GEOTECHNICAL EXPLORATION

24" WATER LINE CROSSING

LITTLE MIAMI RIVER AT OHIO S.R. 48

WARREN COUNTY, OHIO

Prepared for: **Warren County Water and Sewer**
Thelen Project No.: **100228NE**

THELEN ASSOCIATES, INC.

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May 20, 2010

Warren County Water and Sewer
P.O. Box 530
406 Justice Drive
Lebanon, Ohio 45036

Attention: Mr. Chris Brausch, P.E.

Re: Geotechnical Exploration
24" Water Line Crossing
Little Miami River at S.R. 48
Warren County, Ohio

Ladies and Gentlemen:

Contained herein are the results of a geotechnical exploration performed for the extension of a water main beneath the Little Miami River, immediately east of the Ohio S.R. 48 bridge in the Village of South Lebanon, Warren County, Ohio. Our services were performed in accordance with our Proposal-Agreement N210111 dated March 25, 2010. Authorization to proceed based upon this Proposal-Agreement was provided with the receipt of Purchase Order No. 79081 received on April 20, 2010.

We are enclosing with this report a reprint of "Important Information About Your Geotechnical Engineering Report" published by ASFE, Professional Firms Practicing in the Geosciences, which our firm would like to introduce to you at this time.

We appreciate the opportunity to provide the geotechnical exploration for the proposed water line crossing. Should you have any questions concerning the information, conclusions or recommendations contained in this report, please do not hesitate to contact us.

Respectfully submitted,
THELEN ASSOCIATES, INC.

5/21/10

STATE OF OHIO
CHRISTOPHER C. HAMANT
E-63811
REGISTERED ENGINEER

Christopher C. Hamant, P.E.
Senior Geotechnical Engineer

Arthur T. Sturbaum, P.E.
Senior Geotechnical Engineer

CCH:ATS:ph
100228NE

Copies submitted: Client (2m, 1e)
Henderson & Bodwell, LLP (1m, 1e)

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GEOTECHNICAL EXPLORATION
24" WATER LINE CROSSING
LITTLE MIAMI RIVER AT OHIO S.R. 48
WARREN COUNTY, OHIO

1.0 INTRODUCTION

This report contains the results of a geotechnical exploration performed for a water main crossing beneath the Little Miami River, immediately east of the Ohio S.R. 48 bridge in the Village of South Lebanon, Warren County, Ohio.

2.0 SCOPE

The purposes of our services were to determine the general subsurface profile in the vicinity of the water line crossing and to relate the engineering properties of the subsurface soils and bedrock; that is their strength, classification and compressibility characteristics to the proposed design and construction of the waterline crossing.

3.0 PROJECT CHARACTERISTICS

The water line expansion project is designed by Henderson & Bodwell, LLP It is our understanding that the water main will be a 24-inch diameter ductile iron pipe. A crossing beneath the Little Miami River will occur at an alignment between 30 and 150 feet east of the S.R.48 bridge. The water main approaching the river crossing may be buried with minimum cover (4 to 5 feet), however, the depth of cover may deepen for the river crossing and will be based upon the type of construction utilized.

It is our understanding that current considerations for the crossing involve horizontal directional drilling (HDD) or cut and cover techniques. Cut and cover techniques are less preferred due to the ecological sensitivity of the river.

4.0 FIELD EXPLORATION

The scope of our services included four (4) test borings at locations requested by Henderson & Bodwell, LLP The test borings were staked in the field by our personnel and our survey team located the test borings in plan. The elevations of the test borings were related to site features such as manholes, hydrants, etc. The boring locations are indicated on the Boring Plan, Drawing 100228NE-1, which is included in the Appendix to this report. Henderson & Bodwell, LLP provided an elevation for the manhole rim located south of the river, near a fire hydrant. This served as a site benchmark, with a rim at El. 610.4 feet above Mean Sea Level (MSL). The elevations of the test borings relative to this site benchmark were then determined and are indicated on the individual test boring logs.

The test borings were performed with an ATV-mounted drill rig and hollow-stem augers. Two-inch O.D. split-spoon samples were obtained in advance of augering according to the procedures of ASTM D1586. This procedure is described as the standard drive sample method and results in the standard penetration test. In addition, three (3) 3-inch O.D. Shelby tubes were pushed at intervals preselected by the Project Geotechnical Engineer. Representative portions of the recovered split-spoon samples were placed in glass jars and the Shelby tubes were capped and taped to maintain the soils at their in situ moisture contents. All samples were appropriately marked in the field for proper identification.

Once the test borings encountered the surface of the unweathered bedrock, interbedded shale and limestone, Test Borings 1, 3 and 4 were extended to the design 40 foot depth by rock coring using an NX 1-7/8 inch wireline core barrel advanced into the bedrock using water as a lubricant/coolant. The recovered cores were placed in core boxes.

Concurrent with the drilling operation, the Drilling Technician prepared field test boring logs of the subsurface profile, noting soil and bedrock types and stratifications, sample intervals, standard penetration test resistances (N-values), groundwater levels or the lack thereof and other pertinent data.

Field permeability testing was performed on Test Borings 1 and 4. This testing was performed by advancing the hollow stem augers to the test depths, then performing constant head field permeability tests by pumping water into the hollow stems of the augers. A relatively steady flow rate was established while maintaining a consistent hydraulic head. Permeability of the encountered soil strata was then determined based upon US Bureau of Reclamation equations.

5.0 LABORATORY REVIEW

Following completion of the test borings, the samples were returned to our Soil Mechanics Laboratory where they were reviewed and visually classified by the Project Geotechnical Engineer. Representative samples were selected for natural moisture content and natural dry density determinations, Atterberg limit and gradation classification tests and unconfined compressive strength tests. A tabulation of the laboratory test results is included in the Appendix to this report.

Based on the Drilling Technician's field logs, the results of the laboratory tests and the Engineer's visual classification of the samples, the final test boring logs were prepared. Copies of these logs are included in the Appendix along with a Soil Classification Sheet describing the terms and symbols used in their preparation. Recovered rock core samples were classified according to Ohio Department of Transportation (ODOT) guidelines. Photographs of the rock cores were taken and are included in the Appendix to this report.

The dashed lines on the test boring logs identifying the changes between soil or bedrock types were determined by interpolation between the samples and should be considered to be approximate. Only changes which occur within samples can be precisely determined and are indicated by solid lines on the logs. The transition between soil and bedrock types may be abrupt or gradual.

6.0 SUBSURFACE PROFILE

Shallow soils at the site are comprised of flood plain alluvium or some man placed fill, likely resulting from the construction of the bridge and adjacent utilities. The alluvial soils are described as very loose clayey sand or medium stiff to stiff silty clay and extend from the ground surface to a depth between 6.0 and 9.5 feet. A sample of the alluvium between 5.8 and 6.3 feet from the ground surface obtained from a Shelby tube in Test Boring 1 yielded an unconfined compressive strength of 2,670 pounds per square foot and a natural dry density of 94.7 pounds per cubic foot (pcf). This material has an Atterberg liquid limit of 44 and a plasticity index (liquid limit minus plastic limit) of 20. The natural moisture content is 28.4 percent.

Underlying the alluvium, the profile transitions into outwash deposits of sand and gravel. The upper 5 to 10 feet of these deposits often contain 10 to 30 percent fines (silts and clays). These deposits are medium dense to dense. Standard penetration test resistances (N-values) of the outwash deposits are typically in the low teens to low thirties. The N-value is defined as the number of blows required by a 140-pound hammer dropping 30 inches to advance a 2-inch O.D. split-spoon sampler a distance of 12 inches. Blow counts are recorded in 6-inch intervals on the test boring logs. It is customary to disregard the initial 6-inch blow count reading for each sample and to report the N-value as the sum of the second and third readings.

The outwash deposits were classified based upon the Unified Soil Classification System (USCS). These soils range between well-graded silty sand (SW-SM) to well-graded silty gravel (GW-GM). Specific classifications are indicated on the boring log for Test Boring 1, for which laboratory testing was performed on the majority of the strata.

All four test borings extended into the surface of the bedrock, interbedded shale and limestone. The bedrock surface was encountered as depths ranging between 19.5 (Test Boring 4) and 28.3 (Test Boring 1) feet below current grades. The bedrock consists of interbedded Ordovician Age shale and limestone. The bedrock is typical of the area and weathers from the surface down. The upper limits of the bedrock are often described as highly weathered, where the shale portion is brown and is weaker than the underlying shales, having weathered to a near clay-like consistency. In some instances, the weathered bedrock is not present and there is a transition directly from the outwash sand and gravel to the parent, gray, unweathered shale and limestone.

The limestone occurring within the bedrock strata is described as strong. The rock cores reveal limestone thicknesses ranging between ¼ inch and 8 inches. There are also concentrations of limestone. The rock core runs contain between 7 and 32 percent limestone and rock quality designations (RQD) range between 19 and 66 percent. Photographs of the recovered cores can be found in the Appendix.

Groundwater readings were recorded by the Drilling Technician during drilling, at the completion of drilling and prior to backfilling the test boring holes. Groundwater was first noted between 7 and 10 feet from the ground surface, consistent with the water level within the Little Miami River. Water levels at the completion of drilling were as shallow as 3.2 feet and as deep as 9.9 feet. These water levels were essentially static during the one to two day period prior to backfilling the test borings.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based upon our engineering reconnaissance of the site, the test borings, a visual examination of the samples, the laboratory tests, our understanding of the proposed construction and our experience as Consulting Geotechnical Engineers in Southwest Ohio, we have reached the following conclusions and make the following recommendations.

The conclusions and recommendations of this report have been derived by relating the general principles of the discipline of Geotechnical Engineering to the proposed construction outlined by the Project Characteristics, Section 3.0 of this report. Because changes in surface, subsurface, climatic and economic conditions can occur with time and location, we recommend for our mutual interest that the use of this report be restricted to this specific project.

Our understanding of the proposed design and construction is based on the documents provided to us at the time this report was prepared and which are referenced in the Project Characteristics section of this report. We recommend that our office be retained to review the final design documents, plans and specifications, to assess any impact changes, additions or revisions in these documents may have on the conclusions and recommendations of this geotechnical report. Any changes or modifications which are made in the field during the construction phase which alter site grading, structure locations, infrastructure or other related site work should also be reviewed by our office prior to their implementation.

If conditions are encountered in the field during construction which vary from the facts of this report, we recommend that our office be contacted immediately to review the changed conditions in the field and make appropriate recommendations.

The scope of our services did not include any environmental assessment or investigation for the presence or absence of wetlands or hazardous or toxic materials in the soil, bedrock, surface water, groundwater or air, on or below or around this site.

