Geotechnical Exploration and Evaluation Report

JEA SIPS Deerwood Route Water Main from Southside Boulevard Intertie Station to Deerwood III WTP
Jacksonville, Florida

CSI Geo Project No.: 71-20-166-13
Subconsulting Agreement No.: 148014239
JEA Contract No.: 182848

Prepared by

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Prepared for:

Jacobs Engineering Group Inc.

April 19, 2021

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Geotechnical · CMT · CEI

April 19, 2021

Ms. Christine Ellenberger P.E.
Jacobs Engineering Group Inc.
200 W. Forsyth Street, Suite 1520
Jacksonville, FL 32202

RE: JEA SIPS Deerwood Route Water Main
From Southside Boulevard Intertie Station to Deerwood III WTP
Jacksonville, Florida

Subject: Geotechnical Exploration and Evaluation Report
CSI Geo Project No.: 71-20-166-13
Subconsulting Agreement No.: 148014239
JEA Contract No.: 182848

Dear Ms. Ellenberger:

CSI Geo, Inc. has performed the authorized geotechnical exploration and laboratory testing program for the proposed JEA SIPS Deerwood Route Water Main from Southside Boulevard Intertie Station to Deerwood III WTP in Jacksonville, Florida. This geotechnical exploration and evaluation 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.

Nader Amer, Ph.D.
Geotechnical Engineer

JOHN A. IYA
LICENSE
No 77294
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

Digitally signed by John A Iya
Date: 2021.04.19
14:03:52-04'00'

John A. Iya, P.E.
Senior Geotechnical Engineer
Registered, Florida No. 77294

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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 JEA SIPS Deerwood Route Water Main from Southside Boulevard Intertie Station to Deerwood III Water Treatment Plant (WTP) project 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 pipeline crossings design, and general site preparation recommendations for the proposed construction.

Information regarding this project was provided to CSI Geo, Inc. (CSI Geo) by Ms. Christine Ellenberger, P.E. of Jacobs Engineering Group Inc. (Jacobs).

1.2 Project Description and Existing Conditions

The project consists of the construction of a 30" water main to be installed by means of open-cut methods from Southside Boulevard Intertie Station to Deerwood III WTP. The northern portion of the pipeline will be installed through residential neighborhoods while the southern portion will be installed along the JEA T-Line. The SIPS water main will cross at Beach Boulevard, Gate Parkway, and Butler Boulevard (JTB) by means of auger boring or a similar method, or by Horizontal Directional Drilling (HDD). The overall site is generally flat to gently sloping.

2.0 GEOTECHNICAL EXPLORATION

2.1 Field Exploration

The boring locations and depths were determined by Jacobs 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**.

2.1.1 Open-Cut Method of Pipe Installation

The subsurface conditions along the areas where the pipeline will be installed using open-cut method of installation were explored by means of a total of eighty-nine (89) SPT borings B-1 through B-89 drilled to a depth of 15 feet below the existing ground surface. It should be noted that SPT boring B-53 was extended to a depth of 25 feet below the existing ground surface to extend the boring below unsuitable soils. In addition, SPT borings B-82 and B-89 which were performed on elevated grounds south and inside the Deerwood WTP, were extended to depths of 25 and 30 feet, respectively.

2.1.2 Beach Boulevard Crossing

The subsurface conditions in the area of the Beach Boulevard Crossing were explored by means of four Standard Penetration Test (SPT) borings M-1 through M-4 drilled to a depth of 30 feet below the existing ground surface.

2.1.3 Gate Parkway Crossing

The subsurface conditions in the area of the Gate Parkway Crossing were explored by means of four SPT borings M-5 through M-8 drilled to a depth of 30 feet below the existing ground surface.

2.1.4 JTB Crossing

The subsurface conditions in the area of the JTB Crossing were explored by means of four SPT borings D-1 through D-4 drilled to a depth of 80 feet below the existing ground surface.

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, Atterberg limits, and organic content. A Summary of Laboratory Test Results, and Field and Laboratory Test Procedures are included in the **Appendix**.

2.3 Environmental Corrosion Testing

A total of forty-three (43) soil samples were collected from the borings performed for the pipeline alignment to be installed by open-cut methods. The test parameters included Resistivity, pH, Redox potential, Sulfide, and Moisture Content. In addition, a total of twelve (12) soil samples were collected from the borings performed at the three pipeline crossings at Beach Boulevard, Gate Parkway and JTB for environmental classification testing. The test parameters included pH, Chloride, Sulfate, and Resistivity. A Summary of Environmental Corrosion Test Results is included in the **Appendix**.

3.0 GENERAL SUBSURFACE CONDITIONS

3.1 General

An illustrated representation of the subsurface conditions encountered in the proposed construction areas 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-89 indicates that the area is generally underlain by very loose to medium dense sands (A-3) and silty sands (A-2-4) until the boring termination depths. Several borings were performed through the existing roadway pavement generally consisting of 2 to 9 inches of asphalt and 3 to 11 inches of limerock. Very dense slightly silty sands (A-3/Hardpan) were encountered in SPT Borings B-84 and B-85 between 8 and 15 feet of depth below the existing grades.

Unsuitable organic soils, occasionally with wood pieces were encountered in SPT borings B-13, B-24, B-53, B-59, B-72, B-73, B-74, B-83 through B-86, and B-88 at variable depths. The unsuitable organic soils were on the order 4 to 10 feet in thickness in SPT borings B-24, B-53, B-59, and B-86.

3.2.2 Beach Boulevard Crossing

Review of test borings M-1 through M-4 indicates that the area is generally underlain by loose to very dense sands (A-3) and silty sands (A-2-4) topped by 8 to 14 inch of asphalt pavement until the boring termination depth of 30 feet. A layer of organic sands (A-3/A-8) was encountered in SPT boring M-1 between 6 and 8 feet of depth below the existing grades.

3.2.3 Gate Parkway Crossing

Review of test borings M-5 through M-8 indicates that the area is generally underlain by very loose to dense sands (A-3) until the boring termination depth of 30 feet below the existing grades.

3.2.4 JTB Crossing

Review of test borings D-1 through D-4 indicates that the area is generally underlain by very loose to very dense sands (A-3) in the upper 41 to 52 feet of depth followed by firm to very stiff sandy clays (A-6) and medium dense to dense clayey sands (A-2-6) until the borings termination depth of 80 feet.

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 location 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 2.0 to 12.0 feet below the existing grades. The estimated seasonal high groundwater table for the borings performed ranged from 1.0 to 12.0 feet below the existing grades.

Fluctuations of the groundwater level should be anticipated as a result of 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 Environmental Corrosion Test Results

Results of the environmental corrosion testing are presented in the Environmental Corrosion Test Results sheets included in the **Appendix**.

3.5 Existing Pavement System Thickness

Pavement cores were performed at several test boring locations to determine the thickness of the existing pavement system along the northern portion of the pipeline alignment. Generally, the existing pavement system was found to consist of 3 to 14 inches of asphalt. Limerock base was encountered at two locations at SPT borings B-10 and B-15 and was on the order of 3 inches. 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) and sandy clays (A-6) should be considered plastic and highly 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.

Unsuitable soils consisting of organic sands occasionally with wood pieces (A-8) were encountered at variable depths in SPT borings B-13, B-24, B-53, B-59, B-72, B-73, and B-74. All unsuitable organic soils should be considered as muck and not suitable for use as backfill. When unsuitable soils and/or unsuitable organic materials are encountered, they should be removed in their entirety and replaced with select sands (A-3) material. Depending on the design pipe invert elevations, it is likely that some excavated suitable soils will get mixed with unsuitable organic and/or 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.

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 Pipe Crossings

We understand that the proposed pipeline will be installed underneath Beach Boulevard, Gate Parkway, and JTB using auger bore and/or HDD methods of installation. Pipe installation should follow the latest JEA Water & Wastewater Standards Manual and project technical specifications. We recommend that soil parameters and assumptions for design follow the information provided in the Recommended Design Soil Parameters for Pipe Crossings tables included in the **Appendix**. Soil parameters provided in the tables are representative of the soil conditions at 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 2.0 to 12.0 feet below the existing grades. Therefore, groundwater control should be anticipated to be required for excavations below the water table. The groundwater level should be maintained at a minimum of two feet below the subgrade of the proposed inverts.

Similarly, dewatering at the pipe auger bore crossings locations should be maintained at least 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, horizontal drains, or deep wells. Dewatering should continue until carrier pipe installation is complete. Piezometers should be installed to monitor groundwater levels near the entry and exit pits and pipe crossing alignment. Baseline 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) and sandy clays (A-6) should be considered plastic and highly 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. Unsuitable organic sands (A-8) were encountered at variable depths in SPT borings B-13, B-24, B-53, B-59, B-72, B-73, B-74, and M-1. All plastic clayey sands (A-2-6), highly plastic sandy clays (A-6), and unsuitable organic soils (A-8) should be considered unsuitable for backfilling and compaction purposes.

As mentioned earlier, some of the excavated suitable soils will likely get mixed with unsuitable soils and/or 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
- Existing Pavement Thickness System
- Recommended Design Soil Parameters for Road Crossings
- Summary of Laboratory Test Results
- Environmental Corrosion Test Results
- Key to Soil Classification
- Field and Laboratory Test Procedures

Site Location Map

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SITE LOCATION MAP
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Field Exploration Plan

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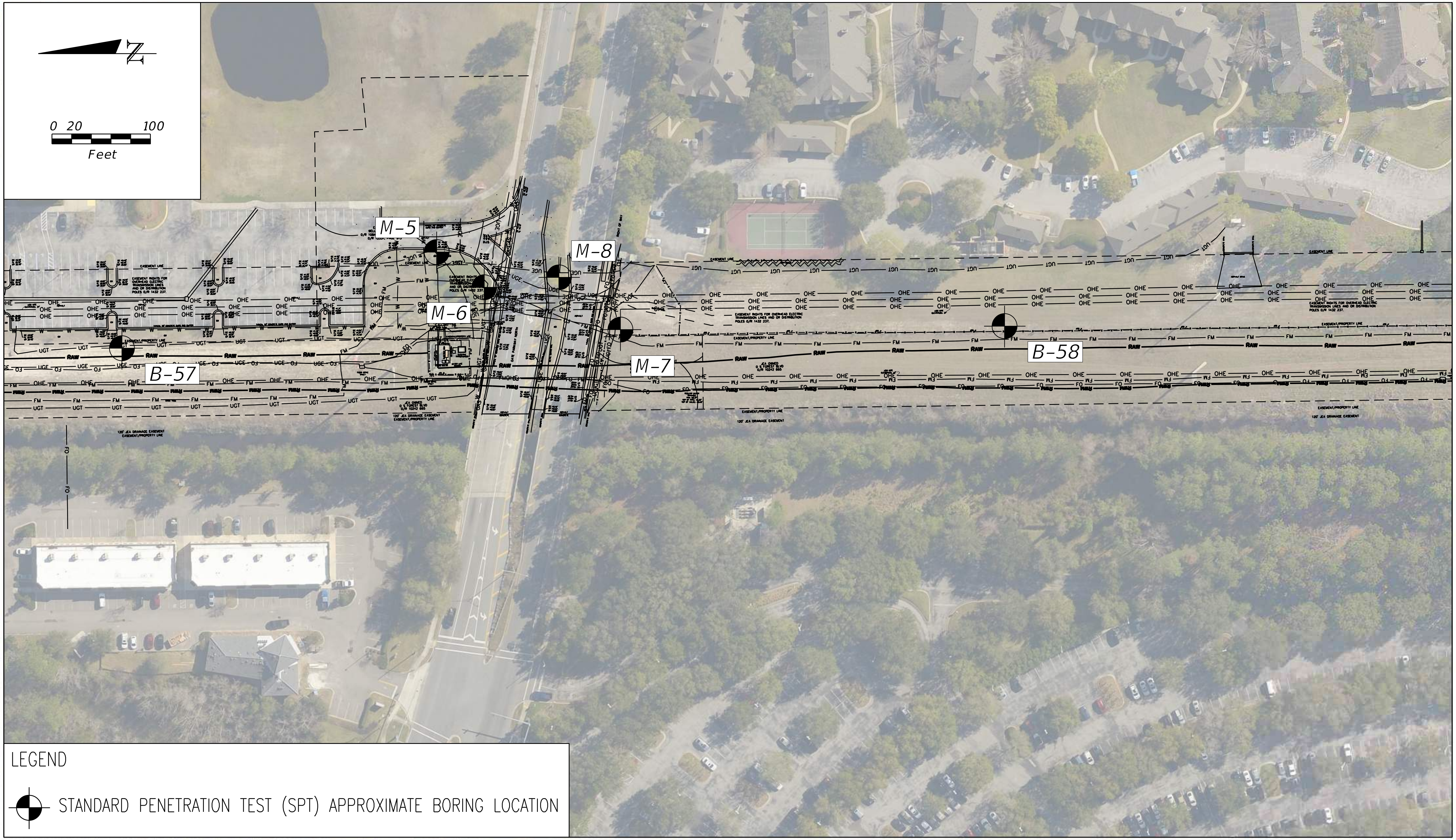

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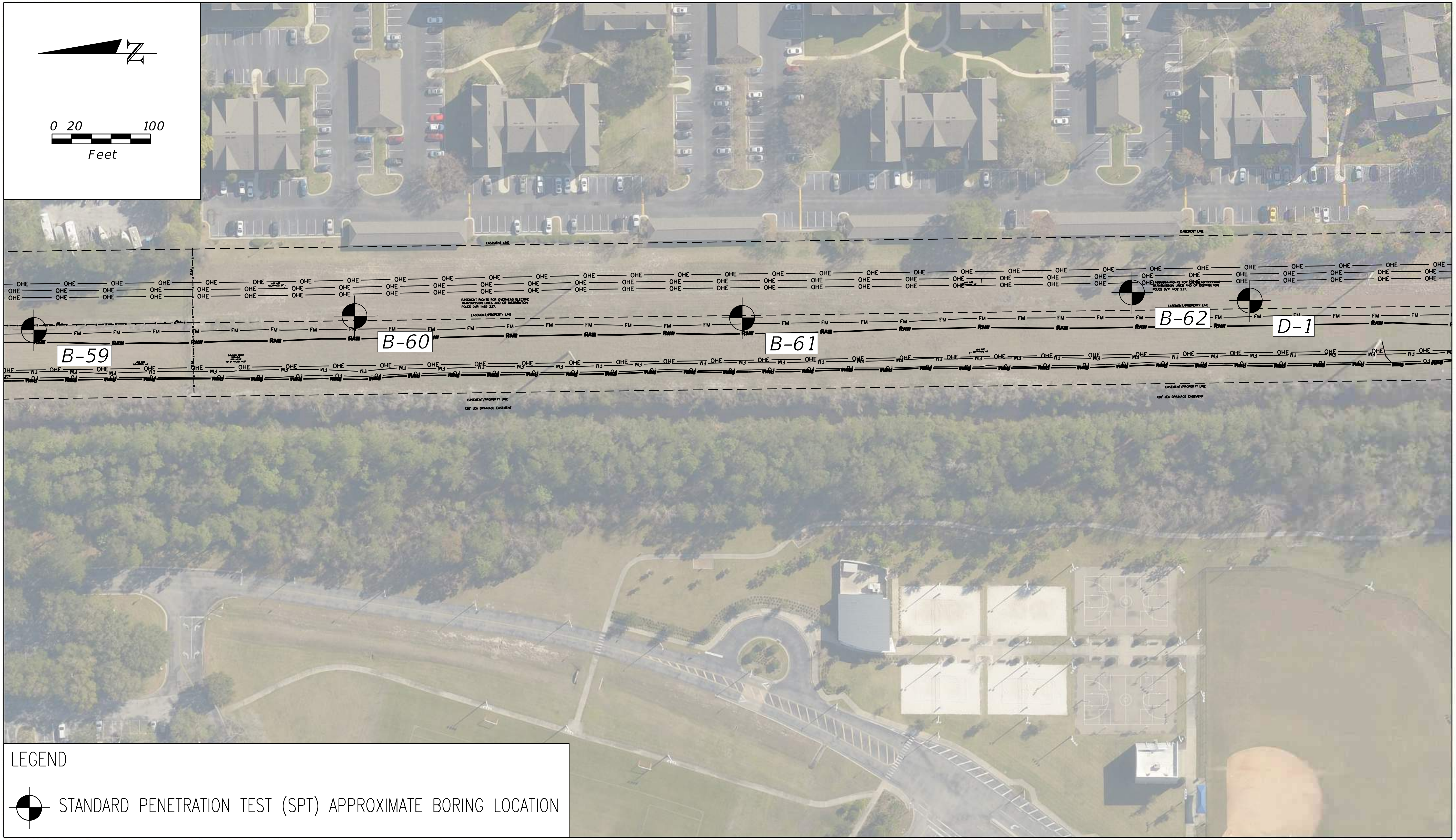

