Community Impact Analysis of Ash Basin Closure Options at the Belews Creek Steam Station

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Prepared on behalf of Duke Energy Carolinas, LLC

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Contents

List of Figures

List of Tables

Acronyms and Abbreviations

AADT	annual average daily traffic
AOW	area of wetness
BCSS	Belews Creek Steam Station
CAMA	North Carolina Coal Ash Management Act
CAP	corrective action plan
CCR	coal combustion residuals
CCR Rule	EPA Coal Combustion Residuals Rule of 2015
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIP	cap in place
COI	constituent of interest
COPC	chemical of potential concern
CSA	comprehensive site assessment
DPM	diesel particulate matter
Duke Energy	Duke Energy Carolinas, LLC
DSAY	discounted service acre-year
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FGD	flue gas desulfurization
HEA	habitat equivalency analysis
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
LOAEL	lowest-observed-adverse-effects level
MOVES	Mobile Vehicle Emissions Simulator
NEBA	net environmental benefit analysis
NCDEQ	North Carolina Department of Environmental Quality
NCDOT	North Carolina Department of Transportation
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effects level
NPDES	National Pollutant Discharge Elimination System
NPP	net primary productivity
NRDA	natural resource damage assessment
OSAT-2	Operational Science Advisory Team-2
RCRA	Resource Conservation and Recovery Act
REL	reference exposure level
RfC	reference concentration
RfD	reference dose
SOC	Special Order by Consent
TRV	toxicity references value
TVA	Tennessee Valley Authority

Limitations

This report sets forth my conclusions, which are based on my education, training, and experience; field work; established scientific methods; and information reviewed by me or under my direction and supervision. These conclusions are expressed to a reasonable degree of scientific certainty. The focus of this report is on local community impacts. I have, therefore, not attempted to evaluate broader environmental impacts, such as impacts from greenhouse gas emissions, that would be associated with each closure option.

The conclusions in this report are based on the documents made available to me by Duke Energy or collected as part of my investigation. I reserve the right to supplement my conclusions if new or different information becomes available to me. As an example, the excavation option presented in this report assumes that landfilling of excavated ash can be accommodated within the boundaries of the currently permitted landfill space. The currently permitted landfill space was sized to accommodate future ash production and did not include the addition of excavated ash from the Belews Creek Steam Station (BCSS) ash basin. If additional landfill space is required to accommodate both excavated ash and future ash production, then additional habitat destruction would be necessary, and that impact has not been factored into this analysis.

Executive Summary[1]

In 2015, the U.S. Environmental Protection Agency (EPA) issued a rule called the "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals [CCR] from Electric Utilities" (CCR Rule), which, among other things, regulates closure of coal ash impoundments in the United States. Closure of coal ash impoundments in North Carolina is further regulated by the North Carolina Coal Ash Management Act of 2014 (CAMA) as amended by H.B. 630, Sess. L. 2016-95. Under both the North Carolina CAMA and the federal CCR Rule, there are two primary alternatives for closure of an ash impoundment:

- "Cap in place" (CIP) closure involves decanting the impoundment and placing a low-permeability liner topped by appropriate cap material, soil, and grass vegetation over the footprint of the ash to restrict vertical transport of water through the ash, as well as a minimum of 30 years of post-closure care, which requires the implementation of corrective action measures if and as necessary;
- Excavation closure involves decanting the impoundment, excavating all ash in the basin, transporting the ash to an appropriate, permitted, lined landfill, and restoring the site.

Duke Energy Carolinas, LLC's (Duke Energy's) Belews Creek Steam Station (BCSS) has one unlined, onsite, active ash basin subject to closure under CAMA. The footprint of the ash basin includes a former chemical holding pond—since drained and now part of the ash basin—and a closed, unlined, capped, ash landfill—the Pine Hall Road Landfill—located south of the ash basin and north of Pine Hall Road. Separate from the footprint of the ash basin, a capped structural fill is located south of the ash basin and south of Pine Hall Road,[2] and Duke Energy operates two separate active onsite, lined landfills—the Craig Road Landfill and the Flue Gas

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1. Note that this Executive Summary does not contain all of the technical evaluations and analyses that support the conclusions. Hence, the main body of this report is at all times the controlling document.
2. Though the structural fill was constructed with fly ash, it is not part of the CAMA closure assessment because it was constructed under the North Carolina Department of Environmental Quality (NCDEQ) Division of Waste Management structural fill rules (15A NCAC 13B .1700, Permit No. CCB0070; SynTerra 2017).

Desulfurization (FGD) Residue Landfill—on the south side of Belews Reservoir and south of the ash basin.

Duke Energy has evaluated three representative types of closure for the ash basin at BCSS—CIP, excavation, and hybrid closure—the latter of which involves excavating and consolidating ash within the basin footprint to reduce the spatial area of CIP closure. The administrative process for selecting an appropriate closure plan for the ash basin is ongoing.

The purpose of my report is to examine how the local community's environmental health and environmental services[3] are differently affected by each closure option as currently defined and to evaluate these differences in a structured framework that can support decision-making in this matter.

Environmental Decision-Making

Environmental decision-making involves understanding complex issues that concern multiple stakeholders. Identifying the best management alternative often requires tradeoffs among stakeholder values. These tradeoffs necessitate a transparent and systematic method to compare alternative actions and support the decision-making process. My analyses in this matter have used a net environmental benefit analysis (NEBA) framework (Efroymson et al. 2003, 2004) to compare the relative risks and benefits from CIP closure, excavation closure, or a hybrid CIP and excavation closure of the ash basin at BCSS. The NEBA framework relies on scientifically supported estimates of risk to compare the reduction of risk associated with chemical(s) of potential concern (COPCs)[4] under different remediation and closure alternatives alongside the creation of any risk during the remediation and closure, providing an objective, scientifically structured foundation for weighing the tradeoffs between remedial and closure alternatives.

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3 Environmental services, or ecosystem services, are ecological processes and functions that provide value to individuals or society (Efroymson et al. 2003, 2004).

4 COPCs are "any physical, chemical, biological, or radiological substance found in air, water, soil or biological matter that has a harmful effect on plants or animals" (https://ofmpub.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&glossaryName=Eco%20Risk%20Assessment%20Glossary).

Despite the scientific basis of the risk characterization process used in NEBA, stakeholders in any environmental decision-making scenario may place different values on different types of risk (i.e., stakeholders may have different priorities for the remediation and closure). NEBA does not, by design, elevate, or increase the value of, any specific risk or benefit in the framework. The purpose of NEBA is to simultaneously and systematically examine all tradeoffs that affect the services provided to humans and the ecosystem by the environment under remediation and closure, allowing decision-makers to more fully understand all potential benefits and risks of each alternative.

NEBA and similar frameworks have been used extensively by regulatory agencies such as the National Oceanic and Atmospheric Administration (NOAA) and EPA to support evaluating tradeoffs in mitigation (e.g., NOAA 1990), remediation (e.g., U.S. EPA 1988, 1994), and restoration (e.g., NOAA 1996). The National Environmental Policy Act (40 CFR § 1502) relies on a structured framework to conduct environmental assessments and produce environmental impact statements; these analyses evaluate potential adverse effects from development projects and identify alternatives to minimize environmental impacts and/or select mitigation measures. Natural resource damage assessment (NRDA) utilizes a structured process to estimate environmental injury and lost services and to identify projects that restore the impacted environment and compensate the public for the lost environmental services (e.g., NOAA 1996). The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial investigation/feasibility study process uses a set of evaluation criteria to identify remediation projects for contaminated sites that meet remediation objectives for effectiveness, implementability, and cost (U.S. EPA 1988). Within the Superfund Program, EPA has also recognized the importance of remediation that comprehensively evaluates cleanup actions "to ensure protection of human health and the environment and to reduce the environmental footprint of cleanup activities to the maximum extent possible" (U.S EPA 2010).

The Tennessee Valley Authority (TVA) recently used a structured framework to compare the impacts and benefits of ash basin closure alternatives at ten of its facilities (TVA 2016). Through a NEBA-like analysis, the TVA identified "issue areas," such as air quality, groundwater, vegetation, wildlife, transportation, and noise, and created a summary table that provided a side-by-side comparison of the impacts of "no action," "closure-in-place," and "closure-by-removal" actions. As a result of this analysis, TVA identified "closure-in-place" as "its preferred alternative" for all ten facilities stating, "[t]his alternative would achieve the purpose and need for TVA's proposed actions and compared to Closure-by-Removal with less environmental impact, shorter schedules, and less cost" (TVA 2016). The BCSS ash basin closure presents similar "issue areas" that can benefit from a similar, systematic analysis of net benefits resulting from closure activities.

Linking Stakeholder Concerns to NEBA

To better understand stakeholder concerns related to closure of the ash basin at BCSS, I reviewed written communications about ash pond closure plans for BCSS submitted to and summarized by the North Carolina Department of Environmental Quality (NCDEQ 2016). From this review, I identified the following categories of stakeholder concerns:

- Drinking water quality
- Groundwater quality
- Surface water quality
- Fish and wildlife
- Maintaining property value
- Preservation of natural beauty
- Recreational value
- Swimming safety
- Failure of the ash impoundment
- Risk created by the closure option outweighing risk from contamination.

The primary concerns expressed by community stakeholders involve perceived risks from exposure to CCR constituents that could negatively affect environmental services that benefit the local community: provision of safe drinking water and food, safe recreational enjoyment (hunting, fishing, swimming), and protection of natural beauty and biodiversity.[5] Potential

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5 Biodiversity is the variety of plants and animals present at a location. Protection of biodiversity refers to provision of habitat and related functions capable of sustaining biological populations.

hazards to the community associated with closure activities include physical disturbance of existing habitats; air pollution from diesel emissions resulting from transportation activities; and traffic, noise, and accidents that could result in property damage, injuries, and fatalities. Table ES-1 links concerns over CCR exposure and potential hazards created by ash basin closure to environmental services that could be affected by closure activities.

Table ES-1. Relationships between environmental services and concerns to the local community associated with CCR and ash basin closure hazards

	Environmental Services							
	Safe drinking water quality	Safe surface water quality	Safe air quality	Safe food quality	Protection of biodiversity	Recreation	Natural beauty	Safe community environment
CCR Concerns								
Drinking water contamination	X	X						X
Groundwater contamination	X	X						X
Surface water contamination	X	X		X	X	X	X	X
Fish/wildlife contamination				X	X	X	X	X
Contamination impacting property value	X	X		X	X	X	X	X
Contamination impacting natural beauty					X		X	X
Contamination impacting recreational enjoyment		X			X	X	X	X
Contamination impacting swimming safety		X				X	X	X
Failure of the ash impoundment	X	X		X	X	X	X	X
Closure Hazards								
Habitat loss		X	X		X	X	X	
Contamination of air			X		X	X		X
Noise, Traffic, Accidents						X		X

In recognition of the potential discrepancy between stakeholder priorities and the broad and balanced treatment of service risks and benefits in NEBA, I organized the NEBA analysis around the following five objectives for ash basin closure that recognize local stakeholder concerns while being consistent with the methods and purpose of NEBA:

1. Protect human health from CCR constituent exposure
2. Protect ecological health from CCR constituent exposure
3. Minimize risk and disturbance to humans from closure
4. Minimize risk and disturbance to the local environment from closure
5. Maximize local environmental services.

In my analysis, I linked environmental services to the local community that could be potentially impacted by ash basin closure and the identified objectives of ash basin closure, and I identified attributes and comparative metrics[6] that characterize the condition of the environmental services (Efroymson et al. 2003, 2004).

I used human health attributes (e.g., risk to onsite construction workers, risk to offsite swimmers) and risk quotients (hazard index [HI], excess lifetime cancer risk [ELCR]) to evaluate whether there would be a potential impact to environmental services related to safe water, air, and food under each ash basin closure option. I also used human health attributes to evaluate whether there would be an impact to air quality during closure activities. I used ecological health attributes (e.g., risk to birds, mammals) and risk quotients (hazard quotients [HQs]) to evaluate whether there would be a potential impact to environmental services related to safe surface water and food and protection of biodiversity and natural beauty under the ash basin closure options. I evaluated risk and disturbance associated with traffic and accidents using transportation metrics and trucking logistics (e.g., number of truck miles driven) associated with each closure option to evaluate potential impacts to community safety. I used net primary productivity (NPP)[7] and discounted service acre-years (DSAYs)[8] to characterize

6 For purposes of this analysis, an attribute is a feature that characterizes environmental services and may be impacted by a closure option. Comparative metrics are features of the attribute (e.g., risk quotients, acreage of habitat) that can be measured and compared between options.

7 NPP represents the mass of chemically fixed carbon produced by a plant community during a given time interval. It reflects the rate at which different ecosystems are able to sequester carbon, which is related to mitigating climate change (https://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD17A2_M_PSN).

differences in the environmental services that derive from habitats (e.g., protection of biodiversity, natural beauty) and that would be impacted by ash basin closure activities. Finally, I assembled all attributes, services, and objectives within a full NEBA to examine which of the closure options best maximizes environmental services for the local community. The metrics I used are scientifically appropriate and commonly applied metrics to evaluate risk to humans and the environment (U.S. EPA 1989, 1997, 2000; NHTSA 2016) and to quantitatively measure differences in environmental services associated with impact and restoration (Dunford et al. 2004; Desvousges et al. 2018; Penn undated; Efroymson et al. 2003, 2004).

Of note, my analysis did not consider the risks involved with on-site construction activities. For example, I did not attempt to evaluate occupational accidents created by on-site construction and excavation. Nor did I attempt to evaluate emissions associated with on-site construction activities. Finally, I did not attempt to consider the risk created by disturbing the ash basin and exposing it to the elements during excavation activities.

Some stakeholders also expressed concern over safety of the ash impoundment dam (NCDEQ 2016). The most recent dam safety report produced by Wood Environment & Infrastructure Solutions, Inc. and submitted to NCDEQ indicates "the construction, design, operation, and maintenance of the CCR surface impoundments have been sufficiently consistent with recognized and generally accepted engineering standards for protection of public safety and the environment" (Browning and Thomas 2018).

Three possible options for closure of the ash basin at BCSS were identified by Duke Energy and summarized in (Table ES-2). I used these options in the NEBA to examine how different closure possibilities impact environmental services to the local community.

[8] DSAYs are derived from habitat equivalency analysis (HEA). HEA is an assessment method that calculates debits based on services lost and credits for services gained from a remediation action (Dunford et al. 2004; Desvousges et al. 2018; Penn undated). A discount rate is used to standardize the different time intervals in which the debits and credits occur, and in doing so, present the service debits and credits at present value. The present value of the services is usually expressed in terms of discounted service acre-years of equivalent habitat, or DSAYs, which provide a means to compare the different service levels of affected habitat acres (Dunford et al. 2004; Desvousges et al. 2018; Penn undated).

Table ES-2. Ash basin closure options provided by Duke Energy (2018)

Closure Option	Description	Closure Duration (years)[a]	Construction Duration (years)[b]
CIP	CIP	9	6
Excavation	Excavate to onsite landfill	16	12
Hybrid	Partially excavate to consolidate ash and CIP consolidated ash	10	7

[a] Includes design and permitting, decanting, site preparation, construction, and site restoration.
[b] Includes site preparation, construction, and site restoration.

NEBA Risk Ratings

NEBA organizes environmental hazard and benefit information into a unitless metric that represents the degree and the duration of impact from remediation and closure alternatives. One approach to structure this analysis is to create a risk-ranking matrix that maps the proportional impact of a hazard (i.e., risk) with the duration of the impact, which is directly related to the time to recovery (Robberson 2006). The risk-ranking matrix used for this application of NEBA is provided in Table ES-3. In this application, the matrix uses alphanumeric coding to indicate the severity of an impact: higher numbers and higher letters (e.g., 4F) indicate a greater extent and a longer duration of impact. Shading of cells within the matrix supports visualization of the magnitude of the effect according to the extent and duration of impact.[9] When there is no meaningful risk, the cell is not given an alphanumeric code. Relative risk ratings for each attribute and closure option examined were assembled into objective-specific summaries to compare the net benefits of the closure options. All closure options in the NEBA were evaluated against current conditions as a “baseline” for comparison.