We have performed the test borings and laboratory tests for our evaluation of the site conditions and for the formulation of the conclusions and recommendations of this report. We assume no responsibility for the interpretation or extrapolation of the data by others.

After you have had an opportunity to study this geotechnical report and to discuss its implications with the Design Civil Engineer, we recommend that a meeting be held between the members of the design team to review the plans and specifications in light of the geotechnical report, paying particular attention to the possible implications of the geotechnical report with respect to potential construction problems and construction procedures which may be standard in the industry, but not consistent with our recommendations. This meeting should be held prior to submitting the contract documents in the market place for bidding.

The test borings indicate that the water main extension at the typical open cut depths will extend to near the base of the alluvial soils. Where added depth is required for the crossing beneath the river, the medium dense outwash deposits will be encountered.

There are numerous methods available to complete the water main alignment across the river. Open cut and cover techniques are the least preferred from an ecological standpoint. Less disruptive techniques include micro tunneling, jack and bore and horizontal directional drilling (HDD). Based upon cost and groundwater concerns, HDD appears to be the next best alternative to open cutting. The adequacy of the subsurface soils for directional drilling techniques should be reviewed by specialized contractors.

The main concern presented by HDD techniques is the potential for surface rupture because drilling fluids are required to be inserted under relatively high pressures. These fluids are typically bentonite based products. A surface rupture beneath the river might result in a contamination greater than the disturbance resulting from open cutting. In order to facilitate the evaluation of the site by HDD Contractors, our services included the performance of field permeability testing in Test Borings 1 and 4. This testing was performed at 5 foot intervals beginning at a 10 foot depth and extending to the surface of the bedrock, interbedded shale and limestone. The tests were performed through the hollow stems of our drill augers and the results of the permeability testing are indicated in Table 1.

Table 1: Field Permeability Testing

Test Boring	Test Depth (ft.)	Test Elevation (MSL)	Average Permeability (cm/sec)	USCS Classification
1	10	598.1	1.4×10^{-3}	GW-GM
	15	593.1	8.6×10^{-4}	GM
	20	588.1	0.00	GW-M
	25	583.1	2.9×10^{-3}	SW-SM
4	10	595.9	2.0×10^{-3}	
	15	590.9	1.2×10^{-3}	
	20	585.9	1.9×10^{-2}	

We anticipate that directional drilling can be completed above the bedrock surface, which was encountered between El. 579.8 and El. 586.4. This allows for approximately 10 to 15 feet between the river water level and the bedrock surface. The depth of the river bed should be confirmed from a field survey. The directional drilling depth should be maximized to avoid surface fracturing.

If directional drilling or other boring methods are unable to be completed or are found to be cost prohibitive, open cut methods can be employed. These methods should respect the ecological sensitivity of the river. Open cut trenches should be braced or laid back in accordance with local, state and federal regulations and in conformance with OSHA standards to protect workers within the narrow trenches. The Contractor should have a "Competent Person" on site to review the excavation procedures and implementation of bracing during all work. Cut and over techniques will require intense localized dewatering or underwater construction procedures. The dewatering techniques should be the responsibility of the installation contractor.

Settlement of trench backfill may be detrimental to long-term performance of adjacent utilities in the vicinity of the installation. We recommend that open cut portions of the trenching be replaced with backfill compacted to a minimum of 95 percent of the maximum dry density per the standard Proctor moisture-density test, ASTM D698. Field density testing can be performed during backfilling and trench restoration to document that project specifications are being met.

CCH:ATS:ph
100228NE

APPENDIX

ASFE Report Information

Tabulation of Laboratory Tests

Unconfined Compression Test Forms

Gradation Analysis Test Forms

Boring Plan, Drawing 100228NE-1

Test Boring Logs

Soil Classification Sheet

Photographs of Rock Cores

Field Permeability Worksheets

Important Information about Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

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Warren County Water & Sewer
Geotechnical Exploration
Water Main Crossing
Little Miami River at S.R. 48
Warren County, Ohio
100228NE

TABULATION OF LABORATORY TESTS

Boring No.	Sample No.	Depth (ft.)		Moisture Content (%)	Natural Dry Density (pcf)	Atterberg Limits (%)			Gradation Analysis (%)				Unconfined Compressive Strength (psf)	USCS Classificatino
		From	To			LL	PL	PI	Gravel	Sand	Silt	Clay		
1	2	2.5	4.0	19.9										
	PT-3	5.6	5.8						0	16	45	39		
	PT-3	5.8	6.3	28.4	94.7	44	24	20					2,670	CL
	5	10.0	11.5						47	47	2	4		GW-GM
	7	15.0	16.5						45	42	9	4		GM
	9	20.0	21.5						54	36	6	4		GP-GM
	10	25.0	26.5						19	71	6	4		
	RC-12	33.5	33.9											

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UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOIL, ASTM - D2166
UNIT WEIGHT AND NATURAL MOISTURE

CLIENT : **Warren County Water and Sewer**
PROJECT : **G.E., Little Miami Water Main Crossing**
LOCATION : **Warren County, Ohio**

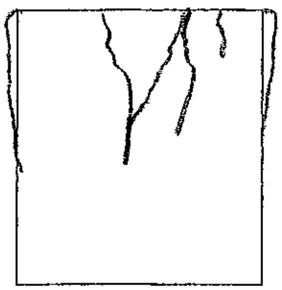
PROJECT NUMBER : **100228NE** LAB NUMBER :
BORING NUMBER : **1** SAMPLE NUMBER : **PT-3** DEPTH (FT.): **5.8** to **6.3**
SAMPLE DESCRIPTION : **Brown stiff SILTY CLAY, little fine sand**

SAMPLE OBTAINED BY : **SHELBY TUBE** CONDITION: **UNDISTURBED** DATE : **03/12/10**

NATURAL UNIT WEIGHT

AVERAGE DIAMETER (in.)	2.83
HEIGHT (in.)	5.44
HEIGHT TO DIAMETER RATIO	1.92
AVERAGE AREA (sq. ft.)	0.0437
VOLUME (cu. ft.)	0.0198
WET WEIGHT (lbs.)	2.41
DRY WEIGHT (lbs.)	1.87
DRY DENSITY (pcf)	**94.7**

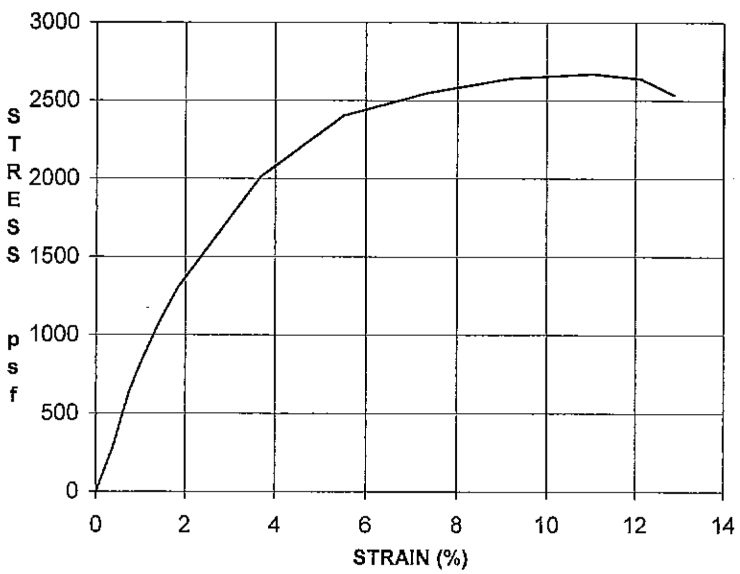
FAILURE SHAPE



WATER CONTENT AFTER SHEAR

CAN NUMBER	OH-4
WET WEIGHT + CAN (lbs.)	2.88
DRY WEIGHT + CAN (lbs.)	2.35
WEIGHT WATER (lbs.)	0.53
WEIGHT CAN (lbs.)	0.48
WEIGHT SOLID (lbs.)	1.87
MOISTURE (%)	**28.4**
LOAD CELL NUMBER	CELL

DEFORM DIAL .001 IN.	LOAD CELL	LOAD LBS.	STRAIN %	CORR. AREA SQ. FT.	STRESS PSF
0	0	0	0	0.0437	0
20	12.0	12.0	0.4	0.0438	274
40	28.0	28.0	0.7	0.0440	637
60	39.0	39.0	1.1	0.0442	883
80	49.0	49.0	1.5	0.0443	1106
100	58.0	58.0	1.8	0.0445	1304
200	91.0	91.0	3.7	0.0453	2007
300	111.0	111.0	5.5	0.0462	2402
400	120.0	120.0	7.4	0.0471	2546
500	127.0	127.0	9.2	0.0481	2641
600	131.0	131.0	11.0	0.0491	2669
660	131.0	131.0	12.1	0.0497	2636
700	127.0	127.0	12.9	0.0501	2534



AVERAGE RATE OF STRAIN TO FAILURE (% per minute)	**1.1**
STRAIN AT FAILURE (%)	**11.0**
UNCONFINED COMPRESSIVE STRENGTH (psf)	**2,670**
SHEAR STRENGTH (psf)	**1335**

REMARKS :

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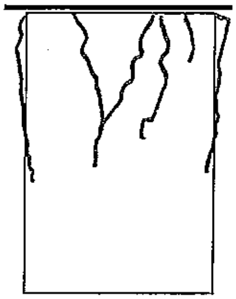
UNCONFINED COMPRESSIVE STRENGTH OF INTACT ROCK CORE, ASTM - D2938
UNIT WEIGHT AND NATURAL MOISTURE

CLIENT : Warren County Water and Sewer
PROJECT: Geotechnical Exploration, Little Miami Water Main Crossing
LOCATION: Warren County , Ohio

PROJECT NO.: 100228N
BORING NO.: 1 SAMPLE NO.: RC-12 DEPTH (ft.): 33.5-33.9
SAMPLE DESCRIPTION: Gray slightly strong SHALE
BEDROCK FORMATION: DATE: 5/17/2010
SAMPLE OBTAINED BY: Rock Core CONDITION: Undisturbed LOAD DIRECTION 90° TO LITHOLOGY

NATURAL UNIT WEIGHT	
AVERAGE DIAMETER (in.)	1.88
HEIGHT (in.)	4.46
HEIGHT TO DIAMETER RATIO	2.38
AVERAGE AREA (sq. ft.)	0.0192
VOLUME (cu. ft.)	0.0071
WET WEIGHT (lbs.)	1.06
DRY WEIGHT (lbs.)	0.99
DRY DENSITY (pcf)	**138.6**

