DUFFIELD
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July 26, 2013

Mr. Daniel Episcopo
State of Delaware – OMB/DFM
DHSS Herman Holloway Campus
1901 North DuPont Highway
Main Administration Building, Room 002
New Castle, DE 19720

RE: Project No. 9862.NA
Geotechnical Evaluation
Northeast State Service Center Retaining Wall
Wilmington, Delaware

Dear Mr. Episcopo:

Duffield Associates, Inc. (Duffield Associates) has completed our geotechnical evaluation of the retaining wall at the Northeast State Service Center on Jessup Street, in Wilmington, Delaware. This report summarizes the data obtained in the field and laboratory testing programs and includes recommendations for the design and construction of the currently proposed retaining wall. These services were performed in general accordance with our agreement, dated May 16, 2013 (State of Delaware Purchase Order Number STATE-0000182403).

To assist with this evaluation, Duffield Associates utilized the following documentation:

- A set of plans titled "Retaining Wall and Site Renovations" for the Northeast State Service Center, provided by Davis Bowen & Friedel, Inc., and dated April 22, 2013.
- Design meeting minutes for the pre-schematic design review of the Northeast State Service Center retaining wall/parking lot renovations, which took place on January 22, 2013.
- A drawing titled "Utility Surface Location Sketch," listing the utility locations as identified by SoftDig, dated May 1, 2013.

Based on our discussions with the project team and the information provided, we understand that the Northeast State Service Center property is separate from the adjacent parcels to the east by a retaining wall, with the adjacent parcels approximately 10 to 13 feet higher than the site parking lot. While no details related to the design or construction of the existing retaining wall are currently known, the stone masonry faced wall appears to be in a state of disrepair, and the wall is showing indications of lateral or tilting movement.

Several alternatives for repairing or replacing the wall have been considered, including construction a new retaining wall on the parking lot side of the existing structure. Duffield Associates performed an evaluation of the site soils to assist in the design of the new structure based on the referenced conceptual sketches prepared by Davis Bowen & Friedel.

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The wall is located on the eastern boundary of the Northeast State Service Center site. Subsurface utilities identified at the site in the vicinity of the retaining wall by MissUtilty of Delaware and Soft Dig included electrical and stormwater utilities run near the wall. The stormwater utility is reported to run parallel to the wall in the parking lot approximately 4 feet from the face of the wall. In addition to the utilities identified, it is reported that an apparent existing underground tank of unknown dimensions could be present adjacent to the retaining wall.

The field program performed during this phase of the project was limited to an evaluation of the soils along the base of the wall, the soil on the retained wall was not evaluated at this time.

## FIELD AND LABORATORY TESTING PROGRAM

On May 23, 2013, three Standard Penetration Test (SPT) borings (ASTM D 1586) were performed at the site along the base of the existing retaining wall. The test borings were extended to depths of approximately 14.2 to 17.1 feet below the existing grades. The test borings were located in areas accessible to a truck-mounted drilling rig and clear of existing utilities and apparent underground obstacles. The approximate test boring locations are indicated on the enclosed Test Boring Location Sketch.

The test borings were performed by CGC Geoservices, LLC, utilizing a truck-mounted Diedrich D-50 drill rig with hollow-stem augers. The locations of the test borings were estimated in the field by Duffield Associates' representative utilizing existing site features as a reference. Duffield Associates' representative was present to review the performance of the test borings. Test boring logs, which describe the conditions observed during the field exploration program, are enclosed. At completion of the drilling, the boreholes were backfilled with soil cuttings and capped with portland cement concrete. Additional settlement and softening of the soil replaced in the boreholes may occur, resulting in a depression or hole in the ground surface. Consequently, future maintenance and restoration of the site may be required.

Following completion of the field program, soil samples were returned to Duffield Associates' office. Seven moisture content (ASTM D 2216) and percent finer than a No. 200 sieve (ASTM D 1140) tests and one Atterberg limits test (ASTM D 4318) were performed on selected samples obtained from the test borings. Results of laboratory testing are indicated on the enclosed test boring logs.

## SUBSURFACE CONDITIONS

Based on the field program performed by Duffield Associates, the subsurface conditions observed along the base of the existing retaining wall beneath a surficial layer of bituminous concrete pavement can generally be described as layers of sand and silt soils derived from the in-place weathering of rock to the extent of the test borings. The weathered rock soils were generally observed to consist of loose to very dense density or medium stiff consistency, with the density generally increasing with depth until auger refusal was encountered in each of the test borings at depths ranging from 13.5 to 16.6 feet below the existing ground surface.

