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### Appendix A – Field Exploration
- Exhibit A-1 Site Location Map
- Exhibit A-2 Boring Location Plan
- Exhibit A-3 Field Exploration Description
- Exhibits A-4 to A-5 Boring Logs B-1 to B-2

### Appendix B – Supporting Documents
- Exhibit B-1 General Notes
- Exhibit B-2 Unified Soil Classification System
December 14, 2015

Renewable Water Resources (ReWa)
561 Mauldin Road
Greenville, South Carolina 29607

Attn: Mr. Ryan Philman, PE

Re: Geotechnical Engineering Report
Lakeside Pump Station
Greenville, South Carolina
Terracon Project No. 86155064

Dear Mr. Philman:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our Proposal No. P86150350, dated October 30, 2015. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,

Terracon Consultants, Inc.

Zhen Liu, Ph.D., E.I.T.
Staff Geotechnical Engineer

Nitin Dudani, P.E.
Senior Geotechnical Engineer

Enclosures
cc: 1 – Client (PDF)
1 – File
1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for the proposed development of Lakeside Pump Station located at 130 Lakeside Road in Greenville, South Carolina. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- foundation design and construction
- lateral earth pressure
- earthwork

Our geotechnical engineering scope of work for this project included the advancement of two borings in the wet well area to 7 ½ feet each.

Logs of the borings along with a Site Location Map and Boring Location Plan are included in Appendix A of this report. Descriptions of the field exploration and laboratory testing are included in their respective appendices.

2.0 PROJECT DESCRIPTION

2.1 Project Description

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site layout</td>
<td>Refer to the Boring Location Plan (Exhibit A-2 in Appendix A)</td>
</tr>
<tr>
<td>Structures</td>
<td>The project will include a wet well and an adjacent value vault and access walkways built as an integral concrete structure. We have assumed that the wet well will have a depth of about 20 feet below the existing ground surface.</td>
</tr>
<tr>
<td>Construction type</td>
<td>The structures and wet well will be reinforced concrete.</td>
</tr>
<tr>
<td>Maximum loads</td>
<td>Not provided</td>
</tr>
<tr>
<td>Maximum allowable settlement</td>
<td>1-inch (assumed)</td>
</tr>
</tbody>
</table>
### 2.2 Site Location and Description

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>The site is located at the northeast of the water treatment plant off of Lakeside Road in Greenville, SC.</td>
</tr>
<tr>
<td>Existing improvements</td>
<td>The existing treatment plant consists of a one-story building and wet well as well as underground piping.</td>
</tr>
<tr>
<td>Current ground cover</td>
<td>Asphalt pavement and grass at the proposed wet well.</td>
</tr>
<tr>
<td>Existing topography</td>
<td>Site is relatively flat in the area of the new wet well.</td>
</tr>
</tbody>
</table>

### 3.0 SUBSURFACE CONDITIONS

#### 3.1 Geology

The project site is located within the Piedmont Physiographic Province of South Carolina, an area underlain by ancient igneous and metamorphic rocks. The topography and relief of the Piedmont has developed from differential weathering of the igneous and metamorphic bedrock. The residual soils in this area are the product of in-place chemical weathering of rock. The typical residual soil profile consists of clayey soils near the surface where soil weathering is more advanced, underlain by sandy silts and silty sands that generally become harder with depth to the top of parent bedrock.

The boundary between soil and rock is not sharply defined due to variations in weathering and the presence of soft rock. The transition zone is locally termed as “partially weathered rock”. Partially weathered rock is defined for engineering purposes as residual material that can be drilled with soil boring methods, but exhibits standard penetration test (SPT) N-values exceeding 100 blows per foot (bpf). The depth to partially weathered rock occurs at irregular depths due to variations in degree of weathering and variations in the material composition of the rock.
3.2 **Typical Subsurface Profile**

Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Approximate Depth to Bottom of Stratum (feet)</th>
<th>Material Encountered</th>
<th>SPT N value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratum 1</td>
<td>3</td>
<td>Fill – Silty sand</td>
<td>10</td>
</tr>
<tr>
<td>Stratum 2</td>
<td>7 ½</td>
<td>Partially weathered rock – Silty sand</td>
<td>&gt; 100</td>
</tr>
</tbody>
</table>

Conditions encountered at the boring location are indicated on boring log. Stratification boundaries on the boring log represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Further details of the boring can be found on the boring log in Appendix A of this report.