FAILURE SHAPE

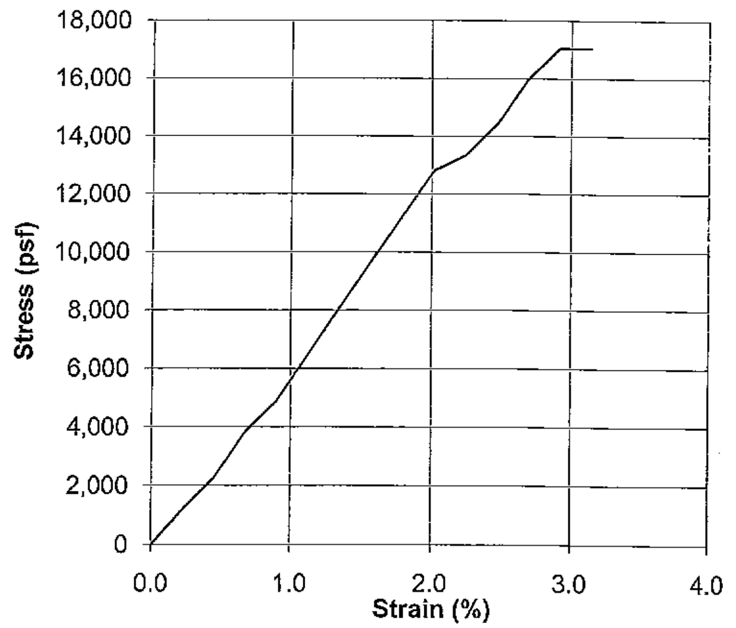


WATER CONTENT AFTER SHEAR	
CAN NUMBER	T21
WET WEIGHT + CAN (lbs.)	1.96
DRY WEIGHT + CAN (lbs.)	1.89
WEIGHT WATER (lbs.)	0.07
WEIGHT CAN (lbs.)	0.90
WEIGHT SOLID (lbs.)	0.99
MOISTURE (%)	**7.2**

PROVING RING NO.: 78-0860

TEST TEMPERATURE: 70°F

DEFORM DIAL (0.001 in.)	LOAD DIAL (0.001 in.)	LOAD (lbs.)	STRAIN (%)	STRESS (psf)
0	0	0	0.0	0
10	3	23	0.2	1,178
20	5	43	0.4	2,236
30	8	73	0.7	3,822
40	10	94	0.9	4,880
50	13	124	1.1	6,467
60	16	154	1.3	8,053
70	19	185	1.6	9,640
80	22	215	1.8	11,227
90	25	246	2.0	12,813
100	26	256	2.2	13,342
110	28	276	2.5	14,400
120	31	307	2.7	15,987
130	33	327	2.9	17,045
140	33	327	3.1	17,045



AVERAGE RATE OF STRAIN TO FAILURE (%/min.)	**1.3**
STRAIN AT FAILURE (%)	**2.9**
UNCONFINED COMPRESSIVE STRENGTH (ksf)	**17.0**
SHEAR STRENGTH (ksf)	**8.5**

REMARKS :

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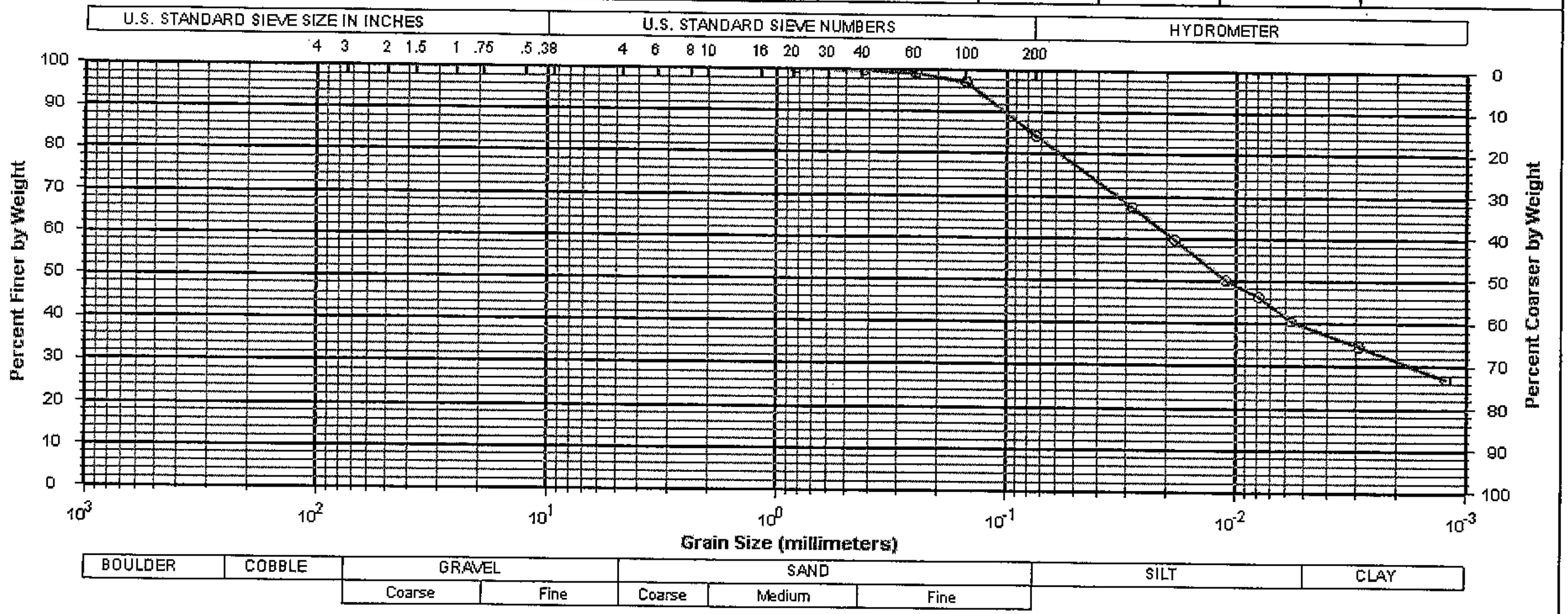
PARTICLE-SIZE ANALYSIS OF SOILS ASTM D-422

Client:	Warren County Water and Sewer					Project No.:	100228N
Project:	Geotechnical Exploration, Little Miami Water Main Crossing,, Warren County, OH					Date:	05/14/2010
Boring No.: 1	Sample No.: PT-3	Depth (ft.): 5.6 - 5.8	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	USCS
Sample Description:	Brown SILTY CLAY, little fine sand		0.0	15.7	45.0	39.3	CL
			LL	PL	PI	Group Index	WC (%)
			44	24	20		28.4



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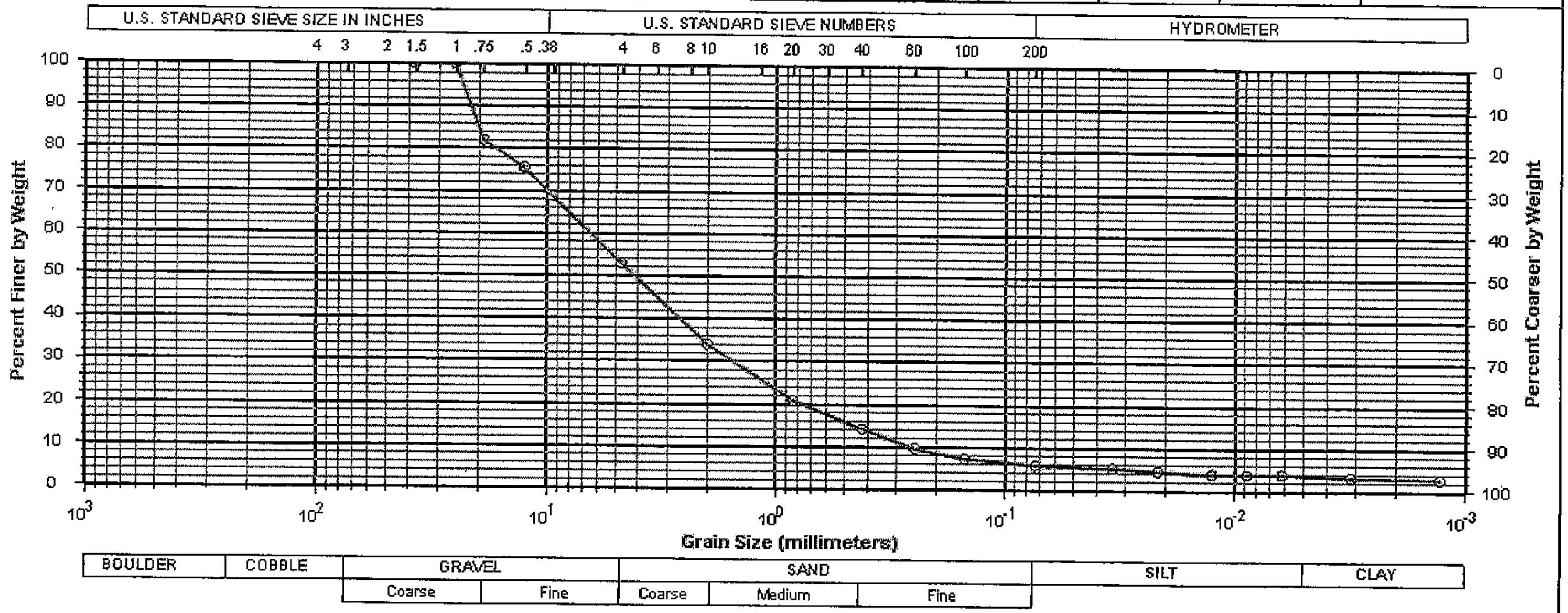
PARTICLE-SIZE ANALYSIS OF SOILS ASTM D-422

Client:	Warren County Water and Sewer									Project No.:	100228N
Project:	Geotechnical Exploration, Little Miami Water Main Crossing,, Warren County, OH									Date:	05/14/2010
Boring No.:	1	Sample No.:	5	Depth (ft.):	10.0 - 11.5	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	USCS	
Sample Description:	Brown and gray medium to coarse SAND and fine to coarse GRAVEL					47.2	46.9	2.2	3.7	GW-GM	
						LL	PL	PI	Group Index	WC (%)	



