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Geotechnical Exploration and Evaluation Report

Boulevard Street Forcemain and Watermain
Jacksonville, Florida

CSI Geo Project No.: 71-19-329-10
Client Project No.: 09302-055-01
JEA Contract No.: 153003
Purchase Order: 179335

Prepared by

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Prepared for

Jones Edmunds & Associates, Inc.

March 11, 2019

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March 11, 2019

Dr. Harold Bridges, Ph.D, P.E.
Jones Edmunds & Associates, Inc.
8657 Baypine Road, Suite 300
Jacksonville, Florida 32256-8634

RE: Boulevard Street Forcemain and Watermain
Jacksonville, Florida

Subject: Geotechnical Exploration and Evaluation Report
CSI Geo Project No.: 71-19-329-10
Client Project No.: 09302-055-01
JEA Contract No.: 153003
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Dear Dr. Bridges:

CSI Geo, Inc. has performed the authorized geotechnical exploration and laboratory testing program for the proposed Boulevard Street forcemain and watermain improvements in Jacksonville, Florida. This report presents our understanding of the subsurface conditions along with our engineering evaluation and recommendations.

We have enjoyed working with you on this project and look forward to working with you on future projects. If you have any questions concerning this report, please contact our office.

Sincerely,

CSI Geo, Inc.

Digitally signed by Bruce B Khosrozadeh
Date: 2019.03.11 10:52:20-04'00'

Nader Amer, Ph.D
Geotechnical Engineer

Bruce Khosrozadeh, P.E.
Senior Geotechnical and Materials Engineer
Registered, Florida No. 45273

TABLE OF CONTENTS

1.0 PROJECT INFORMATION

1.1 General Project Information

The purpose of this geotechnical exploration program was to develop information concerning the subsurface conditions in order to evaluate the site with respect to the proposed Boulevard Street forcemain and watermain improvements in Jacksonville, Florida. The general site location is shown on the Site Location Map included in the **Appendix**. This report describes the field and laboratory testing activities performed and presents the findings. The report also includes the subsurface soil and groundwater conditions encountered, soil parameters for use in the Jack & Bore design, and general site preparation recommendations for the proposed construction.

Information regarding this project was provided to CSI Geo, Inc. (CSI Geo) by Dr. Harold Bridges, Ph.D, P.E and Mr. Kenneth A. Fraser, P.E. of Jones Edmunds & Associates, Inc. (Jones Edmunds). The following document was provided to us in electronic format.

- Boulevard Street Forcemain and Watermain Technical Memorandum
  Provided by: Jones Edmunds
  Dated: August 2018

1.2 Project Description and Existing Conditions

The proposed construction along Boulevard Street consists of the replacement of the existing watermains from West 7th Street to West 11th Street for a distance of about 1,400 LF and upgrading the existing forcemain from West 7th Street to West 16th for a distance of about 3,100 LF. The proposed pipe alignments cross a major roadway at West 8th Street, and also at the CSX railroad tracks just south of West 16th Street. The pipelines at the major crossings will be installed by means of Jack & Bore method. The remaining areas along the alignment are generally flat and will utilize open-cut installation methods.

Boulevard Street within the project limits consists of an undivided two-lane urban roadway with grass shoulders, sidewalks, and several commercial businesses and medical centers on both sides of the road.

2.0 GEOTECHNICAL EXPLORATION

2.1 Field Exploration

The subsurface conditions along the areas where the pipelines will be installed using open-cut method of installation were explored by means of a total of five (5) Standard Penetration Test (SPT) borings B-1 through B-5 drilled to a depth of 15 feet below the existing grades.

The subsurface conditions in the areas of the entry and exit points of the Jack & Bore pipe installation were explored by means of four (4) SPT borings M-1 through M-4 drilled to a depth of 30 feet below the existing grades. Borings M-1 and M-2 were performed for the entry and exit points of the West 8th Street crossing, and borings M-3 and M-4 were performed for the entry and exit points of the CSX railroad crossing.

The boring locations and depths were selected and located in the field by personnel from CSI Geo. All borings were grouted to full depth after boring completion. Soil samples collected were visually classified in the field and then transported to our laboratory for re-classification and testing. Representative soil samples obtained during our field exploration program were visually classified using the American Association of State Highway and Transportation Officials (AASHTO) Soil Classification System. The approximate locations of the soil borings are shown on the Field Exploration Plan sheets included in the **Appendix**.

