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August 10, 2007
August 23, 2007 (REVISED)

Mr. Paul N. Elling, P.E.
Senior Project Manager
Donohue & Associates
101 West Ohio Street
Suite 820
Indianapolis, IN 46204

RE: GEOTECHNICAL INVESTIGATION
PHASE 1 -15TH STREET SEWER CORRECTIONS
NEW ALBANY, INDIANA
GREENBAUM PROJECT NUMBER 07-020 (A)

Dear Mr. Elling:

The attached report details the geotechnical report for the 15th Street New Albany, Indiana sewer project.

It addresses the subsurface problems likely to be encountered during sewer construction. Those include the fine sandy soils, the shallow water table and the potential proximity to the railroad and to homes.

Depending on sewer location and depth, trench bracing and dewatering of the soil to below the trench bottoms are likely solutions.

A dewatering study is underway at this time and the results will be reported as soon as that study is complete.

Let me know if there is any further information that you need.

Yours very truly,

GREENBAUM ASSOCIATES, INC.

Milton M. Greenbaum, P.E.
Principal Engineer

Sandor R. Greenbaum, P.E.
Senior Geotechnical Engineer

GEOTECHNICAL INVESTIGATION

FOR
PHASE 1
15th STREET SEWER CORRECTIONS
NEW ALBANY, INDIANA

FOR
DONOHUE & ASSOCIATES
INDIANAPOLIS, INDIANA

BY:
GREENBAUM ASSOCIATES, INC.
994 LONGFIELD AVENUE
LOUISVILLE, KENTUCKY 40215

AUGUST 10, 2007
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1.0 Introduction

The sewer running the length of 15th Street from Spring Street to Beeler Street in New Albany, Indiana is extremely old and likely has failed in places. The City has engaged a company to examine the sewer through the use of video camera to determine its condition. It has also engaged Donohue & Associates to evaluate the sewer condition and design corrections to bring the sewer to adequate and functional condition. Donohue & Associates has engaged Greenbaum Associates, Inc. to carry out a subsurface investigation resulting in this report. The report is to define soil conditions and determine criteria for the design of corrections and methods suitable for the corrective measures including groundwater conditions and measures necessary to control groundwater to allow the corrective measures. Groundwater control measures will be reported under a separate cover.

The existing sewer is reported to be at depths of 12 to 15 feet while the water table is considerably shallower than that. Soils in the area, particularly below 10 feet, are fine sands and will become quick unless the water table is lowered below the depth of excavation.

The problem is compounded by the proximity of the sewer to homes to the west and to the railroad tracks that bisect 15th Street and are only 8 to 12 feet east of the sewer in places.

2.0 General Geology

Shallow deposits in the area of the sewer, possibly to several feet, are manmade deposits including pavement, base course and fill. Under the center of 15th Street, the soil structure may have been modified much deeper than this. The railroad has removed soil, placed ballast and possibly driven the ballast down into the relatively loose soils under the impact of rail traffic. Borings indicate ballast and base course to a depth of 4 feet but there are indications that stone has been found at sewer depth. This re-ballasting is ongoing and is repeated periodically, especially when rails have settled.

The soils in the area, according to geologic mapping by the Indiana Geological Survey, are alluvial in origin, recent alluvium overlying outwash which was deposited by glacial meltwater. Mapping also indicates that bedrock is present at a depth of 30 to 35 feet. Borings found bedrock shallower than this (18.5 feet to 28.3 feet) north of Shelby Street and considerably deeper than this in what is apparently an old channel (in excess of 51.5 feet deep) near Ekin Street. Bedrock is the New Albany Shale, a carbonaceous black silty shale. Soils are typically fine sand in the deposits below about 10 feet. North of Shelby Street, we found no sand, only alluvium.

The soil stress at the level of the sewers (15 feet $\pm$) will be about 10 percent of applied soil load at the base of railroad ties, assuming ties are about 8 feet long.

The water table is driven by Ohio River stages and may vary considerably as the river rises and falls seasonally. At the time of the investigation, water table was generally at a depth of 8 feet or so.

3.0 Investigation

3.1 Field Investigation

Fourteen (14) borings were carried out on 15th Street at locations shown on the attached location plan. All borings were carried out by Standard Penetration procedures. Eight (8) of these were carried to refusal on apparent bedrock. Five (5) were terminated at a depth of 26.5 feet without encountering bedrock and boring 5, near Ekin Street, was terminated a depth of 51.5 feet without encountering bedrock. Two (2) additional borings were performed on 13th Street and two (2) on Vincennes Street, all to refusal on bedrock.

Six (6) of the 15th Street borings were drilled on the centerline of the railroad while the other eight (8) borings were drilled at the side of the street to minimize interference with rail traffic and to find conditions consistent with that likely to be found at the sewer centerline.

Borings were carried out by standard penetration procedures through the use of 3-1/4" inch inside diameter hollow stem augers. A CME-55 truck mounted drill rig was used to access boring locations. Borings were staked using a 100 foot tape from street centerlines, so boring locations are only as accurate as this procedure allows.

The standard penetration procedure involves driving a standard 2" diameter split spoon in the formation at selected intervals using a 140 pound hammer falling through 30 inches. The blow counts for each 6 inches of drive to a total of 18 inches is recorded and the number of blows for the 12 inches after the first 6 inches is a standard measure of the condition of the soil. As the split spoon is removed from the ground, it retrieves a sample of the soil in a disturbed condition. Nevertheless, this sample is suitable for certain classification tests and is representative of the soils at the depth tested.

3.2 Laboratory Investigation

The laboratory investigation included four (4) sets of classification tests on the shallow, fine grained, which include grain size analyses and Atterberg Limits Tests.

One (1) additional sample from a depth of 20 feet was subjected to sieve analyses including decantation over a number 200 sieve. This gradation is more limited in that it determines the grain size distribution of the sand and gravel fractions and the total fraction finer than the number 200 sieve (the silt and clay without differentiating them).

All soil samples were subjected to moisture determinations. The results are plotted graphically on the boring logs.

Grain size determination arrives at a curve of grain size against that fraction of the soil which is finer than that particular grain size. It also allows the determination of the clay fraction, silt fraction, sand fraction, etc. in any particular soil sample. Based on this division of grain sizes, the field soils classifications are refined and the boring logs adjusted. In the case of fine grained soils, the soils are largely silt and clay, thus requiring that the soils be suspended in an aqueous medium and the rate at which the particles drop out is measured in order to arrive at the grain size distribution. Silt and clay grains are so fine that sieve analysis alone will not function in this range. The coarse fraction of this sample is separated from the fine and run through a nest of sieves in order to further detail the grain size distribution in the coarse range.

The Atterberg Limits determination arrives at those moisture contents at which the soil turns from a solid state to a plastic condition (the Plastic Limit) and then from a plastic condition to a liquid condition (The Liquid Limit). The points in question are arrived at by standard procedures that accept specific cohesive and flow properties of the soil as standards for these limits. Knowing the moisture content of the soil in relation to these limits provides a broad measure of the soil strength and soil characteristics. The arithmetic difference between these two limits is called the Plasticity Index and all three together are used for classifying the soils in a number of standard systems. This test if not applicable to silty and sandy soils.

Natural moisture determinations were run on all fine grained (silts and clays) soil samples. This test arrives at the in-situ moisture content of the soil and is useful for correlating the strength of various samples of like texture and in conjunction with the Atterberg limits, gives a strong measure of the strength range the cohesive soils are likely to be found in.

4.0 Findings

The site is largely covered with 4 to 5 inches of asphalt pavement. Several borings encountered a layer of brick pavement below the asphalt. In one location, concrete pavement was encountered under the asphalt. On 15th Street, this was resting on a crushed stone base course, generally about 4 feet thick. Some locations had about 12 inches of crushed stone in and in once case, 7 feet of crushed stone.

Below this to a depth of 9 to 14 feet, is fine grained soil ranging from lean clay silt to sandy clay silt. These soils are medium stiff with corrected N-values (standard penetration blow counts) of 4 to 8. Moisture content of these soils are 20 to 27 percent. The samples from borings 2 and 8 had a liquid limit of 27, a plastic limit of 8 and 20 and a plasticity index of 7 to 9. The sandy clay classifies CL by the Unified System and as A-4 by the AASHTO system. Samples from borings 13 and 16 were non-plastic, a clay silt classifying ML in the Unified System. Moisture content in this strata was generally 20 to 30 percent, occasionally as high as 32 percent and as low as 12 percent.

The materials below this were entirely granular (fine sand) to refusal on New Albany Shale, usually at a depth of 26 to 34 feet. Combined silt and clay content amounted to less than 10 percent.

The water table was found at a depth of about 8 feet. This may vary seasonally and with stages of the Ohio River.

At the north end of 15th Street, borings 1, 2 and 3, the sand layer was absent and refusal was shallow, 18 to 23 feet.

Boring 5 is apparently in an eroded channel in that it was terminated at 51 feet deep without encountering refusal.

The borings in the two side streets were consistent with those on 15th Street except boring 15 in the north end of Vincennes Street encountered rock much shallower than elsewhere, at a depth of 15 feet and did not have the sand strata.

Those borings that encountered refusal generally encountered New Albany shale at the bottom of the boring.

5.0 Recommendations

5.1 Sewer Trenches

It is contemplated that the sewer replacement or repair will be at a depth of 12 to 15 feet, well below the water table that we found at approximately 8 feet. With construction taking place below water table level, and the soil being fine grained sandy soils, will be unstable (quick) unless the water table is managed in such a fashion that the piezometric surface is below the bottom of any sewer trenches or manholes.

Further, depending on the location of the proposed construction, the slopes would likely destabilize the railroad or adjacent homes.

Therefore, the construction will likely have to include trench wall bracing in the form of sheeting, freezing, braced piling, solider beams and lagging or other means of bracing the trench walls.

In addition, dewatering will be required to lower the water table below the deepest construction. Another report will be submitted addressing criteria for dewatering the construction zone as soon as this study is completed.

The construction is contemplated to be in 15th Street between the railroad and the street right of way lines. However, a limited number of borings were carried out in Vincennes Street and 13th Street in case the client elects to move the sewer to these locations or to another location between those streets.

Boring 15 would indicate that a sewer built in Vincennes Street may run into bedrock at Ekin Street and north. However, the New Albany shale can usually be ripped to 5 feet or more into the bedrock with a heavy track hoe. If a new sewer is to be constructed in a location other than 15th Street, an additional investigation should be performed.

5.2 Site Preparation and Earthwork

Any fill should be placed in lifts not exceeding 8 inches in uncompacted thickness and must be compacted to at least 98 percent of the soils maximum dry density as determined by the Standard Proctor(ASTM D-698). Soil moisture content should be within 2 percent of soils optimum moisture content as determined from the Standard Proctor (ASTM D-698). Soil from any off-site borrow sources should be tested and approved by this office prior to being used on the site.

On site soils are suitable as fill with the exception of fill containing debris. Satisfactory borrow materials are those falling in one of the following classifications: GC, SW, SM, SC, ML or CL. Borrow materials should not be accepted from sources that contain CH or MH soils.

The site should be maintained in a well drained condition both during and after construction. Site grading should provide for drainage or surface run-off from the building.

The placement of compacted fill should be carried out by an experienced excavator with the proper materials. The excavator must be prepared to adapt his procedures, equipment and materials to the type of project, to weather conditions, and the structural requirements of the engineer. Methods and materials used in summer may not be applicable in winter; soil used in proposed fill may require wetting or drying for proper placement and compaction. Conditions may also vary during the course of a project or in different areas of this site. These needs should be addressed in the project drawings and specifications.

During freezing conditions, the fill must **not** be frozen when delivered to the site. It also must not be allowed to freeze during or after compaction. Since the ability to work the soil while keeping it from freezing depends in part on the soil type, the specifications should require the contractor to submit a sample of his proposed fill before construction starts, for laboratory testing. If the soil engineer determines that it is not suitable, it should be rejected. In general, silty sand, clayey sand, and cohesive/semi-cohesive soils should not be used as fill under freezing conditions. All frozen soil of any type should be rejected for use as compacted fill.

It is important that compacted fill be protected from freezing after it is placed. The excavator should be required to submit a plan for protecting the soil. The plan should include details on the type and amount of material (straw, blankets, extra loose fill, topsoil, etc.) proposed for use as frost protection. The need to protect the soil from freezing is ongoing throughout construction and applies both before

and after concrete is placed, until backfilling for final frost protection is completed. Foundations placed on frozen soil can experience heaving and significant settlement, rotation, or other movement as the soil thaws. Such movement can also occur if the soil is allowed to freeze **after** the concrete is placed and then allowed to thaw. The higher the percentage of fines (clay and silt, P-200 material) in the fill, the more critical is the need for protection from freezing.

The contractor should be required to adjust the moisture content of the soil to within a narrow range near the optimum moisture content (as defined by the applicable Proctor or AASHTO Test). In general, fill should be placed within 2% of optimum moisture. The need for moisture control is more critical as the percentage of fines increases. Naturally occurring cohesive/semi-cohesive soil are often much wetter than the optimum. Placing and attempting to compact such soils to the specified density may be difficult. Even if compacted to the specified density, excessively wet soils may not be suitable as pavement subgrades due to pumping under applied load. This is especially true when wet cohesive/semi-cohesive soil is used as backfill in utility trenches and like situations. Excessively wet soil in thick fill sections may cause post-construction settlement beyond that estimated for fill placed at or near (±2%) the optimum moisture content.

5.3 Pump Station or Manhole Walls

Walls to be used for the pump station or manholes will be restrained from movement and, therefore, must be designed based on the "at rest" earth pressure. The coefficient of "at rest" earth pressure (K_0) is 0.53 with a soil unit weight (γ_w) of 125 pounds per cubic foot, resulting in an equivalent fluid of 60 pounds per cubic foot unit weight. Below the water table, hydrostatic pressure will act on the wall in addition to the earth pressure resulting in an equivalent fluid pressure of 90 pounds per cubic foot.

Surcharge above the wall will add additional load. A uniform surcharge must be multiplied by the appropriate coefficient of earth pressure to determine the additional load applied to the wall. The internal angle of friction (Φ) of the soil underlying foundations is 28° resulting in a coefficient of friction of 0.53.

Any retaining wall design must use appropriate factors of safety.

5.4 Pavement

If asphalt or concrete pavement is desired, it may be necessary to use a bridging course to span soft areas such as the driveway we crushed in the alley south of Elm Street. The extent of the bridging course will have to be determined by proofrolling the site with a fully loaded tri-axle truck. Bridging course may consist of 18 to 24 inches of shot rock underlain by a non-woven geotextile. This thickness may be reduced through the use of geogrid base reinforcement with a 1.5 inch maximum size crushed stone.

A pavement structure consisting of 3 inches of asphalt over 8 inches of crushed stone base course should serve very well for car traffic with an occasional medium truck. The asphalt should consist of 1.5 inches of surface mix over 1.5 inches of binder. The stone base course should be single course of Indiana #53 stone.

Where concentrated truck traffic is to be present, we should carry out a pavement analysis based on the anticipated weight and number of trucks. Please provide us with that traffic if you would like such a thickness design to be carried out.

New Albany may have a minimum section that is greater than this, in which case this minimum section will have to be used.

5.5 Limitations

We strongly recommend that bearing surfaces and compaction be monitored by Greenbaum Associates, Inc. Our technicians will be available to further assist you in providing these and other normally specified quality control services. The report is preliminary until such time as these examinations are completed to confirm conditions consistent with those discovered.

The conclusions and recommendations offered in this report are based on the subsurface conditions encountered in the borings. No warranties can be made regarding the continuity of conditions between or beyond borings. If, during construction, soil conditions are encountered that differ from those indicated in this report, a representative of Greenbaum Associates, Inc. should inspect the site to determine if design modification is required.

This study was directed at a specific sanitary sewer system on this site to be constructed within a reasonably short period after this study. Use for any other

location, structures or substantial changes in construction period may invalidate the recommendations. The geotechnical engineer should be consulted relative to any substantial change in these.

This study is directed at mechanical properties of the soils and includes no sampling, testing or evaluation for environmental considerations.

Important Information About Your

Geotechnical Engineering Report

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

The following information is provided to help you manage your risks.

