FGD Residue Landfill
Permit No. 8505

Supplemental Groundwater Assessment

Belews Creek Steam Station

June 4, 2014

REPORT VERIFICATION

PROJECT: SUPPLEMENTAL GROUNDWATER ASSESSMENT
BELEWS CREEK STEAM STATION
FGD RESIDUE LANDFILL
PERMIT NO. 8505

TITLE: SUPPLEMENTAL GROUNDWATER ASSESSMENT

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

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Table of Contents

Page

Table of Contents i
List of Figures ii
List of Tables ii
Section 1 – Introduction 1
Section 2 – Background 3
2.1 Site and FGD Residue Landfill Description 3
2.2 Site Geology and Hydrogeology 4
2.3 Description of Monitoring System 4
2.4 Site Groundwater Flow 5
2.5 Groundwater Quality Monitoring 5
Section 3 – Supplemental Groundwater Assessment 6
3.1 Installation of Monitoring Well BC-32 6
3.2 Analytical Results 7
3.3 Semi-Annual Sampling of Monitoring Wells and Surface Water Sample Location ... 7
3.4 Analytical Results 7
3.4.1 Analytical Results from August 19, 2013, Sampling Event 7
3.4.2 Analytical Results from Semi-Annual Sampling Events 7
3.5 Groundwater Flow Direction 8
3.6 Groundwater Quality Exceedances - Sulfate 8
3.7 Groundwater Quality Exceedances – Total Dissolved Solids 9
3.8 Groundwater Quality Exceedances – Selenium 10
Section 4 – Landfill Operations 11
Section 5 – Possible Sources of Exceedances 12
5.1 Leachate Leaking Through the Engineered Liner System 12
5.2 Gypsum Deposited onto the Ground Surface Infiltrating into Groundwater 13
Section 6 – Conclusions and Recommendations 15
6.1 Conclusions- Sulfate, TDS, and Selenium Exceedances 15
6.2 Recommendations 16
Section 7 – References 17

APPENDICES

APPENDIX A – Letter from North Carolina Department of Environment and Natural Resources. November 9, 2011. To Ed Sullivan, P.E., Duke Energy. DOC ID 15487.

APPENDIX B – Letter from North Carolina Department of Environment and Natural Resources. November 28, 2012. To Ed Sullivan, P.E., Duke Energy. DOC ID 17761.

APPENDIX C – Groundwater Monitoring Well BC-32 Installation Report, FGD Residue Landfill Compliance Network, Duke Energy Belews Creek Steam Station. S&ME Project No. 1584-13-075, September 17, 2013.

List of Figures

1. Site Location Map
2. Sample Locations
3. Generalized Groundwater Surface Contours - May 2013
4. Generalized Groundwater Surface Contours – November 2013
5. Sulfate Concentrations– BC-20, BC-21, BC-25, BC-26, and BC-32
6. TDS Concentrations– BC-20, BC-21, BC-25, BC-26, and BC-32
7. Sulfate and TDS Concentrations – BC-25
8. Selenium Concentrations – BC-20, BC-21, BC-25, BC-26, and BC-32
9. Groundwater Elevations – BC-20, BC-21, BC-25, BC-26, BC-27, BC-29, and BC-7
10. Sulfate Concentrations and Groundwater Elevations – BC-20
11. Sulfate Concentrations and Groundwater Elevations – BC-21
12. Sulfate Concentrations and Groundwater Elevations – BC-25
13. Site Topography – June 2013

List of Tables

1. Field Data Parameters – August 19, 2013 Sampling Event
2. Field and Analytical Results – August 19, 2013 Sampling Event
3. Selected Sulfate Analytical Results for Monitoring Wells BC-20, BC-21, BC-25, BC-26, and BC-32
4. Selected TDS Analytical Results for Monitoring Wells BC-20, BC-21, BC-25, BC-26, and BC-32
5. Selected Selenium Analytical Results for Monitoring Wells BC-20, BC-21, BC-25, BC-26, and BC-32

Section 1 – Introduction

The Belews Creek Steam Station Flue Gas Desulfurization (FGD) Residue Landfill (FGD Residue Landfill), Permit No. 8505, is located at the Belews Creek Steam Station in Stokes County, North Carolina, and is owned and operated by Duke Energy Carolinas, LLC (Duke Energy).

In a letter dated November 9, 2011,[1] to Mr. Ed Sullivan, P.E., of Duke Energy, the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Waste Management (DWM) stated that exceedances of groundwater standards established in Title 15A North Carolina Administrative Code (NCAC) Subchapter 2L .0202 Groundwater Quality Standards (2L Standards) were reported in samples collected from groundwater monitoring well BC-25 during the May 16, 2011, sampling event.[2] The letter is included as Appendix A.

The NCDENR letter stated that iron was reported at a concentration greater than the respective 2L Standard in the groundwater sample collected from BC-25 during this event. Monitoring well BC-25 is located beyond the compliance boundary. NCDENR also stated that industrial landfills are required to comply with the 2L Standards at the compliance boundary in accordance with 15A NCAC 13B .0503 (2)(d)(iv).

In addition, the NCDENR letter stated that iron and manganese were reported at concentrations above their respective 2L Standards in groundwater monitoring wells BC-20, BC-21, BC-23A, BC-26, BC-27, BC-29, and BC-31. These wells are located at or beyond the review boundary.

NCDENR stated that based on these exceedances, Duke Energy must submit a groundwater assessment work plan to the DWM. The assessment work plan, dated February 9, 2012, was prepared by Altamont Environmental Inc. (Altamont) on behalf of Duke Energy and was approved by the DWM on March 23, 2012 (DOC ID 16351).

HDR prepared and submitted an assessment[3] to NCDENR on behalf of Duke Energy for groundwater exceedances at groundwater monitoring wells BC-20, BC-21, BC-23A, BC-25, BC-26, BC-27, BC-29, and BC-31 and at surface water sample location SW-1.

The assessment report concluded:

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[1] *North Carolina Department of Environment and Natural Resources. Division of Waste Management. November 9, 2011, Monitoring Well BC-25 Assessment. Duke Energy – Belews Creek FGD Landfill. DOC ID 15487*.

[2] The NCDENR letter references the monitoring event as occurring on May 6, 2011. The actual date for the sampling event was May 16, 2011.

[3] HDR Engineering, Inc. of the Carolinas report *Groundwater Assessment, Belews Creek Steam Station, FGD Residue Landfill*, Permit No. 8505, dated October 5, 2012.

- the source of iron exceedances reported in monitoring wells BC-20, BC-21, BC-23A, BC-26, BC-27, BC-29, and BC-31 appeared to be related to turbidity introduced from naturally occurring sources;
- the source of manganese exceedances reported in monitoring well BC-27 appeared to be related to turbidity introduced from naturally occurring sources;
- the manganese results at monitoring well BC-21 did not appear to be related to turbidity; and
- the iron and manganese exceedances at surface water sampling location SW-1 appeared to be from naturally occurring sources and not related to impacts from the FGD Residue Landfill.

The report assessed 2L Standard exceedances for iron, sulfate, and total dissolved solids (TDS) at monitoring well BC-25. The iron exceedances were determined to be attributed to turbidity in the groundwater samples and naturally occurring conditions. The assessment report concluded that the source of the sulfate in monitoring well BC-25 appeared to be from the FGD Residue Landfill.

HDR recommended installing an additional monitoring well at the review boundary between monitoring well BC-25 and the FGD Residue Landfill to further delineate the sulfate and TDS concentrations in this area and improve the understanding of groundwater flow and quality near monitoring well BC-25. HDR further recommended that monitoring well BC-21 be re-sampled when the new monitoring well is sampled.

In a letter dated November 28, 2012, to Mr. Ed Sullivan, P.E., of Duke Energy, the NCDENR Solid Waste Section approved the recommendations presented in HDR's groundwater assessment report dated October 5, 2012.[4] The letter is included as Appendix B.

The supplemental groundwater assessment at the FGD Residue Landfill was performed as stated in the recommendations in the groundwater assessment report dated October 5, 2012. This supplemental assessment report includes a description of the additional monitoring well (BC-32) installed at the review boundary between monitoring well BC-25 and the FGD Residue Landfill to further delineate the sulfate and TDS concentrations in this area and improve the understanding of groundwater flow and quality near monitoring well BC-25.

[4] *North Carolina Department of Environment and Natural Resources, Division of Waste Management. November 28, 2012, Groundwater Assessment Report Response. Duke Energy – Belews Creek FGD Landfill, DOC ID 17761.*

Section 2 – Background

2.1 Site and FGD Residue Landfill Description

The FGD Residue Landfill is located at Duke Energy's Belews Creek Steam Station. Belews Creek Steam Station is a two-unit, coal-fired generating facility located on Belews Lake in Stokes County, North Carolina.

The FGD Residue Landfill is permitted under the NCDENR Solid Waste Permit No. 8505. The FGD Residue Landfill is permitted to receive coal combustion products, flue gas desulphurization residue (gypsum), wastewater treatment clarifier sludge, waste limestone material, sand blast material, and waste coal produced at the Belews Creek Steam Station. However, the FGD Residual Landfill typically receives only gypsum. Other waste streams are disposed of in the Craig Road Ash Landfill (Permit #8504). The FGD Residue Landfill is located south of the Belews Creek power plant, on a peninsula of land in Belews Lake. The FGD Residue Landfill and nearby surrounding area are depicted on Figure 1.

Location of the FGD Residue Landfill is on the northwestern facing side of a ridge running the length of the peninsula. A gravel road, located near monitoring wells BC-28 and BC-23A, runs generally along the crest of this ridge. Craig Road is located to the southwest of the FGD Residue Landfill. A gypsum stack-out yard and limestone storage yard are located to the north of the FGD Residue Landfill. A surface water drainage feature is located to the south of the FGD Residue Landfill, draining from the topographic high east of the landfill, to the west towards Craig Road. In general, the original site topography slopes from the ridge to the north and to the west. Two sets of high voltage transmission lines running roughly east to west are located immediately adjacent to and along the northern side of the FGD Residue Landfill.

The FGD Residue Landfill consists of four cells contained in an area of approximately 24 acres, as shown on Figure 2. The landfill has an engineered liner system consisting of a leachate collection system, underlain by a high-density polyethylene (HDPE) geomembrane liner, underlain by a geo-synthetic clay liner (GCL). A stormwater basin is located on the western edge of the FGD Residue Landfill and occupies an area of approximately 2.4 acres. The stormwater basin is used to manage leachate and contact stormwater collected from the FGD Residue Landfill.

The stormwater basin is constructed with a concrete bottom surface, underlain by an HDPE geomembrane liner, underlain by a GCL.

The FGD Residue Landfill first accepted waste in April 2008. Initial waste placement began in Cell 1. As of June 30, 2013, approximately 1,078,464 tons of waste had been placed in the landfill. Waste placement has progressed across all four cells of the landfill. As described in the operations plan, a 12-inch-thick interim soil cover layer is placed as a dust control measure where final waste grades are achieved.[5]

[5] *Belews Creek Steam Station FGD Residue Landfill Operations Plan*, prepared by Joyce Engineering, May 23, 2012, JEI Project:845.1202.11 Task 01, DIN 16987.

2.2 Site Geology and Hydrogeology

In 2005, S&ME, Inc. (S&ME) prepared a site suitability study for the Belews Creek Steam Station FGD residue landfill.[6] The 2004 study serves as the background for the discussion of the site geology and hydrogeology. The Belews Creek Steam Station is located in the Piedmont Physiographic Province of North Carolina, within the Milton Belt. The rocks of the Milton belt were formed during the Precambrian era and metamorphosed during the Paleozoic era. The bedrock in the vicinity of the FGD Residue Landfill generally consists of schist and gneiss. The soils that overlie the bedrock in the area have generally formed from the in-place weathering of the parent bedrock. These soils are termed residuum (residual soils) and saprolite. The residuum is typically finer-grained and has a higher clay content than the underlying saprolite. The highly weathered saprolite generally retains the overall structure and appearance of the underlying bedrock. The saprolite layer grades into partially weathered rock and finally into bedrock.

Groundwater generally occurs within the residuum and saprolite under unconfined conditions. Often, the heterogeneous nature of the soil results in variable porosities and permeabilities both laterally and vertically. However, low permeability units that would result in confining conditions between the overlying soils and bedrock are generally absent. In the underlying bedrock, groundwater occurs predominately in fractures and joints, and flow may occur under either unconfined or confined conditions. As described in S&ME's Site Suitability Study report, the geology/groundwater conditions at the site are consistent with the characteristics of the conceptual groundwater model developed by LeGrand for the Piedmont region (LeGrand 2004).

2.3 Description of Monitoring System

According to the Water Quality Monitoring Plan (WQMP),[7] the groundwater monitoring system at the FGD Residue Landfill consists of the following sampling locations as listed below.

Monitoring Wells		
	BC-7	BC-26
	BC-20	BC-27
	BC-21	BC-28
	BC-22	BC-29
	BC-23A	BC-30
	BC-25	BC-31
Surface Water Sample Location:		SW-1
Leachate Sample:		Leachate

The groundwater monitoring, surface water monitoring, and leachate sample locations are shown on Figure 2. According to the WQMP, monitoring wells BC-23A and BC-28 represent background groundwater quality.

[6] *Geologic and Hydrogeologic Siting Report FGD Scrubber Residue Disposal Site Belews Creek Steam Station Belews Creek, North Carolina, S&ME Project No. 1054-04-955, September 28, 2005.*

[7] *Water Quality Monitoring Plan FGD Scrubber Residue Landfill Belews Creek Steam Station, S&ME Project 1054-04-955*, December 07, 2007.

Monitoring well BC-7 is used for water level measurements only. All other monitoring wells are used to monitor groundwater quality in the residual soil/saprolite layer and to measure groundwater levels.

Sampling location SW-1 is a groundwater seep located to the east of monitoring well BC-28. When water is present, it emanates from the ground just above this sampling location. Therefore, analytical results from sampling location SW-1 are compared to 2L Standards. This surface water feature drains to Belews Lake.

The FGD Residue Landfill leachate is sampled at a location within the stormwater basin as shown on Figure 2.

2.4 Site Groundwater Flow

The FGD Residue Landfill is located on the north-western side of a ridge running the length of a peninsula between the West Belews Creek arm and the East Belews Creek arm of Belews Lake. A gravel road, located near monitoring wells BC-28 and BC-23A, runs generally along the crest of this ridge. Craig Road is located to the west of the FGD Residue Landfill. The approximate ground elevation at monitoring well BC-28 is 815.6 feet and the approximate ground elevation at monitoring well BC-23A is 861.3 feet.

The gypsum stack-out yard and limestone storage yard are located to the north of the FGD Residue Landfill and to the north of monitoring wells BC-25, BC-20, and BC-21. The approximate ground elevation at monitoring well BC-25 is 746 feet. A surface water drainage feature is located to the south of the FGD Residue Landfill and drains to the west towards Craig Road. In general, the original site topography slopes from the ridge near monitoring wells BC-28 and BC-23A towards the north and the west. The typical elevation of Belews Lake ranges from approximately 722 feet to 725 feet.

The predominant groundwater discharge areas in the region of the FGD Residue Landfill are expected to be Belews Lake to the northwest of the landfill. Generalized groundwater surface contours for May 2013 and November 2013 are shown on Figures 3 and 4, respectively.

2.5 Groundwater Quality Monitoring

In accordance with the WQMP, groundwater monitoring is performed semi-annually in May and November. Sampling results are submitted to NCDENR within 90 days of sampling.

The initial groundwater sampling event at the FGD Residue Landfill was performed on November 5, 2007, prior to initial waste placement in April 2008. All 12 monitoring wells were installed prior to the initial sampling event. Surface water sample location SW-1 was first sampled in November 2010. The most recent groundwater monitoring event was conducted on November 25 and 26, 2013.[8]

[8] These results were presented in a report titled Semiannual Groundwater Monitoring Report, Belews Creek Steam Station, FGD Residue Landfill, Permit No.8505, November 2013 Sampling Event, February 4, 2014, prepared by HDR Engineering, Inc. of the Carolinas.

Section 3 – Supplemental Groundwater Assessment

The supplemental groundwater assessment at the FGD Residue Landfill was performed as stated in the recommendations in the groundwater assessment report dated October 5, 2012. This supplemental assessment report includes a description of the additional monitoring well (BC-32) installed at the review boundary between monitoring well BC-25 and the FGD Residue Landfill to further delineate the sulfate and TDS concentrations in this area and improve the understanding of groundwater flow and quality near monitoring well BC-25.

For the purposes of this supplemental assessment report, groundwater standard exceedances of sulfate and TDS in monitoring wells BC-20, BC-21, BC-25, and BC-32 were evaluated. During the August 19, 2013, sampling event, a 2L Standard exceedance for selenium was measured in monitoring well BC-21. While the selenium concentration measured in monitoring well BC-21 was less than the 2L Standard during the subsequent sampling event in November 2013, an assessment of selenium at this monitoring well has also been included in this supplemental assessment report.

3.1 Installation of Monitoring Well BC-32

S&ME installed monitoring well BC-32 to the south of monitoring well BC-25, between monitoring well BC-25 and the FGD Residue Landfill, from August 12 to 15, 2013. Monitoring well BC-32 was installed to improve the understanding of groundwater flow and groundwater quality near monitoring well BC-25. The well installation location is within Duke Energy's transmission right-of-way and is depicted on Figure 2.