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In one test boring (TB-1) located at the southern end of the existing wall (where the wall is highest), a layer of apparently reworked fill soils were observed to extent to a depth of approximately 6 feet below the ground surface. The fill soils were generally observed to consist of silty sand soil material mixed with gravel and observed to be very loose to loose medium density. Additional areas of disturbed soils are considered likely due to previous construction activates at the site. The weathered rock soils encountered underlying the fill materials in this test boring were loose to medium density sands.

Apparent groundwater was encountered in each of the test borings performed at the site at depths ranging from 10.5 to 14.4 feet below the existing ground surface. Groundwater observations during the performance of the test borings are indicated on the test boring logs.

## DISCUSSION AND PRELIMINARY RECOMMENDATIONS

1. **Retaining Wall Design Considerations.** Based on our project discussions with Davis, Bowen & Friedel, we understand that the preferred remediation for the existing wall is to construct a new independent wall along the face of the existing structure. The initial concept for replacement wall include constructing a cantilevered retaining wall supported by H-pile columns cast into drilled shafts installed to depths conceptualized as 10 feet below the existing grade, with a maximum exposed wall height on the order of 12.7 feet at the southern end.

   As part of this construction, the upper portion of the existing wall may be removed. However, the majority of the wall is proposed to remain, with the void created between the two structures to be backfilled with a poorly graded stone (e.g., pea gravel).

   Based on the results of our field observations and analysis, it is Duffield Associates' opinion that the preliminary wall configuration will **not** result a system which provide a sufficient factor of safety to overturning. Additionally, due to depth to apparent bedrock (generally corresponding to the depth to refusal encountered in the test borings), it may not be feasible to increase the proposed drilled shafts to an embedment which would be needed to provide an appropriate factor of safety for the system (specified by the International Building Code as 1.5 for permanent earth retention systems).

   As a result through team discussions, we recommend that the design consider alternatives that could provide additional resistance to overturning within the currently identified site constraints, which included:

   - The limited available access on the upper portion of the wall based on the existing property lines (as identified by Davis, Bowen & Friedel).
   - The limited depth to which the below-grade elements can be installed without installing elements into the bedrock.
   - The safety and housekeeping concerns at the site, which require a smooth face along the exposed portion of the wall.

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Based on our recent discussion with Davis, Bowen & Friedel, we understand that the design team is now considering an easement into the adjacent property that would allow tiebacks to be constructed. It is Duffield Associates' opinion that a retaining wall constructed with tie backs could be designed based on the observed site condition. Another alternative which could be considered would be to construct additional below-grade elements along the face of the wall designed to develop a below-grade "dead man," while maintaining a smooth above-grade face of the wall.

The design of the wall should be based on the subsurface conditions encountered during our field program. A recommended soil profile, including assumed parameters for the retained soils, has been enclosed. In addition, due to the potential to affect the performance of the proposed wall, it is recommended that as existing retaining wall be removed as much as feasible during the construction to limit the influence on the proposed wall. At a minimum, the existing masonry block structure should be removed to half of its current height. A drainage system should be included in the wall design.

2. **Groundwater Observations.** Groundwater was encountered during this evaluation at depths ranging from approximately 10.5 to 14.4 feet below the existing ground surface. It is not anticipated that significant amounts of groundwater would be encountered during earthwork operations. Groundwater could be encountered during deeper excavations (e.g., drilled pier installation) or utility installations (e.g., tank removal operations) depending on the installation depths. Due to the presence of previously placed fill soils overlying weathered rock, localized perched water may be encountered during construction, which may require localized sumping during construction.

3. **Re-Use of On-Site Soils as Structural Fill.** On-site soils, free of organic material, topsoil, miscellaneous fill, debris and rock fragments in excess of 3 inches in their largest dimension, may be suitable as structural fill. Based on the conceptual designs, it appears as though there will be a limited amount of on-site materials that will be available for use as fill from the excavations.

   If sufficient quantities of suitable on-site soils are not available for structural fill based on the proposed cuts and fills, it may be possible to borrow the on-site sands of Stratum C from landscaped areas outside of the building pads and proposed paved areas. Imported borrow consisting of predominately granular soils conforming to the requirements of the Delaware Department of Transportation Standard Specifications Select Borrow, Type C could also be utilized.

