Geotechnical Engineering Report

Sanitary Sewer Extension Project – Phase I

US Route 20

Bellevue, Ohio

June 25, 2010

Project No. N4105037

Prepared for:

City of Bellevue, Ohio

Bellevue, Ohio

Prepared by:

HCN
A Terracon COMPANY

Columbus, Ohio

TABLE OF CONTENTS

June 25, 2010

City of Bellevue, Ohio
3000 Seneca Industrial Parkway
Bellevue, Ohio 44811

Attention: Mr. Kevin Scagnetti
City Engineer
P : [419] 484 5500
E : kevin.scagnetti@cityofbellevue.com

Regarding: Geotechnical Engineering Report
Sanitary Sewer Extension Project – Phase I
US Route 20
Bellevue, Ohio
Terracon Project No. N4105037

Dear Mr. Scagnetti:

H. C. Nutting – A Terracon Company (Terracon) is pleased to submit our Geotechnical Engineering Report for the Sanitary Sewer Extension Project – Phase I planned along US Route 20 in Bellevue, Ohio.

Our geotechnical study was performed in general accordance with our proposal number PN4100151 dated April 16, 2010 and written authorization dated April 20, 2010. The subsurface exploration phase for this project was initiated on May 22, 2010 and was completed on May 25, 2010.

We appreciate the opportunity to be of service to you on this project and look forward to providing additional Geotechnical Engineering and Construction Materials Testing services as the project progresses to its detailed design and construction phases. Please contact us if you have any questions or if we can be of further assistance.

Sincerely,
H.C. NUTTING - A Terracon COMPANY

Prasad S. Rege, P.E.
Office Manager/ Principal

Kevin M. Ernst, P.E.
Geotechnical Department Manager

EXECUTIVE SUMMARY

A geotechnical study has been performed for the proposed sanitary sewer extension project planned along US Route 20 in Bellevue, Ohio. Twelve (12) test borings were completed as a part of this geotechnical study.

Based on the information obtained from our subsurface exploration program, the following geotechnical considerations were identified:

- Our subsurface exploration program indicated that the depth to competent shale and limestone bedrock along the sanitary sewer alignment varied from about 8 to 13.6 feet below the existing ground surface.

- It is anticipated that conventional sewer construction procedures could be implemented within sections of the sewer project which are not bedrock controlled (bedrock not encountered at or above the proposed sewer invert elevation). However, very moist to wet and marginal strength native overburden soils should be anticipated during the sewer excavation process.

- Deeper sewer excavations in areas controlled by bedrock (excavation through the competent bedrock stratum is anticipated) are expected to require significant effort which will result in increased project excavation costs relative to excavation only within the overburden soils. Since the proposed sewer is located along an existing roadway (US Route 20), use of blasting techniques to facilitate rock excavation does not appear to be a feasible option along the majority of the proposed alignment.

- Based on our subsurface findings it is anticipated that the jack and bore construction technique proposed for the length of the sewer pipe crossing below the existing Prairie Road (in the vicinity of test borings B-8 and B-9) will require advancing the near-horizontal steel casing through competent shale and limestone bedrock formations.

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

GEOTECHNICAL ENGINEERING REPORT
SANITARY SEWER EXTENSION PROJECT – PHASE I
US ROUTE 20
BELLEVUE, OHIO

Project No. N4105037
June 25, 2010

1.0 INTRODUCTION

Terracon is pleased to submit our Geotechnical Engineering Report for the proposed sanitary sewer extension project planned along US Route 20 in Bellevue, Ohio. Our geotechnical study was performed in general accordance with our proposal number PN4100151 dated April 16, 2010 and written authorization dated April 20, 2010. The subsurface exploration phase for this project was initiated on May 22, 2010 and was completed on May 25, 2010.

The purpose of this report is to describe the subsurface conditions encountered in the twelve (12) test borings drilled for this study, analyze and evaluate the test data, and provide recommendations with respect to:

- Subsurface Soil Conditions
- Groundwater Conditions
- Design and Construction Considerations

2.0 PROJECT INFORMATION

Site Location

ITEM	DESCRIPTION
Location and site description	The proposed sewer extension project (Phase I) is planned along the north shoulder of the west bound lane of US Route 20 in Bellevue, Ohio. The project will start at Station 60+20.72 and end at approximate Station 90+00 according to the provided plan and profile drawing developed by GGJ, Inc., dated July 2008.
Current ground cover	Unpaved shoulder consisting of dense graded aggregate with occasional asphalt driveways and grass covered right of way.
Existing topography	Ground surface along the sanitary sewer alignment appears to range approximately from elevation 762 feet to 779 feet.

Project Description

ITEM	DESCRIPTION
Sewer Line	Provided information indicates that the proposed sewer line will be constructed in the same trench as that for a proposed water line (to be constructed at a later time) but will be set deeper. The invert depth for the sewer line appears to vary from approximately 8 feet to 20 feet below the existing ground surface. The sewer pipe will consist of a 10-inch diameter SDR 35 PVC pipe. Provided information indicates that jack and bore construction technique will need to be implemented for the length of the sewer pipe crossing below the existing Prairie Road.

Should any of the above information or assumptions be inconsistent with the planned construction, please let us know so that we may make necessary modifications to this report.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Soil Profile

Based on the results of the borings, subsurface conditions on the project site can be generalized as indicated in the following table:

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 1	1 inch to 18 inches	Topsoil	Not Applicable
Stratum 2	5.5 to 13 feet	Native glacial till soils consisting of cohesive: lean clay with sand and sandy lean clay with various proportions of gravel size constituents and rock fragments; and fine textured granular soils: clayey sand, silty sand, poorly graded sand, with various proportions of silt and gravel size constituents and rock fragments	Cohesive Soils – medium stiff to very stiff consistency Granular Soils – very loose to medium dense relative density

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 3	10 to 25 feet (test boring termination depth at test boring locations B-1, B-2, B-3, B-4, B-5, B-6, B-11, and B-12)	Native soils consisting of fat clay (completely weathered shale bedrock)	Very stiff to hard
Stratum 4	25 feet (test boring termination depth at test boring locations B-8 and B-9)	Shale and Limestone Bedrock	Shale bedrock – very soft to medium hard according to bedrock hardness rating Limestone bedrock – moderately hard to hard according to bedrock hardness rating

Note: Auger refusal condition encountered on limestone bedrock surface at an approximate depth range of 8 to 13.6 feet at test boring locations B-7, B-8, B-9, B-10, B-11, and B-12; rock coring performed to an approximate depth of 25 feet at test boring locations B-8 and B-9.

Conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A of this report.

3.2 Groundwater Conditions

The boreholes were observed during and after completion of drilling for the presence and level of groundwater. The water levels observed are noted on the attached boring logs. The table below provides a summary of the test borings where groundwater was encountered during our subsurface exploration:

Boring Number	Depth to groundwater while drilling (ft.)		Depth to groundwater after drilling (ft.)
B-5	WD – 5.5	ACR – 16	WCI – 20
B-6	WD – 8	ACR – 8	WCI – 18
B-7	WD – 5.5	ACR – 5.5	WCI – 5.5
B-8	WD – 3*	ACR – 3*	WCI – 6
B-9	WD – 3*	ACR – 3*	WCI – 7
B-12	WD – 38	ACR – 8	WCI – 9

WCI – Wet cave-in condition after augers were withdrawn

WD - While drilling
ACR – After Casing Removal
*Water added during the rock coring operation. Groundwater reading influenced by external water source

Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 General Assessment

Our subsurface exploration program indicated that the depth to competent shale and limestone bedrock along the sanitary sewer alignment varied from about 8 to 13.6 feet below the existing ground surface. It is anticipated that conventional sewer construction procedures could be implemented within sections of the sewer project which are not bedrock controlled (that is, bedrock not encountered at or above the proposed sewer invert elevation). However, very moist to wet and marginal strength native overburden soils should be anticipated during the sewer excavation process.

Deeper sewer excavations in areas controlled by bedrock (which will require excavation through the competent bedrock stratum) are expected to require significant effort which will result in increased project costs relative to excavation only in the overburden soils. Since the proposed sewer is located along an existing roadway (US Route 20), use of blasting techniques to facilitate rock excavation does not appear to be a feasible option along the majority of the proposed alignment. Based on our findings, it is anticipated that the jack and bore construction technique proposed for the length of the sewer pipe crossing below the existing Prairie Road (in the vicinity of test borings B-8 and B-9) will require advancing the near-horizontal steel casing through competent shale and limestone bedrock formations.

Our geotechnical recommendations are presented in the sections that follow.

4.2 Sewer Line Construction

4.2.1 Excavation for Sewer Line

We have summarized relevant geotechnical information collected during our subsurface exploration and laboratory testing program for the sewer alignment which appears on the

provided plan and profile drawing developed by GGJ, Inc. and dated July 2008. This information is presented below in a tabulated format.

Test Boring Number	Proposed Sewer Invert Elevation (feet)	Corresponding Depth Below Existing Ground Surface (feet)	Potential Issues Related to Sewer Line Excavation
B-1	754	8.5	Fat clays (completely weathered shale) anticipated at the bottom of sewer excavation
B-2	754	8.5	Fat clays (completely weathered shale) anticipated at the bottom of sewer excavation
B-3	755	10	Fat clays (completely weathered shale) anticipated at the bottom of sewer excavation
B-4	755.5	15	Loose and wet granular soils within the uppermost 3 feet of the excavation; fat clays (completely weathered shale) anticipated at the bottom of sewer excavation
B-5	756.5	19.5	Loose and very moist to wet granular soils within the uppermost 8 feet of the excavation; fat clays (completely weathered shale) anticipated at the bottom of sewer excavation
B-6	757	22.5	Loose and very moist granular soils and very moist cohesive soils within the uppermost 10.5 feet of the excavation; fat clays (completely weathered shale) anticipated at the bottom of sewer excavation below this depth
B-7	757.5	20.5	Soft to medium stiff and very moist cohesive soils and very loose and wet granular soils within the uppermost 8 feet of the excavation; auger refusal at 8-foot depth on apparent shale and limestone bedrock – expect difficult rock excavation below this depth
B-8	758	20	Loose and wet granular soils within the uppermost 10 feet of the excavation; competent shale and limestone bedrock encountered at 10 feet depth – expect difficult rock excavation below this depth

Test Boring Number	Proposed Sewer Invert Elevation (feet)	Corresponding Depth Below Existing Ground Surface (feet)	Potential Issues Related to Sewer Line Excavation
B-9	758	19	Loose and wet granular soils within the uppermost 11 feet of the excavation; competent shale and limestone bedrock encountered at 11 feet depth – expect difficult rock excavation below this depth
B-10	759.5	17.5	Very moist to wet cohesive and granular soils within the uppermost 8 feet of the excavation; auger refusal at 8-foot depth on apparent shale and limestone bedrock – expect difficult rock excavation below this depth
B-11	760	18	Very moist cohesive soils within the uppermost 8 feet of the excavation; auger refusal at 12-foot depth on apparent shale and limestone bedrock – expect difficult rock excavation below this depth
B-12	761	19	Very moist and medium stiff cohesive soils and wet and very loose granular soils within the uppermost 8 feet of the excavation; auger refusal at 13.6-foot depth on apparent shale and limestone bedrock – expect difficult rock excavation below this depth

Excavations at this project site should be performed in accordance with governing safety regulations. All vehicles and soil piles should be kept back from the crest of excavation slopes. The stability of excavation slopes should be reviewed continuously by qualified personnel. The responsibility for excavation safety and temporary construction slopes lies solely with the contractor.

OSHA Excavation Regulations classify a cohesive soil with a soft to very soft consistency or granular soil as a Type “C” soil. A Type “C” classification requires open excavation slopes for the sewer pipe and manhole installation to be no steeper than 1.5H:1V. Similarly, OSHA Excavation Regulations classify a cohesive soil with a medium stiff to stiff consistency as a Type “B” soil. A Type “B” classification requires open excavation slopes for the sewer pipe and manhole installation to be no steeper than 1H:1V. These criteria are acceptable provided the depth of excavation within the overburden soils does not exceed 20 feet. If the required temporary excavation slopes are not feasible due to practical restrictions imposed

by existing utilities, right-of-way, etc., then a shield-type (trench box) or temporary bracing system should be considered.

We anticipate that excavations through native overburden soils and completely weathered shale bedrock will be accomplished with a typical backhoe or large hydraulic excavator. However, deeper excavations into shale/limestone bedrock formation will require significant effort. It is likely that hoe rams, rock trenchers, rock saws, and/or rock splitters will be needed to excavate through the bedrock. Significant project costs should be anticipated associated with this rock excavation operation.

Providing detailed recommendations related to the jack and bore construction technique for the length of the sewer pipe crossing the existing Prairie Road is not within the scope of our services.

4.2.2 Sewer Line Bedding and Backfill

The limited subsurface exploration performed along the proposed sewer alignment indicates that completely weathered shale bedrock, as well as, competent shale and limestone bedrock would be exposed at the sewer invert level and proposed manhole bottom level. If soft to medium stiff, loose, or otherwise unsuitable bearing soils are exposed at the proposed bearing elevations, we recommend that these soils be undercut up to a depth of 1 foot and the foundation grade be reestablished with dense graded aggregate fill, such as crushed stone, until a stable base is created.

Bedding material should consist of a clean granular soil with a maximum fragment size of 1.5 inches or less. Suitable material types per the Unified Soil Classification System would include SW, SP, GW, and GP. Bedding material type should conform to the requirements of the ODOT Construction and Materials Specification's latest edition and pipe manufacturer's recommendations.