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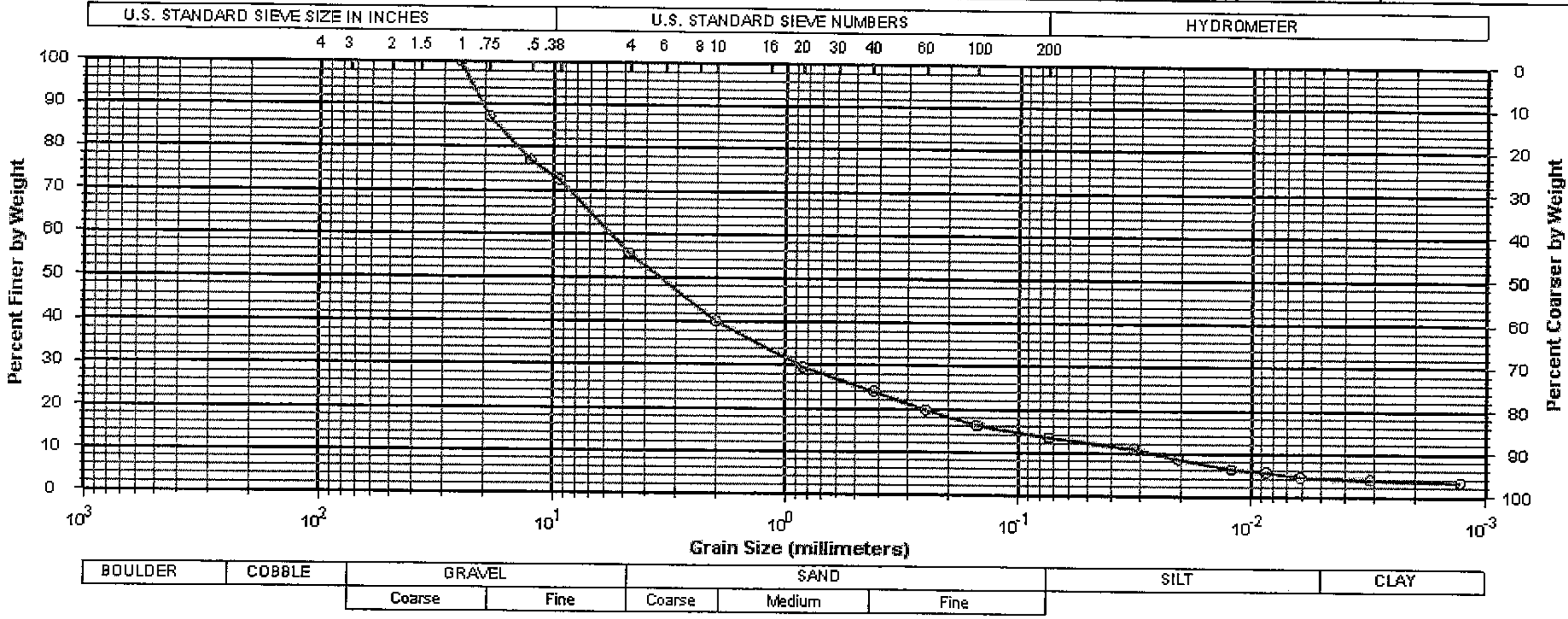
PARTICLE-SIZE ANALYSIS OF SOILS ASTM D-422

Client:	Warren County Water and Sewer								Project No.:	100228N
Project:	Geotechnical Exploration, Little Miami Water Main Crossing,, Warren County, OH								Date:	05/14/2010
Boring No.:	1	Sample No.:	7	Depth (ft.):	15.0 - 16.5	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	USCS
Sample Description:	Brown and gray fine to coarse SAND and GRAVEL, little silty clay					44.5	42.0	9.1	4.4	GM
						LL	PL	PI	Group Index	WC (%)



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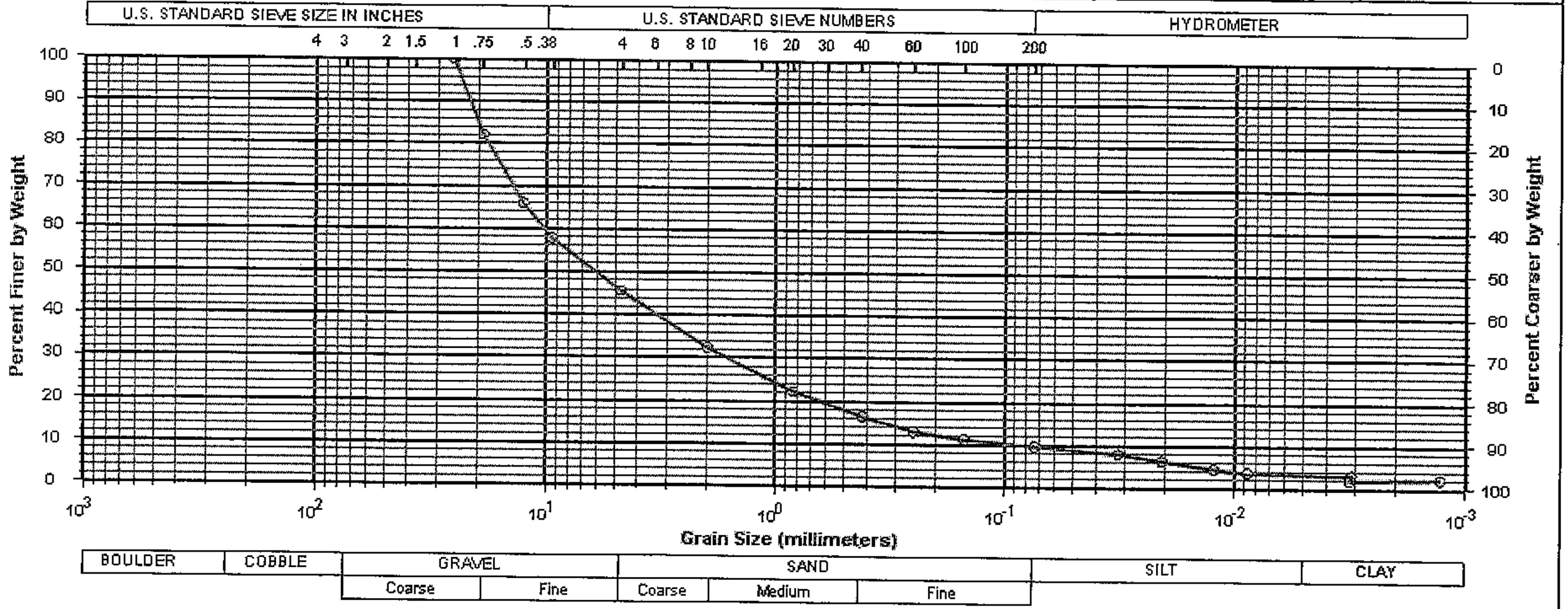
Client:	Warren County Water and Sewer							Project No.:	100228N
Project:	Geotechnical Exploration, Little Miami Water Main Crossing,, Warren County, OH							Date:	05/14/2010
Boring No.:	1	Sample No.:	9	Depth (ft.):	20.0 - 21.5	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	USCS
Sample Description:	Brown and gray medium to coarse SAND and fine to coarse GRAVEL, trace silty clay					54.4	35.8	6.4	3.4	GP-GM
						LL	PL	PI	Group Index	WC (%)



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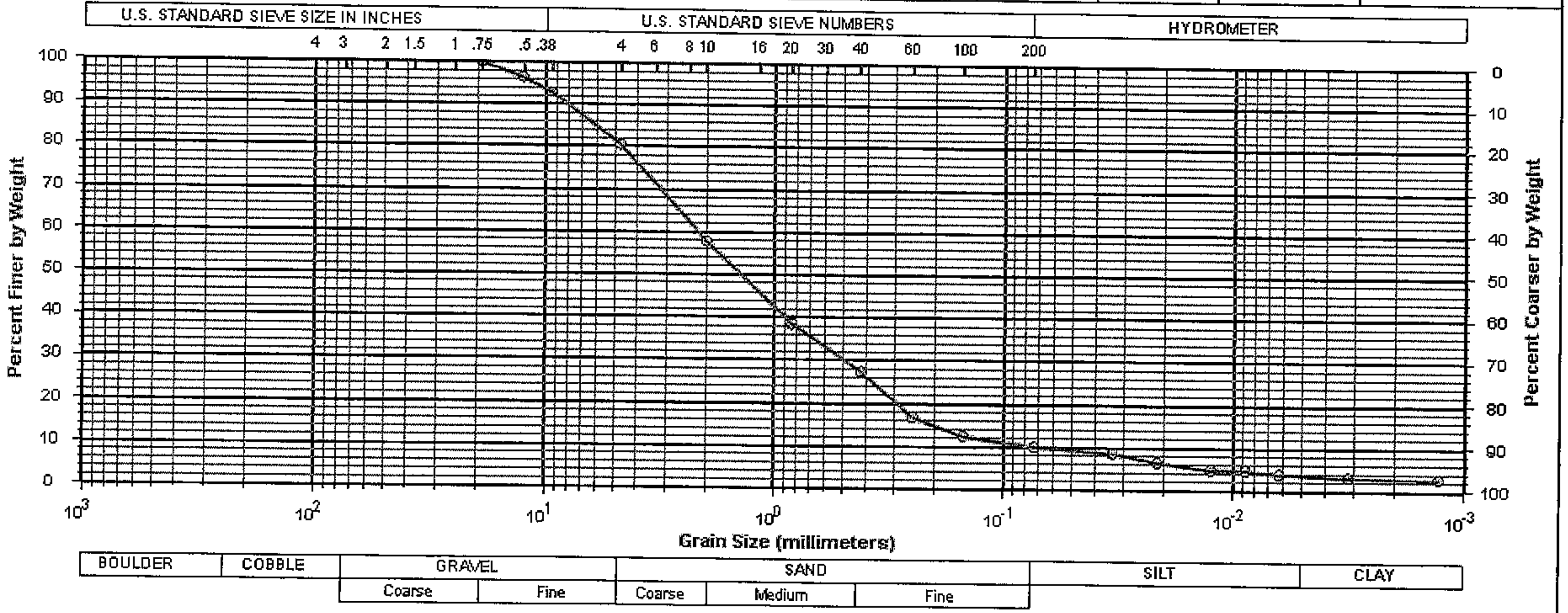
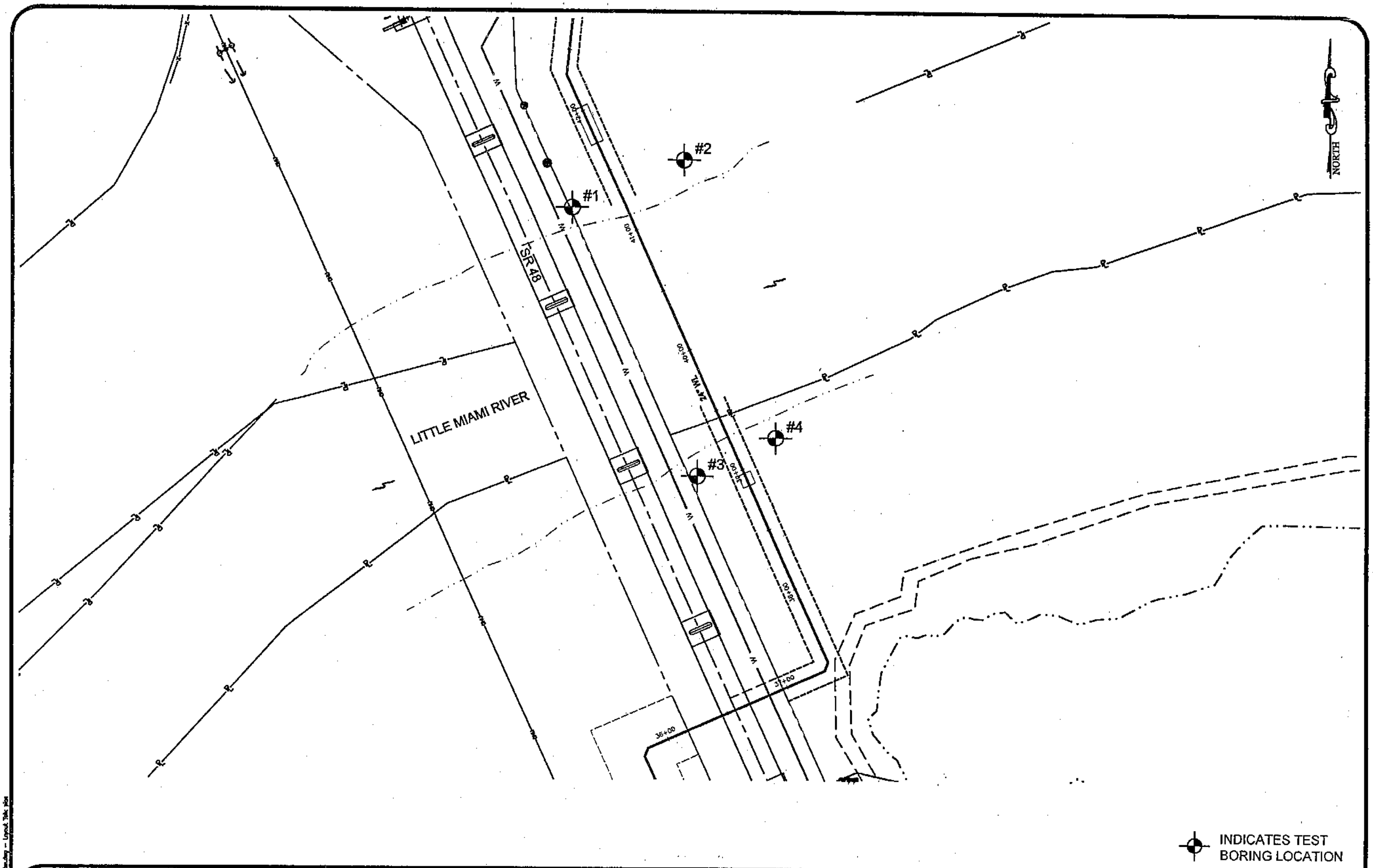
PARTICLE-SIZE ANALYSIS OF SOILS ASTM D-422