2.2 Laboratory Testing

Quantitative laboratory testing was performed on representative soil samples to better define their composition. Laboratory tests performed were percent fines, natural moisture content, and Atterberg limits. A Summary of Laboratory Test Results, and Field and Laboratory Test Procedures, are included in the **Appendix**.

3.0 GENERAL SUBSURFACE CONDITIONS

3.1 General

An illustrated representation of the subsurface conditions encountered is shown on the Report of SPT Borings sheets presented in the **Appendix**. The soil conditions outlined below highlight the major subsurface stratification. The Report of SPT Borings in the **Appendix** should be consulted for a detailed description of the subsurface conditions encountered at each boring location. When reviewing the Report of SPT Borings, it should be understood that soil conditions may vary outside of the explored areas.

3.2 Soil Conditions

3.2.1 Open-Cut Method of Pipe Installation

Review of test borings B-1 through B-5 indicates that the pipeline alignments are generally underlain by very loose to medium dense sands and slightly silty sands (A-3, AASHTO) followed by very loose to medium dense silty sands (A-2-4) and clayey sands (A-2-6) until the borings termination depth of 15 feet below the existing grades.

3.2.2 Jack & Bore Method of Pipe Installation

Review of test borings M-1 through M-4 indicates that the areas of the proposed Jack & Bore installations are generally underlain by loose to medium dense sands and slightly silty sands (A-3) to depths of 4 to 8 feet below the existing grades. The overburden sands are followed by very loose to medium dense silty sands (A-2-4) and firm clayey sands (A-2-6) to depths of 12 to 22 feet below the existing grades. Thereafter, medium dense to dense sands (A-3) were encountered until the borings termination depth of 30 feet below the existing grades.

3.3 Groundwater Conditions

The groundwater level was measured and recorded as encountered at the time of drilling. The depths of the groundwater level and estimated seasonal high water level at the test locations are marked on the Report of SPT Borings sheets presented in the **Appendix**. The depth of groundwater level measured at the time of drilling ranged from 4.0 to 6.0 feet below the existing grades. The estimated seasonal high groundwater table for the borings performed ranged from 3.0 to 4.5 feet below the existing grades.

Fluctuations of the groundwater level should be anticipated as a result of the close proximity to the St. Johns River, urbanization/development, topographic changes, seasonal climatic variations, surface water runoff patterns, fluctuations of adjacent water bodies, construction activities, and other factors. During seasonal high precipitation, groundwater levels can be expected to rise. Therefore, design drawings and specifications should account for the possibility of groundwater level variations, and construction planning should be based on the assumption that such variations will occur.

Determination of the estimated seasonal high groundwater table was made using the methodology described by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS). In sandy soils the method involves examining soil cuttings from the borings for subtle changes in root content and soil coloration. These subtle changes are indicators of the highest level the groundwater level has been for a prolonged period. It should be anticipated that the groundwater level will fluctuate due to seasonal climate variations, surface water runoff patterns, nearby water bodies, construction operations, and other related factors.

3.4 Existing Pavement System Thickness

Pavement cores were performed whenever possible at the test boring locations to determine the thickness of the existing pavement system. Generally, the existing pavement system was found to consist of 1 to 5 inches of asphalt over 4 to 6 ½ inches of concrete. It should be noted that cores taken at borings M-3 and M-4 near the CSX railroad crossing show a pavement system consisting of 4 inches of asphalt over 3 ½ inches of brick followed by 3 inches of limerock base. The results of the pavement cores are included in the **Appendix**.

4.0 DESIGN RECOMMENDATIONS

4.1 General

Our geotechnical evaluation of the site and the subsurface conditions is based on our understanding of the proposed project, our observations, and results of field and laboratory testing. The recommendations provided in this report present construction methods and techniques that are appropriate for the proposed construction. If the project location is changed or if field conditions encountered during construction are different from those presented in this report, the information should be provided to CSI Geo for evaluation. We also recommend that CSI Geo be given the opportunity to review the design plans and specifications to ensure that our recommendations have been properly included and implemented.

4.2 Open-Cut Excavations

In general, we consider the subsurface soil conditions at the site to be favorable for support of the proposed pipe over a properly prepared and compacted subgrade, provided that the site preparation and earthwork construction recommendations in this report are performed.

The (A-3) type soils are considered select material. Silty sands (A-2-4) can be treated as select material, however, they may contain excess moisture and may be difficult to dry and to compact. Clayey sands (A-2-6) should be considered plastic materials and should be excavated to a minimum depth of one foot below the design invert elevations and replaced with suitable A-3 fill material. It is likely that the excavated suitable soils may get mixed with plastic soils during construction and should be regarded as unsuitable for backfill purposes. We recommend that allowances be made for possible overruns in quantities of subsoil removal and replacement with select backfill. It should be noted that boundaries and limits of plastic soils are approximate and represent soils encountered at each boring location. Subsurface variance between borings may occur and should be anticipated.