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

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

Read the Full Report

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

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

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

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

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

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

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

Subsurface Conditions Can Change

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

Most Geotechnical Findings Are Professional Opinions

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

A Report's Recommendations Are *Not* Final

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

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-1	10.0							23.4			
B-10	5.0							22.8			
B-11	5.0							23.6			
B-13	5.0				4.76	63		11.6			
B-14	5.0							26.0			
B-15	5.0							22.9			
B-16	5.0							26.2			
B-16	10.0							23.7			
B-2	5.0							18.7			
B-2	11.0	27	18	9	9.5	90	CL				
B-3	5.0							27.7			
B-5	5.0							23.9			
B-5	10.0							27.8			
B-6	5.0							22.4			
B-7	5.0							27.0			
B-8	5.0	27	20	7							
B-8	6.0				1.19	72					
B-8	20.0				1.19	7					

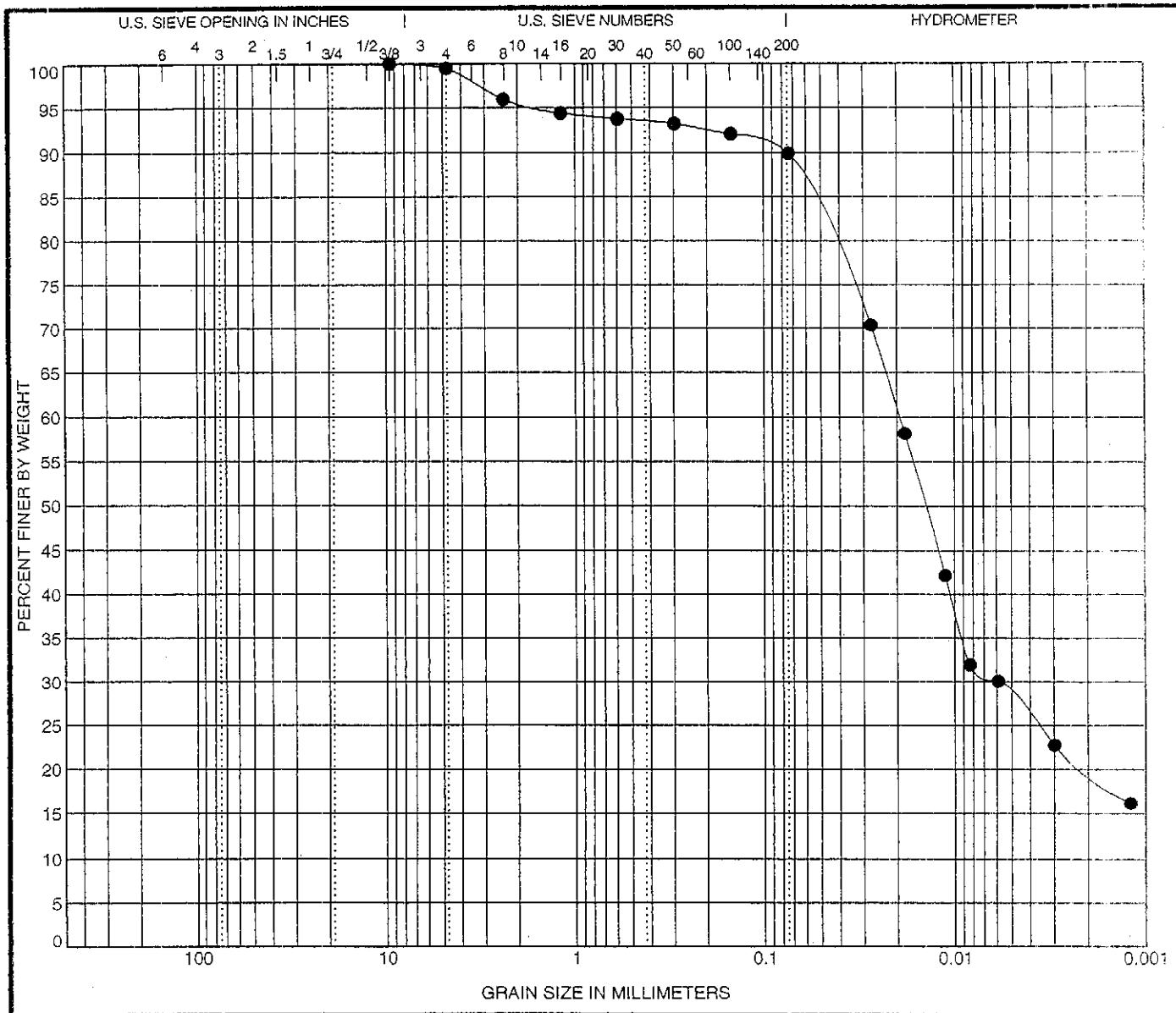
Greenbaum Associates, Inc.

Summary of Laboratory Results

Project: New Albany Sewers, Phase 1

Location: 15th Street Sewer Corrections

Number: 07-020 (A)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-2	11.0	**LEAN CLAY(CL)**	27	18	9		
			CLAY SILT					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-2	11.0	9.5	0.019	0.006		0.5	9.5	61.7	28.3

Greenbaum Associates, Inc.

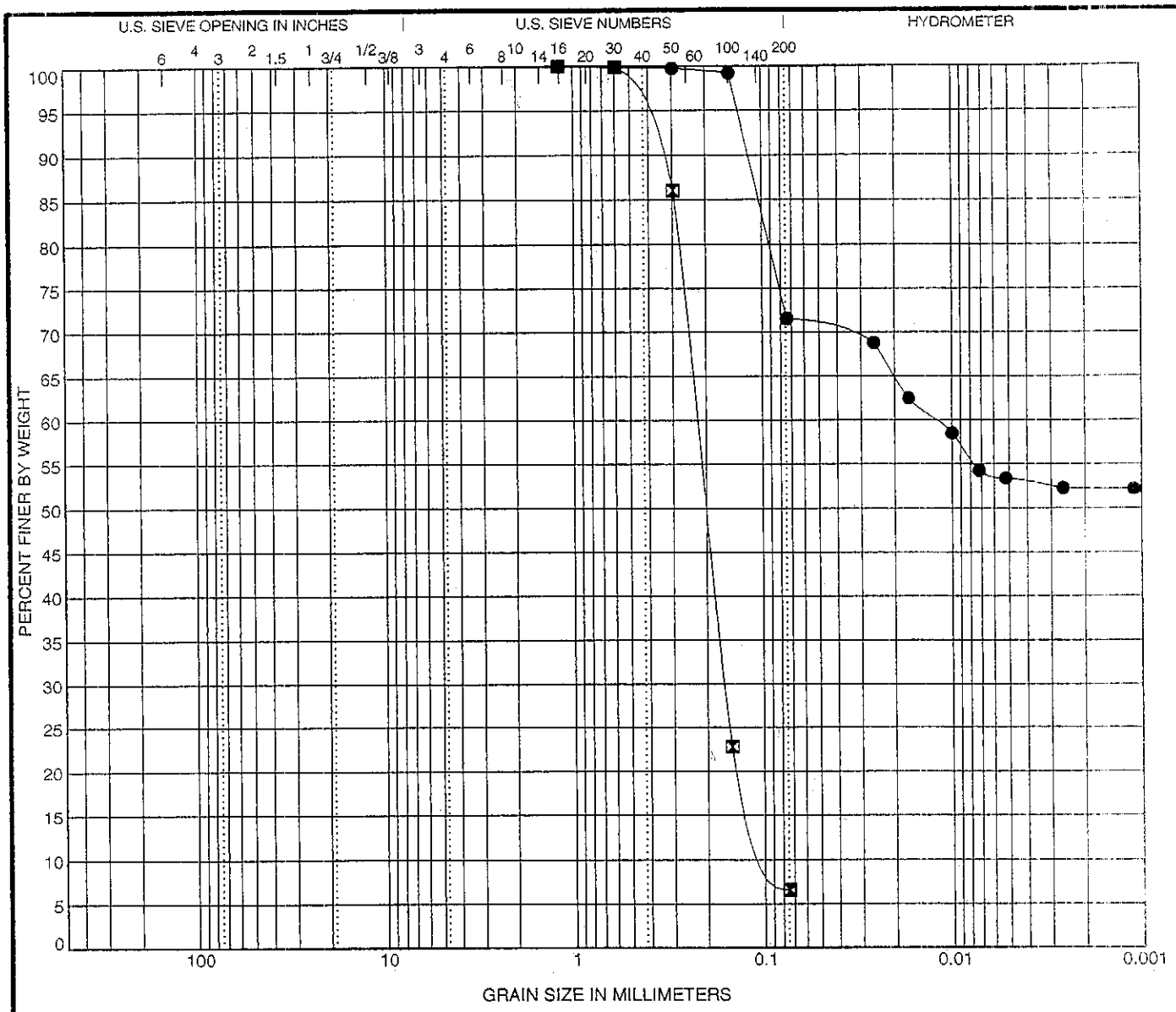
GRAIN SIZE DISTRIBUTION

Project: New Albany Sewers, Phase 1

Location: 15th Street Sewer Corrections

Number: 07-020 (A)

US GRAIN SIZE 07-020(A).GPJ GREENBAUM.GDT 8/8/07



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-8	6.0	SILTY CLAY with SAND(CL-ML)	27	20	7		
⊠	B-8	20.0	FINE SAND (SP)				1.35	2.61

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-8	6.0	1.19	0.012			0.0	27.9	18.7	53.3
⊠	B-8	20.0	1.19	0.224	0.161	0.086	0.0	93.1	6.9	

Greenbaum Associates, Inc.

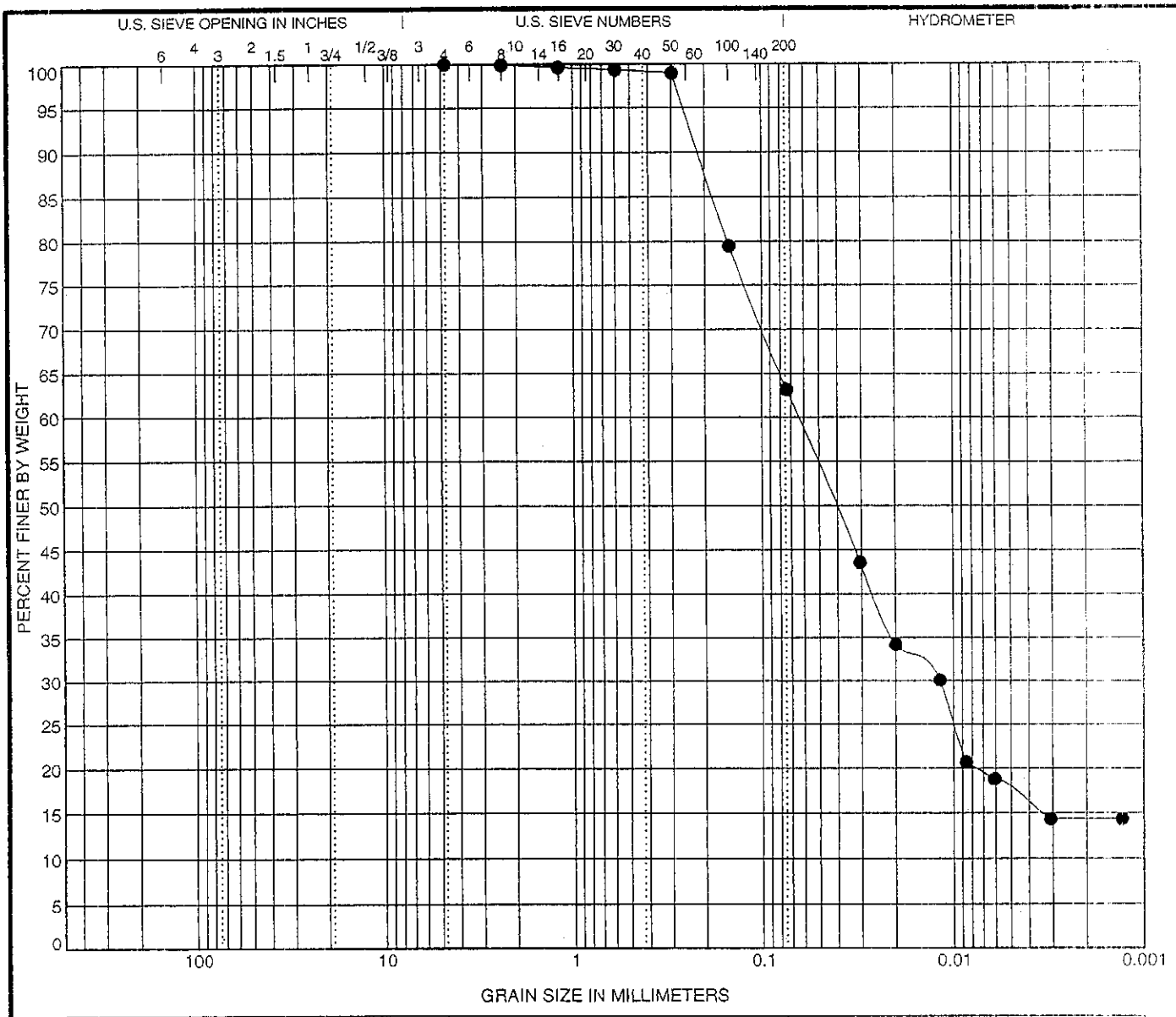
GRAIN SIZE DISTRIBUTION

Project: New Albany Sewers, Phase 1

Location: 15th Street Sewer Corrections

Number: 07-020 (A)

US GRAIN SIZE 07-020(A).GPJ GREENBAUM.GDT 8/3/07



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-13	5.0	SANDY SILT	N.P.				

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-13	5.0	4.76	0.064	0.012		0.0	36.5	46.0	17.5

Greenbaum Associates, Inc.

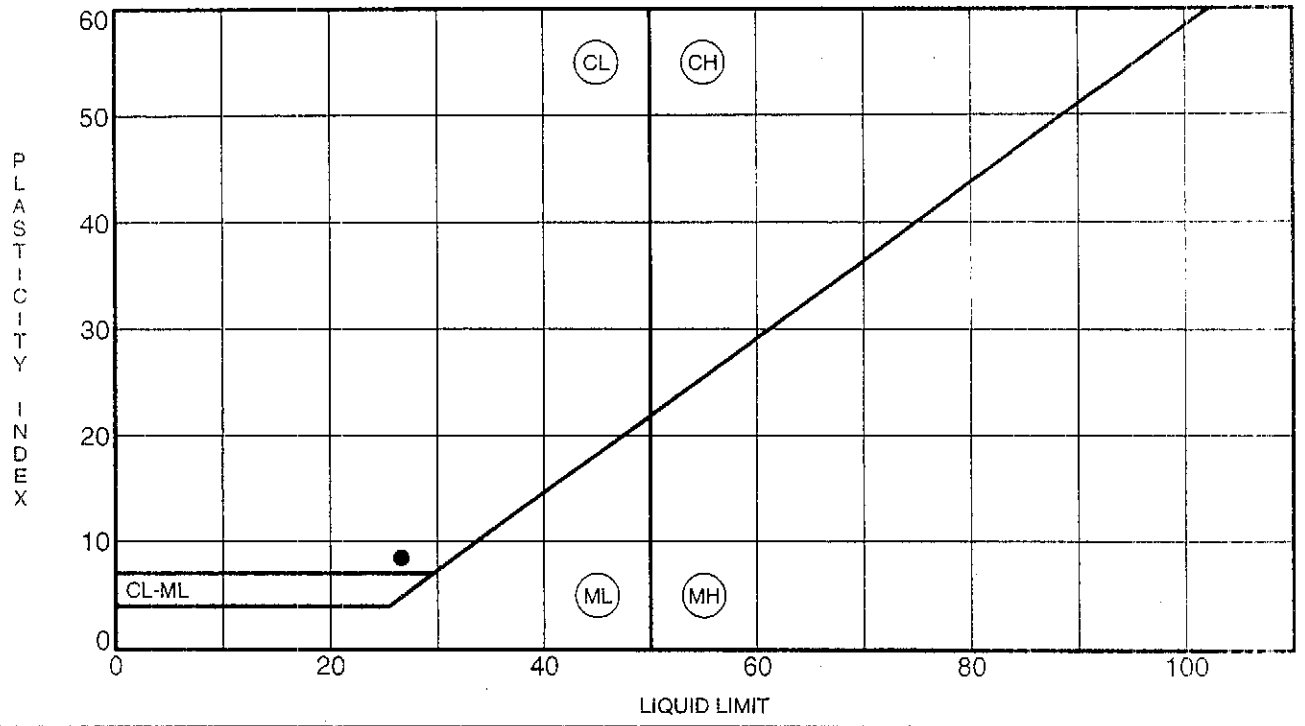
GRAIN SIZE DISTRIBUTION

Project: New Albany Sewers, Phase 1A

Location: 15th Street Sewer Corrections

Number: 07-020 (A)

US GRAIN SIZE 07-020(A).GPJ GREENBAUM.GDT 8/2/07



	Specimen Identification		LL	PL	PI	Fines	Classification
●	B-2	11.0	27	18	9	90	LEAN CLAY(CL)

Greenbaum Associates, Inc.