Client:	Warren County Water and Sewer								Project No.:	100228N
Project:	Geotechnical Exploration, Little Miami Water Main Crossing,, Warren County, OH								Date:	05/14/2010
Boring No.:	1	Sample No.:	10	Depth (ft.):	25.0 - 26.5	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	USCS
Sample Description:	Brown fine to coarse SAND, little fine gravel, trace silty clay					19.5	70.5	6.2	3.8	SW-SM
						LL	PL	PI	Group Index	WC (%)





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Title: BORING PLAN For: Warren County Water and Sewer	Project: Geotechnical Exploration 24" D.I.P. Waterline Crossing, Little Miami River at State Route 48	Location: Warren County, Ohio	Date: 5/20/10 Scale: 1" = 100' Drawing. No.: 100228NE-1

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LOG OF TEST BORING

CLIENT: Warren County Water and Sewer BORING # 1

PROJECT: Geotechnical Exploration, 24-Inch D.I.P. Waterline Crossing, Little Miami River at State Route 48 JOB # 100228NE

PROJECT LOCATION: Warren County, Ohio

LOCATION OF BORING: As shown on Boring Plan, Drawing 100228NE-1

ELEV.	SOIL DESCRIPTION COLOR, MOISTURE, DENSITY, PLASTICITY, SIZE, PROPORTIONS	STRATA DEPTH (ft.)	DEPTH SCALE (ft.)	Cond	Blows/6"	No.	Type	Rec. (in.)
608.1		0.0						
606.1	Brown moist stiff FILL, silty clay and topsoil, trace hairlike roots sand and fine gravel.	2.0		I	2/3/3	1	DS	16
				I	5/16/17	2	DS	15
602.5	Brown moist very stiff FILL, silty clay, little sand, trace topsoil, gravel and limestone fragments.	5.6	5	U		3	PT	16"/24"
601.1	Dark brown moist stiff SILTY CLAY, little fine sand (CL).	7.0						
598.6	Brown very moist very loose clayey fine SAND, trace medium to coarse sand and fine gravel.	9.5		I	1/3/2	4	DS	18
			10	D	5/9/13	5	DS	3
593.6	Brown and gray wet medium dense medium to coarse SAND and fine to coarse GRAVEL (GW-GM).	14.5		D	5/6/7	6	DS	16
591.1	Brown and gray wet medium dense fine to coarse SAND and GRAVEL, little silty clay (GM).	17.0	15	D	4/6/5	7	DS	18
				D	6/7/7	8	DS	18
584.8	Brown and gray wet medium dense medium to coarse SAND and fine to coarse GRAVEL, trace silty clay. (GW-GM).	23.3	20	D	6/7/9	9	DS	18
					Note: Scale Change			
579.8	Brown wet dense fine to coarse SAND, little fine gravel, trace cobbles and silty clay (SW-SM).	28.3	25	D	13/16/16	10	DS	18
577.9	Interbedded gray moist very weak unweathered SHALE and gray strong LIMESTONE (bedrock).	30.2	30		60/3"	11	DS	18
						12	RC	44.5"/46"
564.1	Interbedded gray moist very weak to slightly strong unweathered SHALE and gray strong LIMESTONE. Limestone is crystalline and fossiliferous, occurring in layers varying between 1/4 and 8 inches in thickness. Sample contains 27% limestone and 73% shale, assuming lost sample is shale. Run Loss=14% RQD=54%	44.0	35, 40			13	RC	98"/120"
	Bottom of test boring at 44.0 feet.		45					

Datum MSL	Hammer Wt. 140 lb	Hole Diameter 8 in.	Foreman/Rig JS/BD-1
Surf. Elev. 608.1	Hammer Drop 30 in.	Rock Core Dia. 1⅞ in.	Engineer CCH
Date Started 5-4-10	Pipe Size 2 in. O.D.	Boring Method HSA	Date Completed 5-4-10

SAMPLE CONDITIONS
D - DISINTEGRATED
I - INTACT
U - UNDISTURBED
L - LOST

SAMPLE TYPE
DS - DRIVEN SPLIT SPOON
PT - PRESSED SHELBY TUBE
CA - CONTINUOUS FLIGHT AUGER
RC - ROCK CORE

GROUND WATER DEPTH
FIRST NOTED 9.5 ft.
AT COMPLETION 9.9 ft.
AFTER 48 hrs. Caved @ 9.1 ft.
BACKFILLED 48 hrs.

BORING METHOD
HSA - HOLLOW STEM AUGERS
CFA - CONTINUOUS FLIGHT AUGERS
DC - DRIVING CASING
MD - MUD DRILLING

* STANDARD PENETRATION TEST - DRIVING 2" O.D. SAMPLER 1' WITH 140# HAMMER FALLING 30"; COUNT MADE AT 6" INTERVALS

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LOG OF TEST BORING

CLIENT: Warren County Water and Sewer — BORING # 2
PROJECT: Geotechnical Exploration, 24-Inch D.I.P. Waterline Crossing, Little Miami River at State Route 48 — JOB # 100228NE
PROJECT LOCATION: Warren County, Ohio
LOCATION OF BORING: As shown on Boring Plan, Drawing 100228NE-1

ELEV.	SOIL DESCRIPTION COLOR, MOISTURE, DENSITY, PLASTICITY, SIZE, PROPORTIONS	STRATA DEPTH (ft.)	DEPTH SCALE (ft.)	Cond	Blows/6"	No.	Type	Rec. (in.)
608.6		0.0						
607.7	TOPSOIL	0.9		I	1/1/3	1A 1B	DS	16
604.1	Brown moist stiff lean SILTY CLAY, trace fine sand seams and gravel.	4.5		I	12/21/7	2	DS	5
601.6	Dark brown moist stiff SILTY CLAY, trace hairlike roots.	7.0	5	I	4/5/4	3	DS	18
599.1	Dark brown and gray moist medium stiff SILTY CLAY, little fine sand, trace iron oxide stains.	9.5		I	2/2/2	4	DS	18
596.6	Brown and gray wet medium dense silty fine to medium SAND, trace gravel.	12.0	10	D	1/4/15	5	DS	18
594.1	Brown moist medium dense fine to coarse SAND and GRAVEL, little silty clay.	14.5		D	8/7/7	6	DS	3
591.6	Brown wet loose fine to coarse SAND and GRAVEL, trace silty clay.	17.0	15	D	8/4/4	7	DS	18
				D	4/7/7	8	DS	18
					Note: Scale Change			
585.3	Brown wet medium dense fine to coarse SAND and GRAVEL.	23.3	20	D	5/5/6	9	DS	18
			25	I	19/50/5"	10	DS	10
575.3	Interbedded gray moist very weak slightly weathered SHALE and gray strong LIMESTONE (bedrock).	33.3	30	I	97/6"	11	DS	5
573.1	Interbedded gray moist very weak unweathered SHALE and gray strong LIMESTONE (bedrock).	35.5	35	I	68/6"	12	DS	4
	Split spoon refusal and bottom of test boring at 35.5 feet.							