[9] Categories and shading as defined in the risk-ranking matrix are based on best professional judgment and used for discussion of the relative differences in relative risk ratings. Alternative risk matrices and resulting NEBA classifications are explored in Appendix E.

Table ES-3. Risk-ranking matrix for impacts and risk from closure activities. Darker shading and higher codes indicate greater impact.

		Duration of Impact (years)			
		10–15 **(4)**	5–9 **(3)**	1–4 **(2)**	<1 **(1)**
% Impact	No meaningful risk	--	--	--	--
	<5% **(A)**	**4A**	**3A**	**2A**	**1A**
	5–19% **(B)**	**4B**	**3B**	**2B**	**1B**
	20–39% **(C)**	**4C**	**3C**	**2C**	**1C**
	40–59% **(D)**	**4D**	**3D**	**2D**	**1D**
	60–79% **(E)**	**4E**	**3E**	**2E**	**1E**
	>80% **(F)**	**4F**	**3F**	**2F**	**1F**

NEBA analysis of possible closure options for the ash basin at BCSS helps both Duke Energy and other stakeholders understand the net environmental benefits from the closure option configurations that were examined. If a closure option that is preferred for reasons not considered in the NEBA does not rate as one of the options that best maximizes environmental services to the local community, closure plans for that option can be re-examined, and opportunities to better maximize environmental benefits can be identified (e.g., including an offsite habitat mitigation project to offset environmental services lost from habitat alteration). The NEBA can then be re-run with the updated plan to compare the revised closure plan with other closure options.

The following is a summary of my conclusions and supporting analyses, which are structured around the five objectives identified above.

Conclusion 1: All closure options for the BCSS ash basin are protective of human health.

The first objective for ash basin closure, *to protect human health from CCR constituent exposure*, is represented by environmental services that provide safe drinking water, safe groundwater, safe surface water, safe food consumption, and safe recreation. For purposes of the NEBA, these safety considerations were evaluated based on the following:

1. Provision of permanent alternative drinking water supplies to public and private well water supply users within a 0.5-mile radius of BCSS (Holman 2018);
2. Concentrations of CCR constituents of interest (COIs)[10] in drinking water wells that could potentially affect local residents and visitors, as characterized by HDR (2015a) and SynTerra (2017) in the Comprehensive Site Assessment (CSA); and
3. Risk to various human populations from CCR exposure, as characterized in the updated human health and ecological risk assessment conducted by SynTerra (2018; Appendix B).

Based on these analyses, no CCR impacts to drinking water and no meaningful risk to humans from CCR exposure were found under current conditions[11] or under any closure option. Using the NEBA framework and relative risk ratings, these results are summarized in Table ES-4 within the objective of protecting human health from exposure to CCR constituents.

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[10] COIs are constituents relevant to analysis of potential exposure to CCR constituents but are not necessarily associated with risk to human or ecological receptors.

[11] SynTerra's updated human health risk assessment (HHRA) considered only potential exposure pathways that currently exist and could remain after ash basin closure under any closure option. Any potential risk currently associated with seeps (or areas of wetness [AOWs]) at BCSS was not evaluated in the HHRA or considered in this analysis because any risk resulting from seeps will be eliminated, reduced, or mitigated per the court-enforceable Special Order by Consent (SOC) that Duke entered with the North Carolina Environmental Management Commission on July 12, 2018 (EMC SOC WQ S18-004; See Section 4.2). The SOC requires Duke Energy to accelerate the schedule for decanting the ash basin to "substantially reduce or eliminate" seeps that may be affecting state or federal waters; the SOC also requires Duke Energy to take appropriate corrective actions for any seeps remaining after decanting is complete to ensure the remaining seeps are managed "in a manner that will be sufficient to protect public health, safety, and welfare, the environment, and natural resources" (EMC SOC WQ S18-004).

Table ES-4. Summary of relative risk ratings for attributes that characterize potential hazards to humans from CCR exposure in drinking water, surface water, groundwater, food, and recreation

Objective	Protect Human Health from CCR						
Hazard	Exposure to CCR						
Potentially Affected Populations	Local Residents/Visitors	Onsite Construction Workers	Offsite Recreational Swimmers	Offsite Recreational Waders	Offsite Recreational Boaters	Offsite Recreational Fishers	Offsite Subsistence Fishers
Scenario							
Baseline	--	--	--	--	--	--	--
CIP	--	--	--	--	--	--	--
Excavation	--	--	--	--	--	--	--
Hybrid	--	--	--	--	--	--	--

"--" indicates "no meaningful risk."

Current conditions and conditions under all closure options support provision of safe drinking water, safe surface water, safe food, and safe recreation, satisfying the first objective of ash basin closure—*to protect human health from CCR constituent exposure.*

Conclusion 2: All closure options for the BCSS ash basin are protective of ecological health.

The second objective for ash basin closure, *to protect ecological health from CCR constituent exposure*, is represented by environmental services that provide safe surface water, safe food consumption, and protection of biodiversity and natural beauty. For purposes of the NEBA, these considerations were evaluated based on the following:

1. Risk to ecological receptors from CCR exposure, as characterized by SynTerra (2018; Appendix B) in the updated human health and ecological risk assessment; and

2. Aquatic community health in Belews Reservoir and the Dan River as reported in recent environmental monitoring reports (Brown and Derwort 2014; Duke Energy 2016).

From my review of these analyses, no evidence of impacts to ecological receptors from CCR exposure was identified under current conditions[12] or under any closure option, and both Belews Reservoir and the Dan River continue to support a healthy aquatic community. Using the NEBA framework and relative risk ratings, these results are summarized in Table ES-5 within the objective of protecting ecological health from exposure to CCR constituents.

Current conditions and conditions under all closure options support provision of safe surface water, safe food consumption, and protection of biodiversity and natural beauty, satisfying the second objective of ash basin closure—*to protect ecological health from CCR constituent exposure*.

[12] SynTerra's updated ecological risk assessment (ERA) considered only potential exposure pathways that currently exist and could remain after ash basin closure under any closure option. Any potential risk currently associated with seeps (or AOWs) at BCSS was not evaluated in the ERA or considered in this analysis because any risk resulting from seeps will be eliminated, reduced, or mitigated per the court-enforceable SOC that Duke entered with the North Carolina Environmental Management Commission on July 12, 2018 (EMC SOC WQ S18-004; See Section 4.2). The SOC requires Duke Energy to accelerate the schedule for decanting the ash basin to "substantially reduce or eliminate" seeps that may be affecting state or federal waters; the SOC also requires Duke Energy to take appropriate corrective actions for any seeps remaining after decanting is complete to ensure the remaining seeps are managed "in a manner that will be sufficient to protect public health, safety, and welfare, the environment, and natural resources" (EMC SOC WQ S18-004).

Table ES-5. Summary of relative risk ratings for attributes that characterize potential hazards to ecological resources from CCR exposure in surface water, soil, sediment, and food

Objective	Protect Ecological Health from CCR				
Hazard	Exposure to CCR				
Potentially Affected Populations	Fish Populations	Aquatic Omnivore Birds (mallard)	Aquatic Piscivore Birds (great blue heron)	Aquatic Herbivore Mammals (muskrat)	Aquatic Piscivore Mammals (river otter)
Scenario					
Baseline	--	--	--	--	--
CIP	--	--	--	--	--
Excavation	--	--	--	--	--
Hybrid	--	--	--	--	--

"--" indicates "no meaningful risk."

Conclusion 3: Excavation closure creates greater disturbance to communities.

The third objective for ash basin closure, *to minimize risk and disturbance to humans from closure*, is represented by environmental services that provide safe air quality and a safe community environment. For purposes of the NEBA, these considerations were evaluated based on the following:

1. Health risks from diesel exhaust emissions to the community living and working along transportation corridors during trucking operations to haul

materials to and from the ash basin, as evaluated through the application of diesel truck air emissions modeling and human health risk assessment; and

2. The relative risk for disturbance and accidents resulting from trucking operations affecting residents living and working along transportation corridors during construction operations, as evaluated by comparing the relative differences in trucking operations between the three closure options.

From these analyses, no meaningful health risk is expected from diesel exhaust emissions under any closure option, but the three closure options are expected to produce different levels of community disturbance in the form of noise, traffic congestion, and risk of traffic accidents.

I used the number of trucks per day passing[13] a receptor along a near-site transportation corridor to examine the differences in noise and traffic congestion under the closure options. I compared the increase in the average number of trucks hauling materials to BCSS under the closure options[14] to the current number of truck passes for the same receptor. I specified a baseline level of truck passes[15] on the transportation corridor under current conditions of 94 passes per day. Based on the assumed 94-truck-per-day baseline level and the number of truck trips per day from Duke Energy's projections (Duke Energy 2018), all options would have an impact of 12% or less (CIP = 12%, excavation = 9%, hybrid = 11%) on noise and traffic congestion. I input these percent changes to the risk-ranking matrix (Table ES-3) along with the total duration of trucking activities (6 years CIP; 12 years excavation; 7 years hybrid) to evaluate which of the closure options better minimizes human disturbances.

I also evaluated risk of traffic accidents by comparing the average number of annual offsite road miles driven between closure options relative to an estimate of the current road miles driven in

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13 Truck passes per day resulting from closure activities are calculated as the total number of loads required to transport earthen fill, geosynthetic materials, and other materials multiplied by two to account for return trips. The resulting total number of passes is then divided evenly among the total number of months of construction time multiplied by 26 working days per month.

14 Truck trips to haul ash were not included in the estimate for BCSS ash basin closure because trucks hauling ash would not leave BCSS property and would not affect community receptors along the transportation corridors.

15 A baseline estimate of trucking passes per day for transportation corridors near BCSS was derived from North Carolina Department of Transportation (NCDOT) data of annual average daily traffic (AADT) at thousands of locations across the state and the proportion of road miles driven by large trucks in North Carolina (See Appendix E for details).

Stokes County, North Carolina. I specified a current, or baseline, level of annual road miles driven along the transportation corridor near BCSS of 27.4 million miles,[16] and the road miles driven under the closure options are from the trucking projections provided by Duke Energy (2018). Using the 27.4-million-truck-miles baseline assumption, CIP has a 0.19% impact; excavation closure 0.12%; and the hybrid closure 0.14% impact. All closure options have a relative risk rating of <5%. These relative risk ratings appear to be insensitive to lower assumed baseline annual truck miles (Appendix E).

Table ES-6 summarizes the NEBA relative risk ratings based on the trucking projections and implementation schedules provided by Duke Energy (2018) for the objective of minimizing disturbance to humans during closure. All closure options create a level of risk and disturbance to human populations over baseline conditions. While the excavation closure option produces comparable, if slightly lower, impacts to CIP and hybrid closures on a daily or annual basis, the impacts occur for twice as long as those for CIP closure, resulting in a greater cumulative impact (risk rating 4 compared to 3) from excavation closure based on the trucking projections and implementation schedules provided by Duke Energy (2018).

[16] To estimate the number of baseline truck miles, I multiplied the number of total vehicle miles traveled in Stokes County (NCDMV 2017) by the Stokes County average 7.2% contribution of trucks to total AADT (NCDOT 2015).

Table ES-6. Summary of relative risk ratings for attributes that characterize potential hazards to communities during closure activities. Darker shading and higher codes indicate greater impact.

Objective	Minimize Human Disturbance		
Hazard	Noise and Traffic Congestion	Traffic Accidents	Air Pollution
Potentially Affected Populations	Local Residents/Visitors	Local Residents/Visitors	Reasonable Maximum Exposure
Scenario			
Baseline	baseline	baseline	baseline
CIP	**3B**	**3A**	**--**
Excavation	**4B**	**4A**	**--**
Hybrid	**3B**	**3A**	**--**

"--" indicates "no meaningful risk."

All closure options support safe air quality from diesel truck emissions along the transportation routes, and each creates comparable levels of disturbance and risk on a daily or annual basis that could adversely impact community safety; however, these impacts occur for a substantially longer period under the excavation closure option (12 years for excavation closure compared to 6 and 7 years for CIP and hybrid closures, respectively) Thus, CIP and hybrid closure better satisfy the third objective of ash basin closure—*to minimize risk and disturbance to humans from closure*.

Conclusion 4: Hybrid and excavation closures minimize environmental disturbance.

The fourth objective for ash basin closure, *to minimize risk and disturbance to the local environment from closure*, is represented by two environmental services: protection of biodiversity and natural beauty. For purposes of the NEBA, these considerations were evaluated based on differences in the NPP of impacted habitats under the three closure options, as estimated by the number of DSAYs calculated by a habitat equivalency analysis (HEA).

The results of the HEA indicate that CIP will result in a net loss of environmental services due primarily to the reduced NPP services provided by the grass cap that will replace all the existing habitats in the ash basin but not fully compensate for the service losses resulting from the closure. Conversely, hybrid and excavation closures produce a net gain in environmental services as indicated by the positive DSAY total. These differences are summarized in Table ES-7. A full description of the methods, assumptions, results, and sensitivity analyses for the HEA are provided in Appendix D and E.

Table ES-7. Summary of NPP DSAYs for CIP, excavation, and hybrid closure options

		CIP	Excavation	Hybrid
Ash basin losses				
	Grass Cap	−25	−24	−25
	Open water	−470	−443	−470
	Wetland	−801	−754	−801
	Broadleaf forest	−182	−170	−182
	Needle leaf forest	−9	−8	−9
	Shrub-scrub	−13	−13	−13
	Total losses	−1,500	−1,411	−1,500
Ash basin post-closure gains				
	Grass cap	520		257
	Open field		110	99
	Wetland		68	61
	Broadleaf forest		2,002	1093
	Needle leaf forest		1,515	826
	Shrub-scrub		204	183
	Wetland forest		27	15
	Total gains	520	3,926	2,534
Landfill/borrow losses				
	Forest loss to landfill/borrow	−392	−2,278	−362
	Open field loss to landfill/borrow			
	Total losses	−392	−2,278	−362
Landfill/borrow post-closure gains				
	Land reforested	264		237
	Land restored to grass cap		126	
	Total gains	264	126	237
Net Gain/Loss per Option		**−1,107**	**361**	**908**

Note: DSAYs for specific habitat types are reported here rounded to the nearest whole number. As such, the net gain/loss per option differs slightly from the sum of the individual DSAYs reported in the table.

The impact of closure on environmental services was computed as the percentage difference in net DSAYs produced by the closure option and the baseline DSAYs (or the absolute value of the DSAY losses). The DSAY losses represent the NPP services that would have been produced by the ash basin, borrow areas, and landfills but for the project closure. The DSAY gains represent the NPP services restored after project closure plus any future gains realized from existing habitats before remediation begins. The sum of DSAY losses and gains represents the net change of NPP services for the project resulting from closure. Dividing the closure option net DSAYs by the absolute value of the DSAY losses provides a percentage of the impact. From these calculations, the CIP closure will have a 59% impact,[17] while excavation and hybrid closure will have no net adverse impact on NPP services and will, in fact, increase net NPP services. These percent changes were input to the risk-ranking matrix (Table ES-3) along with the duration of the closure activities (6 years CIP; 12 years excavation; 7 years hybrid) to visualize, within the NEBA framework, which of the closure options best minimizes environmental disturbances (Table ES-8).

Table ES-8. Summary of relative risk ratings for habitat changes that affect protection of biodiversity and natural beauty. Darker shading and higher codes indicate greater impact.

Objective	**Minimize Environmental Disturbance**
Hazard	Habitat Change
Attribute	DSAYs
Scenario	
Baseline	baseline
CIP	**3D**
Excavation	**--**
Hybrid	**--**

"--" indicates "no meaningful risk."

Within the objective of minimizing environmental disturbance from closure, my analyses indicate that both hybrid and excavation closures produce a net benefit in habitat-derived environmental services; however, CIP closure decreases habitat-derived environmental services. Thus, hybrid and excavation closures better satisfy the fourth objective of ash basin closure—*to minimize risk and disturbance to the local environment from closure*.

