DLZ
ENGINEERS • ARCHITECTS • SCIENTISTS
PLANNERS • SURVEYORS

November 14, 2007

Robert Miller, P.E.
Project Manager
CH2M Hill Ltd.
1001 Lakeside Avenue
990 North Point Tower
Cleveland, Ohio 44114

Re: **Bearing Capacity and Settlement Evaluation**
(Culvert at STA. 117+50)
SCI-823-0.00 Portsmouth Bypass
DLZ Job No.: 0121-3070.03
Document # 0093

Dear Mr. Miller:

This letter presents the findings of preliminary evaluations of the proposed culvert at Station 117+50 on the above-referenced project. The findings of other culvert and embankment evaluations will be submitted in separate documents.

It is our understanding that a new culvert will be constructed at STA 117+50 for the above referenced project. The culvert will consist of twin 72-inch Type A conduits in accordance with ODOT Item 706.02 Reinforced Concrete Circular Pipe). Preliminary plans indicate the culvert will be located in a cut section with its invert elevation ranging from approximately 11 to 6 feet below existing grade. The inlet and outlet of the culvert will be supported by headwalls flush with the face of the pipe at both ends. At the time of preparing this letter no further information was available regarding the proposed culvert.

It should be noted that the results of this preliminary evaluation are based upon the findings of two bridge borings (B-1118 and B-1119) and one roadway boring (TR-48) located in the proximity of the proposed alignment of the culvert. The borings were advanced to depths ranging between 30.0 and 35.0 feet below the ground surface. Logs of the borings, a plan and profile drawing showing the approximate locations of the borings, a legend of the boring log terminology and general information regarding the drilling procedures are attached. The surveyed ground elevations at the boring locations are reported on the logs.

Exploration Findings

Borings B-1118, B-1119, and TR-48, generally encountered 8.0 to 11.8 feet of cohesive soil (A4a, A4b, A-6a, A-6b, A-7-6) underlain by granular soil (A-1-b, A-2-4, A-3a) over sandstone and shale bedrock. The consistency of the soil ranged from very soft to hard but was

predominantly very stiff. The bedrock was generally slightly weathered and slightly to severely fractured.

Bearing Capacity and Settlement Evaluation

The preliminary plans indicate that the invert elevations at the inlet and outlet of the proposed culvert are 538.00 and 537.00, respectively. The bottoms of the headwall footings were assumed to be 4 feet below the invert elevations to place them below the frost zone and prevent scour of the headwall (Ohio BDM Section 200). Based on the results of the borings, the footings will bear on or near very loose to loose granular soil (A-1-b, A-2-4). Footings bearing in the native soil may be designed based on an allowable bearing capacity of 1,500 pounds per square foot (psf). Since the proposed culvert is located in an area of negligible change in grade, post construction settlement of the culvert is expected to be insignificant.

Other Considerations

It should be noted that the borings encountered loose to very loose, wet granular soil at or near the proposed bearing elevations. These materials may be unstable under construction activities and will likely require dewatering and/or overexcavation and replacement to allow construction of the headwall footings.

Due to the activity on the proposed tracks, no borings were taken on the existing railroad fill. Consequently, no information can be provided about the material the proposed culvert will be installed through immediately beneath the tracks. We understand that the proposed construction method is jack and bore. The relatively large conduit size and limited clear cover from the conduits to the tracks may be of concern with this construction method.

DLZ
ENGINEERS • ARCHITECTS • SCIENTISTS
PLANNERS • SURVEYORS

We appreciate having the opportunity to be of service to you on this project. Please do not hesitate to call if you have any questions concerning our preliminary findings.

Respectfully submitted,

DLZ OHIO, INC.

Wael Alkasawneh, P.E.
Geotechnical Engineer

Bryan Wilson, P.E.
Senior Geotechnical Engineer

Encl: As noted.

cc: Andy Wolpert (CH2M Hill Ltd.), File

GENERAL INFORMATION
DRILLING PROCEDURES AND LOGS OF BORINGS

Drilling and sampling were conducted in accordance with procedures generally recognized and accepted as standardized methods of investigation of subsurface conditions concerning geotechnical engineering considerations. Borings were drilled with either a truck-mounted or ATV-mounted drill rig.

Drive split-barrel sampling was performed in 1.5 foot increments at intervals not exceeding 5 feet. In the event the sampler encountered resistance to penetration of 6 inches or less after 50 blows of the drop hammer, the sampling increment was discontinued. Standard penetration data were recorded and one or more representative samples were preserved from each sampling increment.

In borings where rock was cored, NXM or NQ size diamond coring tools were used.

