Prepared for

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2016 SURFACE IMPOUNDMENT PERIODIC STRUCTURAL STABILITY ASSESSMENT REPORT

SLURRY POND

WINYAH GENERATING STATION, GEORGETOWN, SOUTH CAROLINA

Prepared by

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engineers | scientists | innovators

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CERTIFICATION STATEMENT

This initial periodic structural stability assessment was conducted in accordance with the requirements of §257.73(d) of the Code of Federal Regulations Title 40, Part 257, Subpart D, and was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering, and no other warranty is provided in connection therewith. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Santee Cooper. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others. Although we were not able to independently verify such data, we found that it was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Santee Cooper and their subconsultants.

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10/13/2016
Date

EXECUTIVE SUMMARY

The Winyah Generating Station (WGS or "Site") is a coal-fired, electric generating facility owned and operated by Santee Cooper and is located approximately four miles southwest of Georgetown, South Carolina (SC). Historically, WGS has utilized six surface impoundments designated for disposal of coal combustion residuals (CCR): Slurry Pond 3&4 (Slurry Pond), West Ash Pond, Unit 2 Slurry Pond, Ash Pond A, Ash Pond B, and the South Ash Pond.

On 17 April 2015, the United States Environmental Protection Agency (USEPA) published rules in 40 CFR (Code of Federal Regulations) Parts 257 and 261, regulating on the design and management of existing and new CCR units (commonly referred to as the "CCR Rule"). The CCR Rule became effective on 17 October 2015. The CCR rule requires owners and operators of existing CCR surface impoundments to conduct periodic structural stability assessments in accordance with §257.73(d) of each surface impoundment and publish the results to the facility's operating record.

The Slurry Pond at WGS is classified as an "existing CCR surface impoundment" by the CCR Rule. On behalf of Santee Cooper, Geosyntec Consultants (Geosyntec) prepared the *2016 Surface Impoundment Periodic Stability Assessment Report: Slurry Pond* (Stability Assessment Report) presents the first periodic (i.e., initial) structural stability assessment in accordance with the CCR Rule for the Slurry Pond at WGS.

A hydrologic and hydraulic analysis (H&H Analysis) of the Slurry Pond and appurtenances was conducted to demonstrate the inflow design flood (IDF) can be managed and conveyed safely (i.e., without overtopping the perimeter dikes) during and after the rainfall event. This H&H Analysis is published separately in the operating record of WGS. Since the Slurry Pond has been classified as a "High Hazard Potential" surface impoundment, the probable maximum flood (PMF) with a rainfall duration of 72 hours was selected as the IDF. The free water level within the Slurry Pond is maintained at an elevation of 19.6 ft National Geodetic Vertical Datum of 1929 (NGVD29) by a Floating Pump Station which ultimately conveys free water to the Site's Cooling Pond. The peak water level during and after the IDF within the Slurry Pond was computed as 35.4 ft NGVD29, which is below the minimum dike crest of 36.0 ft NGVD29. Thus, the Slurry Pond will adequately manage inflows during and following the peak discharge from the PMF in accordance with §257.73(d)(1)(v) of the CCR Rule.

In support of the periodic structural stability assessment, Geosyntec developed and performed geotechnical subsurface investigations and laboratory testing programs to characterize the dike and subsurface soils for the Slurry Pond in 2013 and 2016. Data from historical field investigations was also reviewed and incorporated into the evaluation of the condition of the Slurry Pond and selection of engineering properties for the dike fill and foundation soils. Boring logs, Cone Penetration Test (CPT) sounding data, and laboratory testing results have been provided in Attachments 2, 3, and 4 of the *2016 Surface Impoundment Periodic Safety Factor Assessment Report: Slurry Pond* (Safety Factor Assessment Report), respectively, and the interpretation of the in-situ and laboratory data is described and presented in Attachment 5 of the Safety Factor Assessment Report.

Geosyntec reviewed the available data, performed the safety factor assessment, and inspected the perimeter dikes of the Slurry Pond on 10 and 11 July 2016. The condition of the foundation soils, the compaction of dike fill soils, the slope protection and vegetation of perimeter dike slopes, and the existing pipe penetrations through the perimeter dikes were evaluated and found to meet the requirements listed in §257.73(d)(1)(i) through (vii). Therefore, the Slurry Pond was considered to meet the periodic structural stability criteria for existing surface impoundments described within §257.73(d) of the CCR Rule.

1. INTRODUCTION

1.1 Project Background

The Winyah Generating Station (WGS or "Site") is an electric generating facility owned and operated by Santee Cooper. WGS is located between Pennyroyal and Turkey Creeks, tributaries to Sampit River, and is situated approximately four miles southwest of Georgetown, South Carolina (SC) (see Figures 1a and 1b for Site Location and Site Vicinity Maps). WGS has historically utilized six surface impoundments (Figure 2) designated for disposal of coal combustion residuals (CCR): Slurry Pond 3&4 (Slurry Pond), West Ash Pond, Unit 2 Slurry Pond, Ash Pond A, Ash Pond B, and the South Ash Pond.

On 17 April 2015, the United States Environmental Protection Agency (USEPA) published rules in 40 CFR Parts 257 and 261, regulating the design and management of existing and new CCR units (commonly referred to as the "CCR Rule"). The CCR Rule became effective on 17 October 2015. Within the CCR Rule, §257.73(d) outlines the structural stability criteria for existing CCR surface impoundments.

The Slurry Pond is situated west of the power block. It manages CCRs in the form of flue gas desulfurization (FGD) residuals as well as process water resulted from power generating activities. The Slurry Pond is considered as an existing surface impoundment under the CCR Rule. The *2016 Surface Impoundment Periodic Stability Assessment Report: Slurry Pond* (Stability Assessment Report) has been prepared by Geosyntec Consultants (Geosyntec) on behalf of Santee Cooper to demonstrate that the Slurry Pond meets the criteria for periodic structural stability assessment in accordance with §257.73(d) of the CCR Rule.

1.2 Project Site and Construction History

The Slurry Pond was commissioned in 1980. It has a surface area of approximately 106 acres and is located in the northwest corner of the Site. The Slurry Pond is an unlined surface impoundment and designated to receive FGD residuals that do not meet specifications for beneficial use as wallboard-grade gypsum. It also receives process water resulted from the power generating activities and stormwater runoffs from the Limestone Slurry/Ball Mill area and Coal Pile (generally from the west half of the Coal Pile). The solids within the sluiced FGD residuals and stormwater runoffs are contained in the Slurry Pond by gravity settling.

The Slurry Pond was constructed by compacting excavated soils from the surface impoundment interior to form the perimeter dikes and the divider dike, which separates the Slurry Pond from the adjacent West Ash Pond (closed) to the southwest. During the initial construction, a finger dike was constructed into the center of the Slurry Pond primarily to allow solids to settle prior to recirculation of the wastewater, but also provided for access, maintenance, and observation of the pond interior. The Slurry Pond perimeter dikes are approximately 30 ft in height in the northern and eastern sections, 26 ft in height in the western section, and 15 ft in height in the southern section (Thomas and Hutton, 2012). The upstream and downstream slopes of the perimeter dikes range from 2 Horizontal to 1 Vertical (2H:1V) to 3H:1V. The dike crest is approximately 12- to 15-ft wide and typically at elevations 37.0 to 39.0 ft National Geodetic Vertical Datum of 1929 (NGVD29) (Thomas and Hutton, 2012). The total storage capacity of the Slurry Pond is approximately 1,700 ac-ft, with 30% capacity remaining in the north portion of the surface impoundment (ARCADIS, 2012). Stormwater runoff from the downstream side slope is collected in a stormwater trench, conveyed to Pump Station No. 2, and then pumped into the Slurry Pond.