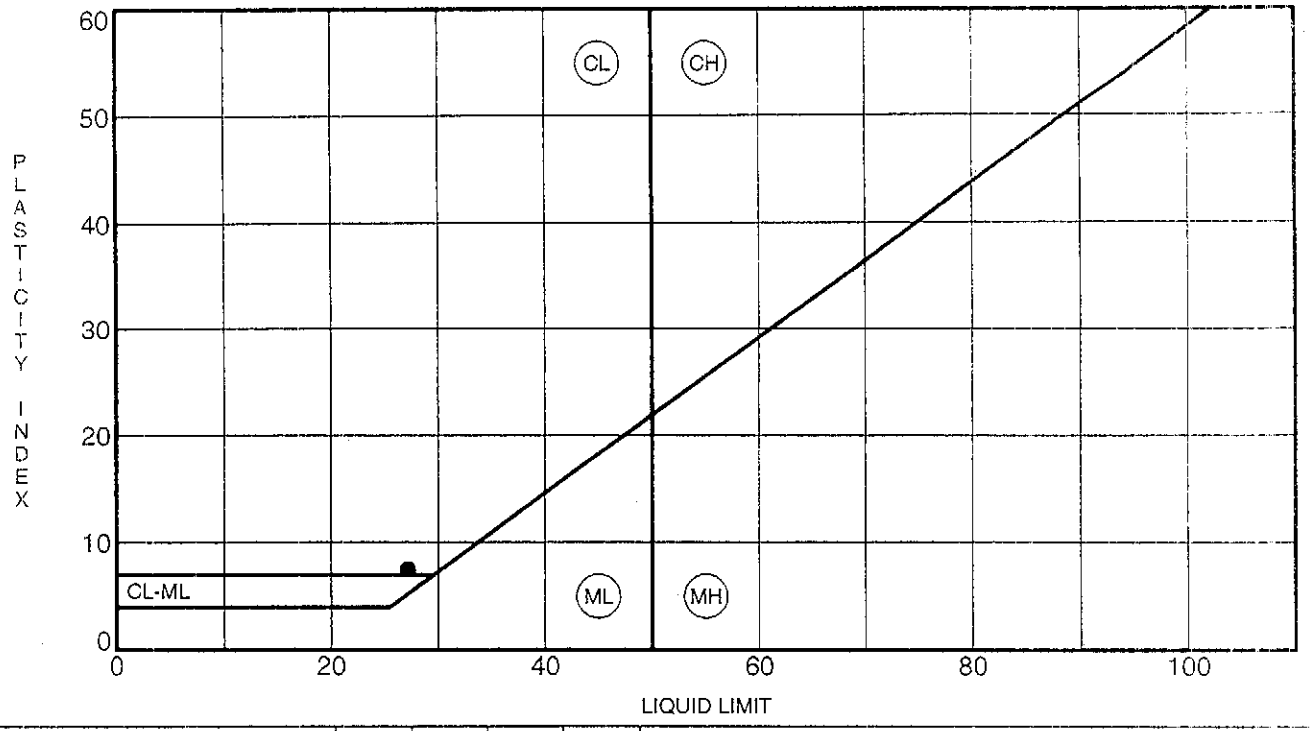
ATTERBERG LIMITS' RESULTS

Project: New Albany Sewers, Phase 1

Location: 15th Street Sewer Corrections

Number: 07-020 (A)

US ATTERBERG LIMITS 07-020(A).GPJ GREENBAUM.GDT 8/8/07



	Specimen Identification		LL	PL	PI	Fines	Classification
●	B-8	6.0	27	20	7	72	SILTY CLAY with SAND(CL-ML)

Greenbaum Associates, Inc.

ATTERBERG LIMITS' RESULTS

Project: New Albany Sewers, Phase 1

Location: 15th Street Sewer Corrections

Number: 07-020 (A)

US ATTERBERG LIMITS 07-020(A).GPJ GREENBAUM.GDT 8/3/07

SOIL DESCRIPTION TERMINOLOGY

Soils are identified and classified in this report according to the Unified Soil Classification System with the following modifiers:

RELATIVE DENSITY OF GRANULAR SOILS

Description	Blows/Foot
Very loose	0 to 4
Loose	4 to 10
Medium Dense	10 to 30
Dense	30 to 50
Very Dense	50 to 80
Extremely Dense	80 +

CONSISTENCY OF COHESIVE SOILS

Description	N	q. (tsf)
Very soft	2	0 to 0.25
Soft	2-4	0.25 to 0.50
Medium	4-8	0.50 to 1.0
Stiff	8-15	1.0 to 2.0
Very Stiff	15-30	2.0 to 4.0
Hard	> 30	4.0 to 8.0
Very Hard		8.0 +

PARTICLE SIZES

Components		Size or Sieve No.
Boulders		over 12 inches
Cobbles		3 to 12 inches
Gravel	Coarse	3/4 to 3 inches
	Fine	No. 4 to 3/4 inches
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40
Fines (silt and clay)		Below No. 200

SOIL MOISTURE

Descriptive Term	
Dry	- Dry of Standard Proctor Optimum
Damp	- Moist, sand only
Moist	- Near Standard Proctor Optimum
Wet	- Wet of Standard Proctor Optimum
Saturated.	- Free water in sample

ROCK QUALITY DETERMINATION

The Rock Quality Determination (Deere et. al., 1969) method of determining rock quality as reported here was obtained by summing up the total length of core recovered in each run, counting only those pieces of core which are four inches (10 cm) in length or longer and which are hard and sound. The sum is then represented as a percentage over the length of the run. If the core is broken by handling or by the drilling process, the fresh broken pieces are fitted together and counted as one piece provided that they form the requisite length of four inches (10 cm). RQD is reported as a percentage.

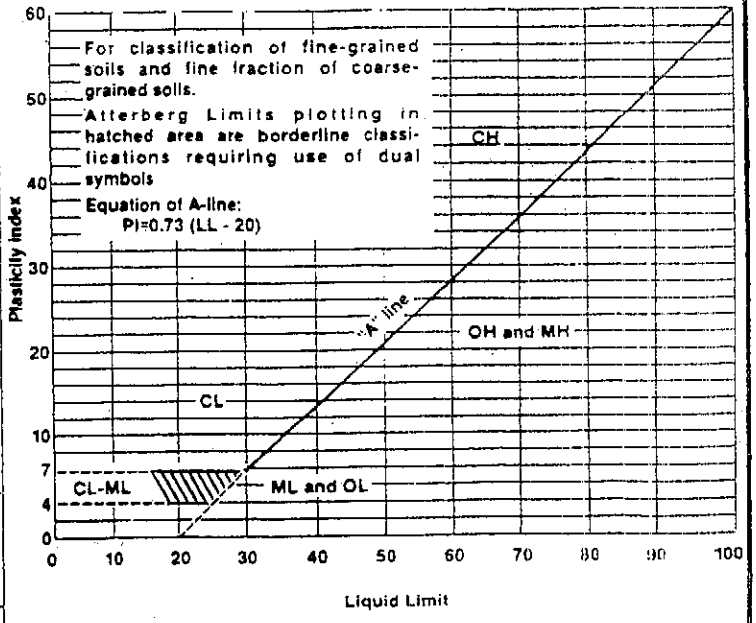
RELATIVE OF RQD AND ROCK QUALITY

RQD (%)	Description of Rock Quality
0 to 25	Very Poor
25 to 50	Poor
50 to 75	Fair
75 to 90	Good
90 to 100	Excellent

NOTE: Recovery as denoted as REC = , is the length of core recovered in a run divided by the length of the run, reported as a percentage.

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
(ASTM: D 2487 and 2488)

Major divisions			Group symbols	Typical names	Laboratory classification criteria		
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	Gravels (More than half of coarse fraction larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 per cent ..... GW, GP, SW, SP; More than 12 per cent ..... GM, GC, SM, SC; 5 to 12 per cent ..... *Borderline* cases requiring dual symbols	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} X D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM d / GM u	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 *are borderline* cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits below "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} X D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM d / SM u	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 *are borderline* cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures		Atterberg limits below "A" line or P.I. greater than 7	
Fine-grained soils More than half of material is *smaller* than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity			
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity, organic silts			
	High organic soils		Pt	Peat and other highly organic soil			



Plasticity Chart

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-1**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Plan, Centerline RR** Surface Elevation: **Ground** Station: **n/a**

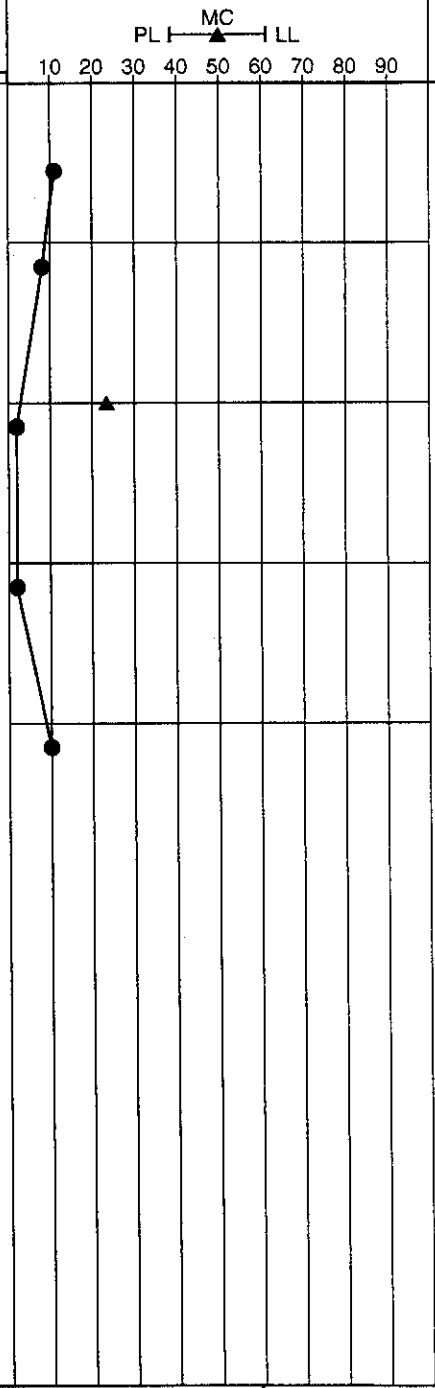
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **14.0** Overburden: Rock: Total Depth: **23.1**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/3/07 - 7/3/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (8")	Ground	
					Crushed Stone		
		SPT	6				11
5		SPT	6				8
					Very Moist Gray Clay Silt CL		
10		SPT	100				2
					Wet Fine Brown Sand		
15		SPT	11				2
20		SPT	100		Wet Gray Silt Sand		10
					AUGER REFUSAL AT 23.08 FEET		

STANDARD PENETRATION TEST (blows/ft)



SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-1**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-2**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

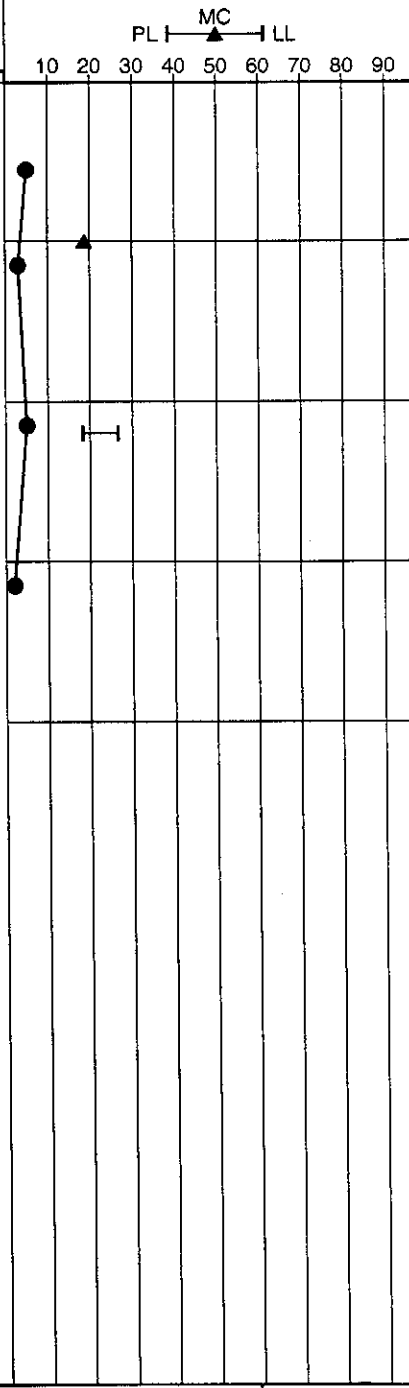
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **16.0** Overburden: Rock: Total Depth: **20.0**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/9/07 - 7/9/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION		ELEVATION (feet)	N VALUE
					Asphalt (4 inches)	CL	Ground	
					Red Brown Brick			
		SPT	67		Crushed Stone			5
5		SPT	100		Gray Clay Silt	CL		3
10		SPT	100		Moist Mottled Brown Gray Clay Silt	CL		5
15		SPT	67		Wet Gray Clay Silt	CL		2
20					AUGER REFUSAL AT 20 FEET			

STANDARD PENETRATION TEST (blows/ft)



SAMPLER TYPE		DRILLING METHOD		Hole No.
SS - Split Spoon	NX - Rock Core, 2-1/8"	HSA - Hollow Stem Auger	RW - Rotary Wash	
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core	B-2
HQ - Rock Core, 2-1/2"	CT - Continuous Tube	DC - Driving Casing		

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client:	Donohue & Associates
Project:	New Albany Sewers, Phase 1 15th Street Sewer Corrections
Project No.:	07-020 (A)

HOLE No. B-3

Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **15.0** Overburden: Rock: Total Depth: **18.5**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/9/07 - 7/9/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (4 inches)	Ground	
					Red Brown Brick		
		SPT	44		Crushed Stone		7
5		SPT	100		Moist, Brown Clay Silt CL		9
10		SPT	56		Same, but very Moist CL		5
15		SPT	56		Wet Gray Clay and Silt CL		4
					AUGER REFUSAL AT 18.41 FEET		

STANDARD PENETRATION TEST (blows/ft) — PL MC LL — 10 20 30 40 50 60 70 80 90

SAMPLER TYPE		DRILLING METHOD		Hole No.
SS - Split Spoon	NX - Rock Core, 2-1/8"	HSA - Hollow Stem Auger	RW - Rotary Wash	B-3
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core	
HQ - Rock Core, 2-1/2"	CT - Continuous Tube	DC - Driving Casing		

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-4**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **15.0** Overburden: Rock: Total Depth: **22.3**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/9/07 - 7/9/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	STANDARD PENETRATION TEST (blows/ft)	N VALUE
					Asphalt (3 inches)	Ground		
					Crushed Stone			
		SPT	33		Fine Gray Sand			6
5		SPT	100					7
10		SPT	100					6
15		SPT	56		Wet Fine Brown Sand			7
20		SPT	0					7
					AUGER REFUSALT AT 22.25 FEET			

STANDARD PENETRATION TEST: PL — MC — LL; 10 20 30 40 50 60 70 80 90

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-4**

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-5**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Plan, Centerline RR** Surface Elevation: **Ground** Station: **n/a**

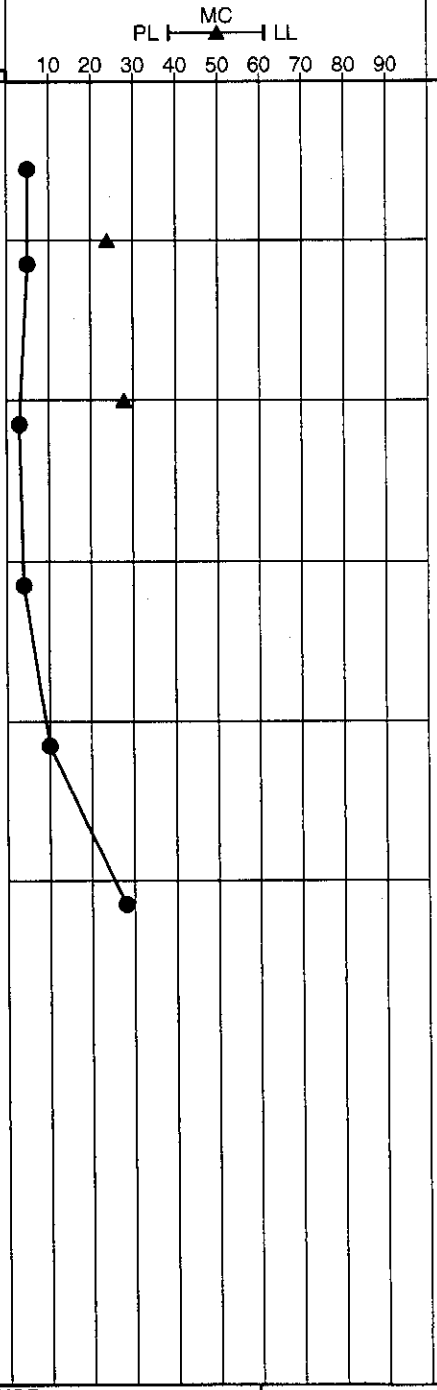
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **10.0** Overburden: Rock: Total Depth: **26.5**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/3/07 - 7/3/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)
					Asphalt (5 inches)	Ground
					Crushed Stone	
		SPT	28		Brown Clay Silt CL	
5		SPT	100			
					Wet Fine Brown Sand	
10		SPT	56			
15		SPT	100			
20		SPT	100			
25		SPT			Gray Sand with Clay	
					TERMINATED AT 26.5 FEET	

STANDARD PENETRATION TEST (blows/ft)



N VALUE: 5, 5, 3, 4, 10, 28

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-5**

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-6**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 2