3.3 **Groundwater Conditions**

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed within the borings.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. In addition, perched water could develop in sand seams and layers overlying lower permeability clay soils following periods of heavy or prolonged precipitation. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

4.0 **RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION**

4.1 **Geotechnical Considerations**

The subsurface data indicate that the subject site is generally suited for the proposed construction of the planned wet well structure, the primary component of the planned pump station. However, bedrock excavation needs to be considered prior to construction of the pump station upgrade project if the depth of pump station is higher than 7 ½ ft.

These items have been discussed in the following sections of this report. Further, we have provided geotechnical design recommendations for foundations and retaining walls and earthwork activities.
4.2  Excavations

4.2.1 Excavation Conditions
The depth of the proposed wet well structure is not available during the writing of this report. With an assumed depth of 20 feet, the construction will require excavation through fill soils, and partially weather rock. Bedrock excavation will be required if the depth is over 7 ½ ft.

Normally, partially weathered rock (material that the auger drilling was able to penetrate) can be excavated by ripping with a CAT D-8 equipped with a single tooth ripper or with a CAT 325 tracked excavator.

We recommend that difficult excavation materials be defined in terms of equipment performance as follows:

- **Mass Rock** – any material which cannot be excavated with a single tooth ripper drawn by a crawler tractor having a minimum draw pull rated at not less than 56,000 lbs. (CAT D-8 or equivalent) and occupying an original volume of at least 1 cubic yard or more.

- **Trench Rock** – any material which cannot be excavated with a track mounted backhoe with a bucket curling force of not less than 20,760 lbs. (CAT 325 or equivalent) and occupying an original volume of at least ½ cubic yard or more.

Mass excavations and other excavations required for construction of this project must be performed in accordance with the United States Department of Labor, Occupational Safety and Health Administration (OSHA) guidelines (29 CFR 1926, Subpart P, Excavations) or other applicable jurisdictional codes for permissible temporary side-slope ratios and/or shoring requirements. The OSHA guidelines require daily inspections of excavations, adjacent areas and protective systems by a “competent person” for evidence of situations that could result in cave-ins, indications of failure of a protective system, or other hazardous conditions.

Construction site safety is the sole responsibility of the contractor who controls the means, methods and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean that Terracon is assuming any responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

4.2.2 Groundwater Control
Groundwater is not observed with the borings, however, groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. To facilitate groundwater removal during construction after the completion of the excavation, the excavation bottom should generally be sloped to the sump points to collect the inflowing water. To aid in maintaining the excavation bottom in a generally dry condition, we recommend slightly over excavating the area and covering it with a layer of
open-graded crushed such as #57 stone for the excavation above bedrock. The thickness of the stone will be dependent on the roughness of the excavation bottom but should be a minimum of about 12 inches deep. The stone will serve as a drainage media and provide a somewhat dry and level surface to construct the base slab.

### 4.2.3 Temporary Shoring/Sloping

The excavation walls cut into the site soils are expected to be unstable unless adequate sloping is provided. The contractor should be aware that the slope inclinations should in no case exceed those specified in local, state, or federal safety regulations; e.g., OSHA Safety and Health Standard for Excavation, 26 CFS Part 126 or successor regulations. Site safety and the means, methods and sequencing of construction operations are the sole responsibility of the contractor.

Given the anticipated excavation depth, sloping of the excavation side walls may not be practical. Therefore, the contractor will need to consider supporting the excavation walls by temporary shoring, either solely or in conjunction with sloping. Excavation support can be achieved by a number of methods including tied-back soldier piles (set in holes cored in the rock) and timber or shot-crete lagging or an internally braced system.

The earth pressure magnitude and distribution on a tie-back retaining structure differs from earth pressures calculated with equivalent fluid pressures for typical retaining walls. To account for the pressures of the retained earth, we recommend that the support system design assume that the soils behind the bracing system will apply a trapezoidal stress distribution based on the excavation depth and the soil’s shear strength. In the table below, we have provided design parameters representing the physical properties of the various soil layers within the excavation zone and the likely depth of embedment of the shoring system. The system can be designed based on these soil parameters. The lateral pressures developed by heavy equipment, stored material, stockpiles soils, existing building foundations, etc., near the top of the excavation must be added to the lateral soil stresses to determine the horizontal loads which must be resisted.
### Depth, ft. | Soil Type | Total Unit Weight, pcf | Internal Friction Angle, Φ | Cohesion, psf |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Existing Fill and Residual</td>
<td>110</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>7 ½</td>
<td>Partially Weathered Rock (PWR)</td>
<td>110</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Up to 20</td>
<td>Bedrock</td>
<td>135</td>
<td>-</td>
<td>3,000</td>
</tr>
</tbody>
</table>