Prior to installation of the monitoring well, a soil boring was advanced using 4½-inch-inside-diameter hollow stem augers. Standard Penetration Testing (SPT) was performed with split spoon samples collected at 5-foot intervals until the boring was terminated at an approximate depth of 29.5 feet below ground surface (bgs).

Monitoring well BC-32 was constructed with a 2-inch diameter Schedule 40 PVC screen and casing. The well consists of a 15-foot-long manufactured well screen with 0.010-inch-wide slots and a pre-packed sand filter installed from approximately 14.4 to 29.4 feet bgs. The well was screened at this depth to monitor the shallow groundwater in this area. The monitoring well was completed with an above grade 4-inch-diameter, lockable, protective steel cover (stickup) and a 2-foot-square concrete pad. Three protective painted steel bollards were installed around the well stickup.

Following the installation of monitoring well BC-32 the well was developed using a portable, electric well pump and polyethylene tubing. After development, two rising head permeability tests (slug tests) were performed at the well. The top of well casing and location of monitoring well BC-32 were surveyed by a North Carolina Professional Surveyor.

A complete description of the well installation including the as-built survey, well completion report, well construction record, well development data, and slug test data and analysis are included in S&ME report Groundwater Monitoring Well BC-32 Installation, dated September 17, 2013. A copy of this report is included in Appendix C.

3.2 Analytical Results

Groundwater sampling and documentation of sampling activities were performed by Duke Energy personnel (Duke Energy Carolinas Field Certification #5193) from newly installed monitoring well BC-32 on August 19, 2013. During this sampling event, groundwater samples were also collected from monitoring wells BC-20, BC-21, and BC-25.[9]

3.3 Semi-Annual Sampling of Monitoring Wells and Surface Water Sample Location

Since the completion and submittal of HDR's October 5, 2012, groundwater assessment report, the monitoring network at the FGD Residue Landfill has been sampled during three semi-annual events:

- November 2012
- May 2013
- November 2013

3.4 Analytical Results

3.4.1 Analytical Results from August 19, 2013, Sampling Event

The groundwater samples collected during the August 19, 2013, sampling event were analyzed by the Duke Energy Analytical Laboratory (North Carolina Laboratory Certification #248) and provided to HDR by Duke Energy. A summary of the field data from this sampling event is presented in Table 1. The field and analytical results from this groundwater sampling event are summarized in Table 2.

3.4.2 Analytical Results from Semi-Annual Sampling Events

The analytical results from the November 2012, May 2013, and November 2013 sampling events are presented in the following reports, prepared by HDR:

- *Semiannual Groundwater Monitoring Report, Belews Creek Steam Station, FGD Residue Landfill, November 2012 Sampling Event*, dated January 28, 2013.
- *Semiannual Groundwater Monitoring Report, Belews Creek Steam Station, FGD Residue Landfill, May 2013 Sampling Event*, dated July 9, 2013.
- *Semiannual Groundwater Monitoring Report, Belews Creek Steam Station, FGD Residue Landfill, November 2013 Sampling Event*, dated February 4, 2014.

[9] Monitoring well BC-26 was scheduled to be sampled during this event; however, a sample was inadvertently not collected. The absence of the August 2013 analytical results for BC-26 does not affect the conclusions or recommendations in this Supplemental Groundwater Assessment.

3.5 Groundwater Flow Direction

The generalized groundwater surface contours at the FGD Residue Landfill are presented in Figure 3 for May 2013 (prior to the installation of monitoring well BC-32), and in Figure 4 for November 2013 (after well installation), for comparative purposes. There are groundwater elevation differences between these two events; however, the water level data obtained with the installation of monitoring well BC-32 (Figure 4) shows the groundwater flow direction in the vicinity of monitoring well BC-25 as having a more northwestern flow direction than the more western flow direction previously depicted (Figure 3). Groundwater flow direction, based on these contours, is from the FGD Residue Landfill through monitoring well BC-32 then towards monitoring well BC-25.

3.6 Groundwater Quality Exceedances - Sulfate

The first sulfate exceedance in the FGD Residue Landfill monitoring network was measured in monitoring well BC-25 during the November 7, 2011, sampling event. The sulfate results from November 2011 through November 2013 for monitoring wells BC-20, BC-21, BC-25, BC-26, and BC-32 are presented in Table 3. These wells are located at or beyond the review boundary.

Exceedances of the sulfate 2L Standard have been measured in monitoring wells BC-20, BC-21, BC-25, and BC-32. Sulfate concentrations in monitoring well BC-26 have consistently been measured at concentrations less than the 2L Standard. Figure 5 depicts the sulfate concentrations for monitoring wells BC-20, BC-21, BC-25, BC-26, and BC-32 over the period of monitoring at the FGD Residue Landfill.

The sulfate concentrations in monitoring wells BC-20 and BC-25 have decreased since the May 2013 sampling event. The sulfate concentration measured in monitoring well BC-21 increased slightly from the May to August 2013 sampling events and then decreased in November 2013. The sulfate concentrations measured in monitoring wells BC-20 and BC-21 were less than the 2L Standard during the most recent (November 2013) sampling event.

Sulfate in monitoring well BC-32 was measured at concentrations greater than the 2L Standard during the installation sampling event (August 2013) and the November 2013 sampling event.

Sulfate concentrations measured in the background monitoring well BC-23A have ranged from 225 to 630 micrograms per liter (µg/L). In background monitoring well BC-28, sulfate concentrations have ranged from <100 to 466 µg/L, with the exception of the period from May 2008 to November 2011 when the laboratory method reporting limit (MRL) for sulfate was reported to be <5000 µg/L.

Monitoring well BC-32 is located between the FGD Residue Landfill and monitoring well BC-25. The sulfate concentrations measured in monitoring well BC-32 during August and November 2013 were less than the sulfate concentrations measured in monitoring well BC-25 during these sampling events. Considering groundwater flow direction, it would be expected that a defect or

damage in the FGD Residue Landfill liner system would result in concentrations measured in monitoring well BC-32 to be greater than those measured in monitoring well BC-25.

3.7 Groundwater Quality Exceedances – Total Dissolved Solids

Total dissolved solids (TDS) is defined by the United States Environmental Protection Agency (USEPA) as consisting of calcium, chlorides, nitrate, phosphorous, iron, sulfur, and other ion particles that will pass through a filter with pores of 2 microns in size (http://water.epa.gov/type/rsl/monitoring/vms58.cfm).

TDS results from monitoring wells at the FGD Residue Landfill appear to be correlated with the sulfate results from these wells. Figure 7 depicts the correlation between sulfate and TDS concentrations in monitoring well BC-25.

The first TDS exceedance in the FGD Residue Landfill monitoring network was measured in monitoring well BC-25 during the November 7, 2011, sampling event. The TDS results from November 2011 through November 2013 for monitoring wells BC-20, BC-21, BC-25, BC-26, and BC-32 are presented in Table 4.

TDS concentrations measured in the background monitoring wells have ranged from 44,000 to 138,000 µg/L in monitoring well BC-23A, and 36,000 to 81,000 µg/L in monitoring well BC-28.

Exceedances of the 2L Standard for TDS have been measured in monitoring wells BC-20,

BC-21, BC-25, and BC-32. Figure 6 depicts the TDS concentrations for monitoring wells

BC-20, BC-21, BC-25, BC-26, and BC-32 over the period of monitoring at the landfill.

The TDS concentrations in monitoring wells BC-20, BC-21, and BC-25 have generally decreased since the May 2013 sampling event. The TDS concentrations measured in monitoring wells BC-20 and BC-21 were less than the 2L Standard during the most recent sampling event (November 2013).

TDS in monitoring well BC-32 was measured at concentrations greater than the 2L Standard during the installation sampling event (August 2013) and the November 2013 sampling event.

Figure 7 presents the sulfate and TDS concentrations measured in monitoring well BC-25 over the period of monitoring. The direct relationship between these two constituents can be seen on this figure.

Monitoring well BC-32 is located between the FGD Residue Landfill and monitoring well BC-25. The TDS concentrations measured in monitoring well BC-32 during August and November 2013 were less than the TDS concentrations measured in monitoring well BC-25 during these sampling events. If the source of TDS measured in these monitoring wells was the landfill, it would be expected that the concentrations measured in monitoring well BC-32 would be greater than those measured in monitoring well BC-25.

3.8 Groundwater Quality Exceedances – Selenium

A 2L Standard exceedance for selenium was measured in monitoring well BC-21 during the August 19, 2013, sampling event. The selenium results from November 2011 through November 2013 for monitoring wells BC-20, BC-21, BC-25, BC-26, and BC-32 are presented in Table 5.

The August 2013 selenium concentration in monitoring well BC-21 is the only exceedance for selenium in the monitoring network over the period of monitoring. The selenium concentration in monitoring well BC-21 returned to a concentration less than the 2L Standard during the subsequent November 2013 sampling event.

The selenium concentrations measured in monitoring well BC-25 have been less than the 2L Standard over the period of monitoring. However, the selenium concentration did increase from 3.70 µg/L during the November 2012 sampling event to 19.2 µg/L during the May 2013 sampling event. The selenium concentrations measured in monitoring well BC-25 have gradually decreased since the May 2013 sampling event.

The selenium concentrations in monitoring wells BC-20, BC-21, BC-25, BC-26, and BC-32 over the period of monitoring are depicted on Figure 8.

Selenium has not been measured at a concentration which attains or exceeds the laboratory method reporting limit in background monitoring wells BC-23A and BC-28 over the period of monitoring.

Section 4 – Landfill Operations

As described in Section 2.1, the FGD Residue Landfill was constructed with an engineered liner system consisting of a leachate collection system, underlain by a 60-millimeter smooth HDPE geomembrane liner, underlain by a GCL.

Waste placement began in Cell 1 in April 2008. As waste placement and elevation in Cell 1 increased, placement progressed southward to Cells 2, 3, and 4. As waste placement elevations exceed the landfill liner anchor trench, operational soil cover is applied as needed for dust control and stormwater management.[10] A 12-inch-thick interim cover layer, consisting of soil, is placed on areas where final waste grades have been reached or where placement will be inactive for 12 months or more. As the waste placement progressed in elevation in Cell 1, an interim soil cover would have been placed along the northern and western exterior slopes of Cell 1 as the elevation of the placed waste increased.

During placement of waste in Cell 1, the primary haul route bringing FGD residue to the FGD Residue Landfill was along the northern side of Cell 1 and then onto the Cell 1 working area. As the elevation of Cell 1 increased, waste placement shifted from placement in Cell 1 to placement in the cells to the south of Cell 1. The primary haul route shifted to enter the landfill in the Cell 4 area.

Duke Energy instituted a dust management plan in January 2013. Additionally, in April 2012, a tire/truck washing system was installed to minimize dusting. The wash system was installed to wash the tires and underneath the trucks prior to the trucks leaving the gypsum stack-out area. A similar washing system is employed for vehicles leaving the FGD Residue Landfill.

Waste placement is currently primarily in Cell 2, 3, and 4 areas. Figure 13 shows the topographic contours for the FGD Residue Landfill as of June, 1, 2013. As the elevation of the waste increased above the elevation of the anchor trench, the routing of stormwater in the FGD Residue Landfill would have changed.

As waste placement progressed to an elevation greater than the anchor trench along the north side of Cell 1, interim cover soil was placed on the finished slope and stormwater on that finished slope would have been directed into sediment basins SB-6 and SB-7. Prior to that time (i.e., when the elevation of waste was less than the anchor trench), contact stormwater would have been routed into the stormwater basin located at the west end of the FGD Residue Landfill.

[10] *Belews Creek Steam Station FGD Landfill Operations Plan*, May 23, 2012, Joyce Engineering, DIN 16987, Sections 2.1.8.1, 2.1.8.2

Section 5 – Possible Sources of Exceedances

HDR evaluated the following as the likely sources of the exceedances for sulfate and TDS in monitoring wells BC-20, BC-21, BC-25, and BC-32 and selenium in BC-21:

- Leachate leakage through the engineered liner system
- Gypsum deposited onto the ground surface infiltrating into groundwater

5.1 Leachate Leaking Through the Engineered Liner System

Based on the decrease observed in the sulfate, TDS, and selenium concentrations beginning in May 2013, it appears unlikely that leachate leakage through the engineered liner system is the source of the exceedances. The design for the engineered liner system calls for a 60 mil smooth HDPE geomembrane which is underlain by a GCL as shown on landfill drawing CP-5 (Notes 2 and 3). The purpose of the GCL is to seal small defects or areas of damage in the geomembrane by expansion of the bentonite clay material into the defect as the bentonite material contained in the GCL hydrates.

The leakage rate through a geomembrane underlain by a GCL depends on a number of factors, such as the size of the defect or damage to the geomembrane, the head of the leachate on the defect, the condition and quantity of bentonite in the GCL, the quality of contact between the geomembrane and the GCL, and the hydraulic conductivity of the underlying soil.

Maintenance repairs to the engineered liner system were performed on the Cell 1 anchor trench and on the north end of the Cell 2 slope in January 2011. Damage to the liner system at the Cell 1 anchor trench consisted of tears in the protective geocomposite and tears in the geomembrane liner. Damage was also observed in the underlying GCL. The liner repairs at the Cell 1 anchor trench were completed in February 2011.[11] According to Duke Energy, the location of these repairs to the anchor trench were south of monitoring well BC-21.

Damage to the liner system at Cell 2 consisted of tears in the protective geocomposite and tears in the geomembrane liner in two locations. The geomembrane and damaged geocomposite were repaired in January 2011. The damaged locations were at elevations above where waste placement had occurred.

Sulfate is a major component of gypsum, is moderately soluble, and is not likely strongly attenuated by site soils. If the source of sulfate and TDS in monitoring wells BC-20, BC-21, and BC-25 and selenium in monitoring well BC-21 were caused by leakage in the liner system, it is reasonable to expect that the concentrations of these constituents in these wells would continue to increase or remain elevated.

Monitoring well BC-32 was installed between the FGD Residue Landfill limit of waste and monitoring well BC-25. Based on groundwater elevations in these wells, flow is from monitoring

[11] *Belews Creek Steam Station, FGD Residual Landfill Liner Repair, Construction Quality Assurance Certification Report*, Joyce Engineering, Inc., JEI Project: 845.1101.12 Task 01, March 10, 2011.

well BC-32 towards monitoring well BC-25. As shown in Tables 3 and 4, the concentrations for sulfate and TDS measured in monitoring well BC-32 were less than those measured in monitoring well BC-25 during the August 2013 and the November 2013 sampling events.

Although it is not possible to eliminate leakage through the liner system as a cause for the exceedances, HDR does not consider leakage through the liner system to be the likely source of the exceedances for the following reasons:

- The concentrations of sulfate and TDS have decreased since May 2013 in monitoring wells BC-20 and BC-25;
- The concentrations of sulfate and TDS have decreased since August 2013 in monitoring well BC-21;
- The concentrations of selenium in monitoring well BC-21 have decreased; and
- If a leak in the landfill liner system was providing the source of the sulfate, TDS, and selenium, it is reasonable to expect that BC-32, the well closer to the FGD Residue Landfill than BC-25, would have greater concentrations of these constituents, which is not the case.

5.2 Gypsum Deposited onto the Ground Surface Infiltrating into Groundwater

As described in Section 4, Duke Energy instituted a dust management plan in January 2013. Additionally, in April 2012, a tire/truck washing system was installed to minimize dusting. It is possible that dusting of gypsum occurred in the area where monitoring wells BC-25, BC-20, and BC-21 are located prior to the initiation of the dust management plan and the installation of the tire/truck washing system. During placement of waste in Cell 1, the primary haul route bringing FGD residue to the FGD Residue Landfill was along the northern side of Cell 1 and then onto the Cell 1 working area. The primary haul route during this period would have been adjacent to well BC-25 and then along a haul road just south of wells BC-20 and BC-21. It is possible that dusting from the truck traffic might have deposited gypsum on the ground surface in this area.

Two non-contact stormwater sediment basins (SB-6 and SB-7) are located to the north of the FGD Residue Landfill (see Figure 2). These basins are located approximately 100 feet from the FGD Residue Landfill limit of waste. Prior to the installation of the interim soil cover of the side slopes of Cell 1 in approximately the fourth quarter of 2011, the stormwater entering these basins was limited to primarily the drainage area north and northeast of the FGD Residue Landfill waste boundary.

Monitoring well BC-21 is located approximately 80 feet east of sediment basin SB-7. Monitoring wells BC-20, BC-25, and BC-32 are located approximately 75, 100, and 50 feet, respectively, from sediment basin SB-6 (see Figure 2).

After completion of the interim soil cover on the northern exterior slope of Cell 1 (Figure 13), an increased volume of non-contact stormwater could flow into sediment basins SB-6 and SB-7.

The groundwater elevations in monitoring wells BC-20, BC-21, BC-25, BC-26, BC-27, BC-29, and BC-7 over the period of monitoring are shown on Figure 9. The water levels in each of these wells increased during the May 2013 sampling event compared to the water levels measured during November 2012. A greater increase in water level elevations in the monitoring wells located near the sediment basins (monitoring wells BC-20, BC-21, and BC-25) can be seen on Figure 9 compared to the wells located away from the sediment basins during this time period.

Figures 10, 11, and 12 depict sulfate concentrations and water level elevations in monitoring wells BC-20, BC-21, and BC-25, respectively. These figures show that the increase in sulfate concentrations measured during the May 2013 sampling event coincides with the highest water level measured in each of these wells over the period of monitoring. It is expected that the increase in water levels in these monitoring wells was a result of rainfall events at the FGD Residue Landfill.

