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From: Nic Vrey <Nic.Vrey@erm.com>
Sent: Friday, April 13, 2018 2:25 PM
To: Cassidy, Greg
Cc: Powell, Richard E.; tom.wilson@erm.com; kevin_boland@csx.com
Subject: Duke Energy_Bramlette Road Site (VCC16-5857-RP)_Groundwater Remedial Investigation Work Plan Addendum

Greg,

Please see attached for the Groundwater RIWP-A for the Duke Energy Bramlette Rd Former MGP Site. 2 Hard Copies and 1 CD copy have be sent for Monday afternoon delivery.

Please feel free to contact me with any questions,

Nicolas G. Vrey

Senior Geologist

ERM
The Towers at Wildwood Plaza | 3200 Windy Hill Road SE Ste1500W | Atlanta, Georgia 30339 |
T (678) 486-2762 | **M** (404) 396-6859
E Nic.Vrey@erm.com | **W** www.erm.com

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Charlotte, NC 28202

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SITE ASSESSMENT, REMEDIATION & REVITALIZATION

Apr. 13, 2018

Mr. Greg Cassidy
South Carolina Department of Health and Environmental Control
State Remediation Section
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

Subject: Remedial Investigation Work Plan Addendum
Bramlette Road Site (VCC16-5857-RP)
400 East Bramlette Road, Greenville, SC

Dear Mr. Cassidy:

Please find attached two hard copies and one electronic copy of the Remedial Investigation Work Plan Addendum for the referenced site.

If you have any questions, please feel free to contact me at 704.497.3627 or at Richard.powell2@duke-energy.com.

Sincerely,

Richard E. Powell

Richard E. Powell, P.G.
Senior Environmental Specialist

cc: Thomas Wilson, ERM
Kevin Boland, CSXT
Daniel Schmitt, CSXT

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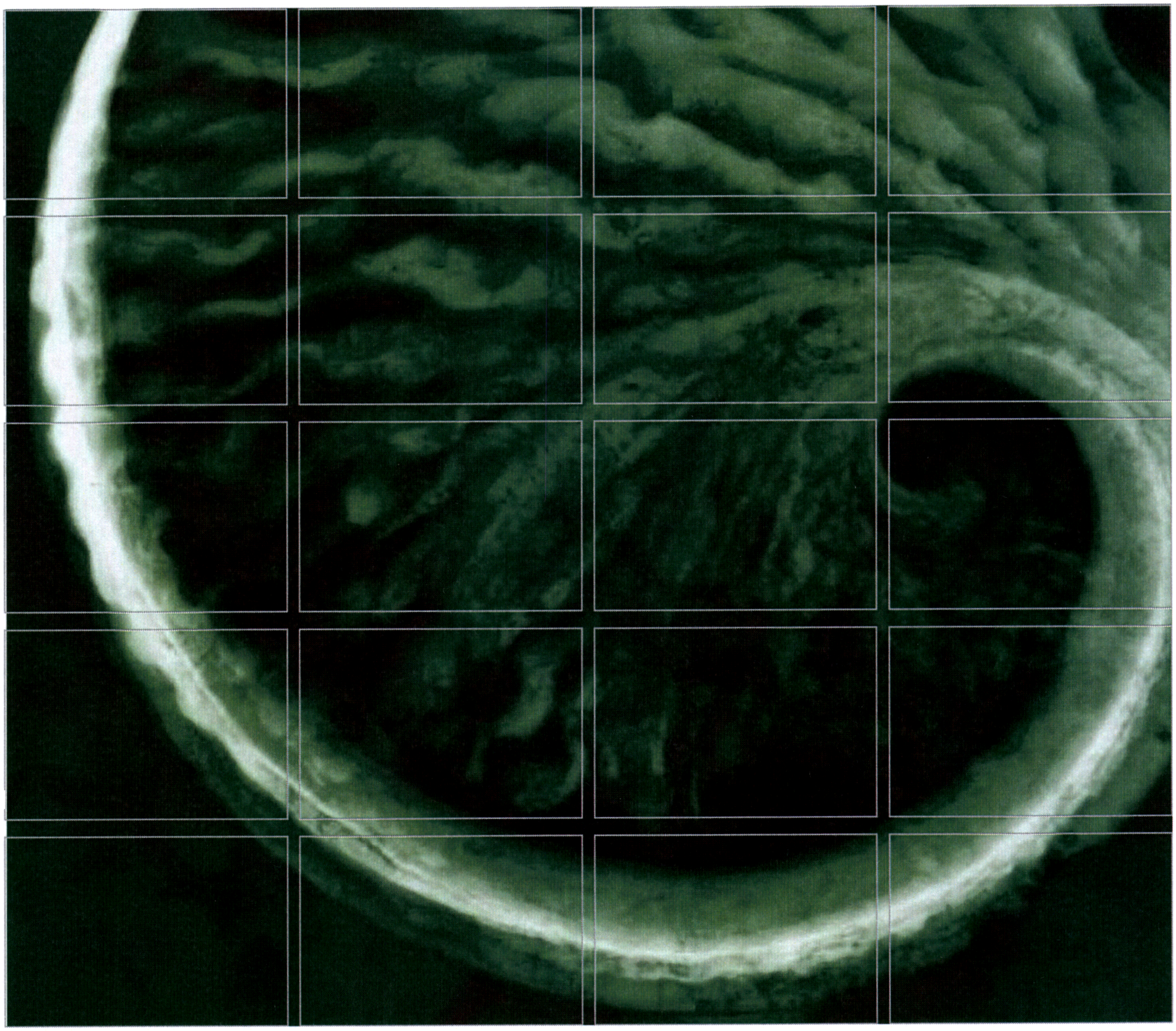

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Groundwater Remedial Investigation Work Plan Addendum

Prepared for:
Duke Energy Carolinas,
LLC

Bramlette MGP Site – Greenville SC
VCC 16-5857-RP

April 13, 2018

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Duke Energy Carolinas, LLC

Groundwater Remedial Investigation Work Plan Addendum

Former Bramlette MGP Site
Greenville, South Carolina

April 13, 2018

Project No. 0439810, Phase 01

Thomas M. Wilson
Partner-in-Charge

Nicolas G. Vrey
Project Manager

ERM NC, Inc.
15720 Brixham Hill Avenue, Suite
Charlotte, NC 28277
T: 704-541-8345

www.erm.com

THOMAS M. WILSON
REGISTERED
NO. 511
SOUTH CAROLINA
PROFESSIONAL GEOLOGIST

TMW

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LIST OF ACRONYMS

μg/L	micrograms per liter
BART	biological activity reaction tests
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylene
COI	constituents of interest
COPC	Constituents of Potential Concern
CSF	carcinogenic slope factor
CSM	conceptual site model
CSXT	CSX Transportation
Duke Energy	Duke Energy Carolinas, LLC
EPA	Environmental Protection Agency
EPC	exposure point concentrations
ft	feet
ft/d	feet per day
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
IRIS	EPA Integrated Risk Information System
MCL	maximum concentration level
MGP	manufactured gas plant
NAPL	non-aqueous phase liquid
PVC	polyvinyl chloride

QA	Quality Assurance
QC	Quality Control
RAGS	EPA's Ecological Risk Assessment Guidance for Superfund
RI	remedial investigation
RIWP	Groundwater Remedial Investigation Work Plan
RIWP-A	Groundwater Remedial Investigation Work Plan Addendum
RSL	Residential Soil Regional Screening Levels
SCDHEC	South Carolina Department of Health and Environment
Site	five parcels owned by CSX Transportation, Inc.
SLERA	Screening Level Ecological Risk Assessment
SVOC	semi-volatile organic compounds
tw	temporary wells
UCL	Upper Confidence Limit
VADEQ	Virginia Department of Environmental Quality
VCC	Voluntary Cleanup Contract
VI	vapor intrusion
VISL	Vapor Intrusion Screening Level
VOC	volatile organic compounds

1.0 INTRODUCTION

Duke Energy Carolinas, LLC (Duke Energy) is conducting a groundwater remedial investigation (RI) at the former Bramlette manufactured gas plant (MGP) facility property located at 400 East Bramlette Road, and four contiguous properties located just outside of the city limits of Greenville, South Carolina. The RI is being conducted under a Responsible Party Voluntary Cleanup Contract (VCC 16-5857-RP) with the South Carolina Department of Health and Environment (SCDHEC) dated July 29, 2016.

Duke Energy has previously performed extensive remedial actions to address impacted soils and other source material (i.e. tar-like non-aqueous phase liquids (NAPL)) formerly located within the Bramlette MGP site. These activities, conducted from 2001 to 2002, included the demolition and removal of the MGP infrastructure and remediation of approximately 61,000 tons of source area soils to depths ranging from 3 to 12 feet below ground surface within and around the former MGP parcel, and approximately 385 feet of a drainage ditch that exited the property to the southwest. All site remediation activities were conducted under the oversight of SCDHEC. The remedial actions successfully achieved the specific objectives of cleaning up soils and reducing the amount of source material contributing to ground water impacts at the former MGP facility.

Stable to declining groundwater concentration trends are indicated overall, based on the results of groundwater monitoring events conducted regularly from 1996 to 2017. No targeted compounds have been detected in surface water samples collected from the Reedy River. In 2017, groundwater samples from eight of the nine monitoring wells at the former MGP property contained no detectable levels of benzene or naphthalene, two MGP-related constituents which are monitored at the Site as indicators of water quality conditions. Under the current VCC, additional assessment is being performed to further characterize the nature and extent of residual impacts to groundwater.

Per the VCC, Anchor QEA (formerly Altamont Environmental, Inc.), on behalf of Duke Energy, prepared a focused *Groundwater Remedial Investigation Work Plan* (RIWP) dated November 14, 2016 which was approved by SCDHEC on January 27, 2017. The purpose of the 2016 RIWP was to assess the current conditions of groundwater at the former Bramlette MGP facility property. The fieldwork proposed in the RIWP was conducted in 2017 by Anchor QEA and results were provided to SCDHEC in quarterly progress reports.

In November 2017, Duke Energy retained ERM to continue the RI. On behalf of Duke Energy, ERM has prepared this *Groundwater Remedial Investigation Work Plan Addendum* (RIWP-A) which proposes additional assessment activities to refine the understanding of site groundwater conditions considering the substantial amount of soil and groundwater data collected at the site, and the additional information proposed to be collected in the RIWP-A.

In accordance with the VCC, the purpose of the RIWP-A is to obtain additional information needed to evaluate potential residual MGP-related NAPL (recognizing that the former MGP site and all associated on-site sources have previously been addressed), and complete the nature and extent evaluation of groundwater impacts resulting from the former operation of the MGP facility. The proposed scope of work in this RIWP-A includes the following major tasks:

- Assess the location and extent of remaining MGP related non-aqueous phase liquid (NAPL) from the former MGP operation;
- Delineate the lateral extent of dissolved phase site-related constituents in groundwater in the hydraulically downgradient direction west of the former MGP property;
- Delineate the vertical extent of site-related dissolved phase constituents in groundwater;
- Assess current surface water quality at the Site;
- Assess current surficial sediment quality at the Site; and
- Conduct risk assessments to evaluate potential human health and ecological risks associated with exposure to environmental media at the site.

A summary of data collected during 2017 as part of the initial RIWP is also provided.

1.1 BACKGROUND

The location of the former Bramlette MGP facility in Greenville, South Carolina is shown in Figure 1. The site layout is shown on Figure 2 and consists of the following five parcels owned by CSX Transportation, Inc. (together the “Site”):

Table 1 ***Site Parcel Descriptions***

Parcel ID	County Tax Map No.	Acreage	Use Descriptor
Parcel 1	0140000300300	3.69	Vacant/former Bramlette MGP facility
Parcel 2	0140000300200	10.25	Active railroad operations
Parcel 3	0138000100100	7.80	Railroad field office/former Vaughn C&D Landfill/ floodplain
Parcel 4	0054000300100	3.82	Vacant/ floodplain
Parcel 5	0054000600100	4.21	Vacant/ floodplain

The Site is approximately 30 acres in size and bounded by the CSX Transportation (CSXT) railroad corridor to the north and west, the Reedy River to the west, Willard Street to the south, and West Washington Street, private residences, the Legacy Charter School, and the City of Greenville Sanitation Department to the east. The Swamp Rabbit Trail (a county linear greenway park) is located just west of the CSXT railroad corridor and parallels the Reedy River. Based on the previous use and the plausible future land use for the Site and adjacent properties, the Site will remain industrial.

As summarized above, the Site includes five parcels. The former MGP property is located on Parcel 1 which is now vacant. Active CSX railroad operations are on portions of Parcels 2 and 3, including a railroad field office. The former Vaughn Landfill, a seven-acre unpermitted construction and demolition debris landfill, is located on Parcel 3. This landfill was not used by Duke Energy and is unrelated to historical MGP activities at the site. Parcels 3, 4 and 5 are located in the eastern bank floodplain of the Reedy River. Parcels 4 and 5 are classified as wetlands by the U.S. Fish and Wildlife Services, National Wetlands Inventory. Historical stormwater conveyance ditches extend through the floodplain/wetlands.

As documented in the VCC and summarized in the 2016 RIWP, extensive assessment and remediation activities have been conducted at the former MGP facility (Parcel 1). A Remedial Action Plan was implemented by Duke Energy to remediate soil impacts at the former MGP facility, and a final report was issued in 2003. More than 61,000 tons of impacted soil were remediated over 3.8 acres on and around Parcel 1 and portions of Parcel 2 (Figure 2). The former Vaughn Landfill is unrelated to the former

Bramlette MGP facility but was concurrently investigated during previous assessment work. In correspondence dated February 26, 2001, regarding the former Vaughn Landfill parcel, SCDHEC noted that removal of the landfill debris was not recommended and the only required action was continued groundwater monitoring proximal to the landfill. This determination was supported based on SCDHEC's evaluation of site risk conditions and recognition of the following facts and conclusions:

- The MGP-related NAPL is very viscous and relatively non-mobile;
- The areal extent of the groundwater impacts had remained stable;
- Biological and geotechnical assessments of the area had demonstrated that the MGP-related constituents were not significantly impacting flora and fauna;
- No surface water or downstream/downgradient impact had been documented;
- No drinking water wells existed within 0.5 miles of the Site; and

SCDHEC recommended that CSXT perform off-site mitigation rather than onsite mitigation to compensate for wetland impacts of the unpermitted landfill.

Routine groundwater monitoring and reporting has been conducted by Duke Energy at the Site on a semi-annual or annual basis. Duke Energy has performed the remedial investigation activities on the CSX-owned property under an annual access agreement which is currently due for renewal.

A list of the major previous reports is listed in Appendix A.

2.0 REMEDIAL INVESTIGATION WORK COMPLETED - 2017

The objectives of the 2016 RIWP by Anchor QEA were to assess the current conditions of groundwater to refine the nature and extent of constituents of interest (COI) in groundwater resulting from the operation of the former MGP facility. In accordance with the VCC and the 2016 RIWP, significant assessment activities were completed in 2017 by Anchor QEA on behalf of Duke Energy. These activities included:

- Installation and sampling of two groundwater monitoring well clusters of three wells each at the former MGP facility parcel to replace monitoring wells previously abandoned to facilitate source area remediation
- Groundwater sampling from temporary wells advanced by direct push technology to assess horizontal distribution of dissolved phase COIs, primarily volatile organic compounds (VOC) and semi-volatile organic compounds (SVOC), at the downgradient (west) perimeter of the former MGP facility; and
- Groundwater sampling of the monitoring well network, including the new monitoring wells, for analysis of VOCs, SVOCs, monitored natural attenuation parameters, and bioassays to assess current groundwater conditions and better define COI fate and transport conditions.

