GROUNDWATER ASSESSMENT
BELEWS CREEK STEAM STATION
PINE HALL ROAD ASH LANDFILL
PERMIT NO. 8503

Prepared for:
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Belews Creek Steam Station
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Charlotte, North Carolina

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REPORT VERIFICATION

PROJECT: **GROUNDWATER ASSESSMENT**
BELEWS CREEK STEAM STATION
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This document has been reviewed for accuracy and quality commensurate with the intended application.

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Section 1
Introduction

The Pine Hall Road Ash landfill, Permit No. 8503, 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 wells MW-3 and MW-6 during the April 19, 2011, monitoring event. This letter is included as Appendix A.

The NCDENR letter stated that iron and manganese were reported at concentrations greater than their respective 2L Standards in the groundwater samples collected from MW-3 and MW-6 during this event. Monitoring well MW-3 is located outside the compliance boundary, and MW-6 appears to be located near 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 concentrations of boron, chromium, iron, manganese, nitrate, selenium, and sulfate were reported at concentrations above their respective 2L Standards in groundwater monitoring wells MW2-7, MW2-9, and MW-4. 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 Solid Waste Section. 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.

HDR Engineering Inc. of the Carolinas (HDR) has prepared this assessment on behalf of Duke Energy. This document presents the results of the assessment of groundwater exceedances at groundwater monitoring wells MW-3, MW2-7, MW2-9, MW-4, and MW-6 and at surface water sample locations SW-1A and SW-2. Groundwater monitoring well MW-7 has also been included based on a revised review boundary location.

[1] *North Carolina Department of Environment and Natural Resources. Division of Waste Management. November 9, 2011, Monitoring Wells MW-3 and MW-6 Assessment. Duke Energy – Belews Creek Pine Hall Road Landfill. DOC ID 15485.*

Section 2
Background

2.1 Site and Landfill Description

The Pine Hall Road Ash 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. It is Duke Energy's largest coal-burning power plant in the Carolinas and consistently ranks among the most efficient coal facilities in the United States.

The Pine Hall Road Ash Landfill was originally permitted in 1983 under NCDENR Solid Waste Permit No. 8503. The landfill was permitted to accept only fly ash from Belews Creek Steam Station operations and was closed in December 2008. The original landfill was unlined and was permitted with a soil cap 1-foot thick on the side slopes and 2-feet thick on flatter areas. A subsequent expansion (Phase 1 Expansion) was permitted in 2003. This phase was also unlined but was permitted with a synthetic cap system to be applied at closure.

After exceedances of 2L Standards were observed in groundwater monitoring wells installed near the landfill, no additional ash was placed in the Phase 1 Expansion. After discussions with NCDENR, in June 2007 Duke Energy responded by submitting a design[2] for an engineered cover system, consisting of a 40-mil Linear Low Density Polyethylene geomembrane, a geonet composite, 18 inches of compacted soil, and 6 inches of vegetative soil cover. The engineered cover system was installed over a 37.9 acre area. An adjacent 14.5 acre area, located to the northeast, had additional soil cover applied and was graded to improve surface drainage. NCDENR approved the closure plan on December 7, 2007, and issued a draft permit for closure.[3] The cover system was installed as a corrective action measure, as described in the Construction Certification Report.[4] The cover system was substantially completed in December 2008.

The Pine Hall Road Ash Landfill and nearby surrounding area are shown on Figure 1. The landfill is located to the north of the surface water divide that runs parallel to Pine Hall Road and east of the surface water divide that runs along Middleton Loop Road. The Belews Creek Steam Station ash basin is located to the north of the landfill and labeled as a "tailings pond" on Figure 1. The ash basin is operated as a water treatment facility and permitted by the National Pollutant Discharge Elimination System (NPDES) program (NPDES Permit #NC0024406).

Two surface water drainage features are located in the area of the landfill. One surface water drainage feature is on the eastern side of the landfill and drains to the ash basin. The second

[2] *Closure Plan, Pine Hall Road Ash Landfill, Duke Energy – Belews Creek Steam Station, Belews Creek, North Carolina, S&ME Project No. 1411-06-108*, dated June 21, 2007, Document ID RCO03497.

[3] Closure Plan Approval, Duke Energy – Belews Creek Steam Station, Pine Hall Road Ash Landfill, Permit 85-03, Stokes County, Document ID No. RCO3425.

[4] *Executive Summary, Construction Certification Report, Pine Hall Road Ash Landfill Closure, Permit 85-03, Duke Energy, Belews Creek Steam Station, Belews Creek, North Carolina*, S&ME Project No. 1356-07-017 Phase 3, Revised February 2009.

surface water drainage feature is located on the western side of the landfill and also drains to the ash basin.

2.2 Site Geology and Hydrogeology

A report on the geology/hydrology of the landfill site was prepared as part of the permitting process for the 2003 landfill expansion. The report, *Geology/Hydrogeology of the Existing Belews Creek Ash Landfill (Permit #85-03) and Proposed Ash Landfill Expansion Site, Stokes County, North Carolina*,[5] (2001 hydrogeologic report) serves as the background for the discussion of the site geology and hydrology.

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 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 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 the 2001 hydrogeologic 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.

2.3 Description of Monitoring System

The groundwater monitoring system at the landfill consists of the following sampling locations as listed below.

Monitoring Wells:	MW-1	MW-1D
	MW-2	MW-3
	MW-4	MW-5
	MW-6	MW-7
	MW2-7	MW2-9
	OB-4	OB-5
	OB-9	
Surface Water Sample Locations	SW-1A	SW-2

[5] Geology/Hydrogeology of the Existing Belews Creek Ash Landfill (Permit #85-03) and Proposed Ash Landfill Expansion Site, Stokes County, North Carolina, September 18, 2001, Duke Engineering & Services.

The locations of the monitoring wells and surface water sample locations are shown on Figure 2. MW-3 is defined by the Groundwater Monitoring Sampling and Analysis Plan (SAP) for the Pine Hall Road Ash Landfill dated November 8, 2010, to represent "background" groundwater quality. The screen for MW-1D is located in fractured bedrock and the other wells are screened to monitor the surfical groundwater in the residual soil/saprolite layer.

The surface water sample locations SW-1A and SW-2 are groundwater seeps which are indicative of groundwater. Therefore, analytical results from groundwater samples collected from these locations are compared to 2L Standards.

2.4 Site Groundwater Flow

Pine Hall Road is located along a topographic high and appears to be coincident with a groundwater divide. Groundwater flow at the site is from areas of higher topography along Pine Hall Road to discharge areas located at lower elevations. The ash basin appears to be the primary discharge area for groundwater flowing generally northward from the groundwater divide. A component of groundwater flow is likely towards the drainage area located to the west of the landfill, running between MW-5 and OB-9. This drainage feature drains to the northeast into the ash basin.

Generalized groundwater surface contours for the site are shown on Figure 3. These contours were developed using the groundwater elevations measured in the wells from the April 23-24, 2012 groundwater sampling event.

Based on the contours developed from groundwater elevations measured during sampling events, the groundwater flow under the landfill is flowing generally toward the surface water drainage features located to the west and east of the landfill and to the northwest and north toward the ash basin.

2.5 Groundwater Quality Monitoring

Groundwater monitoring wells MW-1, MW-2, MW-3, MW-4, and MW-5 were installed in 1989. The initial semi-annual groundwater sampling was performed at these wells beginning in October 1989.

Monitoring wells MW-6, MW2-7, MW2-9, OB-4, OB-5, and OB-9 were installed, and monitoring initiated, as part of the site investigation for the Phase 1 Expansion and subsequent investigation of groundwater exceedances from 2000 to 2004.

Monitoring wells MW-1D and MW-7 were installed after installation of the engineered cover system in 2008.

Monitoring began at surface water sample locations SW-1 and SW-2 in 2005. The groundwater seep at SW-1 was impacted by construction activities and as a result, this location was replaced by SW-1A in 2009. SW-2 was relocated to the current location in October 2009. The previous location was near OB-9.

In accordance with the SAP for the Pine Hall Road Ash Landfill dated November 8, 2010, groundwater monitoring is performed semiannually in April and October. Sampling results are submitted to NCDENR within 60 days of sampling.

In addition to the semiannual constituents listed in the SAP, the groundwater samples are also analyzed for 40 Code of Federal Regulations (CFR) Part 258 Appendix I constituents. Appendix I sampling and analysis is performed as part of the requirements contained in the Closure Plan Approval letter dated December 7, 2007, Document ID RC03425. Condition 11 of that document states:

Ground-water and surface water samples should be analyzed for Appendix I constituents in addition to currently analyzed constituents semi-annually. Appendix I analytical data will be evaluated, and based on results, the compliance Branch of the SWS may not require continued Appendix I analysis.

As a result, the Appendix I constituents have been included in the monitoring program beginning with the April 2009 sampling event.

2.6 Revision to Review Boundary Location near MW-7

During review of the site figures, HDR observed that the review boundary, in the region of MW-7 and MW2-9, appears to have been located from ash placement prior to the final grading associated with the installation of the engineered cover system in 2008. The correct location of the review boundary is 125 feet from the waste under the engineered cover system. Measuring 125 feet from the edge of waste under the engineered cover system, the review boundary moves towards the landfill, as shown in Figure 2.

MW-7 is located at the relocated review boundary. Exceedances reported at MW-7 will be addressed in this assessment based on the revised review boundary location.

2.7 Groundwater Quality Exceedances

As noted in the NCDENR letter dated November 9, 2011, exceedances of the 2L Standards were reported for groundwater monitoring wells during the April 19, 2011, monitoring event. After review of the NCDENR letter, a telephone conversation was conducted between representatives from NCDENR, Duke Energy, and Altamont concerning these exceedances. Participating in that conversation were Ms. Elizabeth Werner, Hydrogeologist (NCDENR), Mr. Ed Sullivan, P.E. (Duke Energy), and Mr. Bill Miller, P.E. (Altamont). During the conversation, Duke Energy proposed that exceedances reported from groundwater sampling events more recently than noted in the NCDENR letter of November 9, 2011, would be addressed in the proposed assessment work plan. NCDENR agreed with this proposal.

Table 1 presents the 2L Standard exceedances reported in the assessment work plan for MW-3 and MW-6 and the analytical results for these constituents from the April 24, 2012, sampling event. These wells are located at or beyond the compliance boundary.

Note that for the sampling performed on April 24, 2012, the analytical results at MW-3 for cobalt, iron, and vanadium, and the analytical results at MW-6 for manganese were below their respective 2L Standards or 2L IMAC. However, since previous sample results were in excess of the 2L Standards, an assessment is provided.

Table 1 – Selected Analytical Results for MW-3 and MW-6

Parameter	Well ID	Analytical Result Reported In Assessment Work Plan (Date Varies)	April 24, 2012 Analytical Result	Units	15A NCAC 2L Standard
Cobalt	MW-3(1)	1.05	0.667 U	µg/L	1*
Iron	MW-3(1)	344	195	µg/L	300
	MW-6(2)	666	178	µg/L	
Manganese	MW-6(2)	55.1	11.5	µg/L	50
Vanadium	MW-3(1)	1.43	0.667 U	µg/L	0.3*

Notes:

1. Result from October 10-11, 2011 sampling event
2. Result from April 19-20, 2011 sampling event

* Indicates 2L Interim Maximum Allowable Concentration (IMAC), Effective January 1, 2010.
U indicates analytical laboratory data qualifier indicating concentrations not detected at concentrations above the method detection limit.

Table 2 presents the 2L Standard exceedances reported in the assessment work plan for MW2-7, MW2-9, and MW-4 and the results from the April 23-24, 2012 sampling event. These wells are located at or beyond the review boundary.

Table 2 – Selected Analytical Results for MW2-7, MW2-9, MW-4, and MW-7

Parameter	Well ID	October 10-11, 2011 Analytical Result	April 23-24, 2012 Analytical Result	Units	15A NCAC 2L Standard
Boron	MW2-7	22,900	21,580	µg/L	700*
	MW2-9	1,421	598	µg/L	
	MW-7	6,740	3,673	µg/L	
Chromium	MW-4	10.14	13.4	µg/L	10
Cobalt	MW2-9	11.92	20	µg/L	1*
	MW-7	<1	1.38	µg/L	
Iron	MW2-9	5,778	11,960	µg/L	300
	MW-7	1,159	8,157	µg/L	
Manganese	MW2-9	5,223	13,070	µg/L	50
	MW-7	113	419	µg/L	
Nitrate as Nitrogen	MW2-7	38,250	34,630	µg/L	10,000
Selenium	MW2-7	204	192	µg/L	20
	MW-7	66.73	35.4	µg/L	
Sulfate	MW2-7	1,140,000	1,240,000	µg/L	250,000
	MW-7	311,300	173,600	µg/L	
Total Dissolved Solids	MW2-7	1,947,000	2,010,000	µg/L	500,000
Vanadium	MW-4	2.42	<1	µg/L	0.3*
	MW-7	1.9	5.84	µg/L	

* Indicates 2L Interim Maximum Allowable Concentration (IMAC), Effective January 1, 2010.

Table 3 presents the 2L Standard exceedances reported in the assessment work plan for surface water sample locations SW-1A and SW-2 and the results from the April 23-24, 2012, sampling event. These surface water sample locations are located at or beyond the review boundary.

Table 3 – Selected Analytical Results for SW-1A and SW-2

Parameter	Sample Location	October 10-11, 2011 Analytical Result	April 23-24, 2012 Analytical Result	Units	15A NCAC 2L Standard
Boron	SW-1A	20,250	16,770	µg/L	700*
	SW-2	3,279	2,988	µg/L	
Manganese	SW-1A	941	1,346	µg/L	50
	SW-2	63.65	65	µg/L	
Nitrate as Nitrogen	SW-1A	30,560	25,340	µg/L	10,000
Selenium	SW-1A	159	128	µg/L	20
	SW-2	22.76	22.3	µg/L	
Sulfate	SW-1A	960,600	870,700	µg/L	250,000
Total Dissolved Solids	SW-1A	1,717,000	1,470,000	µg/L	500,000

* Indicates 2L Interim Maximum Allowable Concentration (IMAC), Effective January 1, 2010.

Section 3
Assessment of Groundwater Exceedances

The assessment of the groundwater at Pine Hall Road Ash Landfill was performed as stated in the proposed assessment work plan. In general, the assessment work plan consisted of the following:

Assessment of exceedances for monitoring wells at or beyond the compliance boundary; MW-3 and MW-6:

- MW-3 - Review site groundwater and hydrogeologic reports to determine if groundwater flow from the landfill is toward MW-3.
- MW-3 and MW-6 - Assessment of exceedances of 2L Standards to determine if the exceedances can be attributed to the site background water quality and/or to sediment or particulate matter that is preserved in the groundwater samples as a result of well construction or groundwater sampling.