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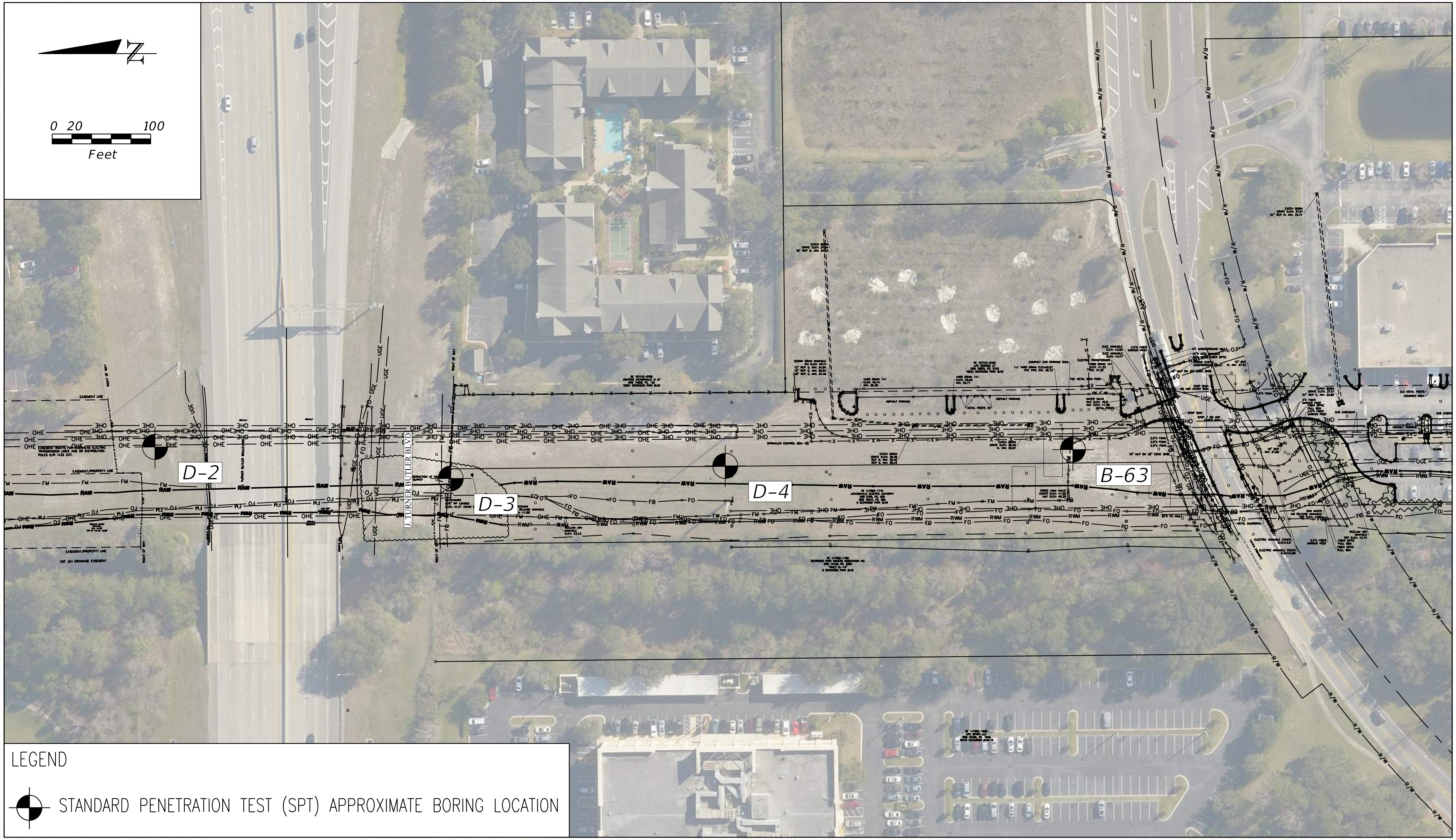

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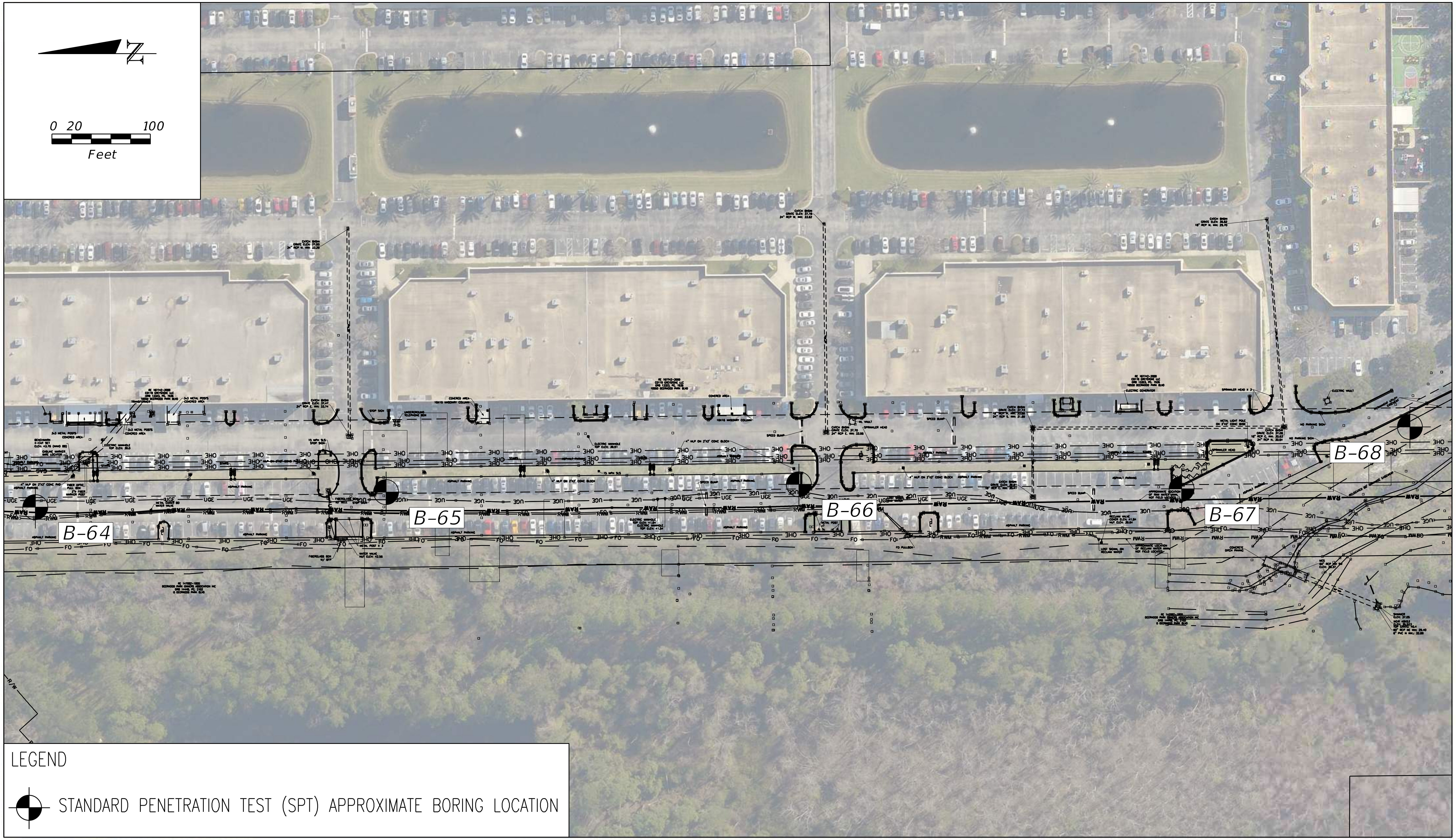

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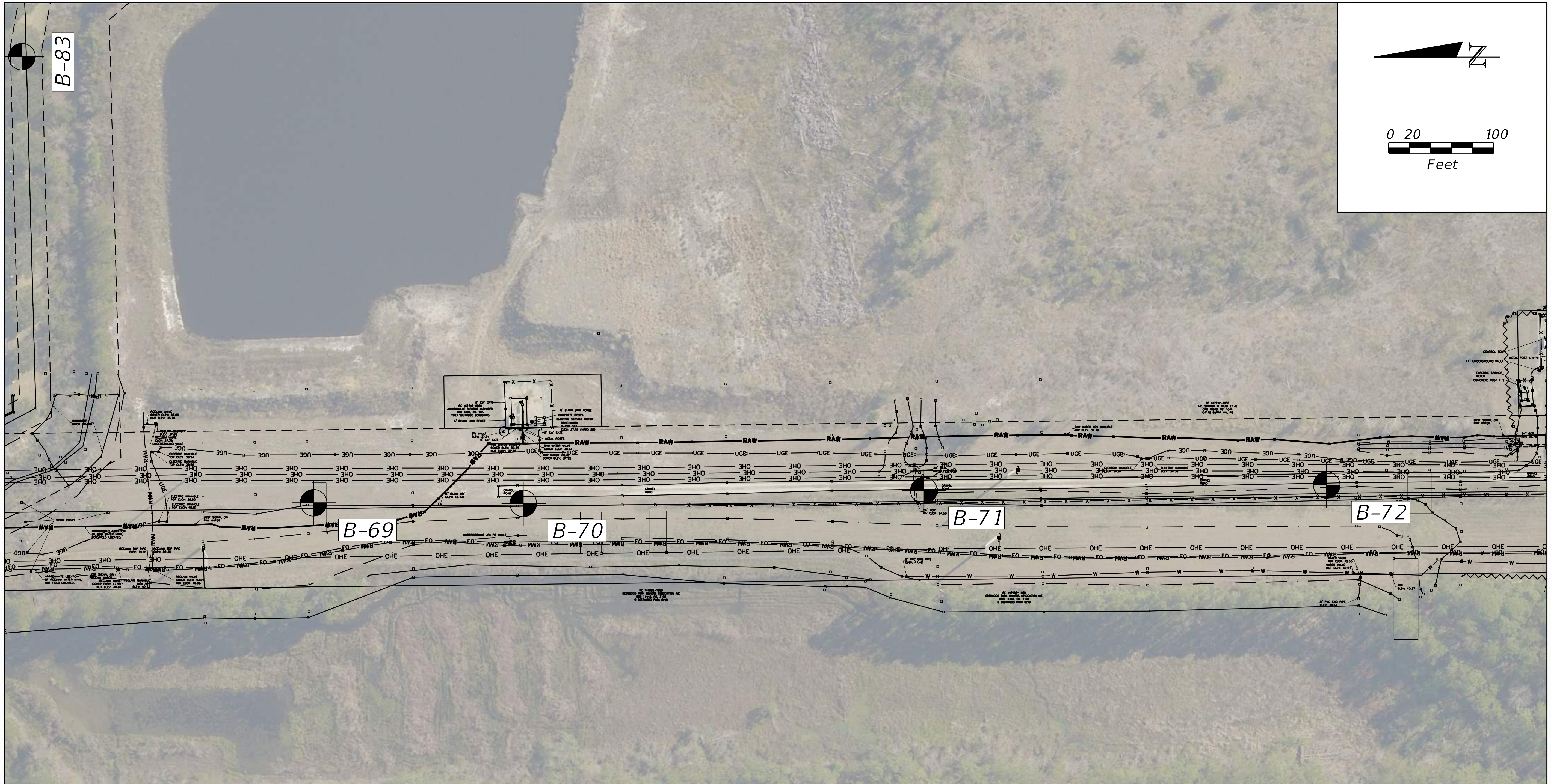

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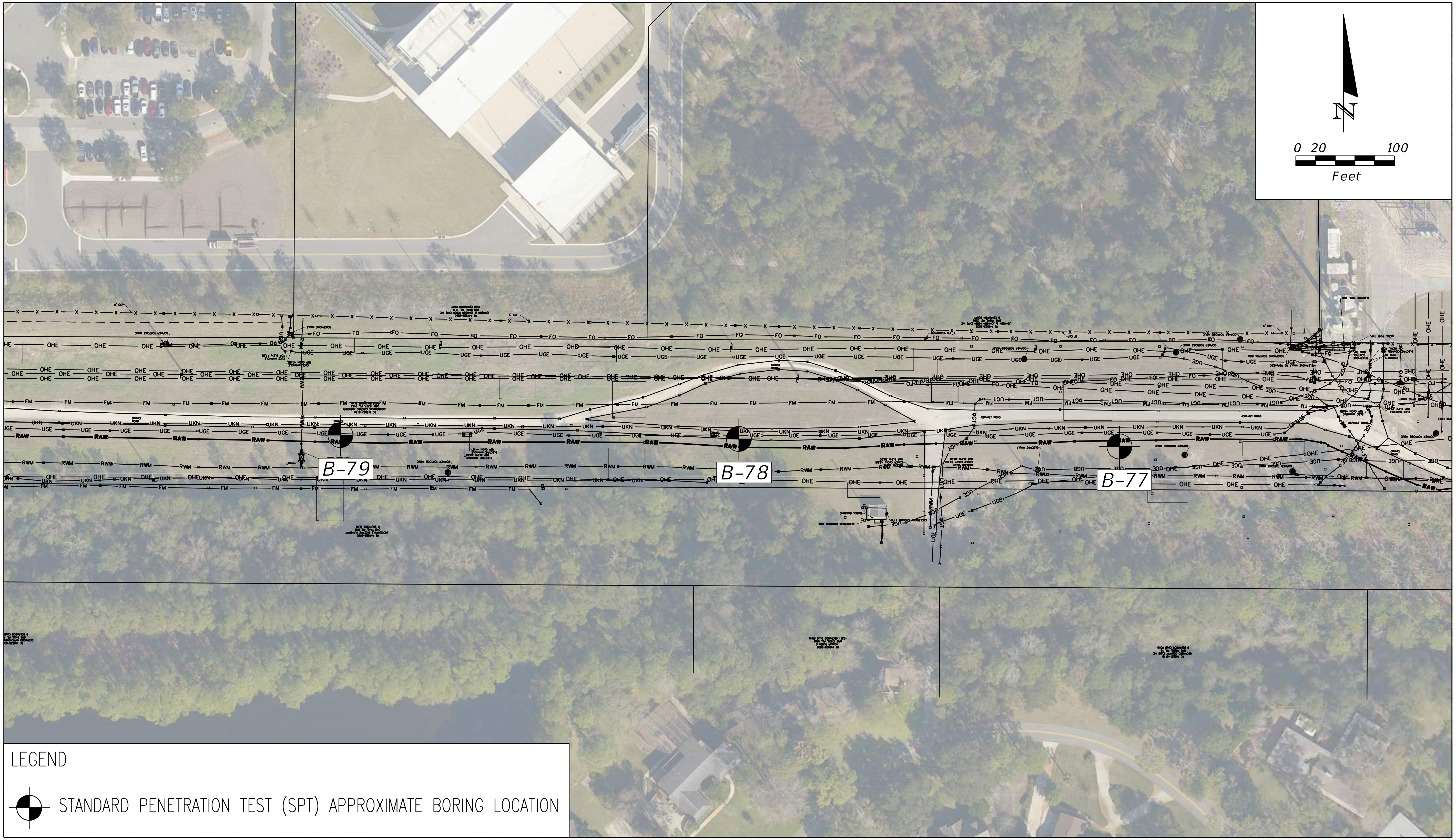