2.1 INSTALLATION OF REPLACEMENT MONITORING WELLS

Two monitoring well clusters were drilled and installed from June 12 – 16, 2017 at the former MGP parcel. The well cluster locations (MW-7R, MW-9R, MW-28 and MW-13R, MW-26 & MW-27) are shown in Figure 2, and well completion data are summarized in Table 2. MW-13R, MW-26, and MW-27 were installed at the hydraulically upgradient northern corner of the former MGP parcel to assess background groundwater entering the Site. MW-7R, MW-9R, and MW-28 were installed near the southwestern corner of the former MGP facility to assess groundwater quality near the downgradient property boundary at the former MGP facility. Select soil samples were collected during the installation of the monitoring wells and submitted for laboratory analyses including VOCs (Environmental Protection Agency [EPA] Method 8260) and SVOCs (EPA Method 8270).

Table 2 *Monitoring Well Construction Details (2017)*

Well ID	Well Diameter (in)	Screened Interval (ft-bgs)	Hydrogeologic Zone Designation
MW-7R	2	5-15	Fill/Residuum
MW-9R	2	21-26	Residuum to Upper Saprolite
MW-28	2	35-45	Bedrock
MW-13R	2	10-20	Fill/Residuum
MW-27	2	25-35	Residuum to Upper Saprolite
MW-26	2	45-55	Bedrock

Nine soil samples were collected for laboratory analyses, including VOCs (EPA Method 8260) and SVOCs (EPA Method 8270), during the installation of the replacement monitoring wells. A table of the results was included in the *Quarterly Progress Report – Third Quarter 2017* prepared by Anchor QEA and in Appendix B. The general findings of the soil analyses are summarized as follows:

- No SVOCs (Method 8270) were detected in any of the soil samples;
- No VOCs (Method 8260) were detected in any of the soil samples collected in MW-13R, MW-26, or MW-27; and
- Low levels of VOCs, primarily benzene, toluene, ethylbenzene, xylene (BTEX) and naphthalene, were detected in soil samples collected from MW-9R, primarily in the sample collected 10 feet (ft) below ground surface (bgs). All detections were below respective EPA Residential Soil Regional Screening Levels (RSLs).

2.2 DIRECT PUSH GROUNDWATER SAMPLING

Shallow groundwater samples were collected using direct push technology to install temporary wells at 13 locations. The purpose of this sampling program was to confirm that source area remediation was effective in limiting ongoing impacts to groundwater from the former MGP property. Temporary groundwater monitoring wells TW-1 through TW-13 were installed from June 19 - 21, (Figure 2). Each boring was visually inspected for NAPL, prior to installing a temporary one-inch diameter polyvinyl chloride (PVC) well and collecting groundwater samples for VOC (EPA Method 8260) and SVOC (EPA Method 8270) analyses. Each well was subsequently abandoned per SCDHEC requirements.

Table 3 *Temporary Monitoring Well Construction Details (2017)*

Well ID	Well Diameter (in)	Well Completion	Screened Interval (ft-bgs)
TW-1	1	Abandoned	8-13
TW-2	1	Abandoned	10-15
TW-3	1	Abandoned	5-15
TW-4	1	Abandoned	10-15
TW-5	1	Abandoned	6-11
TW-6	1	Abandoned	6-16
TW-7	1	Abandoned	5-15
TW-8	1	Abandoned	10-20
TW-9	1	Abandoned	8-13
TW-10	1	Abandoned	7-12
TW-11	1	Abandoned	8-18
TW-12	1	Abandoned	7-17
TW-13	1	Abandoned	7.5-17.5

Results from the direct push groundwater sampling event were presented in *Quarterly Progress Report – Third Quarter 2017* and included as Appendix C. The findings included:

- NAPL was observed in thin discontinuous discrete interbeds (< 2 inches thick) in subsurface soils in only two of thirteen temporary well borings (TW-6 at 11 ft bgs and TW-7 at 7.5 and 11.5 ft bgs) during the 2017 temporary well installation activities (see Figure 6).
- Benzene (the primary VOC of concern) and Naphthalene (the primary SVOC of concern) were detected at concentrations above

screening criteria at five of the thirteen temporary well locations adjacent to stormwater drainage ditches:

- Benzene was detected above the EPA maximum contaminant level (MCL) of 5 micrograms per liter (µg/L) in groundwater samples from only two of the 13 temporary wells (TW-3 and TW-6), both located along the stormwater drainage ditch on the north side of Bramlette Rd (Figure 3).
- Naphthalene was detected in groundwater above the Risk-Based Screening Level (RBSL) of 25 micrograms per liter (µg/L) at four of the 13 temporary wells (TW-6, TW-7, TW-9 and TW-10). TW-6, TW-7 and TW-9 were located along the stormwater drainage ditch on the north side of Bramlette Rd. and TW-10 was located on the western boundary of the former MGP parcel near the head of the former stormwater drainage ditch (Figure 4). There is no South Carolina MCL established for naphthalene in groundwater; the South Carolina RBSL listed in Appendix C of the SCDHEC Quality Assurance Program Plan for the Underground Storage Tank Management Division, February 2016 is considered the appropriate screening criteria for naphthalene at this Site.

2.3 GROUNDWATER SAMPLING – MONITORING WELL NETWORK

Groundwater sampling of the monitoring well network, including the new monitoring wells, was performed in July 2017. Groundwater samples were collected from a total of 21 monitoring wells: MW-1, 2, 3, 3D, 5, 7R, 9R, 13R, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25R, 26, 27 & 28. Depth to water measurements were gauged for water level elevation determination. The groundwater samples were analyzed for the primary COIs: VOCs (EPA Method 8260) and SVOCs (EPA Method 8270).

The 2017 groundwater analytical data were combined with the historical groundwater data to analyze data trends of concentrations over time and distance. The results of the data trend analysis provided an evaluation of stability and attenuation of the groundwater plume.

In addition, as part of the routine groundwater sampling, groundwater samples were analyzed for monitored natural attenuation parameters including nitrate, sulfate, ferrous iron, manganese, alkalinity, ammonia, carbon dioxide, methane and total organic carbon. These data were used to assess the site conditions for natural attenuation of COIs.

Specialized bioassay testing of groundwater was also conducted. Eleven field biological activity reaction tests (BART) were performed to observe for a reaction (color change, foam development) which would indicate a microbial population favorable for biodegradation processes. In addition, nine groundwater bio-trap samples (QuantArray®) were deployed and collected for laboratory DNA-based identification and quantification of functional genes for degraders. The bioassay results were used to assess the presence or absence of naturally occurring COI-reducing bacteria in the subsurface.

Hydraulic conductivity testing was performed by slug test methods in selected monitoring wells to develop estimates of hydraulic conductivity and seepage velocity at the Site.

An updated receptor survey was performed to identify public water supply wells (within one mile of the Site), private and irrigation water supply wells (within 1/2 mile of the Site), and monitoring wells (within 1,500 feet of the Site), and adjacent properties with structures not connected to public-supplied water.

Results from the 2017 groundwater sampling of the monitoring well network were summarized in the *Quarterly Progress Report – Third Quarter 2017* and are included as Appendix D. The general findings related to the CSM and chemical concentration data are summarized below.

<u>CSM Findings</u>

- Aerobic or moderately reducing conditions and microbial populations favorable for BTEX and polycyclic aromatic hydrocarbon degradation exist around the plume perimeter. Overall, favorable natural attenuation conditions exist at the Site.
- Preliminary hydraulic conductivity values developed from slug tests were in the general ranges of one to four feet/day (ft/d) for the shallow water table (fill) groundwater zone (MW-13R, 7R & 2); two to four ft/d for the saprolite groundwater zone (MW-9R, 19 & 27); and less than one ft/d for the bedrock (deep) groundwater zone (MW-26 & 28).
- Preliminary vertical hydraulic gradient estimates for groundwater at the Site were, for the MGP parcel, upward within the saprolite zone (MW-15/MW-16, MW7R/MW-9R, MW-13R/MW-27) and downward between the saprolite and bedrock zones (MW-9R/MW-28, MW-27/MW-26).
- For the Vaughn landfill parcel, the vertical hydraulic gradient trend is upward between the fill and saprolite zones (MW-3/MW-20), and for the southernmost floodplain parcel, slightly downward between the fill-alluvium and saprolite zones (MW-5/MW-22, MW-23/MW-24).

The overall shallow groundwater flow direction at the Site was west-southwestward (Figure 5).

<u>Chemical Concentration Data Findings</u>

- No VOC or SVOC exceedances were observed in saprolite or bedrock in monitoring wells located on the former MGP Parcel (Parcel 1).
- MW-7R, screened in the fill/residuum hydrogeologic zone, was the only well located on the former MGP Parcel which had detected groundwater concentrations above regulatory cleanup standards in July 2017. Benzene (17.8 µg/l) and naphthalene (36.3 µg/l) were detected in the groundwater sample at concentrations slightly above their respective MCL of 5 µg/l and RBSL of 25 µg/l.
- Consistent with historical monitoring results, no detectable concentrations of VOCs or SVOCs were present in groundwater samples from the four monitoring wells located at the southern end of the site on Parcels 4 and 5 (MW-5, 22, 23 & 24).
- No VOCs or SVOCs were detected in groundwater on the Legacy Elementary School Property (MW-25R).
- Reported concentrations for BTEX and naphthalene were below detection limits for the reinstalled hydraulically upgradient well cluster (MW-13R, 26 & 27).
- Groundwater samples from fourteen of the twenty-two monitoring wells at the Site did not contain benzene at concentrations above the MCL (5 µg/l). Benzene was detected at concentrations above the MCL at eight well locations including MW-1, 2, 3, 3D, 7R, 19, 20 & 21 (Figure 3).
- Naphthalene was detected in groundwater samples from seven of the 22 monitoring wells at concentrations above the RBSL (25 µg/L) (Figure 4).
- Dissolved phase COI concentrations in the preexisting wells were generally consistent with historical results indicating that the areal extent of the dissolved phase plume remains stable.
- Consistent with observed favorable conditions for natural degradation and attenuation, preliminary groundwater data trend analyses indicated overall stable to declining COI concentrations at most monitoring well locations.

3.0 *UPDATED CONCEPTUAL SITE MODEL*

Results from the 2017 RI field investigation were incorporated with existing data to develop an updated conceptual site model (CSM) by ERM, as shown in Figure 6. A cross-section location map is included as Figure 7 and cross-sections included as Figures 8 and 9. The key features of the updated CSM are summarized below.

Hydrogeologic Framework

The site is underlain by Piedmont stratigraphy consisting of soils (residuum) (13-16+ ft bgs) over saprolite/weathered rock which grades vertically to partially weathered rock (16-50 ft bgs) over fractured bedrock. A transition zone of relatively higher permeability typically occurs at the base of the partially weathered rock zone immediately above the competent fractured bedrock. South of Bramlette Road, the parcels are within the floodplain/wetlands of the Reedy River, and alluvium overlies the Piedmont stratigraphy. At the parcel containing the Vaughn Landfill, approximately eight feet of construction and demolition debris fill covers alluvium. The depth to groundwater is less than fifteen ft bgs at the former MGP parcel, near ground level in the floodplain areas, and five to 10 feet bgs at the landfill. Groundwater flow is generally westward toward the Reedy River which flows southward along the west perimeter of the site.

Average groundwater seepage velocities (v) were calculated for the Site using a form of Darcy's Law ($v = Ki/n_e$), where:

- K is an average hydraulic conductivity based on a slug test data performed in July 2017.
- i is an average horizontal gradient calculated based on the July 2017 groundwater elevation data.
- n_e is an assumed effective porosity.

Table 4 Seepage Velocity Calculations

Hydraulic Unit	K (ft/day)	n_e	Hydraulic Gradient	Seepage Velocity (ft/year)	Monitoring wells used for gradient
Fill/Residuum	2.5	0.25-0.35	0.0108	28-39	MW-13R/MW-2
Saprolite	3.0	0.35-0.45	0.00785	19-25	MW-09R/MW-20

The calculated groundwater seepage velocities for the Site are relatively low indicating that migration rates of dissolved COIs in groundwater are also relatively low.

Surface Drainage

Surface drainage at the Site is constrained by the elevated railroad that runs along the east bank of the Reedy River. The Reedy River is classified by SCDHEC as a Freshwater (FW) stream and its watershed is described as an urban growth area with 51% urban land use and a high potential for growth. As an urban stream, the actual stream use is secondary contact recreation (activity occurring on or near the water which does not have an intended purpose of direct water contact), and there are no public water supply intakes. Historical drainage ditches serve to drain the surface water southward from the floodplain area east of the elevated railroad. Stormwater drainage ditches from the former MGP parcel drain through a culvert southward under Bramlette Road to the historical drainage ditches in the floodplain. From Bramlette Road, the main floodplain drainage ditch extends approximately 2,200 feet south and drains under a railroad trestle near Willard Street to the Reedy River. There are no known other surface water drainage outlets from the Site to the river between Bramlette Road and the railroad trestle near Willard Street.

Environmental Conditions

Historical releases from the former MGP operations have resulted in soil and groundwater impacts within the Site. However, extensive remedial actions to address these impacts have been performed by Duke Energy. These activities included the demolition and removal of the MGP infrastructure and remediation of approximately 61,000 tons of source area soils to depths ranging from 3 – 12 feet below ground surface within and around the former MGP parcel, and approximately 385 feet of a drainage ditch that exited the property to the southwest, effectively addressing the site-related historic sources associated with the former MGP's operations.

Residual NAPL has been observed in site soils at discrete location within the Site associated with historical drainage ditches. Typically, the NAPL is present in thin (<2 inches) discontinuous bands located at the residuum /saprolite interface located below the drainage ditches southwest of the former MGP parcel.

Groundwater is not used as a drinking water source within ½ mile of the site based on an receptor survey performed in 2017 (Anchor QEA, 2017). The current groundwater monitoring network consists of 22 wells.

Benzene and naphthalene are present in site groundwater at certain locations, with the highest concentrations occurring at the landfill parcel. Stable to declining groundwater concentration trends are indicated overall, based on the results of 28 groundwater monitoring events conducted since 1996. In 2017, groundwater samples from eight of the nine monitoring wells at the former MGP property contained no detectable levels of benzene or naphthalene, indicating that the remedial actions completed at the former MGP property have been effective for groundwater quality remediation. Furthermore, favorable natural attenuation conditions are evident at the Site based on the recent MNA evaluation conducted by AnchorQEA (Anchor QEA, 2017). Overall, the lateral and vertical extent of the affected groundwater has been characterized; however, refinement of the monitoring network is needed to the southwest.

There have been no measured exceedances of surface water quality standards in the Reedy River Based on historical sampling results. Three relatively small potential hydrocarbon sheens were observed during a 2017 site visit at three locations proximate to the Vaughn landfill within the floodplain surface water bodies.

<u>Potential Receptor Evaluation</u>

Overall, the available data and understanding of site conditions indicate a relatively low risk site. No water supply wells are reported located within ½-mile of the Site as the area is served by public water service. The various site parcels are inactive vacant land owned by CSXT railway with the exception of a small field office located on Parcel 3. The westernmost undeveloped portion of the Legacy Charter School property extends into the floodplain. The Swamp Rabbit Trail, a county linear greenway park, is located just west of the CSXT railroad corridor and parallels the Reedy River. The potential human health exposure scenarios are limited to current and future site workers that may disturb soil within the impacted areas and trespassers that may access the property from adjacent public property. Previous assessments of potential environmental receptors indicated no adverse effects to flora (1996) or fauna (1999).