17 As discussed below, this habitat impact could be offset with an appropriate reforestation project.

Conclusion 5: Hybrid closure maximizes environmental services.

Identifying environmental actions that maximize environmental services (the fifth objective for ash basin closure) is a function of NEBA (Efroymson et al. 2003, 2004) and the overarching objective that encompasses each of the other four objectives and all of the environmental services that have been considered to this point.

I organized my analyses around the following five objectives for ash basin closure, and I found the following:

1. Protect human health from CCR constituent exposure
   All closure options for the BCSS ash basin are protective of human health.
2. Protect ecological health from CCR constituent exposure
   All closure options for the BCSS ash basin are protective of ecological health.
3. Minimize risk and disturbance to humans from closure
   Excavation closure creates greater disturbance to communities.
4. Minimize risk and disturbance to the local environment from closure
   Hybrid and excavation closures minimize environmental disturbance.
5. Maximize local environmental services
   Hybrid closure maximizes environmental services.

Table ES-9 summarizes the relative risk ratings for all attributes and objectives that have been considered. From this analysis, which is based on a scientific definition of risk acceptability and includes no value weighting, a hybrid closure best maximizes environmental benefits compared to excavation and CIP closures because it offers equivalent protection of human and ecological health from CCR exposure, results in less disturbance to the community over time compared to excavation closure, and produces a net gain in habitat-derived environmental services. Thus, hybrid closure best satisfies the fifth objective of ash basin closure—*to maximize local environmental services*.

As noted previously, NEBA analysis also provides an opportunity to better understand the net environmental benefits of possible closure options. If Duke Energy's preferred closure option for reasons not considered in the NEBA does not best maximize environmental services to the local community as currently defined, the NEBA results provide insight into how environmental services could be improved for that closure option. For instance, if Duke Energy's preferred closure option for BCSS is CIP closure but the HEA results for the currently defined CIP closure option estimate a net environmental service loss of 1,107 DSAYs, Duke Energy could consider incorporating into an updated CIP closure plan for BCSS a mitigation project that compensates for the net environmental service losses projected from the currently defined CIP closure option. As an example, if Duke Energy started a reforestation project outside of the ash basin in 2022 (when onsite preparation of the ash basin begins), the reforestation project would gain 24.3 DSAYs/acre over the lifetime of the site (150 years in the HEA), requiring an approximate 45.5 acre project to compensate for the 1,107 DSAY loss projected from the HEA based on the current CIP closure plan. Re-analysis of the HEA component of the NEBA for the updated possible closure options would then result in no net environmental losses (as NPP services) from habitat alteration of the basin under any closure option.

By looking at a wide variety of attributes representing a number of different environmental services that directly link to local stakeholder concerns for the BCSS ash basin, I conclude, with a reasonable degree of scientific certainty, that the hybrid closure option for the BCSS ash basin provides greater net environmental services and less disturbance to the community and the environment than the CIP or excavation closures evaluated.

Table ES-9. NEBA for closure of the ash basins at BCSS. Darker shading and higher alphanumeric codes indicate greater impact.

Objective	Protect Human Health from CCR							Protect Ecological Health from CCR					Minimize Human Disturbance			Minimize Environmental Disturbance
Hazard	Exposure to CCR							Exposure to CCR					Noise and Traffic Congestion	Traffic Accidents	Air Pollution	Habitat Change
Potentially Affected Populations	Local Residents/Visitors	Onsite Construction Workers	Offsite Recreational Swimmers	Offsite Recreational Waders	Offsite Recreational Boaters	Offsite Recreational Fishers	Offsite Subsistence Fishers	Fish Populations	Aquatic Omnivore Birds (mallard)	Aquatic Piscivore Birds (great blue heron)	Aquatic Herbivore Mammals (muskrat)	Aquatic Piscivore Mammals (river otter)	Local Residents/Visitors	Local Residents/Visitors	Reasonable Maximum Exposure	DSAYs
Scenario																
Baseline	--	--	--	--	--	--	--	--	--	--	--	--	baseline	baseline	baseline	baseline
CIP	--	--	--	--	--	--	--	--	--	--	--	--	**3B**	**3A**	--	**3D**
Excavation	--	--	--	--	--	--	--	--	--	--	--	--	**4B**	**4A**	--	--
Hybrid	--	--	--	--	--	--	--	--	--	--	--	--	**3B**	**3A**	--	--

"--" indicates "no meaningful risk."

1 Qualifications

I am a senior managing scientist in the Ecological and Biological Sciences Practice at Exponent, a scientific and engineering consulting firm. I am a professional ecologist, toxicologist, and biologist with more than 20 years of experience studying the relationship between human activities and effects on natural resources and people. I have Doctor of Science and Master of Science degrees in environmental health from the Harvard University School of Public Health. I have a Bachelor of Science degree in biology from Rhodes College. My academic and professional training includes a broad background in topics ranging from biology, ecology, toxicology, epidemiology, pollution fate and transport, and statistical analysis. Key areas of my practice involve the use of structured frameworks for evaluating multiple lines of evidence to assess causation of environmental impacts and to weigh the benefits and consequences of decisions that affect ecological and human health.

Decision support projects I have conducted include the following:

- Net environmental benefit analysis (NEBA) to facilitate the selection of a remediation plan for a lead contaminated river and to support closure option analysis for several coal ash basins;
- Developing beach management tools to improve public advisories related to elevated fecal bacteria from sewage contamination at recreational beaches;
- Selecting cleanup thresholds for sediment remediation that quantitatively weigh the tradeoff between sensitivity and specificity of potential thresholds to meet cleanup objectives;
- Natural resource damage assessment (NRDA) to support injury quantification and restoration selection; and
- Review and testimony on the sufficiency of environmental impact analysis to support development planning.

Projects I have been involved in have concerned coal ash basin closures, oil spills, sewage releases, heavy metal contamination, development planning, and various industrial and municipal facilities that have generated complex releases to the aquatic environment. A list of my publications, presentations, and cases for which I have written expert reports, been deposed, and/or provided trial testimony is provided in my *curriculum vitae*, included as Appendix A of this report.

2 Assignment and Retention

I was asked to examine how local environmental health and environmental services are differently affected under closure options for the coal ash basin at Duke Energy Carolinas, LLC's (Duke Energy's) Belews Creek Steam Station (BCSS) and to evaluate these differences in a structured framework that can support decision-making. My assignment included review of the comprehensive site assessment (CSA) and corrective action plan (CAP) documents for BCSS, as well as documents available through the North Carolina Department of Environmental Quality's (NCDEQ's) website and documents prepared as part of Duke Energy's National Pollutant Discharge Elimination System (NPDES) permitting. I visited BCSS on September 4, 2018, and I reviewed expert reports prepared for related matters involving BCSS. A list of the primary documents I relied upon is provided in Section 3 of this report.

3 Reliance Materials

In the process of conducting my analyses, I have reviewed many documents. Of those, I have relied most on the following reports and documents. Technical (scientific literature) references are cited in subsequent sections of this report and listed in Section 12.

- Comprehensive Site Assessment (CSA) for the Belews Creek Steam Station, including all updates (HDR 2015a, 2016b; SynTerra 2017)
- Corrective Action Plan (CAP) for the Belews Creek Steam Station, including all updates (HDR 2015b, 2016a)
    - Baseline Human Health and Ecological Risk Assessment for the Belews Creek Steam Station (HDR 2016c [Appendix F of CAP 2])
- Environmental monitoring reports for Belews Reservoir and the Dan River (Brown and Derwort 2014; Duke Energy 2016)
- NCDEQ Belews Creek Meeting Officer Report (NCDEQ 2016)
    - Attachment V. Written Public Comments Received
    - Attachment VIII. Public Comment Summary Spreadsheet
- Human Health and Ecological Risk Assessment Summary Update for Belews Creek Steam Station (SynTerra 2018; Appendix B)
- Belews Creek Steam Station Ash Basin Closure Options Analysis Summary Report (Duke Energy 2018)
- Closure logistics estimates (Duke Energy 2018).

4 Introduction

In 2015, the U.S. Environmental Protection Agency (EPA) issued a rule called the "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals [CCR] from Electric Utilities" (CCR Rule), which, among other things, regulates closure of coal ash impoundments in the United States. Closure of coal ash impoundments in North Carolina is further regulated by the North Carolina Coal Ash Management Act of 2014 (CAMA), as amended by H.B. 630, Sess. L. 2016-95. Under both the North Carolina CAMA and the federal CCR Rule, there are two primary options for closure of an ash impoundment:

- "Cap in place" (CIP) closure involves decanting the impoundment and placing a low permeability liner topped by appropriate cap material, soil, and grass vegetation over the footprint of the ash to restrict vertical transport of water through the ash, as well as a minimum of 30 years of post-closure care, which requires the implementation of corrective action measures if and as necessary;
- Excavation closure involves decanting the impoundment, excavating all ash in the basin, transporting the ash to an appropriate, permitted, lined landfill, and restoring the site.

Duke Energy has evaluated three representative types of closure for the ash basin at MSS—CIP, excavation to a new onsite landfill at BCSS, and hybrid closure—the latter of which involves excavating and consolidating ash within the basin footprint to reduce the spatial area of CIP closure. The administrative process for selecting an appropriate closure plan is ongoing.

The purpose of my report is to examine how environmental health and environmental services[18] to the local community around BCSS are differently affected by each closure option as currently defined and to evaluate these differences in a structured framework that can support decision-making in this matter.

[18] Environmental services, or ecosystem services, are ecological processes and functions that provide value to individuals or society (Efroymson et al. 2003, 2004).

4.1 Site Setting

BCSS is a two-unit coal-fired power plant located on the north side of Belews Reservoir in Belews Creek, Stokes County, North Carolina (Figure 4-1). The total site owned by Duke Energy covers 6,100 acres, of which Belews Reservoir constitutes 3,800 acres. BCSS began operation in 1974 with Unit 1, adding Unit 2 in 1975.

Coal ash from historical operations at BCSS is stored in an unlined, impounded basin located northwest of the facility. The BCSS ash basin is bound by an earthen dam and a natural ridge to the north, by Middleton Loop Road to the west, and by Pine Hall Road to the south and east. The ash basin was constructed between 1970 and 1972 and received wet sluiced fly ash and bottom ash from 1974 until 1984, when the station converted to dry ash handling. The BCSS ash basin currently holds approximately 12 million tons of ash (Duke Energy 2018) and covers approximately 283 acres (SynTerra 2017).

As originally constructed, the BCSS ash basin outfall discharged to Belews Reservoir (Figure 4-1). In 1976, two years after power generation began at BCSS, a decline in the game fish population of the lake was observed and linked to reproductive impairment from selenium exposure from the ash basin effluent, which was thought to have been exacerbated by the long residence time of waters in the reservoir (Duke Energy 2016). In 1984, BCSS switched to dry fly ash handling to "eliminate most selenium and other trace element inputs to the ash basin," and in 1985, the BCSS ash basin discharge was rerouted from Belews Reservoir to the Dan River (Figure 4-1). NPDES permitted discharge from the ash basin currently occurs at NPDES outfall 003; however, the new (2018) draft NPDES permit specifies the onsite Unnamed Tributary (NCDEQ 2018), formerly known as the "Designated Effluent Channel" (SynTerra 2017), as the receiving waterbody for discharge from the ash basin at NPDES outfalls 003 and 111.

There are four additional CCR structures at BCSS. The closed Pine Hall Road Landfill is located south of the ash basin and north of Pine Hall Road. A closed structural fill is located south of the ash basin on the south side of Pine Hall Road, and the active Craig Road Landfill and Flue Gas Desulfurization (FGD) Residue Landfill are located south of the ash basin.

Closure analyses consider only the BCSS active ash basin, as the other facilities are permitted and managed separately from the ash basin.

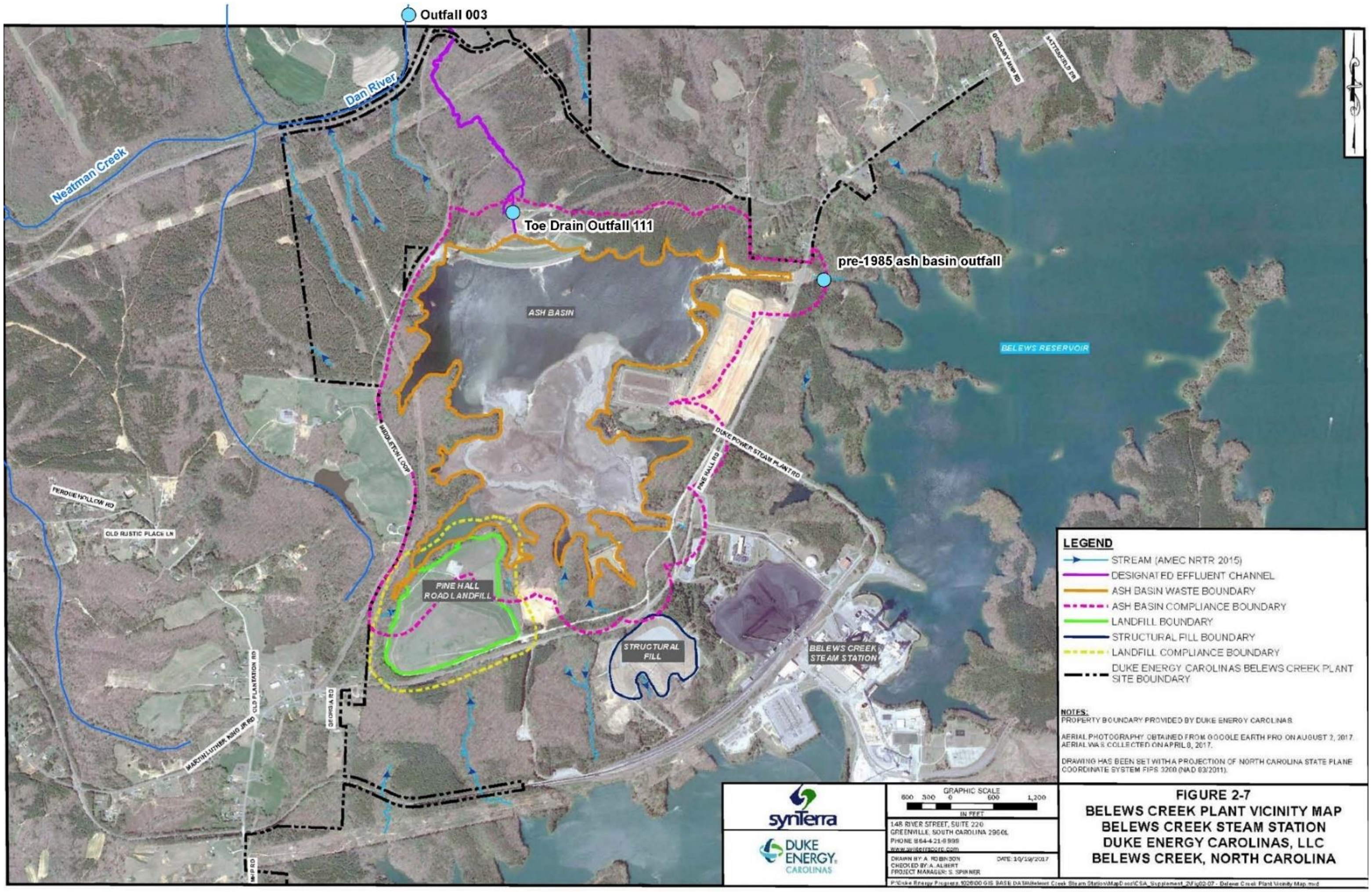

Figure 4-1. Map of BCSS. Reproduced and adapted from Figure 2-7 of the 2017 CSA Supplement (SynTerra 2017). Locations of current NPDES outfalls 003 (to the Dan River, slightly off map) and 111 were added along with the location of the pre-1985 ash basin outfall to Belews Reservoir.