If encountered, unsuitable organic soils (A-8) should be considered as muck and not suitable for use as backfill. if unsuitable organic materials are encountered, they should be removed in their entirety and replaced with select sands (A-3) material.

We anticipate that the buried pipe lines will exert little downward pressure on the subgrade soils. In areas where the surrounding groundwater level is above the pipe invert elevation, the line should be designed to resist lateral earth pressures and hydrostatic uplift pressures appropriate to its depth below the existing grade and the seasonal high-water level.

4.3 Recommended Design Soil Parameters for Jack & Bore Crossings

Jack & Bore will be used to install the proposed pipes underneath West 8th Street and the CSX railroad tracks. Pipes installed using Jack & Bore should follow the latest JEA Water & Wastewater Standards Manual and project technical specifications. We recommend that soil parameters and assumptions for the Jack & Bore design follow the information provided in the Recommended Design Soil Parameters for Jack & Bore tables included in the **Appendix**. Soil parameters provided in the tables are representative of the soil conditions at the variable depths and have been generated based on N-values that were corrected for hammer efficiency and overburden pressure.

5.0 SITE PREPARATION & EARTHWORK RECOMMENDATIONS

5.1 Existing Utilities

The locations of existing utilities should be established prior to construction. Provisions should be made to relocate utilities interfering with the proposed alignments and construction, as needed. Underground pipes that are not operational should be either removed, plugged, or grouted in place otherwise they may become conduits for subsurface erosion and cause settlements.

5.2 Temporary Groundwater Control

Groundwater level was encountered at the time of drilling at depths ranging from 4.0 to 6.0 feet below the existing grades. Therefore, groundwater control should be anticipated. The groundwater level should be maintained at a minimum of two feet below the subgrade of the proposed inverts.

Similarly, dewatering at the Jack & Bore locations should be maintained at two feet below any casing invert elevation and below the entry & exit pits. Dewatering may be achieved by conventional open pumping using ditches graded to a sump, using a well point system, or deep wells. Dewatering should continue until pipe installation is complete. Piezometers should be installed to monitor groundwater levels near the entry and exit pits and Jack & Bore crossings. Base line readings should be obtained prior to excavating the entry and exit pits.

5.3 Excavation Protection

All excavations should meet OSHA Excavation Standard Subpart P regulations for Type C soils. A trench box or braced sheet pile structures may be considered to support open excavations. The soil support system should be designed according to OSHA by a Florida registered Professional Engineer.

5.4 Pipe Backfill and Compaction of Pipe Backfill

The A-3 type soils are considered select material and suitable for use as backfill. Silty sands (A-2-4) can be treated as select material, however, they may contain excess moisture and may be difficult to dry and to compact. Clayey sands (A-2-6) should be considered plastic materials and should be excavated to a minimum depth of one foot below the design invert elevations and replaced with suitable A-3 fill material. Plastic clayey sands (A-2-6) and unsuitable organic soils (A-8), if encountered, should be considered unsuitable for backfilling and compaction purposes.

As mentioned earlier, some of the excavated suitable soils will likely get mixed with plastic soils during construction. Therefore, some of the excavated material should be regarded as unsuitable for backfill purposes. We recommend that allowance be made for overruns in quantities of subsoil removal and replacement with select (A-3) backfill.

The backfill material within the excavation should be placed in thin loose lifts not exceeding 6 inches in thickness. The backfill material should be compacted by the use of hand-operated equipment. The backfill material should be granular (A-3) fill with less than 10 percent material passing the no. 200 mesh sieve and containing less than 3 percent organic matter. The backfill material should be compacted to a minimum density of 98% or 95% of maximum dry density obtained from the Modified Proctor compaction test (ASTM D1557), as required by JEA. The moisture content during compaction should be maintained within $\pm$ 3 percent of the optimum moisture content as obtained from the Modified Proctor compaction test.

Hand held compaction equipment should be used for the backfill placed around the pipe and to a height of 2 feet above the pipe. Heavier equipment may be used on the remaining backfill lifts placed above 2 feet. However, care should be taken not to damage the pipe below. The pipe should be designed to withstand the anticipated dead (overburden) and live loads.

6.0 REPORT LIMITATIONS

The subsurface exploration program including our evaluation and recommendations was performed in general accordance of accepted geotechnical engineering principles and standard practices. CSI Geo is not responsible for any independent conclusions, opinions, or interpretations made by others based on the data presented in this report.

