

Comprehensive Site Assessment Report

Marshall Steam Station Ash Basin

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| Site Name and Location | Marshall Steam Station 8320 NC Highway 150 E Terrell, NC 28682 |
| Groundwater Incident No. | Not Assigned |
| NPDES Permit No. | NC0004987 |
| Date of Report | September 8, 2015 |
| Permittee and Current Property Owner | Duke Energy Carolinas, LLC 526 South Church St Charlotte, NC 28202-1803 704.382.3853 |
| Consultant Information | HDR Engineering, Inc. of the Carolinas 440 South Church St, Suite 900 Charlotte, NC 28202 704.338.6700 |
| Latitude and Longitude of Facility | 35° 35' 52" N, 80° 57' 54" W |

This document has been reviewed for accuracy and quality commensurate with the intended application.



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Executive Summary – Marshall Steam Station

On August 20, 2014, the North Carolina General Assembly passed Session Law 2014-122, the Coal Ash Management Act of 2014 (CAMA). Section 130A-309.211 of the act requires the owner of a coal combustion residuals surface impoundment to submit a Groundwater Assessment Work Plan (Work Plan) to the North Carolina Department of Environment and Natural Resources (NCDENR) no later than December 31, 2014 and a Groundwater Assessment Report (herein referred to as a Comprehensive Site Assessment [CSA]) no later than 180 days following approval of the Work Plan. Duke Energy Carolinas, LLC (Duke Energy) submitted a Work Plan to NCDENR on December 30, 2014 for characterization of the Marshall Steam Station (MSS) ash basin, dry ash landfill (Phases I and II), and Photovoltaic (PV) structural fill and assessment of potential impacts to soil, groundwater, and surface water. The Work Plan was subsequently conditionally approved by the NCDENR in correspondence dated March 12, 2015. This CSA report was prepared to comply with CAMA and is submitted to NCDENR within the allotted 180-day timeframe. Data generated during the CSA will be used to develop the Corrective Action Plan (CAP), due no later than 90 days after submittal of this CSA unless an extension is requested and granted by NCDENR.

The purpose of this CSA is to characterize the extent of contamination resulting from historical production and storage of coal ash, evaluate the chemical and physical characteristics of the contaminants, investigate the geology and hydrogeology of the site including factors relating to contaminant transport, and examine risks to potential receptors and exposure pathways. This CSA was prepared in general accordance with requirements outlined in the following statutes, regulations, and documents:

- Groundwater Classification and Standards, Title 15A NCAC Subchapter 2L;
- Coal Ash Management Act of 2014, N.C. Gen. Stat. §§130A-309.200 et seq.;
- Notice of Regulatory Requirements (NORR) issued by NCDENR on August 13, 2014;
- Conditional Approval of Revised Groundwater Assessment Work Plan issued by NCDENR on March 12, 2015; and
- Subsequent meetings and correspondence between Duke Energy and NCDENR.

For this CSA, the source area is defined as the ash basin, dry ash landfill (Phases I and II), and PV structural fill. Source characterization was performed to identify physical and chemical properties of ash, ash basin surface water, ash porewater, and ash basin seeps. The analytical results for source characterization samples were compared to North Carolina Groundwater Quality Standards, as specified in 15A NCAC 2L.0202 (2L Standards), or Interim Maximum Allowable Concentrations (IMACs), and other regulatory screening levels for the purpose of identifying constituents of interest (COIs) that may be associated with potential impacts to soil, groundwater, and surface water from the source area. The IMACs were issued in 2010, 2011, and 2012; however, NCDENR has not established a 2L Standard for these constituents as described in 15A NCAC 2L.0202(c). For this reason, the IMACs noted in this report are for reference only.

Some COIs are present in background and upgradient monitoring wells and may be naturally occurring, and thus require careful examination to determine whether their presence downgradient of the source area is naturally occurring or a result of ash handling and storage.

In addition to evaluating the distribution of constituents across the MSS site, significant factors affecting constituent transport and the geological and hydrogeological features influencing the movement and chemical and physical character of the COIs were evaluated.

The assessment consisted of the following activities:

- Completion of soil and rock borings and installation of groundwater monitoring wells to facilitate collection and analysis of chemical, physical, and hydrogeological parameters of subsurface materials and groundwater encountered within and beyond the ash basin waste and compliance boundaries;
- Collection and analysis of solid phase (e.g., soil, rock and ash) and liquid phase (e.g., groundwater, ash basin porewater, ash basin surface water, seep, and surface water) samples;
- Evaluation of testing data to supplement the initial site conceptual model presented in the Work Plan;
- Revision to the Receptor Survey previously completed in 2014; and
- Completion of a Screening-Level Risk Assessment.

Based on scientific evaluation of historical and new data obtained during completion of the above-referenced activities, the following conclusions can be drawn:

- No imminent hazard to human health or the environment has been identified as a result of soil, groundwater, or surface water impacts at the site.
- Upgradient, background monitoring wells contain naturally occurring metals and other constituents at concentrations that exceed their respective 2L Standards or IMACs. This information is used to evaluate whether concentrations in groundwater downgradient of the source area are naturally occurring or potentially influenced by migration of constituents from the source area. Naturally occurring metals and constituents reported in background groundwater samples at concentrations greater than 2L Standards or IMACs include barium, chromium, cobalt, iron, lead, manganese, thallium, and vanadium.
- Groundwater in the shallow, deep, and bedrock flow layers beneath the ash basin flows to the southeast toward Lake Norman and slightly east toward an unnamed tributary on Duke Energy property that flows to Lake Norman. This flow direction is away from the direction of the nearest public or private water supply wells. Lake Norman serves as a hydrologic boundary for groundwater within the shallow layer at the site. There are no water supply wells located between the source area and Lake Norman.
- The geological and hydrogeological features influencing the migration, chemical, and physical characteristics of contaminants are related to the Piedmont hydrogeologic system present at the site. The CSA found that the migration of coal ash-related

contaminants is toward Lake Norman and an unnamed tributary that flows to Lake Norman, and appears to be contained within the ash basin compliance boundary.

