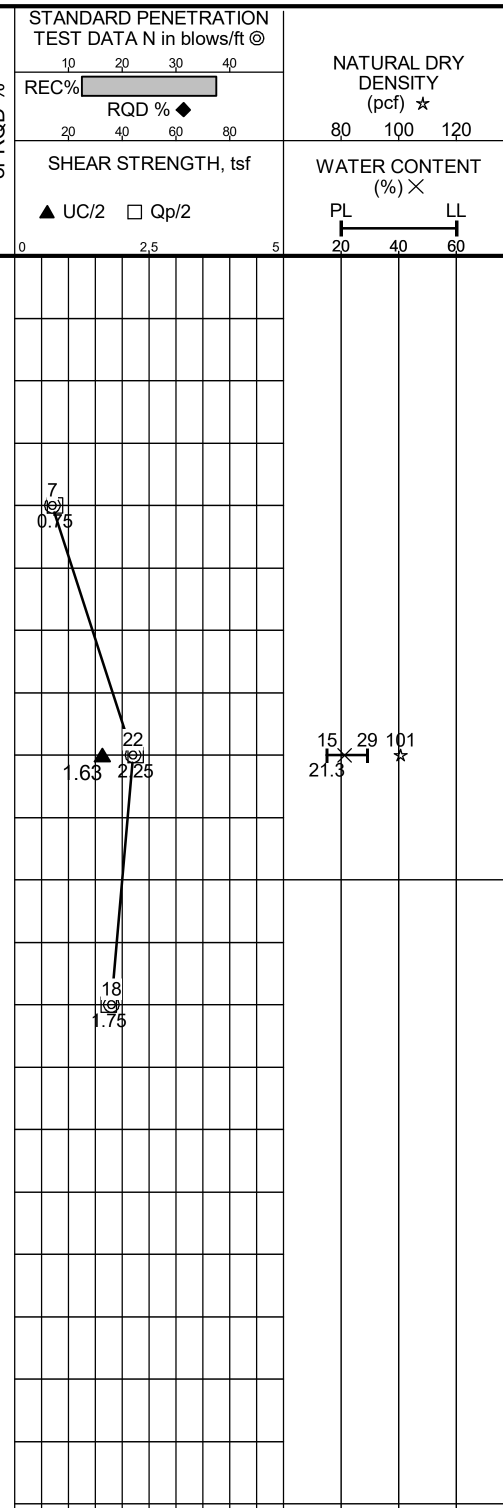
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD188

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS & Bulk
Coordinates:	Lat: 40.65245° Long: -83.85588°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	APPROXIMATELY 5 INCHES OF ASPHALT.				
	0.5	APPROXIMATELY 6 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.4ft			
	1.0	LEAN CLAY (CL): dark gray; moist; medium stiff to very stiff; trace sand and gravel.	0.9ft			
	1.5	1.5': color change to gray and brown.				
	2.0			1	63	7
	4.0	4'-5': intermittent sand seams.		2	96	22
	6.0			3	33	18
	7.0	Bottom of Boring at 7.0 feet	7.0ft			



Date Boring Started:	6/19/20 10:45 am	
Date Boring Completed:	6/19/20 11:05 am	
Logged By:	LEB2	
Drilling Contractor:	TTL	
Drill Rig:	CME 75 Truck	

Water Levels (ft)
After Drilling: Dry
At Time of Drilling: Dry

Remarks:

Weather: 77F, Sunny

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARR\LIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD189

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.63764° Long: -83.84349°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %	Qp/2 (tsf)	Water Content (%)
	0.0	APPROXIMATELY 5 INCHES OF ASPHALT.						
	0.4	APPROXIMATELY 5 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.4ft					
	0.8	LEAN CLAY (CL): dark gray; moist; stiff; trace sand, gravel, and organics; possible fill.	0.8ft					
	2.0			1	67	8	1.25	
	3.3	LEAN CLAY (CL): dark gray; moist; medium stiff; trace sand and gravel.	3.3ft					
	4.0	4': color change to brown and gray.		2	75	9	1.25	
	6.0			3	92	7		27.3
	6.5	6.5': moist to wet.						
	7.0	Bottom of Boring at 7.0 feet	7.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC%; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf; □ Qp/2 (0, 2.5, 5)

NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) ✕; PL, LL (20, 40, 60)

Date Boring Started:	6/19/20 9:10 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/19/20 9:30 am	▽ After Drilling: Dry	
Logged By:	LEB2	▼ At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 71F, Sunny

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

BARR

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD190

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.63766° Long: -83.84723°	Completion Depth:	7.0 ft
Datum:	NAD83		

Column headings: Elevation, feet | Depth, feet | MATERIAL DESCRIPTION | Graphic Log | Samples | Sample No. | % Recovery | SPT, N value or RQD % | STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40); REC% ; RQD % ◆ (20, 40, 60, 80); SHEAR STRENGTH, tsf ☐ Qp/2 (0, 2.5, 5) | NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120); WATER CONTENT (%) × ; PL – LL (20, 40, 60)

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	Material Description	Sample No.	% Recovery	SPT, N value or RQD %	SPT / Shear Strength	Water Content (%)
	0.0	APPROXIMATELY 5.5 INCHES OF ASPHALT.					
	0.5	APPROXIMATELY 5 INCHES OF 3/4" LIMESTONE GRAVEL BASE. (0.5ft)					
	0.9	LEAN CLAY (CL): dark gray; moist; stiff to medium stiff; trace sand and gravel. (0.9ft)					
	2.0		1	46	14	N = 14; Qp/2 = 1.5	
	4.0	4': color change to gray and brown.	2	67	10	N = 10; Qp/2 = 1.25	
	6.0	6': wet for 3 inches.	3	67	6	N = 6	32.9
	7.0	Bottom of Boring at 7.0 feet (7.0ft)					

Date Boring Started:	6/19/20 9:35 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/19/20 9:50 am	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 73F, Sunny

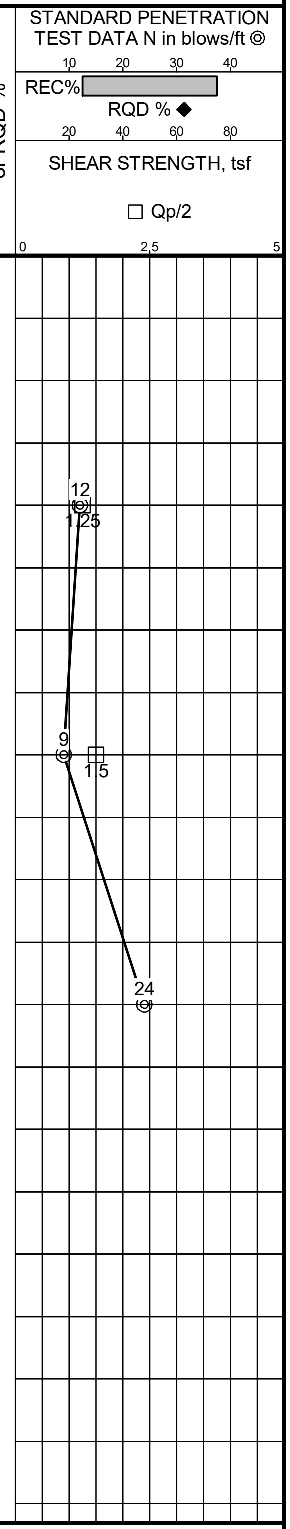
BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD191

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.63766° Long: -83.85120°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
	0.0	APPROXIMATELY 5 INCHES OF ASPHALT.	0.4ft			
	0.5	APPROXIMATELY 6 INCHES OF 3/4" LIMESTONE GRAVEL BASE.	0.9ft			
	1.0	LEAN CLAY (CL): brown; moist; stiff to very stiff; trace sand and gravel.				
	2.0			1	50	12
	4.0	4': small sand seam encountered.		2	33	9
	5.0	5': sampler pushing rock.				
	6.0			3		24
	7.0	Bottom of Boring at 7.0 feet	7.0ft			



Date Boring Started:	6/19/20 9:50 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/19/20 10:05 am	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 73F, Sunny

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD192

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS & Bulk
Coordinates:	Lat: 40.63042° Long: -83.84259°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft / REC% / RQD % / SHEAR STRENGTH, tsf (UC/2, Qp/2)	NATURAL DRY DENSITY (pcf) / WATER CONTENT (%) PL–LL
	0.0	APPROXIMATELY 5.5 INCHES OF ASPHALT.							
	0.5	APPROXIMATELY 5.5 INCHES OF 3/4" LIMESTONE GRAVEL BASE. 0.5ft							
	0.9	LEAN CLAY (CL): dark gray; moist; stiff to medium stiff; trace sand and gravel. 0.9ft 1.5': color change to gray and brown.							
	2.0				1	42	7	N=7; Qp/2=1	
	4.0				2	83	10	N=10; Qp/2=0.75	
	6.0				3	92	8	N=8; UC/2=1.36	PL 22; LL 43; water content 23.5; dry density 103
	7.0	Bottom of Boring at 7.0 feet 7.0ft							

Date Boring Started:	6/19/20 8:10 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/19/20 8:30 am	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 66F, Sunny

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD193

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.63041° Long: -83.84520°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

MATERIAL DESCRIPTION

- 0.0–0.4 ft: APPROXIMATELY 5 INCHES OF ASPHALT.
- 0.4–0.9 ft: APPROXIMATELY 6 INCHES OF 3/4" LIMESTONE GRAVEL BASE.
- 0.9–7.0 ft: SANDY LEAN CLAY (CL): dark gray and brown; moist; stiff to medium stiff; trace sand and gravel.
  - 1.5': color change to gray and brown.
  - 3': color change to brown.
  - 3.5': 3-inch wet sand layer.

Bottom of Boring at 7.0 feet (7.0ft)

Depth, feet	Sample No.	% Recovery	SPT, N value or RQD %	SPT N (blows/ft)	Shear Strength, tsf (UC/2, Qp/2)	Water Content (%)	Natural Dry Density (pcf)
2.0	1	46	8	8	2.00 (Qp/2), 2.09 (UC/2)	19.5	108
4.0	2	83	10	10	0.5 (Qp/2)		
6.0	3	96	8	8	1.5 (Qp/2)	13.5	

Date Boring Started:	6/19/20 8:35 am	Water Levels (ft)	Remarks:
Date Boring Completed:	6/19/20 8:50 am	After Drilling: Dry	
Logged By:	LEB2	At Time of Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 70F, Sunny

C:\USERS\LEB2\DESKTOP\PROJECTS\35331001.16 HARDIN 2020 ROAD EVALUATION\JUNE 2020 ROAD EVALUATION\BORING LOGS\HARDIN ROAD JUNE 2020_35331001.16_LEB2.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD194

Project:	Hardin Wind Project	Surface Elevation:	Not provided.
Job No.:	35331001.16	Drilling Method:	Power Auger
Location:	Hardin County, Ohio	Sampling Method:	SS
Coordinates:	Lat: 40.63045° Long: -83.84843°	Completion Depth:	7.0 ft
Datum:	NAD83		

Surface Elev.: Not provided.

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	APPROXIMATELY 5 INCHES OF ASPHALT.			
	0.4ft	APPROXIMATELY 6 INCHES OF 3/4" LIMESTONE GRAVEL BASE.			
	0.9ft	LEAN CLAY (CL): brown; moist; stiff; trace sand and trace to with gravel.			
	2.0		1	46	10
	3.0ft	CLAYEY SAND (SC): brown; moist; loose; with gravel; possible perched water.			
	4.0		2	50	5
	6.0		3	42	4
	6.9ft	LEAN CLAY (CL): brown; moist; soft to very stiff; trace sand.			
	7.0ft	Bottom of Boring at 7.0 feet			

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC% RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)
☐ Qp/2

N values plotted: 10 (2.0 ft), 5 (4.0 ft), 4 (6.0 ft); Qp/2: 1.5 (2.0 ft)

		Water Levels (ft)	Remarks:
Date Boring Started:	6/19/20 8:55 am	After Drilling: Dry	
Date Boring Completed:	6/19/20 9:05 am	At Time of Drilling: Dry	
Logged By:	LEB2		
Drilling Contractor:	TTL		
Drill Rig:	CME 75 Truck		Weather: 70F, Sunny

Hardin Solar II LLC
Supplement to Application
Case No. 20-1321-EL-BGA

Attachment 2

Updated Pre-Construction Noise Analysis

/s/ Christine M.T. Pirik
Christine M.T. Pirik (0029759)
William Vorys (0093479)
DICKINSON WRIGHT PLLC
150 East Gay Street, Suite 2400
Columbus, Ohio 43215
(614) 591-5461
cpirik@dickinsonwright.com
wvorys@dickinsonwright.com
(Counsel is willing to accept service via email.)

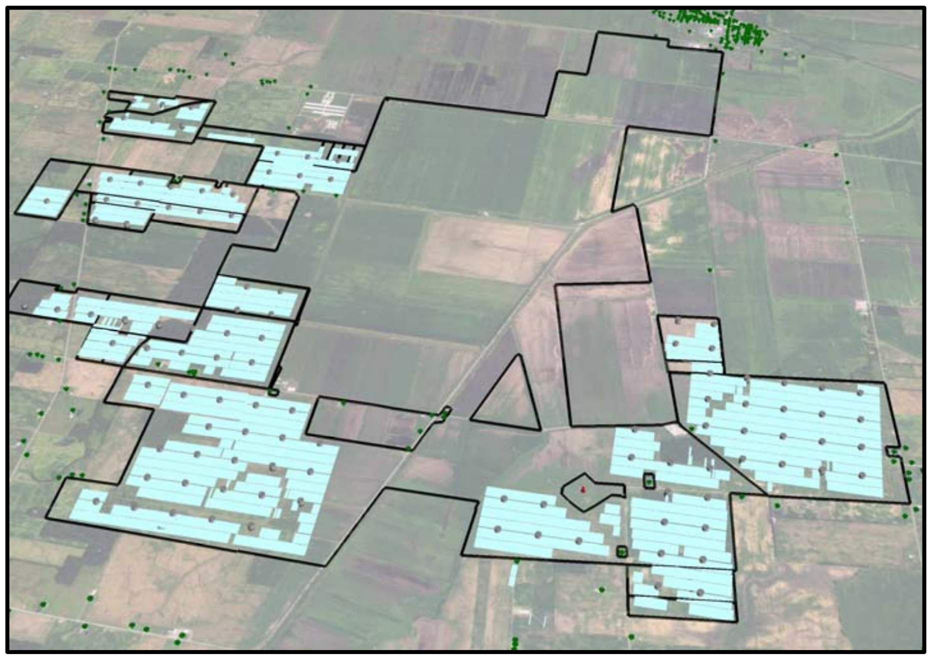
Attorneys for Hardin Solar II LLC

Updated Pre-Construction Noise Analysis

for the proposed

Hardin Solar II Energy Center

August 11, 2020



Prepared for:

Hardin Solar Energy II LLC

Chicago, Illinois

Prepared by:

Hankard Environmental, Inc.

