Condition Evaluation of In-Service Chemically Stabilized Subgrades in a High Sulfate Environment

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16. Abstract
This project included measurements of strength properties, soil properties, and chemical content of natural and chemically stabilized subgrade soil from five projects across Ohio, three from sites that have historically had high sulfate content, and two that have not. The objective was to compare the properties of the soils from the sites and determine if there were crystals of ettringite or thaumasite in the soil, which would indicate potential for heaving.

Site testing included PSPA, FWD, LWD, DCP, SPT, an informal distress survey, and collection of soil specimens for laboratory analysis, which included standard soils tests (Grain size, Atterberg limits, organic content, moisture content, pH, and sulfate content as determined in Ohio Supplement 1122), and chemistry analysis comprising neutralization potential, and X-ray diffraction.

In the control sections, measured sulfate levels were low in the natural subgrade and higher in the stabilized subgrade but still below the criterion of concern at 3000 ppm. In the high sulfate sections, natural subgrade had still higher sulfate content, but still usually below 3000 ppm, while the stabilized subgrade generally had content above 3000 ppm, but no more than 6500 ppm to 9500 ppm depending on the site. However, the X-ray diffraction found no measurable quantity of ettringite or thaumasite crystals, indicating that conditions for formation were not met at any of the sites. The pH of stabilized soil at all locations was just above 10, which was one condition that was met. None of the pavements showed any signs of damage due to sulfate heaving. The continued practice of global stabilization of subgrade soil is recommended. The undercut section on LAK-2 showed less variability than the other section, and this approach may be considered where cost effective.

17. Key Words
Chemical stabilization of subgrade, lime stabilization, cement stabilization, sulfate-rich soils, ettringite, thaumasite

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(°F-32)/9 or (°F-32)/1.8	Celsius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2 or psi	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8°C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2 or psi

* SI is the symbol for the International Symbol of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

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Jen Bowman and Nora Sullivan helped with the chemical and X-ray diffraction testing and analysis. Josh Jordan assisted with specimen collection and other field work. Kamran Majidzadeh oversaw the efforts of subcontractor Resource International, Inc. (Rii), which included FWD and LWD measurements, soil specimen collection, and soil laboratory tests.

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1 Project Background

ODOT sponsored research projects performed by Chou [2004] and Sargand et al. [2014] validated the long term performance of stabilized subgrade and developed pavement thickness design input values and procedures for stabilized subgrade as well as granular base layer. As a result, the Ohio Department of Transportation (ODOT) Office of Pavement Engineering (OPE) revised their design procedure to consider the structural contribution of stabilized subgrade and base, resulting in a reduction in the thickness of designed pavements.

However, during construction of stabilized subgrade, ODOT has encountered soils with high levels of sulfates. Cement used for stabilization reacts with the sulfates leading to a decrease in ride quality and premature pavement cracking. To address the sulfate issue, the ODOT Office of Geotechnical Engineering (OGE) has updated the Specifications for Geotechnical Explorations Section 602 to require visual inspection of proposed subgrade soil for gypsum crystals and Section 603.7 to require determination of sulfate content using the colorimetric method described in Supplement 1122 [ODOT, 2016] and updated in Geotechnical Bulletin GB-1 [ODOT OGE, 2016] to provide guidance for testing for sulfates in subgrade soils and use of stabilization when sulfate levels exceed 3000 ppm.

The effect of sulfate concentration on the engineering properties of the soil is not clearly understood. This project evaluates the effect of high levels of sulfate concentration on the physical and mineral properties of stabilized soil at selected sites in Ohio.

2 Objectives

The objectives of this project include:

1. Obtain samples of chemically stabilized and natural subgrade soil at sites with high and low sulfate content.
2. Determine the mineral and physical properties of these soils.
3. Analyze ODOT-provided data in conjunction with laboratory test results and identify problems in the subgrades.

3 Synthesis of Current Practice

Lime and Portland cement are commonly used to stabilize fine-grained soil prior to the construction of pavement. Stabilization of the subgrade improves the stiffness, strength, and uniformity of the soil. Studies have also shown treated subgrade in Ohio is durable and can be considered in the thickness design of the pavement [Sargand et al., 2014].

However, premature pavement distress can occur if the subgrade soil contains soluble sulfates. Calcium in the lime and cement react with free alumina and the sulfates in the soil to form ettringite and thaumasite. The ettringite expands when hydrated [Anand et al., 2004]. This leads to heaving which reduces ride quality and can even cause premature cracking of the pavement.

Initial research into the mechanism of sulfate-induced heaving found the problem typically occurred within 6 months of construction and was a function of the pH, temperature, availability of water, percent clay-size particles in the native soil, and ion mobility [Hunter, 1988]. Hunter [1988] found heaving will occur when sulfate content is at least 1% (10,000 ppm), clay content is at least 10%, and the soil is frequently saturated.

Rollings et al. [1999] identified two possible mechanisms for sulfate attack of cement stabilized soils. Type 1 is where the cement hydration provides the calcium and alumina to react with sulfates, and Type 2 is where the clay minerals in the soil provide the alumina to react with the sulfates. Mitigation methods provided by Rollings et al. include the use of sulfate-resistant cement (Type II or Type V) when alumina is not present in the clay; or the addition of ground granulated blast furnace slag and/or fly ash [Rollings et al., 1999].

In 2000, the National Lime Association published a Technical Memorandum to provide guidelines for lime stabilization of soils in Texas containing sulfates [National Lime Association, 2000]. A mitigation technique presented in the memorandum is to allow the formation of the ettringite prior to placement and compaction by providing a mellowing period, up to 7 days, while providing adequate water, after mixing the lime with the soil. The memorandum establishes soluble sulfates concentration criteria [National Lime Association, 2000].

- For soils with sulfate levels below 3000 ppm, there should be no concern. Lime slurry is recommended if any sulfates are detected.
- When soluble sulfate levels are between 3000 ppm and 5000 ppm, the risk is moderate. Good mix design and construction techniques are recommended. Lime slurry and mixing water 3% to 5% above optimal for construction, and a mellowing period of at least 72 hours are recommended.
- When soluble sulfate levels are between 5000 ppm and 8000 ppm, the risk is moderate to high. The procedures for the moderate risk soils are recommended. Laboratory testing for swell potential is also recommended.
- When soluble sulfate levels are greater than 8000 ppm, the risk is too high for routine work. Soil should only be stabilized by a contractor experienced in treatment of high sulfate soils. The mellowing period may be as long as 7 days.
- When soluble sulfate levels are greater than 10,000 ppm, the soil is generally not suitable for lime stabilization.

In addition to mellowing the mix, mitigation techniques presented in the memorandum include blending soils with seams of high concentration of sulfates to reduce the overall concentration and progressive, or double application, of lime.

Aldaood, Bouasaker, and Al-Muhktar [2014] examined the free-swell potential of lime-treated fine-grained soils with gypsum content of 0%, 5%, 15%, and 25% using porosimetry, X-ray diffraction, and scanning electron microscopy. They concluded that wetting-drying cycles increased the swell potential of the soils enough to mitigate the benefits of the lime treatment, so consequently they state lime treatment may be effective only in soils where the gypsum content is 5% or less.

The Texas Department of Transportation has sponsored extensive research on stabilization of soils containing sulfates. Puppala et al. [2004] studied the effectiveness of using Type I/II and V sulfate resistant cements to treat soils containing sulfates. Four soils with concentrations of soluble sulfate in the ranges <1000 ppm, 1000 to 2000 ppm, 2000 to 5000 ppm, and >5000 ppm were evaluated in the laboratory to determine the effect of Type I/II and Type V cement stabilization on strength, stiffness, swell, and linear shrinkage strain. Puppala et al. [2004] concluded "… both cement Types I/II and V improved both physical properties by reducing plasticity index values and engineering characteristics by enhancing unconfined compressive strength and stiffness properties and by decreasing free vertical swell strain and linear shrinkage strain potentials of sulfate rich soils." The most effective cement content was about 10%, with low and high sulfate-resistant cement types having statistically similar performance.

Harris et al. [2004] conducted a laboratory study to determine the sulfate content at which the soil can be treated with lime without detrimental effects and to evaluate the effectiveness of extended mellowing, double lime application and increased field moisture content. Lab swell tests were conducted on a soil sample modified to have a sulfate content of 0, 1000, 3000, 5000, 7000, and 12000 ppm. The researchers concluded [Harris et al., 2004]:

- For a typical east Texas soils, the sulfate cutoff for traditional lime stabilization is 3000 ppm.
- A mellowing period up to 3 days after lime application is effective for sulfate concentrations up to 7000 ppm.
- Mellowing of 3 days at 2% above optimal moisture and 6% lime did not result in acceptable swell with 10,000 ppm sulfates.
- Using a moisture content above optimum results in lower swell due to a combination of lower compaction density and faster removal/reaction of sulfates.

Chen, Harris, Scullion, and Bilyeu [2005] reported on a forensic investigation of sulfate heaving on a Texas pavement, which they found was due to ettringite formation. The conditions required for the formation of ettringite are a pH>10, the presence of water, and available aluminum, sulfur, and calcium. Lime and cement can increase the pH to as high as 12, dissolving clay and releasing aluminum, at which point the presence of water is sufficient to form ettringite. They noted conductivity of soil is dependent on the presence of salts, including sulfates, thus a high conductivity reading in soil is an indication that further lab testing is warranted to determine if sulfates are present. Another recommendation is to inspect the soil for visible signs of shiny glassy crystals of gypsum and/or sulfates.

Si [2008] performed another forensic study of pavement heaving in Texas, on US Route 287. Samples on the northbound side had sulfate content of 35,000 ppm (high) and the southbound side had 6800 ppm (moderate). Samples were soaked for ten days and tested for swelling and various soil characteristics. The effects of several treatments were tested. For the high sulfate soil, treatment with a lime and fly ash mixture gave best results, while for the moderate sulfate soil, best results were obtained with a mixture of lime and slag.

In 2005, the Texas Department of Transportation developed guidelines for the treatment of sulfate rich soils [Texas DOT, 2005]. The manual discusses the causes of sulfate heave, presents a method to assess risk, presents best practices for testing for sulfates and constructing a stabilized subgrade, and discusses alternatives for situations where the sulfate level is too high for stabilization. Texas DOT has developed a conductivity test procedure to determine sampling locations in the field, Tex-146-E, and a lab procedure, Tex-145-E, using the colorimetric method, to determine sulfate concentration. This sulfate concentration is used in the flow chart in Figure 1 to select a treatment method [Texas DOT, 2005]. The Veris 3150 soil mapping system is also being employed to evaluate soil conductivity on a construction project [Izzo, 2014].

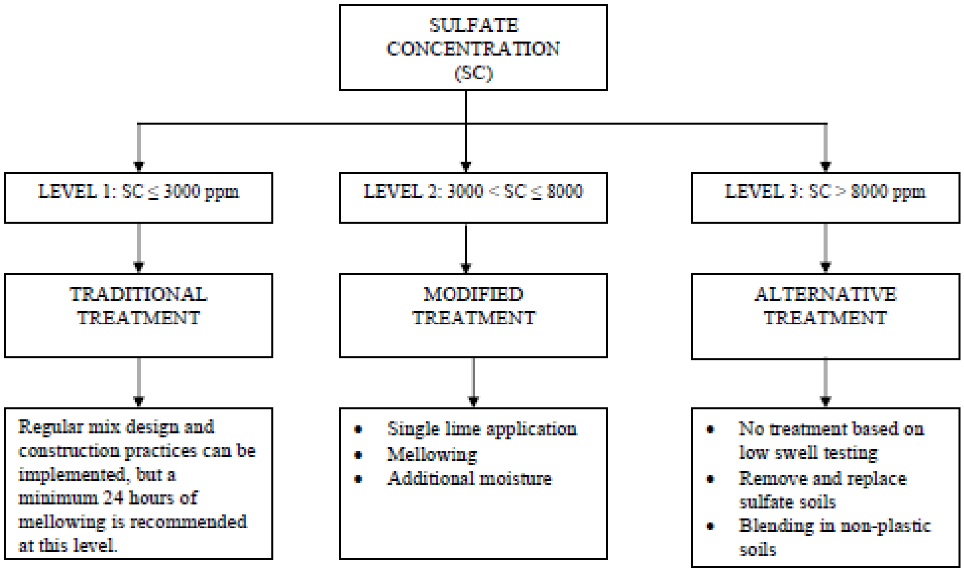


Figure 1. Texas DOT [2005] decision tree to determine type of treatment for varying sulfate content.

Harris et al. [2006] investigated use of stabilizers for soils with sulfate concentrations greater than 7000 ppm. The researchers evaluated nine non-calcium based and three modified calcium based stabilizers. For the soils tested, the calcium based modifier (lime) modified with ground granulated blast furnace slag performed better in terms of swell, strength gain, and permanency of stabilization. Studies in the United Kingdom also found ground granulated blast furnace slag was effective in reducing heave [Higgins, 2005].

Knopp and Moorman [2016] examined the formation of ettrringite and thaumasite crystals in subgrade soils with sulfates. Soils with clay content below 10% and sulfate content above 10,000 ppm may experience swelling–induced heave when water dissolves the sulfates and pH>10. They also note ettringite forms at temperatures between 15°C (59°F) and 20°C (68°F), while thaumasite forms at temperatures below 10°C (50°F). Powder swelling testing on laboratory specimens found burnt lime caused more heaving than cement when sulfate content exceeded 5000 ppm. However, the influence of determining factors could not be investigated and was left to future research.

Celik and Nalbantoglu [2013] looked at the laboratory properties of lime-treated soils with sulfate content of 2000 ppm. 5000 ppm. 10,000 ppm. The 5000 ppm and 10,000 ppm soils showed swelling and the presence of ettringite. However, adding 6% ground granulated blast furnace slag reduced the swell potential of the 10,000 ppm soil from 8% to 1%, and completely eliminated signs of swelling in the 5000 ppm soil.

Little, Nair, and Herbert [2010] point out the formation of ettringite need not occur rapidly, depending on the conditions. One countermeasure is to use as much water as possible during construction dissolve (or "solubilize") sulfates and uniformly distribute nucleation sites. They also note swelling from ettringite is due to both the formation of the crystals and the absorption of water in the crystals.

An assessment of sulfates in Ohio soils was performed and reported by Cutright et al. and by Kevin Freese at the University of Akron [Cutright et. al., 2015; Freese, 2014]. Sources of sulfates in Ohio soils were investigated by performing a literature search and testing soil provided by ODOT and its consultants. 350 soils from 39 counties were assessed. Three areas in Ohio were identified where sulfate in the soil was not random; Lake County, Paulding and Defiance Counties, and Morrow County. Defiance County had the most samples with sulfate content above 5000 ppm (moderate) and even 8000 ppm (unacceptable). It was determined the sources of sulfate were both natural and anthropogenic. A full laboratory analysis is recommended rather than field screening when shale may be present, because the pyrites in shale can oxidize and form sulfates. The Tex-145-E test method is recommended to determine sulfate content before stabilization, and soils with high or excessive sulfate contents should also be subjected to swell tests. Another recommendation is to map sulfate test results to potential sources, such as certain bedrocks, using bedrock maps.

Two national studies addressing stabilization of high sulfate soils have been completed. Little and Nair [2009] developed recommended practices for stabilization of sulfate rich soils under NCHRP project 20-07. The report discusses sources of sulfates in soil, ettringite formation, techniques for treating sulfate rich soils, and sulfate concentration determination. Anand Puppala developed a sensor based on bender element and time domain reflectometry technology to quickly assess sulfate heaving in stabilized soils containing sulfates. The sensor, developed with support from the Transportation Research Board (TRB) Innovation Deserving Exploratory Analysis Programs (IDEA) evaluates heave by measuring changes in moisture and stiffness [Puppala, 2013].

4 Method

4.1 Field Sampling and Testing

ODOT identified five projects for evaluation in this project:

- CLA-70-13.98, PID 84664
- CLI-73-6.52, PID 78571
- LAK-2-7.76, PID 79545
- MRW-71-3.17, PID 86920
- PAU/DEF-24-12.30/0.00, PID 24336, Project 07-778

Their locations are shown on the map in Figure 2. CLA-70-13.98 and CLI-73-6.52 were sections where ODOT has no record of high sulfate soils and served as "control" sections for this study. ODOT found high sulfate (>8000 ppm) soils on LAK-2-7.76, MRW-71-3.17, and PAU/DEF-24-12.30/0.00. ODOT provided the research team with qualitative pavement data for each site. PAU/DEF-24-12.30 was a rigid pavement, the others were flexible. It should be noted the LAK-2-7.76 site consisted of two segments on the westbound direction. The segment from Station 729+00 to 738+00 was built on the natural in-situ subgrade with cement stabilization, similar to the other sites, while the segment from Station 746+50 to 751+00 was built with an undercut backfilled with granular material, representing an alternative method to prepare soft and/or wet subgrade for construction of new pavement. The soil profile developed from the original geotechnical exploration, test and design data available for the sites, and historic ride quality in the form of International Roughness Index (IRI) were provided by the Office of Geotechnical Engineering (OGE). Table 1 has the design thicknesses taken from the plans and the soil classifications taken from the Resource International (Rii) characterizations of specimens.

The IRI and sulfate test data provided by OGE were used to identify areas likely to have premature deterioration. The IRI records contained readings representing ride quality for every 0.1 mi (0.16 km) of road. The Pathway Viewer was used to view images collected by ODOT of the roadway segments to determine if there was any pavement distress.

The research team compared and contrasted the data provided by ODOT and the data to select uniform 500 ft (153 m) to 1000 ft (305 m) sections on each project for further evaluation. The research team did not observe pavement distress indicative of subgrade swelling, such as heaving, on any of the projects. Sections with relatively high IRI values from areas with marginal or high sulfate levels were selected for further evaluation; control sections from projects that had no history of sulfate issues were also selected based on having relatively high IRI. High IRI in these cases means higher than the remainder of the project in the data provided by ODOT.

Hereafter these five project sites will be identified by their county abbreviation and route number: CLA-70, CLI-73, LAK-2, MRW-71, and DEF-24 (the segment studied was in Defiance County).

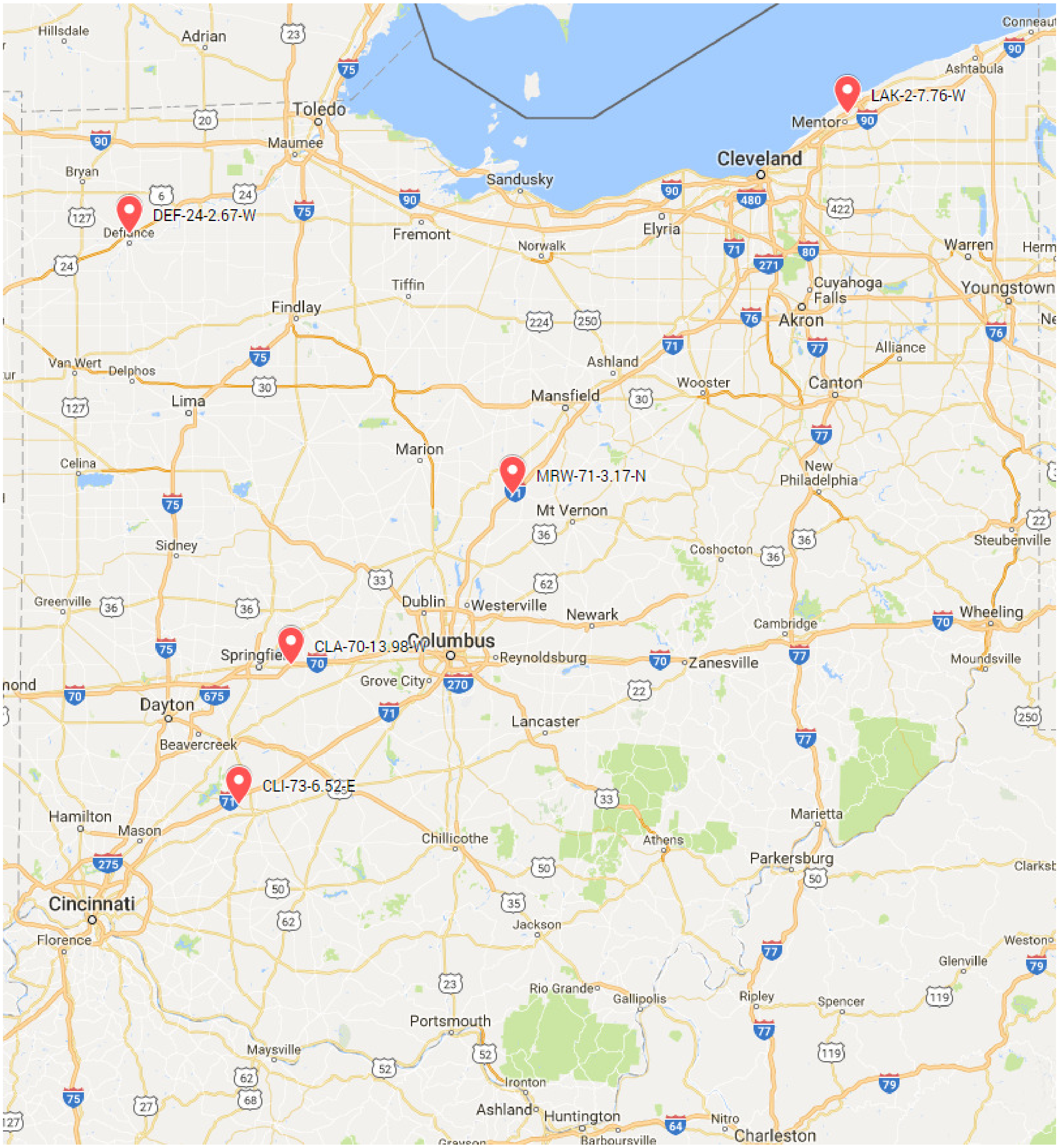


Figure 2. Locations of sites selected for this study.

Table 1. Thickness design of study sections and observed soil characteristics.

		Pavement				Base				Stabilized subgrade			
Project	Pavement Type	ODOT Item	Depth (in (mm))	ODOT Item	Depth (in (mm))	ODOT Item	Depth (in (mm))	ODOT Item	Depth (in (mm))	ODOT Item	Depth (in (mm))	Stabilized subgrade classification	Natural subgrade classification
CLA-70	AC	442 surface course	1.5 (38)	442 intermediate course	1.75 (44)	302 asphalt base	10.5 (267)	304 aggregate base	6 (152)	206 cement stabilized subgrade	12 (305	A-1b, A-2-4, A-1a, A-4a, A-6a	A-4a, A-6b
CLI-73	AC	880 asphalt pavement (7 yr warranty)					11 (279)	304 aggregate base	6 (152)	206 cement stabilized subgrade	16 (406)	A-4a, A-3a, A-6a	A-6a, A-6b, A-7-6
DEF-24	PCC	884 concrete pavement (7 year warranty)					12.5 (318)	304 aggregate base	6 (152)	206 lime stabilized subgrade	16 (406)	A-1b, A-6a, A-7-5, A-2-7, A-7-6, A-2-5, A-6b	A-7-6, A-2-5, A-6b
LAK-2	AC	442 surface course	1.5 (38)	442 intermediate course	1.75 (44)	302 asphalt base	10 (254)	304 aggregate base	6 (152)	206 cement stabilized subgrade	12 (305)	A-3a, A-4a	A-6a, A-4a, A-3a (undercut A-6a)
MRW-71	AC	442 surface course	1.5 (38)	442 intermediate course	1.75 (44)	302 asphalt base	11 (279)	304 aggregate base	6 (152)	206 cement stabilized subgrade	12 (305)	A-1a, A-2-4, A-1b, A-2-6, A-4a	A-4a, A-6a

4.1.1 Selection of Sampling Locations

On each project, ten locations, typically evenly spaced at 100 ft (30.5 m), were identified by GPS coordinates. The Portable Seismic Properties Analyzer (PSPA) was operated to obtain surface wave velocity, followed by deflection readings collected using the FWD. At this point a 6 in (150 mm) pavement core sample was collected, and then the dynamic cone penetrometer (DCP) test was conducted and split-spoon samples of the granular base, stabilized, and untreated soil layers obtained. At one location per project, a 16 in (406 mm) diameter core was taken, and LWD testing performed by Resource International (Rii) on the aggregate base and stabilized subgrade before the DCP measurement and soil sample collection; the exception was LAK-2, where permit restrictions prevented the drilling of a 16 in (406 mm) core. All pavement core holes and borings were backfilled in accordance with ODOT's Specifications for Geotechnical Exploration. More detailed descriptions of each test method follow.

4.1.2 Portable Seismic Pavement Analyzer Testing

The Portable Seismic Properties Analyzer (PSPA) by Geomedia, shown in Figure 3, is a nondestructive pavement testing device that uses seismic waves to determine the modulus of pavement layers. The device applies a small vibration wave to the pavement, which is detected by the device's sensors/receivers after traveling through the pavement medium. Knowing pavement material constants and distances between PSPA receivers, material moduli were determined using standard wave equations and wave arrival time. The test was repeated at each location until three consistent readings were recorded and determined to be free of vibration interference from passing traffic. The PSPA data were used by Ohio University to determine surface layer modulus and reduce variables in the analysis of FWD data, following the approach utilized previously by Sargand et al. [2014].

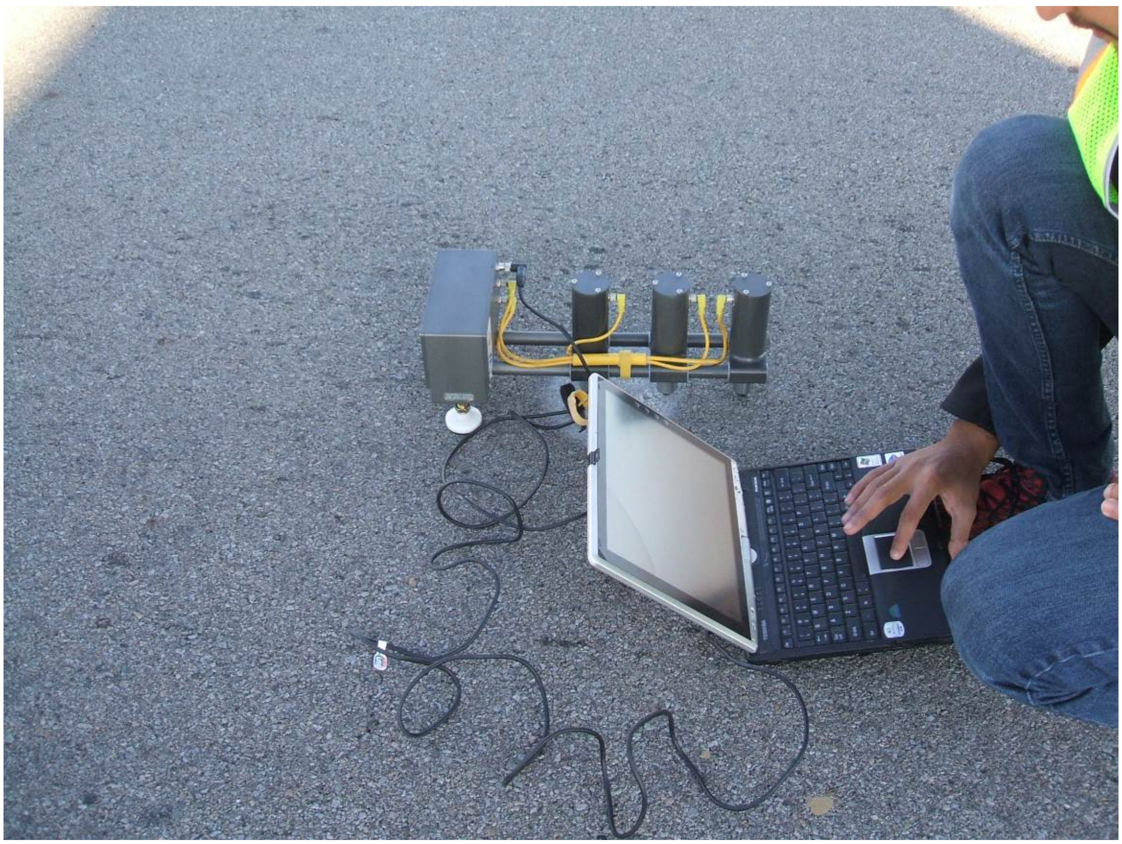


Figure 3. PSPA in operation.

4.1.3 FWD/LWD Testing

Falling Weight Deflectometer (FWD) tests were performed at each of the five project sites after the PSPA and prior to drilling cores. The FWD used was a JILS Model 20HF FWD, depicted in Figure 4. The data from the FWD test are used to back-calculate the moduli of the pavement and underlying layers of base, stabilized subgrade, and natural subgrade. The FWD testing was performed by the subcontractor Resource International (Rii) following ODOT procedures. The FWD device dropped a sequence of loads of approximately 9000 lb (40 kN), 12,000 lb (53 kN), 15,000 lb (67 kN) which mimic the impact of a moving truck wheel on the surface of the pavement. Deflection responses were recorded by the geophones on the FWD and stored in the on-board data collection system for later analysis. Deflections due to this impulse load were recorded in mils (1 mil = 25.4 µm) by 9 geophones positioned at the following distances from the drop point: 0 in (0 mm), 8 in (203 mm), 12 in (305 mm), -12 in (-305 mm), 18 in (457 mm), 24 in (610 mm), 36 in (914 mm), 48 in (1220 mm), and 60 in (1520 mm). To determine the modulus, the readings of the geophones at 12 in (305 mm), -12 in (-305 mm) were averaged and that at 18 in (457 mm) not used.

In addition, Rii cored one 16 in (406 mm) diameter hole and performed lightweight deflectometer (LWD) testing on the aggregate base to establish a composite modulus value for the aggregate base, stabilized subgrade, and natural subgrade. These values were used to confirm the FWD analysis of the pavement. The LWD in use is shown in Figure 5.

Figure 4. FWD trailer on site.

Figure 5. LWD testing on aggregate base through 16 in (406 mm) core hole.

4.1.4 DCP Testing

After FWD testing was complete, a drill rig, shown in Figure 6, was used extract a 6 in (152 mm)) diameter pavement core and allow access for further tests. The first test in the hole was the Dynamic Cone Penetration (DCP) test, shown in Figure 7, which started at the top of the aggregate base layer. The DCP used a 17.6 lb (8 kg) weight falling 2.26 ft (575 mm) to drive a metal rod with a removable cone tip into the soil. The number of blows and the distance the rod traveled were measured using a string potentiometer and sensors monitored by a computer which recorded the data for later analysis. The known height and weight enables the computer to calculate the amount of energy driving the rod. The DCP machine was attached to a trailer pulled by a pickup truck. Once the DCP was properly aligned over the core hole, the trailer was leveled and the cone tipped metal rod lowered into the hole. The device stops lowering the rod when the cone contacts the surface of the soil or base. The computer software would then control the lifting and release of the weight to drive the rod into the soil and record data. The DCP testing penetrated a minimum of 24 in (610 mm) to 36 in (910 mm) into the stabilized subgrade and extended at least 12 in (305 mm) further into the natural subgrade soil to create a complete soil profile. If the DCP could not penetrate to the full depth (termed a "refusal"), the material was augured to loosen the base or subgrade at the refusal point, and a second attempt was made to take a reading in the original hole, or a second hole was drilled nearby and the DCP data collected from the second hole. The data collected were used to calculate moduli of the soil layers and determine their thicknesses, following the procedure described in Wu and Sargand [2007] to filter, smooth, and analyze the data. The layer thicknesses are important in conjunction with the FWD data to determine the modulus of the pavement.

Figure 6. Drilling a 6 in (152 mm) core specimen.

Figure 7. Dynamic Cone Penetrometer (DCP) testing.

4.1.5 Soil sampling

The boring locations were determined by Ohio University personnel and located in the field by Rii personnel. During the field reconnaissance, Rii personnel documented the existing site conditions and mapped all boring locations. Rii utilized a handheld GPS unit to obtain northing and easting coordinates at the boring locations.

The borings were drilled using a truck-mounted rotary drilling machine, utilizing a 4.5-in (115 mm) outside diameter continuous flight auger to advance the holes. Standard penetration testing (SPT) and split spoon sampling were performed at continuous increments to boring termination depths. The SPT, per the American Society for Testing and Materials (ASTM) designation D1586, is conducted using a 140-lb (623 N) hammer free falling 30 in (760 mm) to drive a 2.0-in (51 mm) outside diameter split spoon sampler 18 in (457 mm). Rii utilized a calibrated automatic drop hammer to generate consistent energy transfer to the sampler. Driving resistance is recorded on the boring logs in terms of blows per 6.0-in (150 mm) interval of the driving distance. The second and third intervals are added to obtain the number of blows per foot (N). SPT blow counts aid in estimating soil characteristics used to calculate bearing capacities and settlement potential. Measured blow count (Nm) values are corrected to an equivalent (60%) energy ratio (N60) by the following equation. Both values are represented on boring logs presented in the Appendices

.

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

Where:

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

The hammers for the CME-55 and Mobile B-53 drill rig used for this project were calibrated on September 22, 2016 and have drill rod energy ratio of 85.9% and 77.9% respectively.

Hand penetrometer readings, which provide a rough estimate of the unconfined compressive strength of the soil, were reported on the boring logs in units of tons per square foot (tsf, 1 tsf = 96 kPa) and were utilized to classify the consistency of the cohesive soil in each layer. An indirect estimate of the unconfined compressive strength of the cohesive split spoon samples can be made from a correlation with the blow counts (N_{60}). Please note that split spoon samples are considered to be disturbed and the laboratory determination of their shear strengths may vary from the shear strength in undisturbed conditions.

Upon completion of drilling, the borings were backfilled with the mixture of bentonite chips and soil cuttings generated during the drilling process. Where borings penetrated existing paved surfaces, the borings were patched with equivalent thickness DOT-approved fast-set concrete.

During drilling, field personnel prepared field logs showing the encountered subsurface conditions. Soil samples obtained from the drilling operation were preserved in sealed glass jars and delivered to the soil laboratory. Field personnel identified the extent of the chemically stabilized layer by applying a phenolphthalein solution to the split spoon samples at each location.

4.1.6 SPT

The Standard Penetration Test (SPT) was performed at each sampling location to obtain soil samples for lab testing. After the pavement was cored and the DCP test performed, the drill rig truck positioned the SPT apparatus over the hole, as shown in Figure 8. The SPT hammer would then lower the split spoon into the hole and the test would start at the top of the base layer. The hammer then drove the split spoon into the soil and the number of blows was recorded per 6 in (150 mm). Once the split spoon was driven approximately 18 in (450 mm), the test was ended and the soil was removed and retained for laboratory analysis. The split spoon was then repositioned in the hole and the test repeated to obtain a total of 3 ft (0.9 m) of soil, penetrating a minimum of 12 in (0.3 m) into the natural soil. The number of blows measured is used to determine the N60 which can be used to calculate mechanical properties of the soil.

Figure 8. Preparing for SPT testing in foreground, DCP testing and coring in background.

4.2 Soils Laboratory Testing Methods

4.2.1 Grain Size Analysis

Testing method ASTM D422 was used as the standard test method for the particle size analysis of each soil sample. A sieve analysis was performed for particles larger than 75 µm (3 mil), and a sedimentation process was used for particles smaller than 75 µm (3 mil) which required the use of a hydrometer and a dispersing agent, either sodium hexametaphosphate or sodium metaphosphate.

The sieving of the larger particles was performed using an automatic shaker. After shaking, the material remaining in each sieve was weighed individually to obtain the amount of soil retained. The retained mass on each sieve was used to create the gradation curve.

The hydrometer was then used for the finer grained soils that passed the No. 200 (3 mil or 75 µm) sieve. A sample of approximately 50-100 g (1.75 – 3.5 oz) air dry material was placed in a 250 mL (8 fl oz) beaker. 125 mL (4 fl oz) of dispersant solution was added and the specimen stirred until the soil was completely wet. The specimen was left to sit for at least 16 hours, after which some distilled water was added and the slurry stirred for 1 minute to complete the dispersion process. Immediately afterwards the mixture was transferred to a glass sedimentation cylinder and more distilled water was added to increase the total volume to 1000 mL (34 fl oz). A rubber stopper was then placed in the top of the cylinder and the cylinder was turned upside down and back for one minute. After this agitation of the slurry, hydrometer readings were taken at intervals of 2, 5, 30, 60, 250, and 1440 minutes.

4.2.2 Atterberg Limit Analysis

The Liquid Limit (LL) was calculated based on AASHTO Standard Test Method T89, while the Plastic Limit (PL) and Plasticity Index (PI) were determined following AASHTO Standard Test Method T90.

For the LL test, a 50 g (1.76 oz) sample was placed in a dish with 8 ml (0.27 fl oz) to 10 ml (0.34 fl oz) of distilled water and thoroughly mixed through stirring, kneading, and chopping with a spatula. More water may be added to obtain a consistency close to that of peanut butter. The soil was then transferred to the falling cup device and smoothed into the cup. Once a consistent thickness was achieved, a grooving tool was used to create a small trench in the soil dividing the soil within the cup by about 0.5 in (13 mm). The device was then turned on to lift and drop the cup and the number of cycles to close the gap was recorded. The soil was then returned to the mixing dish and the test was performed again without adding any water. If the closure occurred within 2 shocks of the first, then a portion of the sample within the falling cup was taken to determine the moisture content. The LL was then calculated based on the equation below where *w* was moisture content and *N* was number of cycles. The *LL* is reported as a percentage to the nearest whole number.

$$LL = w * (\frac{N}{25})^{0.121}$$

The PL test, as specified in AASHTO T90, was performed with approximately 20g (0.7 oz) of the soil that passed through the No. 40 sieve. The sample was then mixed with distilled water until it was easily worked into a ball without sticking to the fingers. Then an 8 g (0.28 oz) portion was separated from the ball for the test. The 8g (0.28 oz) test sample was formed into an ellipsoidal shape and cut into 2 g (0.07 oz) portions. One of these portions was then rolled by hand on a glass plate into a uniform cylindrical thread about $^1/_8$ in (3.2 mm) diameter. The cylinder was cut into six smaller pieces which were squeezed back together and rolled back into a thread about $^1/_8$ in (3.2 mm) diameter. This was repeated until the thread began to crumble before reaching the $^1/_8$ in (3.2 mm) diameter. At this point the crumbling thread of soil was placed into a container and the moisture content determined. This procedure was repeated using further 2 g (0.07 oz) portions of soil until the whole 8 g (0.28 oz) sample was finished. The Plastic Limit (*PL*) was the percent moisture as calculated with the following equation where *B* is mass of original sample in grams, and *C* is mass of the dry sample in grams. The *PL* is rounded to the nearest whole number and reported as a percent. A soil is non-plastic when the PL is equal to or greater than the LL or when either the LL or PL cannot be determined.

$$PL = 100 * (B-C)/C$$

With the *LL* and *PL* are calculated, the *PI* may be computed by taking the difference.

$$PI = LL - PL$$

4.2.3 Loss by Ignition (LBI) or Organic Content

Organic content testing was performed only on samples visually determined to be weak or suspected to contain organic material. The organic content of the soil was determined using test standard ASTM D2974. The soil was placed into a porcelain dish and the mass of the soil was obtained to the nearest 0.01 g (0.00035 oz). The dish was kept covered with aluminum foil until it was placed into the muffle furnace. The temperature in the furnace was then gradually increased to 440°C (824°F) and held there until the sample had completely turned to ash and no more change in mass was noticeable from further heating. The ash was then covered and placed into a desiccator to cool, at which point the mass of the ash was measured. The percent ash content D was computed using the first equation below, where E is the mass of the ash, and F is the mass of the oven dried sample. The percent Organic Matter was then determined by subtracting the percent ash content from 100, as in the second equation below.

$$D = 100 * E/F$$

$$\textit{Organic Matter} = 100 - D$$

4.2.4 pH Testing

ASTM Standard Test Method D4972 was used to determine the pH of the soil, following Method A, which calls for the use of a potentiometer equipped with a glass-calomel electrode system. The test required the pH of the soil be tested in distilled water and a 0.01M calcium chloride solution. The air-dried soil sample was first passed through a No. 10 sieve to remove coarse grain soil. Then, 10 g (0.35 oz) of the sample was placed into a glass container and 10mL of distilled water was added and the sample mixed thoroughly. After 1 hour of settling, the pH was measured with the pH meter. Then, another 10 g (0.35 oz) of the original sample was obtained and placed into a second glass container. This time, 10ml (0.34 fl oz) of the 0.01 M calcium chloride solution was added and the sample mixed thoroughly. After a 1 hour wait, the pH of the second sample was measured with the pH meter. Both pH measurements were conducted at room temperature, which was also recorded.

4.2.5 Moisture Content

Moisture content was determined in accordance with ASTM Standard D2216. A specimen was selected to represent the whole sample taken from the field. It was placed into a container with known mass. The container and sample was then weighed and placed in the oven to dry. The oven was kept at a temperature of approximately 110°C (230°F). The sample was then dried until there was no change in mass from further heating. The container and dry sample was then weighed again and recorded. The same scale was used throughout the test. The moisture content was then calculated using the following equation where w is the moisture content, M_{cws} is the mass of the container and wet sample, M_{cds} is the mass of the container and dry sample, and M_c is the mass of the empty container.

$$w = \frac{M_{cws} - M_{cds}}{M_{cds} - M_c} * 100$$

4.2.6 Sulfate Content

Sulfate content in split spoon samples was determined using the colorimetric method in ODOT Supplement 1122, “Determining Sulfate Content In Soils” and that of Sobek et al. [2000.

4.3 Chemical Laboratory Analysis Method

Laboratory analysis was conducted to determine sulfate content and neutralization potential (NP) of all soils, following methods developed by Lawrence and Wang [1997, see also Coastech Research, 1991]. Soluble sulfate content was determined following method Tex-145-E. Methods were tested and modified for samples collected for this project (i.e. strength of NaOH, sample size, dilution, etc.). NP was measured in addition to sulfate following methods developed to characterize mine waste as a simple method for determining the availability of carbonate and hydroxide minerals that may a) react with sulfate minerals naturally to form gypsum or ettringite, b) provide carbonate ions that may drive thaumasite formation, or c) provide additional calcium for ettringite formation.

Dried, desiccated soil samples were prepared by passing first through a #2 (50 mm) sieve, then a #40 (0.425 mm) sieve, to obtain a 30 g (1 oz) pulverized sample.

Neutralization potential (NP) was determined by following the Lawrence modified acid base accounting method [Lawrence and Wang, 1997]. A fizz rating was determined by adding a few drops of 25% HCl to 1-2 g (0.035 – 0.07 oz) of sample, and recording strength of reaction. 90 mL of distilled water and 2 g (0.07 oz) of prepared sample were added to an Erlenmeyer flask, and placed on a shaker plate. The appropriate volume of 1 N HCl was determined based on the strength of the fizz rating and was added at 0 and 2 hours. Samples were left to agitate for 20 hours. At 20 hours, a pH reading was taken and a measured volume of 1 N HCl was pipetted into the sample at 2 hr intervals until the pH stabilized between 2 and 2.5. Shaking was terminated upon stabilization. Distilled water was added to bring the total volume to approximately 125 mL (4 fl oz), and pH was verified to be within range. Using 1.6 N NaOH, the sample was titrated to pH 8.3 with a HACH digital titrator. The titrator reading was multiplied by the titrator volume per unit of 0.00125 mL (4×10^{-6} fl oz) to obtain total NaOH volume. Modified NP (kg $CaCO_3$/mt) was calculated using the following equation.

$$NP = \frac{[N \times \text{vol (mL) HCl}] - [N \times \text{vol (mL)NaOH}) \times 50]}{\text{mass of sample (g)}}$$

To analyze for sulfate content following Tex-145-E, 20 g (0.7 oz) of dried desiccated sample was mixed with 400 mL (13.5 fl oz) distilled water in a 500 mL (16.9 fl oz) HDPE sample bottle. Sample were shaken by hand for 1 minute, then left to equilibrate for a period of 18-24 hours. At the end of the equilibration period, bottles were again hand shaken for 1 minute, then filtered using a 0.45 µm (1.8 mil) glass filter. The filtrate was then tested for sulfate content using a HACH 3900 colorimeter using method 8051 (USEPA Sulfaver 4 Method). Using a clean pipette, 10 mL (0.34 fl oz) of filtrate was added to four sample vials for colorimeter analysis. Three readings were taken per sample and the average calculated. If needed, samples were diluted to remain within the detection limits of method 8051 (2 – 70 mg/L (0.00027-0.0093 oz/gal)).

Acid generating potential (AP), which creates equivalent units to NP, was calculated using the following equation, where S is the sulfate content.

$$AP = S \times 31.25$$

4.4 X-ray diffraction

All soil samples were analyzed using the Ohio University Center for Electrochemical Engineering Research Rigaku Ultima IV X-Ray diffraction system (XRD). XRD can detect crystalline mineral forms occurring in the soils. This method cannot determine the content of amorphous fractions of the soil samples. Dried, dessicated samples were analyzed and the resulting diffraction peak shapes were analyzed for mineral content using PDXL software. Due to the complex mineralogy of the samples, peaks were matched by hand for the following minerals:

- Quartz
- Gypsum
- Calcite
- Dolomite
- Ettringite
- Thaumasite
- Portlandite

Automatic peak matching was used to determine if other crystalline mineral forms dominated any samples.

4.5 Scanning Electron Microscope

This analysis was not performed because no crystals of ettringite or thaumasite were found in any of the collected specimens.

5 Results and Discussion

5.1 Pavement condition

The chemical reaction between the sulfates and calcium based stabilizers can result in subgrade swelling as ettringite is formed. The resulting vertical heave and cracking are typical observed distresses which occur during or shortly after construction [Harris et al, 2005]. The heaving and cracking should also result in a decrease in ride quality, IRI.

No damage of the type associated with swelling was found at the test sites. The only site on which a formal distress survey was performed was LAK-2 westbound, where cracks were counted on both sections (stabilized and undercut) for comparison of the undercut method and stabilization.

A pavement distress survey was conducted while the section was closed for testing and material sampling on June 6, 2017. Observed distresses include single longitudinal cracking

(Figure 9), multiple longitudinal cracking (Figure 10) and transverse cracking (Figure 11). The measured distresses are summarized in Table 2.

Figure 9. LAK-2 WB lane undercut section looking west at a single longitudinal crack.

Figure 10. LAK-2 WB lane stabilized section looking east at multiple longitudinal cracks.

Figure 11. LAK-2 WB lane stabilized section looking north at transverse crack.

Table 2. Lengths and types of cracks observed on LAK-2 WB.

	begin station	end station	Total length of cracks (ft)			Total length of cracks (m)		
			longitudinal		transverse	longitudinal		transverse
			single	multiple	single	single	multiple	single
stabilized	728+00	729+00		24			7.3	
	729+00	730+00	12	12	12	3.7	3.7	3.7
	731+00	732+00		17	18		5.2	5.5
	732+00	733+00		118			36.0	
	733+00	734+00						
	734+00	735+00			12			3.7
	735+00	736+00						
	736+00	737+00						
	737+00	738+00						
undercut, backfilled with granular material	746+50	747+00						
	747+00	747+50		25			7.6	
	747+50	748+00		25			7.6	
	748+00	748+50						
	748+50	749+00		15			4.6	
	749+00	749+50						
	749+50	750+00						
	750+00	750+50						
	750+50	751+00						

The distress was more extensive in the stabilized section from the beginning station, 728+00, to a construction joint in the surface course at approximately station 734+50 (Figure 12) beyond which, as can be seen in Table 2, the extent of cracking noticeably decreased. Modulus values back-calculated from FWD measurements and measured pavement core thickness indicated the section is structurally sound. Therefore, the cracking is likely top down cracking and is related to the surface mix, not the subgrade treatment. Permit limitations prevented additional coring to verify this conclusion.

Figure 12. LAK-2 WB lane stabilized section looking north at construction joint.

5.1.1 Pavement Roughness

Box plots for International Roughness Index (IRI) for all projects are presented in Figure 13. Segments of length 0.10 mi (0.16 km) containing bridges were removed from the data. The bottom and top of the box represent the 1st and 3rd quartiles, respectively. The line inside the box represents the median value and the diamond inside the box represents the mean value. The two lines extending from the box represent values outside the 1st and 3rd quartiles and the horizontal bars on the end of the vertical lines represent the minimum and maximum values. Box plots are useful for determining the spread and skew of the data. The plots can be used to identify outliers for removal from data analysis. When comparing materials, if the boxes do not overlap, there is a difference in ride quality. If the boxes overlap, but do not include both medians, there is likely a difference in ride quality. If the boxes overlap and include both medians, both materials are considered to have the same ride quality. Therefore, the following can be concluded from the box plot analysis of the ride quality data:

- The CLA-70 and MRW-71 sections have the same ride quality.
- The CLI-73, LAK-2 stabilized, and LAK-2 undercut sections have the same ride quality.
- The ride quality of CLA-70 and MRW-71 are likely different from the ride quality of CLI-73 and both sections on LAK-2.
- The ride quality of DEF-24 is different from those of CLA-70, CLI-73, and both sections of LAK-2.
- Of the sections evaluated, CLA-70 and MRW-71 have the best ride quality, followed by CLI-73 and LAK-2, with DEF-24 having the worst ride quality.

An IRI less than or equal to 170 in/mi (2.68 m/km) is considered "acceptable" whereas an IRI less than 95 in/mi (1.50 m/km) is considered good [FHWA, 2014]. All pavements evaluated still had an acceptable ride on average. The section on DEF-24 was the only pavement which did not have a "good" ride quality. This section was the oldest section in the study. The project for DEF-24 sold in 2007 whereas the projects for CLI-73, CLA-70, LAK-2, and MRW-71 sold in 2009, 2010, 2010, and 2013, respectively. This section was also the only concrete section in the study. Asphalt sections typically have a better initial ride quality since they are constructed with multiple lifts, providing the opportunity to improve ride quality with each lift.

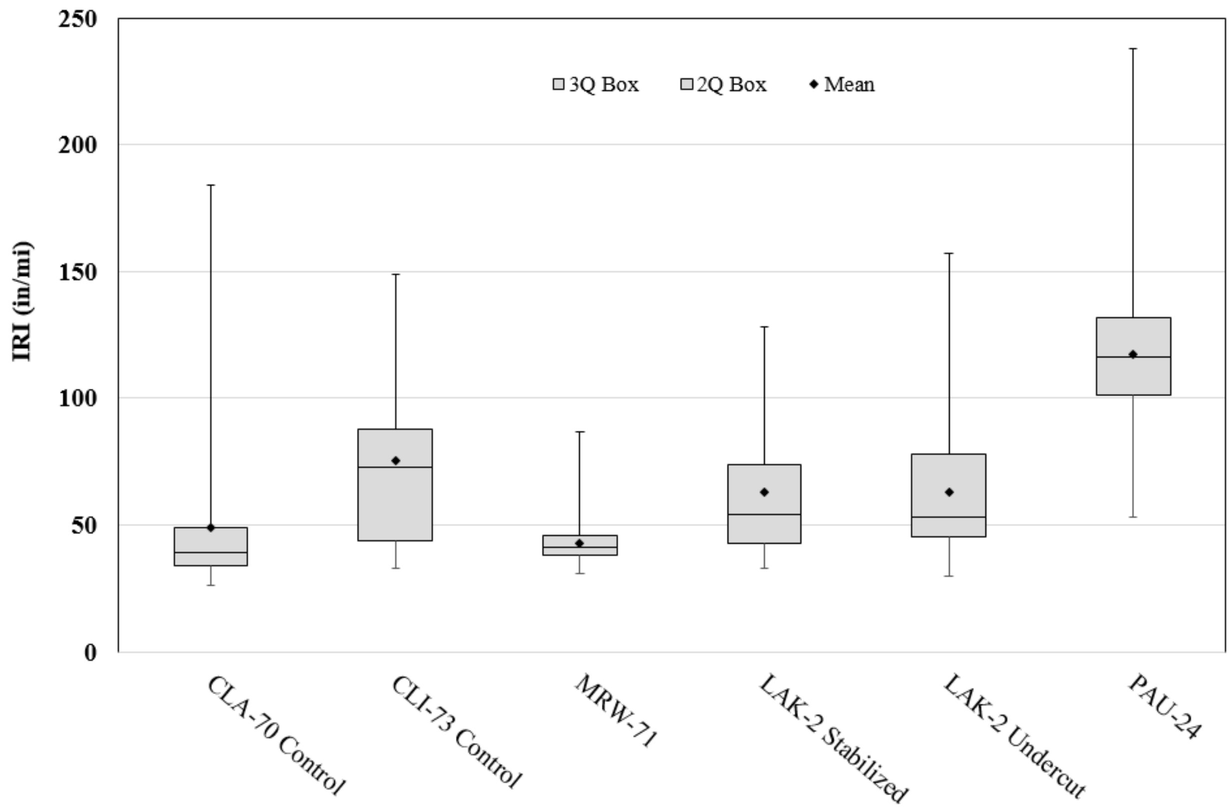


Figure 13. Box plot of IRI measurements for each pavement in this project. (1 in/mi = 0.0158 m/km)

5.2 Modulus/Stiffness

5.2.1 PSPA modulus of pavement layers

The PSPA was used to measure the seismic modulus of the pavement at each site. The average and standard deviation of the seismic modulus from each site are summarized in Table 3 below. The modulus values determined from the PSPA data were used to fix the surface modulus during back-calculation of moduli of other layers using FWD data. Note there are twice as many measurements on LAK-2-7.76 than on the other sites because there were two test sections. The PSPA data for the two have been merged because the pavement layers are the same. More detailed results from PSPA measurements are provided in Appendix A.

Table 3. Seismic modulus of pavement at each project site as determined by PSPA.

			Seismic Modulus					Temperature			
			Average		Std. Dev.		COV	Average		Std. Dev.	
Site	Pavement	N	(ksi)	(MPa)	(ksi)	(MPa)	(%)	(°F)	(°C)	(°F)	(°C)
CLA-70-13.98W	AC	10	2664	386	104	15	3.90%	47.4	8.6	0.8	0.4
CLI-73-6.25E	AC	10	2614	379	297	43	11.36%	42.8	6.0	2.4	1.3
DEF-24-2.67W	PCC	10	5100	740	607	88	11.90%	32.1	0.1	0.2	0.1
LAK-2-7.76W	AC	20	2349	341	304	44	12.94%	61.0	16.1	3.8	2.1
MRW-71-3.17N	AC	10	2477	359	244	35	9.85%	34.3	1.3	2.3	1.3

5.2.2 DCP

The Dynamic Cone Penetration (DCP) test data were analyzed and the moduli of the aggregate base, stabilized subgrade, and natural subgrade layers were calculated. The California Bearing Ratio (CBR) value of each layer was calculated from the DCP field data using the following equation.

$$CBR = \frac{292}{DCP^{1.12}}$$

Where the DCP is the index number in mm/blow. Once the CBR was determined, the modulus of the soil could be calculated by multiplying the CBR by 1200. The modulus was calculated for each blow, and then the average was taken to determine the modulus for the whole layer.

Similar to the results from the FWD, the variability of each bore hole was analyzed, therefore the modulus of each layer was determined for each hole at each of the five project sites. Unlike the FWD results, the modulus of the aggregate base is sometimes lower than the modulus of the stabilized subgrade. This is due to the DCP test starting directly on the aggregate base layer as exposed after collecting the pavement core. Therefore, in this test, the aggregate base is no longer confined between the pavement layer and the stabilized layer; the confinement increases the modulus of the base. The DCP cannot be used to analyze the pavement layer, but it can be used to compare the base and subgrade layers to the FWD calculations.

As determined by the DCP, the base layer had an average modulus of around 100 ksi (650 MPa) with the greatest in MRW-71 at 129 ksi (838 MPa). However, the base layer modulus from LAK-2 was calculated as 38 ksi (252 MPa), which is the lowest of the five sites. The results of the DCP calculations can be seen in Table 4 through Table 9. More detailed results from DCP measurements are provided in Appendix B.

Table 4. Aggregate Base and Soil Resilient Modulus Determined from DCP Data, CLA-70-13.98.

CLA-70-13.98-W								
Hole	Station	Resilient Modulus (ksi)			Resilient Modulus (MPa)			Notes
		Aggregate Base	Stabilized Subgrade	Natural Subgrade	Aggregate Base	Stabilized Subgrade	Natural Subgrade	
1	959+00	105	236	-	725	1625	-	5.321" (135.2 mm) Refusal
	959+00	-	124	61	-	855	423	13" (330 mm) of 304 & SS Removed
2	958+00	151	235	-	1043	1623	-	5.213" (132.4 mm) Refusal
	958+00	-	72	29	-	496	199	16.25" (413 mm) of 304 & SS Removed
3	957+00	142	179	-	977	1233	-	7.532" (191.3 mm) Refusal
	956+98	-	-	40	-	-	273	14.75" (375 mm) of 304 & SS Removed
4	956+00	131	243	-	900	1679	-	5.986" (152.0 mm) Refusal
5	955+00	118	235	-	812	1618	-	5.465" (138.8 mm) Refusal
	954+98	-	118	31	-	811	212	18.85" (479 mm) of 304 & SS Removed
6	954+00	112	227	50	771	1565	341	Full Depth
7	953+00	135	245	-	929	1691	-	5.519" (140.2 mm) Refusal
	952+98	-	95	38	-	656	265	18.17" (462 mm) of 304 & SS Removed
8	952+00	137	224	62	945	1543	430	Full Depth
9	951+00	83	192	-	575	1323	-	3.919" (99.5 mm) Refusal
10	950+00	77	231	-	530	1594	-	6.328" (160.7 mm) Refusal
Average		119	190	44	773	1232	288	
Std. Dev.		25	61	14	171	423	95	

Table 5. Aggregate Base and Soil Resilient Modulus Determined from DCP Data, CLI-73-6.52.

CLI-73-6.52-E							
		Resilient Modulus (ksi)			Resilient Modulus (MPa)		
Hole	Station	Aggregate Base	Stabilized Subgrade	Natural Subgrade	Aggregate Base	Stabilized Subgrade	Natural Subgrade
1	396+60	114	127	24	786	876	165
2	370+60	50	104	38	345	717	262
3	371+60	94	141	-	648	972	-
4	372+60	58	70	13	400	483	90
5	373+60	103	82	91	710	565	627
6	374+60	25	30	16	172	207	110
7	375+60	68	78	19	469	538	131
8	376+60	106	75	15	731	517	103
9	378+60	107	110	20	738	758	138
10	378+89	37	34	9	255	234	62
Average		76	85	27	495	553	177
Std. Dev.		33	36	25	225	251	174

Table 6. Aggregate Base and Soil Resilient Modulus Determined from DCP Data, DEF-24-2.67.

DEF-24-2.67-W							
		Resilient Modulus (ksi)			Resilient Modulus (ksi)		
Hole	Station	Aggregate Base	Stabilized Subgrade	Natural Subgrade	Aggregate Base	Stabilized Subgrade	Natural Subgrade
1	1863+80	88	124	40	607	855	276
2	1862+80	158	219	22	1089	1510	152
3	1861+80	122	96	15	841	662	103
4	1860+80	*	101	17	*	699	116
5	1859+80	141	95	14	972	655	97
6	1858+80	172	114	10	1186	786	69
7	1857+80	49	141	20	338	972	138
8	1856+80	39	114	13	269	786	90
9	1855+80	57	169	18	393	1165	124
10	1854+80	21	163	22	145	1124	152
Average		94	134	19	611	868	124
Std. Dev.		56	40	8	385	275	57
*Base did not record							

Table 7. Aggregate Base and Soil Resilient Modulus Determined from DCP Data, LAK-2-7.76 Undercut Section.

LAK-2-7.76 Undercut Section							
		Resilient Modulus (ksi)			Resilient Modulus (MPa)		
Hole	Station	Aggregate Base	Undercut Subgrade	Natural Subgrade	Aggregate Base	Undercut Subgrade	Natural Subgrade
1	751+00	49	60	14	336	412	97
2	750+50	49	221	23	337	1522	159
3	750+00	36	210	35	246	1445	239
4	749+50	47	201	27	322	1383	188
5	749+00	60	216	24	411	1487	167
6	748+50	44	192	31	301	1320	212
7	748+00	49	214	14	338	1473	99
8	747+50	53	197	184	365	1359	1269
9	747+00	47	206	27	324	1418	185
10	746+50	54	230	32	374	1583	222
Average		49	194	41	316	1262	267
Std. Dev.		6	49	51	44	335	349

Table 8. Aggregate Base and Soil Resilient Modulus Determined from DCP Data, LAK-2-7.76 Stabilized Section.

LAK-2-7.76 Stabilized Section							
		Resilient Modulus (ksi)			Resilient Modulus (MPa)		
Hole	Station	Aggregate Base	Stabilized Subgrade	Natural Subgrade	Aggregate Base	Stabilized Subgrade	Natural Subgrade
11	738+00	51	211	31	351	1456	216
12	737+00	47	237	31	325	1634	211
13	736+00	34	173	24	236	1189	166
14	735+00	37	188	35	252	1294	244
15	743+00	38	236	38	265	1625	259
16	733+00	46	240	36	316	1658	252
17	732+00	33	217	27	225	1493	187
18	731+00	43	217	23	297	1495	159
19	730+00	33	31	31	225	211	211
20	729+00	26	26	26	183	177	177
Average		39	177	30	252	1152	196
Std. Dev.		8	82	5	53	562	36

Table 9. Aggregate Base and Soil Resilient Modulus Determined from DCP Data, MRW-71-3.17.

MRW-71-3.17-N							
		Resilient Modulus (ksi)			Resilient Modulus (MPa)		
Hole	Station	Aggregate Base	Stabilized Subgrade	Natural Subgrade	Aggregate Base	Stabilized Subgrade	Natural Subgrade
1	285+12	180	101	23	1241	695	159
2	286+12	171	137	15	1176	943	100
3	287+12	177	148	53	1220	1020	365
4	288+12	162	139	32	1117	958	221
5	289+12	90	156	52	621	1076	359
6	290+12	79	70	45	546	483	310
7	291+12	143	126	27	983	869	188
8	292+12	98	157	35	676	1082	241
9	293+12	108	98	9	744	673	59
10	294+12	84	93	46	579	641	317
Average		129	122	34	838	795	218
Std. Dev.		41	30	15	285	208	106

The DCP was also used to measure the thickness of subsurface layers in each bore hole, following the method of Sargand and Wu [2007]; pavement thicknesses were measured manually from the extracted cores. Table 10 compares the average measured ("Installed") pavement thicknesses and compared with the design thicknesses obtained from project plans. Of the four AC pavements, two were overbuilt thicker than the design, and two were underbuilt. On average there was 3% overbuild. The one PCC section had nearly 13% overbuild. Table 11 compares the thickness of the ODOT Item 304 aggregate base layer at each site. The design thickness at each site was 6 in (152 mm), while the installed thickness ranged from 4.76 in (120.9 mm) (20.67% low) to 7.03 in (178.6 mm) (17.17% high). On average there was 3.73% overbuild in the base.

A previous study by Sargand et al. [2014] found, on average, the actual stabilized subgrade layer thickness was 84% of the design thickness for cement treated subgrade and for lime treated subgrade the actual thickness was 87% of the design thickness. In the current analysis it was observed, as shown in Table 12, that on average the actual thickness of cement treated subgrade was 104% of the design thickness, in other words the actual thickness exceeded the design thickness as well as the earlier observed ratio of actual to design thickness. For lime treated subgrade the actual thickness was 85% of the design thickness, which was nearly the same percentage of design thickness as in the previous study.

Table 10. Comparison of design thickness and installed thickness for pavements.

Site	Pavement Type	Pavement Design Thickness (in)	(mm)	Pavement Installed Thickness (in)	(mm)	Percentage of Design Installed
CLA-70-13.98-W	AC	13.75	349.3	14.80	375.9	107.64%
CLI-73-6.52-E	AC	11.25	285.8	12.73	323.3	113.16%
LAK-2-7.76-W	AC	13.25	336.6	12.58	319.5	94.94%
MRW-71-3.17-N	AC	14.25	362.0	13.75	349.3	96.49%
					Average	103.06%
					Standard Deviation	8.79%
DEF-24-2.67-W	PCC	12.00	304.8	13.55	344.2	112.92%

Table 11. Comparison of design thickness and installed thickness for aggregate bases.

Site	Base Type	Aggregate Base Design Thickness (in)	(mm)	Aggregate Base Installed Thickness (in)	(mm)	Percentage of Design Installed
CLA-70-13.98-W	Item 304	6.00	152.4	6.64	168.7	110.67%
CLI-73-6.52-E	Item 304	6.00	152.4	7.03	178.6	117.17%
LAK-2-7.76-W	Item 304	6.00	152.4	4.76	120.9	79.33%
MRW-71-3.17-N	Item 304	6.00	152.4	6.19	157.2	103.17%
DEF-24-2.67-W	Item 304	6.00	152.4	6.50	165.1	108.33%
					Average	103.73%
					Standard Deviation	14.54%

Table 12. Comparison of design thickness and installed thickness for stabilized subgrades.

Site	Stabilization Type	Stabilized Subgrade Design Thickness (in)	(mm)	Stabilized Subgrade Field Thickness (in)	(mm)	Percentage of Design Installed
CLA-70-13.98-W	Cement	12.00	304.8	13.17	334.5	109.75%
CLI-73-6.52-E	Cement	16.00	406.4	15.02	381.5	93.88%
LAK-2-7.76-W	Cement	12.00	304.8	14.10	358.1	117.50%
MRW-71-3.17-N	Cement	12.00	304.8	11.33	287.8	94.42%
					Average	103.89%
					Standard Deviation	11.68%
DEF-24-2.67-W	Lime	16.00	406.4	13.67	347.2	85.44%

5.2.3 FWD

Falling Weight Deflectometer (FWD) data were collected and moduli of each layer back-calculated using Modulus 6.1 software at each of the ten bore hole locations on each of the project sites. The measured thicknesses, from the cores, of the pavement layers were used in the analysis as well as the inferred thicknesses of the soil layers, as determined through the change in modulus values from the DCP data. The back-calculated modulus of each layer at each site is given in Table 13 through Table 17. More detailed results from FWD measurements are provided in Appendix C.

The back-calculation results for each project site indicate the moduli of the asphalt pavement layers were on average between 1000-2000 ksi (6800-13800 MPa). The DEF-24 site, which was Portland cement concrete, had a pavement modulus of nearly 2800 ksi (19200 MPa). The aggregate base layer modulus ranged from 100-200 ksi (680-1380 MPa). The stabilized subgrade layer ranged from 50-120 ksi (340-830 MPa). While the natural subgrade remained fairly consistently around 30 ksi (200 MPa) except for CLI-73, which had an average modulus of 18 ksi (122 MPa). The error associated with the software was kept at a minimum when the values were back-calculated. The error needed to be as low as possible, with the threshold for acceptance set at 1%. The highest average error was observed from CLI-73 with a value of 1.08%, which is greater than the other sites which clustered around 0.5 to 0.6%. The results from each site are summarized in the following five tables.

This is fairly similar to the DCP results, however the FWD results showed the base layer's modulus to be on average around 145 ksi (1000 MPa), and about 90 ksi (620 MPa) for the DCP. The stabilized subgrade layer averaged around 142 ksi (979 MPa) with the DCP, but the same average was 90 ksi (620 MPa) with the FWD, roughly reversing the figures for the base layer. The natural subgrade modulus was on average 31 ksi (214 MPa) with the DCP and 29 ksi (201 MPa) for the FWD, which are similar.

Table 13. Pavement Layer Moduli Back-calculated from FWD Data, CLA-70-13.98.

CLA-70-13.98-W Resilient Modulus									
	Asphalt		Aggregate Base		Stabilized Subgrade		Natural Subgrade		Error
Hole	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	
1	2355	16239	197	1360	88	606	47	321	0.79
2	1815	12513	133	914	62	427	36	250	0.39
3	1928	13292	145	1002	150	1036	28	190	0.35
4	1659	11441	210	1448	172	1187	33	225	0.37
5	2228	15360	141	972	102	700	34	232	0.46
6	1917	13214	198	1366	174	1200	29	197	0.44
7	1812	12490	193	1329	113	778	28	191	0.77
8	2203	15187	122	843	56	383	33	225	0.38
9	2187	15075	215	1479	104	717	28	195	0.80
10	1722	11876	218	1506	184	1270	29	201	0.71
Average	1982	13669	177	1222	120	831	32	223	0.55
Std. Dev.	242	1667	37	258	47	324	6	40	0.19

Table 14. Pavement Layer Moduli Back-calculated from FWD Data, CLI-73-6.52.

CLI-73-6.52-E Resilient Modulus									
	Asphalt		Aggregate Base		Stabilized Subgrade		Natural Subgrade		Error
Hole	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	
1	1266	8729	144	991	33	229	15	106	0.98
2	1468	10118	134	927	111	762	22	150	0.90
3	1603	11055	107	734	51	350	19	129	0.82
4	1120	7722	103	712	44	302	23	158	0.71
5	1227	8458	85	587	42	287	27	189	1.50
6	1405	9687	121	834	62	430	19	129	0.97
7	1316	9075	72	497	50	346	14	95	1.11
8	1358	9365	97	668	43	295	16	107	1.24
9	1194	8231	85	589	34	231	11	74	1.25
10	1112	7665	73	502	42	289	13	87	1.36
Average	1307	9010	102	704	51	352	18	122	1.08
Std. Dev.	156	1078	25	171	23	156	5	36	0.25

Table 15. Pavement Layer Moduli Back-calculated from FWD Data, DEF-24-2.67.

DEF-24-2.67-W Resilient Modulus									
	Portland Cement Concrete		Aggregate Base		Stabilized Subgrade		Natural Subgrade		Error
Hole	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	
1	2107	14527	197	1356	147	1013	34	231	0.34
2	2088	14398	203	1397	104	715	38	260	0.45
3	2081	14349	184	1266	125	865	29	202	0.36
4	1741	12004	105	726	82	567	33	230	0.41
5	3023	20845	283	1952	173	1193	28	196	0.53
6	3544	24436	158	1086	121	834	33	228	0.63
7	3911	26967	189	1300	87	603	33	230	0.38
8	3987	27488	181	1247	107	740	30	210	0.74
9	2456	16936	215	1479	131	904	31	211	0.46
10	2956	20380	184	1268	109	754	37	253	0.49
Average	2790	19233	190	1308	119	819	33	225	0.48
Std. Dev.	817	5636	45	307	27	188	3	21	0.13

Table 16. Pavement Layer Moduli Back-calculated from DCP Data, LAK-2-7.76.

LAK-2-7.76-W Resilient Modulus									
Hole	Asphalt		Aggregate Base		Stabilized Subgrade		Natural Subgrade		Error
	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	
11	1534	10577	105	724	65	447	36	250	0.61
12	1231	8485	128	881	89	610	36	250	0.70
13	1135	7822	177	1218	56	385	33	230	0.95
14	1274	8787	131	900	61	420	31	212	0.60
15	1061	7316	90	621	33	225	32	223	0.49
16	1316	9074	97	672	48	332	30	208	0.65
17	1049	7232	61	421	45	312	26	181	0.57
18	920	6342	79	547	56	387	26	180	0.40
19	996	6866	46	316	32	219	20	137	0.63
20	1041	7175	81	560	30	209	21	143	0.66
Average	1156	7968	99	686	51	355	29	201	0.63
Std. Dev.	184	1267	38	261	18	124	6	40	0.14

Table 17. Pavement Layer Moduli Back-calculated from DCP Data, MRW-71-3.17.

MRW-71-3.17-N Resilient Modulus									
Hole	Asphalt		Aggregate Base		Stabilized Subgrade		Natural Subgrade		Error
	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	(ksi)	(MPa)	
1	1195	8239	191	1316	127	875	27	189	1.10
2	1550	10683	149	1027	99	680	38	261	0.44
3	1502	10353	167	1150	92	631	35	240	0.57
4	1225	8445	186	1284	150	1031	35	238	0.94
5	1353	9331	183	1259	138	948	34	235	0.53
6	1453	10017	127	873	63	436	35	242	0.38
7	1147	7908	158	1092	113	778	32	222	0.28
8	1187	8181	144	996	125	858	34	231	1.30
9	1571	10834	171	1177	100	687	32	223	0.72
10	1399	9642	111	767	72	496	37	257	0.44
Average	1358	9364	159	1094	108	742	34	234	0.67
Std. Dev.	160	1106	26	180	28	192	3	20	0.34

The previous study entitled *Incorporating Chemical Stabilization of the Subgrade in Pavement Design and Construction Practices* [Sargand et al, 2014] found the average modulus for the aggregate base was 166 ksi (1144 MPa) when constructed on cement stabilized soil and 181 ksi (1248 MPa) when constructed on lime stabilized soil. The research also found the average modulus for the stabilized layer was 121 ksi (834 MPa) for cement stabilized subgrade and 91 ksi (627 MPa) for lime stabilized subgrade. These results were compared to results for the five sections of road tested in this report. The average modulus for the aggregate base layer was 134 ksi (924 MPa) and 189 ksi (1300 MPa) for the cement and lime treated subgrade respectively. These values are similar to those in the previous study [Sargand et al., 2014]. The modulus of the aggregate base is 19.2% lower then the previous value for pavements with cement treated subgrade. However, the modulus for the aggregate base on the lime treated soil was approximately the same, increasing by only 4.4%. The modulus for the cement stabilized subgrade measured on this project was 83 ksi (572 MPa), which is 31.4% less than the previous results. However, the lime stabilized subgrade modulus was 118 ksi (814 MPa), which is greater than the previous results by 29.7%. It can be observed the stabilization has improved the stiffness of the soil and, as a result, the aggregate base. The values for the soils with high sulfates were comparable to those of the control sections (see Table 18). The improvement was also comparable to the improvement measured during the previous research project for the lime stabilization and slightly less than the improvement observed previously for cement stabilization.

Table 18. Aggregate Base, Stabilized Subgrade and Natural Subgrade Moduli Compared.

Site	Pavement Type	Control / High Sulfate	Pavement (ksi)	Pavement (MPa)	Aggregate Base (ksi)	Aggregate Base (MPa)	Subgrade Stabilization	Stabilized Subgrade (ksi)	Stabilized Subgrade (MPa)	Natural Subgrade (ksi)	Natural Subgrade (MPa)
CLA-70-13.98-W	AC	Control	1982	12873	177	1151	Cement	120	782	32	210
CLI-73-6.52-E	AC	Control	1307	8486	102	663	Cement	51	332	18	115
		Average	1645	10680	140	907		86	557	25	163
		Standard Deviation	338	2194	38	244		35	225	7	47
LAK-2-7.76-W	AC	High Sulfate	1156	7504	99	646	Cement	51	334	29	189
MRW-71-3.17-N	AC	High Sulfate	1358	8819	159	1030	Cement	108	699	34	220
		Average	1257	8161	129	838		80	516	32	205
		Standard Deviation	101	657	30	192		28	182	2	15
DEF-24-2.67-W	PCC	High Sulfate	2790	18114	190	1232	Lime	119	771	33	212

Sargand et al. [2014] found that on average the modulus of the aggregate base layer was 1.2 times the modulus of the stabilized subgrade layer for cement stabilization treatment and 1.5 times the modulus of the stabilized subgrade for lime stabilization. Also, the multiplier for natural subgrade modulus to stabilized subgrade modulus (or the ratio of the stabilized subgrade resilient modulus to that of the natural subgrade) averaged 4.7 for cement stabilization and 3.9 for lime stabilization. The results in Table 19 show the average multiplier for the aggregate base was 1.8 times the stabilized layer for cement treatment and 1.6 for lime treatment. For the stabilized layer, the multiplier on average was 3.0 times the natural layer for cement treatment and 3.7 for lime treatment.