4. **Structural Fill Placement and Review.** Structural fill utilized within the area of the proposed retaining wall building areas should be placed in loose lifts with a maximum thickness of 8 inches. Each lift of fill placed within a proposed construction area (defined as the area extending at least 5 feet beyond the wall perimeter) should be compacted to at least 95% of the maximum dry density, as determined by the Modified Proctor test (ASTM D 1557). The placement and compaction of structural fill should be monitored on a full-time basis by a qualified technician under the supervision of a geotechnical engineer.

5. **Seismic Design.** Based on subsurface conditions encountered during the field program, a Site Class "C," as defined by Table 1613.5.2 of the 2009 International Building Code, is recommended.

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6. **Site Grading.** Site grading should be designed to provide positive drainage away from the proposed retaining structures. Positive site drainage should be maintained throughout the construction activities to protect the exposed earthen slope.

7. **Excavation Safety.** All excavations should be performed in accordance with OSHA guidelines. Due to the current site grading, it is anticipated that the soils retained by the existing wall surficial will consist of reworked soils which should be characterized by OSHA CFR Part 1926 Excavation Standards as Type C soils. Should it be required, all temporary sheeting and shoring should be designed by a qualified engineer registered in the State of Delaware.

8. **Additional Geotechnical Evaluation.** Duffield Associates can provide additional recommendations, and revise the recommendations of this report (if appropriate) as the revised conceptual design is further developed.

These recommendations have been prepared according to generally accepted soil and foundation engineering standards and are based on the conditions encountered by the sampling performed at the site. It is noted that, although soil quality has been inferred from the interpolation of the sampling data, subsurface conditions beyond the sampling points are, in fact, unknown. As a result, these recommendations may require modifications based on the conditions encountered and exposed during construction excavation. Should any conditions encountered during construction differ from those described in this report, this office should be notified immediately in order to review and possibly modify these recommendations. The cost for construction review is <u>not</u> part of the existing agreement. This report applies solely to the size, type, and location of the structure described herein. In the event that changes are proposed, this report will not be considered valid unless the changes have been reviewed and the recommendations of this report modified and reapproved in writing by Duffield Associates, Inc.

We appreciate this opportunity to be of continued service to you. Should you have any questions concerning this evaluation, please do not hesitate to contact us.

Very truly yours,

DUFFIELD ASSOCIATES, INC.

Brian J. Devine, P.E.
Geotechnical Engineer

Hank Stack, P.E.
Field Services Division Director

BJD\WHS:
WORD\9862.00713-NESSC_RETAININGWALL.RPT

Enclosures: Site Location Sketch
Test Boring Location Sketch
Test Boring Logs (3)
Recommended Soil Profile
General Notes