- The U.S. Environmental Protection Agency (USEPA) has identified select constituents as leading indicators for detecting groundwater contamination from coal combustion residuals (CCR) units, which may be evaluated for statistically significant increases over background concentrations with time. Boron and sulfate are leading indicators among these detection monitoring constituents, are expected to be highly mobile in the groundwater environment, and therefore can be used to represent the general extent of groundwater impacted by the ash basin at the site. The horizontal and vertical migration of boron best represents the groundwater flow and potential transport system at the MSS site. Sulfate is generally a good indicator, but can naturally occur above its applicable standards and should be carefully considered for use as an indicator.
- Boron exceedances at the site are primarily present in the shallow and deep flow layers beneath the dry ash landfill (Phase II), east and downgradient of the ash basin and dry ash landfill (Phase I), and southeast and downgradient of the ash basin. There are also boron exceedances present in the deep flow layer beneath the central portion of the ash basin and beneath the western portion of the ash basin. Boron exceedances in bedrock are limited to the area beneath the ash landfill. The boron concentrations are generally higher in the shallow and deep layers beneath the dry ash landfill (Phase II) and in the deep layer beneath the western portion of the ash basin. Bedrock is impeding vertical migration of groundwater and limiting the vertical extent of boron impacts.
- Based on data obtained during this CSA, groundwater flow direction, and the extent of exceedances of boron, it appears that groundwater impacted by the source area is contained within Duke Energy property and the ash basin compliance boundary. Figure ES-1 depicts the horizontal extent of 2L Standard exceedances for boron in the shallow, deep, and bedrock groundwater flow layers at the site.
- Exceedances of 2L Standards and IMACs were observed in monitoring wells at the outermost extent of the monitoring well system, including upgradient and background wells. A preliminary review found that the upgradient and background constituent exceedances of barium, chromium, cobalt, iron, lead, manganese, thallium, and vanadium at the outermost extent of the monitoring system to the west, north, and northwest are related to background water quality, naturally occurring conditions, and/or sampling conditions.
- The horizontal extent of soil contamination is limited to the area beneath the ash basin. Where soil impacts were identified, the vertical extent of contamination beneath the ash/soil interface is generally limited to the uppermost soil sample collected beneath ash.

ES.1 Source Information

Duke Energy owns and operates MSS, which is located on Lake Norman in Catawba County near the town of Terrell, North Carolina. MSS began operation in 1965 as a coal-fired generating station and currently operates four coal-fired units. The CCR from MSS's coal combustion process has historically been stored in the station's ash basin located to the north of



the station and adjacent to Lake Norman. The ash basin system at MSS consists of a single cell impounded by an earthen dike located on the southeast end of the ash basin. The ash basin system was constructed in 1965 and is located north of the power plant. Inflows from the station to the ash basin are discharged into the southwest portion of the ash basin.

The ash basin is operated as an integral part of the station's wastewater treatment system, which receives permitted and variable discharges from the ash removal system, coal pile runoff, landfill leachate, flue gas desulfurization (FGD) wastewater, the station yard drain sump, and site stormwater.

During operations of the coal-fired units, the sluice lines discharge the water/slurry and other permitted flows to the southwest portion of the ash basin. Inflows to the ash basin are highly variable due to station operations and weather.

The dry ash landfill consists of two units; which are located adjacent to the east (Phase I) and northeast (Phase II) portions of the ash basin. Phase I was constructed in September 1984 and the unit was closed in March 1986. Placement of ash in the Phase II unit began around March 1986 and was completed in 1999. The dry ash landfill units were constructed prior to the requirement for lining industrial landfills and were closed with a soil and vegetative cover system.

The PV structural fill was constructed of fly ash under the structural fill rules found in 15A NCAC 13B .1700 *et seq.* and is located adjacent to and partially on top of the northwest portion of the ash basin. Placement of dry ash in the PV structural fill area began in October 2000 and the unit was closed with a soil and vegetative cover system in February 2013.

The industrial landfill No. 1, which is located over portions of the northernmost extent of the ash basin, was constructed with a leachate collection and removal system and a three-component liner system. The subgrade for portions of the industrial landfill were constructed of fly ash under the structural fill rules found in 15A NCAC 13B .1700 *et seq.*

ES.2 Initial Abatement and Emergency Response

No imminent hazard to human health or the environment has been identified; therefore, initial abatement and emergency response actions have not been required.

ES.3 Receptor Survey

Properties located within a 0.5-mile radius of the MSS ash basin compliance boundary generally consist of undeveloped land and Lake Norman to the east, undeveloped land and residential properties located to the north and west, portions of the MSS site (outside the compliance boundary), undeveloped land and residences to the south, and commercial properties to the southeast along North Carolina Highway 150.