Datum MSL — Hammer Wt. 140 lb — Hole Diameter 8 in. — Foreman/Rig JS/BD-1
Surf. Elev. 608.6 — Hammer Drop 30 in. — Rock Core Dia. ____ — Engineer CCH
Date Started 4-30-10 — Pipe Size 2 in. O.D. — Boring Method HSA — Date Completed 4-30-10

SAMPLE CONDITIONS	SAMPLE TYPE	GROUND WATER DEPTH	BORING METHOD
D – DISINTEGRATED	DS – DRIVEN SPLIT SPOON	FIRST NOTED 10.0 ft.	HSA – HOLLOW STEM AUGERS
I – INTACT	PT – PRESSED SHELBY TUBE	AT COMPLETION 7.9 ft.	CFA – CONTINUOUS FLIGHT AUGERS
U – UNDISTURBED	CA – CONTINUOUS FLIGHT AUGER	AFTER 37 hrs. 10.2 ft.	DC – DRIVING CASING
L – LOST	RC – ROCK CORE	BACKFILLED 10.2 hrs.	MD – MUD DRILLING

* STANDARD PENETRATION TEST – DRIVING 2" O.D. SAMPLER 1' WITH 140# HAMMER FALLING 30"; COUNT MADE AT 6" INTERVALS

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LOG OF TEST BORING

CLIENT: Warren County Water and Sewer — BORING # 3

PROJECT: Geotechnical Exploration, 24-Inch D.I.P. Waterline Crossing Little Miami River at State Route 48 — JOB # 100228NE

PROJECT LOCATION: Warren County, Ohio

LOCATION OF BORING: As shown on Boring Plan, Drawing 100228NE-1

ELEV.	SOIL DESCRIPTION COLOR, MOISTURE, DENSITY, PLASTICITY, SIZE, PROPORTIONS	STRATA DEPTH (ft.)	Cond	Blows/6"	No.	Type	Rec. (in.)
607.0		0.0					
			D	1/1/1	1	DS	18
601.8	Dark brown moist very loose clayey fine to medium SAND, trace silty clay layers and hairlike roots.	5.2	D	1/2/2	2	DS	18
601.0	Dark brown and dark gray moist stiff SILTY CLAY, trace fine sand and roots.	6.0	U		3	PT	18"/24"
600.0	Gray moist medium dense silty fine SAND.	7.0					
597.5	Brown moist medium dense fine to coarse SAND and GRAVEL, trace silty clay.	9.5	D	1/5/7	4	DS	16
595.0	Brown wet medium dense fine to coarse SAND and GRAVEL, trace cobbles.	12.0	D	7/15/11	5	DS	14
592.5	Brown wet dense fine to coarse SAND and GRAVEL, trace cobbles.	14.5	D	8/14/24	6	DS	17
			D	7/8/6	7	DS	18
587.5	Brown wet medium dense fine to coarse SAND and GRAVEL.	19.5	D	7/9/12	8	DS	18
				Note: Scale Change			
583.7	Brown and gray wet medium dense fine to coarse SAND and GRAVEL, trace cobbles.	23.3	D	11/12/8	9	DS	18
581.5	Interbedded gray, trace brown moist very weak slightly weathered SHALE and gray strong LIMESTONE (bedrock).	25.5					
574.0	Interbedded gray, trace brown moist very weak to slightly strong slightly weathered SHALE and gray strong LIMESTONE. Limestone is crystalline and fossiliferous occurring in layers varying between 1/4 to 4 1/4 inches in thickness. Sample contains 8% limestone and 92% shale, assuming lost sample is shale. Run Loss=36% RQD=19%	33.0	I	50/6"	10	DS	4
					11	RC	55"/90"
564.0	Interbedded gray moist weak to slightly strong unweathered SHALE and gray LIMESTONE. Limestone is crystalline and fossiliferous occurring in layers varying between 1-1/2 to 7 inches in thickness. Sample contains 30% limestone and 70% shale, assuming lost sample is shale. Run Loss=6% RQD=62%	43.0			12	RC	113"/120"
	Bottom of test boring at 43.0 feet.						

Datum MSL	Hammer Wt. 140 lb	Hole Diameter 8 in.	Foreman/Rig JS/BD-1
Surf. Elev. 607.0	Hammer Drop 30 in.	Rock Core Dia. 1 7/8 in.	Engineer CCH
Date Started 5-5-10	Pipe Size 2 in. O.D.	Boring Method HSA	Date Completed 5-5-10

SAMPLE CONDITIONS
D – DISINTEGRATED
I – INTACT
U – UNDISTURBED
L – LOST

SAMPLE TYPE
DS – DRIVEN SPLIT SPOON
PT – PRESSED SHELBY TUBE
CA – CONTINUOUS FLIGHT AUGER
RC – ROCK CORE

GROUND WATER DEPTH
FIRST NOTED 7.9 ft.
AT COMPLETION 3.2 ft.
AFTER 16 hrs. 6.8 ft.
BACKFILLED 16 hrs.

BORING METHOD
HSA – HOLLOW STEM AUGERS
CFA – CONTINUOUS FLIGHT AUGERS
DC – DRIVING CASING
MD – MUD DRILLING

* STANDARD PENETRATION TEST – DRIVING 2" O.D. SAMPLER 1' WITH 140# HAMMER FALLING 30"; COUNT MADE AT 6" INTERVALS

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LOG OF TEST BORING

CLIENT: Warren County Water and Sewer BORING # 4
PROJECT: Geotechnical Exploration, 24-Inch D.I.P. Waterline Crossing Little Miami River at State Route 48 JOB # 100228NE
PROJECT LOCATION: Warren County, Ohio
LOCATION OF BORING: As shown on Boring Plan, Drawing 100228NE-1

ELEV.	SOIL DESCRIPTION COLOR, MOISTURE, DENSITY, PLASTICITY, SIZE, PROPORTIONS	STRATA DEPTH (ft.)	Cond	Blows/6"	No.	Type	Rec. (in.)
605.9		0.0					
603.9	Brown moist very loose clayey fine SAND.	2.0	I	1/1/1	1	DS	18
601.4	Brown moist very loose SILT, trace clay.	4.5	I	1/1/2	2	DS	16
600.7	Dark brown moist medium dense silty fine SAND, trace roots.	5.2					
598.9	Dark gray moist stiff SILTY CLAY, trace fine sand and roots.	7.0	U		3	PT	11"/24"
596.4	Brown wet dense fine to coarse SAND and GRAVEL, trace cobbles.	9.5	D	6/13/21	4	DS	18
591.4	Gray wet medium dense fine to coarse SAND and GRAVEL, trace cobbles.	14.5	D	10/11/11	5	DS	9
			D	5/6/6	6	DS	18
588.9	Gray wet medium dense fine to coarse SAND and fine GRAVEL.	17.0	D	4/5/6	7	DS	18
586.4	Brown wet medium dense fine SAND and fine to coarse GRAVEL.	19.5	D	7/11/11	8	DS	18
585.4	Interbedded gray moist very weak slightly weathered SHALE and gray strong LIMESTONE (bedrock).	20.5		Note: Scale Change			
575.5	Interbedded gray, trace brown moist very weak to slightly strong slightly weathered SHALE and gray strong LIMESTONE. Limestone is crystalline and fossiliferous, occurring in layers varying between 3/4 to 5-1/2 inches in thickness. Sample contains 7% limestone and 93% shale, assuming lost sample is shale. Run Loss=2% RQD=50%	30.4		104/6"	9	DS	6
					10	RC	36"/36"
					11	RC	118"/120"
562.4	Interbedded gray moist weak to slightly strong unweathered SHALE and gray strong LIMESTONE. Limestone is crystalline and fossiliferous with layers varying between 1 and 5 1/2 inches in thickness. Sample contains 32% limestone and 68% shale, assuming lost sample is shale. Run Loss=8% RQD=66%	43.5			12	RC	107"/120"
	Bottom of test boring at 43.5 feet.						

Datum MSL | Hammer Wt. 140 lb | Hole Diameter 8 in. | Foreman/Rig JS/BD-1
Surf. Elev. 605.9 | Hammer Drop 30 in. | Rock Core Dia. 1⅞ in. | Engineer CCH
Date Started 5-6-10 | Pipe Size 2 in. O.D. | Boring Method HSA | Date Completed 5-6-10

SAMPLE CONDITIONS	SAMPLE TYPE	GROUND WATER DEPTH	BORING METHOD
D - DISINTEGRATED	DS - DRIVEN SPLIT SPOON	FIRST NOTED 7.0 ft.	HSA- HOLLOW STEM AUGERS
I - INTACT	PT - PRESSED SHELBY TUBE	AT COMPLETION 6.7 ft.	CFA- CONTINUOUS FLIGHT AUGERS
U - UNDISTURBED	CA - CONTINUOUS FLIGHT AUGER	AFTER ____ hrs. ____ ft.	DC - DRIVING CASING
L - LOST	RC - ROCK CORE	BACKFILLED Immed. hrs.	MD - MUD DRILLING

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SOIL CLASSIFICATION SHEET

NON COHESIVE SOILS
(Silt, Sand, Gravel and Combinations)

Density

Very Loose	- 5 blows/ft. or less
Loose	- 6 to 10 blows/ft.
Medium Dense	- 11 to 30 blows/ft.
Dense	- 31 to 50 blows/ft.
Very Dense	- 51 blows/ft. or more

Relative Properties

Descriptive Term	Percent
Trace	1 – 10
Little	11 – 20
Some	21 – 35
And	36 – 50

Particle Size Identification

Boulders	- 8 inch diameter or more	
Cobbles	- 3 to 8 inch diameter	
Gravel	- Coarse	- 3/4 to 3 inches
	- Fine	- 3/16 to 3/4 inches
Sand	- Coarse	- 2mm to 5mm (dia. of pencil lead)
	- Medium	- 0.45mm to 2mm (dia. of broom straw)
	- Fine	- 0.075mm to 0.45mm (dia. of human hair)
Silt		- 0.005mm to 0.075mm (Cannot see particles)

COHESIVE SOILS
(Clay, Silt and Combinations)