Notes:
1. Soil parameters were estimated using Standard Penetration Test data and published correlations of shear strength of sands. We note there could be a potential scatter of ± 30 percent in soil parameters given the range of consistency within each layer.
2. The total unit weight would be reduced by the unit weight of water to calculate the effective value below the groundwater level.

Determination of the lateral earth pressures on a potential temporary earth retaining system is beyond the scope of this exploration, but we can perform these calculations, if authorized and provided with information about the locations and depths of proposed excavation limits and the anticipated loads supported by the retained soils (if any).

We recommend that a specialty contractor with at least ten years of experience in this field design the retaining system. The contractor’s design should be subject to the review of the civil and geotechnical engineer before its implementation in the field.

We recognize that the contractor may consider sloping the upper portion of the excavation side walls in lieu of complete shoring/bracing. If so, the contractor should recognize that the majority of the slope would be comprised of very soft to stiff silts (top 5 feet). These materials are very erodible and have poor support characteristics.

#### 4.3 Earthwork

The following presents recommendations for site preparation, subgrade preparation and placement of engineered fills on the project. The recommendations presented for design and construction of earth supported elements including foundations and slabs are contingent upon following the recommendations outlined in this section.

Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.
4.3.1 Site Preparation
After the existing pavements have been razed, any topsoil, asphalt, stone base, remnants of previous construction (remaining foundations, concrete, rubble, and the like) and any other unsuitable materials should be stripped and removed from the construction area. The stripping should extend at least 5 feet beyond the construction limits. Once the contractor’s stripping activities nears completion, we recommend that our representative observe the subgrade to identify any remaining pockets of organics or unsuitable material that should be removed.

4.3.2 Subgrade Preparation
After stripping, the exposed subgrades in the at-grade areas and areas receiving fill should be proofrolled. Any cut areas should be proofrolled after they have been excavated to their proposed subgrade levels. Proofrolling should be performed with a heavily loaded tandem axle dump truck or with similar approved construction equipment under the observation of the Terracon geotechnical engineer. If conditions are found to be unstable, the subgrade should be undercut to soils that would provide a firm base for the compaction of the structural fill. The undercut soils should be replaced with compacted structural fill, placed in thin lifts. Mass fill placement may commence after proofrolling has been completed and the subgrade repaired as necessary.

4.3.3 Material Types
Engineered fill should meet the following material property requirements:

<table>
<thead>
<tr>
<th>Fill Type</th>
<th>USCS Classification</th>
<th>Acceptable Location for Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sands, silty sand, and clayey sand</td>
<td>SW, SM and SC (Fines less than 40 percent)</td>
<td>All at-grade areas</td>
</tr>
<tr>
<td>Low to high plasticity silts and clays</td>
<td>CL/CH ML/MH</td>
<td>Not Recommended</td>
</tr>
<tr>
<td>Clean sands</td>
<td>SW</td>
<td>Confined backfill areas (behind retaining walls and around drainage structures)²</td>
</tr>
<tr>
<td>Well graded sand and gravels</td>
<td>GW</td>
<td>Confined backfill areas (behind retaining walls and around drainage structures)³</td>
</tr>
<tr>
<td>Open-graded aggregates</td>
<td>SCDOT #57 or similar material</td>
<td>Confined backfill areas (behind retaining walls and around drainage structures)³</td>
</tr>
<tr>
<td>On-Site Soils</td>
<td>Varies</td>
<td>The on-site soils, including the existing uncontrolled fill material, typically appear suitable for use as fill; however, they will be increasingly wet with depth and should be expected to have a moisture content well above that consistent with structural fill compaction several feet above the groundwater table. Soils within these depths will require substantial drying to compact it into a stable mass.</td>
</tr>
</tbody>
</table>

² Confined to areas that are fully contained by retaining walls or other structural elements.
³ Confined to areas that are partially contained by retaining walls or other structural elements.
Fill Type ¹ | USCS Classification | Acceptable Location for Placement
--- | --- | ---
1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.
2. Use of clean sand as backfill in confined backfill areas requires it be placed and compacted in thin lifts to avoid post construction settlement and void formation.
3. Use of sand and gravel or open-grade aggregates as backfill in confined backfill areas requires it be separated from adjacent finer grained soils by a non-woven, filter fabric to limit fines migration and void formation.