Assessment of exceedances at or beyond the review boundary for MW2-7, MW2-9, MW-4, MW-7, and at surface water sample locations SW-1A and SW-2:

- Perform a review of the landfill hydrogeologic boundaries. Continue to perform groundwater monitoring on a semiannual basis to monitor the performance of the cover system. The synthetic cover system was installed in December 2008 to minimize rainwater infiltration through the placed fly ash. With reduced infiltration, the groundwater concentrations of constituents attributable to fly ash measured in these wells will likely decrease over time.

3.1 Assessment of Groundwater Exceedances at Monitoring Well MW-3

Note that the analytical results at MW-3 for cobalt, iron, and vanadium for the sampling performed on April 24, 2012, were below the 2L Standards and 2L IMAC. However, since previous sample results were in excess of the 2L Standards, the following assessment is provided.

3.1.1 Review Site Groundwater Flow and Hydrogeologic Reports

MW-3 is located outside of the compliance boundary. This well is located to the east of the landfill, approximately 920 feet from the edge of waste, and is north of Pine Hall Road. MW-3 was installed on August 11, 1989, as part of the groundwater monitoring system for the initial permitted landfill footprint. The well installation records, well depth, and screen interval are described in the 2001 landfill permit application.[6] The well screen was installed in the saprolite layer at a depth of 37 to 47 feet below ground surface (bgs). The SAP described MW-3 as the background monitoring well. The boring log indicates that partially weathered rock lies immediately below the bottom of the well screen.

[6] Duke Energy Belews Creek Steam Station Stokes County, N.C., Landfill Permit Application—Siting Package, October 2, 2001, Volume 2, Attachment .0504(1)(c), Geological and Hydrological Study for Proposed Landfill Site

The 2001 hydrogeologic report prepared for the permit application for the 2001 expansion was reviewed. This report was prepared using information from the wells installed in 1989 and from additional site borings performed for the permit application. The attached Figures BCK-01 and BCK-02 are from that report and show the site, locations of borings, and cross sections. These figures also present site groundwater contours (upper left corner of BCK-01) and contours showing the upper elevation for weathered/fractured bedrock (Area 1 detail in upper right corner of BCK-02).

MW-3 is located to the north of Pine Hall Road, which is located generally along a surface water divide south of the landfill. The ground surface slopes generally to the southeast along the south side of the road and to the northwest along the north side of the road. As shown in the Area 1 detail on Figure BCK-02, the top of weathered/fractured rock contours exhibit a high point between MW-3 and the landfill. The top of weathered/fractured rock and topographical contours both show a divide into two drainage features that lead to the ash basin.

The groundwater contours on BCK-02 are generally consistent with recent depictions of groundwater contours at the site. Figure 3 shows the groundwater contours from the April 2012 sampling event superimposed on the constructed landfill footprint. These groundwater contours show flow from the landfill towards the ash basin, not in the direction of MW-3.

Based on the pre-Phase I construction groundwater contours and current groundwater contours and the flow direction inferred from those contours, MW-3 is not located where groundwater flowing from the landfill would flow to the well location. Although the well is not upgradient from the landfill, it represents background water quality conditions at the site.

3.1.2 Evaluate if the Sources of Exceedances are Naturally Occurring and are from Sediment or Other Particulate Matter

The analytical results for iron at MW-3 have ranged from an initial and maximum value of 8,540 µg/L in October 1989 to a minimum in April 1995, when the lab reported no results detected above 10 µg/L. The April 24, 2012, analytical result for iron was 195 µg/L, which is below the 2L Standard of 300 µg/L and is the lowest reported since April 2007.

Analytical testing for cobalt and vanadium began in April 2009. The analytical results for cobalt exceeded the 2L IMAC[7] in April 2009, measuring 3.6 µg/L, and in October 2011, measuring 1.05 µg/L. The analytical results for the remaining sampling events were reported below the method detection limit (MDL). The MDL for the April 2012 sample was 0.667 µg/L, which is below the Solid Waste Section Limit (SWSL) of 10 µg/L. Therefore, the results for cobalt are considered estimated in accordance with the February 23, 2007, memo.[8]

[7] IMAC or interim maximum allowable concentration.

[8] Matthews, Dexter R. Memo to Solid Waste Directors, Landfill Operators, North Carolina Certified Laboratories, and Consultants. North Carolina Department of Environment and Natural Resources, Division of Waste Management, Solid Waste Section, Raleigh, NC. February 23, 2007.

The analytical results for vanadium have ranged from an initial concentration of 1.2 µg/L in April 2009 to a maximum of 1.43µg/L in October 2011. The vanadium results from the April 2012 sampling were below the MDL, which is 0.667 µg/L, and below the SWSL of 25 µg/L. Therefore, the lab results for vanadium are considered estimated in accordance with the February 23, 2007, memo.

Turbidity values range from an initial value of 8.7 NTUs in October 2000 to a high of 45.5 NTUs in October 2007. The October 2007 sampling event also measured one of the highest iron concentrations. The turbidity measured in the April 24, 2012 event was 19.8 NTUs. The EPA recommends that when possible, especially when sampling for contaminants that may be biased by the presence of turbidity, that the turbidity values in the stabilized well be less than 10 NTUs. (US EPA 2002)

Figure 4 shows the historic analytical results for iron at MW-3 plotted with the measured turbidity values on the secondary axis. Figure 5 shows the historic analytical results for cobalt at MW-3 plotted with the measured turbidity values on the secondary axis. Figure 6 shows the historic analytical results for vanadium at MW-3 plotted with the measured turbidity values on the secondary axis. In Figure 4, a visual correlation can be observed between iron and turbidity results, with increases and decreases in iron results corresponding with increases and decreases in turbidity. In Figures 5 and 6, a visual correlation is not observed between the results for cobalt and vanadium and turbidity results.

Based on the direction of site groundwater flow and the well location, MW-3 does not receive groundwater flow from the landfill. Therefore, the exceedances for iron, cobalt, and vanadium cannot be attributed to Pine Hall Road Ash Landfill. Additionally, the well has exhibited turbidity in excess of 10 NTUs, and the results for iron, cobalt, and vanadium are likely attributed to naturally occurring conditions at the site.

3.2 Assessment of Groundwater Exceedances at Monitoring Well MW-6

Note that the analytical results at MW-6 for iron and manganese from the sampling performed in October 2011 and April 2012 were below the 2L Standards. However, since previous sample results were in excess of the 2L Standards, the following assessment is provided.

MW-6 is located outside of the compliance boundary approximately 185 feet south of the edge of waste. The well was installed on May 3, 2000, as part of the groundwater monitoring system for the proposed expansion of the Pine Hall Road Ash Landfill. The well screen was installed in the residuum layer at a depth of 24 to 34 feet bgs.

MW-6 is located on the south side of Pine Hall Road, which is a topographic or surface water divide. The surface topography generally slopes to the north along the north side of the road and slopes to the south along the south side of the road. As shown on figures BCK-01 and BCK-02, a groundwater divide is located generally along the north side of Pine Hall Road. Both MW-2 and MW-6 are located on the south side of the groundwater divide. The groundwater divide shown on this drawing was developed including data from observation well OB-1, which was abandoned when the engineered cover system was installed. Groundwater flow on the north side of the groundwater divide, where the landfill is located, is generally towards the ash basin, not southward towards MW-6.

As shown on Figure 7, the analytical results for iron at MW-6 have ranged from a minimum of 61 µg/L in April 2007 to a maximum of 1,522 µg/L in April 2005. The April 24, 2012, results for iron were 178 µg/L, below the 2L Standard and the third lowest measurement to date. Figure 7 also shows the results of the filtered samples collected during the April 2012 sampling event. These were field filtered with an in-line, sealed, 0.45 micron filter. The filtered results for iron were <10 µg/L and the unfiltered results were 178 µg/L.

Figure 8 shows that the manganese results have ranged from no results detected above 5 µg/L in April 2006 and 2007 to a maximum of 73.8 µg/L in April 2010. The manganese results for the April 2012 sampling were 11.5 µg/L, well below the 2L Standard of 50 µg/L. Figure 8 also shows the results of the filtered samples collected during the April 2012 sampling event. These were field filtered with an in-line, sealed, 0.45 micron filter. The filtered results for manganese were 3.41 µg/L and the unfiltered results were 11 µg/L.

Turbidity values range from an initial and highest value of 39 NTUs in June 2000 to a low of 1.39 NTUs in October 2011. The measured turbidity was plotted against the analytical results for iron and manganese in Figures 7 and 8, respectively. No visual correlation was observed between iron or manganese and the turbidity results.

Based on review of the site groundwater flow and the analytical results, the source of the iron and manganese exceedances reported to date in MW-6 appear to be naturally occurring sources and not related to impacts associated with Pine Hall Road Ash Landfill.

3.3 Assessment of Groundwater Exceedances at or Beyond The Review Boundary

The NCDENR assessment request was based on review of the results in the semi-annual report for the April 19, 2011, sampling event. Exceedances observed at monitoring wells and surface water sampling locations at or beyond the review boundary after that sampling event were also included in this assessment. Tables 2 and 3 present the groundwater exceedances at MW2-7, MW2-9, MW-4, MW-7 and surface water sampling locations SW-1A and SW-2.

Figure 2 presents the sampling locations for the Pine Hall Road Ash Landfill. Monitoring wells at or beyond the review boundary are screened to monitor surfical groundwater in the residual soil/saprolite layer.

- MW2-7 is located approximately 105 feet to the east of the waste boundary and approximately 40 feet southwest from the sediment basin. The 15-foot long screen was installed at approximately 14 to 29 feet bgs. The sediment basin contains ash transported from the landfill during landfill operations.
- MW2-9 is located approximately 190 feet to the east of the waste boundary. The 10-foot long screen was installed at approximately 2 to 12 feet bgs.
- MW-4 is located approximately 100 feet to the northwest of the waste boundary and approximately 60 feet southeast from the ash basin. A 10-foot long screened zone was installed at approximately 28 to 38 feet bgs.
- MW-7 is located approximately 130 feet to the east of the waste boundary. The 10-foot long screen was installed at approximately 2 to 12 feet bgs in saprolite and partially weathered rock.

Surface water sample locations are groundwater seeps and believed to be representative of groundwater. The sampling locations are in surface drainage features, located on the east and west side of the landfill.

- SW-1A is located approximately 145 feet to the east of the waste boundary and close to MW2-7.
- SW-2 is located approximately 190 feet to the west of the waste boundary.

Boron, total dissolved solids (TDS), and sulfate are among the constituents considered by EPA as indicators of groundwater contamination from coal combustion residues[9] (coal fly ash in the case of the Pine Hall Road Ash Landfill). These constituents are included in the detection monitoring program in the proposed rule for coal combustion residuals (proposed *Appendix III to Part 257*). As described in the referenced proposed rule:

> *In selecting the parameters for detection monitoring, EPA selected constituents that are present in CCRs, and would rapidly move through the subsurface and*

[9] Federal Register/Volume 75, No 118/ Monday, June 21, 2010/Proposed Rules, 35206 Detection Monitoring Program.

thus provide an early detection as to whether contaminants were migrating from the disposal unit.

Iron and manganese were not included in the list of constituents for the detection monitoring program in the proposed rule, however both were included in the list for assessment monitoring in the proposed rule (proposed *Appendix IV to Part 257*).

Boron, TDS, and sulfate can be used as indicators of groundwater contamination from coal combustion residues at sites where they are not typically observed in high concentrations in naturally occurring groundwater. During the April 2012 sampling event, these parameters were measured at background well MW-3 at the following concentrations: boron < 33.4 µg/L; TDS 48,000 µg/L; and sulfate 127 µg/L.

As shown in Table 2 and Table 3 the analytical results for these constituents at MW2-7, MW2-9, and MW-7 and surface water sample locations SW-1A and SW-2 are elevated and indicate impacts to the groundwater at these locations from the landfill.

MW-4 did not exceed the 2L Standard for vanadium in the April 24, 2012 sampling event; however, chromium remained above the 2L Standard and was measured at 13.4 µg/L.

3.3.1 Re-Development and Sampling of Well MW-7

The April 24, 2012, analytical results show that the sample locations with exceedances listed in Table 2 generally did not exhibit high turbidity levels. The exception was the turbidity observed at MW-7, which measured at 134.0 NTUs. The turbidity values for the sample locations with exceedances at the review boundary during the April 24, 2012, sample event are presented in Table 4.

Table 4 - Turbidity Values at Selected Locations April 24, 2012

Sample Location	April 24, 2012 Field Measurement Turbidity (NTUs)
MW-4	3.6
MW2-7	3.5
MW2-9	12.8
MW-7	134.0
SW-1	3.3
SW-2	10.1

In an effort to understand if the turbidity was the cause of the elevated concentrations of iron and other metals at MW-7, the well was redeveloped and then sampled for constituents with exceedances at the well. The redevelopment and sampling was performed on August 28, 2012. Appendix C contains the field data table and the laboratory analytical report (provided by Duke

Energy) for the event. Table presents the analytical results for both the April 24, 2012 and August 29, 2012 sampling events

The turbidity levels after redevelopment of the well decreased from 134.0 NTUs to 8.1 NTUs. There was a significant decrease in the concentrations measured for iron, manganese, cobalt, and vanadium. Iron was measured below the 2L Standard, and manganese was slightly above the 2L Standard.

As shown in Table 5, concentrations of boron, selenium, sulfate, and TDS increased at MW-7 from April 24, 2012 to August 29, 2012, indicating that impacts from the landfill are increasing at this location. However, after redevelopment of the well, a decrease in turbidity was measured, along with a decrease in iron, manganese, cobalt, and vanadium concentrations. This indicates that the exceedances of these constituents at MW-7 were related to turbidity levels.

Table 5 - MW-7 Analytical Results from August 29, 2012, Sampling

Parameter	April 24, 2012 Result	August 29, 2012 Results after Well Redevelopment	Units	15A NCAC 2L Standard
Turbidity	134.0	8.1	NTUs	No Standard
Boron	3,673	5,251	µg/L	700*
Cobalt	1.38	0.667 U	µg/L	1*
Iron	8,157	265	µg/L	300
Manganese	419	59.2	µg/L	50
Selenium	35.4	47.2	µg/L	20
Sulfate	173,600	247,700	µg/L	250,000
Total Dissolved Solids	366,000	522,000	µg/L	500,000
Vanadium	5.84	0.667 U	µg/L	0.3*

* Indicates 2L Interim Maximum Allowable Concentration (IMAC), Effective January 1, 2010.
U – Indicates no results above the laboratory Method Detection Limit

3.3.2 Review of Hydrogeologic Boundaries

A review of the hydrogeologic boundaries at the landfill site was performed, particularly with respect to MW-4, MW2-7, MW2-9, and MW-7 and surface water sample locations SW-1A and SW-2. As described in Sections 2.1, 2.2, and 2.4, based on the site groundwater contours, the groundwater flow under the landfill is flowing generally toward the surface water drainage features located to the west and east of the landfill and to the northwest and north toward the ash basin.