This report does not reflect any variations that may occur adjacent or between soil borings. The discovery of any site or subsurface condition during construction that deviates from the findings and data as presented in this report should be reported to CSI Geo for evaluation. If the project location is changed, our office should be contacted so our recommendations can be re-evaluated. We recommend that CSI Geo be given the opportunity to review the final design drawings and specifications to ensure that our recommendations are properly included and implemented.

APPENDIX

Site Location Map

Field Exploration Plan

Report of SPT Borings

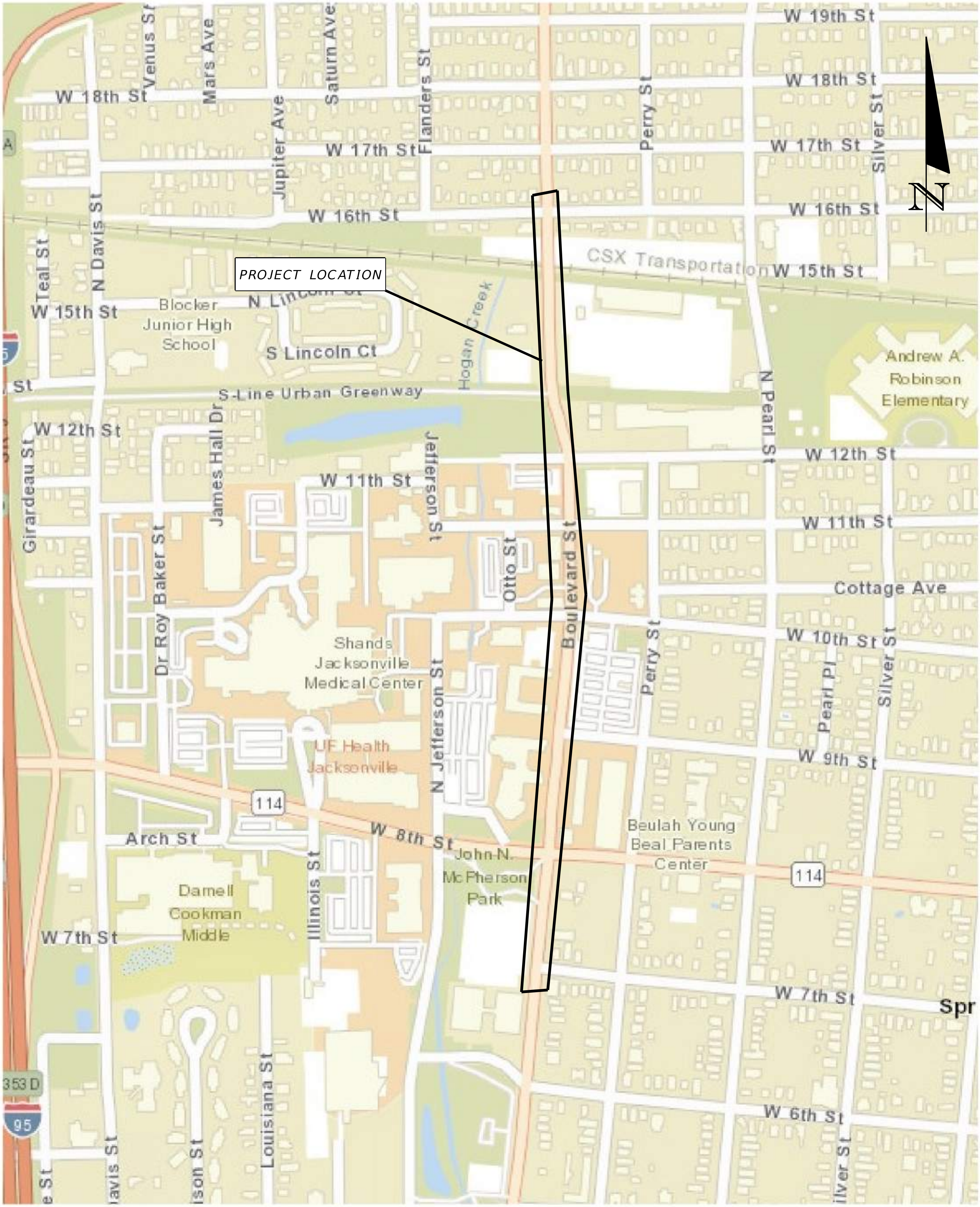
Summary of Laboratory Test Results

Recommended Design Soil Parameters
for Jack & Bore Crossings

Key to Soil Classification

Field and Laboratory Test Procedures

Site Location Map



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SITE LOCATION MAP
BOULEVARD STREET FORCEMAIN & WATERMAIN
JACKSONVILLE, FLORIDA

