Prepared for

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2016 SURFACE IMPOUNDMENT PERIODIC STRUCTURAL STABILITY ASSESSMENT REPORT

ASH POND B

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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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 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 impoundment and publish the results to the facility's operating record.

Ash Pond B at WGS is classified as an "existing CCR surface impoundment" by the CCR Rule. This *2016 Surface Impoundment Periodic Stability Assessment Report: Ash Pond B* (Stability Assessment Report) describes the first periodic (i.e., initial) structural stability assessment in accordance with the CCR Rule for Ash Pond B at WGS.

A hydrologic and hydraulic analysis of Ash Pond B and its 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. Since Ash Pond B has been classified as a "Low Hazard Potential" surface impoundment, the 100-yr rainfall event with a rainfall duration of 72 hours was selected as the IDF. Ash Pond A drains stormwater through a culvert system southward into Ash Pond B. The free water level within Ash Pond B is maintained at an elevation of 34.9 ft National Geodetic Vertical Datum of 1929 (NGVD29) by a concrete riser which discharges westward into the Discharge Canal. The peak water level during and after the IDF within Ash Pond B was computed as 37.1 ft NGVD29, which is below the minimum dike crest of 39.7 ft NGVD29. Thus, Ash Pond B will adequately manage inflows during and following the peak discharge from the IDF 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 fill and subsurface soils for Ash Pond B in 2013 and 2016. 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: Ash Pond B* (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 Ash Pond B on 10 and 11 July 2016. From this evaluation and inspection, the condition of the foundation soils, the compaction of dike fill soils, the slope protection and vegetation of perimeter dike slopes, and 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, Ash Pond B 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.

Ash Pond B is situated southeast of the power block and west of the Site's Cooling Pond. Ash Pond B manages CCR in the form of fly ash, boiler slag, and bottom ash as well as process water resulting from power generating activities. Ash Pond B is considered as an existing surface impoundment under the CCR Rule. The *2016 Surface Impoundment Periodic Stability Assessment Report: Ash Pond B* (Stability Assessment Report) has been prepared by Geosyntec Consultants (Geosyntec) on behalf of Santee Cooper to demonstrate that Ash Pond B meets criteria for periodic structural stability assessments in accordance with §257.73(d) of the CCR Rule.

1.2 Project Site and Construction History

Ash Pond B, spanning approximately 65 acres, is located southeast of the power block and immediately west of the Cooling Pond. Ash Pond B, an unlined surface impoundment commissioned in the early 1970s, is designated for the disposal of fly ash, bottom ash, and boiler slag. Ash Pond B is bounded by the divider dike and Ash Pond A to the north, the Discharge Canal to the west, and the Cooling Pond to the south and east. Ash Ponds A and B were constructed simultaneously and are separated by a recompacted, earthen divider dike spanning west to east from the Discharge Canal to the Cooling Pond.

Ash Pond B was constructed by recompacting excavated soils from the impoundment interior to form the perimeter dikes and a divider dike. The Ash Pond B perimeter dikes are approximately 12 ft to 15 ft in height adjacent to the Discharge Canal and approximately 20 ft to 24.5 ft in height along the east and south sides adjacent to the Cooling Pond (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 Ash Pond B dike crest was originally constructed in the early 1970s with a 12- to 15-ft width and an elevation of 34.5 ft National Geodetic Vertical Datum of 1929 (NGVD29), which was approximately 7 ft lower than the Ash Pond A perimeter and divider dikes. The Ash Pond B dike crest was raised to a design elevation of 41.0 ft NGVD29 in 1997 using downstream construction methods. The crest of Ash Pond B is currently at an elevation between 39.7 ft and 41.4 ft NGVD29 (Thomas and Hutton, 2012; Thomas and Hutton, 2016).

Historically, Ash Pond B has received free water from Ash Pond A, which has been routed southward via rim ditches and a group of culverts. Ash Ponds A and B are hydraulically connected through a 30-inch (in.) diameter corrugated metal pipe (CMP), a 48-in. diameter smooth steel pipe, and a 42-in. diameter smooth steel pipe (Thomas and Hutton, 2016; Thomas and Hutton, 2012). Free water within Ash Pond B is stored in the south corner of the surface impoundment and the free water elevation is managed by a concrete riser structure, which discharges into the Discharge Canal through a 24-in. diameter, smooth interior, corrugated high density polyethylene (HDPE) pipe. Ash Pond A receives low volume wastewater, hydroveyor water, and bottom ash sluice water from electric generating Units 1 and 2 along with bottom ash sluice water from Units 3 and 4 and contact water from the Unit 2 Slurry Pond after rainfall events, which are eventually routed into Ash Pond B.

1.3 Report Organization

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

- Descriptions of the hazard potential classification of Ash Pond B and corresponding performance of the hydraulic structures are presented in Section 2;

- Geotechnical subsurface investigations performed by Geosyntec is presented in Section 3;
- Subsurface conditions and geology at WGS are discussed in Section 4;
- The structural stability assessment of the Ash Pond B perimeter dikes is presented in Section 5; and
- The summary and general conclusions from the structural stability assessment are presented in Section 6.

2. HYDROLOGIC AND HYDRAULIC EVALUATION

The following section discusses the regulatory framework, the methodology and assumptions, and the results of the H&H analysis for Ash Pond B and its appurtenances.

2.1 Regulatory Framework

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:

...