### 4.3.4 Compaction Requirements

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fill Lift Thickness</td>
<td>9-inches or less in loose thickness</td>
</tr>
<tr>
<td>Compaction Requirements ¹</td>
<td>95% of the material's maximum standard Proctor dry density (ASTM D 698)</td>
</tr>
<tr>
<td>Moisture Content Granular Material ²</td>
<td>Workable moisture levels</td>
</tr>
</tbody>
</table>

1. We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

### 4.3.5 Permanent Earth Slopes

We have not performed specific slope stability analysis for this project. Based on the site soils and the provided grading recommendations herein, we recommend that permanent fill slopes be inclined no steeper than 3H:1V. A flatter inclination is more desirable if the slopes will contain marginal materials such as topsoil or organics. We should note that lawn areas constructed on slopes generally steeper than 3H:1V present maintenance problems with motorized equipment especially for taller slopes. This should be considered when landscaping plans are developed.

We recommend that all buildings have a minimum setback of 10 feet from the crest of any slope and that curbs be setback at least 3 feet. Storm sewers should not be located at the crest of fill slopes since leaking pipes or overtopping of inlets may cause maintenance problems or slope instability.

### 4.3.6 Pipe and Structure Bedding

The boring B-1 encountered loose to very dense silty sand within the depth of 7 ½ ft. To improve the support conditions, we recommend that just below the pipe/structure invert these
materials be removed and replaced with a layer of open graded stone such as #57 stone to provide a more firm foundation to support them. The actual depth of the stone should be determined in the field based on the conditions exposed by the excavation, but would likely be on the order of ½ foot to about 1-1/2 feet for the various pipes. If the City or the manufacturer’s bedding requirements for the various types of piping/structures are more extensive than those mentioned, the more stringent should be followed.

For the connecting structures (the overflow structure, valve vault, etc.), the depth of stone required to stabilize the foundation subgrade may be on the order of 1½ to 2 feet. We recommend the contractor should tamp the stone into the subgrade with a trackhoe bucket to displace and densify the subgrade soils. As such, some materials may be lost in the subgrade material.

4.4 Foundation Recommendations

4.4.1 Structural Mat Foundation
The wet well structure will be supported by a concrete mat foundation bearing on bedrock. We recommend a 1±-foot layer of #57 stone placed below the mat foundation to provide a more even working surface and for drainage purposes. We have not been provided with the structural loads associated with the wet well structure. However, a minimum subgrade reaction modulus of 150 pci should be used for the mat design, accounting for the layer of stone.

We recommend that all foundation excavations be evaluated by the geotechnical engineer prior to placement of steel and concrete. The bottom of the foundation excavations should also be clean and free of any loose soil, mud, or debris prior to placing concrete.

4.4.2 Uplift Resistance
The soil backfill placed above the foundation mat, as well as the weight of the structure, can be used to resist the buoyancy forces experienced by the structure. The volume of the soil mass available for uplift restraint includes the mass directly above the edge of the mat plus that contained within the wedge bounded by a vertical line and a line projected at a $10^\circ$ angle with the vertical, both originating from the top outside edge of the mat. The unit weight of 110 pcf and 150 pcf can be used for the soil and concrete, respectively, in calculating the vertical restraint. These values should be reduced by the unit weight of water (62.4 pcf) below the groundwater level. As groundwater was encountered in each boring between 7 and 7.5 feet below the existing grade. The structure should be protected from excessive hydrostatic uplift. If adequate dead load is not available to resist the maximum buoyant condition (an empty structure), it should be protected from excessive uplift loading by using a crushed stone drainage blanket beneath the mat connected to flap valves in the structure bottom. The crushed stone surface beneath the structure’s bottom should be protected (covered) by a heavy impermeable membrane so that concrete will not penetrate into the drainage blanket. Rock anchors may also be used to resist excessive uplift loads.
4.4.3 Shallow Foundations for IPA Building and Chemical Feed Tank

Based on the boring data, IPA building and Chemical Feed Tank can be supported on conventional spread footings bearing on the native soils if separated by a 1-foot layer of newly placed and properly stone base. Footings bearing on these materials may be designed for a maximum net allowable soil bearing pressure of 2,000 pounds per square foot (psf). The foundations should bear a minimum of 24 inches below external grades for protection against frost penetration and as a bearing capacity requirement.