As described in the 2001 hydrogeologic report, the geology and groundwater conditions at the site are consistent with the characteristics of the conceptual groundwater model developed by LeGrand for the Piedmont region. Groundwater flow paths in the Piedmont are almost invariably restricted to the zone underlying the topographic slope extending from a topographic

divide to an adjacent stream. LeGrand describes this as the local slope-aquifer system. LeGrand describes the concave topographic areas between topographic divides as flow compartments that are open-ended down slope. Under natural conditions, the general direction of groundwater flow can be approximated from the surface topography (LeGrand 2004).

In Generalization N-10, LeGrand states that the water-table divides between flow compartments restrict natural groundwater flow between compartments. The water-table divide terms used by LeGrand can also be considered as a groundwater divide. LeGrand also states that the crests of the water table undulations represent natural groundwater divides within a slope-aquifer system and may limit the influence of wells or contaminant plumes within their boundaries. LeGrand describes the boundaries of the slope-aquifer system by stating that a stream, river or lake serves as the lower hydraulic boundary and upper boundary is normally the topographic divide at the ridge top.

The primary hydrogeologic boundaries that form the flow compartment containing the landfill site are the ash basin to the north and the surface water divide, and associated water-table divide, along Pine Hall Road to the south. The groundwater elevation and contours indicate that the ash basin is the primary recharge feature at the landfill site.

The hydrogeologic boundary to the east of the landfill site is the topographic ridge between wells MW-7 and MW-3 that extends northward, decreasing in elevation towards the ash basin. A surface water drainage feature containing SW-1A is located between the landfill site and this ridge. The groundwater elevations and contours depict flow directions that are consistent with these features serving as boundaries.

The hydrogeologic boundary to the west of the landfill site is the topographic ridge running along Middleton Loop Road. A surface water drainage feature containing SW-2 is located between the landfill site and this ridge. The groundwater elevations and contours depict flow directions that are consistent with these features serving as boundaries.

As described in Section 2.1, the ash basin is part of the wastewater treatment system at the Belews Creek Steam Station site. The NPDES permit for the ash basin requires groundwater monitoring, and the ash basin compliance boundary is located 500 feet from the ash basin in accordance with 15A NCAC 02L .0107(a). Figure 2 shows the location of the ash basin compliance boundary near the landfill. MW-2-7, MW-2-9, and MW-4 and surface water sample location SW-1A are located within the compliance boundary for the ash basin. Surface water sample location SW-2 is located approximately at the compliance boundary of the ash basin. MW-7 is located outside of the ash basin compliance boundary.

As described in Section 3.2, Pine Hall Road is located along surface water divide. The surface topography generally slopes to the north along the north side of the road and slopes to the south along the south side of the road. As shown on figure BCK-01 and BCK-02, a groundwater divide is located generally along the north side of Pine Hall Road. Groundwater flow on the north side of the groundwater divide, where the landfill is located, would flow generally towards the ash basin, not southward towards MW-6. MW-6 does not show evidence of constituents that would be attributed to ash.

Based on groundwater contours and surface topography, the surface water drainage feature beginning east of MW-1 and draining northward to the ash basin forms a compartment boundary to the west side of the landfill. MW-1 and MW-5 are located on the west side of this drainage feature and are likely not monitoring groundwater influenced by the landfill. These wells do not show evidence of constituents that would be attributed to ash.

Based on groundwater contours and surface topography, the surface water drainage feature beginning near MW2-9 and draining northward to the ash basin appears to form a compartment boundary on the east side of the landfill. No wells are presently located east of MW-7, MW2-9, and MW-2-7 in this region.

As shown on BCK-02, the 2001 hydrogeologic investigation included groundwater wells that were installed east of the area where MW-7, MW2-9, and MW-2-7 are now located. The groundwater contours shown on figure BCK-02 were developed from groundwater wells and spring heads shown on that figure (i.e., MW-1, MW-2, MW-3, MW-4 and MW-5 and the wells installed for the 2001 hydrogeologic report [MW2-*n* wells, and BC-*n* wells]). The wells installed for the 2001 hydrogeologic report were subsequently abandoned. The groundwater contours on BCK-02 show groundwater flow in the region to the east of the landfill to be generally towards the ash basin with changes in direction that generally are consistent with the surface topography compartments.

3.3.3 Engineered Cover System Performance

The installation of an engineered cover system over approximately 38 acres of the landfill was completed in December 2008. This cover system was designed with a geomembrane barrier, a geocomposite drainage layer, and a vegetative soil cover and was installed to minimize groundwater infiltration through the placed fly ash.

With reduced infiltration, the groundwater concentration of constituents attributable to fly ash measured in the monitoring wells and surface water sampling locations should decrease over time. Monitoring well OB-9 was installed during the site investigation phase associated with the 2001 permit application to expand the landfill. The well is located on the west side of the landfill, approximately 40 feet from the edge of the engineered cover system. During the site investigation phase, the analytical results from MW2-7 and other nearby wells could not be identified to be solely from the ash landfill. OB-9 was installed inside of the review boundary and adjacent to the landfill to provide analytical results that would be solely attributed to the ash landfill.

HDR has reviewed the analytical results at OB-9 for chloride, boron, TDS and sulfate. A reduction of measured concentrations for these constituents would provide an indication that the performance of the engineered cover system is reducing impacts to groundwater. The actual rates of reduction in concentrations depend on the mineralogy of the ash, the infiltration or groundwater flow rate, soil attenuation capacity, and other factors. The rates of reduction in concentrations would likely vary between the different constituents.

Figure 9 presents the analytical results at OB-9 for chloride, boron, TDS, and sulfate. The results for chloride, boron, and TDS peaked at the October 2009 sampling event. As shown on Figure 9, results for those constituents have generally decreased since the peak in Oct 2009. The results for boron have decreased from 33,400 µg/L in October 2009 to 30,400 µg/L in April 2012. TDS has decreased from 2,170,000 µg/L in October 2009 to 2,030,000 µg/L in April 2012.

The results for sulfate decreased from 1,300,000 µg/L in April 2009 to 1,050,000 µg/L in April 2010. Since April 2010, the sulfate results have increased to 1,311,000 µg/L. Based on the results presented in Figure 9, it appears that OB-9 has experienced a reduction in TDS and boron that can likely be attributed to the performance of the engineered cover in reducing impacts to groundwater.

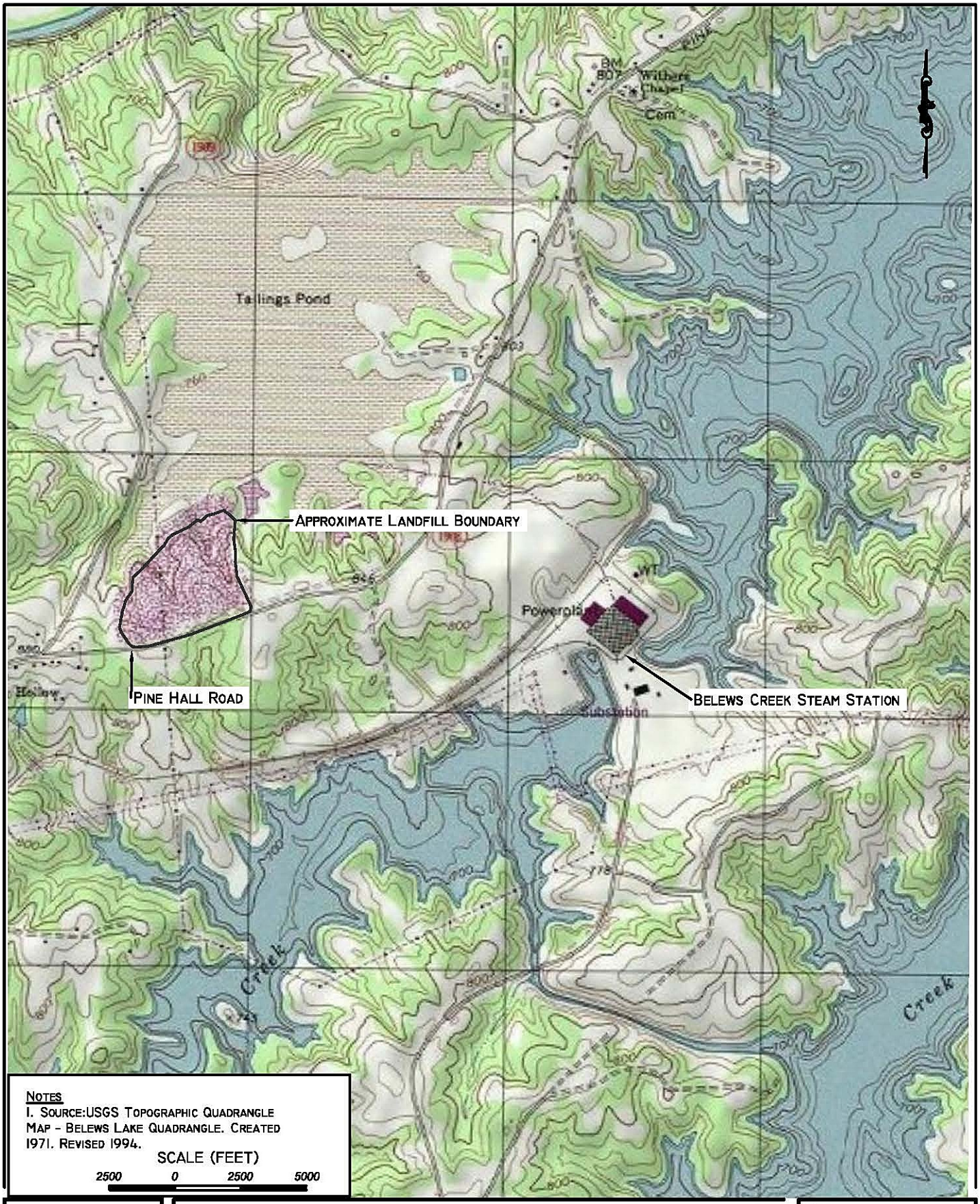
The synthetic cover system was installed in December 2008 to minimize groundwater infiltration through the placed fly ash. With reduced infiltration, the groundwater concentration of constituents attributable to fly ash measured in MW-4, MW2-7, MW2-9, and MW-7 and surface water sample locations SW-1A and SW-2 will likely continue to decrease over time. The time frame and magnitude of reductions in concentrations for these constituents is uncertain. Therefore, HDR recommends groundwater monitoring be continued on a semiannual basis to monitor the performance of the engineered cover system.

Section 4
References

A Master Conceptual Model for Hydrogeological Site Characterization in the Piedmont and Mountain Region of North Carolina. LeGrand, Harry E. Sr. 2004

Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers
GROUND WATER FORUM ISSUE PAPER, Douglas Yeskis and Bernard Zavala, EPA 542-S-02-001, Office of Solid Waste and Emergency Response, May 2002.

FIGURES



NOTES
1. SOURCE:USGS TOPOGRAPHIC QUADRANGLE MAP - BELEWS LAKE QUADRANGLE. CREATED 1971. REVISED 1994.

SCALE (FEET)
2500 0 2500 5000

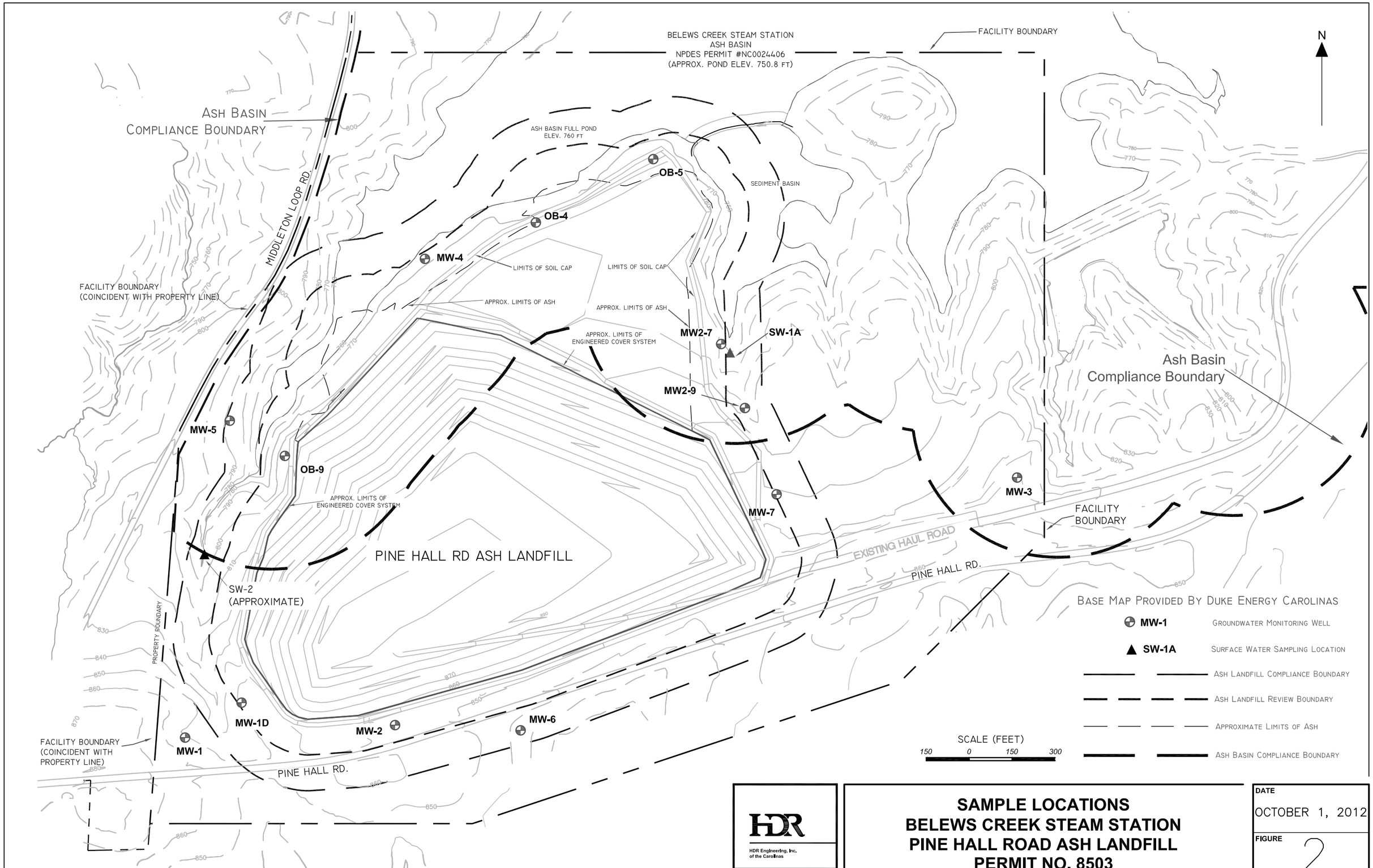
HDR
HDR Engineering, Inc. of the Carolinas
License Number: F-0116
440 South Church Street Charlotte, NC 28202