BCSS is located in an ecological transitional zone between the Appalachian Mountains and the Atlantic coastal plain.[19] Much of the region was transformed historically from oak-hickory-pine forests to farmland and more recently from farmland again to woodlands characterized by successional pine and hardwood forest (Griffith et al. 2002). I observed extensive secondary forest habitat areas onsite, as well as open water, wetland, scrub/shrub,[20] open field, and mowed grass during my September 4, 2018 site visit (Figure 4-2).

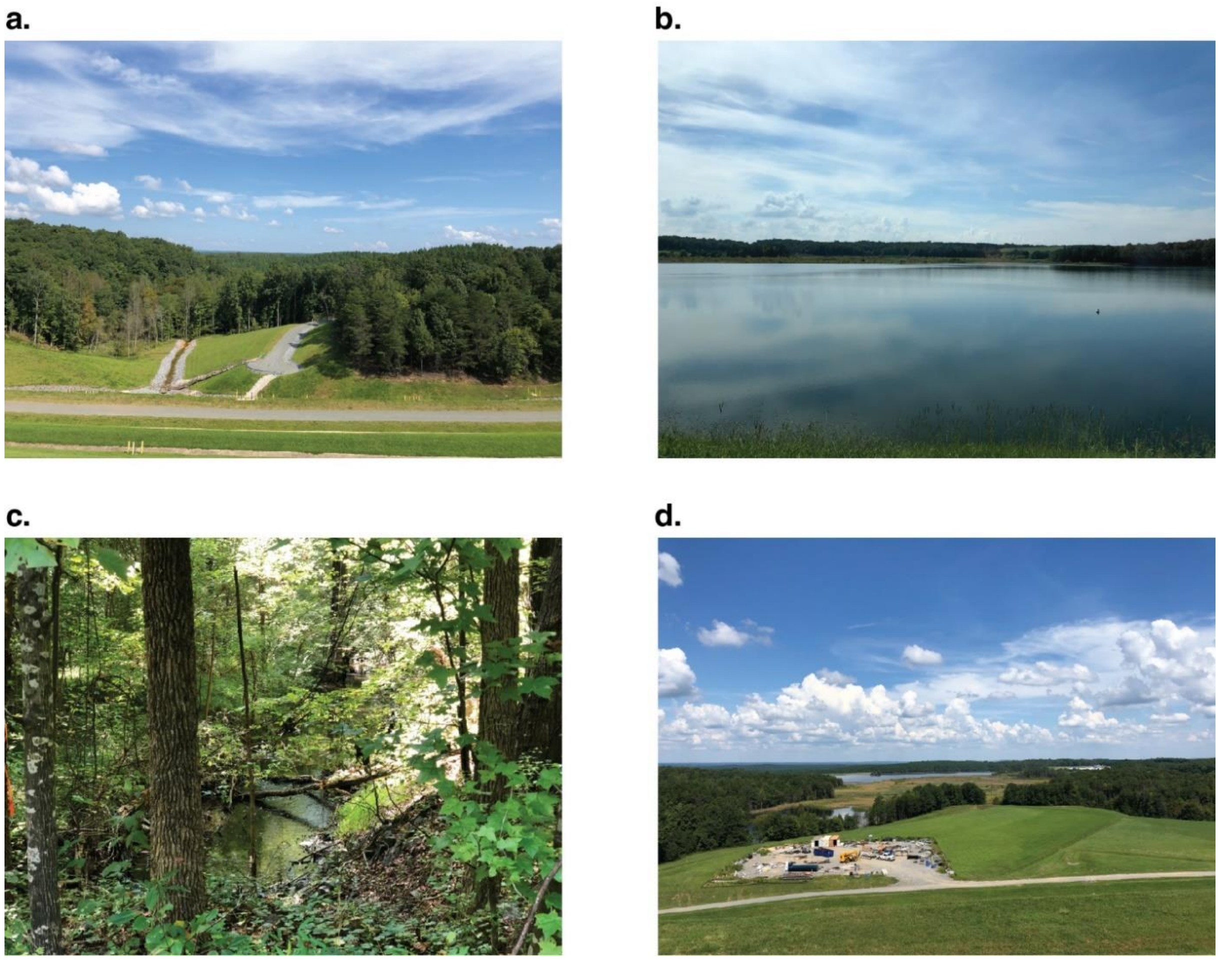

Figure 4-2. Images of various habitat types on and around BCSS. (a) Mixture of broadleaf and coniferous forest and mowed grass habitat looking north from the ash basin dam. (b) Open water and primarily broadleaf forest looking southwest from the ash basin dam. (c) Primarily broadleaf forest understory along the Unnamed Tributary from the ash basin to the Dan River. (d) Open field, mowed grass, wetland, open water, and forest habitats looking north from the Pine Hall Road Landfill over the ash basin. Photographs taken on September 4, 2018.

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[19] BCSS is classified as Northern Inner Piedmont by USEPA's ecoregion classification system. https://www.epa.gov/eco-research/ecoregions.

[20] Scrub/shrub habitat is characterized by low, woody plants.

The area surrounding BCSS consists of farmland, undeveloped land, residential areas, and Belews Reservoir (SynTerra 2017). Belews Reservoir supports fishing, boating, and other recreational activities and was featured as the “Lake of the Month” by the Carolina Sportsman website on November 1, 2012.[21] According to a local fisherman and guide quoted in the article, “There’s a great supply of small baitfish that supplies the bass’ needs. It’s a fabulous fishery year-round.” Primary species caught recreationally in Belews Reservoir include largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), spotted bass (*Micropterus punctulatus*), channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), black crappie (*Promoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), and white bass (*Morone chrysops*).[22] The hot water discharge from BCSS keeps much of the lake warm year round, which “makes for a lot of active bass at times when they would be dormant in other bodies of water, and it protects the threadfin shad that ‘feed’ the fishery from any cold-stun winter kills.”[23]

The Dan River, which flows to the north of BCSS, supports water recreation, including swimming, canoeing, kayaking, and tubing.[24] Many of these services are available through commercial vendors and thus constitute a source of economic activity. The river is also a popular fishing destination. In addition to trout, it also boasts “sizable populations of smallmouth bass, rare species of freshwater mussels, and a large variety of sucker fish.”[25] The Dan River also supports wildlife viewing. According to the Rockingham County website, bird watchers may encounter the eastern wood pewee (*Contopus virens*), hooded warbler (*Setophaga citrina*), and summer tanager (*Piranga rubra*), among others.[26]

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21 http://www.northcarolinasportsman.com/stories/ncs_mag_2903.htm

22 https://www.aa-fishing.com/nc/nc-fishing-lake-belews.html

23 http://www.northcarolinasportsman.com/stories/ncs_mag_2903.htm

24 http://www.danrivercompany.com/
https://files.nc.gov/ncdeq/Coal%20Ash/documents/Coal%20Ash/Dan%20River%20Coal%20Ash%20Scoping%20Document_10012014_Final.pdf
https://files.nc.gov/ncdeq/Coal%20Ash/documents/Coal%20Ash/20140609%20FINAL%20Dan%20River%20cooperative%20NRDAR%20factsheet.pdf

25 https://www.greensboro.com/news/local_news/land-conservancy-brings-trout-fishing-closer-to-home/article_9b8054ec-c20f-5ff9-938c-a18a5a848315.html.

26 http://www.visitrockinghamcountync.com/explore/bird-watching/.

4.2 Closure of the Ash Impoundments at BCSS

Coal ash, or CCR, includes fly ash, bottom ash, boiler slag, and FGD material (U.S. EPA 2017c). CCR are derived from the inorganic minerals in coal, which include quartz, clays, and metal oxides (EPRI 2009). Fine-grained, amorphous particles that travel upward with flue gas are called fly ash, while the coarser and heavier particles that fall to the bottom of the furnace are called bottom ash (EPRI 2009). The chemical composition of coal ash is similar to natural geologic materials found in the earth's crust, but the physical and chemical properties of coal ash vary depending on the coal source and the conditions of coal combustion and cooling of the flue gas (EPRI 2009). The majority of both fly ash and bottom ash are composed of silicon, aluminum, iron, and calcium, similar to volcanic ash and shale (Figure 4-3). Trace elements such as arsenic, cadmium, lead, mercury, selenium, and chromium generally constitute less than 1% of total CCR composition (EPRI 2009; USGS 2015). CCR are classified as a non-hazardous solid waste under the Resource Conservation and Recovery Act (RCRA).[27]

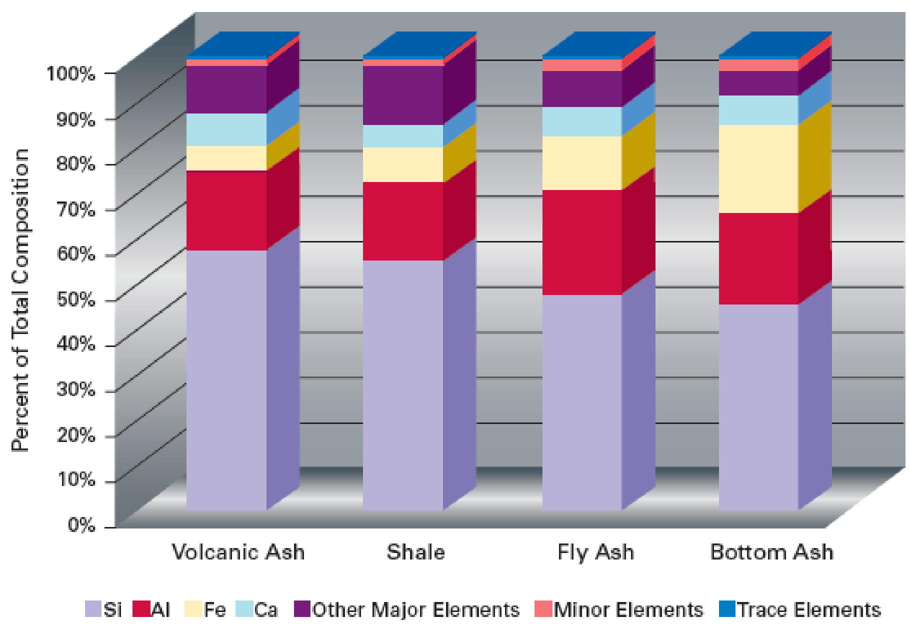

Figure 4-3. Elemental composition of bottom ash, fly ash, shale, and volcanic ash. Excerpt from EPRI (2009).

[27] https://www.epa.gov/coalash/coal-ash-rule

EPA's 2015 CCR Rule (40 CFR §§ 257 and 261) requires groundwater monitoring[28] for CCR landfills and surface impoundments and for corrective action, including closure, of CCR sites under certain circumstances. Owners and operators of CCR landfills and impoundments that are required to close under the regulation must conduct an analysis of the effectiveness of potential corrective measures (a corrective measures assessment) and select a strategy that involves either excavation or capping the "waste-in-place." Per § 257.97(b), the selected strategy must at a minimum be protective of human health and the environment, attain groundwater protection standards, control the source of releases so as to reduce or eliminate further releases of certain CCR constituents into the environment, remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems, and comply with the standards for management of wastes in § 257.98(d).

The CCR Rule does not provide criteria for selecting between these closure options because they are both considered effective closure methods. The CCR Rule states both methods of closure "can be equally protective, provided they are conducted properly." Hence, the final CCR Rule allows the owner or operator to determine whether excavation or closure in place is appropriate for their particular unit (80 FR 21412).

For the last several years, Duke Energy has been evaluating all of its ash impoundments and remains in the midst of further evaluating each one, including at BCSS, under the CCR Rule and pursuant to the administrative process set forth in CAMA. Ultimately, a final closure plan will be approved by NCDEQ.

Three possible options for closure of the ash basin at BCSS were identified by Duke Energy and are summarized in (Table 4-1). These options were used in the NEBA to examine how different closure possibilities impact environmental services to the local community.

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[28] According to the CCR Rule, groundwater must be evaluated for boron, calcium, fluoride, pH, sulfate, and total dissolved solids, which are defined as the constituents for detection monitoring in Appendix III of the Rule. When a statistically significant increase in Appendix III constituents over background concentrations is detected, monitoring of assessment monitoring constituents (Appendix IV) is required. Assessment monitoring constituents are antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, fluoride, lead, lithium, mercury, molybdenum, selenium, thallium, and radium 226 and 228, combined.

Table 4-1. Ash basin closure options provided by Duke Energy

Closure Option	Description	Closure Duration (years)[a]	Construction Duration (years)[b]
CIP	CIP	9	6
Excavation	Excavate to new onsite landfill	16	12
Hybrid	Partially excavate to consolidate ash and CIP consolidated ash	10	7

[a] Includes design and permitting, site preparation, decanting, construction, and site restoration.
[b] Includes site preparation, construction, and site restoration.

Table 4-2 provides a summary of some of the logistical differences between the closure options. Key among these are the following: (1) a substantially longer period of time is necessary to complete excavation closure; (2) substantially more deforestation is required under an excavation closure;[29] and (3) substantially more truck trips per day and total truck miles are required for excavation closure. Considering logistics alone, however, does not provide a complete understanding of the potential benefits and hazards associated with each closure option. An integrated analysis is necessary to place stakeholder concerns regarding risk from CCR in the larger context of risks and benefits to environmental services.

Table 4-2. Overview of some key logistical differences between closure options examined for the BCSS ash basin. Data provided by Duke Energy.

Closure Option	Closure Completion Time (years)[a]	Deforested Acres[b]	Average Truck trips/day[c]	Total truck miles[d]
CIP	9	13	6	324,180
Excavation	16	80[e]	4	378,245
Hybrid	10	12	5	284,700

[a] Includes pre-design investigations, design and permitting, site preparation, construction, and site restoration.
[b] Includes areas deforested to create borrow pits and/or landfill.
[c] Includes the total number of offsite roundtrip truck trips to haul earthen, and geosynthetic material to and from the ash basin.
[d] Includes the total number of onsite and offsite truck miles driven over the duration of construction operations to haul material to and from the ash basin.
[e] The new onsite landfill is estimated as 83 acres; only 80 acres currently contain vegetated habitat.

[29] BCSS has an onsite, lined landfill that could accept some excavated ash from the BCSS ash basins; however, there is insufficient capacity in the currently designed landfill to accept all of the coal ash from the ash basin under an excavation closure. Forest would need to be cleared to expand the landfill capacity beyond its current footprint to create this capacity. Deforestation is also likely under a CIP closure to access surface soil for capping activities.

Closure of the ash basin at BCSS involves decanting any overlying water in the basin and excavating or capping in place the underlying ash, as specified under CAMA and the federal CCR Rule. Additional activities related to, but separate from, closure under CAMA and the CCR Rule concern constructed[30] and non-constructed[31] seeps associated with the ash basin.[32] A Special Order by Consent (SOC; EMC SOC WQ S18-004) was signed by the North Carolina Environmental Management Commission and Duke Energy on July 12, 2018, to "address issues related to the elimination of seeps" from Duke Energy's coal ash basins. The SOC requires Duke Energy to accelerate the schedule for decanting the ash basin to "substantially reduce or eliminate" seeps that may be affecting state or federal waters; the SOC also requires Duke Energy to take appropriate corrective actions for any seeps remaining after decanting is complete to ensure the remaining seeps are managed "in a manner that will be sufficient to protect public health, safety, and welfare, the environment, and natural resources" (EMC SOC WQ S18-004). Given the court-enforceable requirement for Duke Energy to remediate any seeps remaining after decanting the ash basin to meet standards for the protection of public and environmental health, for purposes of my analyses, seeps (or areas of wetness) are assumed to contribute no meaningful risk to humans or the environment following any closure option since all closure options will entail decanting the basins and remediating any risk associated with remaining seeps as required by the SOC (EMC SOC WQ S18-004).

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[30] Constructed seeps are features within the dam structure, such as toe drains or filter blankets, that collect seepage of liquid through the dam and discharge the seepage through a discrete, identifiable point source to a receiving water; Seep S-11 is the only constructed seep at BCSS, and it is now incorporated into the BCSS NPDES permit NC0024406 and managed as part of the wastewater treatment system at BCSS (EMC SOC WQ S18-004).