Field Exploration Plan

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CONSTRUCTION MATERIAL TESTING
CONSTRUCTION ENGINEERING INSPECTION

FIELD EXPLORATION PLAN

BOULEVARD STREET FORCEMAIN & WATERMAIN
JACKSONVILLE, FLORIDA

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BOULEVARD STREET FORCEMAIN & WATERMAIN
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Report of SPT Borings

LEGEND

ASPHALT

CONCRETE

LIMEROCK

BRICK

FINE SAND; SLIGHTLY SILTY FINE SAND (A–3)

SILTY FINE SAND (A–2–4)

CLAYEY FINE SAND (A–2–6)

(A–3) AASHTO SOIL CLASSIFICATION SYSTEM

ESTIMATED SEASONAL HIGH GROUND WATER LEVEL

GROUND WATER LEVEL AT TIME OF DRILLING

W / –200 / LL / PI — NATURAL MOISTURE CONTENT (%) / FINES PASSING NO. 200 SIEVE (%) / LIQUID LIMIT / PLASTICITY INDEX

B.T. STANDARD PENETRATION TEST BORING TERMINATION

N STANDARD PENETRATION RESISTANCE IN BLOWS PER FT UNLESS OTHERWISE NOTED, NUMBERS TO THE LEFT OF BORING INDICATE N–VALUES.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N–VALUE (BLOWS/FT)
VERY LOOSE	LESS THAN 3
LOOSE	3–8
MEDIUM DENSE	8–24
DENSE	24–40
VERY DENSE	GREATER THAN 40

SILTS AND CLAYS

CONSISTENCY	AUTOMATIC HAMMER SPT N–VALUE (BLOWS/FT)
VERY SOFT	LESS THAN 1
SOFT	1–3
FIRM	3–6
STIFF	6–12
VERY STIFF	12–24
HARD	GREATER THAN 24

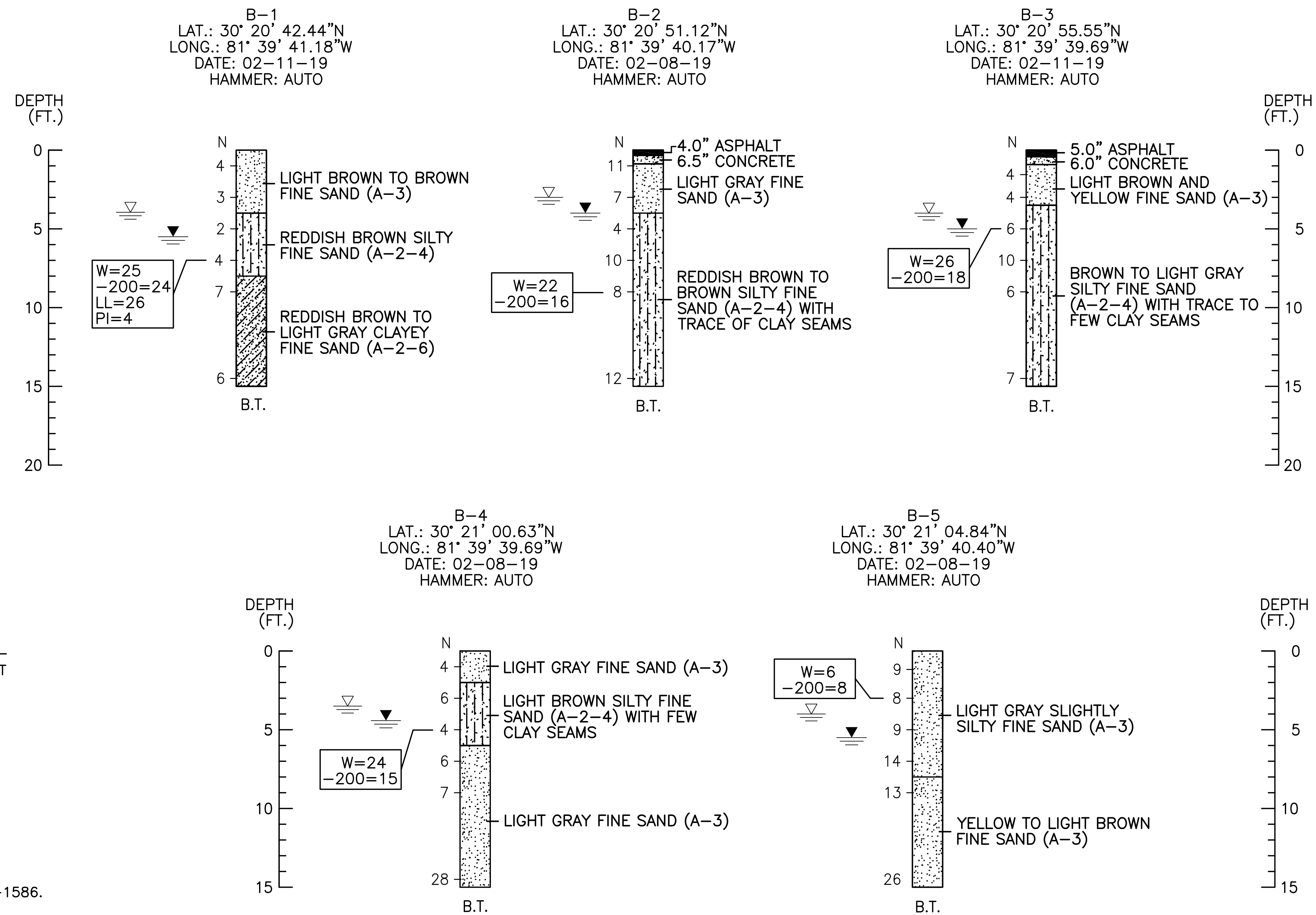
STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.44 INCHES
SPOON OUTSIDE DIA.	2.0 INCHES
ASTM STANDARD DROP HAMMER	
AVG. HAMMER DROP	30.0 INCHES
HAMMER WEIGHT	140.0 LBS