SITE LOCATION MAP
BELEWS CREEK STEAM STATION
PINE HALL ROAD ASH LANDFILL
PERMIT NO. 8503

DATE
OCTOBER 1, 2012

FIGURE
1

C:\pwworking\tpa\d0383242\Site Location Mapmac.dwg, HDR Fig1, 10/1/2012 4:36:02 PM, avoorhee



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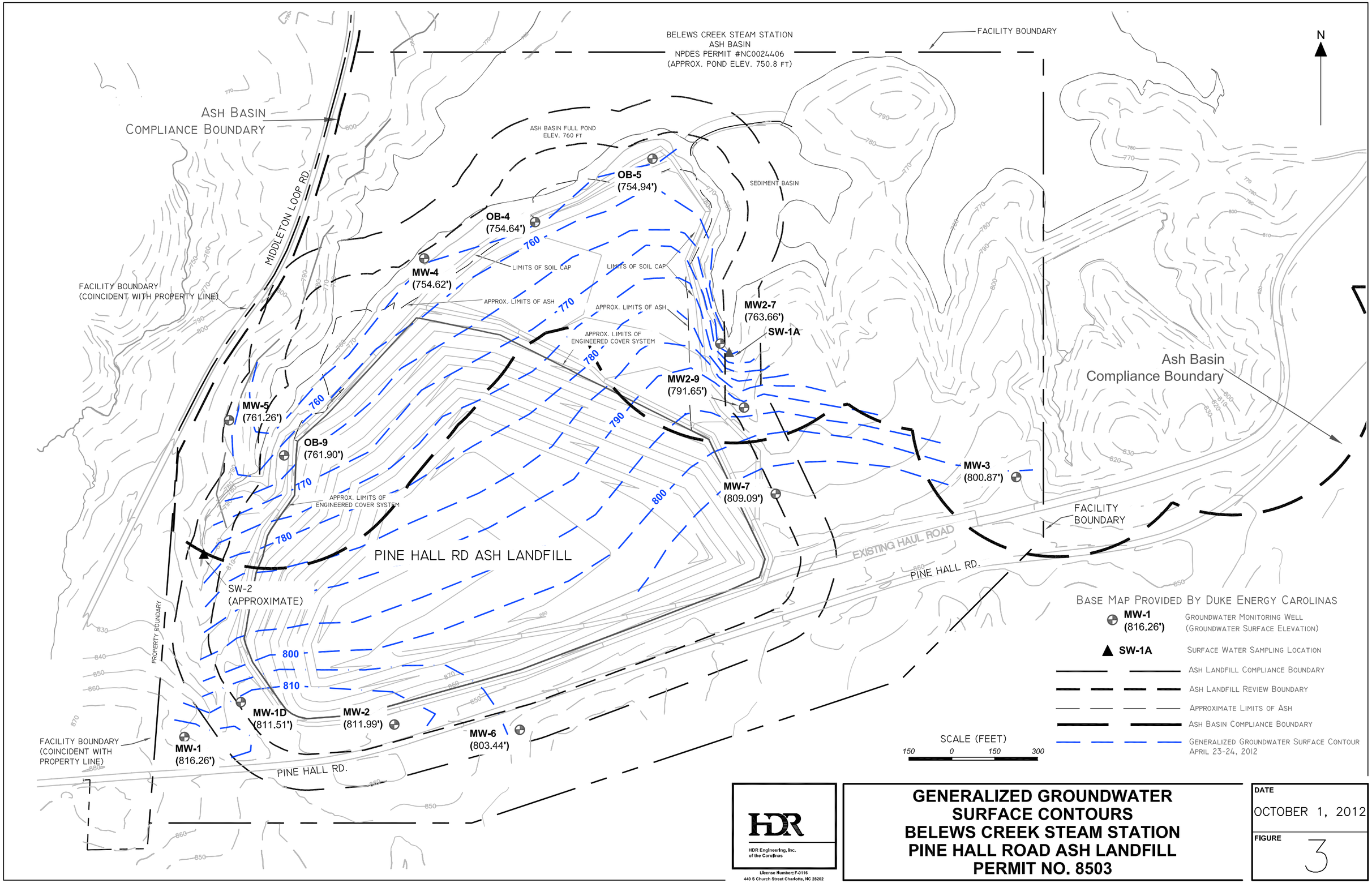
SAMPLE LOCATIONS
BELEWS CREEK STEAM STATION
PINE HALL ROAD ASH LANDFILL
PERMIT NO. 8503

DATE
OCTOBER 1, 2012

FIGURE
2

C:\pwworking\tpad\0383242\Pinehall Rd 2012 Figures 2 & 3 WMM.dwg, HDR Fig 2, 10/1/2012 4:32:53 PM, avoorhee



HDR
HDR Engineering, Inc.
of the Carolinas
License Number: F-0116
440 S Church Street Charlotte, NC 28202

GENERALIZED GROUNDWATER SURFACE CONTOURS
BELEWS CREEK STEAM STATION
PINE HALL ROAD ASH LANDFILL
PERMIT NO. 8503

DATE
OCTOBER 1, 2012

FIGURE
3

C:\pwworking\tpa\d0383242\Pinehall Rd 2012 Figures 2 & 3 WMM.dwg, HDR Fig 3, 10/1/2012 4:33:35 PM, avoorhee

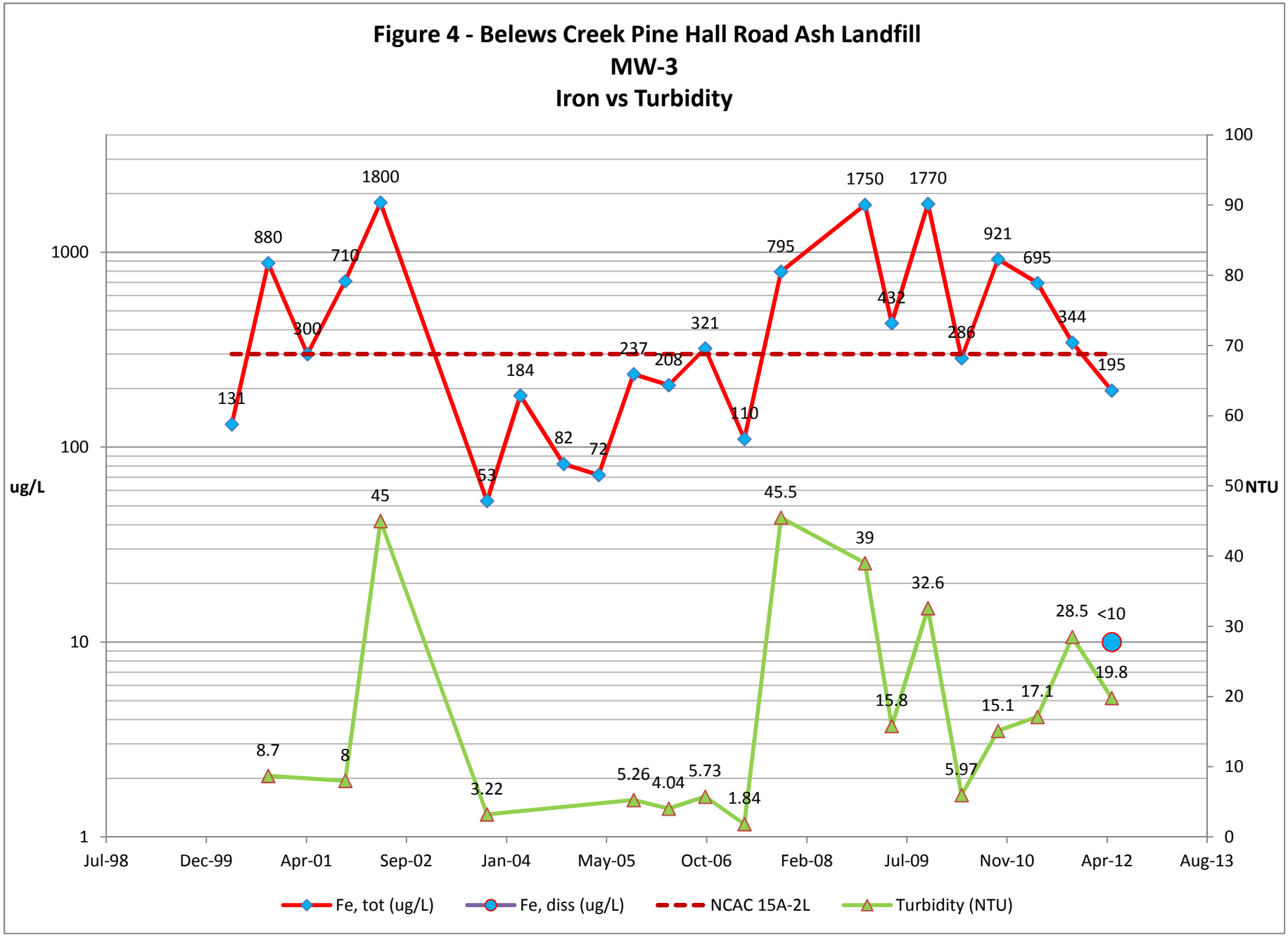


Figure 4 - Belews Creek Pine Hall Road Ash Landfill
MW-3
Iron vs Turbidity
ug/L
NTU
1000
100
10
1
100
90
80
70
60
50
40
30
20
10
0
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
131
880
300
710
1800
53
184
82
72
237
208
321
110
795
1750
432
1770
286
921
695
344
195
8.7
8
45
3.22
5.26
4.04
5.73
1.84
45.5
39
15.8
32.6
5.97
15.1
17.1
28.5
<10
19.8
Fe, tot (ug/L)
Fe, diss (ug/L)
NCAC 15A-2L
Turbidity (NTU)

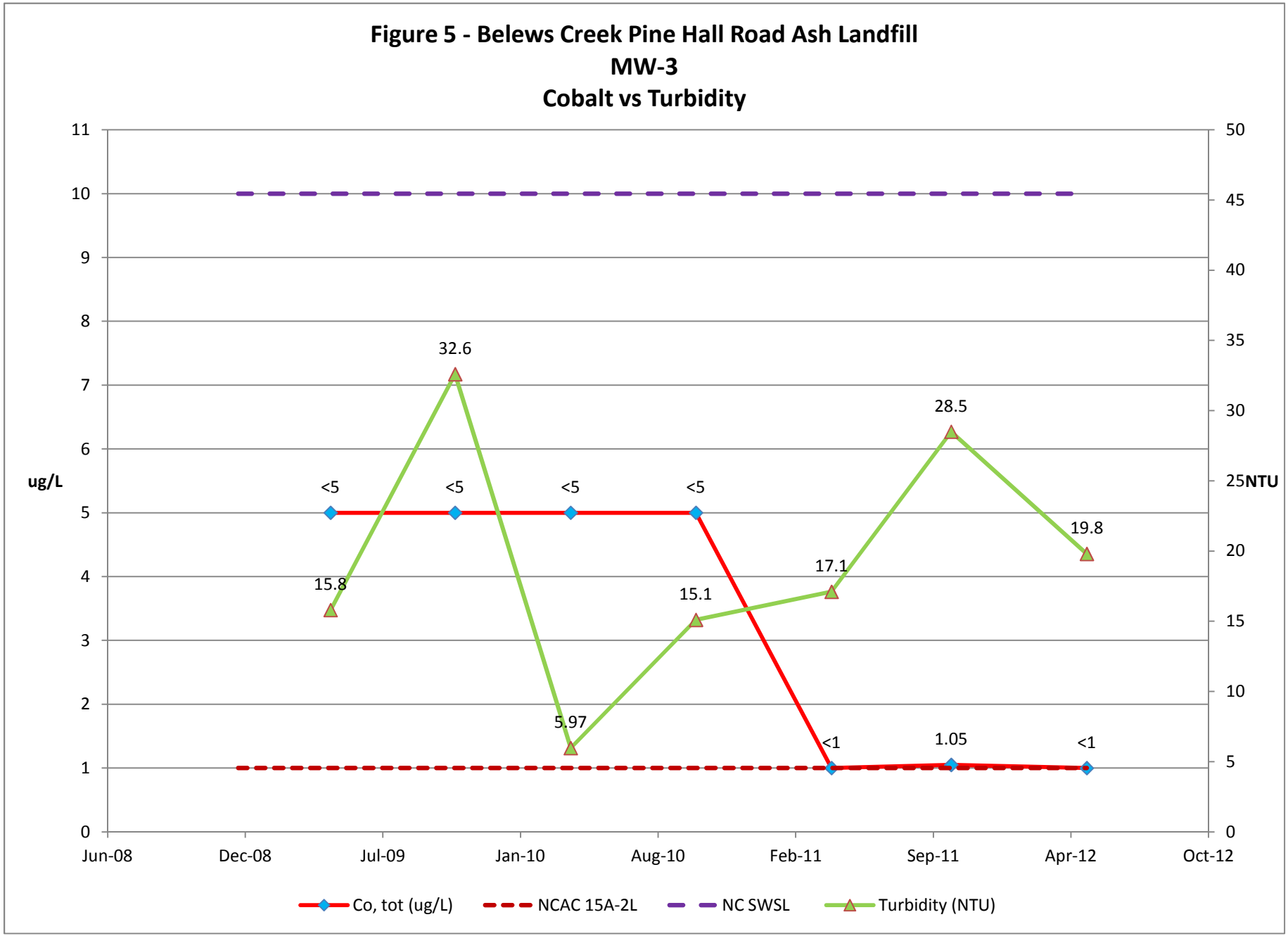


Figure 5 - Belews Creek Pine Hall Road Ash Landfill
MW-3
Cobalt vs Turbidity
ug/L
NTU
11
10
9
8
7
6
5
4
3
2
1
0
50
45
40
35
30
25
20
15
10
5
0
Jun-08
Dec-08
Jul-09
Jan-10
Aug-10
Feb-11
Sep-11
Apr-12
Oct-12
<5
<5
<5
<5
<1
1.05
<1
15.8
32.6
5.97
15.1
17.1
28.5
19.8
Co, tot (ug/L)
NCAC 15A-2L
NC SWSL
Turbidity (NTU)