Comparing the results from this study and the previous study, it can be observed the multiplier for the stabilized layer in this study is lower than that seen previously for the cement treated subgrade, however the control and high sulfate sections are fairly similar. The multiplier for the stabilized layer is fairly similar to that previously observed for lime treated subgrade. The multiplier for the aggregate base layer is similar for both types of treatment.

Table 19. Aggregate Base and Stabilized Subgrade Multipliers.

Site	Control / High Sulfate	Stabilization Type	Aggregate Base M_R / Stabilized Subgrade M_R Average	Std. Dev.	Stabilized Subgrade M_R / Natural Subgrade M_R Average	Std. Dev.
CLA-70-13.98-W	Control	Cement	1.63	0.50	3.92	1.82
CLI-73-6.52-E	Control	Cement	2.20	0.85	2.95	1.01
		Average	1.92		3.44	
		Standard Deviation	0.40		0.49	
LAK-2-7.76-W	High Sulfate	Cement	2.00	0.66	1.74	0.39
MRW-71-3.17-N	High Sulfate	Cement	1.52	0.26	3.23	0.98
		Average	1.76		2.49	
		Standard Deviation	0.34		0.75	
DEF-24-2.67-W	High Sulfate	Lime	1.61	0.28	3.71	1.10

LAK-2 Stabilized vs Undercut Sections

Figure 14 below shows a box plot of the FWD deflections on LAK-2 normalized to 9000 lb (40 kN). The bottom and top of the box represents the 1st and 3rd quartiles, respectively. The line inside the box represents the median value and the diamond inside the box represents the mean value. The two lines extending from the box represents values outside the 1st and 3rd quartile and the horizontal bars on the end of the vertical lines represent the minimum and maximum values. Box plots are useful for determining the spread and skew of the data. The plots can be used to identify outliers for removal from data analysis. When comparing materials, if the boxes do not overlap, there is a difference in the normalized deflections. If the boxes overlap, but do not include both medians, as shown in the figure below, there is likely a difference in the normalized deflections. If the boxes overlap and include both medians, both materials are considered to have the same deflection values.

Based on the limited FWD data collected on this project, undercutting and replacing the high sulfate soils will results in a pavement which will deflect less under traffic, and would therefore be expected to have a longer service life. This type of construction also produces a pavement buildup which is less variable in term of deflection. It was not the intent of this research to determine if the undercut and replacement option is cost effective.

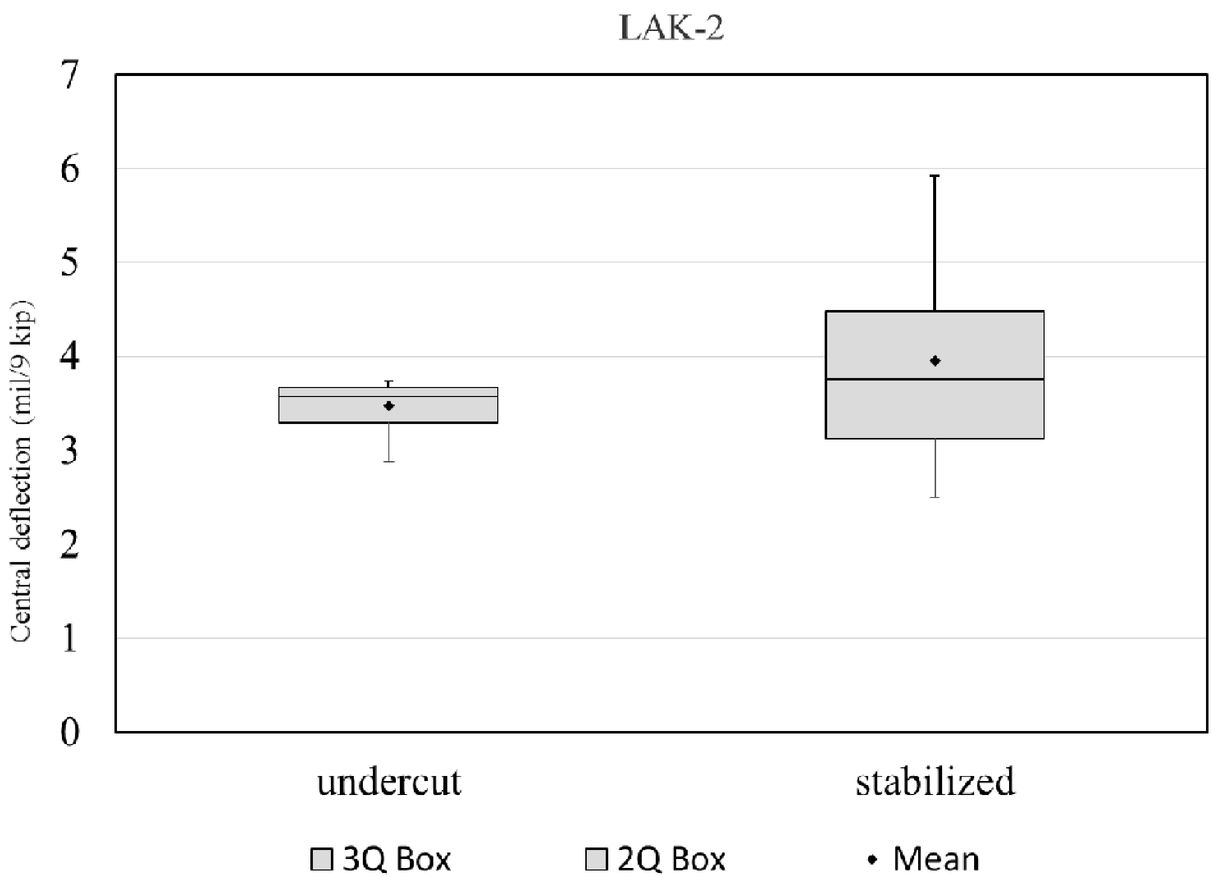


Figure 14. FWD central deflections on LAK-2 normalized to 9000 lb (40 kN) (1 mil/kip = 5.71 mm/MN).

5.2.4 LWD

The amount of data successfully collected with the LWD was limited. The LWD was not used on LAK-2 because permit restrictions did not allow drilling a 16 in (406 mm) core. The data file from CLI-73 did not contain data, as was the case with a second data file from DEF-24. This left data from CLA-70, MRW-71, and the other data file on DEF-24. Once converted from the original format, each file contained 14 readings (13 for MRW-71) for the drop force, pressure, a pulse time, deflection, and modulus. These data are presented in Table 20. The recorded modulus represents a composite of the layers beneath the LWD, which rested on the aggregate base layer. The lower value and longer pulse time for DEF-24 is consistent with earlier findings that aggregate base under rigid pavement tends to be less stiff than that under flexible pavement. More detailed results from LWD measurements are provided in Appendix D.

Table 20. LWD recorded modulus and other data for each site. English units at top, metric units below.

	Force (lb)		Pressure (psi)		Pulse Time (ms)		Deflection (mil)		Modulus (ksi)	
Site	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
CLA-70	3151	23	28.8	0.2	57.5	8.0	4.0	0.5	76.4	8.0
DEF-24	3206	27	29.3	0.2	25.8	0.2	14.0	0.4	24.6	10.7
MRW-71	2987	344	27.3	3.1	55.4	10.3	6.0	0.8	47.3	3.4

	Force (kN)		Pressure (kPa)		Pulse Time (ms)		Deflection (μm)		Modulus (MPa)	
Site	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
CLA-70	14.02	0.10	199	1.4	57.5	8.0	102	13	527	55
DEF-24	14.26	0.12	202	1.4	25.8	0.2	356	10	170	74
MRW-71	13.29	1.53	188	21	55.4	10.3	152	20	326	23

5.3 Soil Properties

5.3.1 Soil pH

The soil pH was tested in accordance with ASTM D4972 Test Method A for ten samples from each project site (twenty samples for LAK-2). The pH was tested in water and a calcium chloride solution. The tests were performed at room temperature, approximately 22.2 - 22.7°C (72.0 - 72.9°F). Table 21 shows the pH results for CLI-73 as an example, and Table 22 shows results from DEF-24. Though DEF-24 had lime stabilization instead of cement stabilization, the results are very similar to CLI-73

Table 21. Treated and Natural Subgrade pH test results for CLI-73.

Stabilized / Natural	Boring	Sample	Date Tested	pH in water	pH in calcium chloride solution	Temperature (°C)	Temperature (°F)
Stabilized	B-1	SS-1	1/12/2017	10.25	10.17	22.3	72.14
	B-2	SS-1	1/12/2017	10.19	10.01	22.4	72.32
	B-3	SS-1	1/12/2017	10.3	10.15	22.4	72.32
	B-4	SS-1	1/12/2017	9.95	9.88	22.3	72.14
	B-5	SS-1	1/12/2017	10.16	10.07	22.3	72.14
	B-6	SS-1	1/12/2017	10.2	9.93	22.4	72.32
	B-7	SS-1	1/12/2017	10.09	9.92	22.4	72.32
	B-8	SS-1	1/12/2017	10.45	10.38	22.4	72.32
	B-9	SS-1	1/12/2017	10.03	9.7	22.2	71.96
	B-10	SS-1	1/12/2017	10.47	10.31	22.2	71.96
	Average			10.21	10.05	22.33	72.19
	Std. Dev.			0.17	0.21	0.08	0.15
Natural	B-1	SS-2	1/12/2017	7.88	7.34	22.3	72.14
	B-2	SS-2	1/12/2017	7.65	7.01	22.3	72.14
	B-3	SS-2	1/12/2017	7.81	7.44	22.3	72.14
	B-4	SS-2	1/12/2017	8.04	7.68	22.4	72.32
	B-5	SS-2	1/12/2017	8.46	7.93	22.4	72.32
	B-6	SS-2	1/12/2017	8.05	7.47	22.4	72.32
	B-7	SS-2	1/12/2017	7.5	6.97	22.4	72.32
	B-8	SS-2	1/12/2017	8.16	7.65	22.4	72.32
	B-9	SS-2	1/12/2017	7.88	7.44	22.3	72.14
	B-10	SS-2	1/12/2017	8.41	7.99	22.3	72.14
	Average			7.98	7.49	22.35	72.23
	Std. Dev.			0.31	0.34	0.05	0.09

Table 22. Treated and Natural Subgrade pH test results for DEF-24.

Stabilized / Natural	Boring	Sample	Date Tested	pH in water	pH in calcium chloride solution	Temperature (°C)	Temperature (°F)
Stabilized	B-1	SS-1	1/16/2017	9.73	9.60	22.6	72.68
	B-2	SS-1	1/16/2017	10.42	10.18	22.6	72.68
	B-3	SS-1	1/16/2017	10.38	10.22	22.6	72.68
	B-3	SS-3B	1/16/2017	9.60	9.17	22.5	72.5
	B-4	SS-1	1/16/2017	10.40	10.26	22.5	72.5
	B-5	SS-1	1/16/2017	10.59	10.26	22.5	72.5
	B-6	SS-1	1/16/2017	10.45	10.14	22.6	72.68
	B-7	SS-1	1/16/2017	10.52	10.39	22.4	72.32
	B-8	SS-1	1/16/2017	10.44	10.32	22.4	72.32
	B-9	SS-1	1/16/2017	10.51	10.48	22.4	72.32
	B-10	SS-1	1/16/2017	10.38	10.33	22.4	72.32
	Average			10.37	10.18	22.49	72.48
	Std. Dev.			0.28	0.37	0.09	0.16
Natural	B-1	SS-3B	1/16/2017	7.65	7.50	22.5	72.5
	B-2	SS-2B	1/16/2017	9.32	9.21	22.4	72.32
	B-3	SS-2A	1/16/2017	8.41	8.14	22.4	72.32
	B-3	SS-4	1/16/2017	8.40	7.51	22.5	72.5
	B-4	SS-2	1/16/2017	7.79	7.64	22.5	72.5
	B-5	SS-2	1/16/2017	7.79	7.57	22.4	72.32
	B-6	SS-2	1/16/2017	7.04	6.13	22.4	72.32
	B-7	SS-2	1/16/2017	7.83	7.81	22.3	72.14
	B-8	SS-2A	1/16/2017	7.85	7.65	22.4	72.32
	B-8	SS-3B	1/16/2017	7.82	7.50	22.4	72.32
	B-9	SS-2	1/16/2017	8.02	7.96	22.3	72.14
	B-10	SS-2	1/16/2017	8.04	7.82	22.5	72.5
	Average			7.90	7.57	22.41	72.34
	Std. Dev.			0.38	0.55	0.07	0.13

The pH results for all five sites were relatively similar, with stabilized subgrade specimens all between 9 and 11 with only a few being less than 9 in both water and calcium chloride ($CaCl_2$) solution. The natural subgrade had pH consistently less than the stabilized subgrade, with values ranging from 7-8.5. The pH in the control sections and the high sulfate sections differed little. It appears there are no significant differences in pH between the control and high sulfate sections.

Table 23 shows the average of the ten hole results for each site for both stabilized and natural subgrade, as well as an average and standard deviation value for the control sections (CLA-70 and CLI-73) and the high sulfate sections (MRW-71, DEF-24, and LAK-2). The pH in the calcium solution consistently produced a slightly smaller value for each site. From the results, it can be concluded all five sites had similar pH values for the stabilized subgrade soils.

The similarity of pH values in control and high sulfate sites is clearly evident in the box plots in Figure 15 and Figure 16. Also, the contrast between stabilized and natural subgrade is clear, with stabilized subgrade in all categories having a mean pH just above 10.

Table 23. Summary of pH results for each site.

Site	Stabilized Subgrade pH				Natural Subgrade pH			
	In water		In $CaCl_2$ soln.		In water		In $CaCl_2$ soln.	
	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
CLA-70	10.31	0.68	10.04	0.78	8.19	0.19	7.76	0.16
CLI-73	10.21	0.17	10.05	0.21	7.98	0.31	7.49	0.34
DEF-24	10.37	0.28	10.18	0.37	7.90	0.38	7.57	0.55
LAK-2 (stabilized)	10.65	0.87	10.59	0.95	7.12	0.18	7.05	0.18
MRW-71	9.94	0.20	9.81	0.18	7.53	0.12	7.34	0.13
Average	10.30	-	10.13	-	7.74	-	7.44	-
Std. Dev.	0.26	-	0.29	-	0.42	-	0.27	-
Average No lime	10.28	-	10.12	-	7.71	-	7.41	-
St. Dev. No lime	0.29	-	0.33	-	0.48	-	0.30	-
Average w/sulfate	10.32	-	10.19	-	7.52	-	7.32	-
Std. Dev. w/ sulfate	0.36	-	0.39	-	0.39	-	0.26	-
Average Control	10.26	-	10.05	-	8.09	-	7.63	-
Std. Dev. Control	0.07	-	0.01	-	0.15	-	0.19	-

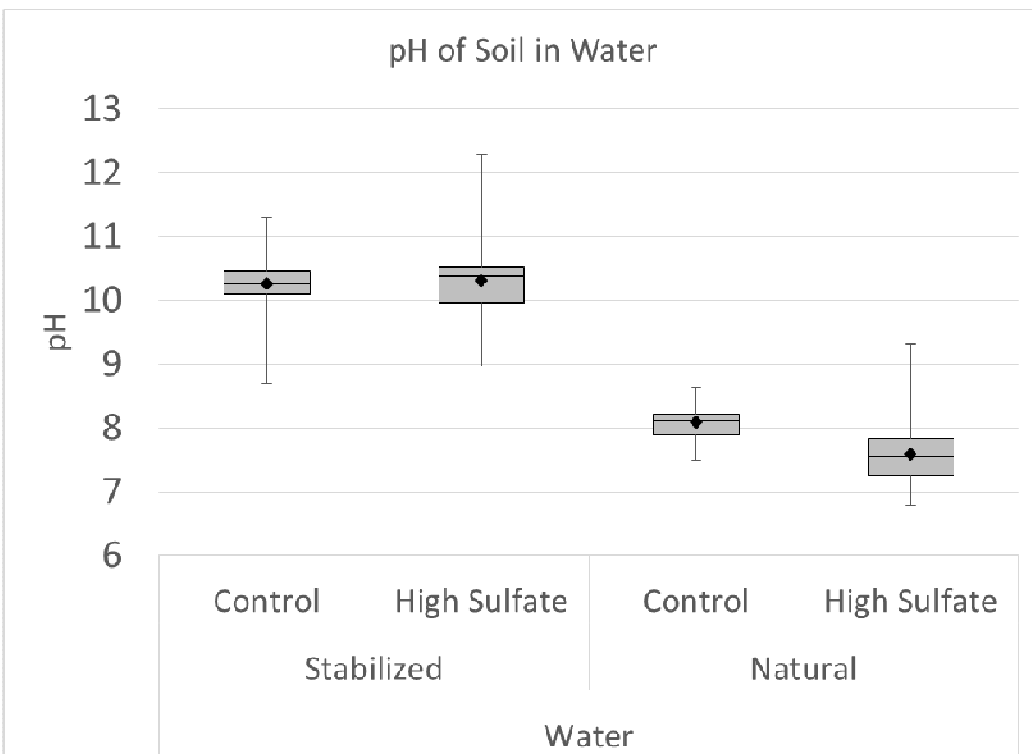


Figure 15. Box plot of pH values in water for subgrades from all sites.

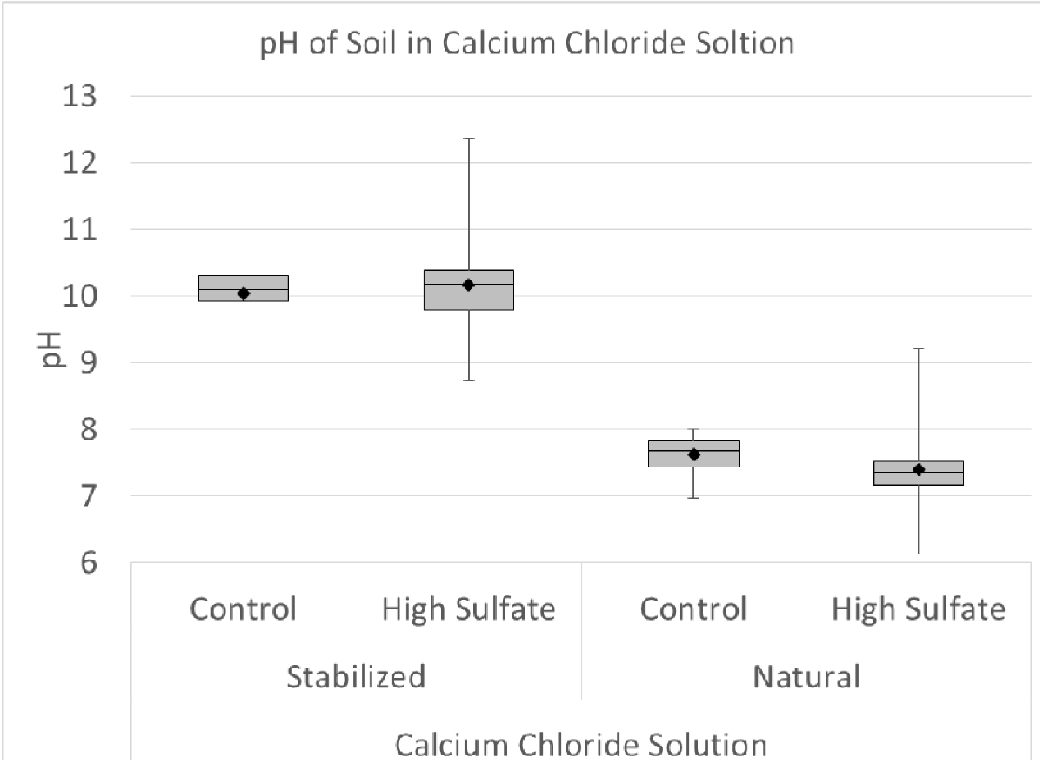


Figure 16. Box plot of pH values in $CaCl_2$ solution for subgrades from all sites.

5.3.2 Atterberg Limits

The Liquid Limit was determined in accordance with AASHTO T89 and the Plastic Limit was determined in accordance with AASHTO T90. The Plasticity Index (PI) characterizes the plastic behavior of the soil. A PI of 0 means the soil is non-plastic while a PI greater than 17 means the soil is highly plastic, and a value in between means the soil has some plastic properties. The greater the PI of the soil, the more flexible it is. A high PI value typically indicates a large amount clay; a lower PI means there is more silt than clay; and non-plastic soils have little or no clay or silt.

From the results of the Atterberg Limit tests on the treated soil samples, most project sites have relatively low PI values. LAK-2 and CLA-70 have mostly non-plastic values for the treated layer of soil, and the few samples that do have a PI value, they are relatively low meaning there is more silt than clay. From Bore Hole 4 in CLA-70 the PI for the treated layer is 3 where 32% of the soil is silt, 11% clay, 18% gravel, and 39% is sand.

As for MRW-71 and CLI-73, the treated layer has a slightly higher PI value for most of the samples. The soils from these two sites contain mostly silts and coarse grained sands. DEF-24 has the highest PI, up to 22. Some samples are non-plastic but most samples have a PI value. The soil from DEF-24 is slightly more plastic than the other sites but still contains mostly silts and coarse sands.

The natural soil samples for all sites had significantly higher PI values than the stabilized subgrade samples. However, DEF-24 had the greater PI values than the other four, with a maximum PI of 43. The typical PI value for the other four sites was in the teens with a few in the twenties and one value of 31 in CLI-73. A majority of the material that made up each specimen was clay and silt. The lowest PI values occurred in MRW-71, however each sample there was still primarily clay and silt.

Table 24 shows a summary of the liquid limit (LL), plastic limit (PL), and plasticity index (PI) for the five sites. The values in this table are an average of the values from the ten bore holes. The average and standard deviation are also shown for the high sulfate sections (DEF-24, LAK-2, and MRW-71) and control section (CLA-70 and CLI-73). From the following table, it can be observed that the average PI for the high sulfate and control sections are fairly similar for the stabilized layer with a value of 4 for control and 6 for high sulfate. Also, in the natural subgrade below the stabilization, the PI is much greater than that of the stabilized layer in a manner control consistent in both control and high sulfate sections. The PI for the control sections is 15 while the high sulfate sections have a PI of 18.

From the results, it can be determined that there is little to no difference between the control sections and high sulfate sections based on LL, PL, and PI because the values are similar. Atterberg limit test results for each sample at each site can be seen in the boring logs in the Appendices.

Table 24. Liquid Limit, Plastic Limit, and Plastic Index values for all sites.

Site	Stabilized Subgrade			Natural Subgrade		
	Liquid Limit	Plastic Limit	Plasticity Index	Liquid Limit	Plastic Limit	Plasticity Index
CLA-70-13.98-W	9	6	2	26	14	12
CLI-73-6.52-E	24	18	6	36	21	18
Average	16	12	4	31	17	15
St. Dev.	11	8	2	7	5	4
DEF-24-2.67-W	33	23	10	54	22	32
LAK-2-7.76-W	11	8	3	28	16	11
MRW-71-3.17-N	26	21	5	27	18	10
Average	23	17	6	36	19	18
St. Dev.	11	8	3	15	3	12

5.3.3 Moisture Content

The moisture contents of both the stabilized and natural untreated soil samples were determined in accordance with ASTM D2216. The moisture content of the soil is the mass of water compared to the mass of soil solid particles expressed as a percentage. Moisture content testing was performed on at least one split-spoon sample of the stabilized soil and one split-spoon sample of the untreated soil at each boring location.

Figure 17 through Figure 21 provide a graphical representation of the moisture contents of the stabilized and untreated soil layers at each site, allowing for a comparison at each bore hole. The average and standard deviations of the moisture contents at each site are in Table 25. At the CLA-70, LAK-2, and MRW-71 projects, the average moisture contents of the stabilized soil layers were higher than the average moisture contents of the untreated soil layers, though the difference is less than the combined standard deviation. At CLA-70 the average moisture content of the stabilized soil layer was 0.8% higher than the average moisture content of the untreated soil layer. At LAK-2, the average moisture content of the stabilized soil layer was 0.6% higher than the average moisture content of the untreated soil layer. At MRW-71 the average moisture content of the stabilized layer was 0.3% higher than the average moisture content of the untreated soil layer.

At the CLI-73 and DEF-24 project locations, the stabilized soil layer average moisture contents were lower than the untreated soil layer average moisture contents. The stabilized soil layer average moisture content was 1.6% lower than the untreated soil layer average moisture content at CLI-73. At DEF-24 the stabilized soil layer average moisture content was 2.1% lower than the average untreated soil layer moisture content. Because all of these differences are less than the standard deviations in the moisture readings, these differences are not statistically significant.

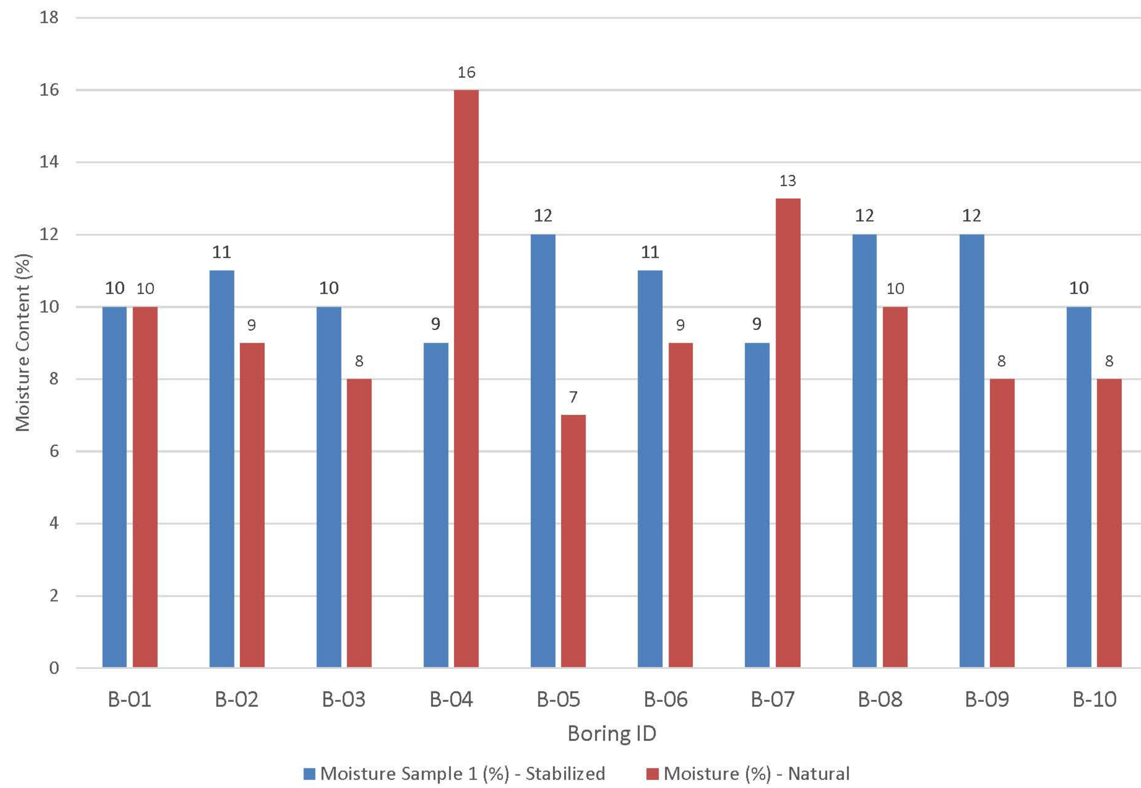


Figure 17. Moisture contents of stabilized and natural soil specimens from CLA-70.

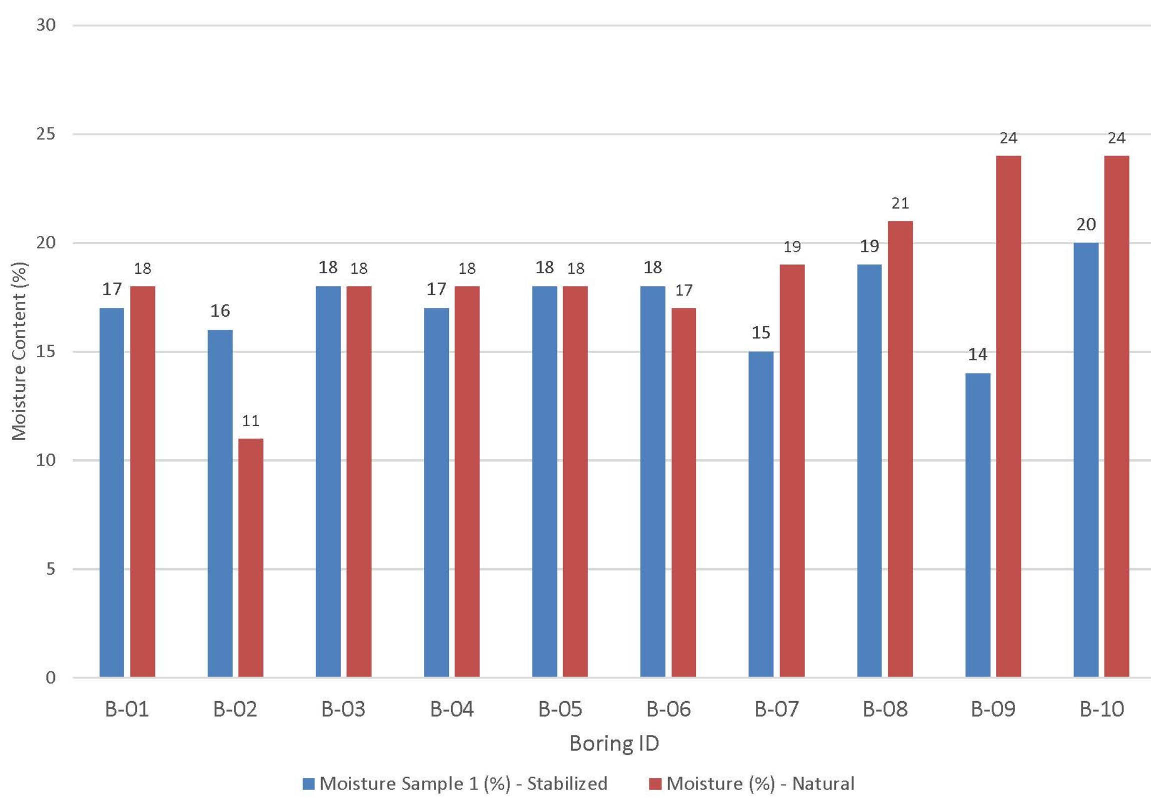


Figure 18. Moisture contents of stabilized and natural soil specimens from CLI-73.

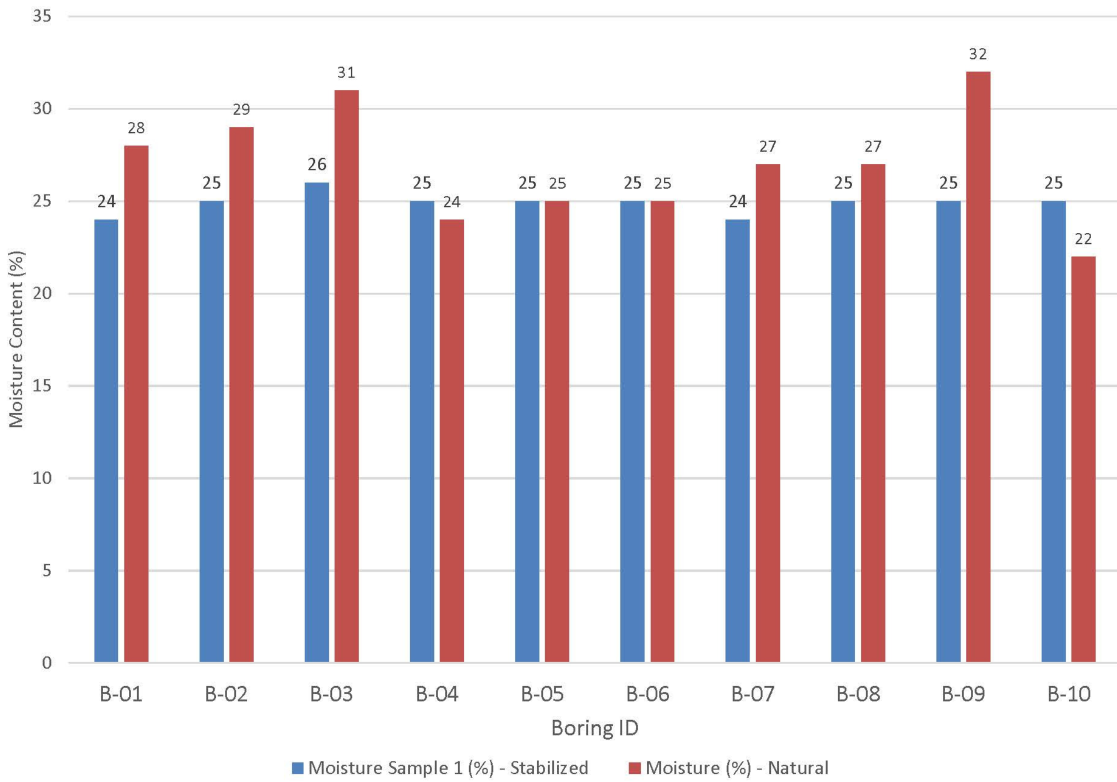


Figure 19. Moisture contents of stabilized and natural soil specimens from DEF-24.

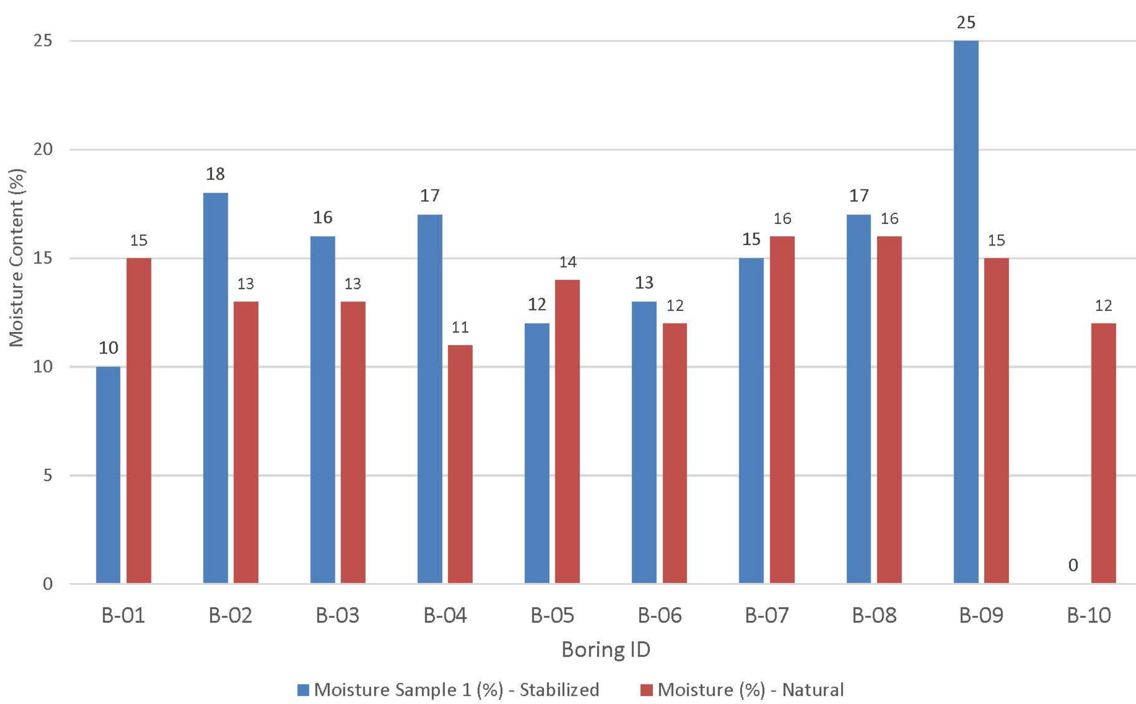


Figure 20. Moisture contents of stabilized and natural soil specimens from LAK-2.

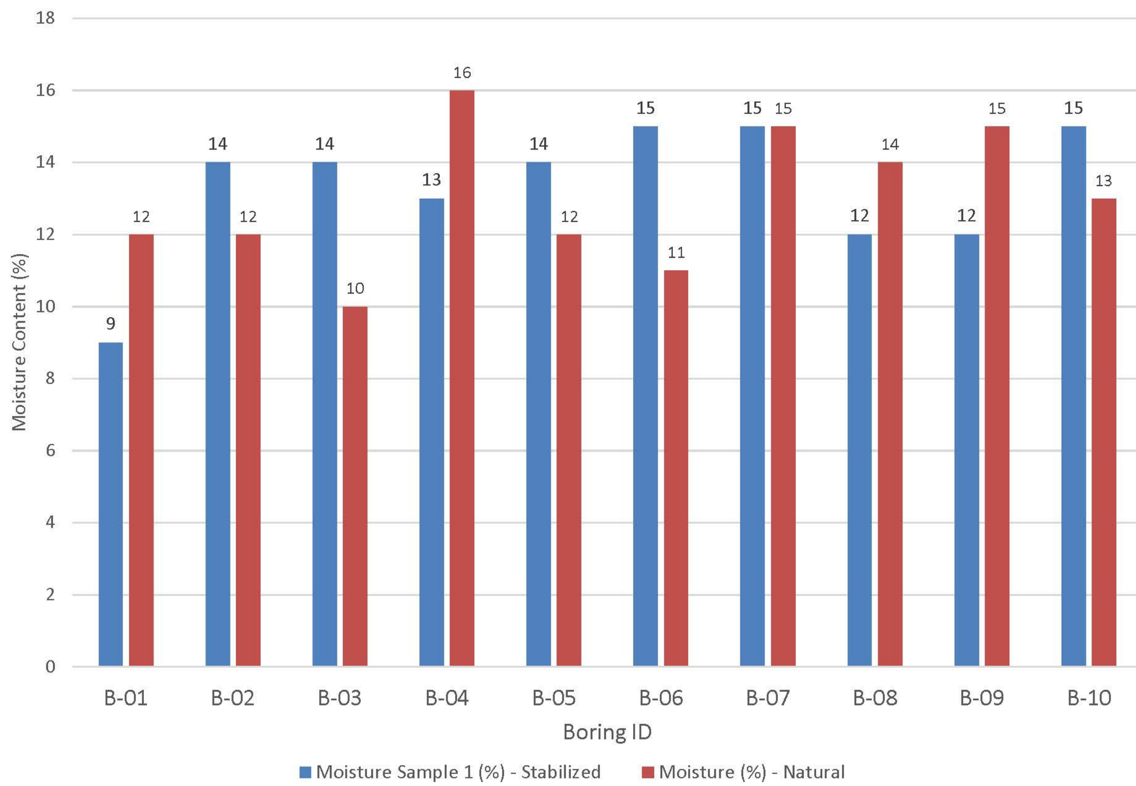


Figure 21. Moisture contents of stabilized and natural soil specimens from MRW-71.

While comparing the average moisture contents of the stabilized and untreated soil layers across each project does not show any consistent relationship, there is consistency among all the stabilized soil layers when comparing the moisture contents of cohesive stabilized soil layers with their respective plastic limits. Considering only soil samples with Atterberg limits, Table 25 shows that the stabilized soil layers have moisture contents consistently below their plastic limits, while the for natural soil the moisture contents range from 5.1% below their plastic limits to 4.8% above their plastic limits. The ability of a cohesive stabilized soil layer to maintain its moisture content well below its plastic state further reinforces the long-term reliability of the stabilized soil layer, further justifying its incorporation into ODOT's current pavement design methodology.

Table 25. Moisture contents and difference between moisture content and plastic limit for plastic soil specimens at all sites.

	Moisture Content (%)				[Moisture Content (%) - Plastic Limit (%)]	
	Stabilized		Natural			
Project	Avg.	Std. Dev.	Avg.	Std. Dev.	Stabilized	Natural
CLA-70	10.60%	1.17%	9.80%	2.74%	-10.0%	3.9%
CLI-73	17.20%	1.81%	18.80%	3.74%	-9.0%	-0.7%
DEF-24	24.90%	0.57%	27.00%	3.13%	-8.4%	-5.1%
LAK-2	14.30%	6.46%	13.70%	1.77%	-6.0%	2.5%
MRW-71	13.30%	1.89%	13.00%	1.94%	-11.9%	4.8%

5.3.4 Sulfate content

The sulfate content of each soil sample was determined through lab testing in compliance with ODOT Supplement 1122 which specifies using test standard TEX-145-E. The test used a colorimeter to quantify the sulfate content of the soil. The reading of the colorimeter can be translated into a concentration in parts per million (ppm). The test was performed on ten samples from each of the five sites. The results presented in this chapter were completed by Resource International Inc. (Rii).

The sulfate content in ppm can be seen in the rightmost column in Table 26. The numerals in red text are sulfate concentrations that exceed 3000 ppm, indicative of a moderate risk of the formation of ettringite in the soil. For sulfate concentrations greater than 8000 ppm, there is a high risk of ettringite formation, and levels greater than 10,000 ppm are not considered suitable for lime stabilization. All samples from the control sections had concentrations below 3000 ppm, validating their selection as control sites. However, the other three sites this was not the case.

From LAK-2, half the samples produced concentrations greater than 3000 ppm but not exceeding 5500 ppm. This means there is a moderate risk of ettringite formation. For MRW-71 and DEF-24, over half the samples produced concentrations greater than 3000 ppm. Multiple samples from each of the two sites had readings greater than 7000 ppm and one sample from MRW was 8907 ppm.

From the data in Table 26 for stabilized subgrade, although some samples came close to 3000 ppm, CLA-70 and CLI-73 had low risk of developing ettringite. For LAK-2, more than half the specimens had concentrations above 3000 ppm and thus moderate risk of some formation of ettringite. However, for DEF-24 and MRW-71, multiple samples from each site had concentrations greater than 7000 ppm and therefore have relatively high chances of ettringite formation. Concentrations higher than 3000 ppm in this and the following tables are marked in red.

The natural subgrade specimens from each site produced significantly lower concentrations than the corresponding stabilized specimens in nearly all cases, with the few exceptions coming from DEF-24, which was the only site to use lime stabilization. The results from the natural subgrade samples can be seen below in Table 27. All samples from CLA-70 and CLI-73 have sulfate concentrations below 1000 ppm as is the case with the majority of those from DEF-24. However, Bore Hole 8 and 10 from DEF-24 have concentrations well above 3000 ppm. LAK-2 has much higher concentrations than the other sites, with all samples in the 1000-3000 ppm range and only one sample above 3000 ppm. MRW-71 has a widely dispersed range with some samples less than 1000 ppm and one sample over 3500 ppm. Although LAK-2 and MRW-71 have natural subgrade samples with sulfate concentrations in the thousands of ppm, this is still less than for their treated samples.

Table 28 contains a summary of the sulfate data for all sites, with stabilized subgrade concentrations in the top half and natural subgrade concentrations in the bottom half. Also, the control section concentrations are on the left portion, while those for the high sulfate sections are on the right. Averages and standard deviations have been computed for each site and for each group to facilitate comparisons. From the table it is clear that the natural subgrade in the control sections has the lowest sulfate concentration, the stabilized subgrade in the control sections has increased sulfur content, but not to levels as great as most of the natural subgrade in the high sulfate sections (MRW-71 is the exception). The stabilized subgrades in the high sulfate sections have the highest sulfate concentrations, which as a group are above 3000 ppm. The large standard deviations for the sulfate concentrations in the high sulfate sections, particularly before stabilization, indicate that sulfate concentration varies greatly from one place to another within the same section.

Table 26. Stabilized subgrade sulfate content in ppm for all five sites.

Site	Boring ID	Sample ID	Sample Depth (ft)	Sample Depth (m)	Soaking Time (hr)	Dilution Ratio	Replicate Sample Readings 1	2	3	Average Reading	Sulfate Content (ppm)
CLA-70	B-1	SS-1B S	1.2	0.37	24	40	58	58	58	58.00	2320
CLA-70	B-2	SS-1B S	1.2	0.37	24	20	75	74	75	74.67	1493
CLA-70	B-3	SS-1B S	1.2	0.37	24	20	77	75	74	75.33	1507
CLA-70	B-4	SS-1B S	1.2	0.37	24	20	78	80	80	79.33	1587
CLA-70	B-5	SS-1B S	1.2	0.37	24	20	91	91	92	91.33	1827
CLA-70	B-6	SS-1B S	1.2	0.37	24	20	73	74	75	74.00	1480
CLA-70	B-7	SS-1B S	1.2	0.37	24	20	94	94	95	94.33	1887
CLA-70	B-8	SS-1B S	1.2	0.37	24	20	76	75	75	75.33	1507
CLA-70	B-9	SS-2A S	2.7	0.82	24	20	12	13	14	13.00	260
CLA-70	B-10	SS-1B S	1.2	0.37	24	20	87	88	89	88.00	1760
CLI-73	B-1	SS-1B S	1.0	0.30	24	40	70	70	70	70.00	2800
CLI-73	B-2	SS-1B S	1.0	0.30	24	40	52	54	54	53.33	2133
CLI-73	B-3	SS-1B S	1.0	0.30	24	20	74	75	77	75.33	1507
CLI-73	B-4	SS-1B S	1.0	0.30	24	20	98	98	97	97.67	1953
CLI-73	B-5	SS-1B S	1.0	0.30	24	40	47	48	49	48.00	1920
CLI-73	B-6	SS-1B S	1.0	0.30	24	40	66	65	64	65.00	2600
CLI-73	B-7	SS-1B S	1.0	0.30	24	20	84	82	82	82.67	1653
CLI-73	B-8	SS-1B S	1.0	0.30	24	40	59	61	61	60.33	2413
CLI-73	B-9	SS-1B S	1.0	0.30	24	20	25	27	28	26.67	533
CLI-73	B-10	SS-1B S	1.0	0.30	24	40	58	58	59	58.33	2333
DEF-24	B-1	SS-1 S	1.1	0.34	24	40	94	95	95	94.67	3787
DEF-24	B-2	SS-1 S	1.1	0.34	24	40	63	63	62	62.67	2507
DEF-24	B-3	SS-1 S	1.1	0.34	24	80	63	63	64	63.33	5067
DEF-24	B-3	SS-3 S	4.1	1.25	24	20	33	34	35	34.00	680
DEF-24	B-4	SS-1 S	1.1	0.34	24	80	71	72	72	71.67	5733
DEF-24	B-5	SS-1 S	1.0	0.30	24	40	69	69	69	69.00	2760
DEF-24	B-6	SS-1 S	1.0	0.30	24	80	49	49	50	49.33	3947
DEF-24	B-7	SS-1 S	1.1	0.34	24	80	79	79	80	79.33	6347
DEF-24	B-8	SS-1 S	1.0	0.30	24	80	88	89	88	88.33	7067
DEF-24	B-9	SS-1 S	1.0	0.30	24	80	88	90	91	89.67	7173
DEF-24	B-10	SS-1 S	1.1	0.34	24	160	43	44	45	44.00	7040
MRW-71	B-1	SS-1 N	1.1	0.34	24	20	23	23	24	23.33	467
MRW-71	B-2	SS-1 S	1.2	0.37	24	80	64	64	65	64.33	5147
MRW-71	B-3	SS-1 S	1.1	0.34	24	20	83	83	82	82.67	1653
MRW-71	B-4	SS-1 S	1.1	0.34	24	80	98	97	96	97.00	7760
MRW-71	B-5	SS-1 S	1.1	0.34	24	160	55	55	57	55.67	8907
MRW-71	B-6	SS-1 S	1.2	0.37	24	80	80	79	79	79.33	6347
MRW-71	B-7	SS-1 S	1.1	0.34	24	80	70	69	69	69.33	5547
MRW-71	B-8	SS-1 S	1.0	0.30	24	80	44	45	45	44.67	3573
MRW-71	B-9	SS-1 S	1.1	0.34	24	80	63	62	62	62.33	4987
MRW-71	B-10	SS-1 S	1.1	0.34	24	20	83	83	82	82.67	1653
LAK-2	B-11	2S-1B	1.6	0.49	24	80	44	45	45	44.67	3573
LAK-2	B-12	2S-1	1.7	0.52	24	80	77	78	78	77.67	6213
LAK-2	B-13	2S-1B	1.7	0.52	24	80	53	53	53	53	4240
LAK-2	B-14	2S-1B	1.6	0.49	24	80	65	65	65	65	5200
LAK-2	B-15	2S-1B	1.5	0.46	24	20	65	65	64	64.67	1293
LAK-2	B-16	2S-1B	1.3	0.40	24	40	72	74	73	73	2920
LAK-2	B-17	2S-1B	1.5	0.46	24	40	74	74	76	74.67	2987
LAK-2	B-18	2S-1B	1.8	0.55	24	40	70	71	72	71	2840
LAK-2	B-19	2S-1B	1.3	0.40	24	80	62	62	60	61.33	4907
LAK-2	B-20	-	-	-	-	-	-	-	-	-	-

Table 27. Natural subgrade sulfate content in ppm for all five sites.

Site	Boring ID	Sample ID	Sample Depth (ft)	Sample Depth (m)	Soaking Time (hr)	Dilution Ratio	Replicate Sample Readings 1	2	3	Average Reading	Sulfate Content (ppm)
CLA-70	B-1	SS-2C N	2.7	0.82	24	20	24	24	24	24.00	480
CLA-70	B-2	SS-2C N	2.7	0.82	24	20	13	11	11	11.67	233
CLA-70	B-3	SS-2C N	2.7	0.82	24	20	21	21	19	20.33	407
CLA-70	B-4	SS-2B N	2.7	0.82	24	20	16	14	14	14.67	293
CLA-70	B-5	SS-2C N	2.7	0.82	24	20	9	9	8	8.67	173
CLA-70	B-6	SS-2C N	2.7	0.82	24	20	14	12	12	12.67	253
CLA-70	B-7	SS-2C N	2.7	0.82	24	20	13	14	13	13.33	267
CLA-70	B-8	SS-2C N	2.7	0.82	24	20	27	27	26	26.67	533
CLA-70	B-9	SS-2C N	2.7	0.82	24	20	6	8	5	6.33	127
CLA-70	B-10	SS-2B N	2.7	0.82	24	20	11	9	10	10.00	200
CLI-73	B-1	SS-2A N	2.5	0.76	24	20	5	5	4	4.67	93
CLI-73	B-2	SS-2A N	2.5	0.76	24	20	9	8	8	8.33	167
CLI-73	B-3	SS-2A N	2.5	0.76	24	20	6	6	6	6.00	120
CLI-73	B-4	SS-2A N	2.5	0.76	24	20	10	10	9	9.67	193
CLI-73	B-5	SS-2A N	2.5	0.76	24	20	10	10	10	10.00	200
CLI-73	B-6	SS-2A N	2.5	0.76	24	20	15	13	13	13.67	273
CLI-73	B-7	SS-2B N	3.0	0.91	24	20	12	11	11	11.33	227
CLI-73	B-8	SS-2A N	2.5	0.76	24	20	11	10	9	10.00	200
CLI-73	B-9	SS-2A N	2.5	0.76	24	20	13	12	11	12.00	240
CLI-73	B-10	SS-2A N	2.5	0.76	24	20	6	6	5	5.67	113
DEF-24	B-1	SS-3B N	4.1	1.25	24	20	9	10	11	10.00	200
DEF-24	B-2	SS-2B N	2.6	0.79	24	20	10	8	9	9.00	180
DEF-24	B-3	SS-2A N	2.6	0.79	24	20	22	23	24	23.00	460
DEF-24	B-3	SS-4 N	5.6	1.71	24	20	29	28	27	28.00	560
DEF-24	B-4	SS-2A N	2.5	0.76	24	20	19	21	20	20.00	400
DEF-24	B-5	SS-2B N	2.5	0.76	24	20	27	28	27	27.33	547
DEF-24	B-6	SS-2B N	2.6	0.79	24	20	15	16	17	16.00	320
DEF-24	B-7	SS-2B N	2.5	0.76	24	20	52	51	50	51.00	1020
DEF-24	B-8	SS-2A N	5.0	1.52	24	160	66	66	67	66.33	10613
DEF-24	B-9	SS-2B N	2.6	0.79	24	80	49	49	50	49.33	3947
DEF-24	B-10	SS-2 N	2.6	0.79	24	80	89	89	80	86.00	6880
MRW-71	B-1	SS-2A N	4.1	1.25	24	20	40	38	37	38.33	767
MRW-71	B-2	SS-2B N	2.7	0.82	24	20	70	72	73	71.67	1433
MRW-71	B-3	SS-2B N	2.6	0.79	24	20	45	46	47	46.00	920
MRW-71	B-4	SS-2B N	2.6	0.79	24	20	45	46	46	45.67	913
MRW-71	B-5	SS-2 N	2.6	0.79	24	40	59	59	60	59.33	2373
MRW-71	B-6	SS-2B N	3.0	0.91	24	20	32	33	34	33.00	660
MRW-71	B-7	SS-2 N	2.6	0.79	24	20	56	55	54	55.00	1100
MRW-71	B-8	SS-2B N	2.8	0.85	24	20	59	60	60	59.67	1193
MRW-71	B-9	SS-2B N	3.1	0.94	24	40	91	91	90	90.67	3627
MRW-71	B-10	SS-2B N	2.9	0.88	24	20	48	48	49	48.33	967
LAK-2	B-11	SS-2	3.2	0.98	24	40	77	78	78	77.67	3107
LAK-2	B-12	SS-2	3.2	0.98	24	40	55	55	54	54.67	2187
LAK-2	B-13	SS-2	2.5	0.76	24	20	69	70	70	69.67	1393
LAK-2	B-14	SS-2	2.6	0.79	24	20	69	68	69	68.67	1373
LAK-2	B-15	2S-2B	2.7	0.82	24	20	76	76	75	75.67	1513
LAK-2	B-16	2S-2B	2.6	0.79	24	40	66	66	66	66	2640
LAK-2	B-17	SS-2	3	0.91	24	40	67	67	67	67	2680
LAK-2	B-18	SS-2	3.1	0.94	24	40	69	69	68	68.67	2747
LAK-2	B-19	SS-2A	3.1	0.94	24	20	78	77	77	77.33	1547
LAK-2	B-20	SS-2	3	0.91	24	40	50	50	50	50	2000

Table 28. Summary table of sulfate content for all sites.

		control			high sulfate					
	Specimen	CLA-70	CLI-73	all	DEF-24	LAK-2	MRW-71	all	cement	lime
stabilized subgrade	1	2320	2800		**3787**	**3573**	**5147**			
	2	1493	2133		2507	**6213**	1653			
	3	1507	1507		**5067**	**4240**	**7760**			
	4	1587	1953		680	**5200**	**8907**			
	5	1827	1920		**5733**	1293	**6347**			
	6	1480	2600		2760	2920	**5547**			
	7	1887	1653		**3947**	2987	**3573**			
	8	1507	2413		**6347**	2840	**4987**			
	9	260	533		**7067**	**4907**	1653			
	10	1760	2333		**7173**	-	-			
	11	-	-		**7040**	-	-			
	average	1563	1985	1774	4737	3797	5064	4547	4430	4737
	std. dev.	527	652	616	2173	1496	2485	2091	2094	2173
	N	10	10	20	11	9	9	29	18	11
natural subgrade	1	480	93		200	**3107**	467			
	2	233	167		180	2187	767			
	3	407	120		460	1393	1433			
	4	293	193		560	1373	920			
	5	173	200		400	1513	913			
	6	253	273		547	2640	2373			
	7	267	227		320	2680	660			
	8	533	200		1020	2747	1100			
	9	127	240		**10613**	1547	1193			
	10	200	113		667	2000	**3627**			
	11	-	-		**3947**	-	967			
	12	-	-		**6880**	-	-			
	average	297	183	240	2149	2119	1311	1861	1696	2149
	std. dev.	134	59	117	3341	646	918	2091	883	3341
	N	10	10	20	12	10	11	33	21	12

Figure 22 is a scatter plot of the natural subgrade sulfate concentration versus that for stabilized subgrade from each bore hole. The y-axis represents the concentration of the natural samples and the x-axis represents the concentrations of the treated samples, each in ppm. Nearly all the points are below the equality line. This means that the sulfate concentrations are greater for the stabilized samples than for the natural samples. Also, the sulfate concentrations for control sections CLA-70 and CLI-73 (hollow markers) had low sulfate concentrations, all below 3000 ppm (dashed red lines), as expected. The stabilized subgrade in the other sites, DEF-24, MRW-71, and LAK-2 (solid markers) had considerably higher concentrations. Even some of the natural subgrade specimens had sulfate concentrations above 3000 ppm, as indicated by the red numerals in Table 27. The differences in sulfate content between control sections and high sulfate sections, and between natural and stabilized subgrade, are expressed in the box plot in Figure 23.

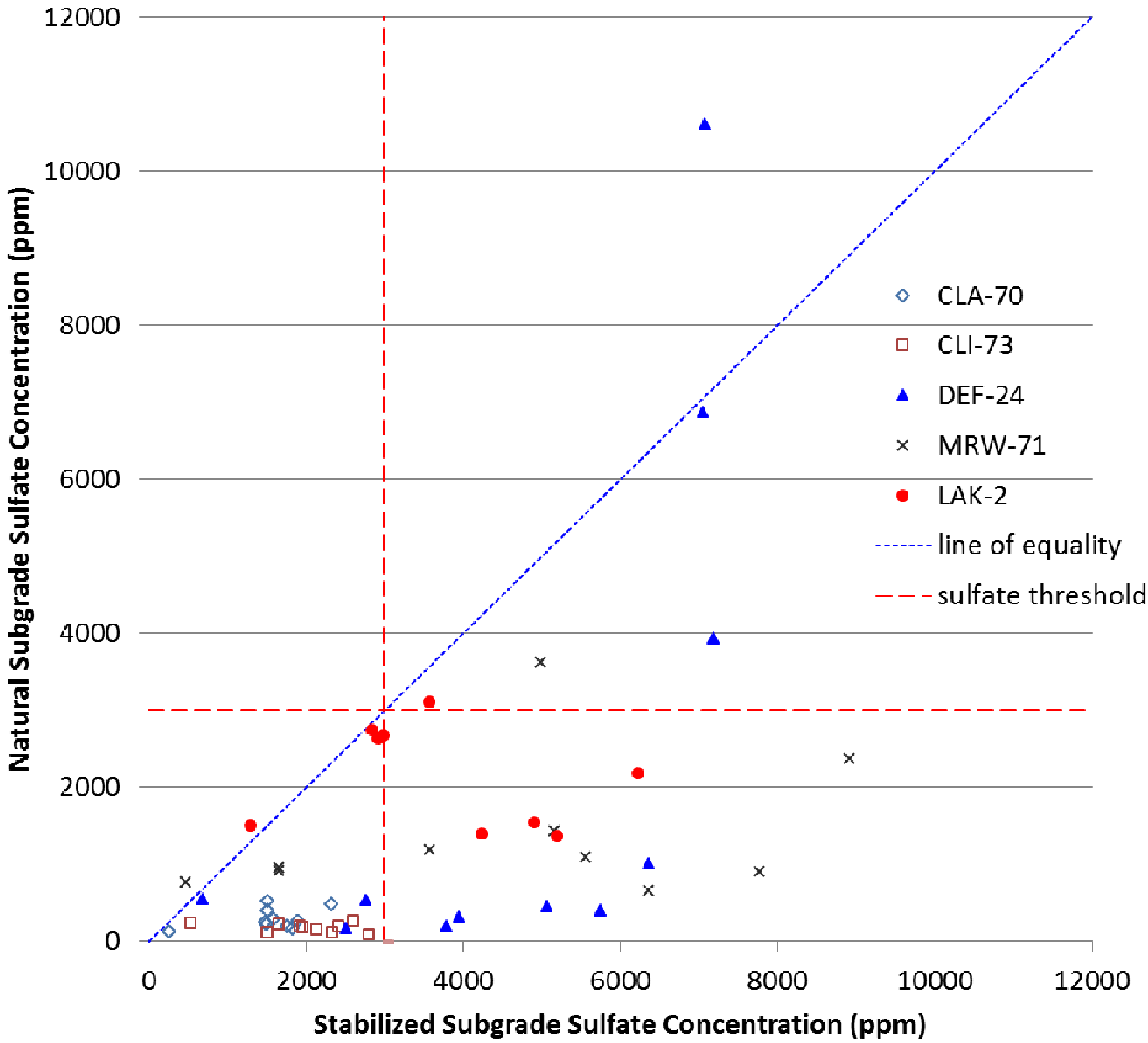


Figure 22. Scatter plot of natural and stabilized sulfate concentrations from each bore hole.

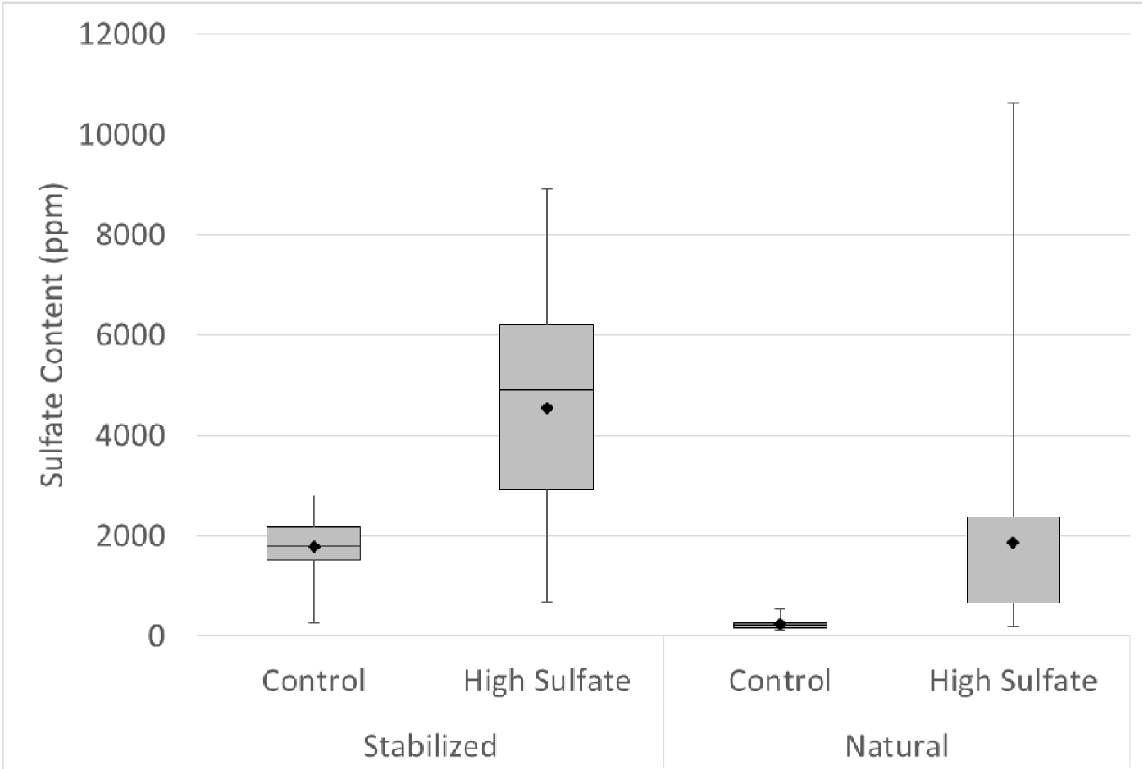
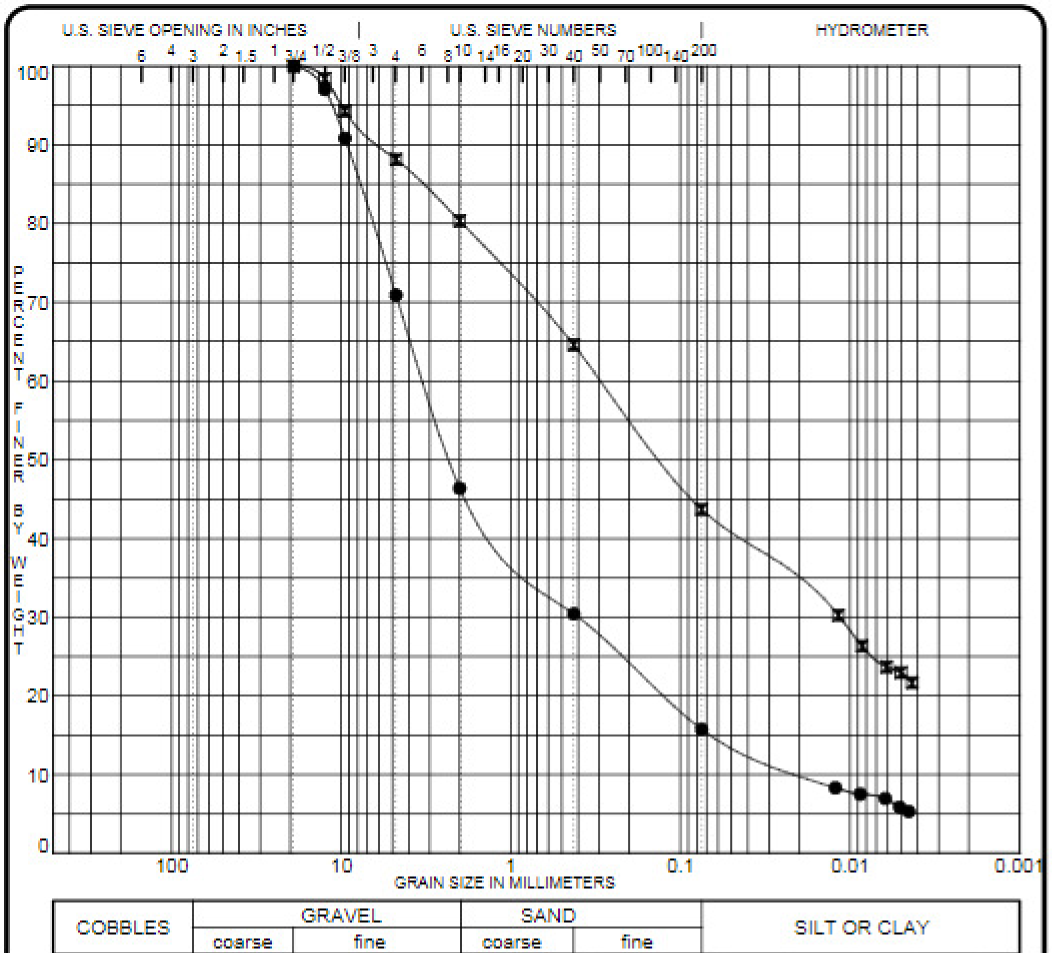


Figure 23. Box plot of sulfate content of stabilized and natural subgrades.

5.3.5 Gradation of stabilized subgrade

A particle size analysis was performed on each sample. The tests were performed based on guidelines of ASTM D422 test method. The test included the use of a mechanical sieve to determine coarse grain particle percentages and a hydrometer to analyze finer grained particles. After completion of each test a curve was created to portray the gradation of the sample. An example of the created curve can be seen below in Figure 24. The figure shows the treated and natural samples from Bore Hole 1 of CLA-70. The treated sample is represented by the line with solid dots while the boxes represent the natural sample.



	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-01	1.2	A-1-b	2320		10	NP	NP	NP	2.73	175.2
⧗	B-01	2.8	A-4a	480		10	22	13	9		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-01	3.23	2.27	0.404	0.0185	0.0	53.6	16.0	14.7	10.0	5.8
⧗	B-01	0.29	0.13	0.011		0.0	19.7	15.8	20.8	20.7	23.0

PROJECT ODOT Cond. Eval. CLA-70 PROJECT NO. W-16-171

GRADATION CURVES

RII

Figure 24. Example of a gradation curve produced from a particle size analysis.

Observations from all gradation curves from CLA-70 show the treated layer is mainly made up of coarse grained materials. The coarse-grained materials are gravel and sand sized particles. Some samples have high percentages of silts as well, up to 30 percent while almost all samples have less than 10% clay. MRW-71 results are similar to those from CLA-70, yielding up to 30% silt, less than 10% clay and the rest is made up of coarse grained materials. DEF-24 also produced similar values to MRW-71 and CLA-70, however the clay content was slightly higher typically in the teens. LAK-2 results are also similar.

CLI-73 has more silt and clay content than other sites. The coarse-grained materials still make up about half the total sample but silts make up about 30-60%. CLI-73 also has higher clay percentages than the other four sites.

From the results of all the treated samples from all five sites, it is determined all are made up primarily of coarse-grained materials. In the stabilized layer at each site, more than half of the particles are coarse-grained, and the fine-grained particles are more silt than clay. All gradation plots can be seen in Appendix A.

5.3.6 Gradation of natural subgrade

After analyzing all the curves from LAK-2, there are considerably larger quantities of silt and clay in the natural layer. The typical percentage of clay and silt are 30% for each sample, however there are usually slightly greater silts. MRW-71 produced similar results to that of LAK-2. Silt and clay content were relatively close around the range of 30% but silts were mostly always slightly greater. The results from CLA-70 were close to those from MRW-71 and LAK-2, having a percentage of silt close to 30% on average and always a smaller percentage of clay. However, there was one case from Bore Hole 3 that yielded a greater clay than silt. The clay was 45.2% while the silt was only 29.6%.

CLI-73 specimens had silt and clay content were fairly close together however at a higher percentage compared to LAK-2 and MRW-71. The percentages for silts ranged between 40-55% while clay was slightly lower ranging from 30-40%. However, silt was always greater than clay.

DEF-24 has a much larger quantity of clay than silt. Many of the samples from DEF-24 have a clay value of 60-70% but there are a few that go as high as 85%. The silt content in these samples range from 10-30%.

The results from all sites for the natural samples shows that there is consistently a greater amount of fine grained particles than coarse grained particles. For a majority of the project sites there was a greater amount of silts than clay but DEF-24 was the only project site that produced greater clay than silt. The larger amount of fine grained particles of silt and clay is the reason that the natural samples always have a larger Plastic Index than the treated samples.

5.3.7 Loss by Ignition (LBI)

The organic content was tested following the method of ASTM D2974, which was performed only if there was evidence of organic material present in the sample. Organic material was present in samples from DEF-24 and CLI-73. The natural sample from Bore Hole 1 was tested from DEF-24, and 4.3% organic matter was found in the sample. The only other sample that was tested for organic matter was the natural sample from Bore Hole 8 in CLI-73. The test produced a value similar to that of the DEF-24 sample of 4.0%.

The results of these two tests determine that the organic material makes up only a small percentage of the soil from these two sites. These tests were also performed by Rii. The results from the test for CLI-73 can be seen below in Figure 25, and those for DEF-24 in Figure 26.

Loss By Ignition (LBI)

D-2974

Project #:	W-16-171
Project Name:	ODOT - Clinton County
Date:	11/17/2016
Technician:	CS

Boring No.	B-8
Sample No.	SS-2A
Crucible No.:	A
Wt. Crucible:	110.77
Wt. Soil used + Crucible:	187.04
Wt. Soil:	76.27
Wt. Crucible + Ash:	184.02
Wt. Ash:	73.25
% Ash:	96.0%
Organic Matter:	4.0%

Figure 25. Test results for organic matter from CLI-73 (weight in grams, 1 g = 0.035 oz).

RESOURCE INTERNATIONAL, INC.
Engineering Consultants

6350 Presidential Gateway
Columbus Ohio, 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Loss By Ignition (LBI)
D-2974

Project #:	W-16-171
Project Name:	ODOT - Defiance County
Date:	11/17/2016
Technician:	CS

Boring No.	B-1
Sample No.	SS-3B
Crucible No.:	A
Wt. Crucible:	53.98
Wt. Soil used + Crucible:	94.27
Wt. Soil:	40.29
Wt. Crucible + Ash:	92.52
Wt. Ash:	38.54
% Ash:	95.7%
Organic Matter:	4.3%

Figure 26. Test results for organic matter from DEF-24 (weight in grams, 1 g = 0.035 oz).

5.4 Chemical Analysis Results

Results are presented by site, comparing the neutralization potential and the soluble sulfate concentration of corresponding natural and stabilized soil samples. In general, most samples, both natural and stabilized, had negative neutralization potential, suggesting low solubility and availability of carbonate and hydroxide minerals, regardless of whether they came from sites with high sulfate content. This suggests that, while XRD results in the next section showed carbonate mineral content in most samples, they may have either low solubility or low concentration in the soils. The neutralization potential of the stabilized soils for most boreholes was similar to that of the natural sample, suggesting little consistent change in the availability or solubility of carbonate and hydroxide minerals during stabilization.

For most samples analyzed, the soluble sulfate concentration in the stabilized soil samples was higher than that of the natural samples. This suggests that sulfur occurred in the untreated soil samples as either sulfide or elemental sulfur and stabilization converted the sulfur to the sulfate form, the sulfate minerals became more soluble during the stabilization process, or the sulfates came from the stabilizing agent and/or the water used in mixing [Cutright, Abbas, and Senko, 2015]. If either of the first two cases applies, decision making about soil stabilization should be made based on total sulfur measurements rather than sulfate measurements in the soil.

Results for neutralization potential and sulfate concentration for CLA-70 samples are shown in Figure 27 and Figure 28, respectively. Unlike the other sites, the neutralization potential of natural subgrade samples was consistently higher (less negative) than the stabilized samples, suggesting that carbonate or hydroxide minerals became more soluble or less abundant during stabilization, potentially as a donor of calcium ions.