The selenium concentrations in monitoring wells BC-20, BC-21, BC-25, BC-26, and BC-32 are depicted on Figure 8. Review of Figure 8 shows the selenium exceedance of 23.7 µg/L measured in monitoring well BC-21 during the August 2013 sampling event followed by a decrease to 2.69 µg/L in the following sampling event in November 2013. Monitoring well BC-25 shows a similar increase in selenium concentrations followed by decreases in concentrations during the following sampling event. The increases and subsequent decreases in selenium concentrations correspond to increases and subsequent decreases in the groundwater elevations as shown on Figure 9. As discussed previously, rainfall records for the FGD Residue Landfill are not available, but it is expected that the increase in water levels in these monitoring wells was a result of rainfall events at the FGD Residue Landfill.

Section 6 – Conclusions and Recommendations

6.1 Conclusions- Sulfate, TDS, and Selenium Exceedances

HDR reviewed the operations of the FGD Residue Landfill, the groundwater flow in the FGD Residue Landfill area, and the analytical results for groundwater monitoring wells, and evaluated the following as the possible sources of the exceedances for sulfates and TDS in monitoring wells BC-20, BC-21, BC-25, and BC-32 and for selenium in monitoring well BC-21:

- Leachate leakage through the engineered liner system
- Gypsum deposited onto the ground surface infiltrating into groundwater

If the source of the sulfate and TDS in monitoring wells BC-20, BC-21, and BC-25 and the source of the selenium in monitoring well BC-21 were caused by leakage in the liner system as a result of the failure of the GCL to seal a defect or damage to the geomembrane, it is reasonable to expect that:

1. The concentration of sulfate, TDS, and selenium in newly installed monitoring well BC-32 would be greater than the concentrations observed in monitoring well BC-25.
2. The concentrations of sulfate and TDS in monitoring wells BC-20, BC-21, and BC-25 and the concentration of selenium in monitoring well BC-21 would continue to increase or remain elevated.

Although it is not possible to eliminate leakage through the liner system as a cause, HDR does not consider leakage through the liner system to be the likely source of the exceedances because:

- The sulfate and TDS concentrations have decreased since May 2013 in monitoring wells BC-20, BC-21, and BC-25, and since August 2013 in monitoring well BC-21.
- The sulfate concentrations measured in monitoring well BC-32 were less than those measured in monitoring well BC-25.
- The selenium concentrations have decreased in monitoring well BC-21 and in BC-25.

Corresponding increases and subsequent decreases in groundwater elevations compared with sulfate and TDS concentrations were observed in monitoring wells BC-20, BC-21, and BC-25 and in selenium concentrations in monitoring well BC-21. These wells are located adjacent to non-contact stormwater basins SB-6 and SB-7.

Increases in precipitation runoff received by non-contact stormwater basins SB-6 and SB-7, due to the progress of filling Cell 1, may have caused deposited FGD residue to be subjected to increased infiltration into the groundwater at these basins.

Sulfate is a major component of gypsum, it is moderately soluble, and it is not likely strongly attenuated by site soils. Based on the correlation between groundwater level and increase in sulfate, TDS, and selenium concentrations observed in the monitoring wells located in close proximity to the sediment basins, it appears that an increase in surface runoff and infiltration of

gypsum into the groundwater in this area may be the source of exceedances of sulfate, TDS, and selenium in these wells.

6.2 Recommendations

1. Concentrations of sulfate in BC-32 are in excess of the 2L Standard. Monitoring well BC-32 was installed at the review boundary and should continue to be sampled as part of the groundwater monitoring program for the FGD Residue Landfill.
2. Although decreasing, concentrations of sulfate and TDS in BC-25 are in excess of the respective 2L Standards. If the concentrations of sulfate and TDS decrease to below the 2L Standard in monitoring wells BC-25 and BC-32 and remain below the 2L Standard for a minimum of two sampling events, HDR recommends that groundwater monitoring be discontinued in monitoring well BC-25 and that monitoring well BC-32 be incorporated into the groundwater monitoring program for the FGD Residue Landfill as BC-32 is located at the review boundary and BC-25 is outside of the compliance boundary. Monitoring well BC-25 would be abandoned at that time.
3. If the concentrations of sulfate and TDS remain above the 2L Standards in monitoring wells BC-25 and BC-32 for the next three sampling events, an additional assessment should be conducted identify the source of the exceedances.

Section 7 – References

LeGrand, Harry E. Sr. 2004. *A Master Conceptual Model for Hydrogeological Site Characterization in the Piedmont and Mountain Region of North Carolina, North Carolina Department of Environment and Natural Resources, Division of Water Quality, Groundwater Section.*

Figures

NOTES:

1. SOURCE: USGS TOPOGRAPHIC MAP - BELEWS LAKE QUADRANGLE. CREATED 1971. REVISED 2010.
2. TOPOGRAPHIC MAP DOES NOT REFLECT REALIGNMENT OF CRAIG ROAD.

SCALE (FEET)

1000 0 1000 2000

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SITE LOCATION MAP
BELEWS CREEK STEAM STATION
FGD RESIDUE LANDFILL
PERMIT NO. 8505

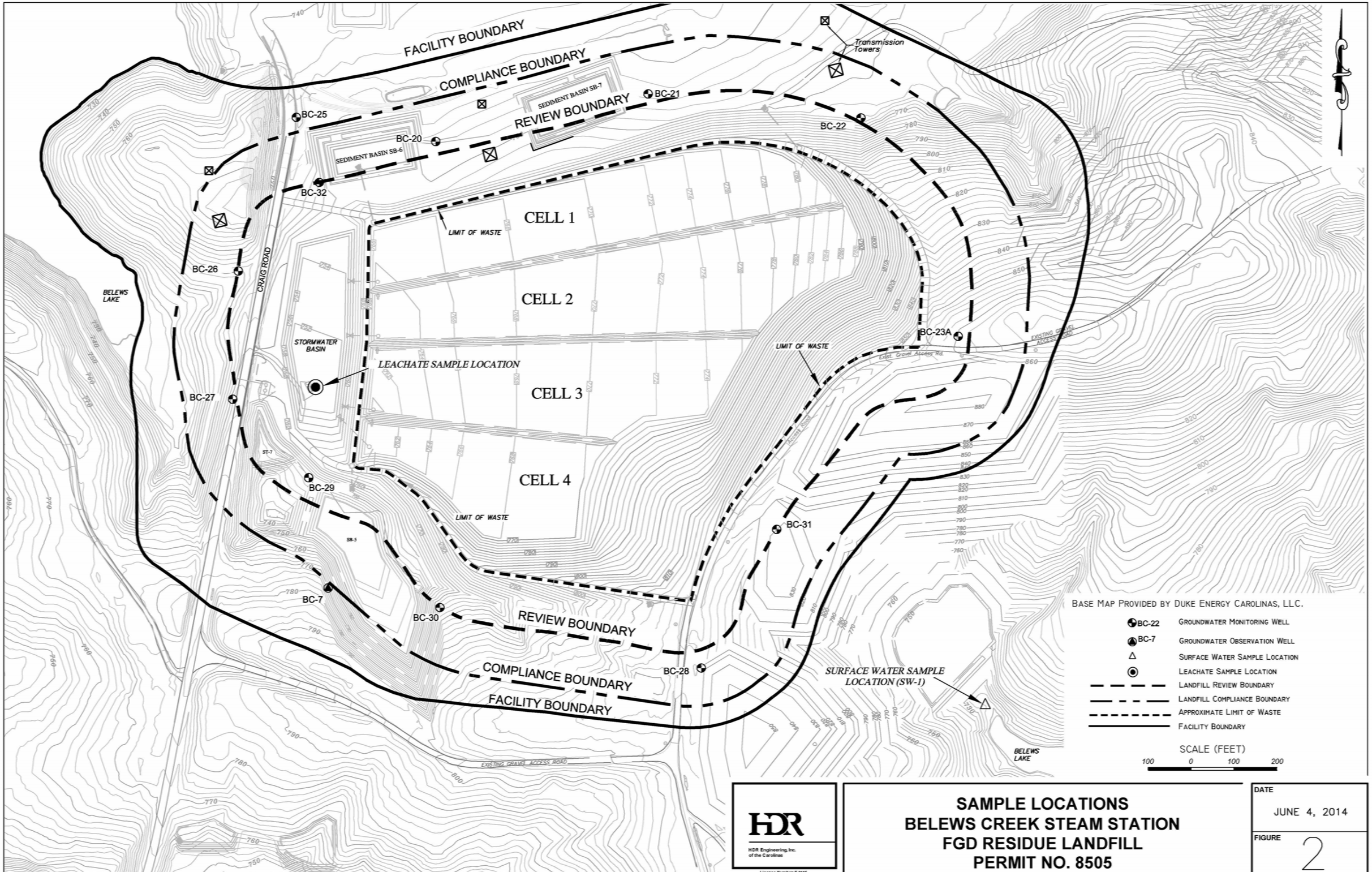
DATE

JUNE 4, 2014

FIGURE

1

C:\pwworking\tpa\d0533391\Figure 1 - Site Location Map.dwg



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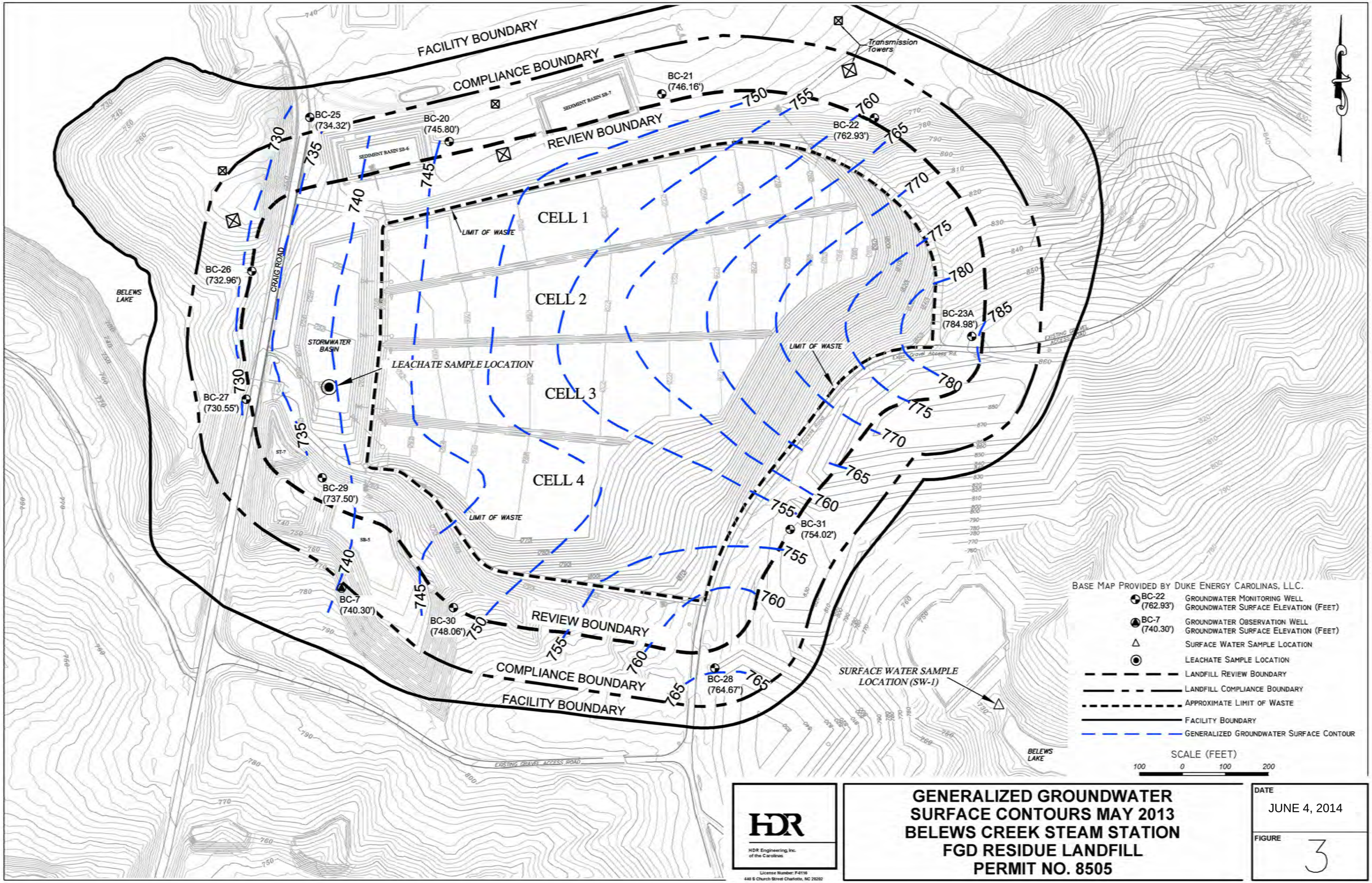
SAMPLE LOCATIONS
BELEWS CREEK STEAM STATION
FGD RESIDUE LANDFILL
PERMIT NO. 8505

DATE: JUNE 4, 2014

FIGURE: 2

C:\pwworking\tpa\d0533391\DCSS FGD LF Figures 2 and 4.dwg



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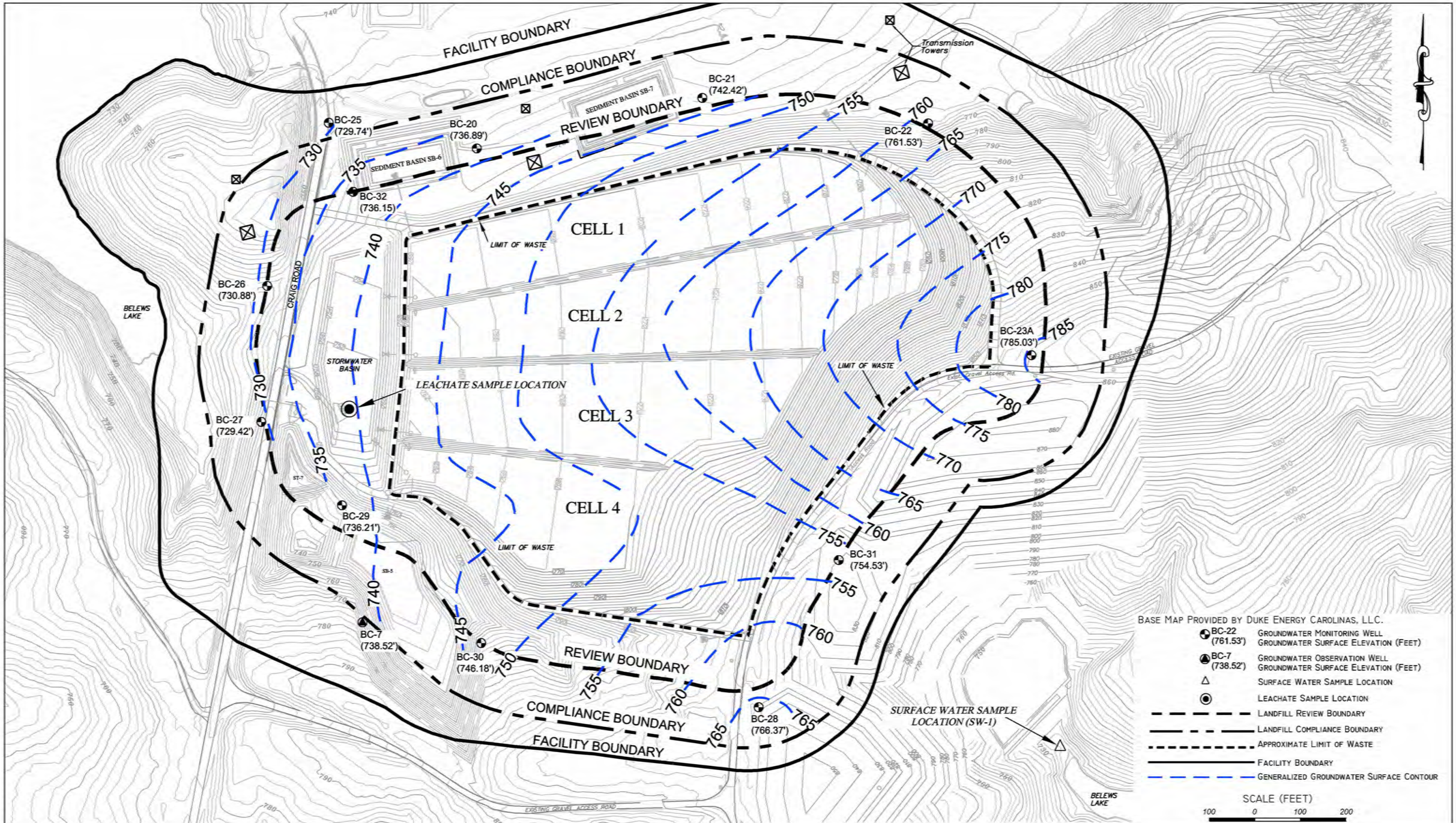
GENERALIZED GROUNDWATER SURFACE CONTOURS MAY 2013
BELEWS CREEK STEAM STATION
FGD RESIDUE LANDFILL
PERMIT NO. 8505