[31] Non-constructed seeps are not on or within the dam structure and do not convey liquid through a pipe or constructed channel; non-constructed seeps at BCSS that require monitoring (and potentially action if they are not eliminated after ash basin decanting) are listed in the SOC (EMC SOC WQ S18-004).

[32] In 2014, Duke Energy provided a comprehensive evaluation of all areas of wetness (AOWs or seeps) on Duke Energy property and formally applied for NPDES coverage for all seeps (EMC SOC WQ S18-004).

5 Approach to Forming Conclusions

Environmental decision-making involves complex issues that concern multiple stakeholders. Identifying the best management alternative often requires tradeoffs among stakeholder values. For example, remediation management alternatives can decrease potential risks to human health and the environment from contaminants, but such benefits can also have unintended consequences, such as adverse impacts to other functions of the environment (e.g., destruction of habitat) or create other forms of risk (e.g., contamination of other environmental media). These tradeoffs between existing and future environmental services necessitate a transparent and systematic method to compare alternative actions and support the decision-making process.

Structured frameworks or processes are commonly used to weigh evidence and support requirements for environmental decision-making. Examples include:

- Environmental assessment (EA) and environmental impact statement (EIS) process that supports National Environmental Policy Act requirements for evaluating impacts from development projects and selecting mitigation measures (40 CFR § 1502);
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial investigation/feasibility study process that characterizes risk from contaminants at a site and then evaluates remediation alternatives (U.S. EPA 1988);
- RCRA corrective measures study process that supports identification, development, and evaluation of potential remedial alternatives for corrective action (U.S. EPA 1994);
- EPA's causal analysis/diagnosis decision information system (CADDIS) that supports stressor identification and selection of appropriate mitigation actions under the Clean Water Act (Cormier et al. 2000);
- NRDA that characterizes injury and lost human services to support selection of restoration projects under a number of environmental laws, including CERCLA and the Oil Pollution Act of 1990 (e.g., NOAA 1996); and

- NEBA that evaluates the tradeoffs in environmental impacts and benefits from remediation alternatives (NOAA 1990; Efroymson et al. 2003, 2004).

These frameworks have different regulatory origins and somewhat different approaches to accomplishing their specific objectives, but they all rely on a common core of analyses, including characterization of exposures, identification of adverse effects, definition of complete pathways between exposures and effects, characterization of risk or impact to exposed receptors (i.e., human and ecological populations), and weight-of-evidence analysis.

My analyses in this matter have used a NEBA framework to compare the relative risks and benefits derived from CIP, excavation, or hybrid closure of the ash basin at BCSS. NEBA was originally developed to examine impacts and benefits to ecological resources and habitats excluding impacts and risk to humans (Efroymson et al. 2004); however, as noted by EPA (2009), remediation and closure actions can also have both direct and indirect consequences to humans. To support a more thorough analysis of the net benefits of each closure option for BCSS, I have included comparative analyses in the NEBA that consider environmental health more broadly, including risks and benefits to both ecological and human populations in the vicinity. My analyses draw on the core principles of the environmental decision support frameworks discussed above and follow a pragmatic and transparent process.

In assembling information for the NEBA and forming my conclusions, I have relied on analyses reported in the CSA and CAP documents, as well as information provided by Duke Energy. Because a NEBA of environmental health necessarily encompasses a variety of scientific disciplines, I assembled a team of professionals within Exponent with expertise in ecological risk assessment (ERA), human health risk assessment (HHRA), contaminant fate and transport, decision support analysis, remediation, and statistics to review documents and, where indicated, conduct analyses at my direction. The results of these efforts are included in this report and have been reviewed by me.

5.1 Net Environmental Benefit Analysis

Net environmental benefits are defined as "the gains in environmental services or other ecological properties attained by remediation or ecological restoration, minus the environmental injuries caused by those actions" (Efroymson et al. 2003, 2004). Environmental services, or ecosystem services, are ecological processes and functions that produce value to individuals or society. A NEBA, as discussed above, is a structured framework for comparing impacts and benefits to environmental services to support decision-making (Efroymson et al. 2003, 2004). NEBA can be useful in evaluating and communicating the short-term and long-term impacts of remedial alternatives but does not make a determination of which alternative is best; that decision must be made by stakeholders and decision-makers and may ultimately involve weighing or prioritizing some values or objectives over others (Efroymson et al. 2003, 2004).

NEBA relies on scientifically supported estimates of risk to compare the reduction of risk associated with the chemicals of potential concern (COPCs)[33] under different remediation and closure alternatives alongside the creation of any risk during the remediation and closure, providing an objective, scientifically structured foundation for weighing the tradeoffs among remedial and closure alternatives. Despite the scientific basis of the risk characterization process, however, stakeholders in any environmental decision-making scenario may place different values on different types of risk. In other words, stakeholders may have different priorities for the remediation and closure. NEBA does not, by design, elevate, or increase the value of, any specific risk or benefit in the framework. The purpose of NEBA is to simultaneously and systematically examine all tradeoffs that affect the services (e.g., provision of safe drinking water, protection of biodiversity[34]) provided to humans and the ecosystem by the environment under remediation and closure, allowing decision-makers to more fully understand all potential benefits and risks of each alternative.

[33] COPCs are "any physical, chemical, biological, or radiological substance found in air, water, soil or biological matter that has a harmful effect on plants or animals" (https://ofmpub.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&glossaryName=Eco%20Risk%20Assessment%20Glossary).

[34] Biodiversity is the variety of plants and animals present at a location. Protection of biodiversity refers to provision of habitat and related functions capable of sustaining biological populations.

EPA supports the use of NEBA (U.S. EPA 2009a) as a means to compare remediation and redevelopment alternatives "based on their contributions to human well-being." EPA and the National Oceanic and Atmospheric Administration (NOAA) also use NEBA to support oil spill response decision-making (Robberson 2006; NOAA 1990). Examples of NEBA in oil-spill decision-making include:

- *Exxon Valdez* Oil Spill: NEBA was first applied to weigh the net environmental benefits of rock-washing to remove beached oil versus leaving the oil in place to naturally degrade (NOAA 1990).
- *Deepwater Horizon* Oil Spill: NEBA was used by the Operational Science Advisory Team-2 (OSAT-2) to "compare the environmental consequences of the defined cleanup endpoints for the oil and beach types considered, and the consequences of cleanup beyond those endpoints," specifically noting, "It is at this juncture that the concept of continued remedial efforts doing 'more harm than good' becomes a concern" (OSAT 2011).

I have personally applied NEBA to evaluate the net environmental benefits associated with two alternative sediment remediation cleanup goals for lead contamination in a tidal river. At that site, the river had been contaminated with lead from a battery manufacturing facility, and the state required removal of contaminated sediment that could potentially pose a health risk to people and the environment. The responsible party conducted human and ecological risk assessments, toxicity tests, and benthic community analyses to support the selection of an appropriate cleanup threshold for lead that would be protective of humans and the natural environment. Uncertainty in the results, however, led to two different remediation threshold concentrations being proposed by the state and by the responsible party. The NEBA was conducted to examine the tradeoffs in environmental impacts associated with the two cleanup thresholds. For one segment of the river, the footprint of remediation, including the size and types of habitat impacted, was substantially different under the alternative cleanup goals. The lower remediation threshold caused much greater impacts to submerged aquatic vegetation and riparian (shoreline) habitat that had cascading consequences to animals that rely on those environments. NEBA was able to demonstrate that remediation to the lower threshold would cause greater ecological harm and disturbance to the local community with little or no decrease in risk to benthic invertebrates (the ecological receptor at issue).[35] Consequently, the higher remediation goal was applied to that segment of the river.

These examples of NEBA are particularly relevant to the issues at BCSS. Remediation and closure of coal ash basins are specifically addressed in CAMA and the CCR Rule, and both CIP and excavation closure satisfy defined cleanup endpoints. At issue is whether removal of the coal ash under an excavation closure crosses the "juncture," as noted by OSAT-2, where the action would do more harm than good (OSAT 2011).

5.2 Linking Stakeholder Concerns to NEBA

To better understand stakeholder concerns related to closure of the ash basin at BCSS, I reviewed written communications about ash basin closure plans for BCSS submitted to and summarized by NCDEQ (NCDEQ 2016). From this review, I identified the following categories of stakeholder concerns:

- Drinking water quality
- Groundwater quality
- Surface water quality
- Fish and wildlife
- Maintaining property value
- Preservation of natural beauty
- Recreational value
- Swimming safety
- Failure of the ash impoundment
- Risk created by the closure option outweighing risk from contamination.

The primary concerns expressed by community stakeholders involve perceived risks from exposure to CCR constituents that could negatively affect environmental services that benefit the community: provision of safe drinking water and food, safe recreational enjoyment (e.g.,

[35] Both remediation goals were found to be protective of human, fish, bird, and mammal health. Uncertainty in toxicity test results and concern for protection of benthic macroinvertebrates (e.g., insect larvae and crustaceans) led the state to propose a lower remediation threshold for lead.

hunting, fishing, swimming), protection of natural beauty, and biodiversity. Potential hazards to the community associated with closure activities include physical disturbance of existing habitats; air pollution from diesel emissions; and traffic, noise, and accidents that could result in property damage, injuries, and fatalities. Table 5-1 links concerns over CCR exposure and potential hazards created by ash basin closure to environmental services that could be affected by closure activities.

Table 5-1. Relationships between environmental services and concerns to the local community associated with CCR and ash basin closure hazards

	Environmental Services							
	Safe drinking water quality	Safe surface water quality	Safe air quality	Safe food quality	Protection of biodiversity	Recreation	Natural beauty	Safe community environment
CCR Concerns								
Drinking water contamination	X	X						X
Groundwater contamination	X	X						X
Surface water contamination	X	X		X	X	X	X	X
Fish/wildlife contamination				X	X	X	X	X
Contamination impacting property value	X	X		X	X	X	X	X
Contamination impacting natural beauty					X		X	X
Contamination impacting recreational enjoyment		X			X	X	X	X
Contamination impacting swimming safety		X				X	X	X
Failure of the ash impoundment	X	X		X	X	X	X	X
Closure Hazards								
Habitat alteration		X	X		X	X	X	
Contamination of air			X		X	X		X
Noise, Traffic, Accidents						X		X

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In recognition of the potential discrepancy between stakeholder priorities and the broad and balanced treatment of service risks and benefits in NEBA, I organized the NEBA in this matter around the following five objectives for ash basin closure that recognize stakeholder concerns while being consistent with the methods and purpose of NEBA:

1. Protect human health from CCR constituent exposure
2. Protect ecological health from CCR constituent exposure
3. Minimize risk and disturbance to humans from closure
4. Minimize risk and disturbance to the local environment from closure
5. Maximize local environmental services.

Associations between environmental services potentially impacted by ash basin closure and the identified objectives of ash basin remediation are shown in Table 5-2.

Table 5-2. Associations between objectives for closure and remediation of the BCSS ash basins and environmental services

	Ash Basin Closure Objectives				
Environmental Services	Protect human health from CCR constituent exposure	Protect ecological health from CCR constituent exposure	Minimize risk and disturbance to humans from closure	Minimize risk and disturbance to the local environment from closure	Maximize local environmental services
Safe drinking water quality	X	X			X
Safe surface water quality	X	X			X
Safe air quality			X		X
Safe food quality	X	X			X
Recreation	X				X
Natural beauty		X		X	X
Protection of biodiversity		X		X	X
Safe community environment			X		X

NEBA relies on comparative metrics for specific attributes of the environment to examine the potential impacts and benefits from remediation and closure alternatives (Efroymson et al. 2003, 2004). NEBA methodology is not, however, prescriptive in defining attributes or comparative metrics because each application of NEBA is unique to contaminant exposure, remediation and closure alternatives, available data, and stakeholder concerns. NEBA is an extension of the risk assessment process (Efroymson et al. 2004). As a result, receptors, exposure pathways, and risks identified in a site risk assessment are key inputs to a NEBA. The links between key environmental services, attributes that represent those services, and comparative metrics used in this NEBA are summarized in Table 5-3.

Table 5-3. Matrix of key environmental services, attributes, and comparative metrics applied in the NEBA

	Attributes			
Environmental Services	Human Health Risk	Ecological Health Risk	Net Primary Productivity	Transportation Metrics
Safe ground water quality	HI/ELCR	--	--	
Safe surface water quality	HI/ELCR	HQ		
Safe soil and sediment quality	HI/ELCR	HQ	--	
Safe air quality	HI/ELCR	--	--	
Safe food quality	HI/ELCR	HQ	--	
Protection of biodiversity		HQ	DSAYs	
Recreation	HI/ELCR[a]	--	DSAYs	
Natural beauty		HQ	DSAYs	
Safe community environment		--		Trucking Logistics

Notes:

DSAYs – discounted service acre-years
ELCR – excess lifetime cancer risk
HI – hazard index
HQ – hazard quotient

[a] Estimated from health risks from consumption of fish.

I used human health attributes (e.g., risk to onsite construction workers, risk to offsite swimmers) and risk quotients (hazard index [HI], excess lifetime cancer risk [ELCR]) to evaluate whether there would be a potential impact to environmental services related to safe water, air, and food under each ash basin closure option. I also used human health attributes to evaluate whether there would be an impact to air quality during closure activities. I used ecological health attributes (e.g., risk to birds, mammals) and risk quotients (hazard quotients [HQs]) to evaluate whether there would be a potential impact to environmental services related to safe surface water and food and protection of biodiversity and natural beauty under the ash basin closure options. I evaluated risk and disturbance associated with traffic and accidents using transportation metrics and trucking logistics (e.g., number of truck miles driven) associated with each closure option to evaluate impacts to community safety. I used net primary productivity (NPP)[36] and discounted service acre-years (DSAYs)[37] to characterize differences in the environmental services that derive from habitats (e.g., protection of biodiversity, natural beauty) and that would be impacted by ash basin closure activities. Finally, I assembled all attributes, services, and objectives within a full NEBA to examine which of the closure options best maximizes environmental services to the local community. These metrics represent scientifically appropriate and commonly applied metrics to evaluate risk to humans and the environment (U.S. EPA 1989, 1997, 2000; NHTSA 2016) and to quantitatively measure differences in environmental services associated with impact and restoration (Dunford et al. 2004; Desvousges et al. 2018; Penn undated; Efroymson et al. 2003, 2004).

Of note, my analysis did not consider the risks involved with on-site construction activities. For example, I did not attempt to evaluate occupational accidents created by on-site construction and excavation. Nor did I attempt to evaluate emissions associated with on-site construction activities. Finally, I did not attempt to consider the risk created by disturbing the ash basin and exposing it to the elements during excavation activities.

Some stakeholders also expressed concern over safety of the ash impoundment dam (NCDEQ 2016). The most recent dam safety report produced by Wood Environment & Infrastructure Solutions, Inc. and submitted to NCDEQ indicates “the construction, design, operation, and

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36 NPP represents the mass of chemically fixed carbon produced by a plant community during a given time interval. It reflects the rate at which different ecosystems are able to sequester carbon, which is related to mitigating climate change (https://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD17A2_M_PSN).

37 DSAYs are derived from habitat equivalency analysis (HEA). HEA is an assessment method that calculates debits based on services lost and credits for services gained from a remediation and closure action (Dunford et al. 2004; Desvousges et al. 2018; Penn undated). A discount rate is used to standardize the different time intervals in which the debits and credits occur, and in doing so, present the service debits and credits at present value. The present value of the services is usually expressed in terms of discounted service acre-years of equivalent habitat, or DSAYs, which provide a means to compare the different service levels of affected habitat acres (Dunford et al. 2004; Desvousges et al. 2018; Penn undated).

maintenance of the CCR surface impoundments have been sufficiently consistent with recognized and generally accepted engineering standards for protection of public safety and the environment" (Browning and Thomas 2018).