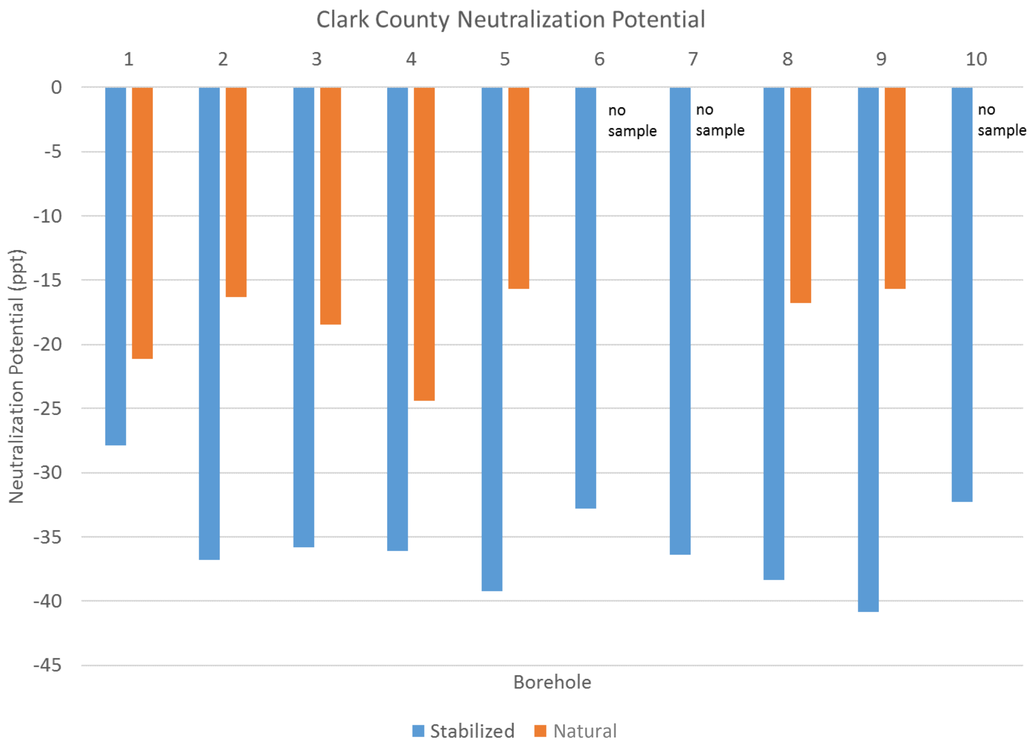


Figure 27. Neutralization potential of stabilized and natural samples from CLA-70. For all complete pairs of samples, the neutralization potential of natural subgrade samples was higher than that of the stabilized samples.

Soluble sulfate concentrations in the CLA-70 soil samples were significantly higher in the stabilized subgrade samples than the natural subgrade samples. This could be due to a change in the form of sulfur in the soils or a change in the solubility of sulfate minerals.

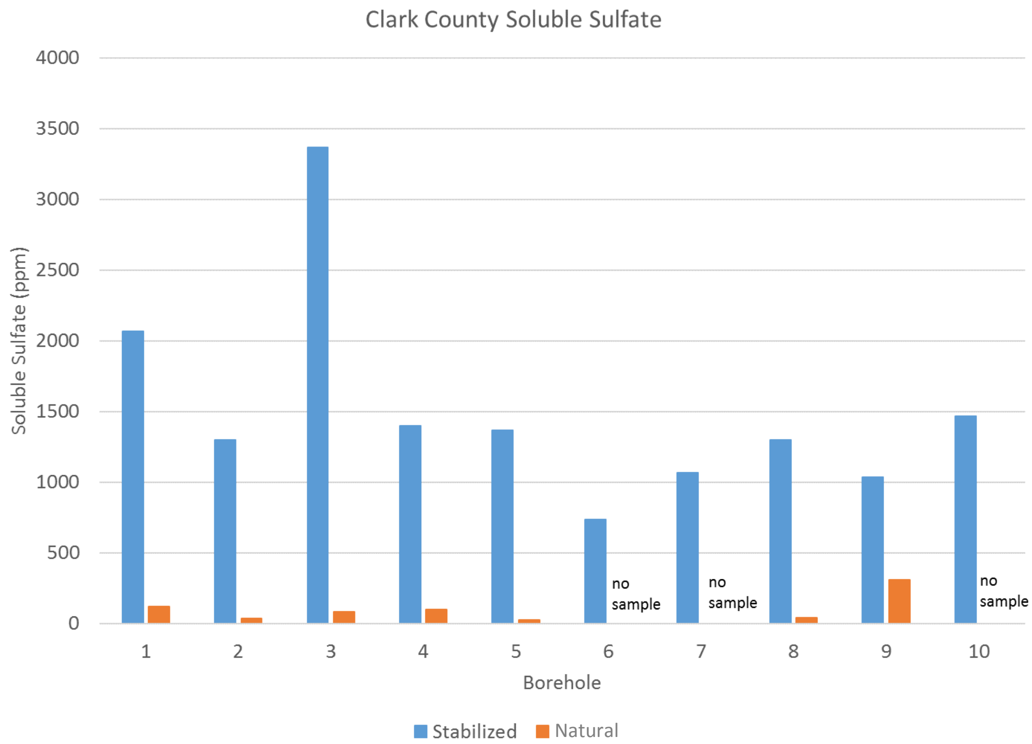


Figure 28. Soluble sulfate concentrations in natural and stabilized soil samples from CLA-70. For all paired samples, the soluble sulfate concentration in the stabilized sample was higher than that in the natural subgrade sample.

Neutralization potential and soluble sulfate concentration for CLI-73 soil samples are shown in Figure 29 and Figure 30, respectively. Unlike CLA-70, the neutralization potential was not consistently lower in the stabilized samples. For most sample pairs, the stabilized and natural samples had similar neutralization potential. Like the other sites, soluble sulfate was consistently higher in the stabilized samples.

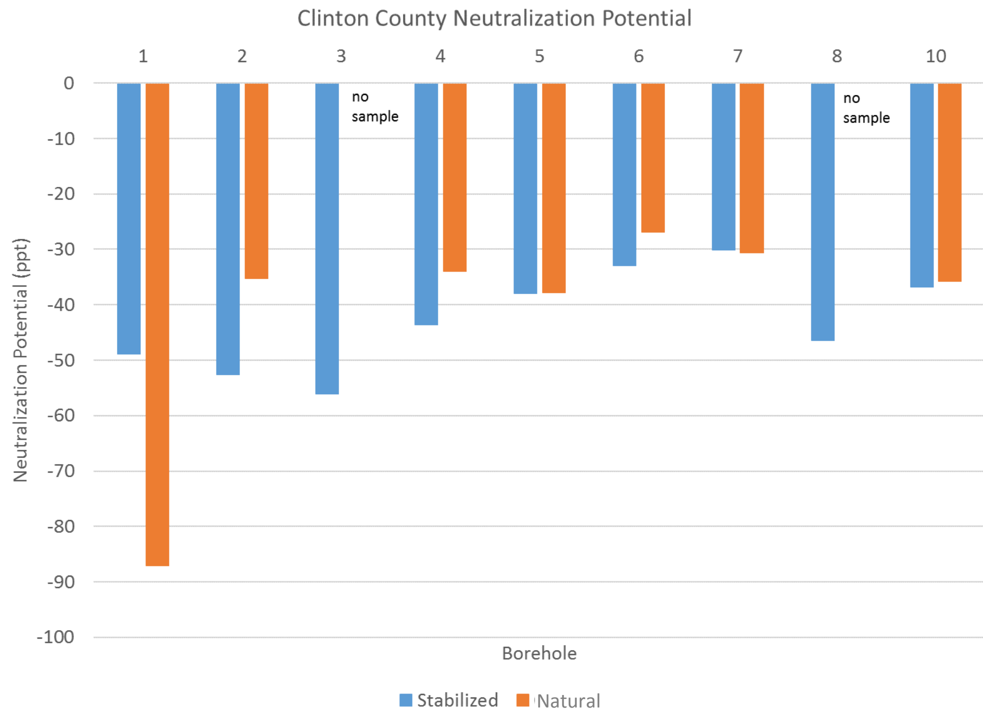


Figure 29. Neutralization potential of stabilized and natural subgrade samples from CLI-73. For most samples, the neutralization potential of corresponding natural and stabilized soil samples had similar values.

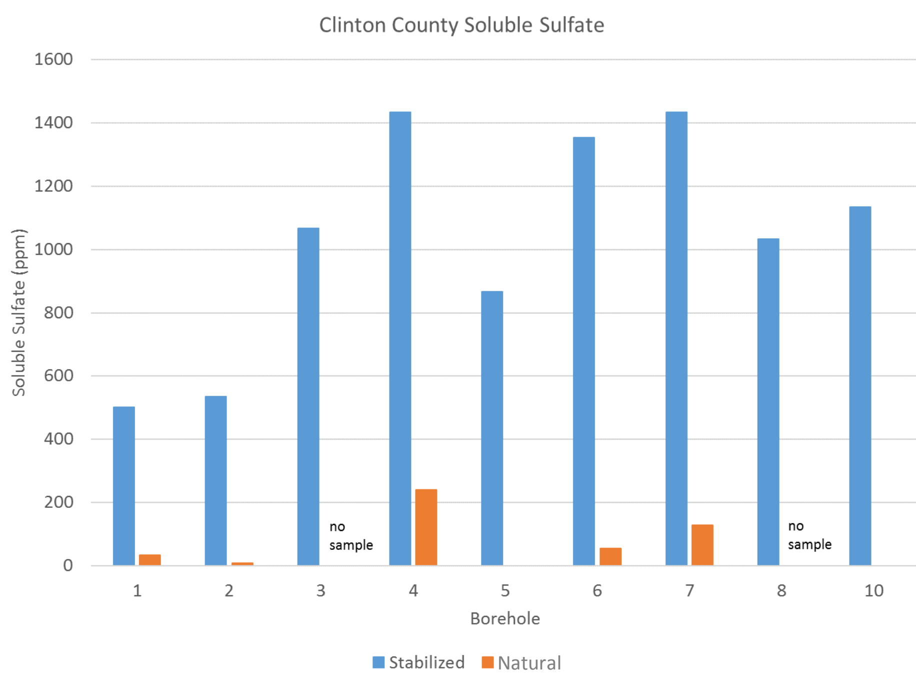


Figure 30. Soluble sulfate concentrations in natural and stabilized soil samples from CLI-73. For all paired samples, the soluble sulfate concentration in the stabilized sample was higher than that in the natural sample.

Neutralization potential and soluble sulfate concentrations measured for natural and stabilized soil samples from DEF-24 are presented in Figure 31 and Figure 32, respectively. Similar to CLI-73 and MRW-71, neutralization potential generally did not show a consistent difference between natural and stabilized samples. Some variation, although not in a consistent direction, is seen in the sample pairs from Bore Holes 2, 7, and 10.

Where soluble sulfate concentrations were high in DEF-24 samples, the natural soluble sulfate concentration tended to be much lower, however, in the sample pair from Bore Hole 2, both the natural and stabilized samples had low soluble sulfate concentrations.

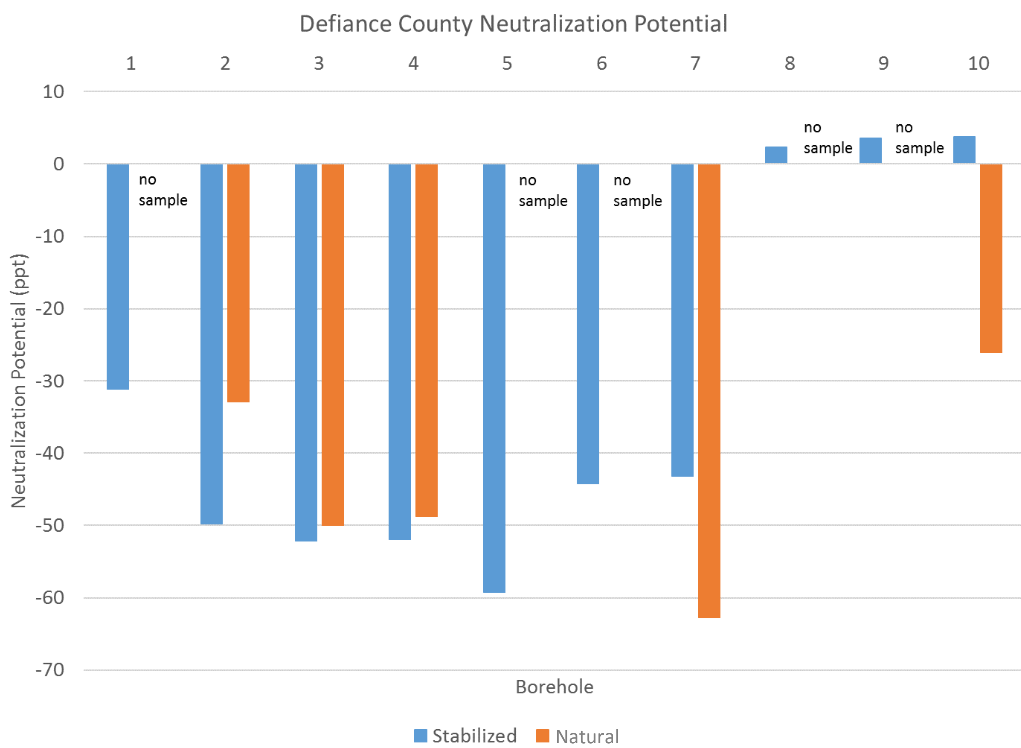


Figure 31. Neutralization potential of stabilized and natural samples from DEF-24. For most samples, the neutralization potential of corresponding natural and stabilized soil samples had similar values.

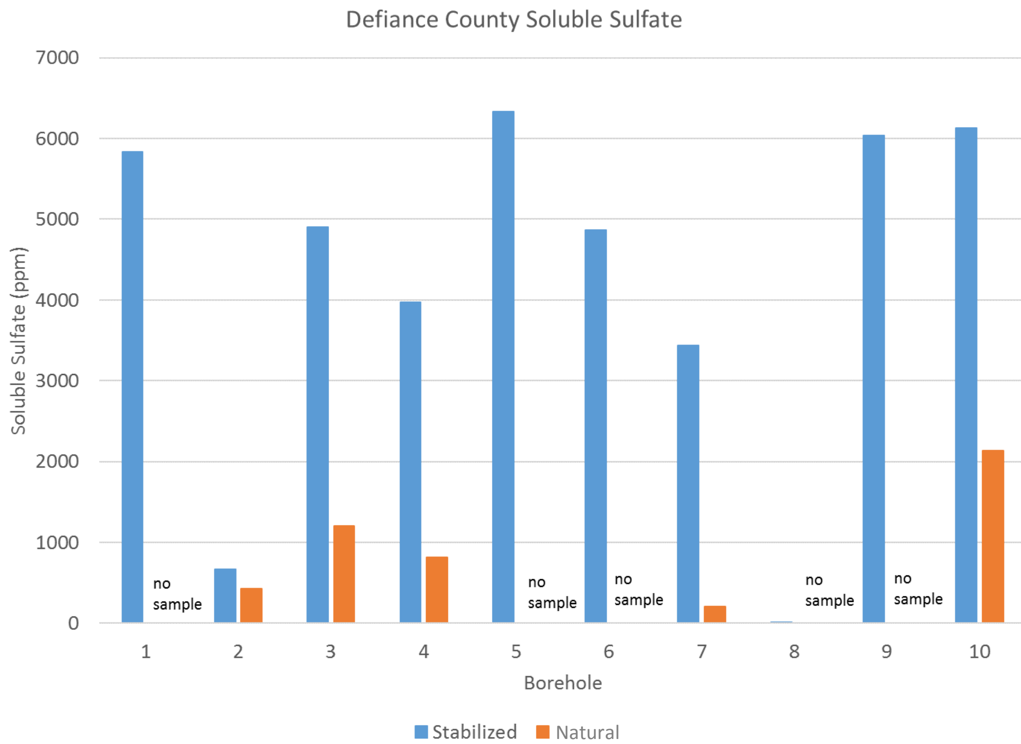


Figure 32. Soluble sulfate concentrations in natural and stabilized soil samples from DEF-24. For all paired samples, the soluble sulfate concentration in the stabilized sample was higher than that in the natural sample. The unpaired stabilized samples had similar soluble sulfate concentrations as the paired ones.

Neutralization potential in samples from LAK-2 is shown in Figure 33. For most paired samples, the neutralization potential of stabilized samples was lower (more negative) than the natural samples suggesting that carbonate and hydroxide minerals from the natural subgrade sample were consumed during the stabilization process. Soluble sulfate concentration of samples from LAK-2 are shown in Figure 34. With the exception of Bore Holes 11 and 17, soluble sulfate concentration was higher in the stabilized samples than the corresponding natural samples. This may be due to formation of soluble sulfate minerals during stabilization alongside the corresponding consumption of carbonate and hydroxide minerals.

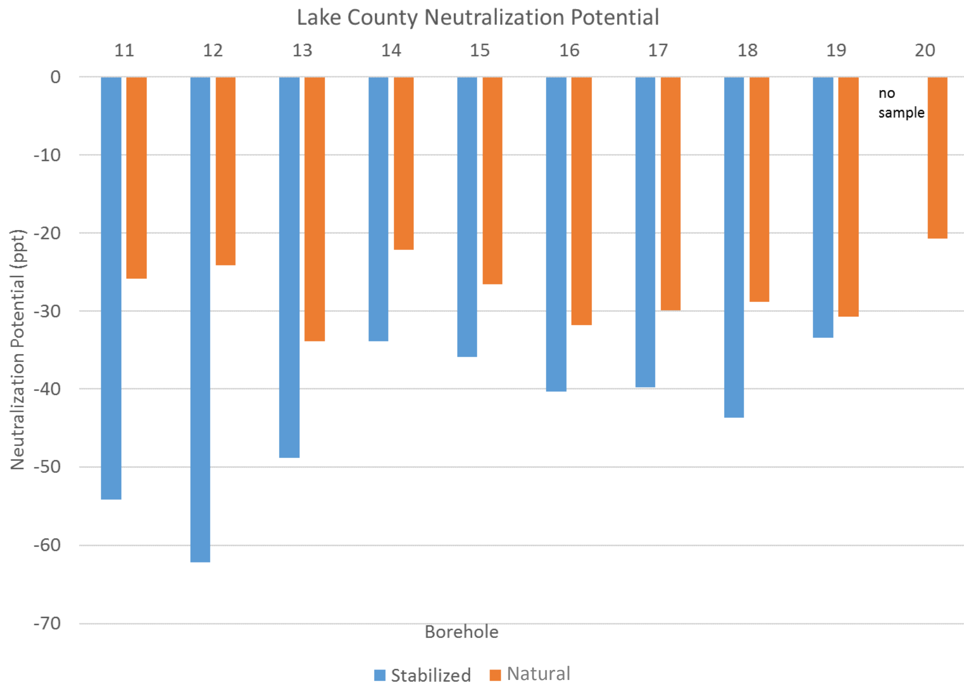


Figure 33. Neutralization potential of stabilized and natural subgrade samples from LAK-2. For most samples, the neutralization potential of corresponding stabilized samples had lower (more negative) neutralization potential than natural samples.

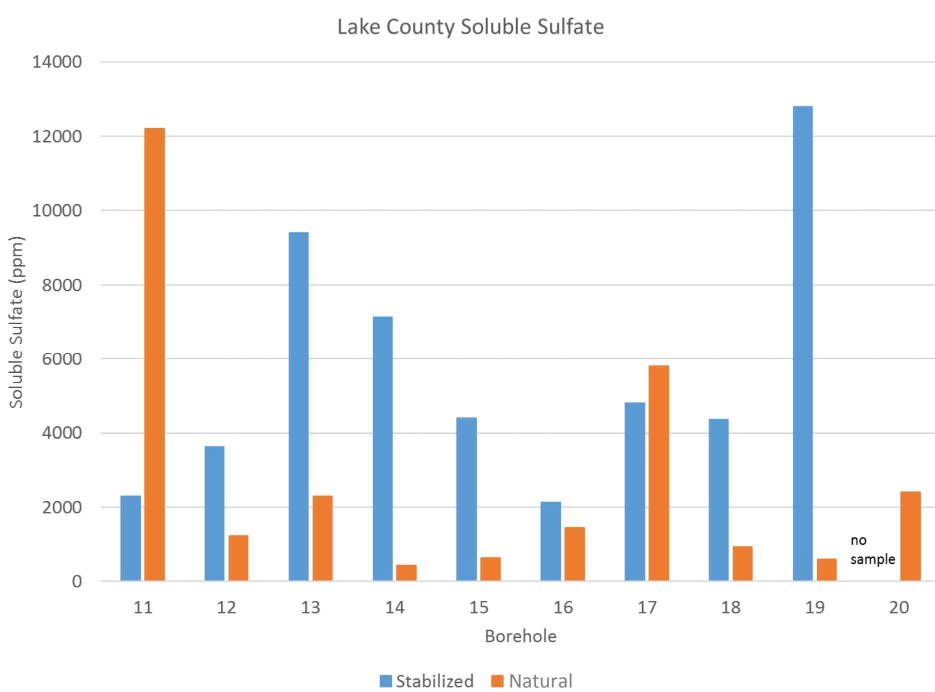


Figure 34. Soluble sulfate concentrations in natural and stabilized soil samples from MRW-71. With the exception of the sample pairs from Bore Holes 11 and 17, the soluble sulfate concentration in the stabilized sample was higher than that in the corresponding natural sample.

Neutralization potential and soluble sulfate concentrations for samples collected from MRW-71 are shown in Figure 35 and Figure 36, respectively. Like DEF-24, there is not a consistnent relationship between the neutralization potential of natural and stablized samples, suggesting spatial variability in soil composition and chemical reactions occuring during stabilization.

Soluble sulfate concentrations in the sample pairs collected from MRW-71 did not have a consistent relationship between stabilized and natural samples. Four bore holes followed the trend in other sites of a much higher soluble sulfate concentration in the stabilized samples, while the other two complete pairs had similar soluble sulfate concentrations in the stabilized and natural samples.

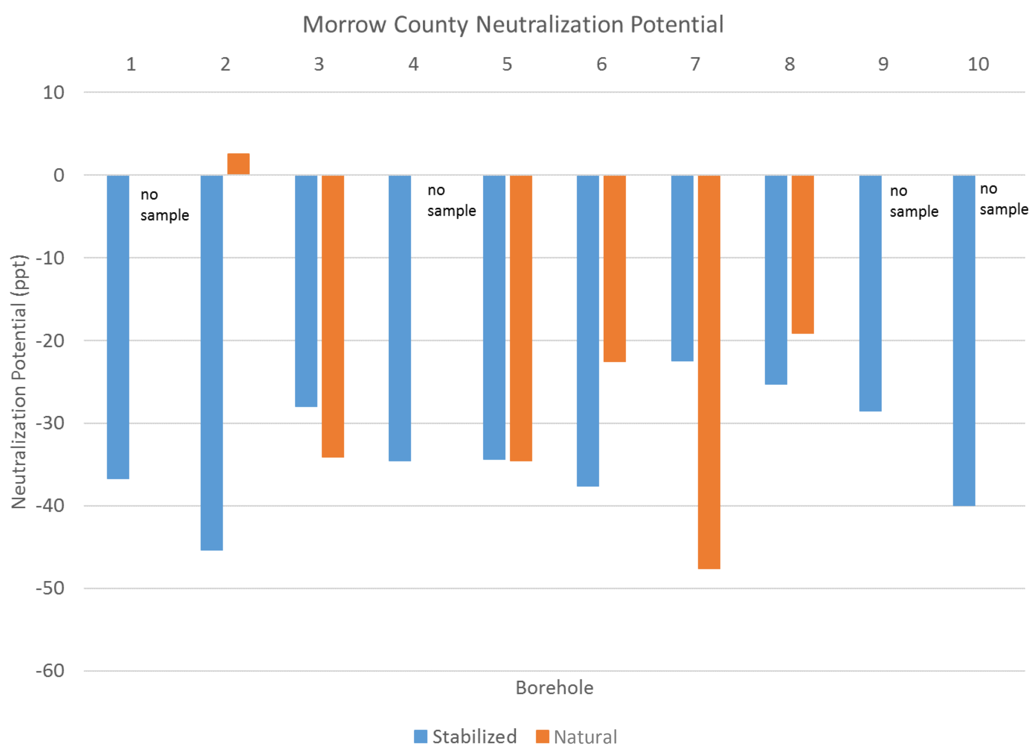


Figure 35. Neutralization potential of stabilized and natural samples from MRW-71. For most samples, the neutralization potential of corresponding natural and stabilized soil samples had similar values.

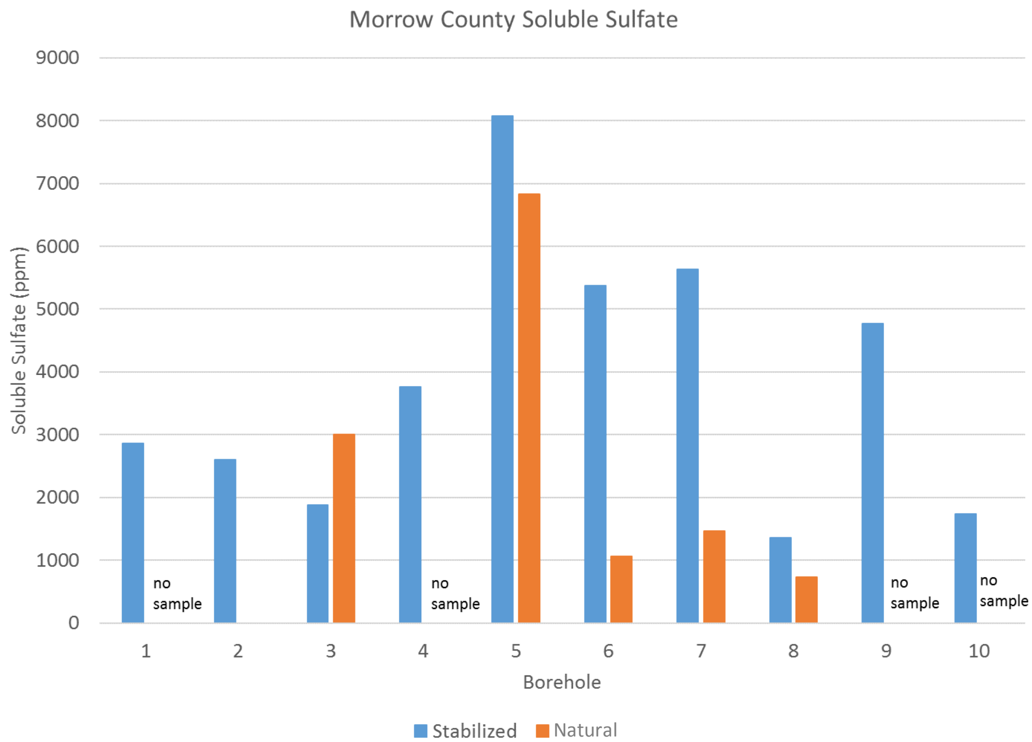


Figure 36. Soluble sulfate concentrations in natural and stabilized soil samples from MRW-71. With the exception of the sample pair from Bore Hole 3, the soluble sulfate concentration in the stabilized sample was higher than that in the natural sample for the other pairs.

5.4.1 Summary of chemical analysis

With few exceptions, sulfate concentrations were higher in the stabilized than the natural subgrade samples and the sulfate concentration of the natural samples was relatively low (<2000 ppm). Natural subgrade samples with high soluble sulfate were in isolated locations rather than being present throughout the road section. The cause of increased soluble sulfate in the stabilized samples with respect to the natural subgrade concentrations may be due to either chemical reactions that transform less soluble sulfur compounds into soluble sulfate compounds (e.g. ettringite and thaumasite, among others) or sulfate present in water used during road construction or in rain water. The soluble sulfate concentrations in the stabilized samples is high in many locations and could lead to future chemical reactions given the right conditions

5.5 X-ray diffraction

Figure 37 shows an example of the output from PDXL software that gives the results of the X-ray diffraction (XRD) measurement. The peak signatures developed through XRD analysis can be identified as specific mineral signatures above the background noise of the results; this means that minerals that occur in trace amounts may not be identified. The primary mineralogy of each soil sample as determined by XRD is organized by site in Table 29 through Table 33.

All samples analyzed contained quartz, as expected since quartz is a highly dominant mineral in soils. Most samples also contained carbonate minerals, either calcite or dolomite or both. MRW-71, DEF-24, and LAK-2 also had common occurrence of gypsum. Several minerals were detected less commonly, including baryocalcite, a barium-calcium carbonate mineral, and less common sulfate minerals. Neither ettringite nor thaumasite were identified in any samples, however, they may be present at levels too low to detect. While the differences between pairs of natural and stabilized samples are discussed throughout this section, soil mineralogy is highly variable spatially and variation may not be due to stabilization efforts.

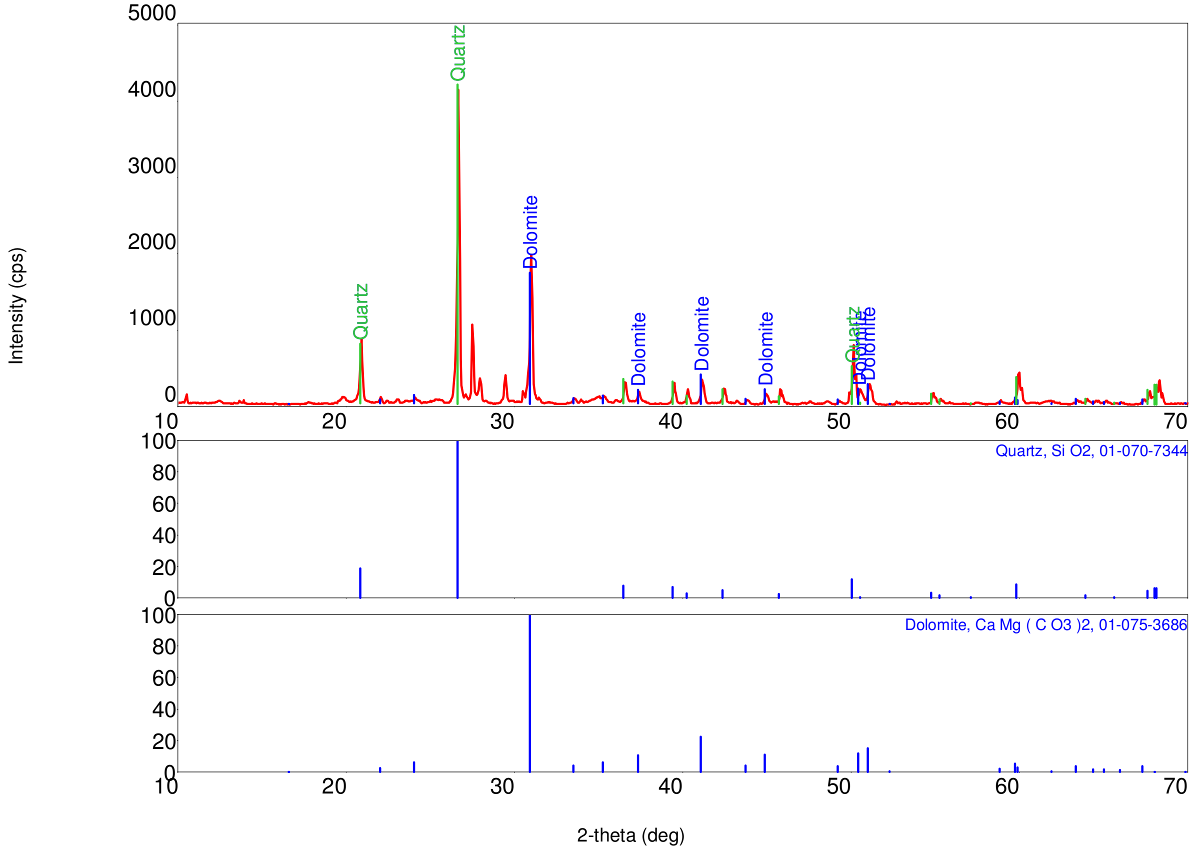


Figure 37. Sample PDXL software output for CLA-70 Bore Hole 1 natural subgrade sample. Peaks that are representative of each of the key crystalline components, quartz and dolomite, are noted.

Table 29 shows the primary crystalline mineralogy for the CLA-70 samples. All samples are composed of quartz and carbonate minerals (calcite and dolomite). Little variation is seen between the natural and stabilized subgrade samples, although the composition of the carbonate fraction does shift for some of the samples. No gypsum or other sulfate minerals were detected above background noise for any CLA-70 samples.

Table 29. Primary mineralogy of stabilized and natural subgrade samples collected from CLA-70 (Q = Quartz, C = Calcite, D = Dolomite, G = Gypsum, S = Other Sulfate Minerals, O = Other).

CLA-70						
Borehole	Q	C	D	G	S	O
Stabilized Samples						
1	x		x			
2	x		x			
3	x	x	x			
4	x	x	x			
5	x	x	x			
6	x	x	x			
7	x	x	x			
8	x	x	x			
9	x	x	x			
10	x	x	x			
Natural Samples						
1	x		x			
2	x	x	x			
3	x	x	x			
4	x		x			
5	x	x	x			
6	no sample					
7	x	x	x			
8	x	x	x			
9	x	x	x			
10	no sample					

The mineralogy of samples from CLI-73 are shown in Table 30. Similar to CLA-70, most samples are dominated by quartz and carbonate minerals. One natural subgrade sample contained gypsum, while the corresponding stabilized sample did not. For most samples, there is little variation between the natural and stabilized samples, with the exception of natural subgrade samples that contain baryocalcite or gypsum without those minerals occurring in the corresponding stabilized sample.

Table 30. Primary mineralogy of stabilized and natural subgrade samples collected from CLI-73 (Q = Quartz, C = Calcite, D = Dolomite, G = Gypsum, S = Other Sulfate Minerals, O = Other).

CLI-73							
Borehole	Q	C	D	G	S	O	
Stabilized Samples							
1	x	x	x				
2	x	x	x				
3	x	x	x				
4	x	x	x				
5	x	x	x				
6	x	x	x				
7	x	x	x				
8	x	x	x				
9	x		x				
10	x	x	x				
Natural Samples							
1	x			x			
2	x		x			x	Ba - calcite
3	no sample						
4	x		x				
5	x	x	x				
6	x	x	x				
7	x	x	x				
8	x						
9	x						
10	no sample						

The mineralogy of the samples collected from MRW-71 are shown in Table 31. The natural subgrade samples from MRW-71 have similar mineralogy to those collected from the other sites – primarily quartz and carbonates. There is a noticeable difference between natural and stabilized subgrade samples, however: 6 samples contain gypsum after stabilization, suggesting that calcium from either the carbonates or from stabilization material has reacted to create gypsum.

Table 31. Primary mineralogy of stabilized and natural subgrade samples collected from MRW-71 (Q = Quartz, C = Calcite, D = Dolomite, G = Gypsum, S = Other Sulfate Minerals, O = Other).

MRW-71						
Borehole	Q	C	D	G	S	O
Stabilized Samples						
1	no sample					
2	x	x	x			
3	x		x	x		
4	x	x		x		
5	x	x	x			
6	x		x	x		
7	x	x	x			
8	x		x	x		
9	x		x	x		
10	x		x	x		
Natural Samples						
1	x	x	x			
2	x		x			
3	x		x			
4	x	x	x			
5	x	x	x			
6	x		x			
7	x					
8	x		x			
9	no sample					
10	no sample					

Mineralogy of the samples collected in DEF-24 are shown in Table 32. The DEF-24 results are similar to those of MRW-71. The natural subgrade samples are primarily quartz and carbonate minerals. Three of the samples also contain gypsum after stabilization, suggesting reactions between sulfates and calcium from either the carbonate minerals or stabilization additives.

Table 32. Primary mineralogy of stabilized and natural subgrade samples collected from DEF-24 (Q = Quartz, C = Calcite, D = Dolomite, G = Gypsum, S = Other Sulfate Minerals, O = Other).

DEF-24						
Borehole	Q	C	D	G	S	O
Stabilized Samples						
1	x		x	x		
2	x			x		
3	x	x		x		
4	x	x	x			
5	x	x	x			
6	x	x	x			
7	x	x	x			
8	x	x	x			
9	x	x	x			
10	x	x	x			
Natural Samples						
1	no sample					
2	x		x			
3	x		x			
4	x					
5	no sample					
6	no sample					
7	x					
8	no sample					
9	no sample					
10	x	x	x			

The mineralogy results for the LAK-2 samples are shown in Table 33. In contrast to the results from MRW-71 and DEF-24, several natural subgrade samples from LAK-2 contained gypsum or other sulfate minerals, while the stabilized samples did not contain sulfate minerals. This could be due to spatial variation in soil composition, due to chemical reactions during stabilization, or sulfates could be in amorphous forms undetectable by XRD.

Table 33. Primary mineralogy of stabilized and natural subgrade samples collected fromLAK-2 stabilized section (Q = Quartz, C = Calcite, D = Dolomite, G = Gypsum, S = Other Sulfate Minerals, O = Other).

LAK-2							
Borehole	Q	C	D	G	S	O	
Stabilized Samples							
11	x						
12	x	x	x				
13	x					x	Ba - calcite
14	x	x	x				
15	x	x	x				
16	x		x				
17	x					x	Ba - calcite
18	x	x	x				
19	x						
20	no sample						
Natural Samples							
11	x	x					
12	x						
13	x					x	Al - phosphate
14	x				x		
15	x				x		
16	x			x			
17	x						
18	x		x				
19	x						
20	x	x	x				

5.6 Ettringite and thaumasite

No signs of significant amounts of ettringite or thaumasite crystals were found at any of the test sites.

5.7 Scanning Electron Microscope

Because no signs of ettringite or thaumasite were found, there was no need to use the scanning electron microscope to study the crystal structure.

6 Conclusions and Recommendations

6.1 Conclusions

- The lack of heaving related distress after 2 to 8 years of service, despite moderate to high levels of sulfate, would indicate the conditions needed to produce sulfate induced heave are not widespread in Ohio.
- With the exception of DEF-24, the ride quality of the control sections were similar to the sections with high sulfate contents in the subgrade soil. The lower ride quality of DEF-24 is likely due to age and pavement material as no heaving related distress was observed.
- The distress rating of the two sections on LAK-2 was inconclusive due to surface asphalt mix issues. However, the FWD deflection measurements indicate the undercut with granular backfill would be expected to have a longer service life than the section with the cement stabilized subgrade. The undercut method also produced a section that was less variable with regard to deflection.
- The stabilized soil and aggregate base moduli and depth of stabilization for the sections with high sulfate soils calculated from DCP data were similar to those of the control sections and not very different from a previous study [Sargand, 2014], indicating the high sulfate soils did not affect the stabilization process.
- Likewise, the stabilized soil and aggregate base moduli values and their ratios for the stabilized sections with high sulfate soils calculated from FWD data were similar to the control sections and not very different from a previous study, indicating the high sulfate soils did not affect the stabilization process.
- The purpose of cement or lime stabilization is to alter the clay or silt particles in soil to produce a soil that is less plastic and more granular. The Atterberg limits and gradations indicate the stabilization was successful in this regard.
- Measured sulfate levels on the control sections were low. Measured sulfate levels in the natural subgrade of the evaluation sections were low to marginal (3000 to 5000 ppm) with one location on MRW-71 having a high sulfate level. None of the sections had sulfate levels exceeding 10,000 ppm, which would be considered unacceptable for lime stabilization.
- With few exceptions, sulfate concentrations were higher in the stabilized than the natural subgrade samples for all project sites. The sulfate concentration of the natural subgrade samples was relatively low (<2000 ppm), with some isolated exceptions in the project sites where higher sulfate content was expected. Thus high soluble sulfate appears to occur in isolated locations rather than being present throughout the road section.
- The cause of increased soluble sulfate in the stabilized subgrade samples with respect to the natural subgrade concentrations may be due to either chemical reactions that transform less soluble sulfur compounds into soluble sulfate compounds (e.g. ettringite and thaumasite, among others) or sulfate present in water used during road construction. The soluble sulfate concentration in the stabilized subgrade samples is high in many locations at the designated high sulfate sites and may lead to future adverse chemical reactions given the right conditions.

- The observed pH values in stabilized subgrade soils was in the range of 9 to 11 for both high sulfate and control sections. A pH of 10 is a condition for the swelling-induced heave [Knopp and Moorman, 2016], and the sulfate levels in the stabilized subgrade in the high sulfate sections were high enough to permit heaving. However, no swelling was observed at the sites, which indicates that some other factor was missing and thus inhibited formation of crystals of ettringite or thaumasite.
- The X-ray diffraction methods did not find any ettringite or thaumasite in quantities sufficient to detect in any of the specimens. This suggests that although soluble sulfate concentrations were high, particularly in stabilized subgrade specimens from high sulfate sites, the conditions for formation of ettringite or thaumasite crystals were not met.

6.2 Recommendations

- ODOT should continue the policy of global stabilization of subgrade soils for reconstruction and new construction.
- The undercut and backfill with granular material on LAK-2 produced a section which is less variable and would be expected to have a longer service life than a section constructed on stabilized subgrade. This method should be considered on other projects where cost effective.
- For the isolated times when swelling does occur during construction, ODOT should develop a contingency specification, such as reworking the stabilized soil, to mitigate the damage. The specification could be incorporated into projects where high sulfate soils are encountered during the subsurface investigation.
- For sites in areas which have historically experienced heaving, it may be warranted to test for total sulfur content in addition to soluble sulfate content, in case there are conditions where reduced or elemental sulfur can weather to become sulfate and induce heaving. However, such testing is more involved than the sulfate test in ODOT Supplement 1122.
- Other situations which might warrant total sulfur testing are a topic for possible further research.

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Appendix A: Soil Boring Logs

CLA-70

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.2 ft.
START: 11/6/16 END: 11/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-01

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.4' - ASPHALT (14.0")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.6																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL AND SAND**, TRACE SILT, TRACE CLAY, MOIST. -SS-1: SULFATE = 2320 PPM; PHW = 10.10; PHC = 9.92 -TOP 1" OF SS-2 IS STABILIZED	-2.8	2	17 30 32	89	83	SS-1	-	53	16	15	10	6	NP	NP	NP	10	A-1-b (0)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
NATURAL: HARD, OLIVE GRAY TO BROWNISH GRAY **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, DAMP. -SS-2B: SULFATE = 480 PPM; PHW = 8.19; PHC = 7.66	-4.2	3 4 EOB	12 8 22	43	94	SS-2B	4.50	19	16	21	21	23	22	13	9	10	A-4a (2)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.2 ft.
START: 11/6/16 END: 11/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-02

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.0")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.6																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, MOIST. -SS-1: SULFATE = 1493 PPM; PHW = 10.42; PHC = 10.13 -TOP 1" OF SS-2 IS STABILIZED	-2.8	2	20 60 63	176	100	SS-1	-	26	24	21	16	13	NP	NP	NP	11	A-2-4 (0)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-2-4 (V)	
NATURAL: HARD, BROWN **SANDY SILT**, SOME CLAY, LITTLE CLAY, DAMP. -TRACE ORGANICS PRESENT IN SS-2B -SS-2B: SULFATE = 233 PPM; PHW = 8.06; PHC = 7.73	-4.2	3 4 EOB	12 7 9	23	83	SS-2B	4.25	19	13	22	24	22	22	14	8	9	A-4a (2)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:38 - U:\GB\PROJECTS\2016\W-16-171 CLARK.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70
TYPE: ROADWAY
PID: BR ID:
START: 11/6/16 END: 11/6/16

DRILLING FIRM / OPERATOR: RII / C.D.
SAMPLING FIRM / LOGGER: RII / A.D.
DRILLING METHOD: 4.5" - CFA
SAMPLING METHOD: SPT

DRILL RIG: CME 55 (SN 386345)
HAMMER: AUTOMATIC
CALIBRATION DATE: 9/22/16
ENERGY RATIO (%): 85.9

STATION / OFFSET: '
ALIGNMENT:
ELEVATION: 0.0 (MSL) EOB: 4.2 ft.
LAT / LONG: Not Recorded

EXPLORATION ID B-03

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.0")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.6																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST. -SS-1: SULFATE = 1507 PPM; PHW = 10.0; PHC = 9.66 -BROKEN LIMESTONE FRAGMENTS PRESENT IN SS-1 -TOP 1" OF SS-2 IS STABILIZED	-2.8	2	24 63 27	129	94	SS-1	-	62	14	10	8	6	NP	NP	NP	10	A-1-a (0)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-1-a (V)	
NATURAL (POSSIBLE FILL): VERY STIFF, BROWN **SILTY CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP. -SS-2B: SULFATE = 407 PPM; PHW = 7.90; PHC = 7.43	-4.2	3 4 EOB	4 3 6	13	89	SS-2B	4.00	5	5	15	30	45	38	16	22	8	A-6b (13)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '	EXPLORATION ID B-04
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.2 ft.	PAGE 1 OF 1
START: 11/6/16 END: 11/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded	

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.4' - ASPHALT (14.0")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.6																	
STABILIZED (FILL): HARD, BROWN **SANDY SILT**, LITTLE FINE GRAVEL, LITTLE SILT, DAMP. -SS-1: SULFATE = 1587 PPM; PHW = 10.44; PHC = 10.23 -TOP 2" OF SS-2 IS STABILIZED	-2.9	2	24 63 27	129	94	SS-1	4.5+	18	18	21	32	11	29	26	3	9	A-4a (2)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
NATURAL (POSSIBLE FILL): VERY STIFF, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP. -SS-2B: SULFATE = 293 PPM; PHW = 8.22; PHC = 7.66	-4.2	3 4 EOB	4 3 6	13	89	SS-2B	4.00	11	9	20	32	28	28	14	14	16	A-6a (7)	

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:38 - U:\GB\PROJECTS\2016\W-16-171 CLARK.GPJ

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.2 ft.
START: 11/6/16 END: 11/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-05

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.0")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.7																	
STABILIZED (FILL): HARD, BROWN **SANDY SILT**, LITTLE FINE GRAVEL, LITTLE CLAY, DAMP. -SS-1: SULFATE = 1827 PPM; PHW = 10.49; PHC = 10.33 -TOP 1" OF SS-2 IS STABILIZED	-2.8	2	25 69 50	170	25	SS-1	4.50	18	21	20	30	11	28	22	6	12	A-4a (1)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
NATURAL (POSSIBLE FILL): VERY STIFF, BROWN **SANDY SILT**, LITTLE FINE GRAVEL, LITTLE CLAY, DAMP. -SS-2B: SULFATE = 173 PPM; PHW = 8.13; PHC = 7.77	-4.2	3 4 EOB	11 8 4	17	22	SS-2B	4.00	17	12	24	33	14	19	13	6	7	A-4a (2)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.2 ft.
START: 11/6/16 END: 11/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-06

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.0")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.6																	
STABILIZED (FILL): VERY DENSE, BROWN **SANDY SILT**, LITTLE FINE GRAVEL, TRACE CLAY, DAMP. -SS-1: SULFATE = 1480 PPM; PHW = 10.26; PHC = 9.99		2	38 180 85	379	72	SS-1	-	15	20	23	32	10	NP	NP	NP	11	A-4a (1)	
-TOP 2" OF SS-2 IS STABILIZED	-2.9					SS-2A	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
NATURAL (POSSIBLE FILL): HARD, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP. -SS-2B: SULFATE = 253 PPM; PHW = 8.20; PHC = 7.77	-4.2	3 4 EOB	15 14 9	33	89	SS-2B	4.50	9	10	22	35	24	27	13	14	9	A-6a (6)	

2016 ODOT BORING LOG BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:38 - U:\GB\PROJECTS\2016\W-16-171 CLARK.GPJ

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.2 ft.
START: 11/6/16 END: 11/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-07

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.0")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.6																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP. -SS-1: SULFATE = 1887 PPM; PHW = 10.78; PHC = 10.52 -TOP 4" OF SS-2 IS STABILIZED	-3.0	2	23 52 30	117	94	SS-1	-	36	21	19	20	4	NP	NP	NP	9	A-1-b (0)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
NATURAL (FILL): HARD, BROWN **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, MOIST. -SS-2B: SULFATE = 267 PPM; PHW = 8.21; PHC = 7.81	-4.2	3 4 EOB	6 9 12	30	100	SS-2B	4.50	22	15	22	27	14	21	12	9	13	A-4a (1)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:38 - U:\GB\PROJECTS\2016\W-16-171 CLARK.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.2 ft.
START: 11/6/16 END: 11/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-08

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.0")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.6																	
STABILIZED (FILL): VERY DENSE, BROWN **SANDY SILT**, LITTLE FINE GRAVEL, TRACE CLAY, DAMP. -SS-1: SULFATE = 1507 PPM; PHW = 10.59; PHC = 10.31		2	24 221 84	437	100	SS-1	-	17	19	22	32	10	NP	NP	NP	12	A-4a (1)	
-TOP 3" OF SS-2 IS STABILIZED	-2.9					SS-2A	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
NATURAL: HARD, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. -LIMESTONE FRAGMENT PRESENT IN SS-2B -SS-2B: SULFATE = 533 PPM; PHW = 8.09; PHC = 7.88	-4.2	3 4 EOB	10 7 6	19	100	SS-2B	4.50	15	15	20	33	17	27	14	13	10	A-6a (4)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT GDT - 1/19/17 15:38 - U:\GB\PROJECTS\2016\W-16-171 CLARK.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.7 ft.
START: 11/6/16 END: 11/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-09

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (13.5")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.6																	
STABILIZED (FILL): HARD, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-1: SULFATE = 1760 PPM; PHW = 8.69; PHC = 8.13		2	27 68 90	226	100	SS-1	4.50	7	10	17	39	27	29	15	14	12	A-6a (8)	
-TOP 6" OF SS-2 IS STABILIZED	-3.2	3	8 11 12	33	56	SS-2A	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
NATURAL: VERY STIFF, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. -LARGE ROCK FRAGMENT PRESENT IN SS-2B		4				SS-2B	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
-SS-2C: SULFATE = 127 PPM; PHW = 8.23; PHC = 8	-4.7	EOB	16	-	100	SS-2C	4.00	13	14	23	33	17	29	14	15	8	A-6a (5)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016 ODOT BORING LOG BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:38 - U:\GBI\PROJECTS\2016\W-16-171 CLARK.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLA-70	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '	EXPLORATION ID B-10
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.2 ft.	PAGE
START: 11/6/16 END: 11/6/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.5")	-1.1	1																
0.4' - AGGREGATE BASE (5.0")	-1.5																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP. -SS-1: SULFATE = 1653 PPM; PHW = 11.30; PHC = 11.14 -TOP 4" OF SS-2 IS STABILIZED	-3.0	2	42 399 19	598	100	SS-1	-	26	27	24	20	3	NP	NP	NP	10	A-1-b (0)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-1-b (V)	
NATURAL (POSSIBLE FILL): HARD, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. -SS-2B: SULFATE = 967 PPM; PHW = 8.63; PHC = 8.0	-4.2	3 4 EOB	9 6 13	27	100	SS-2B	4.50	13	12	21	31	23	26	14	12	8	A-6a (5)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:38 - U:\GB\PROJECTS\2016\W-16-171 CLARK.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-01

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.3' - AGGREGATE BASE (3.0")	-1.3																	
STABILIZED (FILL): VERY DENSE, BROWN **SANDY SILT**, TRACE CLAY, TRACE FINE GRAVEL, MOIST. -SS-1: SULFATE = 2800 PPM; PHW = 10.25; PHC = 10.17	-2.5	2	14 24 18	64	67	SS-1	-	10	23	22	35	10	NP	NP	NP	17	A-4a (2)	
NATURAL: VERY STIFF, MOTTLED BROWN AND GRAY **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -TRACE ORGANICS PRESENT IN SS-2 -SS-2: SULFATE = 93 PPM; PHW = 7.88; PHC = 7.34	-4.0	3 EOB 4	2 2 3	8	67	SS-2	1.00	5	6	11	48	30	31	17	14	18	A-6a (10)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016 ODOT BORING LOG BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:36 - U:\GB\PROJECTS\2016\W-16-171 CLINTON.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-02

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (11.5")	-1.0	1																
0.2' - AGGREGATE BASE (3.0")	-1.2																	
STABILIZED (FILL): HARD, BROWN **SANDY SILT**, LITTLE CLAY, TRACE FINE GRAVEL, DAMP. -SS-1: SULFATE = 2133 PPM; PHW = 10.19; PHC = 10.01	-2.5	2	10 27 16	66	100	SS-1	4.5+	6	17	22	42	13	32	26	6	16	A-4a (4)	
NATURAL (POSSIBLE FILL): VERY STIFF, BROWNISH GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP. -TRACE ORGANICS AND LIMESTONE FRAGMENTS PRESENT IN SS-2 -SS-2: SULFATE = 167 PPM; PHW = 7.65; PHC = 7.01	-4.0	3 EOB 4	3 5 6	17	100	SS-2	4.00	8	8	15	43	26	29	17	12	11	A-6a (8)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:36 - U:\GB\PROJECTS\2016\W-16-171 CLINTON.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '	EXPLORATION ID B-03
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.	PAGE
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.3' - AGGREGATE BASE (4.0")	-1.3																	
STABILIZED (FILL): VERY DENSE, MOTTLED BROWN AND GRAY **COARSE AND FINE SAND**, SOME SILT, LITTLE FINE GRAVEL, TRACE CLAY, MOIST. -SS-1: SULFATE = 1507 PPM; PHW = 10.3; PHC = 10.15	-2.5	2	22 60 30	138	67	SS-1	-	14	27	24	29	6	NP	NP	NP	18	A-3a (0)	
STABILIZED: VERY STIFF, MOTTLED BROWN AND GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	-2.7					SS-2A	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
NATURAL: VERY STIFF, MOTTLED BROWN AND GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -TRACE ORGANICS PRESENT IN SS-2 -SS-2B: SULFATE = 120 PPM; PHW = 7.81; PHC = 7.44	-4.0	3 EOB 4	4 6 7	20	72	SS-2B	4.00	5	7	14	43	31	31	17	14	18	A-6a (9)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-04 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.3' - AGGREGATE BASE (4.0")	-1.3																	
STABILIZED (FILL): DENSE, BROWN AND GRAY **COARSE AND FINE SAND**, SOME SILT, TRACE FINE GRAVEL, TRACE CLAY, MOIST. -SS-1: SULFATE = 1953 PPM; PHW = 9.95; PHC = 9.88	-2.5	2	11 20 11	48	72	SS-1	-	9	35	23	27	6	NP	NP	NP	17	A-3a (0)	
NATURAL (POSSIBLE FILL): HARD, MOTTLED BROWN AND GRAY **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2: SULFATE = 193 PPM; PHW = 8.04; PHC = 7.68	-4.0	3 EOB 4	7 8 7	23	100	SS-2	4.50	6	9	16	40	29	34	14	20	18	A-6b (11)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.5 ft.
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-05

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (11.5")	-1.0	1																
0.3' - AGGREGATE BASE (4.5")	-1.3																	
STABILIZED (FILL): HARD, BROWNISH GRAY **SANDY SILT**, LITTLE CLAY, LITTLE FINE GRAVEL, DAMP. -SS-1: SULFATE = 1920 PPM; PHW = 10.16; PHC = 10.07	-2.5	2	7 21 14	54	72	SS-1	1.50	14	14	21	35	16	33	28	5	18	A-4a (3)	
NATURAL (POSSIBLE FILL): HARD, BROWNISH GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	-4.0	3	6 9 10	29	56	SS-2	4.50	-	-	-	-	-	-	-	-	-	A-6a (V)	
NATURAL: HARD, BROWN **CLAY**, "AND" SILT, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2A: SULFATE = 200 PPM; PHW = 8.46; PHC = 7.93	-4.5	4 EOB	16	-	67	SS-2A	3.00	2	4	11	41	42	44	19	25	18	A-7-6 (15)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-06

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.3' - AGGREGATE BASE (4.0")	-1.3																	
STABILIZED (FILL): VERY STIFF, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP. -SS-1: SULFATE = 2600 PPM; PHW = 10.2; PHC = 9.93	-2.5	2	7 9 6	23	83	SS-1	-	6	10	21	41	22	34	21	13	18	A-6a (7)	
NATURAL (POSSIBLE FILL): VERY STIFF, BROWNISH GRAY **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2: SULFATE = 273 PPM; PHW = 8.05; PHC = 7.47	-4.0	3 EOB 4	5 5 7	18	83	SS-2	4.00	4	5	10	47	34	31	18	13	17	A-6a (9)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:36 - U:\GB\PROJECTS\2016\W-16-171 CLINTON.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-07

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.3' - AGGREGATE BASE (6.0")	-1.5																	
STABILIZED (FILL): HARD, BROWN **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP. -SS-1: SULFATE = 1653 PPM; PHW = 10.09; PHC = 9.92	-2.5	2	10 21 19	61	61	SS-1	-	21	17	19	32	11	30	28	2	15	A-4a (2)	
NATURAL (POSSIBLE FILL): HARD, BROWN **SILT AND CLAY**, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	-3.0	3	9 8 9	26	78	SS-2A	4.50	-	-	-	-	-	-	-	-	-	A-6a (V)	
NATURAL: HARD, BROWN **SILT AND CLAY**, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -TRACE ORGANICS IN SS-2B -SS-2B: SULFATE = 227 PPM; PHW = 7.5; PHC = 6.97	-4.0	EOB 4				SS-2B	4.50	1	2	7	58	32	33	21	12	19	A-6a (9)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-08

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (11.5")	-1.0	1																
0.3' - AGGREGATE BASE (4.5")	-1.3																	
STABILIZED (FILL): HARD, BROWN **SANDY SILT**, LITTLE CLAY, TRACE FINE GRAVEL, DAMP. -SS-1: SULFATE = 2413 PPM; PHW = 10.45; PHC = 10.38	-2.5	2	13 26 24	77	89	SS-1	4.50	8	12	13	49	18	33	24	9	19	A-4a (6)	
NATURAL (POSSIBLE FILL): HARD, BROWNISH GRAY **CLAY**, "AND" SILT, TRACE FINE SAND, TRACE FINE GRAVEL, MOIST. -TRACE ORGANICS PRESENT IN SS-2 -SS-2: SULFATE = 240 PPM; PHW = 8.16; PHC = 7.65	-4.0	3 EOB 4	5 5 5	15	89	SS-2	4.50	1	0	3	52	44	52	21	31	21	A-7-6 (18)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:36 - U:\GB\PROJECTS\2016\W-16-171 CLINTON.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-09

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (11.5")	-1.0	1																
0.3' - AGGREGATE BASE (4.0")	-1.3																	
STABILIZED (POSSIBLE FILL): HARD, DARK BROWNISH GRAY **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TACE FINE GRAVEL, DAMP.	-1.8		7 7 6	20	67	SS-1A	4.50	4	6	10	63	17	36	21	15	14	A-6a (10)	
NATURAL (POSSIBLE FILL): HARD, DARK BROWNISH GRAY **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TACE FINE GRAVEL, DAMP. -SS-1A: SULFATE = 533 PPM; PHW = 10.03; PHC = 9.7	-2.5	2				SS-1B	4.50	-	-	-	-	-	-	-	-	-	A-6a (V)	
NATURAL: VERY STIFF, MOTTLED BROWN AND GRAY **SILTY CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2: SULFATE = 240 PPM; PHW = 7.88; PHC = 7.44	-4.0	3 EOB 4	3 2 4	9	72	SS-2	2.50	3	3	10	52	32	40	18	22	24	A-6b (13)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:36 - U:\GB\PROJECTS\2016\W-16-171 CLINTON.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. CLI-73	DRILLING FIRM / OPERATOR: RII / D	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 11/14/16 END: 11/14/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-10

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
0.9' - ASPHALT (10.5")	-0.9																	
0.5' - AGGREGATE BASE (6.0")	-1.4	1																
STABILIZED (FILL): HARD, BROWN **SANDY SILT**, TRACE CLAY, TRACE FINE GRAVEL, DAMP. -SS-1: SULFATE = 2333 PPM; PHW = 10.47; PHC = 10.31 -TOP 1" OF SS-2 IS STABILIZED	-2.6	2	14 24 18	64	67	SS-1	4.50	3	29	22	44	2	40	35	5	20	A-4a (2)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
NATURAL: VERY STIFF, MOTTLED BROWN AND GRAY **SILT AND CLAY**, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2B: SULFATE = 113 PPM; PHW = 8.41; PHC = 7.99	-4.0	3 EOB 4	2 2 3	8	67	SS-2B	4.00	4	3	5	59	29	35	19	16	24	A-6b (10)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:36 - U:\GB\PROJECTS\2016\W-16-171 CLINTON.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.6 ft.
START: 11/21/16 END: 11/21/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-01

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0
1.1' - ASPHALT (13.0")	-1.1
0.4' - AGGREGATE BASE (5.0")	-1.5
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, LITTLE CLAY, MOIST. -SS-1: SULFATE = 3787 PPM; PHW = 9.73; PHC = 9.6	-2.6
STABILIZED: HARD, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	-4.6
NATURAL: VERY STIFF, BROWN TO GRAY **CLAY**, LITTLE SILT, TRACE FINE SAND, MOIST. -SS-3B: SULFATE = 200 PPM; PHW = 7.65; PHC = 7.5 -TRACE ORGANICS PRESENT	-5.6

DEPTHS: 1, 2, 3, 4, 5, EOB

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)
14 26 12	54	94	SS-1	4.50	22	37	20	12	9	NP	NP	NP	24	A-1-b (0)
6 12 14	37	100	SS-2	4.50	-	-	-	-	-	-	-	-	-	A-6a (V)
12 14 14	40	89	SS-3A	-	-	-	-	-	-	-	-	-	-	A-6a (V)
			SS-3B	3.00	0	0	2	12	86	64	21	43	28	A-7-6 (20)

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '	EXPLORATION ID B-02
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.1 ft.	PAGE
START: 11/21/16 END: 11/21/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.5' - AGGREGATE BASE (6.0")	-1.6																	
STABILIZED (FILL): HARD, BROWN **ELASTIC CLAY**, "AND" COARSE TO FINE SAND, SOME SILT, TRACE FINE GRAVEL, MOIST. -SS-1: SULFATE = 2507 PPM; PHW = 10.42; PHC = 10.18		2	20 34 22	80	94	SS-1	4.50	10	27	21	20	22	54	32	22	25	A-7-5 (5)	
-TOP 4" OF SS-2 IS STABILIZED	-2.9					SS-2A	-	-	-	-	-	-	-	-	-	-	A-7-5 (V)	
NATURAL: HARD, BROWNISH GRAY **CLAY**, SOME SILT, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2B: SULFATE = 180 PPM; PHW = 9.32; PHC = 9.21	-4.1	3 4 EOB	5 7 13	29	100	SS-2B	4.50	2	6	15	31	46	54	26	28	29	A-7-6 (18)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016 ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 14:47 - U:\GB\PROJECTS\2016\W-16-171 DEFIANCE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 7.1 ft.
START: 11/21/16 END: 11/21/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID: B-03

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)
1.1' - ASPHALT (13.0")	-1.1															
0.3' - AGGREGATE BASE (3.5")	-1.4															
STABILIZED (FILL): HARD, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, DAMP. -SS-1: SULFATE = 5067 PPM; PHW = 10.38; PHC = 10.22	-2.6	9 28 18	66	94	SS-1	4.5+	24	29	19	13	15	49	33	16	26	A-2-7 (1)
NATURAL (POSSIBLE FILL): HARD, DARK BROWN AND DARK GRAY **CLAY**, LITTLE SILT, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2A: SULFATE = 460 PPM; PHW = 8.41; PHC = 8.14	-3.6	5 6 11	24	94	SS-2A	4.5+	1	5	10	15	69	55	22	33	22	A-7-6 (19)
STABILIZED (POSSIBLE FILL): HARD, MOTTLED BROWN, GRAY AND BLACK **CLAY**, LITTLE SILT, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.					SS-2B	-	-	-	-	-	-	-	-	-	-	A-7-6 (V)
-SS-3: SULFATE = 680 PPM; PHW = 9.60; PHC = 9.17	-5.6	7 11 13	34	72	SS-3	4.5+	-	-	-	-	-	-	-	-	-	A-7-6 (V)
NATURAL: STIFF, MOTTLED BROWN AND GRAY **CLAY**, LITTLE SILT, TRACE FINE GRAVEL, MOIST. -SS-4: SULFATE = 560 PPM; PHW = 8.40; PHC = 7.51 -TRACE ORGANICS PRESENT	-7.1	9 12 11	33	72	SS-4	2.00	0	0	1	15	84	74	22	52	31	A-7-6 (20)

DEPTHS: 1, 2, 3, 4, 5, 6, 7 — EOB

BACK FILL

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 14:47 - U:\GB\PROJECTS\2016\W-16-171 DEFIANCE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.6 ft.
START: 11/22/16 END: 11/22/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-04

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0
1.1' - ASPHALT (13.0")	-1.1
0.3' - AGGREGATE BASE (3.0")	-1.4
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP. -SS-1: SULFATE = 5733 PPM; PHW = 10.4; PHC = 10.26 -TOP 2" OF SS-2A IS STABILIZED	-2.8
NATURAL (FILL): VERY DENSE, BROWN AND DARK GRAY **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP. -TRACE ORGANICS PRESENT -SS-2A: SULFATE = 400 PPM; PHW = 8.41; PHC = 8.14	-3.6
STABILIZED (FILL): HARD, BROWN **CLAY**, SOME SILT, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	-5.1
NATURAL: HARD, BROWN, OLIVE GREEN AND BLACK **CLAY**, SOME SILT, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -TRACE ORGANICS PRESENT	-5.6

DEPTHS: 1, 2, 3, 4, 5, EOB

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
21 47 35	117	100	SS-1	-	21	36	21	12	10	48	39	9	25	A-2-5 (0)	
7 5 13	26	89	SS-2A	-	-	-	-	-	-	-	-	-	-	A-2-5 (V)	
			SS-2B	4.5+	2	5	8	22	63	56	21	35	24	A-7-6 (19)	
14 18 15	47	89	SS-3A	4.5+	-	-	-	-	-	-	-	-	-	A-7-6 (V)	
			SS-3B	-	-	-	-	-	-	-	-	-	-	A-7-6 (V)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016 ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 14:47 - U:\GB\PROJECTS\2016\W-16-171 DEFIANCE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '	**EXPLORATION ID** B-05
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.	PAGE
START: 11/22/16 END: 11/22/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.4' - AGGREGATE BASE (5.0")	-1.4																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST. -SS-1: SULFATE = 2760 PPM; PHW = 10.59; PHC = 10.26	-2.8	2	22 44 25	99	100	SS-1	-	10	45	24	17	4	NP	NP	NP	25	A-1-b (0)	
			3 5 8	19	83	SS-2A	-	-	-	-	-	-	-	-	-	-	A-1-b (V)	
NATURAL (POSSIBLE FILL): VERY STIFF, BROWN, GRAYISH BROWN AND BLACK **CLAY**, LITTLE SILT, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -TRACE ORGANICS PRESENT -SS-2B: SULFATE = 547 PPM; PHW = 7.79; PHC = 7.64	-4.0	3 EOB 4				SS-2B	3.50	2	2	3	15	78	58	21	37	25	A-7-6 (20)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 14:47 - U:\GB\PROJECTS\2016\W-16-171 DEFIANCE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '	EXPLORATION ID B-06
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.	PAGE
START: 11/22/16 END: 11/22/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.3' - AGGREGATE BASE (4.0")	-1.3																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP. -SS-1: SULFATE = 3947 PPM; PHW = 10.45; PHC = 10.14	-2.7	2	20 42 25	96	94	SS-1	-	7	42	24	18	9	45	37	8	25	A-2-5 (0)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-2-5 (V)	
NATURAL (POSSIBLE FILL): VERY STIFF, BROWN, GREENISH BROWN AND BLACK **CLAY**, SOME SILT, LITTLE FINE GRAVEL, TRACE COARSE TO FINE SAND, MOIST. -SS-2B: SULFATE = 320 PPM; PHW = 7.04; PHC = 6.13 -TRACE ORGANICS PRESENT	-4.0	3 EOB 4	5 3 5	11	78	SS-2B	2.50	18	1	2	22	57	49	19	30	25	A-7-6 (18)	

2016 ODOT BORING LOG BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 14:47 - U:\GB\PROJECTS\2016\W-16-171 DEFIANCE.GPJ

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '	EXPLORATION ID B-07
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.5 ft.	PAGE 1 OF 1
START: 11/22/16 END: 11/22/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded	

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0
1.0' - ASPHALT (12.0")	-1.0
0.4' - AGGREGATE BASE (5.0")	-1.4
STABILIZED (FILL): HARD, BROWN **CLAY**, "AND" COARSE TO FINE SAND, SOME SILT, LITTLE FINE GRAVEL, DAMP. -SS-1: SULFATE = 6347 PPM; PHW = 10.52; PHC = 10.39 -TOP 3" OF SS-2 IS STABILIZED	-2.8
NATURAL (FILL): VERY STIFF, BROWN, DARK GRAY AND TEN **CLAY**, TRACE SILT, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2B: SULFATE = 1020 PPM; PHW = 7.83; PHC = 7.81 -TRACE ORGANICS PRESENT	-3.2
STABILIZED (FILL): VERY STIFF, MOTTLED BROWN AND GRAY **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	-4.0
NATURAL: VERY STIFF, MOTTLED BROWN AND GRAY **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -TRACE ORGANICS PRESENT	-5.5

DEPTHS: 1, 2, 3, 4, 5 — EOB

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
14-33-32	93	100	SS-1	4.50	18	26	19	21	16	42	28	14	24	A-7-6 (1)
5-5-10	21	89	SS-2A	-	-	-	-	-	-	-	-	-	-	A-7-6 (V)
			SS-2B	2.75	4	3	6	6	81	53	24	29	27	A-7-6 (18)
			SS-2C	4.50	-	-	-	-	-	-	-	-	-	A-6b (V)
8-11-11	31	78	SS-3A	3.00	-	-	-	-	-	-	-	-	-	A-6b (V)
			SS-3B	3.50	-	-	-	-	-	-	-	-	-	A-6b (V)

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 14:47 - U:\GB\PROJECTS\2016\W-16-171 DEFIANCE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '	EXPLORATION ID B-08
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.5 ft.	PAGE
START: 11/22/16 END: 11/22/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0
1.0' - ASPHALT (12.0")	-1.0
0.3' - AGGREGATE BASE (4.0")	-1.3
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, DAMP. -SS-1: SULFATE = 7067 PPM; PHW = 10.44; PHC = 10.32	-2.5
NATURAL (FILL): HARD, BROWNISH GRAY **CLAY**, LITTLE SILT, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2A: SULFATE = 10613 PPM; PHW = 7.85; PHC = 7.65	-3.5
STABILIZED: HARD, BROWNISH GRAY **CLAY**, LITTLE SILT, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -ROOT FIBERS PRESENT IN SS-2B -WOOD CHUNKS IN SS-3A	-5.0
NATURAL: HARD, BROWNISH GRAY **CLAY**, LITTLE SILT, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-3B: SULFATE = 667 PPM; PHW = 7.82; PHC = 7.5	-5.5 EOB

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)
13 32 24	80	100	SS-1	-	20	26	21	18	15	46	33	13	25	A-2-7 (1)
6 5 11	23	67	SS-2A	4.5+	7	4	8	19	62	56	23	33	27	A-7-6 (19)
			SS-2B	-	-	-	-	-	-	-	-	-	-	A-7-6 (V)
10 10 10	29	83	SS-3A	4.5+	-	-	-	-	-	-	-	-	-	A-7-6 (V)
			SS-3B	1.50	-	-	-	-	-	-	-	-	-	A-7-6 (V)

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 11/22/16 END: 11/22/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-09

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.4' - AGGREGATE BASE (5.0")	-1.4																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, DAMP. -SS-1: SULFATE = 7173 PPM; PHW = 10.51; PHC = 10.48		2	15 42 36	112	100	SS-1	-	21	27	20	14	18	45	32	13	25	A-2-7 (1)	
-TOPS 2" OF SS-2 IS STABILIZED	-2.8					SS-2A	-	-	-	-	-	-	-	-	-	-	A-2-7 (V)	
NATURAL (POSSIBLE FILL): VERY STIFF, BROWN **CLAY**, LITTLE SILT, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2B: SULFATE = 3947 PPM; PHW = 8.02; PHC = 7.82	-4.0	3 EOB 4	5 5 10	21	67	SS-2B	2.50	4	3	6	14	73	56	25	31	32	A-7-6 (19)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. DEF-24	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (SN 386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.1 ft.
START: 11/21/16 END: 11/21/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.9	LAT / LONG: Not Recorded

EXPLORATION ID B-10

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.4' - AGGREGATE BASE (5.0")	-1.5																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, DAMP. -SS-1: SULFATE = 7040 PPM; PHW = 10.38; PHC = 10.33	-2.6	2	6 22 28	72	94	SS-1	-	7	47	21	15	10	NP	NP	NP	25	A-1-b (0)	
NATURAL: HARD, BROWNISH GRAY **CLAY**, LITTLE SILT, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2: SULFATE = 6880 PPM; PHW = 8.04; PHC = 7.82	-4.1	3 EOB 4	3 5 8	19	67	SS-2	4.25	3	6	11	22	58	38	17	21	22	A-6b (12)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 14:47 - U:\GB\PROJECTS\2016\W-16-171 DEFIANCE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY	DRILLING FIRM / OPERATOR: RII / B.S.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.2 ft.
START: 6/7/17 END: 6/7/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.9	LAT / LONG: Not Recorded

EXPLORATION ID B-11 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.75")	-1.1	1																
0.5' - AGGREGATE BASE (6.0")	-1.6					2S-1A	-	-	-	-	-	-	-	-	-	-		
STABILIZED (FILL): VERY DENSE, BROWN **COARSE AND FINE SAND**, SOME FINE GRAVEL, SOME SILT, TRACE CLAY, DAMP TO MOIST. -2S-1B: SULFATE = 3573 PPM; PHW = 8.97; PHC = 8.72	-3.2	2, 3	23 49 30 15	103	75	2S-1B	-	22	19	32	21	6	NP	NP	NP	10	A-3a (0)	
NATURAL: HARD, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-2: SULFATE = 3107 PPM; PHW = 6.87; PHC = 6.81	-5.2	4, 5 EOB	5 8 12 21	26	100	SS-2	4.5+	4	10	13	39	34	30	17	13	15	A-6a (9)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 7/7/17 08:10 - U:\GINT\PROJECTS\2016\W-16-171 LAKE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY	DRILLING FIRM / OPERATOR: RII / B.S.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: '	EXPLORATION ID B-12
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.2 ft.	PAGE
START: 6/7/17 END: 6/7/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.9	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.5")	-1.2	1																
0.5' - AGGREGATE BASE (5.5")	-1.7																	
STABILIZED (FILL): VERY DENSE, BROWN **COARSE AND FINE SAND**, SOME SILT, LITTLE FINE GRAVEL, TRACE CLAY, DAMP TO MOIST. -2S-1: SULFATE = 6213 PPM; PHW = 10.04; PHC = 10.04	-3.2	2 3			100	2S-1	4.5+	17	20	37	21	5	NP	NP	NP	18	A-3a (0)	
NATURAL: HARD, BROWN TO MOTTLED GRAY AND BLACK **SANDY SILT**, SOME CLAY, TRACE FINE GRAVEL, DAMP TO MOIST. -TRACE ORGANICS PRESENT IN SS-2 -2S-2: SULFATE = 2187 PPM; PHW = 6.79; PHC = 6.72	-5.2	4 5 EOB			100	2S-2	4.5+	5	9	29	29	28	25	15	10	13	A-4a (4)	