Verona, Wisconsin

HANKARD ENVIRONMENTAL

ACOUSTICS AND VIBRATION CONSULTING

Contents

Figures

Tables

Executive Summary

This report describes the results of an analysis of the noise levels that are expected to be generated from the construction and operation of the Hardin Solar II Energy Center (Project, Facility). This report updates and supersedes Hankard Environmental's report *Pre-Construction Noise Analysis for the Hardin II Solar Energy Facility* (November 18, 2018). Changes to the Project and to the noise analysis method between 2018 and the present include the Project leasing additional land on which it plans to develop (Amended Area), modification of the preliminary layout, and an update to the latest information available regarding noise emission factors used to predict noise levels from the proposed inverters.

The Project is a photovoltaic solar electrical generation facility to be located in Hardin County, Ohio, approximately 65 miles northwest of Columbus. The Project has a maximum generating capacity of 170 MW and is the second phase of the Hardin Solar Energy Center. During construction, the Project will generate noise from the operation of typical equipment such as bulldozers and pile drivers. Sources of noise from the operation of the Project include inverters, transformers at the substation, and cooling systems.

Noise emissions from the Project are subject to the provisions of the Ohio Administrative Code, Chapter 4906-4. The Code requires the Project to (1) measure existing ambient (background) noise levels prior to construction, and (2) predict noise levels from the construction and operation of the Project at sensitive receptor locations. The Project is required to compare operational noise levels at noise-sensitive receptors (e.g. residences) located within one mile of the Project to a standard consisting of the ambient noise level plus five A-weighted decibels.

Ambient noise levels were measured in the fall of 2009 at one location near the proposed solar facility as a part of the Hardin Wind Energy Center application. The average daytime and nighttime noise levels were 48 dBA and 41 dBA, respectively. This results in daytime and nighttime noise level standards of 53 dBA and 46 dBA, respectively (ambient plus 5 dBA). Noise levels from the loudest operation of the Facility were predicted at each of the 407 noise-sensitive receptors located within one mile of the Project and at locations along the Project boundary.

During construction the loudest noise levels expected at receptors range from 60 to 66 dBA, with the loudest activity being pile driving. Much of the time construction noise levels will be lower than this range. These levels are below standards typically applicable to construction noise by agencies such as the U.S. Federal Highway Administration. Construction will be limited to daytime hours to the extent practicable, will take place for approximately 12 to 18 months, and will occur near any one receptor location for only a few weeks at a time.

The primary sources of noise from the operation of the Project are the solar inverters located throughout the Facility and the primary step-up transformer located at the substation. The loudest operational noise level of 44 dBA is predicted at three residences in the west-central and southern portions of the Project. All predicted levels are below the 53 dBA daytime standard and the 46 dBA nighttime standard.

1. Introduction

This report describes the results of an updated pre-construction noise analysis conducted by Hankard Environmental for the proposed Hardin Solar II Energy Center (Facility, Project). This update addresses changes that have occurred since publication of the 2018 noise analysis report. Specifically, the noise analysis was updated to reflect a modified preliminary layout, which primarily includes not developing (i.e., siting noise producing equipment) in the northern portion of the previously-approved Hardin Solar II project area, and the addition of leased land (Amended Area) in nearby areas where development is proposed. The general location of the proposed photovoltaic solar electrical generation facility remains the same, which is approximately 65 miles northwest of Columbus, Ohio as shown in Figure 1-1. There is no change to the Project's maximum generating capacity of 170 megawatts (MW).

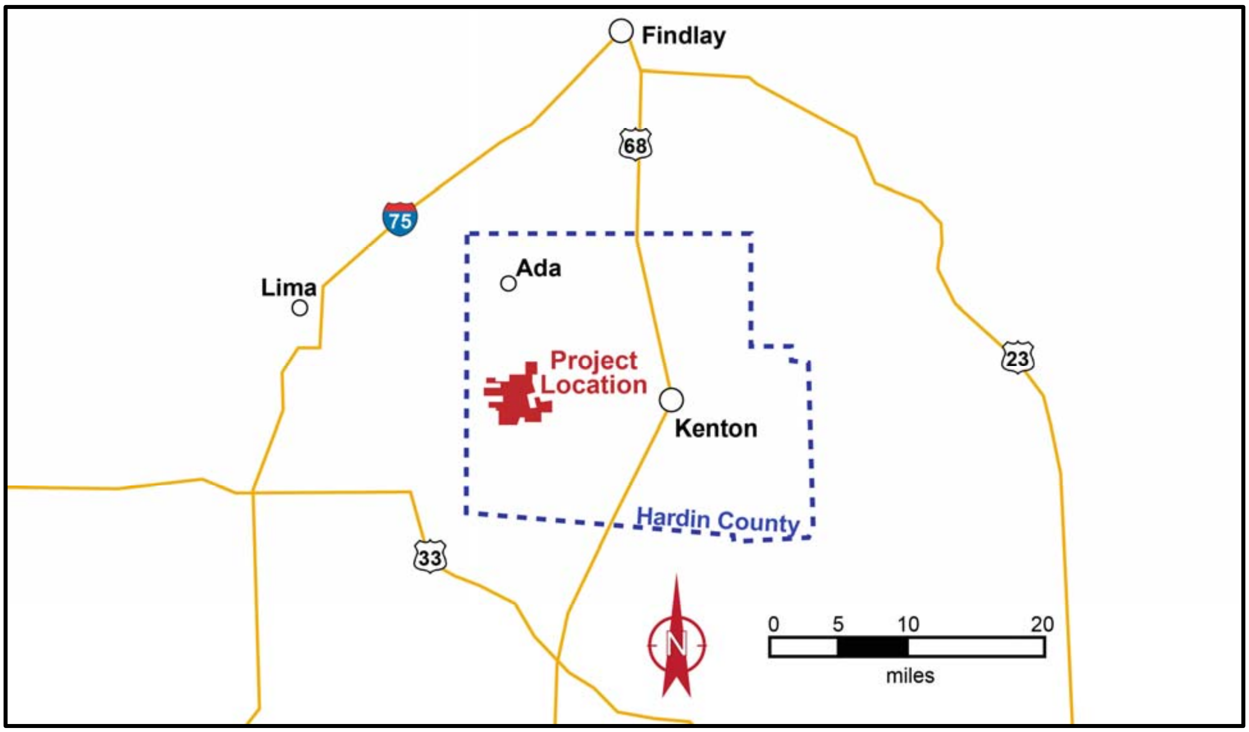


Figure 1-1. General Location of the Proposed Hardin Solar II Energy Center

Figure 1-2 shows the location of the Hardin Solar I Energy Center area (outlined in blue), the previously-approved Hardin Solar II Energy Center area (shown in green), and the Amended Area to the Hardin Solar II Energy Center (shown in red). The Amended Area includes 1,651.49 acres. As with the original noise analysis, the present analysis demonstrates that the Project satisfies the requirements of Chapter 4906-4 of the Ohio Administrative Code, *Certificate Applications for Electric Generation Facilities*, that requires the Project to provide a study of pre-construction (existing) noise levels, a description of construction and operational noise levels at the nearest property boundary and at all noise-sensitive receptors located within approximately one mile of the Project boundary, and the measures that will be taken by the Project to mitigate noise emissions. The following sections describe in more detail the noise regulation applicable to the Project, the Project site and the location of noise sensitive receptors, the results of the pre-construction ambient noise study, the methods and data used to predict construction and operational noise emissions, the predicted construction and operational noise levels, and the mitigative measures to be employed.

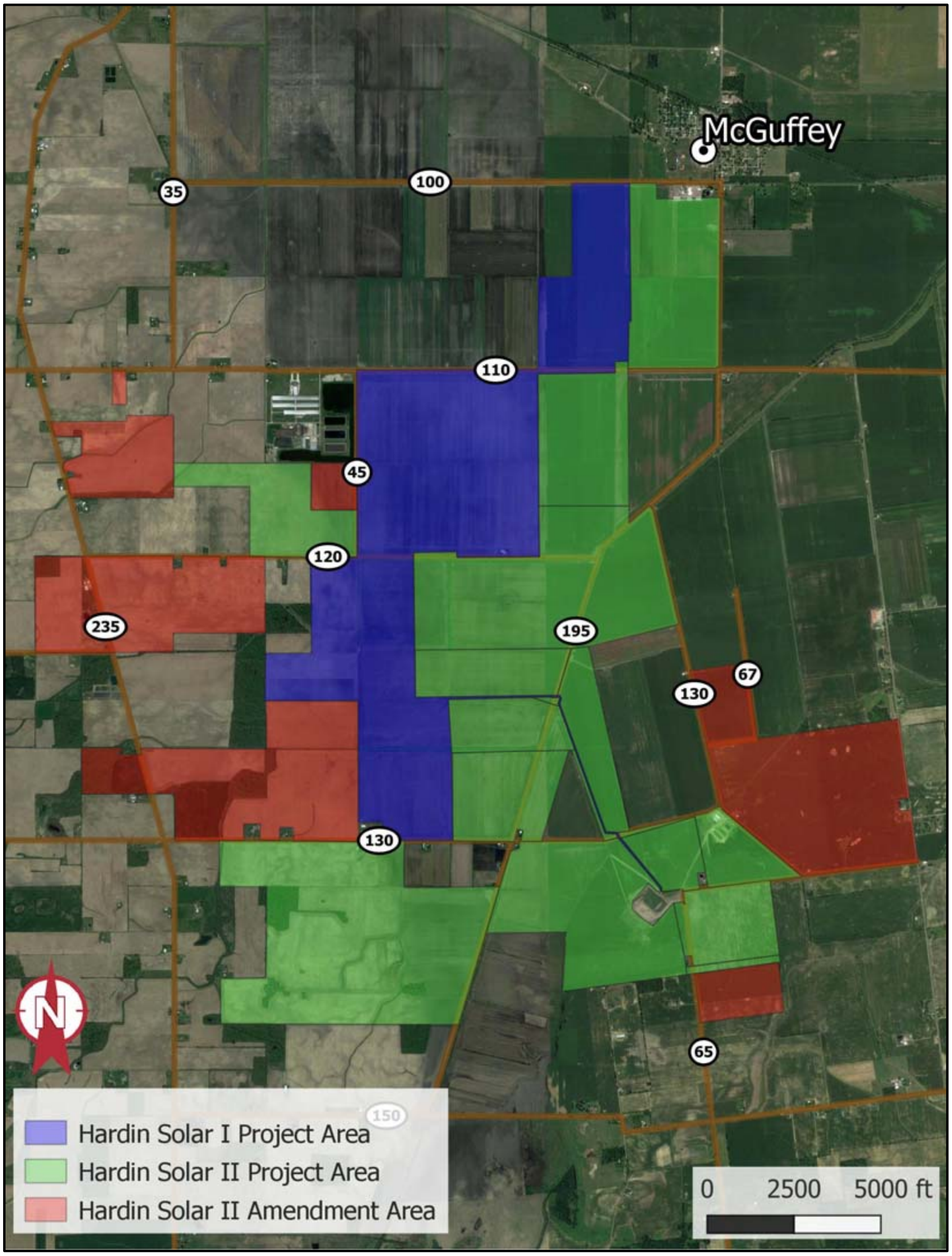


Figure 1-2. Overview of the Hardin II Energy Center Permitted and Amendment Land Areas

2. Applicable Regulation

Chapter 4906-4 of the Ohio Administrative Code, *Certificate Applications for Electric Generation Facilities,* sets forth the rules governing standard certificate applications for electrical generation facilities. Section 4906-4-08, *Health and Safety, Land Use and Ecological Information*, describes the noise information required as part of a certificate application. Specifically, Paragraph (A)(3) requires:

(3) The applicant shall provide information on noise from the construction and operation of the facility.

(a) Describe the construction noise levels expected at the nearest property boundary. The description shall address:
- (i) Blasting activities. (Note – there is no blasting anticipating on this Project.)
- (ii) Operation of earth moving equipment.
- (iii) Driving of piles, rock breaking or hammering, and horizontal directional drilling.
- (iv) Erection of structures.
- (v) Truck traffic.
- (vi) Installation of equipment.

(b) Describe the operational noise levels expected at the nearest property boundary. The description shall address:
- (i) Operational noise from generation equipment. In addition, for a wind facility, cumulative operational noise levels at the property boundary for each non-participating property adjacent to or within the project area, under both day and nighttime operations. The applicant shall use generally accepted computer modeling software (developed for wind turbine noise measurement) or similar wind turbine noise methodology, including consideration of broadband, tonal, and low-frequency noise levels.
- (ii) Processing equipment.
- (iii) Associated road traffic

(c) Indicate the location of any noise-sensitive areas within one mile of the proposed facility, and the operational noise level at each habitable residence, school, church, and other noise-sensitive receptors, under both day and nighttime operations.

(d) Describe equipment and procedures to mitigate the effects of noise emissions from the proposed facility during construction and operation, including limits on the time of day at which construction activities may occur.

(e) Submit a preconstruction background noise study of the project area that includes measurements taken under both day and nighttime conditions.

3. Project Site

The Project is located in Marion, McDonald, and Roundhead townships in Hardin County, Ohio. Figure 3-1 shows the Project site, including the preliminary locations of the solar panels and inverters, the substation, and the Project boundary. The site is bordered to the north by County Road 100, to the south by State Route 150, to the east by County Road 75, and to the west by State Route 235. Figure 3-1 also shows the location of the 407 noise-sensitive receptors within approximately one mile of the Project. The noise-sensitive receptors include 402 residences, two cemeteries, one school, the school's outdoor fields, and one church. The land use immediately surrounding the Project is a mix of agricultural and rural residential.