The potential for vapor intrusion was evaluated by ERM using EPA screening protocols and was determined to be an incomplete pathway. The Site consists of industrial/commercial properties which are primarily vacant. A small CSXT railroad field office structure located on Parcel 3 is the only structure that exists near (within 100 feet of) MGP-related affected groundwater. Relevant groundwater quality data in the vicinity of the railroad field office was screened to assess the need to conduct additional VI assessment for the structure. The field office is located approximately 80 feet south of MW-2. Benzene and naphthalene are the primary COIs at the site. There are no chlorinated VOCs associated with the MGP-related GW impacts. The benzene concentration (244 μg/L) in the 2017 groundwater sample collected from MW-2 (approximately 80 feet north of the structure) exceeded the EPA RSL for non-residential VI screening level for groundwater at the 10^{-5} risk level. However, depth to groundwater at MW-2 has historically ranged from 8 to 11 ft bgs. The most recent guidance (EPA's Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites, June 2015 or Interstate Technology and Regulatory Council's (ITRC) Petroleum VI Guidance, October 2014) for petroleum hydrocarbon impacted sites indicates that sites with groundwater greater than six ft bgs with no LNAPL screen out of further assessment requirements. None of the precluding factors that would limit screening out are present in the groundwater samples collected from MW-2. Therefore, no additional VI assessment at this Site is necessary at this time.

Additional Data Needs

The results of previous remedial actions performed at the site were successful in removing the main areas of MGP-related source material, and in improving groundwater quality based on monitoring data that indicates an overall trend of stable to declining COI concentrations.

Previous investigations have characterized the general extent of the residual NAPL associated with the drainage ditches at the Site; however, additional refinement of the location and extent of NAPL is warranted for remedial feasibility planning purposes. The dissolved phase groundwater plume, which has remained stable since 1996, has been delineated and monitored, except in the hydraulically downgradient direction to the southwest near the Reedy River, and vertically at the former Vaughn Landfill.

Based on the current CSM, and in accordance with the objectives of the VCC, additional information is needed to refine an understanding of site conditions so that a site-specific remedial action plan can be prepared for the site. The following tasks are identified to address additional data needs and objectives to complete the RI in accordance with the VCC requirements and evaluate remedial alternatives:

- Complete a focused residual NAPL investigation to further characterize the horizontal and vertical extent, and to assess the feasibility of remedial alternatives;

- Refine the delineation of the dissolved phase groundwater impacts in the hydraulically downgradient (west) direction by installing monitoring well clusters along the Reedy River;
- Delineate the vertical extent of dissolved phase groundwater impacts in the portion of the Site south of Bramlette Road by installing a deeper monitoring well;
- Perform site-wide groundwater and surface water quality monitoring to determine current water quality conditions at the Site;
- Conduct sediment sampling to assess current sediment quality at the Site; and
- Conduct risk assessments to evaluate potential human health and ecological risks associated with exposure to environmental media at the Site.

4.0 PROPOSED ADDITIONAL REMEDIAL INVESTIGATION ACTIVITIES

The following sections describe the proposed Site investigation activities to address the additional data needs and objectives described above.

4.1 FOCUSED RESIDUAL NAPL ASSESSMENT

The objective of the residual NAPL assessment is to further evaluate the depths, thicknesses and extent of the residual NAPL at the Site, specifically in Parcels 2 and 3. The investigation will focus on the Vaughn landfill at dry-land areas accessible with a conventional track mounted drilling rig as described below. The floodplain/ wetland areas of the Site outside the perimeter of the Vaughn landfill, which are typically submerged below standing water, are not proposed for assessment at this time due to the difficult access conditions and susceptibility for disturbance of the floodplain/ wetlands terrain by drilling rigs.

The technical approach to the residual NAPL assessment is to advance soil borings along transects in proximity to historical drainage features and other areas beneath the landfill where residual NAPL has been observed, to assess NAPL depths, thickness and extent. Soil borings will be advanced using Sonic drilling techniques. Sonic drilling was selected based on its expected capabilities to provide continuous soil cores for NAPL identification, and to penetrate the construction and demolition debris fill. Up to twenty (20) transects are proposed: 17 transects as shown on Figure 10, plus three discretionary transect locations to be determined based on results of the initial 17 transects. In addition to these combined 20 transects, up to 10 discretionary single boring locations are planned, as needed, for the assessment. The location and number of transects are subject to change based on field observations during the investigation.

Three (3) borings will be advanced by sonic drilling method along each of the accessible transects. Continuous soil sampling will be conducted to the top of saprolite (~16 ft bgs) or base of identified NAPL, whichever is deepest. Field personnel will log the depth of NAPL occurrence, thickness, and soil types observed in the boring at each location. Depth to groundwater from land surface will also be measured. A photo ionization detector will be used to screen soils during the investigation, and measurements will be recorded in the field logbook. Up to 20 non-NAPL containing soil samples will be collected for laboratory analyses for VOCs (Method 8260) and SVOCs (Method 8270). Each boring will be abandoned by backfilling with bentonite. The vertical and horizontal location of each boring will be determined by calibrated GPS device.

Prior to any ground-disturbing activities, the work areas will be cleared for subsurface utilities by electromagnetic and ground-penetrating radar techniques by a private utility locator. ERM will also place a public utility locating request. Soil and water wastes generated as part of the assessment will be containerized in 55-gallon steel drums or roll-off boxes. Waste characterization samples will be collected from the containerized solid and liquid materials for proper laboratory characterization of VOCs. These investigation-derived wastes will be managed in an appropriate manner based on the laboratory results.

The data from the proposed NAPL assessment will be evaluated to determine if the assessment is complete. If further NAPL assessment is necessary, an RI work plan addendum will be developed. Otherwise, the NAPL assessment results will be presented in the RI Report.

4.2 MONITORING WELL INSTALLATION

The existing monitoring well network will be expanded by installing seven (7) new monitoring wells to further assess the horizontal and vertical extent of dissolved phase groundwater quality impacts at the Site. The locations for the proposed monitoring wells are included on Figure 10. Prior to monitoring well installation, an exploratory boring will be installed in former Vaughn Landfill footprint. This boring will be advanced in a location estimated to be free of impacts and used to provide lithology and bedrock depth information to assess the site hydrogeologic framework and appropriate target depths and screen intervals for the proposed monitoring wells along the Swamp Rabbit Trail and at the Vaughn landfill.

Three monitoring well clusters will be installed to evaluate the western extent of the groundwater impacts at the Site: two clusters will be installed along the Swamp Rabbit Trail near the east bank of Reedy River (PMW-30 and PMW-31); and one cluster will be installed on the north side of Bramlette Road in Parcel 2 (PMW-29), as shown on Figure 10. Each well cluster will consist of two (2) monitoring wells, one (1) shallow well completed near the water table to an estimated total depth of 15 ft bgs; and one (1) mid-depth well completed in the transition zone to an estimated total depth of 35 to 50 ft bgs. Each well will be completed with a five or 10-foot screen interval, and positioned vertically to avoid overlapping screen intervals. Groundwater quality results from these wells will be assessed to evaluate the need to install additional wells along Swamp Rabbit Trail.

In addition to these three well clusters, one bedrock monitoring well will be installed on the former landfill parcel adjacent to existing wells MW-3 and MW-20 (PMW-32) to assess the vertical extent of groundwater quality impacts at the Site. ERM anticipates that the vertical delineation well will be completed to an estimated total depth of 75 ft bgs, and completed within fractured competent bedrock.

The actual well completions will be determined in the field based on subsurface conditions. The proposed well installations will be subject to obtaining an access agreement for the Swamp Rabbit Trail from Greenville County.

ERM will utilize a certified South Carolina well drilling subcontractor using Sonic drilling technology to install and develop the monitor wells, in accordance with South Carolina well construction standards. Continuous soil cores will be retrieved during drilling, and field personnel will log the soil type in a field logbook. Soil cuttings and well development water will be containerized, characterized, and disposed in an appropriate manner.

Following completion of the proposed monitoring well installations, the horizontal and vertical locations of the monitoring wells will be surveyed by a South Carolina Licensed surveyor. In accordance with the CSXT access agreement, the elevations will be measured relative to North American Vertical Datum of 1988. The survey will also include conversion factors to other datum references as needed.

A monitoring well permit will be obtained from SCDHEC prior to the well installation activities. An SCDHEC Monitoring Well Application for the proposed monitoring wells will be prepared.

4.3 SLUG TESTING

Hydraulic conductivity testing will performed by slug test methods in selected new monitoring wells to develop additional estimates of hydraulic conductivity at the Site. Slug tests will be performed at two new shallow wells, two new saprolite wells, and one new bedrock well location among the wells to be installed, as described below. Slug tests are conducted by instantaneously introducing into or removing from a well a known volume of water, and then monitoring the return of the water level within the well to its original level.

The testing will be conducted in general accordance with field procedures for performing a slug test, as described in ASTM D4044 Standard Test Method (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers. Slug-in and slug-out data will be analyzed with AQTESOLV™ software using the method of Bouwer and Rice (1976) for an unconsolidated aquifer. Data from each test will be used to compute a hydraulic conductivity for that slug test, from which an average hydraulic conductivity will then calculated for each well. Hydraulic conductivity data will be used to estimate groundwater seepage velocities.

4.4 *MONITORING WELL ABANDONMENT*

Five monitoring wells at the Site have been determined to be ineffective or unnecessary for groundwater monitoring, and are therefore proposed for abandonment. The wells proposed for abandonment and the rationale are:

- MW-3D, MW-6A, and MW-19 due to overlapping or insufficient depth differential in screen intervals within well clusters (respectively with MW-3, MW-21 & MW-1); and
- MW-23 and MW-24 due to redundancy, because the nearby MW-05 and MW-22 well pair provides sufficient delineation south of the plume, and due to access constraints because the well pair is installed within a floodplain area with standing water.

The proposed well abandonments will be subject to SCDHEC approval. The monitoring wells listed above will be abandoned by filling with neat cement from bottom to top by tremie-grouting method, and removing the wellhead below grade. Well abandonment logs will be completed and submitted to SCDHEC.

4.5 *GROUNDWATER MONITORING*

After installation and development of the proposed wells, ERM will conduct a site-wide groundwater monitoring event that will include the seven (7) newly installed monitoring wells, and 21 of the 22 existing Site monitoring wells. (Due to access constraints, existing well MW-18 will be replaced by the proposed MW-31 cluster in the sampling program). All site wells will be gauged for water levels prior to sampling.

Monitoring wells will be purged using low-flow methods and groundwater quality parameters (pH, conductivity, temperature, and oxidation-reduction potential) will be stabilized prior to sample collection. Field personnel will utilize a peristaltic pump or submersible pump with dedicated downhole tubing to retrieve groundwater samples.

Samples from each location will be properly preserved and shipped to a South Carolina certified laboratory for analysis VOCs (EPA Method 8260) and SVOCs (EPA Method 8270). All samples will be placed in coolers containing ice and managed under chain-of-custody protocol.

4.6 SURFACE WATER MONITORING

Surface water sampling will be conducted to assess surface water quality of the ponded water within the drainage ditches and floodplain/wetlands areas in the vicinity of the landfill parcel, and of the Reedy River. Surface water samples will be collected by grab method at six locations within the wetlands, and at five locations along the Reedy River as shown on Figure 11. The samples will be collected from downstream to upstream locations. Samples will be properly preserved and submitted to a South Carolina certified laboratory for analysis of VOCs (EPA Method 8260) and SVOCs (EPA Method 8270). All samples will be placed in coolers containing ice and managed under chain-of-custody.

Three relatively small apparent hydrocarbon sheens were observed on surface water at locations in the floodplain/ wetlands shown on Figure 11 during a December 2017 site walk. Field personnel will document the location of any observed sheens encountered during the proposed sampling activities. In order to characterize the sheen constituents, sheen samples will be collected at up to four sheen locations. The sheen layer will be sampled using special sheen collection nets which will be placed in sealed sample jars, properly preserved, and shipped to the certified laboratory for analysis of VOCs (EPA Method 8260) and SVOCs (EPA Method 8270).

In addition, up to three stream gauges will be installed within surface water at the Site and surveyed to monitor surface water elevations, and to evaluate groundwater and surface water interaction (see Figure 10).

4.7 SEDIMENT SAMPLING

Sediment sampling will be conducted to assess current sediment quality in the ponded areas within the drainage ditches and floodplain/wetlands areas in the vicinity of the landfill parcel and in the Reedy River. Eleven samples will be collected in close proximity to the proposed surface water sample locations (Figure 11). Each sample will consist of a surficial sediment sample collected from the 0.0 to 0.5-foot depth using clean stainless steel scoops. Samples will be collected in general accordance with US EPD SESD operation procedure (SESDPROC-200-R3). The sediment samples will be submitted to a South Carolina certified laboratory for analysis of VOCs (EPA Method 8260) and SVOCs (EPA Method 8270). All samples will be placed in coolers containing ice and managed under chain-of-custody.

4.8 *APPLICABLE REGULATORY STANDARDS AND SCREENING LEVELS*

The data collected during the proposed RI activities will be of sufficient quality to meet intended uses, and to allow comparison of results to applicable standards and screening levels. The reported constituent concentrations and detection limits will be compared to the most current applicable criteria/screening levels as listed below.

Groundwater

- SCDHEC R. 61-58 *State Primary Drinking Water Standards*, effective October, 2014, Appendix B MCL based on the EPA *National Recommended Water Quality Criteria*, dated 2006;
- SCDHEC regulation document R.61-68, *Water Classifications & Standards*, effective June 27, 2014, groundwater classification as GB, Human Health MCLs provided in the Appendix of R.61-68
- SCDHEC Quality Assurance Program Plan UST Management Division, effective February 2016, Appendix C

Surface Water

- SCDHEC R.61-68, Water Classifications & Standards, surface water classification as FW, Human Health MCLs provided in the Appendix of R.61-68

Sediment/Soil

- EPA RSLs for industrial soil.

5.0 RISK ASSESSMENT PLANS

Updated risk assessments will be performed to evaluate potential risks associated with exposure to environmental media at the Site. This section describes the approach that will be used to perform human health and ecological risk evaluations resulting from historical release of MGP related constituents to surface water, soil/sediment and groundwater at the Site.

A Baseline Human Health Risk Assessment will be performed for groundwater using selected historical data along with the collection of new groundwater data as described in Section 4.5. A phased, screening level approach will be taken to assess potential human health risk from exposure to surface water and soil/sediment. In addition, a Screening Level Ecological Risk Assessment (SLERA) will be performed to assess potential ecological impacts. The screening level assessments will assist in determining if additional sampling is necessary, and if further risk analyses are warranted. An overview of the methodology and procedures that will be used to estimate potential human health and screening level ecological risks posed by constituents detected at the Site are presented in Sections 5.1 and 5.2.

5.1 HUMAN HEALTH RISK ASSESSMENT WORK PLAN

As described above, the Human Health Risk Assessment will consist of a baseline assessment for groundwater and a screening level assessment for surface water and soil/sediment. The methodology used for these analyses are described below.

5.1.1 Risk Assessment Methodology

For evaluating human health impacts, the Baseline and Screening Level assessments will be conducted in accordance with EPA guidance for the preparation of risk assessments; the primary risk assessment guidance documents that may be employed include:

- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part A (1989);*
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part B - Development of Preliminary Remediation Goals (1991a);*
- *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors (1991b);*
- *Guidelines for Exposure Assessment (1992);*

- *Guidelines for Cancer Risk Assessment (1996a, 1999, 2003b);*
- *Soil Screening Guidance: Users Guide and Technical Background Document (1996b);*
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part D - Standardized Planning, Reporting and Review of Superfund Risk Assessments (2001);*
- *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (2002a);*
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (2002b);*
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part E - Supplemental Guidance for Dermal Risk Assessment (2004);*
- *Exposure Factors Handbook 2011 Edition (Final Report) EPA/600/R-09/052F (2011);*
- *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors Office of Solid Waste and Emergency Response Directive 9200.1-120 (2014).*
- *Vapor Intrusion Screening Level Calculator. (June 2017 or current version).*
- *Regional Screening Levels Tables. (November 2017 or current version). Available at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/.*

In accordance with the above-listed guidance documents, the Human Health Risk Assessment (HHRA) will include the traditional four steps defined by the National Academy of Sciences (1983) in their report, "*Risk Assessment in the Federal Government: Managing the Process*." These steps are as follows:

1. Hazard Identification [which includes Selection of Constituents of Potential Concern (COPC)];
2. Exposure Assessment;
3. Toxicity Assessment; and
4. Risk Characterization, including an Uncertainty Assessment.