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT GDT - 7/7/17 08:10 - U:\GB\PROJECTS\2016\W-16-171 LAKE.GPJ

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY	DRILLING FIRM / OPERATOR: RII / B.S.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: '	EXPLORATION ID B-13
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.2 ft.	PAGE
START: 6/7/17 END: 6/7/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.9	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.0")	-1.2	1																
0.5' - AGGREGATE BASE (6.0")	-1.7					2S-1A	-	-	-	-	-	-	-	-	-	-		
STABILIZED (FILL): HARD, DARK BROWN AND GRAY **SANDY SILT**, LITTLE CLAY, LITTLE FINE GRAVEL, DAMP. -2S-1B: SULFATE = 4240 PPM; PHW = 12.28; PHC = 12.36	-2.5	2	28 27 13 14	52	75	2S-1B	4.5+	11	16	27	32	14	34	25	9	16	A-4a (2)	
NATURAL: HARD, MOTTLED BROWN AND GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		3				2S-1C	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
-SS-2B: SULFATE = 1393 PPM; PHW = 7.04; PHC = 7.04	-5.2	4 5 EOB	5 8 10 11	23	100	SS-2	4.5+	6	8	17	36	33	28	16	12	13	A-6a (8)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 7/7/17 08:10 - U:\GB\PROJECTS\2016\W-16-171 LAKE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY TYPE: ROADWAY PID: BR ID: START: 6/7/17 END: 6/7/17	DRILLING FIRM / OPERATOR: RII / B.S. SAMPLING FIRM / LOGGER: RII / C.D. DRILLING METHOD: 4.5" SFA SAMPLING METHOD: SPT	DRILL RIG: MOBILE B-53 (SN 624400) HAMMER: AUTOMATIC CALIBRATION DATE: 9/22/16 ENERGY RATIO (%): 77.9	STATION / OFFSET: ' ALIGNMENT: ELEVATION: 0.0 (MSL) EOB: 6.7 ft. LAT / LONG: Not Recorded	EXPLORATION ID B-14 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.25")	-1.2	1																
0.4' - AGGREGATE BASE (5.0")	-1.6					2S-1A	-	-	-	-	-	-	-	-	-	-		
STABILIZED (FILL): VERY DENSE, BROWN **SANDY SILT**, LITTLE CLAY, TRACE FINE GRAVEL, DAMP. -2S-1B: SULFATE = 5200 PPM; PHW = 10.65; PHC = 10.64	-2.6	2	18 35 18 15	69	75	2S-1B	4.5+	9	17	36	27	11	NP	NP	NP	17	A-4a (1)	
NATURAL: HARD, BROWN AND GRAY **SANDY SILT**, SOME CLAY, TRACE FINE GRAVEL, DAMP.		3				2S-1C	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
-SS-2B: SULFATE = 1373 PPM; PHW = 7.15; PHC = 7.10		4	4 6 7 9	17	50	SS-2	4.5+	2	8	31	32	27	25	15	10	11	A-4a (5)	
		5																
	-6.7	6 EOB	5 7 7	18	89	SS-3	4.5+	-	-	-	-	-	-	-	-	-	A-4a (V)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 7/7/17 08:10 - U:\GI\PROJECTS\2016\W-16 171 LAKE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY	DRILLING FIRM / OPERATOR: RII / B.S.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.3 ft.
START: 6/7/17 END: 6/7/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.9	LAT / LONG: Not Recorded

EXPLORATION ID B-15

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (11.75")	-1.0	1																
0.5' - AGGREGATE BASE (6.0")	-1.5		106	-	58	2S-1A	-	-	-	-	-	-	-	-	-	-		
STABILIZED (FILL): VERY DENSE, BROWN AND GRAY **COARSE AND FINE SAND**, LITTLE SILT, LITTLE FINE GRAVEL, TRACE CLAY, DAMP. -2S-1B: SULFATE = 1293 PPM; PHW = 10.80; PHC = 10.75	-2.7	2				2S-1B	4.5+	18	21	33	19	9	NP	NP	NP	12	A-3a (0)	
			20 14 14 19	36	100	2S-2A	-	-	-	-	-	-	-	-	-	-	A-3a (V)	
NATURAL: HARD, MOTTLED GRAY AND BROWN **SANDY SILT**, SOME CLAY, TRACE FINE GRAVEL, DAMP. -2S-2B: SULFATE = 1513 PPM; PHW = 7.14; PHC = 7.02	-4.3	3 4 EOB				2S-2B	4.5+	9	12	18	37	24	25	17	8	14	A-4a (5)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 7/7/17 08:10 - U:\GB\PROJECTS\2016\W-16-171 LAKE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY	DRILLING FIRM / OPERATOR: RII / B.S.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 4.3 ft.
START: 6/7/17 END: 6/7/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.9	LAT / LONG: Not Recorded

EXPLORATION ID B-16

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0
1.0' - ASPHALT (12.0")	-1.0
0.3' - AGGREGATE BASE (4.0")	-1.3
STABILIZED (FILL): VERY DENSE, MOTTLED BROWN AND GRAY **COARSE AND FINE SAND**, LITTLE SILT, LITTLE FINE GRAVEL, TRACE CLAY, DAMP. -2S-1B: SULFATE = 2920 PPM; PHW = 10.91; PHC = 10.87	-2.6
NATURAL: HARD, MOTTLED BROWN AND GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP. -2S-2B: SULFATE = 2640 PPM; PHW = 7.18; PHC = 7.08	-4.3

DEPTHS: 1, 2, 3, 4; EOB

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
			2S-1A	-	-	-	-	-	-	-	-	-	-	
149	-	71	2S-1B	4.5+	12	30	34	18	6	NP	NP	NP	13	A-3a (0)
			SS-2A	-	-	-	-	-	-	-	-	-	-	A-3a (V)
19 17 19 19	47	100	SS-2B	4.5+	4	9	13	39	35	27	16	11	12	A-6a (8)

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY	DRILLING FIRM / OPERATOR: RII / B.S.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.0 ft.
START: 6/7/17 END: 6/7/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.9	LAT / LONG: Not Recorded

EXPLORATION ID B-17

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.5' - AGGREGATE BASE (6.0")	-1.5					2S-1A	-	-	-	-	-	-	-	-	-	-		
STABILIZED (FILL): HARD, MOTTLED BROWN AND GRAY **SANDY SILT**, LITTLE CLAY, TRACE FINE GRAVEL, DAMP. -2S-1B: SULFATE = 2987 PPM; PHW = 10.81; PHC = 10.75	-2.6	2	26 35 25 12	78	63	2S-1B	4.5+	9	24	26	25	16	30	23	7	15	A-4a (1)	
NATURAL: HARD, MOTTLED BROWN AND LIGHT GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		3				2S-1C	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
-SS-2: SULFATE = 2680 PPM; PHW = 7.06; PHC = 6.99	-5.0	4 EOB 5	3 5 8 10	17		SS-2	-	3	7	18	34	38	32	18	14	16	A-6a (9)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT GDT - 7/7/17 08:10 - U:\GB\PROJECTS\2016\W-16-171 LAKE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY	DRILLING FIRM / OPERATOR: RII / B.S.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: '	EXPLORATION ID B-18
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.1 ft.	PAGE
START: 6/7/17 END: 6/7/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.9	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.5")	-1.1	1																
0.7' - AGGREGATE BASE (7.5")	-1.8					2S-1A	-	-	-	-	-	-	-	-	-	-		
STABILIZED (FILL): DENSE, MOTTLED BROWN AND GRAY **COARSE AND FINE SAND**, SOME SILT, TRACE FINE GRAVEL, TRACE CLAY, DAMP. -2S-1B: SULFATE = 2840 PPM; PHW = 10.94; PHC = 10.84	-2.5	2	35 27 19 19	60	42	2S-1B	4.50	9	21	39	23	8	NP	NP	NP	17	A-3a (0)	
NATURAL: HARD, MOTTLED BROWN AND GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		3				2S-1C	-	-	-	-	-	-	-	-	-	-	A-3a (V)	
-SS-2: SULFATE = 2747 PPM; PHW = 7.25; PHC = 7.24	-5.1	4 5 EOB	6 6 9 10	19	75	SS-2	4.5+	2	9	21	34	34	26	15	11	16	A-6a (7)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 7/7/17 08:10 - U:\GB\PROJECTS\2016\W-16-171 LAKE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY	DRILLING FIRM / OPERATOR: RII / B.S.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.1 ft.
START: 6/7/17 END: 6/7/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.9	LAT / LONG: Not Recorded

EXPLORATION ID B-19 PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.2' - AGGREGATE BASE (3.0")	-1.3					2S-1A	-	-	-	-	-	-	-	-	-	-		
STABILIZED (FILL): HARD, MOTTLED BROWN AND GRAY **SANDY SILT**, LITTLE CLAY, TRACE FINE GRAVEL, DAMP. -2S-1B: SULFATE = 4907 PPM; PHW = 10.42; PHC = 10.33	-2.0	2	6 8 12 10	26	67	2S-1B	4.5+	9	25	21	31	14	35	26	9	25	A-4a (2)	
NATURAL: HARD, MOTTLED BROWN AND GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, DAMP.		3				2S-1C	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
-SS-2A: SULFATE = 1547 PPM; PHW = 7.35; PHC = 7.24	-4.1	4	3 8 12 14	26	83	SS-2A	4.5+	0	11	15	40	34	29	17	12	15	A-6a (9)	
NATURAL: MEDIUM DENSE, BROWN **COARSE AND FINE SAND**, LITTLE SILT, LITTLE CLAY, TRACE FINE GRAVEL, DAMP.	-5.1	EOB 5				SS-2B	-	5	12	53	19	11	NP	NP	NP	15	A-3a (0)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 7/7/17 08:10 - U:\GB\PROJECTS\2016\W-16-171 LAKE.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. LAKE COUNTY	DRILLING FIRM / OPERATOR: RII / B.S.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 9/22/16	ELEVATION: 0.0 (MSL) EOB: 5.1 ft.
START: 6/7/17 END: 6/7/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.9	LAT / LONG: Not Recorded

EXPLORATION ID B-20

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.4' - AGGREGATE BASE (5.0")	-1.5					2S-1A	-	-	-	-	-	-	-	-	-	-		
NATURAL: HARD, MOTTLED BROWN AND GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP TO MOIST.		2	5 5 9 11	18	63	2S-1B	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
		3																
-SS-2: SULFATE = 2000 PPM; PHW = 7.34; PHC = 7.26		4	5 7 9 11	21	63	SS-2	4.5+	5	10	13	37	35	28	16	12	12	A-6a (8)	
	-5.1	EOB 5																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING OR AFTER DRILLING COMPLETION.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LB. BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. MRW-71	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '	EXPLORATION ID B-01
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: CME AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.6 ft.	PAGE
START: 12/2/16 END: 12/2/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.2' - AGGREGATE BASE (2.0")	-1.3																	
NATURAL (FILL): VERY DENSE, BROWN **GRAVEL**, SOME COARSE TO FINE SAND, LITTLE SILT, TRACE CLAY, MOIST. -SS-1: SULFATE = 467 PPM; PHW = 7.91; PHC = 7.47	-2.6	2	17 44 29	112	67	SS-1	-	61	18	6	11	4	NP	NP	NP	9	A-1-a (0)	
NATURAL (FILL): HARD, DARK BROWN **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, DAMP.		3	11 12 9	32	0	SS-2	-	-	-	-	-	-	-	-	-	-		
-SS-2A: SULFATE = 767 PPM; PHW = 7.38; PHC = 7.16	-4.6	4 EOB	17	-	100	SS-2A	4.50	14	14	11	30	31	25	17	8	12	A-4a (5)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. MRW-71	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.2 ft.
START: 12/2/16 END: 12/2/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-02

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.0")	-1.2	1																
0.6' - AGGREGATE BASE (7.0")	-1.8																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP. -TOP 3" OF SS-2 IS STABILIZED -SS-1: SULFATE = 5147 PPM; PHW = 9.57; PHC = 9.48	-3.0	2	21 33 27	92	94	SS-1	-	32	32	13	17	6	35	28	7	14	A-2-4 (0)	
						SS-2A	-	-	-	-	-	-	-	-	-	-		
NATURAL: HARD, DARK BROWN **SANDY SILT**, SOME CLAY, SOME FINE GRAVEL, DAMP. -SS-2B: SULFATE = 1433 PPM; PHW = 7.38; PHC = 7.16	-4.2	3 4 EOB	4 4 5	14	94	SS-2B	4.50	22	15	10	28	25	25	17	8	12	A-4a (4)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

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RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. MRW-71	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.1 ft.
START: 12/2/16 END: 12/2/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-03

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (13.0")	-1.2	1																
0.5' - AGGREGATE BASE (6.0")	-1.7																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST. -SS-1: SULFATE = 1653 PPM; PHW = 10.12; PHC= 9.94 -TOP 3" OF SS-2 IS STABILIZED	-2.9	2	25 52 33	130	100	SS-1	-	34	40	10	13	3	34	28	6	14	A-1-b (0)	
			5 9 13	34	100	SS-2A	-	-	-	-	-	-	-	-	-	-	A-1-b (V)	
NATURAL: HARD, DARK BROWN **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, DAMP. -SS-2B; SULFATE = 920 PPM; PHW = 7.59; PHC = 7.29	-4.1	3 4 EOB				SS-2B	4.50	12	17	11	34	26	26	17	9	10	A-4a (5)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:33 - U:\GB\PROJECTS\2016\W-16-171 MORROW.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. MRW-71	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '	EXPLORATION ID B-04
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: CME AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.1 ft.	PAGE
START: 12/2/16 END: 12/2/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.5' - AGGREGATE BASE (6.0")	-1.6																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, MOIST. -SS-1: SULFATE = 7760 PPM; PHW = 9.95; PHC = 9.89 -TOP 5" OF SS-2 IS STABILIZED -SILTSTONE FRAGMENTS PRESENT IN SS-2A		2	22 33 22	84	94	SS-1	-	20	35	15	25	5	34	27	7	13	A-2-4 (0)	
	-3.0					SS-2A	-	-	-	-	-	-	-	-	-	-	A-2-4 (V)	
NATURAL: HARD, BROWN **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, MOIST. -SS-2B: SULFATE CONTENT = 913 PPM	-4.1	3 4 EOB	5 5 7	18	94	SS-2B	4.50	17	17	11	29	26	25	17	8	16	A-4a (4)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016 ODOT BORING LOG BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:33 - U:\GB\PROJECTS\2016\W-16-171 MORROW.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. MRW-71	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '	EXPLORATION ID B-05
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: CME AUTOMATIC	ALIGNMENT:	
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.1 ft.	PAGE
START: 12/2/16 END: 12/2/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.2' - AGGREGATE BASE (2.0")	-1.3																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP. -SS-1: SULFATE = 8907 PPM; PHW = 10.10; PHC = 9.92	-2.6	2	18 37 22	90	100	SS-1	-	27	35	15	19	4	34	26	8	14	A-2-4 (0)	
NATURAL: HARD, BROWN AND DARK BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. -SS-2: SULFATE = 2373 PPM; PHW = 7.67; PHC = 7.23	-4.1	3 EOB 4	5 11 15	40	89	SS-2	4.50	12	15	13	34	26	29	17	12	12	A-6a (6)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT:	ODOT COND. EVAL. MRW-71	DRILLING FIRM / OPERATOR:	RII / C.D.	DRILL RIG:	CME 55 (386345)	STATION / OFFSET:	'
TYPE:	ROADWAY	SAMPLING FIRM / LOGGER:	RII / J.A.	HAMMER:	CME AUTOMATIC	ALIGNMENT:	
PID: / BR ID:		DRILLING METHOD:	4.5" - CFA	CALIBRATION DATE:	10/20/14	ELEVATION:	0.0 (MSL) EOB: 4.2 ft.
START: 12/2/16	END: 12/2/16	SAMPLING METHOD:	SPT	ENERGY RATIO (%):	92	LAT / LONG:	Not Recorded

EXPLORATION ID B-06

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.2' - ASPHALT (14.0")	-1.2	1																
0.5' - AGGREGATE BASE (6.0")	-1.7																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, DAMP. -SS-1: SULFATE = 6347 PPM; PHW = 10.02; PHC = 9.73		2	11 19 19	58	94	SS-1	-	25	23	20	27	5	38	25	13	15	A-2-6 (1)	
-TOP 4" OF SS-2 IS STABILIZED	-3.0					SS-2A	-	-	-	-	-	-	-	-	-	-	A-2-6 (V)	
NATURAL: HARD, BROWN AND DARK BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, SOME FINE GRAVEL, DAMP. -SS-2B: SULFATE = 660 PPM; PHW = 7.50; PHC = 7.31	-4.2	3 4 EOB	6 10 14	37	100	SS-2B	4.50	21	9	12	32	26	30	17	13	11	A-6a (6)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

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RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. MRW-71	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.1 ft.
START: 12/2/16 END: 12/2/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-07

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.5' - AGGREGATE BASE (6.0")	-1.6																	
STABILIZED (FILL): HARD, BROWN AND DARK BROWN **SANDY SILT**, LITTLE FINE GRAVEL, LITTLE CLAY, DAMP. -SS-1: SULFATE = 5547 PPM; PHW = 9.95; PHC = 9.78	-2.6	2	15 27 22	75	94	SS-1	4.50	18	18	19	32	13	29	24	5	15	A-4a (2)	
NATURAL: HARD, BROWN AND GRAY **SILT AND CLAY**, SOME FINE GRAVEL, LITTLE COARSE TO FINE SAND, MOIST. -SS-2B: SULFATE = 1100 PPM; PHW = 7.42; PHC = 7.35	-4.1	3 4 EOB	9 8 10	28	89	SS-2	4.50	29	7	11	29	24	29	18	11	15	A-6a (4)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:33 - U:\GINT\PROJECTS\2016\W-16-171 MORROW.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. MRW-71	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.0 ft.
START: 12/2/16 END: 12/2/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID B-08

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")	-1.0	1																
0.5' - AGGREGATE BASE (6.0")	-1.5																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP. -SS-1: SULFATE = 3573 PPM; PHW = 10.16; PHC = 10.10 -TOP 3" OF SS-2 IS STABILIZED	-2.8	2	13 43 26	106	100	SS-1	-	29	32	19	19	1	NP	NP	NP	12	A-1-b (0)	
						SS-2A	-	-	-	-	-	-	-	-	-	-	A-1-b (V)	
NATURAL (POSSIBLE FILL): HARD, BROWN TO BROWNISH GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST. -SS-2B: SULFATE = 1193 PPM; PHW = 7.51; PHC = 7.40	-4.0	3 EOB 4	9 6 8	21	100	SS-2B	4.50	20	13	13	32	22	28	17	11	14	A-6a (4)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016 ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:33 - U:\GBI\PROJECTS\2016\W-16-171 MORROW.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. MRW-71 | TYPE: ROADWAY | PID: | BR ID: | START: 12/2/16 | END: 12/2/16

DRILLING FIRM / OPERATOR: RII / C.D. | SAMPLING FIRM / LOGGER: RII / J.A. | DRILLING METHOD: 4.5" - CFA | SAMPLING METHOD: SPT

DRILL RIG: CME 55 (386345) | HAMMER: CME AUTOMATIC | CALIBRATION DATE: 10/20/14 | ENERGY RATIO (%): 92

STATION / OFFSET: ' | ALIGNMENT: | ELEVATION: 0.0 (MSL) | EOB: 4.1 ft. | LAT / LONG: Not Recorded

EXPLORATION ID B-09 | PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.5' - AGGREGATE BASE (6.0")	-1.6																	
STABILIZED (FILL): VERY DENSE, BROWN **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, DAMP. -SS-1: SULFATE = 4987 PPM; PHW = 9.87; PHC = 9.77 -LIMESTONE FRAGMENTS PRESENT IN SS-2A -TOP 5" OF SS-2 IS STABILIZED	-3.1	2	15 23 18	63	94	SS-1	-	29	19	19	22	11	28	26	2	12	A-2-4 (0)	
		3	7 5 4	14	100	SS-2A	-	-	-	-	-	-	-	-	-	-	A-2-4 (V)	
NATURAL (POSSIBLE FILL): HARD, BROWN **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, DAMP. -SS-2B: SULFATE = 3627 PPM; PHW = 7.55; PHC = 7.49	-4.1	4 (EOB)				SS-2B	4.50	16	12	13	36	23	30	23	7	15	A-4a (5)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:33 - U:\GB\PROJECTS\2016\W-16-171 MORROW.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: ODOT COND. EVAL. MRW-71	DRILLING FIRM / OPERATOR: RII / C.D.	DRILL RIG: CME 55 (386345)	STATION / OFFSET: '
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / J.A.	HAMMER: CME AUTOMATIC	ALIGNMENT:
PID: BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 0.0 (MSL) EOB: 4.1 ft.
START: 12/2/16 END: 12/2/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92	LAT / LONG: Not Recorded

EXPLORATION ID **B-10**

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 0.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
1.1' - ASPHALT (13.0")	-1.1	1																
0.5' - AGGREGATE BASE (6.0")	-1.6																	
STABILIZED (FILL): HARD, BROWN **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, DAMP. -SS-1: SULFATE = 1653 PPM; PHW = 9.71; PHC = 9.65		2	14 28 21	75	100	SS-1	4.50	19	12	12	33	24	29	23	6	15	A-4a (4)	
-TOP 3" OF SS-2 IS STABILIZED	-2.9					SS-2A	4.50	-	-	-	-	-	-	-	-	-		
NATURAL (POSSIBLE FILL): HARD, GRAYISH BROWN **SANDY SILT**, LITTLE CLAY, LITTLE FINE GRAVEL, DAMP. -SS-2B: SULFATE = 967 PPM; PHW = 7.75; PHC = 7.51	-4.1	3 4 EOB	7 11 7	28	100	SS-2B	4.50	11	21	19	31	18	27	18	9	13	A-4a (3)	

2016-ODOT BORING LOG-BR ID SPLIT SAMPL - OH DOT.GDT - 1/19/17 15:33 - U:\GB\PROJECTS\2016\W-16-171 MORROW.GPJ

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

Appendix A: PSPA data

Site	Date	Begin Time	End Time	
CLA-70	11/16/2016	9:34:36 AM	10:02:05 AM	
Station	Seismic Modulus		Temperature	
	(ksi)	(MPa)	(°F)	(°C)
959+00	2602	377	48.0	8.9
958+00	2646	384	46.4	8.0
957+00	2843	412	46.0	7.8
956+00	2562	372	46.7	8.1
955+00	2630	381	48.0	8.9
954+00	2560	371	47.3	8.5
953+00	2657	385	48.0	8.9
952+00	2614	379	48.0	8.9
951+00	2644	383	48.0	8.9
950+00	2880	418	48.0	8.9
Average	2664	386	47.4	8.6
Std. Dev.	104	15	0.8	0.4

Site	Date	Begin Time	End Time	
CLI-73	11/14/2016	9:13:37 AM	9:59:04 AM	
Station	Seismic Modulus		Temperature	
	(ksi)	(MPa)	(°F)	(°C)
369+60	2532	367	38.2	3.4
370+60	2935	426	40.8	4.9
371+60	3207	465	41.0	5.0
372+60	2240	325	41.0	5.0
373+60	2453	356	46.0	7.8
374+60	2810	408	43.0	6.1
375+60	2633	382	45.0	7.2
376+60	2717	394	43.0	6.1
377+60	2388	346	44.5	6.9
378+60	2223	322	45.3	7.4
Average	2614	379	42.8	6.0
Std. Dev.	297	43	2.4	1.3

Site	Date	Begin Time	End Time	
DEF-24	11/21/2016	9:25:46 AM	9:47:42 AM	
Station	Seismic Modulus		Temperature	
	(ksi)	(MPa)	(°F)	(°C)
1863+80	4697	681	32.0	0.0
1862+80	4818	699	32.0	0.0
1861+80	4797	696	32.0	0.0
1860+80	5324	772	32.0	0.0
1859+80	4660	676	32.0	0.0
1858+80	5157	748	32.0	0.0
1857+80	4823	699	32.0	0.0
1856+80	5347	775	32.0	0.0
1855+80	4628	671	32.0	0.0
1854+80	6755	980	32.5	0.3
Average	5100	740	32.1	0.0
Std. Dev.	607	88	0.2	0.1

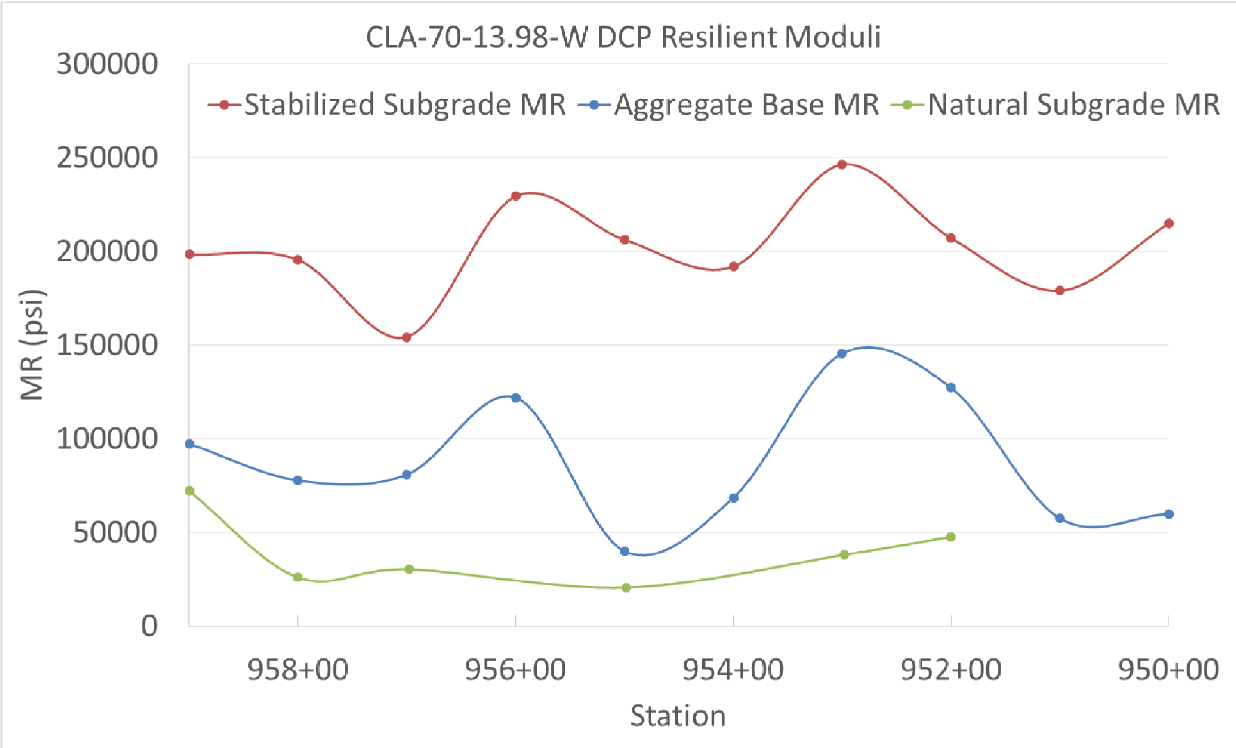
	Site	Date	Begin Time	End Time	
	LAK-2	6/6/2017	9:29:11 AM	10:41:13 AM	
	Station	Seismic Modulus		Temperature	
		(ksi)	(MPa)	°F	°C
Stabilized	738+00	2713	18708	56	14
	737+00	2303	15881	57	14
	736+00	2197	15145	57	14
	735+00	2347	16180	57	14
	734+00	1937	13353	57	14
	733+00	2630	18133	57	14
	732+00	2270	15651	58	15
	731+00	2300	15858	58	14
	730+00	1997	13767	59	15
	729+00	2063	14226	57	14
Undercut	751+00	2463	16984	63	17
	750+50	2663	18363	64	18
	750+00	2610	17995	64	18
	749+50	2377	16387	64	18
	749+00	2520	17375	64	18
	748+50	1450	9997	68	20
	748+00	2613	18018	64	18
	747+50	2367	16318	65	19
	747+00	2713	18708	64	18
	746+50	2437	16800	65	19
	Average	2349	16192	61.0	16.1
	Std. Dev.	304	2097	3.8	2.1

Site	Date	Begin Time	End Time	
MRW-71	12/1/2016	8:29:11 AM	9:02:13 AM	
Station	Seismic Modulus		Temperature	
	(ksi)	(MPa)	(°F)	(°C)
285+12	2390	347	38.0	3.3
286+12	2298	333	37.0	2.8
287+12	2365	343	36.8	2.7
288+12	2042	296	36.0	2.2
289+12	2699	391	34.0	1.1
290+12	2894	420	32.8	0.4
291+12	2340	339	32.0	0.0
292+12	2813	408	32.0	0.0
293+12	2454	356	32.0	0.0
294+12	2475	359	32.0	0.0
Average	2477	359	34.3	1.3
Std. Dev.	244	35	2.3	1.3

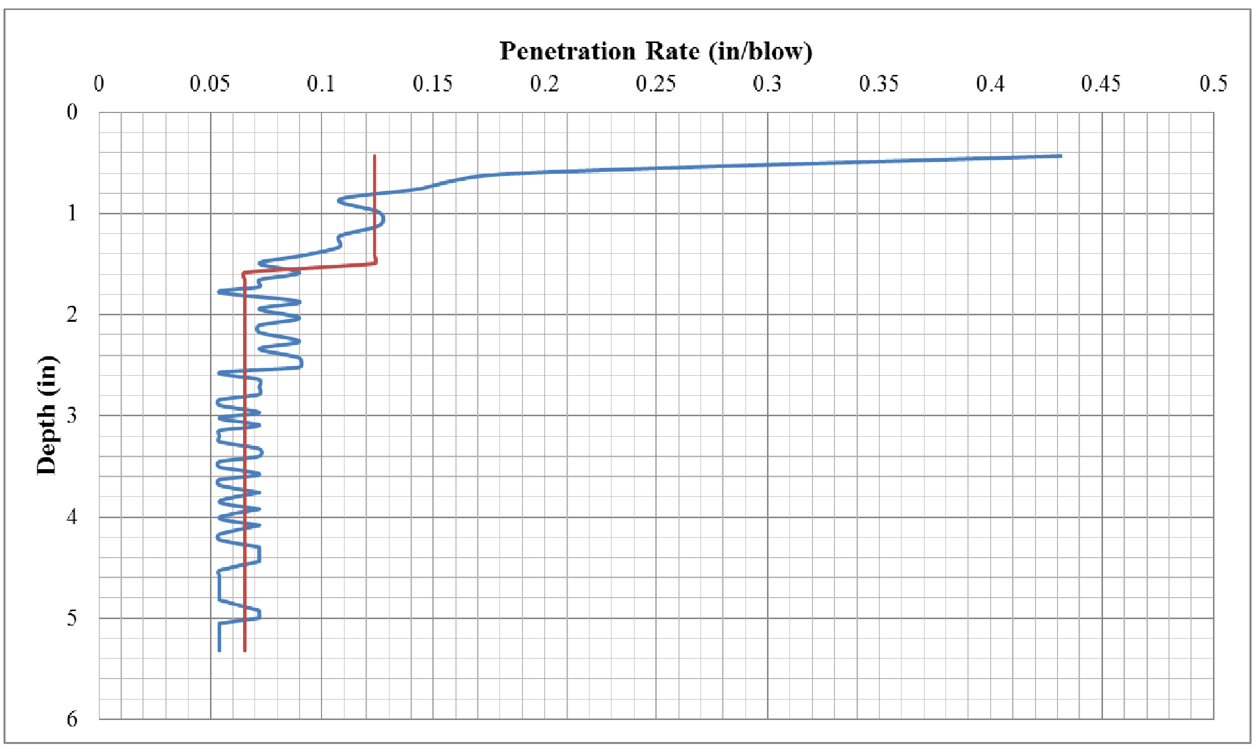
Appendix B: DCP results

DCP Results for CLA-70

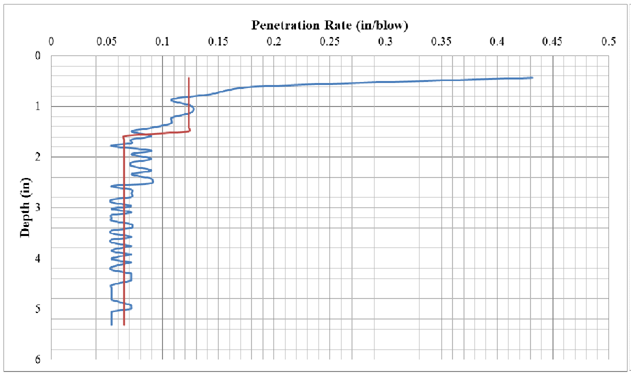
Hole	Station	Aggregate Base					Cement Stabilized Subgrade					Natural Subgrade					Notes
		Avg PR		CBR	M_R		Avg PR		CBR	M_R		Avg PR		CBR	M_R		
		(mm/ blow)	(in/ blow)		(psi)	(MPa)	(mm/ blow)	(in/ blow)		(psi)	(MPa)	(mm/ blow)	(in/ blow)		(psi)	(MPa)	
1	959+00	3.14	0.124	81	97301	671	1.66	0.065	165	198322	1367	-	-	-	-	-	5.321" (135.2 mm) Refusal
2	958+00	3.84	0.151	65	77745	536	1.68	0.066	163	195436	1347	-	-	-	-	-	13" (330 mm) of 304 & SS Removed
3	957+00	3.70	0.146	67	80853	557	2.08	0.082	129	154323	1064	-	-	-	-	-	5.213" (132.4 mm) Refusal
4	956+00	2.57	0.101	102	121927	841	1.46	0.057	191	229377	1581	-	-	-	-	-	16.25" (413 mm) of 304 & SS Removed
5	955+00	6.94	0.273	33	40013	276	1.61	0.063	172	206194	1422	-	-	-	-	-	7.532" (191.3 mm) Refusal
6	954+00	4.29	0.169	57	68543	473	1.71	0.067	160	191899	1323	6.26	0.246	37	44934	310	14.75" (375 mm) of 304 & SS Removed
7	959+00	-	-	-	-	-	-	-	-	-	-	4.10	0.162	60	72095	497	5.986" (152.0 mm) Refusal
8	953+00	2.19	0.086	121	145501	1003	1.37	0.054	205	246288	1698	-	-	-	-	-	5.465" (138.8 mm) Refusal
9	952+00	2.47	0.097	106	127211	877	1.60	0.063	173	207069	1428	5.94	0.234	40	47670	329	18.85" (479 mm) of 304 & SS Removed
10	951+00	5.02	0.198	48	57479	396	1.82	0.072	149	178981	1234	-	-	-	-	-	Full Depth
11	950+00	4.84	0.191	50	59912	413	1.55	0.061	179	214798	1481	-	-	-	-	-	5.519" (140.2 mm) Refusal
12	958+00	-	-	-	-	-	-	-	-	-	-	10.20	0.401	22	26003	179	18.17" (462 mm) of 304 & SS Removed
13	956+98	-	-	-	-	-	-	-	-	-	-	8.89	0.350	25	30319	209	Full Depth
14	954+98	-	-	-	-	-	-	-	-	-	-	12.56	0.494	17	20597	142	3.919" (99.5 mm) Refusal
15	952+98	-	-	-	-	-	-	-	-	-	-	7.25	0.286	32	38092	263	6.328" (160.7 mm) Refusal
Average		3.90	0.154	73	87648	604	1.65	0.065	169	202269	1395	7.89	0.310	33	39959	276	
Std. Dev.		1.45	0.057	29	34381	237	0.20	0.008	21	25558	176	2.87	0.113	14	17238	119	



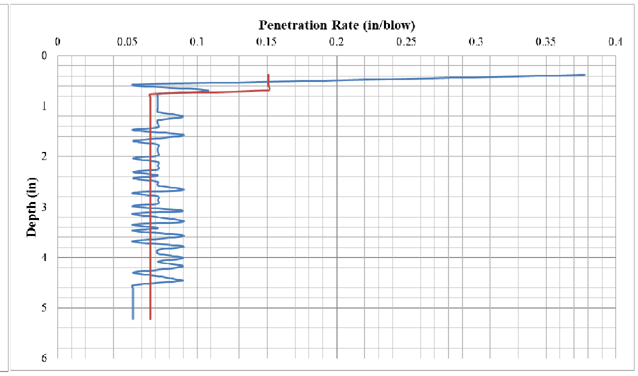
1 psi = 6.89 kPa



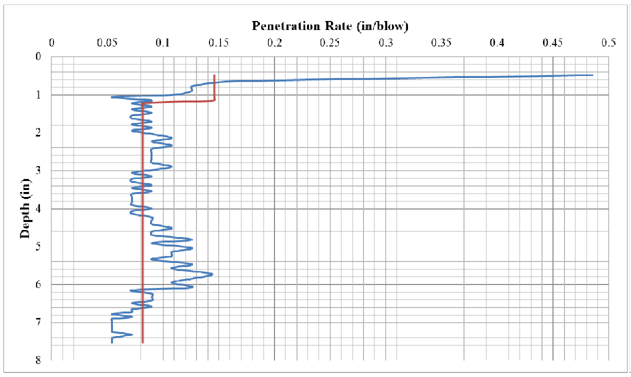
Borehole 1 example plot (1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)



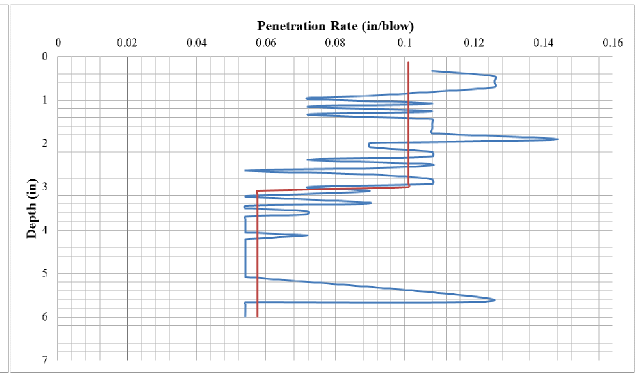
Borehole 1



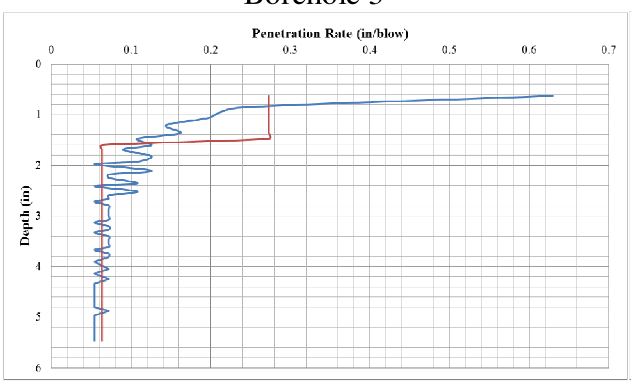
Borehole 2



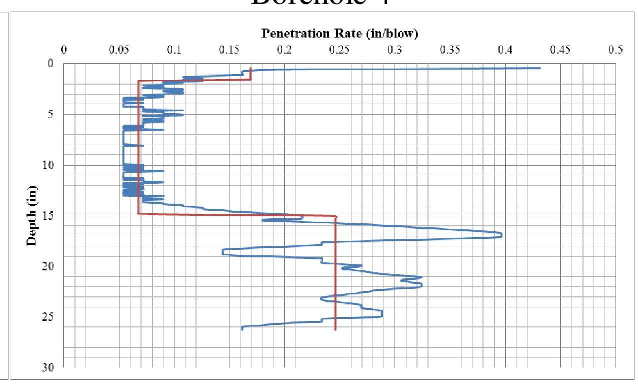
Borehole 3



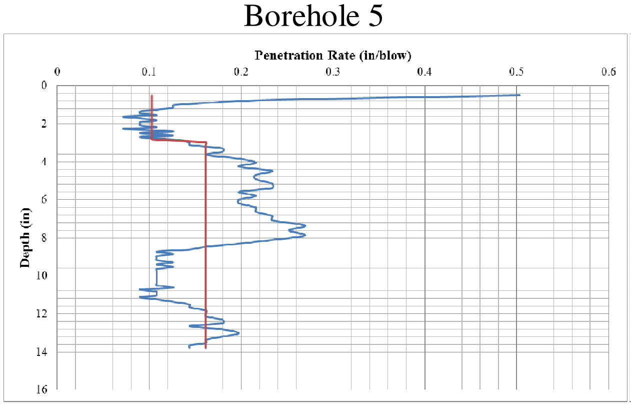
Borehole 4



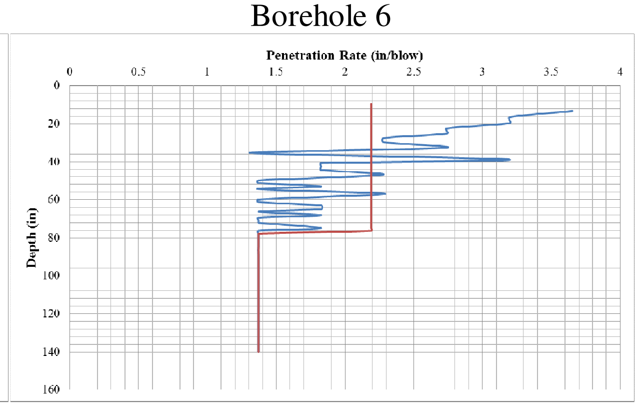
Borehole 5



Borehole 6

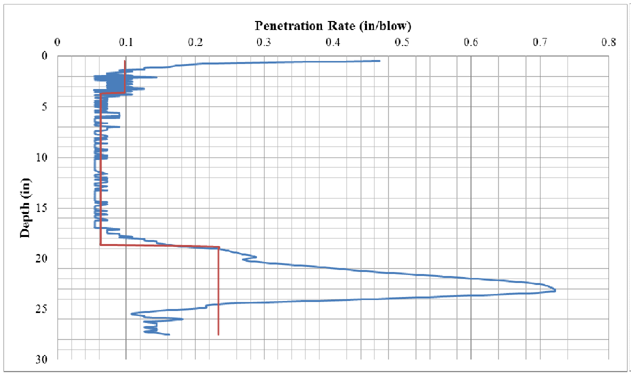


Borehole 7

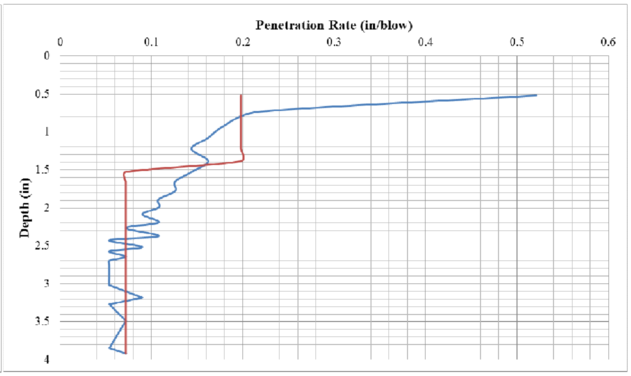


Borehole 8

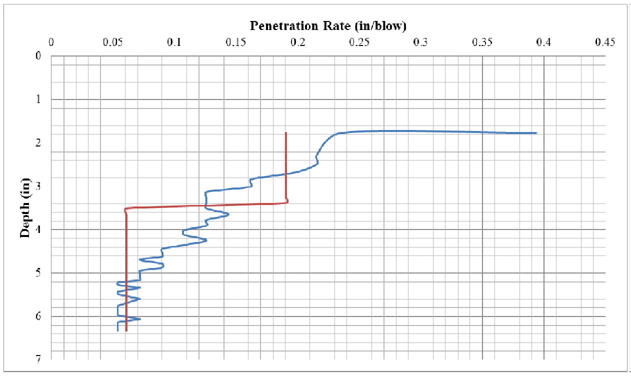
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)



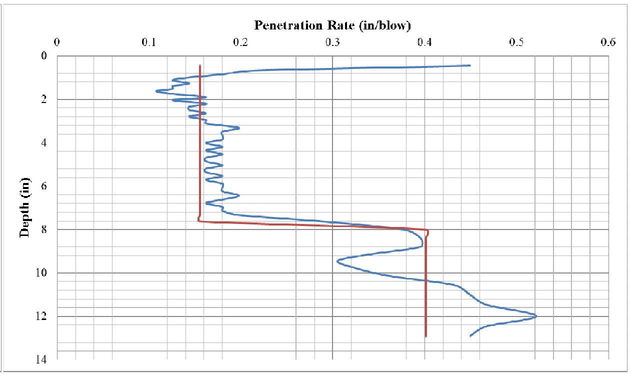
Borehole 9



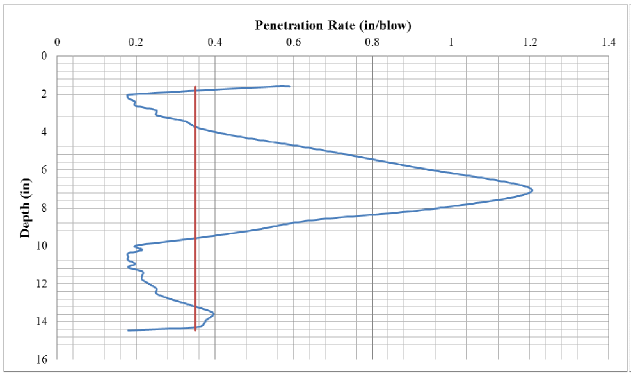
Borehole 10



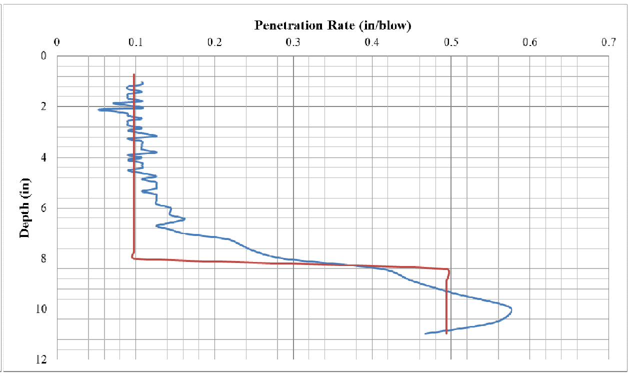
Borehole 11



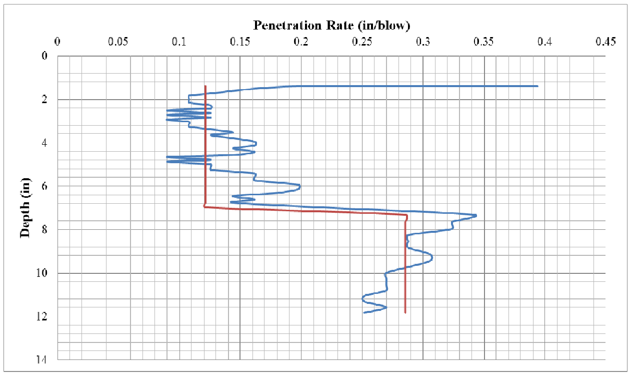
Borehole 12



Borehole 13



Borehole 14

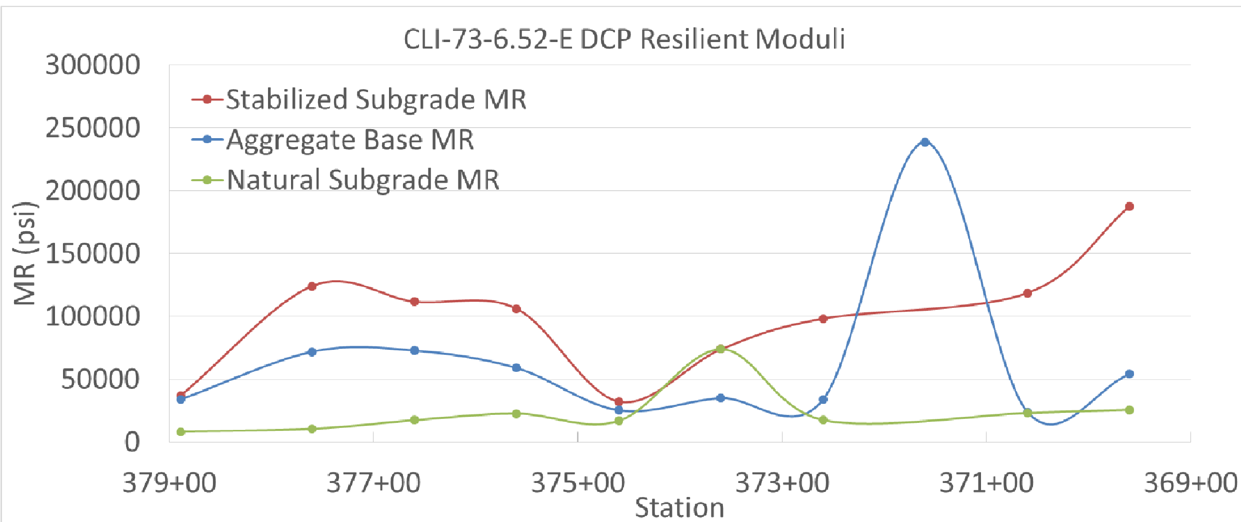


Borehole 15

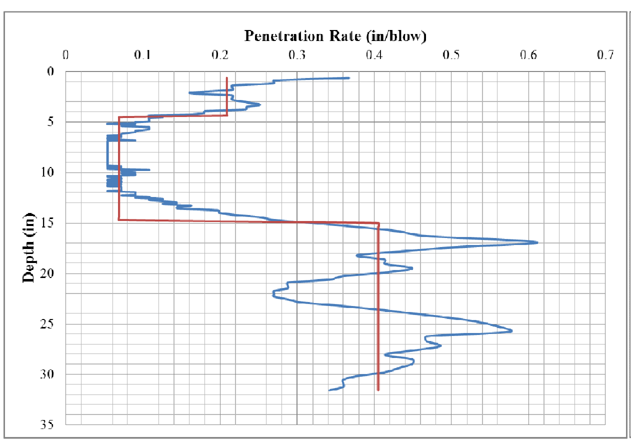
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)

DCP Results for CLI-73

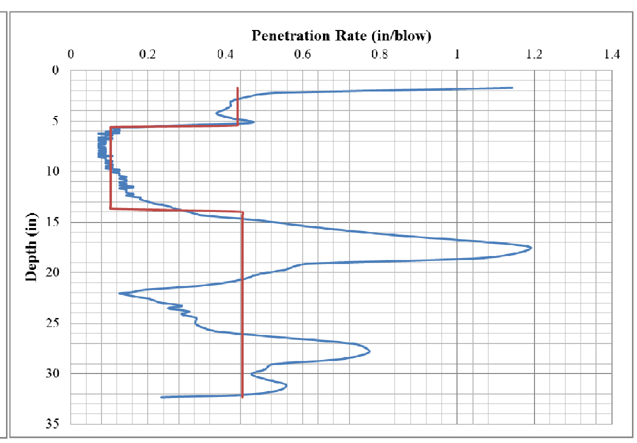
Hole	Station	Aggregate Base					Cement Stabilized Subgrade					Natural Subgrade				
		Average PR		CBR	M_R		Average PR		CBR	M_R		Average PR		CBR	M_R	
		(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)
1	369+60	5.30	0.209	45	54101	373	1.74	0.069	157	187844	1295	10.29	0.405	21	25756	178
2	370+60	10.96	0.431	20	23990	165	2.63	0.104	99	118673	818	11.28	0.444	19	23230	160
3	371+60	1.41	0.055	199	238588	1645	-	-	-	-	-	-	-	-	-	-
4	372+60	8.04	0.316	28	33954	234	3.11	0.123	82	98248	677	14.44	0.568	15	17617	121
5	373+60	7.81	0.308	29	35042	242	4.02	0.158	62	73859	509	4.02	0.158	62	73859	509
6	374+60	10.44	0.411	21	25337	175	8.41	0.331	27	32263	222	14.92	0.588	14	16976	117
7	375+60	4.91	0.193	49	58978	407	2.91	0.114	88	106099	732	11.47	0.452	19	22786	157
8	376+60	4.07	0.160	61	72826	502	2.77	0.109	93	111780	771	14.48	0.570	15	17554	121
9	377+60	4.11	0.162	60	71963	496	2.52	0.099	104	124237	857	22.59	0.889	9	10670	74
10	378+89	8.02	0.316	28	34016	235	7.44	0.293	31	37010	255	28.01	1.103	7	8388	58
Average		6.51	0.256	54	64879	447	3.95	0.156	82	98890	682	14.61	0.575	20	24093	166
Std. Dev.		3.04	0.120	53	63660		2.34	0.092	40	47513	328	7.03	0.277	16	19507	134



1 psi = 6.89 kPa

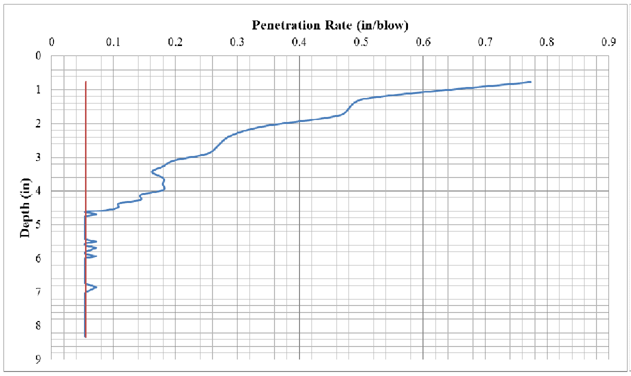


Borehole 1

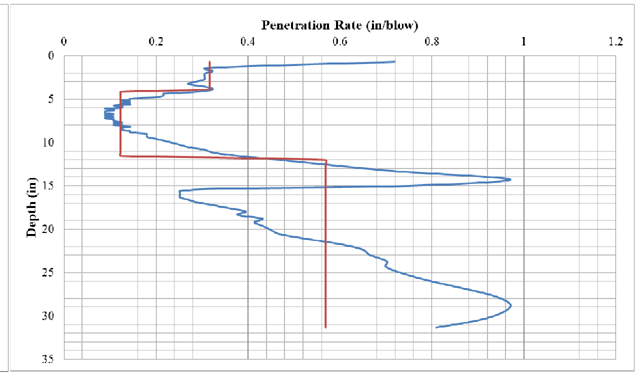


Borehole 2

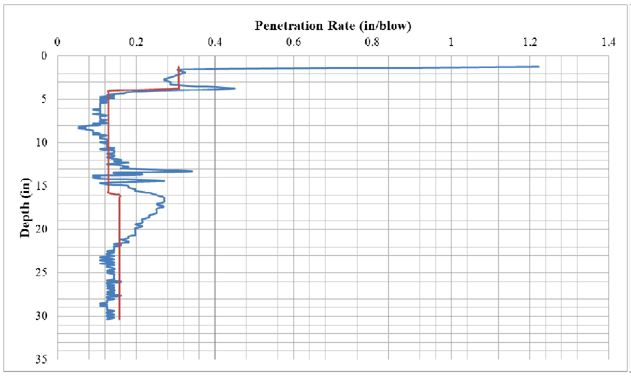
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)



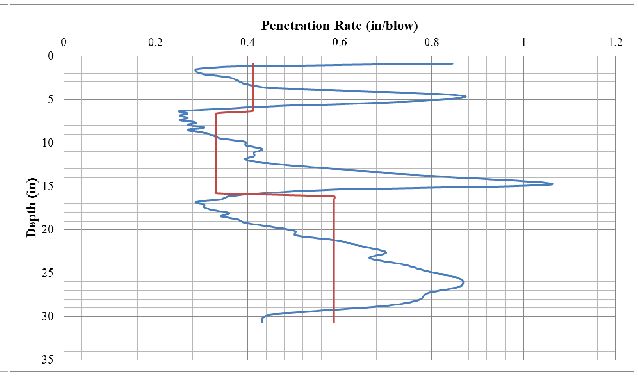
Borehole 3



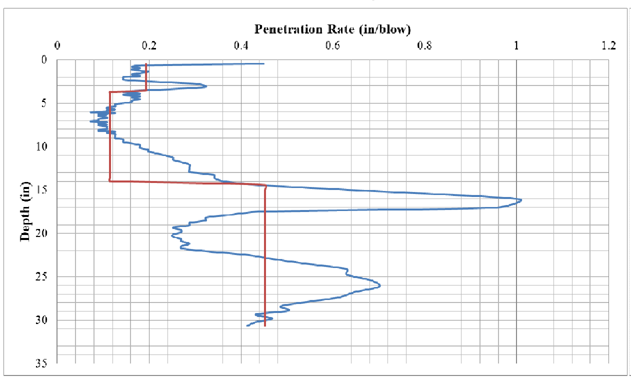
Borehole 4



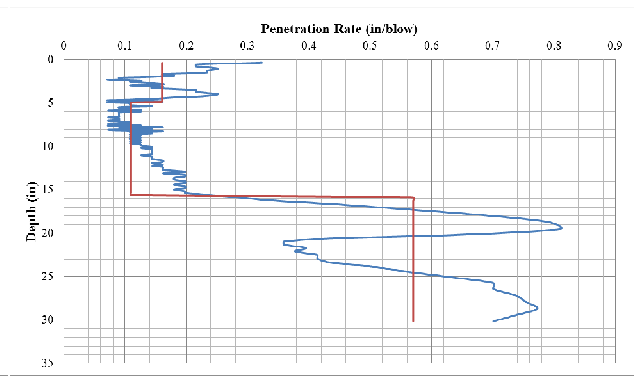
Borehole 5



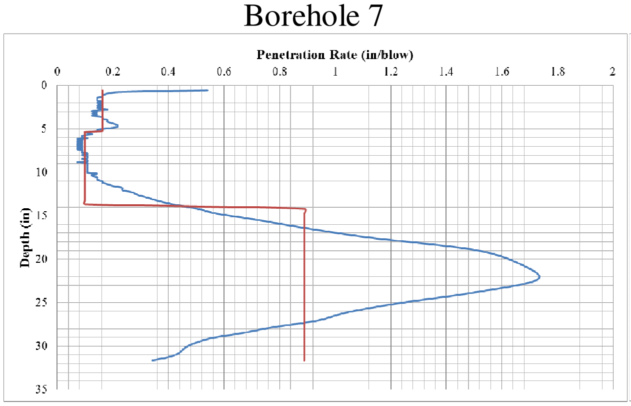
Borehole 6



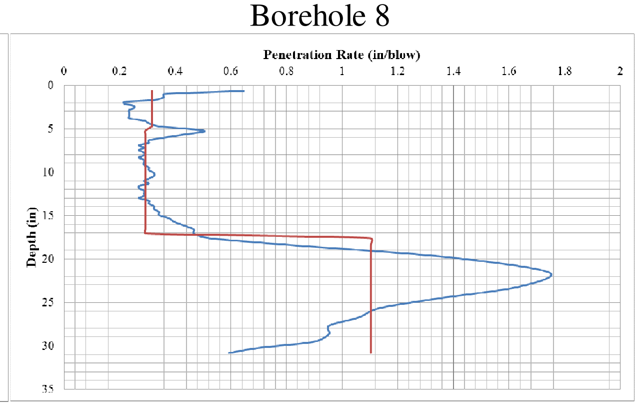
Borehole 7



Borehole 8



Borehole 9

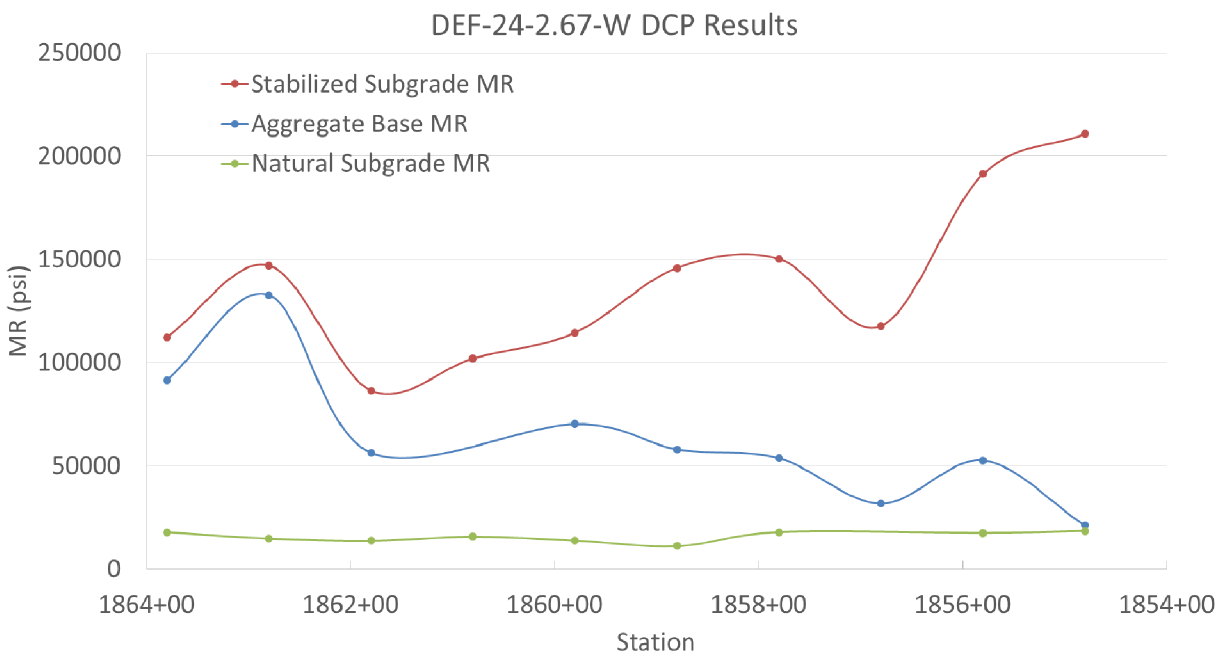


Borehole 10

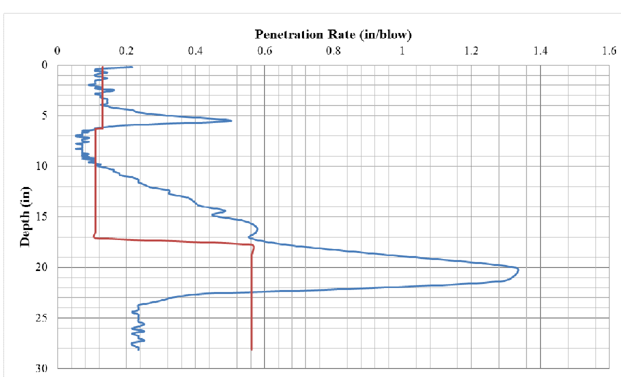
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)

DCP Results for DEF-24

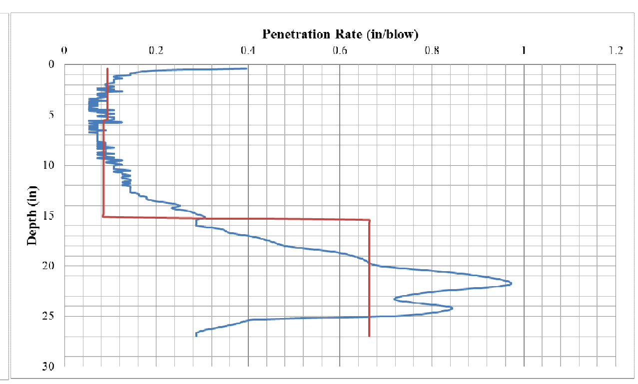
Hole	Station	Aggregate Base					Cement Stabilized Subgrade					Natural Subgrade				
		Average PR		CBR	M_R		Average PR		CBR	M_R		Average PR		CBR	M_R	
		(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)
1	1863+80	3.32	0.131	76	91474	631	2.76	0.109	94	112260	774	14.29	0.563	15	17821	123
2	1862+80	2.38	0.094	111	132726	915	2.17	0.086	122	146986	1013	16.86	0.664	12	14808	102
3	1861+80	5.11	0.201	47	56330	388	3.49	0.137	72	86428	596	18.00	0.709	11	13765	95
4	1860+80	-	-	-	-	-	3.01	0.119	85	101935	703	16.03	0.631	13	15669	108
5	1859+80	4.20	0.165	59	70213	484	2.72	0.107	95	114458	789	17.92	0.706	12	13828	95
6	1858+80	4.98	0.196	48	57970	400	2.19	0.086	122	145806	1005	21.70	0.855	9	11159	77
7	1857+80	5.34	0.210	45	53663	370	2.13	0.084	125	150167	1035	14.28	0.562	15	17835	123
8	1856+80	8.54	0.336	26	31739	219	2.65	0.104	98	117659	811	20.70	0.815	10	11767	81
9	1855+80	5.44	0.214	44	52608	363	1.72	0.068	159	191231	1318	14.52	0.571	15	17511	121
10	1854+80	12.29	0.484	18	21104	146	1.58	0.062	176	210642	1452	13.93	0.548	15	18342	126
Average		5.73	0.226	53	63092	435	2.44	0.096	115	137757	950	16.82	0.662	13	15250	105
Std.Dev.		2.99	0.118	28	33019	228	0.59	0.023	33	39427	272	2.76	0.109	2	2613	18



1 psi = 6.89 kPa

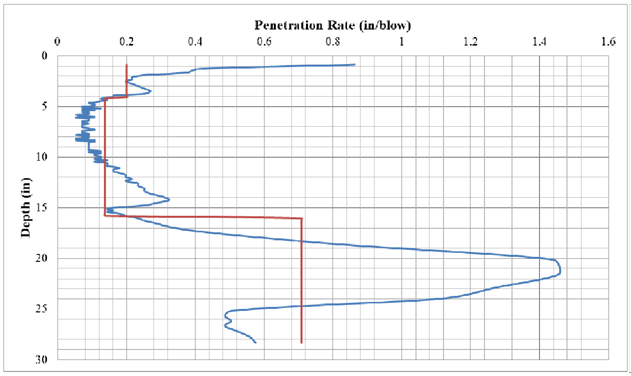


Borehole 1

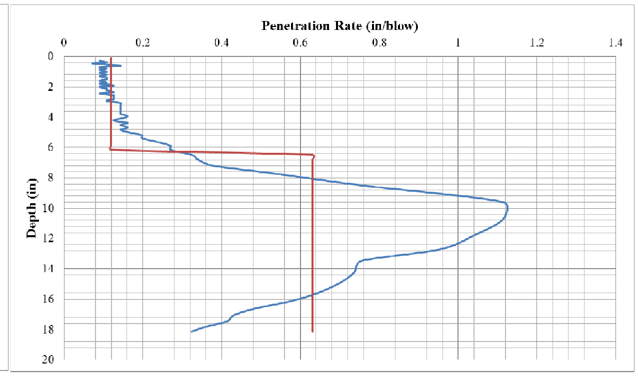


Borehole 2

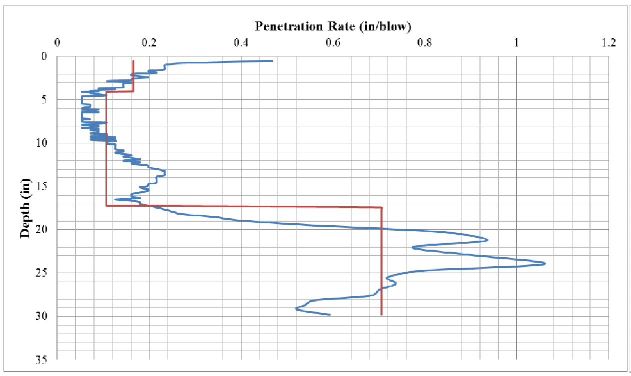
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)



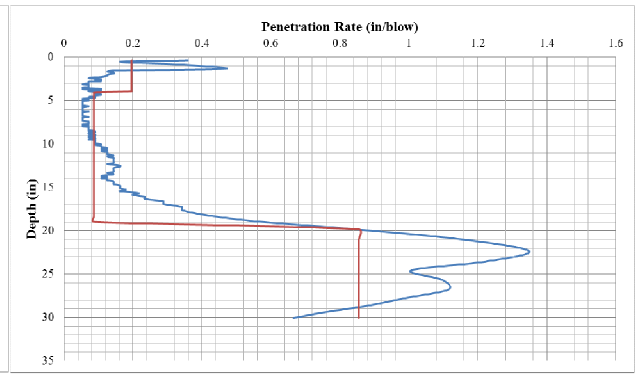
Borehole 3



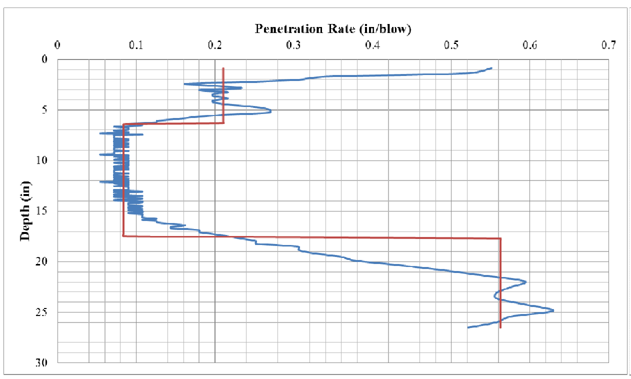
Borehole 4



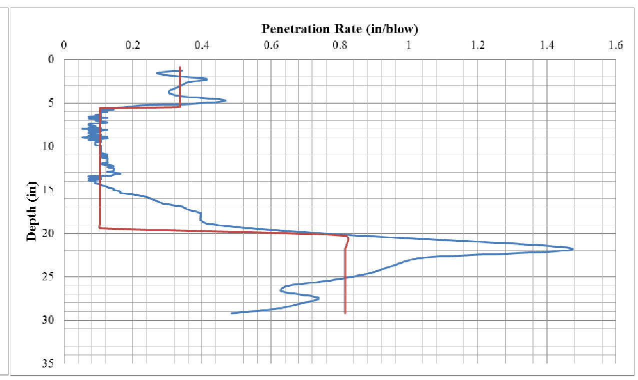
Borehole 5



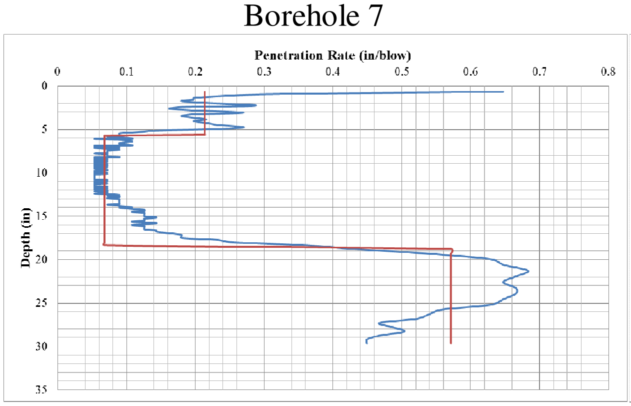
Borehole 6



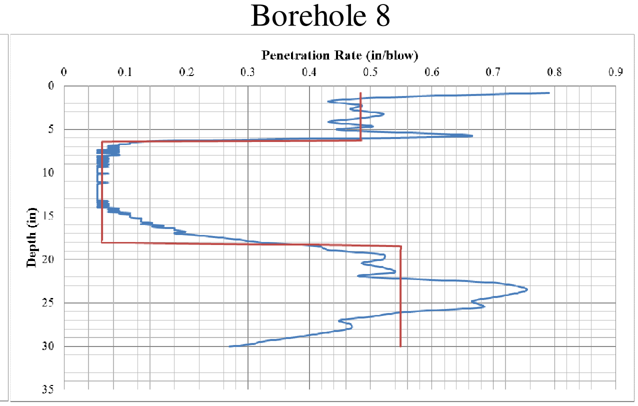
Borehole 7



Borehole 8



Borehole 9

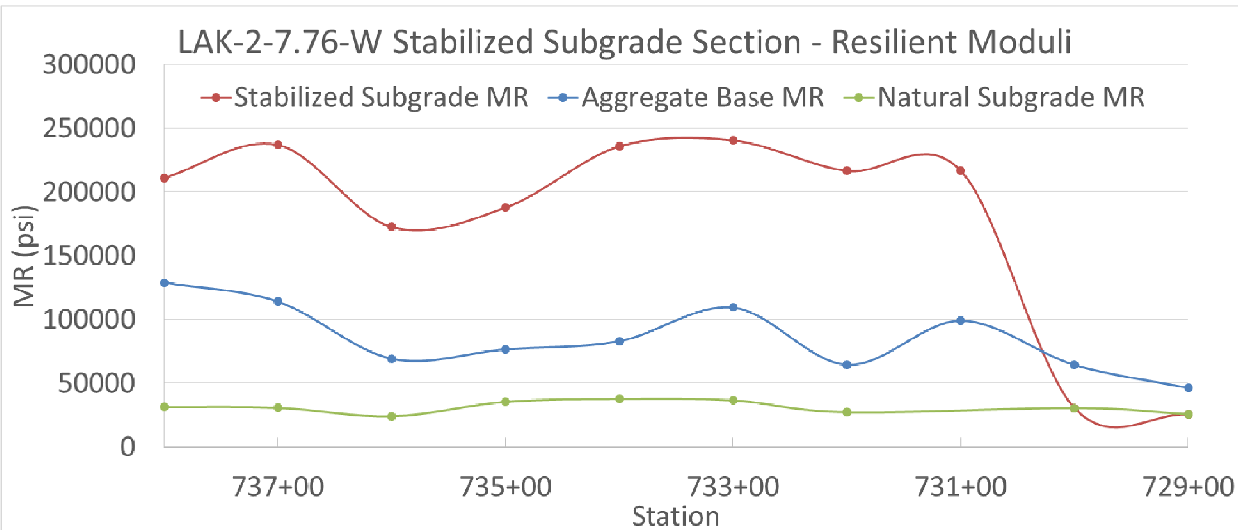


Borehole 10

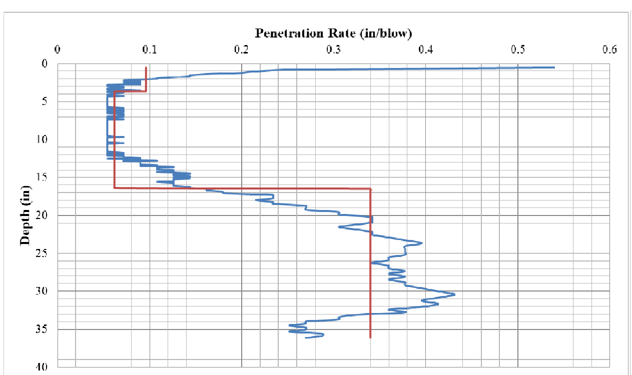
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)