DATE: JUNE 4, 2014

FIGURE: 3

C:\pwworking\tpa\d0387347\DCSS FGD LF Figures 2 and 3.dwg



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GENERALIZED GROUNDWATER SURFACE CONTOURS NOVEMBER 2013 BELEWS CREEK STEAM STATION FGD RESIDUE LANDFILL PERMIT NO. 8505

DATE: JUNE 4, 2014

FIGURE: 4

C:\pwworking\tpa\d0533391\BCSS FGD LF Figures 2 and 4.dwg

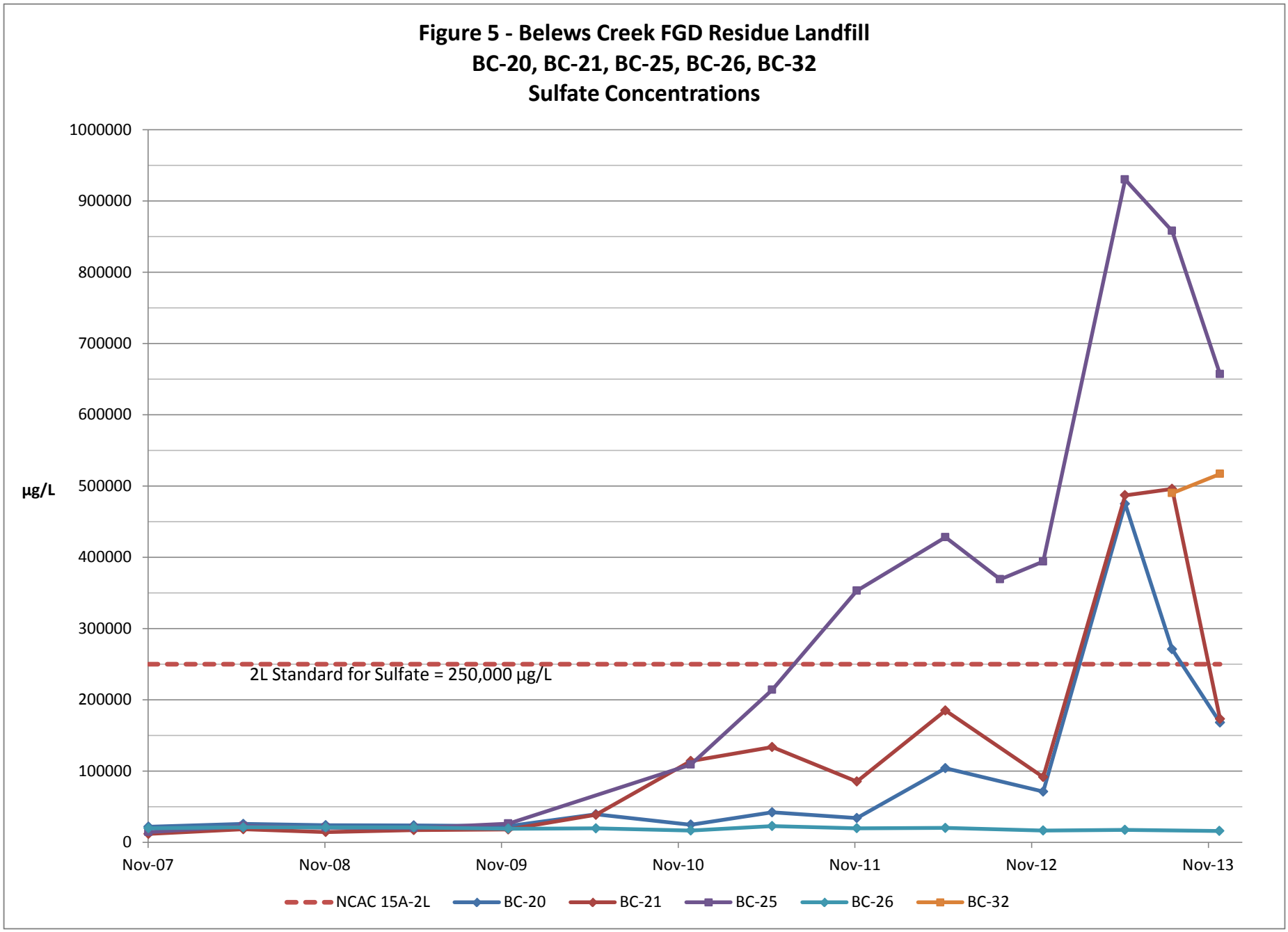


Figure 5 - Belews Creek FGD Residue Landfill
BC-20, BC-21, BC-25, BC-26, BC-32
Sulfate Concentrations
µg/L
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
2L Standard for Sulfate = 250,000 µg/L
Nov-07
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
NCAC 15A-2L
BC-20
BC-21
BC-25
BC-26
BC-32

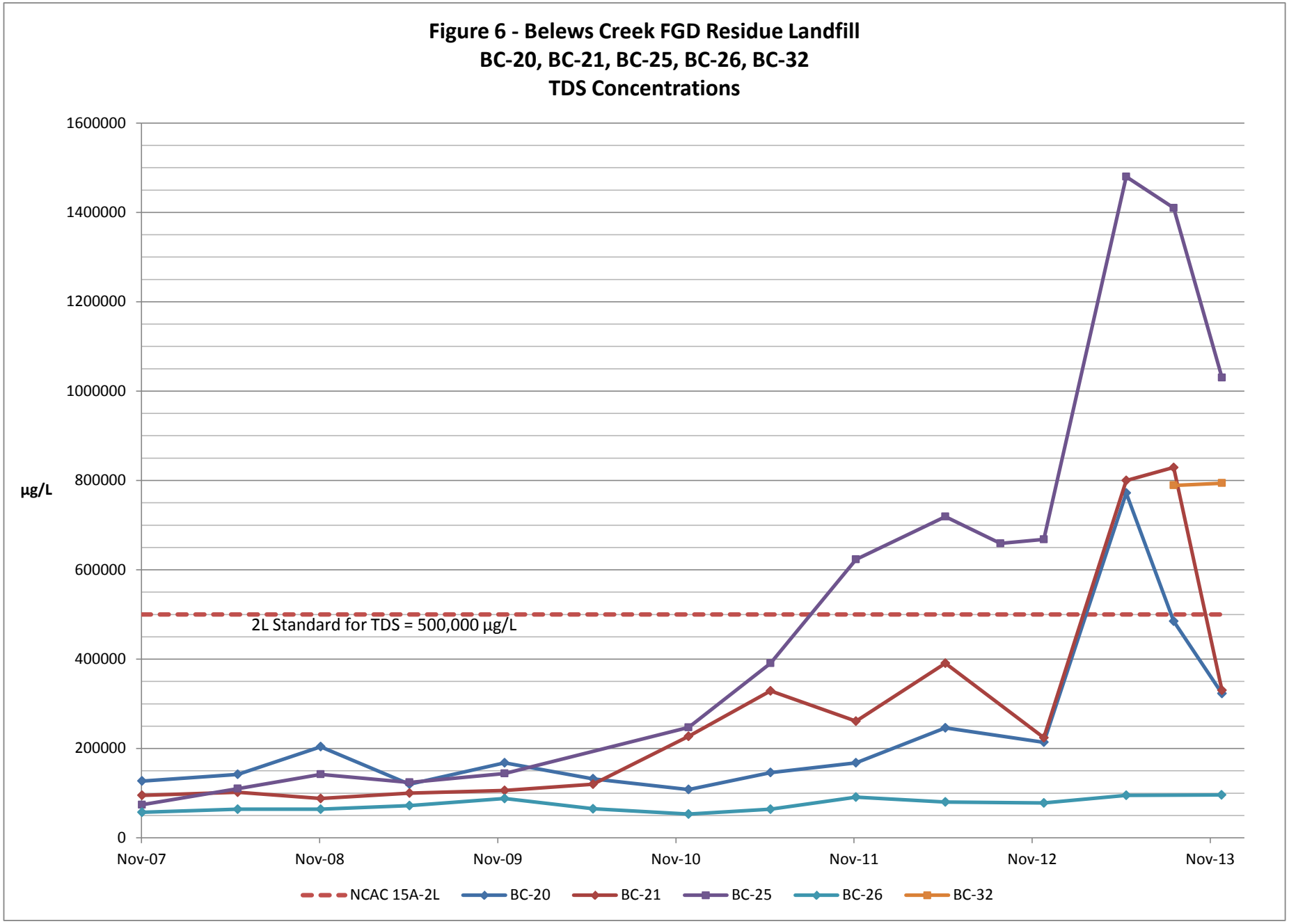


Figure 6 - Belews Creek FGD Residue Landfill
BC-20, BC-21, BC-25, BC-26, BC-32
TDS Concentrations
µg/L
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
2L Standard for TDS = 500,000 µg/L
Nov-07
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
NCAC 15A-2L
BC-20
BC-21
BC-25
BC-26
BC-32

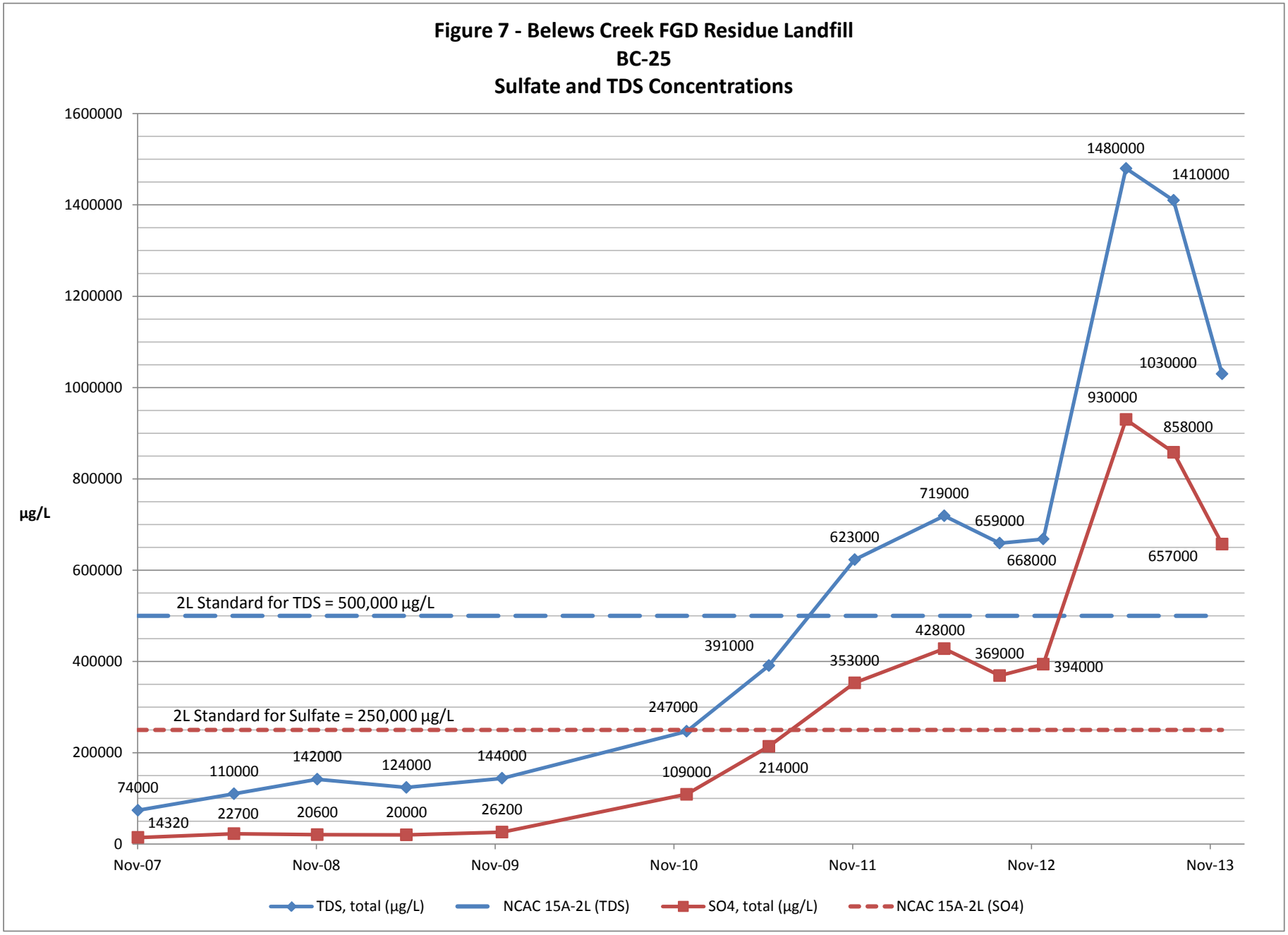


Figure 7 - Belews Creek FGD Residue Landfill
BC-25
Sulfate and TDS Concentrations
µg/L
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
2L Standard for TDS = 500,000 µg/L
2L Standard for Sulfate = 250,000 µg/L
74000
110000
142000
124000
144000
247000
391000
623000
719000
659000
668000
1480000
1410000
1030000
14320
22700
20600
20000
26200
109000
214000
353000
428000
369000
394000
930000
858000
657000
Nov-07
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
TDS, total (µg/L)
NCAC 15A-2L (TDS)
SO4, total (µg/L)
NCAC 15A-2L (SO4)

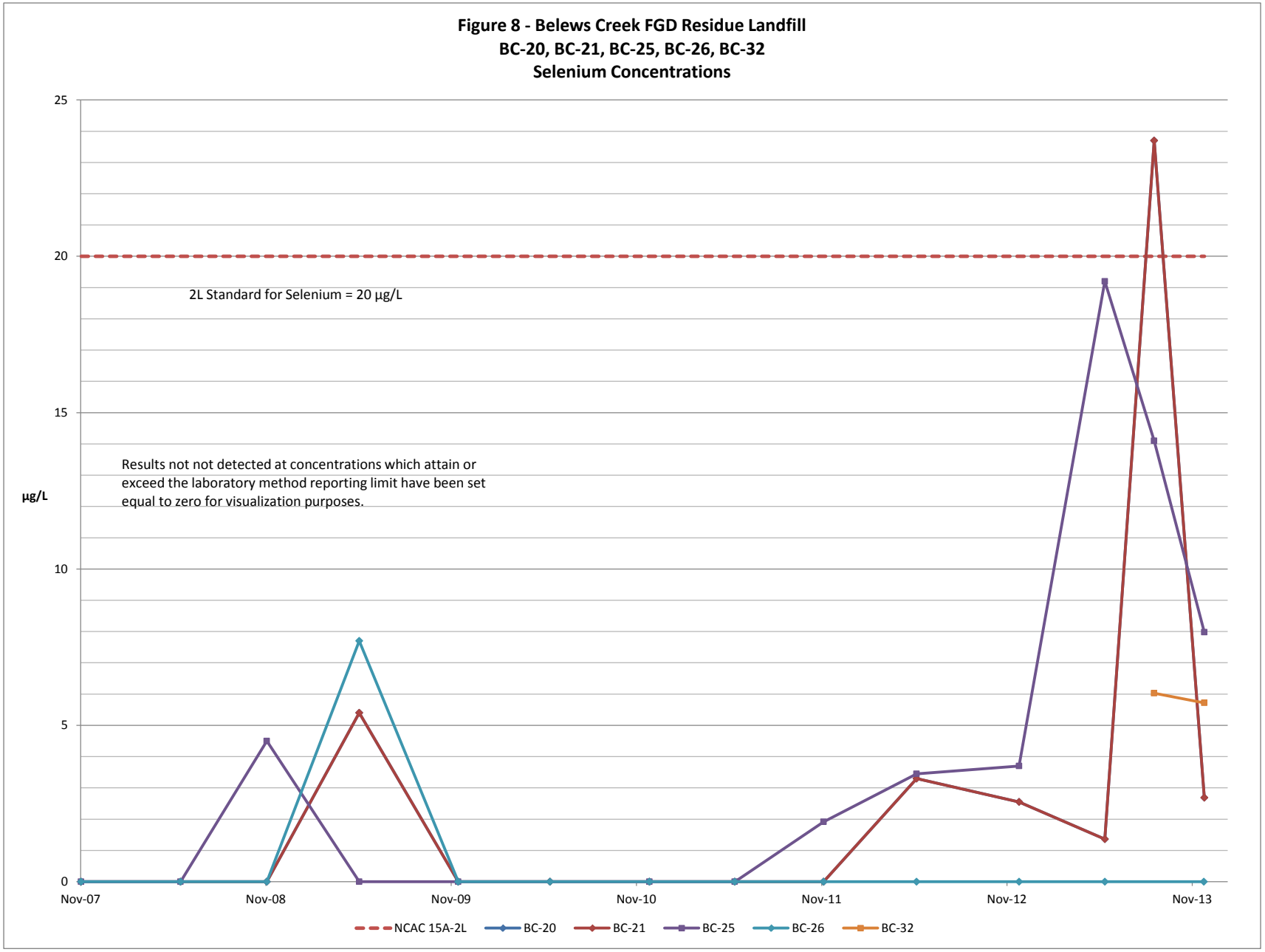


Figure 8 - Belews Creek FGD Residue Landfill
BC-20, BC-21, BC-25, BC-26, BC-32
Selenium Concentrations
25
20
15
10
5
0
µg/L
2L Standard for Selenium = 20 µg/L
Results not not detected at concentrations which attain or exceed the laboratory method reporting limit have been set equal to zero for visualization purposes.
Nov-07
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
NCAC 15A-2L
BC-20
BC-21
BC-25
BC-26
BC-32