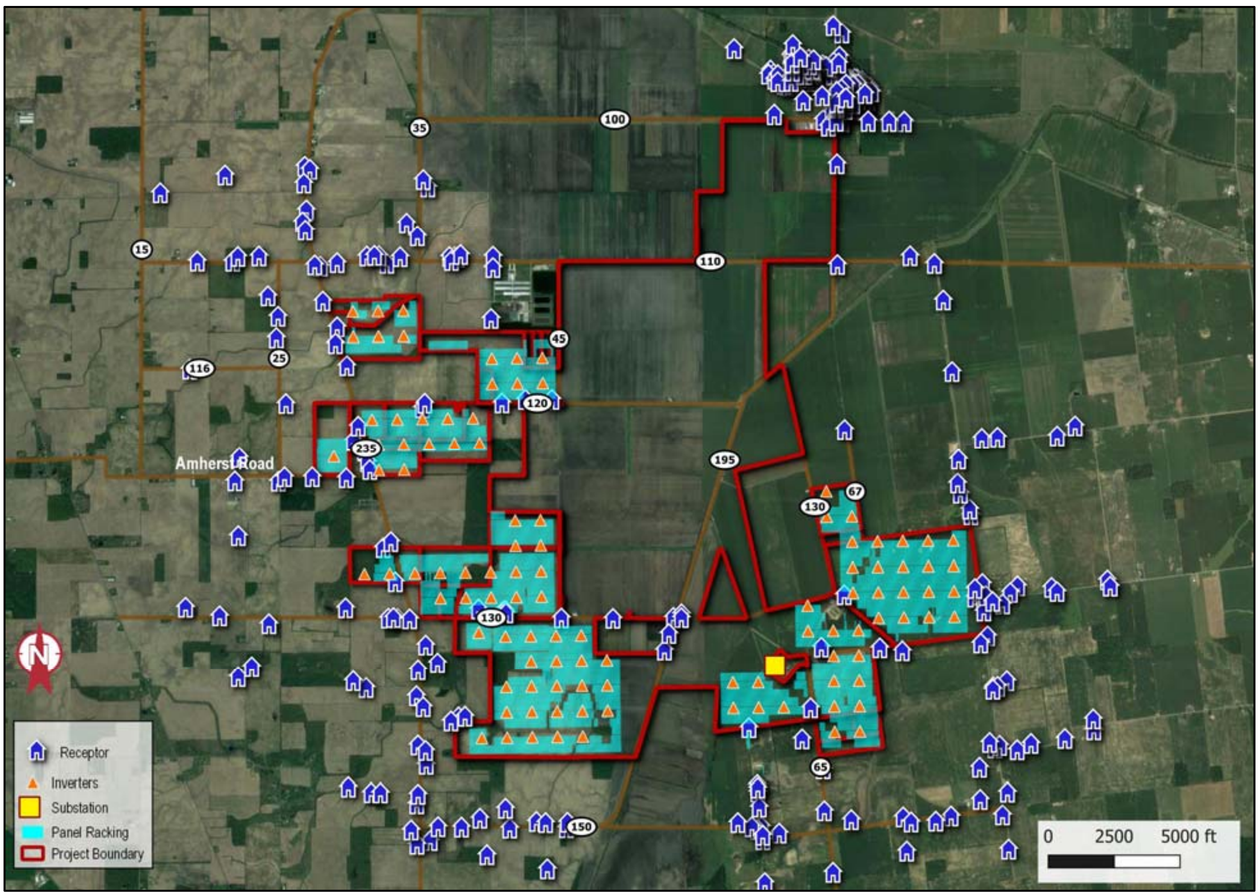


Figure 3-1. Proposed Hardin Solar II Energy Center Layout

4. Pre-Construction Background Noise Study

A background (ambient) noise level survey was conducted in the fall of 2009 as part of the Hardin Wind Energy Center project (*Hardin Wind Farm Baseline Sound Survey Report*, Tetra Tech, December 2009). From this report, Monitoring Position 4 was selected as representative of conditions near the Project. As shown in Figure 4-1, background noise measurements were taken on a residential property (Receptor H-2051) located in the southeast portion of the Project area. Data was collected for approximately three weeks (November 10 through December 1, 2009). Figure 4-2 shows the measured noise levels over that period. After removing all the times when it was precipitating or stormy, the daytime (7:00 am to 7:00 pm) and nighttime (7:00 pm to 7:00 am) average noise levels were calculated to be 48 dBA and 41 dBA, respectively.

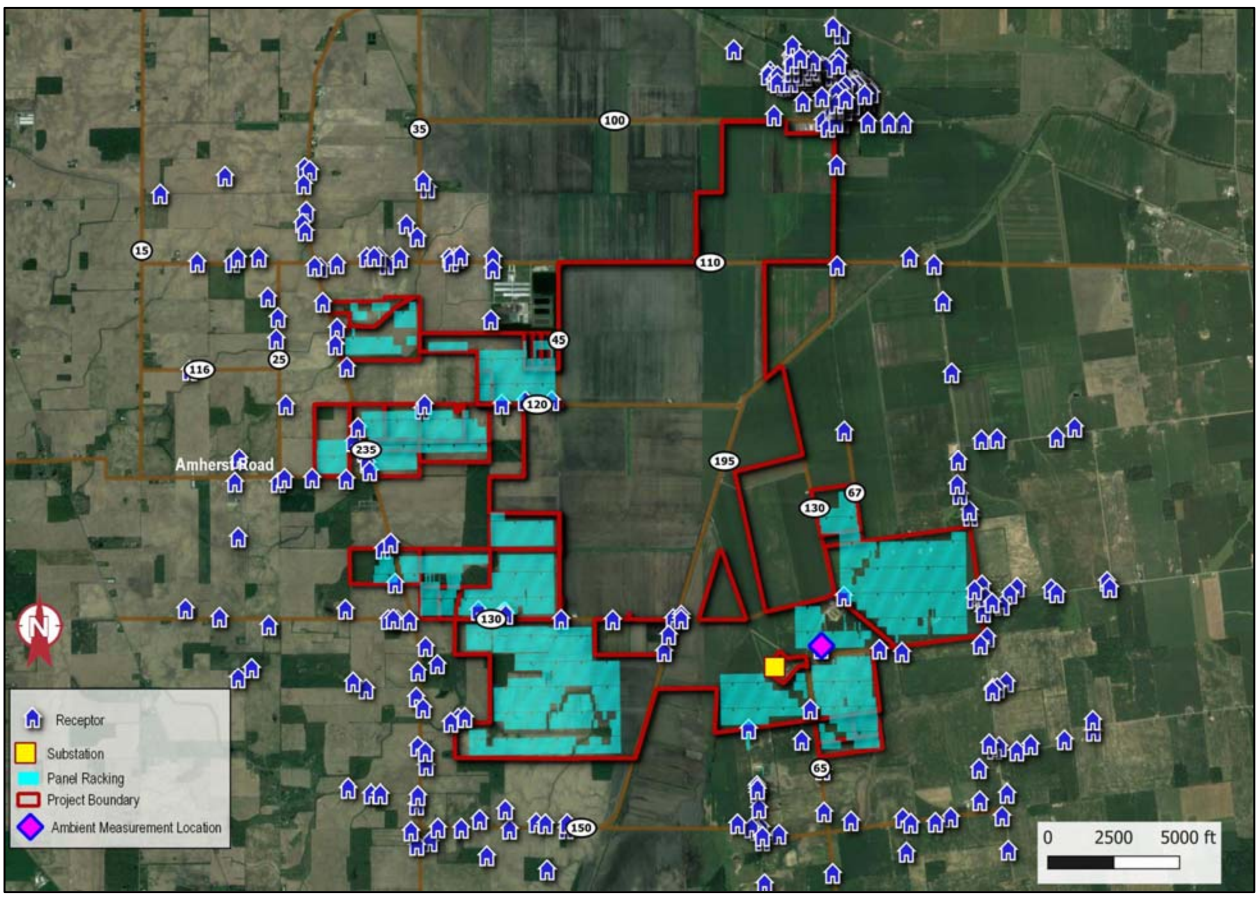


Figure 4-1. Background (Ambient) Noise Measurement Location

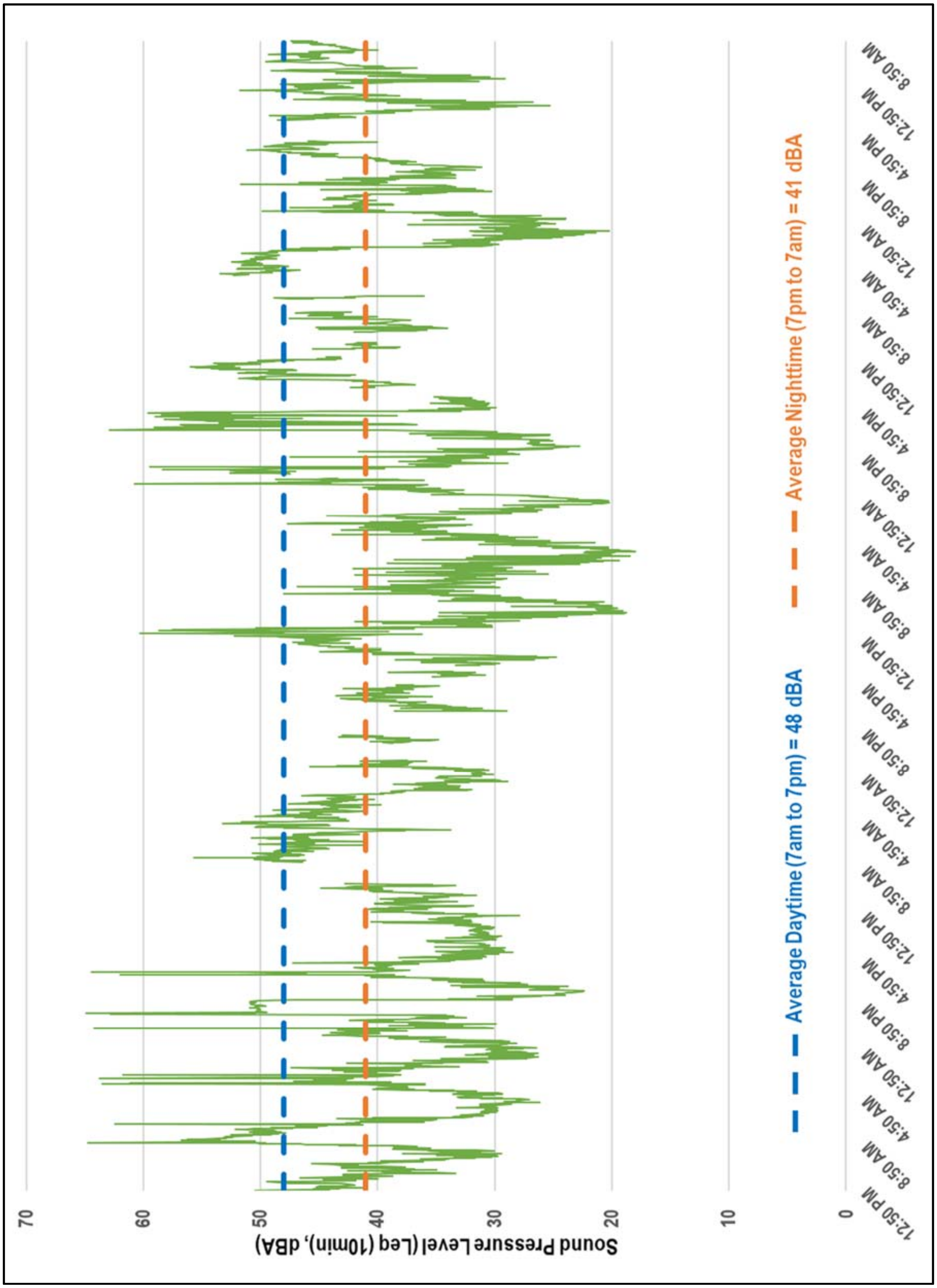


Figure 4-2. Measured Background Noise Levels (November 10 to December 1, 2009)

5. Noise Modeling Method

Noise levels from the proposed Project were predicted using the International Organization for Standardization (ISO) Standard 9613-2:1996, *Attenuation of Sound During Propagation Outdoors - Part 2: General method of calculation*. The calculations were implemented using the SoundPLAN v8.2 acoustical modeling software program. There are a number of parameters in the ISO 9613-2:1996 method, including the locations of the noise sources and receivers, noise source spectral characteristics, terrain and ground type, and atmospheric propagation conditions. The ISO method assumes optimal acoustic propagation in all directions, specifically that a "well-developed, moderate ground-based temperature inversion" is present or, equivalently, that all receptors are downwind of all noise sources at all times. The sections below describe the specific ISO 9613-2:1996 settings used in this analysis to predict the noise levels from the four phases of construction and the one operational phase.

Terrain and Ground Effect

The terrain in the acoustic model was defined using Digital Elevation Model (DEM) data from the U.S. Geological Survey (USGS) National Elevation Dataset. The acoustical effect of the ground was modeled using the ISO 9613-2:1996 General Method. This method requires the selection of ground factors for the ground near the source, near the receiver, and in between. A ground factor of 0.0 represents a completely reflective surface such as pavement, which would result in a higher level of sound reaching a receiver. A ground factor of 1.0 represents absorptive ground such as thick grass or fresh snow, resulting in a lower level of sound reaching the receiver. For this project, a ground factor of 0.5 was used because it is expected that native grasses will be planted after construction. Actual ground conditions could, at rare times, be 0.0 when the ground is completely frozen and bare, but would generally be closer to 0.5 when the ground is covered with vegetation or is bare and unfrozen.

Atmospheric Conditions

The air temperature, relative humidity, and atmospheric pressure were set to standard-day conditions of 10°C, 70%, and 1 atmosphere, respectively. Per ISO 9613-2:1996, these values result in the least amount of atmospheric sound absorption and the highest levels of sound reaching the receivers.

Receptors

In the SoundPLAN model, prediction points (receptors) were located along the Project boundary, as well as at the 407 noise-sensitive receptors within approximately one mile of the Project boundary. Of these receptors, 402 are residential, two are cemeteries, one is a school, one is a school's outdoor fields, and one is a church. Prediction locations are shown in Figures 5-1 to 5-5. In accordance with ISO 9613-2:1996, the height above the ground for each receptor was set to 5 feet.