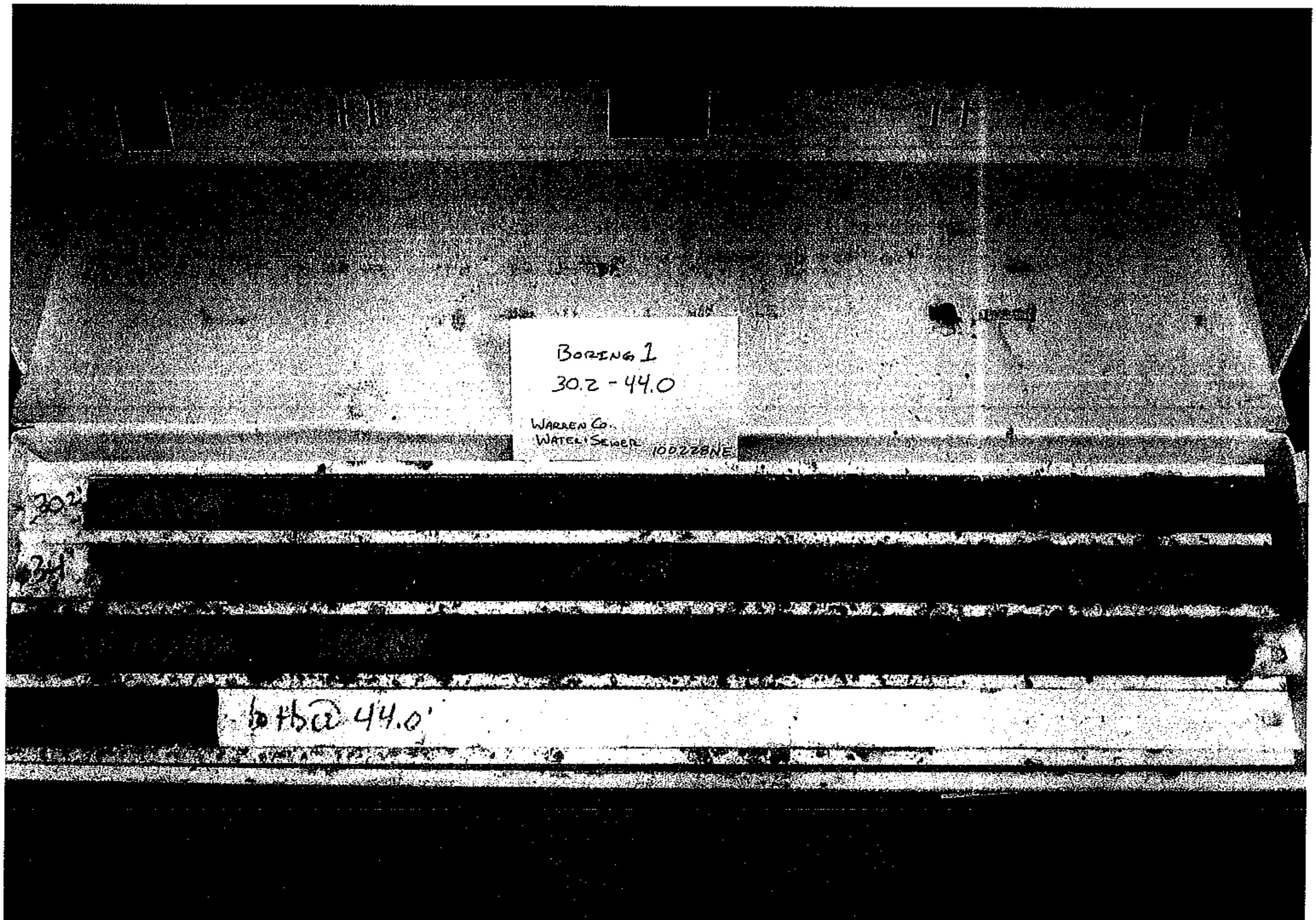
Consistency	Field Identification	Unconfined Compressive Strength (tons/sq. ft.)
Very Soft	Easily penetrated several inches by fist	Less than 0.25
Soft	Easily penetrated several inches by thumb	0.25 – 0.5
Medium Stiff	Can be penetrated several inches by thumb with moderate effort	0.5 – 1.0
Stiff	Readily indented by thumb but penetrated only with great effort	1.0 – 2.0
Very Stiff	Readily indented by thumbnail	2.0 – 4.0
Hard	Indented with difficulty by thumbnail	Over 4.0

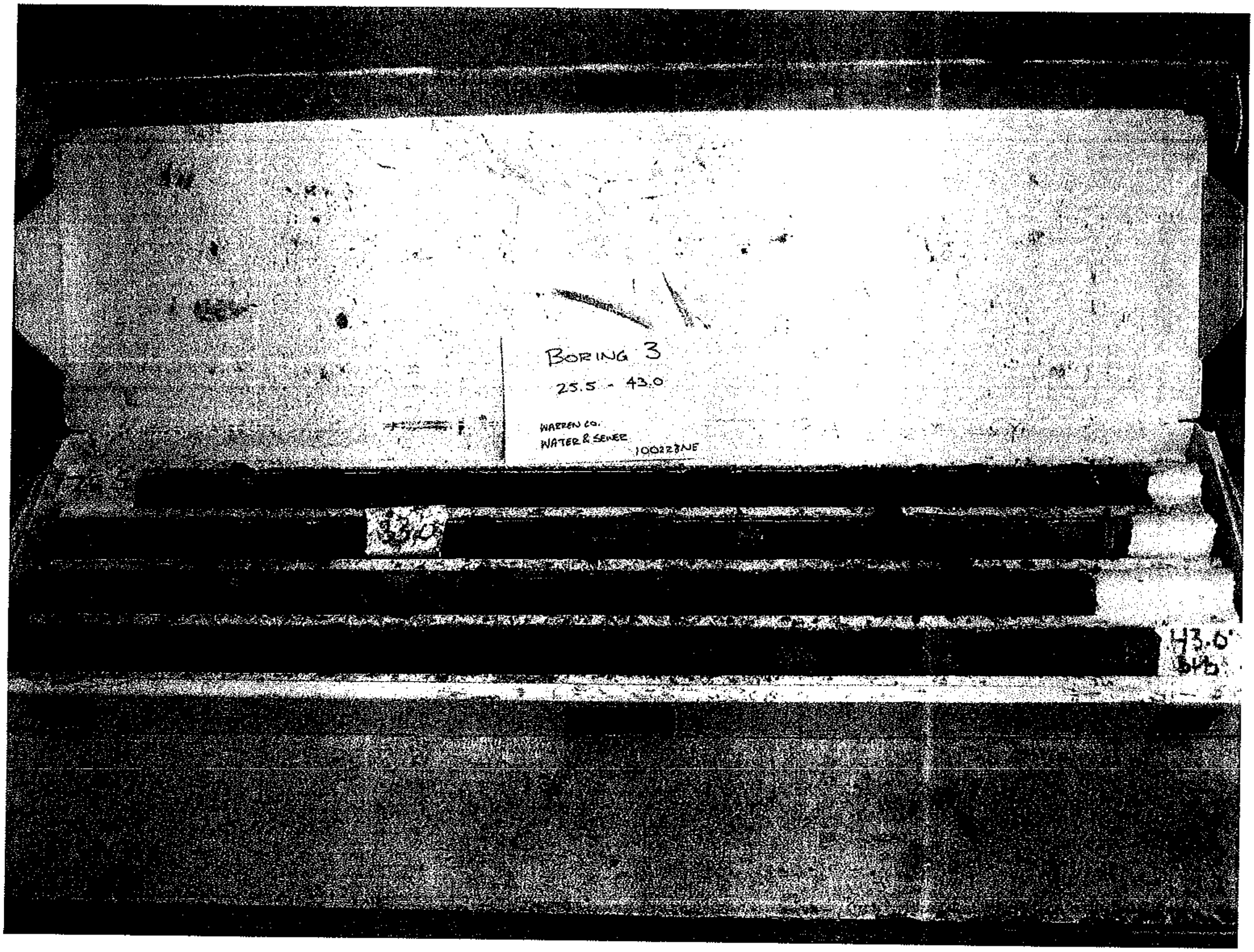
Classification on logs are made by visual inspection.

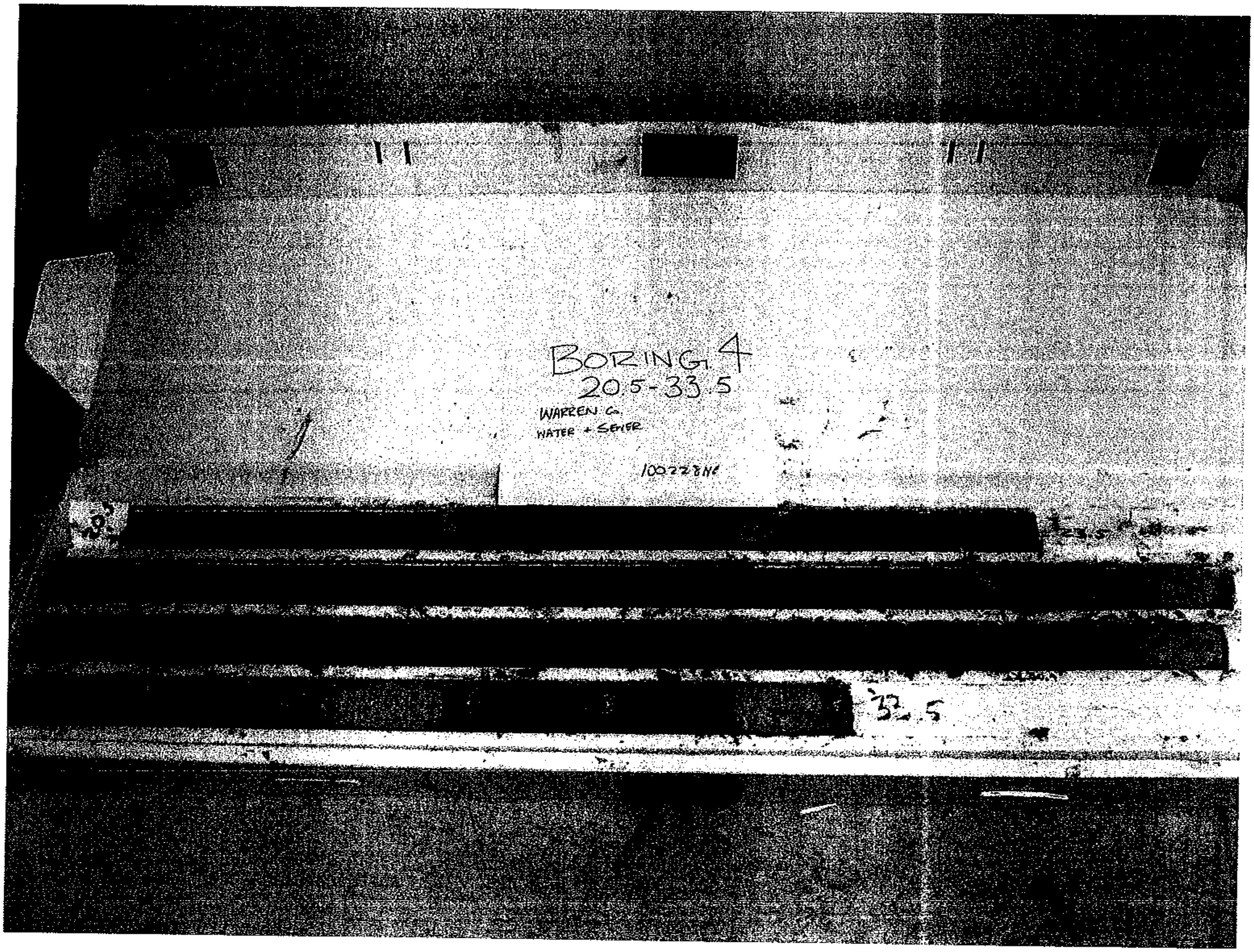
Standard Penetration Test – Driving a 2.0" O.D., 1 3/8" I.D., sampler a distance of 1.0 foot into undisturbed soil with a 140 pound hammer free falling a distance of 30 inches. It is customary to drive the spoon 6 inches to seat into undisturbed soil, then perform the test. The number of hammer blows for seating the spoon and making the tests are recorded for each 6 inches of penetration on the drill log (Example – 6/8/9). The standard penetration test results can be obtained by adding the last two figures (i.e. 8+9=17 blows/ft.). Refusal is defined as greater than 50 blows for 6 inches or less penetration.