Upon completion of bedding placement and sewer line construction, the sewer trench should be backfilled with structural fill up to proposed finish grade. Selected structural fill should be free of organics, debris, and other deleterious substances and have a plasticity index between 10 and 20. Note that some of the existing overburden soils do not meet this requirement and have higher PI values. We recommend that the engineered fill have a moisture content within about 3 percent of its optimum value and be placed in maximum 6 to 8 inch loose lifts and be uniformly compacted to at least 98 percent of standard proctor density, ASTM D698. Structural backfill within the limits of pavement areas and zone of influence of the roadway pavement sections should also conform to the requirements of the latest edition of the ODOT Construction and Materials Specifications.

5.0 GENERAL COMMENTS

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

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

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

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others.

In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION

Field Exploration Description

Twelve (12) test borings were performed during our subsurface exploration program. The test boring locations were selected and marked in the field by Terracon personnel. Ground surface elevations at the individual boring locations were interpolated from the provided plan and profile drawing developed by GGJ, Inc. and dated July 2008. The elevations indicated on the attached boring logs have been rounded to the nearest one half foot. Some of the boring locations were offset from the staked location due to overhead utility conflicts. These off-sets are noted on the individual test boring logs. The test boring locations have been identified by the approximate station marking system utilized on the provided plan and profile drawing. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with an ATV-mounted, rotary drill rig using hollow-stemmed augers to advance the boreholes. Representative samples were obtained using split-barrel sampling procedures. In the split-barrel sampling procedure, a standard 2-inch O.D. split-barrel sampling spoon is driven into the ground with a 140-pound hammer falling a distance of 30 inches. An automatic Standard Penetration Test (SPT) hammer was used to advance the split-barrel sampler in the borings performed on the site. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the standard penetration resistance value. These values are indicated on the boring logs at the depths of occurrence. The samples were sealed and returned to the laboratory for testing and classification. Rock coring, utilizing a NX diamond core barrel, was performed at test boring locations B-8 and B-9.

LOG OF BORING NO. B-1

CLIENT: **City of Bellevue**

SITE: **U.S. Route 20, Bellevue, Ohio**

PROJECT: **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 63+00

Approx. Surface Elev.: 762.5 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES DEPTH, ft.	SAMPLES RECOV, in./(RQD %)	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS LIQUID LIMIT, %	TESTS PLASTICITY INDEX, %	TESTS UNCONFINED STRENGTH, tsf	TESTS POCKET PEN, tsf
	TOPSOIL (18 " THICK)											
	1.5 761		1	SS	1 - 2.5	12	2-3-3 (6)					1.5
	LEAN CLAY WITH SAND Mottled brown and gray, very moist, stiff - medium stiff below 3.0'		2	SS	3.5 - 5	5	2-2-2 (4)	32				0.75
	5.5 - noted organic stained layer with shale fragments at 4.5' 757	5										
	SANDY LEAN CLAY, noted silty sand seam with gravel and shale fragments		3	SS	6 - 7.5	18	7-9-12 (21)	15				3.75
	8 Mottled brown and gray, moist, very stiff 754.5											
	FAT CLAY (completely weathered shale)		4	SS	8.5 - 10	18	10-12-11 (23)					4.5
	10 Gray, moist, very stiff 752.5	10										
	BORING TERMINATED AT 10 ft											

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼
WL	▼ N/E	ACR	▼
WL	DCI @ 7'		

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-23-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/23/10

LOG OF BORING NO. B-2

CLIENT **City of Bellevue**

SITE **U.S. Route 20, Bellevue, Ohio**

PROJECT **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 65+25

Approx. Surface Elev.: 762.5 ft

GRAPHIC LOG	DESCRIPTION		DEPTH, ft.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES DEPTH, ft.	SAMPLES RECOV, in./(RQD %)	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS LIQUID LIMIT, %	TESTS PLASTICITY INDEX, %	TESTS UNCONFINED STRENGTH, tsf	TESTS POCKET PEN, tsf
	0.8 TOPSOIL (10" THICK)	761.7											
	LEAN CLAY, trace sand, trace gravel Mottled brown and gray, very moist, stiff			1	SS	1 - 2.5	13	2-3-4 (7)	26				2.5
				2	SS	3.5 - 5	7	2-3-5 (8)	20				1.75
	5.5	757	5										
	FAT CLAY (completely weathered shale) 7 Mottled gray and brown, moist, very stiff	755.5		3	SS	6 - 7.5	12	6-7-9 (16)	24	55	35		3.25
	FAT CLAY (completely weathered shale) Gray, moist, very stiff to hard			4	SS	8.5 - 10	17	7-11-15 (26)					4.5
			10										
				5	SS	11 - 12.5	18	15-16-16 (32)					4.5+
	12.5	750											

BORING TERMINATED AT 12.5 ft

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼
WL	▽ N/E	ACR	▼
WL	DCI @ 8'		

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-23-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/23/10

LOG OF BORING NO. B-3

CLIENT: **City of Bellevue**

SITE: **U.S. Route 20, Bellevue, Ohio**

PROJECT: **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 68+00

Approx. Surface Elev.: 765 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES DEPTH, ft.	SAMPLES RECOV, in./(RQD %)	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS LIQUID LIMIT, %	TESTS PLASTICITY INDEX, %	TESTS UNCONFINED STRENGTH, tsf	TESTS POCKET PEN, tsf
	1 TOPSOIL (12" THICK) 764											
	LEAN CLAY, trace sand, trace gravel and rock fragments		1	SS	1 - 2.5	12	2-3-4 (7)	19				3.0
	3 Mottled brown and gray, very moist, stiff 762											
	LEAN CLAY WITH SAND, trace gravel and shale fragments		2	SS	3.5 - 5	14	4-4-7 (11)	18	31	13		3.5
	5.5 Brown trace gray, moist, very stiff 759.5	5										
	FAT CLAY, trace sand, trace shale fragments Brown trace gray, moist, very stiff		3	SS	6 - 7.5	18	6-7-8 (15)					4.0
	8 757											
	FAT CLAY (completely weathered shale) Gray, moist, very stiff to hard		4	SS	8.5 - 10	14	7-8-10 (18)					4.5
		10										
			5	SS	11 - 12.5	18	17-20-21 (41)					4.5
	12.5 752.5											

BORING TERMINATED AT 12.5 ft

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

Note: Test boring was moved approximately 6 feet south due to the presence of an overhead power line.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼
WL	▽ N/E	ACR	▼
WL	DCI @ 8'		

H. C. NUTTING

A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-23-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/23/10

LOG OF BORING NO. B-4

CLIENT: **City of Bellevue**

SITE: **U.S. Route 20, Bellevue, Ohio**

PROJECT: **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 70+50

Approx. Surface Elev.: 770 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES DEPTH, ft.	SAMPLES RECOV, in./(RQD %)	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS LIQUID LIMIT, %	TESTS PLASTICITY INDEX, %	TESTS UNCONFINED STRENGTH, tsf	TESTS POCKET PEN, tsf
	0.3 TOPSOIL (3" THICK) 769.7											
	CLAYEY SAND, trace gravel and shale fragments Brown and gray, wet, very loose		1	SS	1 - 2.5	18	1-1-1 (2)	24	24	9		
	3 767											
	LEAN CLAY WITH SAND, trace gravel and shale fragments Gray and brown, moist, very stiff		2	SS	3.5 - 5	18	4-5-7 (12)	14				4.25
		5										
			3	SS	6 - 7.5	14	6-6-7 (13)	12				4.5
	8 762											
	FAT CLAY (completely weathered shale) Gray, moist, very stiff to hard		4	SS	8.5 - 10	16	7-7-9 (16)	17				4.5
		10										
			5	SS	11 - 12.5	14	8-13-15 (28)					4.5+
			6	SS	13.5 - 15	18	15-15-21 (36)	13				4.5+
	15 755	15										
	BORING TERMINATED AT 15 ft											

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

Note: Test boring was moved approximately 7 feet south due to the presence of an overhead power line.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼
WL	▽ N/E	ACR	▼
WL	DCI @ 12'		

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-23-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/23/10

LOG OF BORING NO. B-5

CLIENT: **City of Bellevue**

SITE: **U.S. Route 20, Bellevue, Ohio**

PROJECT: **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 73+00

Approx. Surface Elev.: 776 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	NUMBER	TYPE	DEPTH, ft.	RECOV, in./(RQD %)	BLOWS / 6in. (SPT - N)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNCONFINED STRENGTH, tsf	POCKET PEN, tsf
			SAMPLES					TESTS				
	0.3 TOPSOIL (3" THICK) 775.7											
	SILTY SAND WITH GRAVEL and rock fragments Reddish brown, moist, loose		1	SS	1 - 2.5	18	2-3-3 (6)					
	3 773											
	CLAYEY SAND, trace gravel and shale fragments Brown, very moist, loose		2	SS	3.5 - 5	18	4-3-3 (6)	20				1.0
	5.5 ▽ 770.5	5										
	POORLY GRADED SAND WITH SILT AND FINE GRAVEL and shale fragments Brown, wet, loose		3	SS	6 - 7.5	18	3-3-3 (6)					3.75
	8 768											
	LEAN CLAY WITH SAND, trace gravel and shale fragments Gray, very moist, very stiff		4	SS	8.5 - 10	18	4-5-7 (12)	16				4.5
		10										
			5	SS	11 - 12.5	18	5-6-8 (14)					.5
	13 763											
	FAT CLAY (completely weathered shale) Gray, moist, very stiff to hard ▼		6	SS	13.5 - 15	18	7-9-11 (20)					4.5
		15										
	20 756		7	SS	18.5 - 20	18	15-28-31 (59)					4.5+
	BORING TERMINATED AT 20 ft	20										
	Note: Ground surface elevation interpolated from the provided plan and profile drawing.											

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 5.5	WD	▼
WL	▼ 16	ACR	▼
WL		WCI @ 20'	

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-23-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/24/10

LOG OF BORING NO. B-6

CLIENT: **City of Bellevue**

SITE: **U.S. Route 20, Bellevue, Ohio**

PROJECT: **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 75+50

Approx. Surface Elev.: 779.5 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	NUMBER	TYPE	DEPTH, ft.	RECOV, in./(RQD %)	BLOWS / 6in. (SPT - N)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNCONFINED STRENGTH, tsf	POCKET PEN, tsf
	0.2 TOPSOIL (2" THICK) 779.3											
	SILTY SAND, trace fine gravel Brown, moist, loose		1	SS	1 - 2.5	14	3-2-3 (5)					
			2	SS	3.5 - 5	14	2-3-4 (7)					
	5.5 774	5										
	CLAYEY SAND WITH FINE GRAVEL and shale fragments Brown, very moist, loose		3	SS	6 - 7.5	15	5-3-3 (6)	20				
	8 ▼ 771.5											
	LEAN CLAY WITH SAND, trace gravel and shale fragments Gray trace brown, very moist, very stiff		4	SS	8.5 - 10	12	1-7-5 (12)					3.5
	10.5 769	10										
	FAT CLAY (completely weathered shale) Gray, moist, hard		5	SS	11 - 12.5	18	14-14-38 (52)					4.5+
			6	SS	13.5 - 15	18	20-20-37 (57)	9				4.5+
		15										
			7	SS	18.5 - 20	16	19-14-23 (37)					4.5
		20										
			8	SS	23.5 - 24.3	10	28-50/5"					
	25 Auger refusal at 25 ft. 754.5	25										
	BORING TERMINATED AT 25 ft											

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 8	WD	▼
WL	▼ 8	ACR	▼
WL		WCI @ 18'	

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-25-10		
BORING COMPLETED	5-25-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/24/10

LOG OF BORING NO. B-7

CLIENT: **City of Bellevue**

SITE: **U.S. Route 20, Bellevue, Ohio**

PROJECT: **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 77+50

Approx. Surface Elev.: 778 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	NUMBER	TYPE	DEPTH, ft.	RECOV, in./(RQD %)	BLOWS / 6in. (SPT - N)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNCONFINED STRENGTH, tsf	POCKET PEN, tsf
	0.3 TOPSOIL (3" THICK) 777.7											
	SANDY LEAN CLAY, trace fine gravel Mottled yellowish brown and gray, very moist, soft		1	SS	1 - 2.5	18	2-2-3 (5)					1.0
	3 775											
	SANDY LEAN CLAY WITH GRAVEL and shale fragments Dark brown, very moist, medium stiff		2	SS	3.5 - 5	16	3-4-5 (9)	18				1.25
	5.5 ▼ 772.5	5										
	CLAYEY SAND with fine to coarse rock fragments Brown and yellowish brown, wet, very loose		3	SS	6 - 7.5	17	2-1-25 (26)					0.75
	8 770											
	Auger refusal at 8.0'											
	BORING TERMINATED AT 8 ft											

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 5.5	WD	▼
WL	▼ 5.5	ACR	▼
WL		WCI @ 5.5'	

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-23-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON.20080217.GDT 6/24/10

LOG OF BORING NO. B-8

CLIENT: **City of Bellevue**

SITE: **U.S. Route 20, Bellevue, Ohio**

PROJECT: **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 77+90

Approx. Surface Elev.: 778 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	NUMBER	TYPE	DEPTH, ft.	RECOV, in./(RQD %)	BLOWS / 6in. (SPT - N)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNCONFINED STRENGTH, tsf	POCKET PEN, tsf
							SAMPLES				TESTS	
	0.3 TOPSOIL (4" THICK) 777.7											
	CLAYEY SAND Brown and gray, very moist, loose		1	SS	1 - 2.5	15	2-2-3 (5)					
	3 ▽ 775											
	SILTY SAND, trace fine gravel Brown, wet, medium dense		2	SS	3.5 - 5	18	4-5-8 (13)					
	- with gravel and shale fragments below 6.0'	5	3	SS	6 - 7.5	18	5-8-7 (15)					
	8 770											
	CLAYEY SAND WITH FINE GRAVEL and shale fragments		4	SS	8.5 - 8.7	8	10-50/2"	14	23	10		
	10 Gray, wet, medium dense 768	10										
	Core 10-11.5 Feet:		R1	NX	10 - 11.5	9 (39)						
	11.5 **GRAY SHALE AND GRAY LIMESTONE** 766.5											
	Shale comprises 50% of the core run; is very soft, thinly bedded and friable. Limestone comprises 50% of the core run and is hard; limestone occurs in two layers whick are approximately 7" and 2" thick.		R2	NX	11.5 - 16.5	58 (47)						
	16.5 Core 11.5-16.5 Feet: 761.5											
	GRAY LIMESTONE WITH GRAY SHALE LAYERS		R3	NX	16.5 - 21.5	60 (17)						
	Limestone comprises 95% and is hard. Limestone layers over 1" thick occur in following sequence of thickness: 6"; 4"; 3"; 1.5"; 2"; 4.5"; 6"; 2.5"; 3"; 3.75"; 3.5"; 4.75"; 7"											
	21.5 Shale comprises 5%, is very soft, thinly bedded and friable 756.5		R4	NX	21.5 - 25	42 (63)						
	Core 16.5-21.5 Feet:											
	GRAY SHALE WITH GRAY LIMESTONE LAYERS											
	25 Shale comprises 61% and is very soft to soft, thinly bedded and friable 753											
	Limestone comprises 39% and is hard. Limestone layers over 1" thick occur in following sequence of thickness: 4"; 2.75"; 3"; 3"; 7.5"; 3".											