The zone of new compacted stone base should be consistent with the diagram shown below. In essence, the compacted backfill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation, up to a lateral dimension of at least 6 feet beyond the footing perimeter. The overexcavation and backfill procedure is described in the adjacent figure.

Assuming that the foundation bearing conditions match our boring data, and the new fill placement and footing construction are performed in accordance with our recommendations, it is our opinion that total settlement caused by the weight of the crane column will be about 1 inch with a similar differential settlement.

The passive pressure of the soil surrounding the footing as well as the base friction between the footing and underlying soil can be used to resist the lateral loads of the structure. The passive pressure can be modeled to act as a fluid with an equivalent unit weight of 280 pcf. The use of this unit weight assumes that the backfill will consist of on-site excavated soil compacted to at least 95 percent of its standard Proctor minimum dry density. An ultimate friction coefficient between the concrete and soil of 0.30 can be used to calculate the resistance between these materials. A minimum safety factor of 2 should be used to determine the allowable values for the structural design.

4.4.4 Construction Recommendations

We recommend that the footing excavations be observed and tested by a Terracon representative to check that soil bearing conditions, compatible with the design value, are
achieved. The geotechnical engineer can provide appropriate recommendations, if unforeseen foundation problems develop during footing construction. Observations and testing would include hand auger borings and dynamic penetration testing and random probing.

The foundations bearing surfaces should be free of all loose or fall-in materials and debris. Concrete should not be placed on soils that have been softened by precipitation or frost heave. Foundation subgrades should be protected to prevent loss of subgrade strength because of exposure to the elements.

4.5 Lateral Earth Pressures

Reinforced concrete walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following tables. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls, except as noted.

The table entitled “Pressure Coefficients – Compacted Soil Backfill” is appropriate for the perimeter walls of the shallow below grade structures such as the overflow structure, meter vault, and the like. The earth pressure coefficients for the retaining wall design of the influent structure will be influenced by whether the temporary shoring system will be removed and the size of the excavation outside its perimeter walls. Presuming that the temporary shoring system will remain in-place, the native soil conditions will control the earth pressure coefficients as the temporary system will eventually fail and allow the full lateral pressure of the surrounding soil to be applied to the influent structure walls. The parameters contained in the table entitled “Pressure Coefficients – Native Soil” are appropriate for this condition. Improved earth pressure coefficients would be available by using sand and gravel or open-graded stone as retaining wall backfill; but for the sand and gravel or stone values to be valid, the backfill material must extend out from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active/at-rest and passive cases, respectively. The design parameters for this material type are provided in the table entitled “Pressure Coefficients – Granular Material”.

Regardless of the general backfill materials used or whether the temporary shoring system is removed, we recommend that the narrow portions of the annulus outside the influent structure walls be backfilled with a granular material such as coarse sand and gravel or open-graded stone, such as #57 stone, as such areas are difficult to access and compact soils placed within them. As a rule of thumb, any area that can be accessed with a 30-inch wide Rammax (or equal) roller should be filled with granular material. The granular material should be densified in-placed by rodding or vibrating it in 18-inch maximum lift thicknesses.
### Earth Pressure Coefficients – Compacted Soil Backfill

<table>
<thead>
<tr>
<th>Earth Pressure Conditions</th>
<th>Coefficient for Backfill Type</th>
<th>Equivalent Fluid Density (pcf)</th>
<th>Surcharge Pressure, $p_1$ (psf)</th>
<th>Earth Pressure, $p_2$ (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active ($K_a$)</td>
<td>0.33</td>
<td>36 $[78^{2.3}]$</td>
<td>$(0.33)S$ $[(0.33)S^2]$</td>
<td>$(36)H$ $[(78)H^{2.3}]$</td>
</tr>
<tr>
<td>At-Rest ($K_o$)</td>
<td>0.50</td>
<td>55 $[87^{2.3}]$</td>
<td>$0.50S$ $[(0.50)S^2]$</td>
<td>$(55)H$ $[(87)H^{2.3}]$</td>
</tr>
<tr>
<td>Passive ($K_p$)</td>
<td>3.0</td>
<td>330 $[205^{2.3}]$</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