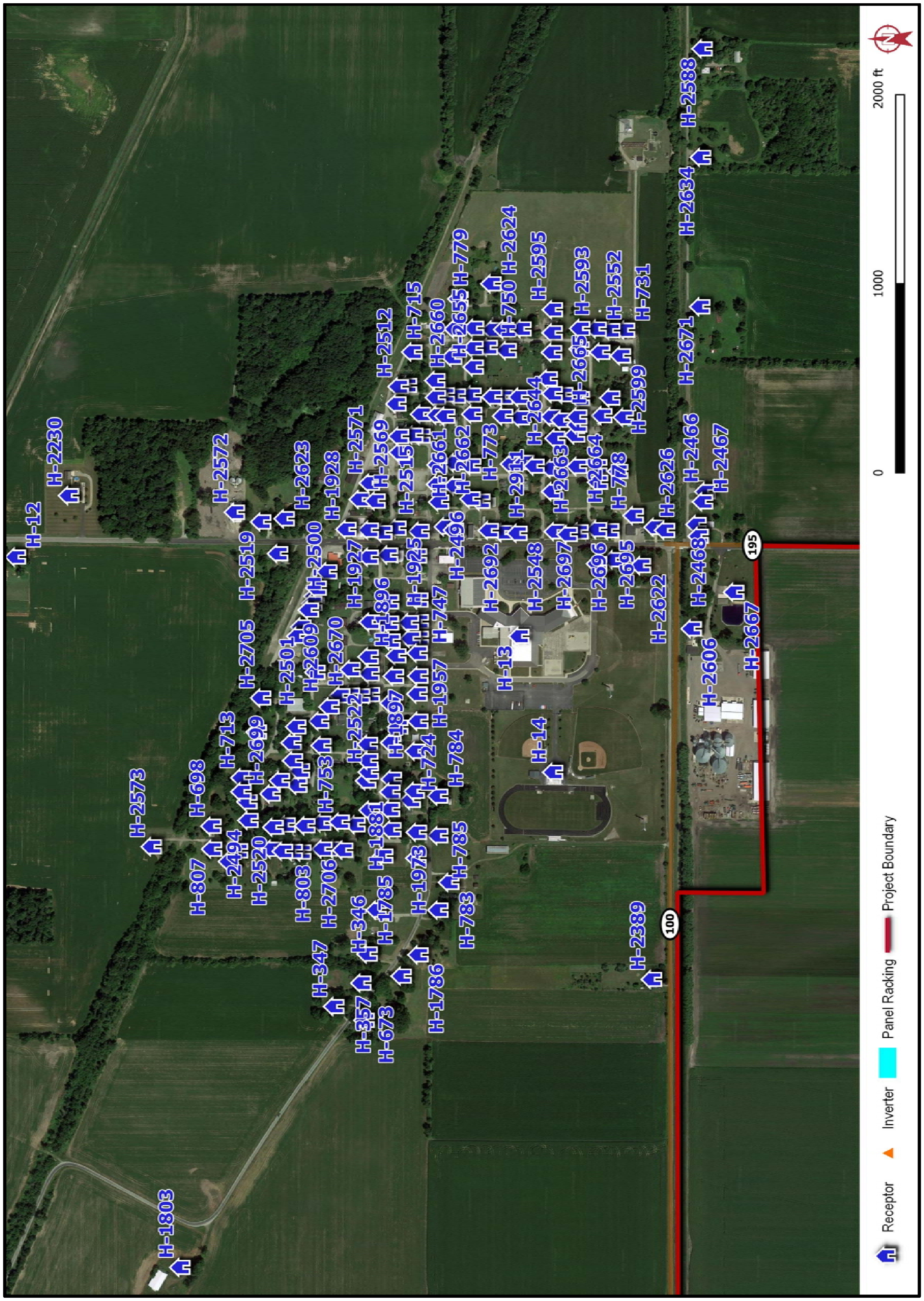


Figure 5-1. Noise-Sensitive Receptors – Northern Area

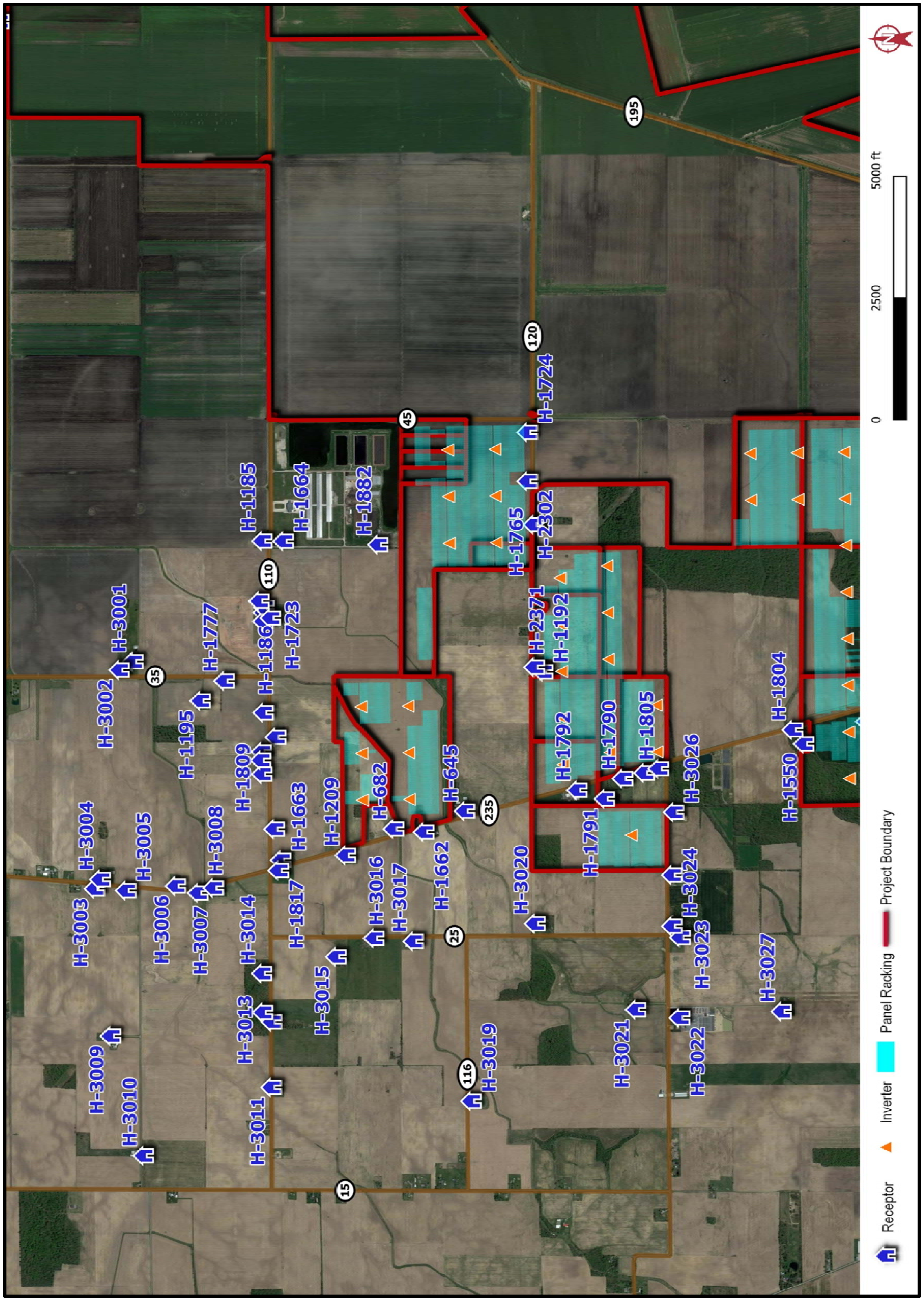


Figure 5-2. Noise-Sensitive Receptors – West-Central Area

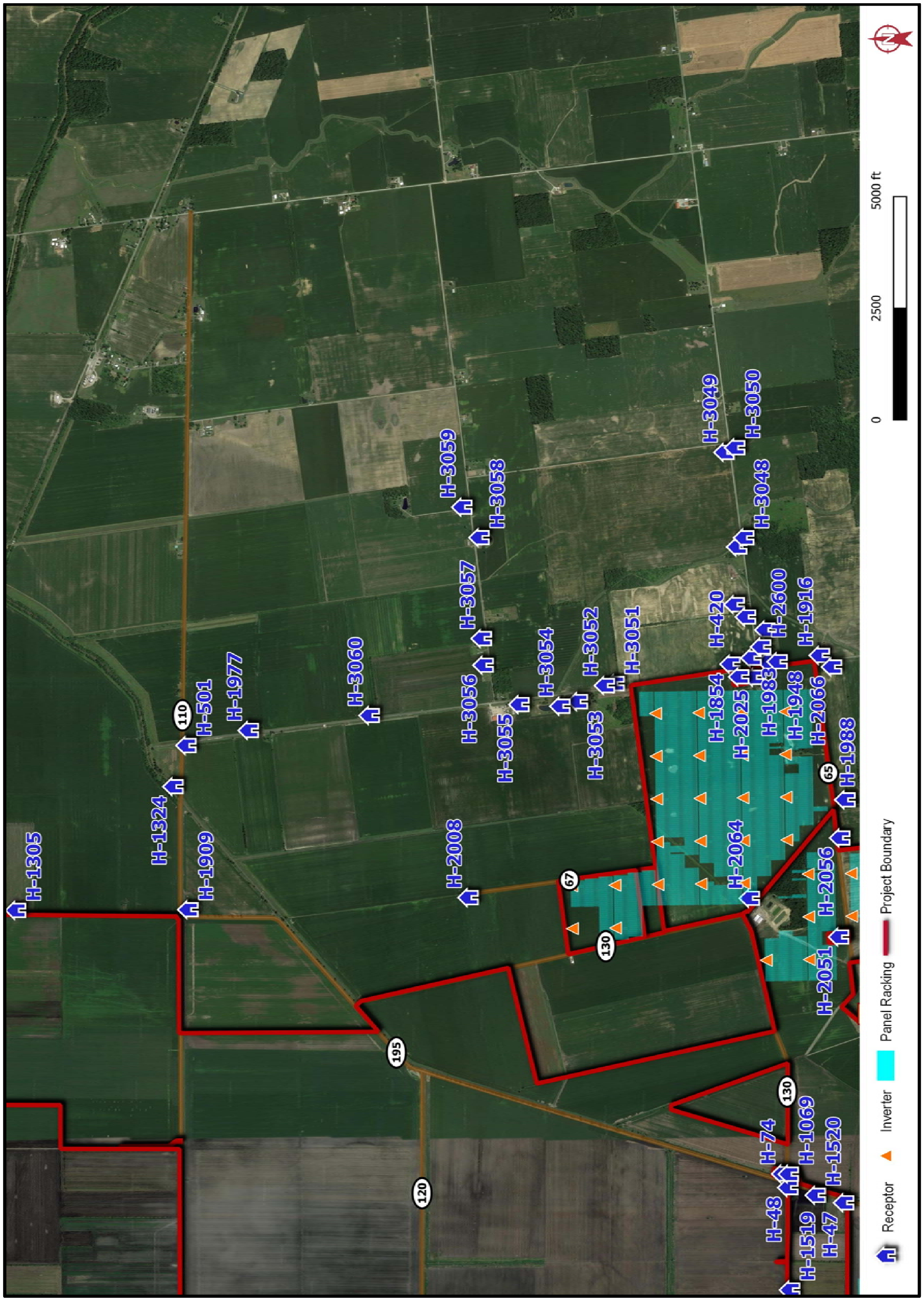


Figure 5-3. Noise-Sensitive Receptors – East-Central Area

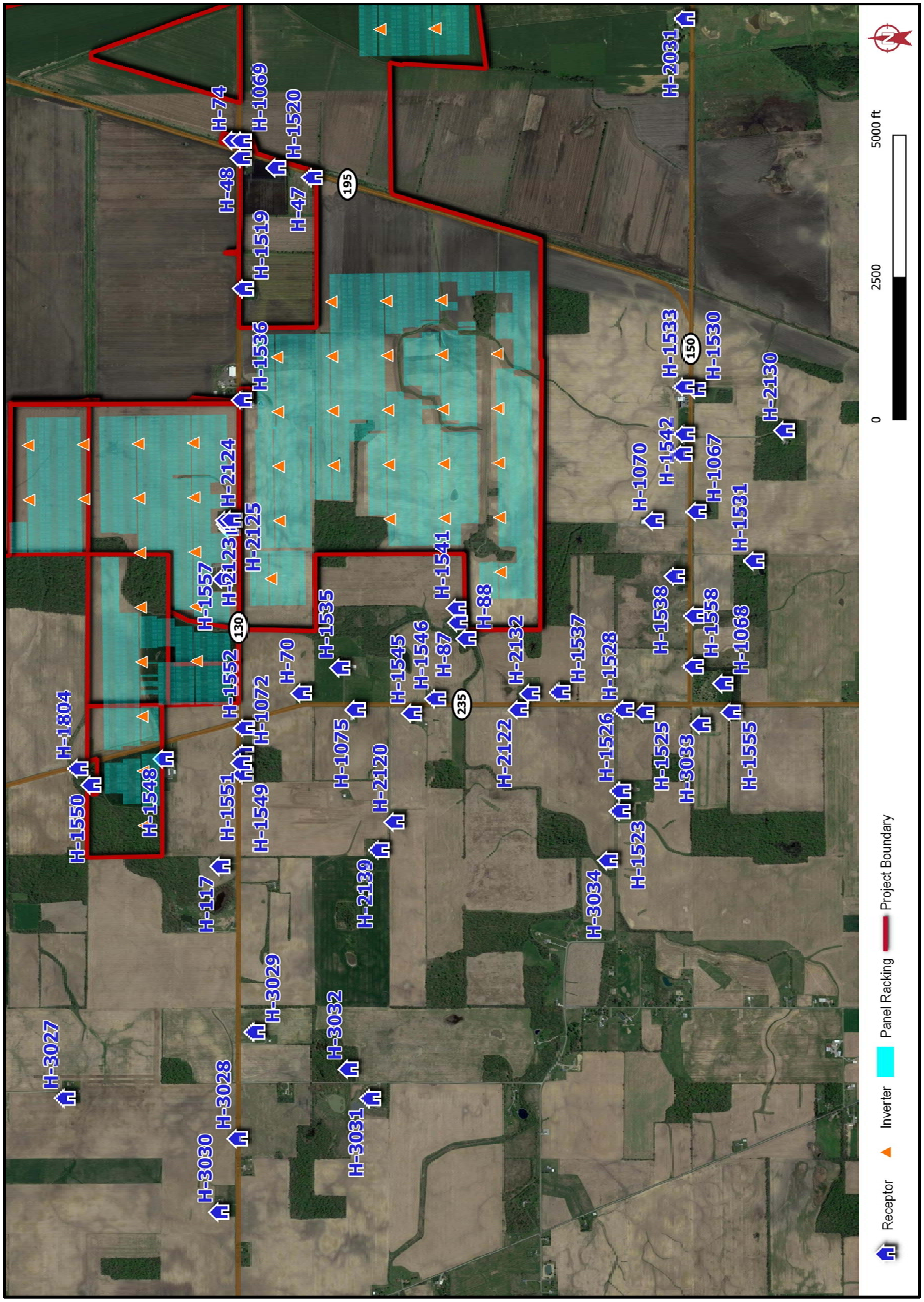


Figure 5-4. Noise-Sensitive Receptors – Southwest Area

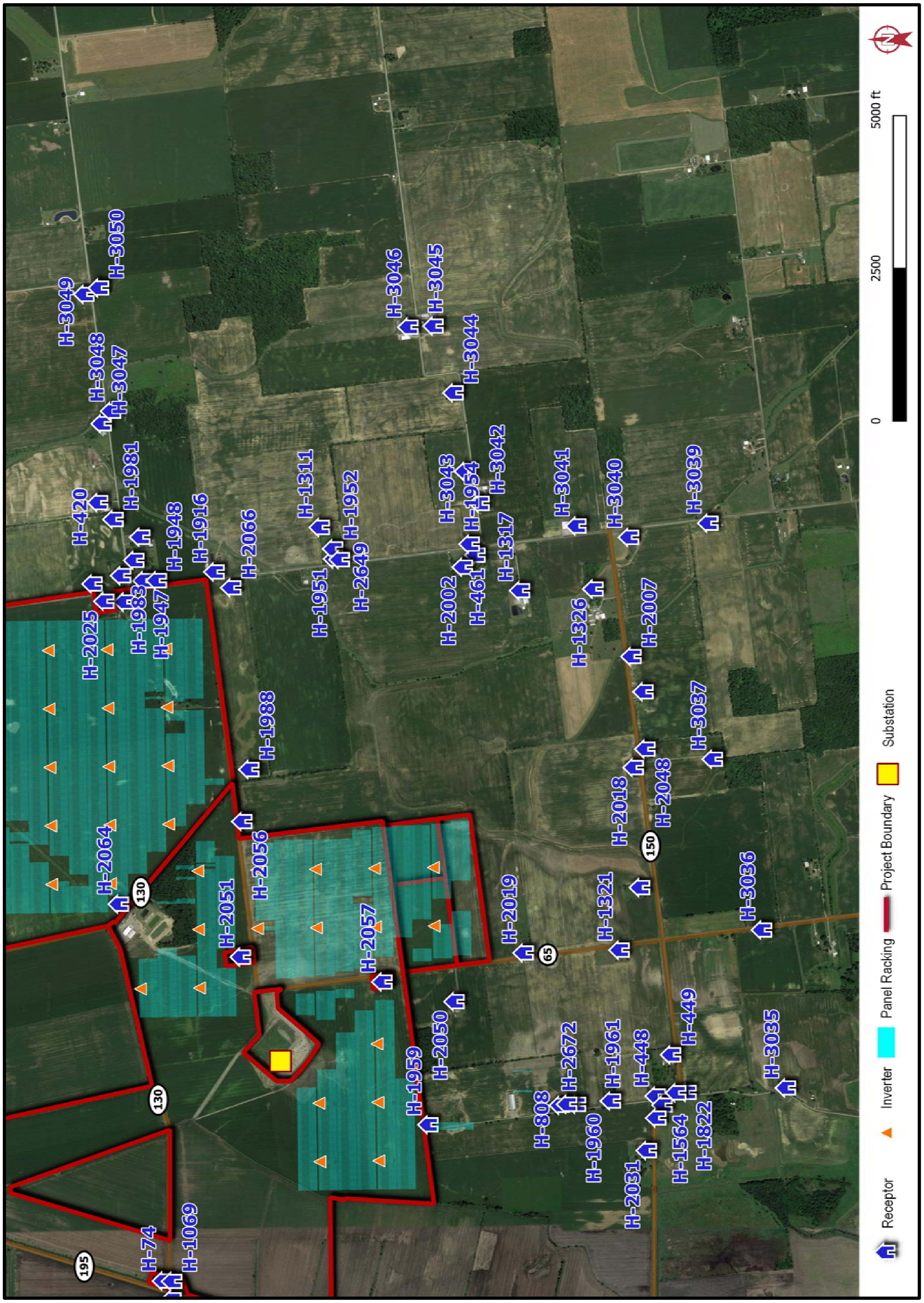


Figure 5-5. Noise-Sensitive Receptors – Southeast Area

Construction Noise Sources

Noise levels were predicted for the four phases of construction: site preparation, civil work, mechanical assembly, and electrical work. Table 5-1 lists the equipment associated with each phase, as well as the number of units to be employed, the sound power level of each unit, and the percent of time that each piece of equipment is expected to be used at full capacity (the usage factor). Construction noise source levels were generally based on measurements of construction equipment made by Hankard Environmental on previous projects. The usage factors were taken from the Federal Highway Administration's (FHWA) Roadway Construction Noise Model (RCNM) v1.1. All construction noise sources were modeled at 10 feet above the ground.

Table 5-1. Noise Source Characteristics of Construction Equipment

Phase	Equipment Type (quantity)	Usage Factor (%)	Octave Band Sound Power Level (dB)									Overall Sound Power Level (dBA)
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1,000 Hz	2,000 Hz	4,000 Hz	8,000 Hz	
1 Site Preparation	Bulldozer (1)	40%	116	111	116	116	105	107	104	95	85	112
	Excavator (2)	40%	103	112	112	107	99	97	95	92	85	104
	Motor Grader (2)	40%	100	99	110	104	101	110	103	94	89	112
	Water Truck (1)	40%	103	107	112	103	106	104	98	94	85	108
	Dump Truck (1)	40%	98	112	105	103	97	98	96	90	82	103
2 Civil Work	Roller (1)	40%	--	138	128	115	101	98	97	94	90	116
	Dump Truck (1)	40%	98	112	105	103	97	98	96	90	82	103
	Excavator (2)	40%	103	112	112	107	99	97	95	92	85	104
	Trencher (1)	50%	109	114	114	108	105	102	101	95	87	108
	Motor Grader (2)	40%	100	99	110	104	101	110	103	94	89	112
	Water Truck (1)	40%	103	107	112	103	106	104	98	94	85	108
3 Mechanical Assembly	Pile Driving (1)	20%	128	130	132	121	125	126	124	119	111	130
	Pickup Truck (2)	40%	100	114	107	105	99	101	98	92	84	105
	Man Lift (2)	20%	102	108	101	92	92	93	94	87	81	99
	Crane (1)	16%	---	139	117	104	102	100	96	90	85	114
	Backhoe/Loader (1)	40%	105	102	111	101	99	101	99	96	91	106
4 Electrical Work	Pickup Truck (2)	40%	100	114	107	105	99	101	98	92	84	105
	Flatbed Truck (1)	40%	100	114	107	105	99	101	98	92	84	105
	Man Lift (1)	20%	102	108	101	92	92	93	94	87	81	99
	Small Generator (1)	50%	103	110	108	108	105	104	103	102	98	110
	Compressor (1)	40%	106	113	111	111	108	107	106	105	101	113

Operational Noise Sources

The model of noise emissions from the Project included 106 inverters, which is more than the approximately 36 inverters that will ultimately be built. As a result, the noise levels described herein are worst-case. The model also accounted for the one primary step-up transformer located at the Facility's substation. Note that noise from solar tracking motors was not included as it has been found to be inaudible off-site at existing solar facilities.

Table 5-2 lists the sound power levels for each source. The Project proposes to use the TMEIC Ninja 4.2 kW model inverter. The sound power level shown are based on field measurements of a TMEIC 3.3 kW model inverter, but the levels are expected to be similar as the majority of noise from inverters is created by cooling systems that are the same or similar between the units. The sound power level of the step-up transformer was estimated using the procedures outlined in the "Electric Power Plant Environmental Noise Guide" from the Edison Electric Institute (EEI, 1984). The inverters and substation transformer were modeled at six feet and ten feet above the ground, respectively. It was assumed that all operational equipment would be in use at all times with the substation transformer operating at its maximum capacity of 195 MVA even though the maximum expected operational load is only 170 MVA.