Continued Next Page

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 3	▼	
WL	▽ 3 *	ACR	▼
WL	WCI @ 6'		

H. C. NUTTING

A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-25-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/24/10

LOG OF BORING NO. B-8

CLIENT **City of Bellevue**

SITE **U.S. Route 20, Bellevue, Ohio**

PROJECT **Sanitary Sewer Extension Project - Phase I**

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: DEPTH, ft.	SAMPLES: RECOV, in./(RQD %)	SAMPLES: BLOWS / 6in. (SPT - N)	TESTS: WATER CONTENT, %	TESTS: LIQUID LIMIT, %	TESTS: PLASTICITY INDEX, %	TESTS: UNCONFINED STRENGTH, tsf	TESTS: POCKET PEN, tsf
	Core 21.5-25 Feet: **GRAY SHALEY LIMESTONE AND GRAY SHALE** Shaley limestone comprises 52% and is moderately hard. Limestone layers over 1" thick occur in following sequence of thickness: 5.5"; 6"; 3.5"; 3.75"; 3". Shale comprises 48% and is soft to medium hard. Shale is thinly bedded and fossileferrous. BORING TERMINATED AT 10 ft Note: Ground surface elevation interpolated from the provided plan and profile drawing. * Water added during the rock coring operation. Groundwater reading influenced by external water source.											

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 3		▼
WL	▽ 3 *	ACR	▼
WL	WCI @ 6'		

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-25-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20060217.GDT 6/24/10

LOG OF BORING NO. B-9

CLIENT: **City of Bellevue**

SITE: **U.S. Route 20, Bellevue, Ohio**

PROJECT: **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 81+25

Approx. Surface Elev.: 777 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES DEPTH, ft.	SAMPLES RECOV, in./(RQD %)	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS LIQUID LIMIT, %	TESTS PLASTICITY INDEX, %	TESTS UNCONFINED STRENGTH, tsf	TESTS POCKET PEN, tsf
	0.3 TOPSOIL (3" THICK) 776.7											
	SILTY SAND Brown and gray, very moist, loose		1	SS	1 - 2.5	15	3-4-5 (9)					
	3 ▽ 774											
	SILTY SAND, trace gravel Light brown, wet, loose		2	SS	3.5 - 5	12	3-4-4 (8)					
	5.5 771.5	5										
	CLAYEY SAND with fine to coarse gravel and rock fragments Light brown and gray, wet, medium dense		3	SS	6 - 7.5	6	19-11-9 (20)	21				
	8 769											
	SILTY SAND with fine to coarse gravel and rock fragments - noted limestone cobble Dark brown and black, very moist, medium dense		4	SS	8.5 - 10	10	9-8-11 (19)					
	11 766	10										
	Core 11-16 Feet: **GRAY LIMESTONE WITH GRAY SHALE LAYERS** Limestone comprises 75% and is hard. Vertical joint, discontinuous and approximately 8.5" in length noticed at 11 feet depth. Limestone layers over 1" thick occur in following sequence of thickness: 8.5"; 2"; 2"; 3.75"; 3.5"; 4"; 1.5"; 9.25"; 3.5"; 4"; 2"; 5.25"; 2"; 2"; 3.25"; 2.5"; 2.25"; 6.75"; 4.5"; 1.5"; 3.5"; 4.75"; 6"; 6.5".		R1	NX	11 - 16	49 (29)						
	16 Shale comprises 25% and is very soft, thinly bedded and friable. 761		R2	NX	16 - 23	60 (44)						

Continued Next Page

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 3		▼
WL	▼ 3 *	ACR	▼
WL	WCI @ 7'		

H. C. NUTTING

A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-25-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

LOG OF BORING NO. B-9

CLIENT **City of Bellevue**

SITE **U.S. Route 20, Bellevue, Ohio**

PROJECT **Sanitary Sewer Extension Project - Phase I**

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES DEPTH, ft.	SAMPLES RECOV, in./(RQD %)	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS LIQUID LIMIT, %	TESTS PLASTICITY INDEX, %	TESTS UNCONFINED STRENGTH, tsf	TESTS POCKET PEN, tsf
	Core 16-21 Feet:											
21	**GRAY LIMESTONE AND GRAY SHALE** 756											
	Limestone comprises 50% and is hard. Limestone layers over 1" thick occur in following sequence of thickness: 5.25"; 2"; 2"; 3.25"; 2.5"; 2.25"; 6.75"; 4.5"; 1.5".		R3	NX	21 - 25	48 (60)						
	Shale comprises 50% and is very soft to soft, thinly bedded and friable.											
	Core 21-25 Feet:											
25	**GRAY SHALEY LIMESTONE AND GRAY SHALE** 752											
	Shaley limestone comprises 50% and is moderately hard. Limestone layers over 1" thick occur in following sequence of thickness: 3.5"; 4.75"; 6"; 6.5".											
	Shale comprises 50% and is soft to medium hard. Shale is thinly bedded and fossilleferous.											
	BORING TERMINATED AT 11 ft											

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

* Water added during the rock coring operation. Groundwater reading influenced by this external water source.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 3		▼
WL	▽ 3 *	ACR	▼
WL	WCI @ 7'		

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-25-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/24/10

LOG OF BORING NO. B-10

CLIENT **City of Bellevue**

SITE **U.S. Route 20, Bellevue, Ohio**

PROJECT **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 83+75

Approx. Surface Elev.: 777 ft

GRAPHIC LOG		DESCRIPTION		DEPTH, ft.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES DEPTH, ft.	SAMPLES RECOV, in./(RQD %)	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS LIQUID LIMIT, %	TESTS PLASTICITY INDEX, %	TESTS UNCONFINED STRENGTH, tsf	TESTS POCKET PEN, tsf
	0.8	TOPSOIL (10" THICK)	776.2											
		SANDY LEAN CLAY, trace gravel Dark brown and yellowish brown, very moist,			1	SS	1 - 2.5	10	4-4-4 (8)					
	3	medium stiff	774											
		CLAYEY SAND trace gravel and rock fragments (limestone) Yellowish brown, wet, loose			2	SS	3.5 - 5	9	4-7-31 (38)	30				0.50
		- with gravel and limestone fragments below 6.0'		5	3	SS	6 - 7.5	5	50/5"					
	8	Auger refusal at 8.0'	769											

BORING TERMINATED AT 8 ft

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼
WL	▼ N/E	ACR	▼
WL		DCI @ 6'	

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-23-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

LOG OF BORING NO. B-11

CLIENT: **City of Bellevue**

SITE: **U.S. Route 20, Bellevue, Ohio**

PROJECT: **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Statioin 86+50

Approx. Surface Elev.: 778 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	NUMBER	TYPE	DEPTH, ft.	RECOV, in./(RQD %)	BLOWS / 6in. (SPT - N)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNCONFINED STRENGTH, tsf	POCKET PEN, tsf
	SAMPLES						TESTS					
	0.8 TOPSOIL (10" THICK) 777.2											
	LEAN CLAY trace sand, trace gravel Mottled yellowish brown and gray, very moist, stiff		1	SS	1 - 2.5	14	2-4-4 (8)					1.0
	3 775											
	FAT CLAY, trace rock fragments Mottled yellowish brown and gray, very moist, stiff		2	SS	3.5 - 5	18	3-3-4 (7)					2.0
		5										
			3	SS	6 - 7.5	7	33-50/4"	33				1.75
	8 - noted limestone fragments at 7.5' 770											
	FAT CLAY (completely weathered shale) Gray, moist, hard		4	SS	8.5 - 10	10	22-26-28 (54)					4.5+
	Auger refusal at 12.0'	10										
	12 766		5	SS	11 - 11.5	6	28-50/1"					4.5+
	BORING TERMINATED AT 12 ft											

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼
WL	▽ N/E	ACR	▼
WL		DCI @ 8'	

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-23-10		
BORING COMPLETED	5-23-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/23/10

LOG OF BORING NO. B-12

CLIENT **City of Bellevue**

SITE **U.S. Route 20, Bellevue, Ohio**

PROJECT **Sanitary Sewer Extension Project - Phase I**

Boring Location: Approximate Station 89+00

Approx. Surface Elev.: 780 ft

GRAPHIC LOG	DESCRIPTION		DEPTH, ft.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES DEPTH, ft.	SAMPLES RECOV, in./(RQD %)	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS LIQUID LIMIT, %	TESTS PLASTICITY INDEX, %	TESTS UNCONFINED STRENGTH, tsf	TESTS POCKET PEN, tsf
	0.1 TOPSOIL (1" THICK)	779.9											
	SANDY LEAN CLAY, trace gravel and rock fragments			1	SS	1 - 2.5	14	1-2-2 (4)					0.75
	3 Mottled reddish brown and gray, very moist, medium stiff	777											
	CLAYEY SAND WITH FINE GRAVEL and rock fragments			2	SS	3.5 - 5	16	3-2-3 (5)	25				
	5.5 Reddish brown and gray, wet, very loose	774.5	5										
	SILTY SAND WITH FINE GRAVEL and rock fragments			3	SS	6 - 7.5	18	4-1-1 (2)	21				
	8 Brown, wet, very loose	772											
	SANDY SILTY CLAY with rock fragments (shale)			4	SS	8.5 - 10	16	4-7-10 (17)					4.0
	10.5 Gray, moist, very stiff	769.5	10										
	FAT CLAY, trace sand (completely weathered shale)			5	SS	11 - 12.5	15	8-10-11 (21)					4.5+
	13 Gray, moist, very stiff	767											
	13.6 **LIMESTONE**	766.4		6	SS	13.5 - 13.6	1	50/1"					
	Gray, highly weathered, moderately hard												
	Auger refusal at 13.6'												
	BORING TERMINATED AT 13.6 ft												

Note: Ground surface elevation interpolated from the provided plan and profile drawing.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 3	WD	▼
WL	▼ 8	ACR	▼
WL		WCI @ 9'	