**Notes:**

1. For use with the shallow below grade structures such as the overflow structure, meter vault, etc. and representative of the alluvium silty sands prevalent at the site.
2. Coefficients for buoyant conditions are shown in brackets and apply below depth of 7 feet.
3. Includes the unit weight of water (62.4 pcf)
### Earth Pressure Coefficients – Granular Material\(^1\)

<table>
<thead>
<tr>
<th>Earth Pressure Conditions</th>
<th>Coefficient for Backfill Type</th>
<th>Equivalent Fluid Density (pcf)</th>
<th>Surcharge Pressure, (p_1) (psf)</th>
<th>Earth Pressure, (p_2) (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active ((K_a))</td>
<td>0.22</td>
<td>23 ([72^{2,3}])</td>
<td>(0.22)S ([(0.22)S^2])</td>
<td>(23)H ([(72)H^{2,3}])</td>
</tr>
<tr>
<td>At-Rest ((K_o))</td>
<td>0.36</td>
<td>38 ([78^{2,3}])</td>
<td>0.36S ([(0.36)S^2])</td>
<td>(38)H ([(78)H^{2,3}])</td>
</tr>
<tr>
<td>Passive ((K_p))</td>
<td>4.0</td>
<td>420 ([233^{2,3}])</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Notes:
1. For use with coarse sand and gravel and open graded stone, as approved by the geotechnical engineer.
2. Coefficients for buoyant conditions are shown in brackets and apply below depth of 7 feet.
3. Includes the unit weight of water (62.4 pcf)
4. Applicable only if the annulus around the influent structure is large enough so that it extends out from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active/at-rest and passive cases, respectively.

Applicable conditions to the above include:
- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 \(H\) to 0.004 \(H\), where \(H\) is wall height.
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance.
- Uniform surcharge, where \(S\) is surcharge pressure.
- In-situ soil backfill weight a maximum of 115 pcf.
- Horizontal backfill, compacted between 95 and 98 percent of standard Proctor maximum dry density.
- Loading from heavy compaction equipment not included.
- No dynamic loading.
- No safety factor included in soil parameters.
- Ignore passive pressure in frost zone.

To calculate the resistance to sliding, a value of 0.35 should be used as the ultimate coefficient of friction between the footing and the underlying soil.

### 4.6 Slabs-on-Grade

The grade slabs should be jointed at appropriate locations so that the slabs and structural foundations can accommodate some minor differential movements without damage. Joints containing dowels or keys may be used in the slab to permit rotational movement between sections of the slab without cracking or sharp vertical displacement.
The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 for procedures and cautions regarding the use and placement of a vapor retarder.

Construction activities such as underslab utility line installation and other events including weather often disturb the floor slab subgrade after mass grading has been completed. Therefore, we recommend that slab subgrades be evaluated by a geotechnical engineer before constructing the slab. The evaluation may include proofrolling with heavily loaded rubber-tired equipment or random probing, as appropriate.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide testing and observation during excavation, grading, foundation and construction phases of the project. The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.
APPENDIX A
FIELD EXPLORATION
LEGEND:

- SPT BORING (APPROX. LOCATION)

NOTES:

1. THE EXPLORATION POINT WAS LOCATED IN THE FIELD BY TERRACON ENGINEER USING MEASUREMENTS OFF OF EXISTING STRUCTURES.

Field Exploration Procedures

SPT and Soil Borings
The subsurface exploration consisted of drilling and sampling soil test borings in the footprint of the planned structures. Two (2) borings were drilled to a depth of 7 ½ feet below existing site grades.

The borings were located by measuring from existing site features shown on the drawing provided to us without the use of surveying equipment. The boring depths were measured from the existing ground surface at the time of our field activities. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled using an ATV-mounted rotary drill rig using continuous flight hollow-stem augers to advance the boreholes. Samples of the soil encountered in the borings were obtained using the split-barrel sampling procedures. In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound conventional safety hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils and consistency of cohesive soils.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further visual examination and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller’s interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on visual observation and tests of the samples.
**BOURING LOG NO. B-1**

**PROJECT:** Lakeside Pump Station  
**SITE:** 130 Lakeside Road  
**GREENVILLE, SOUTH CAROLINA**  
**CLIENT:** Renewable Water Resources (ReWa)