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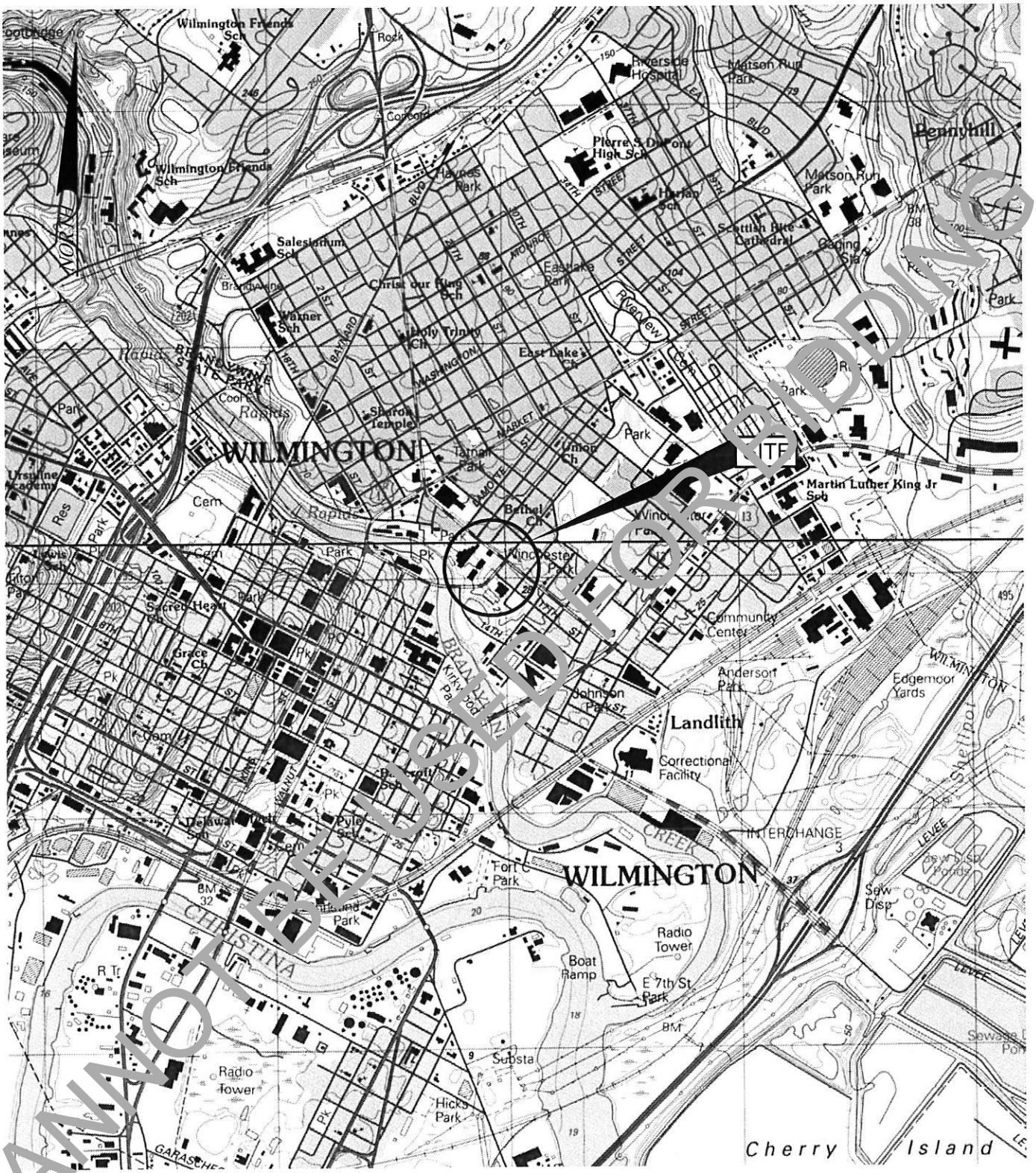