H. C. NUTTING
A Terracon COMPANY

BORING STARTED	5-22-10		
BORING COMPLETED	5-22-10		
RIG	93	FOREMAN	KH
		JOB #	N4105037

BOREHOLE 99 U.S. 20 SANITARY SEWER.GPJ TERRACON 20080217.GDT 6/23/10

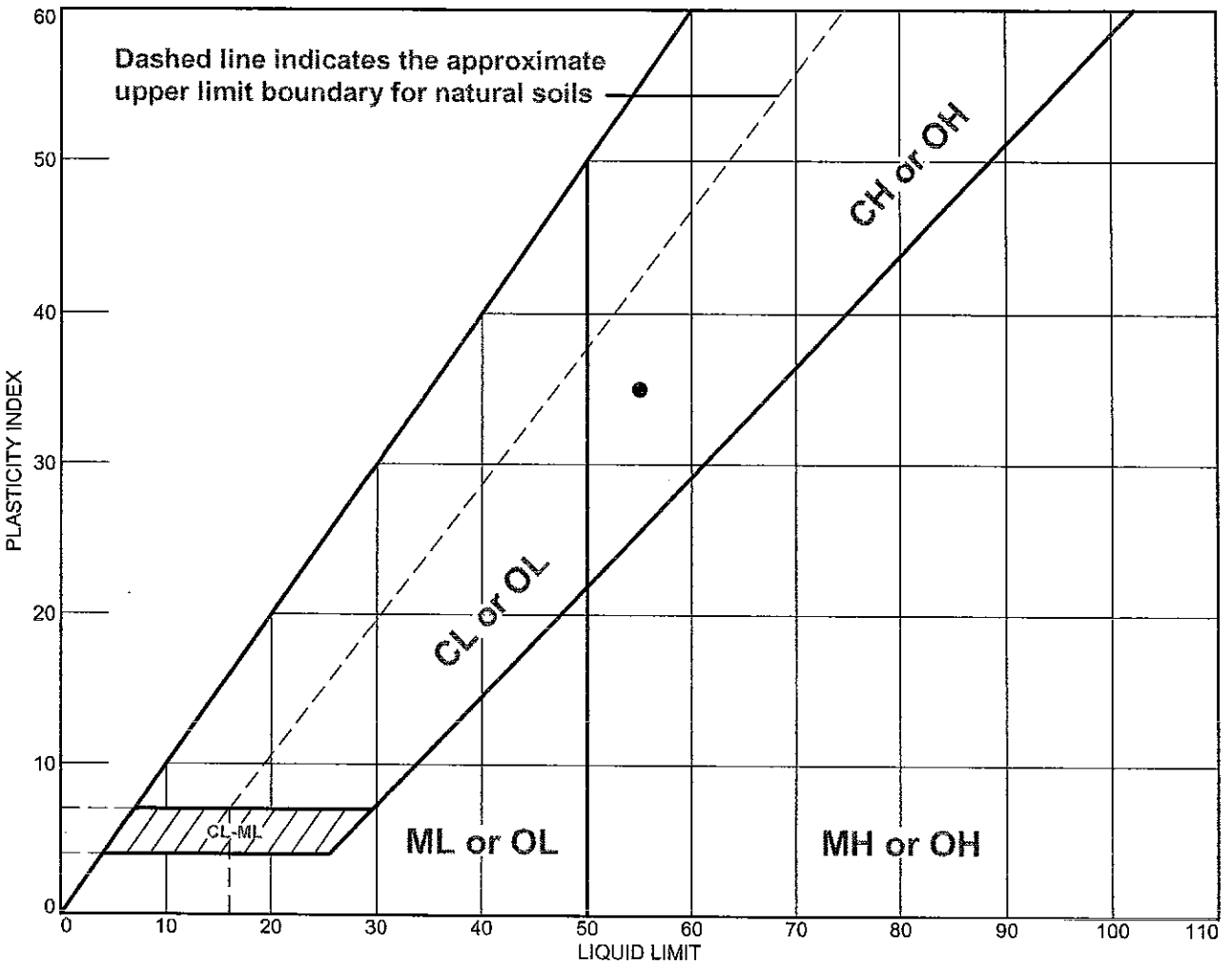
APPENDIX B
LABORATORY TESTING

Laboratory Testing

Representative soil samples were tested in the laboratory to measure their natural water content. A hand penetrometer was used to estimate the approximate unconfined compressive strength of representative cohesive samples. The hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone. The test results are provided on the boring logs included in Appendix A.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. A brief description of this classification system is attached to this report. Rock descriptions are per the attached general notes. All classification was by visual manual procedures. Selected samples were further classified using the results of Atterberg limit testing and gradation analyses. The Atterberg limit test results are also provided on the boring logs. Laboratory data has been included in Appendix B.

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Mottled gray and brown FAT CLAY (completely weathered shale)	55	20	35			

Project No. N4105037 **Client:** City of Bellevue

Project: U.S. Route 20 Sanitary Sewer Extension Phase I

● **Source of Sample:** B-2 **Depth:** 6.0'-7.5' **Sample Number:** S-3

Remarks:

● HCN Lab No. 403
Date: 6-14-10

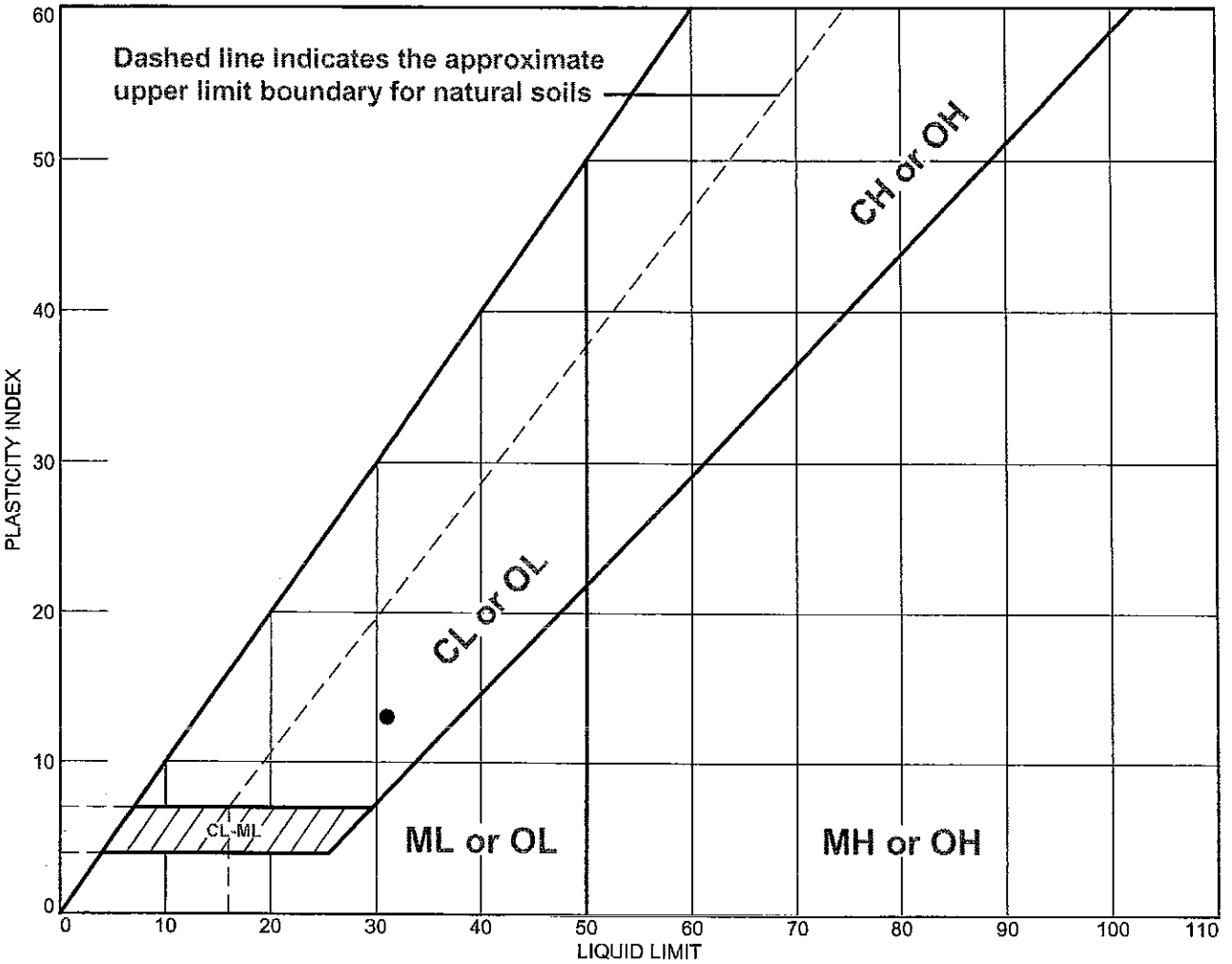
H.C. Nutting
A Terracon Company
Columbus, Ohio

Figure

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Tested By: VP **Checked By:** AM

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown trace gray LEAN CLAY with sand, trace gravel and shale fragments	31	18	13			

Project No. N4105037 **Client:** City of Bellevue

Project: U.S. Route 20 Sanitary Sewer Extension Phase I

● **Source of Sample:** B-3 **Depth:** 3.5'-5.0' **Sample Number:** S-2

Remarks:

● HCN Lab No. 404
Date: 6-14-10

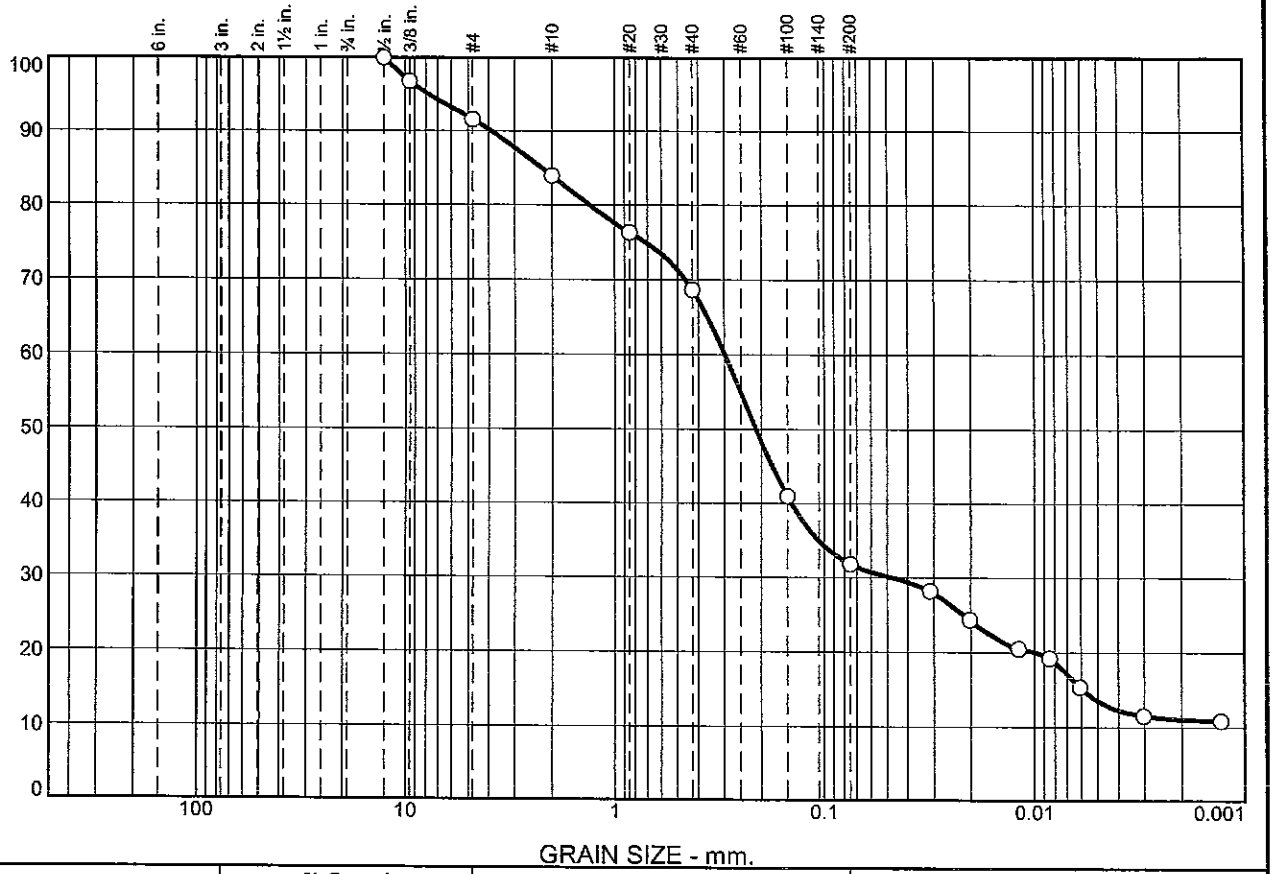
H.C. Nutting
A Terracon Company
Columbus, Ohio

Figure

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	8.4	7.7	15.2	36.9	18.3	13.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2	100.0		
3/8	96.8		
#4	91.6		
#10	83.9		
#20	76.3		
#40	68.7		
#100	40.9		
#200	31.8		

* (no specification provided)

Material Description

Brown and gray CLAYEY SAND trace fine gravel and shale fragments

Atterberg Limits

PL= 15 LL= 24 PI= 9

Coefficients

D_{90}= 3.8815 D_{85}= 2.2452 D_{60}= 0.2977
D_{50}= 0.2117 D_{30}= 0.0481 D_{15}= 0.0059
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