In the laboratory all samples were visually classified by a soils engineer. Moisture contents of representative fine-grained soil samples were determined. A limited number of samples, considered representative of foundation materials present, were selected for performance of grain-size analyses and plasticity characteristics tests. The results of these tests are shown on the boring logs.

The boring logs included in the Appendix have been prepared on the basis of the field record of drilling and sampling, and the results of the laboratory examination and testing of samples. Stratification lines on the boring logs indicating changes in soil stratigraphy represent depths of changes approximated by the driller, by sampling effort and recovery, and by laboratory test results. Actual depths to changes may differ somewhat from the estimated depths, or transitions may occur gradually and not be sharply defined. The boring logs presented in this report therefore contain both factual and interpretative information and are not an exact copy of the field log.

Although it is considered that the borings have disclosed information generally representative of site conditions, it should be expected that between borings conditions may occur which are not precisely represented by any one of the borings. Soil deposition processes and natural geologic forces are such that soil and rock types and conditions may change in short vertical intervals and horizontal distances.

Soil/rock samples will be stored at our laboratory for a period of six months. After this period of time, they will be discarded, unless notified to the contrary by the client.

LEGEND - BORING LOG TERMINOLOGY

Explanation of each column, progressing from left to right

1. Depth (in feet) - refers to distance below the ground surface.

2. Elevation (in feet) - is referenced to mean sea level, unless otherwise noted.

3. Standard Penetration (N) - the number of blows required to drive a 2-inch O.D., 1-3/8 inch I.D., split-barrel sampler, using a 140-pound hammer with a 30-inch free fall. The blows are recorded in 6-inch drive increments. Standard penetration resistance is determined from the total number of blows required for one foot of penetration by summing the second and third 6-inch increments of an 18-inch drive.

   50/n - indicates number of blows (50) to drive a split-barrel sampler a certain number of inches (n) other than the normal 6-inch increment.

4. The length of the sampler drive is indicated graphically by horizontal lines across the "Standard Penetration" and "Recovery" columns.

5. Sample recovery from each drive is indicated numerically in the column headed "Recovery".

6. The drive sample location is designated by the heavy vertical bar in the "Sample No., Drive" column.

7. The length of hydraulically pressed "Undisturbed" samples is indicated graphically by horizontal lines across the "Press" column.

8. Sample numbers are designated consecutively, increasing in depth.

9. Soil Description

   a. The following terms are used to describe the relative compactness and consistency of soils:

Granular Soils - Compactness

Terms	Blows/Foot Standard Penetration
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

Cohesive Soils - Consistency

Term	Unconfined Compression tons/sq.ft.	Blows/Foot Standard Penetration	Hand Manipulation
Very Soft	less than 0.25	below 2	Easily penetrated by fist
Soft	0.25 - 0.50	2 - 4	Easily penetrated by thumb
Medium Stiff	0.50 - 1.00	4 - 8	Penetrated by thumb w/ moderate effort
Stiff	1.0 - 2.0	8 - 15	Readily indented by thumb but not penetrated
Very Stiff	2.0 - 4.0	15 - 30	Readily indented by thumb nail
Hard	over 4.0	over 30	Indented with difficulty by thumb nail

   b. Color - If a soil is a uniform color throughout, the term is single, modified by such adjective as light and dark. If the predominant color is shaded by a secondary color, the secondary color precedes the primary color. If two major and distinct colors are swirled throughout the soil, the colors are modified by the term "mottled".

   c. Texture is based on the ODOT Classification System. Soil particle size definitions are as follows:

Description	Size	Description	Size
Boulders	Larger than 8"	Sand-Coarse	2.00 mm. to 0.42 mm.
Cobbles	8" to 3"	-Fine	0.42 mm. to 0.074 mm.
Gravel-Coarse	3" to 3/4"	Silt	0.074 mm. to 0.005 mm.
-Fine	3/4" to 2.00" mm.	Clay	Smaller than 0.005 mm.

   d. The main soil component is listed first. The minor components are listed in order of decreasing percentage of particle size.

e. Modifiers to main soil descriptions are indicated as a percentage by weight of particle sizes.

trace	- 0 to 10%
little	- 10 to 20%
some	- 20 to 35%
"and"	- 35 to 50%

f. The moisture content of cohesive soils (silts and clays) is expressed relative to plastic properties.