Previously, the impounded free water within the Slurry Pond was routed via rim ditches and a series of culverts to the West Ash Pond and subsequently pumped across an existing pipe bridge to the South Ash Pond. Currently, the free water is managed by the Floating Pump Station, which routes discharge from the Slurry Pond to the Discharge Canal. The surface of the West Ash Pond was closed, re-graded, and capped in 2015 to drain stormwater runoff by gravity to the Slurry Pond using two 36-in diameter corrugated High Density Polyethylene (HDPE) culverts and four 22-in diameter corrugated HDPE through the west side of the divider dike. The free water within the Slurry Pond has been lowered to an operating elevation of 19.6 ft NGVD29 by the Floating Pump Station as a part of the seismic risk mitigation project (Geosyntec, 2014).

1.3 Report Organization

This Stability Assessment Report presents the first (i.e., initial) periodic structural stability assessment for the Slurry Pond at WGS based on the results of subsurface investigations, hydrologic and hydrology (H&H) analysis, geotechnical engineering analyses, a site visit, and a review of available Site information. The remainder of this Stability Assessment Report is organized as follows:

- Descriptions of the hazard potential classification of the Slurry Pond and corresponding performance of the hydraulic structures are presented in Section 2;
- Geotechnical subsurface investigations performed by Geosyntec and others are presented in Section 3;
- Subsurface conditions and geology at WGS are discussed in Section 4;
- The structural stability assessment of the Slurry Pond perimeter dikes is presented in Section 5; and
- The summary and general conclusions from the structural stability are presented in Section 6.

2. HYDROLOGIC AND HYDRAULIC EVALUATION

2.1 Hydrologic and Hydraulic Analysis

The following section discusses the regulatory framework, the methodology and assumptions, and the results of the hydrologic and hydraulic (H&H) analysis for the Slurry Pond and its appurtenances.

2.1.1 Regulatory Framework

The CCR Rule (§257.73(d)(1)) requires that a periodic stability assessment:

"...at minimum, document whether the CCR unit has been designed, constructed, and maintained with:

...

(v) a single spillway or a combination of spillways configured as specified in paragraph (d)(1)(v)(A) of this section. The combined capacity of all spillways must be designed, constructed, operated, and maintained to adequately manage flow during and following the peak discharge event specified in paragraph (d)(1)(v)(B) of this section."

§257.73(d)(1)(v)(B)(1) states that the spillways must manage the peak discharge from the *"Probable maximum flood (PMF) for a high hazard potential CCR surface impoundment."*. Additionally, §257.73(d)(1)(v)(A) indicates that *"All spillways must be either:*

(1) Of non-erodible construction and designed to carry sustained flows; or

(2) Earth- or grass-lined and designed to carry short-term, infrequent flows at non-erosive velocities where sustained flows are not expected."

The Slurry Pond does not have a traditional spillway for discharge of free water from the pond interior. The Slurry Pond has the Floating Pump Station to carry sustained flows and to manage the discharge from the surface impoundment. The Slurry Pond also contains a culvert that hydraulically connects and combines the storage capacity of the Slurry Pond with the West Ash Pond. The spillway referenced within this Stability Assessment Report is the Floating Pump Station. The Inflow Design Flood (IDF) was selected as the PMF in accordance with the CCR Rule because the Slurry Pond has been assigned a "High Hazard Potential" classification (Geosyntec, 2016a). Hydrologic and Hydraulic (H&H) analysis were performed to demonstrate that the Slurry Pond spillway is able to adequately manage flow during and following the peak discharge event without overtopping of perimeter dikes, meeting the criteria in §257.73(d)(1)(v).

2.1.2 Methodology and Assumptions

Details of the H&H analysis are provided in a calculation package titled *"Hydrologic and Hydraulic Analysis for Slurry Pond 3&4 and West Ash Pond",* which is provided as Attachment 1 of the Safety Factor Assessment Report (Geosyntec, 2016b) published in the operating record. The remainder of this section describes the assumptions, conditions, and results of the H&H analysis for the Slurry Pond.

The Floating Pump Station manages and maintains the free water at an elevation of 19.6 ft NGVD29 during normal operating conditions by two (2) Tsurumi GSZ-4-45-4 submersible pumps. The capacity of these two pumps operating in parallel is 3,075 gallons per minute (gpm) at the maximum head, normal pool operating elevation when pumping directly to the Discharge Canal. The Floating Pump Station is held in the north corner of the Slurry Pond by guy wires and typically conveys free water to Pump Station No. 1 and ultimately to the Discharge Canal. The piping from the Floating Pump Station can be partitioned such that it bypasses Pump Station No. 1 and is conveyed directly to the Discharge Canal. The Slurry Pond is hydraulically connected to the 64-acre West Ash Pond, which drains surface water runoff to the Slurry Pond through two (2) 36-in diameter corrugated HDPE culverts (invert: 26.0 ft NGVD29), four (4) 22-in diameter corrugated HDPE culverts (invert: 33.7 ft NGVD29), and a 200-ft wide emergency spillway (invert: 36.25 ft NGVD29). The Slurry Pond also receives a base flow of 2,880,000 gallons per day (gpd) (4.46 ft^3/s) of process water when all four electric generating units at WGS are operating.

HydroCAD® (HydroCAD, 2011) software was utilized to apply the Soil Conservation Service (SCS) Technical Release 20 (TR-20) method (SCS, 1982) to compute stormwater volume and to model the performance of the hydraulic structures of the Slurry Pond during the PMF. The PMF was conservatively selected as the 72-hour (hr) duration precipitation event resulting in a rainfall depth of 53.0 inches (NOAA, 1978) and modeled within HydroCAD® using a SCS Type III rainfall distribution. The analysis was performed under the following assumptions, which were confirmed by WGS personnel:

- The Floating Pump Station was assumed to cease pumping due to temporary loss of power during the PMF;
- Stormwater runoff from the Coal Pile will be routed to the South Ash Pond instead of the Slurry Pond during the PMF;

- Pump Station No. 2 located just north of the Slurry Pond will lose power or be switched off during the PMF and does not route stormwater into the Slurry Pond;
- The process water flow will be routed into the Slurry Pond during the PMF; and
- The maximum normal operating pool within the Slurry Pond is maintained at 19.6 ft NGVD29.

2.1.3 Analysis Results

Under the conditions and assumptions described in Section 2.1.2, the maximum free water level or "maximum surcharge pool" level during and following the PMF event was computed as 35.37 ft NGVD29 (rounded herein to 35.4 ft NGVD29) occurring 47.9 hours into the rainfall event. The lowest elevation of the Slurry Pond perimeter dikes was measured as 36.0 ft NGVD29 (Thomas and Hutton, 2012). While a passive, permanent spillway structure is not provided, the Slurry Pond will still adequately contain and manage flow (i.e., contain without overtopping) during and following the PMF and therefore, meets the criteria listed in §257.73(d)(1)(v) of the CCR Rule.

3. GEOTECHNICAL SUBSURFACE INVESTIGATIONS

This section summarizes the historical and recent subsurface investigation programs. Two subsurface investigations (S&ME, 1978; PCRA 1999) were conducted historically within the vicinity of the Slurry Pond at WGS. More recently in the spring of 2013, Geosyntec conducted a supplementary, focused subsurface investigation program to obtain geotechnical data for global seismic stability analyses requested by the USEPA (Geosyntec, 2013). After completion of the spring 2013 subsurface investigation, Geosyntec returned to the Site in the fall of 2013 and Spring of 2016 and performed additional geotechnical subsurface investigations within the Slurry Pond. Figure 3 presents the locations of soil test borings, Cone Penetration Test (CPT) soundings, and test pit excavations performed during these subsurface investigation programs. In 2014, Geosyntec installed temporary piezometers in the Slurry Pond to monitor the phreatic surface within the perimeter dikes during drawdown of the free water within the surface impoundment.

The geotechnical data obtained during the historical and recent subsurface investigations, including soil test borings, CPT soundings, and laboratory tests, are included in Attachments 2, 3, and 4 of the Safety Factor Assessment Report (Geosyntec, 2016b). The interpretation of the subsurface stratigraphy and materials properties is presented in Attachment 5 of the Safety Factor Assessment Report (Geosyntec, 2016b). The following sections provide summaries of each of the subsurface investigations.