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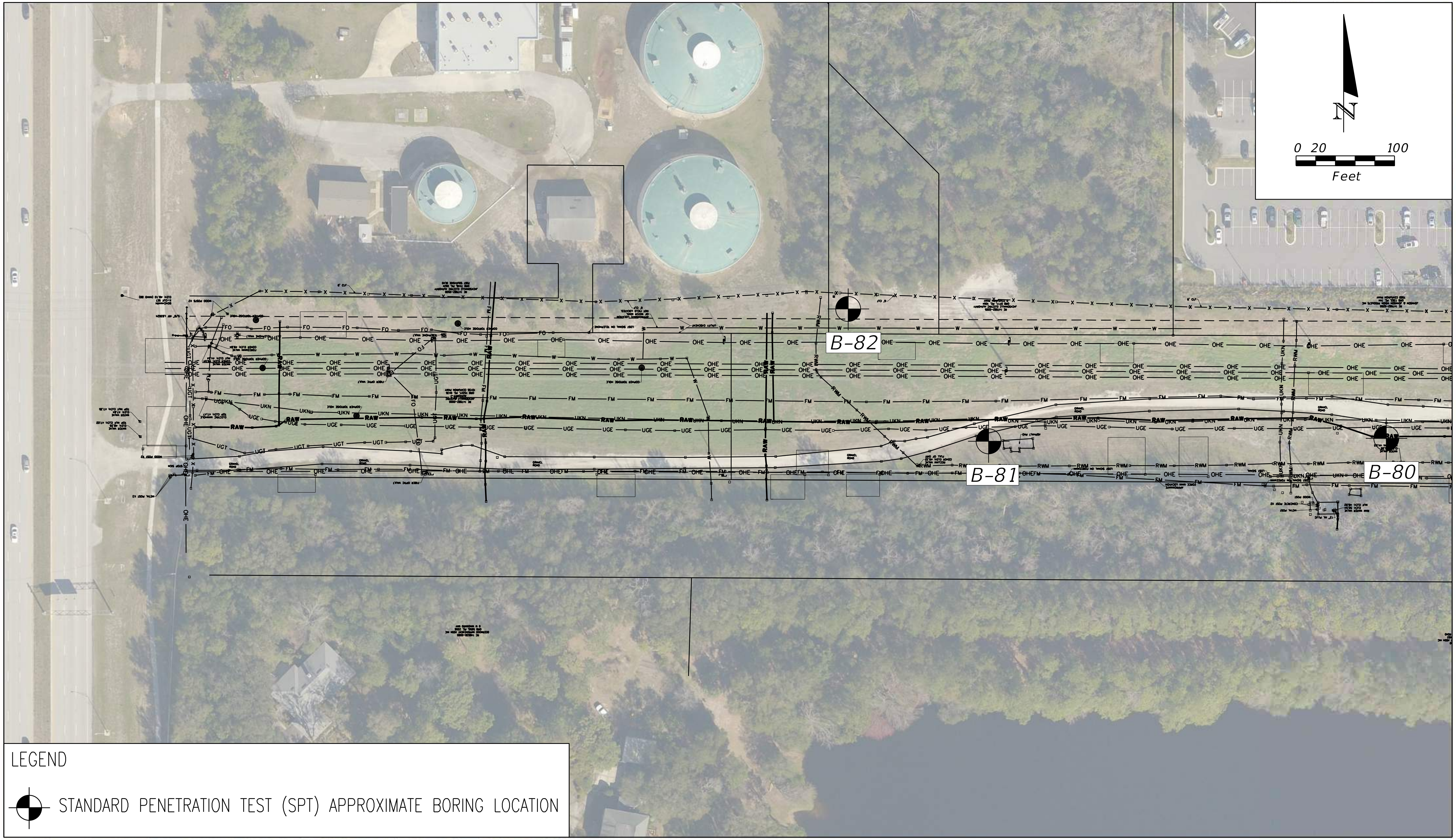

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CONSTRUCTION MATERIAL TESTING
CONSTRUCTION ENGINEERING INSPECTION

FIELD EXPLORATION PLAN

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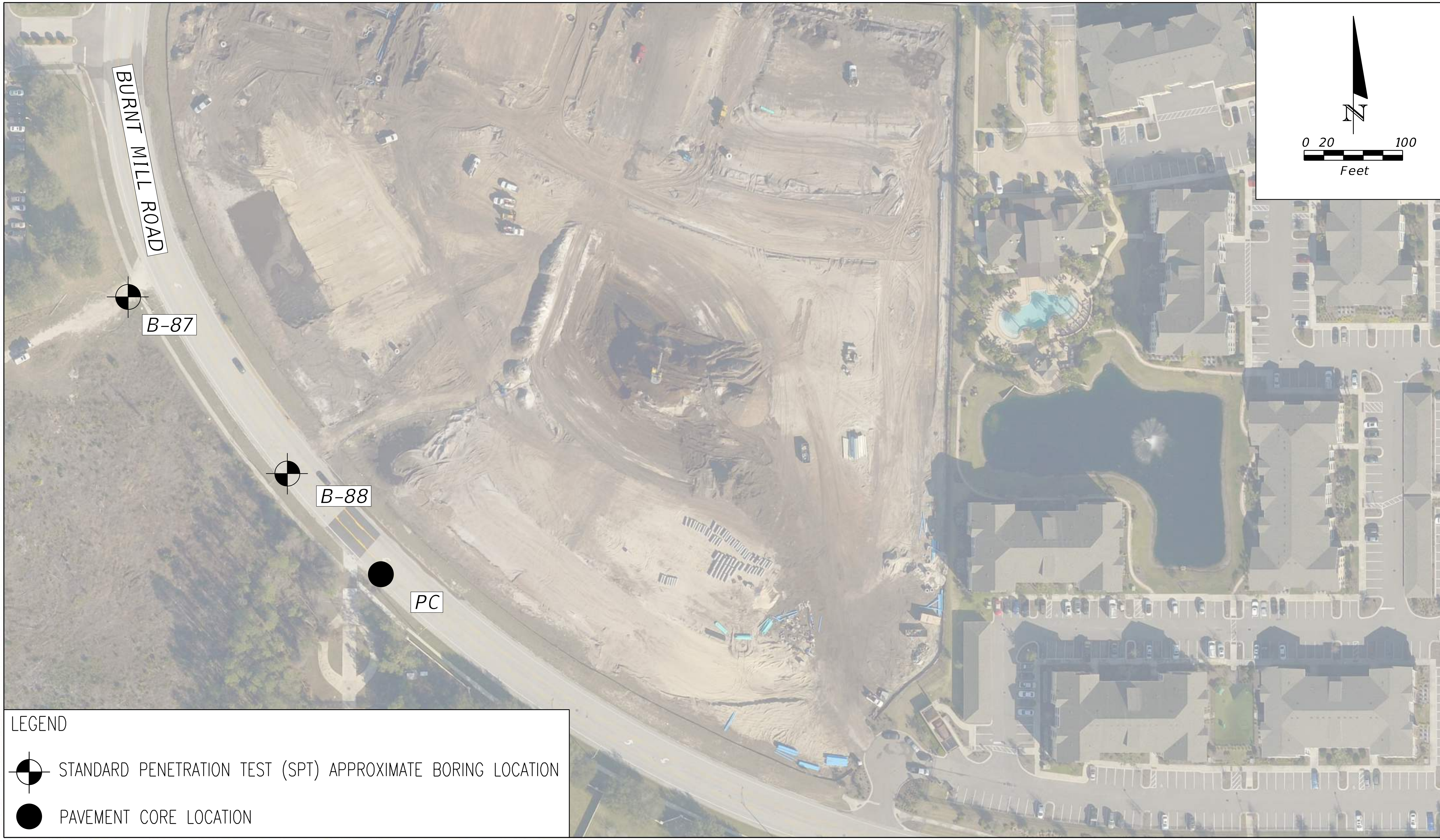

LEGEND

STANDARD PENETRATION TEST (SPT) APPROXIMATE BORING LOCATION

PAVEMENT CORE LOCATION

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Report of SPT Borings

LEGEND

ASPHALT

CLAYEY FINE SAND (A-2-6)

LIMEROCK

SANDY CLAY (A-6)

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

ORGANIC FINE SAND; ORGANIC SILTY FINE SAND (A-8)

SILTY FINE SAND (A-2-4)

(A-3)	AASHTO SOIL CLASSIFICATION SYSTEM	B.T.	STANDARD PENETRATION TEST BORING TERMINATION
▽	ESTIMATED SEASONAL HIGH GROUND WATER LEVEL	N	STANDARD PENETRATION RESISTANCE IN BLOWS PER FT UNLESS OTHERWISE NOTED, NUMBERS TO THE LEFT OF BORING INDICATE N-VALUES.
▼	GROUND WATER LEVEL AT TIME OF DRILLING	G.N.E.	GROUNDWATER NOT ENCOUNTERED
W / -200 / LL / PI / OC%	NATURAL MOISTURE CONTENT (%) / FINES PASSING NO. 200 SIEVE (%) / LIQUID LIMIT / PLASTICITY INDEX / ORGANIC CONTENT	H.A.	HAND AUGER

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

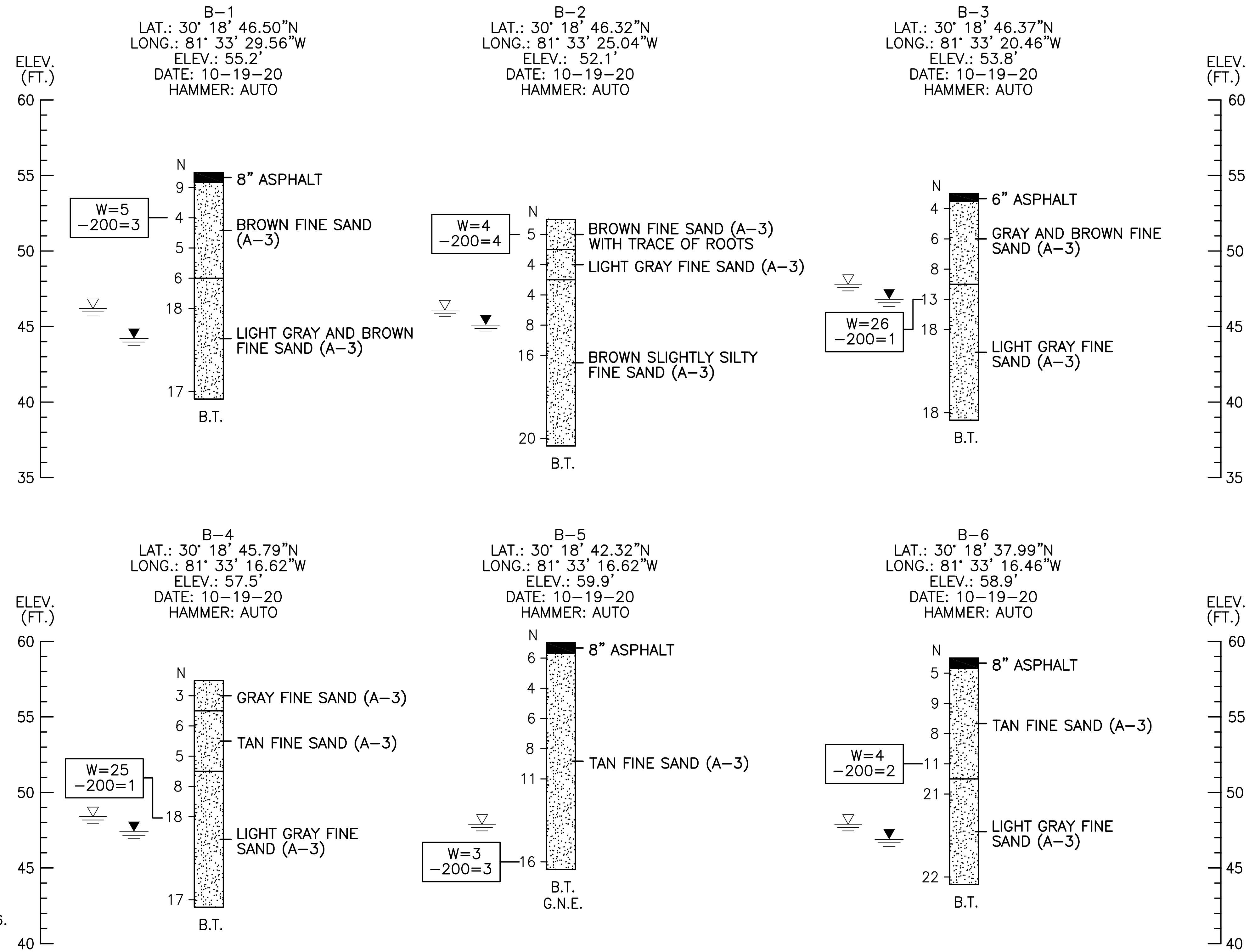
STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.44 INCHES
SPOON OUTSIDE DIA.	2.0 INCHES
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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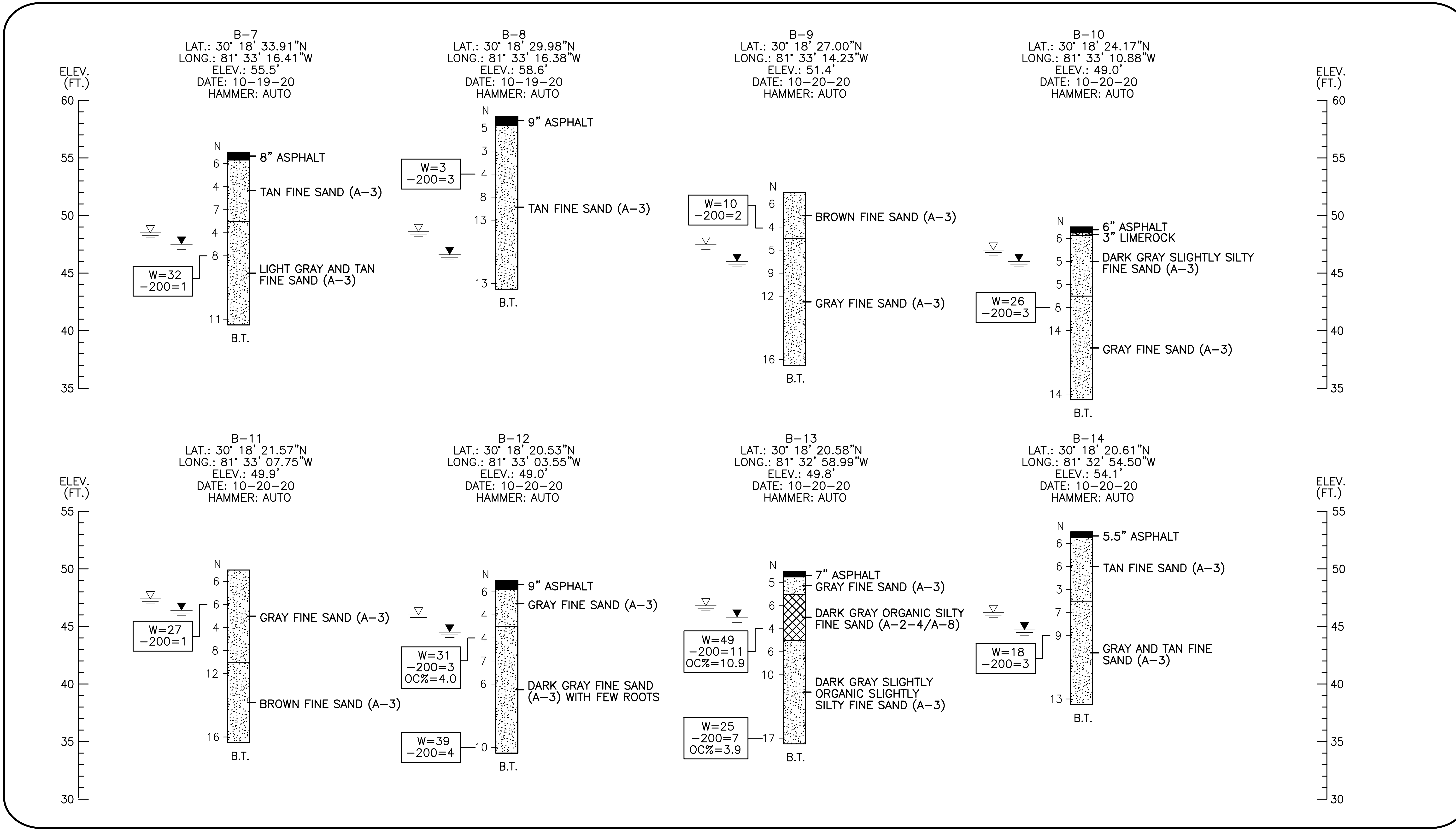