Term	Relative Moisture or Appearance
Dry	Powdery
Damp	Moisture content slightly below plastic limit
Moist	Moisture content above plastic limit, but below liquid limit
Wet	Moisture content above liquid limit

g. Moisture content of cohesionless soils (sands and gravels) is described as follows:

Term	Relative Moisture or Appearance
Dry	No moisture present
Damp	Internal moisture, but none to little surface moisture
Moist	Free water on surface
Wet	Voids filled with free water

10. Rock hardness and rock quality description.

a. The following terms are used to describe the relative hardness of the bedrock.

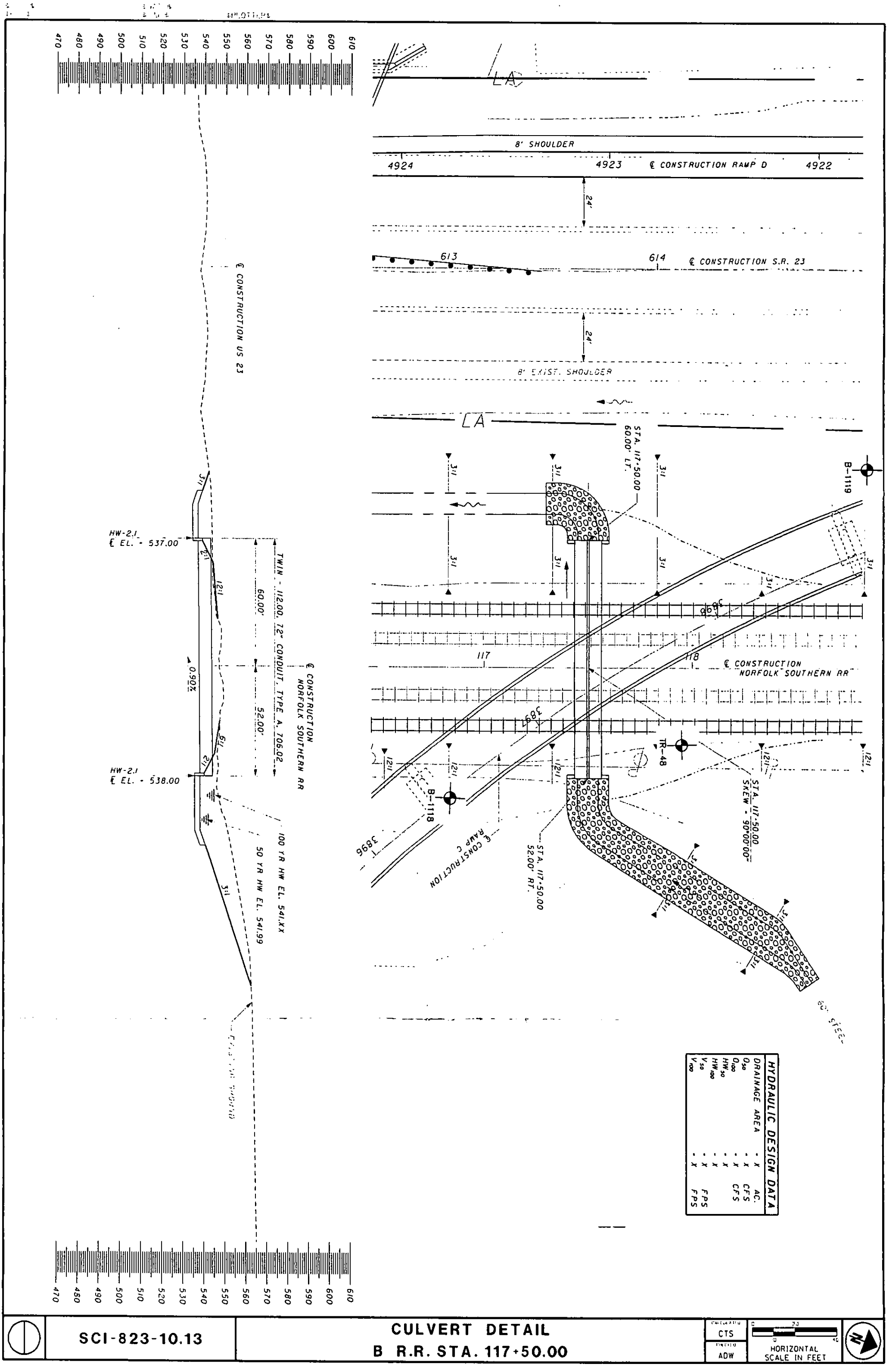
Term	Description
Very Soft	Difficult to indent with thumb nails; resembles hard soil but has rock structure
Soft	Resists indentation with thumb nail but can be abraded and pierced to a shallow depth by a pencil point.
Medium Hard	Resists pencil point, but can be scratched with a knife blade.
Hard	Can be deformed or broken by light to moderate hammer blows.
Very Hard	Can be broken only by heavy blows, and in some rocks, by repeated hammer blows.

b. Rock Quality Designation, RQD - This value is expressed in percent and is an indirect measure of rock soundness. It is obtained by summing the total length of all core pieces which are at least four inches long, and then dividing this sum by the total length of the core run.