HCN Lab No. 405

Source of Sample: B-4 **Depth:** 1.0'-2.5'
Sample Number: S-1

Date: 6-14-10

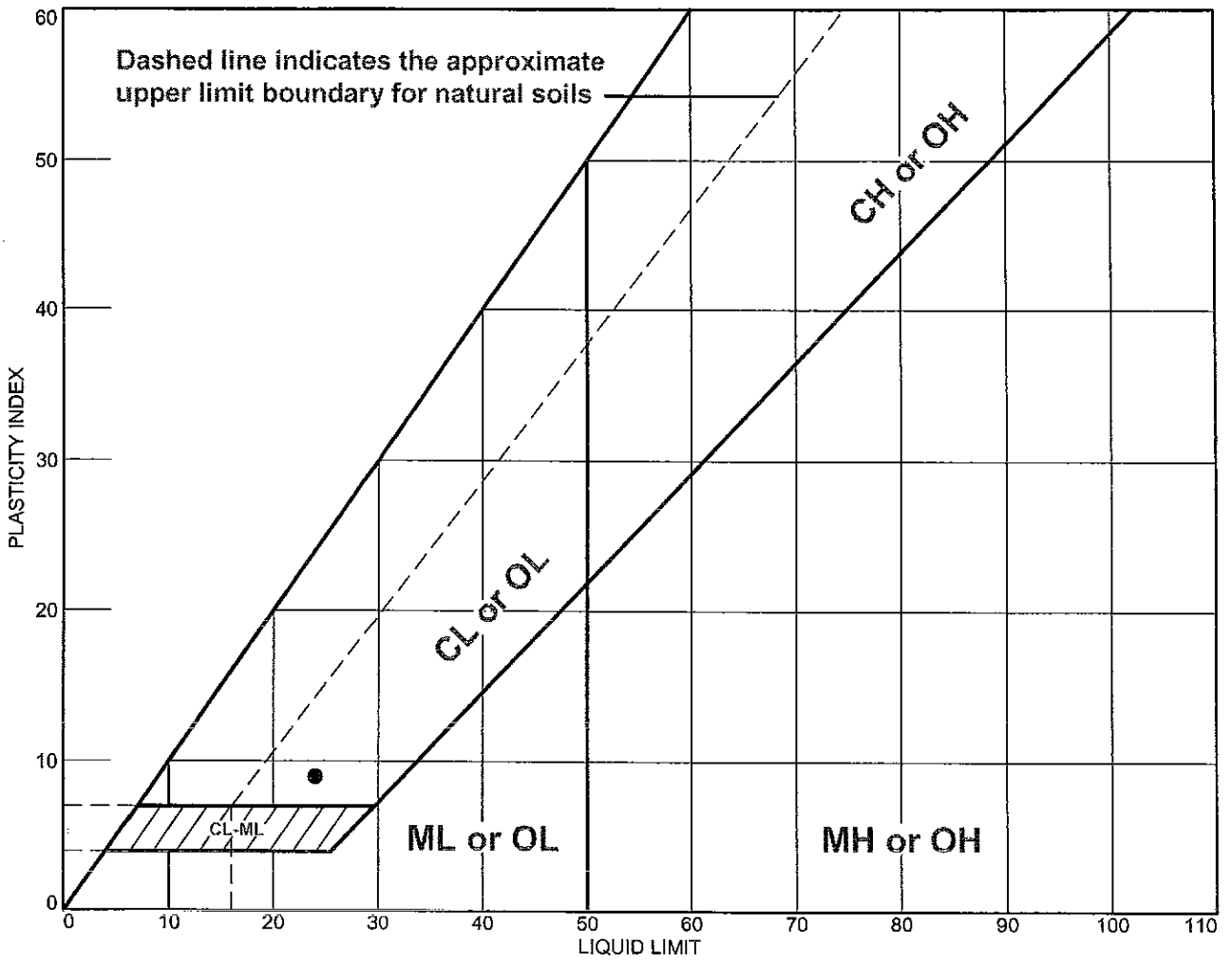
H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown and gray CLAYEY SAND trace fine gravel and shale fragments	24	15	9	68.7	31.8	SC

Project No. N4105037 **Client:** City of Bellevue

Project: U.S. Route 20 Sanitary Sewer Extension Phase I

● **Source of Sample:** B-4 **Depth:** 1.0'-2.5' **Sample Number:** S-1

Remarks:
● HCN Lab No. 405
Date: 6-14-10

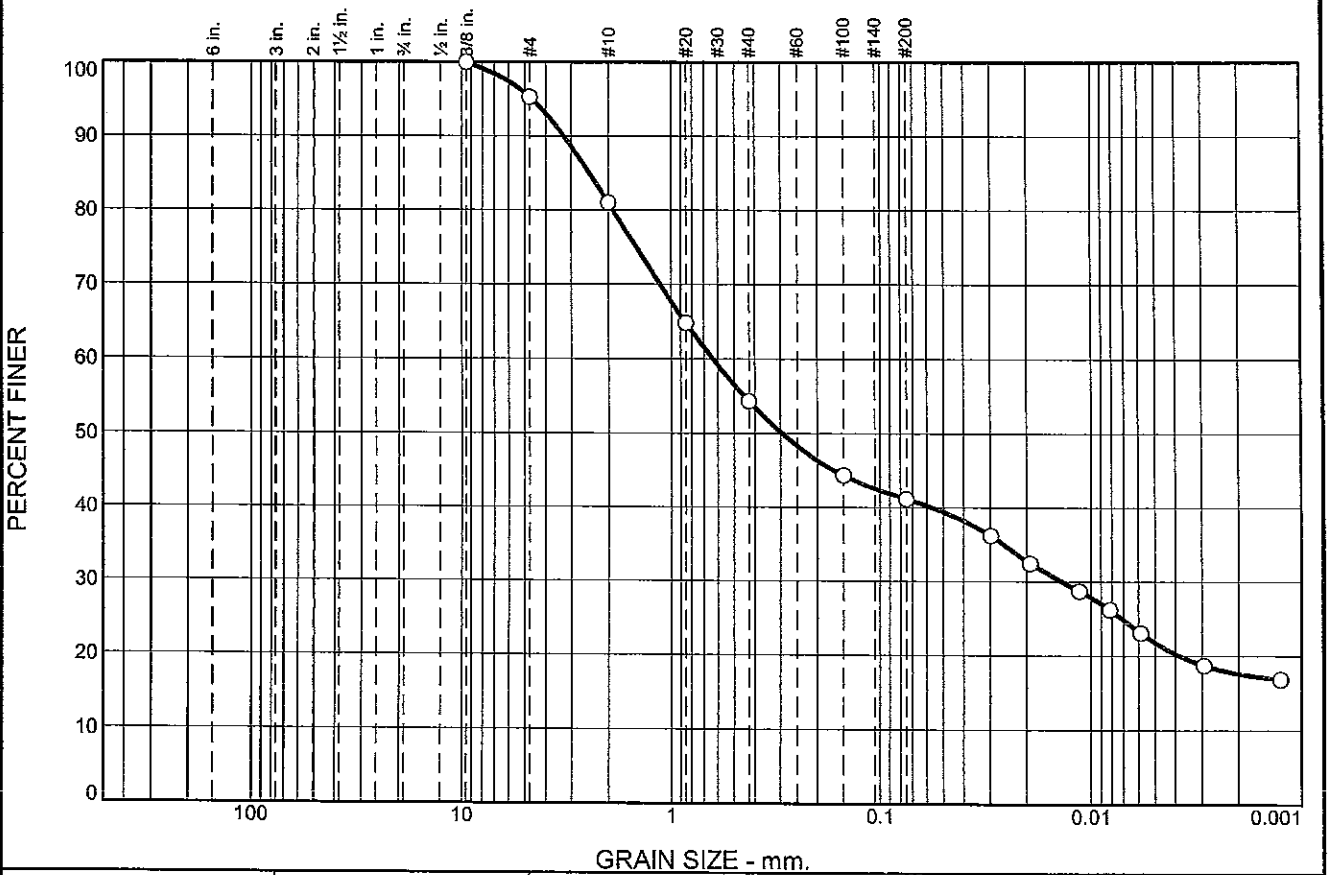
H.C. Nutting
A Terracon Company
Columbus, Ohio

Figure

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.7	14.3	26.7	13.2	19.3	21.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	95.3		
#10	81.0		
#20	64.8		
#40	54.3		
#100	44.3		
#200	41.1		

* (no specification provided)

Material Description

Brown CLAYEY SAND, trace gravel and shale fragments

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 3.2622 D_{85}= 2.4641 D_{60}= 0.6332
D_{50}= 0.2954 D_{30}= 0.0138 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

HCN Lab No. 406

Source of Sample: B-5 **Depth:** 3.5'-5.0'
Sample Number: S-2

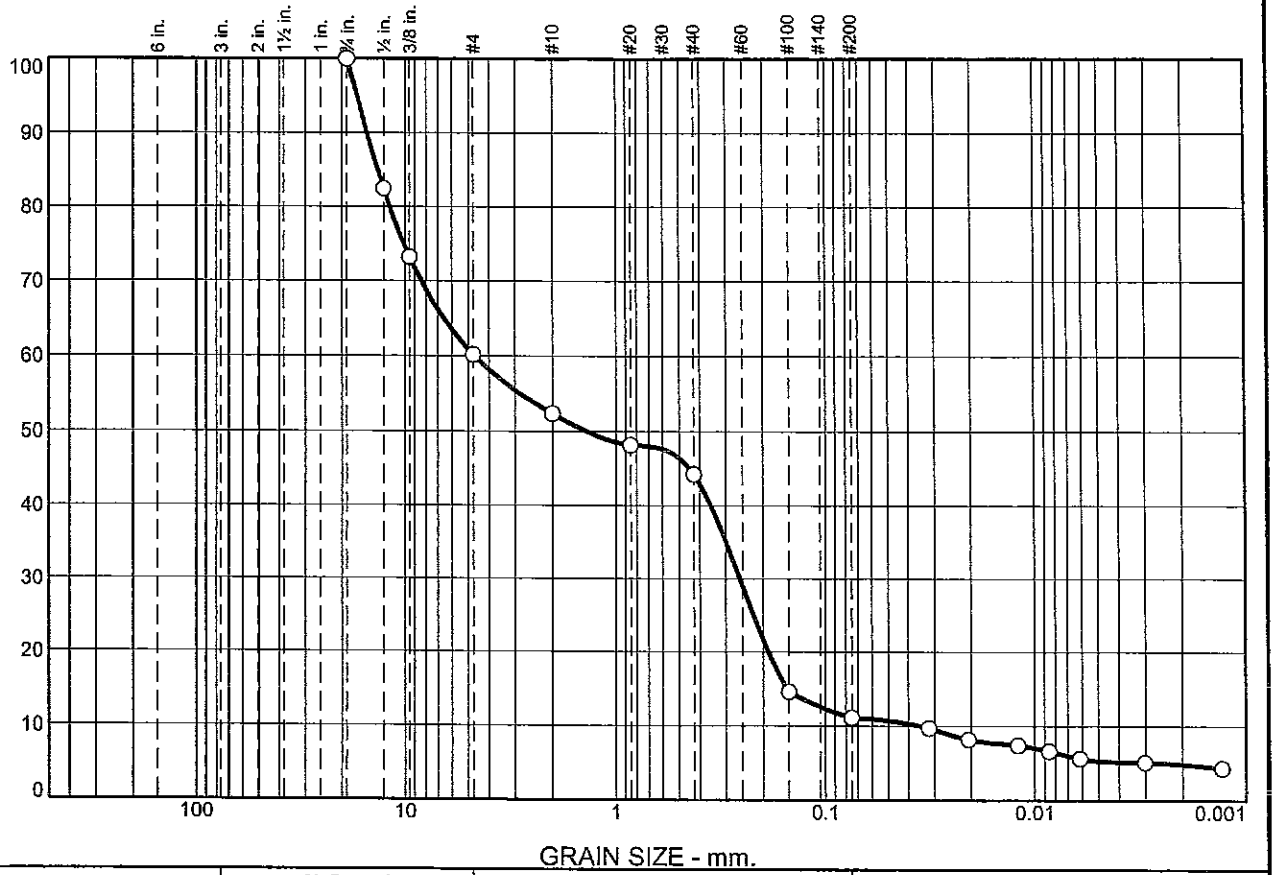
Date: 6-14-10

H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I
Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	39.8	7.8	8.2	33.1	5.8	5.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4	100.0		
1/2	82.4		
3/8	73.2		
#4	60.2		
#10	52.4		
#20	48.2		
#40	44.2		
#100	14.6		
#200	11.1		

* (no specification provided)

Material Description

Brown poorly graded SAND with silt, with fine gravel and shale fragments

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 15.2789 D_{85}= 13.5659 D_{60}= 4.6701
D_{50}= 1.3855 D_{30}= 0.2570 D_{15}= 0.1533
D_{10}= 0.0357 C_u= 130.85 C_c= 0.40

Classification

USCS= SP-SM AASHTO=

Remarks

HCN Lab No. 407

Source of Sample: B-5 **Depth:** 6.0'-7.5'
Sample Number: S-3

Date: 6-14-10

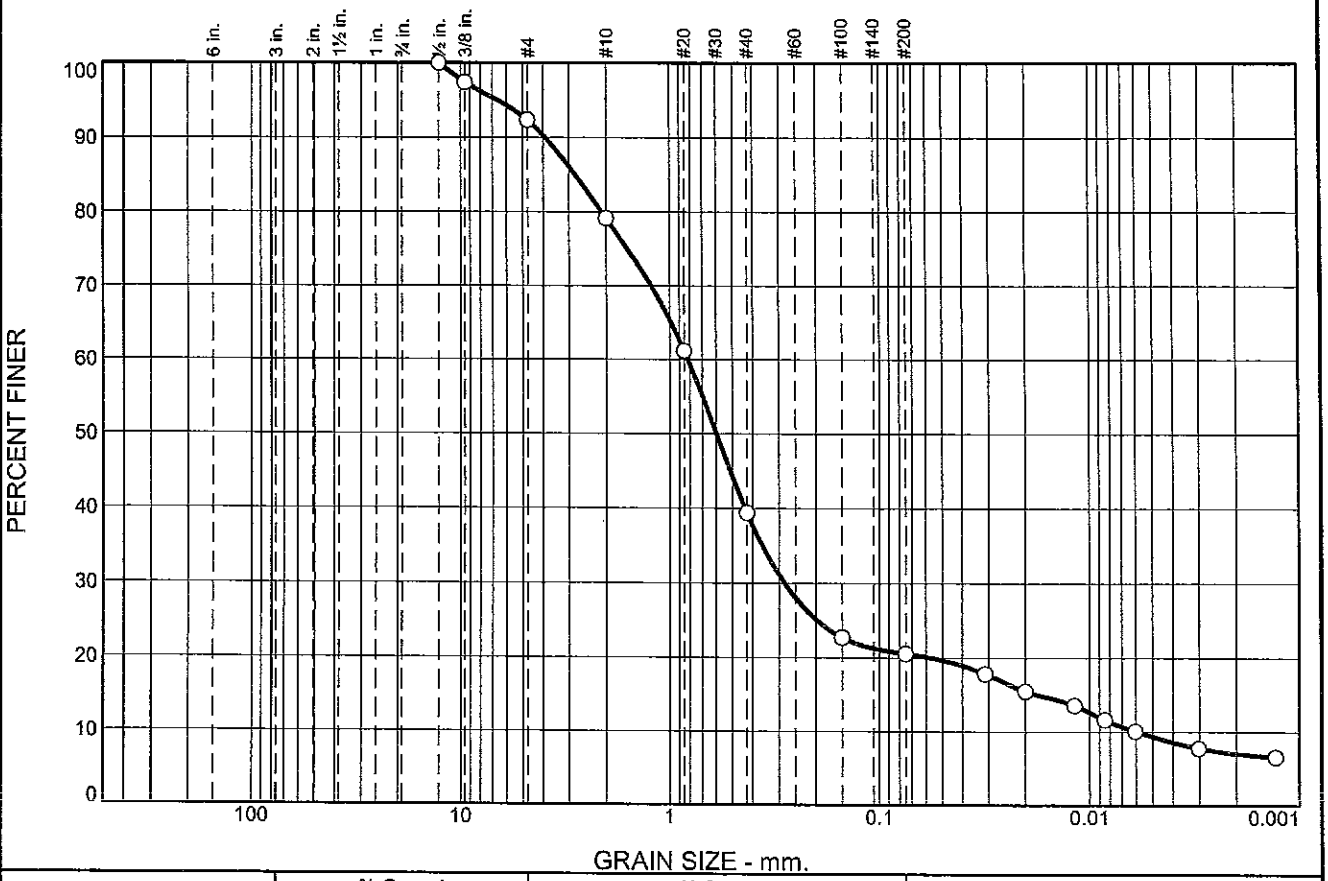
H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	7.7	13.1	39.8	18.9	11.2	9.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2	100.0		
3/8	97.4		
#4	92.3		
#10	79.2		
#20	61.2		
#40	39.4		
#100	22.7		
#200	20.5		