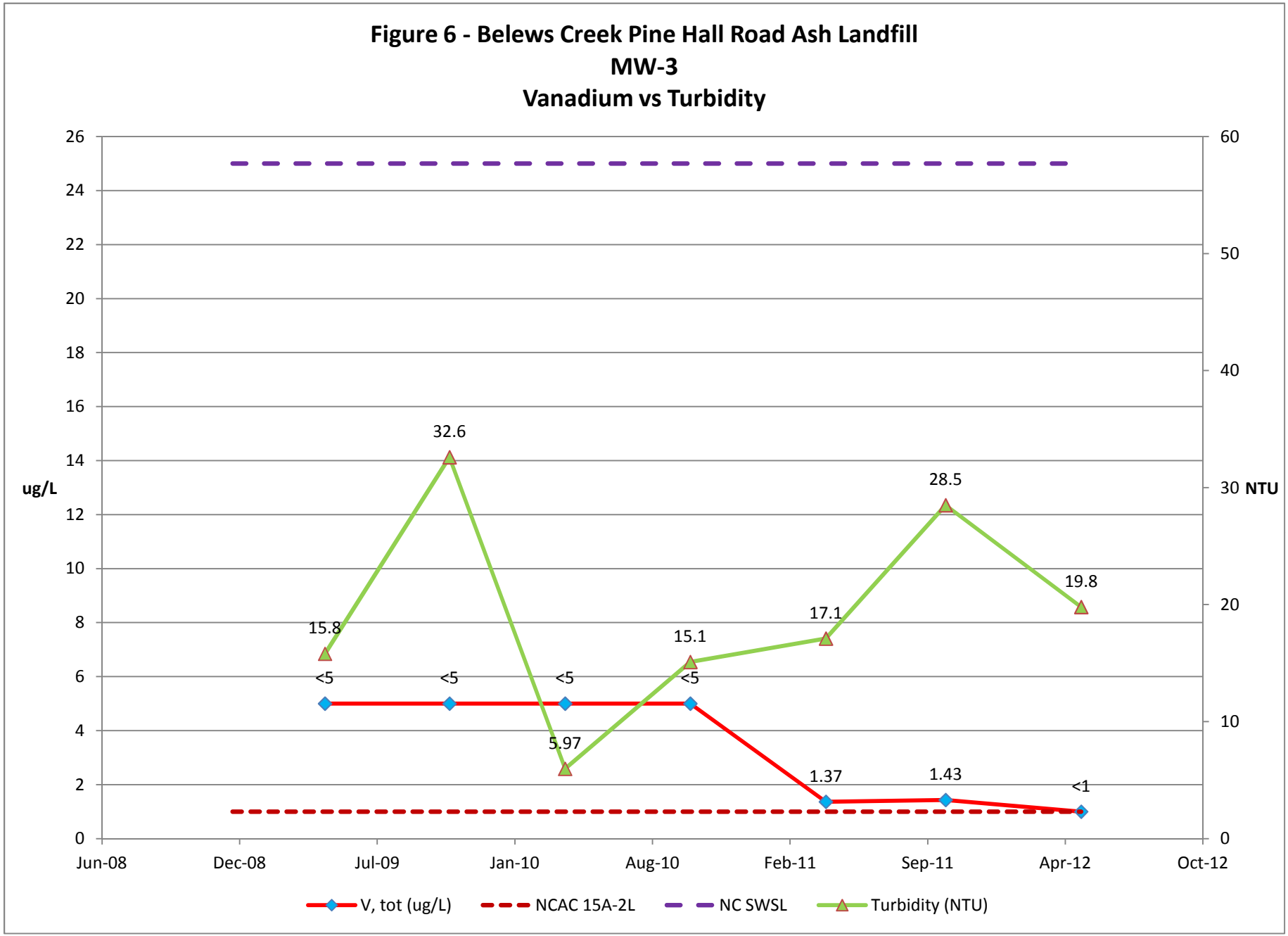


Figure 6 - Belews Creek Pine Hall Road Ash Landfill
MW-3
Vanadium vs Turbidity
ug/L
NTU
26
24
22
20
18
16
14
12
10
8
6
4
2
0
60
50
40
30
20
10
0
Jun-08
Dec-08
Jul-09
Jan-10
Aug-10
Feb-11
Sep-11
Apr-12
Oct-12
15.8
32.6
5.97
15.1
17.1
28.5
19.8
<5
<5
<5
<5
1.37
1.43
<1
V, tot (ug/L)
NCAC 15A-2L
NC SWSL
Turbidity (NTU)

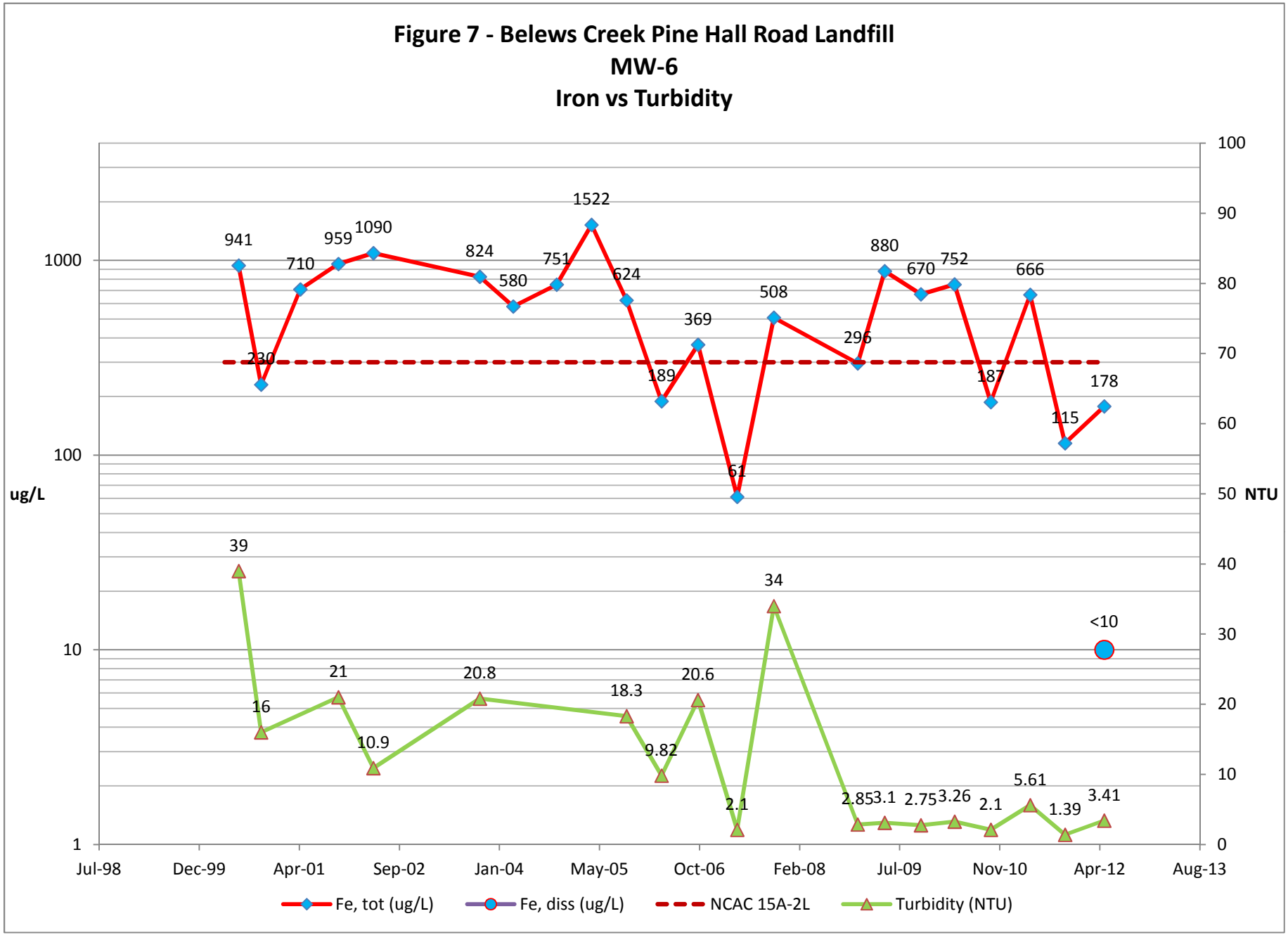


Figure 7 - Belews Creek Pine Hall Road Landfill
MW-6
Iron vs Turbidity
ug/L
NTU
1000
100
10
1
100
90
80
70
60
50
40
30
20
10
0
941
230
710
959
1090
824
580
751
1522
624
189
369
61
508
296
880
670
752
187
666
115
178
39
16
21
10.9
20.8
18.3
9.82
20.6
2.1
34
2.85
3.1
2.75
3.26
2.1
5.61
1.39
3.41
<10
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Fe, tot (ug/L)
Fe, diss (ug/L)
NCAC 15A-2L
Turbidity (NTU)

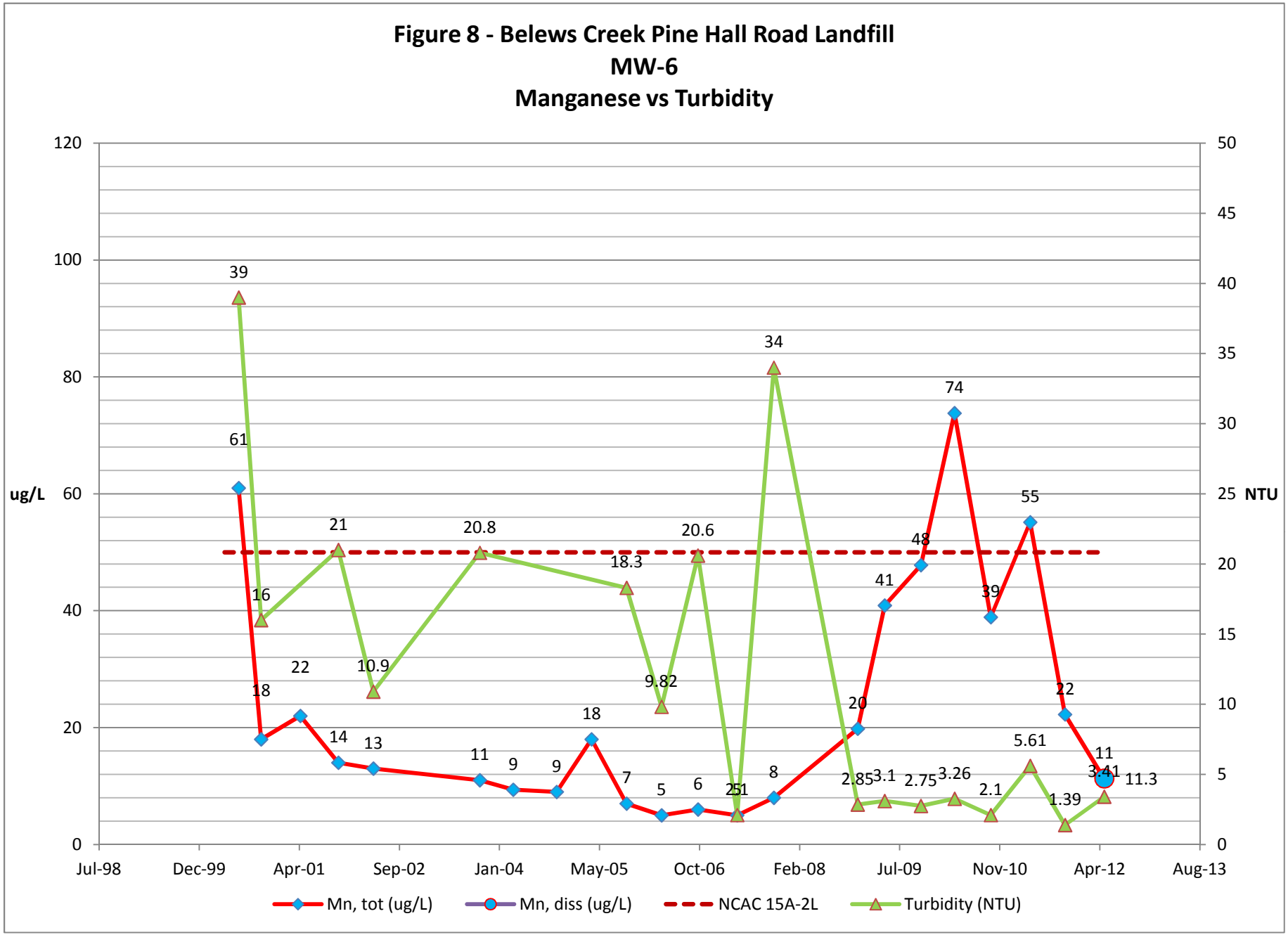


Figure 8 - Belews Creek Pine Hall Road Landfill
MW-6
Manganese vs Turbidity
ug/L
NTU
120
100
80
60
40
20
0
50
45
40
35
30
25
20
15
10
5
0
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Mn, tot (ug/L)
Mn, diss (ug/L)
NCAC 15A-2L
Turbidity (NTU)

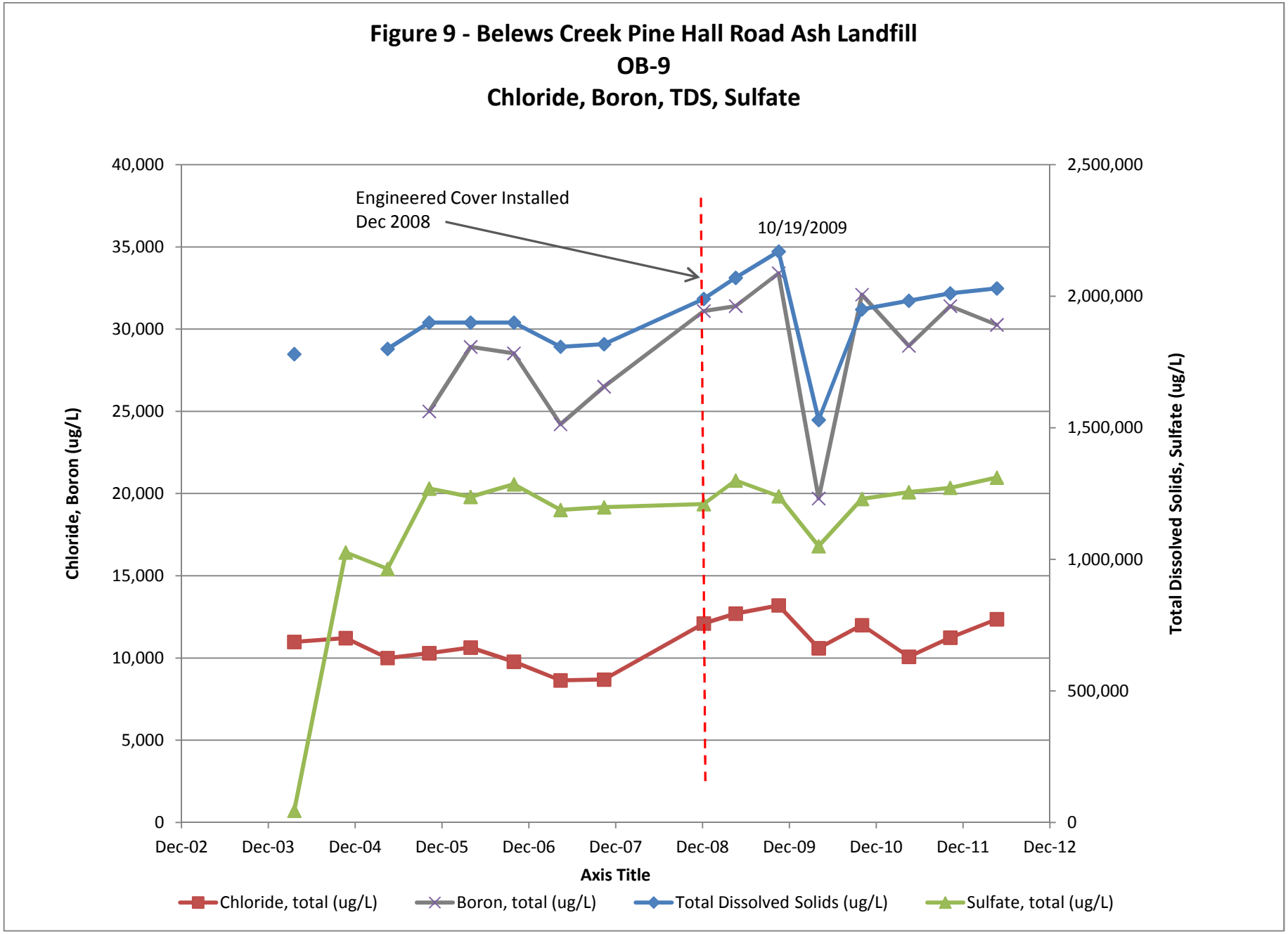


Figure 9 - Belews Creek Pine Hall Road Ash Landfill
OB-9
Chloride, Boron, TDS, Sulfate
Engineered Cover Installed
Dec 2008
10/19/2009
Chloride, Boron (ug/L)
Total Dissolved Solids, Sulfate (ug/L)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Axis Title
Chloride, total (ug/L)
Boron, total (ug/L)
Total Dissolved Solids (ug/L)
Sulfate, total (ug/L)

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 15485.