5.3 NEBA Risk Ratings

NEBA organizes environmental hazard and benefit information into a unitless metric that represents the degree and the duration of impact from a remediation and closure alternative (Efroymson et al. 2003, 2004). One approach to structure this analysis is to create a risk-ranking matrix that maps the proportional impact of a hazard (i.e., risk) with the duration of the impact (Robberson 2006). The risk-ranking matrix used for this application of NEBA is provided in Table 5-4. The matrix uses alphanumeric coding to indicate the severity of an impact: higher numbers and higher letters (e.g., 4F) indicate a greater extent and a longer duration of impact, respectively. Shading of cells within the matrix supports visualization of the magnitude of the effect according to the extent and duration of an impact.[38] When there is no meaningful risk, the cell is not given an alphanumeric code. Risk ratings generated from the risk-ranking matrix for each attribute and closure option examined were assembled into objective-specific summaries to compare the net benefits of the closure options. All closure options in the NEBA were evaluated against current conditions as a "baseline" for comparison.

[38] Categories and shading as defined in the risk-ranking matrix are based on best professional judgment and used for discussion of the relative differences in relative risk ratings. Alternative risk matrices and resulting NEBA classifications are explored in Appendix E.

Table 5-4. Risk-ranking matrix for impacts and risk from remediation and closure activities. Darker shading/higher codes indicate greater impact.

		Duration of Impact (years)			
		10–15 **(4)**	5–9 **(3)**	1–4 **(2)**	<1 **(1)**
% Impact	No meaningful risk	--	--	--	--
	<5% **(A)**	**4A**	**3A**	**2A**	**1A**
	5–19% **(B)**	**4B**	**3B**	**2B**	**1B**
	20–39% **(C)**	**4C**	**3C**	**2C**	**1C**
	40–59% **(D)**	**4D**	**3D**	**2D**	**1D**
	60–79% **(E)**	**4E**	**3E**	**2E**	**1E**
	>80% **(F)**	**4F**	**3F**	**2F**	**1F**

NEBA analysis of possible closure options for the ash basin at BCSS helps both Duke Energy and other stakeholders understand the net environmental benefits from the closure option configurations that were examined. If a closure option that is preferred for reasons not considered in the NEBA does not rate as one of the options that best maximizes environmental services to the local community, closure plans for that option can be re-examined, and opportunities to better maximize environmental benefits can be identified (e.g., including an offsite habitat mitigation project to offset environmental services lost from habitat alteration). The NEBA can then be re-run with the updated plan to compare the revised closure plan with other closure options.

5.4 Risk Acceptability

Selecting any remediation, mitigation, restoration, or closure option involves considerations of risk—risk posed by contamination in place, risk created by the action, risk remaining after the action—and all of these risk considerations must be placed in some contextual framework if informed decisions are to be made. Hunter and Fewtrell (2001) state, “The notion that there is some level of risk that everyone will find acceptable is a difficult idea to reconcile and yet, without such a baseline, how can it ever be possible to set guideline values and standards, given that life can never be risk free?”

EPA defines risk as “the chance of harmful effects to human health or to ecological systems resulting from exposure to an environmental stressor” (U.S. EPA 2017a). In accordance with EPA guidance for conducting ERAs (U.S. EPA 1997) and HHRAs (U.S. EPA 1989), risk to a receptor (e.g., person, animal) exists when exposure to a stressor or stressors occur(s) at some level of effect; however, because not all exposures produce *adverse* effects in humans or ecological species, the exposure concentrations need to overlap with adverse effect thresholds for there to be the potential for meaningful risk. The science supporting individual benchmarks or levels of concern differs by the specific exposure at issue and the receptor at risk; however, such benchmarks are considered by regulatory authorities to represent the best scientific information available to create a baseline for risk (U.S. EPA 2017b).

The potential for risk associated with contamination is often evaluated using HQs, HIs, and ELCRs to screen environmental media (e.g., water, soil) and identify the potential risk associated with contamination (U.S. EPA 1989, 1997, 2000). The HQ is the ratio of an exposure point concentration[39] divided by an appropriate toxicity benchmark for the receptor, chemical, and exposure scenario. An HI, which is used in HHRA, is the sum of the HQs for several chemicals that share the same target organ. If the HQ or HI is less than 1, exposure to that chemical (HQ) or group of chemicals (HI) is expected to result in no adverse effects to even the most sensitive receptors. Cancer risk to humans is typically evaluated using a probabilistic approach that considers an acceptable risk benchmark range of 10^{-4} to 10^{-6}, meaning that a person’s ELCR from the exposure being assessed is less than 1 in 10,000 to 1 in 1,000,000 (U.S. EPA 1989, 2000).

NEBA relies on scientifically supported estimates of risk; however, regardless of the scientific acceptability of the risk characterization process, stakeholders may place different values on different types of risk.

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[39] A conservative estimate of the chemical concentration available from a particular media and exposure pathway.

6 Summary of Conclusions

Based on my review and analyses, I developed the following conclusions, which are structured around the five objectives identified previously:

Conclusions 1: All closure options for the BCSS ash basin are protective of human health. Current conditions[40] and conditions under all closure options support provision of safe drinking water, safe surface water, safe food, and safe recreation, satisfying the first objective of ash basin closure—to protect human health from CCR constituent exposure.

Conclusion 2: All closure options for the BCSS ash basin are protective of ecological health. Current conditions[41] and conditions under all closure options support provision of safe surface water, safe food consumption, and protection of biodiversity and natural beauty, satisfying the second objective of ash basin closure—to protect ecological health from CCR constituent exposure.

Conclusion 3: Excavation closure creates greater disturbance to communities. All closure options support safe air quality from diesel truck emissions along the transportation routes; however, each creates disturbance and risk that could adversely impact community safety, with a greater magnitude of impact from excavation closure due to the extended period of impact. Thus, CIP and hybrid closures better satisfy the third objective of ash basin closure—to minimize risk and disturbance to humans from closure.

Conclusion 4: Hybrid and excavation closures minimize environmental disturbance. Hybrid and excavation closures improve habitat-derived environmental services over baseline

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[40] SynTerra's updated HHRA considered only potential exposure pathways that currently exist and could remain after ash basin closure under any closure option. Any potential risk currently associated with seeps at BCSS was not evaluated in the HHRA or considered in this analysis because any risk resulting from seeps will be eliminated, reduced, or mitigated per the court-enforceable SOC that Duke entered with the North Carolina Environmental Management Commission on July 12, 2018 (EMC SOC WQ S18-004; See Section 4.2).

[41] SynTerra's updated ERA considered only potential exposure pathways that currently exist and could remain after ash basin closure under any closure option. Any potential risk currently associated with seeps at BCSS was not evaluated in the ERA or considered in this analysis because any risk resulting from seeps will be eliminated, reduced, or mitigated per the court-enforceable SOC that Duke entered with the North Carolina Environmental Management Commission on July 12, 2018 (EMC SOC WQ S18-004; See Section 4.2).

conditions, while CIP closure results in a net loss of habitat-derived environmental services. Hybrid closure and excavation closure improve the protection of biodiversity and natural beauty, satisfying the fourth objective of ash basin closure—to minimize risk and disturbance to the local environment from closure—and producing a net environmental benefit.

Conclusion 5: Hybrid closure maximizes environmental services. Hybrid closure better maximizes environmental benefits compared to excavation and CIP closures because it offers equivalent protection of human and ecological health from CCR exposure, results in less disturbance to the community over time compared to excavation closure, and produces a net gain in habitat-derived environmental services, [42] best satisfying the fifth objective of ash basin closure—to maximize local environmental services.

Each conclusion will be discussed in detail in the following sections.

[42] As noted in Section 5 and further discussed in Section 11, loss of habitat-derived environmental services from CIP closure could be offset with an appropriate reforestation project.

7 Conclusion 1: All closure options examined for the ash basin at BCSS are protective of human health.

The first objective for ash basin closure, to protect human health from contaminant exposure, is represented by environmental services that provide safe drinking water, safe groundwater, safe surface water, safe food consumption, and safe recreation. For purposes of the NEBA, these safety considerations were evaluated based on the following:

1. Provision of permanent alternative drinking water supplies to private well water supply users within a 0.5-mile radius of BCSS (Holman 2018);
2. Concentrations of CCR constituents of interest (COIs) [43] in drinking water wells that could potentially affect local residents and visitors, as characterized by HDR (2015a) and SynTerra (2017) in the CSA; and
3. Risk to various human populations from CCR exposure, as characterized in the updated Human Health and Ecological Risk Assessment conducted by SynTerra (2018; Appendix B)

Through these lines of evidence, I evaluated whether CCR constituents are currently impacting drinking water wells, whether they will in the future, and whether other exposures to CCR constituents pose a risk to human populations now or with ash basin closure.

7.1 Private water supply wells pose no meaningful risk to the community around BCSS.

Per H.B. 630, Sess. L. 2016-95, all residents with drinking water supply wells within a 0.5-mile radius of the BCSS ash basin compliance boundary have been provided with permanent alternative drinking water supplies (i.e., filter systems; Draovitch 2018),[44] eliminating drinking water as a potential CCR exposure pathway for local residents or visitors.

[43] COIs are constituents relevant to analysis of potential exposure to CCR constituents but are not necessarily associated with risk to human or ecological receptors.

[44] NCDEQ determined Duke Energy had satisfactorily completed the permanent alternative water provision under CAMA General Statute (G.S.) 130A-309.21 l(cl) on October 12, 2108 (Holman 2018).

Additionally, available data indicate that private well water conditions are not impacted by CCR constituents and groundwater flow paths from the ash basin are away from residential areas (HDR 2015a; SynTerra 2017; HB630 Residential Well Data - Sept 24 2018.xlsx).

According to the 2017 CSA update (SynTerra 2017), one public well (Withers Chapel United Methodist, located hydrologically upgradient of BCSS) and 50 private wells are within a 0.5-mile radius of the ash basin (SynTerra 2017). Wells located west of the ash basin are relatively close to the BCSS basin, but they are cross-gradient from the direction of groundwater flow from the basin (SynTerra 2017). Other wells within a 0.5-mile radius of the basin are either cross-gradient or upgradient of groundwater flow from the BCSS ash basin and, thus, unaffected by the ash basin (SynTerra 2017). No private wells are located downgradient of the ash basin within 0.5 miles.

Water chemistry analyses also provide no indication of CCR impacts to private drinking water wells from the ash basin. Ninety-one samples from 49 private wells were collected between 2015 and summer 2017 by NCDEQ and Duke Energy and analyzed for COIs and standard water chemistry parameters (SynTerra 2017). SynTerra (2017) reported exceedances of North Carolina Groundwater Quality Standards (2L)[45] for arsenic, cobalt, chromium, iron, manganese, and vanadium in several of these private wells. While these COIs are associated with CCR (HDR 2015a), they are also naturally occurring. Based on comparisons of the chemical compositions of ash porewater, downgradient groundwater, and background conditions, the water in the sampled private wells was determined by SynTerra (2017) to be consistent with background bedrock wells (calcium bicarbonate water type) and reflect “natural background conditions.” This conclusion is supported by the fact that groundwater does not flow from the BCSS ash basin towards the private wells (SynTerra 2017). Based on the SynTerra (2017) results, there is no evidence of CCR impacts to private well water within the study area.

Since the 2017 CSA, an additional 74 samples have been collected from 32 private wells, of which five wells were previously sampled (HB630 Residential Well Data - Sept 24 2018.xlsx). Aside from two wells whose locations are unknown, the newly sampled wells are located to the

45 North Carolina Administrative code 15A NCAC 02L Groundwater Rules.

northeast and southwest of the ash basin and generally hydrologically upgradient based on modeling depicted in the 2017 CSA (SynTerra 2017). 2L exceedances were detected for vanadium (in 30 samples), pH (23), arsenic (8), iron (6), manganese (6), and lead (2). All but four samples were below the provisional background threshold value for boron, and none exceeded the boron 2L standard. The frequency and magnitudes of the exceedances are similar to those in the previous sampling campaigns and, together with the upgradient or cross-gradient location of the wells relative to groundwater flow from the ash basin, lend further support to the conclusion that private well water chemistry is not impacted by CCR. While chemistry data are not available for the public well at Withers Chapel United Methodist, its location upgradient of BCSS precludes contamination of well water by CCR from the ash basin.

7.2 CCR constituents from the BCSS ash basin pose no meaningful risk to human populations.

To assess potential risk to humans both onsite and offsite using the most recent and comprehensive data available, SynTerra updated the baseline HHRA (SynTerra 2018) originally conducted by HDR (2016c) as a component of the CAP part 2 (HDR 2016a). The updated HHRA included updates[46] to the conceptual site model, exposure point concentrations for human receptors with complete exposure pathways, screening level risk assessments for human receptors with complete exposure pathways, and hazard calculations (HI, ELCR) for receptors and COPCs with plausible complete exposure pathways.

Consistent with the 2016 baseline human health and ecological risk assessment (HDR 2016c), the updated HHRA (SynTerra 2018) examined CCR constituent exposure to a range of human populations, including well users, construction workers, swimmers, waders, boaters, and recreational and subsistence fishers under different pathways (i.e., exposure to sediment, surface water, groundwater, or fish tissue). HIs and ELCRs were estimated for scenarios with plausible complete exposure pathways.

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[46] Updates to risk assessments are a natural part of the risk analysis process. EPA guidance for ecological risk assessment notes, "The [risk assessment] process is more often iterative than linear, since the evaluation of new data or information may require revisiting a part of the process or conducting a new assessment as more information about a site is gained through site investigations, the risk assessment must be updated to reflect the best knowledge of potential risk at a site" (U.S. EPA 1998). EPA similarly describes human health risk characterization as an iterative process (U.S. EPA 2000).

CCR exposure pathways evaluated in the updated HHRA included the following (SynTerra 2018):

- Onsite construction workers via groundwater
- Offsite recreational swimmers via offsite surface water and sediment
- Offsite recreational waders via offsite surface water and sediment
- Offsite recreational boaters via offsite surface water
- Offsite recreational/subsistence fishers via offsite surface water and fish tissue.

Since all households with drinking water supply wells within a 0.5-mile radius of the BCSS compliance boundary have received permanent alternative water supplies (Holman 2018), and since no potable water wells are located downgradient of BCSS (SynTerra 2017), drinking water risks were not further evaluated for groundwater because there was no complete exposure pathway. Groundwater exposure to onsite construction workers was evaluated in the updated HHRA, though a pathway for exposure was incomplete.[47] A summary of the risk assessment results for offsite receptors from the updated HHRA (SynTerra 2018) is provided in Table 7-1.

Table 7-1. Summary of human health risk assessment hazard index (HI) and excess lifetime cancer risk (ELCR) for offsite receptors from SynTerra (2018)

		Belews Reservoir		Dan River	
Media	**Receptor**	**HI**	**ELCR**	**HI**	**ELCR**
Sediment	Recreational Swimmer	0.01	5.5×10^{-7}	0.01	4.0×10^{-7}
Surface Water	Recreational Swimmer	0.002	2.3×10^{-7}	0.03	7.9×10^{-7}
Sediment	Recreational Wader	0.01	NC	0.004	1.8×10^{-7}
Surface Water	Recreational Wader	0.0008	5.4×10^{-8}	0.03	1.9×10^{-7}
Surface Water	Recreational Boater	0.0000002	4.6×10^{-9}	0.002	1.6×10^{-8}
Surface Water	Recreational Fisher	0.0002	4.6×10^{-9}	0.002	1.6×10^{-8}
Biota (fish)	Recreational Fisher	0.01	3.3×10^{-7}	5	1.2×10^{-6}
Biota (fish)	Subsistence Fisher	0.3	2.5×10^{-5}	151	8.6×10^{-5}

NC: risk-based concentration based on non-cancer HI.
NA: receptor is not expected to be exposed to this media

[47] SynTerra (2018) computed a cumulative HI of 0.001 for non-cancer risk for onsite construction workers exposed to groundwater; the remedial goal was based on the non-cancer hazard index.

No meaningful risks to humans from CCR exposure were identified for exposure scenarios assessed by SynTerra (2018) in Belews Reservoir as well as the majority of exposure scenarios assessed by SynTerra (2018) for the Dan River. HIs for recreational and subsistence fisher exposure scenarios, however, were estimated by SynTerra (2018) to be greater than 1.