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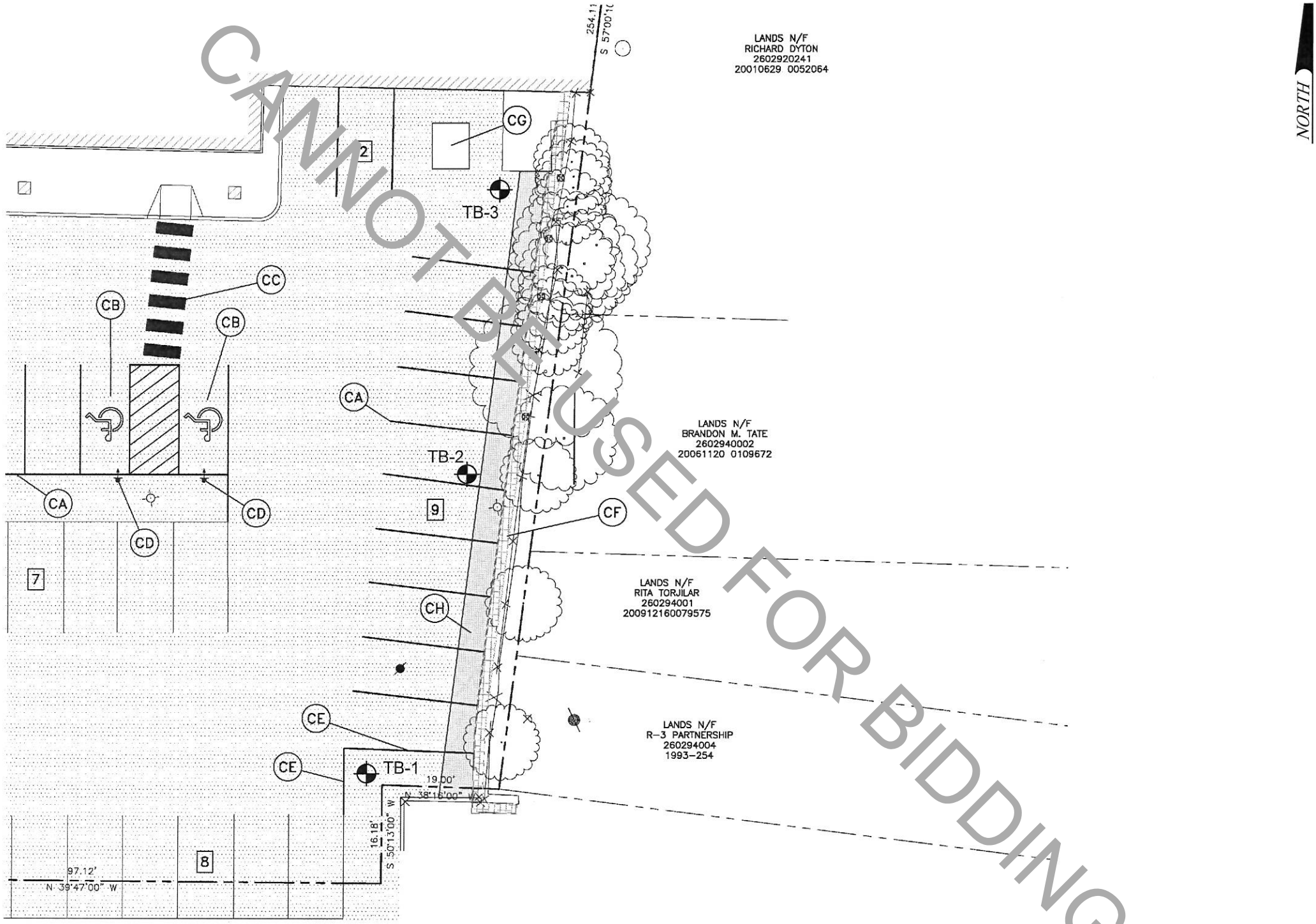
| | | | |
|---|---|---|---|
| DATE: 29 MAY 2013 | SITE LOCATION MAP | DESIGNED BY: WHS | DUFFIELD ASSOCIATES<br>Consultants in the Geosciences |
| SCALE: 1"=2000' | | DRAWN BY: RRN | 5400 LIMESTONE ROAD<br>WILMINGTON, DE 19808-1232<br>TEL. (302)239-6634<br>FAX (302)239-8485 |
| PROJECT. NO. 9862.NA | NE STATE SERVICE CENTER<br>RETAINING WALL | CHECKED BY: WHS | OFFICES IN PHILADELPHIA, PA<br>GEORGETOWN, DE AND<br>STONE HARBOR, NJ |
| SHEET: FIGURE_1 | WILMINGTON~NEWCASTLE COUNTY~DE | FILE: A-9862NA-01 | E-MAIL: DUFFIELD@DUFFNET.COM |

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NOTE:

THIS SKETCH IS ADAPTED FROM A DRAWING PROVIDED BY DAVIS, BOWEN, AND FRIEDEL

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# TEST BORING TB-1



Northeast Delaware State Service Center
Retaining Wall Replacement
Wilmington, Delaware
Project No: 9862.NA

Date Started : May 23, 2013
Date Completed : May 23, 2013
Logged by : RRN
Weather : M. Cloudy 80°
Driller/Agency : J. Feldman/CGCG

Drilling Equipment : Truck-Mounted Diedrich D-50
Drilling Methods : SPT (ASTM D1586, HSA/MR)