NOTES:

1) DRILL AND PENETRATION TESTING WAS PERFORMED IN ACCORDANCE WITH ASTM D–1586.

2) LAYER BOUNDARIES ARE APPROXIMATE AND MAY VARY BETWEEN OR AWAY FROM BORING LOCATIONS.



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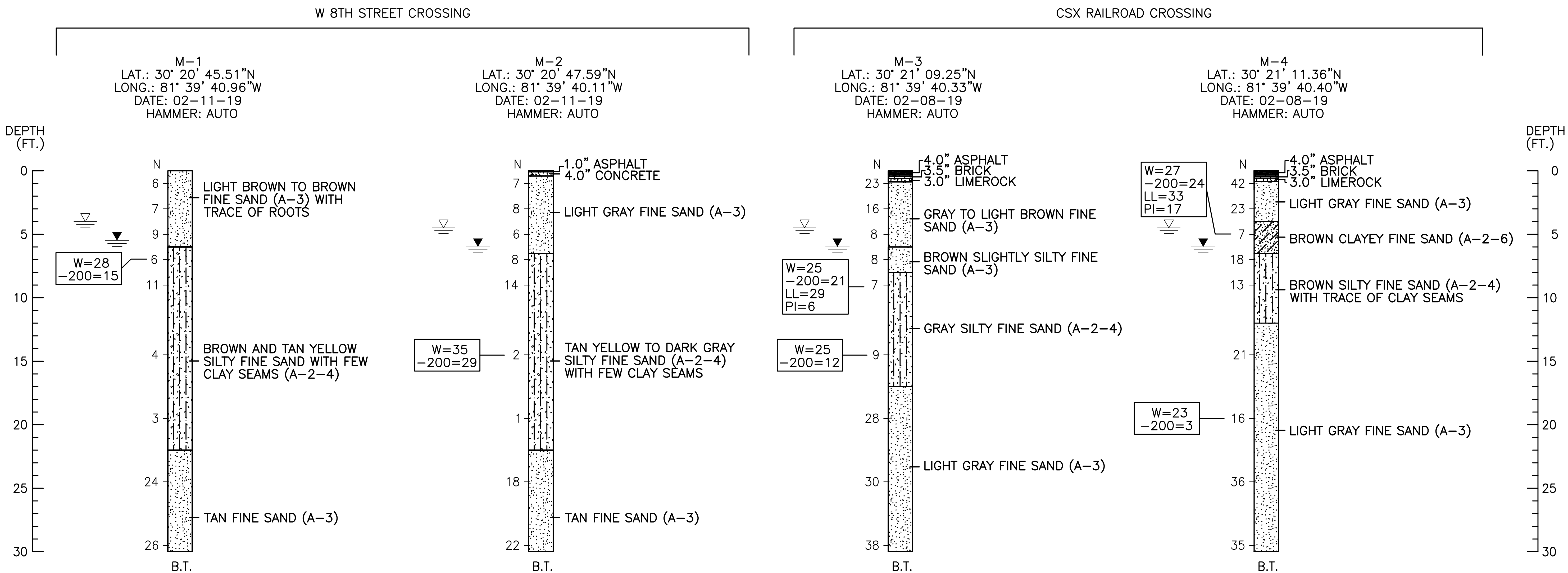
REPORT OF SPT BORINGS