11. Gradation - when tests are performed, the percentage of each particle size is listed in the appropriate column (defined in Item 9c).

12. When a test is performed to determine the natural moisture content, liquid limit moisture content, or plastic limit moisture content, the moisture content is indicated graphically.

13. The standard penetration (N) value in blows per foot is indicated graphically.



SCI-823-10.13

CULVERT DETAIL
B R.R. STA. 117+50.00

CTS

ADW

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-48 | Location: Sta. 3897+72.5, 52.7 ft. RT of US 23 Ramp C BL | Date Drilled: 3/21/05

WATER OBSERVATIONS: Water seepage at: 16.0'-18.0'
Water level at completion: 8.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % / Blows per foot
0	546.3	2 2 3	14	1			No Topsoil FILL: Loose black GRAVEL WITH SAND (A-1-b); contains mostly coal fragments and cinders; damp.							
3.0	543.3	W O H	1	2			FILL: Very loose gray and black SILT AND CLAY (A-6a), little fine to coarse sand; contains roots, coal and cinder fragments; damp.							
5.5	540.8	WOH 2 3	16	3		2.5	Very stiff brown SILT (A-4b), some clay, trace fine sand; moist.							
8.0	538.3	2 5 7	17	4		3.5	Very stiff brown and gray CLAY (A-7-6), trace fine sand; damp to moist.	0	0	--	2	43	55	
10		2 5 6	15	5		3.5								
13.0	533.3	1 2 2	5	6			Very loose brown GRAVEL WITH SAND (A-1-b), little silt, trace clay; moist to wet.							
15		1 1 1	8	7				37	27	--	17	19		Non-Plastic
20		6 6 7	10	8			@ 18.5', medium dense; moist.	52	14	--	15	12	7	Non-Plastic
23.5	522.8	2 7 30	15	9			@ 21.0', dense, trace gravel, trace clay.							
25.0	521.3	20 15 50	12	10			Severely weathered black SHALE.							
30		Core 120°	Rec 120°	RQD 97%	R1		Soft to medium hard black SHALE; carbonaceous, slightly weathered, very thinly bedded, highly fractured. @ 25.3'-25.6', 26.0'-26.4', broken. @ 27.1'-27.2', sandstone seam.							65

STANDARD PENETRATION (N) / Natural Moisture Content, % - ● / PL ⊢—⊣ LL / Blows per foot - ○ (10 20 30 40)

FILE: 0121-3070-03 | 11/8/2007 10:28 AM |

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-48 | Location: Sta. 3897+72.5, 52.7 ft. RT of US 23 Ramp C BL | Date Drilled: 3/21/05

WATER OBSERVATIONS: Water seepage at: 16.0'-18.0'
Water level at completion: 8.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
	516.3													
30.0	516.3						Hard gray SANDSTONE; very fine to fine grained, argillaceous, micaceous, slightly weathered, massive, slightly fractured .							
35.0	511.3						Bottom of Boring - 35.0'							
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/8/2007 10:28 AM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1118 | Location: Sta. 3896+55.5, 6.3 ft. RT of US 23 Ramp C BL | Date Drilled: 10/18/05

WATER OBSERVATIONS: Water seepage at: 11.8'-20.5'
Water level at completion: 12.7' (prior to coring)
15.6' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	546.2												
		1 2 2	18	1		0.75	No topsoil Medium stiff to stiff brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; moist.						
		1 2 3	18	2		1.5		1	2	--	5	62	30
5													
5.5	540.7												
		5 6 9	18	3		2.5	Very stiff brown CLAY (A-7-6), some silt, trace fine sand; moist.	0	0	--	2	31	67
		6 7 8	18	4		2.0	@ 11.0'-11.8', very soft to soft.						
10													
11.8	534.4	4 5 9	18	5A 5B		0.25	Loose to medium dense brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; wet.	41	16	--	9	24	10
		4 5 4	3	6									
15													
15.5	530.7												
		4 7 11	13	7			Medium dense to dense brown GRAVEL WITH SAND (A-1-b), little silt, trace clay; wet.	55	12	--	10	18	5
		7 14 18	13	8									
20													
20.5	525.7												
		17 41 28	10	9			Severely weathered black SHALE.						
		50/3	3	10									
25.0	521.2												
		Core 120"	Rec 120"	RQD 78%	R1		Medium hard black SHALE; moderately weathered, carbonaceous, laminated, slightly to moderately fractured.						
30							@ 28.9'-29.1', broken zone.						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