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

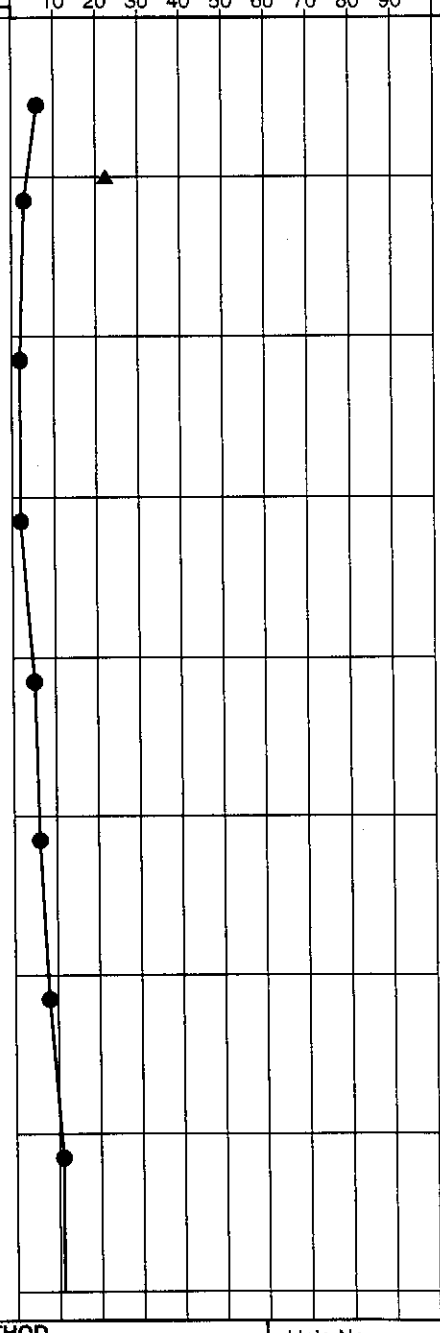
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **15.0** Overburden: Rock: Total Depth: **51.5**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/9/07 - 7/9/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (4 inches)	Ground	
					Red Brown Brick		
		SPT	67		Crushed Stone		6
5		SPT	100		Moist, Brown Clay Silt CL		3
10		SPT	100		Same, but Wet and Sand CL		2
15		SPT	56		Wet Fine Brown Sand		2
20		SPT	56				5
25		SPT	67				6
30		SPT	33				8
35		SPT	33		Wet Gray Clay Silt CL		11
40							

STANDARD PENETRATION TEST ● (blows/ft) PL ⊢ MC ▲ ⊣ LL



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SAMPLER TYPE
SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD
HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-6**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections
Project No.: 07-020 (A)

HOLE No. B-6

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION (Continued)	ELEVATION (feet)	STANDARD PENETRATION TEST (blows/ft) PL MC LL 10 20 30 40 50 60 70 80 90	N VALUE
		SPT	28		Wet Gray Clay Silt *(continued)*			11
45		SPT	0					13
50		SPT	0					13
					TERMINATED AT 51.5 FEET			

SAMPLER TYPE
SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD
HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. B-6

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-7**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	Sheet 1 of 1
Project No.: 07-020 (A)	

Boring Location: **See Boring Plan, Centerline RR** Surface Elevation: **Ground** Station: **n/a**

Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **4.0** Overburden: Rock: Total Depth: **25.5**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/3/07 - 7/3/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)
					Asphalt (5 inches)	Ground
					Crushed Stone	
		SPT	67		Wet Brown Clay Silt (CL)	
5		SPT	83			
10		SPT	89		Wet Fine Brown Sand	
15		SPT	100			
20		SPT	56			
25		SPT	0		Wet Gray Sand with Black Shale	
					TERMINATED AT 25.5 FEET	

STANDARD PENETRATION TEST (blows/ft) — MC, PL, LL — 10 20 30 40 50 60 70 80 90

N VALUE: 5, 7, 6, 9, 19, 17

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-7**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-8**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **15.0** Overburden: Rock: Total Depth: **32.0**

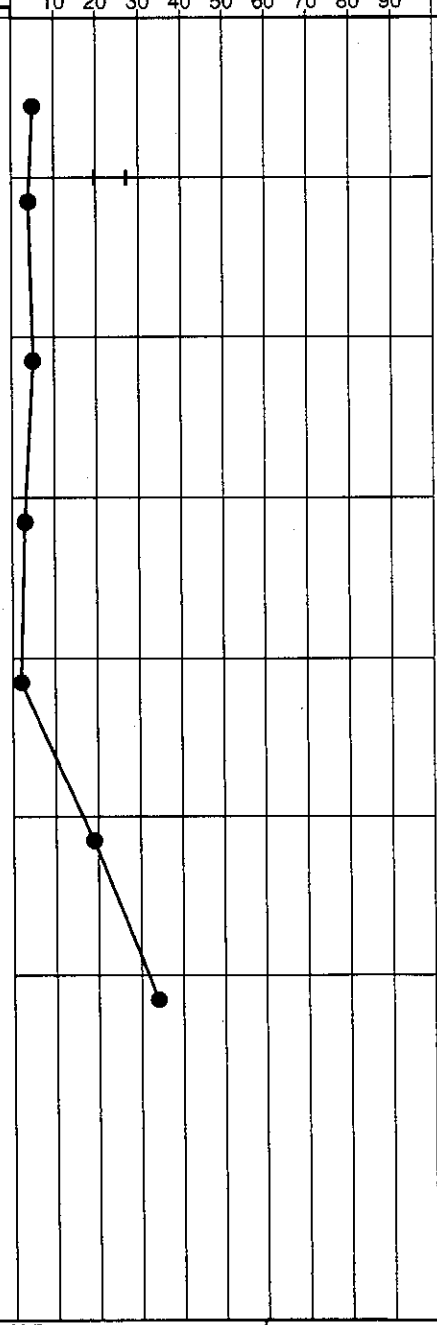
Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/10/07 - 7/10/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (4 inches)	Ground	
					Red Brown Brick		
					Crushed Stone		
		SPT	100		Moist, Brown Silty Clay with Sand CL		5
5		SPT	67				4
10		SPT	89				5
15		SPT	89		Wet Fine Brown Sand		3
20		SPT	67				2
25		SPT	100				19
30		SPT	67		Same, with Black Shale		34
					AUGER REFUSAL AT 32 FEET		

STANDARD PENETRATION TEST

● (blows/ft)

PL ⊢ MC ▲ ⊣ LL



SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-8**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-9**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

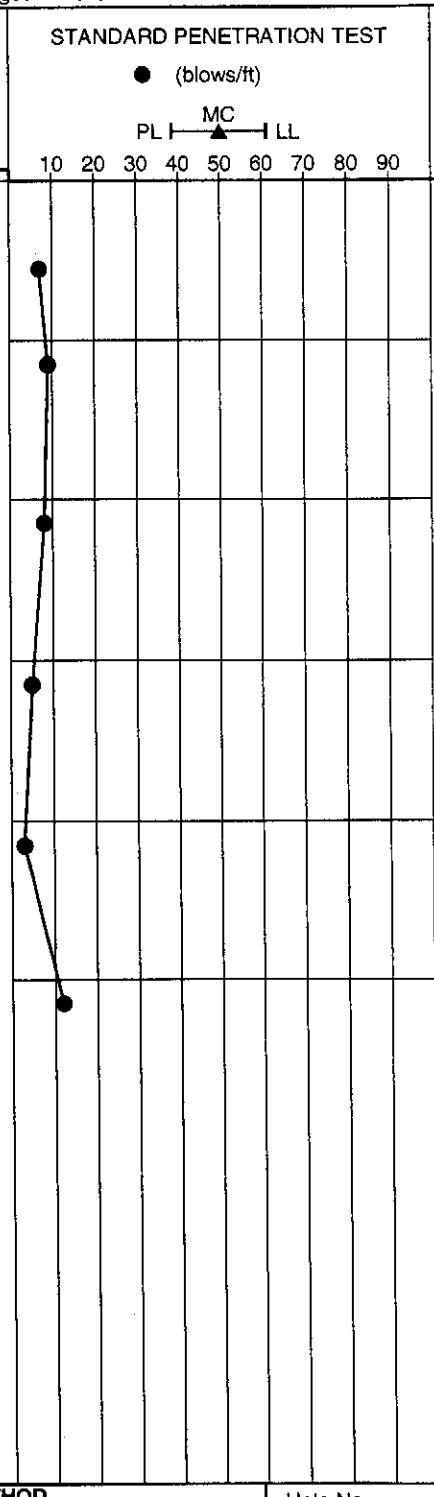
Boring Location: **See Boring Plan, Centerline RR** Surface Elevation: **Ground** Station: **n/a**

Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **20.0** Overburden: Rock: Total Depth: **26.5**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/3/07 - 7/3/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (5 inches)	Ground	
					Crushed Stone		
		SPT	0				7
5		SPT	17		Moist, Brown Clay Silt with Crushed Stone CL		9
					Moist, Fine Brown Sand		
10		SPT	100			▼	8
15		SPT	100		Wet Fine Brown Sand		5
20		SPT	12			▽	3
25		SPT					12
					TERMINATED AT 26.5 FEET		



SAMPLER TYPE
SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD
HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-9**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client:	Donohue & Associates
Project:	New Albany Sewers, Phase 1 15th Street Sewer Corrections
Project No.:	07-020 (A)

HOLE No. B-10

Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

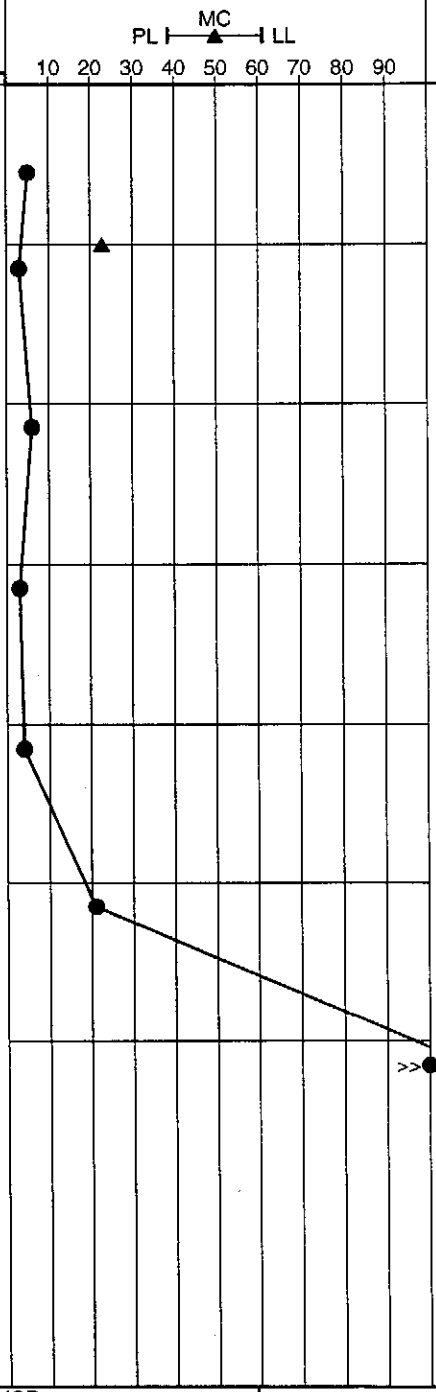
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **15.0** Overburden: Rock: Total Depth: **31.8**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/10/07 - 7/10/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)
					Asphalt (3 inches)	Ground
					Crushed Stone and Sand	
		SPT	33		Red Brown Rock CL	
					Brown Clay Silt	
5		SPT	100			
10		SPT	11			
					Wet Fine Brown Sand	
15		SPT	67			
20		SPT	67			
25		SPT	44			
30		SPT	80		Black Shale	
					AUGER REFUSAL AT 31.67 FEET	

STANDARD PENETRATION TEST



SAMPLER TYPE		DRILLING METHOD		Hole No.
SS - Split Spoon	NX - Rock Core, 2-1/8"	HSA - Hollow Stem Auger	RW - Rotary Wash	B-10
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core	
HQ - Rock Core, 2-1/2"	CT - Continuous Tube	DC - Driving Casing		

Greenbaum Associates, Inc.

Client:	Donohue & Associates
Project:	New Albany Sewers, Phase 1 15th Street Sewer Corrections
Project No.:	07-020 (A)

HOLE No. B-11

Sheet 1 of 1

Boring Location: **See Boring Plan, Centerline RR** Surface Elevation: **Ground** Station: **n/a**

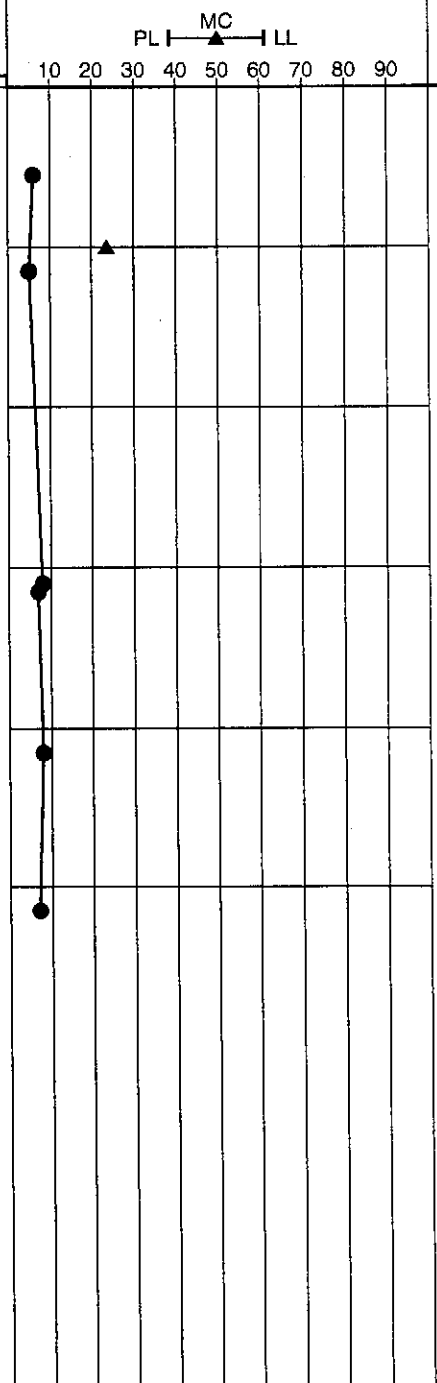
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **13.0** Overburden: Rock: Total Depth: **26.5**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/2/07 - 7/2/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (4 inches)	Ground	
					Crushed Stone		
		SPT	56				6
5		SPT	100		Wet Brown Clay Silt CL		5
10					Same, with Sand CL		
					Wet Fine Brown Sand		
15		SPT	22				8
		SPT	100				7
20		SPT	100				8
25		SPT	56				7
					TERMINATED AT 26.5 FEET		

STANDARD PENETRATION TEST (blows/ft)



SAMPLER TYPE		DRILLING METHOD		Hole No.
SS - Split Spoon	NX - Rock Core, 2-1/8"	HSA - Hollow Stem Auger	RW - Rotary Wash	B-11
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core	
HQ - Rock Core, 2-1/2"	CT - Continuous Tube	DC - Driving Casing		

Greenbaum Associates, Inc.

Client:	Donohue & Associates	**HOLE No. B-12**
Project:	New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.:	07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

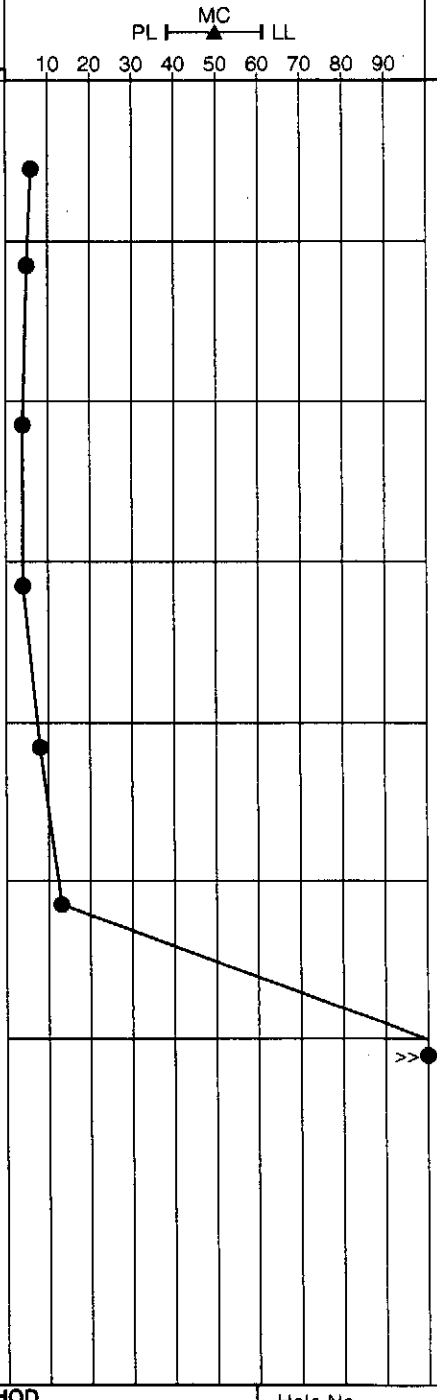
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **15.0** Overburden: Rock: Total Depth: **31.0**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/10/07 - 7/10/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (5 inches)	Ground	
					Red Brown Brick		
		SPT	33		Crushed Stone		6
					Moist, Brown Clay Silt with Sand CL		
5		SPT	83				5
10		SPT	67		Wet Fine Brown Sand		4
15		SPT	67				4
20		SPT	89				8
25		SPT	28				13
30		SPT			Black Shale		50/1"
					AUGER REFUSAL AT 31 FEET		

STANDARD PENETRATION TEST (blows/ft)



SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-12**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-13**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **8.0** Overburden: Rock: Total Depth: **32.3**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/2/07 - 7/2/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (4 inches)	Ground	
					Red Brown Brick		
		SPT	100		Crushed Stone		9
					Fine Brown Sandy Silt CL		
5		SPT	100				7
10		SPT	89		Wet Fine Brown Sand		4
15		SPT	100				7
20		SPT	100				7
25		SPT	67				8
30		SPT	67				7
					Black Shale		
					AUGER REFUSAL AT 32.25 FEET		

STANDARD PENETRATION TEST (blows/ft) — PL MC LL — 10 20 30 40 50 60 70 80 90

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-13**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-14**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Plan, Centerline RR** Surface Elevation: **Ground** Station: **n/a**

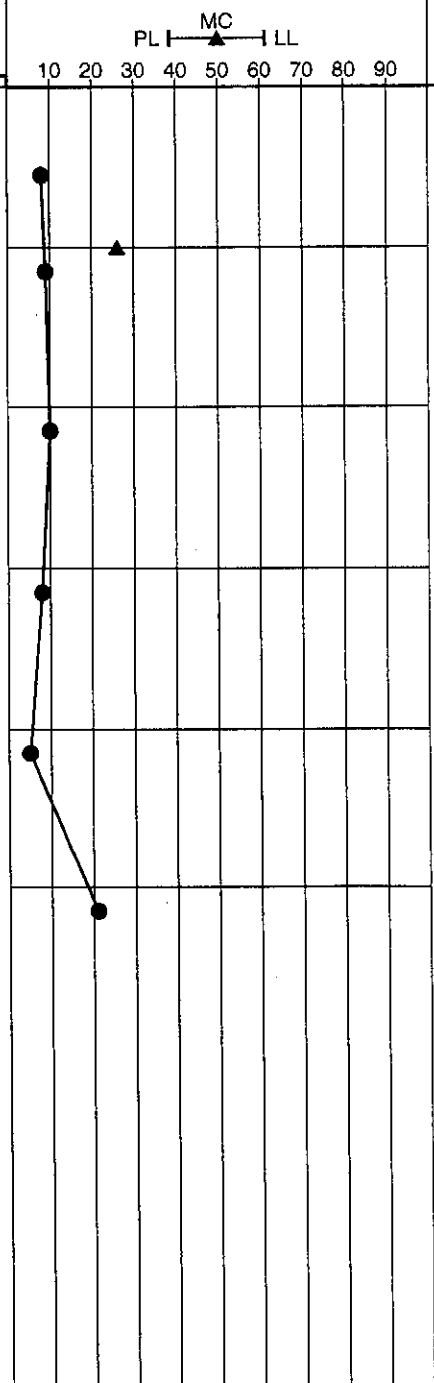
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **6.0** Overburden: Rock: Total Depth: **26.5**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **7/2/07 - 7/2/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (4 inches)	Ground	
		SPT	0		Crushed Stone		8
5		SPT	89		Moist, Brown Clay Silt CL		9
					Wet Fine Brown Sand		
10		SPT	100				10
15		SPT	100				8
20		SPT	100				5
25		SPT					21
					TERMINATED AT 26.5 FEET		

STANDARD PENETRATION TEST (blows/ft)



SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-14**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-15**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

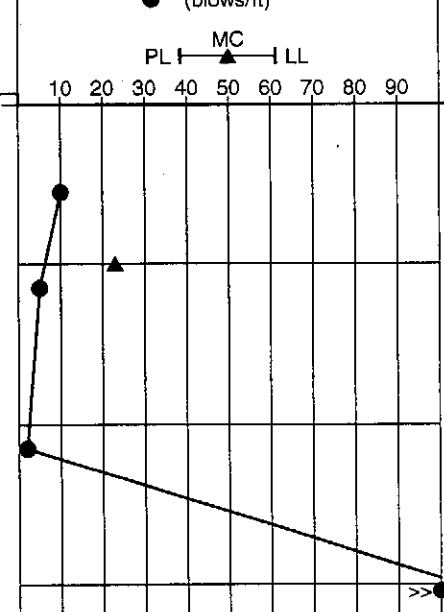
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **8.0** Overburden: Rock: Total Depth: **15.5**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **6/28/07 - 6/28/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (5 inches)	Ground	
					Crushed Stone	CL	
		SPT	67		Moist, Brown Clay Silt		10
5		SPT	89				5
					Wet Gray Clay Silt	CL	
10		SPT	100				2
					New Albany Shale		
15		SPT	73		AUGER REFUSAL AT 15.42 FEET		50/ 5"

STANDARD PENETRATION TEST



SAMPLER TYPE		DRILLING METHOD		Hole No.
SS - Split Spoon	NX - Rock Core, 2-1/8"	HSA - Hollow Stem Auger	RW - Rotary Wash	
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core	
HQ - Rock Core, 2-1/2"	CT - Continuous Tube	DC - Driving Casing		B-15

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-16**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

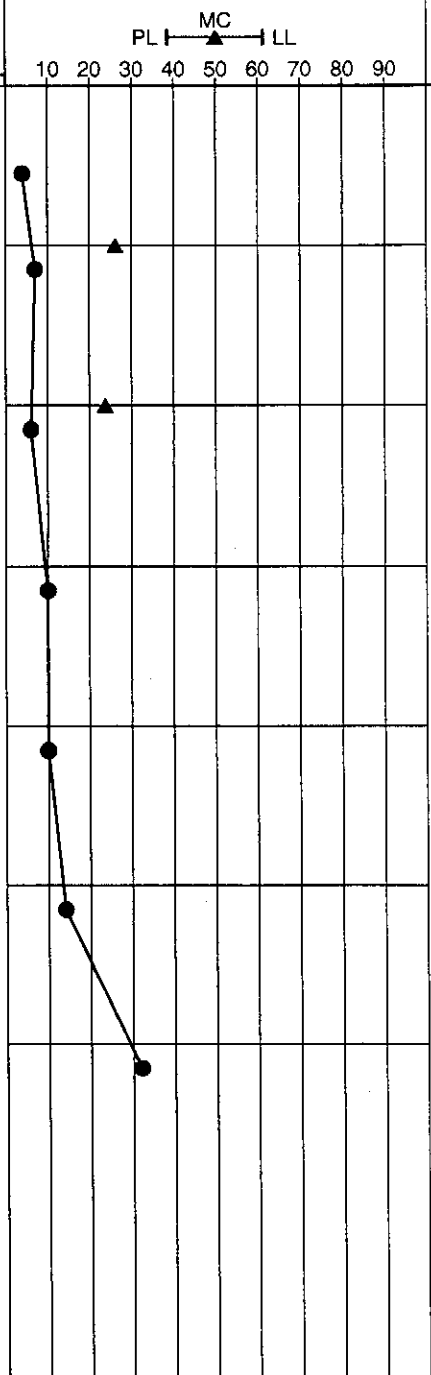
Drilling Equipment: **CME-55** Drilling Method: **HSA**

Depth to water immediately: **18.0** Overburden: Rock: Total Depth: **34.2**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **6/28/07 - 6/28/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (4 inches)	Ground	
					Crushed Stone	CL	
		SPT	44		Moist, Brown Clay Silt with Sand		4
5		SPT	67				7
10		SPT	67				6
15		SPT	0				10
					Wet Brown Sandy Silt		
20		SPT	89				10
25		SPT	100		Wet Fine Brown Sand		14
30		SPT	100				32
					AUGER REFUSAL AT 34.17 FEET		

STANDARD PENETRATION TEST (blows/ft)



SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-16**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client: Donohue & Associates	**HOLE No. B-17**
Project: New Albany Sewers, Phase 1 15th Street Sewer Corrections	
Project No.: 07-020 (A)	Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

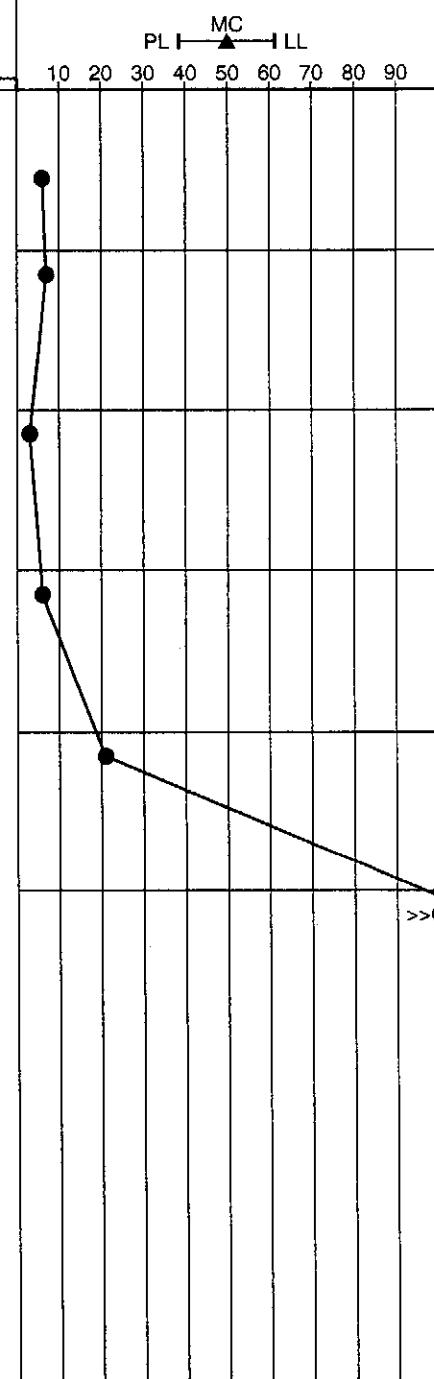
Drilling Equipment: **CME-550 (ATV)** Drilling Method: **HSA**

Depth to water immediately: **27.7** Overburden: Rock: Total Depth: **27.7**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **6/29/07 - 6/29/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (4 inches) CL	Ground	
					Brown Clay Silt with Crushed Stone		
		SPT					6
5		SPT			Moist, Brown Clay Silt CL		7
10		SPT					3
					Same, with Wet Sand CL	▼	
15		SPT					6
20		SPT					21
					Wheathered Black Shale		
25		SPT					>> 50/2'
					AUGER REFUSAL AT 27.58 FEET	▽	

STANDARD PENETRATION TEST



SAMPLER TYPE		DRILLING METHOD		Hole No.
SS - Split Spoon	NX - Rock Core, 2-1/8"	HSA - Hollow Stem Auger	RW - Rotary Wash	
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core	
HQ - Rock Core, 2-1/2"	CT - Continuous Tube	DC - Driving Casing		B-17

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07

Greenbaum Associates, Inc.

Client:	Donohue & Associates
Project:	New Albany Sewers, Phase 1 15th Street Sewer Corrections
Project No.:	07-020 (A)

HOLE No. B-18

Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**

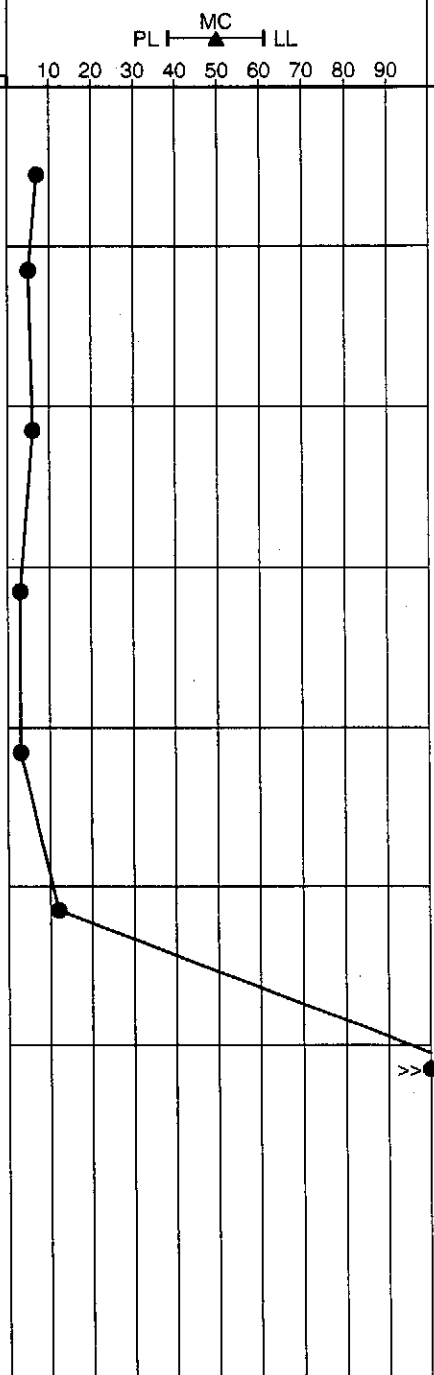
Drilling Equipment: **CME-550 (ATV)** Drilling Method: **HSA**

Depth to water immediately: **33.2** Overburden: Rock: Total Depth: **33.2**

Logged By: **M. Wells** Driller: **M. Wells** Date Logged: **6/29/07 - 6/29/07**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION	ELEVATION (feet)	N VALUE
					Asphalt (1 inche) / Concrete	Ground	
		SPT	100		Brown Clay Silt	CL	7
5		SPT	100		Same, with Sand		5
10		SPT	100		Moist, Brown Sand with Silt		6
					Wet Fine Brown Sand		
15		SPT	100				3
20		SPT	100				3
25		SPT	55				12
30		SPT					>> 50/3'
					AUGER REFUSAL AT 33.16 FEET		

STANDARD PENETRATION TEST (blows/ft)



SAMPLER TYPE

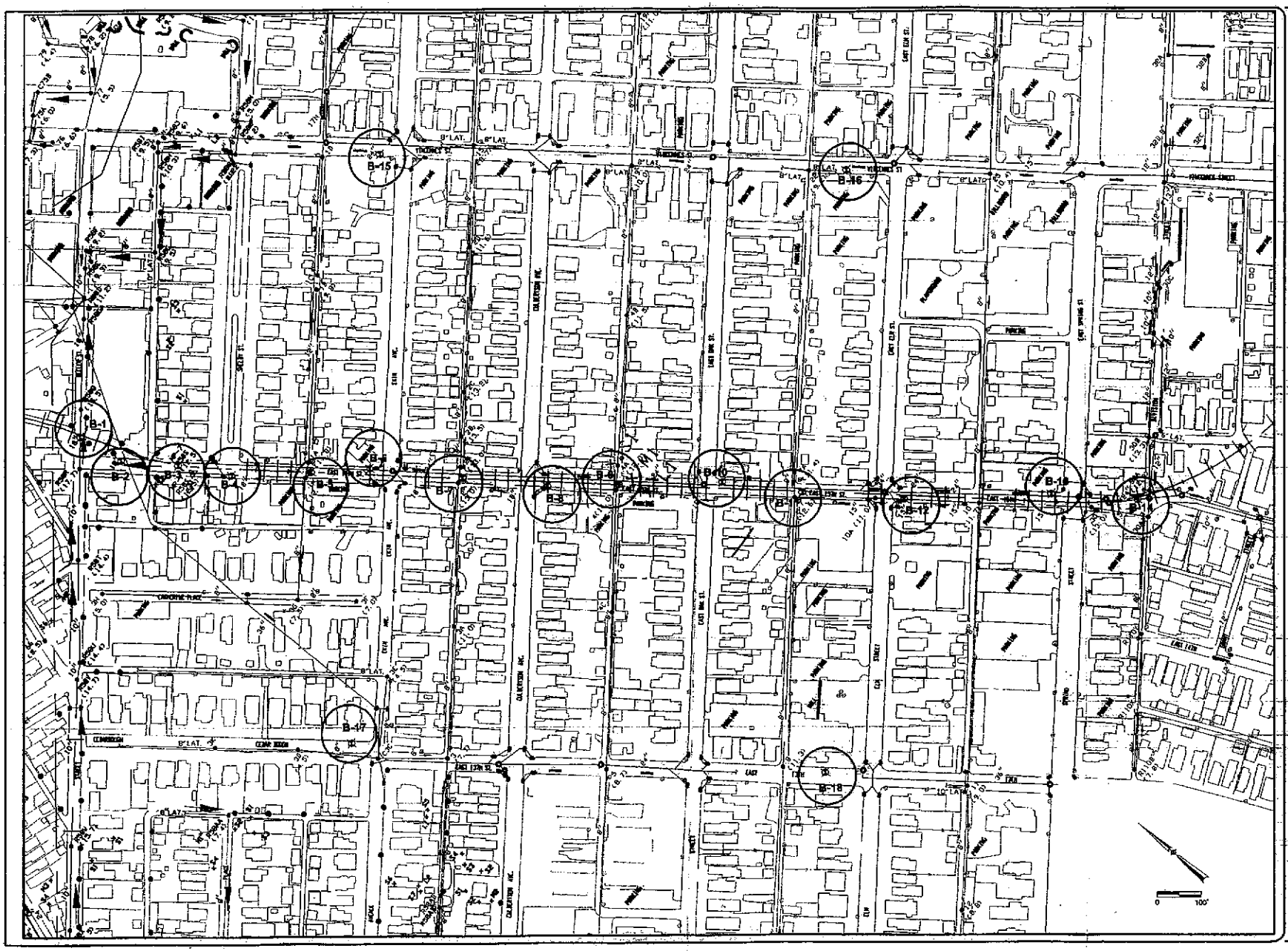
SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-18**

LOG WITH WELL AND SPT GRAPH 07-020(A).GPJ GREENBAUM.GDT 8/23/07



Revision Number	Revision Description	Drawn By	Checked By	Date

Designed By	PNE
Drawn By	PNE
Checked By	
Approved By	
Filename	15TH ST. FIGURE.DWG
Project No.	NUMBER
Project Date	DATE

CLIENT NAME
PROJECT NAME LINE 1
PROJECT NAME LINE 2
PROJECT LOCATION

SOIL BORING LAYOUT

DONOHUE ASSOCIATES

Sheet No. 1

Drawing No. 1

GREENBAUM ASSOCIATES, INC.
GEOTECHNICAL & CIVIL ENGINEERS
994 Longfield Avenue
Louisville, Ky 40215
502/361-8447
FAX 502/361-4793

March 1, 2007

Paul N. Elling, P.E.
Donohue Associates
101 West Ohio Street, Suite 820
Indianapolis, IN 46204

RE: PHASE 1A
15TH STREET SEWER REMEDIATION
NEW ALBANY, IN
GREENBAUM PROJECT NUMBER 07-020

Dear Paul:

The authorized program for Phase 1A has been completed and its results are reported in the attached report.