Table 5-2. Noise Source Characteristics of Operational Equipment

Equipment Type	Equipment Quantity	Octave Band Sound Power Level (dB)									Overall Sound Power Level (dBA)
		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1,000 Hz	2,000 Hz	4,000 Hz	8,000 Hz	
Solar Inverter	106	99	95	99	98	95	86	79	73	69	95
Transformer (195 MVA)	1	98	104	106	101	101	95	90	85	78	101

6. Predicted Construction Noise Levels

Noise levels from construction of the proposed Project were predicted along the Project property boundary, as well as at the 407 noise-sensitive receptors located within approximately one mile of the Project boundary. Noise levels were predicted for each of the four primary phases of construction. The first phase is site preparation, which is expected to last approximately nine weeks. The second phase is civil work, which involves grading (30 weeks), the construction of access roads (30 weeks), and final grading and landscaping (four weeks). The third phase is the installation of piers, racks, and modules, and is expected to last approximately ten months. The final phase is the electrical work, which consists of connecting all the equipment, and is expected to last approximately 11 months. Some of this work will be conducted concurrently, although in different areas of the site, resulting in an approximate overall schedule of 12 to 18 months.

Noise levels were predicted assuming that all equipment associated with a particular phase was operating simultaneously. While construction will take place throughout the Project area, the worst-case scenario is when it occurs near receptors. To assess this, noise levels for each phase were predicted at the six representative locations shown in Figure 6-1. The results of the predictions are listed in Table 6-1. Noise levels ($L_{eq\text{-}1hr}$) along the boundary of the Project range from less than 15 dBA to 67 dBA, with Mechanical Assembly (w/pile driving) being the loudest activity. Construction noise levels ($L_{eq\text{-}1hr}$) predicted at the receptors range from less than 15 dBA to 66 dBA, and again, Mechanical Assembly (w/pile driving) is the loudest activity. Construction noise level predictions at each receptor are provided in Appendix A.

These levels are worst-case, as they assume that all of the equipment associated with each phase is operating close to the Project boundary or representative location. Much of the time, noise levels will be far lower when (1) some or all the equipment is idling or off, (2) construction takes place farther into the interior of the Project area, or (3) atmospheric conditions are less conducive to sound propagation than the worst-case condition modeled here. In terms of construction noise mitigation, the primary measure is to limit construction to daytime to the extent practicable, particularly for loud operations taking place near the Project boundary. Secondly, the contractor should be required to use well-maintained equipment, particularly with respect to mufflers. Finally, a construction noise or general complaint telephone hotline should be established.

Table 6-1. Predicted Construction Noise Levels

Construction Phase	$L_{eq\text{-}1hr}$ (dBA)			
	Boundary Line		Noise Sensitive Receptors	
	Minimum	Maximum	Minimum	Maximum
1 – Site Preparation	< 15	59	< 15	58
2 – Civil Work	< 15	62	< 15	61
3 – Mechanical Assembly (w/o pile driving)	< 15	55	< 15	54
3 – Mechanical Assembly (w/ pile driving)	< 15	67	< 15	66
4 – Electrical Work	< 15	54	< 15	54

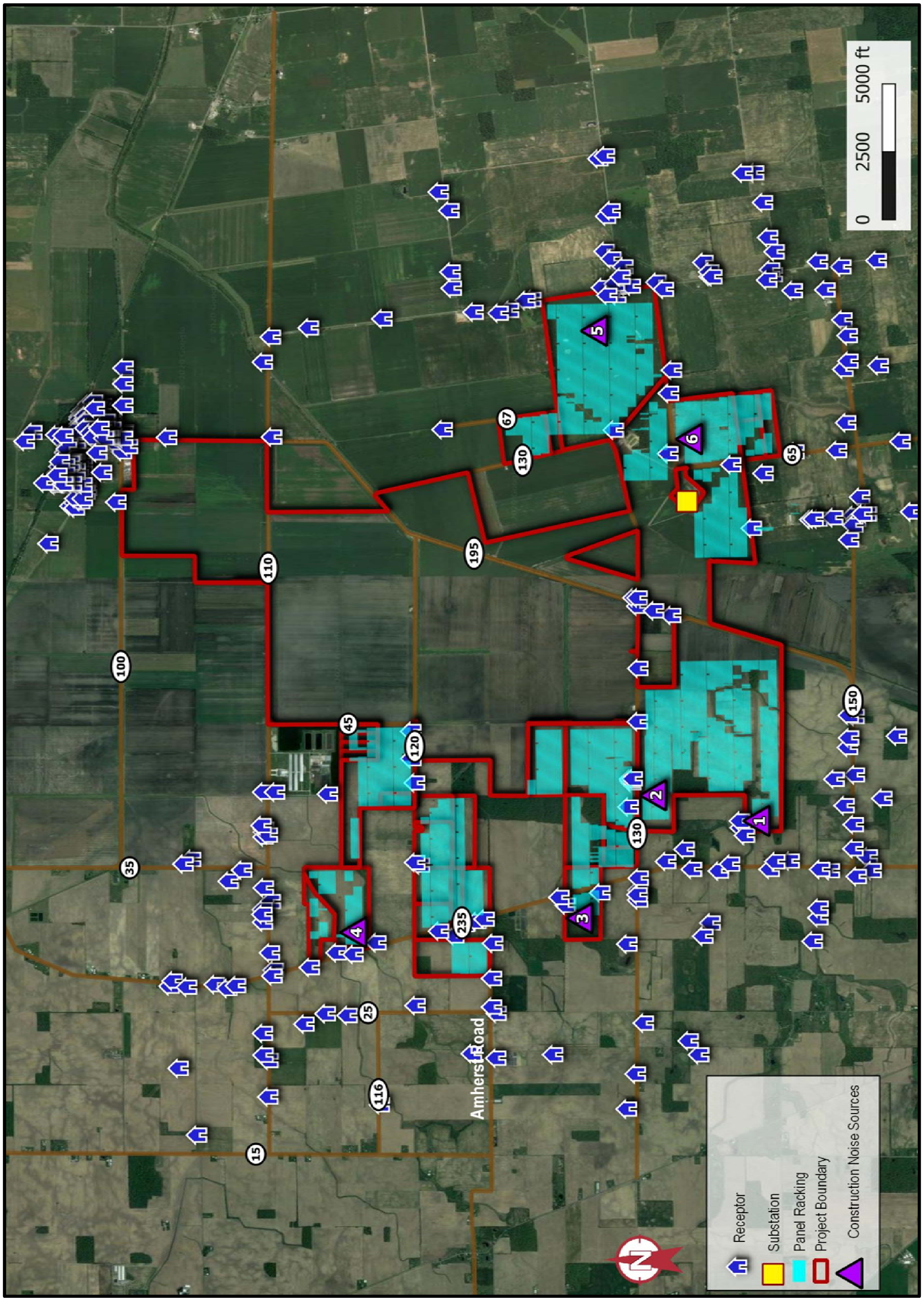


Figure 6-1. Construction Activity Representative Locations for Noise Predictions

7. Predicted Operational Noise Levels

The primary noise sources associated with the operation of the Project include the pad-mounted inverters located throughout the Project area and the 195 MVA transformer located at the substation. This analysis assumed that 106 inverters were operating simultaneously. Worst-case operational noise levels were predicted along the Project boundary and at the 407 noise-sensitive receptors located within approximately one mile of the Property boundary.