3.1 <u>Historical Investigations</u>

3.1.1 Soil and Materials Engineers (S&ME) Investigation

In 1977 and 1978, Soil and Materials Engineers, Inc. (S&ME) performed a general subsurface investigation in support of the design and construction of the Slurry Pond, the West Ash Pond, the South Ash Pond, and the Unit 2 Slurry Pond. The subsurface investigation included soil test borings with Standard Penetration Tests (SPTs) generally at 5-ft depth intervals and test pits excavated 10 to 15 ft below ground surface (bgs). Twenty borings and fifteen test pit excavations were performed within the footprint of the Slurry Pond and the West Ash Pond. These boring logs and test pit logs were presented in the subsurface investigation report prepared by S&ME (1978). The boring logs pertaining to the Slurry Pond are provided in Attachment 2-A of the Safety Factor Assessment Report (Geosyntec, 2016b).

During the S&ME investigation, representative samples were collected from SPTs by means of a standard split spoon sampler or from test pit excavations as bulk samples.

Additionally, thin-walled Shelby tube samples were collected for index and triaxial strength testing. Overall, the laboratory program for this subsurface investigation consisted of index testing (grain size distribution and Atterberg Limit tests), unit weight, compaction testing, consolidation testing, and shear strength testing. Recompacted samples were also tested to evaluate the design shear strength properties of the dike structure to be constructed.

3.1.2 Paul C. Rizzo and Associates (PCRA) Investigation

In 1999, Paul C. Rizzo and Associates, Inc. (PCRA) conducted a geotechnical and hydrogeologic subsurface investigation at WGS primarily through the perimeter dikes of the Slurry Pond and Unit 2 Slurry Pond. The intent of this subsurface investigation was to evaluate the subsurface and hydrogeologic conditions in the vicinity of these surface impoundments. Eighteen borings were advanced through the perimeter dike centerline of the Slurry Pond and the centerline of the divider dike bounding the Slurry Pond and the West Ash Pond. One temporary piezometer was installed near the downstream toe of the perimeter dike of the Slurry Pond. These soil test borings were reported to have been performed using the mud rotary wash drilling method and a side discharge bit.

Two drilling subcontractors were utilized during this subsurface investigation: Carolina Drilling and Mid-Atlantic Drilling, Inc. (MAD). Carolina Drilling, in general, continuously collected samples with SPT blow counts recorded until refusal was encountered at “limestone” (geologic interpretation of this stratum is discussed in Section 4.2.1). Once “limestone” was encountered, a casing was installed to allow rock coring of the “limestone” layer. Borings advanced by Carolina Drilling were generally terminated once the underlying “Black Mingo Formation” (geologic interpretation of this stratum is also discussed in Section 4.2.1) was encountered, but a few of these borings penetrated into the upper 5 to 10 ft of this stiff to very hard clay formation. MAD advanced borings without sampling (i.e., without SPT measurements) to locate the top of “limestone.” These borings were generally terminated when the “Black Mingo Formation” stratum was reached. In a few cases, however, MAD cored the “limestone” layer and penetrated nearly 10 ft into the “Black Mingo Formation” (PCRA, 1999). The boring logs from this exploration that are pertinent to the material property interpretation and liquefaction potential analyses are presented in Attachment 2-B of the Safety Factor Assessment Report. PCRA also performed a limited geotechnical testing program consisting of index testing to characterize the hydraulic behavior of the soil; nine of which were located in the Slurry Pond.

3.2 Geosyntec Investigations

3.2.1 Spring 2013 Subsurface Investigation

From February 21st to March 6th, 2013, Geosyntec conducted a geotechnical subsurface investigation in the Slurry Pond and the West Ash Pond areas, which included eleven mud rotary soil test borings, two hollow stem auger borings, fifty-three CPT soundings, and three test pit excavations in the vicinity of the Slurry Pond. Soil Consultants, Inc. (SCI) of Charleston, SC was subcontracted to advance the soil test borings using the mud rotary method. Eight soil test borings were advanced through the Slurry Pond perimeter dike centerline and three soil test borings were advanced near the downstream toe of the perimeter dikes. These borings were terminated when "Chicora Member" (geologic interpretation of this stratum is discussed in Section 4.2.1) was encountered. Refusal was encountered when the paddle, side discharge drill bit encountered the partially cemented "Chicora Member" stratum and SPT blow counts exceeded 50 blows per foot. In one boring (GSB-4), the split spoon penetrated through the "Chicora Member" stratum and entered the underlying "Williamsburg Formation Clay" (geologic interpretation of this stratum is discussed in Section 4.2.1). The boring was advanced an additional 10 ft after encountering the "Chicora Member" before the boring was terminated. During these soil test borings, representative samples were collected by SPT with a standard split spoon sampler typically in 5-ft depth intervals. In addition to the eleven soil test borings, two hollow stem auger borings were also advanced to 25 to 30 ft bgs through the dike centerline to measure a 24-hr water level within the dike fill without the influence of bentonite slurry within the borehole. Soil samples were not collected during these hollow stem auger borings. The boring logs describing these borings are provided in Attachment 2-C of the Safety Factor Assessment Report (Geosyntec, 2016b).

The two hollow stem auger borings were used to measure the phreatic surface at the dike centerline. These boreholes were left open for two to three days prior to abandonment with cement-bentonite grout. The depths to water levels were measured and recorded after 1 hour and 24 hours after the completion of drilling. At the time of the 2013 subsurface investigation, the free water level within the Slurry Pond had been maintained at approximately 34.3 ft NGVD29 for several years.

Twenty-three CPT soundings with pore pressure measurements were performed through the centerlines of the perimeter, divider, and finger dikes of the Slurry Pond. An additional twenty-five CPT soundings were performed at the toe of the perimeter dike of this surface impoundment. Four CPT soundings were advanced within the Slurry Pond, which were terminated when the tip resistance and friction sleeve signatures indicated a material transition from CCRs to the natural soils beneath the pond. The CPT sounding logs for the Slurry Pond area are presented the Safety Factor Assessment Report (Geosyntec, 2016b).

In-situ tests were performed in conjunction with selected CPT soundings. The shear wave velocity (V_S) of the subsurface materials was measured and recorded in 5-ft depth intervals at four locations along the dike centerline: two locations at the downstream toe of the perimeter dike of the Slurry Pond. Additionally, porewater pressure dissipation tests were performed at different depths for several CPT soundings along and within the dike centerline, downstream dike toe, and interior of the Slurry Pond. Attachments 3-B and 3-C within the Safety Factor Assessment Report (Geosyntec, 2016b) provide the original shear wave velocity and porewater pressure dissipation test data, respectively.

Three test pits were excavated to a depth of 5-ft bgs within the Slurry Pond at locations that are approximately 60 ft from the finger dike. The excavation was made using a long stick excavator operated by a Santee Cooper construction crew. One test pit was excavated on the western side of the finger dike; the other two test pits were excavated on the eastern side of the finger dike. Bulk samples were collected in 5-gallon buckets and transported to a laboratory for testing.

3.2.2 Fall 2013 Subsurface Investigation

In October and November 2013, Geosyntec mobilized to WGS to collect geotechnical subsurface data through additional soil test borings and CPT soundings in support of evaluating preliminary and conceptual closure alternatives for each CCR surface impoundment at WGS. The subsurface investigation was focused in the vicinity of the South Ash Pond, Unit 2 Slurry Pond, Ash Pond A, and Ash Pond B. However, five soil test borings advanced by mud rotary wash drilling method and six CPT soundings were advanced within the vicinity of the Slurry Pond. The purposes of these investigation locations were to: (i) characterize impounded CCRs; (ii) investigate materials underlying the “Chicora Member” stratum; and (iii) investigate the perimeter dikes near GSB-11 where the dike material was observed to have SPT blow counts of weight of hammer (i.e., zero blow counts) during the Spring 2013 investigation. One boring was advanced to a depth of 100 ft bgs to evaluate the material properties of the Williamsburg Formation Clay. In this soil test borings, SCI switched to a tri-cone rotary wash drill bit once the Chicora Member was encountered to reach the target depth. The remaining four soil test borings were advanced 20 to 25 ft bgs and were utilized to collect Shelby tube samples of CCRs. Three CPT soundings were advanced within the interior, and two V_S profiles were collected within the Slurry Pond. The remaining three CPT soundings were advanced on both sides of GSB-11 to identify if the observed weight of hammer material within the dike fill soils was located in an isolated area.