(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)(3) states that the spillway or spillways must manage the peak discharge from the *"100-year flood for a low 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 concrete riser structure situated in the south corner of Ash Pond B serves as the spillway for the CCR surface impoundment and manages the discharge during and after the Inflow Design Flood (IDF). The IDF was selected as the 100-yr rainfall event because Ash Pond B was assigned a "Low Hazard Potential" classification (Geosyntec, 2016a) since a potential failure would be contained within the property boundary and is not anticipated to migrate offsite. H&H analyses were performed to demonstrate that the Ash Pond B riser structure is able to adequately manage flow during and following the 100-yr design rainfall (i.e., peak discharge event) without overtopping of perimeter dikes, meeting the criteria in §257.73(d)(1)(v).

2.2 Methodology and Assumptions

Details of the H&H analysis are provided in a calculation package titled *"Hydrologic* *and Hydraulic Analysis for Ash Pond B"*, which is included 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 Ash Pond B.

Ash Ponds A and B are hydraulically connected and thus, modeled as a single pond connected by: (i) a 30-in. diameter CMP culvert with an upstream invert at 37.50 ft NGVD29; (ii) a 48-in. diameter smooth steel pipe with an upstream invert at 35.49 ft NGVD29; and (iii) a 42-in. diameter smooth steel pipe with an upstream invert at 36.20 ft NGVD29 (Thomas and Hutton, 2016; Thomas and Hutton, 2012). These culverts allow for the southward conveyance of stormwater and process water from Ash Pond A into Ash Pond B.

Ash Pond A receives contact water from the Unit 2 Slurry Pond after rainfall events. The Unit 2 Slurry Pond is equipped with a 6JSVE Thompson pump operating at a maximum capacity of 2,600 gallons per minute (gpm) (5.79 ft^3/s), which was considered a base flow into Ash Pond A. Low volume wastewater, hydroveyor water, and bottom ash sluice water from Units 1 and 2 and bottom ash sluice water from Units 3 and 4 were considered to have a combined base inflow to Ash Pond A totaling 6,099 gpm (13.59 ft^3/s). These process water inflows are ultimately routed into Ash Pond B.

The operating level in Ash Pond B is maintained by a 4-ft by 4-ft concrete riser structure (or spillway) with a top stop log elevation of 34.9 ft NGVD 29 (Thomas and Hutton, 2016) and a 24-in. diameter smooth interior, corrugated HDPE pipe discharging to the Discharge Canal. The tailwater conditions associated with discharge from Ash Pond B into the Discharge Canal were modeled using a fixed water surface elevation within the Discharge Canal and Cooling Pond estimated by conservatively assuming 2.5-ft of free water overtopping the Cooling Pond emergency spillway during a significant rainfall event. The top of the stop log bolted to the top of the concrete spillway of the Cooling Pond is at elevation 21.65 ft NGVD 29 (Thomas and Hutton, 2016). The water surface of the Discharge Canal and Cooling Pond was assumed to be at 24.15 ft NGVD 29 (21.65 ft NGVD 29 plus an additional 2.5 ft of water) during the IDF.

HydroCAD® (HydroCAD, 2011) software was utilized to apply the Soil Conservation Service (SCS) Technical Release 20 (TR-20) method (SCS, 1982) to compute the stormwater volume and to model the performance of the hydraulic structures of Ash Ponds A and B during the 100-yr rainfall event. The 100-yr rainfall event was selected with a 72-hour (hr) duration precipitation event resulting in a rainfall depth of 12.8 inches (NOAA, 2006), and modeled within HydroCAD® using a SCS Type III rainfall distribution. The analysis was performed under the following assumptions, which was confirmed by WGS personnel:

- The Site will construct a 100-ft wide emergency spillway with an invert elevation of 37.0 ft NGVD 29 in the divider dike between Ash Ponds A and B by October 2016. The emergency spillway will be constructed with 10H:1V side slopes and will be located between the 48-in. diameter smooth steel pipe and the 42-in. diameter smooth steel pipe.
- Ash Ponds A and B effectively operate as a single surface impoundment with respect to hydraulic performance (i.e., the two impoundments are "hydraulically connected").

2.3 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 IDF was computed as 37.1 ft NGVD29 occurring 42.6 hours into the rainfall event. The minimum elevation of the Ash Pond B perimeter dikes was recently measured as 39.7 ft NGVD29 (Thomas and Hutton, 2016). Thus, Ash Pond B will adequately contain and manage flow during and following the 100-yr rainfall event without overtopping the perimeter dikes and thus, meets the requirements of §257.73(d)(1)(v) of the CCR Rule.

3. GEOTECHNICAL SUBSURFACE INVESTIGATIONS

This section summarizes the geotechnical subsurface investigation programs performed in the vicinity of the Ash Pond B perimeter dikes at WGS. In the fall of 2013, Geosyntec conducted a focused geotechnical subsurface investigation program to obtain geotechnical data necessary to evaluate closure alternatives for the surface impoundment. Geosyntec returned to the Site in the spring of 2016 and performed an additional geotechnical subsurface investigation to collect subsurface information within and along the Ash Pond B perimeter dikes. Historically, soil borings were performed in the vicinity of Ash Pond B prior to construction of the CCR surface impoundment; however, records (i.e., locations, soil boring logs, laboratory testing results) pertaining to these subsurface investigations were not available during the preparation of this Stability Assessment Report. Paul C. Rizzo Associates (PCRA) performed a geotechnical subsurface investigation program supporting the raising of crest of the Ash Pond B perimeter dikes in 1993. These available soil boring logs were utilized during this evaluation. Figure 3 presents the locations of soil borings and Cone Penetration Test (CPT) soundings performed during historical (when available) and Geosyntec's geotechnical subsurface investigations.

The geotechnical data obtained from these subsurface investigation programs, including soil borings, CPT sounding data, and laboratory test results, are provided in Attachments 2, 3, and 4, respectively, of the Safety Factor Assessment Report (Geosyntec, 2016b). The interpretation of the subsurface stratigraphy and material properties is presented in Attachment 5 of the Safety Factor Assessment Report (Geosyntec, 2016b). The following sections provide summaries of each of the geotechnical subsurface investigations in the vicinity of Ash Pond B.