Figure 7-1 shows the predicted worst-case operational noise levels at the forty receptors with the loudest predicted levels along with the daytime and nighttime noise level limits of 53 dBA and 46 dBA, respectively. Overall, predicted worst-case noise levels (Leq-1hr) at the 402 nearby residences, two cemeteries, two school buildings, and one church range from 0 to 44 dBA, with 96% of the receptors having levels 40 dBA or less. The loudest locations, which reach 44 dBA, are a residence behind Quickstep Pentecostal Church of God (H-1192) and two residences in the southern portion of the Project area off Dodds Road (H-2051 and H-2064). See Appendix B for a list of predicted operational noise levels at all receptors.

The operational noise levels are depicted graphically in Figure 7-2. Shown are the 53 dBA and 46 dBA noise level contours which represent the daytime and nighttime noise level limits, respectively. Note that the 53 dBA contours lie very close to the sources and are obscured by the 46 dBA contour at the scale shown. Along the property boundary, the predicted worst-case operational noise levels are as high as 47 dBA. These levels are predicted at boundary locations adjacent to agricultural or undeveloped land uses which are not considered noise-sensitive. As previously described, maximum noise levels at residences are 44 dBA or less.

The Project should not use equipment with rated sound power levels exceeding those listed in Table 5-2. All maintenance activities should be conducted during daytime hours using well-maintained and properly muffled vehicles and equipment.

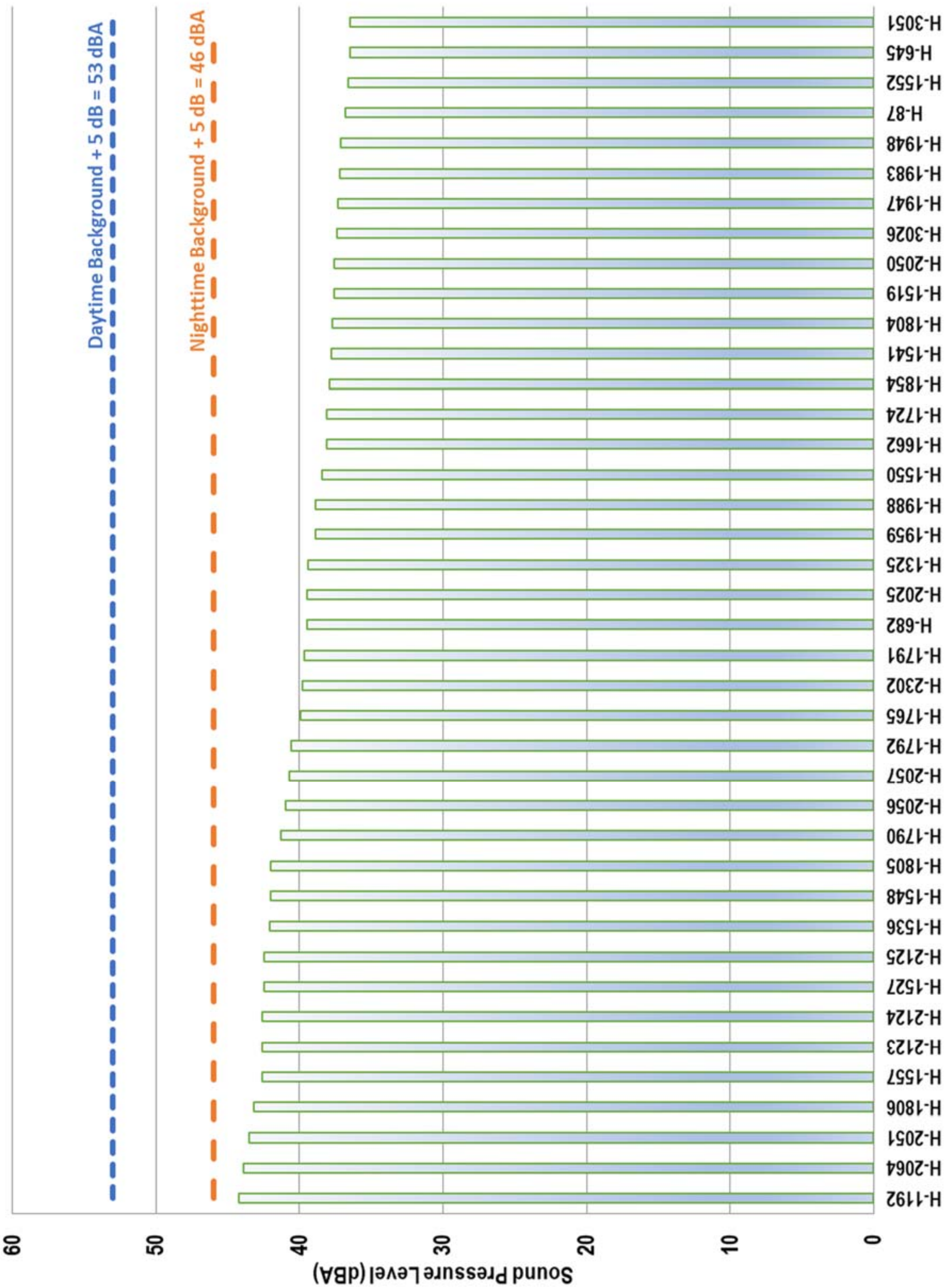


Figure 7-1. Predicted Operational Noise Levels and OPSB Limits

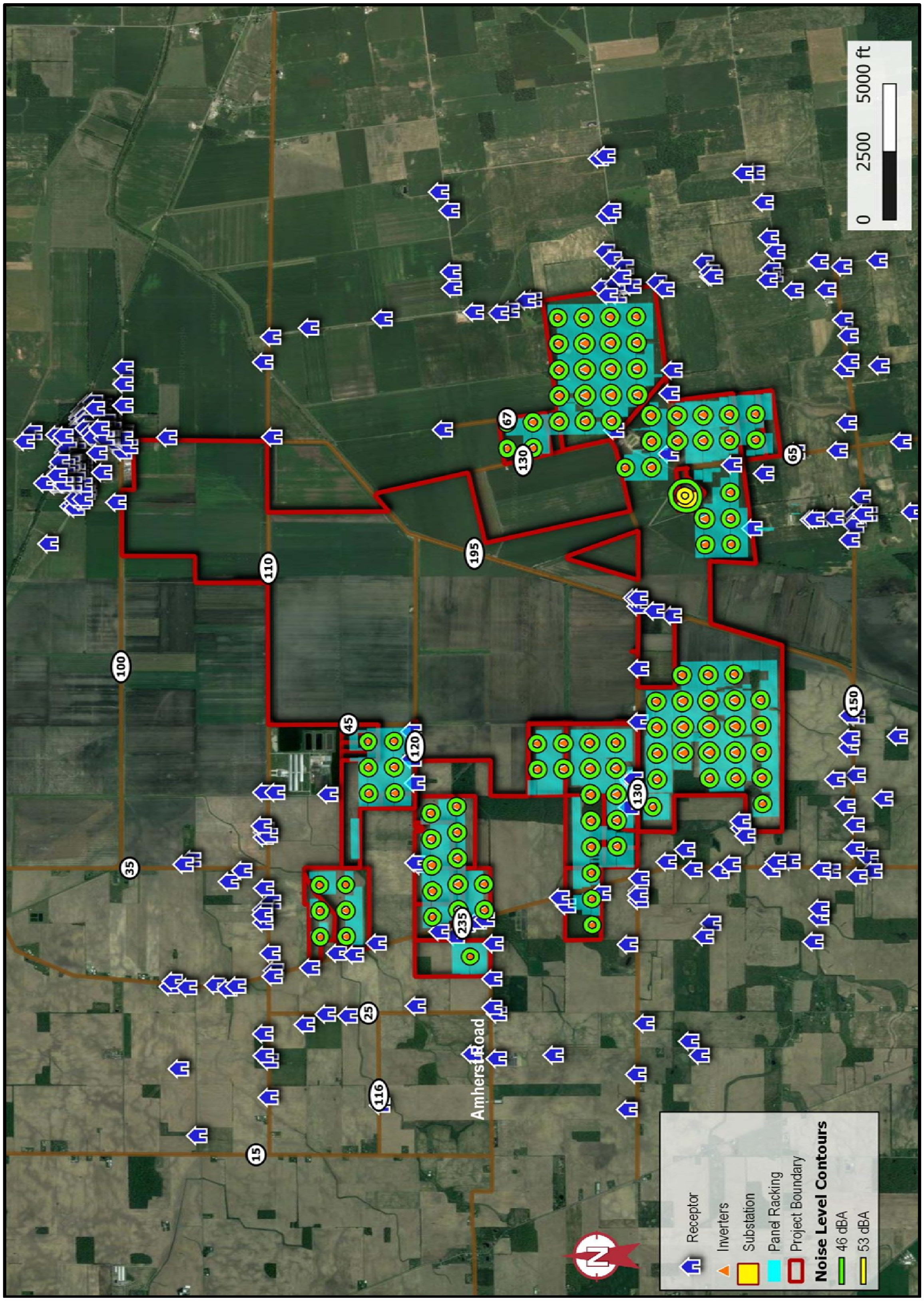


Figure 7-2. Predicted Operational Noise Level Contours

Appendix A: Predicted Construction Noise Levels

Table A-1. Predicted Construction Noise Levels

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
Property Line	Worst Case	53	57	52	63	51
H-11	Residence	<15	<15	<15	<15	<15
H-12	Residence	<15	<15	<15	<15	<15
H-47	Residence	36	44	40	46	34
H-48	Residence	36	43	40	45	33
H-70	Residence	45	49	45	54	42
H-74	Residence	36	43	40	45	33
H-87	Residence	53	56	52	63	51
H-88	Residence	52	55	51	62	50
H-117	Residence	45	49	45	55	43
H-346	Residence	<15	<15	<15	<15	<15
H-347	Residence	<15	<15	<15	<15	<15
H-357	Residence	<15	<15	<15	<15	<15
H-420	Residence	43	48	43	52	41
H-448	Residence	33	41	37	42	30
H-449	Residence	33	40	37	42	30
H-461	Residence	34	41	37	44	32
H-501	Residence	24	34	31	34	22
H-645	Residence	52	55	51	62	50
H-673	Residence	<15	<15	<15	<15	<15
H-674	Residence	41	45	41	50	38
H-680	Residence	<15	<15	<15	<15	<15
H-682	Residence	52	55	50	61	49
H-689	Residence	<15	<15	<15	<15	<15
H-695	Residence	<15	<15	<15	<15	<15
H-696	Residence	<15	<15	<15	<15	<15
H-697	Residence	<15	<15	<15	<15	<15
H-698	Residence	<15	<15	<15	<15	<15
H-713	Residence	<15	<15	<15	<15	<15
H-714	Residence	<15	<15	<15	<15	<15
H-715	Residence	<15	<15	<15	<15	<15
H-718	Residence	<15	<15	<15	<15	<15
H-724	Residence	<15	<15	<15	<15	<15
H-725	Residence	<15	<15	<15	<15	<15

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-726	Residence	<15	<15	<15	<15	<15
H-731	Residence	<15	<15	<15	<15	<15
H-732	Residence	<15	<15	<15	<15	<15
H-733	Residence	<15	<15	<15	<15	<15
H-734	Residence	<15	<15	<15	<15	<15
H-738	Residence	<15	<15	<15	<15	<15
H-739	Residence	<15	<15	<15	<15	<15
H-740	Residence	<15	<15	<15	<15	<15
H-741	Residence	<15	<15	<15	<15	<15
H-747	Residence	<15	<15	<15	<15	<15
H-750	Residence	<15	<15	<15	<15	<15
H-752	Residence	<15	<15	<15	<15	<15
H-753	Residence	<15	<15	<15	<15	<15
H-754	Residence	<15	<15	<15	<15	<15
H-755	Residence	<15	<15	<15	<15	<15
H-767	Residence	<15	<15	<15	<15	<15
H-772	Residence	<15	<15	<15	<15	<15
H-773	Residence	<15	<15	<15	<15	<15
H-776	Residence	<15	<15	<15	<15	<15
H-777	Residence	<15	<15	<15	<15	<15
H-778	Residence	<15	<15	<15	<15	<15
H-779	Residence	<15	<15	<15	<15	<15
H-780	Residence	<15	<15	<15	<15	<15
H-783	Residence	<15	<15	<15	<15	<15
H-784	Residence	<15	<15	<15	<15	<15
H-785	Residence	<15	<15	<15	<15	<15
H-786	Residence	<15	<15	<15	<15	<15
H-797	Residence	<15	<15	<15	<15	<15
H-798	Residence	<15	<15	<15	<15	<15
H-799	Residence	<15	<15	<15	<15	<15
H-800	Residence	<15	<15	<15	<15	<15
H-801	Residence	<15	<15	<15	<15	<15
H-802	Residence	<15	<15	<15	<15	<15
H-803	Residence	<15	<15	<15	<15	<15
H-804	Residence	<15	<15	<15	<15	<15