3.2.3 Spring 2016 Subsurface Investigation

In February and March 2016, Geosyntec mobilized to WGS to further investigate subsurface conditions supporting the design of potential CCR landfills within the footprints of the Unit 2 Slurry Pond, Ash Pond A, and Ash Pond B. Additional soil test borings were also advanced in the western half of the South Ash Pond to further evaluate engineering properties of the soft clays encountered within the area during the Spring 2013 investigation. One additional soil boring was advanced by Geosyntec adjacent to the historical boring GSB-11, which was completed by Geosyntec in 2013 using mud rotary drilling techniques. Except when Shelby tubes were pushed to collect undisturbed soil samples, the soil test boring (GSB-11A) was advanced continuously with SPTs through the perimeter dike soil (i.e., upper 30 ft bgs) and at 5-ft intervals thereafter. The depth to water level was measured as 8.2 ft bgs prior to borehole abandonment with cement-bentonite grout. Since the measured groundwater depth was observed to be inconsistent with historical piezometer measurements, an engineer with Santee Cooper supervised the advancement of a Geoprobe® boring (without sampling) to a depth of 30 ft bgs and the installation of a temporary standpipe. After 96-hrs, the depth to water within the standpipe was measured as 24.4 ft bgs before the instrument was pulled and abandoned.

3.2.4 Laboratory Testing

For both subsurface investigations performed in 2013, Geosyntec subcontracted Excel Geotechnical Testing, Inc. (EGT) of Roswell, Georgia to conduct a geotechnical laboratory testing program on representative disturbed (i.e., bulk or split spoon) sample and undisturbed (i.e., Shelby tube) samples. During the Spring 2013 investigation, the testing program on subsurface soils included grain size distribution tests (some with hydrometer tests), Atterberg limits tests, natural water content tests, shear strength tests (2- to 3-point consolidated-undrained [CU] triaxial tests), and unit weight tests. Additionally, grain size distribution, Atterberg limits, and unit weight tests were performed on the CCR samples collected from the interior the Slurry Pond.

During the Fall 2013 subsurface investigation, the laboratory program consisted of natural water content tests, grain size distribution tests, Atterberg Limits, fines content, and specific gravity tests predominantly performed on CCR. Additionally, one-dimensional consolidation tests FGD residuals and Williamsburg Formation Clay. Three CU tests (2- to 3-point) were conducted FGD residuals. One hydraulic conductivity test was also performed on the Williamsburg Formation Clay as a part of this investigation.

During the 2016 subsurface investigation, a grain size distribution, an Atterberg limits, and a CU test were performed on a sample of dike fill soil collected 19 ft bgs from GSB-11A. Additionally, natural moisture content determinations were performed on each of the soil samples from GSB-11A.

Laboratory testing results from each subsurface investigation are provided in Attachment 4 of the Safety Factor Assessment Report (Geosyntec, 2016b).

4. SUBSURFACE CONDITIONS AND GEOLOGY

This section presents the regional geology and subsurface conditions for the Slurry Pond based on the geotechnical subsurface investigation programs discussed in Section 3. A summary of the regional geology is also provided as a framework to develop the subsurface stratigraphy model. Additional information on the subsurface conditions and the material properties is presented in Attachment 5 of the Safety Factor Assessment Report (Geosyntec, 2016b).

4.1 Regional Geology

Georgetown County, SC is located in the Atlantic Coastal Plain physiographic province, which is characterized by Quaternary terrace deposits produced by fluctuating sea levels. Coastal Plain sediments are underlain by Tertiary and late Cretaceous sediments to a depth of approximately 2,200 ft bgs in the Georgetown area. Descriptions of geologic units of interest in the area have been referenced from Campbell and Coes (2010) and are summarized below from top to bottom. The approximate thicknesses of each unit were estimated from several borings referenced in Campbell and Coes (2010). The specific borings used for this estimation include: 1) CHN-0820 located approximately 12 miles to the south of WGS; 2) GEO-0088 located approximately 7 miles to the southeast of WGS; and 3) GEO-0185 located less than 1.5 miles to the northwest of WGS.

- Undifferentiated Quaternary sediments consist of yellowish-brown and reddish-orange poorly sorted, very fine to very coarse, clayey sand and gravel. Accessory minerals include opaque heavy minerals, mica, and feldspar. The reported thickness of Undifferentiated Quaternary sediments ranges between 20 and 42 ft in the area.
- The Williamsburg Formation (Williamsburg) consists of gray to black interbedded clay and coarse quartz sand overlying shelly clay and calcareous clay. The Williamsburg can include sandy shale, fuller's earth, fossiliferous clayey sand (Lower Bridge Member), and fossiliferous clayey sand and mollusk-rich, bioclastic limestones (Chicora Member). The reported thickness of the Williamsburg in the vicinity of the site ranges between 30 and 90 ft.
- The Lang Syne Formation (Muthig and Colquhoun, 1988) was described as consisting of red and yellow (where weathered) or white, gray, and black (where freshly exposed) interbedded sand, silt, and clay and thin beds of silicified shell debris. Opaline clay stone is the most characteristic lithology.

- The Rhems Formation which consists of light-gray to black shale interlaminated with thin seams of fine-grained sand and mica.
- The Peedee Formation which consists of a dark-green to gray, fossiliferous, glauconitic clayey sand and silt. The combined thickness of the Lang Syne and Rhems and Peedee Formations ranges between 185 and 378 ft in the vicinity of the WGS.

Additional late Cretaceous Formations are present to a depth of approximately 2,200 ft bgs in the area. These Formations, in descending order, include: Donoho Creek, Bladen, Coachman, Cane Acre, Caddin, Sheppard Grove, Pleasant Creek, Cape Fear and undifferentiated Cretaceous sediments. The most important geologic units for this report are the undifferentiated Quaternary and Williamsburg Formations, which are encountered within 60 to 100 ft bgs as described in detail by Doar (2012).

4.2 Perimeter Dike Subsurface Conditions

4.2.1 Subsurface Stratigraphy

The subsurface stratigraphy at the Site was developed from information obtained from the historical and more recent geotechnical investigations and from regional geologic data. The information indicates that the subsurface soils primarily consist of four geotechnical units, within the depth of interest for the analyses presented in this Stability Assessment Report. A brief description on each unit is presented as follows:

- Dike Fill: Materials within the dike consist predominantly of loose to medium dense, brown to gray, silty/clayey fine to medium sands, and stiff, sandy clays to low to medium plasticity clays. The dike fill is located approximately between elevations 37 to 40 ft NGVD29 (dike crest) and 10 to 19 ft NGVD29 (dike toe).

- Foundation Soils: Foundation soils encountered during the borings onsite consist typically of brown to gray, clayey sands, silty sands, and poorly graded fine to medium sands with varying amounts of shells. Several clay lenses or thin layers of clay were occasionally encountered in more sandy foundation soils. The relative density of the foundation soils ranged from very loose to medium dense. The foundation soils were generally found to be 10 to 30 ft thick. In the majority of borings, the lower 5 to 10 ft of foundation soils consist heavily of shell fragments and shells. This layer was described in the field typically as loose to medium dense, clayey fine sand with interbedded shells.