The purpose of the receptor survey was to identify the potential exposure locations that are critical to be considered in the groundwater transport modeling and human health risk assessment. The CSA receptor survey activities included contacting and/or reviewing state and

local agencies/records to identify public and private water supply sources, confirm the location of wells, and/or identify any wellhead protection areas located within a 0.5-mile radius of the MSS ash basin compliance boundary. Duke Energy submitted a receptor survey to NCDENR (HDR 2014a) in September 2014, and subsequently submitted to NCDENR a supplement to the receptor survey (HDR 2014b) in November 2014. The supplementary information was obtained from responses to water supply well survey questionnaires mailed to property owners within a 0.5-mile (2,640-foot) radius of the MSS ash basin compliance boundary requesting information on the presence of water supply wells and well usage for the properties.

The receptor survey activities identified four public water supply wells and 83 private water supply wells in use, along with six assumed private water supply wells, located within the 0.5-mile radius of the ash basin compliance boundary. No wellhead protection areas were identified within a 0.5-mile radius of the ash basin compliance boundary. Several surface water bodies that flow from the topographic divide along Sherrills Ford Road toward Lake Norman were identified within a 0.5-mile radius of the ash basin compliance boundary. No water supply wells (including irrigation wells and unused or abandoned wells) were identified between the source area and Lake Norman.

ES.4 Sampling / Investigation Results

ES.4.1 Background Findings

As part of the CSA, Duke Energy installed six additional background monitoring wells (three shallow, two deep, and one bedrock). Based on existing knowledge of the site, the background locations were selected to maximize physical separation from the ash basin, dry ash landfill units, and PV structural fill in areas believed not to be impacted by ash to provide sufficient background soil and groundwater quality data. Analyses of groundwater samples collected from the six newly installed background wells and two existing ash basin compliance background wells indicated that the following naturally occurring constituents exceed 2L Standards or IMACs in background locations: barium, chromium, cobalt, iron, lead, manganese, thallium, and vanadium. The results for all other constituents were reported below 2L Standards or IMACs. The range of concentrations reported in the new background wells is presented below.



Table ES-1. Concentrations Reported in New Background Wells

| Constituent of Interest | NC 2L Standard or IMAC (µg/L) | Background Well Range of Concentrations (µg/L) |
|-------------------------|-------------------------------|--|
| Antimony | 1* | 0.33J to <2.5 |
| Arsenic | 10 | 0.17J to 7.5 |
| Barium | 700 | 28 to 760 |
| Beryllium | 4* | <0.2 to <1 |
| Boron | 700 | 26J+ to <50 |
| Chloride | 250,000 | 1,200 to 4,800 |
| Chromium | 10 | 1.2J+ to 80.4 |
| Cobalt | 1* | 0.38J to 11.9 |
| Iron | 300 | 77 to 18,200 |
| Lead | 15 | 0.078J to 17.5 |
| Manganese | 50 | 4.1J to 380 |
| Selenium | 20 | 0.37J to <2.5 |
| Sulfate | 250,000 | <1000 to 16,000 |
| TDS | 500,000 | 42,000J+ to 369,000 |
| Thallium | 0.2* | 0.018J to <0.5 |
| Vanadium | 0.3* | 2.2J to 100 |

Notes:

1. µg/L indicates micrograms per liter.
2. J indicates an estimated concentration.
3. J+ indicates an estimated concentration, biased high.
4. * denotes an IMAC

ES.4.2 Source Characterization

Source characterization was performed through the completion of soil and rock borings, installation of monitoring wells, and collection and analysis of associated solid matrix and aqueous samples to identify physical and chemical properties of ash, ash basin surface water, ash porewater, and ash basin seeps. The physical and chemical properties evaluated as part of the characterization have been used to better understand impacts to soil and groundwater from the source area and will be utilized as part of groundwater model development in the CAP.

Review of laboratory analytical results of ash samples collected from the ash basin, dry ash landfill (Phase II), and PV structural fill identified nine COIs: antimony, arsenic, barium, boron, cobalt, iron, manganese, selenium, and vanadium.

COIs identified in ash porewater samples include antimony, arsenic, barium, beryllium, boron, cadmium, chloride, chromium, cobalt, iron, lead, manganese, nickel, selenium, sulfate, thallium, TDS, and vanadium.

COIs identified in ash basin surface water samples include arsenic, beryllium, boron, cadmium, chloride, cobalt, copper, lead, manganese, nickel, selenium, sulfate, thallium, TDS, vanadium, and zinc.

Synthetic Precipitation Leaching Procedure (SPLP) testing was conducted to evaluate the leaching potential of constituents from ash. Although SPLP analytical results are being compared to 2L Standards and IMACs, these leaching results do not represent groundwater samples. The results of SPLP analyses indicate that the following constituents exceeded their 2L Standards: antimony, arsenic, barium, boron, chromium, cobalt, iron, lead, manganese, nickel, selenium, thallium, and vanadium. However, many factors influence the transport of these constituents and any potential impacts to groundwater over time will be investigated through modeling as part of the CAP.

One seep sample associated with the ash basin (S-2), one NCDENR seep re-sample location (MSSW001 S001), and one NCDENR surface water re-sample location (MSSW002 S001) were sampled during this CSA. Seep sample S-2 contained reported concentrations above 2L Standards or IMACs for arsenic, barium, boron, beryllium, chromium, cobalt, lead, manganese, selenium, thallium, TDS, and vanadium. Note that the reported concentrations in sample S-2 are likely affected by turbidity/suspended solids. The NCDENR re-samples had reported exceedances of 2L Standards or IMACs, or 2B Standards¹, for arsenic, boron, cobalt, manganese, thallium, TDS, and vanadium.