Sample Condition: Remolded

Water Levels: During Drilling; At completion

| Depth in feet | Layer Depth feet | GRAPHIC | USCS | DESCRIPTION | SAMPLES | Sample Number | Blows per 6 inches | Recovery (ft) | Moisture Content (%) | Percent Passing 200 Sieve | WATER LEVEL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | Bituminous Concrete Pavement | | | | | | | |
| | 0.5 | | | FILL: Ground fine to coarse aggregate base coarse and fine to coarse sand, little silt (dry) | | | | | | | |
| | 1.5 | | | POSSIBLE FILL: Brown, orange medium to coarse sand, little fine to coarse angular gravel, little silt (dry to moist) | | S-1 | 5-7-7 | 0.9 | | | |
| 2 | | | | | | | | | | | |
| 4 | | | | POSSIBLE FILL: Brown, orange medium to coarse sand, little fine to coarse angular gravel, little silt (dry to moist) | | S-2 | 2-2-2 | 0.4 | 10.6 | 8.3 | |
| 6 | 6.0 | | SM | WEATHERED ROCK: Orangish brown, gray fine to medium SAND and SILT, trace clay (moist) | | S-3 | 4-7-3 | 0.6 | 20.8 | 42.0 | |
| 8 | | | | | | | | | | | |
| | 8.5 | | | WEATHERED ROCK: Orangish blue-gray medium SAND and fine angular GRAVEL, lenses of orangish brown silt, little fine to medium sand, little clay (moist to wet) (Atterberg Limits: Liquid Limit=31, Plasticity Index=7) | | S-4 | 4-13-13 | 0.8 | 19.4 | 24.0 | ▽ |
| 10 | | | | | | | | | | | ▼ |
| | | | SP | WEATHERED ROCK: Orange and dark blue-gray medium SAND and fine angular GRAVEL, lenses of orangish brown, gray silt, little clay, little fine to medium sand (moist to wet) | | S-5A | 20-32-32 | 1.5 | | | |
| 12 | | | | WEATHERED ROCK: Varicolored, dark blue-gray micaceous, medium SAND, trace angular gravel (moist) (highly weathered gneiss cobble) | | S-5B | | | | | |
| | | | | NO RECOVERY | | S-6 | 50/.4 | 0.0 | | | |
| 14 | 14.2 | | | WEATHERED ROCK: Brown medium to coarse SAND and fine to coarse angular GRAVEL, some silt, little coarse hard fresh to slightly weathered blue granite cobbles | | S-6A | | 0.5 | | | |
| 16 | | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |

NOTES:
1. Test boring terminated at ± 14.2 feet below existing ground surface (b.e.g.s.) due to spoon refusal. Auger refusal at ± 13.5 feet b.e.g.s.
2. Wet-on-spoon conditions observed at ± 10.0 feet b.e.g.s. Groundwater observed through augers at ± 10.5 feet wit the augers at ± 12.5 feet.
3. Upon removal of the auger, the borehole was observed to be caved at 10.0 feet, with the water level at 10.0 feet b.e.g.s.
4. Soil descriptions performed in general accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

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# TEST BORING TB-2



Northeast Delaware State Service Center
Retaining Wall Replacement
Wilmington, Delaware
Project No: 9862.NA

Date Started : May 23, 2013
Date Completed : May 23, 2013
Logged by : RRN
Weather : M. Cloudy 80°
Driller/Agency : J. Feldman/CGCG

Drilling Equipment : Truck-Mounted Diedrich D-50
Drilling Methods : SPT (ASTM D1586, HSA/MR)

Sample Condition: Remolded

Water Levels: During Drilling; At completion

| Depth in feet | Layer Depth feet | GRAPHIC | USCS | DESCRIPTION | SAMPLES | Sample Number | Blows per 6 inches | Recovery (%) | Moisture Content (%) | Percent Passing 200 Sieve | WATER LEVEL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | Bituminous Concrete Pavement | | | | | | | |
| | 0.5 | | | FILL: Ground fine to coarse aggregate base coarse and fine to coarse sand, little silt (dry) | | | | | | | |
| | 1.2 | | SP | WEATHERED ROCK: Light orange brown fine to coarse SAND, little silt, little fine angular gravel, lenses of orange brown silt, little clay, little fine sand (moist to dry) | | S-1 | 5-6-8 | 1.2 | 13.1 | 24.9 | |
| 2 | | | | | | | | | | | |
| 4 | | | SP | WEATHERED ROCK: Light orange brown fine to coarse SAND, trace to little silt, little fine angular gravel, veins of orange brown silt, little clay, little fine sand (moist) | | S-2 | 10-13-13 | 1.3 | | | |
| 6 | | | | WEATHERED ROCK: Varicolored, light orange brown, blue, dark gray fine to coarse SAND, trace to little silt, little fine angular gravel, veins of orange brown silt, little clay, little fine sand (moist) | | S-3 | 17-17-21 | 1.2 | | | |
| 8 | 8.5 | | ML | WEATHERED ROCK: Varicolored stratified SILT, little clay, frequent lenses of medium orange, dark blue sand (moist to wet) (Atterberg Limits: Liquid Limit=37, Plasticity Index=12) | | S-4 | 2-3-5 | 1.5 | 24.4 | 51.6 | |
| 10 | | | | | | | | | | | |
| 12 | 12.0 | | SP | WEATHERED ROCK: Brown fine to coarse SAND, little silt, little fine angular gravel (wet) (coloration is likely brown due to oxidation from groundwater) | | S-5 | 22-22-24 | 0.9 | | | |
| 14 | | | | | | | | | | | |
| 16 | | | | WEATHERED ROCK: Varicolored blue, white, brown, medium to coarse sand and fine to coarse angular gravel, some silt (moist to dry) (highly weathered gneiss) | | S-6 | ---50-50/0.1 | 0.5 | | | |
| | 17.1 | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |

NOTES:
1. Test boring terminated at ± 17.1 feet below existing ground surface (b.e.g.s.) due to spoon refusal. Auger refusal at ± 16.6 feet b.e.g.s.
2. Wet-on-spoon conditions observed at ± 11.5 feet b.e.g.s. Groundwater observed through augers at ± 12.0 feet wit the augers at ± 12.5 feet.
3. Upon removal of the auger, the borehole was observed to be caved at 12.1 feet, with the water level at 12.1 feet b.e.g.s.
4. Soil descriptions performed in general accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

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# TEST BORING TB-3



Northeast Delaware State Service Center
Retaining Wall Replacement
Wilmington, Delaware
Project No: 9862.NA

Date Started : May 23, 2013
Date Completed : May 23, 2013
Logged by : RRN
Weather : M. Cloudy 80°
Driller/Agency : D. Wilson/CGCG

Drilling Equipment : Truck-Mounted Diedrich D-50
Drilling Methods : SPT (ASTM D1586, HSA/MR)

Sample Condition: Remolded
Water Levels: During Drilling

| Depth in feet | Layer Depth feet | GRAPHIC | USCS | DESCRIPTION | SAMPLES | Sample Number | Blows per 6 inches | Recovery (ft) | Moisture Content (%) | Percent Passing 200 Sieve | WATER LEVEL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | ASPHALT | | | | | | | |
| | 0.5 | | | FILL: Ground fine to coarse aggregate base coarse and fine to coarse sand, little silt (dry) | | | | | | | |
| | 1.0 | | | WEATHERED ROCK: Light orange brown fine to coarse SAND, some to little fine angular gravel, little silt, lenses of gray-orange silt, little to trace clay, trace fine to medium sand (moist to dry) | | S-1 | 3-4-6 | 0.8 | | | |
| 2 | | | | | | | | | | | |
| 4 | | | | WEATHERED ROCK: Light orange brown fine to coarse SAND, some to little fine angular gravel, little silt, lenses of gray-orange silt, little to trace clay, trace fine to medium sand (moist to dry) | | S-2 | 15-19-25 | 0.9 | | | |
| 6 | | | | WEATHERED ROCK: Light orange brown, black fine to coarse SAND, some to little fine angular gravel, little silt, lenses of gray-orange silt, little to trace clay, trace fine to medium sand (moist) | | S-3 | 10-14-20 | 0.7 | | | |
| 8 | | | SP | WEATHERED ROCK: Light orange brown, black fine to coarse SAND, some to little fine angular gravel, little silt, lenses of gray-orange silt, little to trace clay, trace fine to medium sand (moist) | | S-4A | 8-15-22 | 1.2 | 11.9 | 13.5 | |
| 10 | | | | WEATHERED ROCK: Varicolored, dark blue-black micaceous medium SAND (moist) (highly weathered gneiss cobble) | | S-4B | | | | | |
| 12 | | | | | | | | | | | |
| 14 | | | | WEATHERED ROCK: Light orange brown, black fine to coarse SAND, some to little fine angular gravel, little silt, veins of gray-orange silt, little to trace clay, trace fine to medium sand (moist) | | S-5 | 13-22-36 | 0.9 | 17.4 | 14.0 | ▼ |
| 16 | 16.3 | | | NO RECOVERY | | S-6 | 42-70/0.4 | 0.0 | | | |
| 20 | | | | | | | | | | | |

NOTES:
1. Test boring terminated at ± 16.3 feet below existing ground surface (b.e.g.s.) due to spoon refusal. Auger refusal at ± 15.8 feet b.e.g.s.
2. Wet-on-spoon conditions observed at ± 12.9 feet b.e.g.s. Groundwater observed through augers at ± 14.4 feet wit the augers at ± 15.0 feet.
3. Upon removal of the auger, the borehole was observed to be caved at 13.1 feet b.e.g.s. and dry.
4. Soil descriptions performed in general accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