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 Wells MW-3 and MW-6 Assessment
Duke Energy - Belews Creek Pine Hall Road Landfill
Permit #85-03
Stokes County
DOC ID 15485

Dear Mr. Sullivan:

A review of groundwater analytical data from the Pine Hall Road Landfill indicates exceedances of groundwater standards established in 15A NCAC 2L .0202 (2L Standards) during the April 19, 2011 monitoring event. Iron and manganese have been reported at concentrations greater than their respective 2L Standards in groundwater samples collected from MW-3 and MW-6. Monitor well MW-3 is located outside the compliance boundary and MW-6 appears to be located near 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 MW-3 and MW-6 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 MW2-7, MW2-9 and MW-4 have boron, chromium, iron, manganese, nitrate, selenium and sulfate 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,

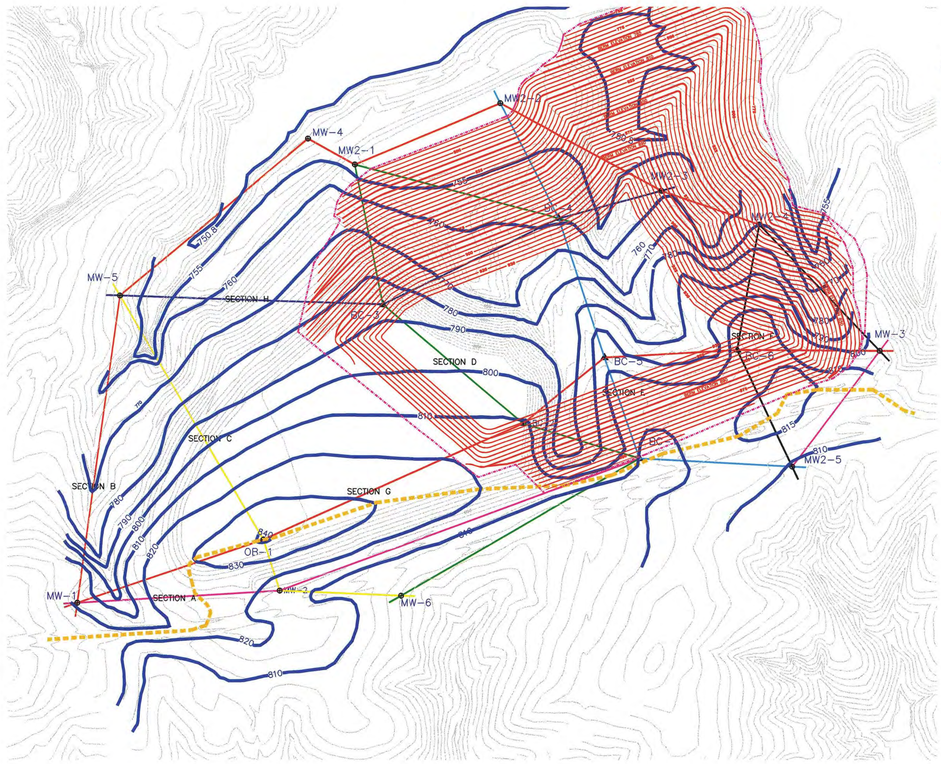
Elizabeth S Werner
Hydrogeologist

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

APPENDIX B

Drawings from Geological and Hydrological Study for Proposed Landfill Site

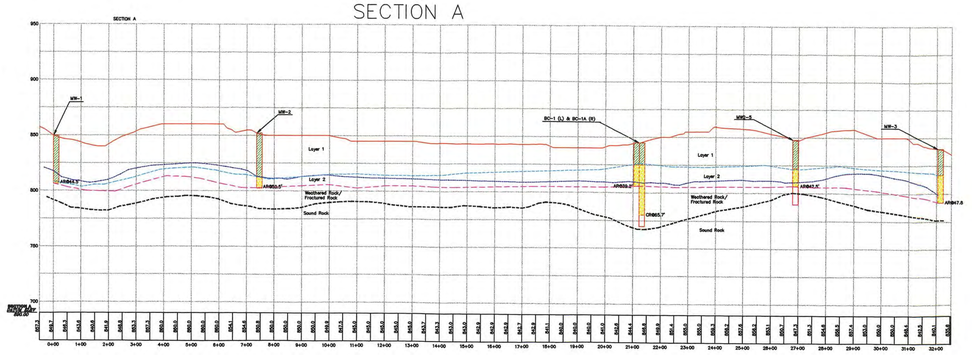
BCK-01 and BCK-02



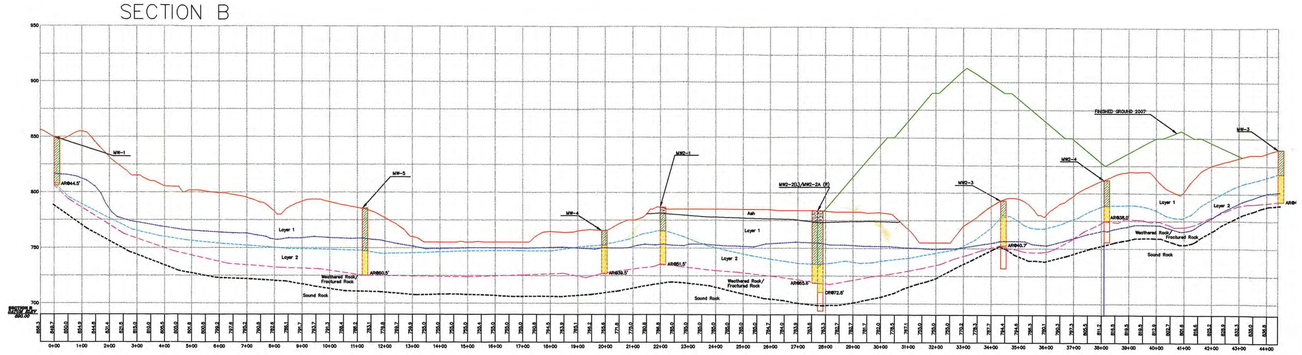
EXPLANATION – Plan

- Monitoring Well.
- MW-2 Test Boring and Temporary Monitoring Well
- BC-1 Groundwater Contours.
- Drainage Basin Divide.
- Proposed Landfill Footprint

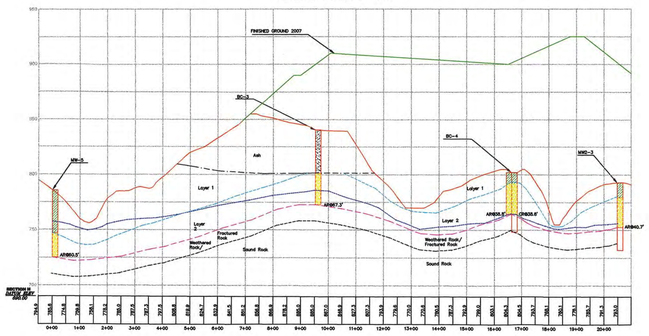
SECTION A



SECTION B



SECTION H



HORIZONTAL SCALE

0 100 200 400 600

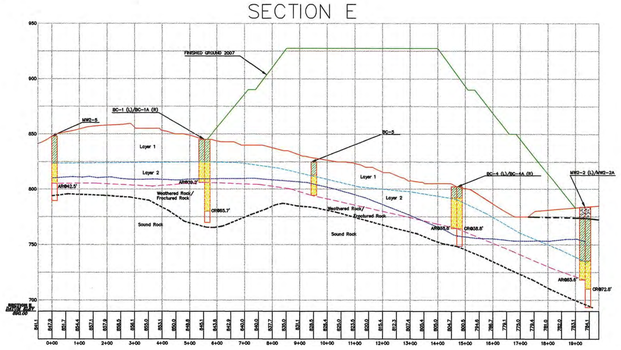
SCALE IN FEET

VERTICAL SCALE

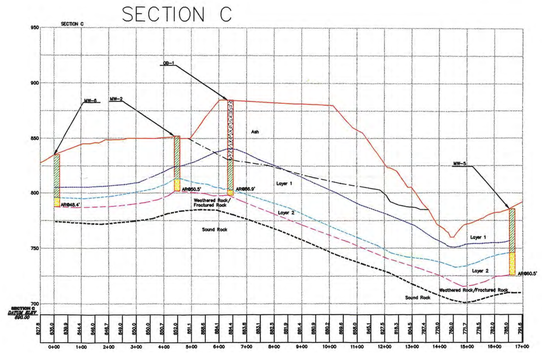
0 25 50 100 300

SCALE IN FEET

SECTION E



SECTION C



EXPLANATION – Cross-Sections

- Ash.
- Layer 1 – Residual Soil and Saprolite, primarily sandy silts (ML) to silty sands (SM). Standard Penetration Resistance, N≤30.
- Layer 2 – Saprolite and weathered rock consisting of sandy silts (ML) and silty sands (SM) with layers of moderately to severely weathered rock. Standard Penetration Resistance, N≥30.
- Weathered Rock/Fractured Rock – Severely to slightly weathered rock and fractured rock. Recovery less than 90% and Rock Quality Designation (RQD) less than 50%.
- Sound Rock – Rec.>90% and RQD>50%.

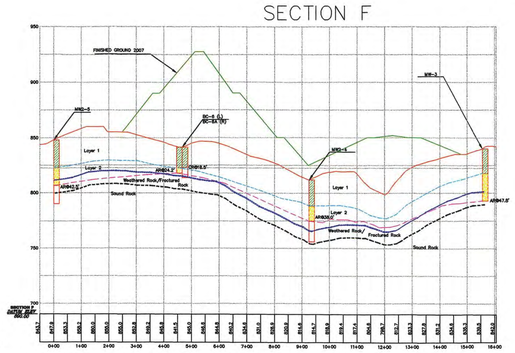
CR040.6' Carbide Refusal.
AR040.5' Auger Refusal.

- Groundwater Table/Potentiometric Surface.
- Contact between Ash and Underlying Soil.
- Contact between Layer 1 and Layer 2.
- Contact between Layer 2 and Weathered/Fractured Rock.
- Contact between Weathered/Fractured Rock and Sound Rock.

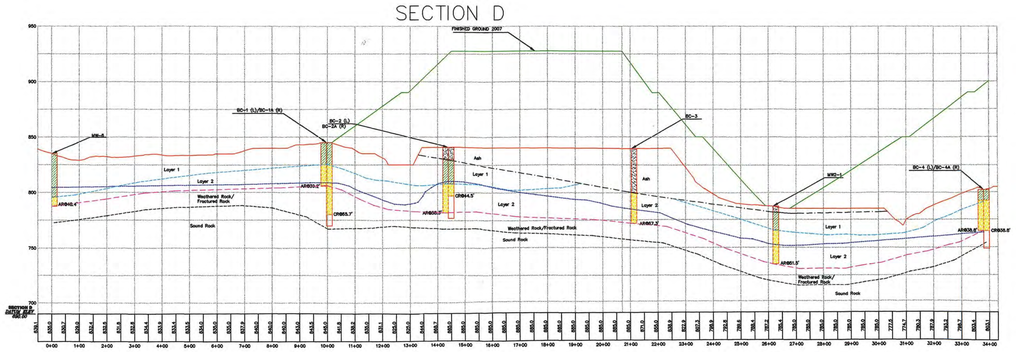
All contacts approximate.

Note: Weathered/Fractured Rock and Sound Rock indicated by same pattern. Separated by approximate contact.