The following sections of this HHRA work plan describe each of these steps and identify key issues involving specific conditions pertinent to the Site.

5.1.2 *Hazard Identification and Selection of COPCs*

The hazard identification process: 1) evaluates the nature and extent of constituents reported at the Site; and 2) selects a subset of constituents identified as COPCs. For the hazard identification, all analytical data will be compiled. From this compilation, the data will be analyzed for risk assessment purposes. The components of the hazard identification are described in the following section.

Based on the results of previous site investigations described in Sections 1.0 and 2.0, the targeted COPCs at the Site are VOCs primarily BTEX, and polynuclear aromatic hydrocarbons, primarily naphthalene.

5.1.3 *Exposure Assessment*

The exposure assessment evaluates the likelihood, magnitude and frequency of exposure to the COPCs, and identifies pathways and routes by which human receptors may be exposed to these constituents. The physical characteristics of the Site are examined to identify pathways by which human receptors may be exposed to constituents at the Site. Exposure scenarios are developed based on demographics, land use, and general human behavior patterns. Intake factors will be subsequently developed for the identified receptor populations under the defined conditions of exposure. Following the development of exposure scenarios and calculation of intakes, exposure point concentrations will be estimated. The intake factors and exposure point concentrations are used in the succeeding steps of the risk assessment to characterize quantitatively the potential risks associated with the defined exposure scenarios.

Prior to conducting the risk assessment, a summary of the proposed technical assumptions to be used for the risk assessment will be developed and submitted for SCDHEC for review. This summary will include assumed land use scenarios, plausible receptors and exposure pathways, and exposure parameters. The preliminary risk assumptions are presented in the following sections.

Identification of Potentially Exposed Populations

The identification of potential human receptors is based on several factors, including current and future anticipated land use and groundwater usage. This information will be the basis to identify individuals working and/or engaging in activities on the Site, both currently and potentially in the future. Thus, considering all potential human receptor populations that may frequent the Site and the anticipated pathways of exposure by which the receptors could contact each medium, the plausible receptors include those listed below.

Current Land Use

- CSX Site workers, and
- Trespassers/recreators (adolescent receptors represent the most sensitive age group of this population).

Future Land Use

- Construction/utility workers,
- Site workers, and
- Trespassers/recreators (adolescent receptors represent the most sensitive age group of this population).

For each of these potentially-exposed populations, potential exposure pathways are described in the following section.

5.1.3.1 Identification of Exposure Pathways

The initial step is to identify the exposure pathways to be evaluated in the HHRA. To qualify for evaluation, a pathway must include the following four elements:

- A source and mechanism of constituent release to the environment;
- A transport medium by which the released constituent may reach a receptor (e.g., groundwater);
- A point of potential contact by the human receptor with the contaminated medium (e.g., an individual accesses the Site and contacts the contaminated medium); and,
- An exposure route (e.g., ingestion, dermal contact, inhalation).

Considering each of the above elements, each sampled medium (surface water, sediment and groundwater) may be considered a potential transport medium for constituent migration in the HHRA. Potential receptors may contact constituents in surface water and sediment through ingestion, dermal contact and/or inhalation. These media may be contacted directly, or through a secondary exposure medium such as the atmosphere.

Thus, considering all potential human receptor populations that may frequent the Site, and the anticipated pathways of exposure by which the receptors could contact each medium, the plausible receptor and exposure pathways include: 1) current land use; and, 2) plausible future land use. For both, it is anticipated that the land use will remain as commercial/industrial as there are no known plans for redevelopment of this Site.

Current and Plausible Future Land Use

Plausible receptor and exposure pathways include the following scenarios.

Construction Worker Scenario. Construction/utility workers may contact impacted media while conducting construction/utility maintenance activities, specifically those requiring subsurface disturbance. Construction/utility workers may contact shallow groundwater while conducting subsurface activities (i.e., excavation/trenching activities) via incidental ingestion, dermal contact and inhalation of vapors. These potential routes of exposure will be included in the Baseline Risk Assessment.

Site Worker Scenario**.** Workers could also be exposed to constituents in surface water and sediment via incidental ingestion, dermal contact and inhalation of vapors and released particulates while conducting maintenance activities. These potential routes of exposure will be included in the Screening Level Risk Assessment. In addition, site workers may indirectly contact vapors (via inhalation) that may migrate from subsurface soil and/or groundwater into the railroad field office.

Trespasser/Recreator Scenario**.** Trespassers/recreators could be exposed to constituents via incidental ingestion, dermal contact and inhalation of vapors and particulates released from surface water and sediment. Recreators using the Swamp Rabbit Trail could trespass onto the adjacent Site, and make contact with surface water and sediment in the floodplain area. These potential routes of exposure will be included in the Screening Level Risk Assessment.

5.1.3.2 Establishment of Exposure Parameters

Appropriate intake parameters will be identified for each of the exposure scenarios discussed above. Values for the exposure parameters used generally reflect reasonable maximum exposure assumptions. Where EPA guidance (EPA, 1989) has specified intake parameters for the above-mentioned receptors, these values will be adopted. If specific inputs are not required, EPA guidance and other sources will be utilized to develop reasonable exposure assumptions. This guidance will include the *Exposure Factors Handbook* (EPA 2011), Supplemental *Guidance: Update of Standard Default Exposure Factors* (EPA, 2014) and EPA's Ecological Risk

Assessment Guidance for Superfund (*RAGS*) *Part E Guidance* (EPA, 2004). The intake parameters will be used to calculate intake factors for each scenario according to the methods presented in RAGS Part A (EPA, 1989) and the guidance documents enumerated above. The standardized equations presented in EPA (1989a) will be used to estimate a receptor average daily dose, both lifetime and chronic. Specific formulas and all calculations will be presented in the risk assessment section of the RI.

5.1.3.3 Estimation of Exposure Point Concentrations

Exposure point concentrations (EPC) can be projected by using either monitoring data alone or a combination of monitoring data and fate and transport modeling. For each COPC, the EPC will be calculated as the Upper Confidence Limit (UCL) on the mean of the analytical data, as recommended and calculated by the EPA software program ProUCL (Version 5.01.002).

Summary statistics for all COPCs retained for further evaluation will be presented. The summaries will list the COPCs; the arithmetic mean of the data; the ProUCL-recommended UCL; the EPC value, statistic, and rationale for the reasonable maximum exposure evaluation; and the EPC value, statistic, and rationale for the CT evaluation. The EPC was defined as the lower of the ProUCL-recommended UCL or the maximum-detected concentration for each COPC. As needed, models used to predict air concentrations will be provided, as described below.

<u>Trench Air Concentrations from Groundwater</u>

EPCs of volatile COPCs in trench air from shallow groundwater will be calculated using a model developed by the Virginia Department of Environmental Quality (VADEQ) for the Virginia Voluntary Remediation Program. This model assumes that the depth to groundwater is less than 15 feet and that a construction worker would encounter groundwater when digging an excavation or a trench. To estimate the migration of volatile COPCs in groundwater to air in a construction or utility trench, the VADEQ trench model uses a combination of a vadose zone model to estimate volatilization of gases from groundwater into a trench, and a box model to estimate dispersion of the constituents from the air inside the trench into the aboveground atmosphere. Specific exposure assumptions for this model will include the site groundwater temperature, and will assume that the trench dimensions will be 3 feet wide by 8 feet long and the construction worker may be exposed up to 125 days/year (VADEQ's default values).

5.1.3.4 *Quantification of Exposure Doses*

To estimate the potential risk to human health that may be posed by the presence of COPCs, it is first necessary to estimate the potential exposure dose of each COPC. The exposure dose is estimated for each constituent via each exposure pathway by which the receptor is assumed to be exposed. Exposure dose equations combine the estimates of constituent concentrations in the environmental medium of interest with assumptions regarding the type and magnitude of each receptor potential exposure to provide a numerical estimate of the exposure dose. The exposure dose is defined as the amount of COPC acquired by the receptor and is expressed in units of milligrams of COPC per kilogram of body weight per day (mg/kg-day).

Exposure doses are defined differently for potential carcinogenic and non-carcinogenic effects. The chronic average daily dose is used to estimate a receptor potential intake from exposure to a COPC with non-carcinogenic effects. According to EPA (1989a), the chronic average daily dose should be calculated by averaging the dose over the period of time for which the receptor is assumed to be exposed. Therefore, the averaging period is the same as the exposure duration. For COPCs with potential carcinogenic effects, however, the lifetime average daily dose is employed to project potential exposures. In accordance with EPA (1989a) guidance, the lifetime average daily dose is calculated by averaging exposure over a receptor assumed lifetime of 70 years. Therefore, the averaging period is the same as the receptor assumed lifetime.

COPC-specific chronic daily intakes (doses) for the receptors and pathways selected for quantitative evaluation in the HHRA will be calculated using EPA equations (EPA 1989) for all exposure scenarios. Detailed formulas and calculations will be provided in the risk assessment presented in the RI.

5.1.4 *Toxicity Assessment*

The toxicity assessment will incorporate toxicity indices from sources identified in *Human Health Toxicity Values in Superfund Risk Assessments* (EPA, 2003). Current toxicological indices; i.e., carcinogenic slope factors and reference doses, will be identified for each constituent of potential concern according to the following hierarchy:

- EPA Integrated Risk Information System (IRIS), an on-line toxicity data base updated monthly by EPA;
- EPA Provisional Toxicity Values, as provided in the EPA RSL Table; and,

- Other Sources; e.g., the *Health Effects Assessment Summary Tables, HEAST* (EPA) and other toxicological information sources, such as the California EPA and ATSDR.

The following information will be tabulated for each carcinogenic COPC:

- The current carcinogenic slope factor (CSF) from IRIS or the other sources listed above;
- Weight-of-evidence narrative summary; and,
- Type of cancer for Class A carcinogens.

Oral exposures are used to evaluate dermal exposures through route-to-route extrapolation from the oral CSF to a dermal CSF.

The following information was tabulated for each non-carcinogenic COPC:

- Current reference doses and reference concentrations; and
- Target organ(s) and uncertainty factors.

5.1.5 Baseline Risk Characterization

In the final step of the risk assessment, the results of the exposure assessment, i.e., the calculated intakes, will be integrated with toxicity information to derive quantitative estimates of potential risk associated with the defined exposure scenarios. Risk projections will be calculated following the standard procedures defined in RAGS Part A (EPA, 1989) and the results will be compared to levels of acceptable risk defined by EPA (EPA, 1990).

The incremental carcinogenic risk associated with exposure to COPCs detected at the Site will be calculated according to the following equation (EPA, 1989):

$$\text{Incremental Carcinogenic Risk} = \text{Intake Factor} \times \text{EPC} \times \text{Cancer Slope Factor}$$

The resulting risk will be compared to the acceptable range of risk levels defined by EPA (1990) in the National Oil and Hazardous Substances Pollution Contingency Plan; i.e., 1×10^{-6} to 1×10^{-4}.

Non-carcinogenic hazards will also be calculated for each COPC according to the methods described in *Risk Assessment Guidance for Superfund/Part A* (EPA, 1989). Potential non-carcinogenic effects will be evaluated based on a comparison of constituent-specific chronic exposure doses with corresponding protective doses derived from health criteria. The result of this comparison is expressed as the hazard quotient. Hazard indices will be calculated as the sum of all appropriate hazard quotients to fully evaluate the potential non-carcinogenic hazard associated with a defined exposure. If necessary, hazard indices will be segregated according to target organ effects to more accurately assess the potential for adverse health effects to occur as a result of the defined conditions of exposure.

5.1.6 Results of Screening Level Risk Assessment

As a described in previously, surface water and soil/sediment data will be compared to appropriate screening criteria to provide a preliminary assessment of potential human health risk associated with potential exposure. The data comparison to screening criteria will be tabulated for evaluation. The results of this analysis will be used to determine if additional data collection is needed to fully characterize the site and if further risk evaluation is warranted.

5.1.7 Uncertainty Analysis

The HHRA will present a qualitative and quantitative discussion of the uncertainties associated with each step of the risk assessment process and an evaluation of the significance of those uncertainties. An uncertainty analysis is an integral part of any risk assessment in that it enhances evaluations, which shape subsequent risk management decisions. This discussion will include an evaluation of the uncertainties associated with the risk assessment process itself as well as the specific assumptions used in developing the risk assessment.

5.2 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

ERM will conduct a SLERA according to EPA's RAGS: Process for Designing and Conducting Ecological Risk Assessment, Interim Final (EPA, 1997), to evaluate potential ecological risks associated with exposure to environmental media at the site. As described in EPA guidance, the SLERA involves the completion of the first two steps in an eight-step process, described as follows:

Step 1. Screening-level problem formulation and ecological effects evaluation: Problem formulation establishes the goals and focus of the SLERA.

Step 2. Screening-level exposure estimate and risk calculation: Exposure and potential risk is estimated based on a comparison of site data against literature-based ecological screening values. This Step involves refining and interpreting the data screening, and will include detailed, site-specific analyses to provide a realistic assessment of potential ecological exposure and risk.

At the conclusion of the SLERA, a Scientific/Management Decision Point will be reached. ERM will prepare a draft and final SLERA Report, which will make recommendations regarding the need for a Baseline Ecological Risk Assessment and/or risk management options, as necessary.

6.0 SCHEDULE AND REPORTING

Following completion of the RIWP-A activities described above, a determination as to the completeness of the remedial investigation will be made. If the RI is determined to be incomplete, another RI Work Plan Addendum would be developed to address the data gaps. After the remedial investigation is deemed complete, a *Remedial Investigation Report* will be prepared. The report will summarize the compiled results of remedial investigations conducted under the VCC. The *Remedial Investigation Report* will include a description of activities undertaken at the Site, results of the sample analysis, and an updated CSM. The report will include laboratory data sheets, data tables summarizing results of the assessment, and figures illustrating assessment activities and results of the sampling activities.

The following preliminary schedule is proposed, which is dependent on SCDHEC's written approval of the Work Plan and obtaining the necessary property access agreements. Upon approval of the RIWP-A by SCDHEC, an updated project schedule will be developed.

Table 5 Proposed Schedule

Task	Preliminary Target Completion Date
RI Work Plan Addendum submittal to SCDHEC	April 13, 2018
Submit 1st Quarter 2018 Progress Report	April 15, 2018
SCDHEC approval of RI Work Plan and Well Permit issued	2nd Quarter 2018
Execute Access Agreements	90 days from work plan approval
Submit 2nd Quarter 2018 Progress Report	July 15, 2018
Complete monitoring well installation fieldwork	3rd to 4th Quarter 2018
Complete sediment, surface water, slug testing and groundwater sampling event fieldwork	3rd to 4th Quarter 2018
Submit 3rd Quarter 2018 Progress Report	October 15, 2018
Conduct NAPL Assessment	4th Quarter 2018 to 1st Quarter 2019
Submit 4th Quarter 2018 Progress Report	January 15, 2019
Develop RI Report or RI Work Plan Addendum	2nd Quarter 2019

7.0 HEALTH AND SAFETY PLAN

In accordance with ERM's procedures and Duke Energy safety requirements, a Health and Safety Plan (HASP) will be prepared for use during field activities to provide specific guidelines and establish procedures to protect project personnel and the public during the investigation activities. The HASP will be reviewed and signed by each sampling staff member prior to work on-site and appropriate project management staff, and will be kept on file. ERM will develop a job hazard analysis for each individual task to be included within the HASP.