Groundwater and running sand will be a problem at the manhole/pump station that is to be built in the alley south of Elm Street, east of 15th Street. To construct this structure, it will be necessary to sheet (brace) the excavation to avoid an overly large hole that encroaches on private property and which might involve damage to garages and other utilities in the alley. If the sheeting is to be taken to refusal on New Albany Shale, this should limit inflow of groundwater and permit pumping of water from inside the sheet pile cell to control groundwater inflow.

There is discussion of dewatering the area, but the scope of this investigation did not include test wells or a pump test to determine well size and pump capacity and their influence on the water table.

There are soft, wet soils in and around the allies that will have to be addressed prior to paving. There is also discussion of the force main, but this does not involve the water table or running sands if the depth is kept shallow.

Review the report and, should there be any questions regarding this report, please don't hesitate to call.

Yours very truly,

GREENBAUM ASSOCIATES, INC.

Milton M. Greenbaum, P.E.
Principal Engineer

Sandor R. Greenbaum, P.E.
Senior Geotechnical Engineer

GEOTECHNICAL INVESTIGATION

FOR
PHASE 1 A
15th STREET SEWER CORRECTIONS
NEW ALBANY, INDIANA

FOR
DONOHUE & ASSOCIATES
INDIANAPOLIS, INDIANA

BY:
GREENBAUM ASSOCIATES, INC.
994 LONGFIELD AVENUE
LOUISVILLE, KENTUCKY 40215

MARCH 1, 2007

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TABLE OF CONTENTS

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- 5.2 Force Main
- 5.3 Site Preparation and Earthwork
- 5.4 Pump Station Walls
- 5.5 Pavement
- 5.6 Limitations

APPENDIX

Grain Size Distribution Curves (4 sheets)

Atterberg Limits' Test (1 sheet)

Soil Description Terminology / Rock Quality Determination (1 sheet)

Classification of Soils for Engineering Reports (1 sheet)

Test Boring Reports (3 sheets)

Boring Location Plan (1 sheet)

1.0 Introduction

A sewer in the alley south of Elm Street and crossing South 15th Street is apparently obstructed under the railroad that runs down the middle of 15th Street in New Albany, Indiana. The New Albany Sewage Works wishes to alleviated this problem and towards that end has contracted with Donahue & Associates to design a bypass force main from a new manhole to be constructed in the middle of that alley about 50 feet east of 15th Street. That force main is to be constructed from this proposed manhole/pump station west to the east side of 15th Street, thence north, crossing Elm Street to an existing manhole in the alley just north of Elm Street. That manhole is also east of 15th Street.

Construction in the past has encountered:

- the sewer at a depth of about 12 feet
- a water table shallower than the sewer
- unstable sandy soil at the level of the sewer.

We were asked by Donahue & Associates to carry out a geotechnical investigation directed at determining the soils conditions in the area of the subject sewer and provide recommendations relative to sewer construction and temporary support of trenching.

2.0 General Geology

Shallow deposits in the area of the sewer, possibly to several feet , are manmade deposits including pavement, base course and fill. Under the center of 15th Street, the soil structure may have been modified much deeper than this. The railroad has removed soil, placed ballast and possibly driven the ballast down into the relatively loose soils under the impact of rail traffic. Before any construction is conducted under the railroad, additional investigation under the railroad will need to be carried out to determine the accuracy of this presumption.

The soils in the area, according to geologic mapping by the Indiana Geological Survey, are alluvial in origin, recent alluvium overlying outwash which was deposited by glacial meltwater. Mapping also indicates that bedrock is present at a depth of 30 to 35 feet. Bedrock is likely to be the New Albany Shale, a carbonaceous black silty shale. Soils are typically fine grained (silty and clay) in the shallowest deposits transitioning through progressively coarser materials with depth, possibly as coarse as sand and gravel in the deepest deposits.

The water table is driven by Ohio River stages and may vary considerably as the river rises and falls seasonally.

3.0 Investigation

3.1 Field Investigation

Three (3) soil borings were carried out along the proposed alignment of the force main and manhole/pump station. The first boring was carried out near the manhole/pump station and was carried out by standard penetration procedures to refusal on apparent bedrock at a depth of 31.1 feet. The location was moved off the alley to avoid utilities and to minimize interferences with traffic. Unfortunately, the pavement for the concrete driveway was exceptionally thin and the subgrade soft, resulting in damage to a homeowner's driveway. The construction contractor will likely encounter the same sort of problem.

The second boring was in the north side of Elm Street and the third was in the alley north of Elm Street. Both of these were carried out by standard penetration procedures to a depth of 10.5 feet. Boring locations are shown on the attached boring location plan.

Borings were carried out by standard penetration procedures through the use of 3-1/4" inch inside diameter hollow stem augers. A CME-55 truck mounted drill rig was used to access boring locations. Borings were staked using a 100 foot tape from street centerlines, so boring locations are only as accurate as this procedure allows.

The standard penetration procedure involves driving a standard 2" diameter split spoon in the formation at selected intervals using a 140 pound hammer falling through 30 inches. The blow counts for each 6 inches of drive to a total of 18 inches is recorded and the number of blows for the 12 inches after the first 6 inches is a standard measure of the condition of the soil. As the split spoon is removed from the ground, it retrieves a sample of the soil in a disturbed condition. Nevertheless, this sample is suitable for certain classification tests and is representative of the soils at the depth tested.

3.2 Laboratory Investigation

The laboratory investigation included two (2) sets of classification tests on the shallow, fine grained, which include grain size analyses and Atterberg Limits Tests.

Two (2) additional samples from depths of 5 and 10 feet were subjected to sieve analyses including decantation over a number 200 sieve. This gradation is more limited in that it determines the grain size distribution of the sand and gravel fractions and the total fraction finer than the number 200 sieve (the silt and clay without differentiating them).

All soil samples were subjected to moisture determinations. The results are plotted graphically on the boring logs.

Grain size determination arrives at a curve of grain size against that fraction of the soil which is finer than that particular grain size. It also allows the determination of the clay fraction, silt fraction, sand fraction, etc. in any particular soil sample. Based on this division of grain sizes, the field soils classifications are refined and the boring logs adjusted. In the case of fine grained soils, the soils are largely silt and clay, thus requiring that the soils be suspended in an aqueous medium and the rate at which the particles drop out is measured in order to arrive at the grain size distribution. Silt and clay grains are so fine that sieve analysis alone will not function in this range. The coarse fraction of this sample is separated from the fine and run through a nest of sieves in order to further detail the grain size distribution in the coarse range.

The Atterberg Limits determination arrives at those moisture contents at which the soil turns from a solid state to a plastic condition (the Plastic Limit) and then from a plastic condition to a liquid condition (The Liquid Limit). The points in question are arrived at by standard procedures that accept specific cohesive and flow properties of the soil as standards for these limits. Knowing the moisture content of the soil in relation to these limits provides a broad measure of the soil strength and soil characteristics. The arithmetic difference between these two limits is called the Plasticity Index and all three together are used for classifying the soils in a number of standard systems. This test if not applicable to silty and sandy soils.

Natural moisture determinations were run on all soil samples. This test arrives at the in-situ moisture content of the soil and is useful for correlating the strength of various samples of like texture and in conjunction with the Atterberg limits, gives a strong measure of the strength range the cohesive soils are likely to be found in.

4.0 Findings

The site is largely covered with pavement, usually concrete, sometimes asphalt. Stone base course is thin or non-existent. Boring one encountered a layer of brick.

Below this to a depth of 7 to 9 feet is fine grained soil ranging from lean sandy clay to sandy silt. These soils are medium stiff with corrected N-values (standard penetration blow counts) of 4 to 6. Moisture content of these soils are 20 to 27 percent. The sample from boring three had a liquid limit of 30, a plastic limit of 20 and a plasticity index of 10. The sandy clay classifies CL by the Unified System and as A-6 by the AASHTO system. The sample from boring one was non-plastic, a clay silt classifying ML in the Unified System.

The materials below this were entirely granular to refusal on New Albany Shale at a depth of 31.1 feet in boring one. To 25 feet depth, these were a red silty fine to medium sand. Combined silt and clay content amounted to 15 to 35 percent. Moisture content was 21 to 25 percent.

The water table was found at a depth of about 9 feet. This will vary seasonally and with stages of the Ohio River.

At 31.1 feet, the split spoon refused and recovered a sample of New Albany Shale.

5.0 Recommendations

5.1 Pump Station

Excavation for the pump station is likely to be 12 to 14 feet deep or more, but we do not have the pipe invert elevation at this time. This depth will place it well into the water table and into sandy soil. If the soil is excavated to such depths without soil dewatering, the soils will become quick and flow into the excavation.

There are basically two solutions to this instability problem:

1) Groundwater level can be lowered by dewatering wells placed around the construction site. If this is done, the slopes will have to be laid back to no steeper than 2 horizontal to 1 vertical or the excavation will have to be braced. Dewatering wells will likely have to be taken to bedrock at a depth of 30 to 35 feet. The number of wells and pumping capacity will be a function of a pump test or experience of the contractor in dewatering these soils.

2) Alternately, the pump station can be constructed inside of a cell of sheet piling. The cell of sheet piling will need to be carried to the impermeable New Albany Shale at a depth of 31 feet, more or less. Once the sheet pile cell is complete, water can be pumped from inside the cell to a depth below foundation level.

Bearing capacity is not relevant since the structure plus contents is of a lower mass than the soil removed. Nevertheless, net bearing capacity of 2000 pounds per square foot should not be exceeded.

The structure should be of such mass that it will not float with a water table about 7 feet below existing grade.

5.2 Force Main

The force main is a pipe that will not have to be particularly deep. To avoid the need for mandatory bracing or laid back slopes, the force main should be placed no deeper than 5 feet. It is possible that there will be localized deposits of granular soil, in which case the excavation will have to be laid back or braced.

Temporary slopes in cohesive soil, no higher than 4 feet, may be constructed to vertical faces. Faces higher than this must be braced or stepped such that they are no steeper than 1 horizontal to 1 vertical.

5.3 Site Preparation and Earthwork

Any fill should be placed in lifts not exceeding 8 inches in uncompacted thickness and must be compacted to at least 98 percent of the soils maximum dry density as determined by the Standard Proctor(ASTM D-698). Soil moisture content should be within 2 percent of soils optimum moisture content as determined from the Standard Proctor (ASTM D-698). Soil from any off-site borrow sources should be tested and approved by this office prior to being used on the site.

On site soils are suitable as fill with the exception of fill containing debris. Satisfactory borrow materials are those falling in one of the following classifications: GC, SW, SM, SC, ML or CL. Borrow materials should not be accepted from sources that contain CH or MH soils.

The site should be maintained in a well drained condition both during and after construction. Site grading should provide for drainage or surface run-off from the building.

The placement of compacted fill should be carried out by an experienced excavator with the proper materials. The excavator must be prepared to adapt his procedures, equipment and materials to the type of project, to weather conditions, and the structural requirements of the engineer. Methods and materials used in summer may not be applicable in winter; soil used in proposed fill may require wetting or drying for proper placement and compaction. Conditions may also vary during the course of a project or in different areas of this site. These needs should be addressed in the project drawings and specifications.

During freezing conditions, the fill must **not** be frozen when delivered to the site. It also must not be allowed to freeze during or after compaction. Since the ability to work the soil while keeping it from freezing depends in part on the soil type, the specifications should require the contractor to submit a sample of his proposed fill before construction starts, for laboratory testing. If the soil engineer determines that it is not suitable, it should be rejected. In general, silty sand, clayey sand, and cohesive/semi-cohesive soils should not be used as fill under freezing conditions. All frozen soil of any type should be rejected for use as compacted fill.

It is important that compacted fill be protected from freezing after it is placed. The excavator should be required to submit a plan for protecting the soil. The plan should include details on the type and amount of material (straw, blankets, extra loose fill, topsoil, etc.) proposed for use as frost protection. The need to protect the soil from freezing is ongoing throughout construction and applies both before **and** after concrete is placed, until backfilling for final frost protection is completed. Foundations placed on frozen soil can experience heaving and significant settlement, rotation, or other movement as the soil thaws. Such movement can also occur if the soil is allowed to freeze **after** the concrete is placed and then allowed to thaw. The higher the percentage of fines (clay and silt, P-200 material) in the fill, the more critical is the need for protection from freezing.

The contractor should be required to adjust the moisture content of the soil to within a narrow range near the optimum moisture content (as defined by the applicable Proctor or AASHTO Test). In general, fill should be placed within 2% of optimum moisture. The need for moisture control is more critical as the percentage of fines increases. Naturally occurring cohesive/semi-cohesive soil are often much wetter than the optimum. Placing and attempting to compact such soils to the specified density may be difficult. Even if compacted to the specified density, excessively wet soils may not be suitable as pavement subgrades due to pumping under applied load. This is especially true when wet cohesive/semi-cohesive soil is used as backfill in utility trenches and like situations. Excessively wet soil in thick fill sections may cause post-construction settlement beyond that estimated for fill placed at or near (±2%) the optimum moisture content.

5.4 Pump Station Walls

Walls to be used for the pump station will be restrained from movement and, therefore, must be designed based on the "at rest" earth pressure. The coefficient of "at rest" earth pressure (K_0) is 0.53 with a soil unit weight (γ_w) of 125 pounds per cubic foot, resulting in an equivalent fluid of 60 pounds per cubic foot unit weight. Below the water table, hydrostatic pressure will act on the wall in addition to the earth pressure resulting in an equivalent fluid pressure of 90 pounds per cubic foot.

Surcharge above the wall will add additional load. A uniform surcharge must be multiplied by the appropriate coefficient of earth pressure to determine the additional load applied to the wall. The internal angle of friction (Φ) of the soil underlying foundations is 28° resulting in a coefficient of friction of 0.53.

Any retaining wall design must use appropriate factors of safety.

5.5 Pavement

If asphalt or concrete pavement is desired, it may be necessary to use a bridging course to span soft areas such as the driveway we crushed in the alley south of Elm Street. The extent of the bridging course will have to be determined by proofrolling the site with a fully loaded triaxle truck. Bridging course may consist of 18 to 24 inches of shot rock underlain by a non-woven geotextile. This thickness may be reduced through the use of geogrid base reinforcement with a smaller grade of stone.

A pavement structure consisting of 3 inches of asphalt over 8 inches of crushed stone base course should serve very well for car traffic with an occasional medium truck. The asphalt should consist of 1.5 inches of surface mix over 1.5 inches of binder. The stone base course should be single course of Indiana #53 stone.

Where concentrated truck traffic is to be present, we should carry out a pavement analysis based on the anticipated weight and number of trucks. Please provide us with that traffic if you would like such a thickness design to be carried out.

New Albany may have a minimum section that is greater than this, in which case this minimum section will have to be used.