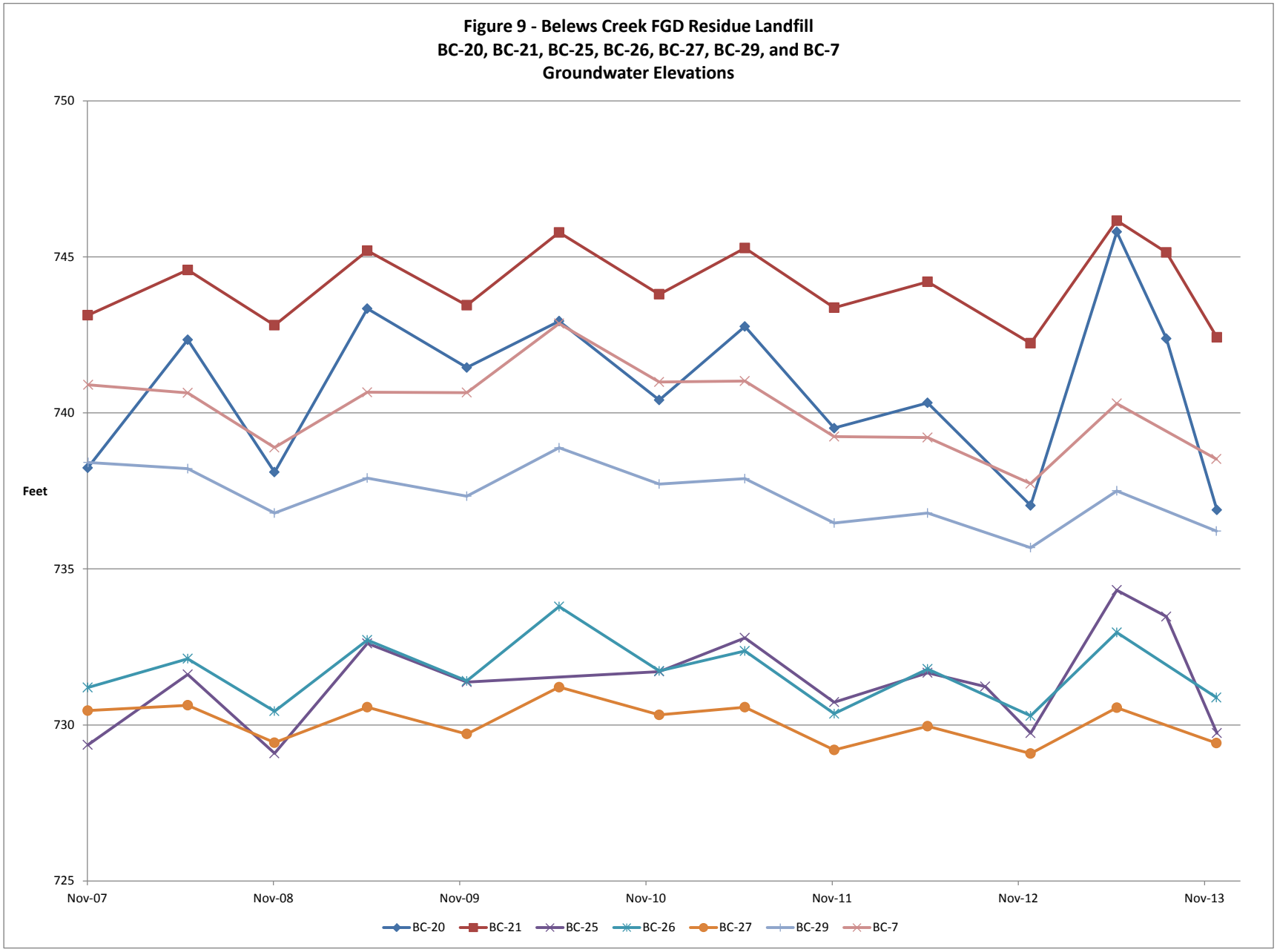


Figure 9 - Belews Creek FGD Residue Landfill
BC-20, BC-21, BC-25, BC-26, BC-27, BC-29, and BC-7
Groundwater Elevations
750
745
740
735
730
725
Feet
Nov-07
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
BC-20
BC-21
BC-25
BC-26
BC-27
BC-29
BC-7

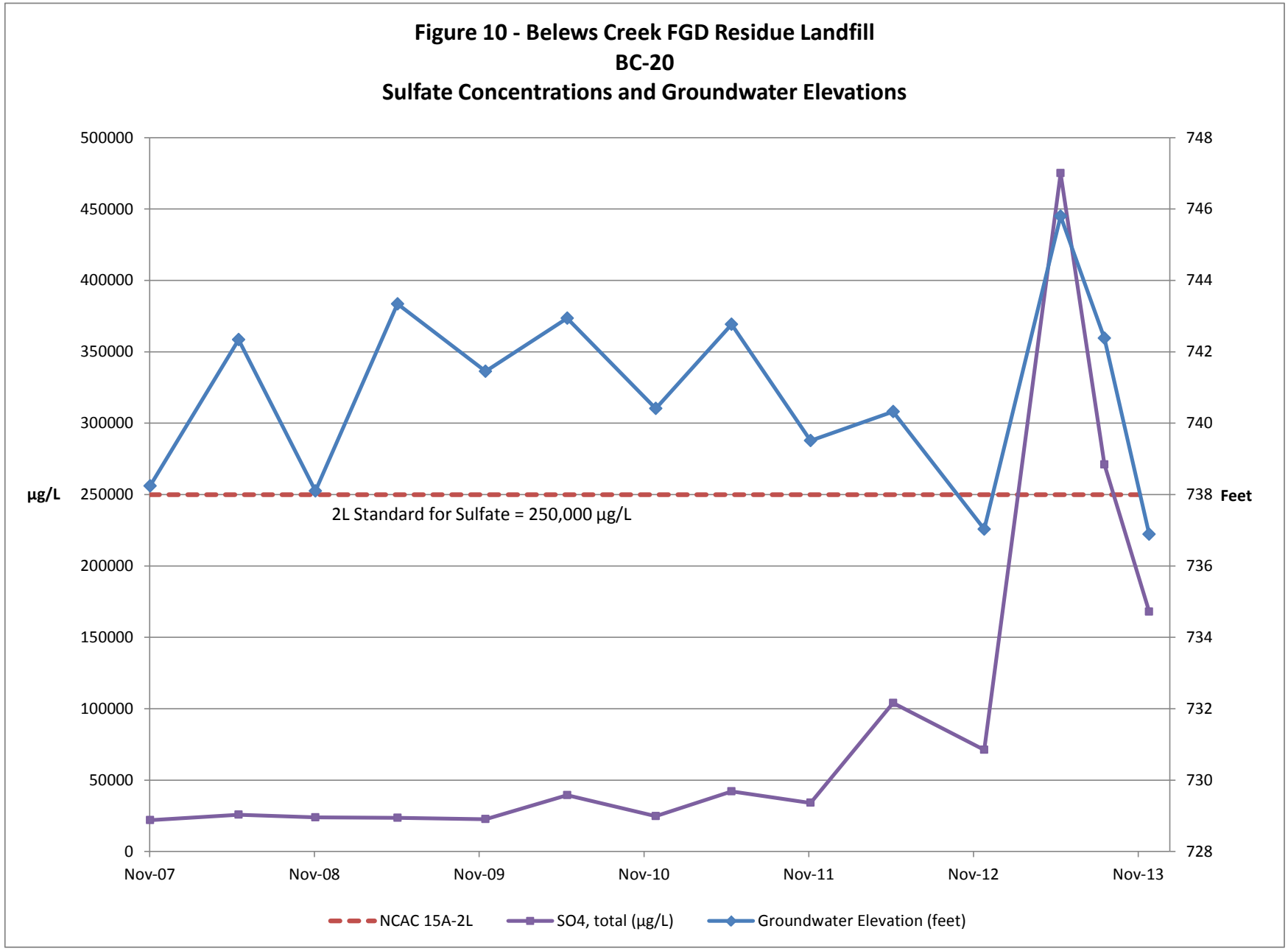


Figure 10 - Belews Creek FGD Residue Landfill
BC-20
Sulfate Concentrations and Groundwater Elevations
µg/L
Feet
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
748
746
744
742
740
738
736
734
732
730
728
2L Standard for Sulfate = 250,000 µg/L
Nov-07
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
NCAC 15A-2L
SO4, total (µg/L)
Groundwater Elevation (feet)

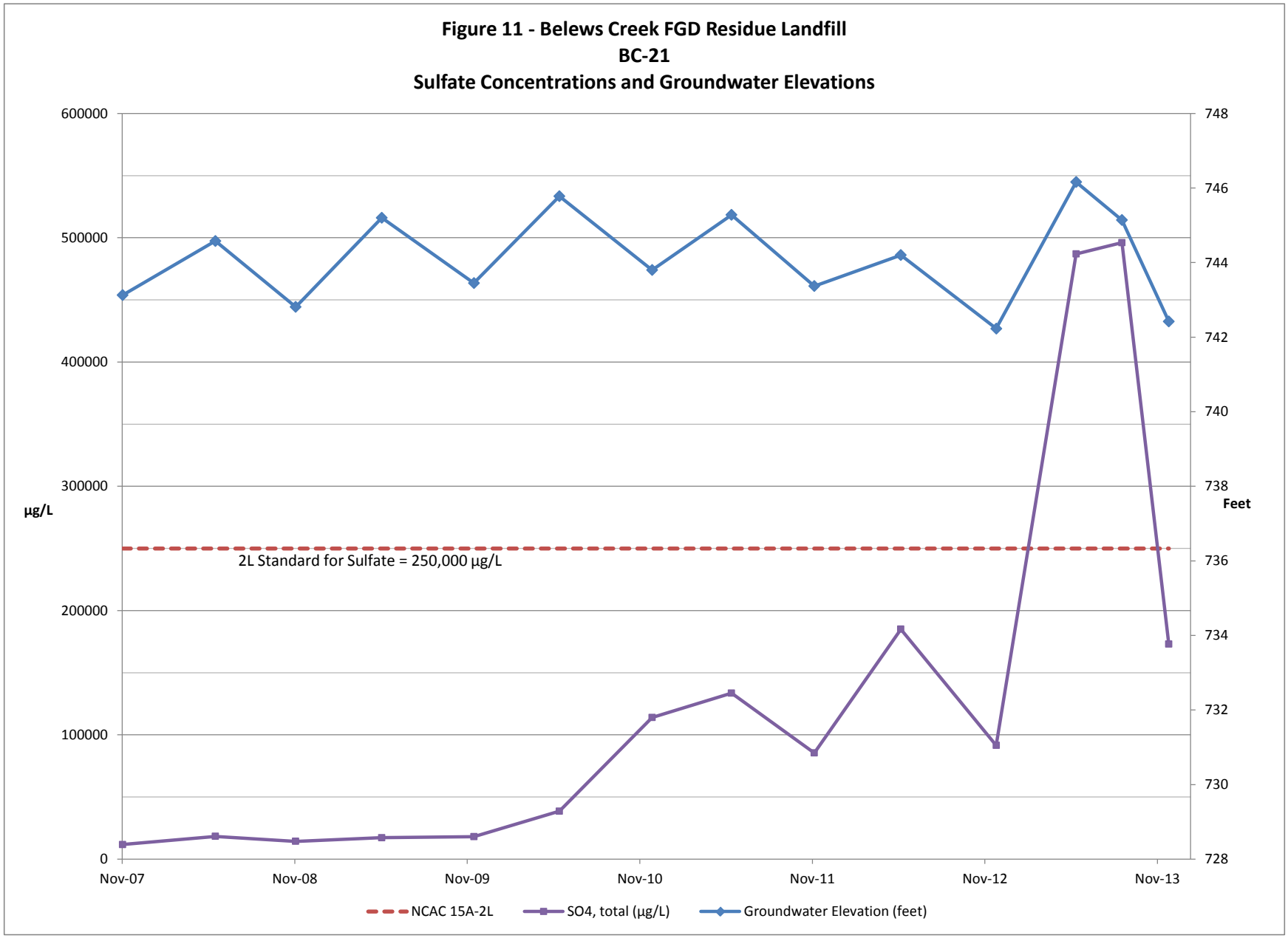


Figure 11 - Belews Creek FGD Residue Landfill
BC-21
Sulfate Concentrations and Groundwater Elevations
600000
500000
400000
300000
200000
100000
0
µg/L
748
746
744
742
740
738
736
734
732
730
728
Feet
2L Standard for Sulfate = 250,000 µg/L
Nov-07
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
NCAC 15A-2L
SO4, total (µg/L)
Groundwater Elevation (feet)

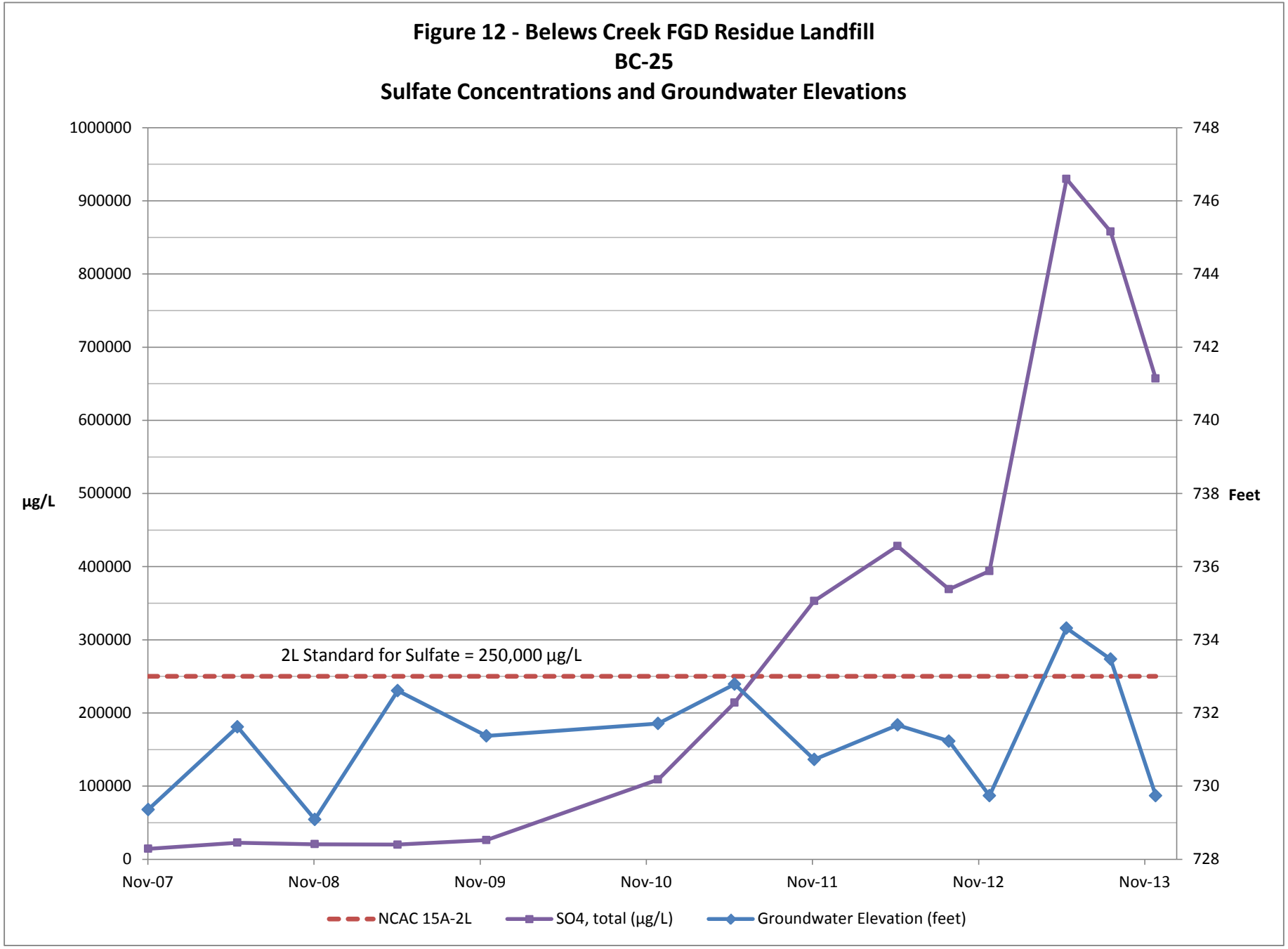
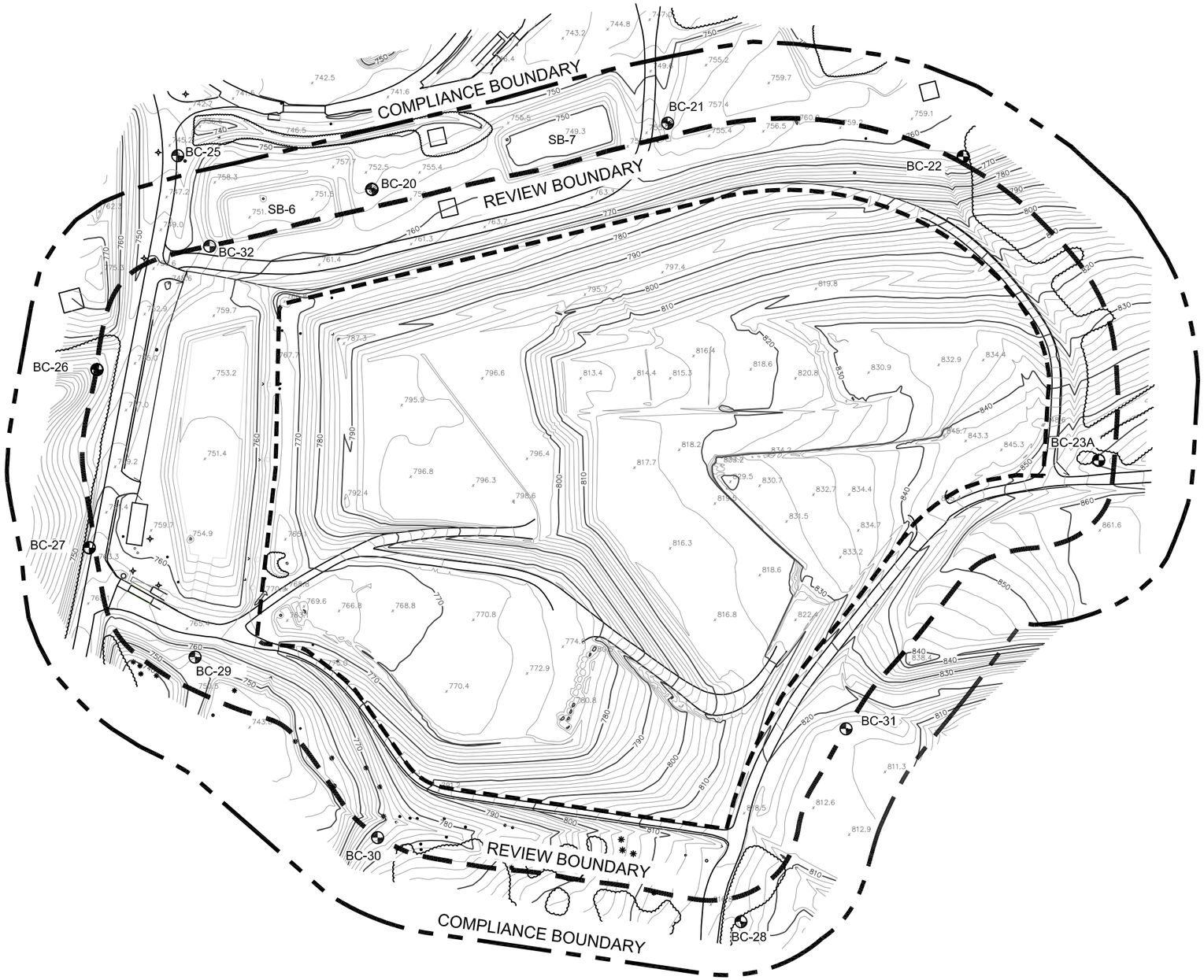