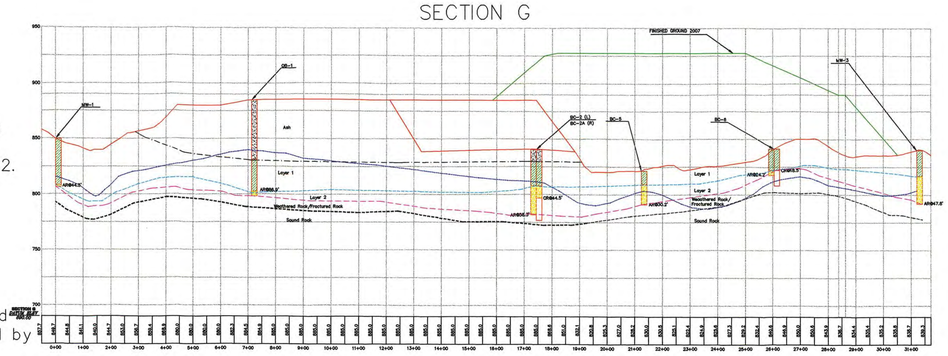
SECTION F



SECTION D



SECTION G



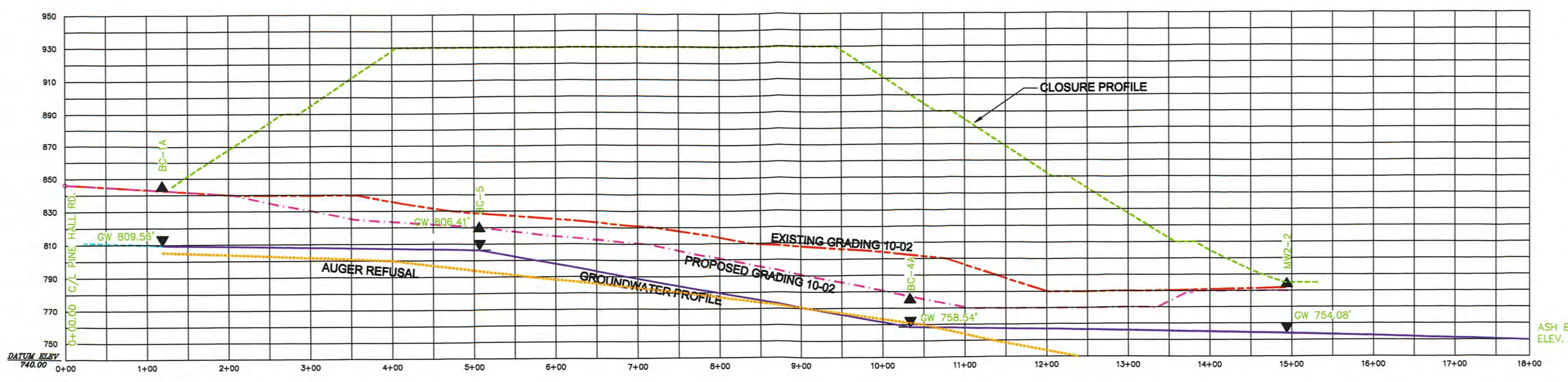
DRIG. NO.	REVISIONS	DRN	DATE	CHKD	DATE	APPR	DATE	CIVIL	ELEC.	MECH.
								INSPECTED		

DWG NO. REV.

DUKE POWER COMPANY
BELEWS CREEK STEAM STATION

Belews Creek Existing Ash Landfill and Proposed Expansion
Plan, Groundwater Contours, and Cross-Sections
A, B, C, D,
E, F, G, AND H

DESIGNER MFSchoeffer DATE 02/09/01 INSP. DATE
DRAWN CAHines/MFSchoeffer DATE 02/09/01 INSP. DATE
CHECKED MFSchoeffer DATE 09/18/01 APPR. DATE
SCALE as noted DWG NO. BCK-01 REV.



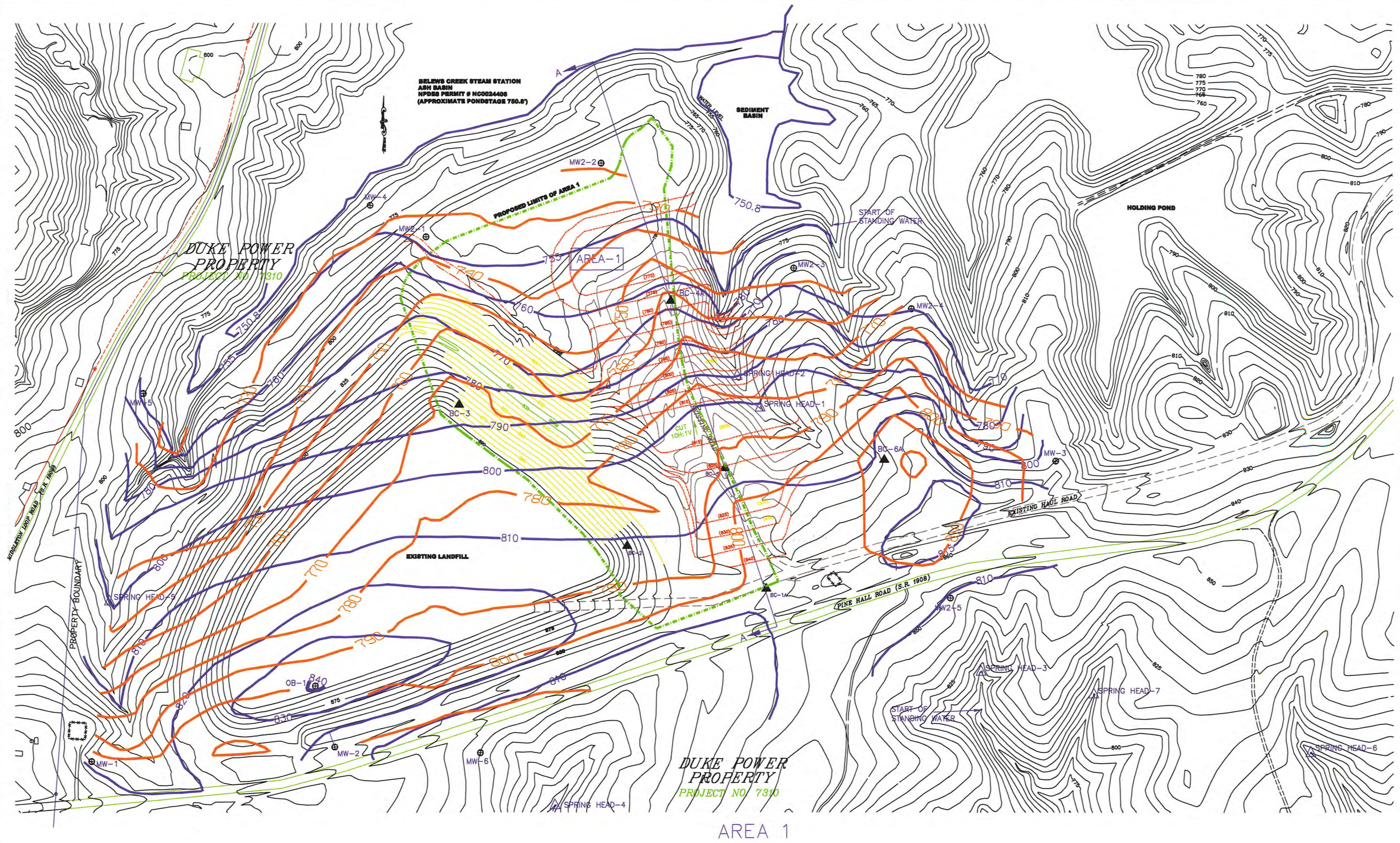
SECTION A–A (AREA 1)

SCALE

VERTICAL – 1" = 50'

HORIZONTAL – 1" = 100'

Groundwater profile based on measurements taken in April, 2001



AREA 1

SCALE: 1"=200'

LEGEND

- FOOTPRINT OF AREA 1
- MONITORING WELL
- SOIL BORING/TEMPORARY WELL
- SPRING HEAD
- (850) GRADED ELEVATION LABEL
- 850 EXISTING ELEVATION LABEL
- PROPOSED EXCAVATION CUT
- 810 GROUNDWATER CONTOUR (APRIL 2001)
- 780 AUGER REFUSAL - TOP OF WEATHERED/FRACTURED ROCK CONTOUR

DUKE POWER COMPANY
BELEWS CREEK STEAM STATION

Belews Creek Ash Landfill - Expansion
Groundwater Contours, Top of Weathered/Fractured Rock Contours and Proposed Area 1 Grades

DESIGNER M.F.Schaeffer	DATE	INSP.	DATE
DRAWN W. R. McConnell	DATE	INSP.	DATE
CHECKED M.F.Schaeffer	DATE	APPR.	DATE

Drawing BCK-02 **FRAMATOME ANP DE&S**

APPENDIX C

MW-7 Field and Analytical Data from August 28, 2012

FIELD SAMPLING CALIBRATION FORM

STUDY:	BELEWS CREEK STEAM STATION - PINE HALL LANDFILL GROUNDWATER MONITORING		
DATE (s):	August 28 - 29, 2012	SURFACE UNIT READER:	LDC
COLLECTORS:	LDC, MJR	SURFACE UNIT SERIAL #:	S05042
ANALYZER MODEL#:	MS5	ANALYZER SERIAL #:	60901
OTHER EQUIPMENT:	TURBIDIMETER NO.1 - 3260.2	WEATHER CONDITIONS:	Cloudy, slight breeze, 70 deg F

PROCEDURE #: HYDROLAB 3210.4 VALIDATED BY: WC 8/29/12

Calibration Date / Time		DATE:	29-Aug-12	TIME:	540	DATE:	29-Aug-12	TIME:	855
		BP (mmHg)			741.2	BP (mmHg)			742.5
Parameter	Calibation Standard	Instrument Value		Standard Value	Calibration Results	Instrument Value		Standard Value	Calibration Results
SPEC. COND. (uS/cm)	SS	0.0	—/—►	0.0	Instrument Zeroed	0.0	—/—►	0.0	Zero Pass
	SS	231.0	—►	227	Calibration Accepted	217.2	—/—►	227	Calibration Pass
	SS	75.3	—/—►	75	Calibration Accepted	73.2	—/—►	75	Calibration Pass
pH (units)	B (7.00)	6.95	—►	7.00	Calibration Accepted	7.07	—/—►	7.00	Calibration Pass
	B (4.00)	4.00	—►	4.00	Calibration Accepted	4.07	—/—►	4.00	Calibration Pass
	B (10.00)	10.05	—/—►	10.01	Calibration Accepted	10.16	—/—►	10.01	Calibration Pass
			Buffer Temp.	23.69			Buffer Temp.	23.65	
Mid-Day Ck	B (7.00)		—►						
Time:			Buffer Temp.						
☑ ORP (mV)	SS (7.00)	291	—►	287	Calibration Accepted	282	—/—►	286	Calibration Pass
	SS (4.00)	N/A	—/—►	464		N/A	—/—►	463	
			ORP Temp.	23.96			ORP Temp.	24.35	
☑ DO (mg/L)	W			7.20				7.30	
	W			7.20				7.40	
	AW	7.53	—►	7.20	Calibration Accepted	7.33	—/—►	7.35	Calibration Pass
☑ TURB (ntu)	SS	52.8	—/—►	53.4	Calibration Accepted	52.8	—/—►	53.4	Calibration Accepted
Temp Cert Device #									
TEMP (deg C)	NIST	N/A	—/—►	N/A	Adjustment Not Available	N/A	—/—►	N/A	Adjustment Not Available
AMMONIUM (mg/L)	SS	N/A	—/—►	N/A		N/A	—/—►	N/A	
	SS	N/A	—/—►	N/A		N/A	—/—►	N/A	

INSTRUMENT MAINTENANCE	DATE / TIME
Conductance Subsystem	*pH Subsystem*
☐ Cleaned Electrodes	☐ Cleaned Electrodes
☐ Tested - OK	☐ Replaced ref Electrode KCL
☐ See Notes	☐ Replaced Ref. Electrode Tip
	☐ Tested - OK ☐ See Notes
Dissolved Oxygen Subsystem	*Ammonium Subsystem*
☐ Replaced Teflon Membrane	☐ Cleaned Electrode Tip
☐ Replaced DO electrolyte	☐ Installed New Electrode
☐ Cleaned Electrode	☐ Removed Electrode / Installed Plug
☐ See Notes	☐ Tested - OK ☐ See Notes
Oxidation Reduction Subsystem	*Turbidity Subsystem*
☐ Cleaned Electrode	☐ Cleaned Electrode & Wiper
☐ Tested - OK ☐ See Notes	☐ Tested - OK ☐ See Notes
Temperature Subsystem	*Depth Subsystem*
☐ Cleaned Electrode	☐ Reset / Calibrated
☐ Tested - OK ☐ See Notes	☐ Tested - OK ☐ See Notes

KEY: B = Buffer; SS = Standard solution; W = Winkler; AW = Average Winkler; —► = Adjusted To; —/—► = Not Adjusted To; N/A = Not Applicable

NOTES:

DUKE ENERGY

GROUNDWATER MONITORING DATA SHEET
FOR CONVENTIONAL SAMPLING

PROCEDURE NO	3175.1

SITE NAME	BELEWS CREEK STEAM STATION	PERMIT #	85-03	SITE ID	N/A
PROJECT NAME	PINE HALL LANDFILL	FIELD CREW	LDC, MJR		
SAMPLING DATE(s)	☑ 28-Aug-2012 ☐ 29-Aug-2012 ☐ ☐	WELL/LOCATION NAME	MW-7 DEV		

MONITORING WELL INFORMATION

WELL DIAMETER (in)	2	TOC ELEV (ft msl)	815.57	MIDDLE OF WETTED SCREEN (ft toc)	11.65
WELL DEPTH (ft TOC)	14.26	GS ELEV (ft msl)	812.52	PUMP INTAKE DEPTH (ft TOC)	13.26
SCREEN LENGTH (ft)	10.00	ELEV REF	NAVD 88	SCREEN INTERVAL (ft TOC)	4.26 TO 14.26

EQUIPMENT INFORMATION

LEVEL METER SERIAL#	26056	SAMPLING EQUIPMENT	QED T1200	PURGE METHOD
		TUBING DIAMETER (in)	1/2 OD	Conventional

PUMP CONTROLLER SETTINGS

PRESSURE	8	(psi)	RECHARGE	10	(sec)	DISCHARGE	5	(sec)

SAMPLING INFORMATION

INITIAL DEPTH TO WATER (ft TOC)	9.03	WATER COLUMN (ft)	5.23
WATER ELEVATION (ft msl)	806.54	WELL VOLUME (gal)	0.85
DETECTED ODOR	None	CONVERSION FACTOR	0.1631
APPEARANCE	Colloidal		

Well Volume = water column X conversion factor
(Conversion factor dependent on well diameter and selected well volume units)

PURGE VOLUME 0.85 (gal)	WATER LEVEL AFTER PURGE * (ft)	COMPLETE EVACUATION (YES/NO)	☑ TEMP (deg C)	☑ SPECIFIC COND. (umho/cm)	☑ pH (SU)	☑ TURBIDITY (NTU)	☑ ORP (mV-NHE)	☑ DISSOLVED OXYGEN (mg/L)	☐ (gal) WELL VOL (recalculates on current water level)
3.00		YES				> 1000			
2.00		YES				> 1000			
2.00		YES				N/A			
1.00		YES				29.9			
1.00		YES				9.4			

TOTAL PURGE VOLUME	* Optional measurement to recalculate well volume when purging results in substantial drawdown of water column	COLLECT SAMPLE - SAMPLE CRITERIA SATISFIED			CHLORINE (mg/l)
		SAMPLE COLLECTED BY	DATE	TIME	
9.00			8/28/2012	@	N/A

QC By: WC 8/29/12

WELL CONDITION			ADDITIONAL WELL CONDITION NOTES
PROTECTIVE CASING	Good Condition		
WELL PAD	Good Condition		
WELL CASING	Good Condition		
WELL TAG	Good Tag		

SAMPLING NOTES

Removed pump, sounded bottom at 14.52 ft (hard bottom), replaced sampling pump and used to re-develop with surging. Dead ants in initial one gal removed. After 5 well volumes, purge water was collodial (not "muddy"). Decided to remove sampling pump and purge with development pump to ensure well bottom was being reached and removed an additional 2 gal (purge water was muddy). Replaced sampling pump and removed 1 gal.