* (no specification provided)

Material Description

Brown SILTY SAND, trace fine gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 3.9024 D_{85}= 2.8057 D_{60}= 0.8160
D_{50}= 0.5967 D_{30}= 0.2817 D_{15}= 0.0175
D_{10}= 0.0059 C_u= 137.48 C_c= 16.39

Classification

USCS= SM AASHTO=

Remarks

HCN Lab No. 408

Source of Sample: B-6 **Depth:** 1.0'-2.5'
Sample Number: S-1

Date: 6-14-10

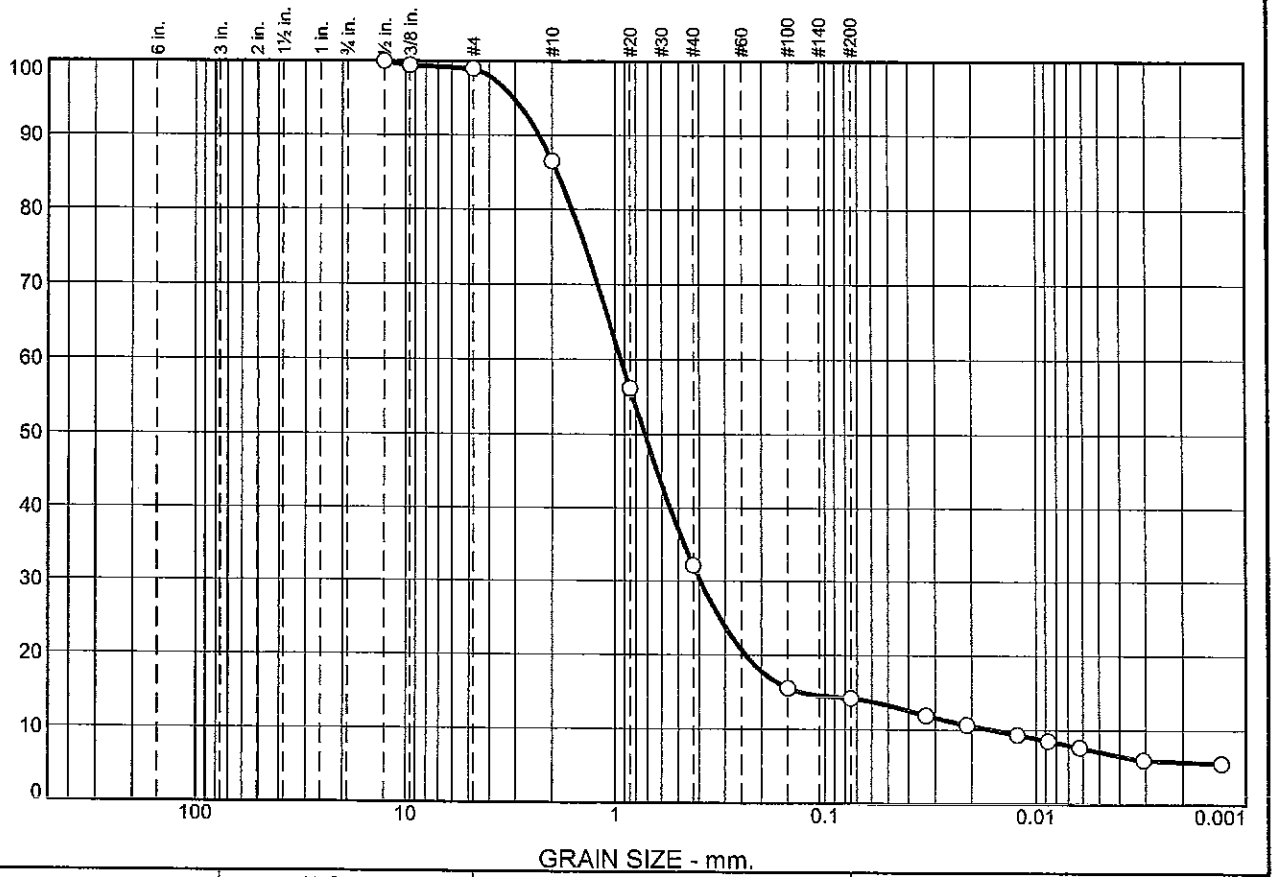
H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.0	12.5	54.4	17.9	7.1	7.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2	100.0		
3/8	99.4		
#4	99.0		
#10	86.5		
#20	56.2		
#40	32.1		
#100	15.5		
#200	14.2		

* (no specification provided)

Material Description

Brown SILTY SAND, trace fine gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 2.3073 D_{85}= 1.8939 D_{60}= 0.9368
D_{50}= 0.7229 D_{30}= 0.3933 D_{15}= 0.1325
D_{10}= 0.0162 C_u= 57.96 C_c= 10.21

Classification

USCS= SM AASHTO=

Remarks

HCN Lab No. 409

Source of Sample: B-6 **Depth:** 3.5'-5.0'
Sample Number: S-2

Date: 6-14-10

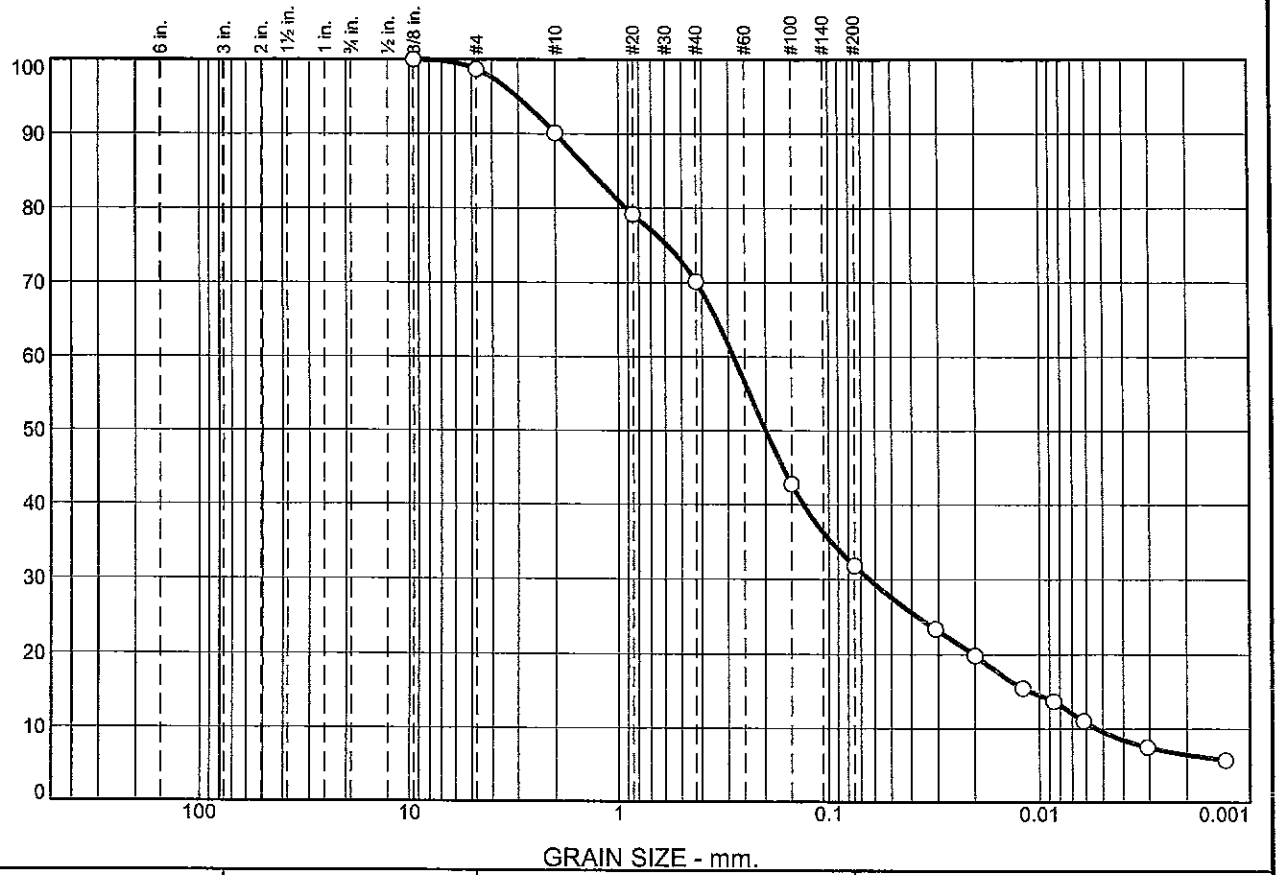
H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.3	8.6	20.0	38.3	22.2	9.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	98.7		
#10	90.1		
#20	79.2		
#40	70.1		
#100	42.7		
#200	31.8		

* (no specification provided)

Material Description

Brown SILTY SAND, trace fine gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 1.9871 D_{85}= 1.3612 D_{60}= 0.2821
D_{50}= 0.1990 D_{30}= 0.0636 D_{15}= 0.0111
D_{10}= 0.0054 C_u= 52.65 C_c= 2.68

Classification

USCS= SM AASHTO=

Remarks

HCN Lab No. 411

Source of Sample: B-8 **Depth:** 3.5'-5.0'
Sample Number: S-2

Date: 6-14-10

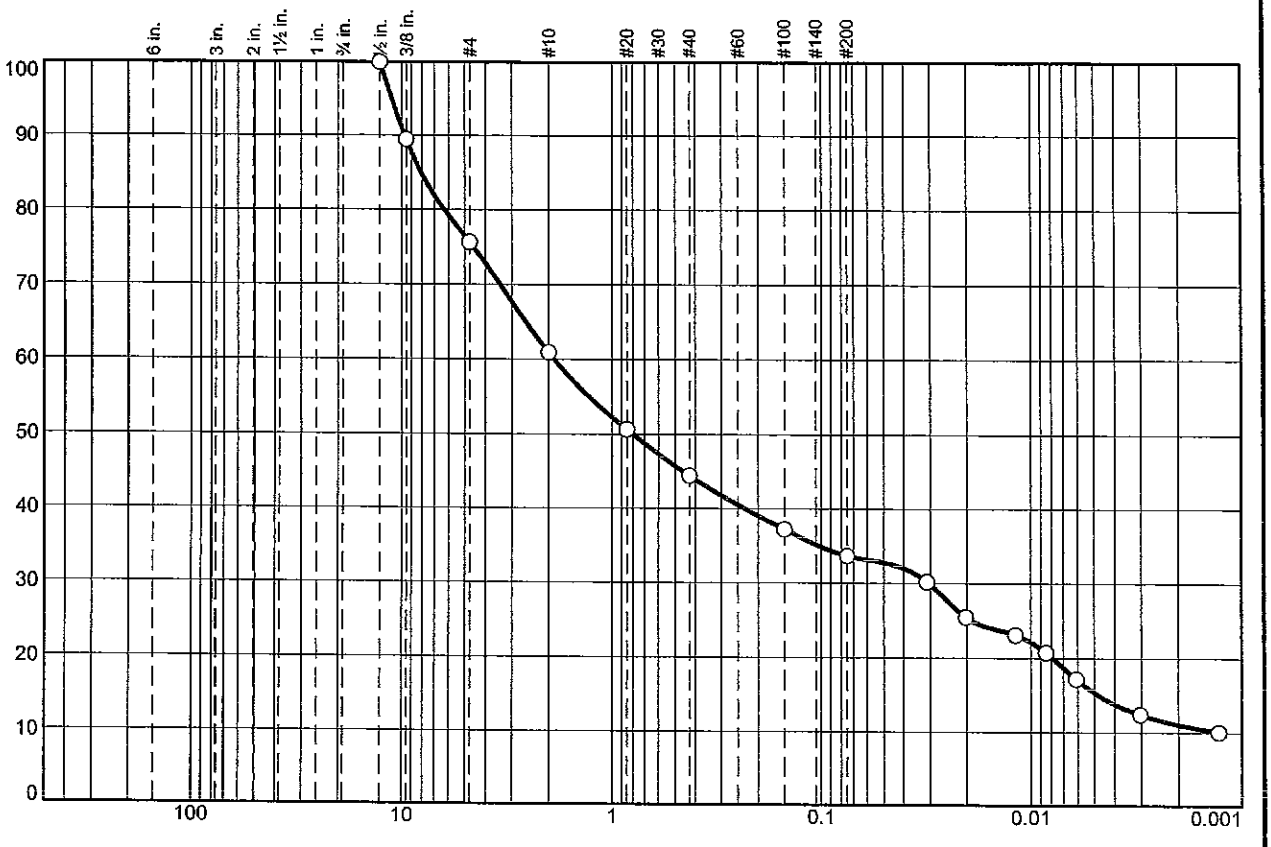
H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	24.3	14.8	16.5	10.8	18.2	15.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2	100.0		
3/8	89.4		
#4	75.7		
#10	60.9		
#20	50.6		
#40	44.4		
#100	37.2		
#200	33.6		