3.1 Paul C. Rizzo Associates (PCRA) Investigation

In 1993, PCRA conducted a focused subsurface investigation of the Ash Pond B perimeter dikes to evaluate the feasibility of raising the structures by 7 ft. PCRA's investigation included six soil borings which were advanced 25 to 30 ft below ground surface (ft bgs) using a CME-55 drilling rig and the hollow stem auger (4.25-inch inner diameter) drilling method. Standard Penetration Tests (SPTs) were conducted in 5-ft depth intervals using a rope-and-cathead system to apply the 140-lb hammer falling 30 inches. Boring logs prepared by PCRA indicated that the perimeter dikes were constructed of medium dense to dense sand with some trace clay and silt. Underlying the dike fill soils, poorly graded sand to clayey and silty sands with some shell fragments were generally encountered within the foundation soils. Depth to water (DTW) level measurements were collected from each soil boring location prior to termination. During this subsurface investigation, the surface water elevation within Ash Pond B was maintained approximately at 29.2 ft NGVD29 (PCRA, 1993). Additionally, PCRA identified a potential offsite borrow source adjacent to WGS containing suitable soil for structural fill to raise the perimeter dikes. Two samples of the potential borrow soils were collected and tested for index properties (i.e., grain size distribution and Atterberg limits tests) and compaction properties (i.e., standard Proctor tests).

3.2 Geosyntec Investigations

3.2.1 Fall 2013 Subsurface Investigation

In October 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. In the Ash Pond B area, Geosyntec advanced four soil borings by the mud rotary wash drilling method and seven CPT soundings. Soil Consultants, Inc. (SCI) of Charleston, South Carolina was the drilling contractor during this subsurface investigation while Mid-Atlantic Drilling, Inc. (MAD) from Wilmington, North Carolina performed the CPT soundings. One soil boring (SPT-122) and three CPT soundings (CPT-152, CPT-153, and CPT-154) were advanced within the interior of Ash Pond B, but were terminated once native or foundation materials were encountered. The remaining soil borings and CPT soundings during this investigation were performed on the perimeter and divider dikes and were terminated once refusal was encountered, which was defined as SPT N-value of 50 blows per foot over an advancement of 6" or the inability to further advance the cone.

For each soil boring, split spoon samples were collected and SPT blow counts (i.e., N-values) were measured typically in 5-ft depth intervals. Attempts were made to push Shelby tubes within dike fill and foundation soils; however, these soils were typically found to be dense and cohesionless and thus, undisturbed samples were unable to be collected. In one soil test boring (SPT-115), SCI switched from a paddle drilling bit to a tri-cone rotary wash drill bit once the Chicora Member stratum was encountered to penetrate the stratum and extend the borehole into the underlying stiff clay. In SPT-115, an attempt was made to push a Shelby tube to collect a sample of the underlying stiff clay for laboratory testing. However, the Shelby tube was sheared during extraction from the borehole (i.e., the screws attached to the drilling rods sheared). For select CPT soundings, the shear wave velocity (V_S) was measured in 5-ft depth intervals or a porewater pressure dissipation test was performed to evaluate the phreatic surface at the location. Results of the V_S and porewater pressure dissipation tests are provided in Attachment 3 of the Safety Factor Assessment Report (Geosyntec, 2016b).

In November 2013, Geosyntec returned to WGS to install piezometers as part of the development of the hydrogeological model at the Site. One piezometer (PPZW-10D) was installed adjacent to a Site monitoring well (WAP-10) by South Atlantic Environmental Drilling and Construction Co. Inc. (SAEDACCO). Prior to installing the piezometer, subsurface soils were collected within the borehole using a split spoon sampler and logged by a geologist.

3.2.2 Spring 2016 Subsurface Investigation

Geosyntec mobilized to WGS in the spring of 2016 to perform a focused geotechnical subsurface investigation in the vicinity of the South Ash Pond, Ash Pond A, Ash Pond B, and the former Unit 2 Slurry Pond. The investigation program along the Ash Pond B perimeter dikes consisted of two soil test borings (SPT-309 and SPT-310) advanced using the mud-rotary drilling technique by MAD and three CPT soundings (CPT-225, CPT-226, and CPT-227) advanced by Terracon. Additionally, Terracon (by means of Carolina Drilling, Inc.) advanced two additional borings (SPT-307 and SPT-308) and several CPT soundings within the Ash Pond B interior in support of evaluating preliminary and conceptual closure alternatives. For SPT-309 and SPT-310, split spoon samples were collected and SPTs were performed continuously in the upper 20 ft bgs and in 5-ft depth intervals thereafter until refusal was encountered. Refusal was defined as SPT N-values of 50 blows per foot over an advancement of 6 inches or less. Select soil samples were sealed and transported to a geotechnical laboratory for testing.

3.2.3 Laboratory Testing

For the geotechnical subsurface investigations led by Geosyntec, Excel Geotechnical Testing, Inc. (EGT) of Roswell, Georgia and Terracon were subcontracted to conduct the geotechnical laboratory testing programs on representative disturbed (i.e., bulk or split spoon) samples of the dike fill and foundations soils, including twelve grain size distribution tests with two hydrometer tests, twenty-two fines content tests (to supplement the grain size distribution tests), seven Atterberg limits tests, and thirty-five natural water content tests. Additionally, EGT conducted two grain size distribution tests, two Atterberg limits tests, two CU triaxial tests, and one 1-D consolidation test on undisturbed (i.e., thin-walled Shelby tube) samples of impounded fly ash collected from the interior of Ash Pond B. Laboratory testing results from each geotechnical subsurface investigation are provided in Attachment 4 and the interpretation of the laboratory testing results is discussed in Attachment 5 of the Safety Factor Assessment Report (Geosyntec, 2016b).