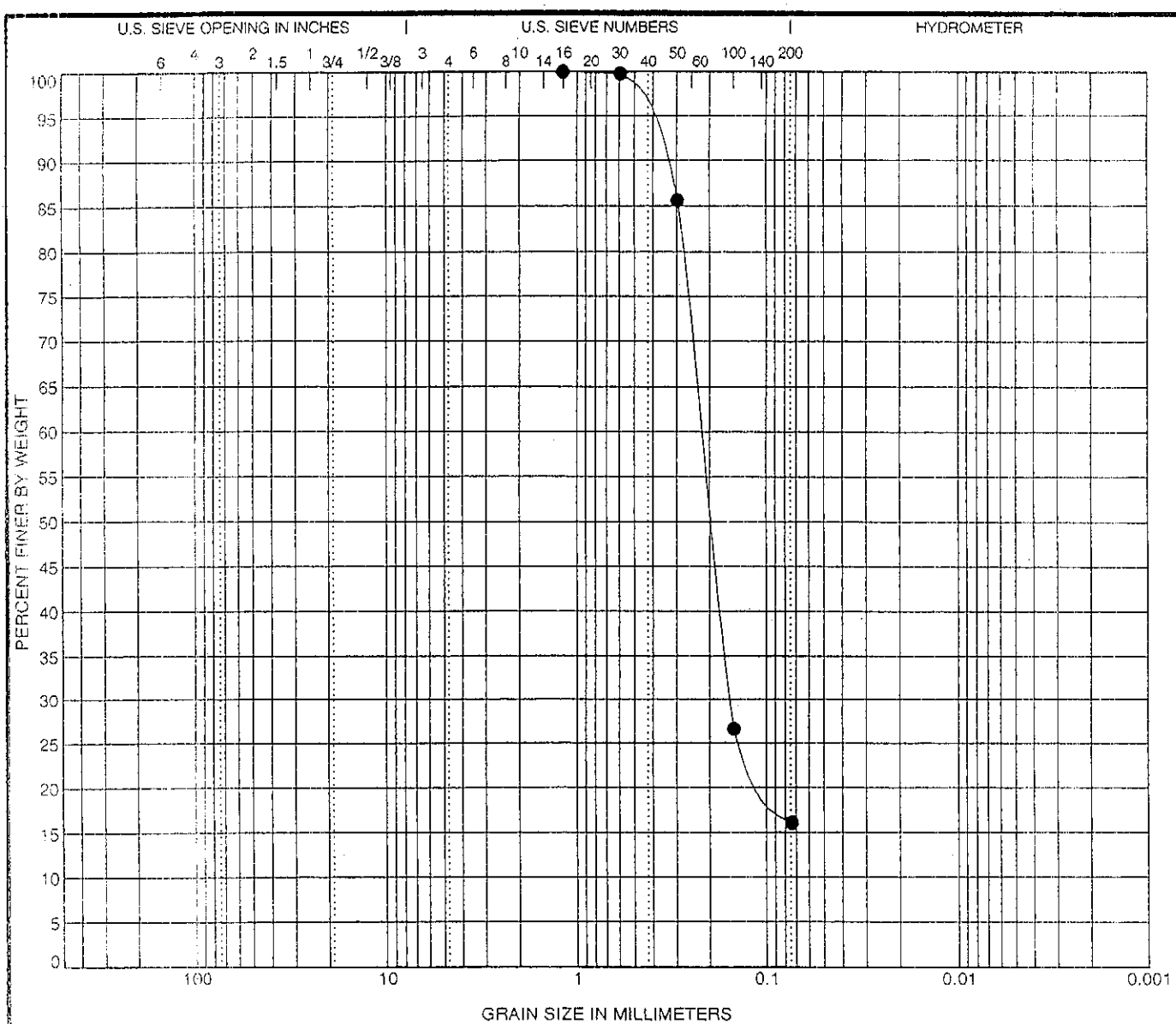
5.5 Limitations

We strongly recommend that bearing surfaces and compaction be monitored by Greenbaum Associates, Inc. Our technicians will be available to further assist you in providing these and other normally specified quality control services. The report is preliminary until such time as these examinations are completed to confirm conditions consistent with those discovered.

The conclusions and recommendations offered in this report are based on the subsurface conditions encountered in the borings. No warranties can be made regarding the continuity of conditions between or beyond borings. If, during construction, soil conditions are encountered that differ from those indicated in this report, a representative of Greenbaum Associates, Inc. should inspect the site to determine if design modification is required.

This study was directed at a specific pump station and force main on this site, to be constructed within a reasonably short period after this study. Use for any other location, structures or substantial changes in construction period may invalidate the recommendations. The geotechnical engineer should be consulted relative to any substantial change in these.

This study is directed at mechanical properties of the soils and includes no sampling, testing or evaluation for environmental considerations.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● B-1	10.0	**Fine Sand**					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-1	10.0	1.19	0.22	0.155		0.0	83.7	16.3	

Greenbaum Associates, Inc.

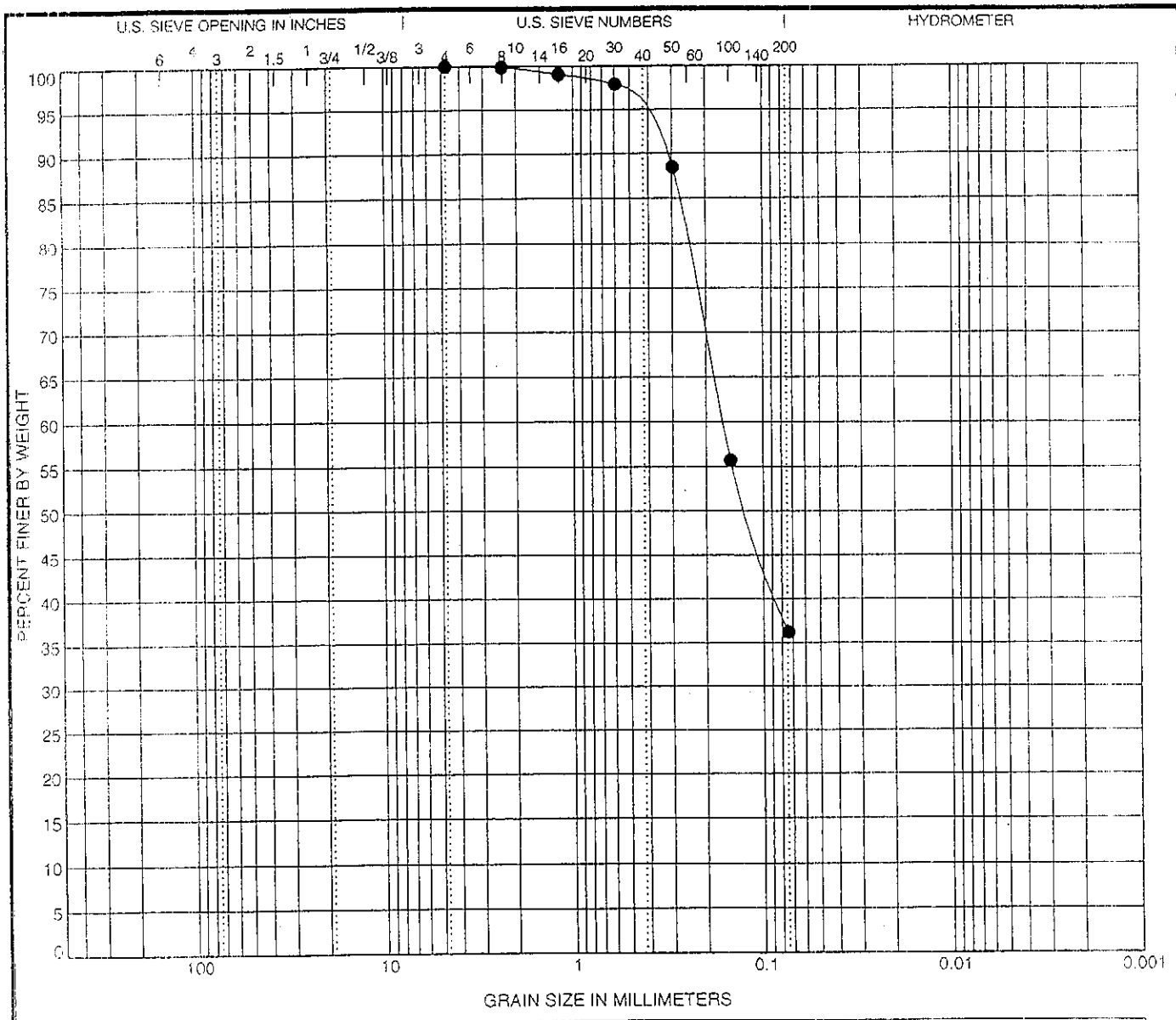
GRAIN SIZE DISTRIBUTION

Project: New Albany Sewers, Phase 1A

Location: 15th Street Sewer

Number: 07-020

US GRAIN SIZE 07-020.GPJ GREENBAUM.GDT 2/1/07



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● B-2	5.0	**Silty Sand**					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-2	5.0	4.76	0.163			0.0	63.4	36.6	

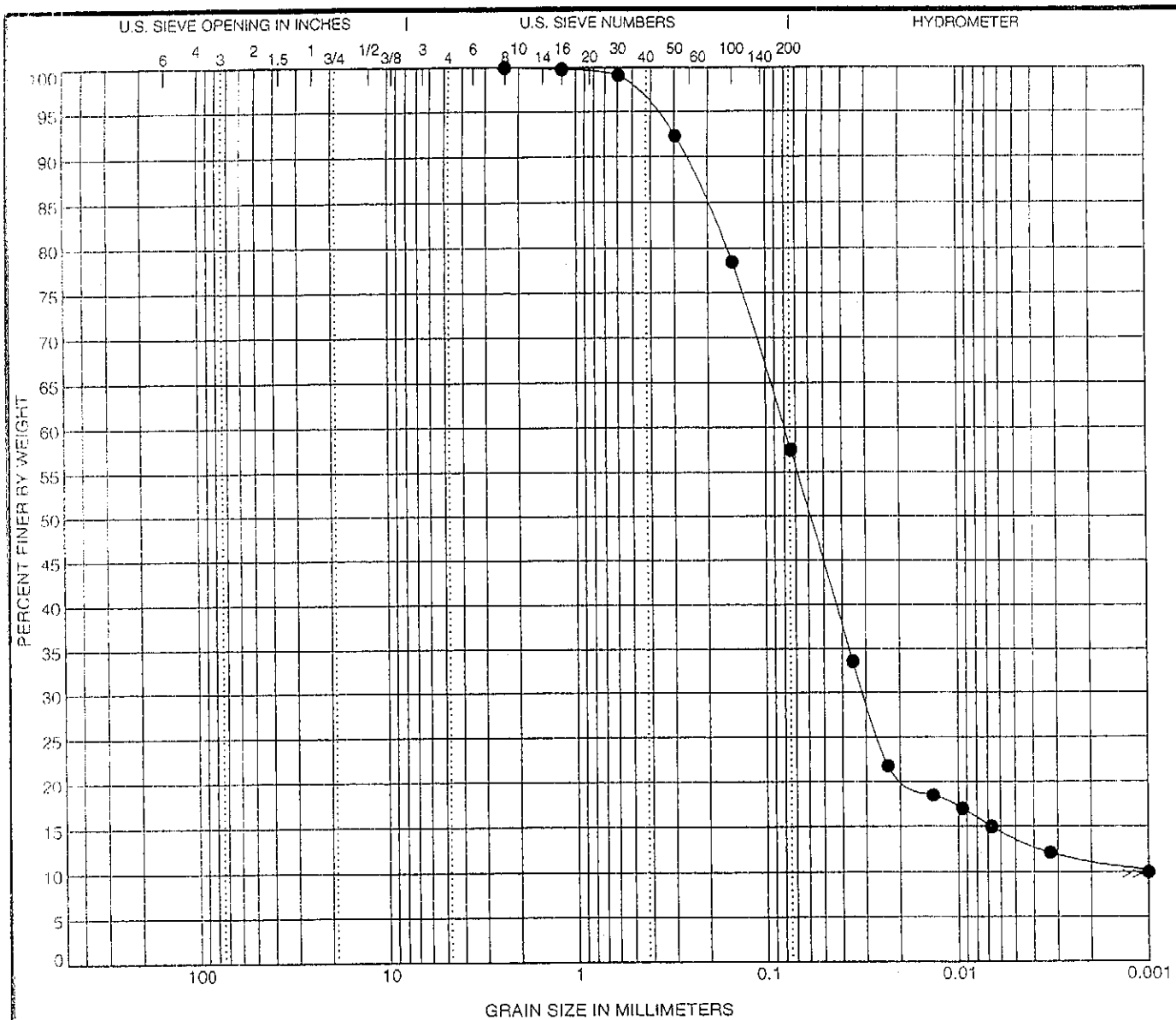
Greenbaum Associates, Inc.

GRAIN SIZE DISTRIBUTION

Project: New Albany Sewers, Phase 1A

Location: 15th Street Sewer

Number: 07-020



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● B-1	5.0					17.07	114.84

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-1	5.0	2.38	0.08	0.031	0.001	0.0	42.1	44.1	13.8

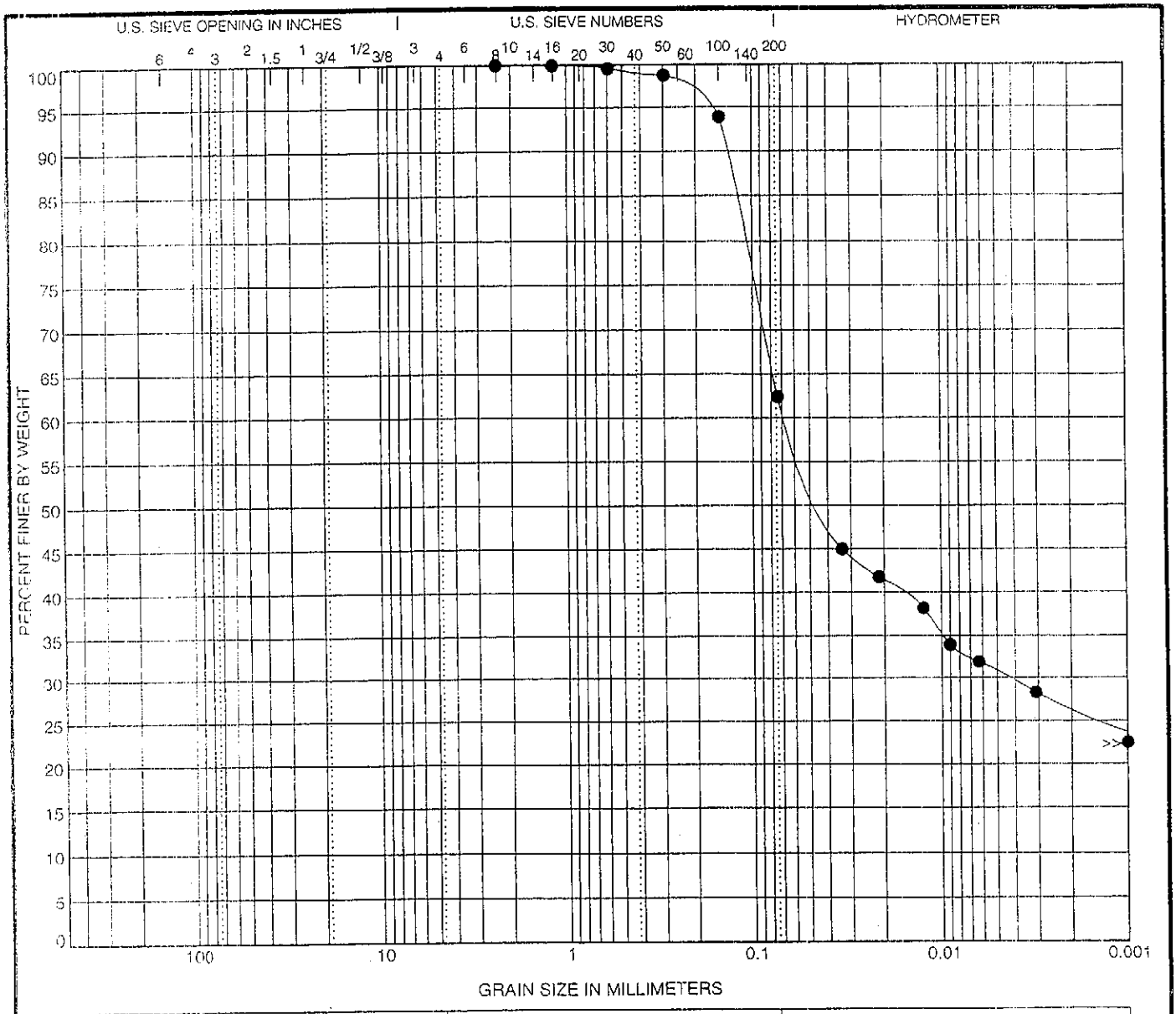
Greenbaum Associates, Inc.