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-805	Residence	<15	<15	<15	<15	<15
H-806	Residence	<15	<15	<15	<15	<15
H-807	Residence	<15	<15	<15	<15	<15
H-808	Residence	35	42	39	45	32
H-1067	Residence	40	45	41	49	37
H-1068	Residence	38	44	40	47	35
H-1069	Residence	36	43	40	45	33
H-1070	Residence	42	47	43	52	40
H-1072	Residence	47	50	46	56	44
H-1075	Residence	44	49	45	53	41
H-1185	Residence	33	40	37	43	31
H-1186	Residence	36	42	38	45	33
H-1192	Residence	41	46	42	50	38
H-1195	Residence	36	42	38	45	33
H-1208	Residence	41	46	41	50	38
H-1209	Residence	46	49	44	55	42
H-1291	Residence	<15	<15	<15	<15	<15
H-1303	Residence	<15	<15	<15	<15	<15
H-1304	Residence	<15	<15	<15	<15	<15
H-1305	Residence	16	29	26	28	16
H-1307	Residence	<15	<15	<15	<15	<15
H-1311	Residence	38	43	40	47	35
H-1314	Residence	<15	<15	<15	<15	<15
H-1317	Residence	34	41	37	43	31
H-1321	Residence	35	42	38	44	32
H-1324	Residence	24	34	30	34	21
H-1325	Residence	51	53	50	61	49
H-1326	Residence	32	39	36	42	30
H-1519	Residence	39	45	41	48	36
H-1520	Residence	36	43	40	46	33
H-1523	Residence	37	44	40	47	35
H-1525	Residence	41	46	42	50	38
H-1526	Residence	38	44	40	48	36
H-1527	Residence	56	58	53	65	52
H-1528	Residence	42	47	42	51	39

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-1530	Residence	37	43	39	46	34
H-1531	Residence	37	44	39	47	35
H-1532	Residence	40	46	41	50	38
H-1533	Residence	37	43	39	46	34
H-1535	Residence	45	50	46	55	43
H-1536	Residence	45	49	45	55	42
H-1537	Residence	45	50	45	55	43
H-1538	Residence	42	47	42	51	39
H-1539	Residence	39	45	41	48	36
H-1541	Residence	54	57	53	64	52
H-1542	Residence	38	44	40	48	36
H-1545	Residence	44	49	45	54	42
H-1546	Residence	45	50	46	55	43
H-1548	Residence	56	58	54	65	54
H-1549	Residence	47	50	46	56	44
H-1550	Residence	58	61	54	66	53
H-1551	Residence	47	50	46	56	44
H-1552	Residence	46	50	46	56	44
H-1555	Residence	37	43	39	46	34
H-1557	Residence	51	54	49	60	48
H-1558	Residence	40	45	41	49	37
H-1564	Residence	33	40	37	42	30
H-1662	Residence	53	56	51	62	50
H-1663	Residence	41	45	41	50	37
H-1664	Residence	34	41	37	43	31
H-1682	Residence	36	42	38	46	34
H-1683	Residence	36	42	38	45	33
H-1723	Residence	37	42	38	46	34
H-1724	Residence	33	41	38	43	31
H-1751	Residence	40	45	41	50	37
H-1759	Residence	41	46	41	50	38
H-1765	Residence	36	43	39	45	33
H-1777	Residence	37	42	38	46	34
H-1784	Residence	<15	<15	<15	<15	<15
H-1785	Residence	<15	<15	<15	<15	<15

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-1786	Residence	<15	<15	<15	<15	<15
H-1790	Residence	40	46	42	50	38
H-1791	Residence	41	46	42	50	38
H-1792	Residence	42	47	43	51	39
H-1803	Residence	<15	<15	<15	<15	<15
H-1804	Residence	54	58	52	63	50
H-1805	Residence	41	46	42	50	38
H-1806	Residence	41	47	42	50	38
H-1808	Residence	40	45	40	49	37
H-1809	Residence	41	45	41	50	37
H-1817	Residence	40	45	41	49	37
H-1821	Residence	33	41	37	42	30
H-1822	Residence	32	40	37	42	29
H-1852	Residence	<15	<15	<15	<15	<15
H-1854	Residence	51	54	49	60	48
H-1867	Residence	<15	<15	<15	<15	<15
H-1868	Residence	<15	<15	<15	<15	<15
H-1881	Residence	<15	<15	<15	<15	<15
H-1882	Residence	36	42	39	45	33
H-1896	Residence	<15	<15	<15	<15	<15
H-1897	Residence	<15	<15	<15	<15	<15
H-1898	Residence	<15	<15	<15	<15	<15
H-1904	Residence	<15	<15	<15	<15	<15
H-1905	Residence	<15	<15	<15	<15	<15
H-1909	Residence	23	34	30	34	21
H-1916	Residence	43	47	43	53	41
H-1917	Residence	<15	<15	<15	<15	<15
H-1918	Residence	<15	<15	<15	<15	<15
H-1924	Residence	<15	<15	<15	<15	<15
H-1925	Residence	<15	<15	<15	<15	<15
H-1926	Residence	<15	<15	<15	<15	<15
H-1927	Residence	<15	<15	<15	<15	<15
H-1928	Residence	<15	<15	<15	<15	<15
H-1929	Residence	<15	<15	<15	<15	<15
H-1930	Residence	<15	<15	<15	<15	<15

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-1931	Residence	<15	<15	<15	<15	<15
H-1932	Residence	<15	<15	<15	<15	<15
H-1933	Residence	<15	<15	<15	<15	<15
H-1934	Residence	<15	<15	<15	<15	<15
H-1947	Residence	48	51	47	58	46
H-1948	Residence	47	50	46	57	45
H-1951	Residence	38	43	40	48	36
H-1952	Residence	38	43	40	47	35
H-1954	Residence	34	41	37	44	32
H-1955	Residence	<15	<15	<15	<15	<15
H-1956	Residence	<15	<15	<15	<15	<15
H-1957	Residence	<15	<15	<15	<15	<15
H-1958	Residence	<15	<15	<15	<15	<15
H-1959	Residence	38	44	40	48	35
H-1960	Residence	35	42	38	44	32
H-1961	Residence	34	41	38	43	31
H-1973	Residence	<15	<15	<15	<15	<15
H-1974	Residence	<15	<15	<15	<15	<15
H-1975	Residence	<15	<15	<15	<15	<15
H-1977	Residence	26	35	32	36	23
H-1981	Residence	44	48	44	54	42
H-1983	Residence	49	52	48	58	46
H-1984	Residence	<15	<15	<15	<15	<15
H-1985	Residence	45	49	44	54	42
H-1988	Residence	46	49	45	55	43
H-2002	Residence	35	41	38	44	32
H-2007	Residence	32	39	36	42	30
H-2008	Residence	32	40	36	42	30
H-2018	Residence	34	40	37	43	31
H-2019	Residence	39	44	40	48	36
H-2025	Residence	53	55	51	62	50
H-2030	Residence	34	41	38	44	32
H-2031	Residence	33	41	37	42	30
H-2048	Residence	33	40	36	42	30
H-2050	Residence	42	46	42	51	39

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-2051	Residence	52	55	51	61	49
H-2056	Residence	49	52	47	58	46
H-2057	Residence	47	51	46	56	44
H-2064	Residence	44	48	44	53	41
H-2066	Residence	43	47	43	53	41
H-2120	Residence	40	46	42	50	38
H-2123	Residence	55	57	53	64	52
H-2124	Residence	55	57	53	64	51
H-2125	Residence	56	58	53	65	52
H-2130	Residence	35	42	38	44	32
H-2139	Residence	40	45	42	49	37
H-2230	Residence	<15	<15	<15	<15	<15
H-2286	Residence	35	42	38	45	33
H-2302	Residence	34	42	38	44	32
H-2389	Residence	<15	<15	<15	<15	<15
H-2465	Residence	<15	<15	<15	<15	<15
H-2466	Residence	<15	<15	<15	<15	<15
H-2467	Residence	<15	<15	<15	<15	<15
H-2468	Residence	<15	<15	<15	<15	<15
H-2469	Residence	<15	<15	<15	<15	<15
H-2471	Residence	<15	<15	<15	<15	<15
H-2472	Residence	<15	<15	<15	<15	<15
H-2494	Residence	<15	<15	<15	<15	<15
H-2495	Residence	<15	<15	<15	<15	<15
H-2496	Residence	<15	<15	<15	<15	<15
H-2498	Residence	<15	<15	<15	<15	<15
H-2499	Residence	<15	<15	<15	<15	<15
H-2500	Residence	<15	<15	<15	<15	<15
H-2501	Residence	<15	<15	<15	<15	<15
H-2502	Residence	<15	<15	<15	<15	<15
H-2503	Residence	<15	<15	<15	<15	<15
H-2511	Residence	<15	<15	<15	<15	<15
H-2512	Residence	<15	<15	<15	<15	<15
H-2513	Residence	<15	<15	<15	<15	<15
H-2514	Residence	<15	<15	<15	<15	<15

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-2515	Residence	<15	<15	<15	<15	<15
H-2518	Residence	<15	<15	<15	<15	<15
H-2519	Residence	<15	<15	<15	<15	<15
H-2520	Residence	<15	<15	<15	<15	<15
H-2521	Residence	<15	<15	<15	<15	<15
H-2522	Residence	<15	<15	<15	<15	<15
H-2547	Residence	<15	<15	<15	<15	<15
H-2548	Residence	<15	<15	<15	<15	<15
H-2549	Residence	<15	<15	<15	<15	<15
H-2550	Residence	<15	<15	<15	<15	<15
H-2552	Residence	<15	<15	<15	<15	<15
H-2553	Residence	<15	<15	<15	<15	<15
H-2556	Residence	<15	<15	<15	<15	<15
H-2566	Residence	<15	<15	<15	<15	<15
H-2567	Residence	<15	<15	<15	<15	<15
H-2569	Residence	<15	<15	<15	<15	<15
H-2571	Residence	<15	<15	<15	<15	<15
H-2572	Residence	<15	<15	<15	<15	<15
H-2573	Residence	<15	<15	<15	<15	<15
H-2582	Residence	<15	<15	<15	<15	<15
H-2588	Residence	<15	<15	<15	<15	<15
H-2590	Residence	<15	<15	<15	<15	<15
H-2591	Residence	<15	<15	<15	<15	<15
H-2593	Residence	<15	<15	<15	<15	<15
H-2594	Residence	<15	<15	<15	<15	<15
H-2595	Residence	<15	<15	<15	<15	<15
H-2596	Residence	<15	<15	<15	<15	<15
H-2597	Residence	<15	<15	<15	<15	<15
H-2598	Residence	<15	<15	<15	<15	<15
H-2599	Residence	<15	<15	<15	<15	<15
H-2600	Residence	47	50	46	56	44
H-2601	Residence	<15	<15	<15	<15	<15
H-2602	Residence	<15	<15	<15	<15	<15
H-2603	Residence	<15	<15	<15	<15	<15
H-2605	Residence	<15	<15	<15	<15	<15

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-2606	Residence	<15	<15	<15	<15	<15
H-2607	Residence	<15	<15	<15	<15	<15
H-2608	Residence	<15	<15	<15	<15	<15
H-2609	Residence	<15	<15	<15	<15	<15
H-2622	Residence	<15	<15	<15	<15	<15
H-2623	Residence	<15	<15	<15	<15	<15
H-2624	Residence	<15	<15	<15	<15	<15
H-2625	Residence	<15	<15	<15	<15	<15
H-2626	Residence	<15	<15	<15	<15	<15
H-2634	Residence	<15	<15	<15	<15	<15
H-2643	Residence	<15	<15	<15	<15	<15
H-2644	Residence	<15	<15	<15	<15	<15
H-2645	Residence	<15	<15	<15	<15	<15
H-2646	Residence	<15	<15	<15	<15	<15
H-2647	Residence	<15	<15	<15	<15	<15
H-2648	Residence	<15	<15	<15	<15	<15
H-2649	Residence	38	43	40	47	35
H-2652	Residence	<15	<15	<15	<15	<15
H-2653	Residence	<15	<15	<15	<15	<15
H-2654	Residence	<15	<15	<15	<15	<15
H-2655	Residence	<15	<15	<15	<15	<15
H-2656	Residence	<15	<15	<15	<15	<15
H-2657	Residence	<15	<15	<15	<15	<15
H-2658	Residence	<15	<15	<15	<15	<15
H-2659	Residence	<15	<15	<15	<15	<15
H-2660	Residence	<15	<15	<15	<15	<15
H-2661	Residence	<15	<15	<15	<15	<15
H-2662	Residence	<15	<15	<15	<15	<15
H-2663	Residence	<15	<15	<15	<15	<15
H-2664	Residence	<15	<15	<15	<15	<15
H-2665	Residence	<15	<15	<15	<15	<15
H-2666	Residence	<15	<15	<15	<15	<15
H-2667	Residence	<15	<15	<15	<15	<15
H-2668	Residence	<15	<15	<15	<15	<15
H-2669	Residence	<15	<15	<15	<15	<15

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-2670	Residence	<15	<15	<15	<15	<15
H-2671	Residence	<15	<15	<15	<15	<15
H-2672	Residence	35	42	38	44	32
H-2677	Residence	<15	<15	<15	<15	<15
H-2678	Residence	<15	<15	<15	<15	<15
H-2685	Residence	<15	<15	<15	<15	<15
H-2689	Residence	<15	<15	<15	<15	<15
H-2690	Residence	<15	<15	<15	<15	<15
H-2691	Residence	<15	<15	<15	<15	<15
H-2692	Residence	<15	<15	<15	<15	<15
H-2693	Residence	<15	<15	<15	<15	<15
H-2694	Residence	<15	<15	<15	<15	<15
H-2695	Residence	<15	<15	<15	<15	<15
H-2696	Residence	<15	<15	<15	<15	<15
H-2697	Residence	<15	<15	<15	<15	<15
H-2698	Residence	<15	<15	<15	<15	<15
H-2699	Residence	<15	<15	<15	<15	<15
H-2700	Residence	<15	<15	<15	<15	<15
H-2701	Residence	<15	<15	<15	<15	<15
H-2702	Residence	<15	<15	<15	<15	<15
H-2703	Residence	<15	<15	<15	<15	<15
H-2704	Residence	<15	<15	<15	<15	<15
H-2705	Residence	<15	<15	<15	<15	<15
H-2706	Residence	<15	<15	<15	<15	<15
H-2707	Residence	<15	<15	<15	<15	<15
H-2708	Residence	<15	<15	<15	<15	<15
H-2899	Residence	32	40	37	42	30
H-2910	Residence	<15	<15	<15	<15	<15
H-2911	Residence	<15	<15	<15	<15	<15
H-3001	Residence	32	39	35	41	29
H-3002	Residence	32	39	35	41	29
H-3003	Residence	31	38	34	40	28
H-3004	Residence	31	38	35	41	28
H-3005	Residence	32	39	35	41	29
H-3006	Residence	34	41	36	43	31