Figure 12 - Belews Creek FGD Residue Landfill
BC-25
Sulfate Concentrations and Groundwater Elevations
µg/L
Feet
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
748
746
744
742
740
738
736
734
732
730
728
2L Standard for Sulfate = 250,000 µg/L
Nov-07
Nov-08
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
NCAC 15A-2L
SO4, total (µg/L)
Groundwater Elevation (feet)



BASE MAP PROVIDED BY DUKE ENERGY CAROLINAS, LLC.
DATE OF MAPPING: 06-01-2013

BC-22 GROUNDWATER MONITORING WELL
BC-7 GROUNDWATER OBSERVATION WELL
APPROXIMATE LIMIT OF WASTE
LANDFILL REVIEW BOUNDARY
LANDFILL COMPLIANCE BOUNDARY

SCALE (FEET)
100 0 100 200

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JUNE 2013 SITE TOPOGRAPHY
BELEWS CREEK STEAM STATION
FGD RESIDUE LANDFILL
PERMIT NO. 8505

DATE
JUNE 4, 2014

FIGURE
13

Tables

Table 1–Field Data Parameters
Duke Energy Carolinas LLC/Belews Creek Steam Station
FGD Residue Landfill, Permit No. 8505

DATE	SAMPLE ID	WELL DEPTH (feet)	DEPTH TO WATER (feet)	WATER ELEV. (feet)	ODOR	PURGE METHOD	PUMP RATE (mL/min)	WELL VOLUME (gal)	EVAC VOLUME (gal)	EVAC (YES/NO)	TEMP (deg C)	SPECIFIC Conductance (umho/cm)	pH (SU)	TURBIDITY (NTU)	ORP (mV-NHE)	DO (mg/L)
8/19/2013	BC-20	24.22	14.84	742.38	None	LF	354	1.53	1.45	N/A	17.38	629.9	5.1	29.1	442	5.99
8/19/2013	BC-21	16.77	11.55	745.14	None	LF	160	0.85	1.15	N/A	18.07	1,024	4.7	2.1	462	6.92
8/19/2013	BC-25	23.15	12.49	733.47	None	LF	80	1.74	0.70	N/A	20.36	1,631	5.0	7.5	331	5.44
8/19/2013	BC-26	23.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NS	NS	NS	NS	NS	NS
8/19/2013	BC-32	33.01	16.26	739.68	None	CP	N/A	2.73	8.25	NO	16.94	979.5	5.3	9.5	429	5.20

Notes:

1. Purge Methods; LF=Low Flow, CP=Conventional Purge (3-5 well volumes), NP=No Purge (HydraSleeve), LO=Level Only. Pump rate applicable to LF purging only.
2. Field sampling performed by Duke Energy Carolinas, LLC personnel.
3. EVAC indicates whether the water level in the well was drawn down to the level of the pump during purging.
4. umho/cm indicates microohms per centimeter.
5. SU indicates Standard Units.
6. NTU indicates Nephelometric Turbidity Units.
7. mV-NHE indicates millivolts-Normal Hydrogen Electrode.
8. mg/L indicates milligrams per liter.
9. N/A indicates not applicable.
10. NS indicates not sampled.
11. Monitoring well BC-26 was inadvertently not sampled during this event. Samples were not scheduled to be collected from BC-7, BC-22, BC-23A, BC-27, BC-28, BC-29, BC-30, BC-31, BC-SW1, or BC-Leachate during this event.
12. Information provided by Tim Hunsucker of Duke Energy Carolinas, LLC on September 16, 2013.

Table 2–Field and Analytical Results
Duke Energy Carolinas LLC/Belews Creek Steam Station
FGD Residue Landfill, Permit No. 8505

Sample Date: August 19, 2013

Field Sampling performed by Duke Energy Carolinas, LLC

Laboratory Certificate Codes:
Duke Energy Carolinas Field #5193
Duke Energy Analytical Laboratory #248

Parameter	SWS ID	Units	Certificate Code	Monitoring Wells 8505 BC-20		8505 BC-21		8505 BC-25		8505 BC-26	8505 BC-32		SWSL	15A NCAC 2L
Field pH	320	SU	5193	**5.1**		**4.7**		**5.0**		N/A	**5.3**		-	6.5-8.5
Field Specific Conductance	323	umho/cm	5193	742.38		745.14		733.47		N/A	739.68		-	-
Temperature	325	°C	5193	24.22		16.77		23.15		23.26	33.01		-	-
Top of Casing	328	feet	-	635.03		1,028.66		1,636.04		749.32	984.83		-	-
Depth to Water	318	feet	-	5.1		4.7		5.0		NS	5.3		-	-
Water Elevation	319	feet	-	630		1,024		1,631		NS	980		-	-
Well Depth	411	feet	-	17.38		18.07		20.36		NS	16.94		-	-
Arsenic	14	µg/L	248	0.078	U	3.01	J'	0.078	U	NS	0.663	J	10	10
Barium	15	µg/L	248	59.6	J'	32.3	J'	69.4	J'	NS	82.3	J'	100	700
Boron	428	µg/L	248	6.15	J	3.3	U	15.4	J	NS	10.5	J	NE	700
Cadmium	34	µg/L	248	0.495	J	0.656	J	0.117	J	NS	0.584	J	1	2
Chloride	301	µg/L	248	5,010		23,600		21,600		NS	2,860		NE	250,000
Chromium	51	µg/L	248	0.791	J	0.5	U	0.5	U	NS	0.5	U	10	10
Copper	54	µg/L	248	1	U	1	U	1	U	NS	1	U	10	1,000
Fluoride	312	µg/L	248	75.6	J	75	J	200	J	NS	200	J	2,000	2,000
Iron	340	µg/L	248	**823**		22.2	J'	**417**		NS	**388**		300	300
Lead	131	µg/L	248	0.139	J	0.103	J	0.091	J	NS	0.382	J	10	15
Manganese	342	µg/L	248	14.9	J'	**240**		**57**		NS	**234**		50	50
Mercury	132	µg/L	248	0.006	U	0.006	U	0.013	J	NS	0.006	U	0.2	1
Nickel	152	µg/L	248	8.94	J'	2.6	J	38.9	J'	NS	60.6		50	100
Nitrate (as Nitrogen)	303	µg/L	248	5,540	J'	1,800	J'	3,590	J'	NS	1,640	J'	10,000	10,000
Selenium	183	µg/L	248	1.96	J'	**23.7**		14.1		NS	6.03	J'	10	20
Silver	184	µg/L	248	0.7	U	0.7	U	0.7	U	NS	0.7	U	10	20
Sulfate	315	µg/L	248	**271,000**		**496,000**		**858,000**		NS	**490,000**		250,000	250,000
Total Dissolved Solids	311	µg/L	248	485,000		**829,000**		**1,410,000**		NS	**789,000**		NE	500,000
Zinc	213	µg/L	248	11.2		5.38	J'	9.27	J'	NS	27		10	1,000

Notes:

1. Concentrations presented in micrograms per liter (µg/L).
2. SWS ID is the Solid Waste Section Identification Number.
3. SWSL is the Solid Waste Section Limit. NCDENR defines the SWSL as the lowest amount of analyte in a sample that can be quantitatively determined with suitable precision and accuracy.
4. 15A NCAC 2L Standard refers to Class GA Standards as found in 15A NCAC 02L. 0202 Groundwater Quality Standards, last amended on April 1, 2013.
5. NE indicates not established. N/A indicates not applicable. Blank cells indicate that there is no information relevant to the respective row.
6. Grayed values indicate values that attain or exceed the SWSL Standard.
7. Bold values indicate values that attain or exceed the 15A NCAC 2L Standard.
8. Qualifiers in non-italicized text are laboratory data qualifiers or "flags". "U" is used to identify results not detected at concentrations which attain the laboratory's method detection limit (MDL).
   "J" is used to identify estimated concentrations which attain or exceed the MDL but are less than the laboratory's method reporting limit (MRL).
   An italicized *J'* -flag is a data qualifier, added by HDR to indicate concentrations which attain or exceed the laboratory's MRL but are less than the SWSL.
9. SU indicates Standard Units.
10. umho/cm indicates micromhos per centimeter.
11. NS indicates not sampled.
12. According to the Constituent Look-up webpage on the NCDENR Division of Waste Management webpage, there is no SWSL or 2L Standard for chloride associated with CAS number 16887-00-6, which is the CAS reported by the laboratory for the analyses completed. Therefore, the SWSL and 2L Standards listed are for the chloride with CAS number SW301 as specified on the Constituent Look-up webpage (last updated June 13, 2011).
13. Analytical results obtained from Electronic Data Deliverable (EDD) provided by Tim Hunsucker of Duke Energy Carolinas, LLC on December 16, 2013.

Table 3–Selected Sulfate Analytical Results for Monitoring Wells BC-20, BC-21, BC-25, BC-26, and BC-32 Duke Energy Carolinas LLC/Belews Creek Steam Station FGD Residue Landfill, Permit No. 8505

Well ID	November 7, 2011 Analytical Results	May 8, 2012 Analytical Results	November 26, 2012 Analytical Results	May 14, 2013 Analytical Results	August 19, 2013 Analytical Results	November 25-26, 2013 Analytical Results	Units	15A NCAC 2L Standard
BC-20	34,080	104,000	71,200	**475,000**	**271,000**	168,000	µg/L	250,000
BC-21	85,400	185,000	91,500	**487,000**	**496,000**	173,000	µg/L	
BC-25	**353,000**	**428,000**	**394,000**	**930,000**	**858,000**	**657,000**	µg/L	
BC-26	19,760	20,200	16,500	17,300	NS	15,900	µg/L	
BC-32	NS	NS	NS	NS	**490,000**	**517,000**	µg/L	

Notes:

1. µg/L indicates micrograms per liter.
2. 15A NCAC 2L Standard refers to Class GA Standards as found in 15A NCAC 02L. 0202 Groundwater Quality Standards, last amended on April 1, 2013.
3. Bold values indicate values that attain or exceed the 15A NCAC 2L Standard.
4. NS indicates not sampled.
5. Concentrations based on data in Duke Energy Carolinas, LLC analytical results database.

Table 4--Selected TDS Analytical Results for Monitoring Wells BC-20, BC-21, BC-25, BC-26, and BC-32 Duke Energy Carolinas LLC/Belews Creek Steam Station FGD Residue Landfill, Permit No. 8505

Well ID	November 7, 2011 Analytical Results	May 8, 2012 Analytical Results	November 26, 2012 Analytical Results	May 14, 2013 Analytical Results	August 19, 2013 Analytical Results	November 25-26, 2013 Analytical Results	Units	15A NCAC 2L Standard
BC-20	168,000	246,000	214,000	**772,000**	**485,000**	323,000	µg/L	500,000
BC-21	261,000	391,000	224,000	**800,000**	**829,000**	330,000	µg/L	
BC-25	**623,000**	**719,000**	**668,000**	**1,480,000**	**1,410,000**	**1,030,000**	µg/L	
BC-26	91,000	80,000	78,000	95,000	NS	96,000	µg/L	
BC-32	NS	NS	NS	NS	**789,000**	**794,000**	µg/L	

Notes:

1. µg/L indicates micrograms per liter.
2. 15A NCAC 2L Standard refers to Class GA Standards as found in 15A NCAC 02L. 0202 Groundwater Quality Standards, last amended on April 1, 2013.
3. Bold values indicate values that attain or exceed the 15A NCAC 2L Standard.
4. NS indicates not sampled.
5. Concentrations based on data in Duke Energy Carolinas, LLC analytical results database.

Table 5–Selected Selenium Analytical Results for Monitoring Wells BC-20, BC-21, BC-25, BC-26, and BC-32 Duke Energy Carolinas LLC/Belews Creek Steam Station FGD Residue Landfill, Permit No. 8505

Well ID	November 7, 2011 Analytical Results	May 8, 2012 Analytical Results	November 26, 2012 Analytical Results	May 14, 2013 Analytical Results	August 19, 2013 Analytical Results	November 25-26, 2013 Analytical Results	Units	15A NCAC 2L Standard
BC-20	<1	<1	1.18	2.19	1.96	1.78	µg/L	20
BC-21	<1	3.3	2.55	1.36	**23.7**	2.69	µg/L	
BC-25	1.92	3.45	3.70	19.2	14.1	7.98	µg/L	
BC-26	<1	<1	<1	<1	NS	<1	µg/L	
BC-32	NS	NS	NS	NS	6.03	5.72	µg/L	

Notes:

1. µg/L indicates micrograms per liter.
2. 15A NCAC 2L Standard refers to Class GA Standards as found in 15A NCAC 02L. 0202 Groundwater Quality Standards, last amended on April 1, 2013.
3. Bold values indicate values that attain or exceed the 15A NCAC 2L Standard.
4. NS indicates not sampled.
5. Concentrations based on data in Duke Energy Carolinas, LLC analytical results database.
6. Analytical results with "<" preceeding the result indicates that the parameter was not detected at a concentration which attains or exceeds the laboratory method reporting limit (MRL).

A

Appendix A

Letter from North Carolina Department of Environment and Natural Resources,

November 9, 2011, To Ed Sullivan, P.E., Duke Energy DOC ID 15487.

North Carolina Department of Environment and Natural Resources
Division of Waste Management

Beverly Eaves Perdue
Governor

Dexter R. Matthews
Director

Dee Freeman
Secretary

November 9, 2011

Mr. Ed Sullivan, P.E.
Mail Code EC13K
PO Box 1006
Charlotte, NC 28201

RE: Monitoring Well BC-25 Assessment
Duke Energy - Belews Creek FGD Landfill
Permit #85-05
Stokes County
DOC ID 15487

Dear Mr. Sullivan:

A review of groundwater analytical data from the FGD Landfill indicates exceedances of groundwater standards established in 15A NCAC 2L .0202 (2L Standards) during the May 6, 2011 monitoring event. Iron has been reported at concentrations greater than the 2L Standards in groundwater samples collected from BC-25. Monitor well BC-25 appears to be located outside the compliance boundary. Industrial landfills are required to comply with the 2L standards at the compliance boundary in accordance with 15A NCAC 13B .503 (2)(d)(iv).

Duke Energy shall acquire the services of a North Carolina licensed professional geologist and submit a groundwater assessment work plan to the Solid Waste Section (Section) outlining how the reported metals contamination in BC-25 will be delineated. The Section will review the submitted work plan, approve, or request additional information or amendments before implementation. Please submit this work plan within 90 days of receiving this letter. The work plan may include, but not limited to an alternate source demonstration for the metals contamination. In addition, monitoring wells BC-20, BC-21, BC-23A, BC-26, BC-27, BC-29 and BC-31 have iron and manganese concentrations above their respective 2L Standards and appear to be located at or beyond the review boundary, which triggers the need for assessment.