8.0 QUALITY ASSURANCE PLAN

ERM will prepare a site-specific Quality Assurance Project Plan for the project. The Quality Assurance Project Plan will identify the Quality Assurance (QA) and Quality Control (QC) procedures that will be used to ensure that technical data generated during planned RI activities are accurate, complete and representative of actual field conditions and of sufficient quality to support decisions concerning corrective action measures. The QA program will establish the appropriate methods and equipment and data quality objectives to be used to assure reliability of monitoring and measurement data. QC measures will provide for the routine application of field and laboratory procedures for obtaining prescribed performance standards for monitoring, measuring, and assessment data.

Figures

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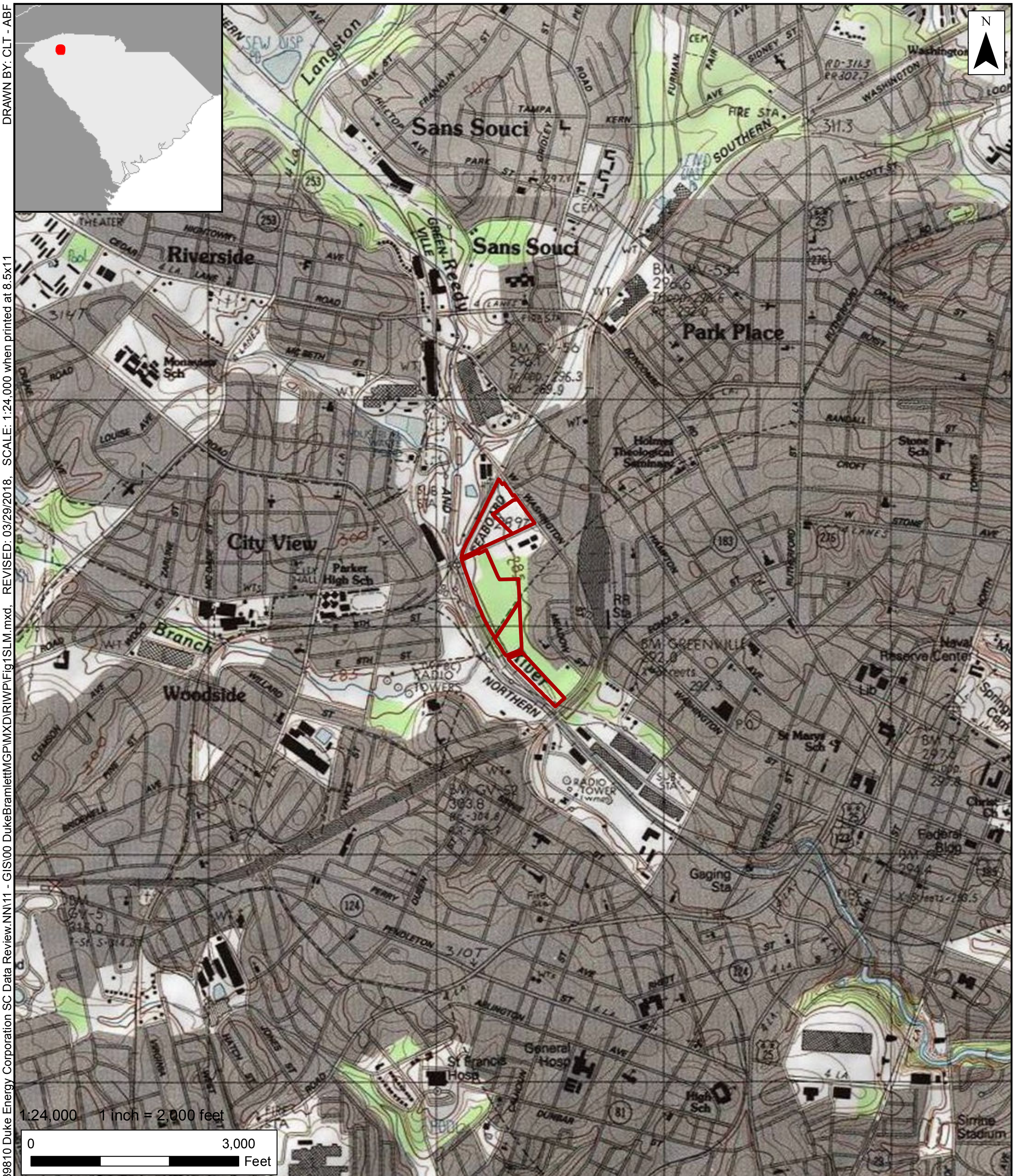

Legend

Site

Figure 1

Site Location Map

Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

ERM Environmental Resources Management www.erm.com

DUKE ENERGY.

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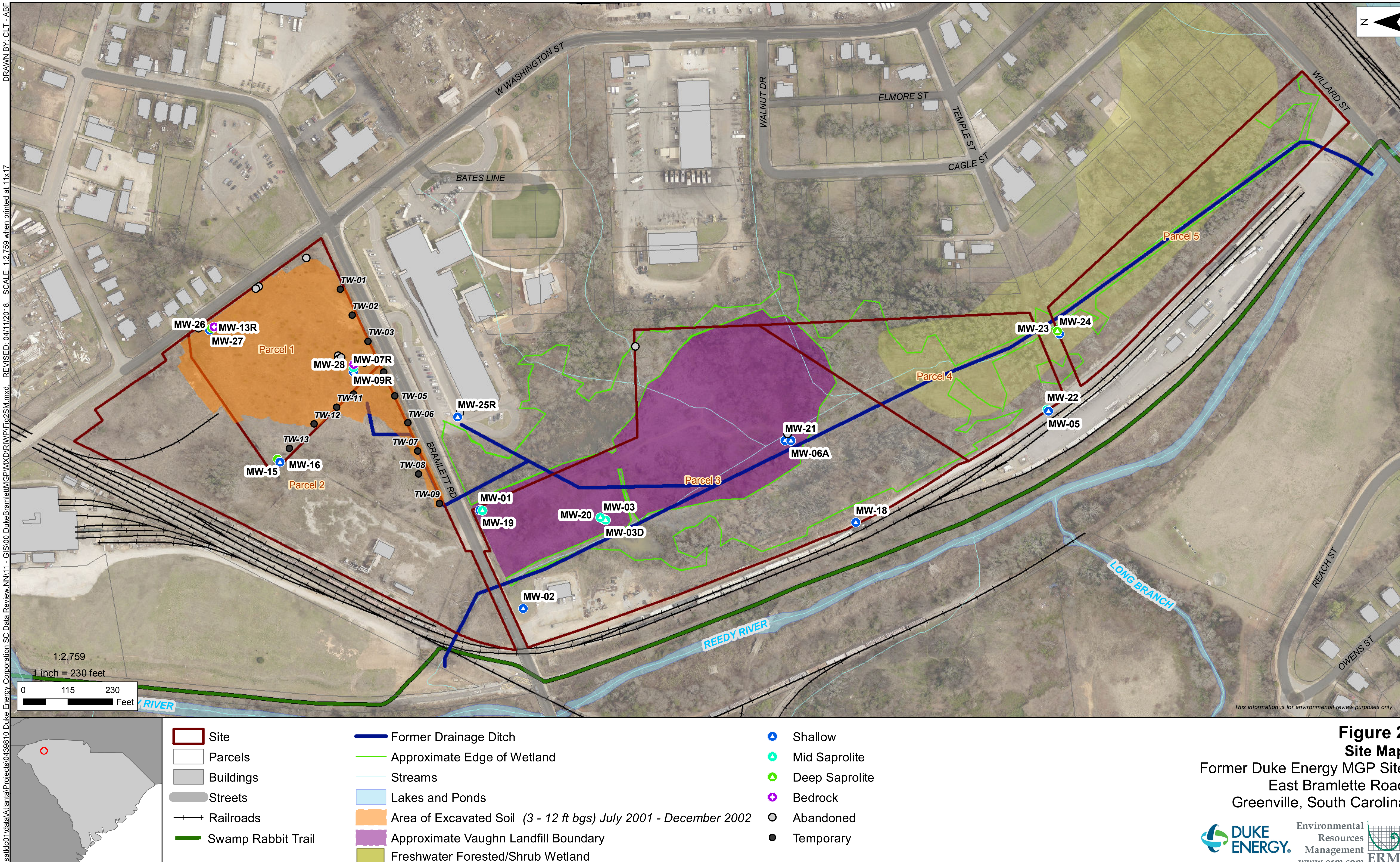
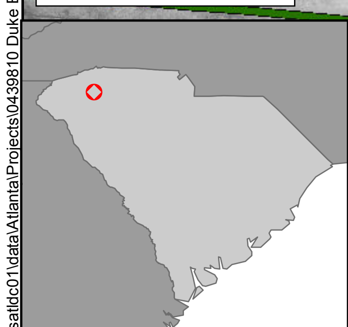


Figure 2
Site Map
Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

Source: USFWS, Greenville County GIS

DRAWN BY: CLT - ABF   REVISED: 04/11/2018   SCALE: 1:2,759 when printed at 11x17

\\usatldc01\data\Atlanta\Projects\0439810 Duke Energy Corporation SC Data Review.NN\11 - GIS\00 DukeBramlettMGP\MXD\RIWP\Fig2SM.mxd



Site	Former Drainage Ditch
Parcels	Approximate Edge of Wetland
Buildings	Streams
Streets	Lakes and Ponds
Railroads	Area of Excavated Soil
Swamp Rabbit Trail	Approximate Vaughn Landfill Boundary
	Freshwater Forested/Shrub Wetland

- Shallow
- Mid Saprolite
- Deep Saprolite
- Bedrock
- Abandoned
- Temporary

Notes:
Benzene concentrations collected June/July 2017.
Results given in micrograms per liter (ug/L).
ND = Not detected
NA = Not analyzed

Figure 3
Benzene Concentration Map - Groundwater
Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

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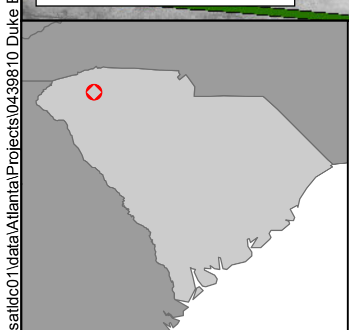
Source: USFWS, Greenville County GIS

\\usatldc01\data\Atlanta\Projects\0439810 Duke Energy Corporation SC Data Review.NN\11 - GIS\00 DukeBramlettMGP\MXD\RI\WP\Fig3Benzene.mxd. REVISED: 04/12/2018. SCALE: 1:1,920 when printed at 11x17 DRAWN BY: CLT - ABF



- Site
- Parcels
- Buildings
- Streets
- Railroads
- Swamp Rabbit Trail
- Former Drainage Ditch
- Approximate Edge of Wetland
- Streams
- Lakes and Ponds
- Area of Excavated Soil
- Approximate Vaughn Landfill Boundary
- Freshwater Forested/Shrub Wetland
- Shallow
- Mid Saprolite
- Deep Saprolite
- Bedrock
- Abandoned
- Temporary

Notes:
Naphthalene concentrations collected July 2017.
Results given in micrograms per liter (ug/L).
ND = Not detected
NA = Not analyzed

Figure 4
Naphthalene Concentration Map - Groundwater
Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

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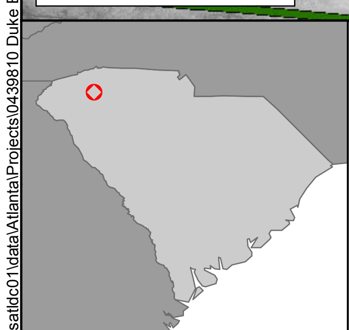
Source: USFWS, Greenville County GIS

\\usatldc01\data\Atlanta\Projects\0439810 Duke Energy Corporation SC Data Review.NN\11 - GIS\00 DukeBramlettMGP\MXD\RIWP\Fig4Naphthalene.mxd.   REVISED: 04/11/2018.   SCALE: 1:1,920 when printed at 11x17   DRAWN BY: CLT - ABF



Site	Former Drainage Ditch
Parcels	Approximate Edge of Wetland
Buildings	Streams
Streets	Lakes and Ponds
Railroads	Area of Excavated Soil
Swamp Rabbit Trail	Approximate Vaughn Landfill Boundary
	Freshwater Forested/Shrub Wetland

- Shallow
- Mid Saprolite
- Deep Saprolite
- Bedrock

- Groundwater Elevation Contour
- Approximate groundwater flow direction

Notes:
Elevations given in feet above mean sea level.
Shallow monitor well elevations were used for contours
(*) indicates deep or bedrock well (measurement not used in contouring)

Figure 5
Groundwater Elevation Map
Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

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Source: USFWS, Greenville County GIS

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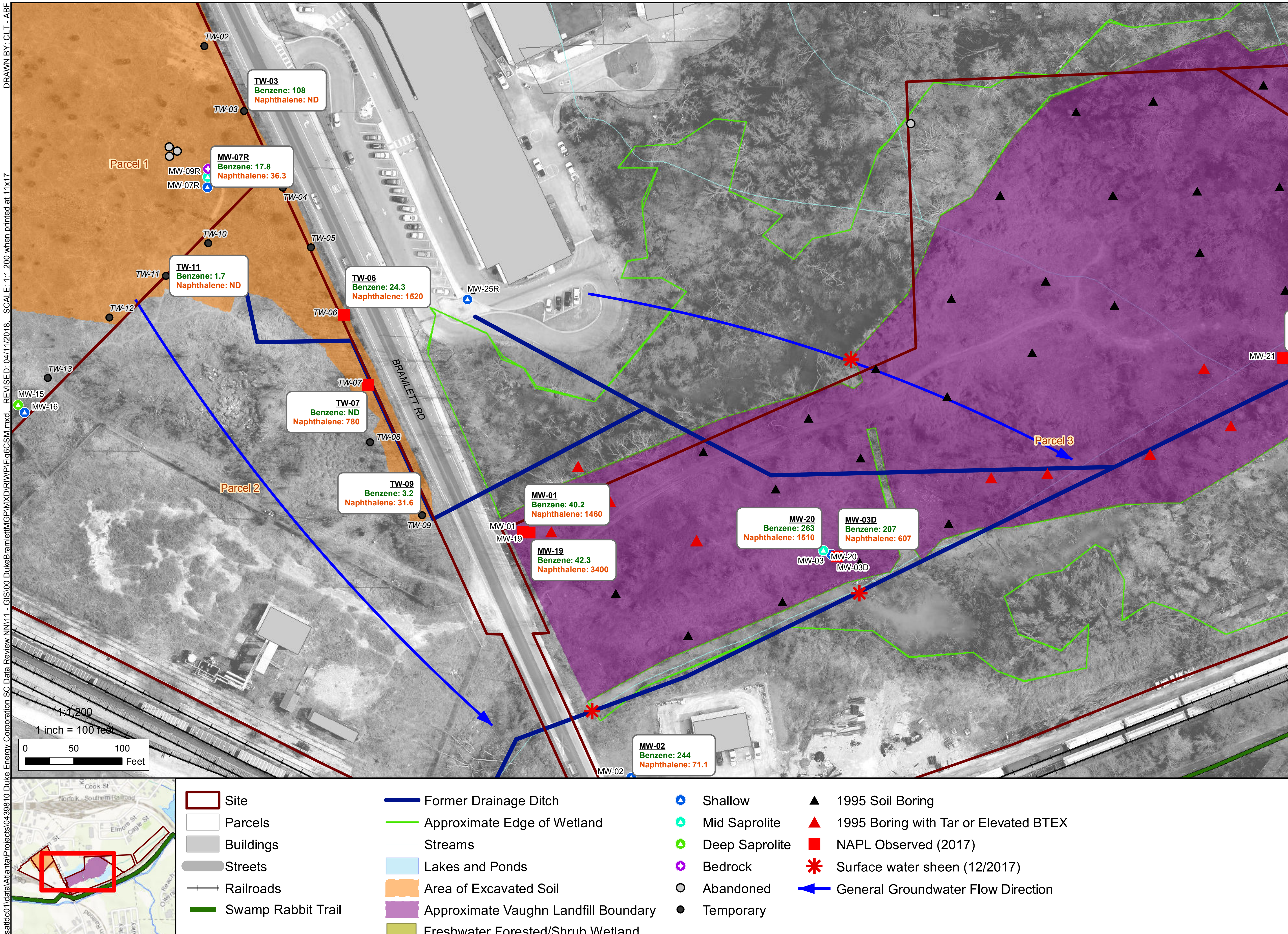