ES.4.3 Nature and Extent of Contamination

The CSA found that soil and groundwater beneath the ash basin and dry ash landfill (Phase II), soil and groundwater to the east and downgradient of the ash basin and dry ash landfill (Phase I), and groundwater to the southeast and downgradient of the ash basin (within the compliance boundary) have been impacted by ash handling and storage at the MSS site.

Ash basin COIs in soil and groundwater in these areas are likely the result of leaching from coal ash contained in the ash basin and dry ash landfill units. However, exceedances of some COIs (i.e., barium, chromium, cobalt, iron, lead, manganese, thallium, and vanadium) may be due in part or in whole to naturally occurring conditions based on review of background soil and groundwater quality data.

ES.4.3.1 Soil

The horizontal extent of soil impacts is limited to the area beneath the ash basin and one location east and downgradient of the dry ash landfill (Phase I). Where soil impacts were identified beneath the ash basin, the vertical extent of contamination beneath the ash/soil interface is generally limited to the uppermost soil sample collected beneath ash. Reported concentrations of soil samples were compared to background concentrations in addition to the North Carolina Industrial Health (Industrial) and Protection of Groundwater (POG) Preliminary Soil Remediation Goals (PSRGs) to delineate the extent of contamination. Arsenic was the only COI with exceedances of background concentrations and North Carolina PSRGs beneath the ash basin and at the one location east of the dry ash landfill (Phase I). In general, constituent concentrations of barium, cobalt, iron, manganese, and vanadium were higher in soil compared to ash, and are considered to represent naturally occurring background conditions.

¹ Surface water classifications in North Carolina are promulgated in Title15A NCAC Subchapter 2B (2B Standards).

ES.4.3.2 Groundwater

The approximate horizontal extent of groundwater impacts is limited to beneath the ash basin and dry ash landfill (Phase II), east and downgradient of the ash basin and dry ash landfill (Phase I), and southeast and downgradient of the ash basin, within the ash basin compliance boundary. The approximate vertical extent of groundwater impacts is generally limited to the shallow and deep flow layers, and vertical migration of COIs is impeded by the underlying bedrock.

Constituents with concentrations that exceeded 2L Standards or IMACs at the site that are likely due to naturally occurring concentrations include antimony, barium, chromium, cobalt, iron, lead, manganese, thallium, and vanadium.

Concentrations of several COIs exceeded their respective 2L Standards or IMACs in groundwater at the site and appear to be caused by the source area, including arsenic, beryllium, boron, chloride, selenium, sulfate, and TDS. The nature and extent of contamination for each source-related COI identified in groundwater are described below.

- Arsenic concentrations that exceeded the 2L Standard are limited to the shallow flow layer immediately downgradient of the ash basin dam.
- Beryllium concentrations that exceeded the IMAC are limited to the shallow flow layer at one location east and downgradient of the ash basin and dry ash landfill (Phase I).
- Boron concentrations that exceeded the 2L Standard are present in the shallow, deep, and bedrock flow layers. In the shallow flow layer, boron exceedances were reported beneath the dry ash landfill (Phase II), east and downgradient of the ash basin and dry ash landfill (Phase I), and southeast and downgradient of the ash basin. In the deep flow layer, exceedances were reported beneath the dry ash landfill (Phase II), beneath the central portion of the ash basin, beneath the western portion of the ash basin, and east and downgradient of the ash basin and dry ash landfill (Phase I). In the bedrock flow layer, one boron exceedance was reported beneath the dry ash landfill (Phase II).
- Chloride concentrations that exceeded the 2L Standard are limited to the shallow flow layer downgradient of the ash basin and dry ash landfill (Phase I) and the deep flow layer beneath the central portion of the ash basin.
- Selenium concentrations that exceeded the 2L Standard are limited to the shallow and bedrock layers beneath the dry ash landfill (Phase II).
- Sulfate concentrations that exceeded the 2L Standard are limited to the shallow and deep flow layers beneath the dry ash landfill (Phase II).
- TDS concentrations that exceeded the 2L Standard are present in the shallow and deep flow layers. In the shallow flow layer, TDS exceedances were reported beneath the dry ash landfill (Phase II), to the east and downgradient of the ash basin and dry ash landfill (Phase I), and southeast and downgradient of the ash basin. In the deep flow layer, exceedances were reported beneath the dry ash landfill (Phase II), beneath the central portion of the ash basin, southeast and downgradient of the ash basin, and to the south and upgradient of the ash basin at GWA-2D.



ES.4.4 Maximum Contaminant Concentrations

Maximum COI concentrations in ash porewater samples are located throughout the ash basin. The higher concentrations of constituents were mainly located in the central portion of the ash basin, in the dry ash landfill (Phase II), and the PV structural fill porewater.

The maximum concentrations of COIs in groundwater were mainly detected in shallow groundwater beneath the dry ash landfill (Phase II), east and downgradient of the ash basin and dry ash landfill (Phase I), and southeast and downgradient of the ash basin. The maximum concentration of boron was detected in deep groundwater beneath the dry ash landfill (Phase II).

The maximum contaminant concentrations for COIs reported in groundwater, ash porewater, seep water, and ash basin surface water samples collected during the CSA are listed below.