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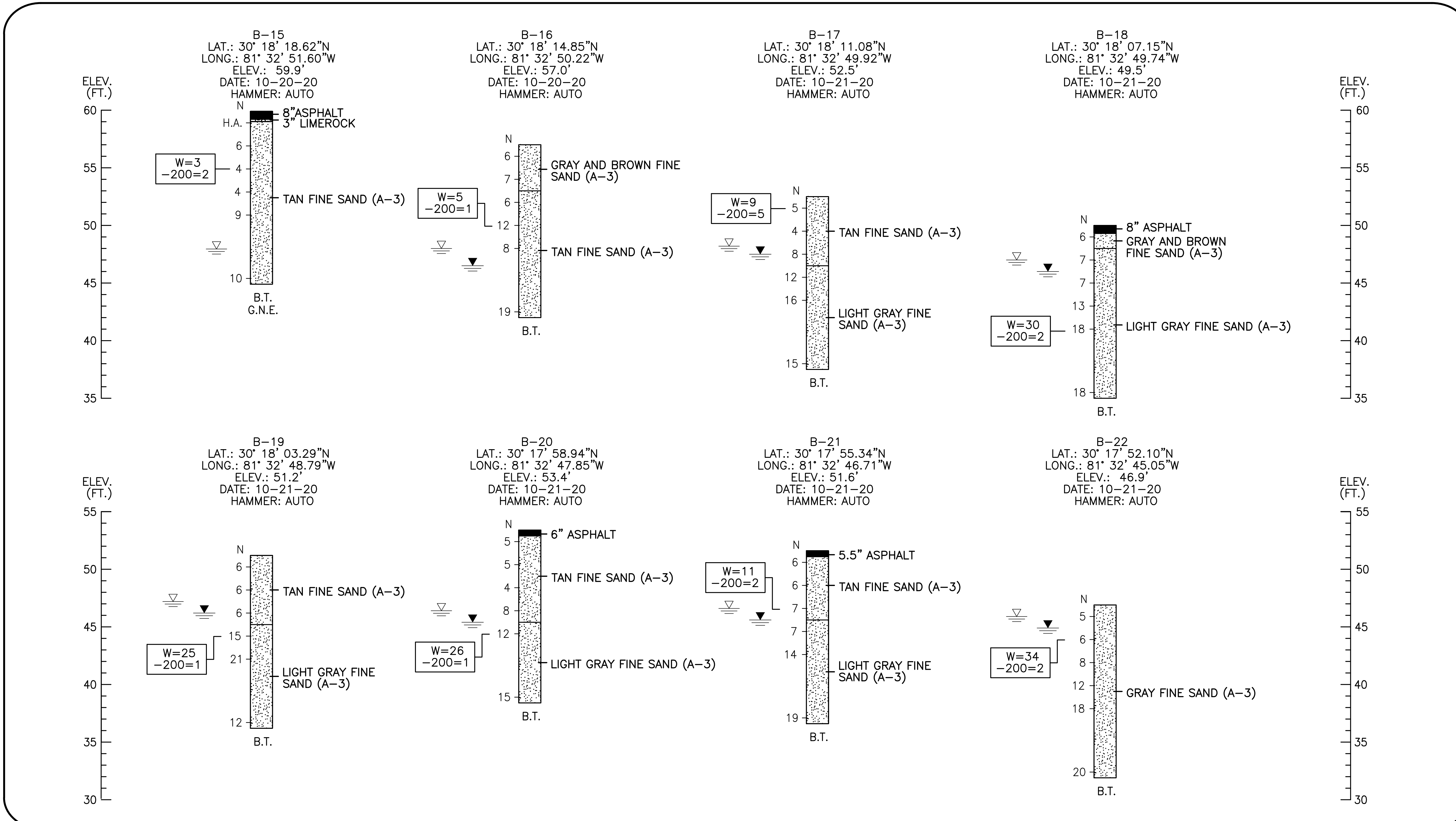

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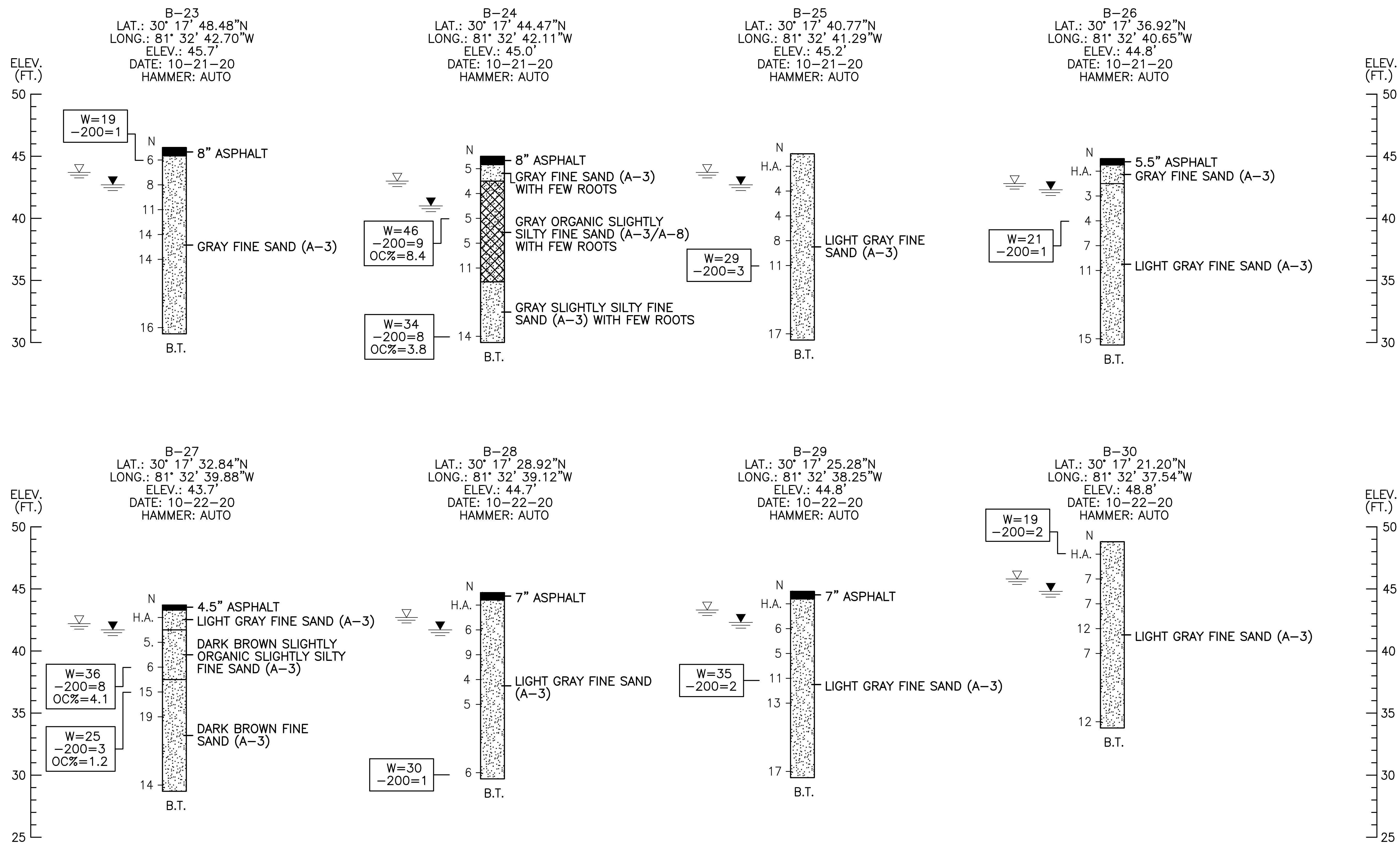

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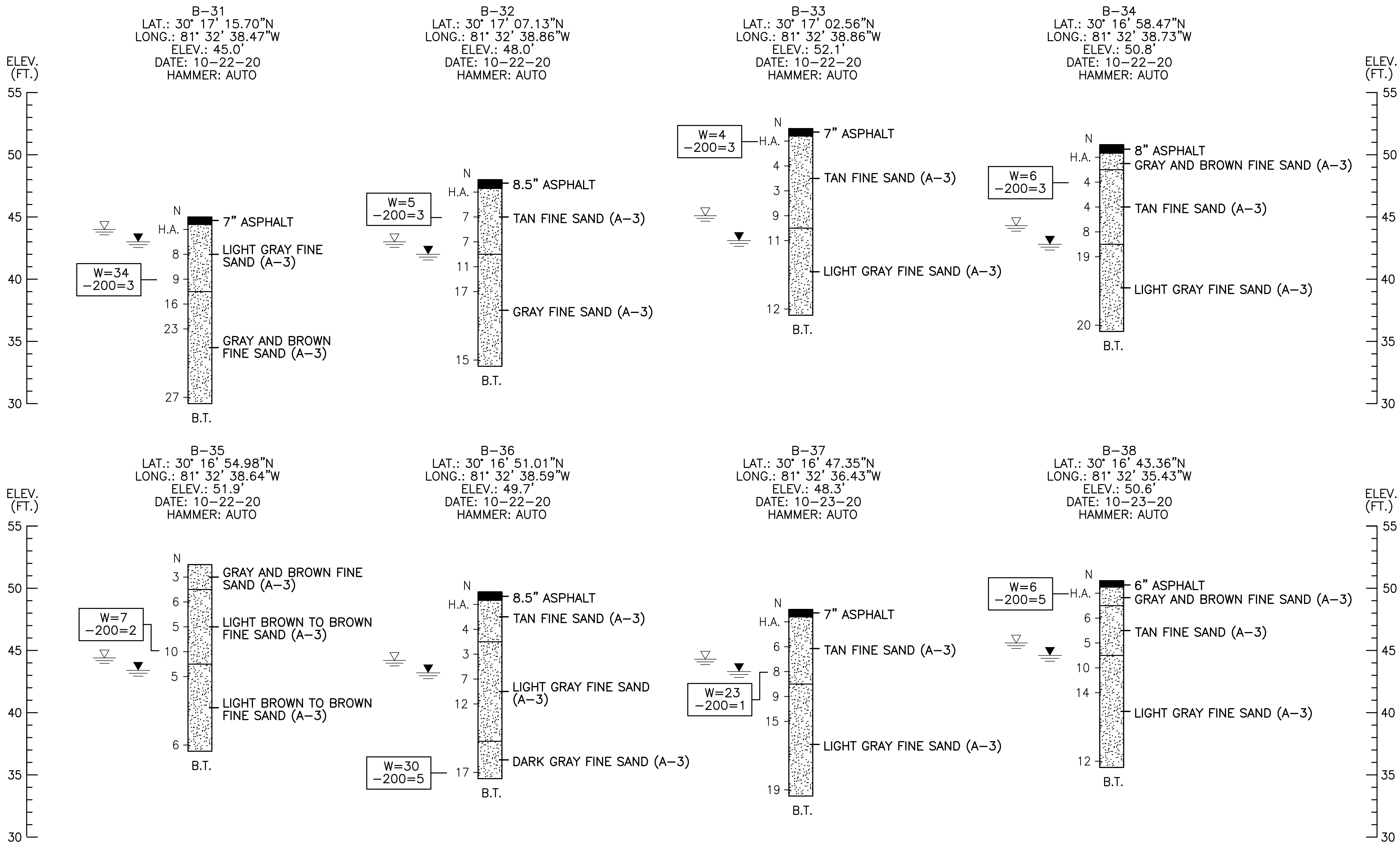

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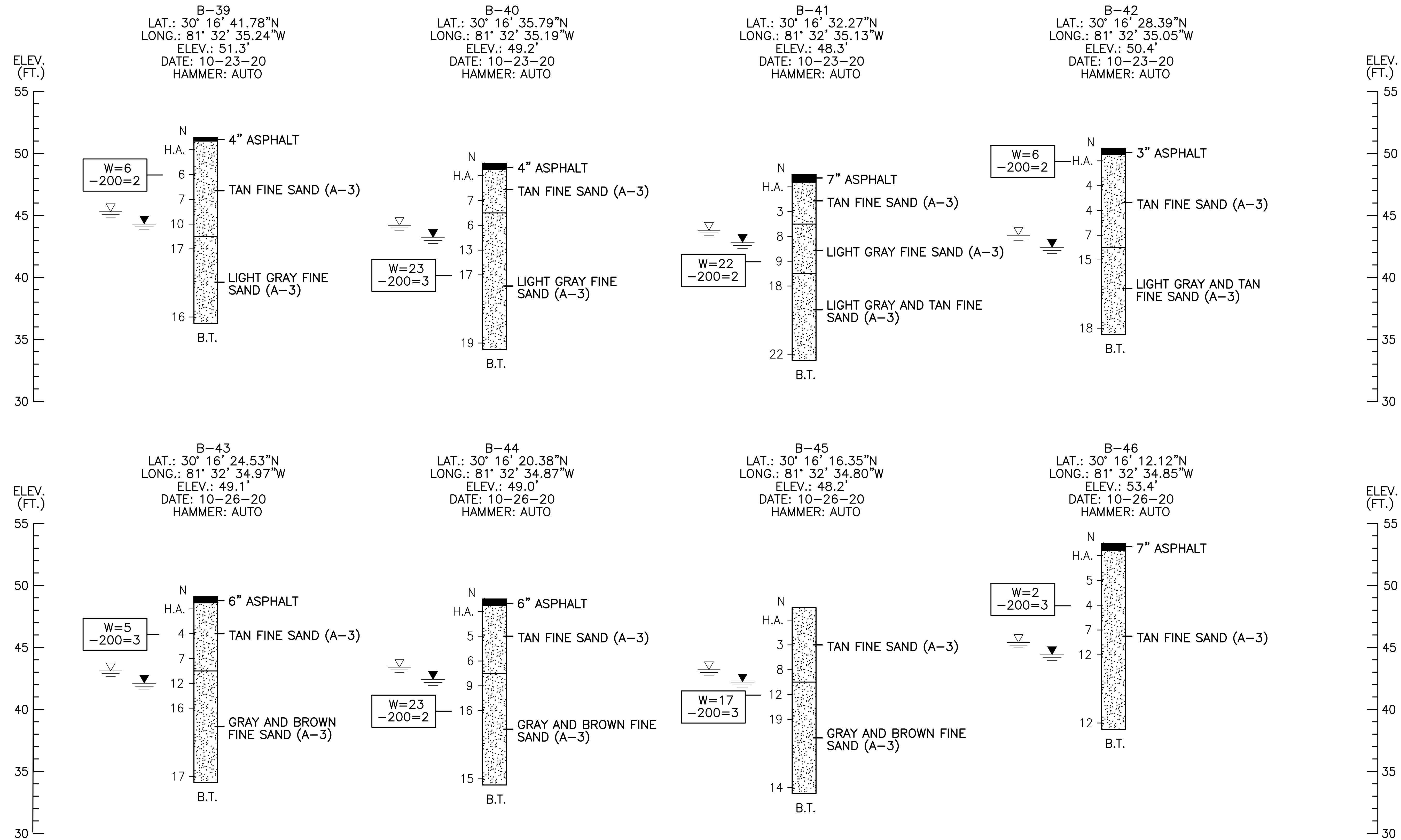