- Chicora Member: A layer of dense to very dense, partially cemented to heavily cemented shells was encountered beneath the foundations soils during the past subsurface investigations. Blow counts in this layer exceeded 50 blows over less than 6 in. of advancement with minimal sample recovery. Historical borings indicated that the thickness of this layer typically ranged from 1 to 10 ft, and was fairly thin in the eastern corner of the Slurry Pond. The PCRA report (1999) referred to this layer as "limestone" or "shell hash – Coquina – limestone". The S&ME report (2001) described this layer as "Coquina", a local name used to describe shell hash and partially cemented shells. Doar (2012) indicated this layer could be considered to be Shell Hash and described the stratum as "Chicora". Due to limited samples recovered from Geosyntec's subsurface investigations, Geosyntec primarily relied on the review of the literature listed above and information from previous subsurface investigations and the regional geology for the geologic interpretation of this layer. Based on these sources, this layer is defined as "Chicora" or "Chicora Member of the Williamsburg Formation". The term Chicora Member is used to refer to this soil unit throughout this Stability Assessment Report.

- Williamsburg Formation Clay: The Williamsburg Formation Clay was encountered beneath the Chicora Member located in the upper reaches of the overall Williamsburg Formation and described as stiff to very hard, dark gray to black, medium to high plasticity clay or silt with sand. The Williamsburg Formation Clay has historically been referred to as "Black Mingo Clay" or the "Black Mingo Formation" at the Site. The term "Williamsburg Formation Clay" is used throughout this Stability Assessment Report.

4.2.2 GSB-11 Evaluation

During the Spring 2013 geotechnical subsurface investigation (Section 3.2.1), Geosyntec observed very soft high plasticity clays and clayey sands within the perimeter dike fill materials exhibiting "weight-of-hammer" SPT measurements at GSB-11. Subsequently in fall 2013 (Section 3.2.2), CPT-116, CPT-116a, and CPT-117 were advanced within 100-ft of GSB-11 to evaluate the presence and lateral extent of this soft zone. Cone tip resistance (q_t), soil behavior index (I_c), effective friction angle (ϕ'), and undrained shear strength ratio (S_u/σ'_v) were evaluated by methods described in Attachment 5 of the Safety Factor Assessment Report (Geosyntec, 2016b) and compared with other CPTs advanced through perimeter dikes. A weak zone was not observed in CPT-116, CPT-116a, and CPT-117, and the correlated engineering properties were similar to those across the entirety of the perimeter dike with laboratory triaxial strength testing. Based on this information, the "weight of hammer" material observed in GSB-11 was considered to be an isolated area.

As described in Section 3.2.3, Geosyntec remobilized to WGS to investigate the Slurry Pond perimeter dikes adjacent to GSB-11 with a single soil test boring (GSB-11A) and to inspect the condition of the downstream perimeter dikes. The soil test boring encountered Dike Fill material with measured N-values between 2 and 20 blows per foot with a majority of the soil intervals exceeding 6 blows per foot. A CU test on the dike fill material resulted in a $\phi' = 31.7$ degrees and $c' = 0$ psf. Meanwhile, the natural moisture content test results on dike fill soils at GSB-11A ranged generally between 17 percent and 27 percent and were consistent with moisture content test results from other areas of the Slurry Pond perimeter dikes. Elevated moisture content measurements were not identified within the dike fill soils. The water level measured within the temporary standpipe was consistent with adjacent historical piezometers suggesting a phreatic surface below the base of the dike fill material.

5. STRUCTURAL STABILITY ASSESSMENT

This section presents a summary of the structural stability assessment for the perimeter dikes surrounding the Slurry Pond at WGS, demonstrating that the Slurry Pond meets the requirements of 257.73(d)(1)(i) through (iii) and (vi) to (vii) of the CCR Rule. Section 2 of this Stability Assessment Report presents the analysis demonstrating that the Slurry Pond meets the requirements of 257.73(d)(1)(v) of the CCR Rule.

5.1 Site Visit

Geosyntec visited WGS on 10 and 11 July 2016 to inspect the condition of the CCR surface impoundment dikes regulated by the CCR Rule. Prior to the dike inspection, weekly and annual dike inspection reports and available historical engineering reports were reviewed to develop an understanding of the operational and maintenance history of the Slurry Pond. During the inspection, Geosyntec observed the condition of the upstream slopes, downstream slopes, stormwater features, pond appurtenances, and pipe penetrations through the dikes of the Slurry Pond. Geosyntec observed that the Slurry Pond perimeter dikes were generally operated and maintained in accordance with commonly accepted engineering practice and did not observe evidence of a deficiency to the structural integrity of the surface impoundment.

5.2 <u>Stable Foundations and Abutments</u>

The CCR Rule (§257.73(d)(1)) requires that the periodic structural stability assessment:

"...at minimum, document whether the CCR unit has been designed, constructed, and maintained with: (i) Stable foundations and abutments;"

Based on the observations made during the subsurface investigations (Section 3) and the results of the safety factor assessment (Geosyntec, 2016b), the Slurry Pond appears to have been designed, constructed, and maintained with stable foundations. Potential slip surfaces through the foundation soils of the perimeter dikes were evaluated under the static and seismic loading conditions in accordance with §257.73(e) and were found to meet or exceed the required safety factors under the CCR Rule. Details of the slope stability analysis are provided in the Safety Factor Assessment Report (Geosyntec, 2016b).

5.3 <u>Condition of Perimeter Dike Slopes</u>

The CCR Rule (§257.73(d)(1)) requires that the periodic stability assessment:

"...at minimum, document whether the CCR unit has been designed, constructed, and maintained with:

...

(ii) Adequate slope protection to protect against surface erosion, wave action, and adverse effects of sudden drawdown;

The interior (upstream) side slopes of the Slurry Pond perimeter dikes have generally been lined with rip-rap slope protection. Over time, sluiced FGD residuals have been deposited and some vegetation (i.e., phragmites) has flourished within the voids of the rip-rap slope protection during the operations of the surface impoundment. The riprap armor provides protection from surface erosion and wave action generated during rainfall events and periods of high wind. Grass has been established and is routinely maintained on the downstream 2H:1V to 3H:1V perimeter dike slopes. WGS facility personnel cut the vegetation as a part of routine maintenance of the perimeter dikes. Water levels within the Slurry Pond are maintained at 19.6 ft NGVD29, which results in a minimal storage of free water. WGS personnel have been trained in the operation of the Floating Pump Station and the Site does not rapidly drawdown impounded free water after a rainfall event. Thus, the Slurry Pond dikes have been constructed, operated, and maintained in accordance with §257.73(d)(1) (ii) of the CCR Rule. Note that §257.73(d)(1)(iv) was vacated by the USEPA in 2016 and is no longer a requirement of the CCR rule. However, WGS continues to cut the grass on a routine basis as a part of regular maintenance activities.

5.4 Compaction of Dike Fill Materials

The CCR Rule (§257.73(d)(1)) requires that the periodic stability assessment:

"...at minimum, document whether the CCR unit has been designed, constructed, and maintained with:

...

(iii) Dike mechanically compacted to a density sufficient to withstand the range of loading."

The design report for the Slurry Pond (S&ME, 1978) described earthwork and compaction requirements for the construction of the Slurry Pond perimeter dike structures. This design report indicated that organic material (i.e., roots, shrubs, etc.) or wet areas observed the top soil or localized depressions be stripped and removed and the underlying soils proof-rolled with at least two passes using pneumatic tire mounted equipment, having a weight at least 15 tons. Soils that are observed to exhibit excessive "pumping" during proof-rolling were to be undercut and replaced with recompacted materials. The design report recommended that *"compaction of all fill material be a minimum of 95% of its standard Proctor maximum dry density as defined by ASTM D-698"* and *"compacted not exceeding 2% of its optimum moisture content for silty sandy borrow soils and 4% for clayey sandy soils."* The maximum dry density (γ_d) and optimum moisture content (OMC) reported by S&ME (1978) ranged from 106 pcf to 113.1 pcf and 14.5 percent to 16.0 percent, respectively. The total or wet unit weight (γ_t) is computed to range from 121.9 pcf to 130.8 pcf. Further description of compaction or a construction quality assurance (CQA) for the construction of the Slurry Pond perimeter and divider dikes was not available at the time of the Stability Assessment Report.