53
69
50+

FILE: 0121-3070-03 [11/8/2007 10:28 AM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1118 | Location: Sta. 3896+55.5, 6.3 ft. RT of US 23 Ramp C BL | Date Drilled: 10/18/05

WATER OBSERVATIONS: Water seepage at: 11.8'-20.5'
Water level at completion: 12.7' (prior to coring)
15.6' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	516.2													
30.6	515.6						Medium hard black SHALE; moderately weathered, carbonaceous, laminated, slightly to moderately fractured.							
							Hard gray SANDSTONE; very fine to fine grained, slightly to moderately weathered, micaceous, thickly bedded, slightly fractured. @ 30.8', 33.6', 33.7', 34.8', low angle clay filled fractures. @ 30.8'-33.8', calcareous.							
35.0	511.2						Bottom of Boring - 35.0'							
40														
45														
50														
55														
60														

FILE: 0121-3070-03 | 11/8/2007 10:29 AM |

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1119 | Location: Sta. 3898+99.1, 24.8 ft. LT of US 23 Ramp C BL | Date Drilled: 7/18/05

WATER OBSERVATIONS: Water seepage at: 10.0'-25.0'
Water level at completion: 12.0' (prior to coring)
5.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % / Blows per foot
0	542.0													
0.3	541.7	6 6 5	7	1		3.0	Topsoil - 4" Very stiff brown SANDY SILT (A-4a), little clay, trace gravel; possible organic; damp.							
3.0	539.0	4 5 7	12	2		4.5+	Hard brown CLAY (A-7-6), trace fine to coarse sand, trace gravel; damp.							
5.5	536.5	4 4 5	12	3		2.0	Stiff to very stiff brown SILTY CLAY (A-6b), "and" fine to coarse sand, trace gravel; moist.	9	11	--	32	22	26	
8.0	534.0	3 3 3	10	4			Very loose to loose brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; wet.	46	18	--	9	18	9	
		1 1 1	8	5										
13.0	529.0	1 1 2	14	6			Very loose to loose brown COARSE AND FINE SAND (A-3a), little gravel, trace clay; trace silt; wet.							
		2 4 3	12	7				12	47	--	22	19		Non-Plastic
18.0	524.0	5 8 9	13	8			Medium dense brown GRAVEL WITH SAND AND SILT (A-2-4), little clay; contains sandstone fragments; wet.	36	22	--	11	18	13	Non-Plastic
20.5	521.5	4 5 17	12	9			Medium dense to dense brown COARSE AND FINE SAND (A-3a), little silt, little clay; contains sandstone fragments; moist.	14	6	--	48	20	12	Non-Plastic
		7 17 19	14	10										
25.0	517.0	Core 60"	Rec 59"	RQD 30%	R-1		Very hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, argillaceous, micaceous, thinly bedded to medium bedded, highly fractured, iron-staining @ 28.7'-28.9', high angle fractures.							
30.0	512.0						Bottom of Boring - 30.0'							

FILE: 0121-3070-03 [11/8/2007 10:28 AM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1119 | Location: Sta. 3898+99.1, 24.8 ft. LT of US 23 Ramp C BL | Date Drilled: 7/18/05

WATER OBSERVATIONS:
Water seepage at: 10.0'-25.0'
Water level at completion: 12.0' (prior to coring)
5.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○
30	512.0													10 20 30 40
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/8/2007 10:28 AM]

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070-03
PROJECT	Portsmouth Bypass	SHEET NO.	1 OF 1
SUBJECT	Culvert at Station 117+50	COMP. BY	BEW DATE 11/14/07
	Bearing Capacity Analysis	CHECKED BY	DATE

Base analysis on results of boring C-121

qu =	0	tsf
c =	0	psf
ϕ =	30	degrees
Assume B =	3	ft
Assume γ =	120	pcf
Factor of Safety (FS) =	3	(ODOT BDM 202.2.3.1)

For cohesionless foundation soil:

Meyerhof's Method

$q_u = S_c*c*N_c+q*N_q+0.5\gamma*B*N_\gamma*S_\gamma$ Use buoyant unit weight in calculation.

$q = \gamma*D$

S_γ = 1

$N\gamma$ = 15.70 for ϕ equal to 30 degrees

Nq = 18.40 for ϕ equal to 30 degrees

$q_a = q_u/FS$ = 1512

Use $q_a <$ 1500 psf