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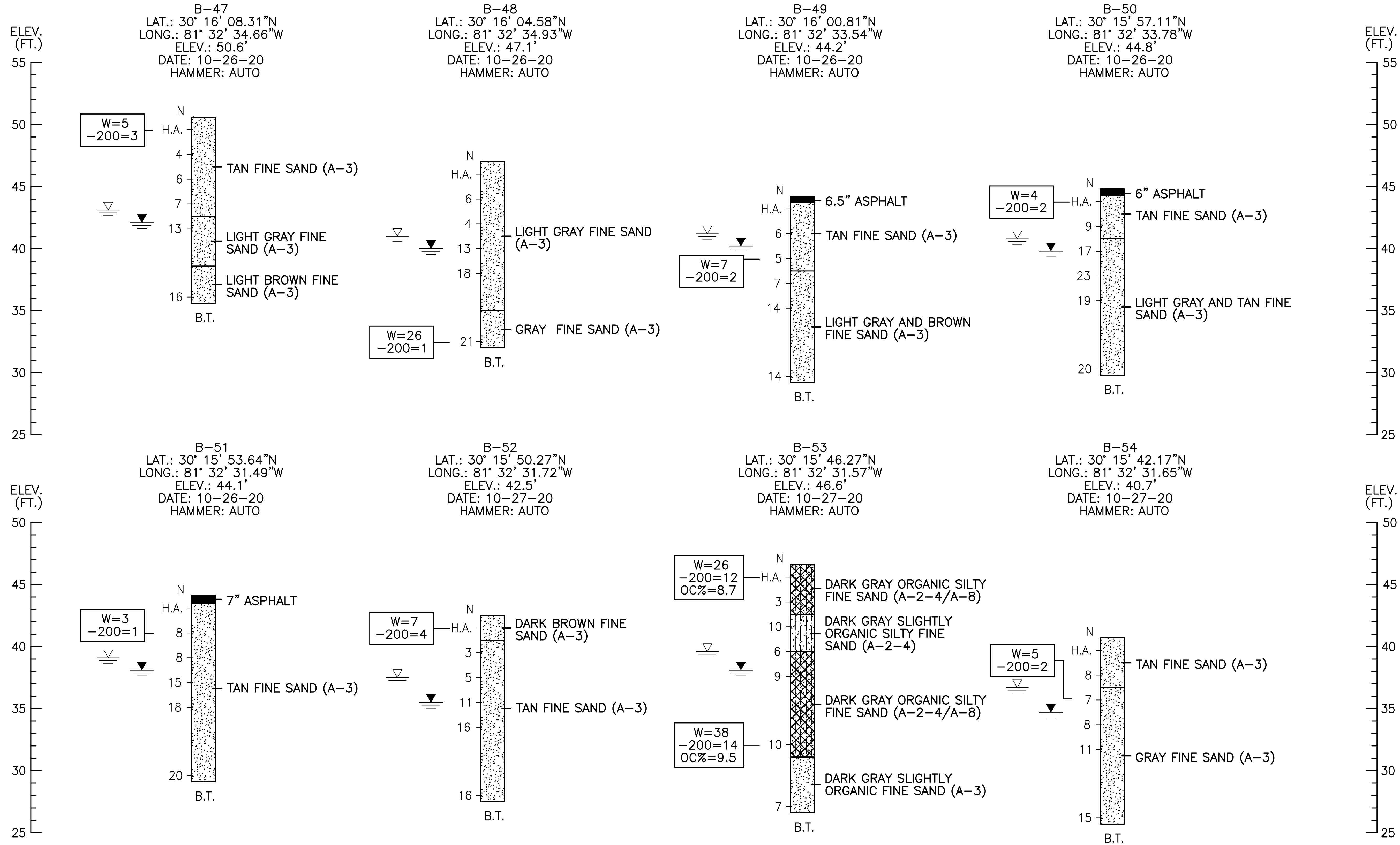

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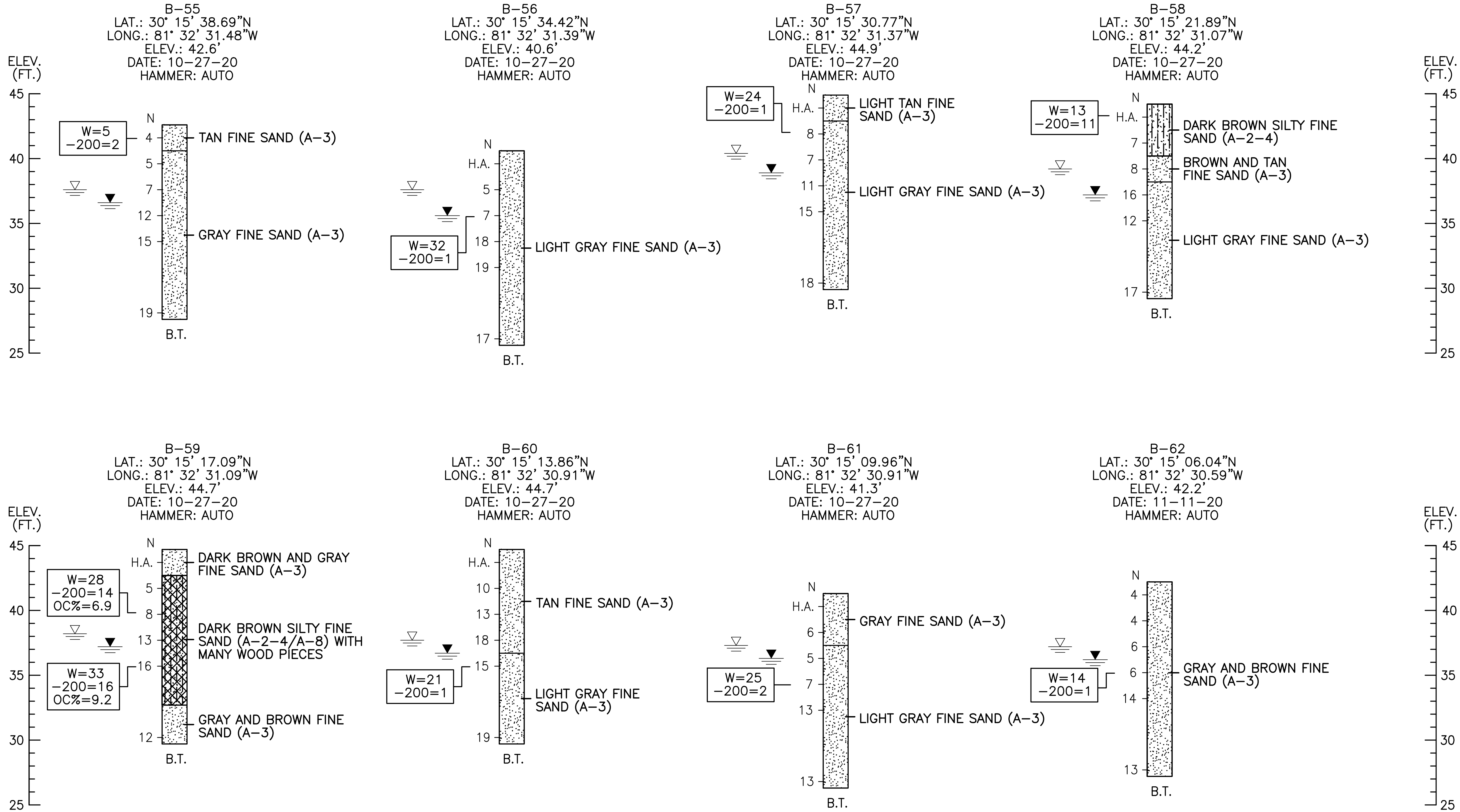

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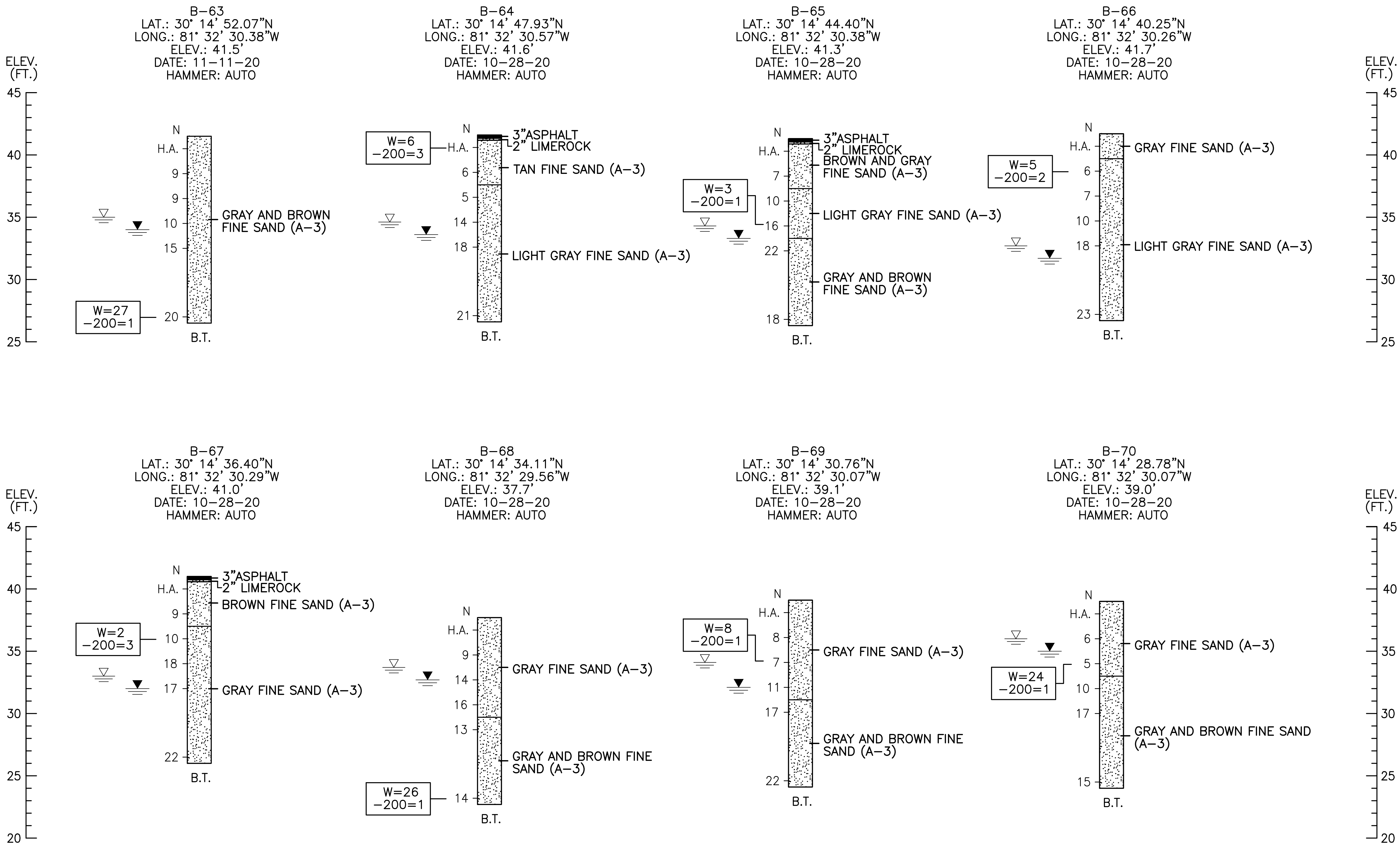

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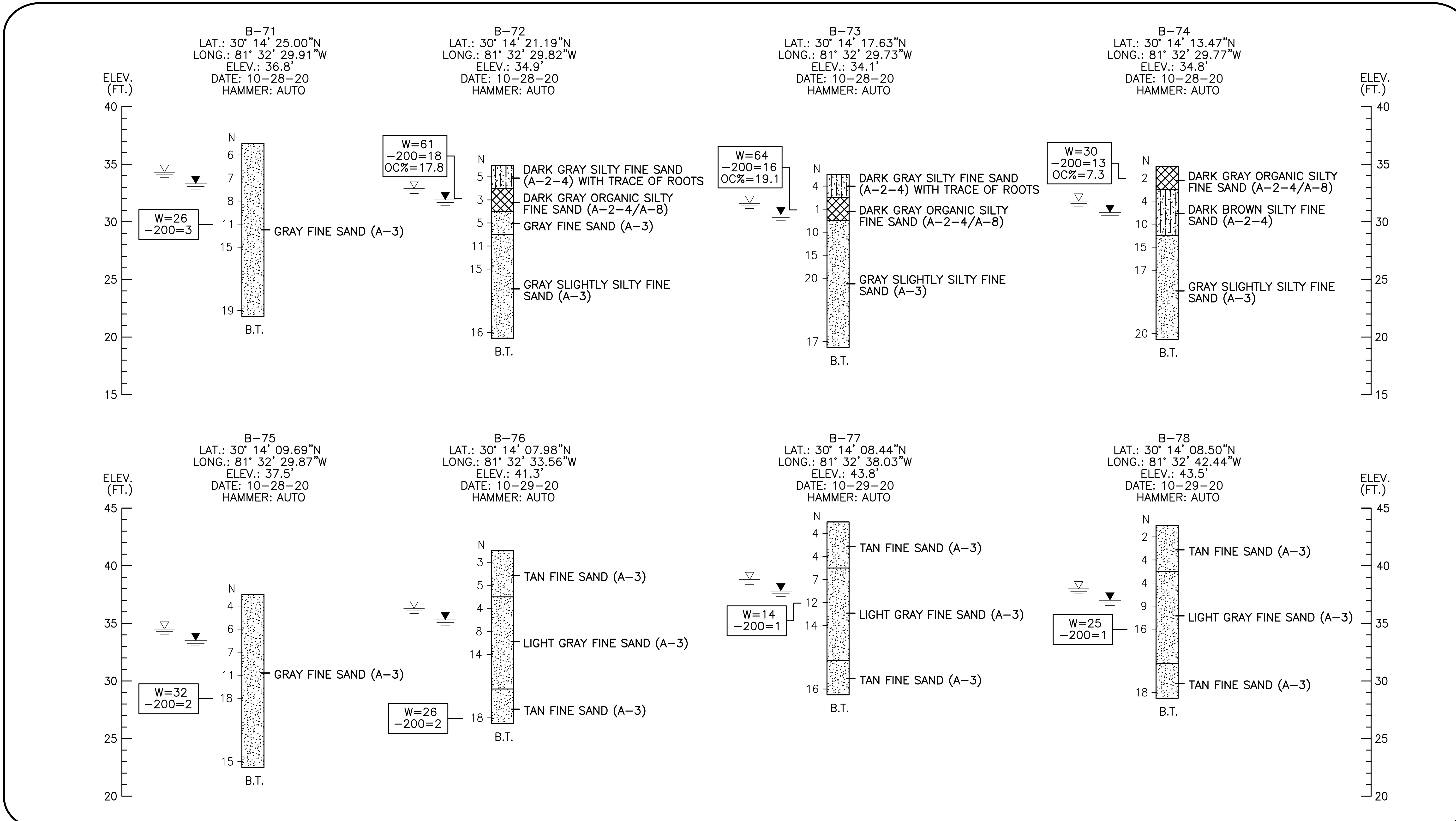