* (no specification provided)

Material Description

Gray CLAYEY SAND with fine gravel and shale fragments

Atterberg Limits

PL= 13 LL= 23 PI= 10

Coefficients

D_{90}= 9.6988 D_{85}= 8.1052 D_{60}= 1.8823
D_{50}= 0.7984 D_{30}= 0.0305 D_{15}= 0.0048
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

HCN Lab No. 412

Source of Sample: B-8 **Depth:** 8.5'-10.0'
Sample Number: S-4

Date: 6-14-10

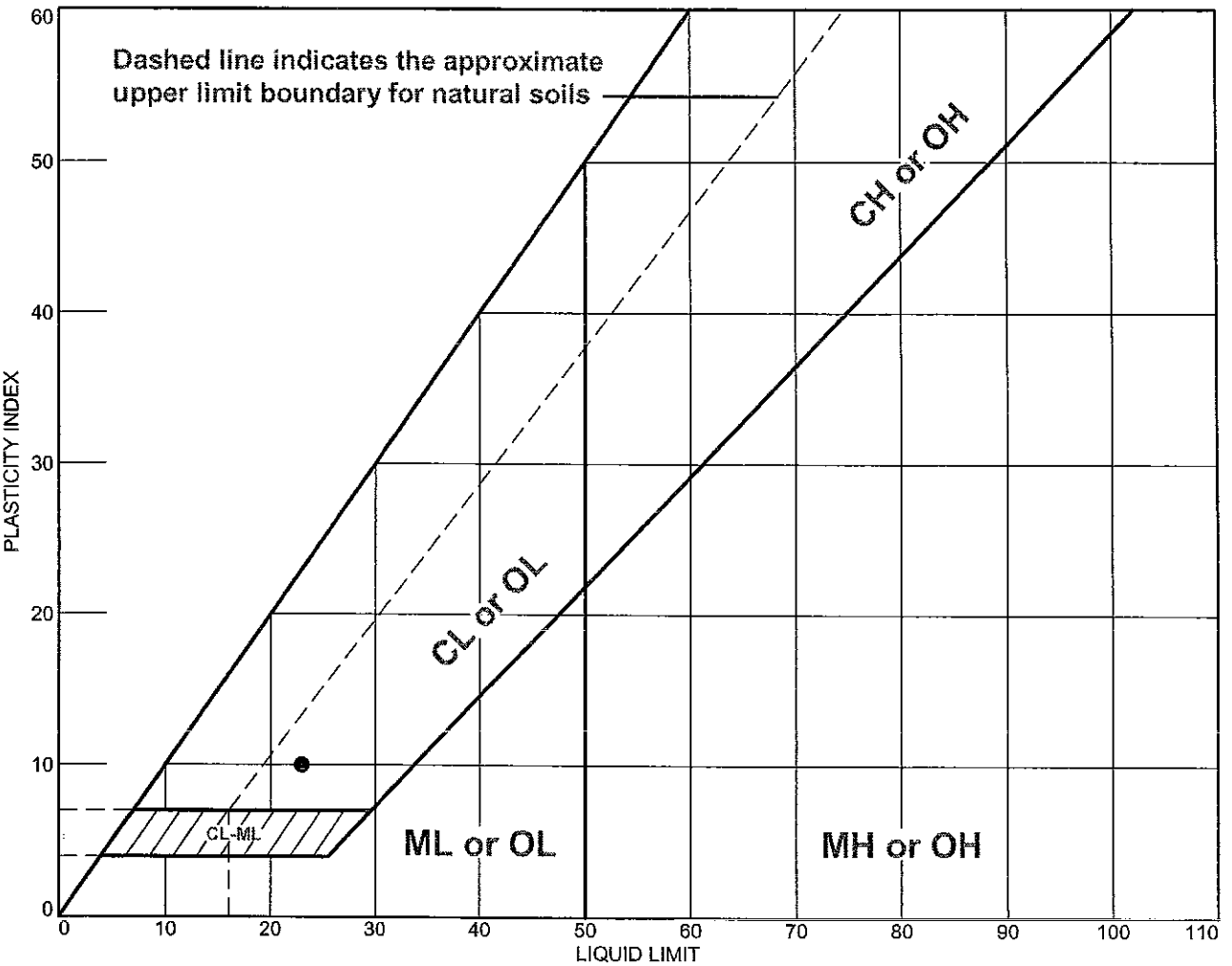
H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Gray CLAYEY SAND with fine gravel and shale fragments	23	13	10	44.4	33.6	SC

Project No. N4105037 **Client:** City of Bellevue

Project: U.S. Route 20 Sanitary Sewer Extension Phase I

● **Source of Sample:** B-8 **Depth:** 8.5'-10.0' **Sample Number:** S-4

Remarks:
● HCN Lab No. 412
Date: 6-14-10

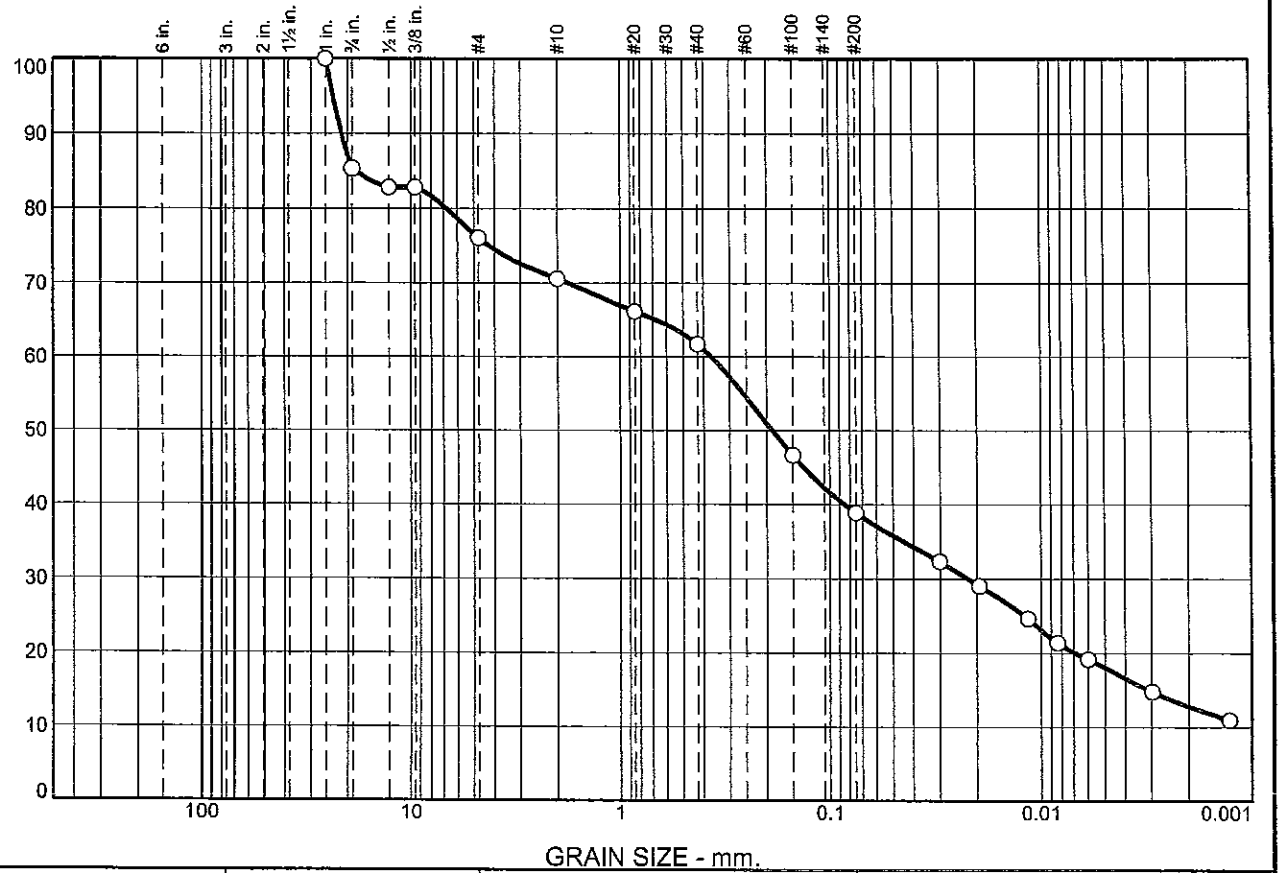
H.C. Nutting
A Terracon Company
Columbus, Ohio

Figure

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	14.7	9.2	5.5	8.9	22.9	20.7	18.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.0	100.0		
3/4	85.3		
1/2	82.8		
3/8	82.8		
#4	76.1		
#10	70.6		
#20	66.2		
#40	61.7		
#100	46.6		
#200	38.8		

* (no specification provided)

Material Description

Light brown and gray CLAYEY SAND with fine to coarse gravel and rock fragtments

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 21.3210 D_{85}= 18.4131 D_{60}= 0.3659
D_{50}= 0.1882 D_{30}= 0.0221 D_{15}= 0.0031
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

HCN Lab No. 413

Source of Sample: B-9 **Depth:** 6.0'-7.5'
Sample Number: S-3

Date: 6-14-10

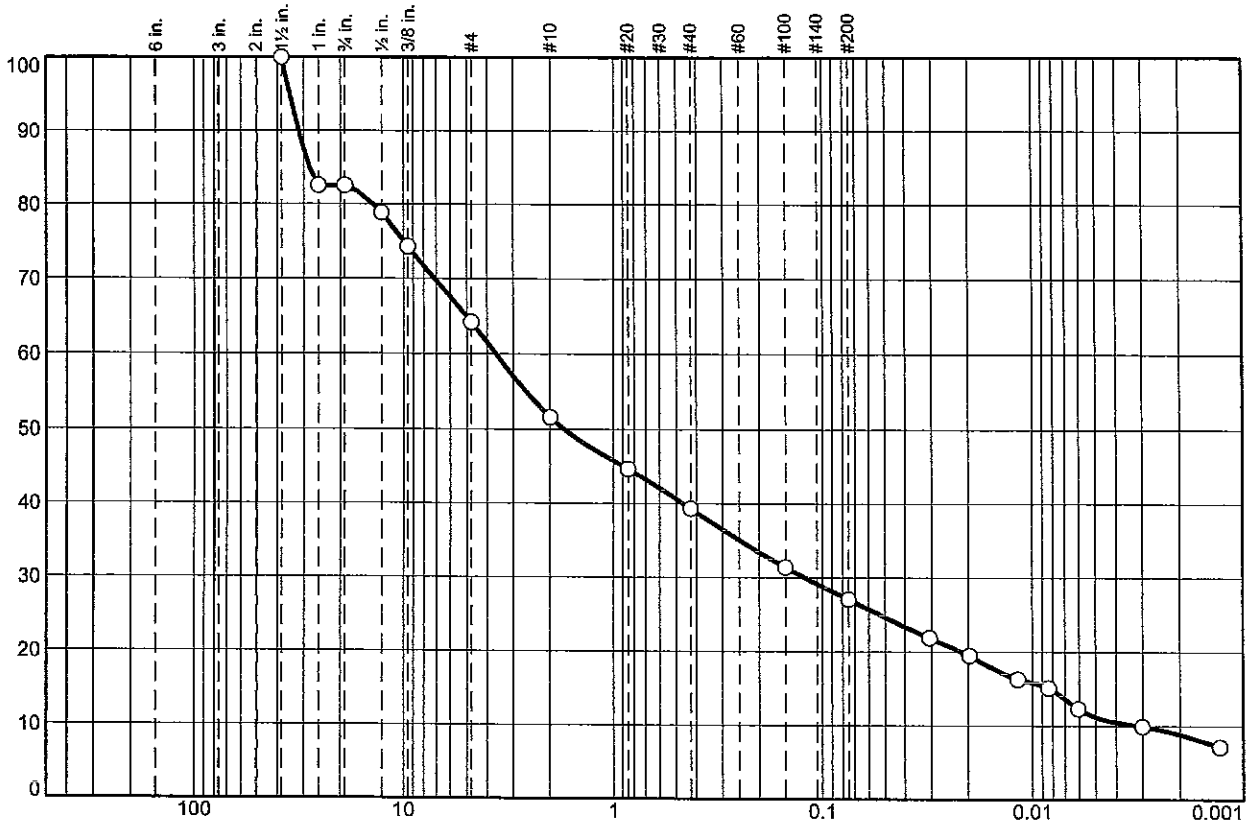
H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	17.5	18.3	12.6	12.3	12.3	15.9	11.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1.0	82.5		
3/4	82.5		
1/2	78.8		
3/8	74.3		
#4	64.2		
#10	51.6		
#20	44.7		
#40	39.3		
#100	31.4		
#200	27.0		