4. SUBSURFACE CONDITIONS AND GEOLOGY

This section presents subsurface conditions, phreatic surface and free water levels, and material properties for Ash Pond B 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 and Water Levels

4.2.1 Subsurface Stratigraphy

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

- Dike Fill: Dike fill soils for the Ash Pond B perimeter dikes were generally observed to be medium dense to very dense poorly graded silty sands with uncorrected SPT blow counts typically ranging between 9 and 51 blows per foot. CPT tip resistances in the top 10 ft of fill typically ranged between 30 and 200 tons per square foot (tsf), while CPT tip resistances below the top 10 ft of fill typically ranged between 200 and 450 tsf. Grain size distribution analyses indicated that the dike fill soils consist of approximately 70 percent to 90 percent sand-sized particles (smaller than No. 4 sieve but greater than No. 200 sieve) and 8 percent to 27 percent silt and clay-sized particles (i.e., “fines” with diameters smaller than a No. 200 sieve).

- Foundation Soils: Foundation materials were observed to be variable across the Ash Pond B footprint, consisting primarily of poorly graded silty sands with shells and a few isolated seams of clayey sand or high plasticity clay. Uncorrected SPT blow counts within sandy foundations typically ranged between 2 and 30 blows per foot, while CPT tip resistances typically ranged between 25 and 150 tsf.

- Chicora Member: A dense to very dense layer of partially cemented to heavily cemented shells was encountered beneath the foundations soils during the past subsurface investigations at WGS. Blow counts in this layer exceeded 50 blows over less than 6 in. of advancement with minimal sample recovery. The thickness of the Chicora Member varies across WGS, particularly the partially cemented layers of the stratum. Based on review of historical and existing data, this layer is the upper portion of the overall Williamsburg Formation and has also been referred to as “Coquina” or “Shell Hash” by others. The term “Chi,cora Member” or “Chicora” has been used to refer to this soil unit throughout this Stability Assessment Report (Doar 2012). Soil boring and CPT refusal was typically encountered at the top of this stratum, though one soil boring (SPT-115) within the Ash Pond B area penetrated this stratum.

- Williamsburg Formation Clay: The Williamsburg Formation Clay stratum was encountered beneath the Chicora Member. The Williamsburg Formation Clay is 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 the most recent geological term for this stratum and is used throughout this Stability Assessment Report. The Williamsburg Formation Clay was found to be between 30-ft and 90-ft thick in the vicinity of WGS based on a review of the regional geology.

5. STRUCTURAL STABILITY ASSESSMENT

This section presents a summary of the structural stability assessment for the perimeter dikes surrounding Ash Pond B, demonstrating that Ash Pond B 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 Ash Pond B 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 Ash Pond B. During the inspection, Geosyntec observed the condition of the upstream slopes, downstream slopes, stormwater features, pond appurtenances, and pipe penetrations through the dikes of Ash Pond B. Geosyntec observed that the Ash Pond B 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 Stable Foundations and Abutments

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 Ash Pond B 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 Condition of Perimeter Dike Slopes

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 Ash Pond B perimeter dikes have generally been lined with rip-rap slope protection. Over time, sluiced fly ash has 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. Since the concrete riser structure inlet has a minimum elevation of 34.9 ft NGVD29, a significant volume of ponded water is unable to drawn down rapidly within Ash Pond B. Thus, the Ash Pond B 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."

Design reports, technical specifications, or construction quality assurance (CQA) certification reports for the construction of the Ash Pond B perimeter dikes were not available at the time of this Stability Assessment Report. However, a design drawing (CV-511) provides design cross sections for the construction of the Ash Pond B perimeter dikes. The design cross sections indicate that the perimeter dikes consist of

"Compacted Fill" and that *"Organic Material"* at the base of the structure shall be removed from the area. Burns and Roe and Lockwood-Greene, the engineering and design firms for Ash Pond B, also designed the surface impoundments constructed subsequently at WGS for which compaction specifications were developed. It is anticipated that compaction specifications were drafted and utilized for Ash Pond B, but were not available at this time. When the perimeter dikes of Ash Pond B were raised in 1997, compaction specifications were developed by PCRA (1993) for a nearby borrow source. These specifications indicate that *"Fill shall be compacted to 95 percent of maximum dry density"* (γ_d) and *"the moisture content shall be within +/- 2 percent of optimum moisture content"* (OMC). From two standard Proctor tests, PCRA (1993) reported γ_d values of 108.8 pcf and 109.2 pcf and OMC values of 17.2 percent and 17.0 percent, respectively. However, a CQA report detailing earthwork and activities was not available at the time of this Stability Assessment Report.

Soil borings and CPT soundings during various geotechnical subsurface investigation programs have been spaced at approximately 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 for Ash Pond B were generally observed to be medium dense to very dense poorly graded silty sands with uncorrected SPT blow counts typically ranging between 9 and 51 blows per foot. CPT tip resistances in the top 10 ft of fill typically ranged between 30 and 200 tsf, while CPT tip resistances below the top 10 ft of fill typically ranged between 200 and 450 tsf. Based on interpretation of in-situ (i.e., CPT soundings and SPT N-values) presented in Attachment 5 of the Safety Factor Assessment Report (Geosyntec, 2016b), the perimeter dikes of Ash Pond B appear to have been mechanically compacted to sufficient densities to withstand the range of 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"

As described within Section 2, Ash Pond A manages and routes stormwater and process water through three culverts into Ash Pond B. These culverts penetrate the divider dike at depths between 6 and 8 ft bgs, and spill directly into rim ditches within Ash Pond B. These culverts are routinely inspected and have been found to meet the criteria listed in §257.73(d)(1)(vi).