Risk assessment is subject to a number of uncertainties, including the representativeness of sample data, the degree to which exposure assumptions approximate actual exposure, estimation of chemical toxicity, and characterization of background concentrations. Risk assessment typically addresses these uncertainties by including conservative assumptions that tend to overestimate exposure and risk. For example, to evaluate potential risk to subsistence fishers in the BCSS HHRA, SynTerra (2018) used a fish consumption rate of 170 g/day, which represents the highest level of consumption (95th percentile) in a high consuming subsistence Native American population living in an area with plentiful fish resources that can support such high fish consumption (Columbia River Tribes in Oregon) (U.S. EPA 2000a, 2011a).[48] SynTerra (2018) further assumes this rate of fish consumption would continue for many years using only fish from a single water body with fish tissue COPC concentrations estimated using a conservative uptake model (bioconcentration factors [BCFs]) from the highest surface water COPC concentrations. Each exposure pathway in the HHRA uses similarly conservative assumptions to address uncertainty. While this serves to ensure a health protective assessment, results that exceed target risk levels should be examined in more depth to understand the context. Therefore, I examined the foundation for each exceedance in more detail.

Risk to fishers was modeled by SynTerra (2018) by estimating fish tissue concentrations from surface water sample data from Belews Reservoir and the Dan River. For the Dan River, the cumulative HIs from these exposures, 5 for recreational fishers and 151 for subsistence fishers, were driven by concentrations of thallium (recreational fishers) and thallium, cobalt, and zinc (subsistence fishers). Similar risks were noted previously in the baseline HHRA (HDR 2016c), and HDR (2016c) attributed these estimated risks to the conservative assumptions used to generate the exposure point concentrations (EPCs), which included using onsite surface water concentrations in lieu of offsite data, using the maximum detected concentrations of thallium in

[48] In the case of BCSS, SynTerra has not identified any populations of subsistence fishers in the area.

surface water, and conservative literature based bioconcentration factors (HDR 2016c). While SynTerra (2018) used offsite water data to update EPCs in the updated HHRA, other conservative assumptions were retained.

Examining each of the COPCs individually, in the case of thallium, EPA concluded in its latest toxicological reviews that the available toxicological database for thallium is "generally of poor quality" and therefore not adequate to derive an oral reference dose (RfD)[49] (U.S. EPA 2009b, 2012). Although EPA concluded that issues with study design and results interpretation limited the value of this study for risk assessment, EPA developed a screening value using a study on the effects of oral thallium exposure in rats and based on the assumption that the hair loss (alopecia) observed in many of the rats and damage to the hair follicles in 2 of the 20 rats in the high-dose group was due to the thallium exposure (U.S. EPA 2012). Thus, while thallium may have been retained as a COPC in the screening level risk assessment (SynTerra 2018) based on concentrations present in the Dan River, calculating an HI associated with this COPC is highly uncertain. Of the 39 surface water samples that were collected from the Dan River, only 5 (14%) contained detectable levels of thallium. Because of this low rate of detection, the maximum detected concentration of thallium, 1.1 µg/L, was used as the EPC rather than the more typically used 95% upper confidence limit of the mean, thus adding another conservative assumption to this risk calculation. Taken together, the available scientific data do not support a meaningful quantitative risk estimate for thallium associated with fish consumption or other exposure pathways.

For cobalt, the EPA provisional oral RfD of 0.3 µg/kg/day may also be considered overly conservative. A recent reanalysis of relevant human and animal studies involving oral exposure to cobalt proposed a new RfD for cobalt of 30 µg/kg/day, which is 100 times higher than the current EPA RfD (Finley et al. 2012; Schoof 2017). Other government agencies have derived higher guidance values for cobalt, including the Dutch National Institute of Public Health and the Environment (tolerable daily intake of 98 µg/day, or 1.4 µg/kg/day for a 70 kg adult) and the European Food Safety Authority (EFSA) (600 µg/day, or 8.6 µg/kg/day) (Schoof 2017). If the

[49] The reference dose (RfD) is an estimate of a daily exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime.

recent cobalt RfD reported in Finley et al. (2012) were applied instead of the current EPA RfD for cobalt, the HI for cobalt exposure to fishers in the Dan River would be 0.13, indicating a lack of risk from cobalt exposure associated with subsistence fish consumption. If the RfDs derived by other regulatory agencies were applied, the predicted HIs would be even lower. Additionally, SynTerra (2018) notes that concentrations of cobalt in background samples were similar to the EPC used in risk calculations and would predict a comparable level of background risk unassociated with CCR exposure. Therefore, I conclude there is no meaningful risk to subsistence fishers from exposure to cobalt in the Dan River.

Finally, the HI associated with zinc exposure was 2.0. Zinc is an essential nutrient for humans, and while a wide range of clinical symptoms have been associated with zinc deficiency, effects of excess zinc intake are typically limited to changes in copper status[50] in the body (U.S. EPA 2005). The four studies on which the EPA zinc oral RfD of 0.3 mg/kg/day is based all used indicators of body copper status as their endpoints. The studies did not report any overt toxic effect associated with increased zinc intake, only that body copper *indicator* levels were affected, "which may not be adverse in themselves" (U.S. EPA 2005). In addition, the level of zinc intake associated with subsistence fish consumption estimated in the risk assessment is less than the daily dose in typical zinc nutritional supplements (50 mg/day, or 0.7 mg/kg/day for a 70 kg person).[51] When considered with the conservative assumptions used to derive the EPC for zinc (i.e., using surface water concentrations in lieu of offsite fish tissue concentrations and using conservative bioconcentration factors), I conclude zinc exposure poses no meaningful risk to subsistence fishers in the Dan River.

Given the lack of meaningful risk under current conditions,[52] there is also no meaningful risk to humans from CCR exposure under any of the ash basin closure options since all options reduce

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50 Zinc exposure can result in changes in absorption, availability, and activity of copper in humans (EPA 2005).

51 National Institutes of Health, Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Zinc-HealthProfessional/

52 SynTerra's updated HHRA considered only potential exposure pathways that currently exist and could remain after ash basin closure under any closure option. Any potential risk currently associated with seeps at MSS was not evaluated in the HHRA or considered in this analysis because any risk resulting from seeps will be eliminated, reduced, or mitigated per the court-enforceable SOC that Duke entered with the North Carolina Environmental Management Commission on April 18, 2018 (EMC SOC WQ S17-009; See Section 4.2).

or eliminate exposure pathways following closure. Thus, all closure options are protective of public health.

7.3 NEBA – Protection of Human Health from CCR Exposure

Based on these analyses, there is no CCR risk from drinking water supplies, no evidence of CCR impacts to drinking water wells, and no meaningful risk to humans from CCR exposure under current conditions or under any closure option. Using the NEBA framework and relative risk ratings, these results are summarized in Table 7-2 within the objective of protecting human health from exposure to CCR constituents.

Table 7-2. Summary of relative risk ratings for attributes that characterize potential hazards to humans from CCR exposure in drinking water, surface water, groundwater, soil, sediment, food, and through recreation

Objective	Protect Human Health from CCR						
Hazard	Exposure to CCR						
Potentially Affected Populations	Local Residents/Visitors	Onsite Construction Workers	Offsite Recreational Swimmers	Offsite Recreational Waders	Offsite Recreational Boaters	Offsite Recreational Fishers	Offsite Subsistence Fishers
Scenario							
Baseline	--	--	--	--	--	--	--
CIP	--	--	--	--	--	--	--
Excavation	--	--	--	--	--	--	--
Hybrid	--	--	--	--	--	--	--

"--" indicates "no meaningful risk."

Current conditions and conditions under all closure options support provision of safe drinking water, safe surface water, safe food, and safe recreation, satisfying the first objective of ash basin closure—to protect human health from CCR constituent exposure.

8 Conclusion 2: All closure options for the BCSS ash basin are protective of ecological health.

The second objective for ash basin closure, to protect ecological health from CCR constituent exposure, is represented by environmental services that provide safe surface water, safe food consumption, and protection of biodiversity and natural beauty. For purposes of the NEBA, these considerations were evaluated based on the following:

1. Risk to ecological receptors from CCR exposure, as characterized by SynTerra (2018; Appendix B) in the updated human health and ecological risk assessment; and
2. Aquatic community health in Belews Reservoir and the Dan River as reported in recent environmental monitoring reports (Brown and Derwort 2014; Duke Energy 2016).

Through these two lines of evidence, I evaluated whether CCR constituents pose a risk to ecological receptors now or after ash basin closure.

8.1 No meaningful risks to ecological receptors from CCR exposure exist under current conditions or any closure option.

As noted in Section 4.1, in 1976, two years after power generation began at BCSS, a decline in the game fish population of Belews Reservoir was observed and linked to reproductive impairment from selenium exposure from the ash basin effluent, which was thought to have been exacerbated by the long residence time of waters in the reservoir (Duke Energy 2016). Since 1985, BCSS ash basin discharge has been to the Dan River at NPDES outfall 003 (Figure 4-1). As required by their NPDES permit, Duke Energy has conducted surveys of both Belews Reservoir and the Dan River aquatic populations (i.e., fish and macroinvertebrates) for more than three decades (Harden et al. 1988; Duke Energy 2016; Brown and Derwort 2014). Balanced and indigenous aquatic populations now reside in Belews Reservoir (Duke Energy 2016), and rerouting the ash basin discharge to the Dan River has not adversely affected the water quality or aquatic populations of the Dan River (Harden et al. 1998; Brown and Derwort 2014).

According to the most recent environmental monitoring report for Belews Reservoir, benthic macroinvertebrate community monitoring has demonstrated that "legacy selenium concentrations in the lentic[53] food web continue to decline or remain stable over time, and that the operation of BCSS is not having a detrimental impact on the macroinvertebrate community of Belews Reservoir" (Duke Energy 2016). Additionally, selenium concentrations in Belews Reservoir fish have "remained below levels considered detrimental to fish," and "Belews Reservoir continues to maintain multiple trophic levels of fish, including necessary food web organisms, for a self-sustaining balanced and indigenous fish population" (Duke 2016). In the Dan River, selenium concentrations in fish muscle tissue are "consistently below levels considered toxic to fish," indicating "no impairment of the Dan River fish community due to the operation of BCSS" (Brown and Derwort 2014). Similarly, "there do not appear to be any long-term significant impacts of BCSS ash basin discharges on Dan River macroinvertebrate communities" (Brown and Derwort 2014).

To assess potential risk to ecological receptors both onsite and offsite using the most recent and comprehensive data available, SynTerra (2018) updated the baseline human health and ecological risk assessment originally conducted by HDR (2016c) as a component of the CAP part 2 (HDR 2016a). The updated ERA included updates to the conceptual site model, exposure point concentrations for receptors with complete exposure pathways, and screening level risk assessments for ecological receptors with potentially complete exposure pathways. Updated HQs were estimated for receptors and COPCs with plausible potentially complete exposure pathways (SynTerra 2018).

The ecological receptors evaluated in the ERA are common representatives of particular groups of organisms inhabiting different habitats and aspects of the food web. Key receptors in SynTerra's updated ERA (SynTerra 2018) and their potential pathways for CCR exposure included the following:

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[53] Lentic refers to waters that are relatively still, such as lakes.

- **Birds:** Avifauna species may be exposed by ingestion of food and surface water and by incidental ingestion of sediment and soil. Aquatic/wetland species included were mallard duck (omnivore) and great blue heron (piscivore).
- **Mammals:** Aquatic/wetland species may be exposed by ingestion of food and surface water and by incidental ingestion of sediment and soil. Species included were muskrat (omnivore) and river otter (piscivore).

Ecological risk for these indicator species was characterized by SynTerra (2018) using a risk-based screening approach that compared chemical exposure levels to chemical toxicity reference values (TRVs) to calculate HQs for COPCs. TRVs in the ERA included no-observed-adverse-effects levels (NOAELs)[54] and lowest-observed-adverse-effects levels (LOAELs)[55] derived from the literature for each COPC.

HQ results for the site were evaluated for two exposure areas of BCSS[56] (Figure 8-1). HQs less than 1 indicate no meaningful risk to ecological receptor species associated with exposure to the COPCs evaluated.

- **Exposure Area 1:** NOAEL HQ >1 for muskrat exposure to aluminum; however, LOAEL HQ <1 for muskrat exposure to aluminum, indicating no meaningful risk. All other HQs<1, also indicating no meaningful risk to the other ecological receptors.

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54 A NOAEL is a concentration below which no adverse effects have been observed for a specific receptor and pathway of exposure. NOAELs are typically estimated from laboratory toxicity tests.

55 A LOAEL is a concentration associated with the lowest concentration level at which adverse effects have been observed for a specific receptor and pathway of exposure. LOAELs are typically estimated from laboratory toxicity tests.

56 The baseline ecological risk assessment conducted by HDR in 2016 (HDR 2016c) included five exposure areas. Exposure Area 4 (located south of the ash basin near the structural fill) and Exposure Area 5 (located within the steam station area) are hydrologically separated from the ash basin and, as such, are not representative of exposure from CCR constituents in the ash basin and not relevant to this analysis since there are no exposure pathways from the ash basin to these areas. Exposure Area 2 is affected by seeps subject to the SOC (see Section 4.2) and not included in the NEBA because the SOC requires Duke Energy to take appropriate corrective actions for any seeps remaining after decanting is complete to ensure the remaining seeps are managed "in a manner that will be sufficient to protect public health, safety, and welfare, the environment, and natural resources" (EMC SOC WQ S18-004). As such, any ecological risk associated with the seeps is required to be addressed under the SOC such that there will be no meaningful risk under any closure option.

- **Exposure Area 3:** All HQs <1, indicating no meaningful risk to ecological receptors.

Based on the updated ecological risk assessment (SynTerra 2018), there are currently no meaningful risks to ecological receptors associated with CCR exposure at BCSS.

Given the lack of meaningful risk from CCR exposure under current conditions based on the lines of evidence evaluated, all closure options would be protective of ecological receptors since all closure options reduce or eliminate potential exposure pathways.

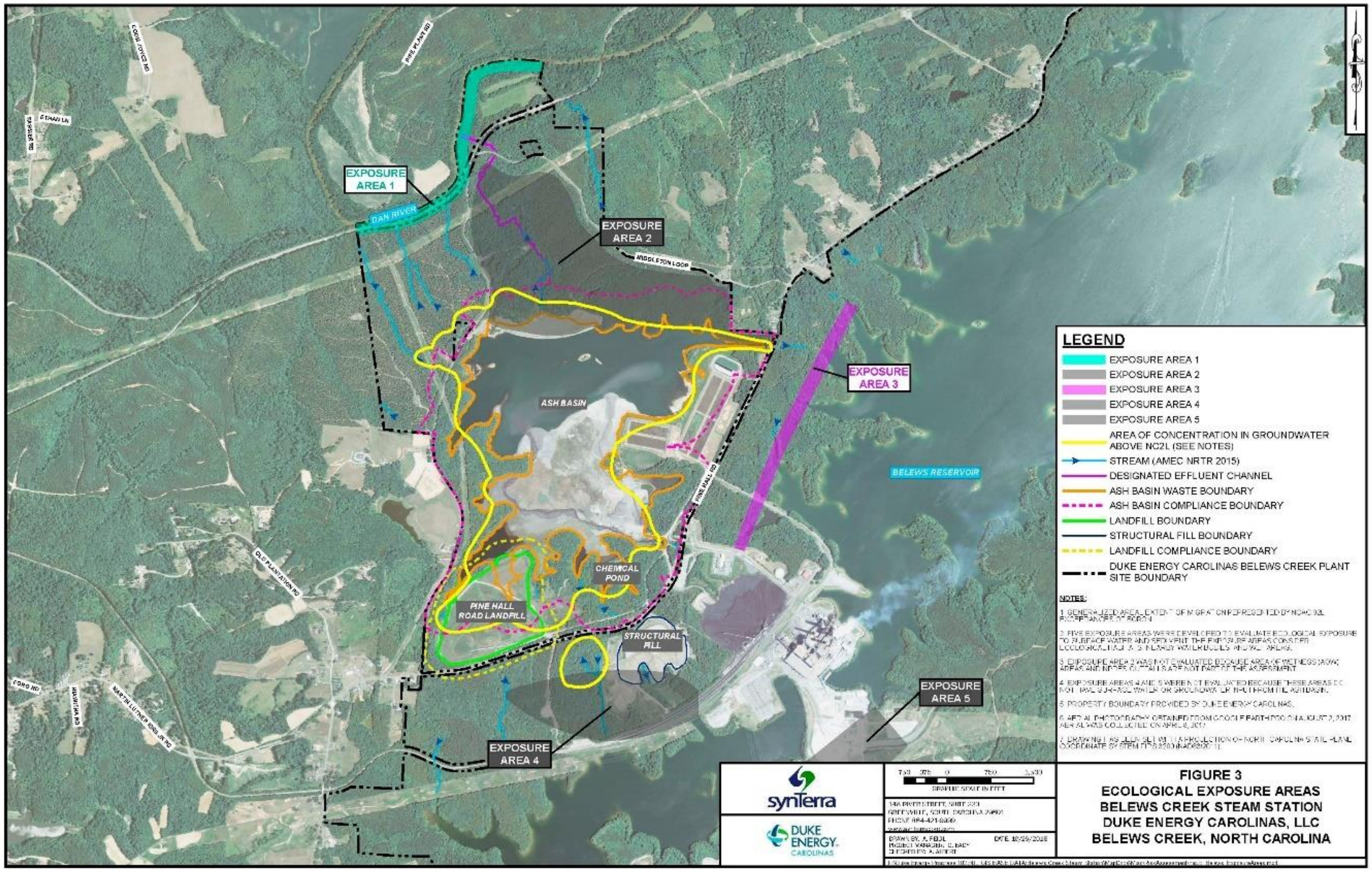

Figure 8-1. Exposure areas evaluated in the 2018 Ecological Risk Assessment update (SynTerra 2018)

8.2 NEBA – Protection of Ecological Health from CCR Exposure

Based on these analyses, no meaningful risk to ecological receptors from CCR exposure was found under current conditions[57] or under any closure option. Using the NEBA framework and relative risk ratings, within the objective of protecting ecological health from exposure to CCR chemical constituents, these results are summarized in Table 8-1.