Figure 6
Conceptual Site Model
Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

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Source: USFWS
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community, Greenville County GIS

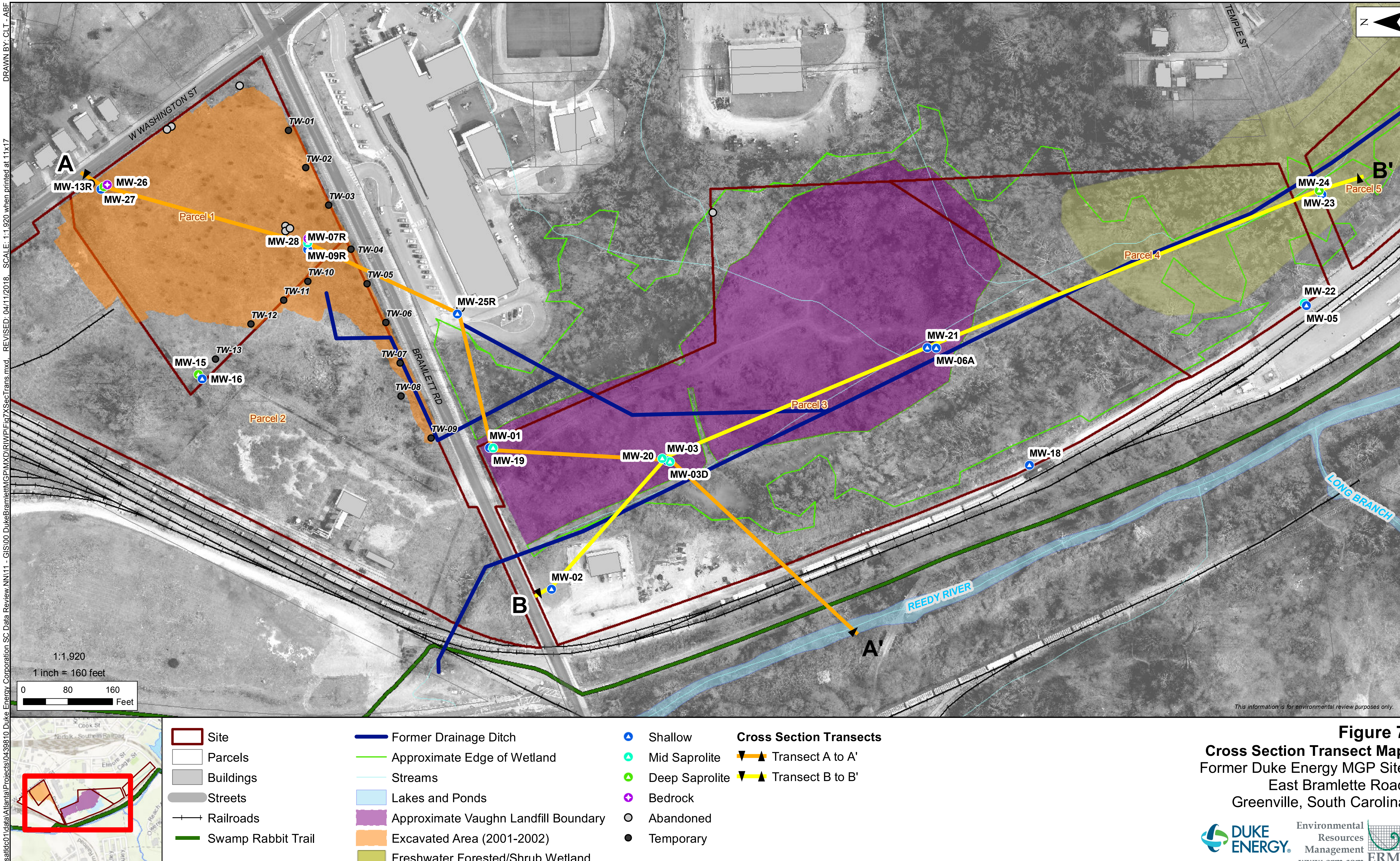
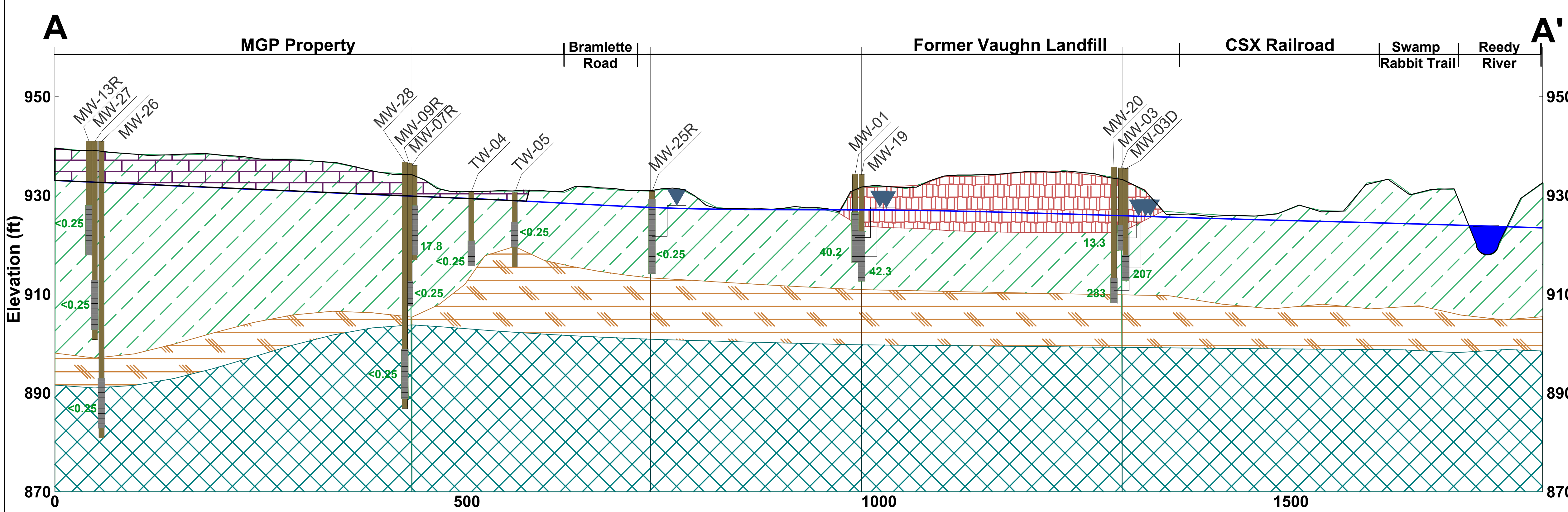
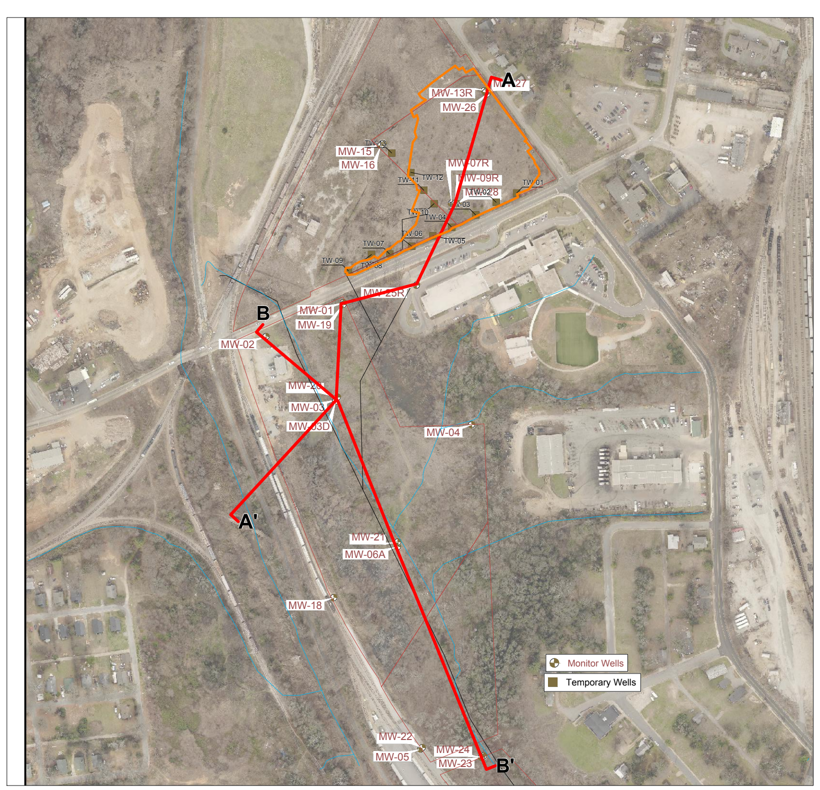


Figure 7
Cross Section Transect Map
Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community, Greenville County GIS





Wells

- Casing
- Screen

Water Level (ft)

Potentiometric Surface

- Fill
- Residuum
- Saprolite
- Bedrock
- Excavated/ Treated Soil Area

283 Benzene concentration at well

Benzene Isoconcentration

Note:
Concentration in micrograms per liter
Samples collected in 2017

Figure 8
Cross Section A-A'
Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

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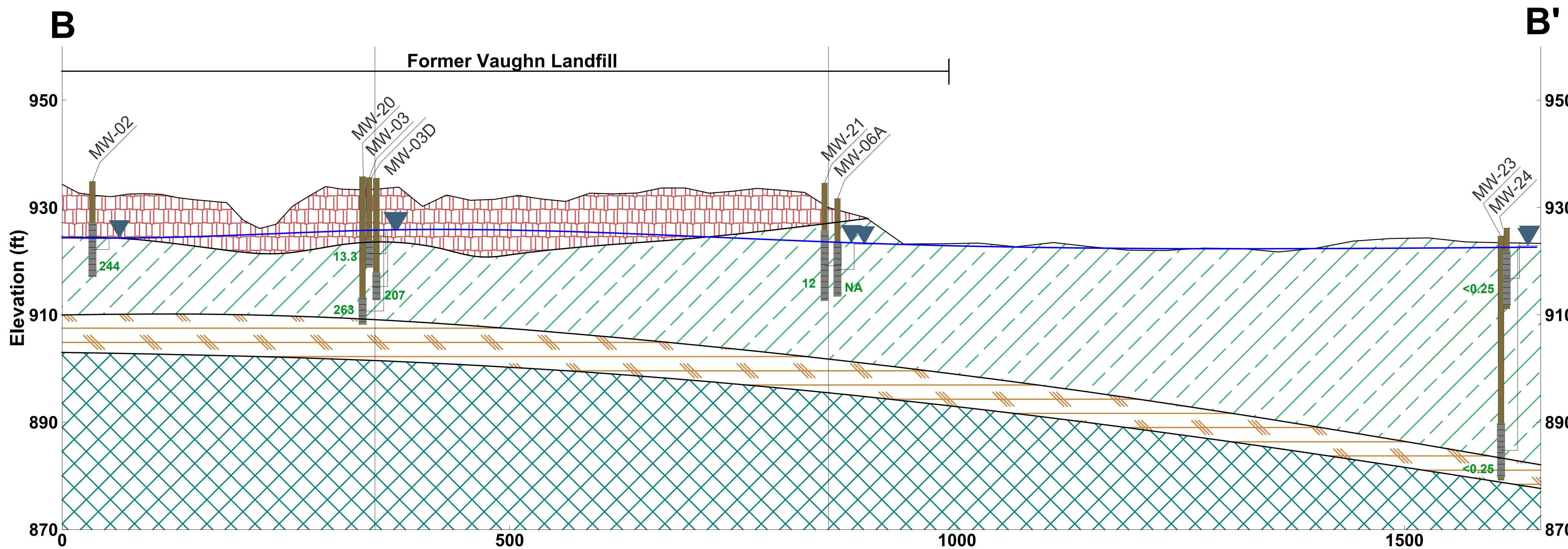

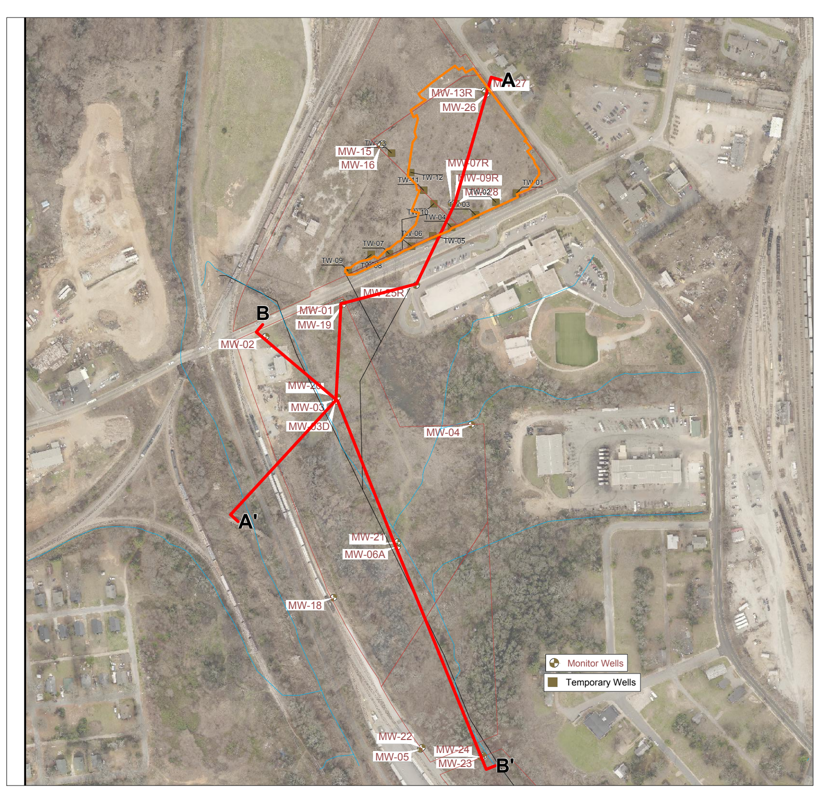

Wells

Casing

Screen

Water Level (ft)

Potentiometric Surface

Fill

Residuum

Saprolite

Bedrock

283 Benzene concentration at well

Benzene Ixoconcentration

Note:
Concentration in micrograms per liter
Samples collected in 2017

Figure 9
Cross Section B-B'
Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