---

**LOCATION**  
See Exhibit A-2

---

**DEPTH**  
**WATER LEVEL OBSERVATIONS**  
**FIELD TEST RESULTS**  
**WATER CONTENT (%)**

<table>
<thead>
<tr>
<th>Depth (Ft.)</th>
<th>Sample Type</th>
<th>Water Level</th>
<th>Field Test</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>FILL - SILTY SAND (SM), fine grained, red to brown, loose</td>
<td>4-5-5</td>
<td>N=10</td>
<td>21</td>
</tr>
<tr>
<td>5.0</td>
<td>PARTIALLY WEATHERED ROCK, sampled as SILTY SAND (SM), fine grained, orange to brown, very dense</td>
<td>4-50/2&quot;</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>7.5</td>
<td>fine grained, orange to brown, very dense</td>
<td>50/2&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Auger Refusal at 7.5 Feet**

---

**Stratification lines are approximate. In-situ, the transition may be gradual.**

---

**Hammer Type:** Rope and Cathead

---

**Advancement Method:**

**Abandonment Method:**  
Borings backfilled with soil cuttings upon completion.

---

**Notes:**

---

**WATER LEVEL OBSERVATIONS**

No free water observed

---

**Terracon**  
3534 Rutherford Road  
Taylors, South Carolina

---

**Boring Started:** 11/20/2015  
**Boring Completed:** 11/20/2015

---

**Drill Rig:** CME-45  
**Driller:** J. Pawless

---

**Project No.: 86155064**  
**Exhibit:** A-4
**BORING LOG NO. B-2**

**PROJECT:** Lakeside Pump Station  
**SITE:** 130 Lakeside Road  
Greenville, South Carolina

**CLIENT:** Renewable Water Resources (ReWa)

---

**LOCATION**  
See Exhibit A-2

**DEPTH**  
Augered to refusal. No samples were taken.

**GRAPHIC LOG**

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>FIELD TEST RESULTS</th>
<th>WATER CONTENT (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Auger Refusal at 7.5 Feet**

Stratification lines are approximate. In-situ, the transition may be gradual.

**Hammer Type:** Rope and Cathead

---

**Advancement Method:**  
See Exhibit A-3 for description of field procedures.

**Abandonment Method:**  
Borings backfilled with cement-bentonite grout upon completion.

**Notes:**  
See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

---

**WATER CONTENT (%)**

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>OBSERVATIONS</th>
<th>FIELD TEST RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**WATER LEVEL OBSERVATIONS**

**Hammer Type:** Rope and Cathead

---

**Driller:** J. Pawless  
**Boring Completed:** 11/20/2015

**Notes:**

- Boring Started: 11/20/2015
- Boring Completed: 11/20/2015
- Drill Rig: CME-45
- Driller: J. Pawless
- Project No.: 86155064
- Exhibit: A-5

**Terracon**

3534 Rutherford Road  
Taylors, South Carolina

---

**THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT.**

GEO SMART LOG - NO WELL 86155064.GPJ  TERRACON2015.GDT 12/4/15
APPENDIX B
SUPPORTING DOCUMENTS
### Plasticity Description

<table>
<thead>
<tr>
<th>Term</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-plastic</td>
<td>0</td>
</tr>
<tr>
<td>Low</td>
<td>1 - 10</td>
</tr>
<tr>
<td>Medium</td>
<td>11 - 30</td>
</tr>
<tr>
<td>High</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

### Descriptive Soil Classification

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

### Location and Elevation Notes

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

### Water Level

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

### Descriptive Symbols and Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(HP)</td>
<td>Hand Penetrometer</td>
</tr>
<tr>
<td>(T)</td>
<td>Torvane</td>
</tr>
<tr>
<td>(b/f)</td>
<td>Standard Penetration Test (blows per foot)</td>
</tr>
<tr>
<td>(PID)</td>
<td>Photo-Ionization Detector</td>
</tr>
<tr>
<td>(OVA)</td>
<td>Organic Vapor Analyzer</td>
</tr>
</tbody>
</table>

### Relative Proportions of Sand and Gravel

<table>
<thead>
<tr>
<th>Descriptive Term(s) of other constituents</th>
<th>Percent of Dry Weight</th>
<th>Major Component of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt; 15</td>
<td>Boulders</td>
</tr>
<tr>
<td>With</td>
<td>15 - 29</td>
<td>Cobbles</td>
</tr>
<tr>
<td>Modifier</td>
<td>&gt; 30</td>
<td>Gravel</td>
</tr>
</tbody>
</table>