Soil borings and CPT soundings during various subsurface investigation programs have been spaced at 200 to 500 ft intervals along the perimeter dike crest (not considering the divider dike), in general accordance with the United States Army Corps of Engineers (USACE) EM-1110-2-1913 engineering manual (USACE, 2000). Typically, the perimeter dikes of the Slurry Pond were found to consist of sandy clays and clayey sands with blow counts ranging between 5 and 25 blows per foot and tip resistances greater than 15 tsf. The γ_t of dike fill soils was measured during triaxial strength tests (described within Attachment 5 of the Safety Factor Assessment Report [Geosyntec, 2016b]), and was found to range between 124.3 pcf and 132.1 pcf. These ranges are consistent with the compacted total unit weights per the specifications recommended within the design report (S&ME, 1978). Based on interpretation of in-situ (i.e., CPT soundings and SPT N-values) and laboratory data (i.e., triaxial shear strength tests) presented in Attachment 5 of the Safety Factor Assessment Report, the perimeter dikes of the Slurry Pond appear to be mechanically compacted to sufficient densities to withstand the anticipated loading conditions.

5.5 Hydraulic Structures Underlying the CCR Unit

The CCR Rule (§257.73(d)(1)) requires that the periodic stability assessment:

"...at minimum, document whether the CCR unit has been designed, constructed, and maintained with:

...

(vi) Hydraulic structures underlying the base of the CCR unit or passing through the dike of the CCR unit that maintain structural integrity and are free of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, and debris, which may negatively affect the operation of the hydraulic structure"

The Slurry Pond has had three hydraulic structures penetrating the base or dike structure since its original construction: (i) the construction drain pipe; (ii) the pipeline from the Floating Pump Station to Pump Station #1; and (iii) the pipeline from Pump Station #2 discharging into the Slurry Pond.

During its original construction, dewatering trenches or channels were constructed within the Slurry Pond interior, which were graded to drain northward to a 30-in. diameter corrugated metal pipe (CMP). The perimeter dike was constructed over the CMP, which was fitted with six, concrete anti-seepage collars, and free water was allowed to drain outside of the surface impoundment footprint (Lockwood-Greene, 1978). Once construction was completed, the 30-in diameter CMP was grouted in place and abandoned. In 2011, a 225-ft long slag-bentonite slurry wall around the abandoned CMP was installed approximately 1-ft into the Chicora stratum. Further details pertaining to the slurry wall installation project such as a CQA Certification Report, technical specifications, etc. are not available at the time of this Stability Assessment Report. Since this CMP has been abandoned and cut off by concrete anti-seepage collars and a slag-bentonite slurry wall, the CMP is considered to meet the requirements of §257.73(d)(1)(vi) of the CCR Rule.

A 14-inch diameter HDPE forcemain conveys free water from the Floating Pump Station to Pump Station #1. The HDPE forcemain is positioned along the interior dike crest slope until it crosses the perimeter dike approximately 3 ft below the dike crest and runs along the surface of downstream perimeter dike slope connecting to Pump Station #1. The pipe crossing at this location was constructed by placing the HDPE forcemain on existing grade (i.e., across the dike crest) and constructing a gravel road over the pipe. Thus, this pipe does not penetrate the dike structure, but effectively crosses over the dike crest. Similarly, a 10-in. diameter HDPE forcemain in the north corner of the Slurry Pond from Pump Station #2 runs along downstream slope until it penetrates the perimeter dike less than 5 ft below the dike crest. After penetrating the dike crest, the forcemain discharges directly into the Slurry Pond after rainfall events. In both of these cases, the pipe penetration or crossing is positioned above the phreatic surface through the dike and piping or seepage along its alignment is not expected. Thus, these pipe penetrations or the crossing is not anticipated to negatively affect the performance of the perimeter dike structure.

5.6 Sudden Drawdown of Adjacent Water Body

The CCR Rule (§257.73(d)(1)) requires that the periodic stability assessment:

"...at minimum, document whether the CCR unit has been designed, constructed, and maintained with:

...

(vii) For CCR units with downstream slopes which can be inundated by the pool of an adjacent water body, such as a river, stream, or lake, downstream slopes that maintain structural stability during low pool of the adjacent water body of sudden drawdown of the adjacent water body."

The Slurry Pond is not located adjacent to a water body at the Site, and therefore sudden drawdown or structural stability during the low pool was not evaluated within this Stability Assessment Report.

6. SUMMARY AND GENERAL CONCLUSIONS

The following section provides a summary and general conclusions of the structural stability assessment presented in this Stability Assessment Report:

- The hydrologic and hydraulic performance of the Slurry Pond during the PMF was evaluated. Based on the evaluation results, the Slurry Pond will adequately contain and manage (i.e., without overtopping the perimeter dikes) the flow during and following the PMF in compliance with §257.73(d)(1)(v) of the CCR Rule.

- A desktop review of site history and engineering reports, subsurface investigation, and laboratory testing program was carried out to evaluate the construction history, characterize the dike and subsurface soils, and understand the existing conditions of the Slurry Pond. Based on the information available at the time of this Stability Assessment Report, the Slurry Pond appears to have been designed, operated, and maintained with mechanically compacted dikes and stable foundations under static and seismic conditions and slope protection in accordance with §257.73(d)(1)(i) through (iii) of the CCR Rule. The influence of hydraulic structures underlying and penetrating the perimeter dikes was evaluated and found to meet the requirements of §257.73(d)(1)(vi).

- The Slurry Pond is not located adjacent to a water body at the Site, and therefore sudden drawdown or structural stability during the low pool of an adjacent water body was not evaluated for the requirements of §257.73(d)(1)(vii).

Based on the evaluations presented within this Stability Assessment Report, the Slurry Pond at WGS satisfies the periodic structural stability criteria for existing surface impoundments specified in §257.73(d) of the CCR Rule.

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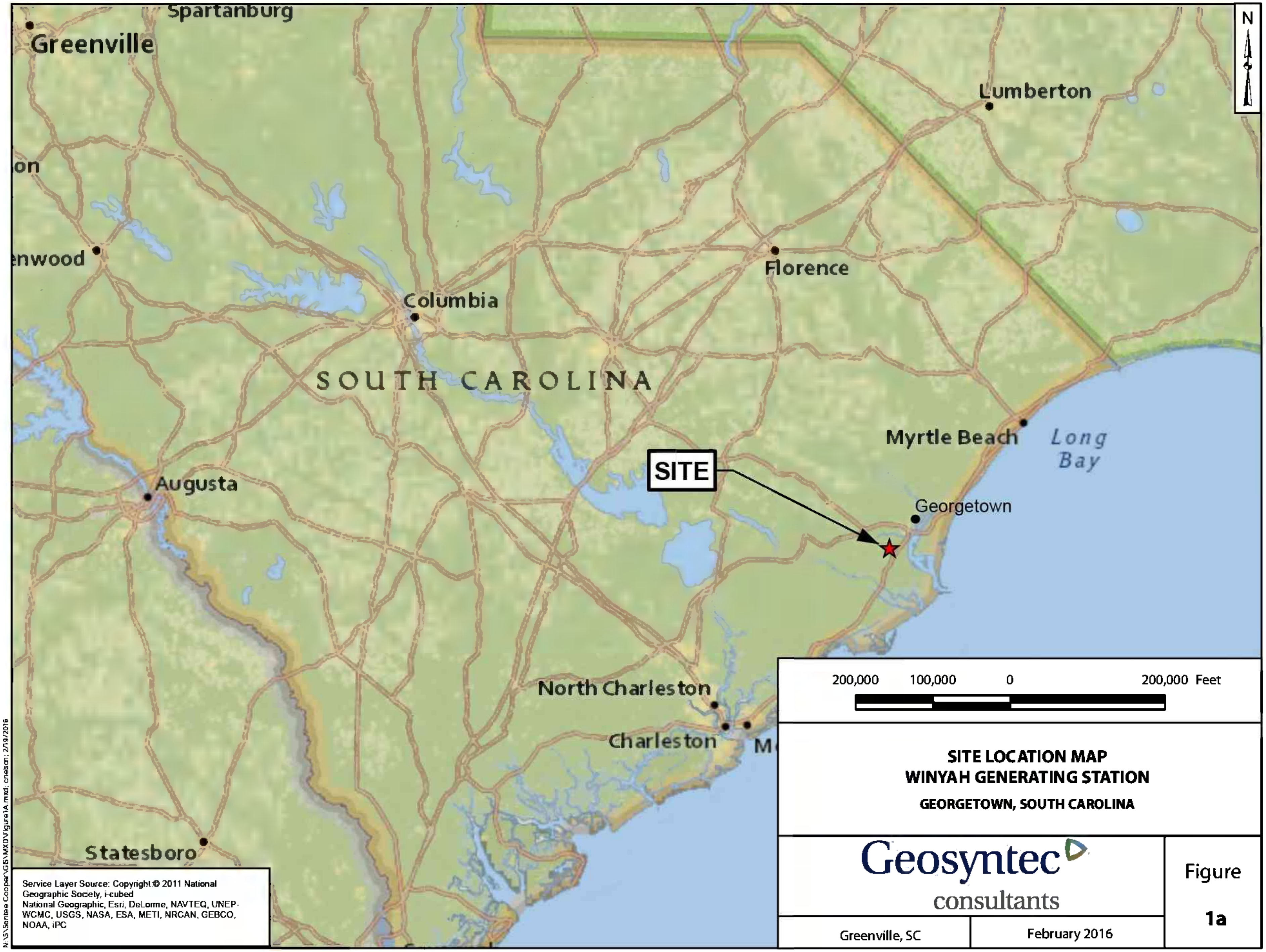
FIGURES