Design documents for Ash Pond B identify a Drawdown Structure III (Drawings CV-504 and CV-508) located approximately 360-ft north of the south corner of Ash Pond B. Drawdown Structure III consists of a concrete riser structure with a 24-in. diameter reinforced concrete pipe (RCP) penetrating the western perimeter dike toward the Discharge Canal. Once outside the perimeter dike footprint, the discharge pipe of Drawdown Structure III transitions into a 24-in. diameter corrugated metal pipe (CMP) before discharging into the Discharge Canal. Concrete anti-seepage collars were provided along the alignment of both the RCP and CMP sections of the discharge pipe exiting the concrete riser of Drawdown Structure III (Lockwood-Greene, 1972).

In 2011, a new concrete riser structure and spillway (i.e., an outlet pipe) were installed in the south corner of Ash Pond B with a discharge pipe penetrating the perimeter dike structure. The new outlet control structure was constructed on the upstream perimeter dike slope and penetrates the perimeter dike with a 24-in. diameter high density polyethylene (HDPE) pipe which was installed within a shallow trench. The 24-in. diameter HDPE pipe penetrates the dike at a 1.95 percent slope and has an invert elevation of 29.9 ft NGVD29 (Thomas and Hutton, 2016). Once the Ash Pond B perimeter dike is penetrated, the 24-in. diameter HDPE pipe follows the downstream dike slope and existing grade until the Discharge Canal is reached. The 24-in. diameter (Standard Dimension Ratio [SDR] 21) HDPE pipe was encased in controlled low strength material (CLSM) (i.e., flowable fill) within the perimeter dike, covered with structural fill, and compacted to 95 percent maximum dry density within and at the base of the Ash Pond B perimeter dikes (Santee Cooper, 2012).

After the new Ash Pond B discharge structure was in service for seven months, Santee Cooper abandoned the original riser structure (i.e., Drawdown Structure III) by removing approximately 8 ft from the end of the RCP downstream of the perimeter dikes and constructed a CLSM plug (Santee Cooper, 2012). Afterwards, CLSM using Type I/II Portland cement was pumped into Drawdown Structure III and was allowed to settle and set for 24 hours. Subsequently, additional CLSM was used to backfill the remaining void space of Drawdown Structure III and the outlet pipe (Santee Cooper, 2012). Based on the available documentation, the original pipe penetrations through the Ash Pond B perimeter dikes have been adequately constructed or properly abandoned (in the case of Drawdown Structure III) and meet the criteria listed in §257.73(d)(1)(vi).

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."

Ash Pond B is located adjacent to the Cooling Pond for WGS and the free water within the Cooling Pond is maintained by a concrete riser structure and emergency spillway. As generating activities are reliant on a minimum water level for process water cooling, sudden drawdown or structural stability during the low pool was not considered a potential failure mechanism and 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 Ash Pond B during the 100-yr rainfall event was evaluated. Based on the evaluation results, Ash Pond B will adequately contain and manage (i.e., without overtopping the perimeter dikes) the flow during and following the 100-yr rainfall event in compliance with §257.73(d)(1)(v) of the CCR Rule.

- A desktop review of site history and engineering reports (when available), geotechnical subsurface investigations, and laboratory testing programs was carried out to evaluate the construction history, characterize the dike and subsurface soils, and understand the existing conditions of Ash Pond B. Based on the information available at the time of this Stability Assessment Report, Ash Pond B 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).

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

7. REFERENCES

Campbell, B.G., and Coes, A.L. (2010), Groundwater availability in the Atlantic Coastal Plain of North and South Carolina: U.S. Geological Survey Professional Paper 1773, 241 p., 7 pls.

Doar, W.R. III (2012), Geologic Map of the Georgetown South 7.5-minute Quadrangle, Georgetown County, South Carolina.

Geosyntec Consultants, Inc. (2016a), "Hazard Potential Classification Assessment: Ash Pond B", Project No. GSC5242.

Geosyntec Consultants, Inc. (2016b), "2016 Surface Impoundment Periodic Safety Factor Assessment Report: Ash Pond B", Project No. GSC5242.

HydroCAD (2011), *HydroCAD* Stormwater Modeling, HydroCAD Software Solutions, LLC, revised 2011.

Lockwood-Greene, (1972), A Drawing Set for Santee Cooper Winyah Generating Station.

Muthig, M.G and D.J. Colquhoun (1988), Formal recognition of two members within the Rhems Formation in Calhoun County, South Carolina: South Carolina Geology, V. 32, nos. 1-2, p. 11-19.

NOAA. (2006). *Precipitation-Frequency Atlas of the United States.* Atlas 14, Volume 2, Version 3.0. National Oceanic and Atmospheric Administration.

Santee Cooper. (2012). *Inter-Office Communication - WGS Ash Pond B - Abandon Existing Drawdown Structure.*

Soil Conservation Service (1982), *Technical Release Number 20 (TR-20)*, National Technical Information Service.