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-3007	Residence	35	41	37	44	32
H-3008	Residence	36	42	38	45	33
H-3009	Residence	29	37	33	38	26
H-3010	Residence	24	34	31	34	21
H-3011	Residence	31	38	35	40	28
H-3012	Residence	34	40	36	43	31
H-3013	Residence	34	40	36	43	31
H-3014	Residence	35	41	37	44	32
H-3015	Residence	38	44	39	47	35
H-3016	Residence	40	45	41	50	37
H-3017	Residence	41	46	41	50	38
H-3019	Residence	32	40	36	42	30
H-3020	Residence	40	45	41	49	37
H-3021	Residence	35	42	38	44	32
H-3022	Residence	34	42	38	44	32
H-3023	Residence	37	44	40	47	34
H-3024	Residence	37	44	40	47	35
H-3025	Residence	39	45	41	48	36
H-3026	Residence	41	46	42	50	38
H-3027	Residence	35	42	38	45	32
H-3028	Residence	33	41	37	43	31
H-3029	Residence	37	43	39	46	34
H-3030	Residence	29	39	36	40	27
H-3031	Residence	33	41	37	43	31
H-3032	Residence	34	42	38	44	32
H-3033	Residence	38	44	40	47	35
H-3034	Residence	36	43	39	46	34
H-3035	Residence	30	39	35	40	27
H-3036	Residence	31	39	36	40	28
H-3037	Residence	31	39	35	41	28
H-3038	Residence	32	39	36	42	30
H-3039	Residence	29	37	34	38	26
H-3040	Residence	30	38	35	40	28
H-3041	Residence	31	39	35	41	29
H-3042	Residence	33	40	36	43	31

Receiver	Description	Phase 1: Site Preparation	Phase 2: Civil Work	Phase 3: Mechanical Assembly		Phase 4: Electrical Work
				No Pile Driving	With Pile Driving	
H-3043	Residence	33	40	36	42	30
H-3044	Residence	29	38	35	40	27
H-3045	Residence	28	38	35	39	26
H-3046	Residence	29	38	35	39	26
H-3047	Residence	38	44	40	47	35
H-3048	Residence	36	43	39	46	33
H-3049	Residence	31	40	36	41	28
H-3050	Residence	31	39	36	41	28
H-3051	Residence	44	49	43	52	41
H-3052	Residence	43	48	43	52	40
H-3053	Residence	41	47	41	50	38
H-3054	Residence	40	46	40	49	37
H-3055	Residence	37	43	39	46	34
H-3056	Residence	35	41	37	44	32
H-3057	Residence	34	41	37	43	31
H-3058	Residence	30	39	35	40	27
H-3059	Residence	28	38	34	38	25
H-3060	Residence	30	38	34	39	27
H-3061	Residence	43	47	44	53	41
H-13	School	<15	<15	<15	<15	<15
H-14	School	<15	<15	<15	<15	<15
H-2371	Church	41	46	42	50	38
H-2122	Cemetery	45	50	45	55	43
H-2132	Cemetery	45	50	45	55	43

Appendix B: Predicted Operational Noise Levels

Table B-1. Predicted Operational Noise Levels

Receptor	Description	Noise Level (dBA)	Receptor	Description	Noise Level (dBA)
H-11	Residence	9	H-752	Residence	8
H-12	Residence	0	H-753	Residence	10
H-47	Residence	35	H-754	Residence	8
H-48	Residence	34	H-755	Residence	11
H-70	Residence	36	H-767	Residence	10
H-74	Residence	34	H-772	Residence	10
H-87	Residence	37	H-773	Residence	10
H-88	Residence	36	H-776	Residence	12
H-117	Residence	34	H-777	Residence	12
H-346	Residence	11	H-778	Residence	11
H-347	Residence	11	H-779	Residence	8
H-357	Residence	11	H-780	Residence	10
H-420	Residence	33	H-783	Residence	12
H-448	Residence	30	H-784	Residence	12
H-449	Residence	29	H-785	Residence	11
H-461	Residence	28	H-786	Residence	10
H-501	Residence	21	H-797	Residence	10
H-645	Residence	37	H-798	Residence	10
H-673	Residence	11	H-799	Residence	10
H-674	Residence	33	H-800	Residence	12
H-680	Residence	11	H-801	Residence	11
H-682	Residence	40	H-802	Residence	10
H-689	Residence	10	H-803	Residence	10
H-695	Residence	10	H-804	Residence	10
H-696	Residence	10	H-805	Residence	9
H-697	Residence	10	H-806	Residence	9
H-698	Residence	8	H-807	Residence	8
H-713	Residence	9	H-808	Residence	32
H-714	Residence	10	H-1067	Residence	31
H-715	Residence	6	H-1068	Residence	27
H-718	Residence	10	H-1069	Residence	34
H-724	Residence	11	H-1070	Residence	32
H-725	Residence	10	H-1072	Residence	36
H-726	Residence	10	H-1075	Residence	34
H-731	Residence	12	H-1185	Residence	30
H-732	Residence	12	H-1186	Residence	31
H-733	Residence	8	H-1192	Residence	44
H-734	Residence	8	H-1195	Residence	29
H-738	Residence	8	H-1208	Residence	34
H-739	Residence	8	H-1209	Residence	35
H-740	Residence	10	H-1291	Residence	10
H-741	Residence	11	H-1303	Residence	11
H-747	Residence	10	H-1304	Residence	12
H-750	Residence	10	H-1305	Residence	16

Receptor	Description	Noise Level (dBA)
H-1307	Residence	8
H-1311	Residence	31
H-1314	Residence	13
H-1317	Residence	28
H-1321	Residence	31
H-1324	Residence	21
H-1325	Residence	39
H-1326	Residence	27
H-1519	Residence	38
H-1520	Residence	35
H-1523	Residence	27
H-1525	Residence	29
H-1526	Residence	28
H-1527	Residence	43
H-1528	Residence	29
H-1530	Residence	31
H-1531	Residence	28
H-1532	Residence	29
H-1533	Residence	31
H-1535	Residence	36
H-1536	Residence	42
H-1537	Residence	32
H-1538	Residence	31
H-1539	Residence	31
H-1541	Residence	38
H-1542	Residence	31
H-1545	Residence	33
H-1546	Residence	33
H-1548	Residence	42
H-1549	Residence	35
H-1550	Residence	38
H-1551	Residence	36
H-1552	Residence	37
H-1555	Residence	27
H-1557	Residence	43
H-1558	Residence	29
H-1564	Residence	29
H-1662	Residence	38
H-1663	Residence	31
H-1664	Residence	31
H-1682	Residence	31
H-1683	Residence	31
H-1723	Residence	31
H-1724	Residence	38

Receptor	Description	Noise Level (dBA)
H-1751	Residence	33
H-1759	Residence	32
H-1765	Residence	40
H-1777	Residence	30
H-1784	Residence	12
H-1785	Residence	11
H-1786	Residence	11
H-1790	Residence	41
H-1791	Residence	40
H-1792	Residence	41
H-1803	Residence	11
H-1804	Residence	38
H-1805	Residence	42
H-1806	Residence	43
H-1808	Residence	33
H-1809	Residence	33
H-1817	Residence	31
H-1821	Residence	29
H-1822	Residence	29
H-1852	Residence	11
H-1854	Residence	38
H-1867	Residence	10
H-1868	Residence	11
H-1881	Residence	11
H-1882	Residence	36
H-1896	Residence	10
H-1897	Residence	10
H-1898	Residence	10
H-1904	Residence	9
H-1905	Residence	11
H-1909	Residence	22
H-1916	Residence	35
H-1917	Residence	10
H-1918	Residence	10
H-1924	Residence	10
H-1925	Residence	8
H-1926	Residence	8
H-1927	Residence	8
H-1928	Residence	8
H-1929	Residence	10
H-1930	Residence	10
H-1931	Residence	10
H-1932	Residence	9
H-1933	Residence	9

Receptor	Description	Noise Level (dBA)
H-1934	Residence	10
H-1947	Residence	37
H-1948	Residence	37
H-1951	Residence	31
H-1952	Residence	31
H-1954	Residence	28
H-1955	Residence	10
H-1956	Residence	10
H-1957	Residence	11
H-1958	Residence	11
H-1959	Residence	39
H-1960	Residence	32
H-1961	Residence	31
H-1973	Residence	11
H-1974	Residence	11
H-1975	Residence	10
H-1977	Residence	22
H-1981	Residence	34
H-1983	Residence	37
H-1984	Residence	11
H-1985	Residence	35
H-1988	Residence	39
H-2002	Residence	29
H-2007	Residence	27
H-2008	Residence	32
H-2018	Residence	29
H-2019	Residence	35
H-2025	Residence	40
H-2030	Residence	30
H-2031	Residence	30
H-2048	Residence	28
H-2050	Residence	38
H-2051	Residence	44
H-2056	Residence	41
H-2057	Residence	41
H-2064	Residence	44
H-2066	Residence	35
H-2120	Residence	30
H-2123	Residence	43
H-2124	Residence	43
H-2125	Residence	43
H-2130	Residence	28
H-2139	Residence	30
H-2230	Residence	0

Receptor	Description	Noise Level (dBA)
H-2286	Residence	30
H-2302	Residence	40
H-2389	Residence	14
H-2465	Residence	10
H-2466	Residence	13
H-2467	Residence	13
H-2468	Residence	13
H-2469	Residence	10
H-2471	Residence	10
H-2472	Residence	10
H-2494	Residence	9
H-2495	Residence	9
H-2496	Residence	10
H-2498	Residence	11
H-2499	Residence	8
H-2500	Residence	8
H-2501	Residence	8
H-2502	Residence	8
H-2503	Residence	8
H-2511	Residence	6
H-2512	Residence	6
H-2513	Residence	6
H-2514	Residence	8
H-2515	Residence	10
H-2518	Residence	10
H-2519	Residence	6
H-2520	Residence	10
H-2521	Residence	11
H-2522	Residence	10
H-2547	Residence	11
H-2548	Residence	11
H-2549	Residence	10
H-2550	Residence	10
H-2552	Residence	11
H-2553	Residence	9
H-2556	Residence	8
H-2566	Residence	10
H-2567	Residence	10
H-2569	Residence	8
H-2571	Residence	8
H-2572	Residence	6
H-2573	Residence	7
H-2582	Residence	8
H-2588	Residence	12

Receptor	Description	Noise Level (dBA)
H-2590	Residence	10
H-2591	Residence	10
H-2593	Residence	10
H-2594	Residence	10
H-2595	Residence	9
H-2596	Residence	10
H-2597	Residence	10
H-2598	Residence	11
H-2599	Residence	12
H-2600	Residence	36
H-2601	Residence	9
H-2602	Residence	9
H-2603	Residence	8
H-2605	Residence	12
H-2606	Residence	13
H-2607	Residence	8
H-2608	Residence	8
H-2609	Residence	8
H-2622	Residence	13
H-2623	Residence	6
H-2624	Residence	8
H-2625	Residence	13
H-2626	Residence	13
H-2634	Residence	12
H-2643	Residence	10
H-2644	Residence	10
H-2645	Residence	10
H-2646	Residence	10
H-2647	Residence	10
H-2648	Residence	10
H-2649	Residence	31
H-2652	Residence	8
H-2653	Residence	9
H-2654	Residence	9
H-2655	Residence	9
H-2656	Residence	10
H-2657	Residence	10
H-2658	Residence	9
H-2659	Residence	9
H-2660	Residence	9
H-2661	Residence	10
H-2662	Residence	10
H-2663	Residence	10
H-2664	Residence	10

Receptor	Description	Noise Level (dBA)
H-2665	Residence	10
H-2666	Residence	12
H-2667	Residence	14
H-2668	Residence	10
H-2669	Residence	10
H-2670	Residence	10
H-2671	Residence	13
H-2672	Residence	32
H-2677	Residence	13
H-2678	Residence	10
H-2685	Residence	11
H-2689	Residence	10
H-2690	Residence	10
H-2691	Residence	10
H-2692	Residence	11
H-2693	Residence	11
H-2694	Residence	11
H-2695	Residence	12
H-2696	Residence	11
H-2697	Residence	11
H-2698	Residence	11
H-2699	Residence	10
H-2700	Residence	10
H-2701	Residence	10
H-2702	Residence	10
H-2703	Residence	10
H-2704	Residence	10
H-2705	Residence	8
H-2706	Residence	11
H-2707	Residence	10
H-2708	Residence	10
H-2899	Residence	29
H-2910	Residence	9
H-2911	Residence	10
H-3001	Residence	26
H-3002	Residence	26
H-3003	Residence	23
H-3004	Residence	24
H-3005	Residence	24
H-3006	Residence	26
H-3007	Residence	27
H-3008	Residence	27
H-3009	Residence	21
H-3010	Residence	16

Receptor	Description	Noise Level (dBA)
H-3011	Residence	23
H-3012	Residence	25
H-3013	Residence	25
H-3014	Residence	26
H-3015	Residence	28
H-3016	Residence	30
H-3017	Residence	30
H-3019	Residence	25
H-3020	Residence	31
H-3021	Residence	28
H-3022	Residence	28
H-3023	Residence	31
H-3024	Residence	31
H-3025	Residence	35
H-3026	Residence	37
H-3027	Residence	27
H-3028	Residence	25
H-3029	Residence	27
H-3030	Residence	21
H-3031	Residence	25
H-3032	Residence	25
H-3033	Residence	27
H-3034	Residence	26
H-3035	Residence	26
H-3036	Residence	27
H-3037	Residence	27
H-3038	Residence	27
H-3039	Residence	24
H-3040	Residence	25
H-3041	Residence	26
H-3042	Residence	27
H-3043	Residence	27
H-3044	Residence	22
H-3045	Residence	21
H-3046	Residence	21
H-3047	Residence	29
H-3048	Residence	26
H-3049	Residence	22
H-3050	Residence	22
H-3051	Residence	37
H-3052	Residence	36
H-3053	Residence	35
H-3054	Residence	34
H-3055	Residence	31

Receptor	Description	Noise Level (dBA)
H-3056	Residence	29
H-3057	Residence	28
H-3058	Residence	22
H-3059	Residence	21
H-3060	Residence	26
H-3061	Residence	32
H-13	School	11
H-14	School	12
H-2371	Church	42
H-2122	Cemetery	32
H-2132	Cemetery	32