BOULEVARD STREET FORCEMAIN AND WATERMAIN
JACKSONVILLE, FLORIDA



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REPORT OF SPT BORINGS

BOULEVARD STREET FORCEMAIN AND WATERMAIN
JACKSONVILLE, FLORIDA

Summary of Laboratory Test Results

SUMMARY OF LABORATORY TEST RESULTS

Boulevard Street Forcemain & Watermain
Jacksonville, Florida

Boring No.	Sample No.	Approximate Depth (ft)			Natural Moisture Content (%)	Organic Content (%)	Percent Passing Sieve Size (%)						Atterberg Limits		Soil Classification Symbol
							#4	#10	#40	#60	#100	#200	LL	PI	
B-1	4	6.0	-	8.0	25							24	26	4	A-2-4
B-2	5	8.0	-	10.0	22							16			A-2-4
B-3	3	4.0	-	6.0	26							18			A-2-4
B-4	3	4.0	-	6.0	24							15			A-2-4
B-5	2	2.0	-	4.0	6							8			A-3
M-1	4	6.0	-	8.0	28							15			A-2-4
M-2	6	13.5	-	15.0	35							29			A-2-4
M-3	5	8.0	-	10.0	25							21	29	6	A-2-4
M-3	6	13.5	-	15.0	25							12			A-2-4
M-4	3	4.0	-	6.0	27							24	33	17	A-2-6
M-4	7	18.5	-	20.0	23							3			A-3

Recommended Design Soil Parameters for Jack & Bore Crossings

Recommended Design Soil Parameters for Jack & Bore Crossings

Boulevard Street Forcemain and Watermain

Boring M-3 (South of CSX Railroad Crossing)

Soil Parameter*	Loose to Medium Dense Sands & Silty Sands	Loose Silty Sands	Medium Dense Sands
Depth (ft)	0.0 to 8.0	8.0 to 17.0	17.0 to 30.0
Saturated Unit Weight – γ (pcf)	115	110	120
Submerged Unit Weight – γ' (pcf)	53	48	58
Angle of Internal Friction – ϕ (degrees)	32	29	36
Cohesion – C (psf)	-	-	-
At Rest Earth Pressure Coefficient – K_o	0.47	0.52	0.41
Active Earth Pressure Coefficient - K_a	0.31	0.35	0.26
Passive Earth Pressure Coefficient – K_p	3.25	2.88	3.85

* Representative soil parameters based on N-values corrected for hammer efficiency and overburden

Boring M-4 (North of CSX Railroad Crossing)

Soil Parameter*	Medium Dense to Very Dense Sands	Stiff Clayey Sands	Medium Dense Silty Sands	Medium Dense to Dense Sands
Depth (ft)	0.0 to 4.0	4.0 to 6.5	6.5 to 12.0	12.0 to 30.0
Saturated Unit Weight – γ (pcf)	120	105	115	120
Submerged Unit Weight – γ' (pcf)	58	43	53	58
Angle of Internal Friction – ϕ (degrees)	36	-	33	38
Cohesion – C (psf)	-	1,600	-	-
At Rest Earth Pressure Coefficient – K_o	0.41	1.0	0.46	0.38
Active Earth Pressure Coefficient - K_a	0.26	1.0	0.29	0.24
Passive Earth Pressure Coefficient – K_p	3.85	1.0	3.39	4.20

* Representative soil parameters based on N-values corrected for hammer efficiency and overburden

Recommended Design Soil Parameters for Jack & Bore Crossings

Boulevard Street Forcemain and Watermain

Borings M-1 & M-2 (W 8th Street Crossing)

Soil Parameter*	Loose to Medium Dense Sands & Silty Sands	Very Loose to Loose Silty Sands	Medium Dense Sands
Depth (ft)	0.0 to 11.0	11.0 to 22.0	22.0 to 30.0
Saturated Unit Weight – γ (pcf)	115	100	120
Submerged Unit Weight – γ' (pcf)	53	38	58
Angle of Internal Friction – ϕ (degrees)	31	26	36
Cohesion – C (psf)	-	-	-
At Rest Earth Pressure Coefficient – K_o	0.48	0.56	0.41
Active Earth Pressure Coefficient - K_a	0.32	0.39	0.26
Passive Earth Pressure Coefficient – K_p	3.12	2.56	3.85