Table ES-2. Maximum Constituent of Interest Concentrations

| COI | Maximum Constituent of Interest (COI) Concentrations (µg/L) | | | | |
|-----------|---|------------------------|---------------------------|-------------------------|-----------------------------|
| | Groundwater | Ash Porewater | Seep Water | Ash Basin Surface Water | Background Groundwater |
| Antimony | 11.4 (GWA-6D) | 26.6 (AB-20S) | 0.86 (S-2) | 0.32 (SW-1) | <2.5 (BG-2BR) |
| Arsenic | 10.5 (MW-7S) | 6,380 (AB-12SL) | 87.1 (S-2) | 24.4 (SW-3) | 7.5 (BG-2BR) |
| Barium | 960 (AL-2S) | 780 (AB-12SL) | 990 (S-2) | 77 (SW-2) | 760 (BG-3D) |
| Beryllium | 9.9 (AL-1S) | 23.5 (AB-5S) | 15.2 (S-2) | 14.4 (SW-3) | <1 (MW-4) |
| Boron | 15,200 (AL-4D) | 73,400 (AL-3S) | 6,800 (MSSW002) | 7,000 (SW-1) | <50 (all BG wells) |
| Cadmium | 0.7 (AL-1S) | 6.3 (AL-3S) | 6,800 (S-2) | 1.8 (SW-3) | <0.08 (several BG wells) |
| Chloride | 464,000 (AB-12D) | 3,650,000 (AB-12S) | 218,000 (MSSW001) | 231,000 (SW-1) | 4,800 (BG-1D) |
| Chromium | 189 (GWA-2D) | 71.6 (AB-20S) | 85.7 (S-2) | 7 (SW-5) | 80.4 (BG-2BR) |
| Cobalt | 57.6 (MW-7S) | 423 (AB-20S) | 333 (S-2) | 291 (SW-3) | 11.9 (BG-2BR) |
| Copper | 21.5 (GWA-7S) | 245 (AB-5S) | 112 (S-2) | 17.7 (SW-5) | 137 (BG-2BR) |
| Iron | 54,000 (AL-2S) | 2,300,000 (AB-5S) | 242 (MSWW002) | 1,370 (SW-3) | 18,200 (BG-2BR) |
| Lead | 10.2 (AB-11S) | 28.7 (AB-20S) | 227 (S-2) | 2.6 (SW-5) | 17.5 (BG-2BR) |
| Manganese | 9,690 (AB-1S) | 19,400 (AB-5S) | 11,600 (S-2) | 42,100 (SW-3) | 380 (BG-2BR) |
| Nickel | 66 (MW-14S) | 333 (AB-5S) | 51 (S-2) | 115 (SW-3) | 49.6 (BG-3S) |
| Selenium | 108 (AL-2S) | 454 (AB-20S) | 25.1 (S-2) | 33.2 (SW-3) | <2.5 (MW-4) |
| Sulfate | 979,000 (AL-2S) | 8,850,000 (AB-5S) | 140,000 (MSSW001) | 1,210,000 (SW-4) | 16,000 (BG-3D) |
| TDS | 1,610,000 (AL-2S) | 11,600,000 (AB-12S) | 989,000 (MSSW001 S001) | 1,710,000 (SW-5) | 369,000 (BG-2BR) |
| Thallium | 0.37 (MW-7S) | 14.8 (AB-20S) | 8.6 (S-2) | 2.3 (SW-5) | 0.23J (BG-2BR) |
| Vanadium | 57.5 (AB-7D) | 163 (AL-3S) | 566 (S-2) | 1.8 (SW-2) | 100 (BG-2BR) |
| Zinc | 170 (AL-2S) | 890 (AB-5S) | 240 (S-2) | 160 (SW-5) | 68 (BG-2BR) |

ES.4.5 Regional Geology and Hydrogeology

The MSS site is underlain by the Charlotte and Kings Mountain terranes (Horton et al. 1989; Hibbard et al. 2002; Hatcher et al. 2007). On the northwest side, the Charlotte/Kings Mountain terranes are in contact with the Inner Piedmont zone along the Central Piedmont suture along its northwest boundary, The Kings Mountain terrane is distinguished by its abundance of metasedimentary and metavolcanic rocks at lower metamorphic grade than the metaigneous rocks of higher metamorphic grade in the Charlotte terrane (Butler 1991; Butler and Secor 1991; Hatcher et al. 2007). The Charlotte terrane is dominated by a complex sequence of plutonic rocks that intrude a suite of metaigneous rocks (amphibolite metamorphic grade) including mafic gneisses, amphibolites, metagabbros, and metavolcanic rocks with lesser amounts of granitic gneiss and ultramafic rocks with minor metasedimentary rocks. Units mapped by Goldsmith et al. (1988) underlying the eastern portion of the MSS site are alaskitic granite described as a fine-grained light colored muscovite-biotite granite and a fine-grained biotite gneiss of granodioritic composition of probable volcanic origin.

The groundwater system in the Piedmont province, in most cases, is comprised of two interconnected layers, or mediums: 1) residual soil/saprolite and weathered fractured rock (regolith) overlying 2) fractured crystalline bedrock (Heath 1980; Harned and Daniel 1992; Figure 5-3). The regolith layer is a thoroughly weathered and structureless residual soil that occurs near the ground surface with the degree of weathering decreasing with depth. The residual soil grades into saprolite, a coarser grained material that retains the structure of the parent bedrock. Beneath the saprolite, partially weathered/fractured bedrock occurs with depth until sound bedrock is encountered. The regolith layer serves as the principal storage reservoir and provides an intergranular medium through which the recharge and discharge of water from the underlying fractured rock occurs. Within the fractured crystalline bedrock layer, the fractures control both the hydraulic conductivity and storage capacity of the rock mass. A transition zone (TZ) at the base of the regolith has been interpreted to be present in many areas of the Piedmont. Harned and Daniel (1992) described the zone as consisting of partially weathered/fractured bedrock and lesser amounts of saprolite that grades into bedrock and they described the zone as “being the most permeable part of the system, even slightly more permeable than the soil zone”. Harned and Daniel (1992) suggested the zone may serve as a conduit of rapid flow and transmission of contaminated water.