DCP Results for LAK-2
Stabilized Subgrade Section

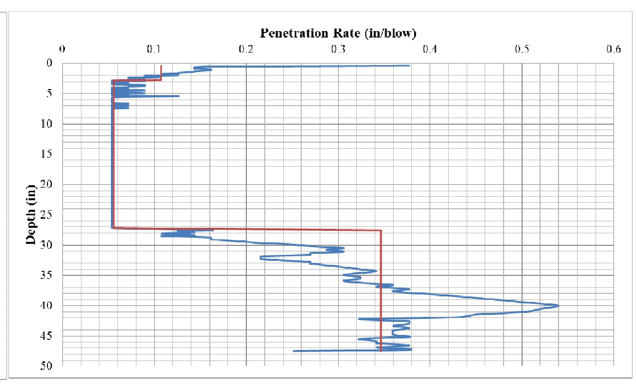
Hole	Station	Aggregate Base					Cement Stabilized Subgrade					Natural Subgrade				
		Average PR		CBR	M_R		Average PR		CBR	M_R		Average PR		CBR	M_R	
		(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)
1	738+00	2.44	0.096	107	128942	889	1.57	0.062	176	211115	1456	8.64	0.340	26	31306	216
2	737+00	2.73	0.107	95	114013	786	1.42	0.056	197	236943	1634	8.80	0.347	26	30658	211
3	736+00	4.25	0.167	58	69236	477	1.88	0.074	144	172509	1189	10.94	0.431	20	24036	166
4	735+00	3.89	0.153	64	76597	528	1.75	0.069	156	187687	1294	7.75	0.305	29	35365	244
5	734+00	3.62	0.142	69	82987	572	1.42	0.056	196	235689	1625	7.34	0.289	31	37563	259
6	733+00	2.83	0.111	91	109354	754	1.40	0.055	200	240460	1658	7.53	0.297	30	36499	252
7	732+00	4.53	0.179	54	64451	444	1.54	0.061	180	216559	1493	9.82	0.387	23	27123	187
8	731+00	3.09	0.122	83	99005	683	1.54	0.060	181	216770	1495	11.38	0.448	19	22998	159
9	730+00	4.54	0.179	54	64354	444	8.83	0.348	25	30557	211	8.83	0.348	25	30557	211
10	729+00	6.09	0.240	39	46338	319	10.32	0.406	21	25660	177	10.32	0.406	21	25660	177
Average		3.80	0.150	71	85528	590	3.17	0.125	148	177395	1223	9.14	0.360	25	30177	208
Std. Dev.		1.11	0.044	22	26301	181	3.40	0.134	68	81553	562	1.43	0.056	4	5186	36



1 psi = 6.89 kPa

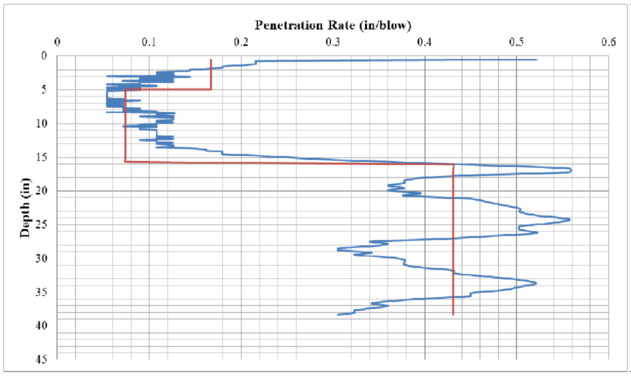


Borehole 1

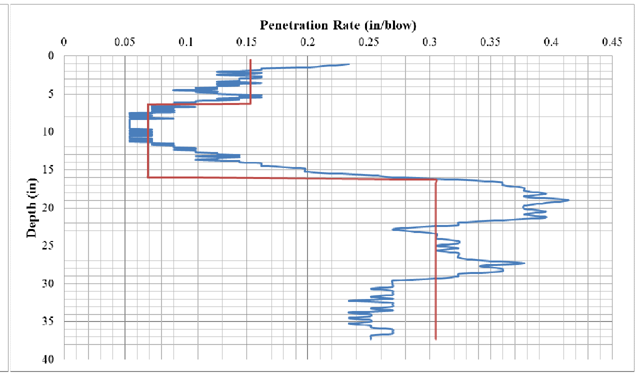


Borehole 2

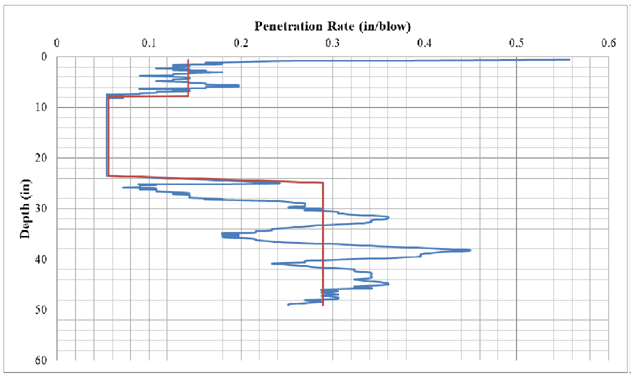
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)



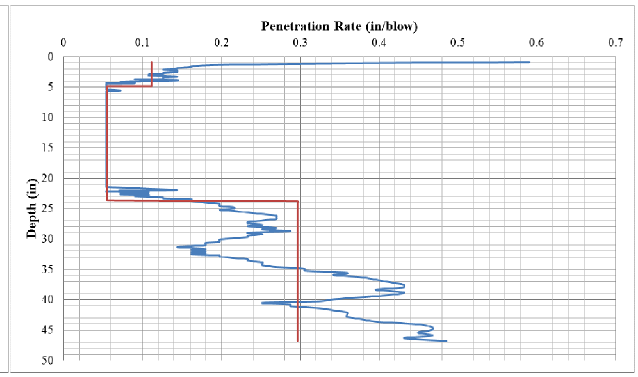
Borehole 3



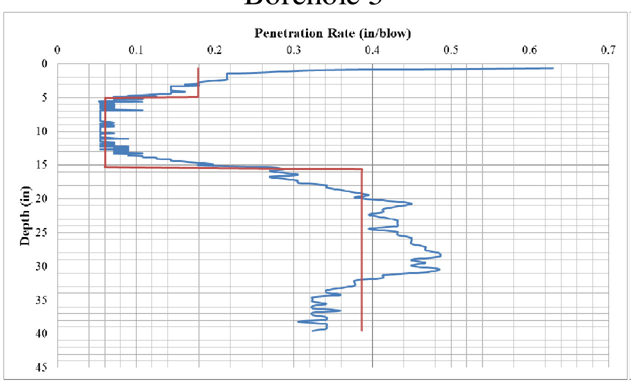
Borehole 4



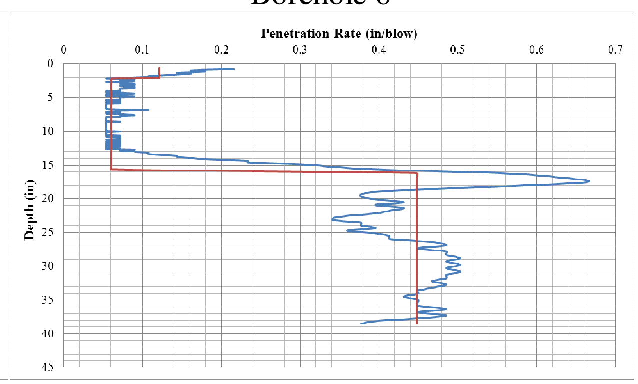
Borehole 5



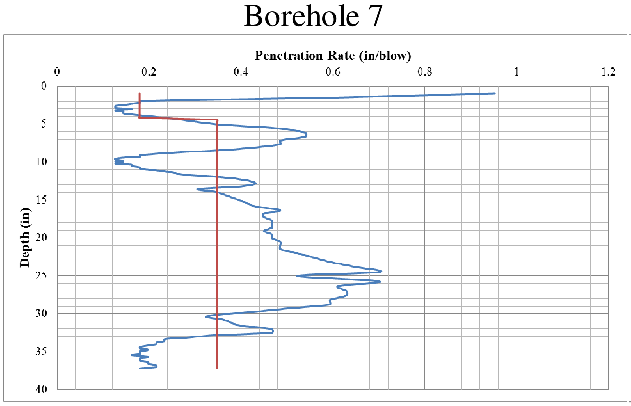
Borehole 6



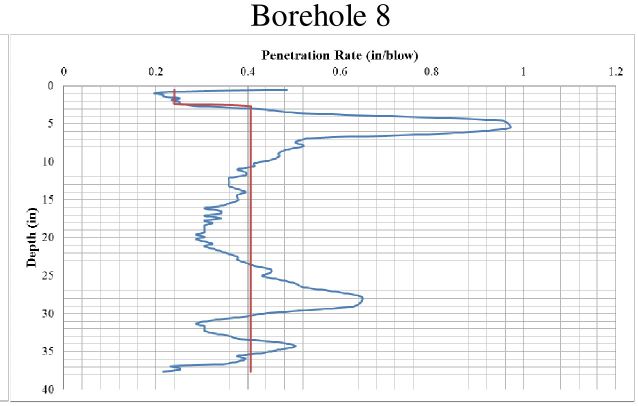
Borehole 7



Borehole 8



Borehole 9

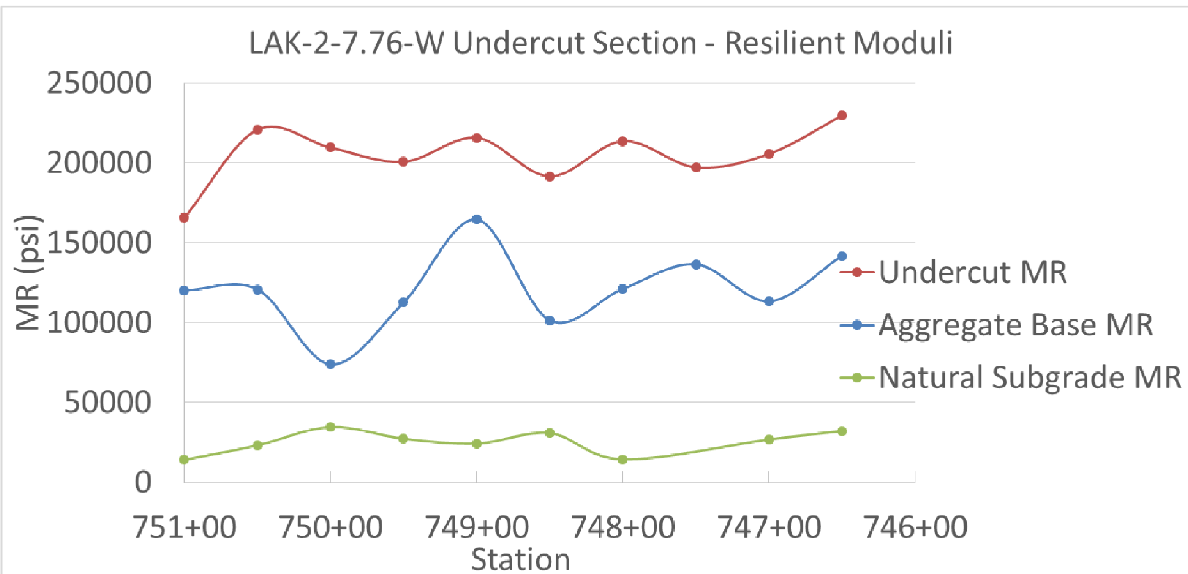


Borehole 10

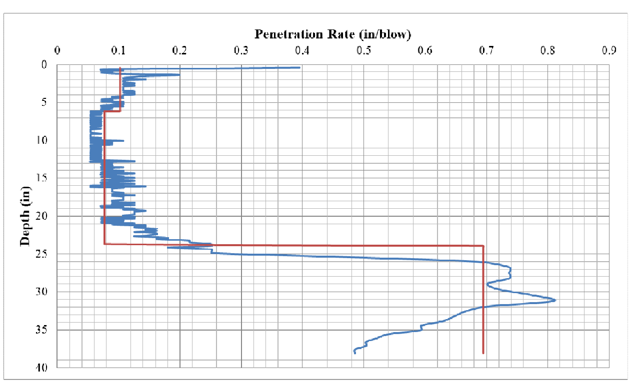
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)

LAK-2 Undercut Section

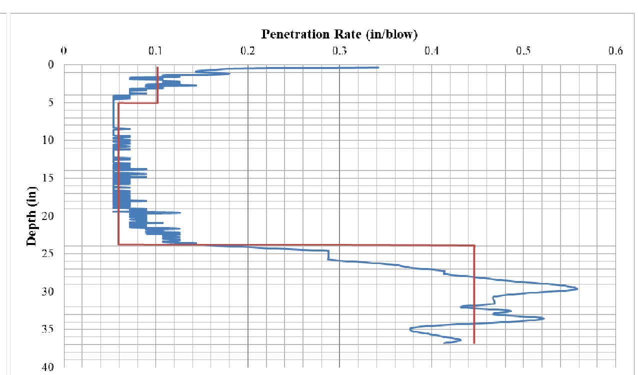
Hole	Station	Aggregate Base					Cement Stabilized Subgrade					Natural Subgrade				
		Average PR		CBR	M_R		Average PR		CBR	M_R		Average PR		CBR	M_R	
		(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)
1	751+00	2.60	0.102	100	120112	828	1.95	0.077	138	165562	1142	17.65	0.695	12	14072	97
2	750+50	2.59	0.102	101	120819	833	1.51	0.059	184	220732	1522	11.34	0.446	19	23090	159
3	750+00	4.02	0.158	61	73797	509	1.58	0.062	175	209540	1445	7.90	0.311	29	34607	239
4	749+50	2.76	0.109	94	112576	776	1.65	0.065	167	200627	1383	9.77	0.385	23	27293	188
5	749+00	1.96	0.077	137	164517	1134	1.54	0.061	180	215690	1487	10.87	0.428	20	24205	167
6	748+50	3.03	0.119	84	101310	699	1.71	0.068	160	191510	1320	8.78	0.346	26	30761	212
7	748+00	2.58	0.102	101	121108	835	1.56	0.061	178	213615	1473	17.32	0.682	12	14369	99
8	747+50	2.32	0.091	114	136515	941	1.67	0.066	164	197144	1359	1.78	0.070	153	184053	1269
9	747+00	2.74	0.108	94	113327	781	1.61	0.063	171	205599	1418	9.94	0.391	22	26768	185
10	746+50	2.24	0.088	118	141835	978	1.46	0.057	191	229593	1583	8.44	0.332	27	32160	222
Average		2.68	0.106	100	120592	831	1.62	0.064	171	204961	1413	10.38	0.409	34	41138	284
Std.Dev.		0.56	0.022	20	24298	168	0.14	0.005	15	17888	123	4.58	0.181	42	50679	349



1 psi = 6.89 kPa

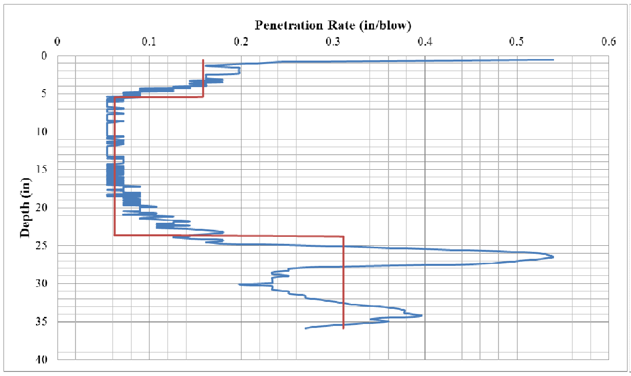


Borehole 1

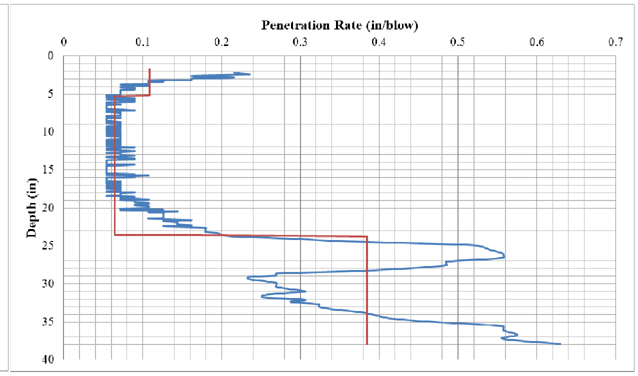


Borehole 2

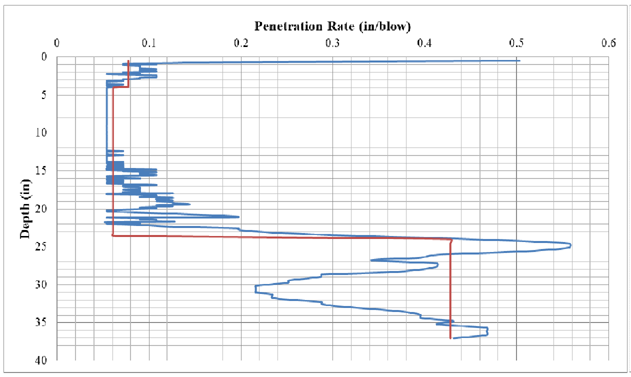
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)



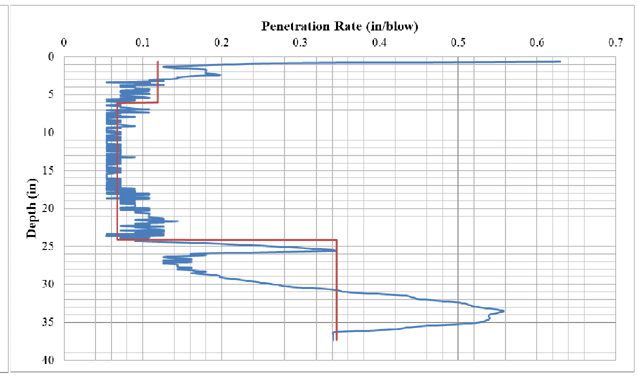
Borehole 3



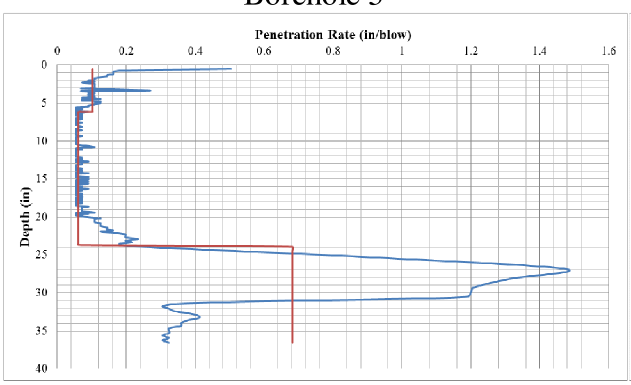
Borehole 4



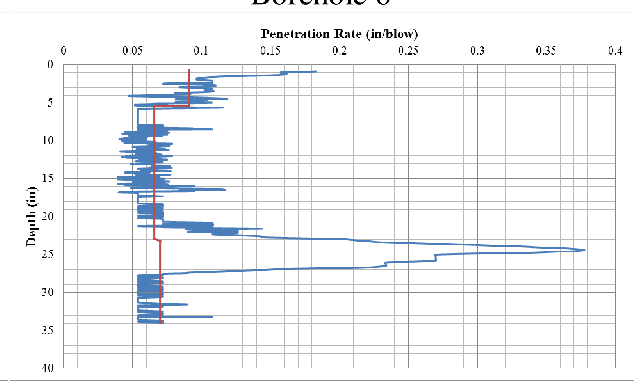
Borehole 5



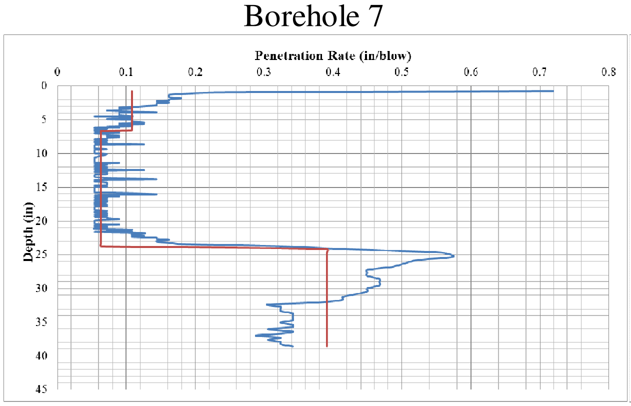
Borehole 6



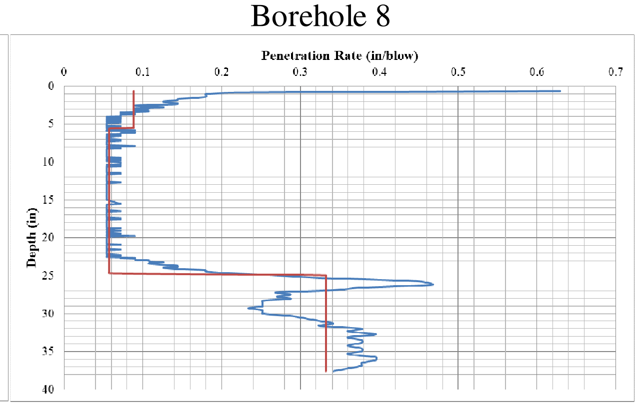
Borehole 7



Borehole 8



Borehole 9

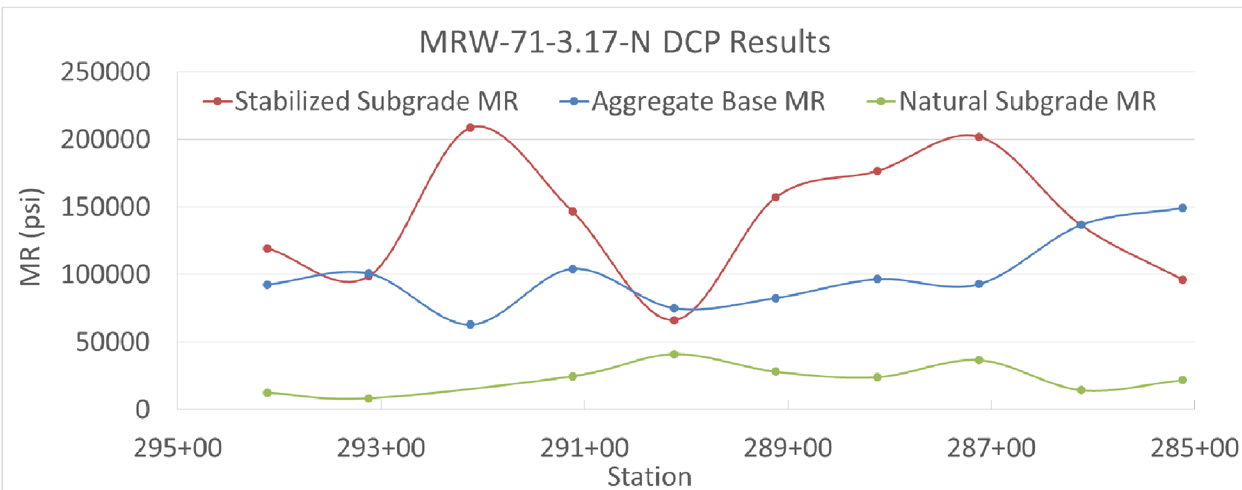


Borehole 10

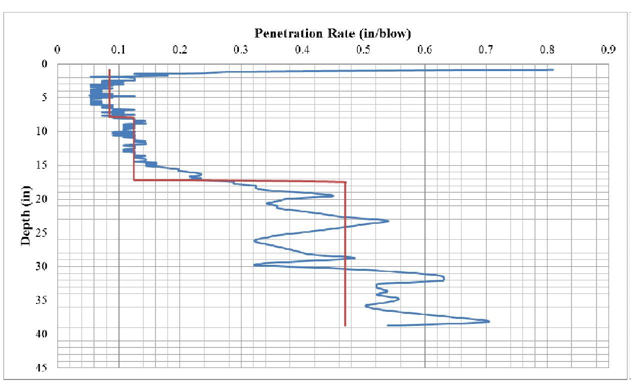
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)

DCP Results for MRW-71

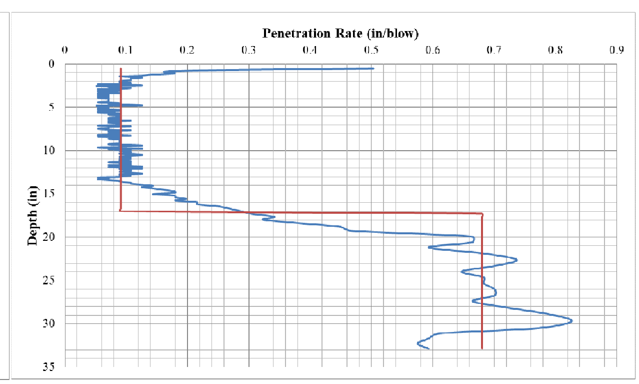
Hole	Station	Aggregate Base					Cement Stabilized Subgrade					Natural Subgrade				
		Average PR		CBR	M_R		Average PR		CBR	M_R		Average PR		CBR	M_R	
		(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)	(mm/blow)	(in/blow)		(psi)	(MPa)
1	285+12	2.14	0.084	124	149170	1028	3.17	0.125	80	96139	663	11.93	0.470	18	21806	150
2	286+12	2.32	0.091	114	136630	942	2.32	0.091	114	136630	942	17.28	0.680	12	14402	99
3	287+12	3.27	0.129	77	92878	640	1.63	0.064	168	202080	1393	7.51	0.296	31	36637	253
4	288+12	3.16	0.124	80	96544	666	1.84	0.073	147	176646	1218	10.94	0.431	20	24047	166
5	289+12	3.63	0.143	69	82637	570	2.05	0.081	131	157133	1083	9.54	0.376	23	28013	193
6	290+12	3.96	0.156	63	75070	518	4.42	0.174	55	66268	457	6.79	0.267	34	41008	283
7	291+12	2.95	0.116	87	104206	718	2.17	0.086	122	146807	1012	10.68	0.420	21	24691	170
8	292+12	4.64	0.183	52	62826	433	1.59	0.063	174	208626	1438	9.22	0.363	24	29098	201
9	293+12	3.04	0.120	84	100712	694	3.10	0.122	82	98736	681	27.95	1.100	7	8406	58
10	294+12	3.28	0.129	77	92522	638	2.61	0.103	100	119536	824	19.48	0.767	10	12594	87
Average		3.24	0.128	83	99319	685	2.49	0.098	117	140860	971	13.13	0.517	20	24070	166
Std. Dev.		0.73	0.029	22	26239	181	0.87	0.034	39	46824	323	6.58	0.259	9	10337	71



1 psi = 6.89 kPa

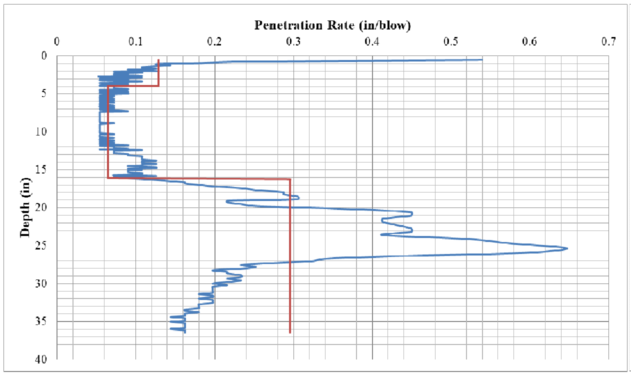


Borehole 1

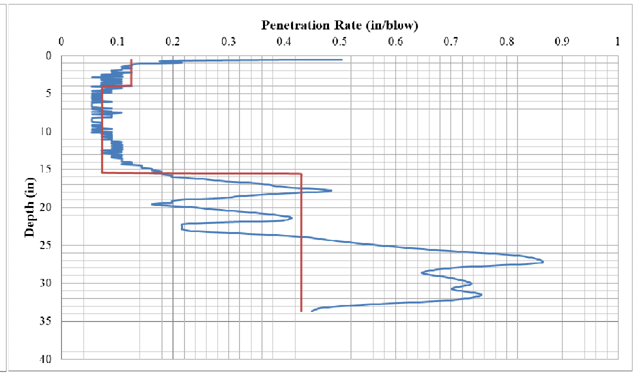


Borehole 2

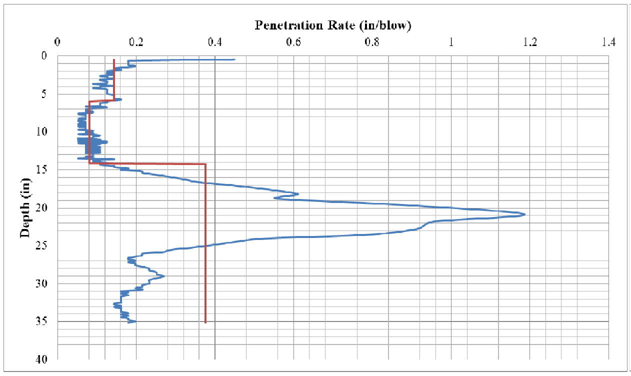
(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)



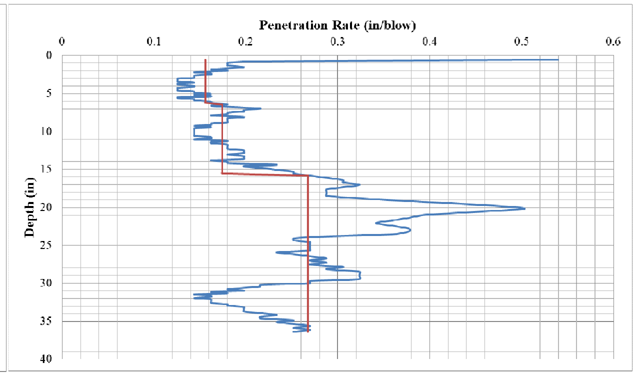
Borehole 3



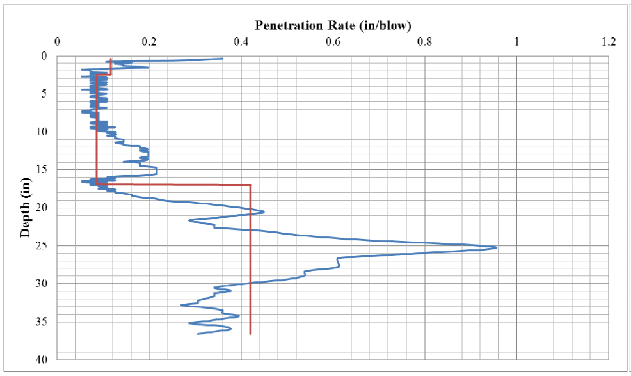
Borehole 4



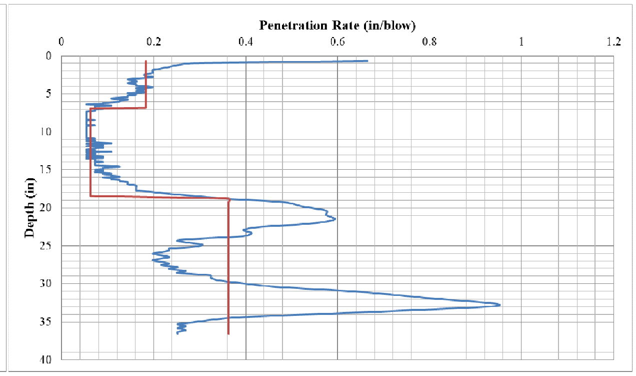
Borehole 5



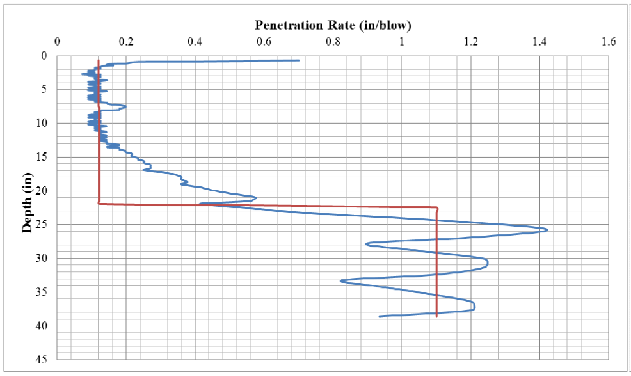
Borehole 6



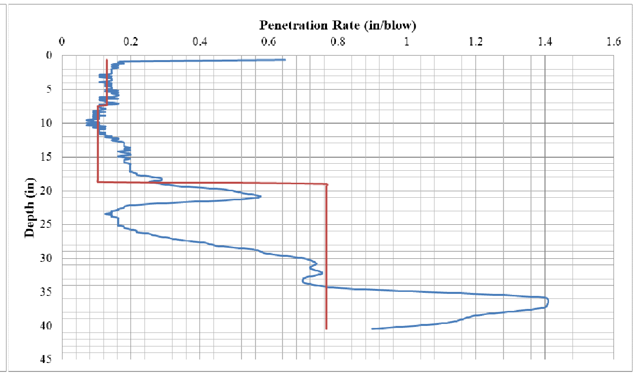
Borehole 7



Borehole 8



Borehole 9



Borehole 10

(1 in = 25.4 mm, 1 in/blow = 25.4 mm/blow)

Appendix C: Falling Weight Deflectometer (FWD) results

CLA-70 (time: 9:55)					12 in (305 mm) diameter plate				Air Temperature 50.4°F (10.2°C)																	
Distance		Pavement Temp.		Drop	Stress		Load		D1		D2		D3		D4		D5		D6		D7		D8		D9	
(ft)	(m)	(°F)	(°C)		(psi)	(MPa)	(lb)	(kN)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)
0.00	0.00	58.7	14.8	1	79.4	0.547	8981	39.95	1.77	45.0	1.51	38.4	1.39	35.3	1.40	35.6	1.28	32.5	1.20	30.5	0.96	24.4	0.83	21.1	0.70	17.8
0.00	0.00	58.7	14.8	2	105.6	0.728	11944	53.13	2.33	59.2	2.01	51.1	1.85	47.0	1.85	47.0	1.70	43.2	1.57	39.9	1.32	33.5	1.12	28.4	0.95	24.1
0.00	0.00	58.7	14.8	3	133.9	0.923	15145	67.37	2.83	71.9	2.42	61.5	2.25	57.2	2.26	57.4	2.08	52.8	1.93	49.0	1.61	40.9	1.36	34.5	1.14	29.0
95.04	28.97	57.7	14.3	1	79.4	0.547	8981	39.95	2.45	62.2	2.10	53.3	1.95	49.5	1.95	49.5	1.78	45.2	1.65	41.9	1.34	34.0	1.09	27.7	0.88	22.4
95.04	28.97	57.7	14.3	2	105.3	0.726	11910	52.98	3.17	80.5	2.75	69.9	2.55	64.8	2.55	64.8	2.35	59.7	2.16	54.9	1.76	44.7	1.43	36.3	1.18	30.0
95.04	28.97	57.7	14.3	3	130.0	0.896	14704	65.41	3.86	98.0	3.35	85.1	3.12	79.2	3.10	78.7	2.86	72.6	2.61	66.3	2.14	54.4	1.74	44.2	1.44	36.6
195.36	59.55	57.7	14.3	1	79.8	0.550	9026	40.15	2.23	56.6	1.89	48.0	1.75	44.5	1.78	45.2	1.63	41.4	1.51	38.4	1.27	32.3	1.06	26.9	0.84	21.3
195.36	59.55	57.7	14.3	2	103.8	0.716	11740	52.22	2.88	73.2	2.48	63.0	2.30	58.4	2.34	59.4	2.14	54.4	1.98	50.3	1.65	41.9	1.37	34.8	1.11	28.2
195.36	59.55	57.7	14.3	3	132.4	0.913	14975	66.61	3.57	90.7	3.02	76.7	2.83	71.9	2.88	73.2	2.61	66.3	2.43	61.7	2.02	51.3	1.67	42.4	1.38	35.1
295.68	90.12	57.7	14.3	1	80.6	0.556	9116	40.55	2.20	55.9	1.79	45.5	1.67	42.4	1.69	42.9	1.56	39.6	1.43	36.3	1.20	30.5	1.02	25.9	0.84	21.3
295.68	90.12	57.7	14.3	2	106.6	0.735	12057	53.63	2.81	71.4	2.35	59.7	2.17	55.1	2.18	55.4	2.01	51.1	1.86	47.2	1.57	39.9	1.32	33.5	1.11	28.2
295.68	90.12	57.7	14.3	3	131.9	0.909	14919	66.36	3.45	87.6	2.89	73.4	2.65	67.3	2.68	68.1	2.46	62.5	2.29	58.2	1.93	49.0	1.62	41.1	1.37	34.8
396.00	120.70	56.7	13.7	1	80.6	0.556	9116	40.55	2.23	56.6	1.92	48.8	1.81	46.0	1.84	46.7	1.68	42.7	1.56	39.6	1.32	33.5	1.08	27.4	0.92	23.4
396.00	120.70	56.7	13.7	2	105.6	0.728	11944	53.13	2.86	72.6	2.49	63.2	2.33	59.2	2.37	60.2	2.17	55.1	2.03	51.6	1.68	42.7	1.42	36.1	1.17	29.7
396.00	120.70	56.7	13.7	3	130.2	0.898	14726	65.50	3.51	89.2	3.04	77.2	2.85	72.4	2.89	73.4	2.65	67.3	2.48	63.0	2.09	53.1	1.74	44.2	1.45	36.8
496.32	151.28	56.0	13.3	1	80.1	0.552	9060	40.30	2.35	59.7	1.99	50.5	1.87	47.5	1.90	48.3	1.75	44.5	1.63	41.4	1.37	34.8	1.16	29.5	0.96	24.4
496.32	151.28	56.0	13.3	2	105.7	0.729	11955	53.18	3.06	77.7	2.62	66.5	2.45	62.2	2.47	62.7	2.30	58.4	2.15	54.6	1.83	46.5	1.55	39.4	1.29	32.8
496.32	151.28	56.0	13.3	3	130.4	0.899	14749	65.61	3.67	93.2	3.16	80.3	3.00	76.2	3.01	76.5	2.80	71.1	2.63	66.8	2.23	56.6	1.90	48.3	1.60	40.6
596.64	181.86	57.3	14.1	1	80.1	0.552	9060	40.30	2.41	61.2	2.01	51.1	1.92	48.8	1.91	48.5	1.78	45.2	1.67	42.4	1.42	36.1	1.19	30.2	1.01	25.7
596.64	181.86	57.3	14.1	2	105.1	0.725	11887	52.88	3.08	78.2	2.62	66.5	2.48	63.0	2.47	62.7	2.31	58.7	2.17	55.1	1.84	46.7	1.54	39.1	1.31	33.3
596.64	181.86	57.3	14.1	3	130.2	0.898	14726	65.50	3.73	94.7	3.17	80.5	3.01	76.5	2.98	75.7	2.81	71.4	2.65	67.3	2.24	56.9	1.89	48.0	1.59	40.4
696.96	212.43	56.7	13.7	1	77.5	0.534	8766	38.99	2.34	59.4	2.06	52.3	1.93	49.0	1.96	49.8	1.81	46.0	1.68	42.7	1.39	35.3	1.15	29.2	0.94	23.9
696.96	212.43	56.7	13.7	2	104.1	0.718	11774	52.37	3.07	78.0	2.72	69.1	2.55	64.8	2.60	66.0	2.38	60.5	2.21	56.1	1.85	47.0	1.53	38.9	1.26	32.0
696.96	212.43	56.7	13.7	3	127.3	0.878	14398	64.05	3.71	94.2	3.27	83.1	3.07	78.0	3.11	79.0	2.87	72.9	2.68	68.1	2.23	56.6	1.85	47.0	1.53	38.9
797.28	243.01	57.0	13.9	1	77.7	0.536	8788	39.09	2.30	58.4	1.98	50.3	1.87	47.5	1.85	47.0	1.77	45.0	1.67	42.4	1.41	35.8	1.18	30.0	0.99	25.1
797.28	243.01	57.0	13.9	2	104.7	0.722	11842	52.68	2.99	75.9	2.60	66.0	2.47	62.7	2.44	62.0	2.32	58.9	2.18	55.4	1.87	47.5	1.56	39.6	1.30	33.0
797.28	243.01	57.0	13.9	3	126.5	0.872	14308	63.65	3.60	91.4	3.13	79.5	2.97	75.4	2.95	74.9	2.79	70.9	2.62	66.5	2.23	56.6	1.89	48.0	1.62	41.1
897.60	273.59	56.0	13.3	1	78.8	0.543	8913	39.65	2.21	56.1	1.85	47.0	1.73	43.9	1.74	44.2	1.63	41.4	1.51	38.4	1.27	32.3	1.07	27.2	0.89	22.6
897.60	273.59	56.0	13.3	2	101.4	0.699	11469	51.02	2.82	71.6	2.36	59.9	2.22	56.4	2.18	55.4	2.06	52.3	1.95	49.5	1.63	41.4	1.37	34.8	1.16	29.5
897.60	273.59	56.0	13.3	3	126.7	0.874	14330	63.74	3.51	89.2	2.93	74.4	2.75	69.9	2.74	69.6	2.58	65.5	2.40	61.0	2.02	51.3	1.73	43.9	1.46	37.1

CLI-73 (time: 10:03)					12 in (305 mm) diameter plate				Air Temperature 53.4°F (11.9°C)																	
Distance		Pavement Temp.		Drop	Stress		Load		D1		D2		D3		D4		D5		D6		D7		D8		D9	
(ft)	(m)	(°F)	(°C)		(psi)	(MPa)	(lb)	(kN)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)
0.00	0.00	56.4	13.6	1	80.1	0.552	9060	40.30	4.17	105.9	3.67	93.2	3.46	87.9	3.54	89.9	3.20	81.3	2.98	75.7	2.39	60.7	1.90	48.3	1.49	37.8
0.00	0.00	56.4	13.6	2	105.0	0.724	11876	52.83	5.26	133.6	4.66	118.4	4.38	111.3	4.48	113.8	4.06	103.1	3.76	95.5	3.05	77.5	2.41	61.2	1.88	47.8
0.00	0.00	56.4	13.6	3	128.5	0.886	14534	64.65	6.41	162.8	5.67	144.0	5.34	135.6	5.45	138.4	4.94	125.5	4.60	116.8	3.71	94.2	2.94	74.7	2.29	58.2
95.04	28.97	58.7	14.8	1	80.6	0.556	9116	40.55	3.77	95.8	3.27	83.1	3.07	78.0	3.13	79.5	2.82	71.6	2.58	65.5	2.09	53.1	1.69	42.9	1.37	34.8
95.04	28.97	58.7	14.8	2	104.5	0.721	11819	52.57	4.81	122.2	4.18	106.2	3.91	99.3	3.99	101.3	3.59	91.2	3.29	83.6	2.69	68.3	2.16	54.9	1.75	44.5
95.04	28.97	58.7	14.8	3	130.4	0.899	14749	65.61	5.77	146.6	5.09	129.3	4.74	120.4	4.83	122.7	4.36	110.7	4.00	101.6	3.25	82.6	2.61	66.3	2.11	53.6
195.36	59.55	57.0	13.9	1	80.6	0.556	9116	40.55	3.54	89.9	3.14	79.8	2.94	74.7	2.99	75.9	2.69	68.3	2.48	63.0	1.98	50.3	1.55	39.4	1.22	31.0
195.36	59.55	57.0	13.9	2	104.7	0.722	11842	52.68	4.58	116.3	4.10	104.1	3.83	97.3	3.88	98.6	3.51	89.2	3.23	82.0	2.58	65.5	2.03	51.6	1.61	40.9
195.36	59.55	57.0	13.9	3	131.2	0.905	14839	66.01	5.62	142.7	5.04	128.0	4.71	119.6	4.77	121.2	4.33	110.0	3.96	100.6	3.18	80.8	2.49	63.2	1.97	50.0
295.68	90.12	58.3	14.6	1	79.8	0.550	9026	40.15	3.90	99.1	3.30	83.8	3.08	78.2	3.11	79.0	2.83	71.9	2.59	65.8	2.06	52.3	1.62	41.1	1.30	33.0
295.68	90.12	58.3	14.6	2	106.2	0.732	12012	53.43	5.10	129.5	4.35	110.5	4.06	103.1	4.09	103.9	3.71	94.2	3.41	86.6	2.72	69.1	2.15	54.6	1.71	43.4
295.68	90.12	58.3	14.6	3	133.9	0.923	15145	67.37	6.26	159.0	5.35	135.9	4.99	126.7	5.05	128.3	4.58	116.3	4.18	106.2	3.34	84.8	2.64	67.1	2.12	53.8
396.00	120.70	57.0	13.9	1	78.3	0.540	8856	39.39	3.65	92.7	3.29	83.6	2.91	73.9	2.85	72.4	2.61	66.3	2.39	60.7	1.89	48.0	1.51	38.4	1.22	31.0
396.00	120.70	57.0	13.9	2	103.8	0.716	11740	52.22	4.73	120.1	4.26	108.2	3.76	95.5	3.68	93.5	3.41	86.6	3.10	78.7	2.44	62.0	1.95	49.5	1.58	40.1
396.00	120.70	57.0	13.9	3	128.0	0.883	14477	64.40	5.77	146.6	5.21	132.3	4.61	117.1	4.50	114.3	4.15	105.4	3.76	95.5	2.98	75.7	2.39	60.7	1.94	49.3
496.32	151.28	58.0	14.4	1	79.2	0.546	8958	39.85	3.82	97.0	3.36	85.3	3.20	81.3	3.22	81.8	2.97	75.4	2.78	70.6	2.29	58.2	1.90	48.3	1.55	39.4
496.32	151.28	58.0	14.4	2	103.4	0.713	11695	52.02	4.84	122.9	4.25	108.0	4.04	102.6	4.09	103.9	3.77	95.8	3.51	89.2	2.90	73.7	2.39	60.7	1.96	49.8
496.32	151.28	58.0	14.4	3	129.3	0.891	14624	65.05	5.90	149.9	5.21	132.3	4.94	125.5	4.98	126.5	4.60	116.8	4.28	108.7	3.56	90.4	2.89	73.4	2.38	60.5
596.64	181.86	58.3	14.6	1	79.0	0.545	8935	39.74	3.85	97.8	3.40	86.4	3.21	81.5	3.28	83.3	2.99	75.9	2.77	70.4	2.25	57.2	1.82	46.2	1.42	36.1
596.64	181.86	58.3	14.6	2	103.0	0.710	11650	51.82	5.04	128.0	4.43	112.5	4.18	106.2	4.27	108.5	3.90	99.1	3.63	92.2	2.95	74.9	2.36	59.9	1.86	47.2
596.64	181.86	58.3	14.6	3	129.7	0.894	14670	65.26	6.18	157.0	5.42	137.7	5.16	131.1	5.25	133.4	4.81	122.2	4.45	113.0	3.64	92.5	2.92	74.2	2.30	58.4
696.96	212.43	51.4	10.8	1	79.0	0.545	8935	39.74	3.97	100.8	3.55	90.2	3.38	85.9	3.41	86.6	3.15	80.0	2.93	74.4	2.40	61.0	1.94	49.3	1.53	38.9
696.96	212.43	51.4	10.8	2	105.0	0.724	11876	52.83	5.22	132.6	4.66	118.4	4.43	112.5	4.50	114.3	4.12	104.6	3.84	97.5	3.15	80.0	2.55	64.8	2.03	51.6
696.96	212.43	51.4	10.8	3	128.5	0.886	14534	64.65	6.39	162.3	5.68	144.3	5.37	136.4	5.47	138.9	5.03	127.8	4.69	119.1	3.86	98.0	3.09	78.5	2.47	62.7
797.28	243.01	59.3	15.2	1	77.3	0.533	8743	38.89	4.93	125.2	4.44	112.8	4.18	106.2	4.20	106.7	3.87	98.3	3.57	90.7	2.88	73.2	2.23	56.6	1.69	42.9
797.28	243.01	59.3	15.2	2	105.1	0.725	11887	52.88	6.54	166.1	5.88	149.4	5.55	141.0	5.58	141.7	5.15	130.8	4.76	120.9	3.82	97.0	2.97	75.4	2.26	57.4
797.28	243.01	59.3	15.2	3	129.1	0.890	14602	64.95	7.90	200.7	7.12	180.8	6.70	170.2	6.74	171.2	6.23	158.2	5.76	146.3	4.61	117.1	3.58	90.9	2.74	69.6
897.60	273.59	59.7	15.4	1	78.6	0.542	8890	39.54	4.68	118.9	4.16	105.7	3.90	99.1	3.93	99.8	3.60	91.4	3.30	83.8	2.60	66.0	1.99	50.5	1.50	38.1
897.60	273.59	59.7	15.4	2	106.5	0.734	12046	53.58	6.15	156.2	5.49	139.4	5.15	130.8	5.18	131.6	4.75	120.7	4.38	111.3	3.45	87.6	2.65	67.3	1.99	50.5
897.60	273.59	59.7	15.4	3	131.9	0.909	14919	66.36	7.53	191.3	6.73	170.9	6.34	161.0	6.36	161.5	5.83	148.1	5.35	135.9	4.24	107.7	3.25	82.6	2.46	62.5

DEF-24 (time: 9:39)					12 in (305 mm) diameter plate				Air Temperature 29.2°F (-1.6°C)																	
Distance		Pavement Temp.		Drop	Stress		Load		D1		D2		D3		D4		D5		D6		D7		D8		D9	
(ft)	(m)	(°F)	(°C)		(psi)	(MPa)	(lb)	(kN)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)
0.00	0.00	37.2	2.9	1	76.0	0.524	8596	38.24	2.52	64.0	2.23	56.6	2.09	53.1	2.45	62.2	1.98	50.3	1.85	47.0	1.59	40.4	1.37	34.8	1.20	30.5
0.00	0.00	37.2	2.9	2	97.3	0.671	11005	48.95	3.15	80.0	2.78	70.6	2.63	66.8	3.07	78.0	2.48	63.0	2.31	58.7	2.00	50.8	1.74	44.2	1.52	38.6
0.00	0.00	37.2	2.9	3	120.0	0.827	13573	60.38	3.81	96.8	3.36	85.3	3.21	81.5	3.70	94.0	2.99	75.9	2.81	71.4	2.41	61.2	2.08	52.8	1.82	46.2
110.88	33.80	39.9	4.4	1	80.3	0.554	9082	40.40	2.52	64.0	2.18	55.4	2.06	52.3	2.46	62.5	1.94	49.3	1.81	46.0	1.55	39.4	1.32	33.5	1.14	29.0
110.88	33.80	39.9	4.4	2	98.2	0.677	11107	49.41	3.04	77.2	2.64	67.1	2.49	63.2	2.97	75.4	2.34	59.4	2.17	55.1	1.85	47.0	1.61	40.9	1.40	35.6
110.88	33.80	39.9	4.4	3	122.2	0.843	13821	61.48	3.63	92.2	3.18	80.8	2.99	75.9	3.59	91.2	2.81	71.4	2.63	66.8	2.24	56.9	1.92	48.8	1.66	42.2
221.76	67.59	37.6	3.1	1	80.7	0.556	9128	40.60	2.89	73.4	2.55	64.8	2.43	61.7	2.85	72.4	2.28	57.9	2.13	54.1	1.87	47.5	1.62	41.1	1.42	36.1
221.76	67.59	37.6	3.1	2	100.4	0.692	11356	50.51	3.50	88.9	3.12	79.2	2.95	74.9	3.45	87.6	2.78	70.6	2.64	67.1	2.27	57.7	1.98	50.3	1.73	43.9
221.76	67.59	37.6	3.1	3	122.6	0.845	13867	61.68	4.17	105.9	3.71	94.2	3.51	89.2	4.11	104.4	3.31	84.1	3.12	79.2	2.73	69.3	2.35	59.7	2.06	52.3
332.64	101.39	38.2	3.4	1	82.5	0.569	9331	41.51	3.08	78.2	2.67	67.8	2.52	64.0	3.13	79.5	2.33	59.2	2.16	54.9	1.81	46.0	1.53	38.9	1.30	33.0
332.64	101.39	38.2	3.4	2	101.9	0.703	11525	51.27	3.75	95.3	3.30	83.8	3.08	78.2	3.86	98.0	2.89	73.4	2.67	67.8	2.25	57.2	1.90	48.3	1.65	41.9
332.64	101.39	38.2	3.4	3	122.2	0.843	13821	61.48	4.31	109.5	3.80	96.5	3.56	90.4	4.42	112.3	3.32	84.3	3.07	78.0	2.55	64.8	2.16	54.9	1.84	46.7
448.80	136.79	41.9	5.5	1	81.3	0.561	9195	40.90	2.27	57.7	2.03	51.6	1.96	49.8	2.10	53.3	1.85	47.0	1.79	45.5	1.61	40.9	1.45	36.8	1.28	32.5
448.80	136.79	41.9	5.5	2	101.7	0.701	11503	51.17	2.77	70.4	2.48	63.0	2.42	61.5	2.61	66.3	2.33	59.2	2.20	55.9	1.98	50.3	1.80	45.7	1.59	40.4
448.80	136.79	41.9	5.5	3	122.4	0.844	13844	61.58	3.27	83.1	2.93	74.4	2.84	72.1	3.05	77.5	2.73	69.3	2.60	66.0	2.31	58.7	2.09	53.1	1.87	47.5
559.68	170.59	40.9	4.9	1	81.6	0.563	9229	41.05	2.33	59.2	2.08	52.8	2.00	50.8	2.18	55.4	1.92	48.8	1.81	46.0	1.60	40.6	1.41	35.8	1.24	31.5
559.68	170.59	40.9	4.9	2	102.1	0.704	11548	51.37	2.89	73.4	2.60	66.0	2.51	63.8	2.72	69.1	2.38	60.5	2.27	57.7	2.02	51.3	1.79	45.5	1.57	39.9
559.68	170.59	40.9	4.9	3	123.4	0.851	13957	62.08	3.38	85.9	3.06	77.7	2.93	74.4	3.20	81.3	2.79	70.9	2.68	68.1	2.35	59.7	2.06	52.3	1.80	45.7
665.28	202.78	42.2	5.7	1	80.7	0.556	9128	40.60	2.34	59.4	2.17	55.1	2.08	52.8	2.26	57.4	1.98	50.3	1.87	47.5	1.65	41.9	1.44	36.6	1.24	31.5
665.28	202.78	42.2	5.7	2	103.0	0.710	11650	51.82	2.90	73.7	2.67	67.8	2.57	65.3	2.79	70.9	2.44	62.0	2.32	58.9	2.05	52.1	1.78	45.2	1.56	39.6
665.28	202.78	42.2	5.7	3	123.7	0.853	13991	62.24	3.44	87.4	3.19	81.0	3.06	77.7	3.31	84.1	2.90	73.7	2.76	70.1	2.40	61.0	2.10	53.3	1.83	46.5
776.16	236.57	41.5	5.3	1	81.3	0.561	9195	40.90	2.58	65.5	2.33	59.2	2.25	57.2	2.47	62.7	2.13	54.1	2.04	51.8	1.80	45.7	1.58	40.1	1.38	35.1
776.16	236.57	41.5	5.3	2	103.8	0.716	11740	52.22	3.22	81.8	2.93	74.4	2.81	71.4	3.08	78.2	2.68	68.1	2.55	64.8	2.23	56.6	1.96	49.8	1.70	43.2
776.16	236.57	41.5	5.3	3	124.6	0.859	14093	62.69	3.80	96.5	3.47	88.1	3.34	84.8	3.64	92.5	3.19	81.0	3.01	76.5	2.66	67.6	2.34	59.4	2.03	51.6
887.04	270.37	42.2	5.7	1	80.6	0.556	9116	40.55	2.56	65.0	2.29	58.2	2.18	55.4	2.49	63.2	2.06	52.3	1.97	50.0	1.72	43.7	1.51	38.4	1.34	34.0
887.04	270.37	42.2	5.7	2	101.7	0.701	11503	51.17	3.24	82.3	2.89	73.4	2.76	70.1	3.16	80.3	2.60	66.0	2.48	63.0	2.16	54.9	1.90	48.3	1.68	42.7
887.04	270.37	42.2	5.7	3	125.6	0.866	14206	63.19	3.88	98.6	3.44	87.4	3.27	83.1	3.75	95.3	3.09	78.5	2.93	74.4	2.56	65.0	2.26	57.4	1.99	50.5
997.92	304.17	42.8	6.0	1	81.2	0.560	9184	40.85	2.30	58.4	2.06	52.3	1.97	50.0	2.20	55.9	1.85	47.0	1.78	45.2	1.53	38.9	1.34	34.0	1.17	29.7
997.92	304.17	42.8	6.0	2	103.6	0.714	11718	52.12	2.89	73.4	2.60	66.0	2.48	63.0	2.78	70.6	2.33	59.2	2.21	56.1	1.91	48.5	1.67	42.4	1.43	36.3
997.92	304.17	42.8	6.0	3	126.1	0.869	14263	63.44	3.48	88.4	3.10	78.7	2.96	75.2	3.34	84.8	2.80	71.1	2.65	67.3	2.28	57.9	2.00	50.8	1.73	43.9

LAK-2 Stabilized Section (time: 13:01)					12 in (305 mm) diameter plate				Air Temperature 74.9°F (23.8°C)																	
Distance		Pavement Temp.		Drop	Stress		Load		D1		D2		D3		D4		D5		D6		D7		D8		D9	
(ft)	(m)	(°F)	(°C)		(psi)	(MPa)	(lb)	(kN)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)
0.00	0.00	76.8	24.9	1	78.6	0.542	8890	39.54	2.78	70.6	2.35	59.7	2.17	55.1	2.12	53.8	1.97	50.0	1.79	45.5	1.44	36.6	1.14	29.0	1.00	25.4
0.00	0.00	76.8	24.9	2	104.5	0.721	11819	52.57	3.59	91.2	3.07	78.0	2.84	72.1	2.79	70.9	2.58	65.5	2.32	58.9	1.89	48.0	1.49	37.8	1.29	32.8
0.00	0.00	76.8	24.9	3	129.1	0.890	14602	64.95	4.37	111.0	3.74	95.0	3.44	87.4	3.39	86.1	3.12	79.2	2.83	71.9	2.28	57.9	1.82	46.2	1.55	39.4
108.00	32.92	77.8	25.4	1	78.3	0.540	8856	39.39	2.68	68.1	2.17	55.1	1.99	50.5	1.98	50.3	1.83	46.5	1.65	41.9	1.34	34.0	1.07	27.2	0.90	22.9
108.00	32.92	77.8	25.4	2	107.7	0.743	12181	54.18	3.56	90.4	2.87	72.9	2.66	67.6	2.64	67.1	2.41	61.2	2.19	55.6	1.78	45.2	1.41	35.8	1.20	30.5
108.00	32.92	77.8	25.4	3	137.1	0.945	15507	68.98	4.32	109.7	3.53	89.7	3.23	82.0	3.22	81.8	2.93	74.4	2.65	67.3	2.15	54.6	1.70	43.2	1.43	36.3
200.00	60.96	76.8	24.9	1	76.8	0.530	8686	38.64	3.02	76.7	2.50	63.5	2.29	58.2	2.24	56.9	2.08	52.8	1.88	47.8	1.51	38.4	1.18	30.0	0.99	25.1
200.00	60.96	76.8	24.9	2	104.1	0.718	11774	52.37	4.05	102.9	3.34	84.8	3.04	77.2	2.98	75.7	2.78	70.6	2.52	64.0	2.03	51.6	1.56	39.6	1.35	34.3
200.00	60.96	76.8	24.9	3	126.1	0.869	14263	63.44	4.84	122.9	4.02	102.1	3.67	93.2	3.61	91.7	3.35	85.1	3.02	76.7	2.41	61.2	1.89	48.0	1.60	40.6
301.00	91.74	78.8	26.0	1	77.5	0.534	8766	38.99	3.37	85.6	2.87	72.9	2.62	66.5	2.60	66.0	2.35	59.7	2.13	54.1	1.70	43.2	1.33	33.8	1.13	28.7
301.00	91.74	78.8	26.0	2	106.5	0.734	12046	53.58	4.45	113.0	3.81	96.8	3.48	88.4	3.44	87.4	3.13	79.5	2.83	71.9	2.25	57.2	1.76	44.7	1.48	37.6
301.00	91.74	78.8	26.0	3	126.5	0.872	14308	63.65	5.34	135.6	4.55	115.6	4.16	105.7	4.09	103.9	3.75	95.3	3.36	85.3	2.70	68.6	2.09	53.1	1.78	45.2
400.00	121.92	78.1	25.6	1	76.4	0.527	8641	38.44	3.66	93.0	3.11	79.0	2.81	71.4	2.81	71.4	2.50	63.5	2.21	56.1	1.72	43.7	1.31	33.3	1.08	27.4
400.00	121.92	78.1	25.6	2	103.0	0.710	11650	51.82	4.87	123.7	4.14	105.2	3.74	95.0	3.73	94.7	3.35	85.1	2.95	74.9	2.31	58.7	1.75	44.5	1.44	36.6
400.00	121.92	78.1	25.6	3	125.8	0.867	14229	63.29	5.95	151.1	5.03	127.8	4.54	115.3	4.53	115.1	4.05	102.9	3.58	90.9	2.76	70.1	2.11	53.6	1.76	44.7
497.00	151.49	78.1	25.6	1	78.6	0.542	8890	39.54	3.45	87.6	2.99	75.9	2.72	69.1	2.64	67.1	2.44	62.0	2.17	55.1	1.72	43.7	1.35	34.3	1.13	28.7
497.00	151.49	78.1	25.6	2	104.5	0.721	11819	52.57	4.53	115.1	3.89	98.8	3.56	90.4	3.48	88.4	3.20	81.3	2.87	72.9	2.26	57.4	1.76	44.7	1.47	37.3
497.00	151.49	78.1	25.6	3	128.0	0.883	14477	64.40	5.52	140.2	4.72	119.9	4.33	110.0	4.23	107.4	3.89	98.8	3.48	88.4	2.75	69.9	2.12	53.8	1.78	45.2
598.00	182.27	79.4	26.3	1	77.3	0.533	8743	38.89	4.36	110.7	3.68	93.5	3.38	85.9	3.34	84.8	3.01	76.5	2.68	68.1	2.12	53.8	1.60	40.6	1.34	34.0
598.00	182.27	79.4	26.3	2	104.1	0.718	11774	52.37	5.70	144.8	4.88	124.0	4.47	113.5	4.41	112.0	3.99	101.3	3.57	90.7	2.79	70.9	2.12	53.8	1.76	44.7
598.00	182.27	79.4	26.3	3	126.7	0.874	14330	63.74	6.90	175.3	5.92	150.4	5.42	137.7	5.36	136.1	4.86	123.4	4.32	109.7	3.35	85.1	2.55	64.8	2.12	53.8
699.00	213.06	80.1	26.7	1	79.2	0.546	8958	39.85	4.39	111.5	3.67	93.2	3.32	84.3	3.30	83.8	2.97	75.4	2.64	67.1	2.05	52.1	1.59	40.4	1.32	33.5
699.00	213.06	80.1	26.7	2	107.3	0.740	12136	53.98	5.73	145.5	4.78	121.4	4.36	110.7	4.32	109.7	3.88	98.6	3.45	87.6	2.68	68.1	2.07	52.6	1.70	43.2
699.00	213.06	80.1	26.7	3	127.1	0.876	14376	63.95	6.84	173.7	5.76	146.3	5.25	133.4	5.21	132.3	4.69	119.1	4.18	106.2	3.26	82.8	2.50	63.5	2.06	52.3
800.00	243.84	78.1	25.6	1	79.7	0.550	9014	40.10	5.93	150.6	5.08	129.0	4.69	119.1	4.68	118.9	4.18	106.2	3.72	94.5	2.84	72.1	2.15	54.6	1.75	44.5
800.00	243.84	78.1	25.6	2	104.1	0.718	11774	52.37	7.62	193.5	6.56	166.6	6.03	153.2	6.04	153.4	5.39	136.9	4.81	122.2	3.69	93.7	2.77	70.4	2.25	57.2
800.00	243.84	78.1	25.6	3	127.8	0.881	14455	64.30	9.25	235.0	8.00	203.2	7.36	186.9	7.33	186.2	6.58	167.1	5.87	149.1	4.49	114.0	3.35	85.1	2.71	68.8
902.00	274.93	79.1	26.2	1	79.0	0.545	8935	39.74	5.31	134.9	4.61	117.1	4.22	107.2	4.20	106.7	3.79	96.3	3.37	85.6	2.59	65.8	1.98	50.3	1.59	40.4
902.00	274.93	79.1	26.2	2	104.1	0.718	11774	52.37	7.02	178.3	6.08	154.4	5.58	141.7	5.55	141.0	5.00	127.0	4.50	114.3	3.45	87.6	2.58	65.5	2.07	52.6
902.00	274.93	79.1	26.2	3	128.9	0.889	14579	64.85	8.68	220.5	7.45	189.2	6.84	173.7	6.83	173.5	6.15	156.2	5.50	139.7	4.25	108.0	3.18	80.8	2.55	64.8
1000.00	304.80	80.4	26.9	1	80.7	0.556	9128	40.60	4.54	115.3	3.88	98.6	3.58	90.9	3.59	91.2	3.23	82.0	2.90	73.7	2.29	58.2	1.77	45.0	1.46	37.1
1000.00	304.80	80.4	26.9	2	103.4	0.713	11695	52.02	5.95	151.1	5.08	129.0	4.70	119.4	4.69	119.1	4.24	107.7	3.80	96.5	3.00	76.2	2.31	58.7	1.91	48.5
1000.00	304.80	80.4	26.9	3	130.0	0.896	14704	65.41	7.34	186.4	6.32	160.5	5.86	148.8	5.85	148.6	5.28	134.1	4.73	120.1	3.71	94.2	2.84	72.1	2.33	59.2

LAK-2 Undercut Section (time: 17:55)					12 in (305 mm) diameter plate				Air Temperature 76.9°F (24.9°C)																	
Distance		Pavement Temp.		Drop	Stress		Load		D1		D2		D3		D4		D5		D6		D7		D8		D9	
(ft)	(m)	(°F)	(°C)		(psi)	(MPa)	(lb)	(kN)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)	(mil)	(µm)
0.00	0.00	81.7	27.6	1	77.9	0.537	8811	39.19	3.65	92.7	3.14	79.8	2.90	73.7	2.93	74.4	2.62	66.5	2.38	60.5	1.90	48.3	1.53	38.9	1.24	31.5
0.00	0.00	81.7	27.6	2	105.6	0.728	11944	53.13	4.88	124.0	4.13	104.9	3.80	96.5	3.87	98.3	3.45	87.6	3.13	79.5	2.49	63.2	1.98	50.3	1.61	40.9
0.00	0.00	81.7	27.6	3	126.7	0.874	14330	63.74	5.89	149.6	5.01	127.3	4.63	117.6	4.72	119.9	4.21	106.9	3.80	96.5	3.02	76.7	2.40	61.0	1.96	49.8
45.00	13.72	84.0	28.9	1	77.9	0.537	8811	39.19	2.83	71.9	2.43	61.7	2.21	56.1	2.20	55.9	2.03	51.6	1.84	46.7	1.47	37.3	1.22	31.0	1.00	25.4
45.00	13.72	84.0	28.9	2	108.0	0.745	12215	54.34	3.91	99.3	3.21	81.5	2.98	75.7	2.96	75.2	2.70	68.6	2.45	62.2	1.99	50.5	1.60	40.6	1.32	33.5
45.00	13.72	84.0	28.9	3	130.6	0.900	14772	65.71	4.76	120.9	4.00	101.6	3.69	93.7	3.67	93.2	3.36	85.3	3.02	76.7	2.44	62.0	1.97	50.0	1.61	40.9
95.00	28.96	80.4	26.9	1	77.3	0.533	8743	38.89	3.19	81.0	2.74	69.6	2.53	64.3	2.50	63.5	2.29	58.2	2.07	52.6	1.65	41.9	1.31	33.3	1.06	26.9
95.00	28.96	80.4	26.9	2	107.5	0.741	12159	54.09	4.34	110.2	3.75	95.3	3.45	87.6	3.43	87.1	3.11	79.0	2.81	71.4	2.22	56.4	1.74	44.2	1.42	36.1
95.00	28.96	80.4	26.9	3	130.0	0.896	14704	65.41	5.29	134.4	4.57	116.1	4.23	107.4	4.19	106.4	3.81	96.8	3.45	87.6	2.73	69.3	2.12	53.8	1.75	44.5
146.00	44.50	84.7	29.3	1	77.1	0.532	8720	38.79	3.24	82.3	2.74	69.6	2.51	63.8	2.52	64.0	2.27	57.7	2.07	52.6	1.64	41.7	1.30	33.0	1.06	26.9
146.00	44.50	84.7	29.3	2	108.4	0.747	12261	54.54	4.39	111.5	3.70	94.0	3.42	86.9	3.40	86.4	3.06	77.7	2.76	70.1	2.18	55.4	1.74	44.2	1.42	36.1
146.00	44.50	84.7	29.3	3	131.0	0.903	14817	65.91	5.41	137.4	4.57	116.1	4.21	106.9	4.20	106.7	3.80	96.5	3.40	86.4	2.70	68.6	2.14	54.4	1.74	44.2
208.00	63.40	77.8	25.4	1	78.2	0.539	8845	39.34	3.57	90.7	3.06	77.7	2.79	70.9	2.84	72.1	2.51	63.8	2.25	57.2	1.76	44.7	1.37	34.8	1.10	27.9
208.00	63.40	77.8	25.4	2	106.0	0.731	11989	53.33	4.74	120.4	3.99	101.3	3.67	93.2	3.75	95.3	3.28	83.3	2.94	74.7	2.28	57.9	1.78	45.2	1.44	36.6
208.00	63.40	77.8	25.4	3	130.2	0.898	14726	65.50	5.94	150.9	5.01	127.3	4.58	116.3	4.71	119.6	4.13	104.9	3.68	93.5	2.89	73.4	2.25	57.2	1.81	46.0
257.00	78.33	80.4	26.9	1	78.2	0.539	8845	39.34	3.52	89.4	2.94	74.7	2.68	68.1	2.75	69.9	2.42	61.5	2.16	54.9	1.70	43.2	1.35	34.3	1.11	28.2
257.00	78.33	80.4	26.9	2	102.1	0.704	11548	51.37	4.58	116.3	3.83	97.3	3.50	88.9	3.55	90.2	3.15	80.0	2.83	71.9	2.22	56.4	1.74	44.2	1.45	36.8
257.00	78.33	80.4	26.9	3	130.2	0.898	14726	65.50	5.80	147.3	4.84	122.9	4.47	113.5	4.48	113.8	4.00	101.6	3.58	90.9	2.82	71.6	2.22	56.4	1.82	46.2
308.00	93.88	80.7	27.1	1	79.4	0.547	8981	39.95	3.43	87.1	2.83	71.9	2.58	65.5	2.56	65.0	2.30	58.4	2.07	52.6	1.62	41.1	1.28	32.5	1.04	26.4
308.00	93.88	80.7	27.1	2	103.0	0.710	11650	51.82	4.51	114.6	3.70	94.0	3.39	86.1	3.38	85.9	3.04	77.2	2.71	68.8	2.13	54.1	1.69	42.9	1.36	34.5
308.00	93.88	80.7	27.1	3	129.7	0.894	14670	65.26	5.54	140.7	4.62	117.3	4.21	106.9	4.20	106.7	3.77	95.8	3.38	85.9	2.63	66.8	2.08	52.8	1.70	43.2
357.00	108.81	84.4	29.1	1	78.6	0.542	8890	39.54	3.55	90.2	2.93	74.4	2.66	67.6	2.61	66.3	2.32	58.9	2.06	52.3	1.59	40.4	1.23	31.2	1.00	25.4
357.00	108.81	84.4	29.1	2	103.6	0.714	11718	52.12	4.73	120.1	3.88	98.6	3.51	89.2	3.44	87.4	3.07	78.0	2.72	69.1	2.08	52.8	1.61	40.9	1.31	33.3
357.00	108.81	84.4	29.1	3	129.1	0.890	14602	64.95	5.87	149.1	4.81	122.2	4.35	110.5	4.29	109.0	3.80	96.5	3.39	86.1	2.59	65.8	2.01	51.1	1.61	40.9
411.00	125.27	82.1	27.8	1	77.9	0.537	8811	39.19	3.63	92.2	3.00	76.2	2.65	67.3	2.65	67.3	2.35	59.7	2.05	52.1	1.57	39.9	1.22	31.0	1.00	25.4
411.00	125.27	82.1	27.8	2	104.2	0.718	11786	52.43	4.84	122.9	3.95	100.3	3.55	90.2	3.56	90.4	3.12	79.2	2.72	69.1	2.09	53.1	1.62	41.1	1.33	33.8
411.00	125.27	82.1	27.8	3	128.0	0.883	14477	64.40	6.01	152.7	4.93	125.2	4.42	112.3	4.44	112.8	3.87	98.3	3.40	86.4	2.60	66.0	2.04	51.8	1.63	41.4
463.00	141.12	80.7	27.1	1	78.3	0.540	8856	39.39	3.64	92.5	3.06	77.7	2.78	70.6	2.84	72.1	2.46	62.5	2.19	55.6	1.69	42.9	1.32	33.5	1.05	26.7
463.00	141.12	80.7	27.1	2	106.2	0.732	12012	53.43	4.96	126.0	4.14	105.2	3.74	95.0	3.85	97.8	3.32	84.3	2.93	74.4	2.28	57.9	1.74	44.2	1.42	36.1
463.00	141.12	80.7	27.1	3	130.8	0.902	14794	65.81	6.03	153.2	5.03	127.8	4.56	115.8	4.68	118.9	4.05	102.9	3.61	91.7	2.77	70.4	2.16	54.9	1.75	44.5

MRW-71 (time: 8:59)					12 in (305 mm) diameter plate				Air Temperature 55.1°F (12.8°C)																	
Distance		Pavement Temp.		Drop	Stress		Load		D1		D2		D3		D4		D5		D6		D7		D8		D9	
(ft)	(m)	(°F)	(°C)		(psi)	(MPa)	(lb)	(kN)	(mil)	(μm)	(mil)	(μm)	(mil)	(μm)	(mil)	(μm)	(mil)	(μm)	(mil)	(μm)	(mil)	(μm)	(mil)	(μm)	(mil)	(μm)
0.00	0.00	62.6	17.0	1	82.2	0.567	9297	41.36	2.87	72.9	2.41	61.2	2.22	56.4	2.24	56.9	2.03	51.6	1.84	46.7	1.46	37.1	1.18	30.0	0.94	23.9
0.00	0.00	62.6	17.0	2	105.7	0.729	11955	53.18	3.65	92.7	3.07	78.0	2.82	71.6	2.86	72.6	2.58	65.5	2.33	59.2	1.87	47.5	1.49	37.8	1.20	30.5
0.00	0.00	62.6	17.0	3	130.0	0.896	14704	65.41	4.36	110.7	3.67	93.2	3.39	86.1	3.45	87.6	3.12	79.2	2.83	71.9	2.25	57.2	1.79	45.5	1.44	36.6
110.88	33.80	59.3	15.2	1	82.1	0.566	9286	41.31	2.55	64.8	2.13	54.1	1.96	49.8	1.99	50.5	1.81	46.0	1.65	41.9	1.34	34.0	1.09	27.7	0.91	23.1
110.88	33.80	59.3	15.2	2	105.6	0.728	11944	53.13	3.22	81.8	2.68	68.1	2.48	63.0	2.51	63.8	2.26	57.4	2.07	52.6	1.68	42.7	1.35	34.3	1.10	27.9
110.88	33.80	59.3	15.2	3	129.7	0.894	14670	65.26	3.89	98.8	3.23	82.0	2.99	75.9	3.03	77.0	2.72	69.1	2.50	63.5	2.02	51.3	1.62	41.1	1.33	33.8
221.76	67.59	61.3	16.3	1	81.3	0.561	9195	40.90	2.63	66.8	2.19	55.6	2.04	51.8	2.06	52.3	1.86	47.2	1.71	43.4	1.38	35.1	1.14	29.0	0.92	23.4
221.76	67.59	61.3	16.3	2	105.3	0.726	11910	52.98	3.34	84.8	2.77	70.4	2.56	65.0	2.59	65.8	2.35	59.7	2.15	54.6	1.75	44.5	1.42	36.1	1.15	29.2
221.76	67.59	61.3	16.3	3	129.3	0.891	14624	65.05	4.03	102.4	3.34	84.8	3.09	78.5	3.13	79.5	2.84	72.1	2.61	66.3	2.11	53.6	1.71	43.4	1.39	35.3
332.64	101.39	61.3	16.3	1	80.3	0.554	9082	40.40	2.84	72.1	2.27	57.7	2.11	53.6	2.14	54.4	1.93	49.0	1.76	44.7	1.40	35.6	1.13	28.7	0.91	23.1
332.64	101.39	61.3	16.3	2	106.2	0.732	12012	53.43	3.67	93.2	2.95	74.9	2.75	69.9	2.76	70.1	2.50	63.5	2.29	58.2	1.81	46.0	1.46	37.1	1.18	30.0
332.64	101.39	61.3	16.3	3	130.2	0.898	14726	65.50	4.43	112.5	3.57	90.7	3.30	83.8	3.35	85.1	3.01	76.5	2.72	69.1	2.19	55.6	1.74	44.2	1.42	36.1
443.52	135.18	61.3	16.3	1	80.6	0.556	9116	40.55	2.68	68.1	2.21	56.1	2.05	52.1	2.08	52.8	1.85	47.0	1.71	43.4	1.38	35.1	1.13	28.7	0.93	23.6
443.52	135.18	61.3	16.3	2	103.6	0.714	11718	52.12	3.43	87.1	2.80	71.1	2.61	66.3	2.65	67.3	2.38	60.5	2.19	55.6	1.77	45.0	1.44	36.6	1.18	30.0
443.52	135.18	61.3	16.3	3	129.5	0.893	14647	65.15	4.20	106.7	3.45	87.6	3.20	81.3	3.25	82.6	2.91	73.9	2.65	67.3	2.16	54.9	1.77	45.0	1.44	36.6
554.40	168.98	61.3	16.3	1	79.0	0.545	8935	39.74	2.64	67.1	2.20	55.9	2.02	51.3	2.08	52.8	1.85	47.0	1.69	42.9	1.36	34.5	1.08	27.4	0.88	22.4
554.40	168.98	61.3	16.3	2	103.0	0.710	11650	51.82	3.42	86.9	2.85	72.4	2.63	66.8	2.67	67.8	2.40	61.0	2.19	55.6	1.74	44.2	1.39	35.3	1.13	28.7
554.40	168.98	61.3	16.3	3	128.7	0.887	14557	64.75	4.18	106.2	3.48	88.4	3.21	81.5	3.26	82.8	2.90	73.7	2.67	67.8	2.12	53.8	1.70	43.2	1.36	34.5
665.28	202.78	61.3	16.3	1	79.0	0.545	8935	39.74	2.85	72.4	2.32	58.9	2.12	53.8	2.14	54.4	1.90	48.3	1.73	43.9	1.38	35.1	1.10	27.9	0.87	22.1
665.28	202.78	61.3	16.3	2	104.2	0.718	11786	52.43	3.71	94.2	3.01	76.5	2.76	70.1	2.76	70.1	2.47	62.7	2.25	57.2	1.78	45.2	1.42	36.1	1.15	29.2
665.28	202.78	61.3	16.3	3	128.0	0.883	14477	64.40	4.47	113.5	3.66	93.0	3.36	85.3	3.37	85.6	3.00	76.2	2.71	68.8	2.16	54.9	1.74	44.2	1.41	35.8
776.16	236.57	60.3	15.7	1	79.7	0.550	9014	40.10	2.75	69.9	2.16	54.9	1.99	50.5	2.00	50.8	1.79	45.5	1.64	41.7	1.27	32.3	1.03	26.2	0.81	20.6
776.16	236.57	60.3	15.7	2	105.1	0.725	11887	52.88	3.60	91.4	2.84	72.1	2.60	66.0	2.63	66.8	2.34	59.4	2.15	54.6	1.70	43.2	1.34	34.0	1.08	27.4
776.16	236.57	60.3	15.7	3	128.7	0.887	14557	64.75	4.28	108.7	3.39	86.1	3.09	78.5	3.13	79.5	2.80	71.1	2.56	65.0	2.03	51.6	1.62	41.1	1.30	33.0
887.04	270.37	59.7	15.4	1	81.2	0.560	9184	40.85	2.66	67.6	2.22	56.4	2.05	52.1	2.07	52.6	1.87	47.5	1.71	43.4	1.38	35.1	1.10	27.9	0.89	22.6
887.04	270.37	59.7	15.4	2	105.6	0.728	11944	53.13	3.43	87.1	2.86	72.6	2.65	67.3	2.67	67.8	2.41	61.2	2.21	56.1	1.78	45.2	1.41	35.8	1.12	28.4
887.04	270.37	59.7	15.4	3	132.4	0.913	14975	66.61	4.17	105.9	3.48	88.4	3.22	81.8	3.25	82.6	2.95	74.9	2.69	68.3	2.16	54.9	1.70	43.2	1.37	34.8
1013.76	308.99	62.3	16.8	1	80.7	0.556	9128	40.60	2.67	67.8	2.22	56.4	1.99	50.5	2.04	51.8	1.80	45.7	1.62	41.1	1.27	32.3	1.00	25.4	0.79	20.1
1013.76	308.99	62.3	16.8	2	105.6	0.728	11944	53.13	3.46	87.9	2.84	72.1	2.59	65.8	2.66	67.6	2.34	59.4	2.12	53.8	1.64	41.7	1.29	32.8	1.03	26.2
1013.76	308.99	62.3	16.8	3	131.2	0.905	14839	66.01	4.26	108.2	3.51	89.2	3.20	81.3	3.27	83.1	2.87	72.9	2.61	66.3	2.02	51.3	1.59	40.4	1.27	32.3

Appendix D: Light weight deflectometer (LWD) results

LWD setup information

Setup number		1
Number of sensors		1
Poisson's ratio		0.35
Powerdown timeout		0
Pulse base	**(%)**	2
Load plate radius	**(in)**	5.9
	(mm)	150
Radial offset 1	**(in)**	0
	(mm)	0
Radial offset 2	**(in)**	14.5
	(mm)	368
Radial offset 3	**(in)**	23.2
	(mm)	589
Sample time	**(ms)**	60
Stress distribution		2

Note: LWD data could not be collected from either LAK-2 section due to permit restrictions. The data for CLI-73 were lost due to malfunction of LWD data collection equipment.
Tables in English units at top, metric units below.