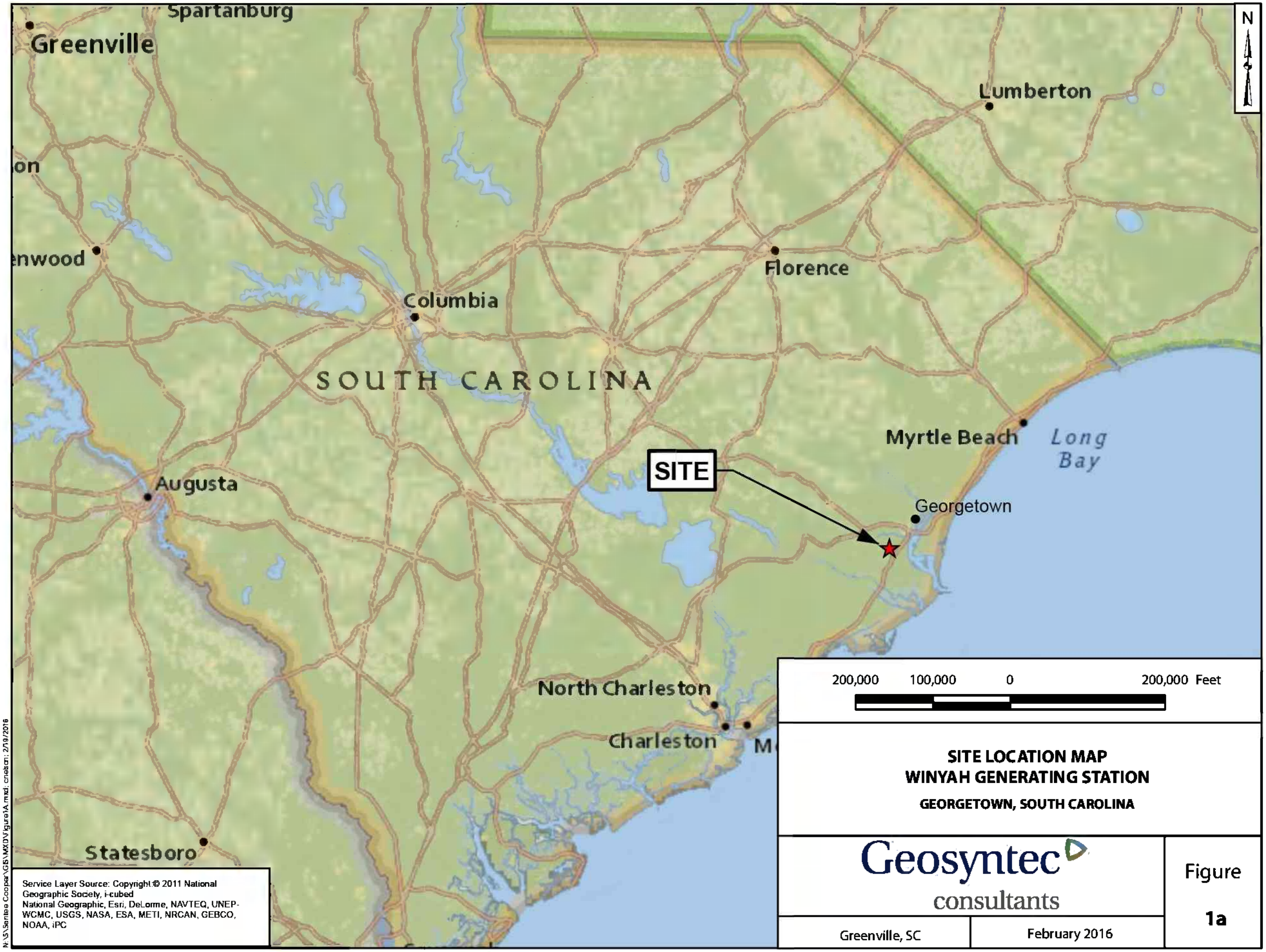
Thomas and Hutton (2012). "Topographic Survey of A Portion of Santee Cooper Winyah Generating Station", prepared for Santee Cooper, 14 January 2014.

Thomas and Hutton. (2016). "Topographic Survey of the Dike Crests at Santee Cooper Winyah Generating Station."

USACE (2000), "Design and Construction of Levees", EM-1110-2-1913, Washington DC, April 30, 2000.

USEPA (1995). "RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities", Office of Research and Development, EPA/600/R-95/051, April 1995.