Typically, the residual soil/saprolite is partially saturated and the water table fluctuates within it. Water movement is generally preferential through the overlying soil and saprolite and weathered/fractured bedrock of the TZ.

ES.4.6 Site Geology and Hydrogeology

The Geologic Map of the Charlotte Quadrangle, North Carolina and South Carolina shows four map/rock units underlying MSS: a biotite gneiss, quartz-sericite schist, the High Shoals Granite, and alaskitic (light-colored) granite. The primary rock types encountered in the boreholes during the CSA included medium- to coarse-grained biotite gneiss with some schistose texture, biotite schist, a fine- to medium-grained biotite gneiss, granite, meta-quartz diorite, and quartz-sericite schist. The medium- to coarse-grained biotite gneiss and granite are part of the High Shoals

Granite and are present in the western portion of the site. In the area mapped as alaskitic granite, the primary rock encountered in the boreholes is a meta-quartz diorite and it underlies the eastern portion of the ash basin. The fine- to medium-grained biotite gneiss (metavolcanic) and the quartz-sericite schist (metasedimentary) are between the High Shoals Granite and the meta-quartz diorite and underlie the middle portion of the ash basin. The rocks have been subject to multiple deformations due to tectonic stress before and during the intrusion of the meta-quartz diorite and High Shoals Granite. The biotite gneiss (metavolcanic) and quartz-sericite schist (metasedimentary) have undergone polyphase folding resulting in two subparallel, axial planar foliations that are pervasive. Most of the rock encountered in the boreholes exhibits some degree of foliation/schistosity related to these fold events and is the dominant structure with respect to the bedrock underlying MSS.

Based on the site investigation, the groundwater system in the natural materials (alluvium, soil, soil/saprolite, and bedrock) at MSS is consistent with the regolith-fractured rock system and is an unconfined, connected system of flow layers. The MSS groundwater system is divided into three layers referred to in this report as the shallow, deep (TZ), and bedrock flow layers to distinguish the flow layers within the connected aquifer system. In general, groundwater within the shallow and deep layers (S and D wells) and bedrock layer (BR wells) flows from northwest and north to the southeast toward Lake Norman.

ES4.7 Existing Groundwater Monitoring Data

Duke Energy implemented voluntary groundwater monitoring around the MSS ash basin from November 2007 until October 2011. During this period, the voluntary groundwater monitoring wells were sampled a total of nine times, and the analytical results were submitted to NCDENR DWR. Groundwater monitoring as required by the MSS NPDES Permit NC0004987 began in February 2011. NPDES Permit Condition A (11), Version 1.1, dated June 15, 2011, lists the groundwater monitoring wells to be sampled, the parameters and constituents to be measured and analyzed, and the requirements for sampling frequency and reporting results.

Compliance and voluntary groundwater monitoring wells were sampled as part of this CSA to supplement the expanded groundwater assessment, assess background groundwater quality, and calculate statistical analyses of background groundwater chemical concentrations.

Concentrations of several COIs were reported above 2L Standards or IMACs in groundwater samples collected from compliance and voluntary monitoring wells located downgradient of the source area, including arsenic, boron, cobalt, manganese, selenium, thallium, and TDS. Sample results from upgradient and background compliance wells are consistent with previous results.

ES.4.8 Screening-Level Risk Assessments

The prescribed goal of the human health and ecological screening-level risk assessments is to evaluate the analytical results from the COI sampling and analysis effort and, using the various criteria taken from applicable guidance, determine which of the COIs may present an unacceptable risk, in what media, and therefore, should be further evaluated in a baseline human health or ecological risk assessment or other analysis, if required. Contaminants of

Potential Concern (COPCs) are those COIs identified as having possible adverse effects on human or ecological receptors that may have exposure to the COPCs at or near the site. The COPCs serve as the foundation for further evaluation of potential risks to human and ecological receptors.

To support the CSA effort and inform corrective action decisions, a screening-level evaluation of potential risks to human health and the environment to identify preliminary, media-specific COPCs was performed in accordance with applicable federal and state guidance, including the Guidelines for Performing Screening Level Ecological Risk Assessments within the North Carolina Division of Waste Management (NCDENR 2003). The criteria for identifying COPCs vary by the type of receptor (human or ecological) and media in which they occur.

COIs were not screened out as COPCs based on a comparison to background concentrations, as the NCDENR Division of Waste Management's Screening Level Environmental Risk Assessment guidance (2003) does not allow for screening based on background. Site-specific background concentrations will be considered in the uncertainty section of the baseline ecological risk assessment, if determined to be necessary.

The screening-level risk assessment included a review of NCDENR water well testing results from private water supply wells located near MSS. According to NCDENR's August 20, 2015 online summary of well testing near coal ash ponds, approximately 38 water supply wells have been sampled and analyzed as part of the NCDENR well testing program. In summary, the North Carolina Department of Health and Human Services (NCDHHS) recommended that 35 wells sampled should not be utilized for drinking water due to the presence of one or more constituents above screening levels defined by DHHS, including chromium, iron, lead, manganese, and vanadium. These constituents are naturally occurring in groundwater in the region surrounding the MSS site.