* (no specification provided)

Material Description

Dark brown and black SILTY SAND with fine to coarse gravel and rock fragments

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 31.6509 D_{85}= 28.0463 D_{60}= 3.6162
D_{50}= 1.7192 D_{30}= 0.1219 D_{15}= 0.0083
D_{10}= 0.0031 C_u= 1157.82 C_c= 1.32

Classification

USCS= AASHTO=

Remarks

HCN Lab No. 414

Source of Sample: B-9 **Depth:** 8.5'-10.0'
Sample Number: S-4

Date: 6-14-10

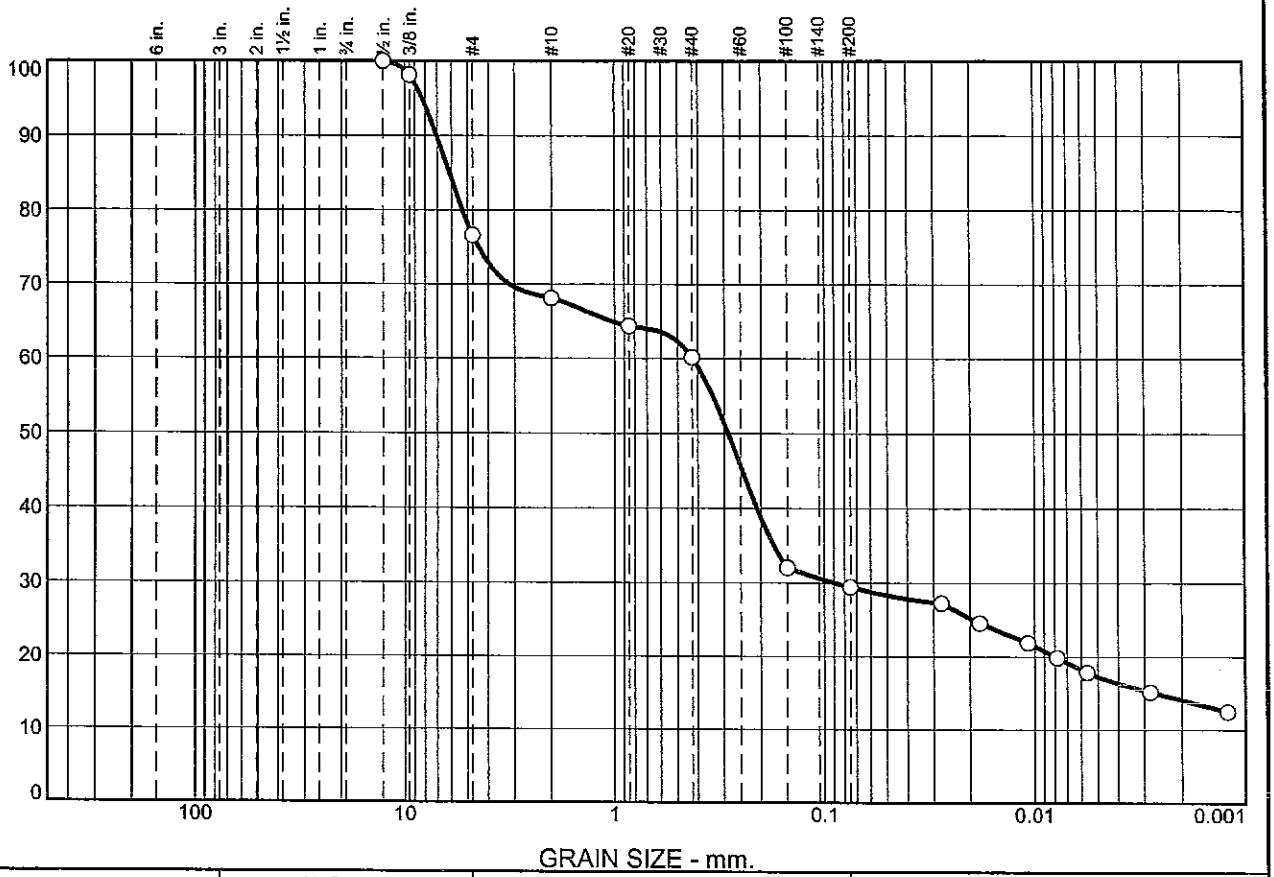
H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	23.4	8.5	7.9	30.8	12.2	17.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2	100.0		
3/8	98.1		
#4	76.6		
#10	68.1		
#20	64.4		
#40	60.2		
#100	32.0		
#200	29.4		

* (no specification provided)

Material Description

Reddish brown CLAYEY SAND with fine gravel and rock fragments

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 7.0463 D_{85}= 6.1250 D_{60}= 0.4213
D_{50}= 0.2870 D_{30}= 0.0898 D_{15}= 0.0027
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

HCN Lab No. 415

Source of Sample: B-12 **Depth:** 3.5'-5.0'
Sample Number: S-2

Date: 6-14-10

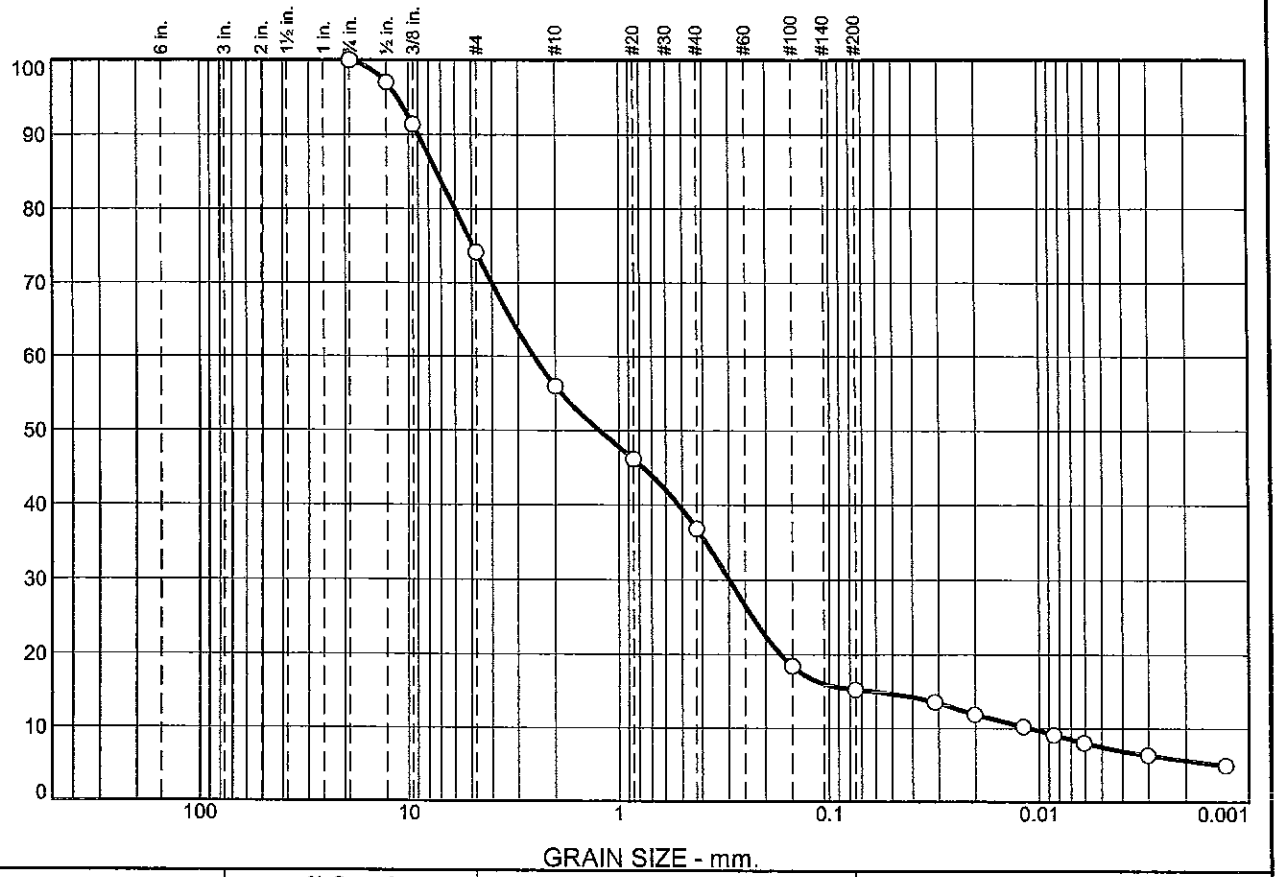
H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	25.8	18.3	19.1	21.6	7.8	7.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4	100.0		
1/2	97.0		
3/8	91.4		
#4	74.2		
#10	55.9		
#20	46.1		
#40	36.8		
#100	18.4		
#200	15.2		

* (no specification provided)

Material Description

Brown SILTY SAND with fine gravel and rock fragments

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 8.9757 D_{85}= 7.3054 D_{60}= 2.5272
D_{50}= 1.2430 D_{30}= 0.2976 D_{15}= 0.0631
D_{10}= 0.0111 C_u= 227.39 C_c= 3.15

Classification

USCS= AASHTO=

Remarks

HCN Lab No. 416

Source of Sample: B-12 **Depth:** 6.0'-7.5'
Sample Number: S-3

Date: 6-14-10

H.C. Nutting
A Terracon Company
Columbus, Ohio

Client: City of Bellevue
Project: U.S. Route 20 Sanitary Sewer Extension Phase I

Project No: N4105037 **Figure**

Tested By: VP **Checked By:** AM

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1-3/8" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube – 2" O.D., 3" O.D., unless otherwise noted	PA:	Power Auger (Solid Stem)
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	BCR:	Before Casing Removal
WCI:	Wet Cave in	WD:	While Drilling	ACR:	After Casing Removal
DCI:	Dry Cave in	AB:	After Boring	N/E:	Not Encountered

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	0 - 1	Very Soft
500 – 1,000	2 - 4	Soft
1,000 – 2,000	4 - 8	Medium Stiff
2,000 – 4,000	8 - 15	Stiff
4,000 – 8,000	15 - 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 50	Dense
> 50	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	≥ 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75mm)
Sand	#4 to #200 sieve (4.75 to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	> 30

GENERAL NOTES
Description of Rock Properties

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding and Foliation Spacing in Rock[a]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

Rock Quality Designator (RQD)[b]		Joint Openness Descriptors	
RQD, as a percentage	Diagnostic description	Openness	Descriptor
Exceeding 90	Excellent	No Visible Separation	Tight
90 – 75	Good	Less than 1/32 in.	Slightly Open
75 – 50	Fair	1/32 to 1/8 in.	Moderately Open
50 – 25	Poor	1/8 to 3/8 in.	Open
Less than 25	Very poor	3/8 in. to 0.1 ft.	Moderately Wide
		Greater than 0.1 ft.	Wide

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.
b. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976.
U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

Terracon

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils	Gravels	Clean Gravels	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
More than 50% retained	More than 50% of coarse fraction retained on No. 4 sieve	Less than 5% fines[C]	$Cu < 4$ and/or $1 > Cc > 3$[E]		GP	Poorly graded gravel[F]
on No. 200 sieve		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands	Clean Sands	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		SW	Well-graded sand[I]
	50% or more of coarse fraction passes No. 4 sieve	Less than 5% fines[D]	$Cu < 6$ and/or $1 > Cc > 3$[E]		SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils	Silts and Clays	inorganic	PI > 7 and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
50% or more passes the No. 200 sieve	Liquid limit less than 50		PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays	inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
	Liquid limit 50 or more		PI plots below "A" line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

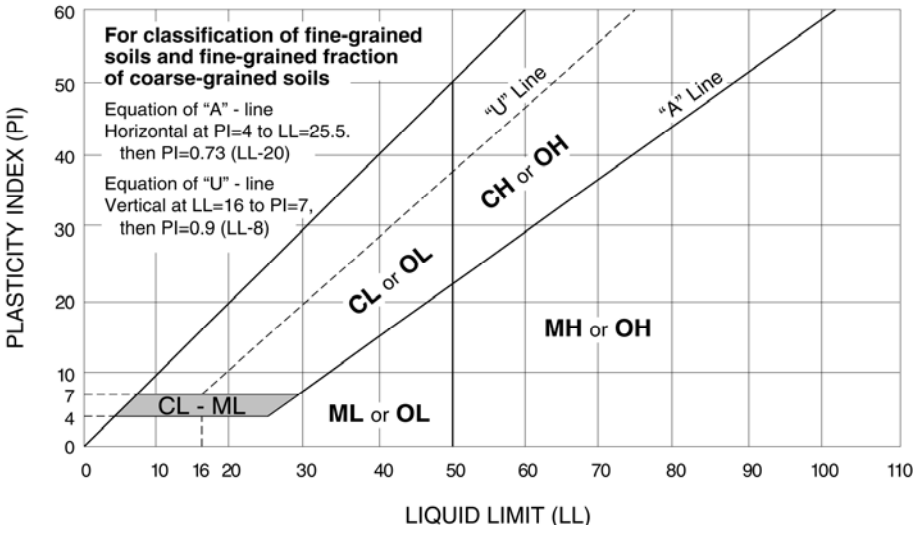
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Terracon