Location: CLA-70 Borehole 1					
	Force	Pressure	Pulse Time	D1	E1
Time	(lb)	(psi)	(ms)	(mil)	(ksi)
23:10:03	3145	28.7	59.8	3.55	83.7
23:10:19	3156	28.8	59.8	3.66	81.5
23:17:07	3151	28.8	59.8	4.67	63.8
23:17:29	3124	28.5	59.8	5.34	55.3
23:19:58	3200	29.2	59.8	3.70	81.7
23:20:05	3186	29.1	59.8	3.89	77.4
23:20:11	3128	28.6	30.8	3.61	82.0
23:20:17	3114	28.4	59.8	3.60	81.8
23:20:26	3151	28.8	59.8	3.82	78.0
23:20:38	3160	28.8	59.8	3.86	77.4
23:20:46	3138	28.6	59.8	3.82	77.8
23:20:53	3149	28.7	59.8	3.93	75.8
23:21:00	3156	28.8	59.8	3.92	76.2
average	3151	28.8	57.5	3.95	76.4
std. dev.	23	0.2	8.0	0.50	8.0

	Force	Pressure	Pulse Time	D1	E1
Time	(kN)	(kPa)	(ms)	(µm)	(MPa)
23:10:03	13.99	198	59.8	90.3	577
23:10:19	14.04	199	59.8	93.0	562
23:17:07	14.01	198	59.8	118.6	440
23:17:29	13.90	197	59.8	135.6	382
23:19:58	14.24	201	59.8	94.1	564
23:20:05	14.17	200	59.8	98.9	534
23:20:11	13.92	197	30.8	91.7	565
23:20:17	13.85	196	59.8	91.4	564
23:20:26	14.02	198	59.8	97.0	538
23:20:38	14.06	199	59.8	98.1	533
23:20:46	13.96	197	59.8	96.9	536
23:20:53	14.01	198	59.8	99.9	523
23:21:00	14.04	199	59.8	99.4	526
average	14.01	198.3	57.5	100.4	526.5
std. dev.	0.10	1.5	8.0	12.8	55.5

Location: DEF-24 Borehole 10					
	Force	Pressure	Pulse Time	D1	E1
Time	(lb)	(psi)	(ms)	(mil)	(ksi)
01:13:33	3239	29.6	25.8	6.71	45.7
01:13:55	3237	29.5	25.5	14.56	21.0
01:14:23	3236	29.5	26.0	12.26	25.0
01:14:41	3219	29.4	26.3	15.73	19.4
01:14:58	3202	29.2	25.5	20.34	14.9
01:15:17	3211	29.3	26.0	19.40	15.7
01:15:36	3206	29.3	25.8	15.57	19.5
01:17:20	3137	28.6	25.5	6.31	47.0
01:17:31	3183	29.1	25.8	9.22	32.7
01:17:46	3199	29.2	25.8	13.67	22.1
01:18:00	3206	29.3	25.5	14.24	21.3
01:18:19	3203	29.2	25.8	17.82	17.0
01:18:28	3198	29.2	25.8	16.55	18.3
average	3206	29.3	25.8	14.0	24.6
std. dev.	27	0.2	0.2	4.4	10.7

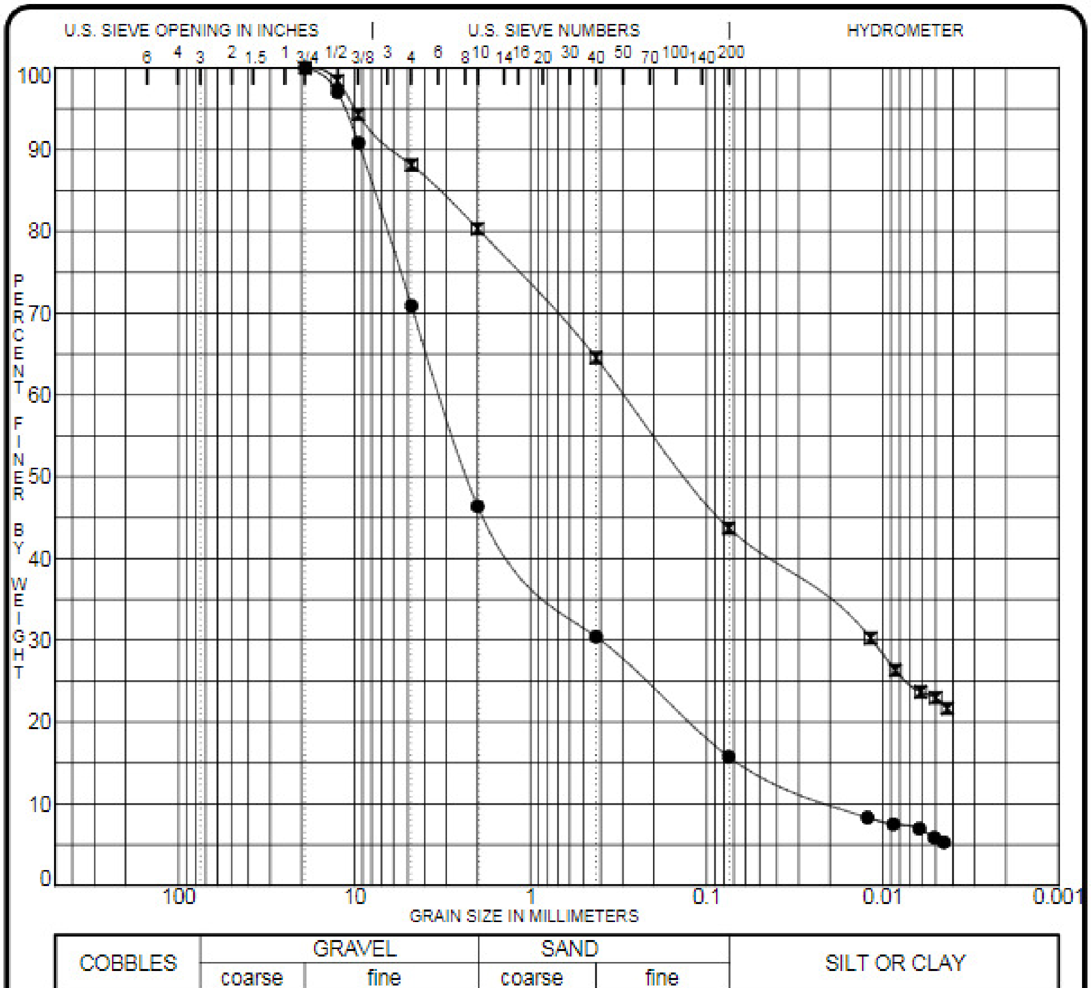
	Force	Pressure	Pulse Time	D1	E1
Time	(kN)	(kPa)	(ms)	(µm)	(MPa)
01:13:33	14.41	204	59.8	170.4	315
01:13:55	14.40	204	59.8	369.8	145
01:14:23	14.39	204	59.8	311.5	172
01:14:41	14.32	203	59.8	399.5	133
01:14:58	14.24	201	59.8	516.7	103
01:15:17	14.28	202	59.8	492.7	108
01:15:36	14.26	202	30.8	395.5	134
01:17:20	13.95	197	59.8	160.3	324
01:17:31	14.16	200	59.8	234.2	225
01:17:46	14.23	201	59.8	347.2	153
01:18:00	14.26	202	59.8	361.7	147
01:18:19	14.25	202	59.8	452.6	117
01:18:28	14.22	201	60.8	420.3	126
average	14.26	201.7	57.6	356.3	169.4
std. dev.	0.12	1.7	8.1	112.3	73.6

Location: MRW-71 Borehole 1					
	Force	**Pressure**	**Pulse Time**	**D1**	**E1**
Time	**(lb)**	**(psi)**	**(ms)**	**(mil)**	**(ksi)**
21:28:50	2926	26.7	31.0	5.62	49.3
21:28:59	3118	28.5	36.0	5.94	49.6
21:29:08	3103	28.3	59.8	6.04	48.6
21:29:16	3162	28.9	59.8	6.69	44.7
21:29:24	3172	29.0	59.8	6.96	43.1
21:29:37	3173	29.0	59.8	6.45	46.6
21:29:52	3174	29.0	59.8	6.35	47.3
21:31:29	3167	28.9	59.8	6.99	42.8
21:31:40	2272	20.7	59.8	4.86	44.2
21:31:52	2261	20.6	59.8	4.59	46.6
21:32:54	3158	28.8	59.8	5.80	51.5
21:33:06	3158	28.8	59.8	5.56	53.8
average	2987	27.3	55.4	6.0	47.3
std. dev.	344	3.1	10.3	0.8	3.4

	Force	**Pressure**	**Pulse Time**	**D1**	**E1**
Time	**(kN)**	**(kPa)**	**(ms)**	**(μm)**	**(MPa)**
21:28:50	13.02	184	59.8	142.7	340
21:28:59	13.87	196	59.8	151.0	342
21:29:08	13.80	195	59.8	153.3	335
21:29:16	14.07	199	59.8	170.0	308
21:29:24	14.11	200	59.8	176.7	297
21:29:37	14.11	200	59.8	163.7	321
21:29:52	14.12	200	30.8	161.3	326
21:31:29	14.09	199	59.8	177.6	295
21:31:40	10.11	143	59.8	123.4	305
21:31:52	10.06	142	59.8	116.6	321
21:32:54	14.05	199	59.8	147.4	355
21:33:06	14.05	199	59.8	141.2	371
average	13.29	188.0	57.3	152.1	326.4
std. dev.	1.53	21.6	8.4	19.3	23.2

Appendix E: Soil gradations

CLA-70 Gradation Plots



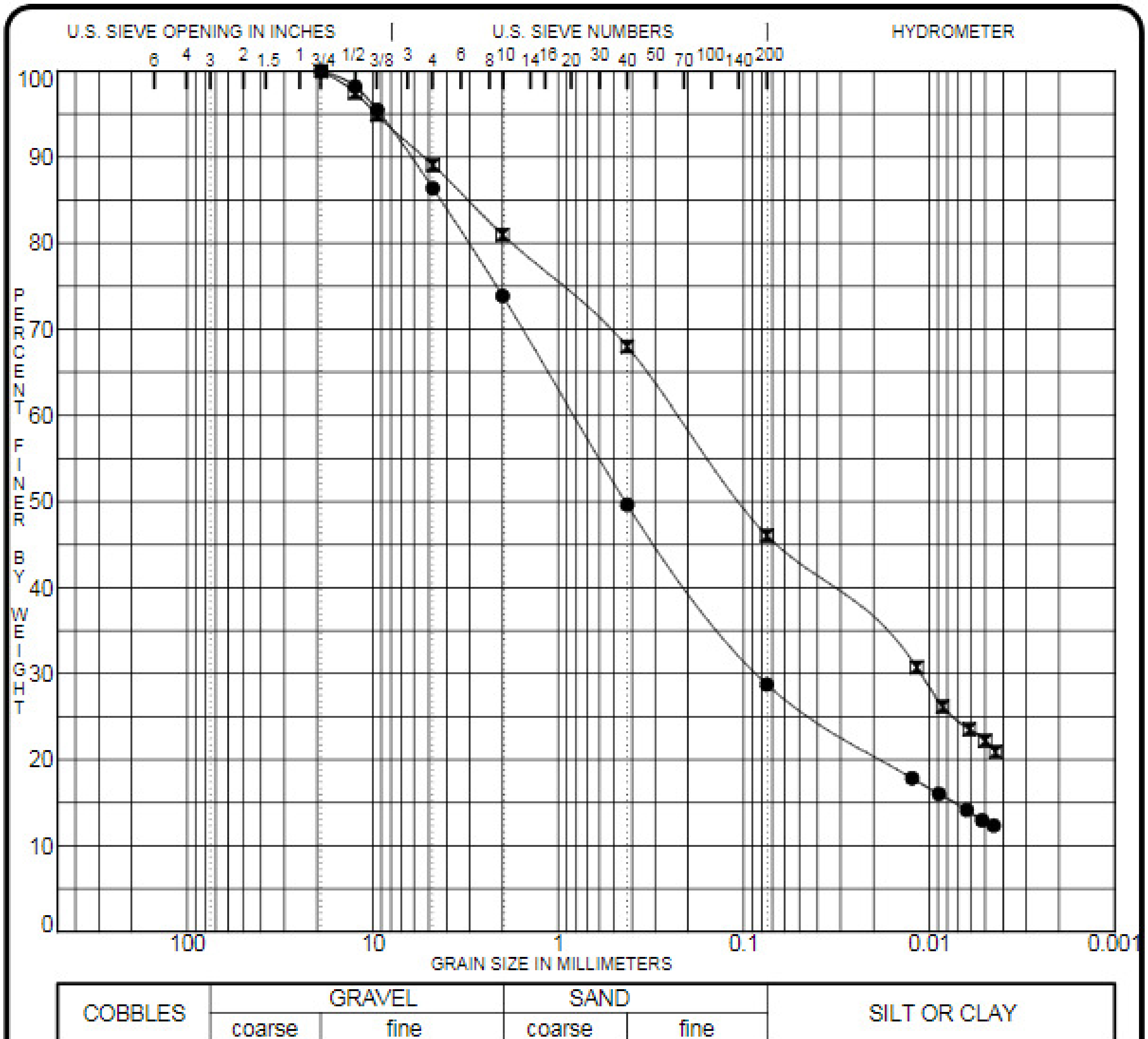
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-01	1.2	A-1-b	2320		10	NP	NP	NP	2.73	175.2
⊠	B-01	2.8	A-4a	480		10	22	13	9		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-01	3.23	2.27	0.404	0.0185	0.0	53.6	16.0	14.7	10.0	5.8
⊠	B-01	0.29	0.13	0.011		0.0	19.7	15.8	20.8	20.7	23.0

PROJECT ODOT Cond. Eval. CLA-70 PROJECT NO. W-16-171

GRADATION CURVES

RII



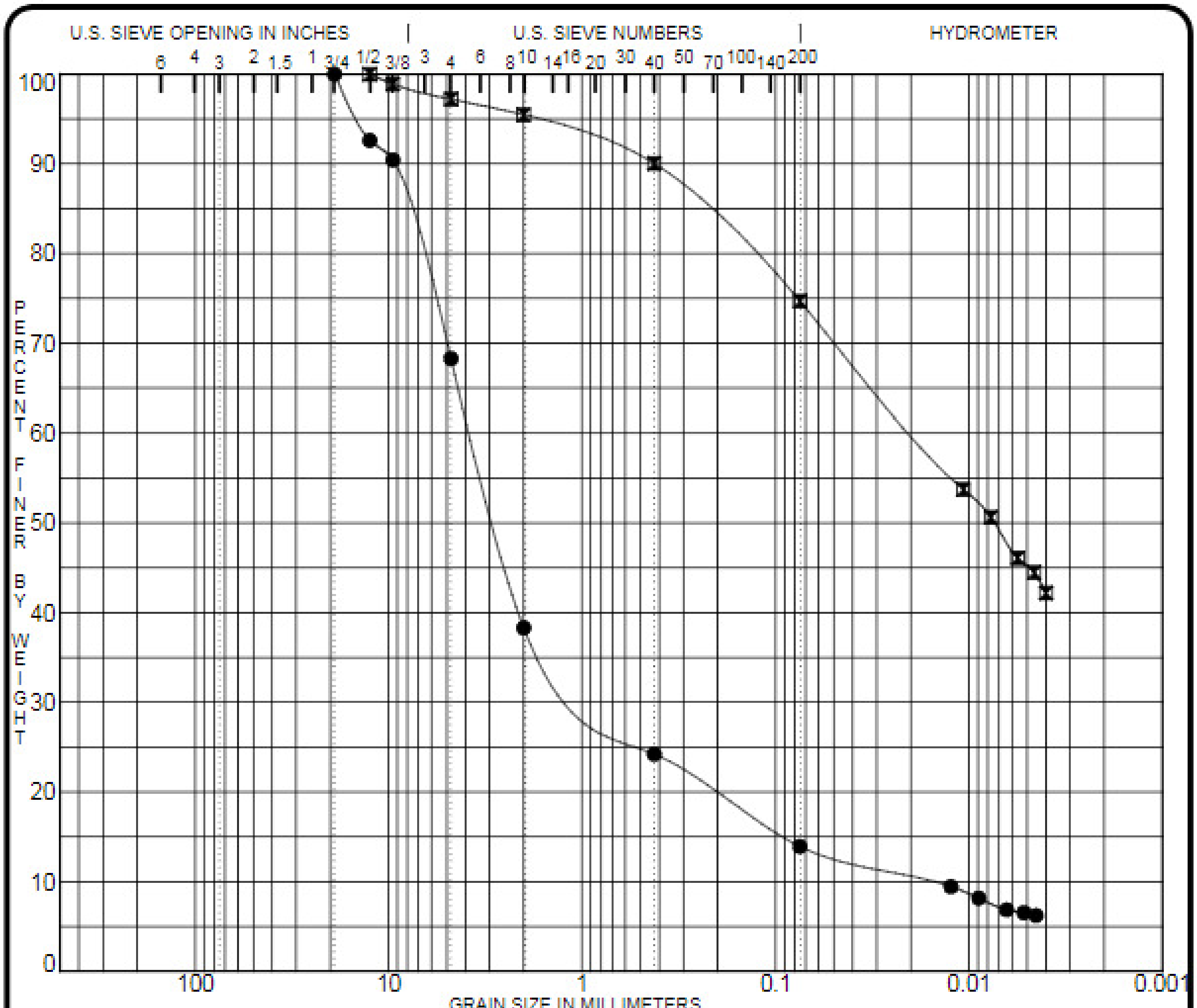
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	**B-02**	**1.2**	**A-2-4**	**1493**		**11**	**NP**	**NP**	**NP**		
⌧	**B-02**	**2.8**	**A-4a**	**433**		**9**	**22**	**14**	**8**		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	**B-02**	**0.82**	**0.44**	**0.083**		**0.0**	**26.1**	**24.2**	**20.9**	**16.0**	**12.8**
⌧	**B-02**	**0.23**	**0.10**	**0.011**		**0.0**	**19.0**	**13.0**	**21.9**	**23.9**	**22.2**

PROJECT **ODOT Cond. Eval. CLA-70** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

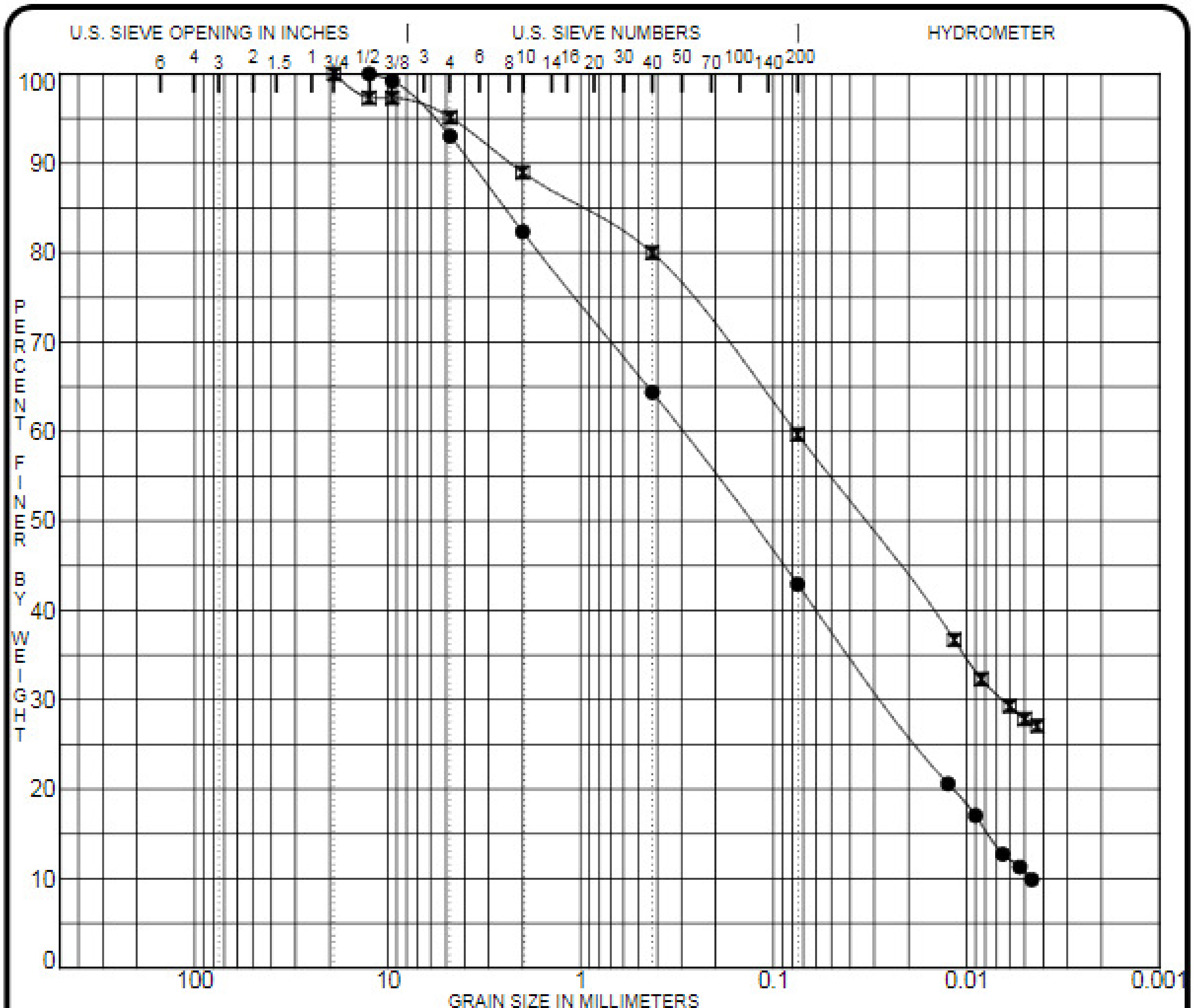
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-03	1.2	A-1-a	1507		10	NP	NP	NP	11.08	240.6
⌧	B-03	2.8	A-6b	407		8	38	16	22		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-03	3.74	2.80	0.803	0.0155	0.0	61.7	14.1	10.3	7.5	6.4
⌧	B-03	0.02	0.01			0.0	4.5	5.4	15.3	29.6	45.2

PROJECT ODOT Cond. Eval. CLA-70 PROJECT NO. W-16-171

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

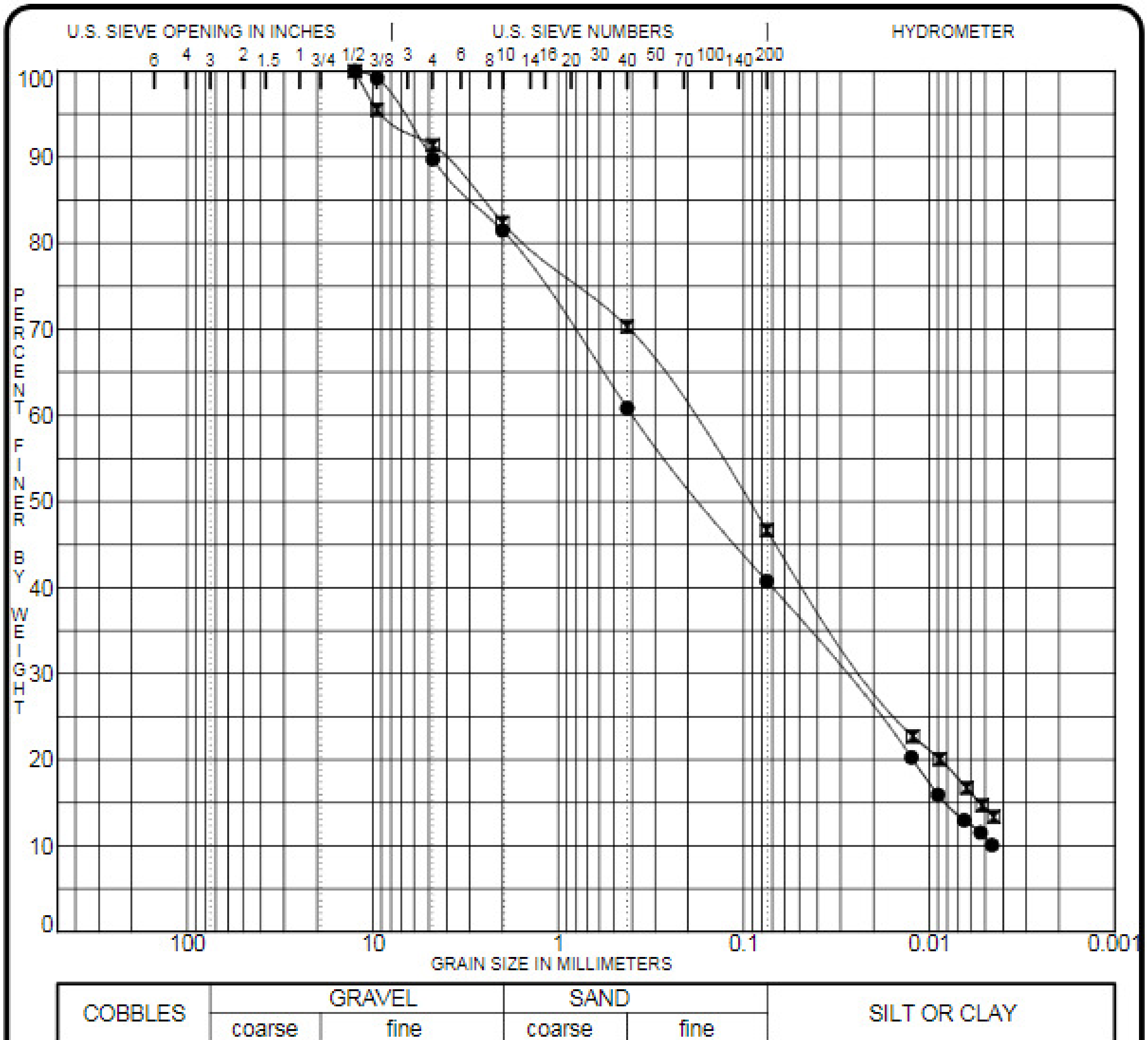
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	**B-04**	**1.2**	**A-4a**	**1587**		**9**	**29**	**26**	**3**	**0.51**	**64.0**
⌧	**B-04**	**2.9**	**A-6a**	**293**		**16**	**28**	**14**	**14**		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	**B-04**	**0.30**	**0.13**	**0.027**	**0.0047**	**0.0**	**17.7**	**17.9**	**21.5**	**32.2**	**10.7**
⌧	**B-04**	**0.08**	**0.03**	**0.006**		**0.0**	**11.0**	**9.0**	**20.3**	**31.9**	**27.8**

PROJECT **ODOT Cond. Eval. CLA-70** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



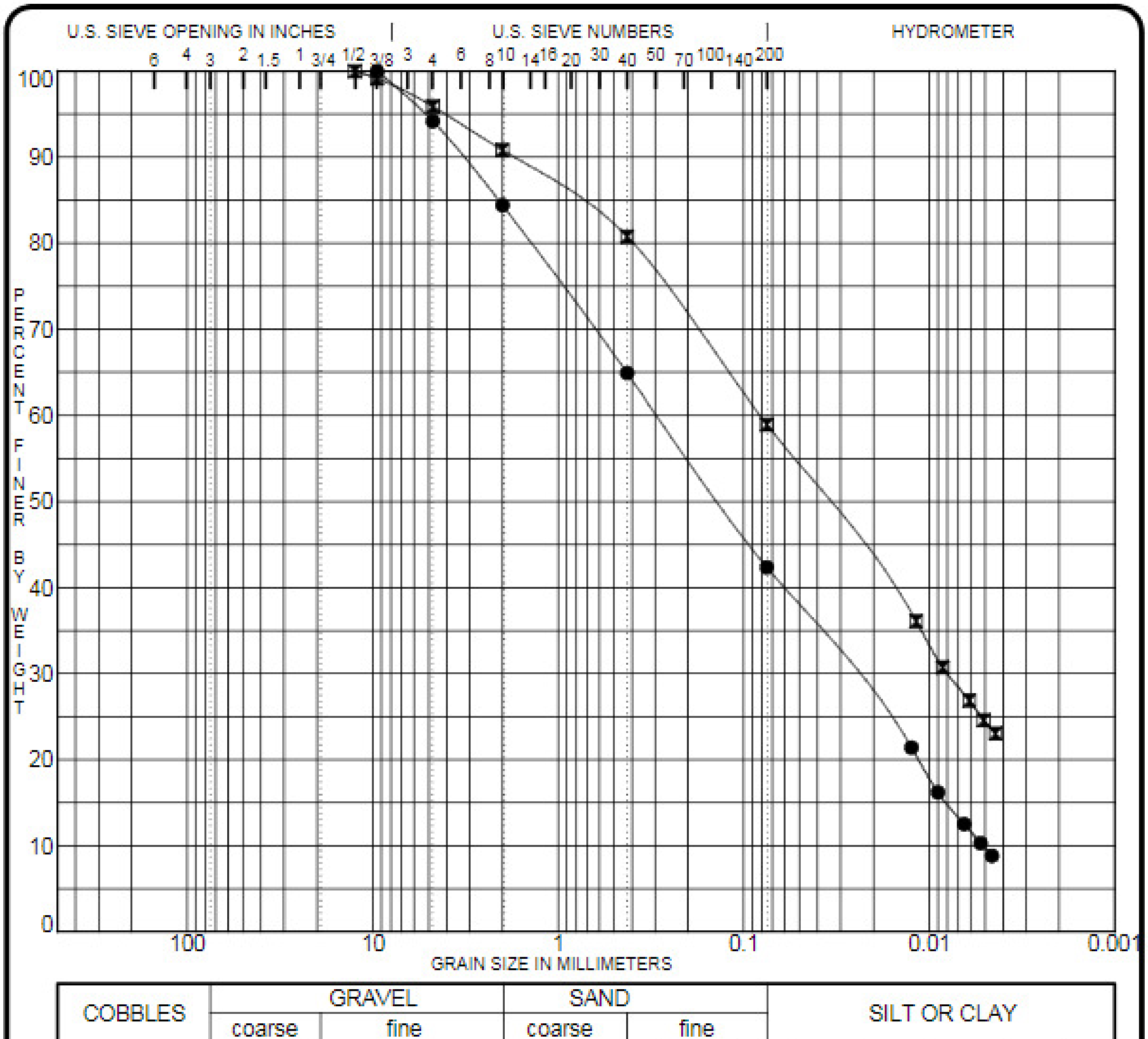
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-05	1.2	A-4a	1827		12	28	22	6		
⌧	B-05	2.8	A-4a	173		7	19	13	6		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-05	0.39	0.17	0.029		0.0	18.5	20.6	20.1	29.8	10.9
⌧	B-05	0.20	0.10	0.021		0.0	17.6	12.1	23.6	32.4	14.3

PROJECT **ODOT Cond. Eval. CLA-70** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



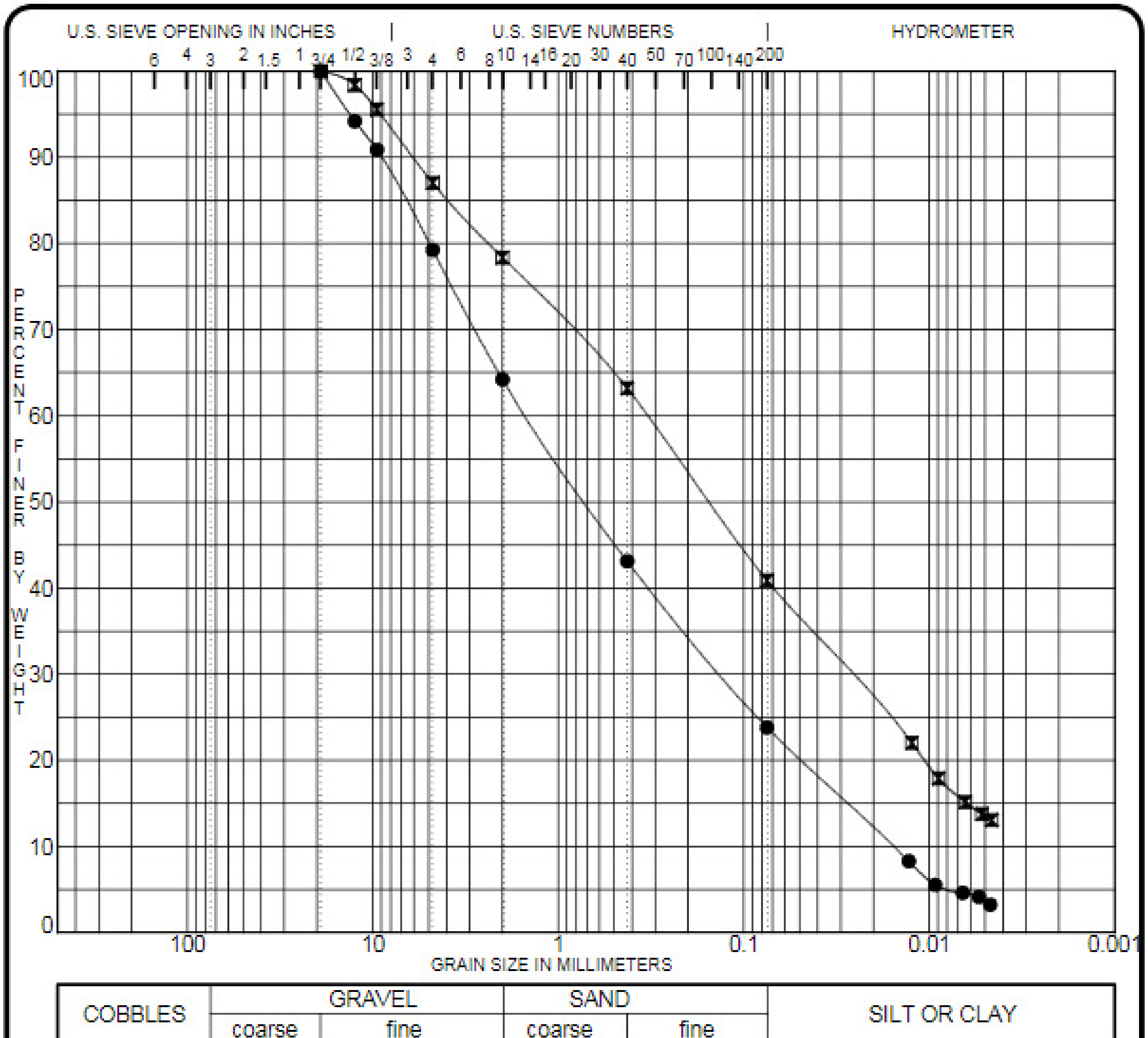
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-06	1.2	A-4a	1480		11	NP	NP	NP	0.45	56.6
⌧	B-06	2.8	A-6a	253		9	27	13	14		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-06	0.29	0.14	0.026	0.0051	0.0	15.6	19.5	22.5	32.7	9.7
⌧	B-06	0.08	0.04	0.008		0.0	9.2	10.1	21.8	34.6	24.4

PROJECT **ODOT Cond. Eval. CLA-70** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



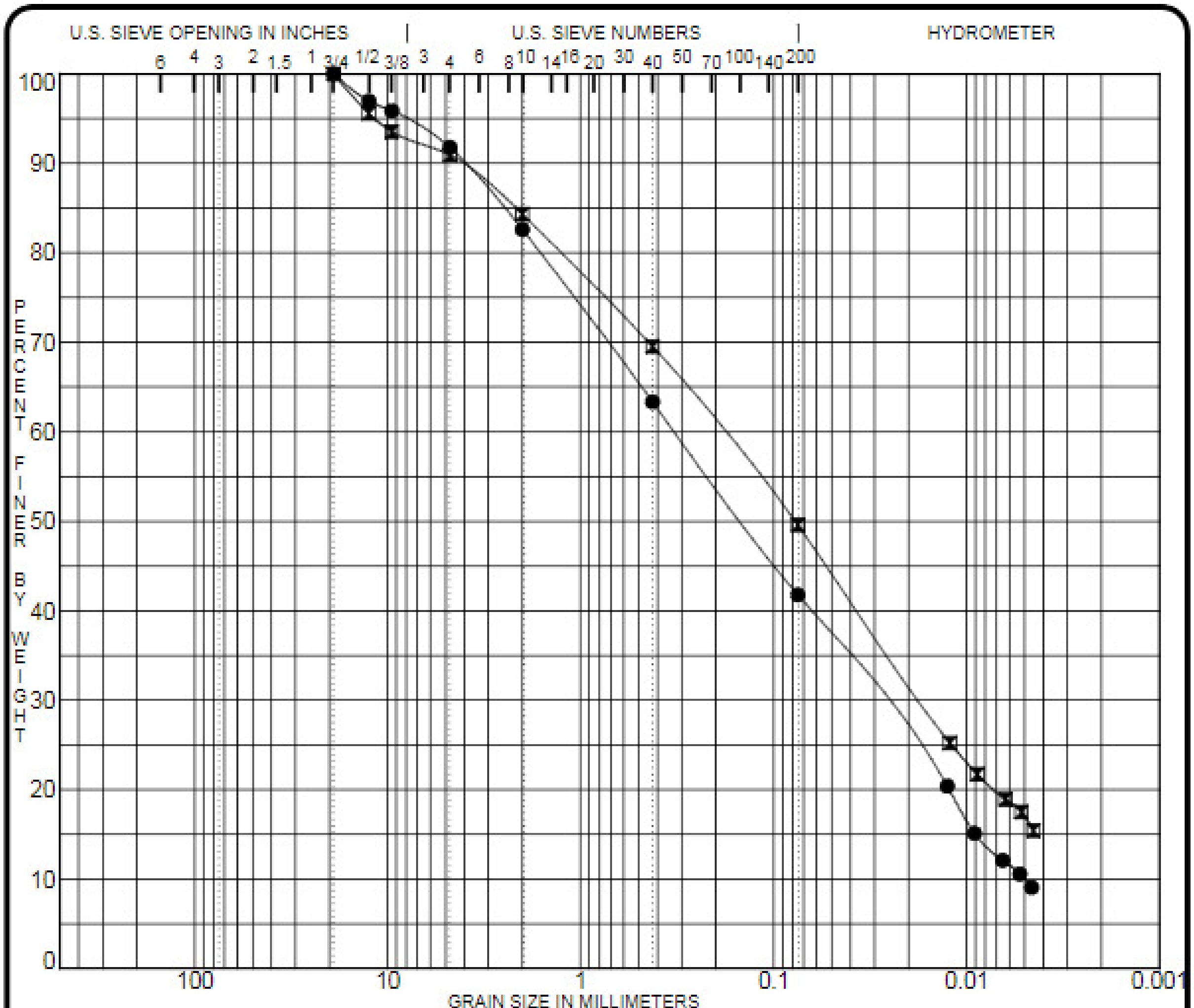
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-07	1.2	A-1-b	1887		9	NP	NP	NP	0.74	93.8
⧗	B-07	3.0	A-4a	267		13	21	12	9		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-07	1.47	0.70	0.131	0.0157	0.0	35.8	21.1	19.3	20.2	3.6
⧗	B-07	0.33	0.15	0.027		0.0	21.6	15.2	22.3	27.4	13.5

PROJECT **ODOT Cond. Eval. CLA-70** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

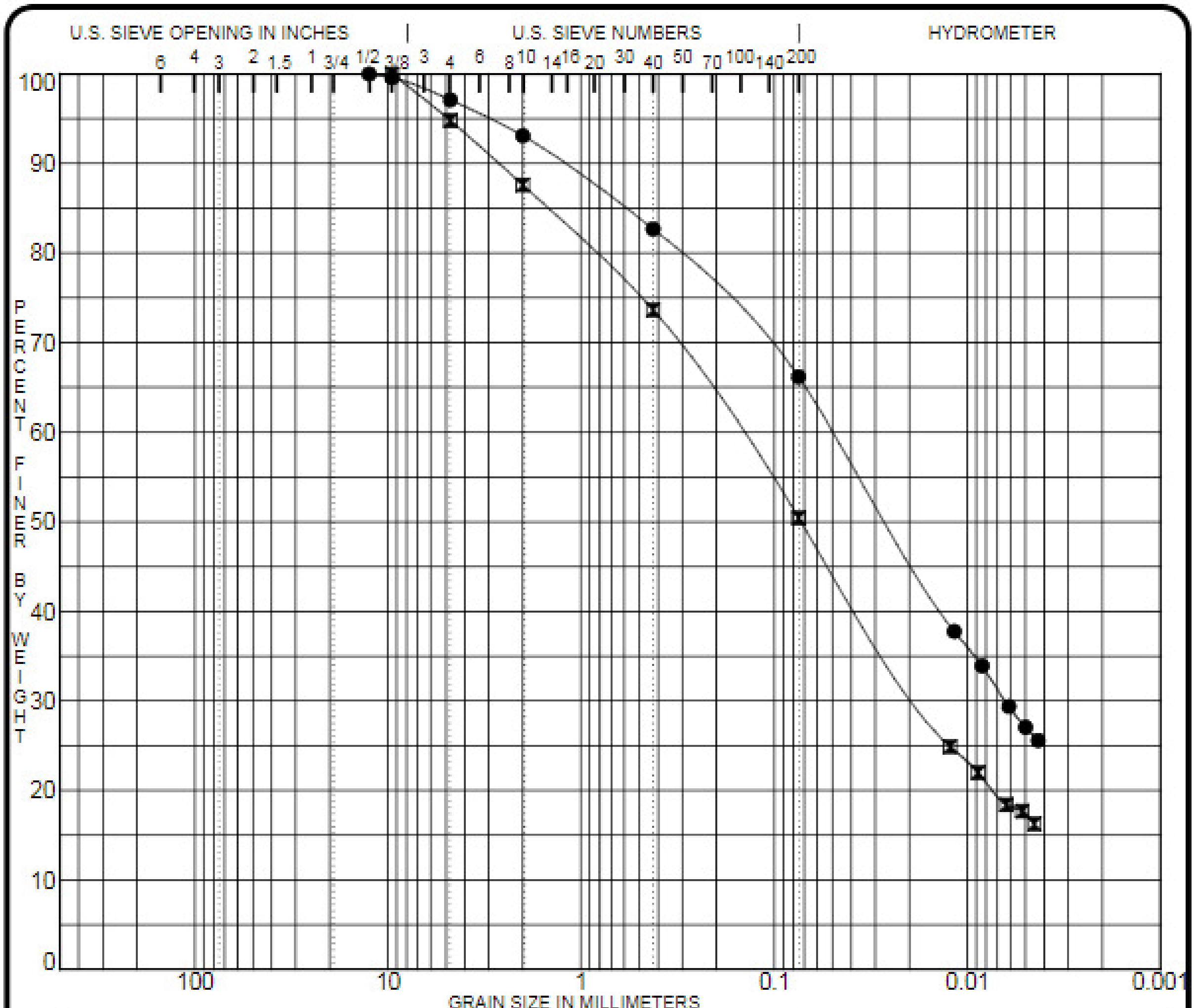
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-08	1.2	A-4a	1507		12	NP	NP	NP	0.48	64.8
⧗	B-08	2.9	A-6a	533		10	27	14	13		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-08	0.33	0.15	0.028	0.0050	0.0	17.4	19.3	21.5	31.8	9.9
⧗	B-08	0.19	0.08	0.017		0.0	15.7	14.8	19.9	32.7	16.9

PROJECT ODOT Cond. Eval. CLA-70 PROJECT NO. W-16-171

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

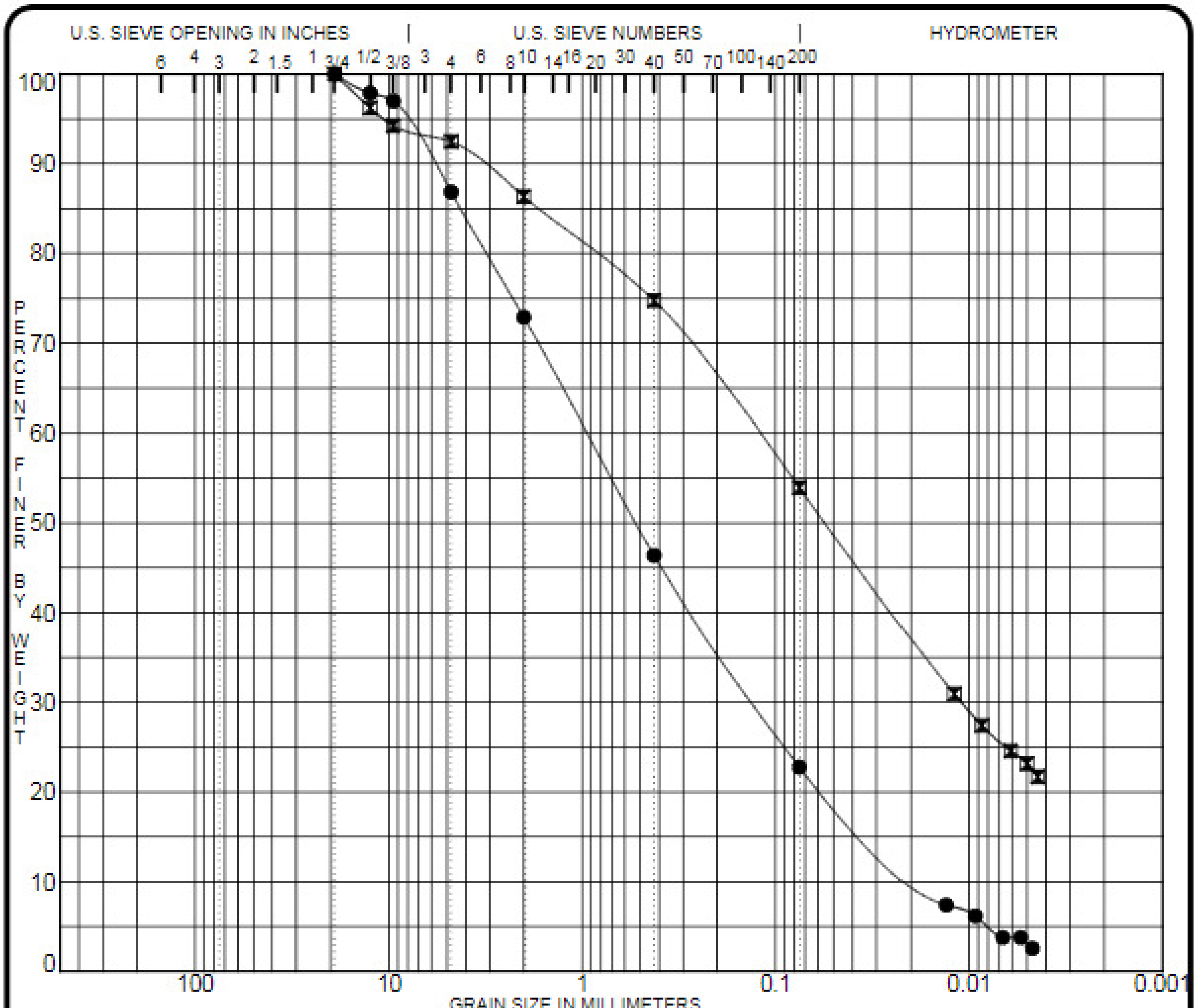
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-09	1.2	A-6a	260		12	29	15	14		
⌧	B-09	4.2	A-6a	127		8	29	14	15		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-09	0.05	0.03	0.006		0.0	6.9	10.4	16.5	39.1	27.1
⌧	B-09	0.15	0.07	0.018		0.0	12.4	14.0	23.2	33.2	17.3

PROJECT **ODOT Cond. Eval. CLA-70** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	**B-10**	**1.2**	**A-1-b**	**1760**		**10**	**NP**	**NP**	**NP**	**0.98**	**53.5**
⌛	**B-10**	**3.0**	**A-6a**	**200**		**8**	**26**	**14**	**12**		

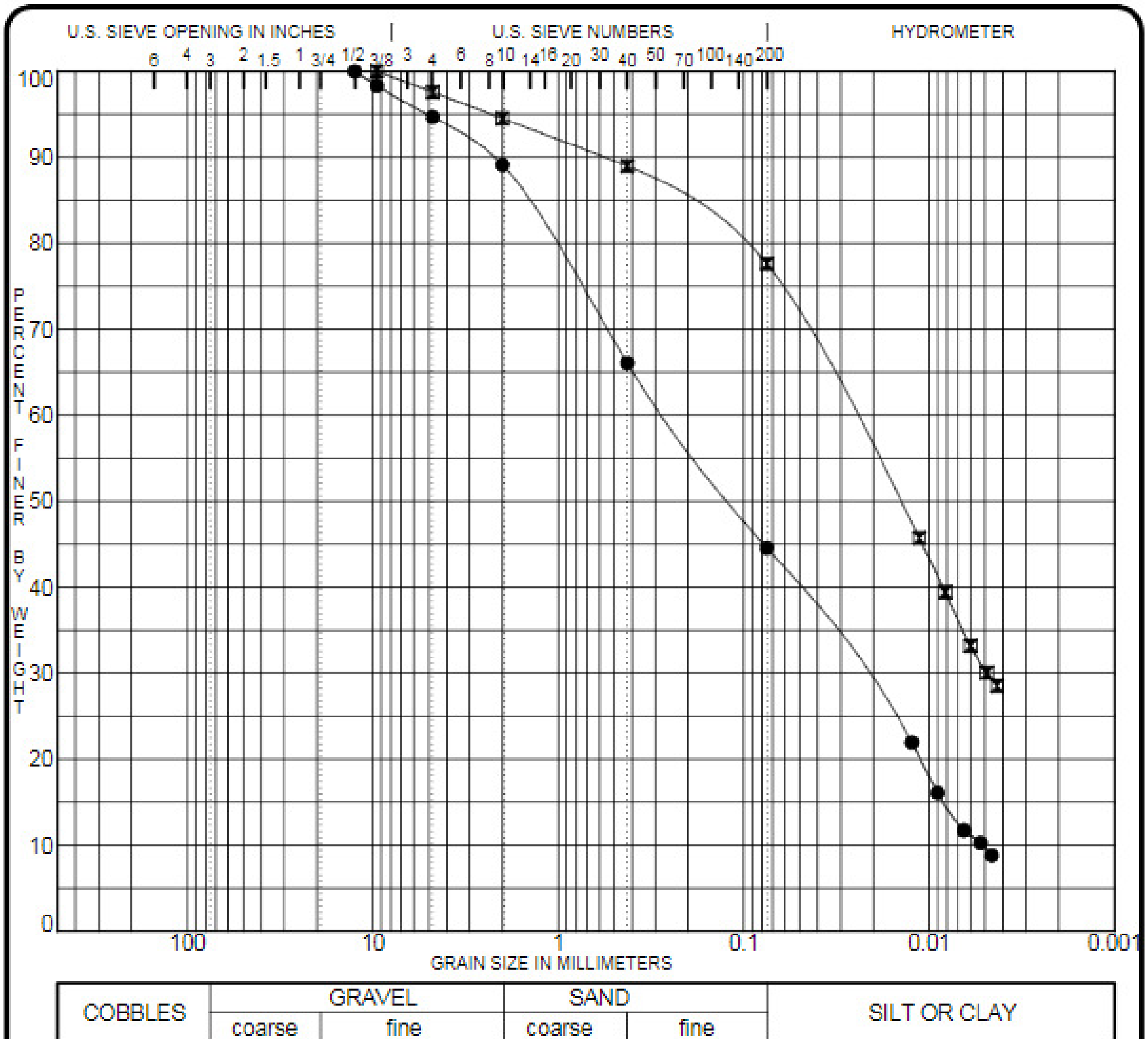
	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	**B-10**	**0.94**	**0.53**	**0.128**	**0.0176**	**0.0**	**27.1**	**26.5**	**23.6**	**19.7**	**3.1**
⌛	**B-10**	**0.12**	**0.05**	**0.011**		**0.0**	**13.6**	**11.6**	**20.9**	**30.8**	**23.1**

PROJECT **ODOT Cond. Eval. CLA-70** PROJECT NO. **W-16-171**

GRADATION CURVES

RII

CLI-73 Gradation Plots



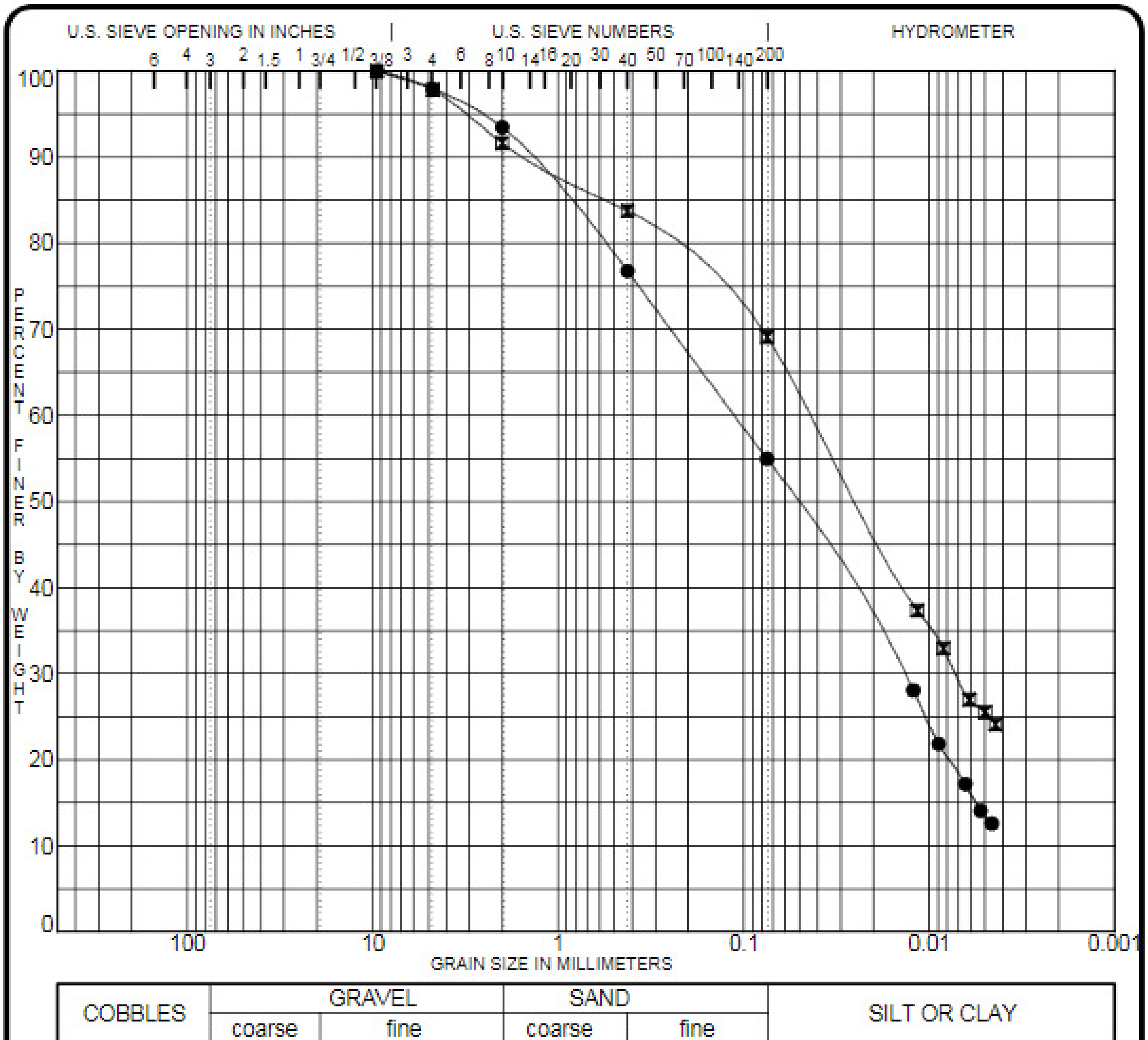
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-01	1.0	A-4a	2800		17	NP	NP	NP	0.41	50.4
⧗	B-01	2.5	A-6a	93		18	31	17	14		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-01	0.26	0.12	0.024	0.0052	0.0	10.9	23.1	21.5	34.9	9.7
⧗	B-01	0.03	0.01	0.005		0.0	5.5	5.5	11.4	47.3	30.3

PROJECT ODOT Cond. Eval. CLI-73 PROJECT NO. W-16-171

GRADATION CURVES

RII



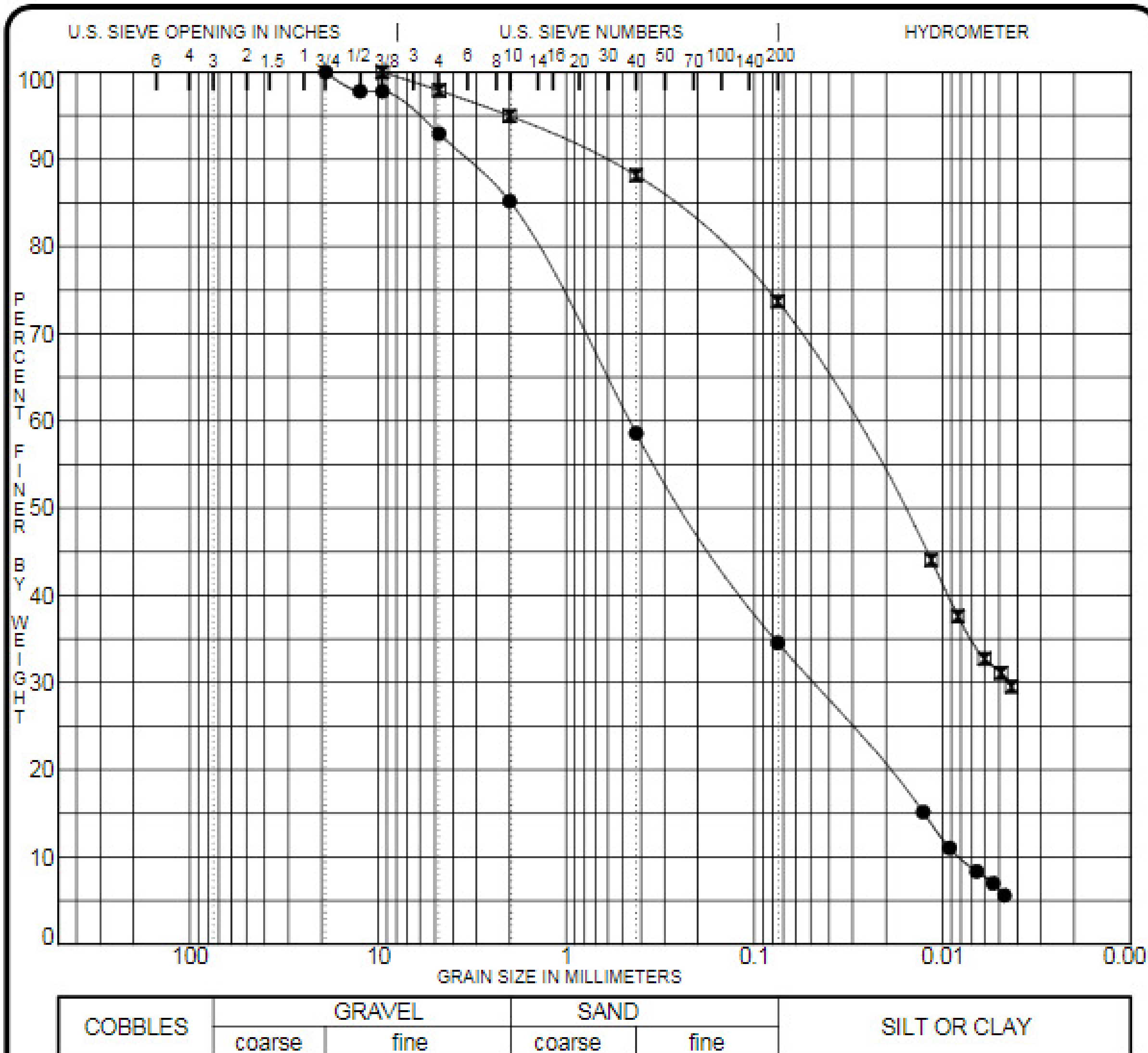
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-02	1.0	A-4a	2133		16	32	26	6		
⧗	B-02	2.5	A-6a	167		11	29	17	12		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-02	0.11	0.05	0.014		0.0	6.5	16.7	21.8	41.5	13.5
⧗	B-02	0.04	0.02	0.007		0.0	8.4	7.9	14.6	43.6	25.5

PROJECT ODOT Cond. Eval. CLI-73 PROJECT NO. W-16-171

GRADATION CURVES

RII



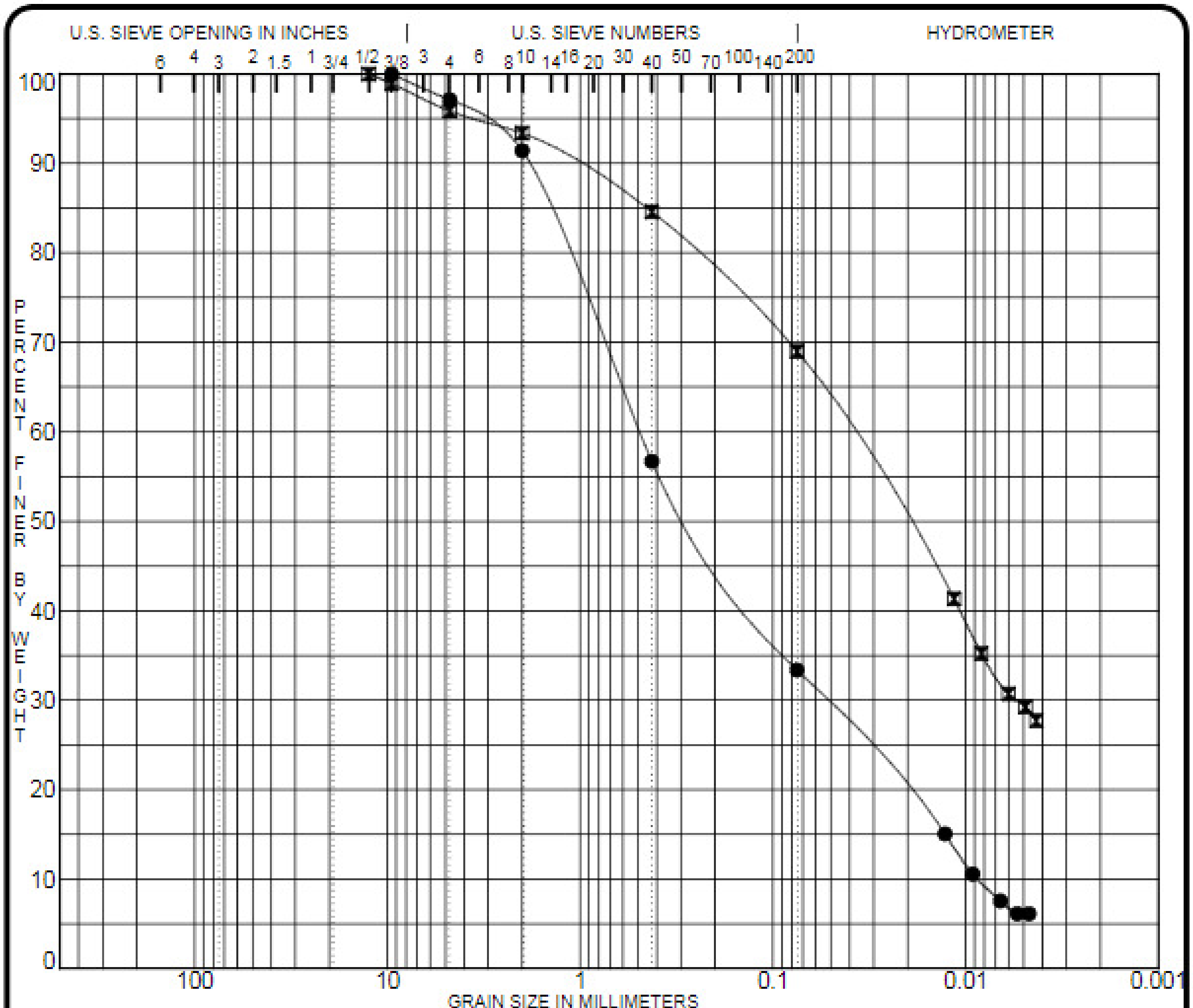
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-03	1.0	A-3a	1507		18	NP	NP	NP	0.66	57.0
⊠	B-03	2.7	A-6a	120		18	31	17	14		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-03	0.46	0.23	0.050	0.0081	0.0	14.8	26.6	24.1	28.3	6.2
⊠	B-03	0.03	0.02	0.004		0.0	5.0	6.8	14.5	42.5	31.3

PROJECT **ODOT Cond. Eval. CLI-73** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

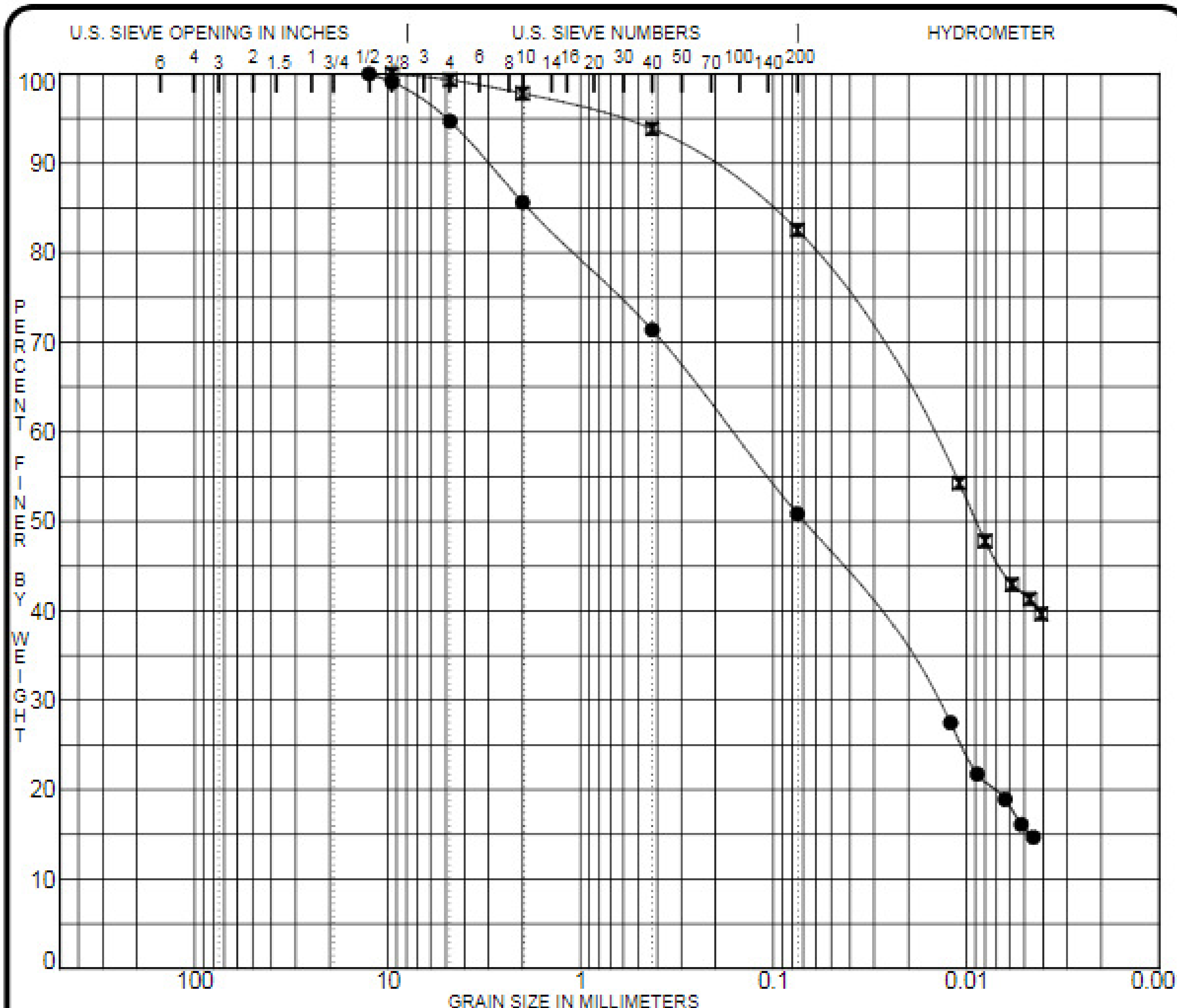
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-04	1.0	A-3a	1953		17	NP	NP	NP	0.69	56.8
⧗	B-04	2.5	A-6b	193		18	34	14	20		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-04	0.49	0.26	0.054	0.0087	0.0	8.6	34.7	23.3	27.3	6.1
⧗	B-04	0.04	0.02	0.005		0.0	6.6	8.8	15.6	39.6	29.4