ES.4.9 Development of Site Conceptual Model

In the initial hydrogeologic site conceptual model presented in the Work Plan, the geological and hydrogeological features influencing the movement, chemical, and physical characteristics of contaminants were related to the Piedmont hydrogeologic system present at the site. A hydrogeological site conceptual model was developed from data generated during previous assessments, existing groundwater monitoring data, and CSA activities. The ash basin discharges porewater to the subsurface beneath the basin and via seeps through the embankments. Groundwater flows to the southeast toward Lake Norman and an unnamed tributary that flows to Lake Norman. Horizontal migration of groundwater at the site is controlled by topographic highs along the west and north property boundaries and Lake Norman to the southeast. The site conceptual hydrogeologic model will continue to be refined following evaluation of the completed groundwater model in the CAP.

ES.4.10 Identification of Data Gaps

Through completion of the CSA activities and evaluation of data collected, data gaps have been identified that will be evaluated further to refine the site conceptual model. The data gaps have

been separated into two groups: 1) data gaps resulting from temporal constraints and 2) data gaps resulting from evaluation of data collected during the CSA. Temporal data gaps consist of evaluation of petrographic analysis of rock data and refinement of speciation sampling in groundwater monitoring wells. Data gaps resulting from evaluation of the data collected during the CSA activities consist of evaluation of additional background groundwater monitoring wells, collection of background surface water samples (located in unnamed tributaries northwest of the ash basin and PV structural fill), and additional assessment to fully delineate the horizontal extent of boron concentrations in groundwater east and downgradient of the ash basin and dry ash landfill (Phase I).

ES.5 Conclusions

The CSA identified the horizontal and vertical extent of groundwater contamination resulting from the ash basin, dry ash landfill (Phases I and II), and the PV structural fill at the MSS site, and found it is limited to within the ash basin compliance boundary. The source and cause of impacts from boron, as shown on Figure ES-1, is the CCR contained in the ash basin. The cause of contamination shown on this figure is leaching of constituents from CCR into the underlying soil and groundwater at the site. However, some groundwater, surface water, and soil standards were also exceeded due to naturally occurring elements found in the subsurface, including antimony, barium, chromium, cobalt, iron, lead, manganese, thallium, and vanadium.

The CSA found no imminent hazards to public health and the environment; therefore, no actions to mitigate imminent hazards are required. However, corrective action at the site is required to address soil and groundwater contamination present at the site. Proposed corrective action will be outlined in the CAP to be submitted in accordance with CAMA.

The horizontal extent of soil impacts is limited to the area beneath the ash basin and one location east and downgradient of the dry ash landfill (Phase I). Where soil impacts were identified beneath the ash basin, the vertical extent of contamination beneath the ash/soil interface is generally limited to the uppermost soil sample collected beneath ash. Arsenic was the only COI with exceedances of background concentrations and North Carolina PSRGs beneath the ash basin. In general, constituent concentrations of barium, cobalt, iron, manganese, and vanadium were higher in soil compared to ash, and are considered to represent naturally occurring background conditions.

The CSA found that groundwater COIs at the site include antimony, arsenic, barium, beryllium, boron, chloride, chromium, chromium, cobalt, iron, manganese, selenium, sulfate, thallium, TDS, and vanadium, although many of these constituents are found above 2L Standards due to naturally occurring concentrations. The approximate horizontal extent of groundwater impacts is limited to beneath the ash basin and dry ash landfill (Phase II), east and downgradient of the ash basin and dry ash landfill (Phase I), and southeast and downgradient of the ash basin, within the ash basin compliance boundary. The approximate vertical extent of groundwater impacts is generally limited to the shallow and deep flow layers. Bedrock is impeding vertical migration of groundwater and limiting the vertical extent of groundwater impacts.