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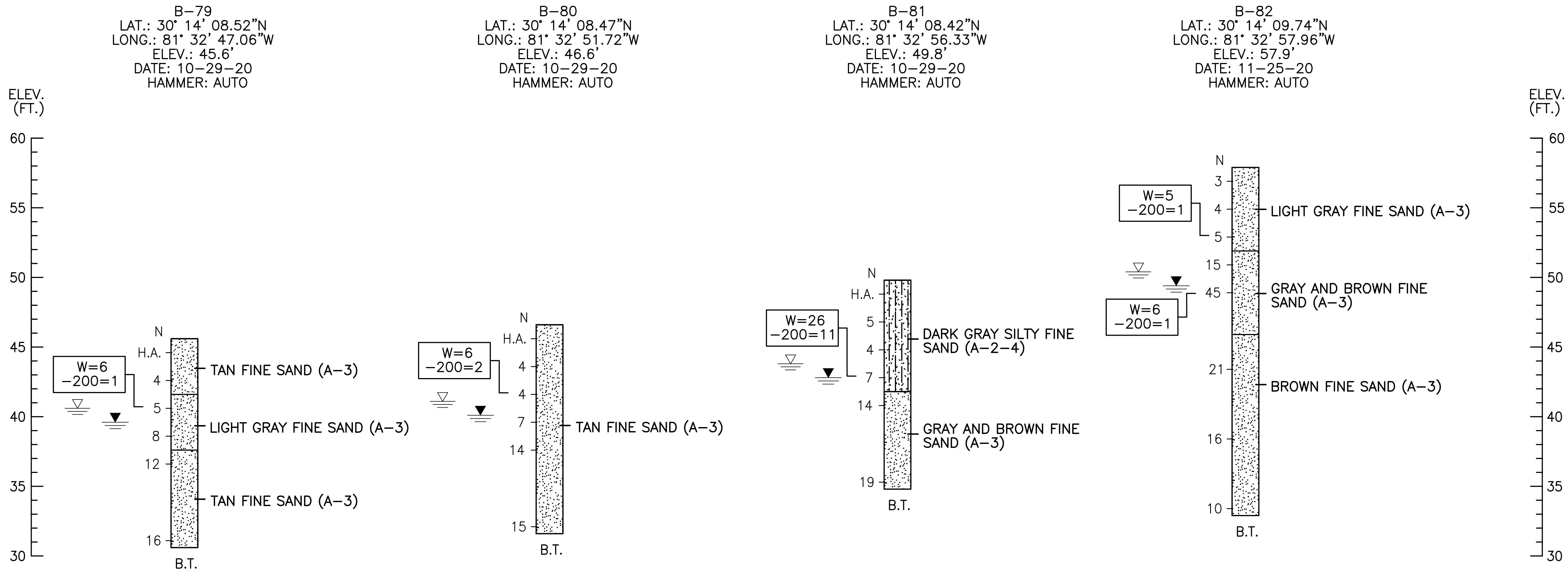

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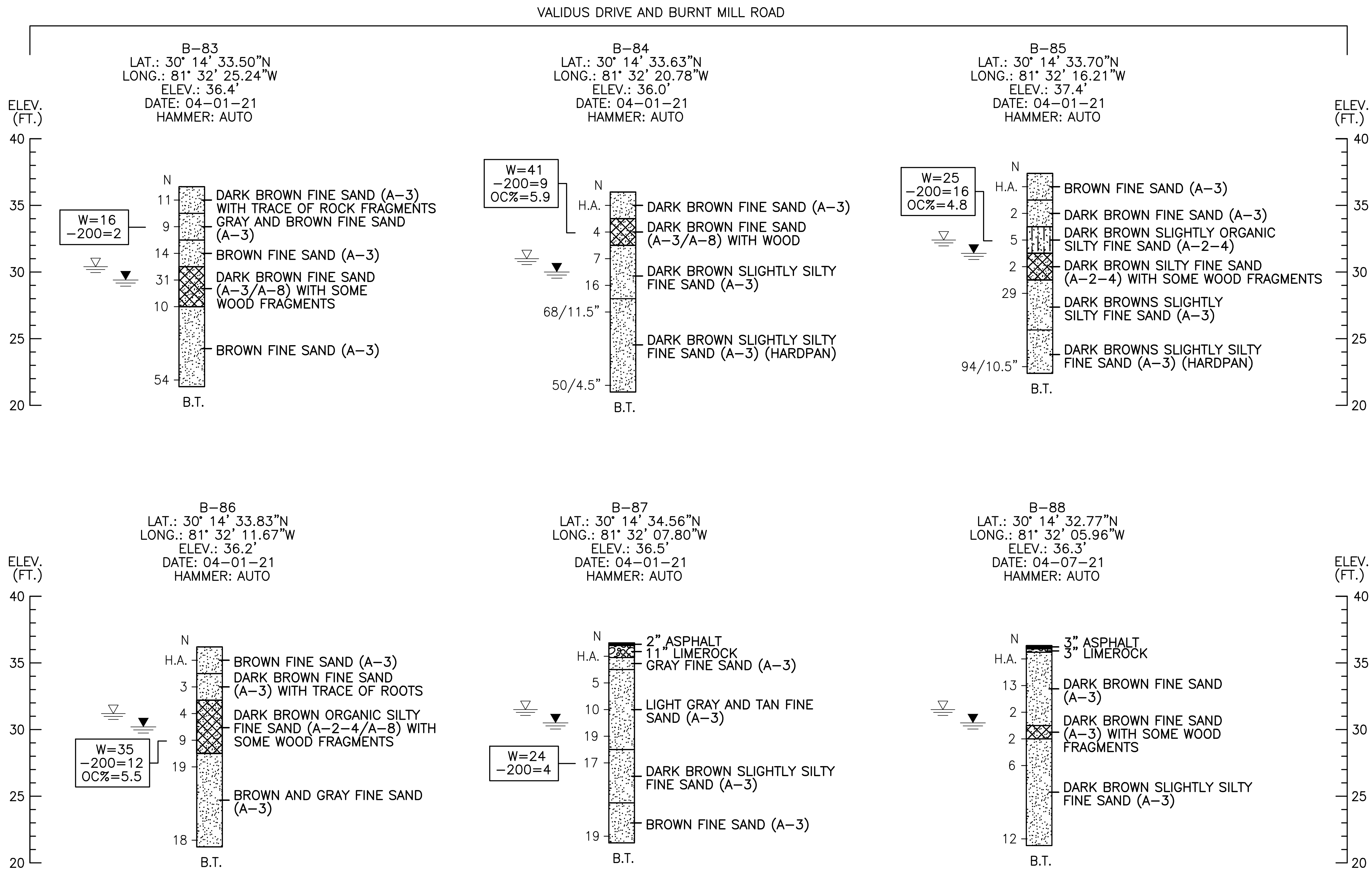

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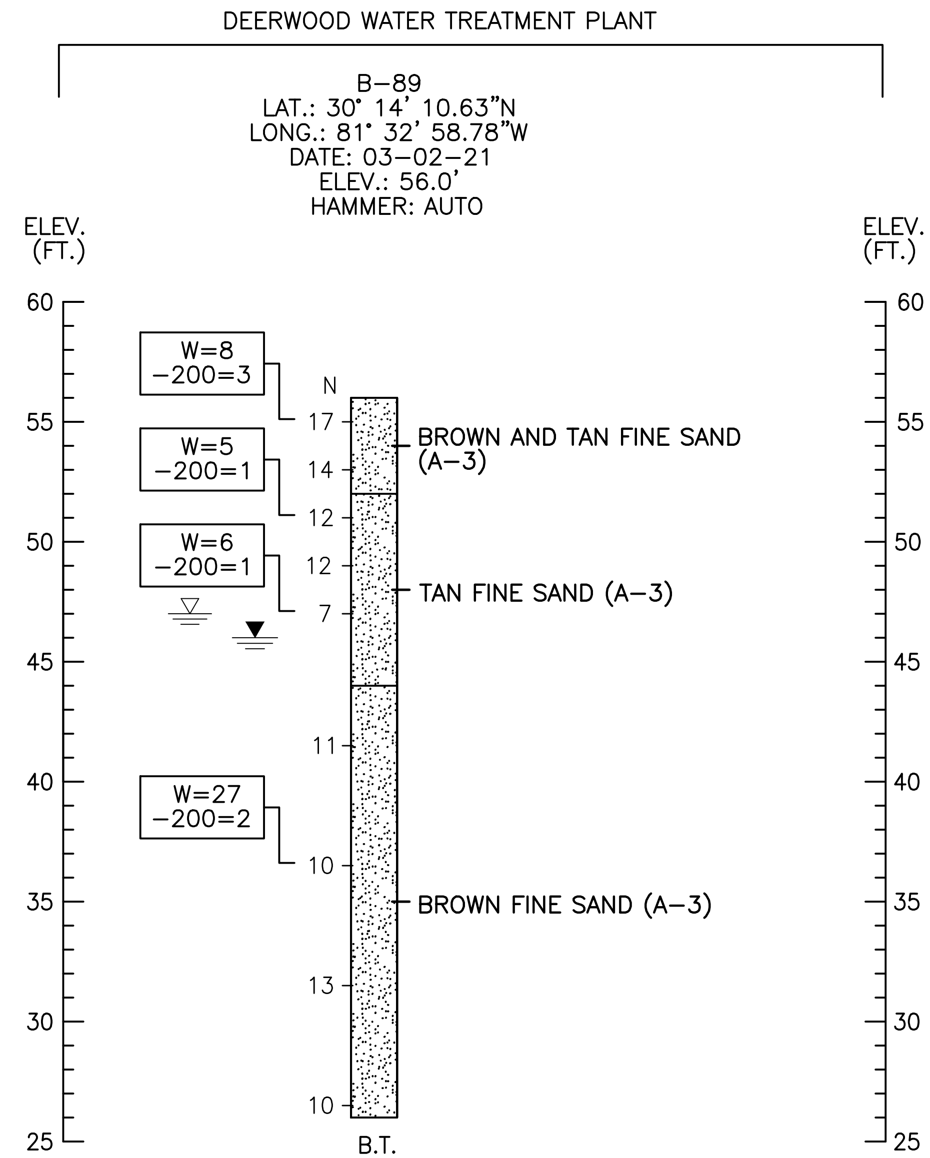

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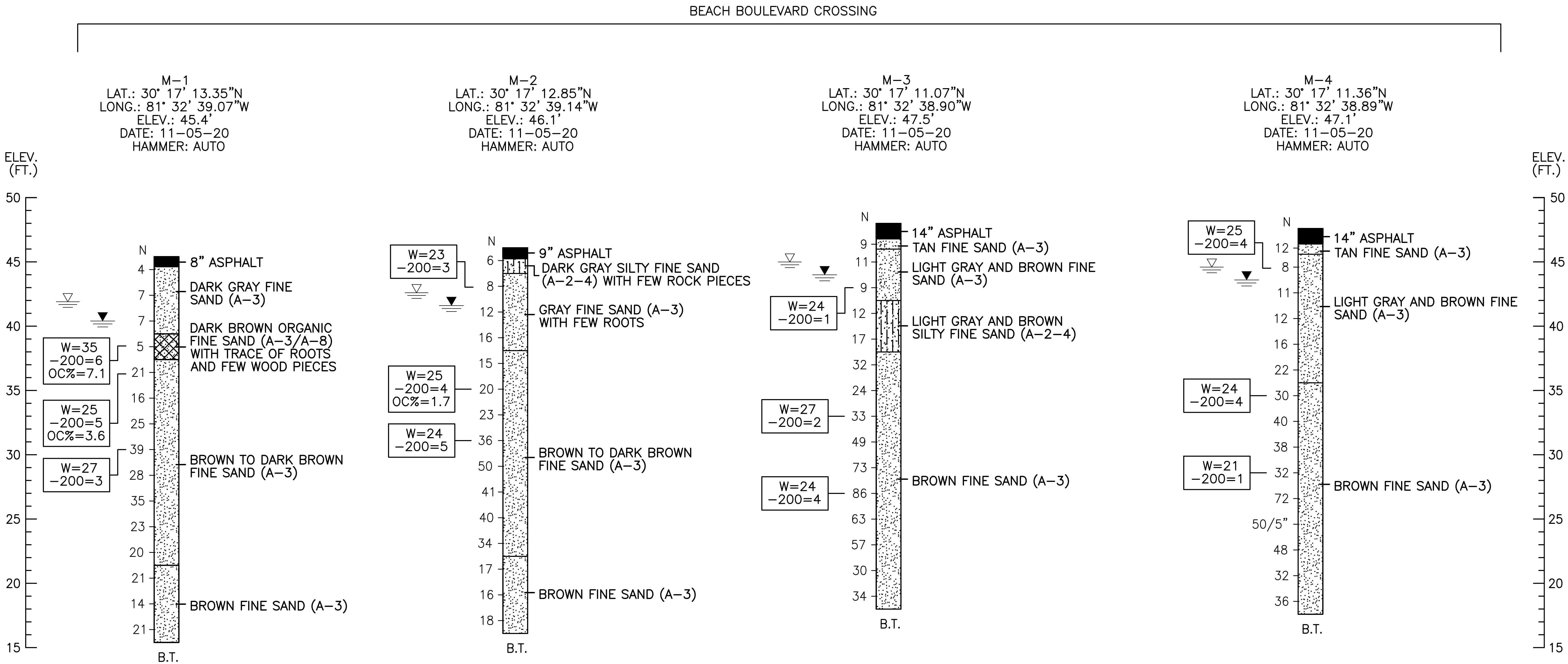

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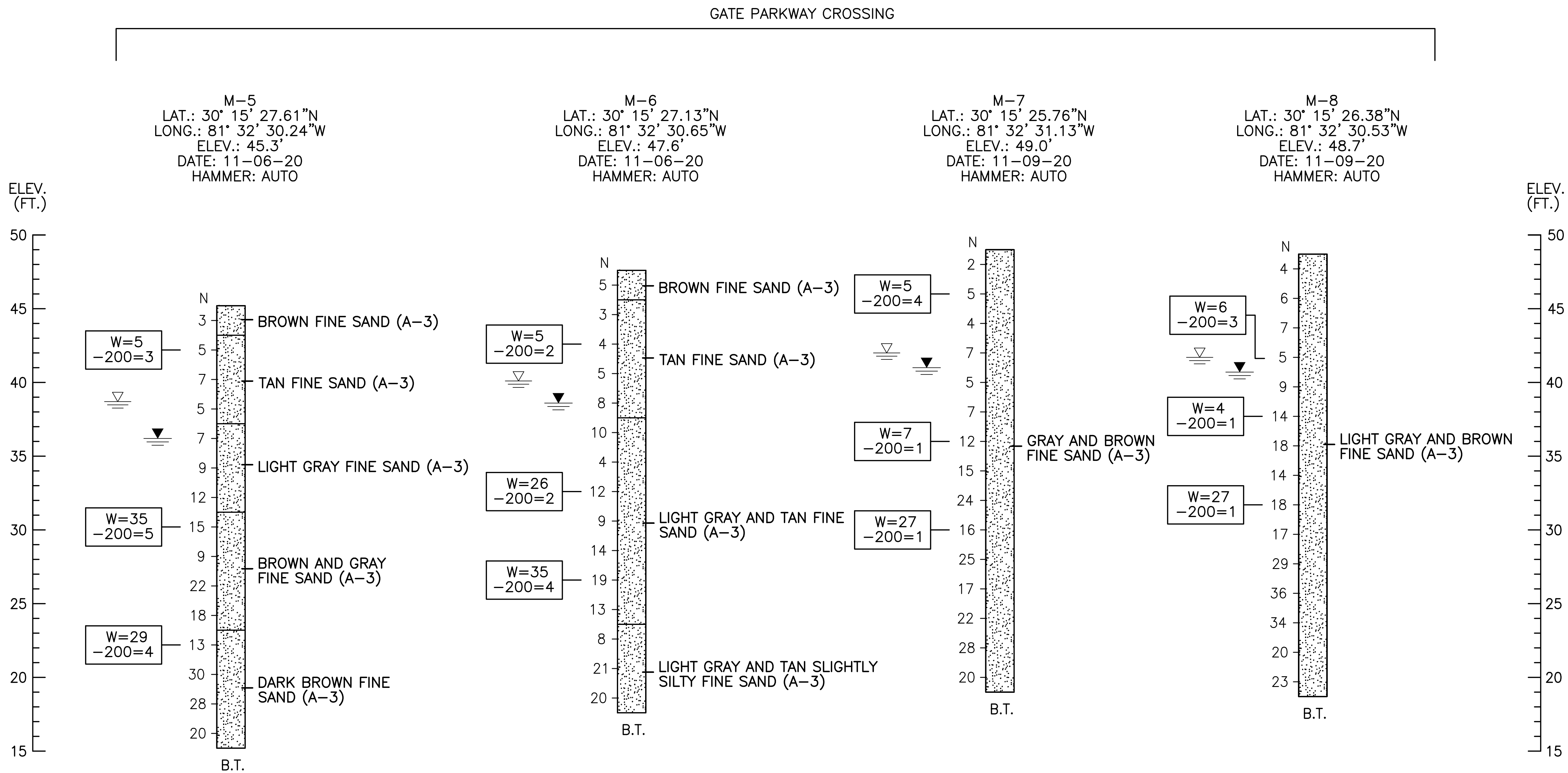