FIGURES



SITE LOCATION MAP
WINYAH GENERATING STATION
GEORGETOWN, SOUTH CAROLINA

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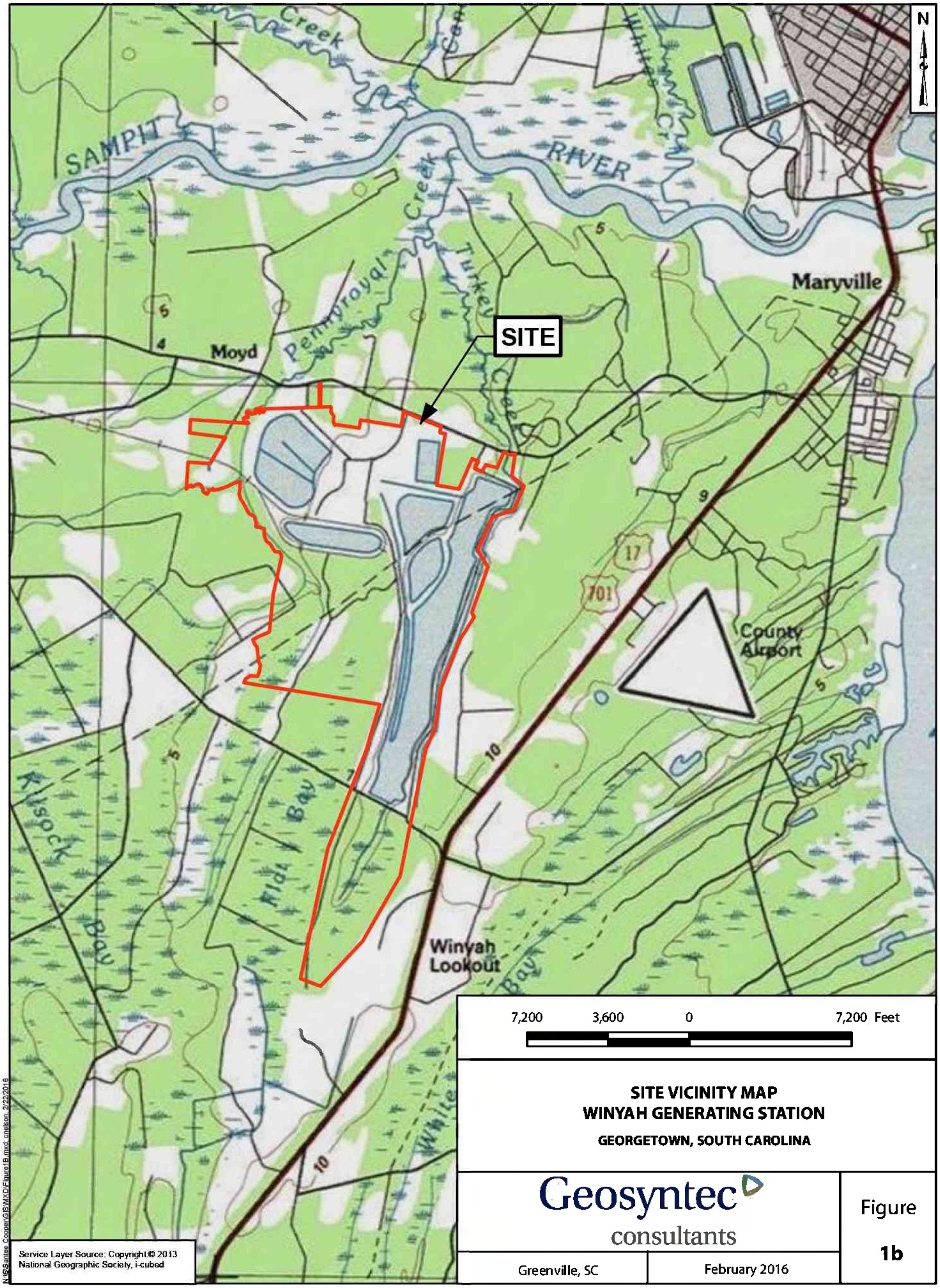
Greenville, SC | February 2016

Figure 1a



7,200 3,600 0 7,200 Feet

SITE VICINITY MAP
WINYAH GENERATING STATION
GEORGETOWN, SOUTH CAROLINA

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Figure **1b**

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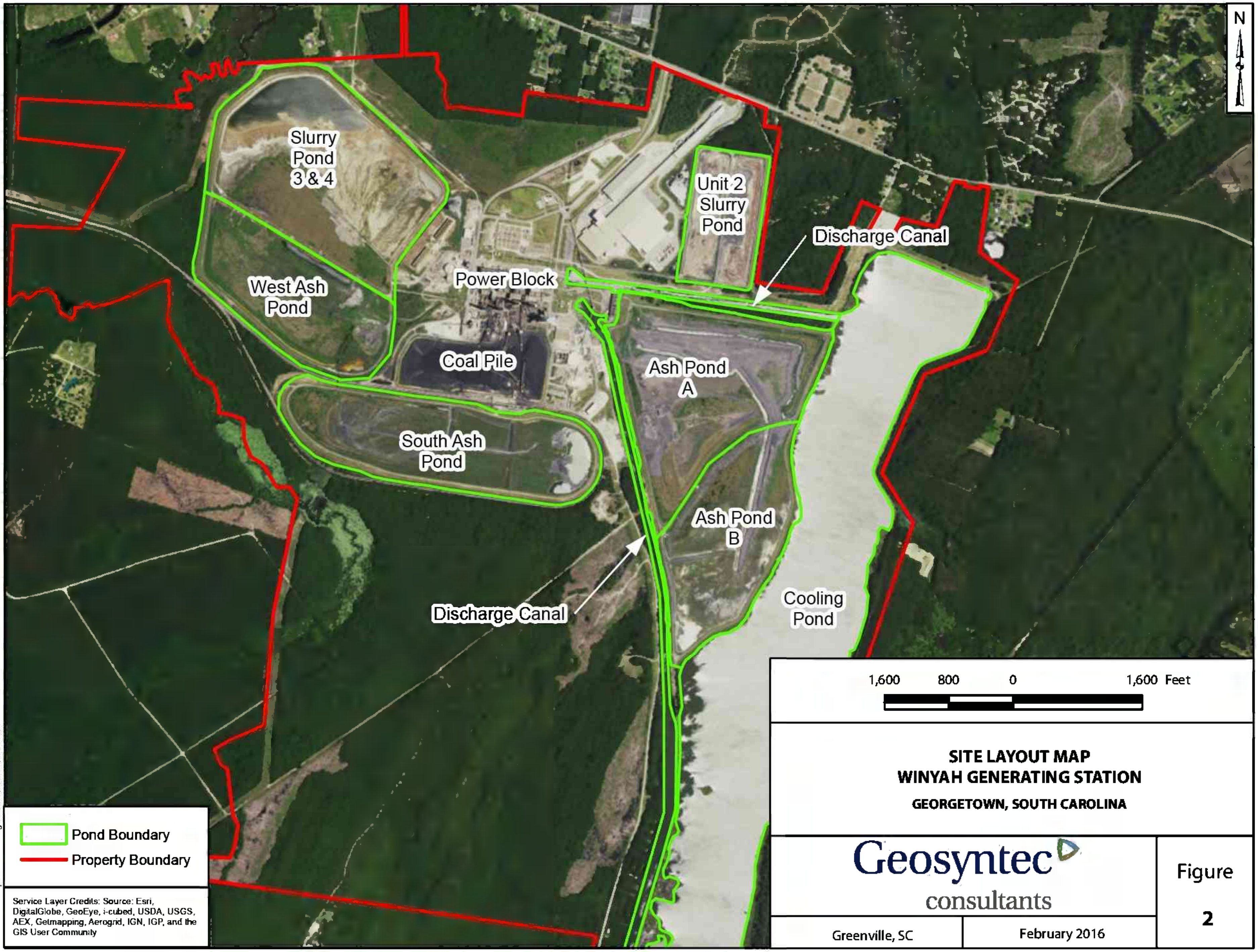