DUKE ENERGY

GROUNDWATER MONITORING DATA SHEET
FOR CONVENTIONAL SAMPLING

PROCEDURE NO	3175.1

SITE NAME	BELEWS CREEK STEAM STATION	PERMIT #	85-03	SITE ID	N/A
PROJECT NAME	PINE HALL LANDFILL	FIELD CREW	LDC, MJR		
SAMPLING DATE(s)	☐ 28-Aug-2012 ☑ 29-Aug-2012 ☐ ☐	WELL/LOCATION NAME	MW-7		

MONITORING WELL INFORMATION

WELL DIAMETER (in)	2	TOC ELEV (ft msl)	815.57	MIDDLE OF WETTED SCREEN (ft toc)	11.36
WELL DEPTH (ft TOC)	14.26	GS ELEV (ft msl)	812.52	PUMP INTAKE DEPTH (ft TOC)	13.26
SCREEN LENGTH (ft)	10.00	ELEV REF	NAVD 88	SCREEN INTERVAL (ft TOC)	4.26 TO 14.26

EQUIPMENT INFORMATION

LEVEL METER SERIAL#	26056	SAMPLING EQUIPMENT	QED T1200	PURGE METHOD	
		TUBING DIAMETER (in)	1/2 OD	Conventional	

PUMP CONTROLLER SETTINGS

PRESSURE	8	(psi)	RECHARGE	10	(sec)	DISCHARGE	10	(sec)

SAMPLING INFORMATION

INITIAL DEPTH TO WATER (ft TOC)	8.46	WATER COLUMN (ft)	5.80
WATER ELEVATION (ft msl)	807.11	WELL VOLUME (gal)	0.95
DETECTED ODOR	None	CONVERSION FACTOR	0.1631
APPEARANCE	Normal		

Well Volume = water column X conversion factor
(Conversion factor dependent on well diameter and selected well volume units)

PURGE VOLUME 0.95 (gal)	WATER LEVEL AFTER PURGE * (ft)	COMPLETE EVACUATION (YES/NO)	☑ TEMP (deg C)	☑ SPECIFIC COND. (umho/cm)	☑ pH (SU)	☑ TURBIDITY (NTU)	☑ ORP (mV-NHE)	☑ DISSOLVED OXYGEN (mg/L)	☐ (gal) WELL VOL (recalculates on current water level)
1.00		NO	20.79	629	5.34	27.4	414	5.85	
1.00		NO	20.57	647	5.35	72.0	414	6.27	
1.00		NO	20.36	673	5.35	71.7	415	5.65	
2.00		YES	20.36	649	5.31	20.5	418	4.69	
0.50		YES	20.41	645	5.32	8.1	418	4.46	

TOTAL PURGE VOLUME	* Optional measurement to recalculate well volume when purging results in substantial drawdown of water column	COLLECT SAMPLE - SAMPLE CRITERIA SATISFIED				CHLORINE (mg/l)
		SAMPLE COLLECTED BY	DATE		TIME	
5.50		LDC	8/29/2012	@	0820	N/A

QC By: LDC 8/29/12

WELL CONDITION

PROTECTIVE CASING	Good Condition	
WELL PAD	Good Condition	
WELL CASING	Good Condition	
WELL TAG	Good Tag	

ADDITIONAL WELL CONDITION NOTES

SAMPLING NOTES

After 3rd well vol and turbidity remained steady (> 50 ntu) pumping at 8 psi, I changed pressure to 20 psi attempting to evacuate the well and lower turbidity (decision based on previous day development and evacuating the well yielding lower turbidity). Initial turbidity was 137 ntu but steadily dropped. Used 20 psi with 20 sec refill and 5 sec discharge.

BELEWS CREEK STEAM STATION
PINE HALL LANDFILL
GROUNDWATER MONITORING FIELD DATA
PERMIT # 85-03

DATE	WELL NO.	WELL DEPTH (feet-toc)	DEPTH TO WATER (feet-toc)	WATER ELEV. (feet)	APPEARANCE	ODOR	Purge Method	AVG * PMP RATE (ml/min)	WELL VOL (gal)	EVAC VOL (gal)	EVAC (yes/no)	TEMP (deg C)	SPECIFIC CONDUCTANCE (umho/cm)	pH (units)	TURBIDITY (NTU)	ORP (mV-NHE)	DO (mg/l)
8/28/2012	MW-1	47.20			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	MW-1D	90.53			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	MW-2	50.00			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	MW-3	49.50			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	MW-4	40.20			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	MW-5	60.20			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	MW-6	36.84			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/29/2012	MW-7	14.26	8.46	807.11	Normal	None	C	N/A	0.95	5.50	YES	20.41	645	5.3	8.1	418	4.46
8/28/2012	MW2-7	30.62			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	MW2-9	14.61			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	OB-4	30.03			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	OB-5	36.60			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	OB-9	48.57			Normal	None	C	N/A		0.00		0.00	0	0.0	0.0	0	0.00
8/28/2012	SW-1A	N/A	N/A	N/A	Normal	None	NP	N/A	N/A	N/A	N/A	0.00	0	0.0	0.0	0	0.00
8/28/2012	SW-2	N/A	N/A	N/A	Normal	None	NP	N/A	N/A	N/A	N/A	0.00	0	0.0	0.0	0	0.00

Purge Methods
LF = Low Flow
LF(M) = Low Flow (Mod.)
C = Connventional
NP = No Purge
EOP = Equip. Only Purge
LO = Level Only

* = Applicable to LF & LF(M) Purging Only

Analytical Laboratory

13339 Hagers Ferry Road
Huntersville, NC 28078-7929
McGuire Nuclear Complex - MG03A2
Phone: 980-875-5245 Fax: 980-875-4349

Order Summary Report

Order Number: **J12080370**

Customer Name(s): Chuck Campbell, Tim Hunsucker, Ed Sullivan

Customer Address: 3195 Pine Hall Rd
Mailcode: Belews Steam Station
Belews Creek, NC 28012

Lab Contact: Jason C Perkins Phone: 980-875-5348

Report Authorized By: (Signature) _____ **Date:** 9/7/2012

Program Comments:

Please contact the Program Manager (Jason C Perkins) with any questions regarding this report.

Data Flags & Calculations:

Any analytical tests or individual analytes within a test flagged with a Qualifier indicate a deviation from the method quality system or quality control requirement. The qualifier description is found at the end of the Certificate of Analysis (sample results) under the qualifiers heading. All results are reported on a dry weight basis unless otherwise noted. Subcontracted data included on the Duke Certificate of Analysis is to be used as information only. Certified vendor results can be found in the subcontracted lab final report. Duke Energy Analytical Laboratory subcontracts analyses to other vendor laboratories that have been qualified by Duke Energy to perform these analyses except where noted.

Data Package:

This data package includes analytical results that are applicable only to the samples described in this narrative. An estimation of the uncertainty of measurement for the results in the report is available upon request. This report shall not be reproduced, except in full, without the written consent of the Analytical Laboratory. Please contact the Analytical laboratory with any questions. The order of individual sections within this report is as follows:

Job Summary Report, Sample Identification, Technical Validation of Data Package, Analytical Laboratory Certificate of Analysis, Analytical Laboratory QC Reports, Sub-contracted Laboratory Results, Customer Specific Data Sheets, Reports & Documentation, Customer Database Entries, Test Case Narratives, Chain of Custody (COC)

Certification:

The Analytical Laboratory holds the following State Certifications : North Carolina (DENR) Certificate #248, South Carolina (DHEC) Laboratory ID # 99005. Contact the Analytical Laboratory for definitive information about the certification status of specific methods.

Sample ID's & Descriptions:

Sample ID	Plant/Station	Collection Date and Time	Collected By	Sample Description
2012018290	BELEWS	29-Aug-12 8:20 AM	LDC	MW-7
2012018291	BELEWS	29-Aug-12 8:30 AM	LDC	FIELD BLANK

2 Total Samples

Technical Validation Review

Checklist:

COC and .pdf report are in agreement with sample totals and analyses (compliance programs and procedures).	☑ Yes	☐ No
All Results are less than the laboratory reporting limits.	☐ Yes	☑ No
All laboratory QA/QC requirements are acceptable.	☑ Yes	☐ No

Report Sections Included:

- ☑ Job Summary Report
- ☑ Sample Identification
- ☑ Technical Validation of Data Package
- ☑ Analytical Laboratory Certificate of Analysis
- ☐ Analytical Laboratory QC Report
- ☐ Sub-contracted Laboratory Results
- ☐ Customer Specific Data Sheets, Reports, & Documentation
- ☐ Customer Database Entries
- ☑ Chain of Custody
- ☑ Electronic Data Deliverable (EDD) Sent Separately

Reviewed By: DataBase Administrator Date: 9/7/2012

Certificate of Laboratory Analysis

This report shall not be reproduced, except in full.

Order # J12080370

Site: MW-7 **Sample #: 2012018290**

Collection Date: 29-Aug-12 8:20 AM Matrix: GW_RCRA

Analyte	Result	Units	Qualifiers	RDL	DF	Method	Analysis Date/Time	Analyst
INORGANIC IONS BY IC								
Sulfate	**250**	mg/L		5	50	EPA 300.0	8/31/2012 12:26:00 F	JAHERMA
TOTAL EXTRACTABLE METALS BY ICP								
Boron (B)	**5.25**	mg/L		0.05	1	EPA 200.7	9/6/2012 10:33:00 A	DJSULL1
Iron (Fe)	**0.265**	mg/L		0.01	1	EPA 200.7	9/6/2012 10:33:00 A	DJSULL1
Manganese (Mn)	**0.059**	mg/L		0.005	1	EPA 200.7	9/6/2012 10:33:00 A	DJSULL1
TOTAL EXTRACTABLE METALS BY ICP-MS								
Cobalt (Co)	**< 1**	ug/L		1	1	EPA 200.8	9/4/2012 12:19:00 P	KRICHAR
Selenium (Se)	**47.2**	ug/L		1	1	EPA 200.8	9/4/2012 12:19:00 P	KRICHAR
Vanadium (V)	**< 1**	ug/L		1	1	EPA 200.8	9/4/2012 12:19:00 P	KRICHAR
TOTAL DISSOLVED SOLIDS								
TDS	**520**	mg/L		10	1	SM2540C	9/4/2012 1:30:00 PM	TJA7067

Site: FIELD BLANK **Sample #: 2012018291**

Collection Date: 29-Aug-12 8:30 AM Matrix: GW_RCRA

Analyte	Result	Units	Qualifiers	RDL	DF	Method	Analysis Date/Time	Analyst
INORGANIC IONS BY IC								
Sulfate	**< 0.1**	mg/L		0.1	1	EPA 300.0	8/31/2012 2:49:00 P	JAHERMA
TOTAL EXTRACTABLE METALS BY ICP								
Boron (B)	**< 0.05**	mg/L		0.05	1	EPA 200.7	9/6/2012 11:03:00 A	DJSULL1
Iron (Fe)	**< 0.01**	mg/L		0.01	1	EPA 200.7	9/6/2012 11:03:00 A	DJSULL1
Manganese (Mn)	**< 0.005**	mg/L		0.005	1	EPA 200.7	9/6/2012 11:03:00 A	DJSULL1
TOTAL EXTRACTABLE METALS BY ICP-MS								
Cobalt (Co)	**< 1**	ug/L		1	1	EPA 200.8	9/4/2012 12:28:00 P	KRICHAR
Selenium (Se)	**< 1**	ug/L		1	1	EPA 200.8	9/4/2012 12:28:00 P	KRICHAR
Vanadium (V)	**< 1**	ug/L		1	1	EPA 200.8	9/4/2012 12:28:00 P	KRICHAR

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST FORM

Duke Energy℠

For Detailed Instructions, see:
http://dewww/essenv/coc/

Duke Energy Analytical Lab Services
Mail Code MGO3A2 (Building 7405)
13339 Hagers Ferry Rd
Huntersville, N. C. 28078
(704) 875-5245
Fax: (704) 875-5038

Analytical Laboratory Use Only

LIMS # J12080370 | MATRIX: GW RCRA | Samples Originating From: NC √ SC ___

Logged By: cpb | Date & Time: 8-27-12 1250

VENDOR | Cooler Temp (C): 25

SAMPLE PROGRAM: Ground Water √ | NPDES ___ | Drinking Water ___ | UST ___ | RCRA Waste ___

PO # | MR #

[19]Page 1 of 1

DISTRIBUTION
ORIGINAL to LAB, COPY to CLIENT

Rev 3/27/12

Customer must Complete

1)Project Name: *BELEWS CREEK LANDFILL - PINE HALL Permit #85-03*		2)Phone No: 875-5257
3)Client: C Campbell / T Hunsucker / Ed Sullivan		4)Fax No:875-4349
5)Business Unit: 20003	6)Process: BENVWS	7)Resp. To: BC00
8)Project ID:	9)Activity ID:	10)Mail Code: MGO3A3

Customer to complete all appropriate NON-SHADED areas.

Customer to complete appropriate columns to right

Preserv.: 1=HCL 2=H_2SO_4 3=HNO_3 4=Ice 5=None

LAB USE ONLY [11]Lab ID	[12]Chem Desktop No.	[13]Sample Description or ID	[14]Collection Information Date	Time	Signature	[18]TESTS	[18]Grab	SO4	Metals Prep - 3030C (ICP - EPA-200.7) B, Fe, Mn (IMS- 200.8) Co, Se, V	TDS				[20]Total # of Containers
						[16]Analyses Required		4	3	4				
2012018290		MW-7	8/29/12	0820	DC	4	X	1	1	1				3
2012018291		FIELD BLANK	8/29/12	0830	DC	3	X	1	1					2
								√	√	√				

Customer to sign & date below

21)Relinquished By: [signature]	Date/Time: 8/29/12 1135	Accepted By: [signature]	Date/Time: 8/29/12 1135
Relinquished By	Date/Time	Accepted By:	Date/Time
Relinquished By	Date/Time	Accepted By:	Date/Time
23)Seal/Locked By	Date/Time	Sealed/Lock Opened By	Date/Time

24)Comments: Regulatory Agency : NCDENR/DWM -SW Section - State EDD Format Required / Permit # 85-03
Use indicated or comparible analytical methods

Customer, important please indicate desired turnaround

[22]Requested Turnaround
14 Days √
*7 Days ___
*48 Hr ___
*Other RUSH * Add. Cost Will Apply