PROJECT ODOT Cond. Eval. CLI-73 PROJECT NO. W-16-171

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

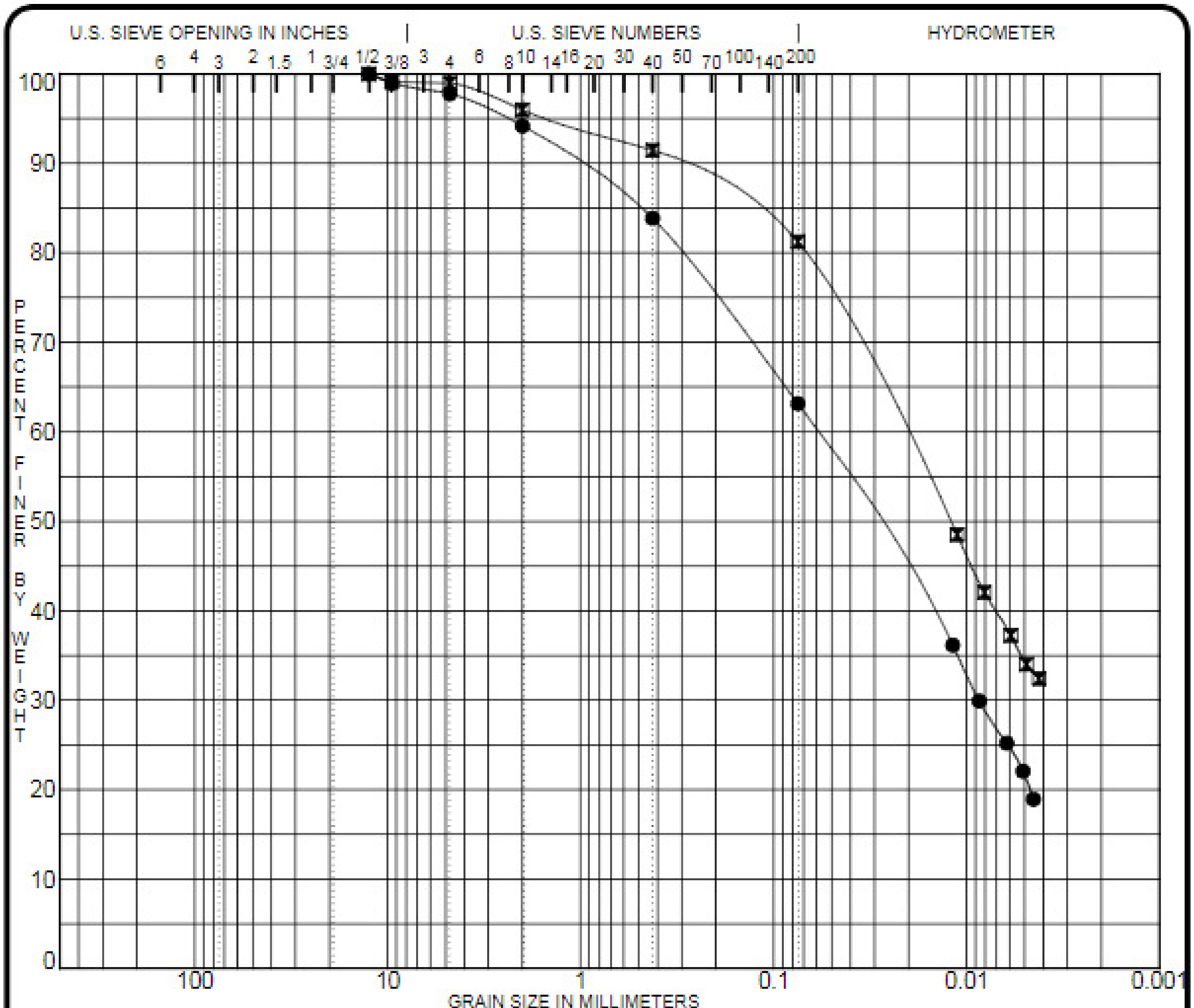
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-05	1.0	A-4a	1920		18	33	28	5		
⧗	B-05	4.0	A-7-6	200		18	44	19	25		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-05	0.16	0.07	0.015		0.0	14.4	14.3	20.5	35.1	15.7
⧗	B-05	0.02	0.01			0.0	2.2	3.9	11.3	40.8	41.8

PROJECT **ODOT Cond. Eval. CLI-73** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

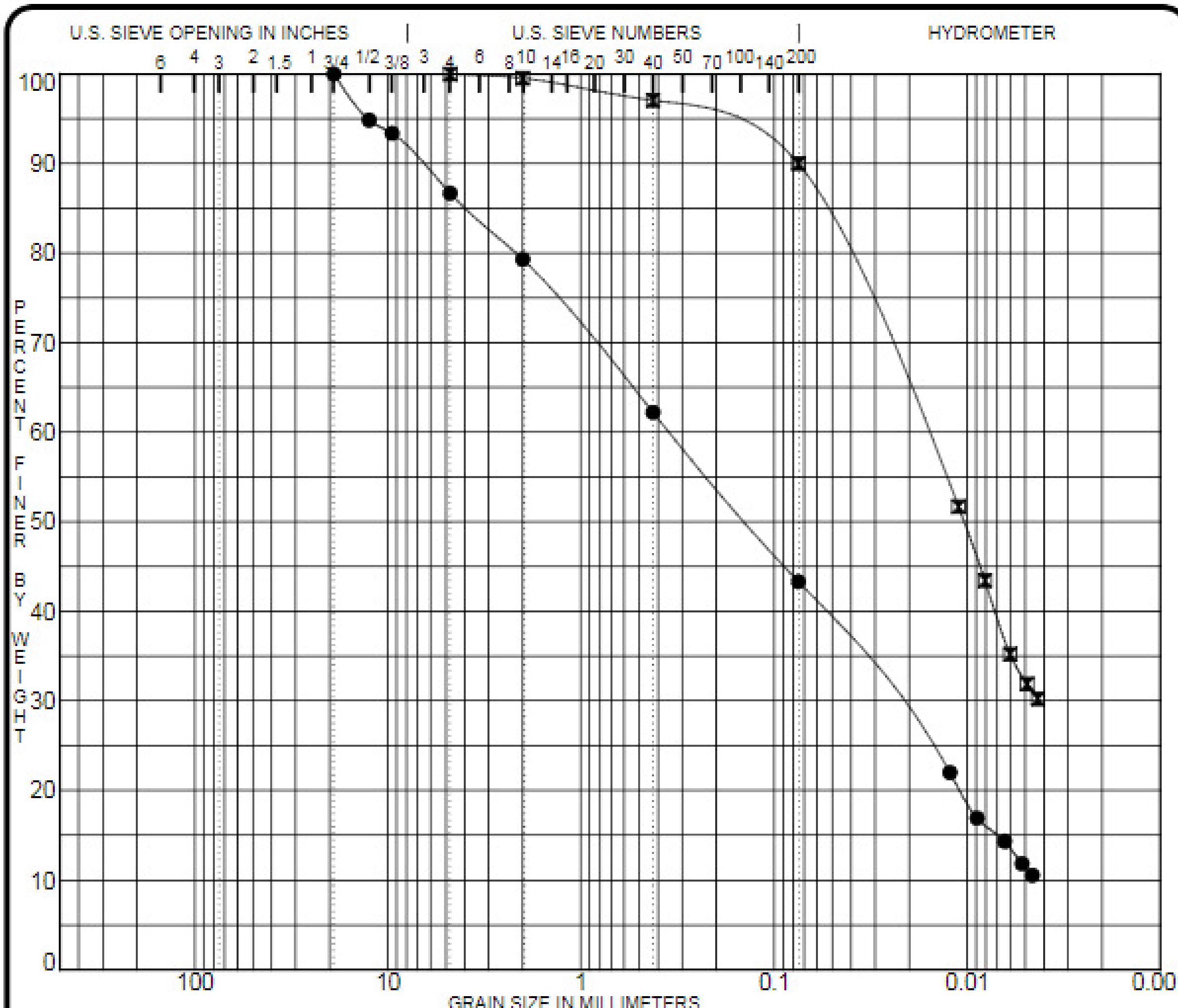
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	**B-06**	**1.0**	**A-6a**	**2600**		**18**	**34**	**21**	**13**		
⊠	**B-06**	**2.5**	**A-6a**	**273**		**17**	**31**	**18**	**13**		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	**B-06**	**0.06**	**0.03**	**0.009**		**0.0**	**5.8**	**10.3**	**20.7**	**41.6**	**21.6**
⊠	**B-06**	**0.02**	**0.01**			**0.0**	**4.0**	**4.5**	**10.2**	**46.8**	**34.4**

PROJECT **ODOT Cond. Eval. CLI-73** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

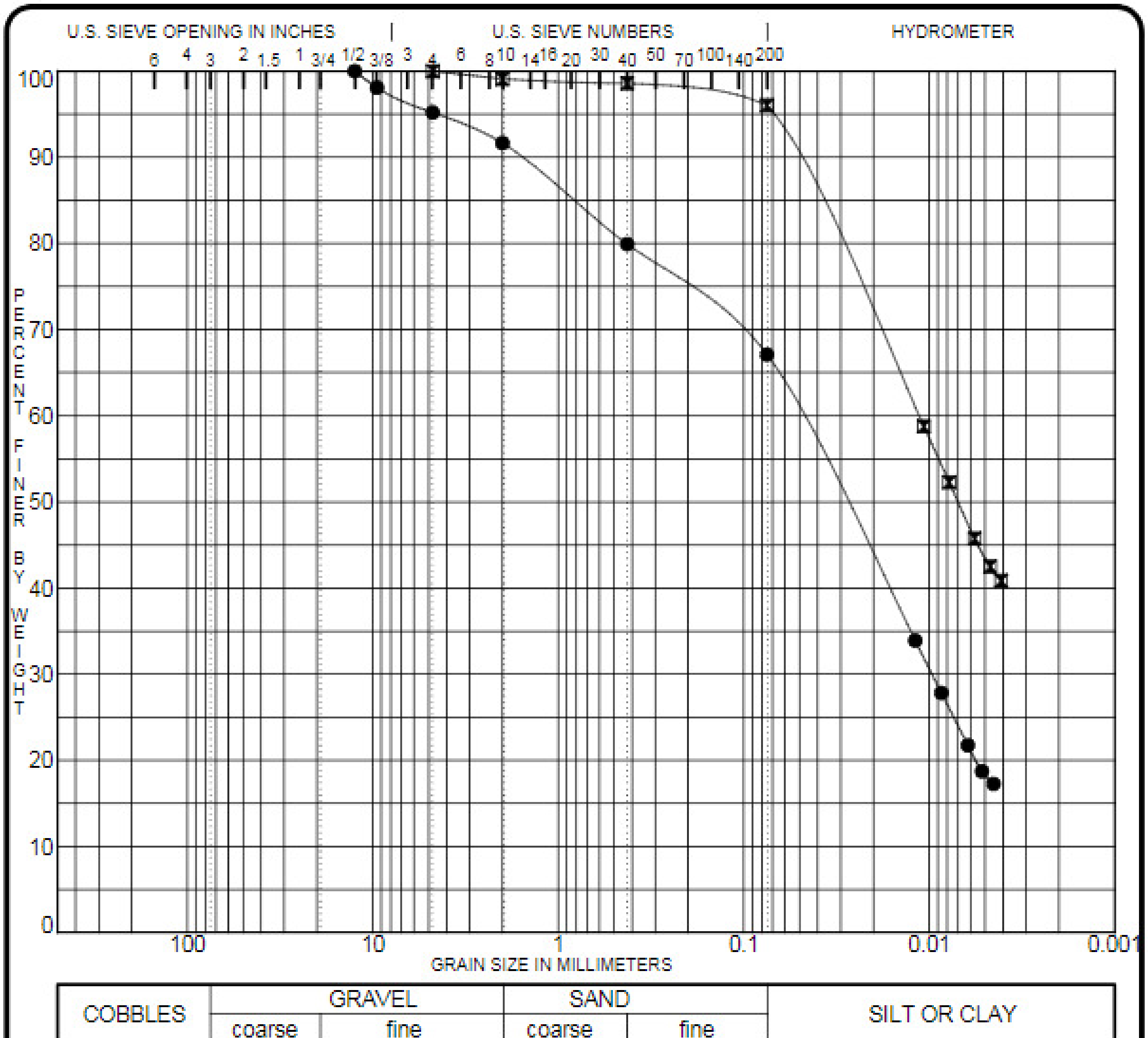
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-07	1.0	A-4a	1653		15	30	28	2		
⧖	B-07	3.0	A-6a	227		19	33	21	12		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-07	0.35	0.14	0.024		0.0	20.7	17.1	18.9	31.9	11.4
⧖	B-07	0.02	0.01			0.0	0.5	2.5	7.1	57.8	32.2

PROJECT **ODOT Cond. Eval. CLI-73** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



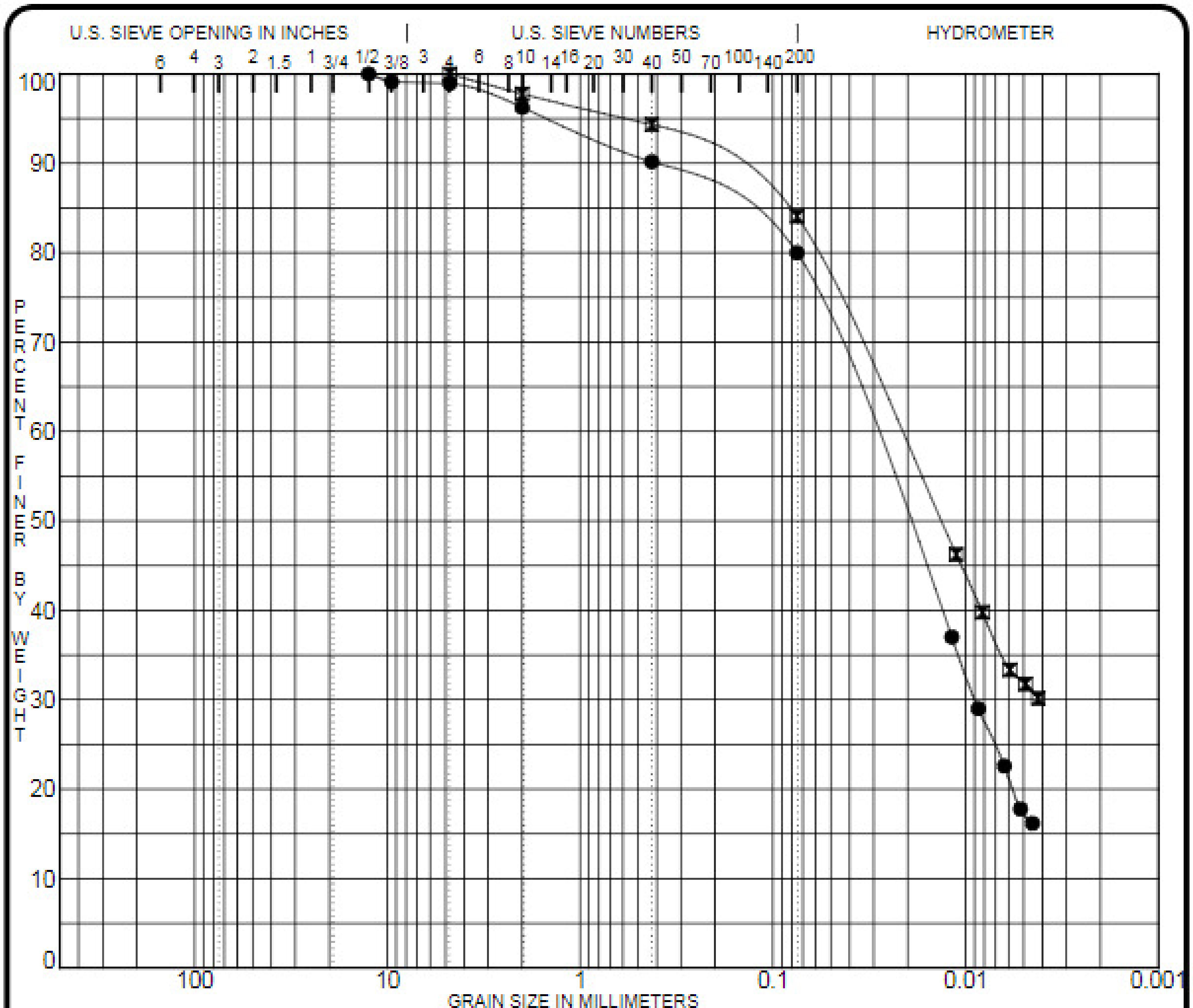
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-08	1.0	A-4a	2413		19	33	24	9		
⌧	B-08	2.5	A-7-6	200	4.0	21	52	21	31		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-08	0.05	0.03	0.010		0.0	8.4	11.7	12.8	48.8	18.3
⌧	B-08	0.01	0.01			0.0	0.9	0.5	2.6	52.5	43.6

PROJECT **ODOT Cond. Eval. CLI-73** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

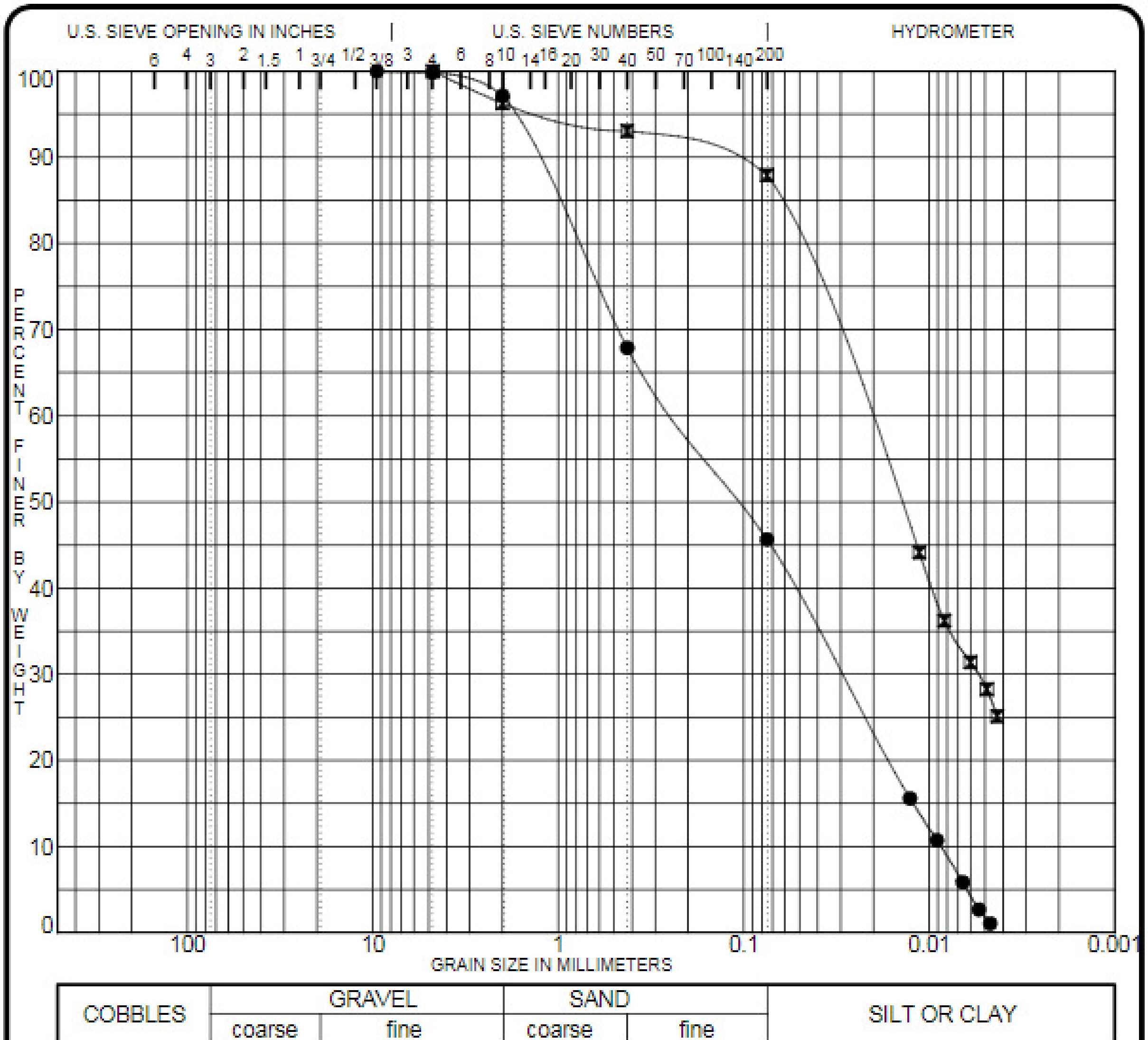
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-09	1.0	A-6a	533		14	36	21	15		
⌧	B-09	2.5	A-6b	240		24	40	18	22		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-09	0.03	0.02	0.009		0.0	3.7	6.1	10.2	62.6	17.3
⌧	B-09	0.02	0.01			0.0	2.2	3.4	10.3	52.1	31.9

PROJECT **ODOT Cond. Eval. CLI-73** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-10	1.0	A-4a	2333		20	40	35	5	0.44	26.5
⊠	B-10	2.6	A-6b	113		24	35	19	16		

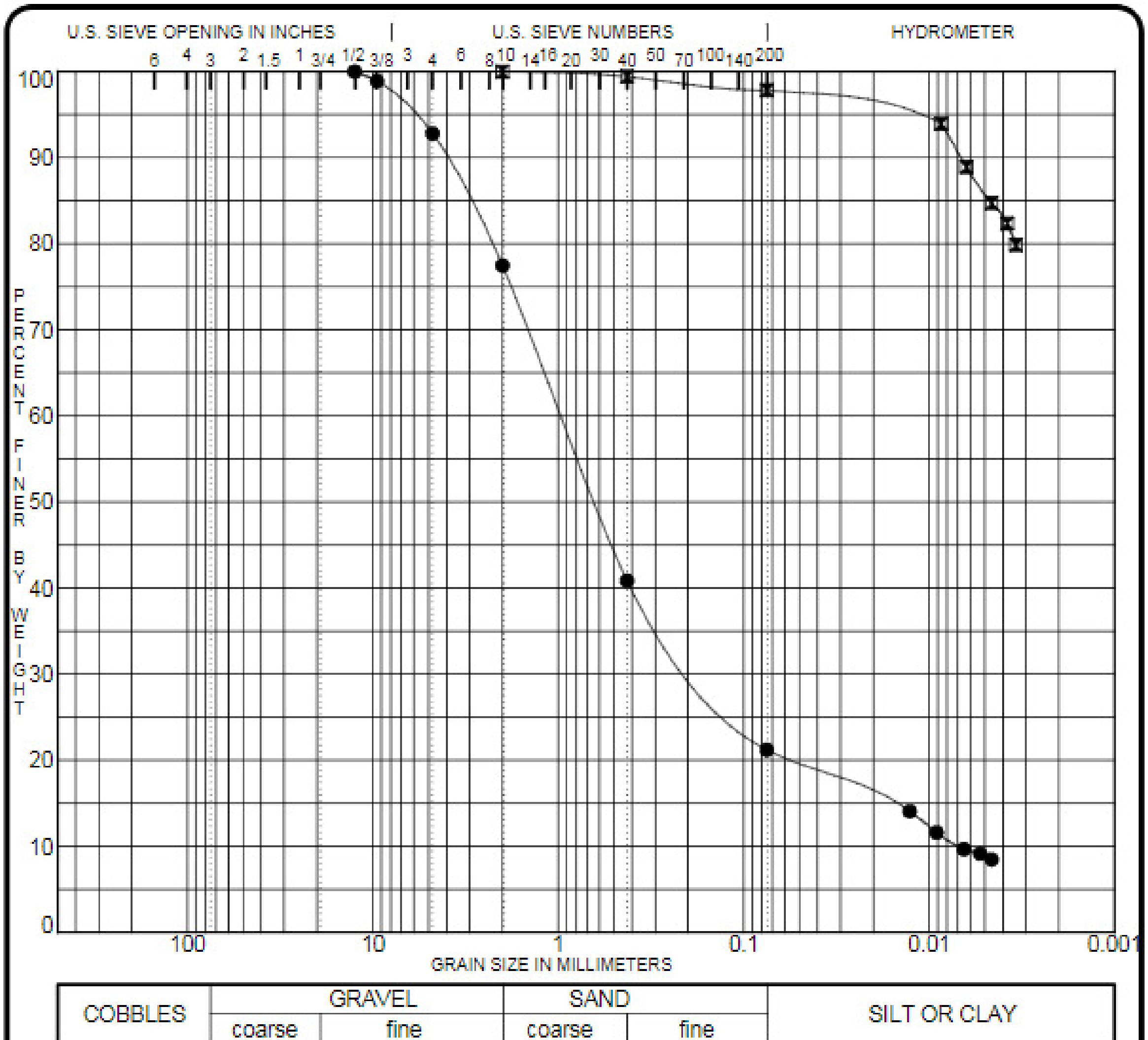
	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-10	0.23	0.11	0.030	0.0087	0.0	2.8	29.3	22.2	43.9	1.8
⊠	B-10	0.02	0.01	0.005		0.0	3.7	3.2	5.1	59.3	28.6

PROJECT ODOT Cond. Eval. CLI-73 PROJECT NO. W-16-171

GRADATION CURVES

RII

DEF-24 Gradation Plots



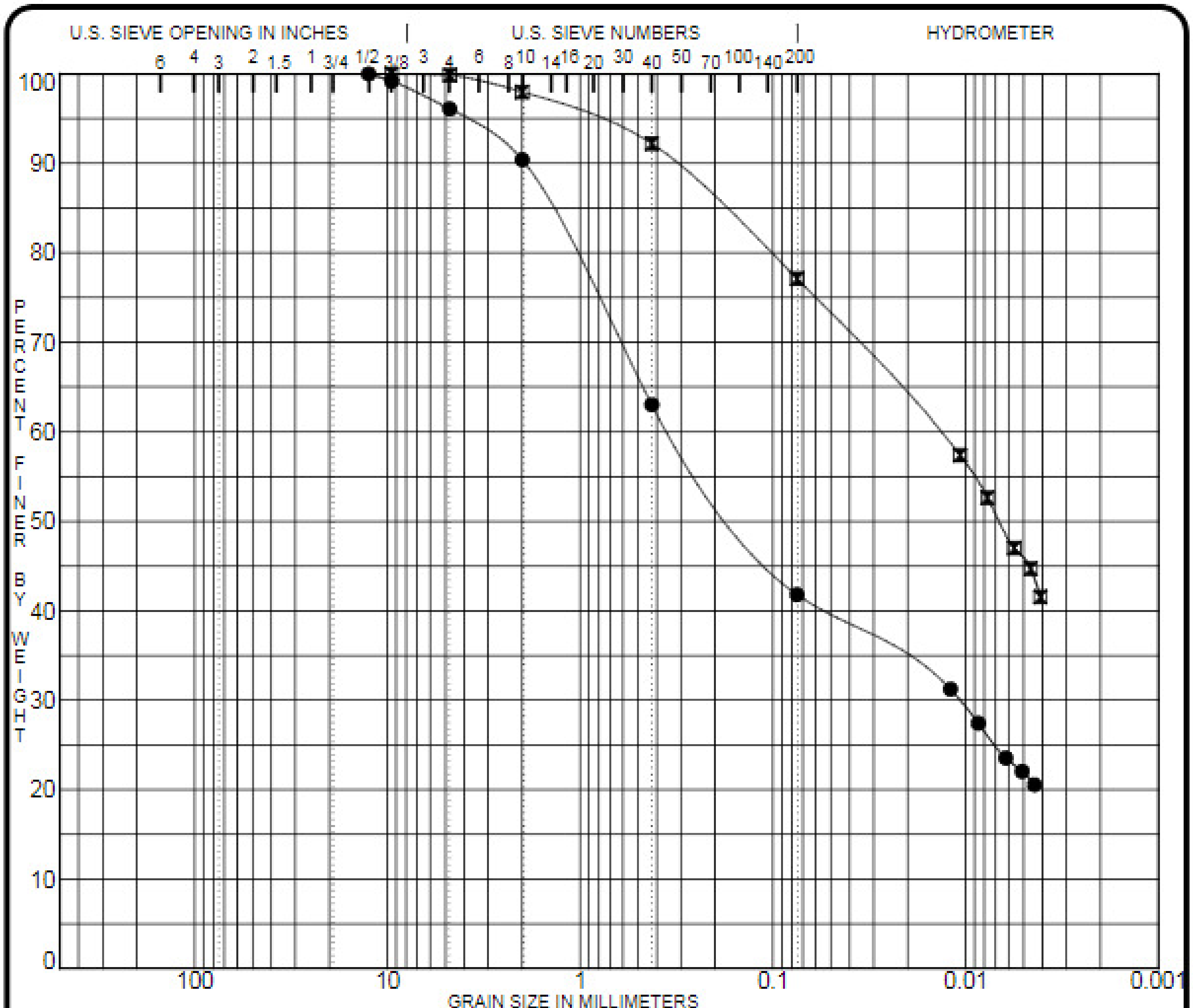
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-01	1.1	A-1-b	3787		24	NP	NP	NP	4.06	139.1
⌧	B-01	4.6	A-7-6	200		28	64	21	43		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-01	0.96	0.63	0.163	0.0069	0.0	22.5	36.6	19.6	12.3	8.8
⌧	B-01					0.0	0.0	0.6	1.6	12.0	85.8

PROJECT ODOT Cond. Eval. DEF-24 PROJECT NO. W-16-171

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

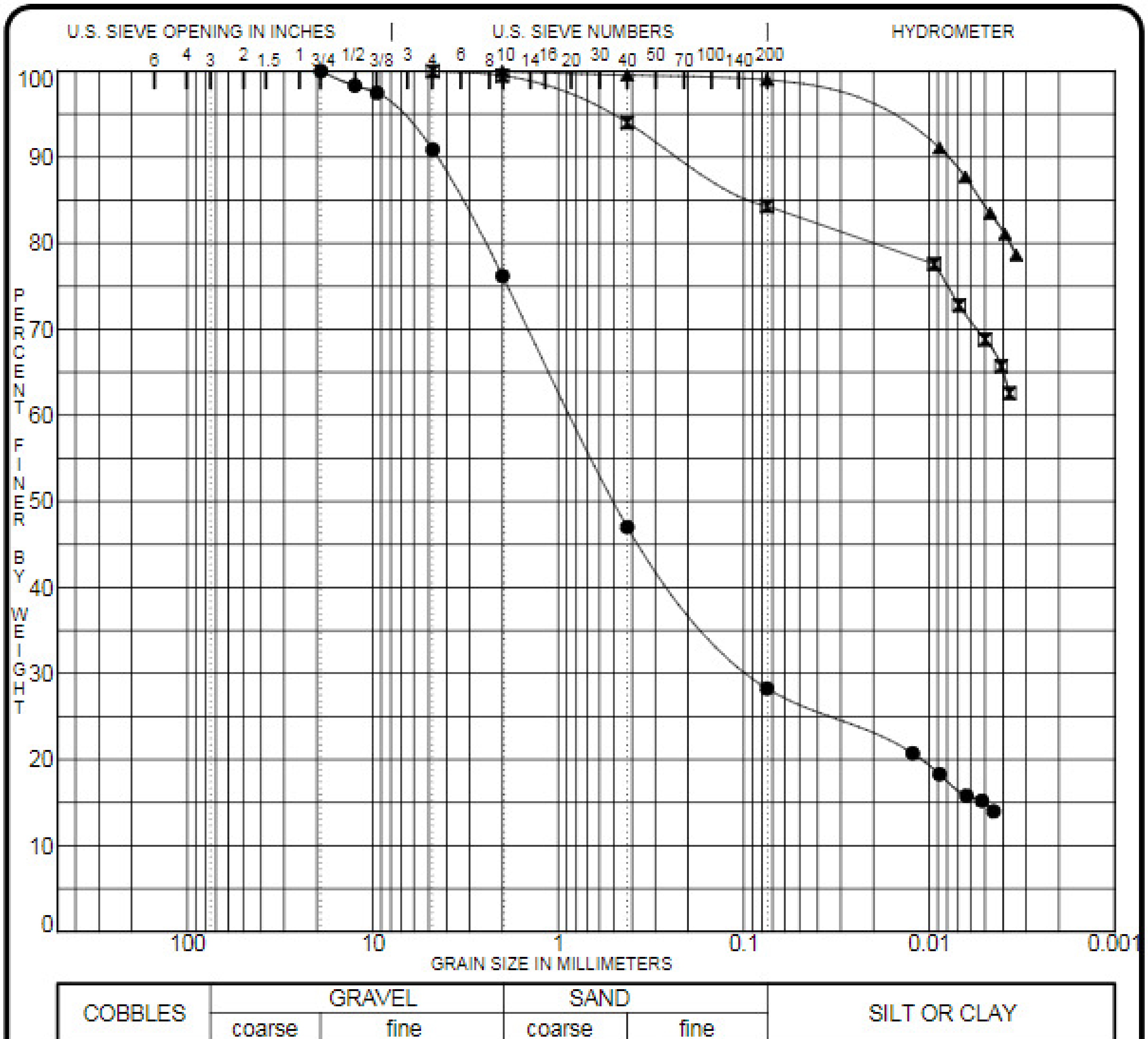
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-02	1.1	A-7-5	2507		25	54	32	22		
⌧	B-02	2.9	A-7-6	180		29	54	26	28		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-02	0.33	0.15	0.011		0.0	9.6	27.4	21.2	20.0	21.8
⌧	B-02	0.01	0.01			0.0	2.0	5.8	15.1	31.4	45.7

PROJECT ODOT Cond. Eval. DEF-24 PROJECT NO. W-16-171

GRADATION CURVES

RII



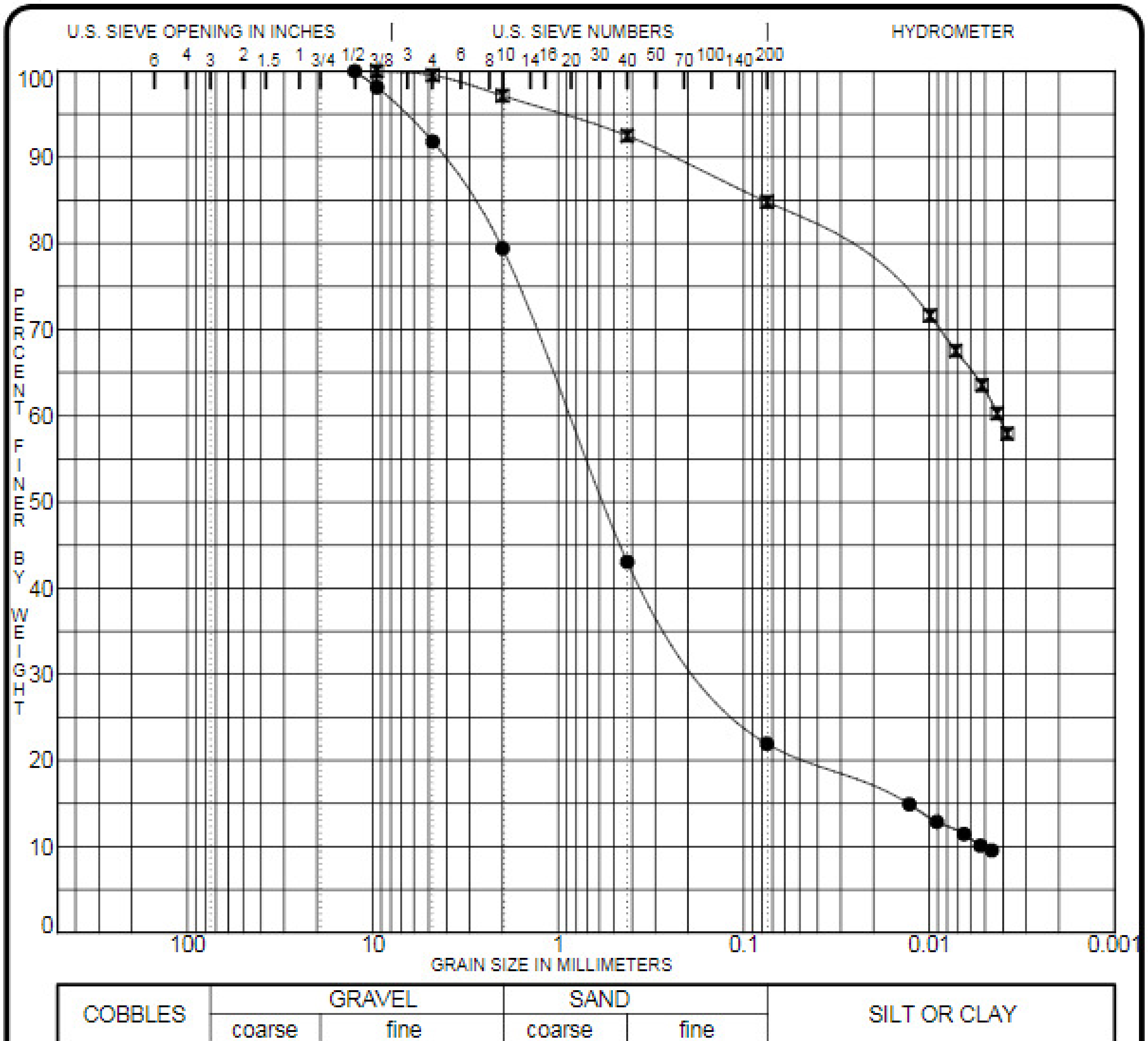
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-03	1.1	A-2-7	5067		26	49	33	16		
⧗	B-03	2.6	A-7-6	460		22	55	22	33		
▲	B-03	5.6	A-7-6	560		31	74	22	52		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-03	0.85	0.50	0.088		0.0	23.8	29.2	18.8	13.4	14.9
⧗	B-03					0.0	0.5	5.5	9.7	15.5	68.8
▲	B-03					0.0	0.0	0.5	0.5	14.7	84.3

PROJECT ODOT Cond. Eval. DEF-24 PROJECT NO. W-16-171

GRADATION CURVES

RII



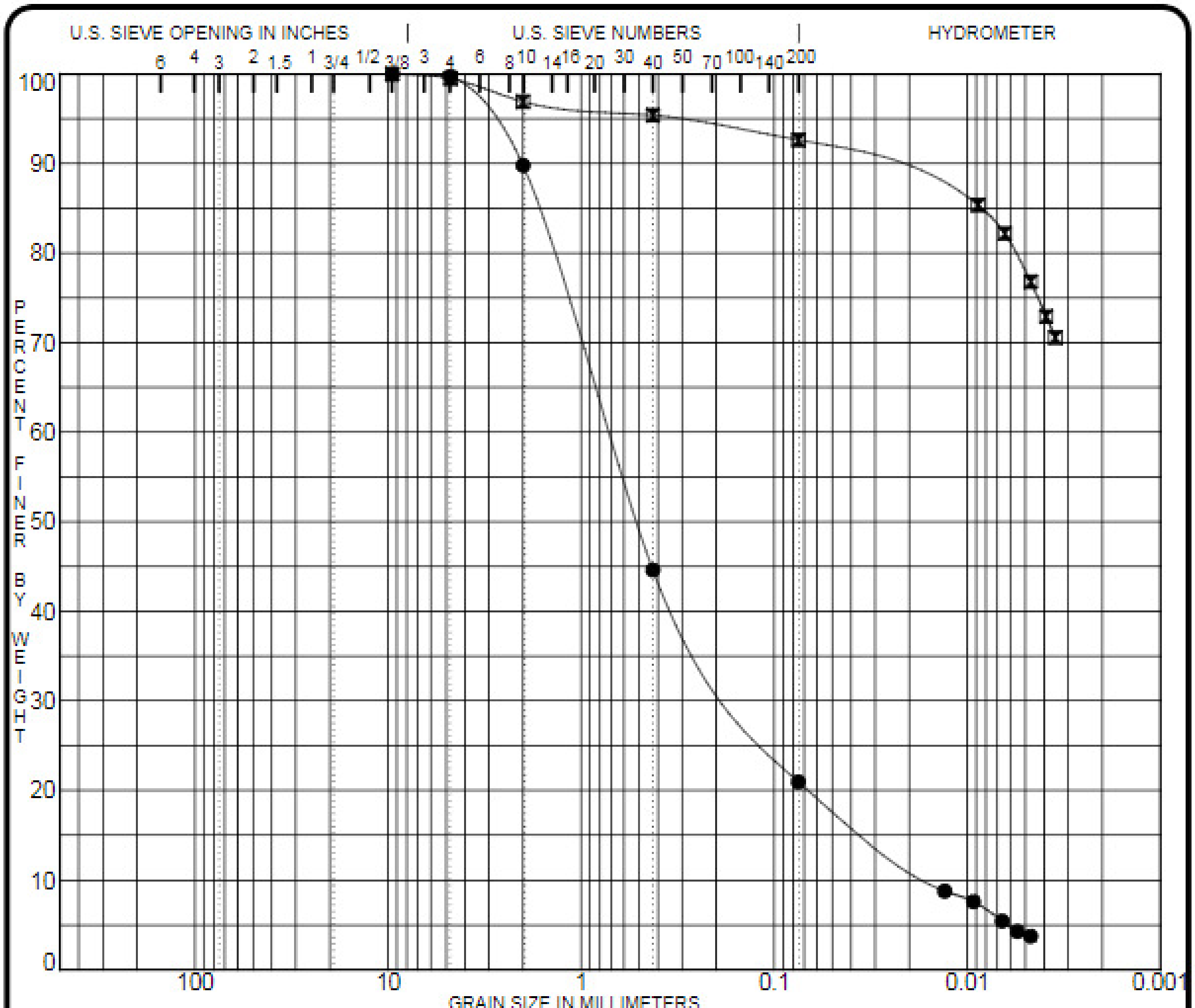
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-04	1.1	A-2-5	5733		25	48	39	9	4.68	169.2
⧗	B-04	3.6	A-7-6	400		24	56	21	35		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-04	0.87	0.57	0.146	0.0052	0.0	20.6	36.4	21.1	12.1	9.9
⧗	B-04	0.00				0.0	2.8	4.7	7.7	21.9	62.9

PROJECT **ODOT Cond. Eval. DEF-24** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

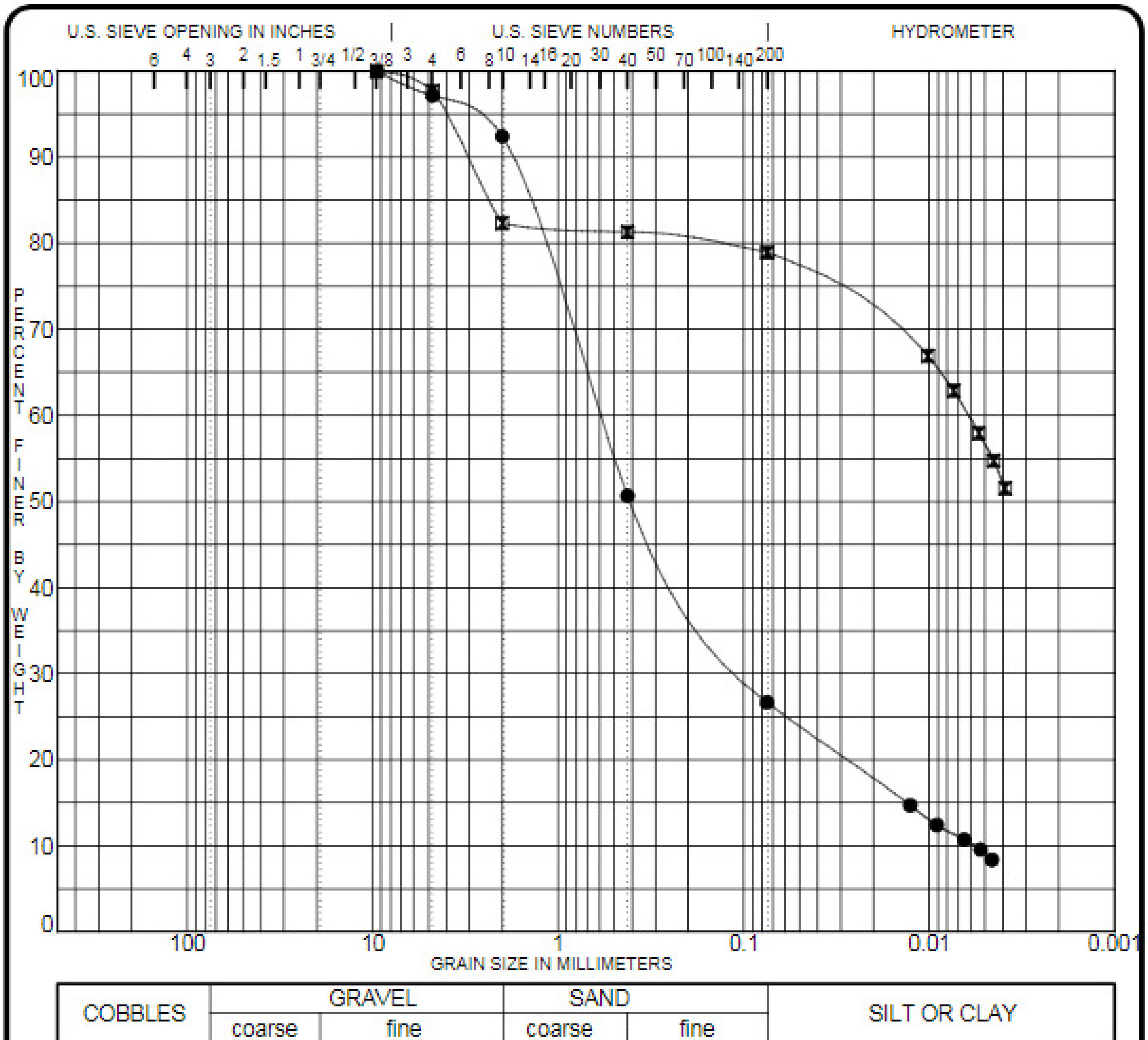
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-05	1.0	A-1-b	2760		25	NP	NP	NP	1.89	46.3
⧗	B-05	2.8	A-7-6	547		25	58	21	37		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-05	0.72	0.51	0.146	0.0156	0.0	10.2	45.2	23.7	17.0	4.0
⧗	B-05					0.0	3.1	1.5	2.8	14.8	77.9

PROJECT **ODOT Cond. Eval. DEF-24** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



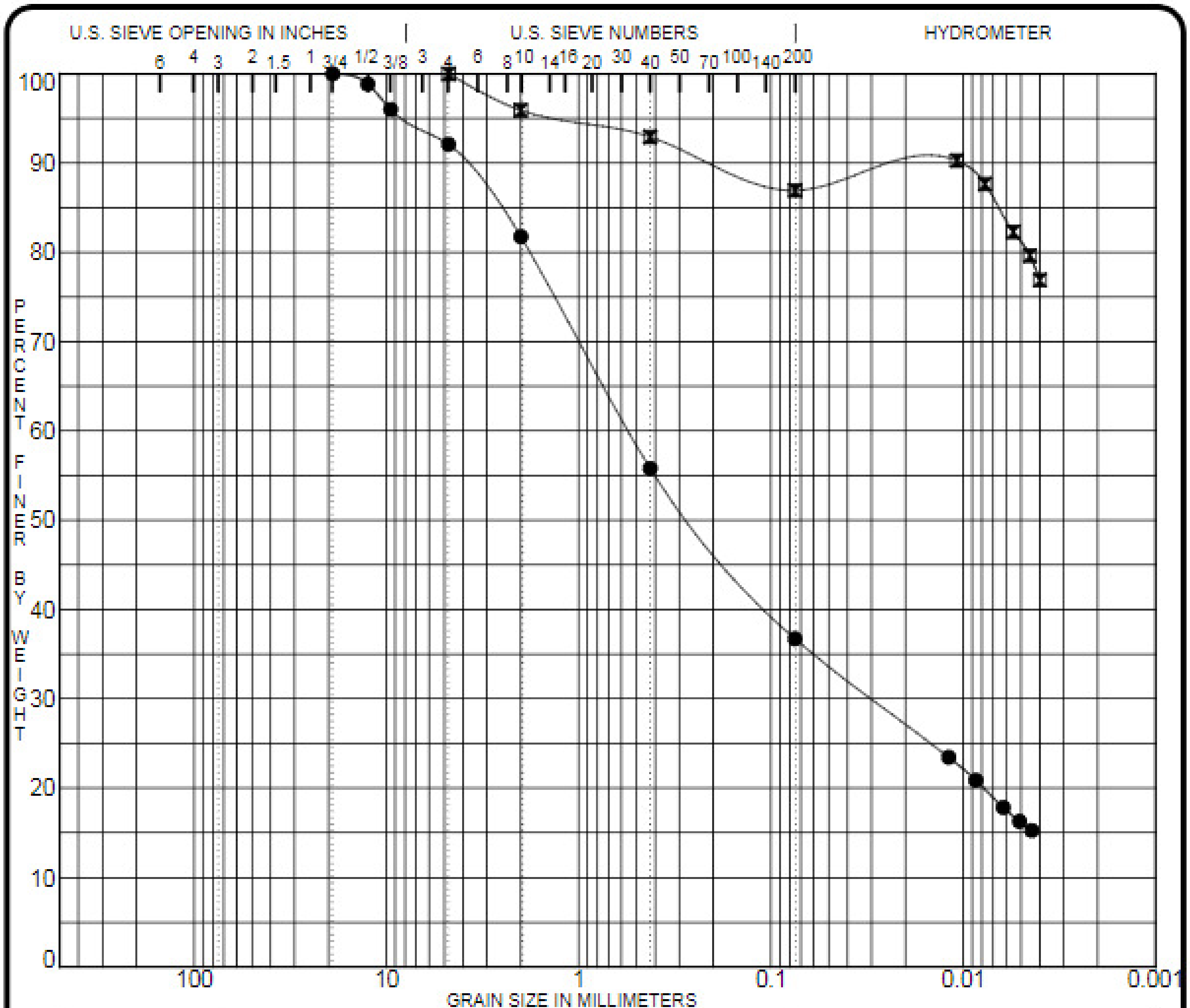
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-06	1.0	A-2-5	3947		25	45	37	8	2.64	104.6
⌧	B-06	2.7	A-7-6	320		25	49	19	30		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-06	0.60	0.40	0.096	0.0057	0.0	7.6	41.7	24.0	17.6	9.1
⌧	B-06	0.01				0.0	17.7	1.0	2.4	22.3	56.6

PROJECT ODOT Cond. Eval. DEF-24 PROJECT NO. W-16-171

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

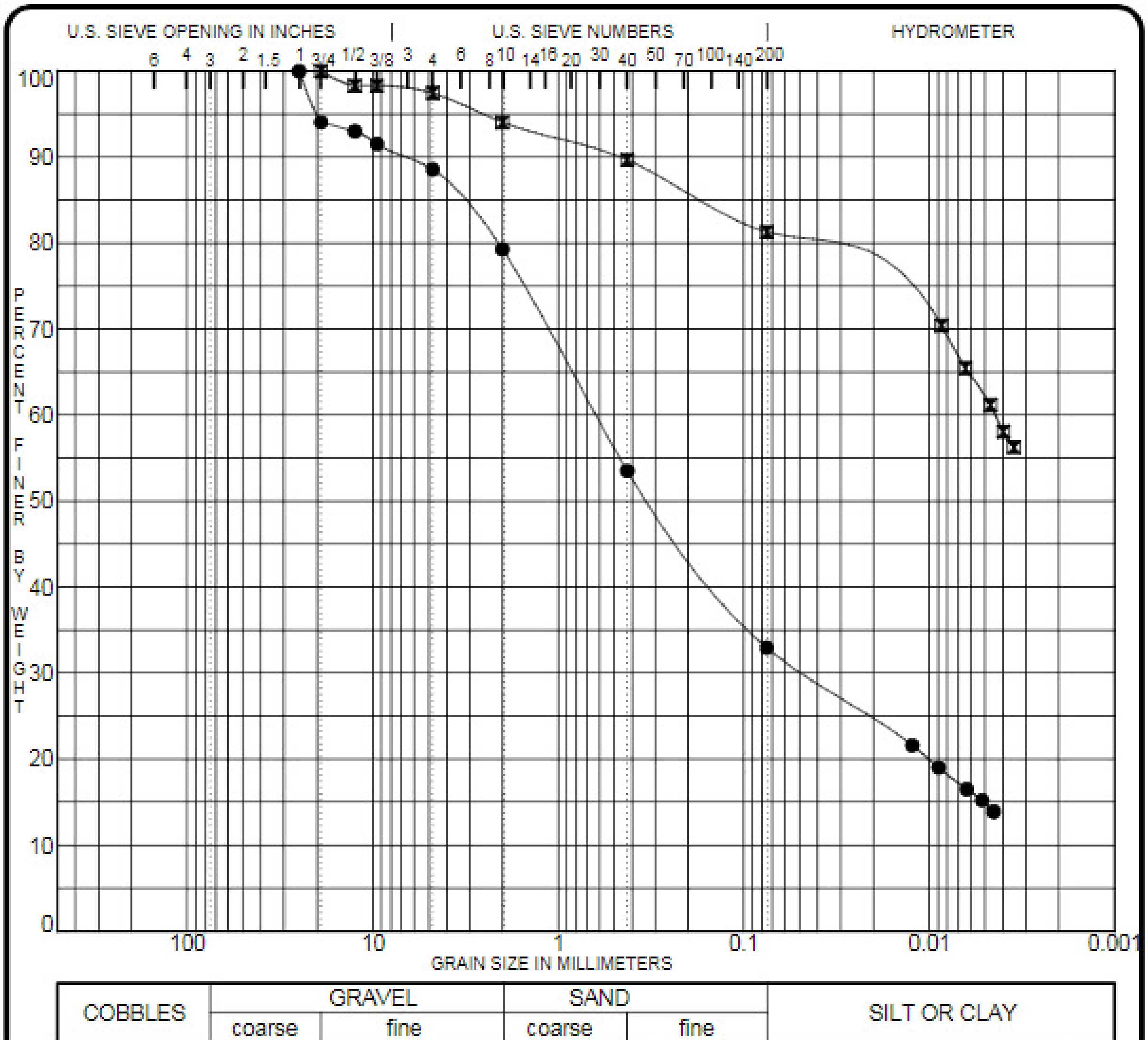
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-07	1.0	A-7-6	6347		24	42	28	14		
⧗	B-07	2.8	A-7-6	1020		27	53	24	29		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-07	0.55	0.25	0.030		0.0	18.2	25.9	19.1	20.6	16.1
⧗	B-07					0.0	4.1	3.0	6.0	5.9	81.0

PROJECT **ODOT Cond. Eval. DEF-24** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



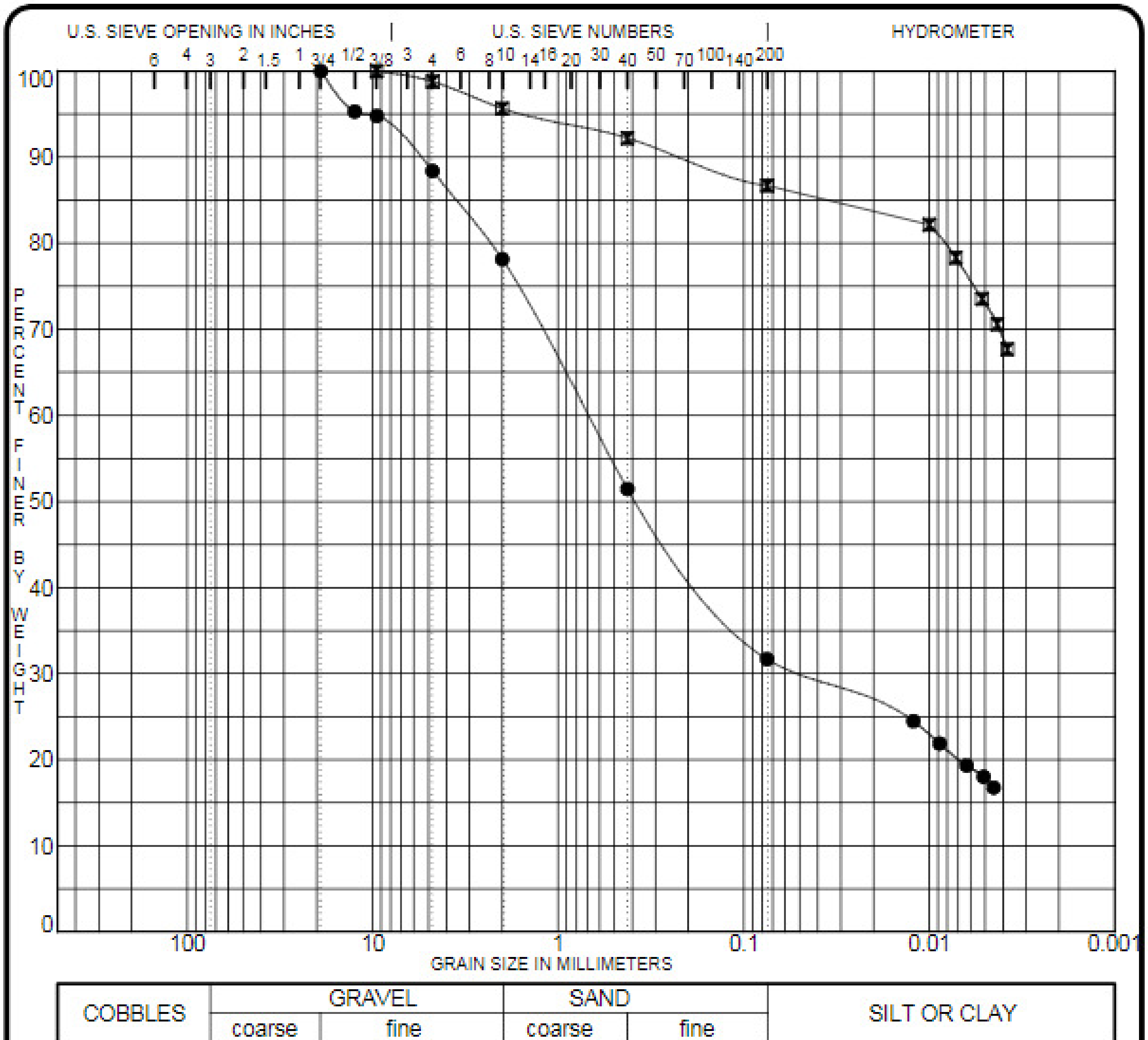
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-08	1.0	A-2-7	7067		25	46	33	13		
⊠	B-08	2.5	A-7-6	10613		27	56	23	33		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-08	0.63	0.32	0.047		5.9	14.8	25.8	20.6	18.1	14.8
⊠	B-08	0.00				0.0	5.9	4.4	8.4	19.3	62.0

PROJECT **ODOT Cond. Eval. DEF-24** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



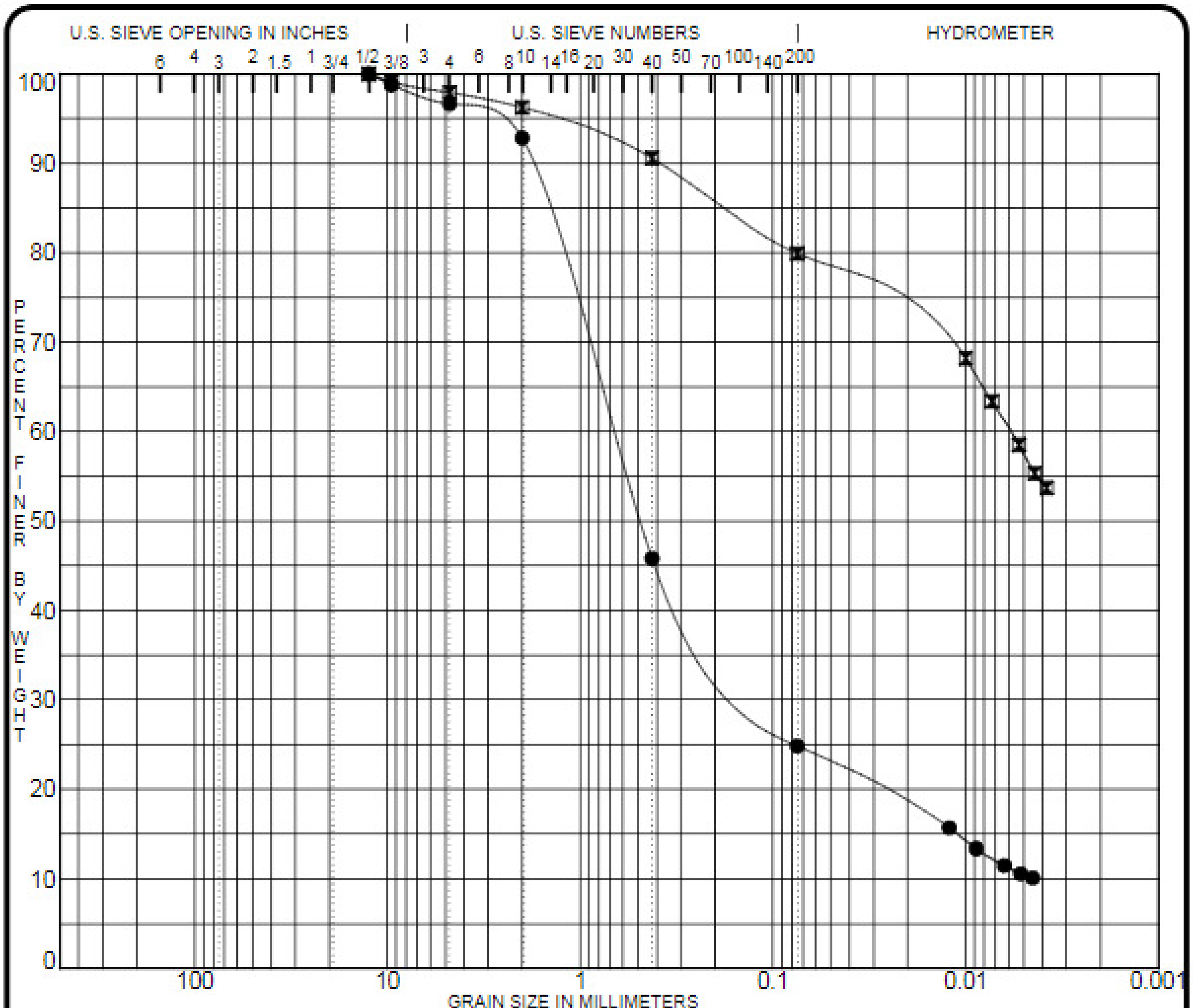
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-09	1.0	A-2-7	7173		25	45	32	13		
⌛	B-09	2.8	A-7-6	3947		32	56	25	31		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-09	0.70	0.37	0.049		0.0	21.9	26.7	19.8	13.9	17.8
⌛	B-09					0.0	4.3	3.4	5.5	13.8	72.9

PROJECT ODOT Cond. Eval. DEF-24 PROJECT NO. W-16-171

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	**B-10**	**1.1**	**A-1-b**	**7040**		**25**	**NP**	**NP**	**NP**		
⌧	**B-10**	**2.6**	**A-6b**	**6880**		**22**	**38**	**17**	**21**		

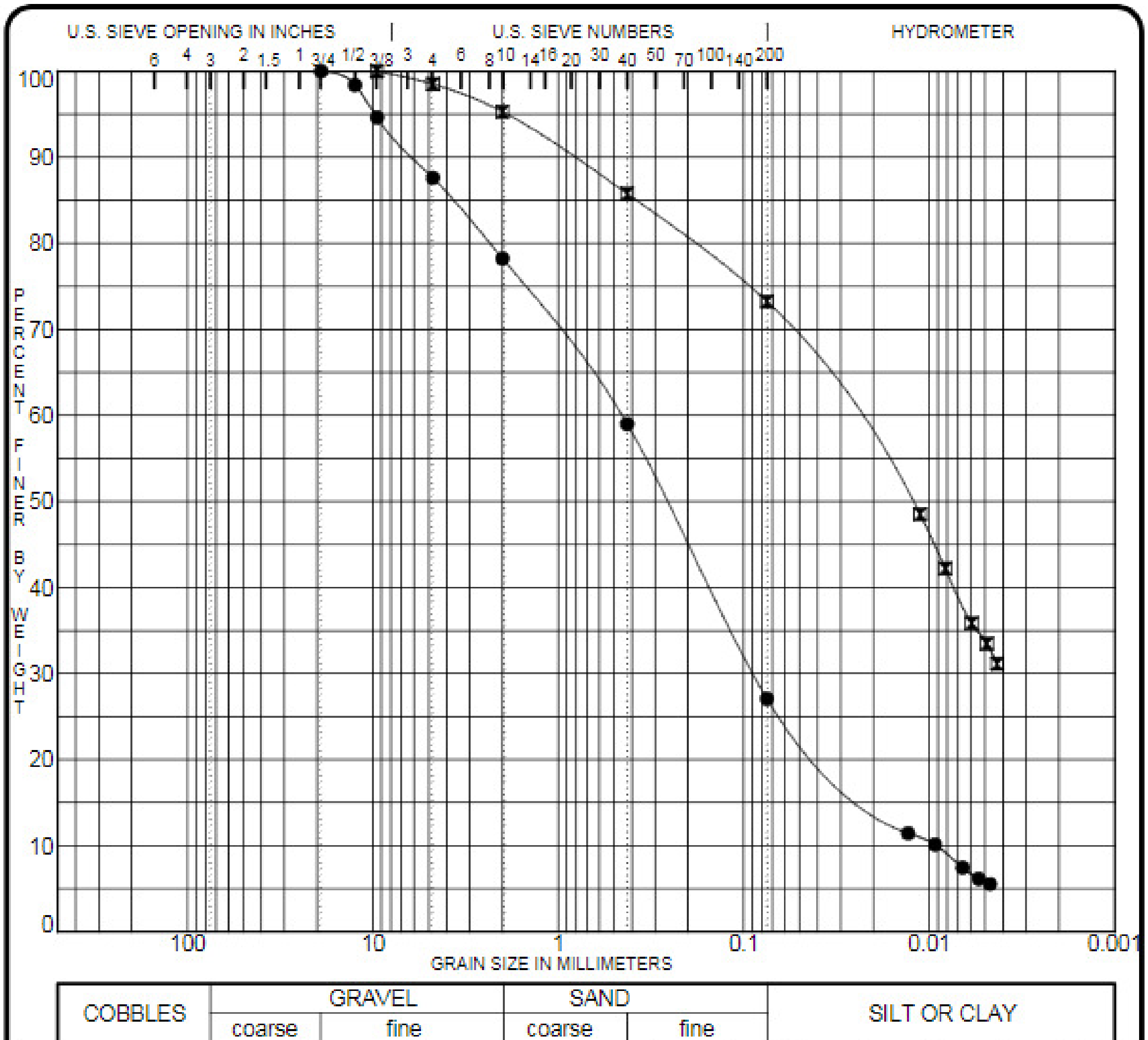
	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	**B-10**	**0.68**	**0.49**	**0.115**		**0.0**	**7.2**	**47.0**	**20.9**	**14.4**	**10.4**
⌧	**B-10**	**0.01**				**0.0**	**3.8**	**5.6**	**10.7**	**22.4**	**57.5**

PROJECT **ODOT Cond. Eval. DEF-24** PROJECT NO. **W-16-171**

GRADATION CURVES

RII

LAK-2 Gradation Plots



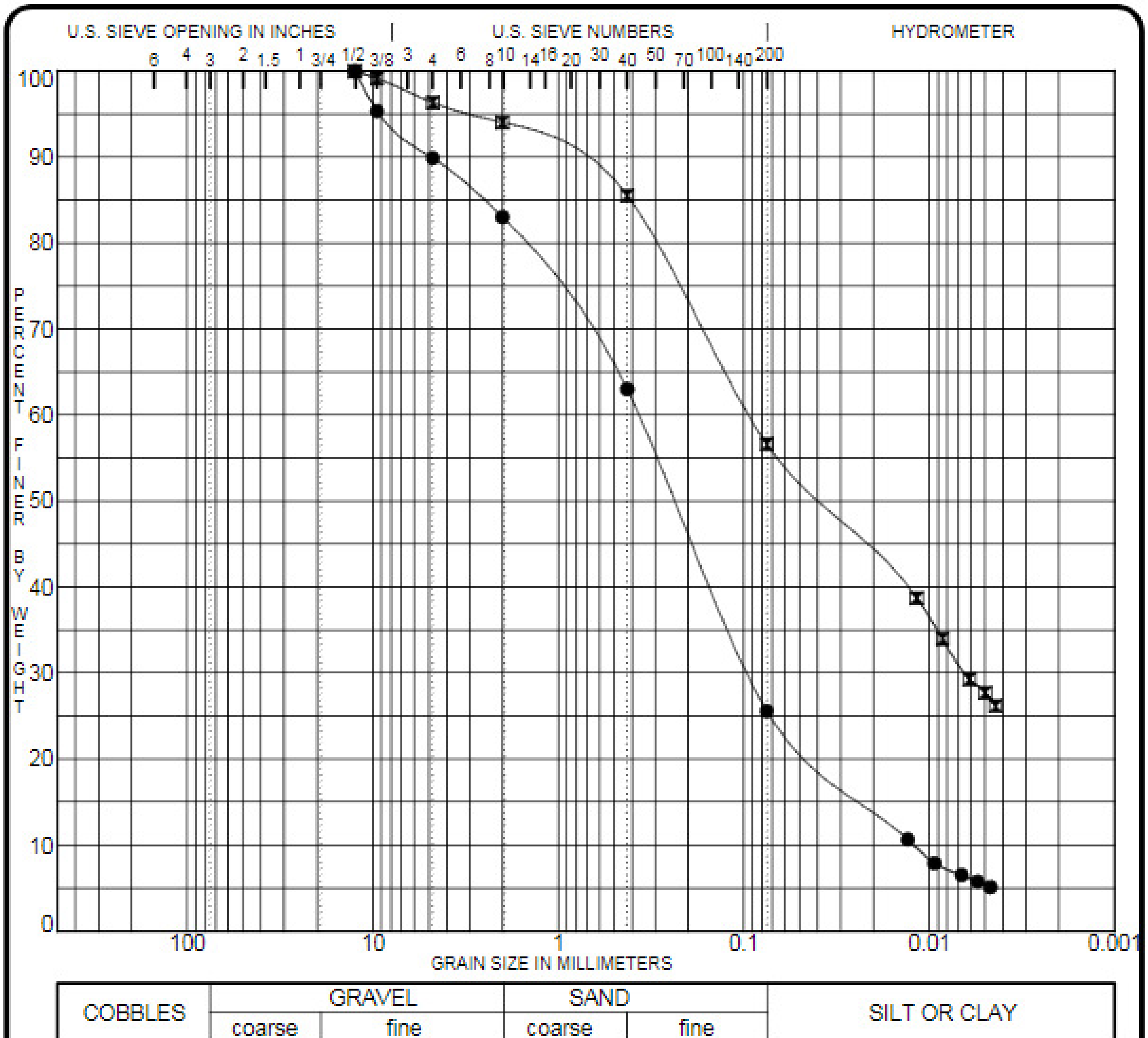
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-11	1.6	A-3a	3573		10	NP	NP	NP	1.84	50.3
⧗	B-11	3.2	A-6a	3107		15	30	17	13		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-11	0.46	0.26	0.088	0.0092	0.0	21.8	19.2	31.9	21.3	5.8
⧗	B-11	0.03	0.01			0.0	4.7	9.5	12.5	39.5	33.7

PROJECT ODOT COND. EVAL. LAKE COUNTY PROJECT NO. W-16-171

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.