* Representative soil parameters based on N-values corrected for hammer efficiency and overburden

Key to Soil Classification

KEY TO SOIL CLASSIFICATION

Correlation of Penetration Resistance with Relative Density and Consistency

Granular Materials

Relative Density	**Auto Hammer SPT N-Value (Blows/foot)**
Very Loose	Less than 3
Loose	3 – 8
Medium Dense	8 - 24
Dense	24 - 40
Very Dense	Greater than 40

Silts and Clays

Consistency	**Auto Hammer SPT N-Value (Blows/foot)**
Very Soft	Less than 1
Soft	1 – 3
Firm	3 - 6
Stiff	6 - 12
Very Stiff	12 - 24
Hard	Greater than 24

Particle Size Identification (Unified Soil Classification System)

Boulders:	Diameter exceeds 8 inches
Cobbles:	3 to 8 inches diameter
Gravel:	Coarse - 3/4 to 3 inches in diameter
	Fine - 4.76 mm to 3/4 inch in diameter
Sand:	Coarse - 2.0 mm to 4.76 mm in diameter
	Medium - 0.42 mm to 2.0 mm in diameter
	Fine - 0.074 mm to 0.42 mm in diameter

Modifiers

These modifiers provide our estimate of the amount of fines (silt or clay size particles) in soil samples.

Approximate Fines Content	Modifiers
5% Fines 12%	Slightly silty or slightly clayey
12% Fines 30%	Silty or clayey
30% Fines 50%	Very silty or very clayey

These modifiers provide our estimate of shell, rock fragments, or roots in the soil sample.

Approximate Content, By Weight	Modifiers
< 5%	Trace
5% to 10%	Few
15% to 25%	Little
30% to 45%	Some
50% to 100%	Mostly

These modifiers provide our estimate of organic content in the soil sample.

Organic Content	Modifiers
1% to 3%	Trace
3% to 5%	Slightly Organic
5% to 20%	Organic
20% to 75%	Highly Organic (Muck)
> 75%	Peat

Field and Laboratory Test Procedures

FIELD AND LABORATORY TEST PROCEDURES

FIELD TEST PROCEDURES

Standard Penetration Test (SPT) Borings – Standard Penetration Tests (SPT) borings were made in general accordance with ASTM D-1586-67, "Penetration Test and Split-Barrel Sampling of Soils". The borings were continuously sampled to 10 ft. Below 10 feet and until boring termination depths, split spoon sampling was performed at a spacing of 5 feet. Below the groundwater levels, the borings were advanced using rotary drilling techniques with side discharge and circulating bentonite fluid for borehole flushing and stability. Drilling tools were removed from the borehole and a split-barrel sampler inserted to the borehole bottom and driven 18-24 inches into the material using a 140-pound SPT hammer falling on the average 30 inches per hammer blow. The number of hammer blows for the second and third six inch intervals of penetration is termed the "penetration resistance, blow count, or N-value". After driving the sampler 24 inches or to refusal at each test interval, the sampler was retrieved from the borehole and a representative sample of the material within the split-barrel was placed in a glass jar or plastic bag and sealed. After completing the drilling operations, the samples for the boring were transported to our laboratory where they were examined by one of our geotechnical engineers to verify the driller's field classifications.

LABORATORY TEST PROCEDURES

Natural Moisture Content

The water content is the ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of the solid particles. This test was conducted in the general accordance with ASTM D2216.

Percent Fine Content

To determine the percentage of soils finer than No. 200 sieve, the dried samples were washed over a 200 mesh sieve. The material retained on the sieve was oven dried and then weighed and compared with the unwashed dry weight in order to determine the weight of the fines. The percentage of fines in the soil sample was then determined as the percentage of weight of fines in the sample to the weight of the unwashed sample. This test was conducted in accordance with ASTM D 1140.

Plasticity (Atterberg Limits) - The soil's Plastic Index (PI) is bracketed by the Liquid Limit (LL) and Plastic Limit (PL). The LL is the moisture content at which the soil flows as a heavy viscous fluid and is determined in general accordance with FM 1-T 089. The PL is the moisture content at which the soil begins to crumble when rolled into a small thread and is also determined in general accordance with FM 1-T 090. The water-plasticity ratio is computed from the above test data. This ratio is an expression comparing the relative natural state of soil with its liquid and plastic consolidation characteristics.