The Section solicits your cooperation and would like to remind you that it is your responsibility to comply with the requirements of the rules and statues since the rules are self-implementing. Please contact me at (919) 707-8253 or via email Elizabeth.werner@ncdenr.gov if you have any questions or concerns regarding this letter. Thank you in advance for your anticipated cooperation in this matter.

Sincerely,

Elizabeth S Werner
Hydrogeologist

cc: William M. Miller, PE, Altamont Environmental Inc.
Mark Poindexter, SWS
Ellen Lorscheider, SWS
Jason Watkins, SWS
Hugh Jernigan, SWS
Central File

B

Appendix B

Letter from North Carolina Department of Environment and Natural Resources,

November 28, 2012, To Ed Sullivan, P.E., Duke Energy DOC ID 17761.

North Carolina Department of Environment and Natural Resources
Division of Waste Management

Beverly Eaves Perdue
Governor

Dexter R. Matthews
Director

Dee Freeman
Secretary

November 28, 2012

Sent via email to Ed.Sullivan@duke-energy.com

Mr. Ed Sullivan, P.E.
Mail Code EC13K
PO Box 1006
Charlotte, NC 28201

RE: Groundwater Assessment Report Response
Duke Energy – Belews Creek FGD Landfill
Permit #85-05
Stokes County
DOC ID 17761

Dear Mr. Sullivan:

The Solid Waste Section (Section) has reviewed the Groundwater Assessment Report for the Belews Creek Steam Station FGD Landfill submitted by HDR Engineering, Inc. of the Carolinas on October 5, 2012 (Doc ID 17400). The Section approves the three recommendations described in the report. These recommendations are as follows:

1. Install a new monitoring well south of BC-25, between BC-25 and the landfill, and along the same alignment of BC-20 as humanly possible. The Section understands the difficulty in finding a good location for the new well due to the overhead electric transmission lines. After installation and initial sampling of the new well, a supplemental assessment will be conducted for the new well along with BC-21, BC-20, BC-25 and BC-26.
2. Resample BC-21 when the new well is sampled and submit the results with the supplemental assessment described above.
3. Continue to perform semi-annual water quality monitoring at all groundwater wells and the surface water monitoring location.

If you have any questions, please do not hesitate to contact me via email Elizabeth.werner@ncdenr.gov or phone (919) 707-8253.

Sincerely,

Elizabeth S Werner
Hydrogeologist
Solid Waste Section

cc: William M. Miller, HDR
Hugh Jernigan, SWS
Mark Poindexter, SWS
Larry Frost, SWS
Jason Watkins, SWS
Central File

C

Appendix C

Groundwater Monitoring Well BC-32 Installation Report,

FGD Residue Landfill Compliance Network,

Duke Energy Belews Creek Steam Station, S&ME Project No. 1584-13-075

GROUNDWATER MONITORING WELL
BC-32 INSTALLATION
FGD Residue Landfill Compliance Network

Duke Energy Belews Creek Steam Station
Belews Creek, North Carolina

S&ME Project No. 1584-13-075

Prepared for:

DUKE ENERGY® CAROLINAS

526 South Church Street
Charlotte, North Carolina 28202

Prepared by:

S&ME

3718 Old Battleground Road
Greensboro, North Carolina 27410

September 17, 2013

September 17, 2013

Ms. Kimberlee Hutchinson, P.E.
Mail Code EC13K
Duke Energy
3195 Pine Hall Road
Belews Creek, North Carolina 27009

Via electronic mail to Kim.Hutchinson@duke-energy.com

Reference: **GROUNDWATER MONITORING WELL BC-32 INSTALLATION**
FGD Residue Landfill Compliance Network
Duke Energy Belews Creek Steam Station
Belews Creek, North Carolina
S&ME Project No. 1584-13-075

Dear Ms. Hutchinson:

As requested, S&ME, Inc. (S&ME), installed one shallow groundwater compliance monitoring well (BC-32) at a location pre-determined by Duke Energy (Duke) near the FGD Landfill at Belews Creek Steam Station. The project was completed in general accordance to S&ME Proposal No. 1584-13-P190, dated July 19, 2013, and as authorized by Duke Energy Carolina, LLC Purchase Order No. 6612219. Additional technical reference for the project was Duke Energy's *Water Quality Monitor Plan-FGD Scrubber Residue Landfill*. This report summarizes the well installation activities and includes the associated documentation as referenced.

WELL INSTALLATION ACTIVITIES

S&ME installed shallow groundwater compliance monitoring well BC-32 at the location shown on the attached figure titled *As-Built Survey of Well BC-32*. The installation location is within Duke's transmission right-of-way, with Duke's authorization.

Prior to arrival on site, all down-hole equipment was cleaned with high pressure hot water utilizing a steam cleaner. All drilling activities were performed under the responsibility of a North Carolina registered well driller provided by S&ME. An Environmental Scientist, Lyndal Butler, was on-site during drilling activities and performed soil classification under the supervision of North Carolina Licensed Geologist, Edmund Henriques.

Drilling activities were performed using a track-mounted, CME 550X drill rig on August 12, 2013. A soil boring was advanced using 4 ¼-inch inside diameter hollow stem augers. Standard Penetration Testing was performed with split spoon samples collected

at 5-foot intervals until the boring was terminated at an approximate depth 29.5 feet below ground surface. Apparent man-made fill soil was encountered in the first 4 feet of the soil boring. The fill was underlain by residuum consisting of sandy silt and silty sand. Partially weathered rock (as defined by the Standard Penetration Test exceeding 100 blows per foot) consisting of sandy silt was encountered from a depth 18 feet below ground surface until boring termination. Bedrock was not encountered by the soil boring. A more complete description of the subsurface conditions is provided on the *Completion Report of Well No. BC-32* included in Appendix I.

After boring completion, a Type II monitoring well was constructed within the boring. The well was constructed of 2-inch diameter Schedule 40 PVC screen and casing. The screen comprised a 15-foot length section of manufactured well screen with 0.010-inch width slots and a pre-packed sand filter, installed at the bottom of the borehole. The remaining annulus between the borehole and pre-packed screen was filled with #2 filter sand to a height 1.6 feet above the top of the screen. Above the sand interval, a 2.6-foot thick bentonite seal was placed and hydrated. Approximately 1.5 hours after hydrating the bentonite seal, the remaining annular space was filled with neat cement grout proportioned with 5 gallons of water for each 97-pound bag of Portland cement.

On August 13, the well was completed with an above grade 4-inch, post-type, lockable, steel protective cover and 2-foot square concrete pad. The well number (BC-32) was scribed into the concrete surface of the well pad and a permanent well ID tag was engraved and attached to the protective cover. Three, 5-foot length steel traffic guard posts, primed and painted yellow prior to installation, were installed in a triangular pattern around the monitoring well, in boreholes 2± feet deep filled with Sakrete®. Soil spoils, from the boring proper and guard post installations, were stockpiled near the well location at the request of Duke.

The monitoring well construction described above is depicted on the *Completion Report of Well No. BC-32* included in Appendix I. Also, Appendix I includes a copy of the *Well Construction Record (NCDENR Form GW-1)* that S&ME submitted (under separate cover) to the North Carolina Department of Environment and Natural Resources, as required by regulation.

WELL DEVELOPMENT, SLUG TESTING, AND SURVEY

On August 14, 2013, monitoring well BC-32 was developed in order to remove clay, silt, sand and other fines which may have been introduced into the formation or sand pack during the drilling and well installation activities, and to establish equilibrium of the well with the aquifer. Well development was performed with a portable, electric well pump and polyethylene tubing with a ball valve that were decontaminated prior to use.

Development continued until the development water was relatively clear and sediment free. During development, S&ME recorded pH, conductivity, temperature, ORP, turbidity and depth to water. These measurements along with total volumes purged are summarized on the *Groundwater Sampling Field Data* sheet included in Appendix II.

On August 15, 2013, two rising head permeability tests (slug tests) were performed at newly installed well BC-32. The slug testing initially comprised lowering a pressure transducer to below the water level into the well for the collection of time, temperature, and pressure. Time was allowed for the water level to equilibrate from the transducer insertion and the water level was recorded as the initial measurement from which to measure water level recovery. Water was then removed from the well by pumping and the pressure transducer/data recorder recorded the rate of water level change back toward static condition. The test was repeated after the water level recovered approximately 89%.

The transducer data were graphically evaluated in the field using Win-Situ® computer software. The Win-Situ® data were imported into Microsoft Excel® for analysis using Bouwer-Rice techniques (Bouwer, 1989; Bouwer and Rice, 1976) for partially- or fully-penetrating well screens using Aqtesolv® computer software. Based on the data obtained during the slug tests, the hydraulic conductivity for well BC-32 ranged from 2.7×10^{-4} to 3.2×10^{-4} centimeters per second. *Well Test Analysis* sheets for each slug test performed on well BC-32 are included in Appendix II.

On August 15, 2013, S&ME subcontractor Providence Land Group, PLLC, surveyed the top of casing elevation and location of well BC-32 relative a temporary site datum(s), as shown on the attached figure *As Built Survey of Well BC-32* (Appendix I).

CLOSING

S&ME appreciates this and every opportunity we have to be of service to you and Duke Energy. We trust this information is responsive to your needs at this time. If you have any questions, please do not hesitate to contact us.

Sincerely,
S&ME, Inc.

Lynda Butler
Environmental Scientist

Edmund Q.B. Henriques, L.G.
Environmental Department Manager

Senior Reviewed by Larry Armstrong, P.E.

LB/EQBH/lss

ATTACHMENTS/APPENDICES
Figures:
As Built Survey of Well BC-32
Appendix I:
Completion Report of Well No. BC-32
Well Construction Record (NCDENR Form GW-1)
Appendix II:
Groundwater Sampling Field Data
Well Test Analysis sheets

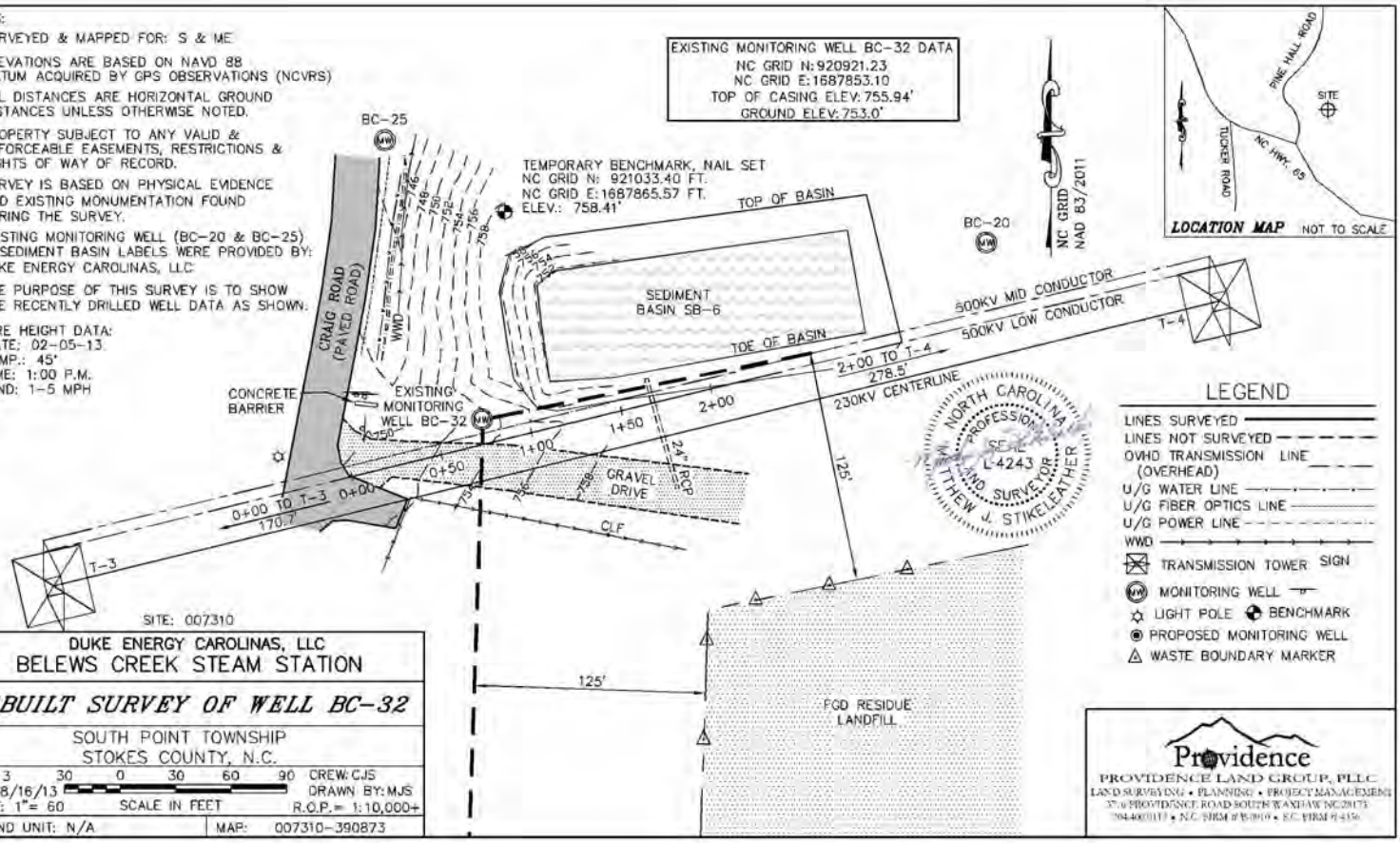
FIGURES

As Built Survey of Well BC-32

NOTES:

- SURVEYED & MAPPED FOR: S & ME
- ELEVATIONS ARE BASED ON NAVD 88 DATUM ACQUIRED BY GPS OBSERVATIONS (NCVRS)
- ALL DISTANCES ARE HORIZONTAL GROUND DISTANCES UNLESS OTHERWISE NOTED.
- PROPERTY SUBJECT TO ANY VALID & ENFORCEABLE EASEMENTS, RESTRICTIONS & RIGHTS OF WAY OF RECORD.
- SURVEY IS BASED ON PHYSICAL EVIDENCE AND EXISTING MONUMENTATION FOUND DURING THE SURVEY.
- EXISTING MONITORING WELL (BC-20 & BC-25) & SEDIMENT BASIN LABELS WERE PROVIDED BY: DUKE ENERGY CAROLINAS, LLC
- THE PURPOSE OF THIS SURVEY IS TO SHOW THE RECENTLY DRILLED WELL DATA AS SHOWN.
- WIRE HEIGHT DATA:
  DATE: 02-05-13
  TEMP.: 45°
  TIME: 1:00 P.M.
  WIND: 1-5 MPH

EXISTING MONITORING WELL BC-32 DATA
NC GRID N: 920921.23
NC GRID E: 1687853.10
TOP OF CASING ELEV: 755.94'
GROUND ELEV: 753.0'



LEGEND

- LINES SURVEYED
- LINES NOT SURVEYED
- OVHD TRANSMISSION LINE (OVERHEAD)
- U/G WATER LINE
- U/G FIBER OPTICS LINE
- U/G POWER LINE
- WWD
- TRANSMISSION TOWER SIGN
- MONITORING WELL
- LIGHT POLE
- BENCHMARK
- PROPOSED MONITORING WELL
- WASTE BOUNDARY MARKER

SITE: 007310

DUKE ENERGY CAROLINAS, LLC
BELEWS CREEK STEAM STATION

ASBUILT SURVEY OF WELL BC-32

SOUTH POINT TOWNSHIP
STOKES COUNTY, N.C.

BOOK: 3 | CREW: CJS
DATE: 8/16/13 | DRAWN BY: MJS
SCALE: 1"= 60 | SCALE IN FEET | R.O.P.= 1:10,000+
LAND UNIT: N/A | MAP: 007310-390873

Providence
PROVIDENCE LAND GROUP, PLLC
LAND SURVEYING • PLANNING • PROJECT MANAGEMENT
37 N. PROVIDENCE ROAD SOUTH WAXHAW NC 28173
704.400.0117 • N.C. FIRM # C-3819 • S.C. FIRM # 4356

APPENDIX I

Completion Report of Well No. BC-32

Well Construction Record
(NCDENR Form GW-1)

COMPLETION REPORT OF WELL No. BC-32

PROJECT: **Belews Creek Steam Station - FGD Landfill**
PROJECT NO: **1584-13-075**
PROJECT LOCATION: **Belews Creek, NC**

WATER LEVEL: **Depth to water 16.41 feet below top of casing**
LATITUDE: **NC Grid N: 920921.23**
LONGITUDE: **NC Grid E: 1687853.10**
TOP OF CASING ELEVATION: **755.94**
DATUM: **NAVD 88 (Vertical)**
LOGGED BY: **L. Butler**

DRILLING CONTRACTOR: **J. Little**
DRILLING METHOD: **4 ¼" H.S.A.**
DATE DRILLED: **8/12/13**

STRATA

DESCRIPTION	SYMBOL	DEPTH (ft.)
Topsoil Fill: Brown Tan Fine Slightly Sandy **SILT**; Dry		0
Topsoil Residuum: Tan and Orange Gray Silty Fine to Medium **SAND**; Dry		5
Orange To Gray Brown Fine Sandy **SILT** with Relict texture; Micaceous; Damp		10, 15
Partially Weathered Rock: sampled as Gray Brown Fine Sandy **SILT** with Relict texture; Micaceous; Moist; Saturated at 21 feet		20, 25

WELL DETAILS

DEPTH (ft.)	LEGEND	ELEVATION (ft.)
0.00	GS	753.00
0.01	CG	752.99
9.80	BS	743.20
12.40	FP	740.60
14.00	TSC	739.00
29.40	BSC	723.60
29.50	TD	723.50

WELL CONSTRUCTION DETAILS

PROTECTIVE CASING
Diameter:
Type:
Interval:

RISER CASING
Diameter: **2"**
Type: **SCH40 PVC**
Interval: **2.94'-14'**

GROUT
Type: **Neat Cement Grout**
Interval: **0'-9.8'**

SEAL
Type: **Bentonite**
Interval: **9.8'-12.4'**

FILTERPACK
Type: **#2 Sand**
Interval: **12.4'-29.4'**

SCREEN
Diameter: **2"**
Type: **0.010'**
Interval: **14'-29'**

LEGEND
- FILTER PACK
- BENTONITE
- CEMENT GROUT
- CUTTINGS / BACKFILL
- STATIC WATER LEVEL

TOC	TOP OF CASING
GS	GROUND SURFACE
BS	BENTONITE SEAL
FP	FILTER PACK
TSC	TOP OF SCREEN
BSC	BOTTOM OF SCREEN
TD	TOTAL DEPTH
CG	CEMENT GROUT

S&ME
ENGINEERING • TESTING
ENVIRONMENTAL SERVICES

COMPLETION REPORT OF WELL No. BC-32

MONITORING WELL 1584-13-075 BELEWS CREEK.GPJ S&ME.GDT 9/17/13

WELL CONSTRUCTION RECORD

This form can be used for single or multiple wells

1. Well Contractor Information:

S&ME, Inc.