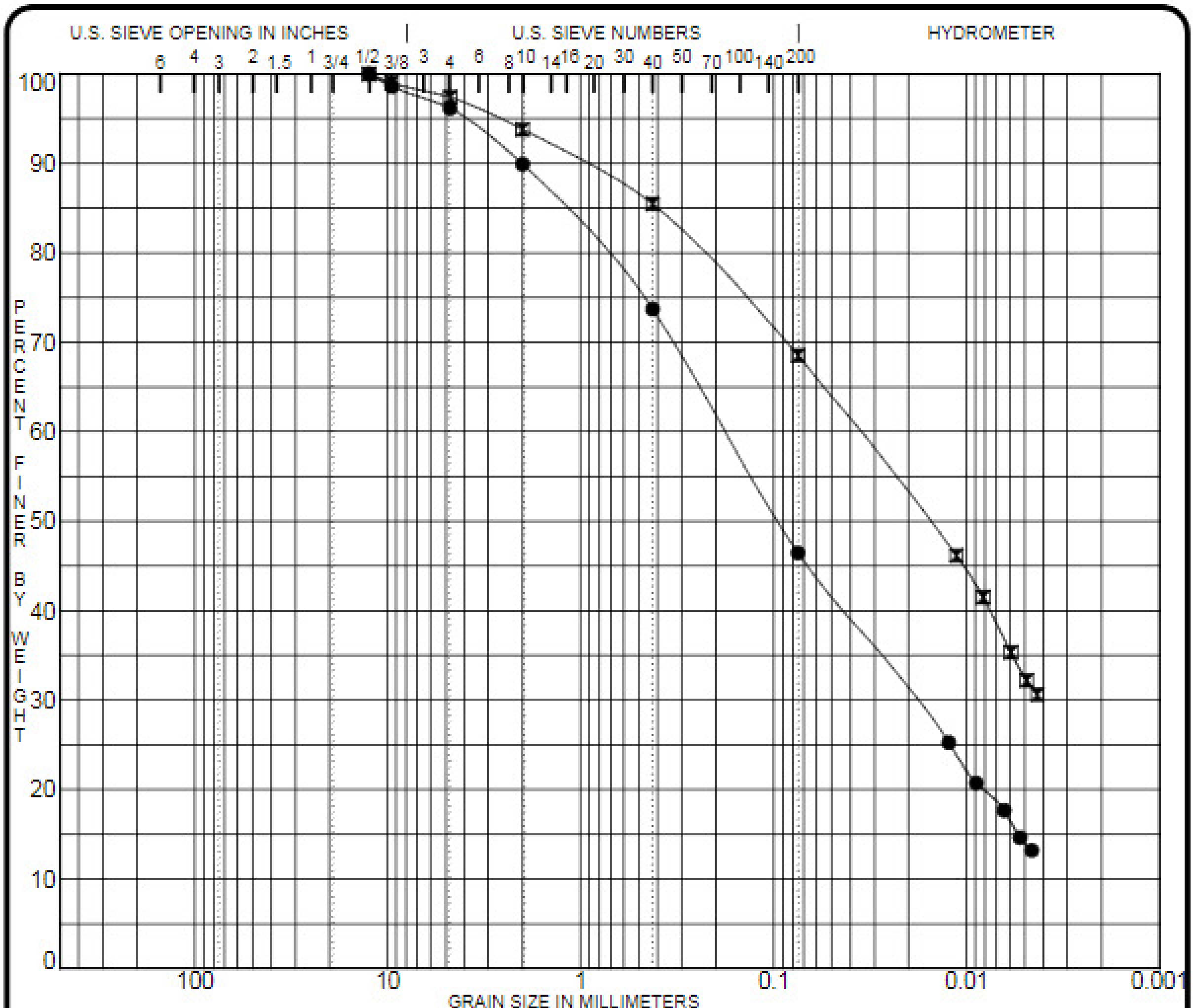
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-12	1.7	A-3a	6213		18	NP	NP	NP	1.89	30.6
⌧	B-12	3.2	A-4a	2187		13	25	15	10		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-12	0.37	0.23	0.092	0.0121	0.0	17.0	20.0	37.4	20.2	5.4
⌧	B-12	0.09	0.04	0.006		0.0	6.0	8.5	28.9	28.9	27.7

PROJECT **ODOT COND. EVAL. LAKE COUNTY** PROJECT NO. **W-16-171**

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

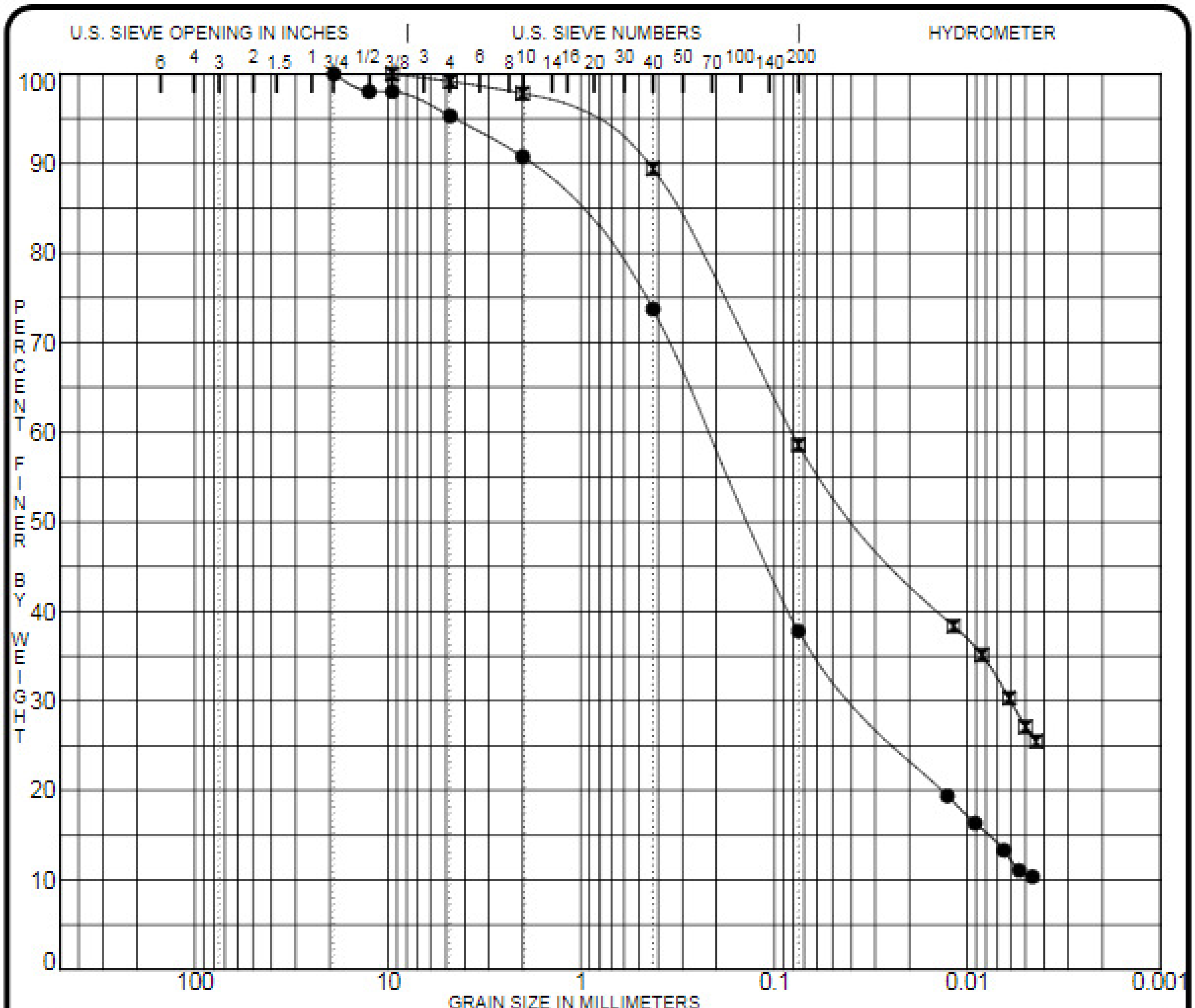
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-13	1.7	A-4a	4240		16	34	25	9		
⊠	B-13	3.2	A-6a	1393		13	28	16	12		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-13	0.18	0.09	0.019		0.0	10.1	16.2	27.3	32.4	14.1
⊠	B-13	0.04	0.02			0.0	6.2	8.3	16.9	36.0	32.5

PROJECT ODOT COND. EVAL. LAKE COUNTY PROJECT NO. W-16-171

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

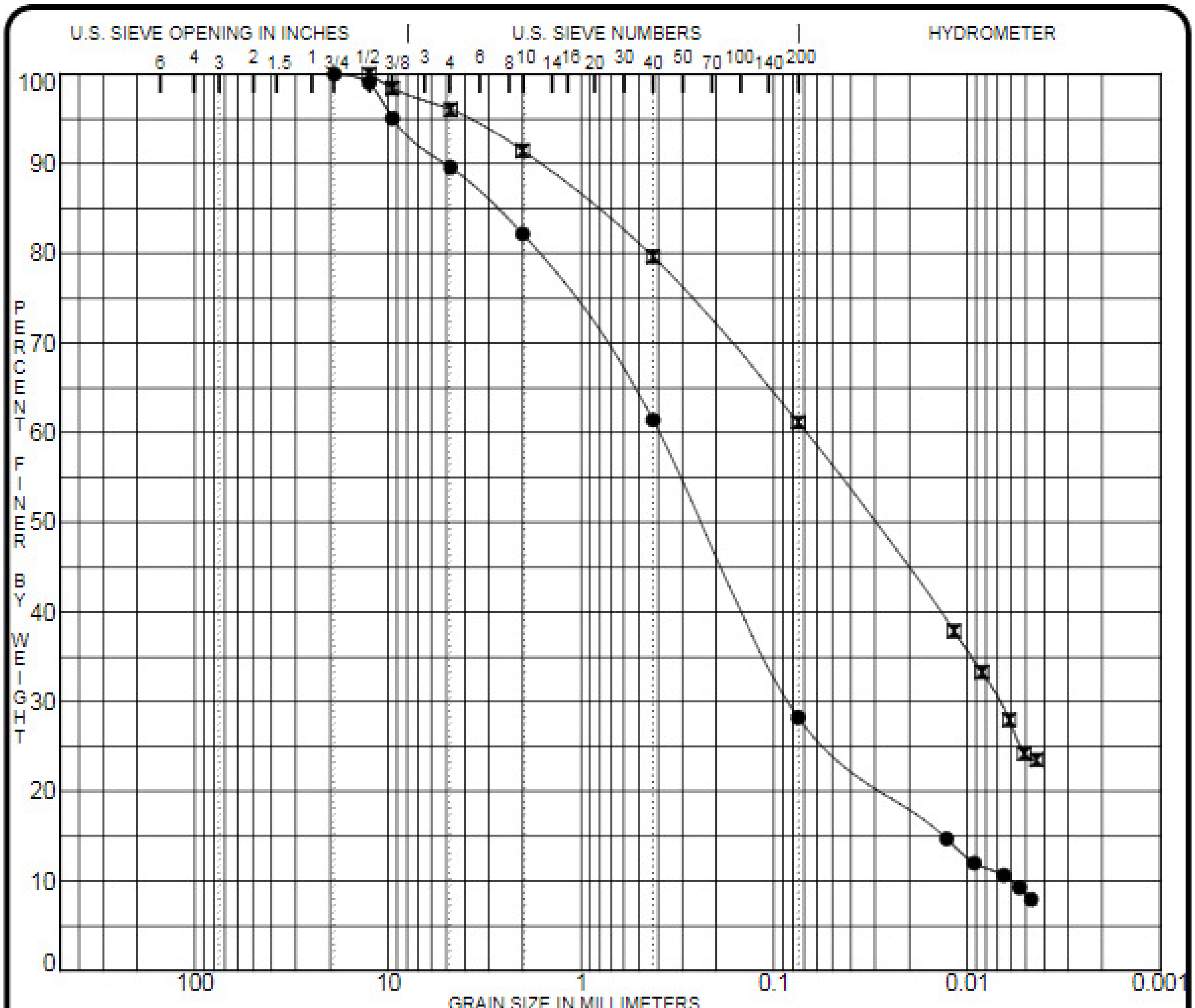
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-14	1.6	A-4a	5200		17	NP	NP	NP		
⊠	B-14	3.2	A-4a	1373		11	25	15	10		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-14	0.22	0.14	0.035		0.0	9.2	17.0	35.9	27.1	10.7
⊠	B-14	0.08	0.03	0.006		0.0	2.2	8.4	30.8	31.5	27.1

PROJECT ODOT COND. EVAL. LAKE COUNTY PROJECT NO. W-16-171

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

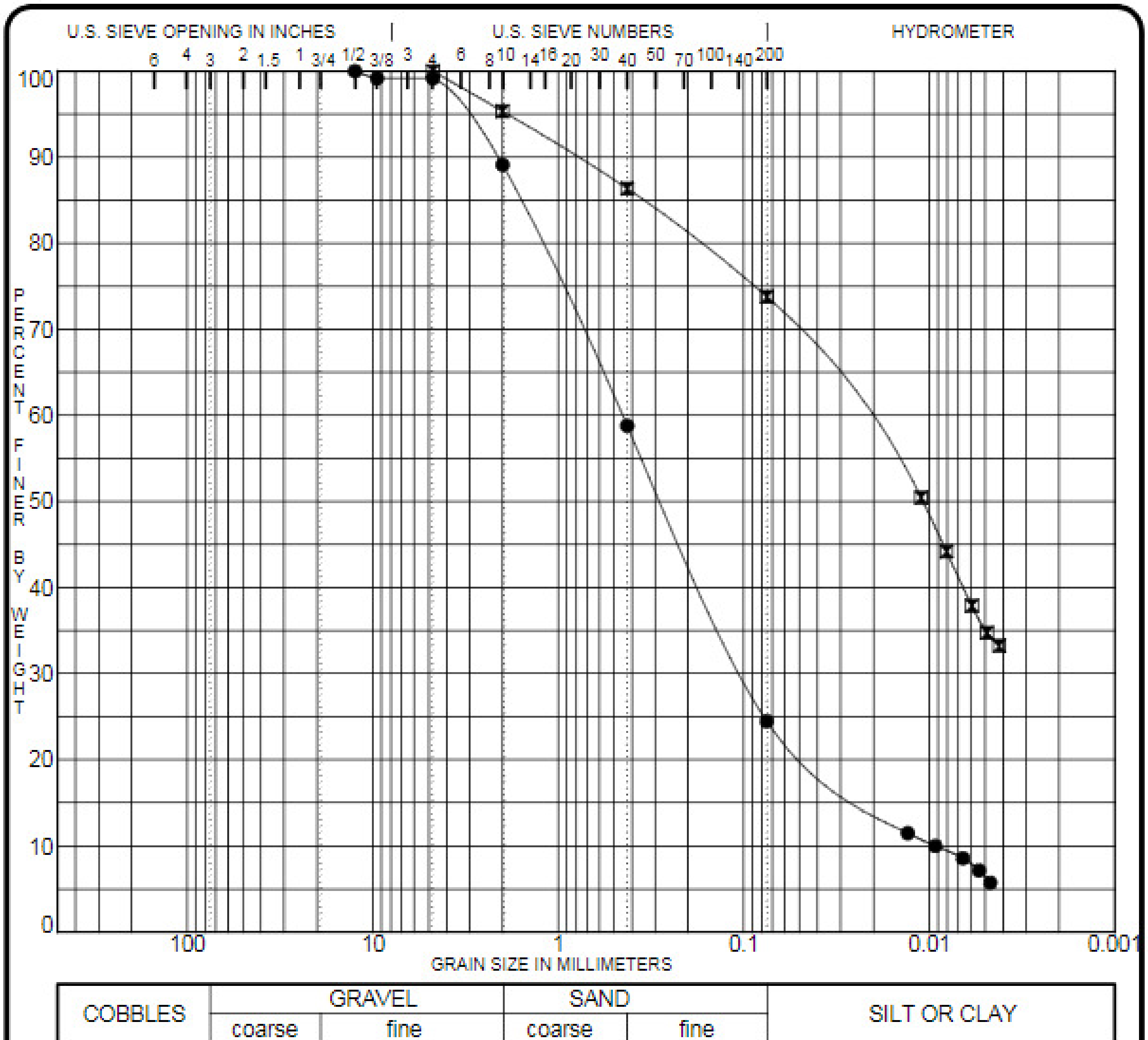
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	**B-15**	**1.5**	**A-3a**	**1293**		**12**	**NP**	**NP**	**NP**	**2.87**	**65.9**
⊠	**B-15**	**2.7**	**A-4a**	**1513**		**14**	**25**	**17**	**8**		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	**B-15**	**0.39**	**0.23**	**0.082**	**0.0060**	**0.0**	**17.9**	**20.7**	**33.2**	**19.7**	**8.5**
⊠	**B-15**	**0.07**	**0.03**	**0.007**		**0.0**	**8.6**	**11.8**	**18.5**	**37.1**	**24.1**

PROJECT **ODOT COND. EVAL. LAKE COUNTY** PROJECT NO. **W-16-171**

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.



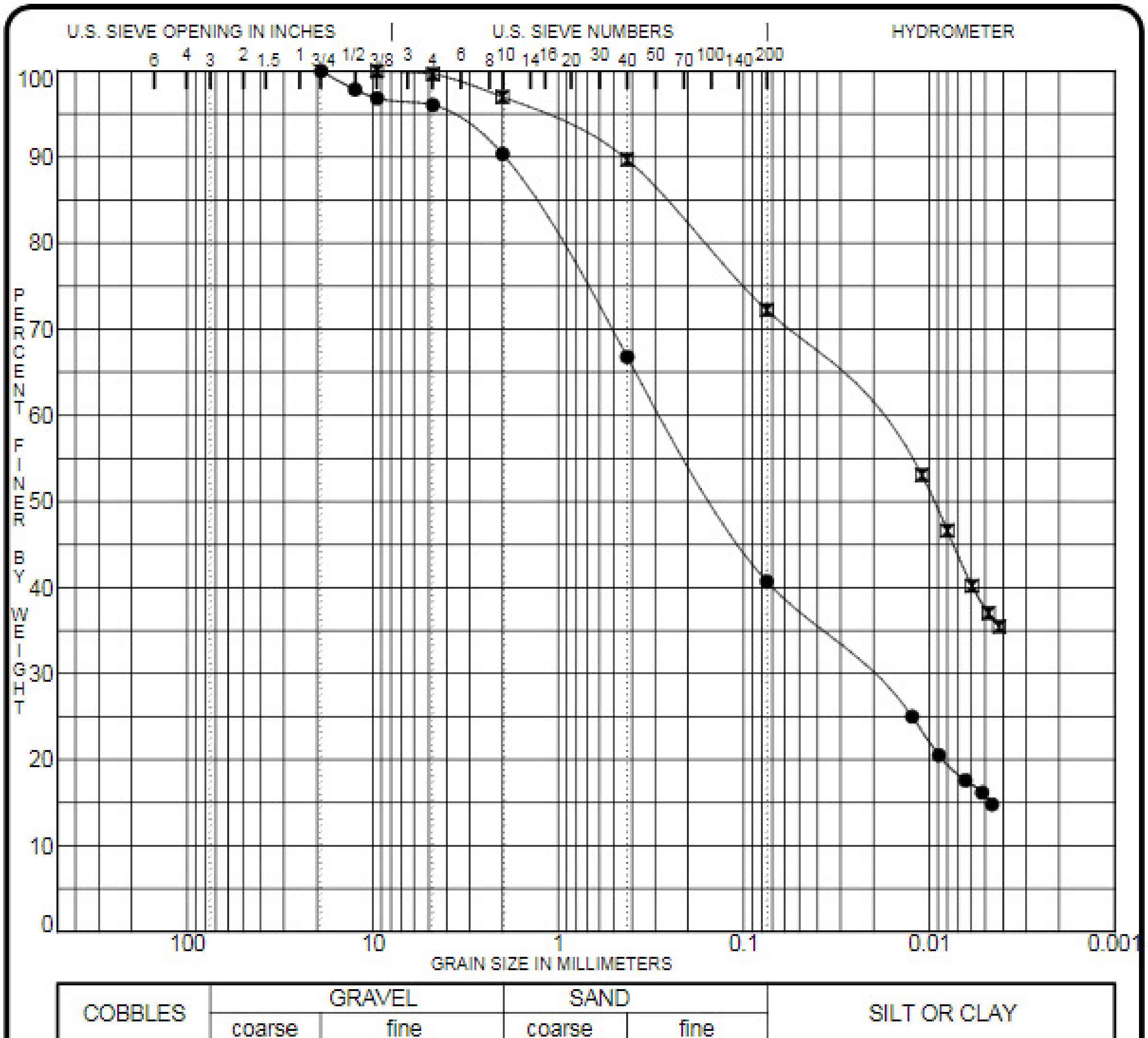
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-16	1.3	A-3a	2920		13	NP	NP	NP	2.35	48.7
⊠	B-16	2.6	A-6a	2640		12	27	16	11		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-16	0.45	0.27	0.099	0.0093	0.0	10.9	30.3	34.4	18.1	6.4
⊠	B-16	0.02	0.01			0.0	4.7	9.0	12.6	38.7	35.1

PROJECT **ODOT COND. EVAL. LAKE COUNTY** PROJECT NO. **W-16-171**

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.



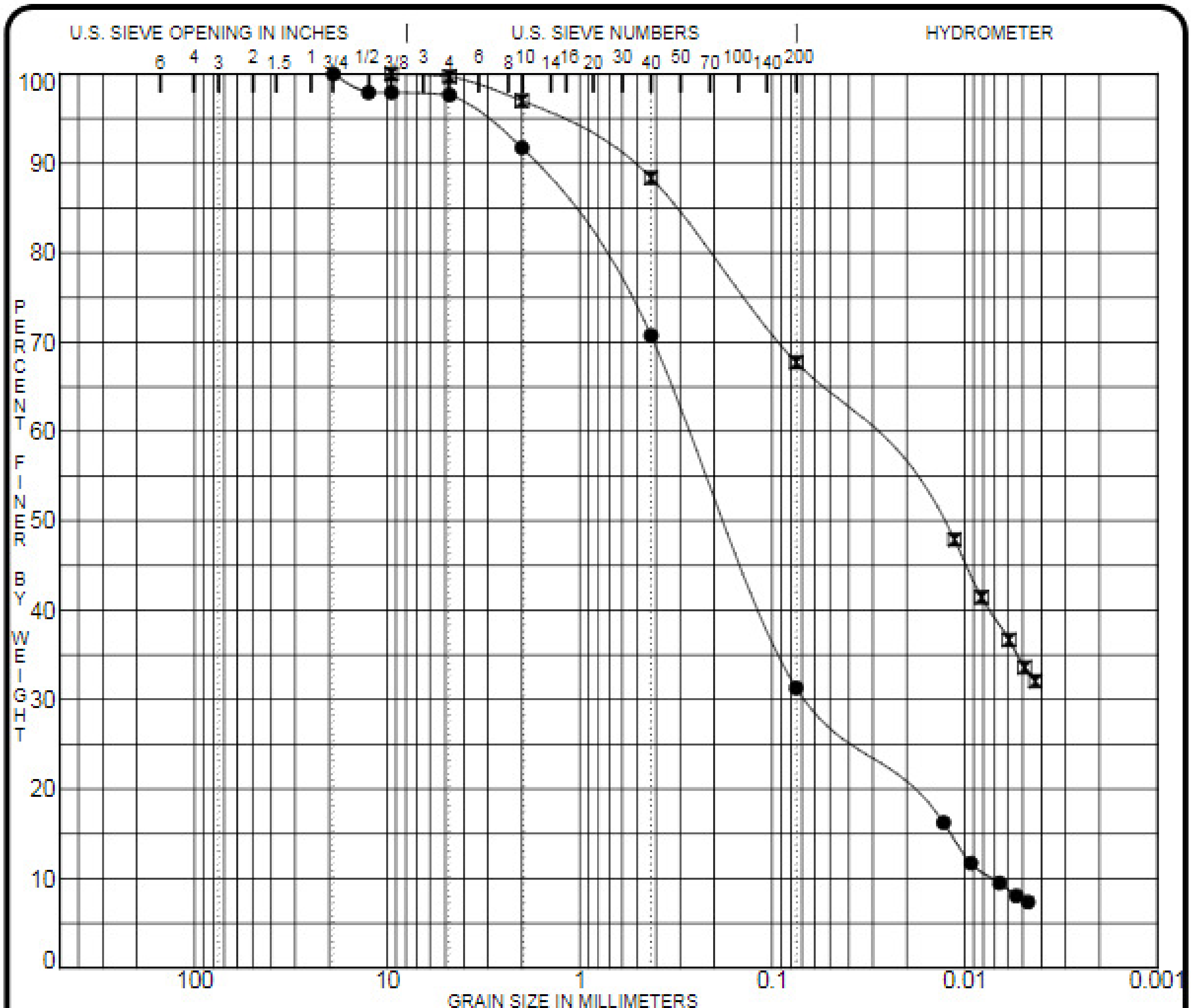
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-17	1.5	A-4a	2987		15	30	23	7		
⌧	B-17	3.0	A-6a	2680		16	32	18	14		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-17	0.27	0.14	0.022		0.0	9.6	23.6	26.1	25.0	15.7
⌧	B-17	0.02	0.01			0.0	3.0	7.3	17.5	34.6	37.7

PROJECT ODOT COND. EVAL. LAKE COUNTY PROJECT NO. W-16-171

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

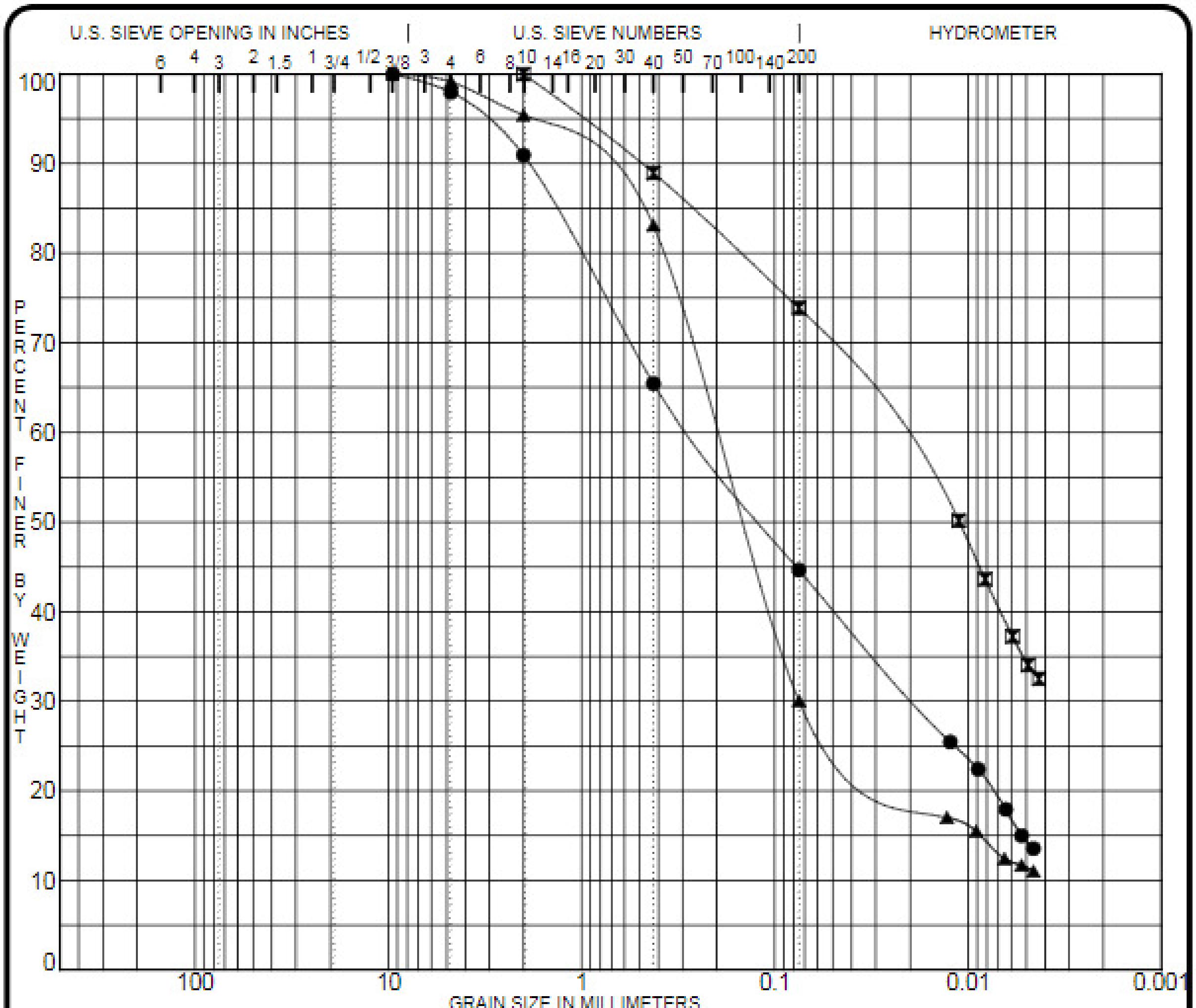
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-18	1.8	A-3a	2840		17	NP	NP	NP	2.19	37.1
⊠	B-18	3.1	A-6a	2747		16	26	15	11		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-18	0.26	0.17	0.064	0.0071	0.0	8.2	21.0	39.4	23.6	7.7
⊠	B-18	0.04	0.01			0.0	3.0	8.6	20.6	33.8	33.9

PROJECT **ODOT COND. EVAL. LAKE COUNTY** PROJECT NO. **W-16-171**

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

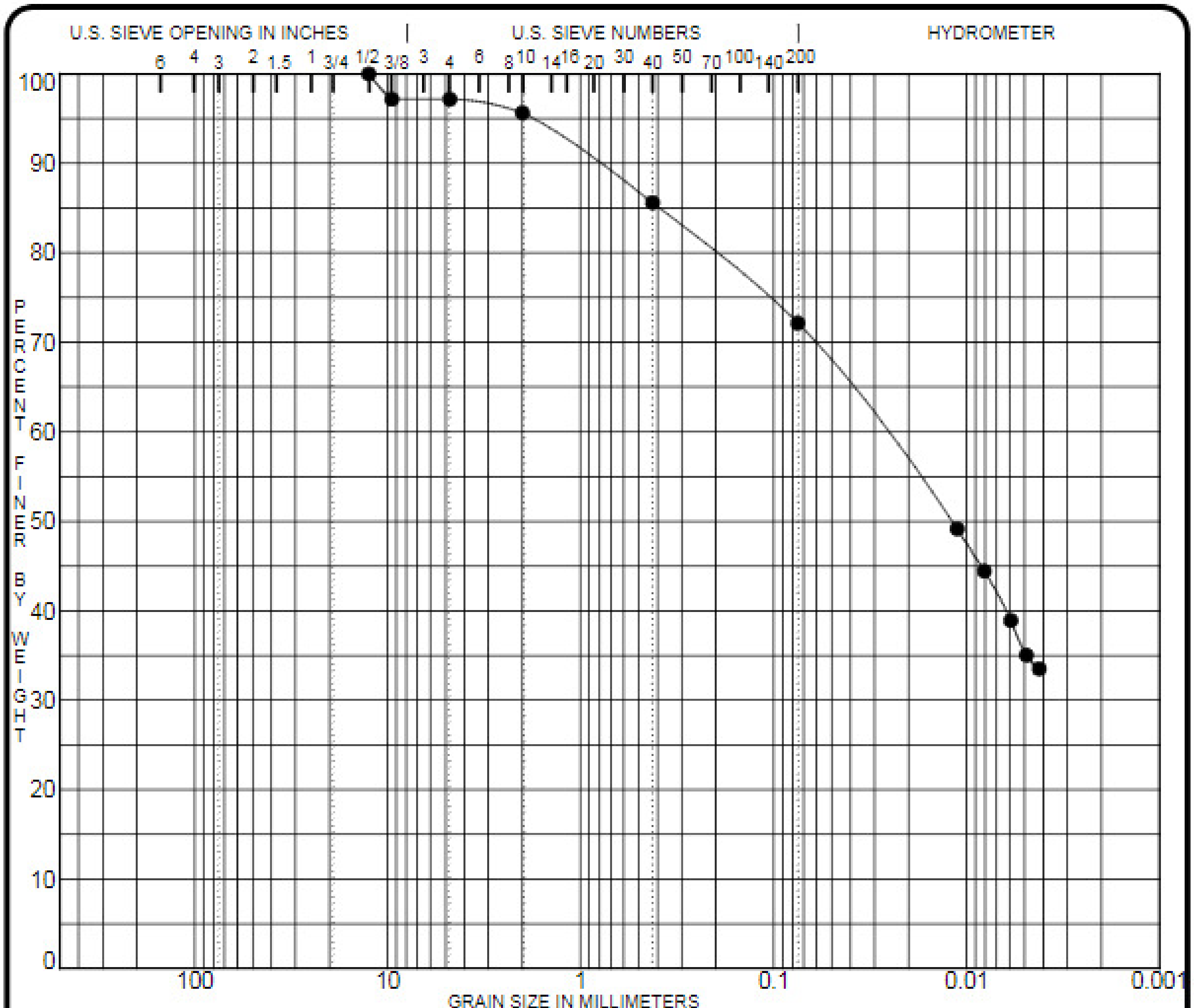
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-19	1.3	A-4a	4907		25	35	26	9		
⌧	B-19	3.1	A-6a	1547		15	29	17	12		
▲	B-19	4.1	A-3a			15	NP	NP	NP		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-19	0.27	0.12	0.019		0.0	9.1	25.5	20.8	30.3	14.4
⌧	B-19	0.02	0.01			0.0	0.0	11.0	15.1	39.5	34.4
▲	B-19	0.20	0.14	0.075		0.0	4.6	12.3	53.1	18.6	11.4

PROJECT ODOT COND. EVAL. LAKE COUNTY PROJECT NO. W-16-171

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-20	3.1	A-6a	2000		12	28	16	12		

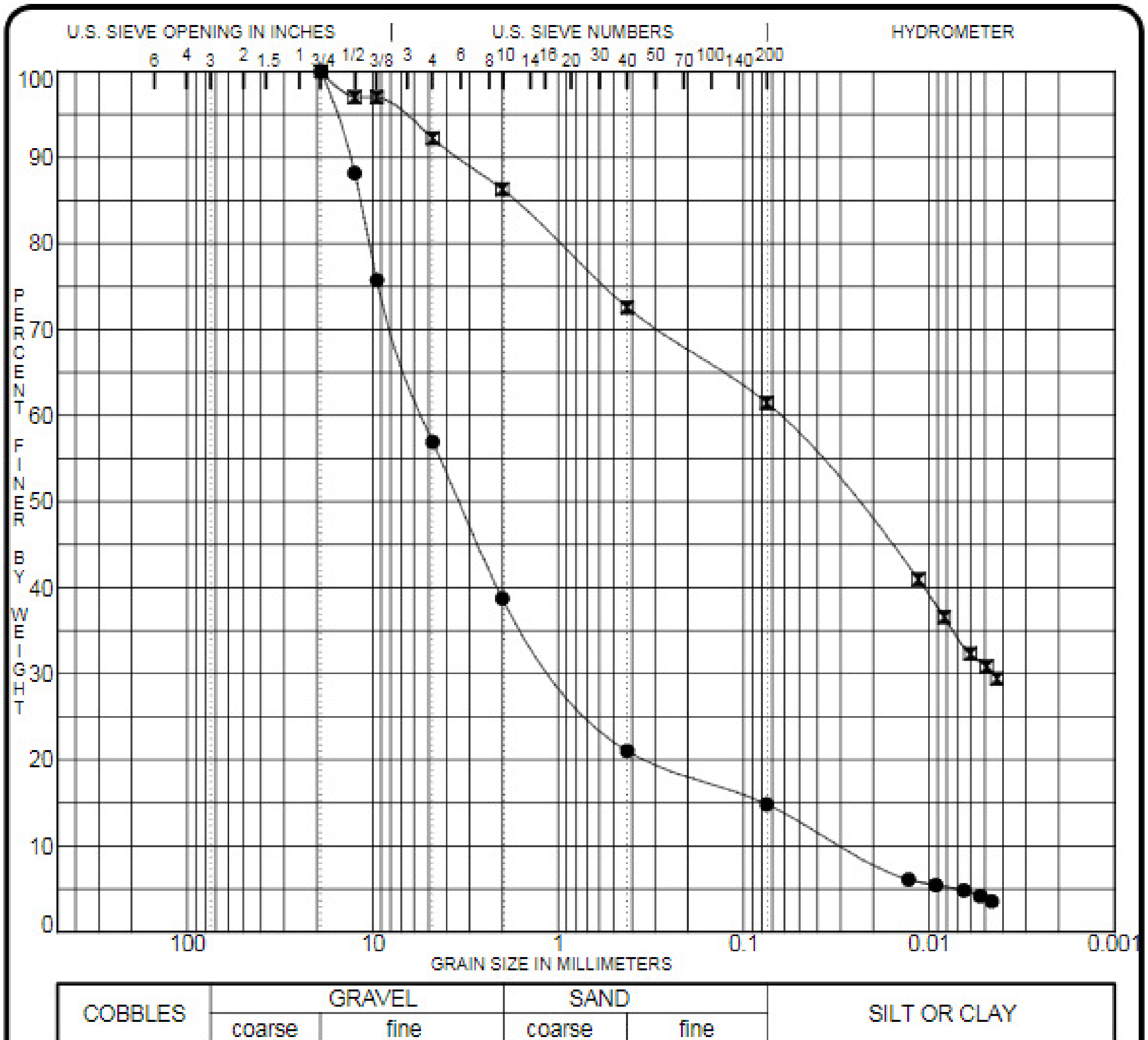
	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-20	0.03	0.01			0.0	4.3	10.1	13.5	36.7	35.5

PROJECT ODOT COND. EVAL. LAKE COUNTY PROJECT NO. W-16-171

GRADATION CURVES

RESOURCE INTERNATIONAL, INC.

MRW-71 Gradation Plots



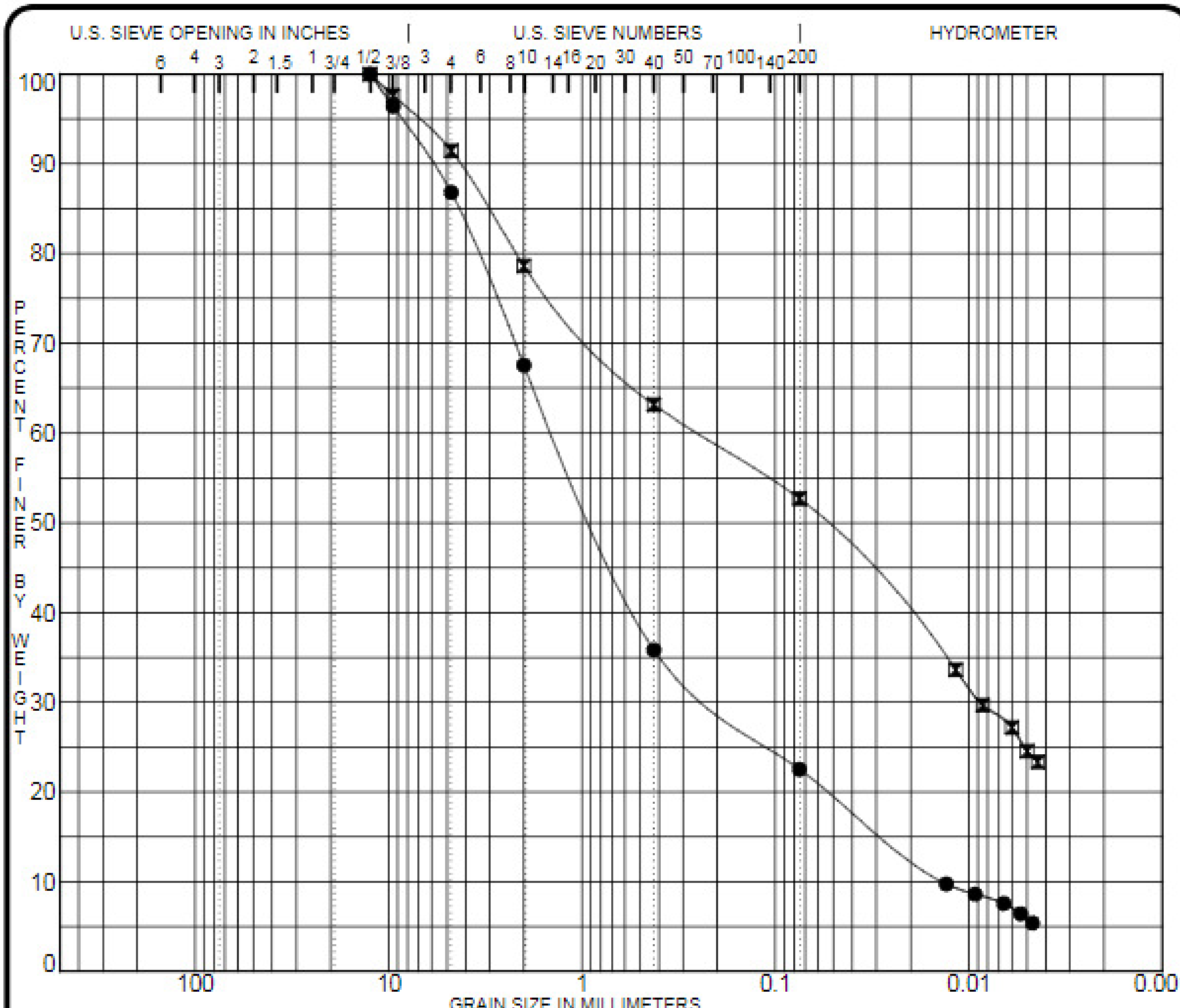
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-01	1.1	A-1-a	467		9	NP	NP	NP	5.74	187.2
⧗	B-01	4.1	A-4a	767		12	25	17	8		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-01	5.32	3.42	0.931	0.0284	0.0	61.3	17.7	6.2	10.9	3.9
⧗	B-01	0.07	0.03	0.005		0.0	13.7	13.7	11.1	30.5	31.0

PROJECT ODOT Cond. Eval. MRW-71 PROJECT NO. W-16-171

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

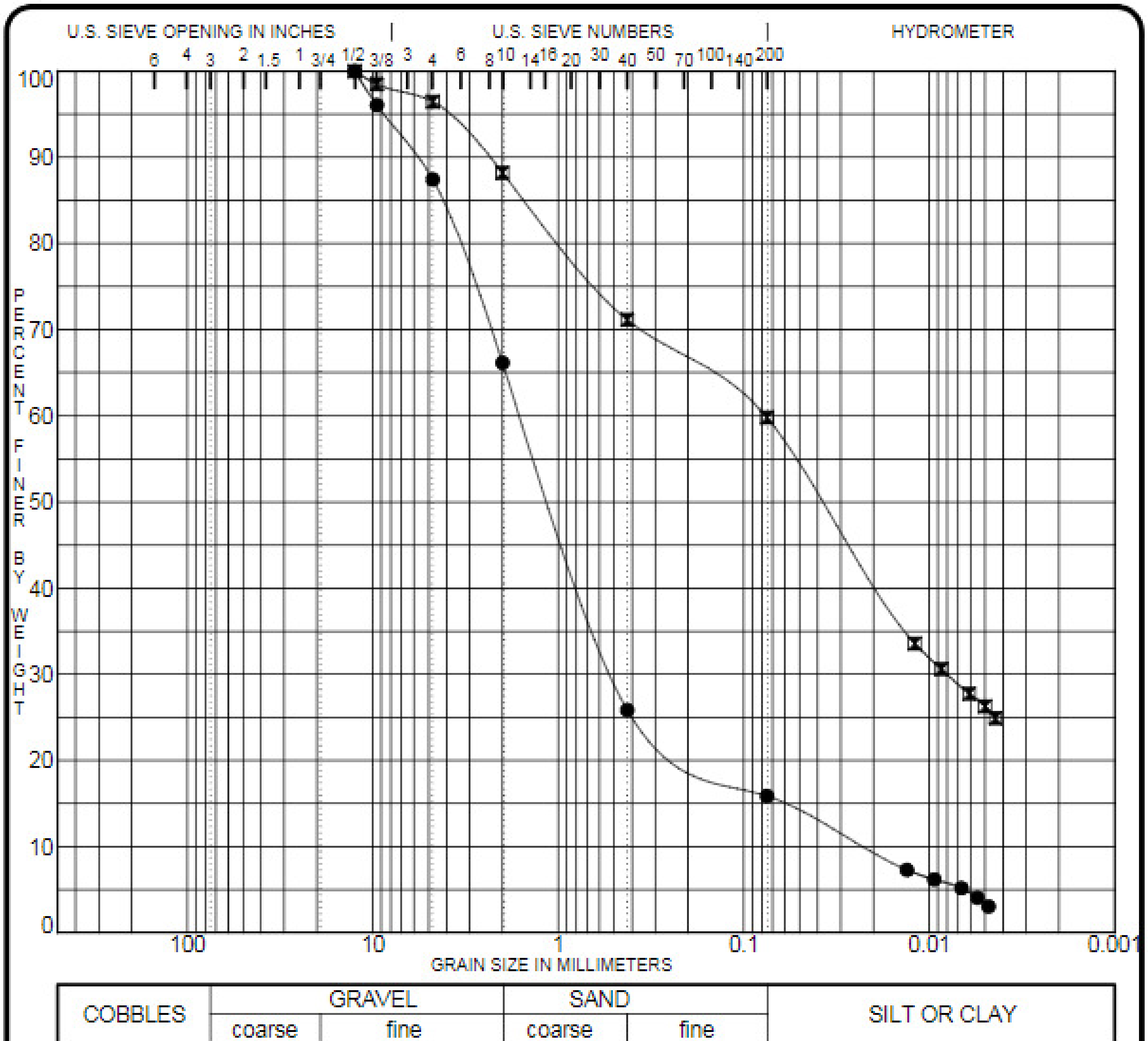
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-02	1.2	A-2-4	5147		14	35	28	7	2.09	101.8
⌧	B-02	3.0	A-4a	1433		12	25	17	8		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-02	1.38	0.85	0.199	0.0136	0.0	32.5	31.7	13.3	16.7	5.8
⌧	B-02	0.25	0.06	0.009		0.0	21.4	15.5	10.4	28.2	24.5

PROJECT **ODOT Cond. Eval. MRW-71** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-03	1.1	A-1-b	1653		14	34	28	6	6.87	69.0
⌧	B-03	2.9	A-4a	920		10	26	17	9		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-03	1.58	1.08	0.498	0.0229	0.0	33.9	40.3	10.0	12.5	3.3
⌧	B-03	0.08	0.04	0.008		0.0	11.8	17.1	11.3	33.6	26.3

PROJECT ODOT Cond. Eval. MRW-71 PROJECT NO. W-16-171

GRADATION CURVES

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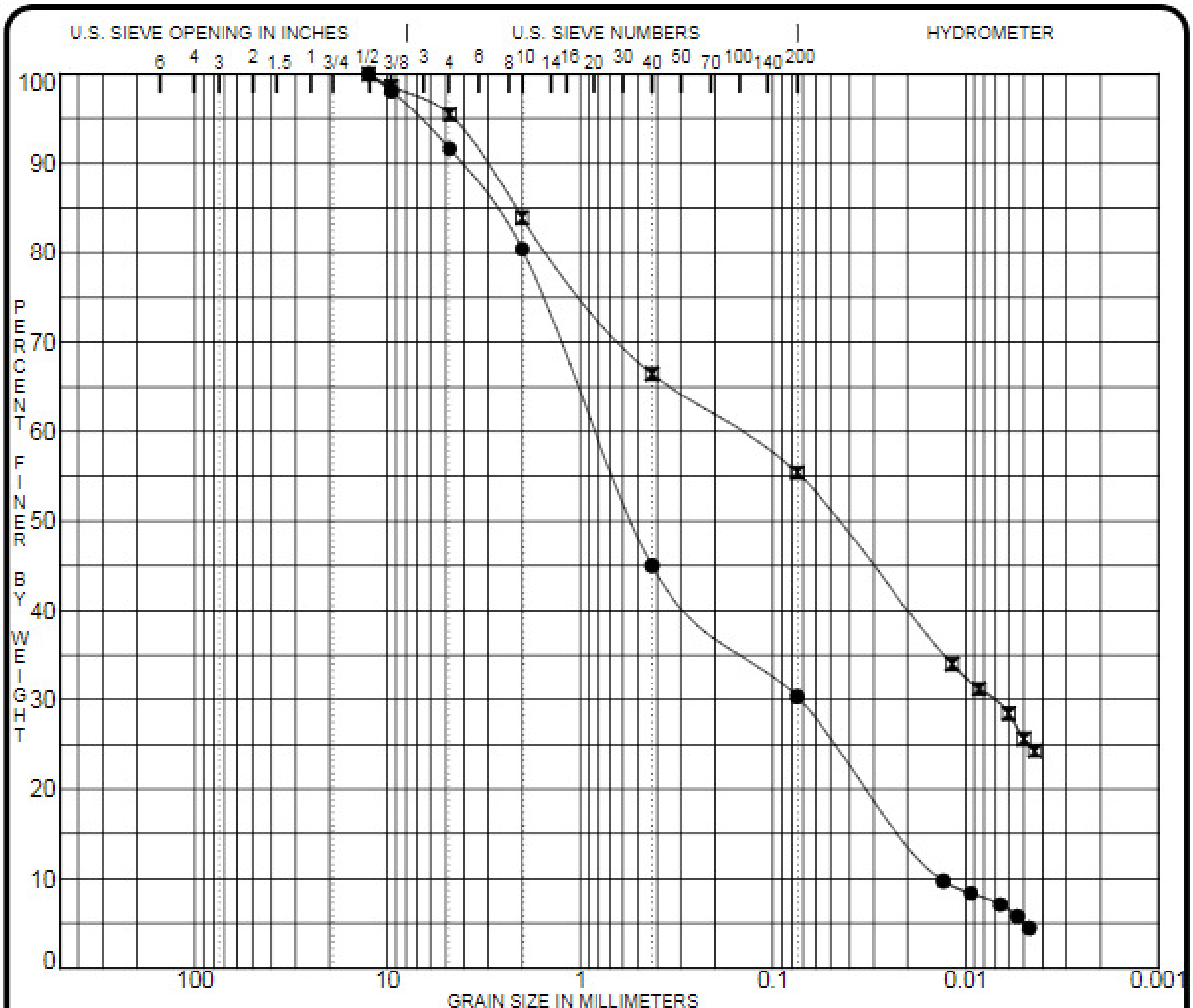

COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-04	1.1	A-2-4	7760		13	34	27	7	0.49	61.1
⧗	B-04	2.9	A-4a	913		16	25	17	8		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-04	0.82	0.53	0.073	0.0134	0.0	19.6	35.4	14.7	25.3	5.0
⧗	B-04	0.15	0.05	0.007		0.0	16.1	17.5	11.1	29.8	25.6

PROJECT ODOT Cond. Eval. MRW-71 PROJECT NO. W-16-171

GRADATION CURVES

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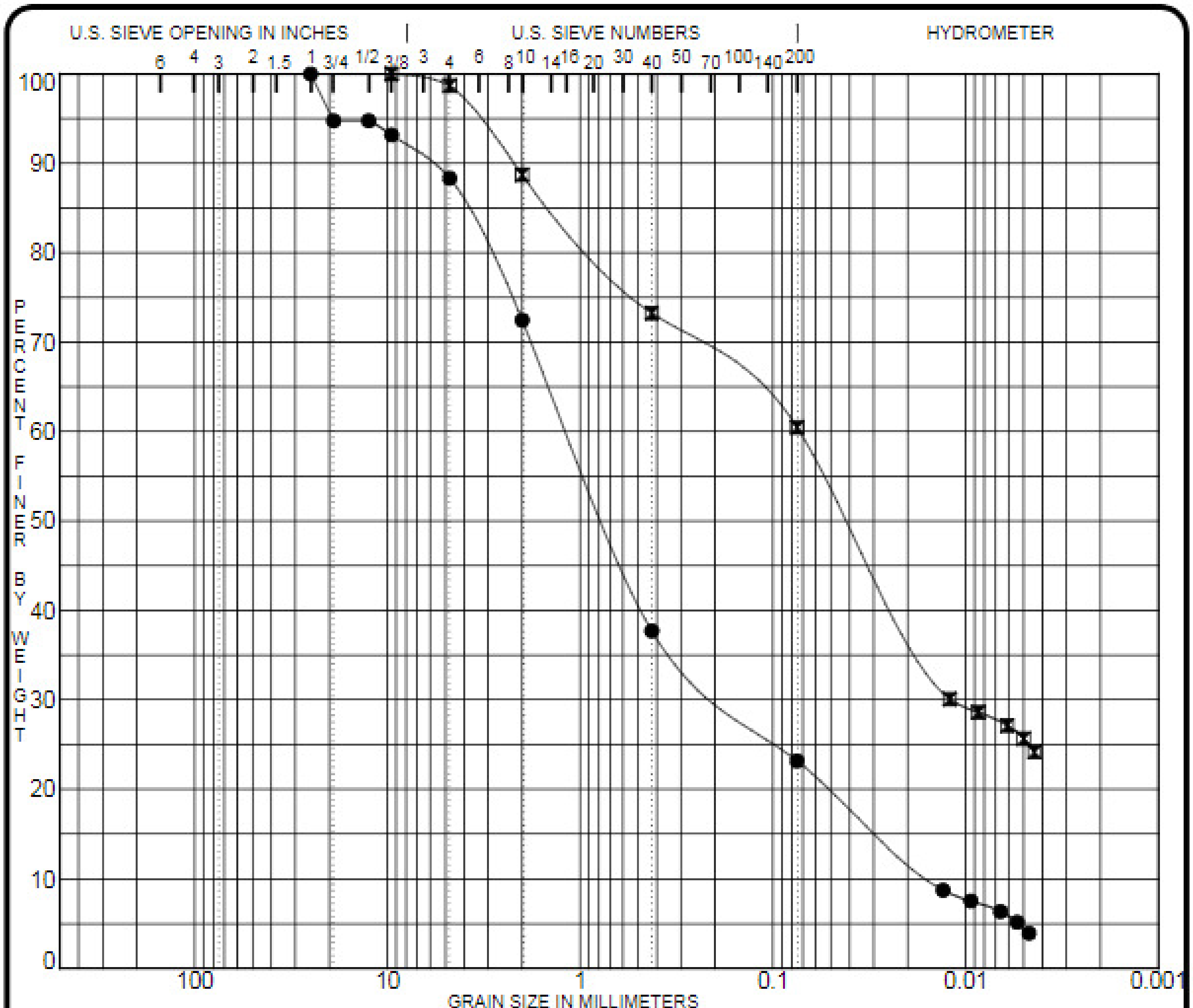

COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-05	1.1	A-2-4	8907		14	34	26	8	1.64	75.3
⌧	B-05	2.6	A-6a	2373		12	29	17	12		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-05	1.15	0.74	0.170	0.0152	5.2	22.3	34.8	14.5	18.7	4.5
⌧	B-05	0.07	0.04	0.012		0.0	11.3	15.5	12.8	34.8	25.6

PROJECT **ODOT Cond. Eval. MRW-71** PROJECT NO. **W-16-171**

GRADATION CURVES

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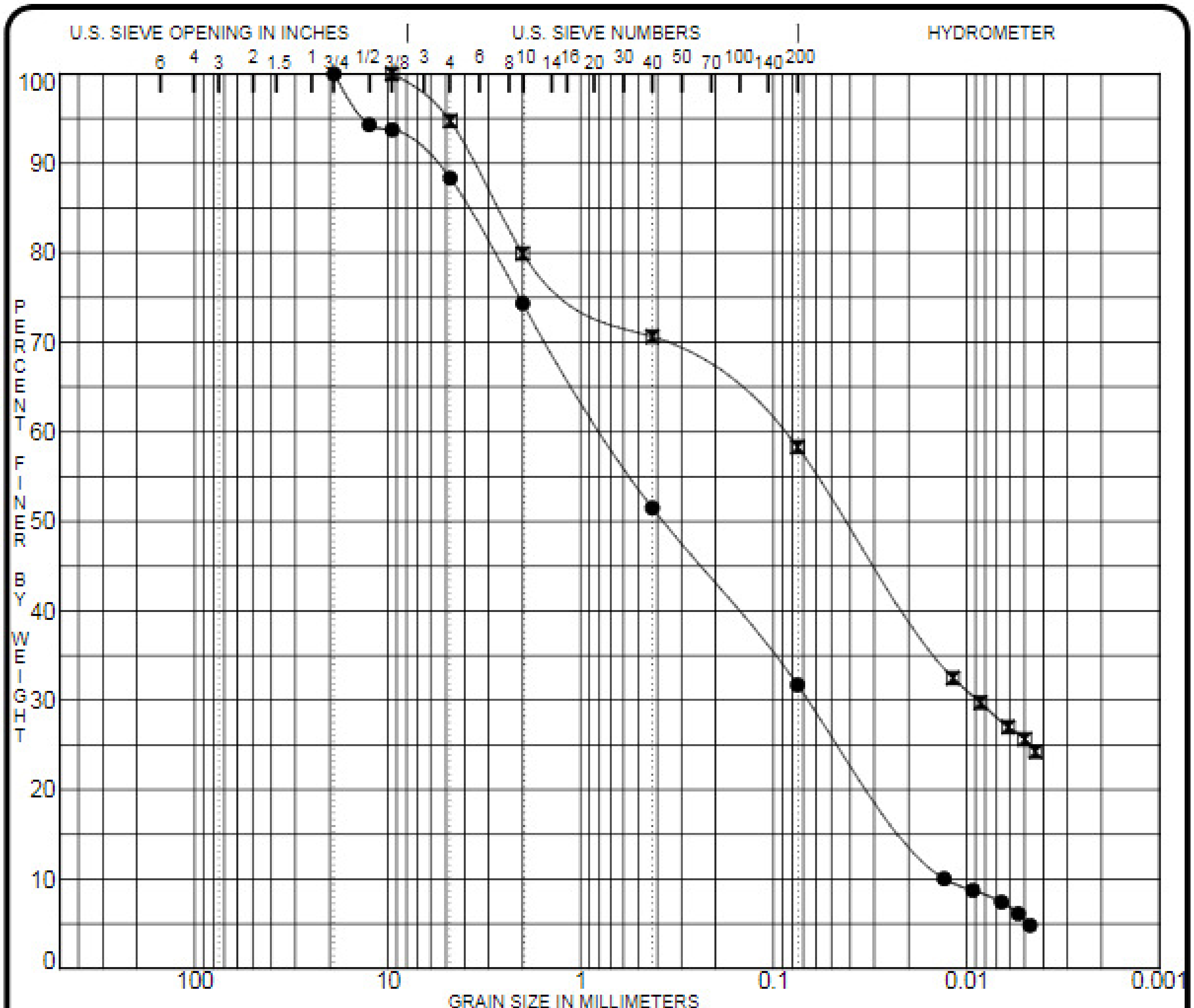

COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-06	1.2	A-2-6	660		15	38	25	13	0.43	58.2
⧗	B-06	3.0	A-6a	6347		11	30	17	13		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-06	0.76	0.37	0.065	0.0130	0.0	25.7	22.8	19.8	26.3	5.4
⧗	B-06	0.10	0.04	0.009		0.0	20.1	9.3	12.3	32.7	25.6

PROJECT **ODOT Cond. Eval. MRW-71** PROJECT NO. **W-16-171**

GRADATION CURVES

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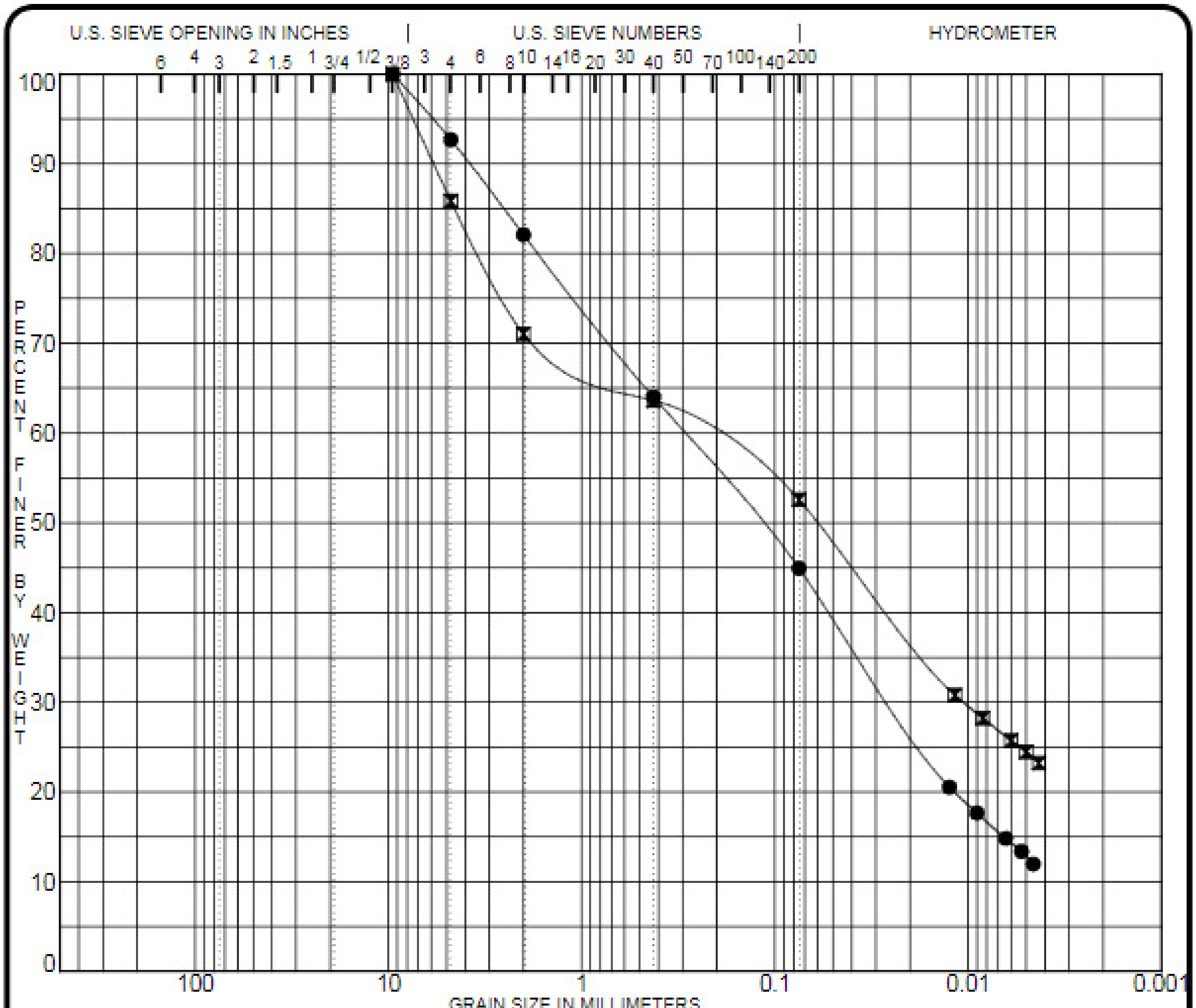

COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-07	1.1	A-4a	5547		15	29	24	5		
⧗	B-07	2.6	A-6a	1100		15	29	18	11		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-07	0.30	0.12	0.025		0.0	17.9	18.1	19.0	32.1	12.8
⧗	B-07	0.24	0.06	0.011		0.0	29.0	7.4	11.0	28.1	24.5

PROJECT ODOT Cond. Eval. MRW-71 PROJECT NO. W-16-171

GRADATION CURVES

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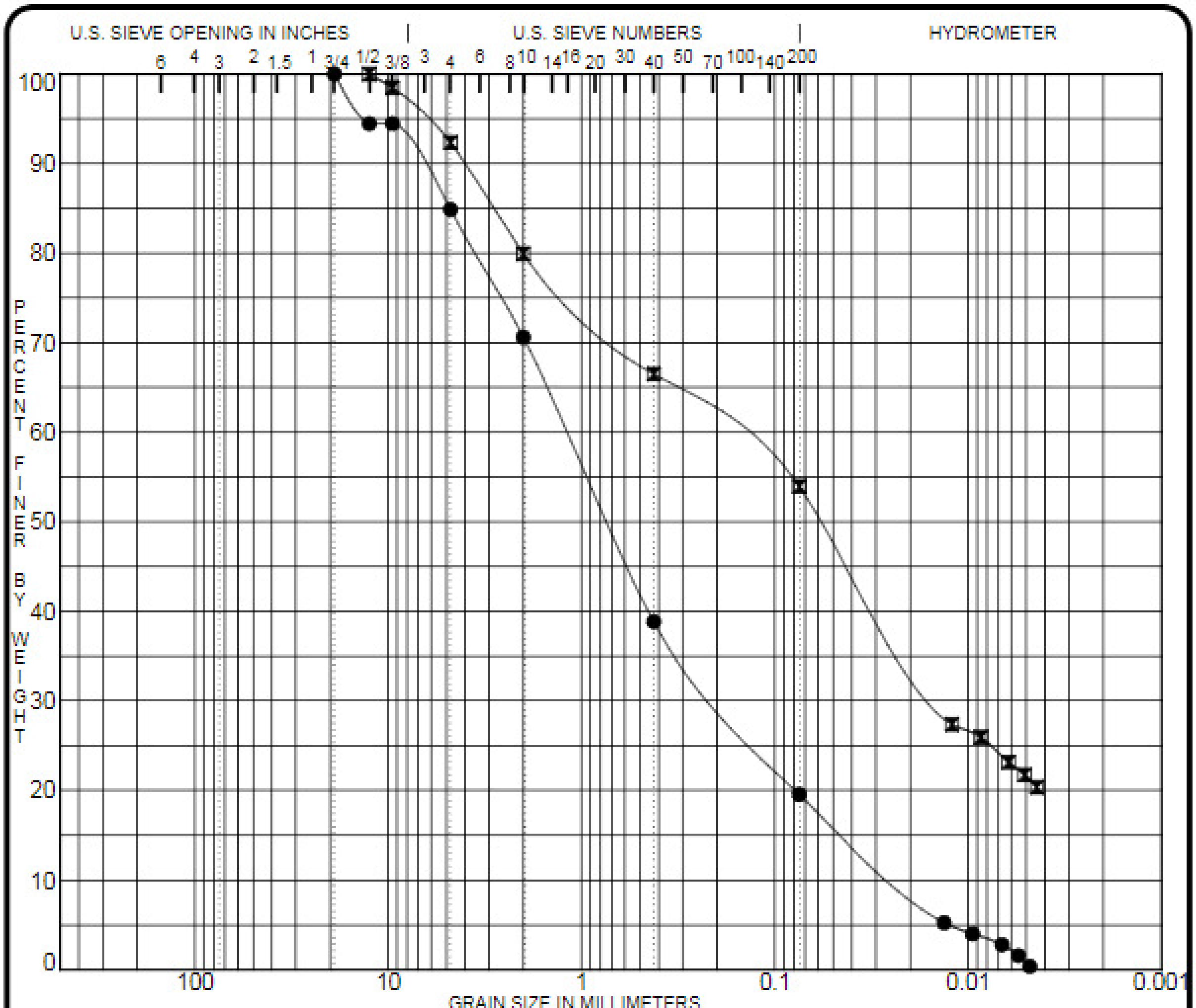

COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-08	1.0	A-1-b	3573		12	NP	NP	NP	1.31	50.4
⧗	B-08	2.8	A-6a	1193		14	28	17	11		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-08	1.19	0.73	0.192	0.0237	0.0	29.4	31.8	19.3	18.7	0.8
⧗	B-08	0.17	0.06	0.014		0.0	20.1	13.5	12.5	32.4	21.5

PROJECT **ODOT Cond. Eval. MRW-71** PROJECT NO. **W-16-171**

GRADATION CURVES

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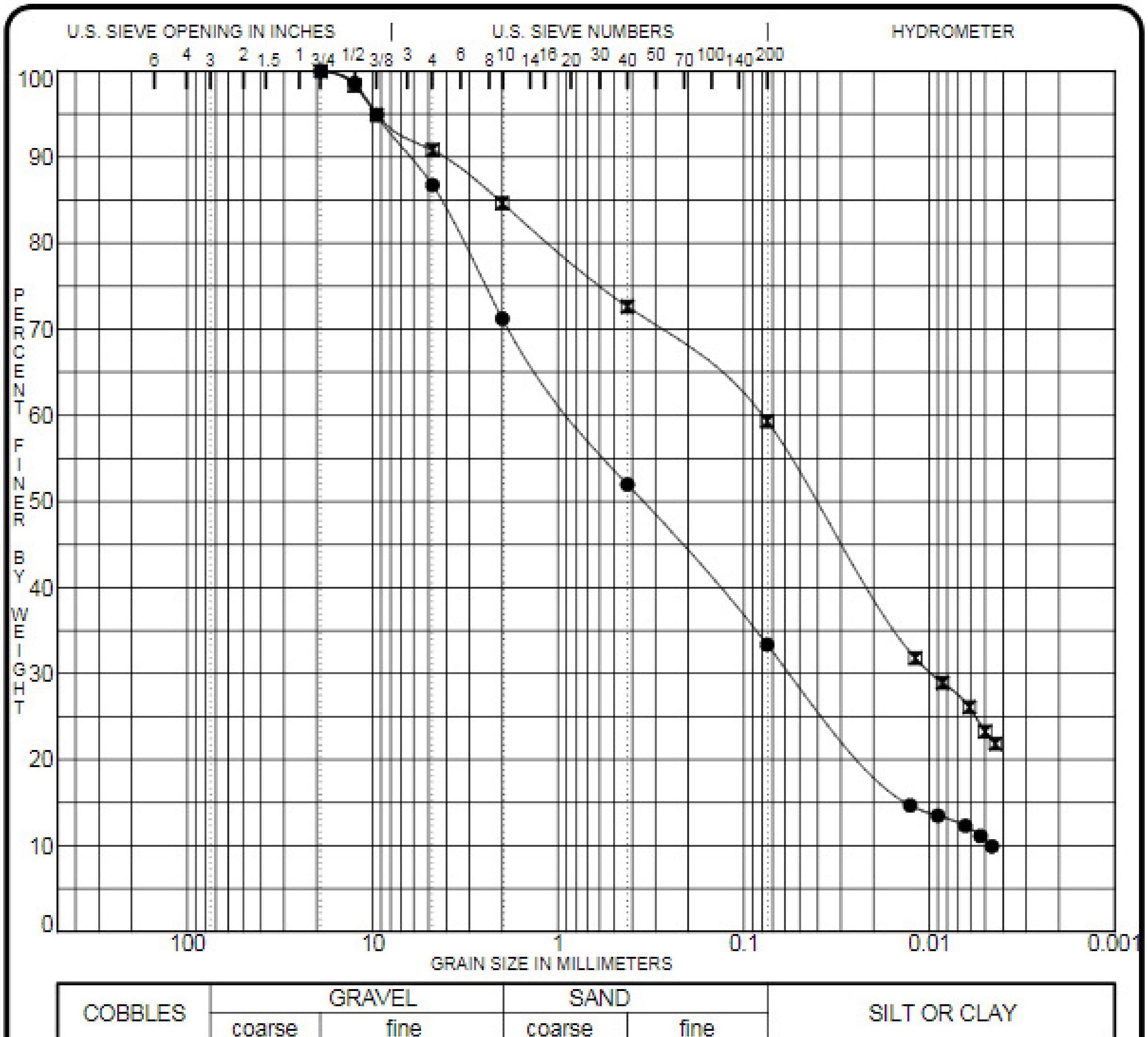


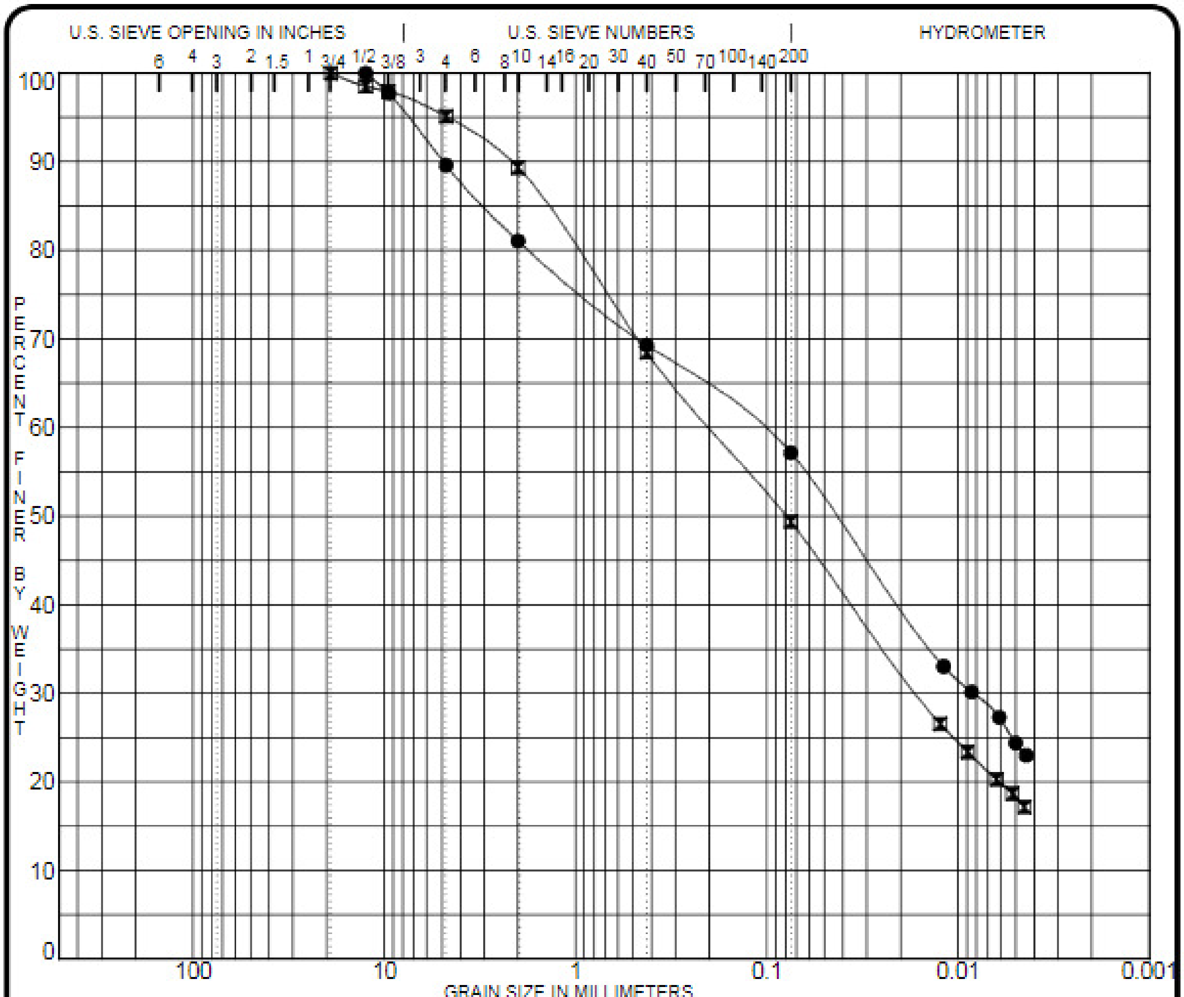
	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-09	1.1	A-2-4	4987		12	28	26	2	0.79	174.3
⧗	B-09	3.1	A-4a	3627		15	30	23	7		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-09	0.81	0.35	0.054	0.0046	0.0	28.8	19.2	18.6	22.8	10.6
⧗	B-09	0.08	0.04	0.010		0.0	15.4	12.0	13.3	36.1	23.2

PROJECT **ODOT Cond. Eval. MRW-71** PROJECT NO. **W-16-171**

GRADATION CURVES

RII



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen ID / Station	Depth	Classification	SC(ppm)	LBI%	MC%	LL	PL	PI	Cz	Cu
●	B-10	1.1	A-4a	1653		15	29	23	6		
⌧	B-10	2.9	A-4a	967		13	27	18	9		

	Specimen ID	D60	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	B-10	0.11	0.04	0.008		0.0	19.0	11.8	12.1	32.8	24.4
⌧	B-10	0.20	0.08	0.016		0.0	10.6	20.9	19.1	31.1	18.3

PROJECT ODOT Cond. Eval. MRW-71 PROJECT NO. W-16-171

GRADATION CURVES

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