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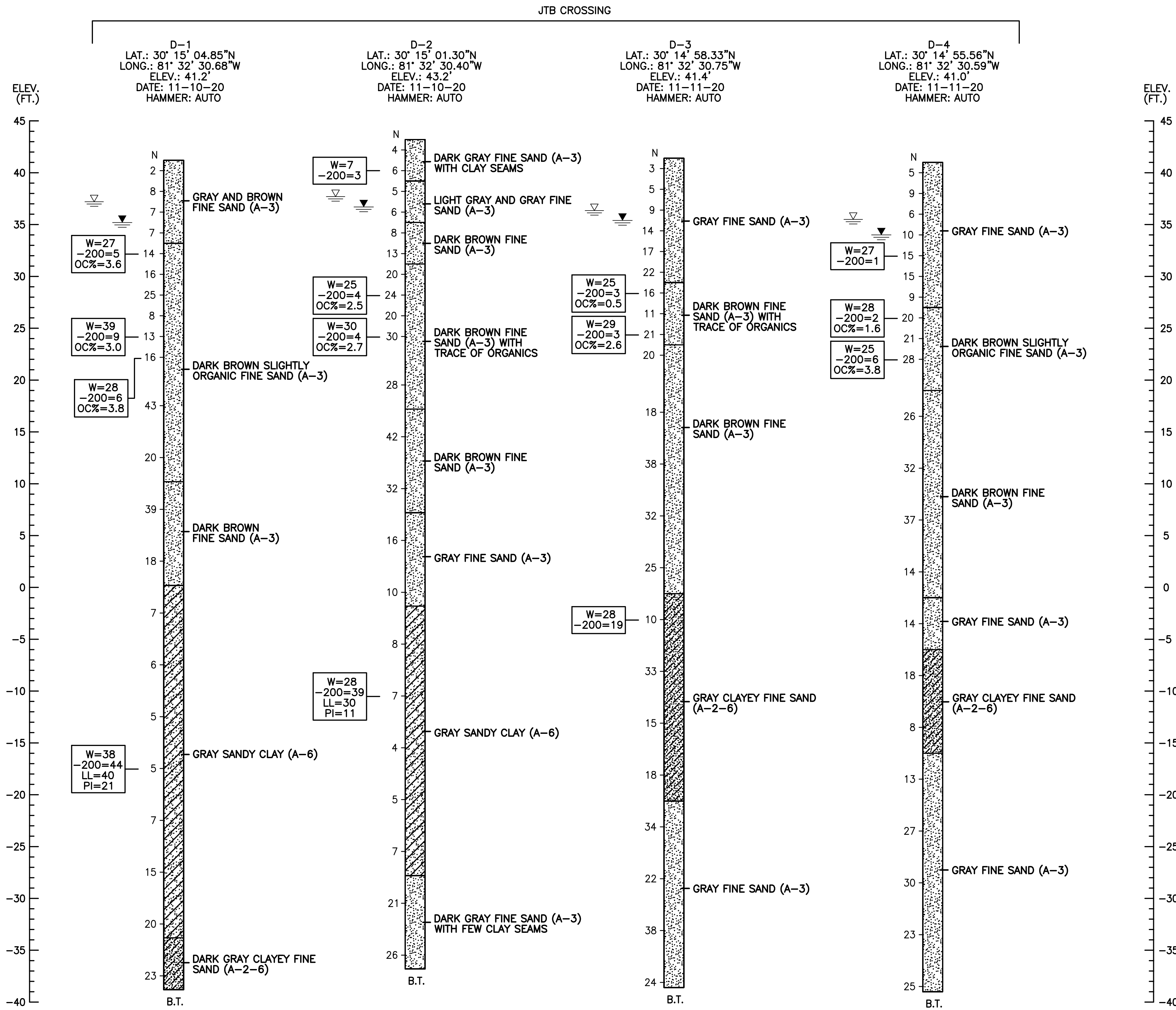

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REPORT OF SPT BORINGS
JEA SIPS DEERWOOD ROUTE WATER MAIN
JACKSONVILLE, FLORIDA

Existing Pavement Thickness System

ASPHALT AND LIMEROCK CORE THICKNESS

JEA SIPS Deerwood Route Water Main
Jacksonville, Florida

Boring No.	Latitude	Longitude	Asphalt Thickness (in)	Limerock Thickness (in)
B-1	30°18'46.50"N	81°33'29.56"W	8	-
B-3	30°18'46.37"N	81°33'20.46"W	6	-
B-5	30°18'42.32"N	81°33'16.50"W	8	-
B-6	30°18'37.99"N	81°33'16.46"W	8	-
B-7	30°18'33.91"N	81°33'16.41"W	8	-
B-8	30°18'29.98"N	81°33'16.38"W	9	-
B-10	30°18'24.17"N	81°33'10.88"W	6	3
B-12	30°18'20.53"N	81°33'3.55"W	9	-
B-13	30°18'20.58"N	81°32'58.99"W	7	-
B-14	30°18'20.61"N	81°32'54.50"W	5 1/2	-
B-15	30°18'18.62"N	81°32'51.60"W	8	3
B-18	30°18'7.15"N	81°32'49.74"W	8	-
B-20	30°17'58.94"N	81°32'47.85"W	6	-
B-21	30°17'55.34"N	81°32'46.71"W	5 1/2	-
B-23	30°17'48.48"N	81°32'42.70"W	8	-
B-24	30°17'44.47"N	81°32'42.11"W	8	-
B-26	30°17'36.92"N	81°32'40.65"W	5 1/2	-
B-27	30°17'32.84"N	81°32'39.88"W	4 1/2	-
B-28	30°17'28.92"N	81°32'39.12"W	7	-
B-29	30°17'25.28"N	81°32'38.25"W	7	-
B-31	30°17'15.70"N	81°32'38.47"W	7	-
B-32	30°17'7.13"N	81°32'38.86"W	8 1/2	-
B-33	30°17'2.56"N	81°32'38.86"W	7	-
B-34	30°16'58.47"N	81°32'38.73"W	8	-
B-36	30°16'51.01"N	81°32'38.59"W	8 1/2	-
B-37	30°16'47.35"N	81°32'36.43"W	7	-
B-38	30°16'43.36"N	81°32'35.43"W	6	-
B-39	30°16'41.78"N	81°32'35.24"W	4	-
B-40	30°16'35.79"N	81°32'35.19"W	6 1/2	-
B-41	30°16'32.27"N	81°32'35.13"W	7	-
B-42	30°16'28.39"N	81°32'35.05"W	3	-
B-43	30°16'24.53"N	81°32'34.97"W	6	-
B-44	30°16'20.38"N	81°32'34.87"W	6	-
B-46	30°16'12.12"N	81°32'34.85"W	7	-
B-49	30°16'0.81"N	81°32'33.54"W	6 1/2	-
B-50	30°15'57.11"N	81°32'33.78"W	6	-
B-51	30°15'53.64"N	81°32'31.49"W	7	-
B-87	30°14'34.56"N	81°32'07.80"W	2	11
B-88	30°14'32.77"N	81°32'05.96"W	3	3
M-1	30°17'13.35"N	81°32'39.07"W	8	-
M-2	30°17'12.85"N	81°32'39.14"W	9	-
M-3	30°17'11.07"N	81°32'38.90"W	14	-
M-4	30°17'11.36"N	81°32'38.89"W	14	-
PC-1	30°14'31.76"N	81°32'4.89"W	4	6

Recommended Design Soil Parameters for Road Crossings

Recommended Design Soil Parameters for Road Crossings
JEA SIPS Deerwood Route Water Main

Borings M-1 and M-2 (North Side of Beach Boulevard Crossing)

Soil Parameter*	Loose Sands and Organic Sands	Medium Dense to Dense Sands
Elevation (ft)	46.1’ to 37.4’	37.4’ to 16.1’
Saturated Unit Weight – γ (pcf)	105	120
Submerged Unit Weight – γ’ (pcf)	43	58
Angle of Internal Friction – ϕ (degrees)	29	37
Cohesion – Undrained C (psf)	-	-
At Rest Earth Pressure Coefficient – K_o	0.52	0.40
Active Earth Pressure Coefficient - K_a	0.35	0.25
Passive Earth Pressure Coefficient - K_p	2.88	4.02

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

Borings M-3 and M-4 (South Side of Beach Boulevard Crossing)

Soil Parameter*	Medium Dense Sands and Silty Sands	Dense to Very Dense Sands
Elevation (ft)	47.5’ to 38.0’	38.0’ to 17.5’
Saturated Unit Weight – γ (pcf)	115	120
Submerged Unit Weight – γ’ (pcf)	53	58
Angle of Internal Friction – ϕ (degrees)	33	37
Cohesion – Undrained C (psf)	-	-
At Rest Earth Pressure Coefficient – K_o	0.46	0.40
Active Earth Pressure Coefficient - K_a	0.29	0.25
Passive Earth Pressure Coefficient - K_p	3.39	4.02

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

Recommended Design Soil Parameters for Road Crossings
JEA SIPS Deerwood Route Water Main

Borings M-5 and M-6 (North Side of Gate Parkway Crossing)

Soil Parameter*	Loose Sands	Medium Dense Sands
Elevation (ft)	47.6’ to 33.0’	33.0’ to 15.3’
Saturated Unit Weight – γ (pcf)	105	115
Submerged Unit Weight – γ’ (pcf)	43	53
Angle of Internal Friction – ϕ (degrees)	30	35
Cohesion – Undrained C (psf)	-	-
At Rest Earth Pressure Coefficient – K_o	0.50	0.43
Active Earth Pressure Coefficient - K_a	0.33	0.27
Passive Earth Pressure Coefficient - K_p	3.00	3.69

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

Borings M-7 and M-8 (South Side of Gate Parkway Crossing)

Soil Parameter*	Loose Sands	Medium Dense to Dense Sands
Elevation (ft)	49.0’ to 37.0’	37.0’ to 18.7’
Saturated Unit Weight – γ (pcf)	110	120
Submerged Unit Weight – γ’ (pcf)	48	58
Angle of Internal Friction – ϕ (degrees)	32	37
Cohesion – Undrained C (psf)	-	-
At Rest Earth Pressure Coefficient – K_o	0.47	0.40
Active Earth Pressure Coefficient - K_a	0.31	0.25
Passive Earth Pressure Coefficient - K_p	3.25	4.02

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

Recommended Design Soil Parameters for Road Crossings
JEA SIPS Deerwood Route Water Main

<u>Borings D-1 and D-2 (North Side of JTB Crossing)</u>

Soil Parameter*	Loose to Medium Dense Sands	Medium Dense Sands	Dense Sands	Medium Dense Sands	Stiff Clays	Medium Dense Clayey Sands
Elevation (ft)	43.2' to 33.2'	33.2' to 20.2'	20.2' to 6.0'	6.0' to 0.2'	0.2' to -28.0'	-28.0' to -38.8'
Saturated Unit Weight – γ (pcf)	110	115	120	115	95	115
Submerged Unit Weight – γ' (pcf)	48	53	58	53	33	53
Angle of Internal Friction – ϕ (degrees)	31	34	37	34	-	31
Cohesion – Undrained C (psf)	-	-	-	-	900	-
At Rest Earth Pressure Coefficient – K_o	0.48	0.44	0.40	0.44	1.00	0.41
Active Earth Pressure Coefficient - K_a	0.32	0.28	0.25	0.28	1.00	0.32
Passive Earth Pressure Coefficient - K_p	3.12	3.54	4.02	3.54	1.00	3.12

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

Recommended Design Soil Parameters for Road Crossings
JEA SIPS Deerwood Route Water Main

Borings D-3 and D-4 (South Side of JTB Crossing)

Soil Parameter*	Loose to Medium Dense Sands	Medium Dense to Dense Sands	Medium Dense Clayey Sands	Medium Dense Sands
Elevation (ft)	41.4’ to 27.4’	27.4’ to -0.6’	-0.6’ to -20.6’	-20.6’ to -38.6’
Saturated Unit Weight – γ (pcf)	110	120	110	115
Submerged Unit Weight – γ’ (pcf)	48	58	48	53
Angle of Internal Friction – ϕ (degrees)	32	36	28	34
Cohesion – Undrained C (psf)	-	-	-	-
At Rest Earth Pressure Coefficient – K_o	0.47	0.41	0.53	0.44
Active Earth Pressure Coefficient - K_a	0.31	0.26	0.36	0.28
Passive Earth Pressure Coefficient - K_p	3.25	3.85	2.77	3.54

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

Summary of Laboratory Test Results

SUMMARY OF LABORATORY TEST RESULTS

JEA SIPS Deerwood Route Water Main
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	2	2.0 - 4.0	5							3			A-3
B-2	1	0.0 - 2.0	4							4			A-3
B-3	4	6.0 - 8.0	26							1			A-3
B-4	5	8.0 - 10.0	25							1			A-3
B-5	6	13.5 - 15.0	3							3			A-3
B-6	4	6.0 - 8.0	4							2			A-3
B-7	5	8.0 - 10.0	32							1			A-3
B-8	3	4.0 - 6.0	3							3			A-3
B-9	2	2.0 - 4.0	10							2			A-3
B-10	4	6.0 - 8.0	26							3			A-3
B-11	2	2.0 - 4.0	27							1			A-3
B-12	3	4.0 - 6.0	31	4.0						3			A-3
B-12	6	13.5 - 15.0	39							4			A-3
B-13	3	4.0 - 6.0	49	10.9						11			A-2-4/A-8
B-13	6	13.5 - 15.0	25	3.9						7			A-3
B-14	5	8.0 - 10.0	18							3			A-3
B-15	3	4.0 - 6.0	3							2			A-3
B-16	4	6.0 - 8.0	5							1			A-3
B-17	1	0.0 - 2.0	9							5			A-3
B-18	5	8.0 - 10.0	30							2			A-3
B-19	4	6.0 - 8.0	25							1			A-3
B-20	5	8.0 - 12.0	26							1			A-3
B-21	3	4.0 - 6.0	11							2			A-3
B-22	2	2.0 - 4.0	34							2			A-3