Well Contractor Name

2717A

NC Well Contractor Certification Number

S&ME, Inc.

Company Name

2. Well Construction Permit #: _____

List all applicable well permits (i.e. County, State, Variance, Injection, etc.)

3. Well Use (check well use):

Water Supply Well:

- ☐Agricultural
- ☐Municipal/Public
- ☐Geothermal (Heating/Cooling Supply)
- ☐Residential Water Supply (single)
- ☐Industrial/Commercial
- ☐Residential Water Supply (shared)
- ☐Irrigation

Non-Water Supply Well:

- ☑Monitoring
- ☐Recovery

Injection Well:

- ☐Aquifer Recharge
- ☐Groundwater Remediation
- ☐Aquifer Storage and Recovery
- ☐Salinity Barrier
- ☐Aquifer Test
- ☐Stormwater Drainage
- ☐Experimental Technology
- ☐Subsidence Control
- ☐Geothermal (Closed Loop)
- ☐Tracer
- ☐Geothermal (Heating/Cooling Return)
- ☐Other (explain under #21 Remarks)

4. Date Well(s) Completed: August 12, 2013 **Well ID#** BC-32

5a. Well Location:

Duke Energy Carolinas LLC

Facility/Owner Name

Facility ID# (if applicable)

3195 Pine Hall Road, Belews Creek 27009

Physical Address, City, and Zip

Stokes

County

Parcel Identification No. (PIN)

5b. Latitude and Longitude in degrees/minutes/seconds or decimal degrees:
(if well field, one lat/long is sufficient)

NC Grid N 920921.23 N NC Grid E 1687853.10 W

6. Is (are) the well(s): ☑**Permanent** or ☐**Temporary**

7. Is this a repair to an existing well: ☐**Yes** or ☑**No**

If this is a repair, fill out known well construction information and explain the nature of the repair under #21 remarks section or on the back of this form.

8. Number of wells constructed: 1

For multiple injection or non-water supply wells ONLY with the same construction, you can submit one form.

9. Total well depth below land surface: 29.50 **(ft.)**

For multiple wells list all depths if different (example- 3@200' and 2@100')

10. Static water level below top of casing: 16.41 **(ft.)**

If water level is above casing, use "+"

11. Borehole diameter: 8 **(in.)**

12. Well construction method: auger rotary

(i.e. auger, rotary, cable, direct push, etc.)

FOR WATER SUPPLY WELLS ONLY:

13a. Yield (gpm) _____ **Method of test:** _____

13b. Disinfection type: _____ **Amount:** _____

For Internal Use ONLY:

14. WATER ZONES

FROM	TO	DESCRIPTION
13.5 ft.	29.5 ft.	
ft.	ft.	

15. OUTER CASING (for multi-cased wells) OR LINER (if applicable)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
- ft.	- ft.	in.		

16. INNER CASING OR TUBING (geothermal closed-loop)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
- ft.	- ft.	in.		
ft.	ft.	in.		

17. SCREEN

FROM	TO	DIAMETER	SLOT SIZE	THICKNESS	MATERIAL
14 ft.	29 ft.	2020 M in.	0.010"	Sch. 40	PVC
ft.	ft.	2" in.			

18. GROUT

FROM	TO	MATERIAL	EMPLACEMENT METHOD & AMOUNT
0 ft.	9.8 ft.	cement grout	gravity, 235 pounds
9.8 ft.	12.4 ft.	bentonite	gravity, 50 pounds
ft.	ft.		

19. SAND/GRAVEL PACK (if applicable)

FROM	TO	MATERIAL	EMPLACEMENT METHOD
12.4 ft.	29.5 ft.	#2 washed sand	gravity
ft.	ft.		

20. DRILLING LOG (attach additional sheets if necessary)

FROM	TO	DESCRIPTION (color, hardness, soil/rock type, grain size, etc.)
0 ft.	3.9 ft.	topsoil and fill- brown tan fine sandy silt
3.9 ft.	9.5 ft.	Res.- v.stiff tan & orange gray silty f-m sand
9.5 ft.	18 ft.	very dense orange & gray brown fine sandy s
18 ft.	29.5 ft.	partially weathered rock as fine sandy silt
ft.	ft.	
ft.	ft.	
ft.	ft.	

21. REMARKS

22. Certification:

Signature of Certified Well Contractor — Date: 9-12-2013

By signing this form, I hereby certify that the well(s) was (were) constructed in accordance with 15A NCAC 02C .0100 or 15A NCAC 02C .0200 Well Construction Standards and that a copy of this record has been provided to the well owner.

23. Site diagram or additional well details:

You may use the back of this page to provide additional well site details or well construction details. You may also attach additional pages if necessary.

SUBMITTAL INSTUCTIONS

24a. For All Wells: Submit this form within 30 days of completion of well construction to the following:

Division of Water Resources, Information Processing Unit,
1617 Mail Service Center, Raleigh, NC 27699-1617

24b. For Injection Wells ONLY: In addition to sending the form to the address in 24a above, also submit a copy of this form within 30 days of completion of well construction to the following:

Division of Water Resources, Underground Injection Control Program,
1636 Mail Service Center, Raleigh, NC 27699-1636

24c. For Water Supply & Injection Wells:

Also submit one copy of this form within 30 days of completion of well construction to the county health department of the county where constructed.

APPENDIX II

Groundwater Sampling Field Data

Well Test Analysis Sheets

GROUNDWATER SAMPLING FIELD DATA

Location: Belews Creek Steam Station
Project No.: 1584-13-075
Source Well: BC-32

Locked?: Yes: _____ No: _____
Sampled By: Gary Simcox

Purge Date: Wednesday, August 14, 2013
Purge Time: 6 hours
Sample Date: _____
Sample Time: _____
Weather: Sunny
Air Temp: 75 *F

Water Level & Well Data

Depth to water from measuring point: 16.41 feet
Depth to well bottom from measuring point: 33.00 feet
Height of water column: 16.59 feet
Measuring point: TOC

Well Purging & Sample Collection

Purge Method: Whaler Pump w/ Ball Valve
Sample Method: _____
Purge Rate: 0.25 gal/min
Control Settings: On: _____ sec.
Off: _____ sec.
Pressure: _____ psi

Purge Time
Start 955 Stop 1700

Sample Collection Time
Start _____ Stop _____

Volume of water in well

2" well:

height: 16.59 x .163 = 2.70417

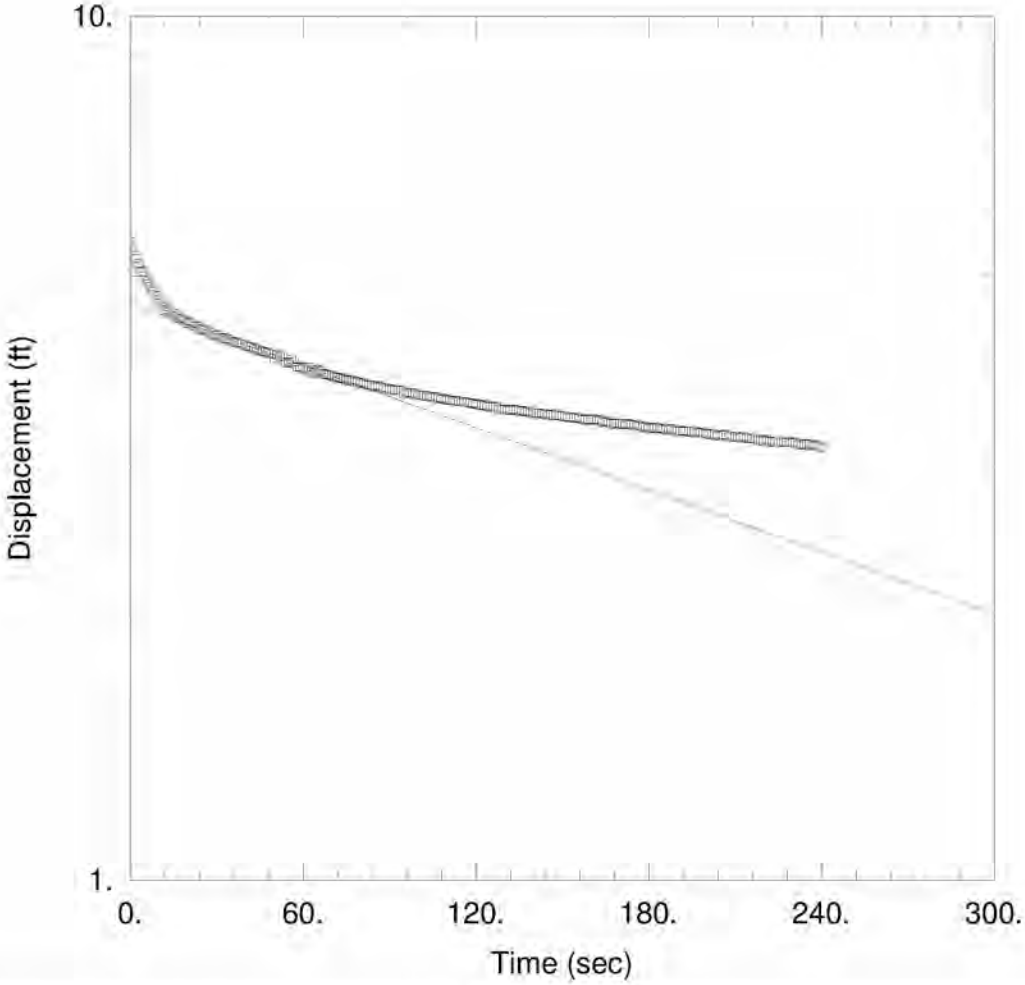
Volume of water removed: 80.0 gallons X liters _____

Was well purged dry: Yes X No _____

Field Analyses

*Stabilization Parameters

Time	Gal.	Temp *C	pH units	Conductivity u S	*ORP	*D.O.	*Turbidity NTU	DTW
1015	10.0	18.50	5.84	863.000	n/m	n/m	36.0	24.42
1040	20.0	18.90	5.88	862.000	n/m	n/m	16.6	25.64
1105	25.0	19.50	5.82	909.000	n/m	n/m	2.27	25.97
1125	30.0	18.30	5.85	922.000	n/m	n/m	70.1	29.46
1145	35.0	18.50	5.89	952.000	n/m	n/m	145	31.14
1205	40.0	19.30	5.90	916.000	n/m	n/m	211	Dry
Note: Let well recover for approx. 60 minutes (18')								
1340	45.0	18.30	5.78	836.000	n/m	n/m	149	22.99
1400	50.0	18.10	5.67	885.000	n/m	n/m	49.1	27.14
1425	55.0	18.70	5.74	889.000	n/m	n/m	267	29.56
1445	60.0	18.80	5.77	909.000	n/m	n/m	458	Dry
Note: Let well recover for approx. 45 minutes (22')								
1545	65.0	18.20	5.64	908.000	n/m	n/m	43.2	26.48
1610	70.0	19.10	5.71	872.000	n/m	n/m	14.0	27.88
1635	75.0	19.00	5.68	902.000	n/m	n/m	10.7	29.17
1700	80.0	18.80	5.71	906.000	n/m	n/m	14.6	30.25



WELL TEST ANALYSIS

Data Set: S:\...\Slug test for BC-32 (cps).aqt
Date: 09/17/13 Time: 11:02:08

PROJECT INFORMATION

Company: S&ME, Inc.
Client: Duke Energy
Project: 1264-10-075
Location: Belews Creek, NC
Test Well: BC-32
Test Date: 8/15/13

AQUIFER DATA

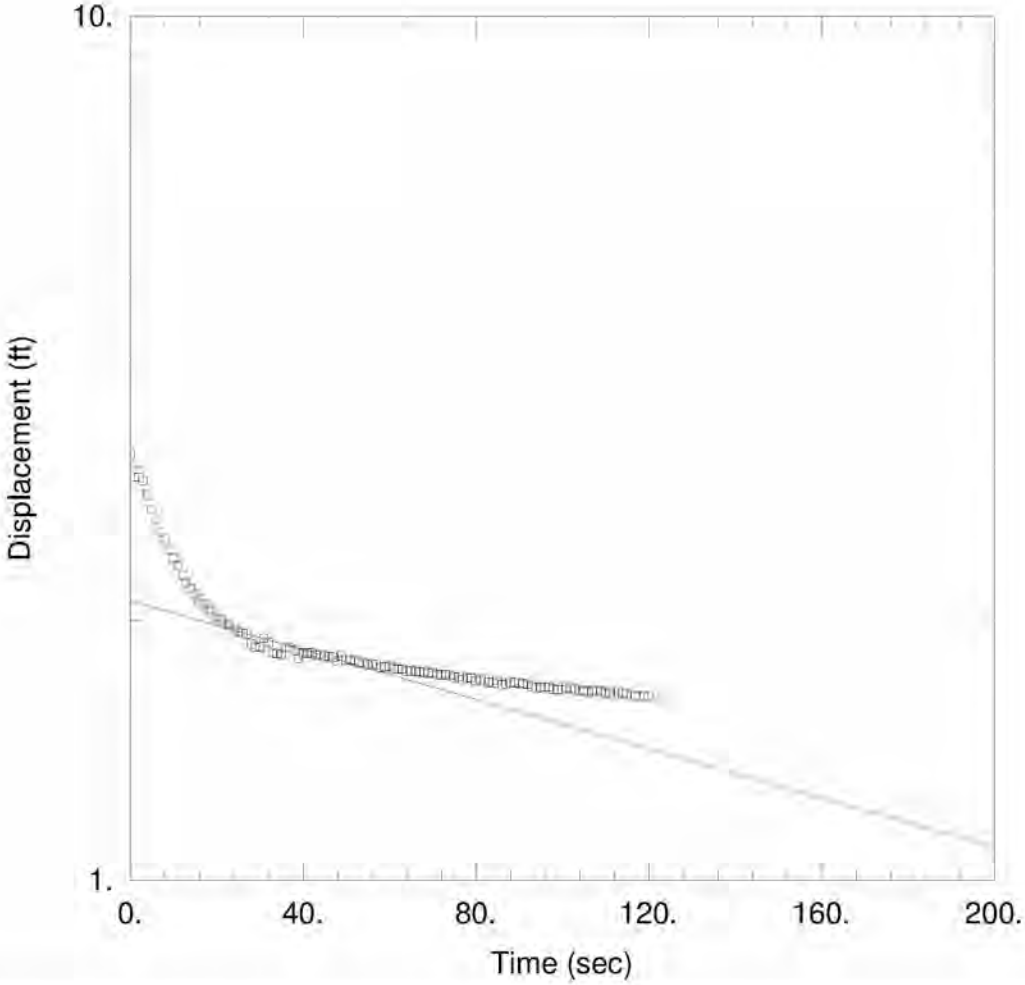
Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BC-32)

Initial Displacement: 5.48 ft
Total Well Penetration Depth: 16.03 ft
Casing Radius: 0.083 ft
Static Water Column Height: 13.97 ft
Screen Length: 15. ft
Well Radius: 0.333 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0002719 cm/sec
y0 = 4.648 ft



WELL TEST ANALYSIS

Data Set: S:\...\Slug test for BC-32 (2) (cps).aqt
Date: 09/17/13 Time: 11:04:19

PROJECT INFORMATION

Company: S&ME, Inc.
Client: Duke Energy
Project: 1264-10-075
Location: Belews Creek, NC
Test Well: BC-32
Test Date: 8/15/13

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BC-32)

Initial Displacement: 3.11 ft
Total Well Penetration Depth: 16.03 ft
Casing Radius: 0.083 ft
Static Water Column Height: 13.97 ft
Screen Length: 15. ft
Well Radius: 0.333 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0003234 cm/sec
y0 = 2.106 ft