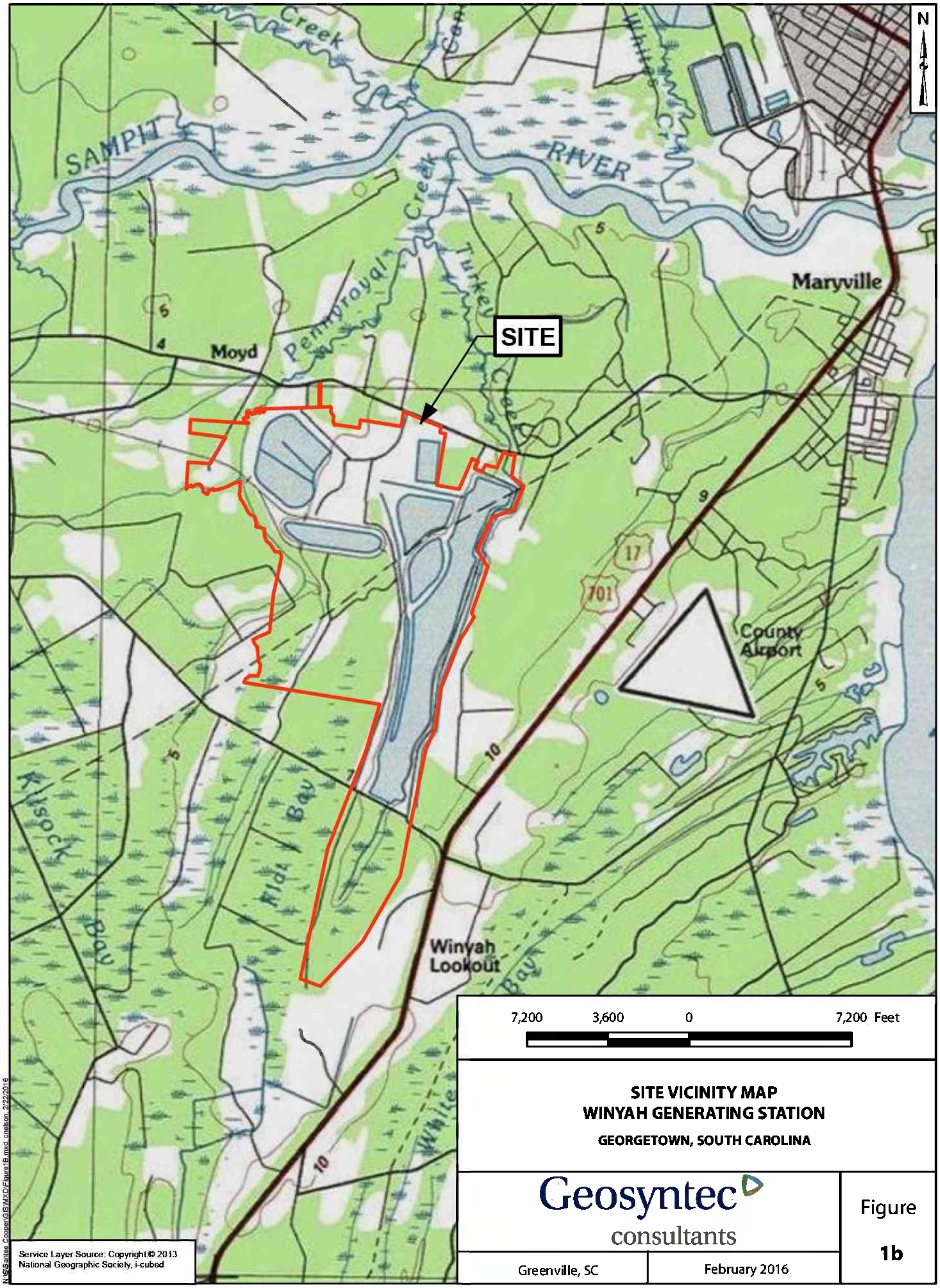


SITE LOCATION MAP
WINYAH GENERATING STATION
GEORGETOWN, SOUTH CAROLINA

Geosyntec consultants

Greenville, SC | February 2016

Figure 1a

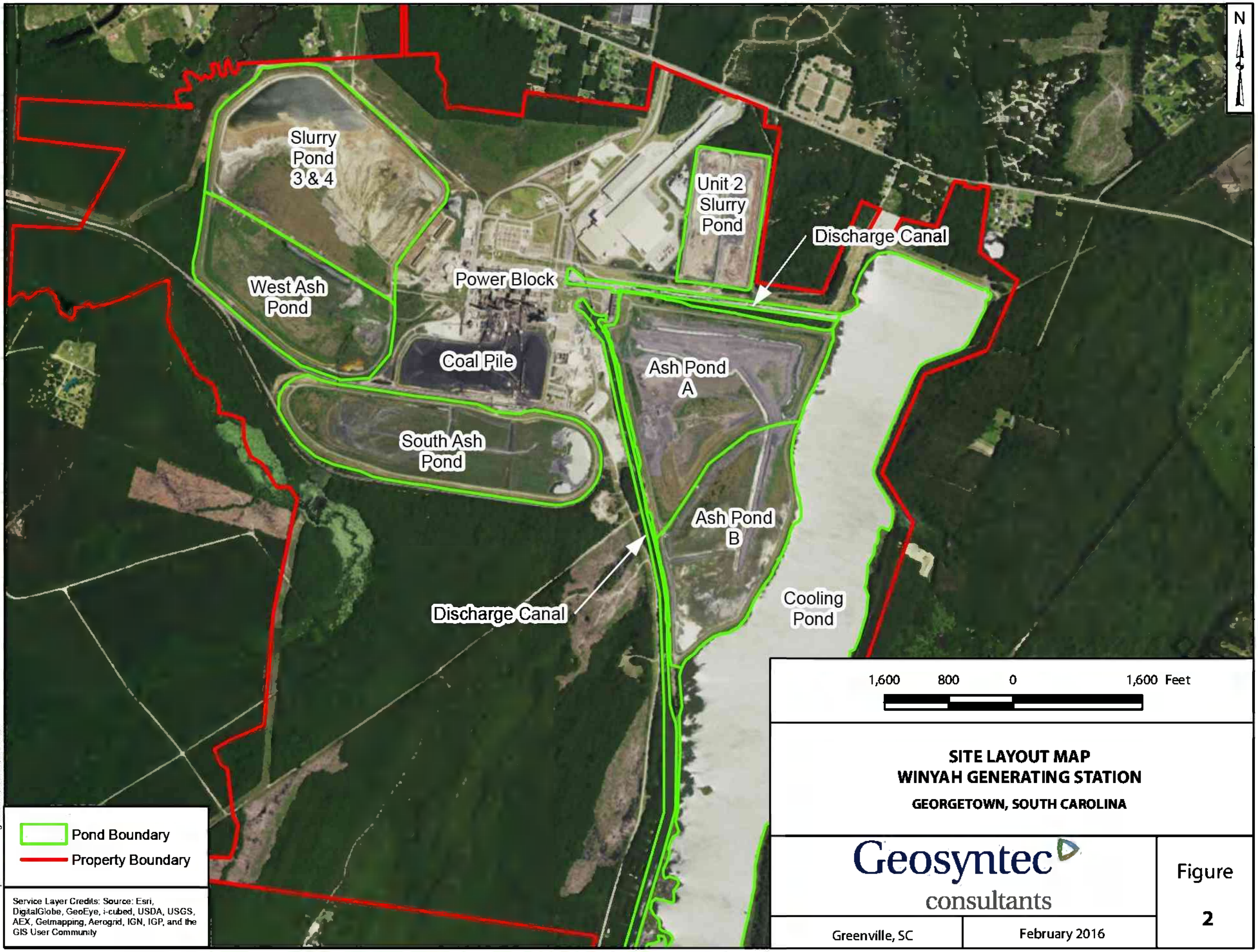


SITE VICINITY MAP
WINYAH GENERATING STATION
GEORGETOWN, SOUTH CAROLINA

Geosyntec consultants

Greenville, SC | February 2016

Figure **1b**



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

SITE LAYOUT MAP
WINYAH GENERATING STATION

GEORGETOWN, SOUTH CAROLINA

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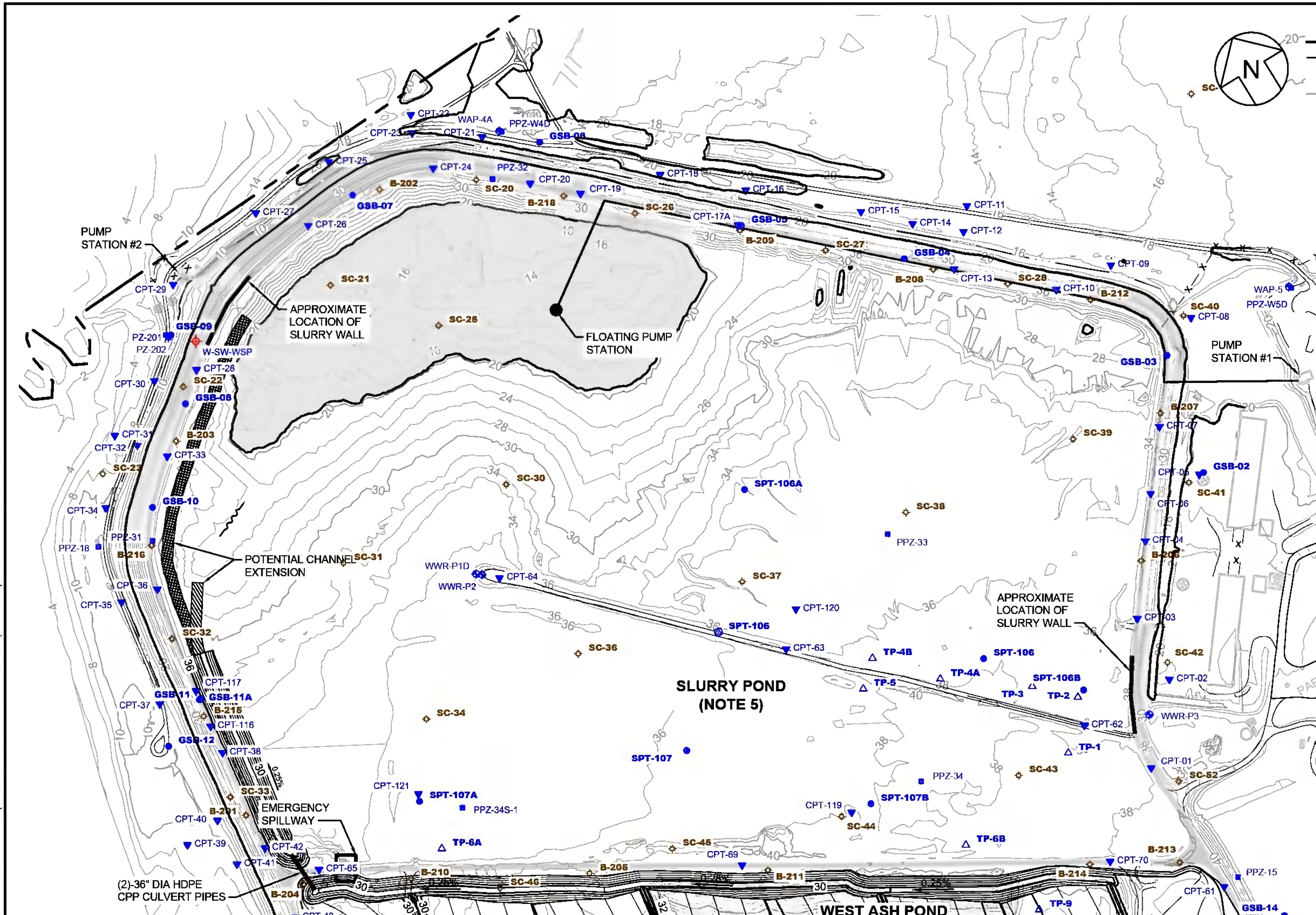
Figure 2



LEGEND

30	DESIGN MAJOR GRADE CONTOUR
10	EXISTING MAJOR GRADE CONTOUR
W-SW-WSP	EXISTING STAFF GAUGE
B-201 SC-20	BORING BY OTHERS
CPT-01	GEOSYNTEC CONE PENETRATION TEST
GSB-02	GEOSYNTEC SOIL BORING
WAP-4A, WWR-P1D	MONITORING WELL
PZ-201, PPZ-15, PPZ-W4D	PIEZOMETER
TP-1	TEST PIT

NOTES:

1. TOPOGRAPHIC SURVEY PROVIDED BY THOMAS & HUTTON DATED 06/29/11 AND REVISED ON 01/14/12.