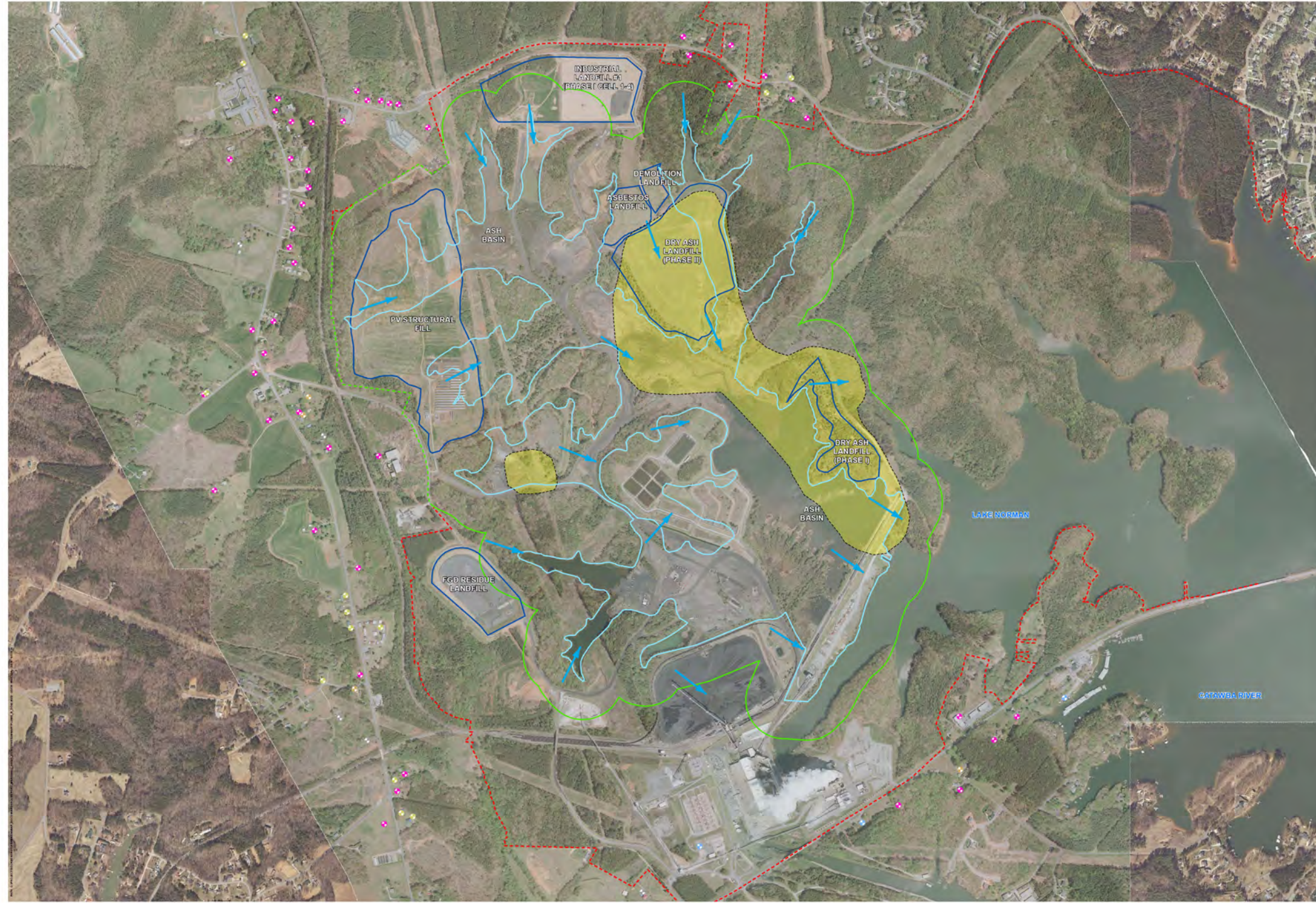


Significant factors affecting contaminant transport are those factors that determine how the contaminant reacts with the soil/rock matrix, resulting in retention by the soil/rock matrix and removal of the contaminant from groundwater. The interaction between the contaminant and the retention by soils are affected by the chemical and physical characteristics of the soil, geochemical conditions present in the matrix (if present), matrix materials, and chemical characteristics of the contaminant. Migration of each contaminant is related to the groundwater flow direction, the groundwater flow velocity, and the rate at which a particular contaminant reacts with materials in the respective soil/rock matrix. The data indicates that geologic conditions present beneath the ash basin impede the vertical migration of contaminants. The CSA found that the direction of mobile contaminant transport is to the southeast toward Lake Norman and an unnamed tributary that flows to Lake Norman, and not towards off-site receptors.

The human health and ecological screening-level risk assessments did not specifically identify the presence of health or environmental risks; however, the results indicate that constituents in environmental media could be of concern and further investigation by a site-specific risk assessment may be warranted. No imminent hazards to human health and the environment were identified during the screening-level risk assessments.

In accordance with CAMA, Duke Energy is required to implement closure and remediation of the MSS ash basin no later than August 1, 2029 (or sooner if classified as intermediate or high risk). Closure for the MSS ash basin was not defined in CAMA.

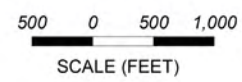
Based on the findings of this CSA report, soil and groundwater impacts are present beneath and downgradient of the ash basin, and remain within Duke Energy property and the ash basin compliance boundary. Duke Energy will pursue corrective action under 15A NCAC 02L .0106. The approaches to corrective action under rule .0106(k) or (l) will be evaluated along with other remedies depending on the results of groundwater modeling and evaluation of the site's suitability to use Monitored Natural Attenuation or other industry-accepted methodologies.



LEGEND:

- ASSUMED PRIVATE WATER SUPPLY WELL
- FIELD IDENTIFIED PRIVATE WATER SUPPLY WELL
- PUBLIC WATER SUPPLY WELL
- RECORDED PRIVATE WATER SUPPLY WELL
- REPORTED PRIVATE WATER SUPPLY WELL
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- AREA OF BORON EXCEEDANCES OF 2L STANDARDS
- ASH BASIN COMPLIANCE BOUNDARY
- ASH BASIN COMPLIANCE BOUNDARY COINCIDENT WITH DUKE ENERGY PROPERTY BOUNDARY
- ASH BASIN WASTE BOUNDARY
- DUKE ENERGY PROPERTY BOUNDARY
- LANDFILL/STRUCTURAL FILL BOUNDARY
- STREAM

NOTES:
 NC 2L GROUNDWATER STANDARD FOR BORON IS 700 µg/L



SITE CONCEPTUAL MODEL - PLAN VIEW MAP
AREA OF BORON EXCEEDANCES OF 2L STANDARDS
DUKE ENERGY CAROLINAS, LLC
MARSHALL STEAM STATION ASH BASIN
 CATAWBA COUNTY, NORTH CAROLINA

DATE
 SEPTEMBER 2015
 FIGURE
 ES-1