### Grain Size Terminology

- **Particle Size**
  - Boulders: Over 12 in. (300 mm)
  - Cobbles: 12 in. to 3 in. (300 mm to 75 mm)
  - Gravel: 3 in. to #4 sieve (75 mm to 4.75 mm)
  - Sand: #4 to #200 sieve (4.75 mm to 0.075 mm)
  - Silt or Clay: Passing #200 sieve (0.075 mm)

### Relative Proportions of Fines

<table>
<thead>
<tr>
<th>Descriptive Term(s) of other constituents</th>
<th>Percent of Dry Weight</th>
<th>Term</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt; 5</td>
<td>Non-plastic</td>
<td>0</td>
</tr>
<tr>
<td>With</td>
<td>5 - 12</td>
<td>Low</td>
<td>1 - 10</td>
</tr>
<tr>
<td>Modifier</td>
<td>&gt; 12</td>
<td>Medium</td>
<td>11 - 30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

### Exhibit B-1
## UNIFIED SOIL CLASSIFICATION SYSTEM

### Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests

<table>
<thead>
<tr>
<th>Coarse Grained Soils: More than 50% retained on No. 200 sieve</th>
<th>Fine-Grained Soils: 50% or more passes the No. 200 sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gravels:</strong> More than 50% of coarse fraction retained on No. 4 sieve</td>
<td><strong>Sands and Clays:</strong> Liquid limit less than 50</td>
</tr>
<tr>
<td><strong>Gravels with Fines:</strong> More than 12% fines</td>
<td><strong>Sands and Clays:</strong> Liquid limit 50 or more</td>
</tr>
</tbody>
</table>
| **Clean Gravels:** Less than 5% fines | **Inorganic:** \( \text{PI > 7 and plots on or above “A” line} \)
| **Clean Gravel with Fines:** Fines classify as ML or MH | **PI < 4 or plots below “A” line** |
| **Clean Sands:** Less than 5% of coarse fraction | **Sands:** Liquid limit - oven dried
| **Clean Sand with Fines:** Fines classify as ML or MH | **Liquid limit - not dried** |
| **Sands:** 50% or more of coarse fraction | **PI plots on or above “A” line** |
| **Sands with Fines:** More than 12% fines | **PI plots below “A” line** |

### Highly Organic Soils:
- Primarily organic matter, dark in color, and organic odor

<table>
<thead>
<tr>
<th>Soil Classification</th>
<th>Group Symbol</th>
<th>Group Name</th>
</tr>
</thead>
</table>
| GW | Well-graded gravel | F
| GP | Poorly graded gravel | F
| GM | Silty gravel | F, G, H
| GC | Clayey gravel | F, G, H
| SW | Well-graded sand | I
| SP | Poorly graded sand | I
| SM | Silty sand | I
| SC | Clayey sand | I

### Equations

\[ Cu = \frac{D_{60}}{D_{10}} \]

\[ Cc = \frac{D_{25}^2}{D_{10} \times D_{60}} \]

\[ \text{If soil contains } \geq 15\% \text{ gravel, add “with gravel” to group name.} \]

\[ \text{If soil contains } \geq 15\% \text{ sand, add “with sand” to group name.} \]

\[ \text{If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.} \]

\[ \text{If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.} \]

\[ \text{If soil contains } \geq 30\% \text{ plus No. 200 predominantly sand, add “sandy” to group name.} \]

\[ \text{If soil contains } \geq 30\% \text{ plus No. 200, predominantly gravel, add “gravelly” to group name.} \]

\[ \text{PI plots on or above “A” line.} \]

\[ \text{PI plots below “A” line.} \]

\[ \text{PI plots on or above “B” line.} \]

\[ \text{PI plots below “B” line.} \]

\[ \text{PI plots on or above “C” line.} \]

\[ \text{PI plots below “C” line.} \]

\[ \text{PI plots on or above “D” line.} \]

\[ \text{PI plots below “D” line.} \]

\[ \text{PI plots on or above “E” line.} \]

\[ \text{PI plots below “E” line.} \]

---

**Notes:**

- Based on the material passing the 3-in. (75-mm) sieve
- If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.
- Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
- Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
- If fines classify as CL-ML, use dual symbol GC-GM, or SC-SC.
- If fines contain 15% sand, add “with sand” to group name.
- If fines are organic, add “with organic fines” to group name.