2. TEMPORARY PZ-31 AND PZ-32 WERE INSTALLED IN JUNE 2014 TO MEASURE THE PHREATIC SURFACE WITHIN THE SLURRY POND PERIMETER DIKES. PZ-31 AND PZ-32 WERE DESTROYED IN OCTOBER 2015 AND JUNE 2013, RESPECTIVELY.
3. ELEVATIONS FROM THIS SURVEY ARE REFERENCED TO NGVD 1929 DATUM AS DERIVED FROM NGS MONUMENT PID#DD1957.
4. THE POSITION OF UNDERGROUND UTILITIES SHOWN ON THIS DRAWING IS BASED UPON THE LOCATION OF SURFACE APPURTENANCES AND/OR SURFACE MARKINGS AND SHOULD BE CONSIDERED APPROXIMATE.
5. THE FREE WATER LEVEL IN THE SLURRY POND IS MAINTAINED AT AN ELEVATION OF 19.6 FT NATIONAL GEODETIC VERTICAL DATUM OF 1928 (NGVD29) BY A FLOATING PUMP STATION. THE MAXIMUM SURCHARGE POOL WITHIN THE SLURRY POND WAS COMPUTED BASED ON THE INFLOW DESIGN FLOOD (IDF) AS 35.3 FT NGVD29.
6. PZ-201 AND PZ-202 WERE INSTALLED BY PAUL C. RIZZO AND ASSOCIATES (PCRA) IN 1999 AND HAVE SINCE BEEN ABANDONED.

WGS - SLURRY POND
BORING LOCATION MAP

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FIGURE 3

PROJECT NO: GSC5242 | SEPTEMBER 2016

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