SITE LAYOUT MAP
WINYAH GENERATING STATION
GEORGETOWN, SOUTH CAROLINA

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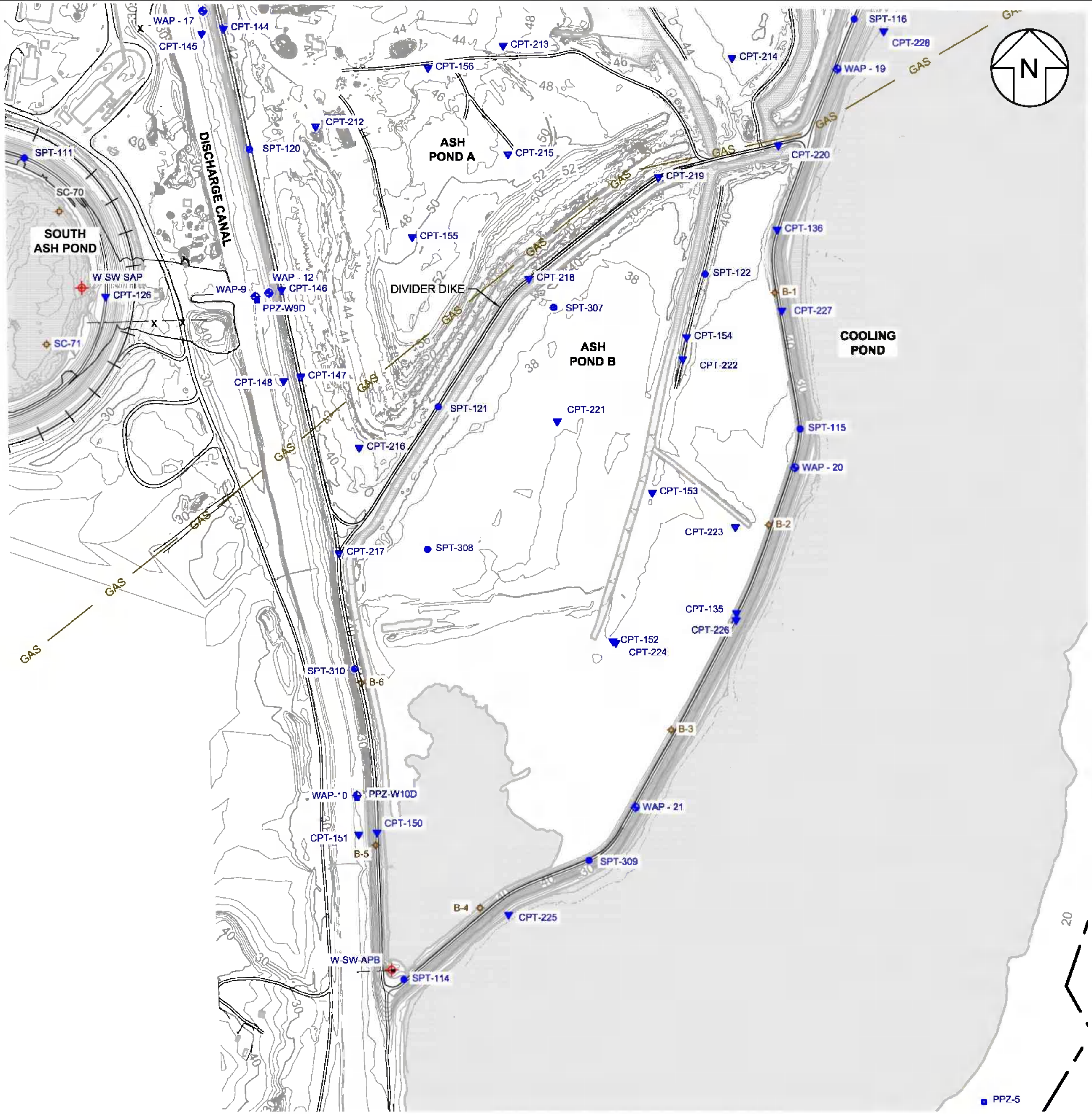
Figure 2



LEGEND

GAS — GAS	EXISTING GAS LINE
— 30 —	EXISTING MAJOR GRADE CONTOUR
	EXISTING RAILROAD
	EXISTING WATER
W-SW-APB	EXISTING STAFF GAUGE
CPT-144	GEOSYNTEC CONE PENETRATION TEST
SPT-111	GEOSYNTEC SOIL BORING
B-1	HISTORICAL BORING
WAP-9	GROUNDWATER MONITORING WELL
PPZ-5, PPZ-W9D	PIEZOMETER

NOTES:

1. TOPOGRAPHIC SURVEY PROVIDED BY THOMAS & HUTTON DATED 06/29/11 AND REVISED ON 01/14/12.
2. ELEVATIONS FROM THIS SURVEY ARE REFERENCED TO NGVD 1929 DATUM AS DERIVED FROM NGS MONUMENT PID#DD1957.
3. 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.

0 400' 800'

SCALE IN FEET

BORING LOCATION MAP - ASH POND B

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FIGURE 3

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