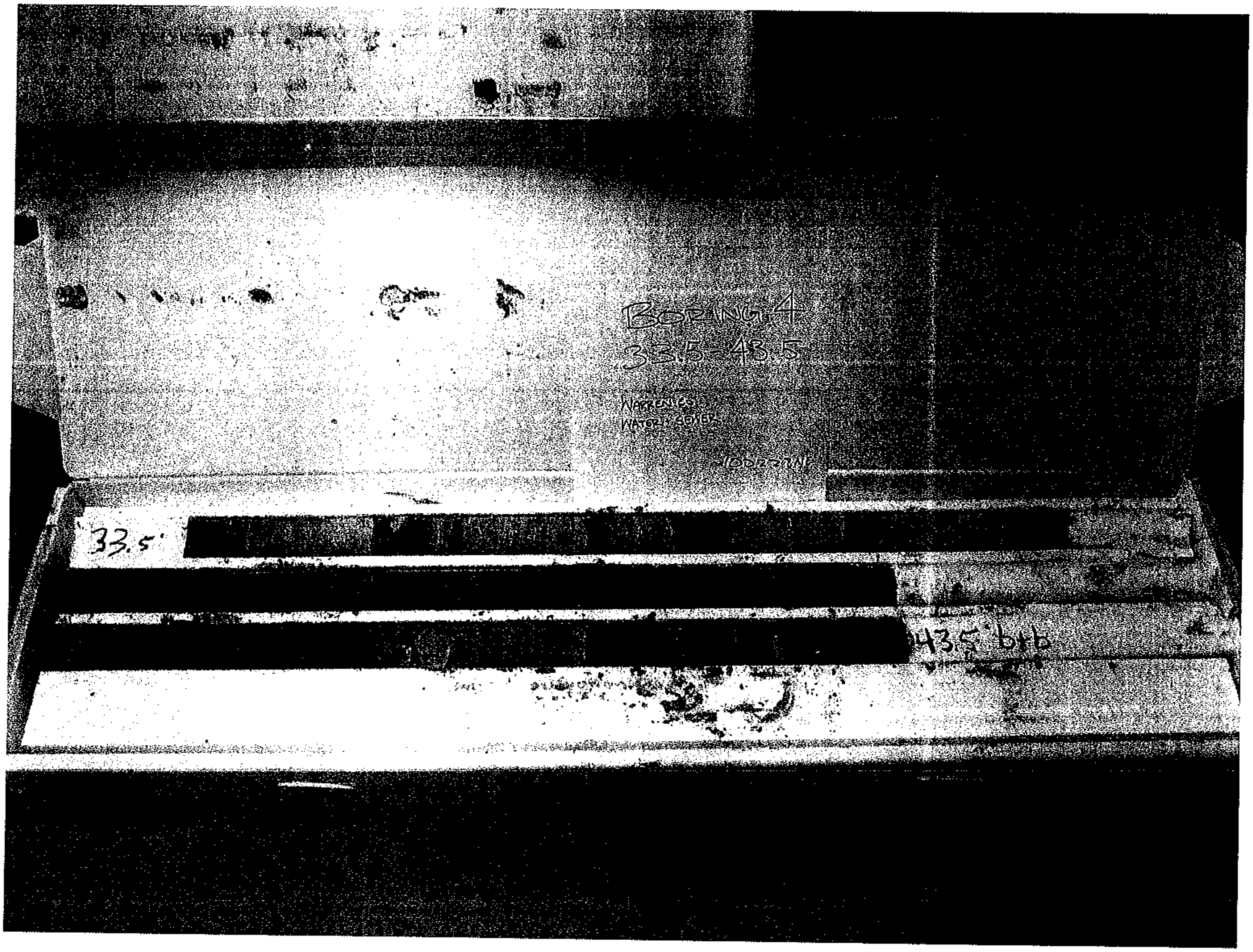
Strata Changes – In the column "Soil Descriptions" on the drill log, the horizontal lines represent strata changes. A solid line (————) represents an actually observed change; a dashed line (— — — —) represents an estimated change.

Groundwater observations were made at the times indicated. Porosity of soil strata, weather conditions, site topography, etc., may cause changes in the water levels indicated on the logs.


BORING 1
30.2 - 44.0
WARREN CO.
WATER SEWER
100228NE
30.2'
34'
btb @ 44.0'


BORING 3
25.5 - 43.0
WARREN CO.
WATER & SEWER
100228NE
43.0'


BORING 4
20.5-33.5
WARREN Co.
WATER + SEWER
100228NC
32.5


BORING 4
33.5-43.5
WARREN CO
WATER & SEWER
33.5'
43.5'

Constant Head Field Permeability
U.S. Bureau of Reclamation
k=q/5.5rh

Client	Warren County Water and Sewer
Project	Little Miami River Crossing
Project No.	100228NE
Location	Warren County, Ohio

Hole Diameter (in.) = 8
Groundwater Depth (ft.) 7

Well Location	Depth of test (ft.)	Differential Head (ft.)	Pump Volume Reading (gal.)	Vol. (gal.)	Time from last reading (sec.)	Flow Rate (gpm)	k (cm/sec)
4	10	7	861.5				
		7	862.5	1.0	60	1	5.29E-03
		7	862.9	0.4	60	0.4	2.12E-03
		7	863.1	0.2	60	0.2	1.06E-03
		7	863.3	0.2	60	0.2	1.06E-03
		7	863.4	0.1	60	0.1	5.29E-04

Average Permeability 2.01E-03

Well Location	Depth of test (ft.)	Differential Head (ft.)	Pump Volume Reading (gal.)	Vol. (gal.)	Time from last reading (sec.)	Flow Rate (gpm)	k (cm/sec)
4	15	7	866.3				
		7	866.6	0.3	60	0	0.00E+00
		7	866.7	0.1	60	0.1	5.29E-04
		7	866.9	0.2	60	0.2	1.06E-03
		7	867.4	0.5	60	0.5	2.65E-03
		7	867.7	0.3	60	0.3	1.59E-03

Average Permeability 1.16E-03

Well Location	Depth of test (ft.)	Differential Head (ft.)	Pump Volume Reading (gal.)	Vol. (gal.)	Time from last reading (sec.)	Flow Rate (gpm)	k (cm/sec)
4	20	7	829.1				
		7	832.9	3.8	60	3.8	2.01E-02
		7	836.5	3.6	60	3.6	1.90E-02
		7	840.0	3.5	60	3.5	1.85E-02
		7	843.2	3.2	60	3.2	1.69E-02
		7	846.8	3.6	60	3.6	1.90E-02

Average Permeability 1.87E-02

Thelen Associates, Inc.
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Constant Head Field Permeability
U.S. Bureau of Reclamation
k=q/5.5rh

Client	Warren County Water and Sewer
Project	Little Miami River Crossing
Project No.	100228NE
Location	Warren County, Ohio

Hole Diameter (in.) = 8
Groundwater Depth (ft.) 9.5

Well Location	Depth of test (ft.)	Differential Head (ft.)	Pump Volume Reading (gal.)	Vol. (gal.)	Time from last reading (sec.)	Flow Rate (gpm)	k (cm/sec)
1	10	9.5	795.6				
		9.5	796.0	0.4	60	0.4	1.56E-03
		9.5	796.5	0.5	60	0.5	1.95E-03
		9.5	796.7	0.2	60	0.2	7.80E-04
		9.5	796.9	0.2	60	0.2	7.80E-04
		9.5	797.4	0.5	60	0.5	1.95E-03

Average Permeability 1.40E-03

Well Location	Depth of test (ft.)	Differential Head (ft.)	Pump Volume Reading (gal.)	Vol. (gal.)	Time from last reading (sec.)	Flow Rate (gpm)	k (cm/sec)
1	15	9.5	782.4				
		9.5	782.9	0.5	60	0	0.00E+00
		9.5	783.4	0.5	60	0.5	1.95E-03
		9.5	783.7	0.3	60	0.3	1.17E-03
		9.5	783.9	0.2	60	0.2	7.80E-04
		9.5	784.0	0.1	60	0.1	3.90E-04

Average Permeability 8.58E-04

Well Location	Depth of test (ft.)	Differential Head (ft.)	Pump Volume Reading (gal.)	Vol. (gal.)	Time from last reading (sec.)	Flow Rate (gpm)	k (cm/sec)
1	20	9.5	789.0				
		9.5	789.0	0.0	60	0	0.00E+00
		9.5	789.0	0.0	60	0	0.00E+00
		9.5	789.0	0.0	60	0	0.00E+00
		9.5	789.0	0.0	60	0	0.00E+00
		9.5	789.0	0.0	60	0	0.00E+00

Average Permeability 0.00E+00

Well Location	Depth of test (ft.)	Differential Head (ft.)	Pump Volume Reading (gal.)	Vol. (gal.)	Time from last reading (sec.)	Flow Rate (gpm)	k (cm/sec)
1	25	9.5	804.8				
		9.5	805.7	0.9	60	0.9	3.51E-03
		9.5	806.2	0.5	60	0.5	1.95E-03
		9.5	806.9	0.7	60	0.7	2.73E-03
		9.5	807.8	0.9	60	0.9	3.51E-03
		9.5	808.5	0.7	60	0.7	2.73E-03

Average Permeability 2.89E-03

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