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WILMINGTON, DELAWARE 19808
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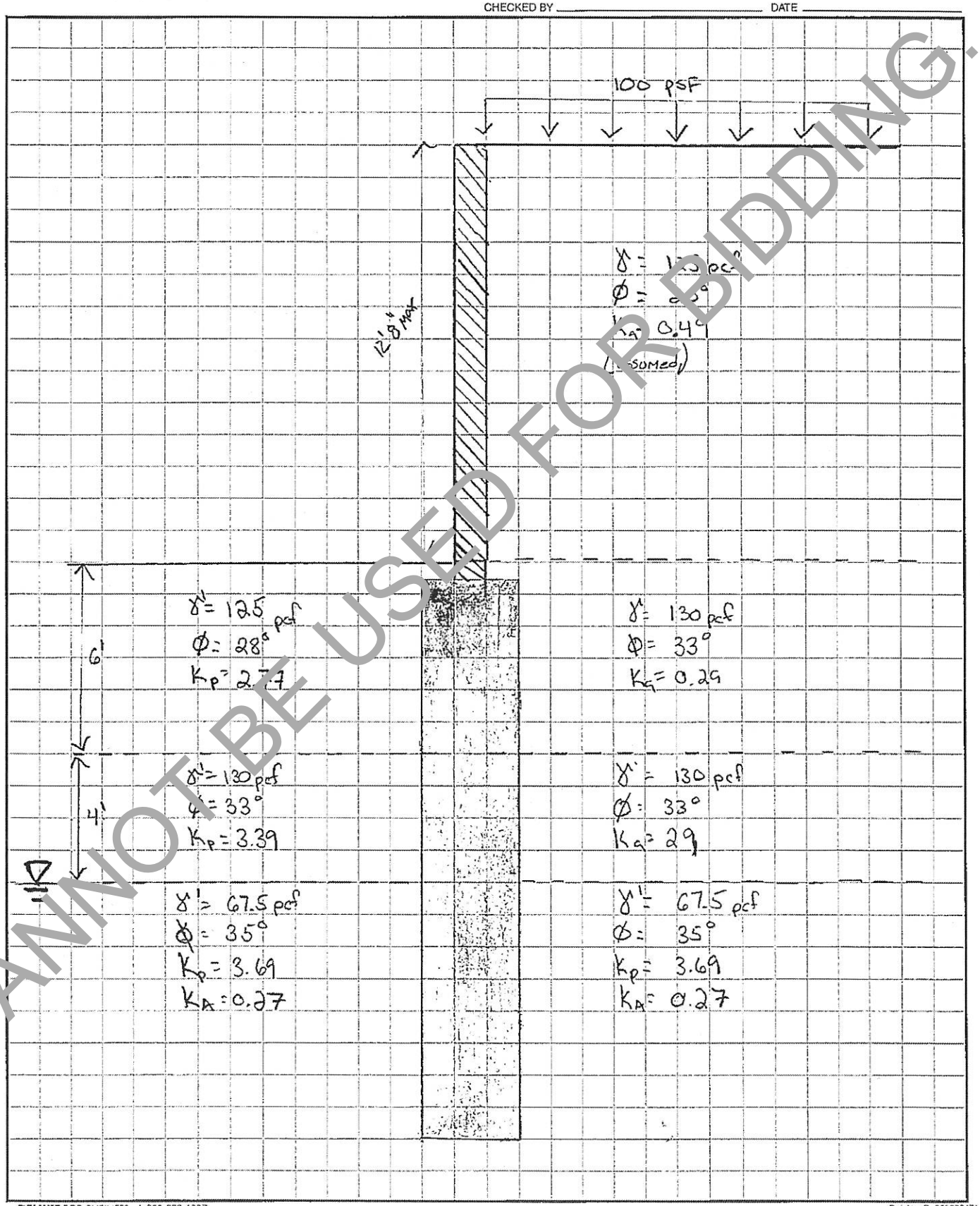
PROJECT NO. 9862.NA NAME NE SCL
RE Retaining Wall - Recommended Soil Profile
SHEET NO. 1 OF 1
CALCULATED BY BJD DATE 6/13
CHECKED BY DATE

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