GRAIN SIZE DISTRIBUTION

Project: New Albany Sewers, Phase 1A

Location: 15th Street Sewer

Number: 07-020



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen identification		Classification	LL	PL	PI	Cc	Cu
● B-3	1.0	**SANDY LEAN CLAY(CL)**	30	20	10		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-3	1.0	2.38	0.066	0.004		0.0	37.0	32.2	30.8

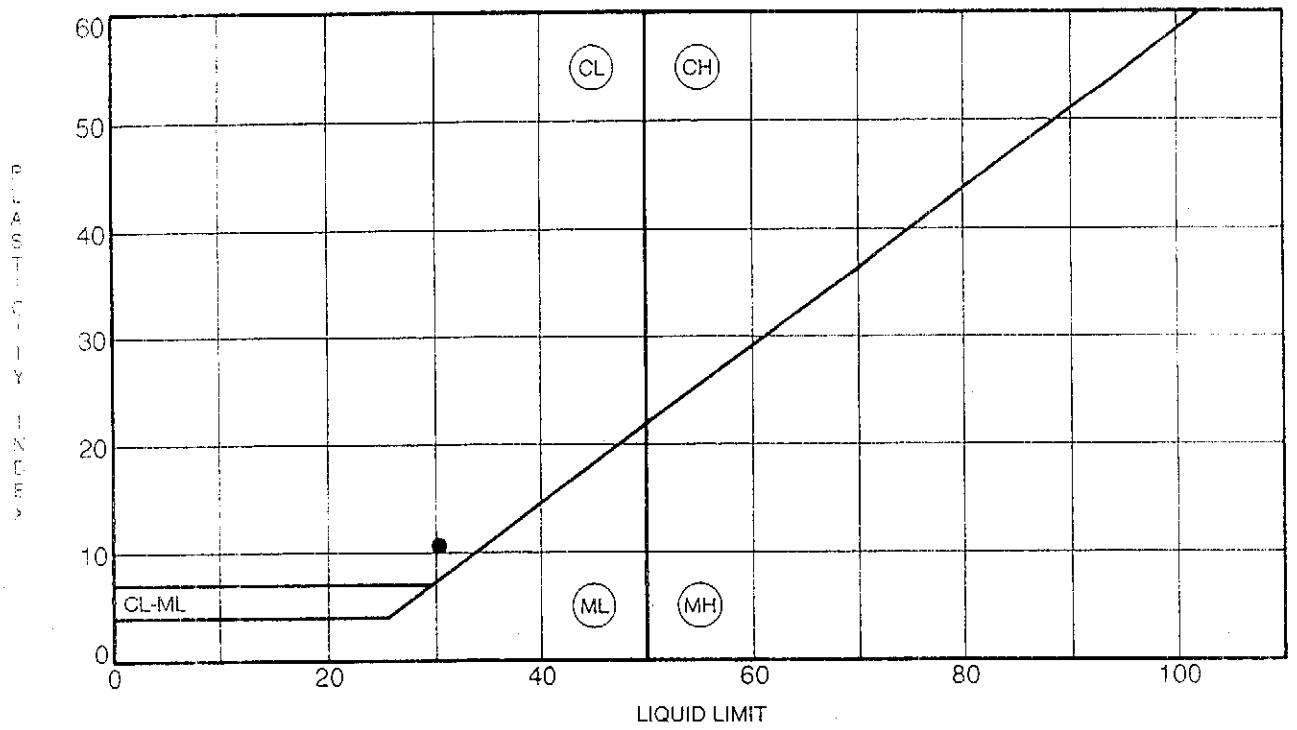
Greenbaum Associates, Inc.

GRAIN SIZE DISTRIBUTION

Project: New Albany Sewers, Phase 1A

Location: 15th Street Sewer

Number: 07-020



Specimen Identification		LL	PL	PI	Fines	Classification
● B-3	1.0	30	20	10	63	**SANDY LEAN CLAY(CL)**

Greenbaum Associates, Inc.

ATTERBERG LIMITS' RESULTS

Project: New Albany Sewers, Phase 1A

Location: 15th Street Sewer

Number: 07-020

SOIL DESCRIPTION TERMINOLOGY

Soils are identified and classified in this report according to the Unified Soil Classification System with the following modifiers:

RELATIVE DENSITY OF GRANULAR SOILS

Description	Blows/Foot
Very loose	0 to 4
Loose	4 to 10
Medium Dense	10 to 30
Dense	30 to 50
Very Dense	50 to 80
Extremely Dense	80 +

CONSISTENCY OF COHESIVE SOILS

Description	N	q. (tsf)
Very soft	2	0 to 0.25
Soft	2-4	0.25 to 0.50
Medium	4-8	0.50 to 1.0
Stiff	8-15	1.0 to 2.0
Very Stiff	15-30	2.0 to 4.0
Hard	> 30	4.0 to 8.0
Very Hard		8.0 +

PARTICLE SIZES

Components		Size or Sieve No.
Boulders		over 12 inches
Cobbles		3 to 12 inches
Gravel	Coarse	3/4 to 3 inches
	Fine	No. 4 to 3/4 inches
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40
Fines (silt and clay)		Below No. 200

SOIL MOISTURE

Descriptive Term	
Dry	- Dry of Standard Proctor Optimum
Damp	- Moist, sand only
Moist	- Near Standard Proctor Optimum
Wet	- Wet of Standard Proctor Optimum
Saturated	- Free water in sample

ROCK QUALITY DETERMINATION

The Rock Quality Determination (Deere et. al., 1969) method of determining rock quality as reported here was obtained by summing up the total length of core recovered in each run, counting only those pieces of core which are four inches (10 cm) in length or longer and which are hard and sound. The sum is then represented as a percentage over the length of the run. If the core is broken by handing or by the drilling process, the fresh broken pieces are fitted together and counted as one piece provided that they form the requisite length of four inches (10 cm). RQD is reported as a percentage.

RELATIVE OF RQD AND ROCK QUALITY

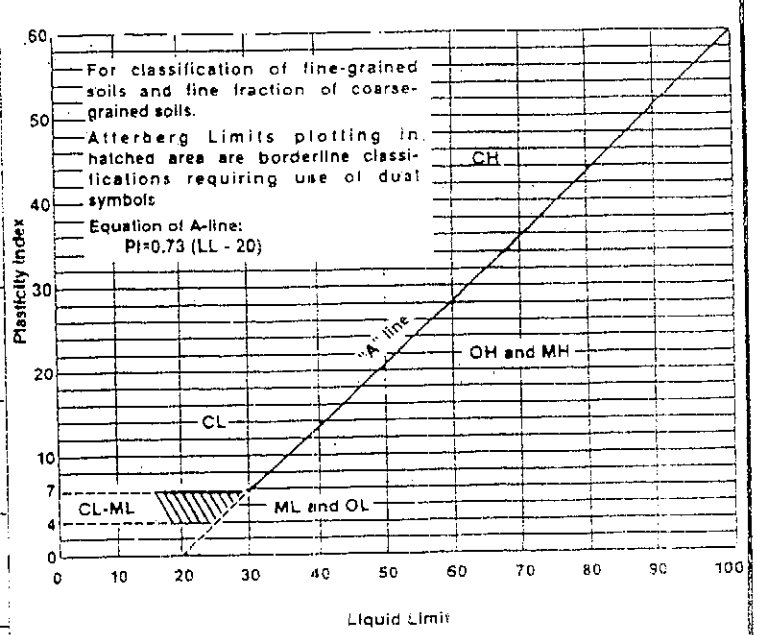
RQD (%)	Description of Rock Quality
0 to 25	Very Poor
25 to 50	Poor
50 to 75	Fair
75 to 90	Good
90 to 100	Excellent

NOTE: Recovery as denoted as REC = , is the length of core recovered in a run divided by the length of the run, reported as a percentage.

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

(ASTM: D 2487 and 2488)

Major divisions			Group symbols	Typical names	Laboratory classification criteria		
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 per cent ..... GW, GP, SW, SP; More than 12 per cent ..... GM, GC, SM, SC; 5 to 12 per cent ..... *Borderline* cases requiring dual symbols	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} X D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM d / GM u	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 *are borderline* cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits below "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} X D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM d / SM u	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 *are borderline* cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures		Atterberg limits below "A" line or P.I. greater than 7	
Fine-grained soils (More than half of material is smaller than No. 200 sieve size)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity			
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity, organic silts			
	Highly organic soils		Pt	Peat and other highly organic soil			



Plasticity Chart

Greenbaum Associates, Inc.

Client:	**HOLE No. B-1**
Project: New Albany Sewers, Phase 1A 15th Street Sewer	Sheet 1 of 1
Project No.: 07-020	

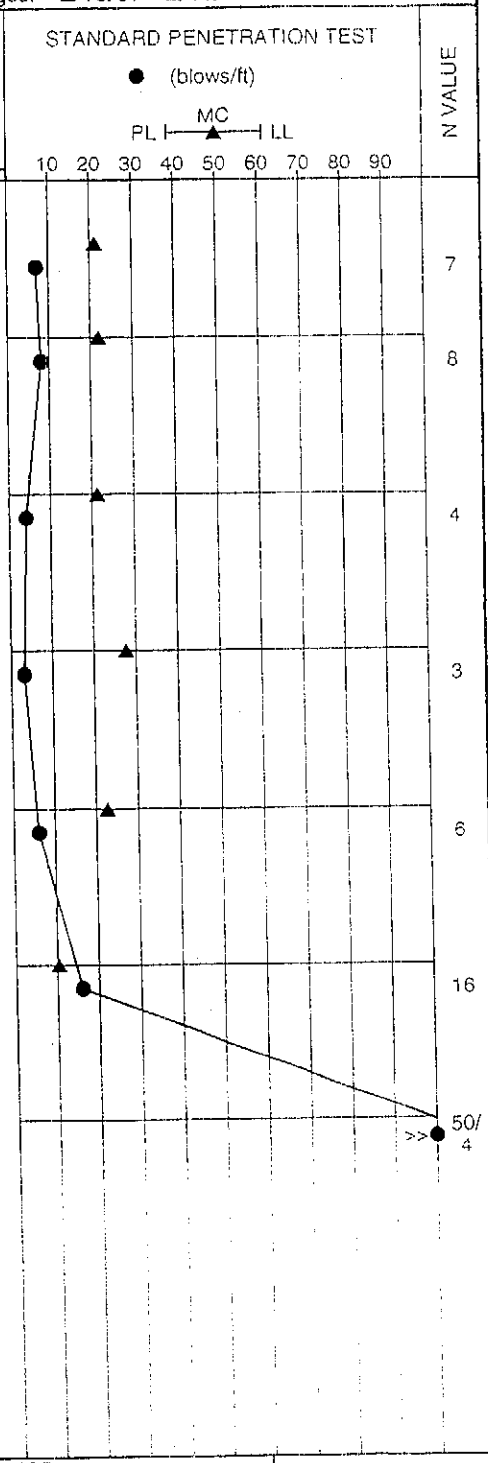
Boring Location: See Boring Location Plan Surface Elevation: Ground Station: n/a

Drilling Equipment: CME-550 (ATV) Drilling Method: HSA

Depth to water immediately: Dry Overburden: Rock: Total Depth: 31.1

Logged By: T. Powers Driller: M. Wells Date Logged: 2/13/07 - 2/13/07

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION		ELEVATION (feet)	N VALUE
					Concrete and Red Brick		Ground	
		SS	75		Moist, Medium Stiff, Mottled, Tan, Clay Silt	CL		7
		SS	100		Moist, Medium Stiff, Mottled, Brown and Gray Clay Silt	CL		8
					Same, Soft	CL		
10		SS	80		Wet, Very Loose, Red, Fine to Medium Fine Sand	SP		4
15		SS	100		Same, but Loose	SP		3
20		SS	65					6
25		SS	65		Wet, Medium Dense, Gray Course Sand With Gravel	SPG		16
30		SS	35		Black New Albany Shale	Shale		50/4
					AUGER REFUSAL AT 31.1'			



SAMPLER TYPE

SS Split Spoon
ST Shelby Tube
RC Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD

HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. B-1

Greenbaum Associates, Inc.

Client:

Project: New Albany Sewers, Phase 1A 15th Street Sewer

Project No.: 07-020

HOLE No. B-2

Sheet 1 of 1

Boring Location: See Boring Location Plan | Surface Elevation: Ground | Station: n/a

Drilling Equipment: CME-550 (ATV) | Drilling Method: HSA

Depth to water immediately: Dry | Overburden: | Rock: | Total Depth: 10.5

Logged By: T. Powers | Driller: M. Wells | Date Logged: 2/13/07 - 2/13/07

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO	RECOVERY %	RQD %	MATERIAL DESCRIPTION		ELEVATION (feet)	STANDARD PENETRATION TEST (blows/ft) PL MC LL 10 20 30 40 50 60 70 80 90	N VALUE
					Topsoil (3")	SM	Ground		
		SS	45		Moist, Loose, Mottled, Brown Clay Silt With Sand				6
5		SS	100		Wet, Loose, Brown Sandy Silt	MLS			6
10		SS	100		TERMINATED AT 10.5'				5

SAMPLER TYPE	DRILLING METHOD	Hole No
NX - Rock Core, 2-1/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
CT - Continuous Tube	DC - Driving Casing	B-2

Greenbaum Associates, Inc.

HOLE No. B-3

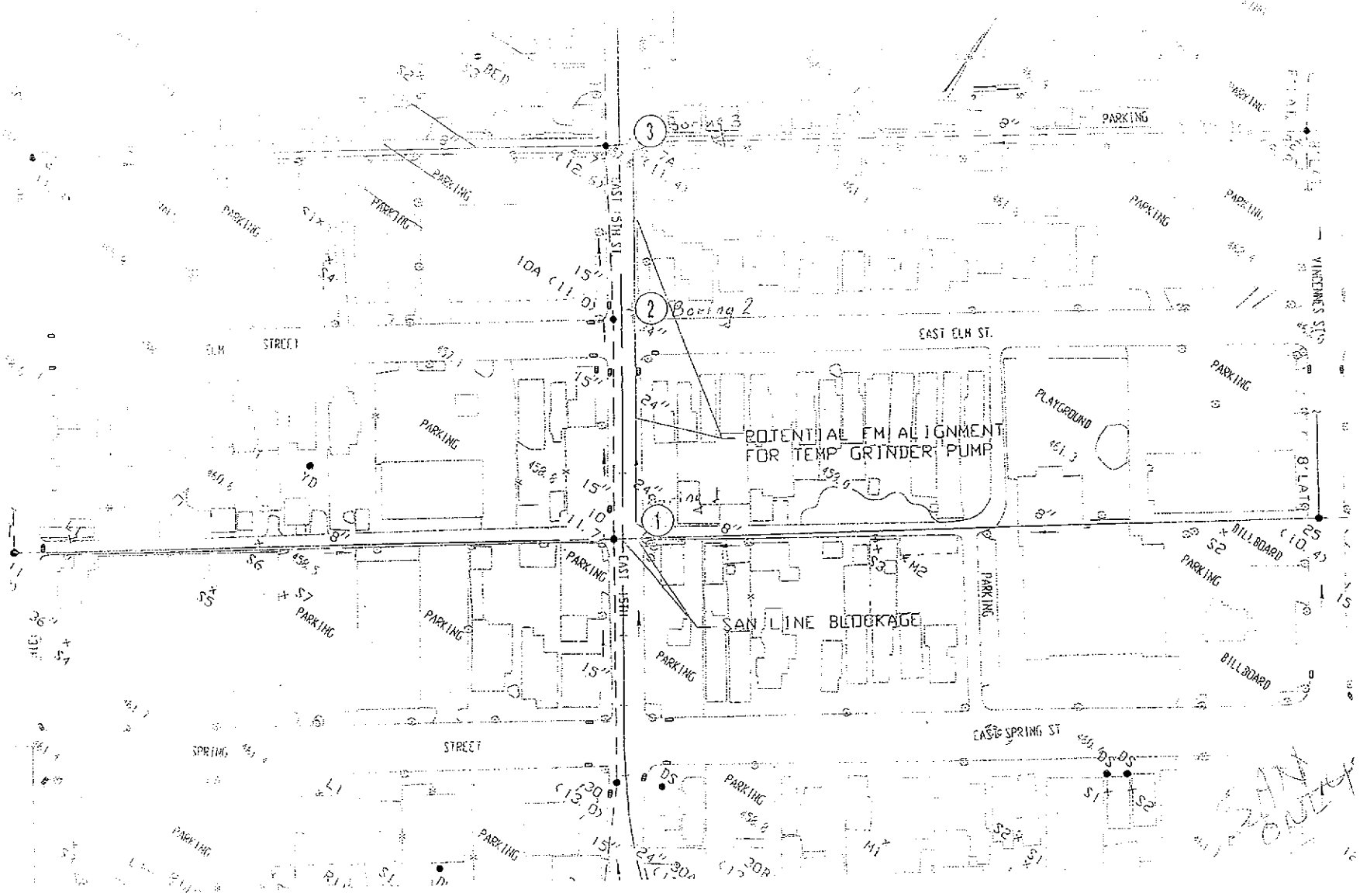
Sheet 1 of 1

Client:
Project: New Albany Sewers, Phase 1A 15th Street Sewer
Project No.: 07-020

Boring Location: See Boring Location Plan Surface Elevation: Ground Station: n/a
Boring Equipment: CME-550 (ATV) Drilling Method: HSA
Depth to water immediately: Dry Overburden: Rock: Total Depth: 10.5
Logged By: T. Powers Driller: M. Wells Date Logged: 2/13/07 - 2/13/07

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION		ELEVATION (feet)	STANDARD PENETRATION TEST ● (blows/ft) PL ⊢—▲—⊣ LL (MC) 10 20 30 40 50 60 70 80 90	N VALUE
					Asphalt (4")	CL	Ground		
		SS	90		Moist, Medium Stiff, Mottled Brown Clay Silt				6
5		SS	100		Same, With Sand	SM			5
10		SS	100		Wet, Very Loose, Brown Sand	SP	▼		4
					TERMINATED AT 10.5'				

SAMPLER TYPE		DRILLING METHOD		Hole No.
[illegible]	NX - Rock Core, 2-1/8"	HSA - Hollow Stem Auger	RW - Rotary Wash	B-3
[illegible]	CC - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core	
[illegible]	CT - Continuous Tube	DC - Driving Casing		



Phase 1A
15th Street Sewer Improvements
New Albany, IN
Boring Location Plan

Greenbaum Associates, Inc.
994 Longfield Avenue
Louisville, Kentucky 40215
(502) 361-8447

Scale: Not To Scale
Drawn: S.G. Checked: M.G.
Date: March 1, 2007
Greenbaum P.N. 07-020