SUMMARY OF LABORATORY TEST RESULTS

JEA SIPS Deerwood Route Water Main
Jacksonville, Florida

Boring No.	Sample No.	Approximate Depth (ft)			Natural Moisture Content (%)	Organic Content (%)	Percent Passing Sieve Size (%) #4	#10	#40	#60	#100	#200	Atterberg Limits LL	PI	Soil Classification Symbol
B-23	1	0.0	-	2.0	19							1			A-3
B-24	3	4.0	-	6.0	46	8.4						9			A-3/A-8
B-24	6	13.5	-	15.0	34	3.8						8			A-3
B-25	5	8.0	-	10.0	29							3			A-3
B-26	3	4.0	-	6.0	21							1			A-3
B-27	3	4.0	-	6.0	36	4.1						8			A-3
B-27	4	6.0	-	8.0	35	1.2						3			A-3
B-28	6	13.5	-	15.0	30							1			A-3
B-29	4	6.0	-	8.0	35							2			A-3
B-30	1	0.0	-	2.0	19							2			A-3
B-31	3	4.0	-	6.0	34							3			A-3
B-32	2	2.0	-	4.0	5							3			A-3
B-33	1	0.0	-	2.0	4							3			A-3
B-34	2	2.0	-	4.0	6							3			A-3
B-35	4	6.0	-	8.0	7							2			A-3
B-36	6	13.5	-	15.0	30							5			A-3
B-37	3	4.0	-	6.0	23							1			A-3
B-38	1	0.0	-	2.0	6							5			A-3
B-39	2	2.0	-	4.0	6							2			A-3
B-40	5	8.0	-	10.0	23							3			A-3
B-41	4	6.0	-	8.0	22							2			A-3
B-42	1	0.0	-	2.0	6							2			A-3
B-43	2	2.0	-	4.0	5							3			A-3
B-44	5	8.0	-	10.0	23							2			A-3

SUMMARY OF LABORATORY TEST RESULTS

JEA SIPS Deerwood Route Water Main
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-45	4	6.0	-	8.0	17							3			A-3
B-46	3	4.0	-	6.0	2							3			A-3
B-47	1	0.0	-	2.0	5							3			A-3
B-48	6	13.5	-	15.0	26							1			A-3
B-49	3	4.0	-	6.0	7							2			A-3
B-50	1	0.0	-	2.0	4							2			A-3
B-51	2	2.0	-	4.0	3							1			A-3
B-52	1	0.0	-	2.0	7							4			A-3
B-53	1	0.0	-	2.0	26	8.7						12			A-2-4/A-8
B-53	6	13.5	-	15.0	38	9.5						14			A-2-4/A-8
B-54	3	4.0	-	6.0	5							2			A-3
B-55	1	0.0	-	2.0	5							2			A-3
B-56	3	4.0	-	6.0	32							1			A-3
B-57	2	2.0	-	4.0	24							1			A-3
B-58	1	0.0	-	2.0	13							11			A-2-4
B-59	3	4.0	-	6.0	28	6.9						14			A-2-4/A-8
B-59	5	8.0	-	10.0	33	9.2						16			A-2-4/A-8
B-60	5	8.0	-	10.0	21							1			A-3
B-61	4	6.0	-	8.0	25							2			A-3
B-62	4	6.0	-	8.0	14							1			A-3
B-63	6	10.0	-	15.0	27							1			A-3
B-64	1	0.0	-	2.0	6							3			A-3
B-65	4	6.0	-	8.0	3							1			A-3
B-66	2	2.0	-	4.0	5							2			A-3

SUMMARY OF LABORATORY TEST RESULTS

JEA SIPS Deerwood Route Water Main
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-67	3	4.0	-	6.0	2							3			A-3
B-68	6	13.5	-	15.0	26							1			A-3
B-69	3	4.0	-	6.0	8							1			A-3
B-70	3	4.0	-	6.0	24							1			A-3
B-71	4	6.0	-	8.0	26							3			A-3
B-72	2	2.0	-	4.0	61	17.8						18			A-2-4/A-8
B-73	2	2.0	-	4.0	64	19.1						16			A-2-4/A-8
B-74	1	0.0	-	2.0	30	7.3						13			A-2-4/A-8
B-75	5	8.0	-	10.0	32							2			A-3
B-76	6	13.5	-	15.0	26							2			A-3
B-77	4	6.0	-	8.0	14							1			A-3
B-78	5	8.0	-	10.0	25							1			A-3
B-79	3	4.0	-	6.0	6							1			A-3
B-80	3	4.0	-	6.0	6							2			A-3
B-81	4	6.0	-	8.0	26							11			A-2-4
B-82	3	4.0	-	6.0	5							1			A-3
B-82	5	8.0	-	10.0	6							1			A-3
B-83	2	2.0	-	4.0	16							2			A-3
B-84	2	2.0	-	4.0	41	5.9						9			A-3/A-8
B-85	3	4.0	-	6.0	25	4.8						16			A-2-4
B-86	4	6.0	-	8.0	35	5.5						12			A-2-4/A-8
B-87	5	8.0	-	10.0	24							4			A-3
B-89	1	0.0	-	2.0	8		100	100	99	91	29	3			A-3
B-89	3	4.0	-	6.0	5		100	100	99	92	27	1			A-3

SUMMARY OF LABORATORY TEST RESULTS

JEA SIPS Deerwood Route Water Main
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-89	5	8.0	-	10.0	6		100	100	99	91	24	1			A-3
B-89	7	18.5	-	20.0	27		100	100	100	94	31	2			A-3
M-1	4	6.0	-	8.0	35	7.1						6			A-3/A-8
M-1	5	8.0	-	10.0	25	3.6						5			A-3
M-1	8	14.0	-	16.0	27							3			A-3
M-2	2	2.0	-	4.0	23							3			A-3
M-2	6	10.0	-	12.0	25	1.7						4			A-3
M-2	8	14.0	-	16.0	24							5			A-3
M-3	3	4.0	-	6.0	24							1			A-3
M-3	8	14.0	-	16.0	27							2			A-3
M-3	11	20.0	-	2.0	24							4			A-3
M-4	2	2.0	-	4.0	25							4			A-3
M-4	7	12.0	-	19.0	24							4			A-3
M-4	10	18.0	-	20.0	21							1			A-3
M-5	2	2.0	-	4.0	5							3			A-3
M-5	8	14.0	-	16.0	35							5			A-3
M-5	12	22.0	-	24.0	29							4			A-3
M-6	3	4.0	-	6.0	5							2			A-3
M-6	8	14.0	-	16.0	26							2			A-3
M-6	11	20.0	-	22.0	35							4			A-3
M-7	2	2.0	-	4.0	5							4			A-3
M-7	7	12.0	-	14.0	7							1			A-3
M-7	10	18.0	-	20.0	27							1			A-3
M-8	4	6.0	-	8.0	6							3			A-3

SUMMARY OF LABORATORY TEST RESULTS

JEA SIPS Deerwood Route Water Main
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	
M-8	6	10.0	-	12.0	4							1			A-3
M-8	9	16.0	-	18.0	27							1			A-3
D-1	5	8.0	-	10.0	27	3.6						5			A-3
D-1	9	16.0	-	18.0	39	3.0						9			A-3
D-1	10	18.0	-	20.0	28	3.8						6			A-3
D-1	18	55.0	-	60.0	38							44	40	21	A-6
D-2	2	2.0	-	4.0	7							3			A-3
D-2	8	14.0	-	16.0	25	2.5						4			A-3
D-2	10	18.0	-	20.0	30	2.7						4			A-3
D-2	17	50.0	-	55.0	28							39	30	11	A-6
D-3	7	12.0	-	14.0	25	0.5						3			A-3
D-3	9	16.0	-	18.0	29	2.6						3			A-3
D-3	15	40.0	-	45.0	28							19			A-2-6
D-4	5	8.0	-	10.0	27							1			A-3
D-4	8	14.0	-	16.0	28	1.6						2			A-3
D-4	10	18.0	-	20.0	25	3.8						6			A-3

Environmental Corrosion Test Results

ENVIRONMENTAL CORROSION TEST RESULTS

JEA SIPS Deerwood Route Water Main
Jacksonville, Florida

Sample No.	Depth (ft)	Natural Moisture Content (%)	pH (S.U.)[a]	Resistivity (ohm-cm)	Redox Potential (mV)	Sulfides
B-2	8.0 - 15.0	17.5	7.3	24,300	BRL*	Positive
B-4	0.0 - 4.0	4.1	7.2	16,540	BRL	Negative
B-6	8.0 - 15.0	3.5	7.1	58,500	BRL	Negative
B-8	0.0 - 4.0	3.1	6.7	8,800	BRL	Negative
B-10	2.0 - 6.0	17.3	6.8	6,100	BRL	Negative
B-12	0.0 - 4.0	22.8	6.7	5,700	BRL	Negative
B-14	4.0 - 8.0	2.7	6.9	27,240	BRL	Negative
B-16	2.0 - 6.0	17.9	7.1	21,800	BRL	Negative
B-18	0.0 - 4.0	17.9	7.3	17,000	BRL	Negative
B-20	4.0 - 8.0	4.8	7.2	25,600	54	Negative
B-22	5.0 - 6.0	17.8	7.2	13,860	40	Negative
B-24	4.0 - 5.0	23.5	5.4	21,730	230	Negative
B-26	1.0 - 2.0	19.6	6.7	9,500	110	Negative
B-28	3.0 - 4.0	17.1	6.6	4,948	130	Negative
B-30	4.0 - 5.0	25.6	6.9	12,100	150	Positive
B-32	5.0 - 6.0	4.7	8.9	17,600	170	Positive
B-34	3.0 - 4.0	16.1	8.5	16,150	130	Positive
B-36	1.0 - 2.0	14.3	8.9	20,100	130	Negative
B-38	2.0 - 3.0	8.4	8.8	17,400	120	Negative
B-40	1.0 - 2.0	16.5	8.4	40,700	130	Negative
B-42	2.0 - 3.0	17.5	8.3	20,310	140	Negative
B-44	4.0 - 8.0	2.0	8.7	31,570	150	Negative
B-46	6.0 - 10.0	2.1	6.4	24,500	150	Negative
B-48	6.0 - 10.0	16.3	8.8	17,590	190	Negative
B-50	2.0 - 6.0	17.7	8.7	12,530	190	Negative
B-52	6.0 - 10.0	6.4	8.6	21,200	210	Negative
B-54	0.0 - 4.0	15.3	7.7	22,600	BRL	Negative
B-56	6.0 - 10.0	13.5	8.2	36,900	140	Negative
B-58	2.0 - 6.0	4.0	4.9	19,280	170	Negative
B-60	4.0 - 8.0	5.3	7.1	24,850	190	Negative
B-61	0.0 - 4.0	17.5	5.9	61,500	200	Negative
B-64	2.0 - 6.0	17.3	7.2	11,000	260	Negative
B-66	4.0 - 8.0	3.9	7.9	29,490	210	Negative
B-68	2.0 - 6.0	4.8	8.2	31,700	200	Negative
B-70	0.0 - 4.0	19.2	6.7	3,600	290	Negative
B-72	4.0 - 8.0	27.0	7.1	21,590	320	Negative
B-74	4.0 - 8.0	18.7	6.7	18,180	370	Negative
B-76	0.0 - 4.0	10.5	7.5	31,310	270	Negative
B-78	0.0 - 4.0	5.3	7.8	30,300	260	Negative
B-80	0.0 - 4.0	17.5	8.1	26,510	240	Negative
B-81	2.0 - 6.0	11.6	7.9	13,210	230	Negative
B-83	2.0 - 6.0	17.3	4.4	10,550	360	Negative
B-88	0.0 - 4.0	13.3	7.9	3,080	230	Negative

Notes: [a]S.U. : pH standard units
*BRL : Below Reporting Limit

ENVIRONMENTAL CORROSION TEST RESULTS

JEA SIPS Deerwood Route Water Main
Beach Boulevard, Gate Parkway, and JTB Crossings
Jacksonville, Florida

Sample No.	Depth (ft)	pH (S.U.)[a]	Resistivity (ohm-cm)	Sulfates (ppm)	Chlorides (ppm)	FDOT Environmental Classification (Substructures)	
						Steel	Concrete
M-1	2.0 - 6.0	8.9	15,740	U	10	Slightly Aggressive	Slightly Aggressive
M-2	4.0 - 8.0	8.9	22,430	U	25	Slightly Aggressive	Slightly Aggressive
M-3	6.0 - 10.0	8.9	10,530	6	25	Slightly Aggressive	Slightly Aggressive
M-4	6.0 - 10.0	9.0	10,260	6	40	Slightly Aggressive	Slightly Aggressive
M-5	6.0 - 10.0	9.1	25,600	U	25	Slightly Aggressive	Slightly Aggressive
M-6	6.0 - 10.0	8.8	23,040	U	25	Slightly Aggressive	Slightly Aggressive
M-7	8.0 - 12.0	7.7	28,520	U	25	Slightly Aggressive	Slightly Aggressive
M-8	2.0 - 6.0	7.1	34,350	U	25	Slightly Aggressive	Slightly Aggressive
D-1	12.0 - 16.0	4.8	6,990	102	25	Extremely Aggressive	Extremely Aggressive
D-2	10.0 - 14.0	9.3	10,840	U	10	Slightly Aggressive	Slightly Aggressive
D-3	6.0 - 10.0	9.4	6,820	3	25	Slightly Aggressive	Slightly Aggressive
D-4	2.0 - 6.0	6.3	39,200	U	10	Moderately Aggressive	Slightly Aggressive

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 – The soil penetration test borings were made in general accordance with ASTM D-1586, "Penetration Test and Split-Barrel Sampling of Soils". The borings were advanced by continuous driving the split spoon sampler to the depths of 10 to 30 feet below the existing ground surface. Below the 10 to 30 feet and until boring termination depths, split spoon sampling was performed at a spacing of 5 feet. Bentonite drilling fluid was used below the ground water level to stabilize the sides and to flush the cuttings. At the sampling intervals, the drilling tools were removed and soil samples were obtained with a standard 1.4 inch I.D., 2.0 inch O.D., split-tube sampler. The sampler was first seated six inches and then driven an additional foot with blows of a 140 pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is designated the "Penetration Resistance". The penetration resistance, when properly interpreted, is an index to the soil strength and density. An automatic hammer was used with an assumed energy ratio of 0.8 (N_{80}). Representative portions of the soil samples, obtained from the sampler, were containerized and transported to our laboratory. The samples were then examined by a geotechnical engineer to confirm the 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 percent of weight of fines in the sample to the weight of the unwashed sample. This test was conducted in accordance with ASTM D1140.

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 ASTM D4318. 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.

pH - The pH is an expression of the concentration of dissociated hydrogen ions present in an aqueous solution. pH values range from 1 to 14, with values below 7 indicating acidic conditions and values above 7 indicating alkaline (basic) conditions. This test is performed using a calibrated electronic pH meter with a sensing probe. The meter is calibrated by immersing the probe in a solution with a known pH. The soil pH is determined by mixing equal weights of soil and distilled water and testing the supernatant solution with the pH probe. This test was conducted in accordance with FM 5-550.

FIELD AND LABORATORY TEST PROCEDURES

Soil Resistivity - Resistivity is a measure of the resistance to flow of electrical current through the soil. Resistivity, the inverse of conductivity, is measured in units of ohm-centimeters. This measurement is performed with a calibrated electronic conductivity/resistivity meter which is equipped with a sensing probe. The conductivity/resistivity of soil samples is conductivity/resistivity of the supernatant solution with the sensing probe. This test was conducted in accordance with FM 5-551.

Sulfate and Chloride Content - The sulfate (SO_4,$^{-2}$) and chloride (Cl^-) content of the site soils were determined and performed in general accordance with FM 5-552 for chloride ions in soils and FM 5-553 for sulfate ions in soils.