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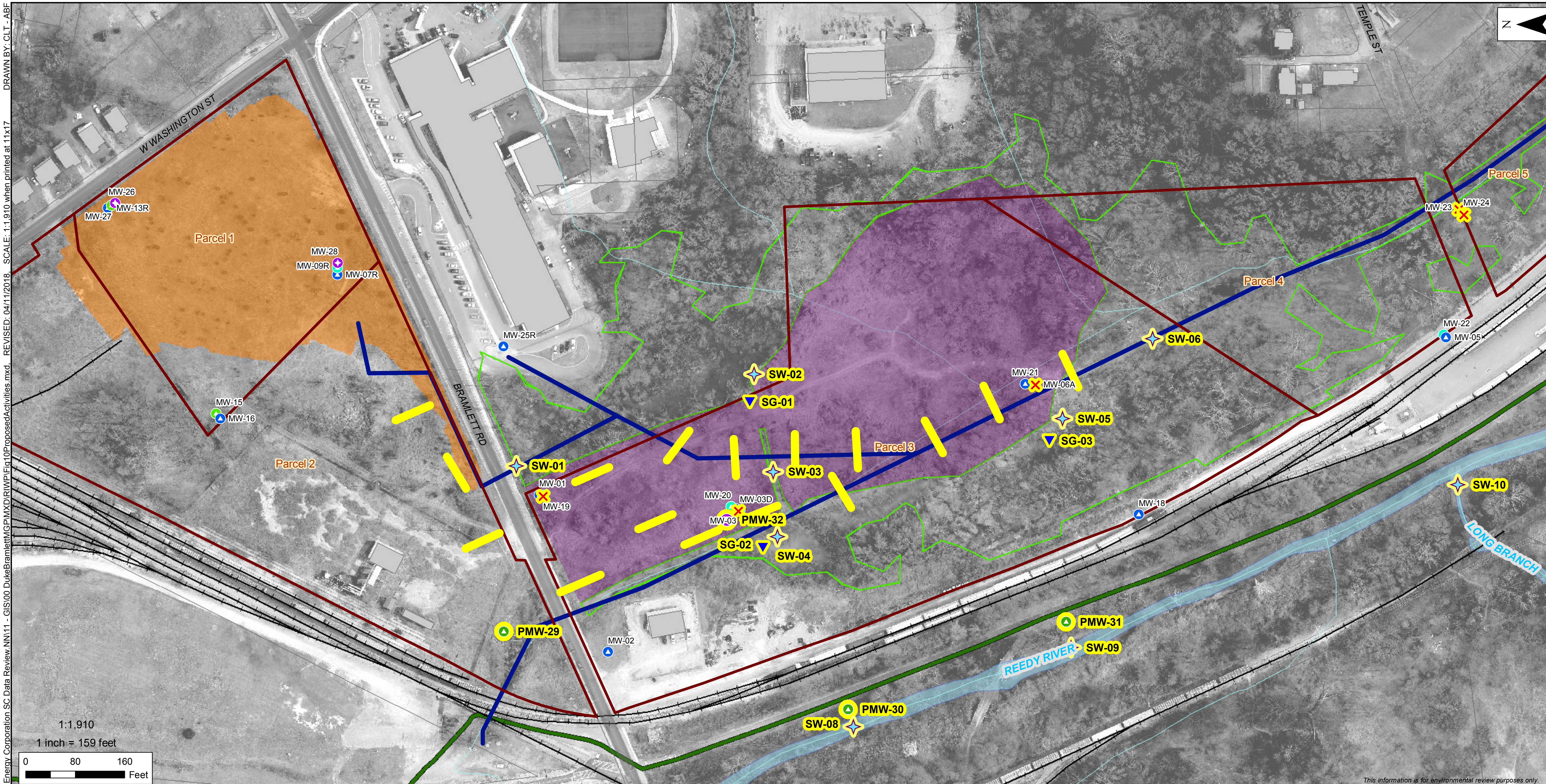

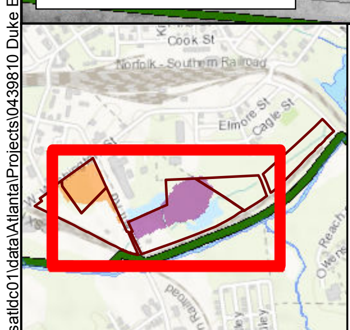

- Former Drainage Ditch
- Excavated Area (2001-2002)
- Approximate Vaughn Landfill Boundary
- Shallow
- Mid Saprolite
- Deep Saprolite
- Bedrock

Proposed Locations

- Surface Water / Sediment Samples
- Stream Gauge
- Shallow & Saprolite Well Pair
- Bedrock Well
- Proposed Well to Abandon
- Proposed Boring Transect (3 borings each)

Figure 10

Proposed Work Plan Activities

Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

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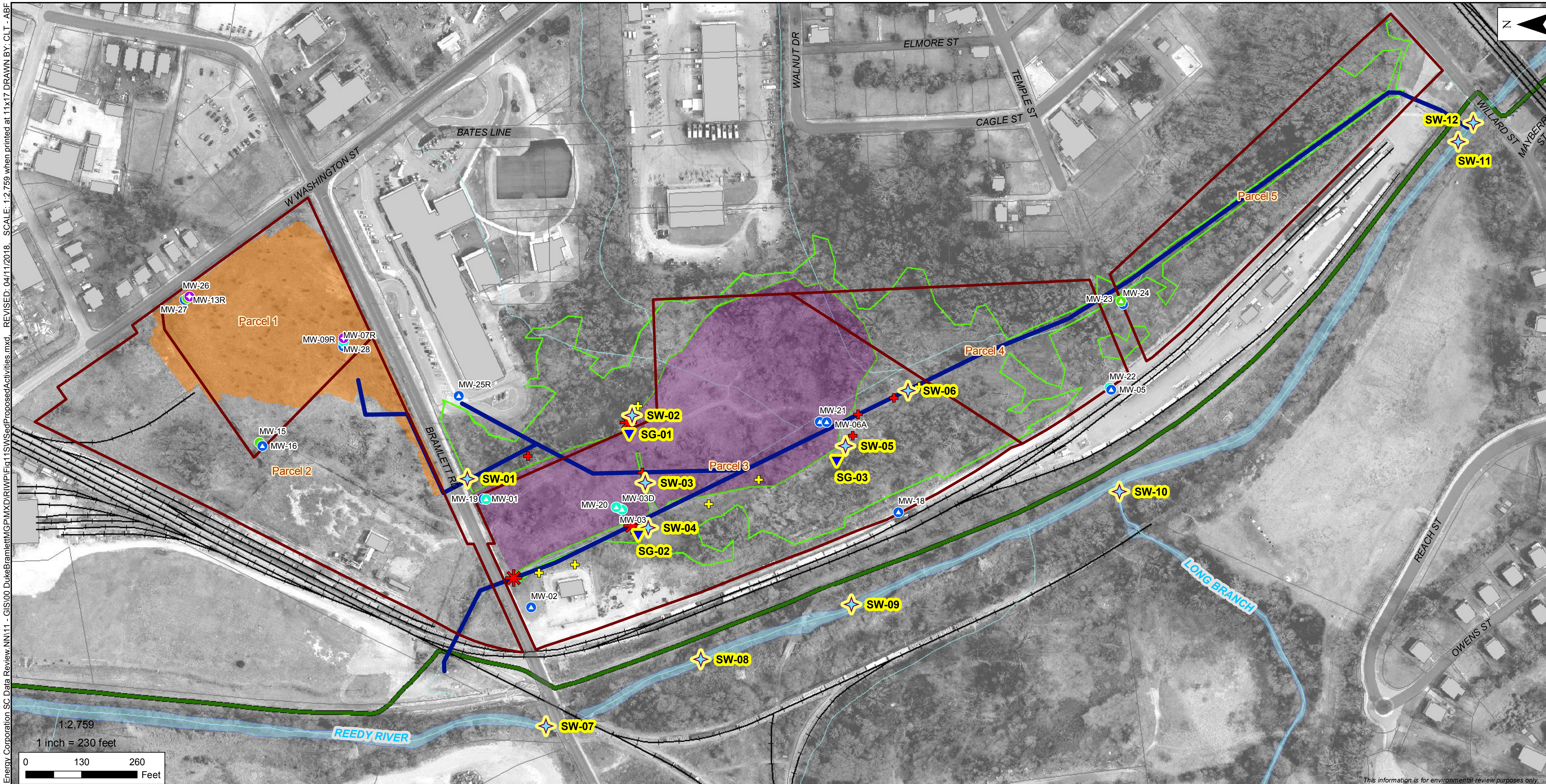
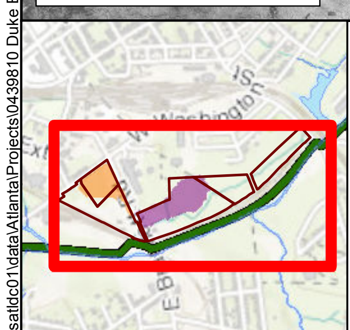
\\usatldc01\data\Atlanta\Projects\0439810 Duke Energy Corporation SC Data Review.NN11 - GIS\00 DukeBramlettMGP\MXD\RIWP\Fig10ProposedActivities.mxd.

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community, Greenville County GIS



\\usatldc01\data\Atlanta\Projects\0439810 Duke Energy Corporation SC Data Review.NN\11 - GIS\00 DukeBramlettMGP\MXD\RIWP\Fig11SWSedProposedActivities.mxd REVISED: 04/11/2018 SCALE: 1:2,759 when printed at 11x17 DRAWN BY: CLT - ABF



- Former Drainage Ditch
- Excavated Area (2001-2002)
- Approximate Vaughn Landfill Boundary
- Shallow
- Mid Saprolite
- Deep Saprolite
- Bedrock
- Surface water sheen (12/2017)
- 1995-1996 Sediment Sample
- 1995-1996 Sediment Sample with visable coal tar

Proposed Locations

- Surface Water / Sediment Samples
- Stream Gauge

Figure 11

Proposed Sediment/Surface Water Samples

Former Duke Energy MGP Site
East Bramlette Road
Greenville, South Carolina

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Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community, Greenville County GIS

Appendix A Summary of Historical Documents

Appendix A
Summary of Historical Documents

Author	**Report Title**	**Date of Report**
Applied Engineering and Science	Site Investigation Soil, Sediment, and Groundwater Sampling, Vaughn Landfill CSX Real Property, Greenville, South Carolina	1995
Applied Engineering and Science	Workplan, Site Investigation and Monitoring Well Installations, CSX/Vaughn Landfill, CSX Transportation, Greenville, South Carolina	1995
Applied Engineering and Science	Site Investigation Phase II Vaughn Landfill/Duke Power Sites, CSXT Real Properties, Bramlette Road, Greenville, South Carolina	1996
Duke Energy	CSX/Vaughn Landfill and Bramlette Road, MGP Site Phase III Workplan	1997
Duke Energy	CSX/Vaughn Landfill and Bramlette Road MGP Sites, Phase III Investigation and Site Assessment Report, Volume I and Volume II (2000)	2000
Duke Energy	CSX/Vaughn Landfill and Bramlette Road MGP Sites - Remedial Action Plan (2000)	2000
Duke Energy	Suburban Propane Property and Northwest Area Investigation Report	2002
Duke Energy	CSX/Vaughn Landfill and Bramlette Road, Greenville Manufactured Gas Plant Groundwater Monitoring Report, December 2002 Sampling	2002
Duke Energy	CSX/Vaughn Landfill and Bramlette Road MGP Sites, Remedial Action Plan Final Report	2003
S&ME	Well Repair Documentation, Duke Energy Bramlette Road MGP Site, Greenville, South Carolina	2006
S&ME	Water Well Abandonment Record (SCDHEC Form 1903) for Well MW-4. Duke Power Bramlette Road MGP/Vaughn Landfill Site, Greenville, South Carolina	2006
S&ME	Corrective Action Plan	2010
S&ME	Site History, Bramlette Road MGP and CSX/Vaughn Landfill Site, Greenville, South Carolina	2013
S&ME	Groundwater Monitoring Report, November 2013, CSX/Vaughn Landfill and Bramlette Road MGP Site, Greenville, South Carolina	2013
Anchor QEA	Progress Report—60-Day Report	2016
Anchor QEA	Groundwater Remedial Investigation Work Plan	2016
Anchor QEA	Quarterly Progress Reports—Fourth Quarter 2016 through Third Quarter 2017	2016-2017
ERM	Quarterly Progress Report—Fourth Quarter 2017	2018

Appendix B
Summary of Soil Sampling Results

Table 1
Summary of Soil Sampling Results

	Sample ID Sample Date Depth	MW-7R 9' 6/16/2017 9 ft	MW-9R 7' 6/16/2017 7 ft	MW-9R 10' 6/16/2017 10 ft	MW-9R 24' 6/16/2017 24 ft	MW-13R 2' 6/14/2017 2 ft	MW-13R 15' 6/14/2017 15 ft	MW-26 45' 6/13/2017 45 ft	MW-27 10' 6/14/2017 10 ft	MW-27 30' 6/14/2017 30 ft	DUP-1 6/14/2017 (MW-27 30')
Conventional Parameters (g/g)	**Method**										
Fractional organic carbon	ASTM D2974	**0.0227**	**0.0274**	**0.00191**	**0.00769**	--	**0.00671**	--	**0.0396**	**0.00384**	--
Conventional Parameters (pct)											
Fraction of organic matter	ASTM D2974	**3.91**	**4.72**	**0.329**	**1.33**	--	**1.16**	--	**6.84**	**0.661**	--
Moisture	ASTM D2974	**25.2**	**20.6**	**15**	**20.9**	**12.8**	**22.9**	**15.8**	**27**	**12.8**	**10**
Conventional Parameters (su)											
pH	SW9045	**6.4**	**6.7**	**7.3**	**6.4**	--	**6.3**	--	**4.9**	**6.7**	--
Volatile Organics (mg/kg)											
Benzene	SW8260	--	0.0014 U	**0.027**	0.0015 U	0.0018 U	0.0019 U	0.0019 U	--	0.0015 U	0.0012 U
Ethylbenzene	SW8260	--	0.0016 U	**0.029**	0.0017 U	0.0021 U	0.0021 U	0.0022 U	--	0.0017 U	0.0014 U
m,p-Xylene	SW8260	--	0.0033 U	**0.02**	0.0034 U	0.0041 U	0.0043 U	0.0043 U	--	0.0035 U	0.0028 U
Naphthalene	SW8260	--	0.0011 U	**0.198**	**0.008**	0.0014 U	0.0014 U	0.0014 U	--	0.0012 U	0.00093 U
Total xylene (reported, not calculated)	SW8260	--	0.0033 U	**0.02**	0.0034 U	0.0041 U	0.0043 U	0.0043 U	--	0.0035 U	0.0028 U
Semivolatile Organics (µg/kg) - None Detected											

Notes:

Bold: indicates an analyte that was detected by the laboratory

--: the analyte was not tested for by the laboratory

µg/kg: micrograms per kilogram

ft: feet

g/g: gram per gram

mg/kg: milligram per kilogram

pct: percent

su: standard unit

U: the reported analyte was not detected above the method detection limit shown

Appendix C
Summary of Temporary Well Groundwater Sampling Results

Table 3
Summary of Temporary Well Groundwater Sampling Results

	Location ID	TW-1	TW-2	TW-3	TW-4	TW-4	TW-5	TW-6	TW-7	TW-8	TW-9	TW-10	TW-11	TW-12	TW-13
	Sample Date	6/20/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017
Volatile Organics (µg/L)	**Method**														
1,3-Dichloropropene, cis-	SW8260	0.13 U	--	0.65 U	0.13 U	0.13 U	0.13 U	2.6 U	1.3 U	0.13 U	0.13 U	0.52 U	0.13 U	0.13 U	0.13 U
4-Methyl-2-pentanone (Methyl isobutyl ketone)	SW8260	0.33 U	--	1.6 U	0.33 U	0.33 U	0.33 U	6.6 U	3.3 U	0.33 U	0.33 U	1.3 U	0.33 U	0.33 U	0.33 U
Acetone	SW8260	10 U	--	50 U	10 U	**53.7**	10 U	200 U	100 U	**89.5**	**30.1**	40 U	**57.1**	**36.3**	**43.2**
Benzene	SW8260	0.25 U	--	**108**	0.25 U	0.25 U	0.25 U	**24.3**	2.5 U	0.25 U	**3.2**	1 U	**1.7**	0.25 U	0.25 U
Dichloromethane (Methylene chloride)	SW8260	0.97 U	--	**25.6**	0.97 U	0.97 U	0.97 U	19.4 U	9.7 U	0.97 U	0.97 U	**11.1**	0.97 U	0.97 U	0.97 U
Ethylbenzene	SW8260	0.3 U	--	**13.9**	0.3 U	0.3 U	**13.5**	**57.2**	**28.8**	0.3 U	0.3 U	**5.3**	0.3 U	0.3 U	0.3 U
m,p-Xylene	SW8260	0.66 U	--	**123**	0.66 U	0.66 U	0.66 U	**65.4**	6.6 U	0.66 U	0.66 U	2.6 U	0.66 U	0.66 U	0.66 U
Methyl ethyl ketone (2-Butanone)	SW8260	0.96 U	--	4.8 U	0.96 U	0.96 U	0.96 U	19.2 U	9.6 U	0.96 U	0.96 U	3.8 U	**5.7**	0.96 U	0.96 U
Methyl tert-butyl ether (MTBE)	SW8260	0.21 U	--	1 U	0.21 U	0.21 U	0.21 U	4.2 U	2.1 U	0.21 U	0.21 U	0.84 U	0.21 U	0.21 U	0.21 U
Naphthalene	SW8260	0.24 U	--	**691**	0.24 U	0.24 U	**1.1**	**3,200**	**1570**	**69.9**	**27.7**	**696**	**58.7**	0.24 U	0.24 U
o-Xylene	SW8260	0.23 U	--	**56.5**	0.23 U	0.23 U	0.23 U	**37.4**	**16**	0.23 U	**1.9**	0.92 U	0.23 U	0.23 U	0.23 U
Toluene	SW8260	0.26 U	--	**146**	0.26 U	0.26 U	0.26 U	5.2 U	2.6 U	0.26 U	0.26 U	1 U	0.26 U	0.26 U	0.26 U
Total xylene (reported, not calculated)	SW8260	1 U	--	**180**	1 U	1 U	1 U	**103**	**16**	1 U	**1.9**	4 U	1 U	1 U	1 U
Semivolatile Organics (µg/L)															
1-Methylnaphthalene	SW8270	1.4 U	1.4 U	4.8 U	1.4 U	1.4 U	2 U	**270**	**307**	**14**	**194**	**20.9**	1.4 U	2 U	1.4 U
2-Methylnaphthalene	SW8270	1.4 U	1.4 U	4.7 U	1.4 U	1.4 U	2 U	**363**	**203**	**13.9**	2.8 U	1.4 U	1.4 U	2 U	1.4 U
Acenaphthene	SW8270	1.6 U	1.6 U	5.3 U	1.6 U	1.6 U	2 U	**95.4**	**168**	**11.5**	**98.8**	**15.4**	1.6 U	2 U	1.6 U
Acenaphthylene	SW8270	1.5 U	1.5 U	4.9 U	1.5 U	1.5 U	1.5 U	**13.2**	1.5 U	1.5 U	3 U	1.5 U	1.5 U	1.5 U	1.5 U
Anthracene	SW8270	1.7 U	1.7 U	5.7 U	1.7 U	1.7 U	**0.095**	**14.3**	**10**	1.7 U	3.4 U	1.7 U	1.7 U	0.05 U	1.7 U
Benzo(a)anthracene	SW8270	2.1 U	2.1 U	7 U	2.1 U	2.1 U	0.1 U	**1.4**	2.1 U	2.1 U	4.2 U	2.1 U	2.1 U	0.1 U	2.1 U
Benzo(a)pyrene	SW8270	2.2 U	2.2 U	7.4 U	2.2 U	2.2 U	0.2 U	**0.86**	2.2 U	2.2 U	4.4 U	2.2 U	2.2 U	0.2 U	2.2 U
Benzo(b)fluoranthene	SW8270	2.2 U	2.2 U	7.3 U	2.2 U	2.2 U	0.2 U	**0.89**	2.2 U	2.2 U	4.4 U	2.2 U	2.2 U	0.2 U	2.2 U
Benzo(g,h,i)perylene	SW8270	2.1 U	2.1 U	6.9 U	2.1 U	2.1 U	0.2 U	**0.42**	2.1 U	2.1 U	4.2 U	2.1 U	2.1 U	0.2 U	2.1 U
Benzo(k)fluoranthene	SW8270	2 U	2 U	6.6 U	2 U	2 U	0.2 U	**0.42**	2 U	2 U	4 U	2 U	2 U	0.2 U	2 U
Chrysene	SW8270	2.1 U	2.1 U	7 U	2.1 U	2.1 U	0.1 U	**1.2**	2.1 U	2.1 U	4.2 U	2.1 U	2.1 U	0.1 U	2.1 U
Dibenzofuran	SW8270	1.7 U	1.7 U	5.6 U	1.7 U	1.7 U	--	--	**19.2**	1.7 U	3.4 U	1.7 U	1.7 U	--	1.7 U
Fluorene	SW8270	1.6 U	1.6 U	5.2 U	1.6 U	1.6 U	**0.37**	**68.2**	**47.6**	1.6 U	**22.0**	**12.0**	1.6 U	0.31 U	1.6 U
Naphthalene	SW8270	1.4 U	1.4 U	4.7 U	1.4 U	1.4 U	1.5 U	**1520**	**780**	**21.8**	**31.6**	**47.2**	1.4 U	1.5 U	1.4 U
Phenanthrene	SW8270	1.6 U	1.6 U	5.3 U	1.6 U	1.6 U	**0.28**	**76**	**60.4**	1.6 U	**58.1**	**26.2**	1.6 U	0.2 U	1.6 U
Phenol	SW8270	1.4 U	1.4 U	4.7 U	1.4 U	1.4 U	--	--	2 U	2 U	4 U	2 U	2 U	--	2 U
Pyrene	SW8270	1.6 U	1.6 U	5.3 U	1.6 U	1.6 U	**0.12**	**9.9**	1.5 U	1.5 U	3 U	1.5 U	1.5 U	0.1 U	1.5 U

Notes:

Bold: indicates an analyte that was detected by the laboratory

--: the analyte was not tested for by the laboratory

µg/L: microgram per liter

U: the reported analyte was not detected at or above the method detection limit shown

Appendix D
Summary of Permanent Well Groundwater Sampling Results

Table 2

Summary of Permanent Well Groundwater Sampling Results

	Location ID	MW-1	MW-2	MW-3	MW-3D	MW-5	MW-7R	MW-9R	MW-13R	MW-15	MW-15	MW-16	MW-18	MW-19	MW-20	MW-21	MW-22	MW-23	MW-24	MW-25R	MW-25R	MW-26	MW-27	MW-28
	Sample Date	7/12/2017	7/13/2017	7/12/2017	7/12/2017	7/11/2017	7/11/2017	7/11/2017	7/12/2017	7/11/2017	7/11/2017	7/11/2017	7/13/2017	7/12/2017	7/12/2017	7/12/2017	7/11/2017	7/10/2017	7/10/2017	7/13/2017	7/13/2017	7/13/2017	7/13/2017	7/12/2017
Conventional Parameters (°C)	**Method**																							
Temperature (field)	Field	**20.7**	**24.7**	**27.7**	**27.6**	**23.4**	**22.9**	**23.5**	**24.4**	--	**22.7**	**21.2**	**19.7**	**20.4**	**21.3**	**20.9**	**21.2**	**18.3**	**22.9**	--	**25.1**	**23.5**	**22.7**	**27.9**
Conventional Parameters (mg/L)																								
Alkalinity, total as calcium carbonate (CaCO3)	SM2320B	**141**	**188**	**321**	**101**	**70.1**	**60.4**	**19.7**	1 U	--	**20.6**	**350**	**93.4**	**154**	**71.9**	**221**	**38.9**	**14.1**	**154**	--	**39.8**	**454**	**11.2**	**150**
Ammonia as nitrogen	E350.1	**3.5**	**1.3**	**2.4**	**0.49**	**1**	**4.1**	0.05 U	0.05 U	--	0.05 U	**0.37**	**0.48**	**3.6**	**0.21**	**0.81**	0.05 U	0.05 U	**0.13**	--	**0.47**	**0.37**	0.05 U	0.05 U
Carbon dioxide	AM20GAX	--	**140**	**120**	--	--	--	**45**	**85**	--	--	**160**	**79**	**110**	**79**	--	--	--	--	--	--	--	--	**21**
Methane	RSK175	--	**7.25**	**13.2**	--	--	--	0.01 U	**0.327**	--	--	**0.0374**	**7.02**	**9.61**	**5.85**	--	--	--	--	--	--	--	--	**0.0588**
Nitrate as nitrogen	E353.2	0.01 U	0.01 U	0.01 UJ	**0.021 J**	0.01 U	**0.81 J**	**4.3 J**	**1.1 J**	--	**7.4 J**	0.01 UJ	0.01 U	0.01 UJ	**0.023 J**	0.01 UJ	**2.4 J**	**3.6 J**	0.01 UJ	--	0.01 U	**0.088**	**1**	0.01 UJ
Sulfate	E300.0	0.5 U	**2**	0.5 U	0.5 U	**45.8**	**3.8**	**17.8**	**33.1**	--	**2.5**	**271**	**51.2**	0.5 U	0.5 U	**21.7**	**15.1**	**18**	**49.4**	--	**18.9**	**32.8**	**5.1**	**114**
Conventional Parameters, Dissolved (mg/L)																								
Dissolved oxygen (field)	Field	**0.23**	**0.3**	**0.31**	**0.24**	**0.18**	**0.61**	**1.32**	**0.48**	--	**3.69**	**0.28**	**0.34**	**0.24**	**0.12**	**0.33**	**1**	**4.63**	**0.9**	--	**0.69**	**0.4**	**0.74**	**0.58**
Conventional Parameters (mV)																								
Reduction oxidation potential (EH)	Field	**33.3**	**-15.1**	**-47.2**	**-31.7**	**-37.2**	**12.6**	**173.8**	**228.3**	--	**165.9**	**19.6**	**43.1**	**-31.6**	**-9.3**	**-60.9**	**253.5**	**192.5**	**17.2**	--	**41.5**	**-127.6**	**279.1**	**-82.1**
Conventional Parameters (NTU)																								
Turbidity (field)	Field	**2.63**	**10.41**	**13.82**	**19.13**	**2.57**	**40.73**	**3.18**	**11.8**	--	**0.95**	**22.41**	**0.59**	**2.19**	**2.14**	**11.84**	**7.33**	**2.52**	**37.95**	--	**6.02**	**4.51**	**4.77**	**11.08**
Conventional Parameters (mg/L)																								
Total organic carbon	SM5310B	--	**4.4**	**10**	--	--	--	0.5 U	**2.8**	--	--	**8.7**	**5**	**4.8**	**4.3**	--	--	--	--	--	--	--	--	**14.7**
Conventional Parameters (su)																								
pH (field)	Field	**5.95**	**6.16**	**6.42**	**6.26**	**5.73**	**6.21**	**5.37**	**4.63**	--	**5.72**	**6.31**	**5.8**	**6.08**	**6.07**	**6.47**	**5.2**	**5.16**	**6.04**	--	**5.69**	**11.66**	**4.55**	**6.92**
Conventional Parameters (umhos/cm)																								
Conductivity (field)	Field	**376.5**	**421.7**	**713**	**281**	**241.2**	**187.4**	**147.8**	**116.7**	--	**131.4**	**109.7**	**326**	**377.7**	**224.8**	**623**	**189.8**	**160.9**	**436.9**	--	**199.9**	**2,082**	**64.8**	**640**
Metals (µg/L)																								
Ferrous iron	SM3500FEB	**11,100**	**2,900**	**1,400**	**4,100**	**7,500**	**7,900**	500 U	500 U	--	500 U	**810**	**4,800**	**7,600**	**8,600**	**2,900**	500 U	500 UJ	**2,500 J**	--	**5,300**	500 U	500 U	500 U
Iron	SW6010	**29,100**	**9,670**	**15,500**	**13,700**	**9,910 J**	**13,600 J**	25 U	**150**	--	25 U	**1,820 J**	**6,870**	**28,400**	**15,700**	**21,000**	**89.3 J**	**308**	**21,600**	--	**6,490**	**267**	25 U	**5,280**
Manganese	SW6010	**2,590**	**1,260**	**720**	**176**	**1,430**	**3,540**	**182**	**481**	--	2.5 U	**231**	**788**	**2,460**	**208**	**426**	**40**	**14.8**	**1470**	--	**276**	**85.4**	**188**	**580**
Volatile Organics (µg/L)																								
Acetone	SW8260	100 U	20 U	10 U	100 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	250 U	125 U	10 U	10 U	10 U	10 U	10 U	10 U	**38.4**	10 U	10 U
Benzene	SW8260	**40.2**	**244**	**13.3**	**207**	0.25 U	**17.8**	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	**42.3**	**263**	**12.0**	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
Dichloromethane (Methylene chloride)	SW8260	9.7 U	1.9 U	0.97 U	**23.9**	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	24.2 U	12.1 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U
Ethylbenzene	SW8260	**35.7**	**7.0**	**3.9**	**109**	0.3 U	**8.8**	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	**56.5**	**67.9**	**2.3**	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U
m,p-Xylene	SW8260	**33.3**	**10.3**	0.66 U	**72.5**	0.66 U	**9.7**	0.66 U	0.66 U	0.66 U	0.66 U	0.66 U	0.66 U	**50.5**	**116**	0.66 U	0.66 U	0.66 U	0.66 U	0.66 U	0.66 U	0.66 U	0.66 U	0.66 U
Methyl ethyl ketone (2-Butanone)	SW8260	9.6 U	1.9 U	0.96 U	9.6 U	0.96 U	0.96 U	0.96 U	0.96 U	0.96 U	0.96 U	0.96 U	0.96 U	24 U	12 U	0.96 U	0.96 U	0.96 U	0.96 U	0.96 U	0.96 U	**9.5**	0.96 U	0.96 U
Methyl tert-butyl ether (MTBE)	SW8260	2.1 U	0.42 U	0.21 U	2.1 U	0.21 U	**1.1**	**2.0**	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	5.2 U	2.6 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	**1.6**	**1.4**
Naphthalene	SW8260	**1,780**	**207**	0.24 U	**1,880**	0.24 U	**68.1**	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	**2,840**	**2,500**	**63.3**	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	**16.8**
o-Xylene	SW8260	**25.7**	0.46 U	**1.4**	**41.8**	0.23 U	**1.2**	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	**32.7**	**59.7**	**2.2**	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U
Toluene	SW8260	**21.3**	0.52 U	0.26 U	**10.9**	0.26 U	**1.3**	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	**28.7**	**22.7**	**1.4**	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
Total xylene	SW8260	**59**	**10.3**	**1.4**	**114**	1 U	**10.9**	1 U	1 U	1 U	1 U	1 U	1 U	**83.2**	**176**	**2.2**	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Semivolatile Organics (µg/L)																								
2-Methylnaphthalene	SW8270	**644**	**32.2**	1.4 U	**133**	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	**1,160**	**333**	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U
2-Methylphenol (o-Cresol)	SW8270	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U
Acenaphthene	SW8270	**257**	**14.4**	1.6 U	**54.4**	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	**252**	**100**	1.6 U	1.6 UJ	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U
Anthracene	SW8270	**12.9**	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	**11.2**	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U
Dibenzofuran	SW8270	**28.4**	1.7 U	1.7 U	1.7 U	1.7 U	1.7 UJ	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	**23.5**	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U
Fluorene	SW8270	**81**	1.6 U	1.6 U	**20.4**	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	**72.4**	**29.1**	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U
Naphthalene	SW8270	**1,460 J**	**71.1**	1.4 U	**607**	1.4 U	**36.3 J**	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	**10.9**	**3,400 J**	**1,510 J**	**34.9**	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U
Phenanthrene	SW8270	**79.4**	1.6 U	1.6 U	**20.9**	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	**66.3**	**27.3**	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U

Notes:

Bold: indicates an analyte that was detected by the laboratory

--: the analyte was not tested for by the laboratory

µg/L: microgram per liter

EH: reduction oxidation potential

J: the reported analyte was detected above the method detection limit but less than the reporting limit

mg/L: milligram per liter

mV: millivolt

NTU: Nephelometric Turbidity Unit

su: standard unit

U: the reported analyte was not detected at or above the method detection limit shown

umhos/cm: micromhos per centimeter