Table 8-1. Summary of relative risk ratings for attributes that characterize potential hazards to ecological resources from CCR exposure in surface water, soil, sediment, and food

Objective	Protect Ecological Health from CCR				
Hazard	Exposure to CCR				
Potentially Affected Populations	Fish/Shellfish Populations	Aquatic Omnivore Birds (mallard)	Aquatic Piscivore Birds (great blue heron)	Aquatic Herbivore Mammals (muskrat)	Aquatic Piscivore Mammals (river otter)
Scenario					
Baseline	--	--	--	--	--
CIP	--	--	--	--	--
Excavation	--	--	--	--	--
Hybrid	--	--	--	--	--

"--" indicates "no meaningful risk."

Current conditions and conditions under all closure options support provision of safe surface water, safe food consumption, and protection of biodiversity and natural beauty, satisfying the

[57] SynTerra's updated ERA considered only potential exposure pathways that currently exist and could remain after ash basin closure under any closure option. Any potential risk currently associated with seeps (or areas of wetness) at BCSS was not evaluated in the ERA or considered in this analysis because any risk resulting from seeps will be eliminated, reduced, or mitigated per the court-enforceable SOC that Duke entered with the North Carolina Environmental Management Commission on July 12, 2018 (EMC SOC WQ S18-004; See Section 4.2).

second objective of ash basin closure—to protect ecological health from CCR constituent exposure.

9 Conclusion 3: Excavation closure creates greater disturbance to communities.

The third objective for ash basin closure, to minimize risk and disturbance to humans from closure, is represented by environmental services that provide safe air quality and a safe community environment. For purposes of the NEBA, these considerations were evaluated based on the following:

1. Health risks from diesel exhaust emissions to the community living and working along transportation corridors during trucking operations to haul materials to and from the ash basin, as evaluated through the application of diesel truck air emissions modeling and HHRA; and
2. The relative risk for disturbance and accidents resulting from trucking operations affecting residents living and working along transportation corridors during construction operations, as evaluated by comparing the relative differences in trucking operations between the closure options.

All closure options require increased trucking activity to haul materials to the site (e.g., transport cap material to the ash basin). These activities involve the use of diesel-powered trucks, which increase local diesel exhaust emissions and traffic, both of which present potential hazards to local populations in the form of air pollution and roadway hazards. Table 9-1 summarizes the transportation logistics associated with each of the closure options Duke Energy is considering for BCSS (Duke Energy 2018). From this summary, the amount of offsite trucking involved is comparable between all closure options, but excavation closure requires more truckloads of cap and fill material and more miles driven over a substantially longer period.

Table 9-1. Summary of offsite transportation logistics associated with each closure option (Duke Energy 2018)

Logistics	CIP	Excavation	Hybrid
Closure Duration (years)[a]	9	16	10
Construction Duration (years)[b]	6	12	7
Offsite truckloads to haul cap & fill material[c]	11,070	14,376	10,986
Offsite miles driven to haul cap & fill material[c]	324,180	378,245	284,700

[a] Includes design and permitting, decanting, site preparation, construction, and site restoration.
[b] Includes site preparation, construction, and site restoration.
[c] Includes cover soil, top soil, and geosynthetic material.

Costs to society associated with trucking include accidents (fatalities, injuries, and property damage), emissions (air pollution and greenhouse gases), noise, and the provision, operation, and maintenance of public roads and bridges (Forkenbrock 1999). Generally, the magnitude of these impacts scales with the frequency, duration, and intensity of trucking operations (Forkenbrock 1999). Figure 9-1 illustrates the normalized differences between offsite transportation activities under the excavation and hybrid options compared to CIP. From these results, it is clear that risk and disturbance associated with transportation activities will be relatively comparable between CIP and hybrid closure options. However, excavation closure has a greater total potential for risk and disturbance from the increased number of offsite truckloads and total miles driven; excavation closure also requires a substantially longer duration for closure activities.

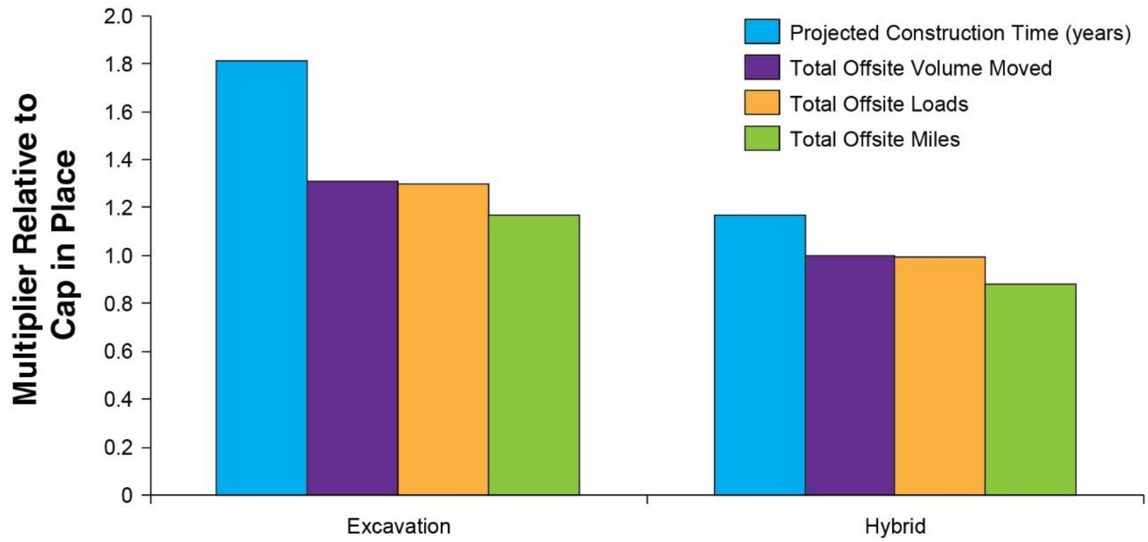

Figure 9-1. Normalized differences between all offsite transportation activities under CIP, excavation, and hybrid closure options. Bars represent the increased activity under closure options compared to CIP.

9.1 There is no meaningful risk from diesel emissions to people living and working along the transportation corridor.

The types of large dump trucks that will be used in closure activities at BCSS are generally diesel powered, and diesel exhaust includes a variety of different particulates and gases, including more than 40 toxic air contaminants.[58] North Carolina does not have a diesel-specific health-based toxicity threshold because diesel exhaust is not currently regulated as a toxic air pollutant. North Carolina also does not regulate $PM_{2.5}$ or PM_{10}[59] as toxic air pollutants. North Carolina defers to EPA's chronic non-cancer reference concentration (RfC) for diesel particulate matter of 5 µg/m^3 based on diesel engine exhaust to estimate risk from diesel emissions.[60] California is, to my knowledge, the only state that currently regulates diesel as a toxic air contaminant and has identified both an inhalation non-cancer chronic reference exposure level

58 https://oehha.ca.gov/air/health-effects-diesel-exhaust

59 $PM_{2.5}$ and PM_{10} are airborne particulate matter sizes. $PM_{2.5}$ is particulate matter that is 2.5 µm or less in size; PM_{10} is particulate matter that is 10 µm or less in size.

60 Integrated Risk Information System (IRIS). U.S. EPA. Diesel engine exhaust.

(REL)[61] of 5 μg/m^3 and a range of inhalation potency factors indicating that a "reasonable estimate" for the inhalation unit risk is 3.0×10^{-4} (μg/m^3)$^{-1}$ "until more definitive mechanisms of toxicity become available" (OEHHA 2015). California bases the non-cancer and cancer health factors on the whole (gas and particulate matter) diesel exhaust and uses PM_{10} as a surrogate measure.

As PM_{10} is the basis for both the non-cancer and inhalation risk factors for diesel exhaust exposure in California, I relied on a PM_{10} exposure model to evaluate potential non-cancer and cancer health risks from diesel exhaust.[62]

A representative segment of road was simulated using EPA's AERMOD model[63] to quantify air concentrations at set distances away from the road (U.S. EPA 2016). Diesel truck emissions were configured in the model in a manner consistent with the recommendations from EPA's Haul Road Working Group (U.S. EPA 2011). The emission rate for diesel trucks was calculated using the EPA Mobile Vehicle Emissions Simulator (MOVES) model (U.S. EPA 2015).[64] Emission factors were then applied to the average number of anticipated offsite truck trips each year to define the average annual amount of diesel particulate matter emitted along the representative road segment, and these exposures were then summed over seventy years.[65] AERMOD simulations were run for four transportation orientation directions and used five years of local meteorological data to estimate exposure point concentrations at regular intervals

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[61] A chronic REL is a concentration level (expressed in units of micrograms per cubic meter [μg/m^3]) for inhalation exposure at or below which no adverse health effects are anticipated following long-term exposure. EPA has defined long-term exposure for these purposes as at least 12% of a lifetime, or about eight years for humans.

[62] California regulations and guidance indicate that when comparing whole diesel exhaust to speciated components of diesel (e.g., polycyclic aromatic hydrocarbons, metals) the cancer risk from inhalation of whole diesel exhaust will outweigh the multi-pathway analysis for speciated components.

[63] AERMOD will calculate both the downwind transport and the dispersion of pollutants emitted from a source. Both transport and dispersion are calculated based on the observed meteorology and characteristics of the surrounding land. AERMOD is maintained by EPA and is the regulatory guideline model for short-range applications (transport within 50 km).

[64] The MOVES model allows a user to determine fleet average emission factors (in units of grams of pollutant per mile traveled) for specific classes of vehicles and specific years. In this application, factors defined by MOVES for single-unit short-haul diesel truck were used.

[65] For the cancer risk analysis, emissions were calculated as an average over the regulatory default 70-year residential exposure duration. If the truck activity for a closure option occurs over a shorter period, the duration of the truck activity exposure is factored into the 70-year averaging time (OEHHA 2015).

from 10 to 150 m perpendicular to either side of the road. The results of the model were translated into average PM_{10} exposure ($\mu g/m^3$) and excess cancer risk over a 70-year period using reasonable maximum exposure.[66] Results of the exposure modeling are provided in Table 9-2. Full results and a more detailed description of the model are provided in Appendix C.

Table 9-2. Hazard indices (HI) and excess lifetime cancer risk (ELCR) from exposure to diesel exhaust emissions along transportation corridors in North Carolina. Results are for the maximum exposures modeled.

Perpendicular Distance from the Road	CIP		Excavation		Hybrid	
	ELCR	HI	ELCR	HI	ELCR	HI
10 m	3.46E-09	0.0000	2.43E-09	0.0000	2.73E-09	0.0000
20 m	2.91E-09	0.0000	2.05E-09	0.0000	2.30E-09	0.0000
30 m	2.32E-09	0.0000	1.63E-09	0.0000	1.83E-09	0.0000
40 m	1.92E-09	0.0000	1.35E-09	0.0000	1.52E-09	0.0000
50 m	1.63E-09	0.0000	1.15E-09	0.0000	1.29E-09	0.0000
60 m	1.43E-09	0.0000	1.01E-09	0.0000	1.13E-09	0.0000
70 m	1.28E-09	0.0000	9.03E-10	0.0000	1.01E-09	0.0000
80 m	1.16E-09	0.0000	8.17E-10	0.0000	9.17E-10	0.0000
90 m	1.06E-09	0.0000	7.46E-10	0.0000	8.37E-10	0.0000
100 m	9.77E-10	0.0000	6.87E-10	0.0000	7.70E-10	0.0000
110 m	9.05E-10	0.0000	6.36E-10	0.0000	7.14E-10	0.0000
120 m	8.42E-10	0.0000	5.92E-10	0.0000	6.64E-10	0.0000
130 m	7.88E-10	0.0000	5.54E-10	0.0000	6.21E-10	0.0000
140 m	7.40E-10	0.0000	5.20E-10	0.0000	5.83E-10	0.0000
150 m	6.97E-10	0.0000	4.90E-10	0.0000	5.50E-10	0.0000

66 Long-term exposure was incorporated into the air simulation as the average exposure given estimated trucking rates for 12 hours per day—7am to 7 pm—6 days a week for the duration of the project trucking time.

Based on the assumptions applied in the air model, no meaningful risk from diesel emissions associated with ash basin closure trucking operations was identified for people living and working along the transportation corridor. The exposure model and risk assessment applied here represent a simple approach to estimate risk. A more refined estimate of risk could be computed with a more sophisticated air and risk model; however, it is unlikely to change the conclusion that there is no meaningful risk to people living and working along the transportation corridor from diesel emissions associated with ash basin closure construction operations.

9.2 All closure options produce comparable risk and disturbance from transportation activities on a daily or annual basis, but excavation closure produces these impacts for substantially longer than CIP or hybrid closures.

Increased trucking increases noise and traffic congestion and creates a statistically based risk of increased traffic accidents that could result in fatalities, injuries, and/or property damage (Forkenbrock 1999; NHTSA 2016). The BCSS is located on Pine Hall Road, which connects to NC Highway 65 approximately four miles to the south and to the town of Pine Hall and US 311 approximately 5 miles to the North (see Figure 4-1). There will be an increase in trucking traffic hauling topsoil and/or geosynthetic material under each closure option along this corridor with a statistically increased likelihood of traffic accidents (NHTSA 2016). These accidents and associated risks to life, health, and property will generally scale with the frequency, mileage, and duration of trucking, total number of truckloads, number of roundtrip truck trips per day, and duration of the closure.

For purposes of the NEBA two attributes of offsite truck traffic that create disturbance to local communities were considered: (1) noise and congestion and (2) accidents. Noise and congestion were evaluated by comparing the number of times a construction truck would be expected to pass a given location along the transportation corridor during closure construction activities, assuming all trucks must pass this location. The difference in the likelihood of traffic accidents between the closure options was assumed to be a function of the number of offsite road miles driven by construction trucks (NHTSA 2016).

9.2.1 Noise and Congestion

Regardless of the option, closure of the ash basin at BCSS will result in an increased number of large trucks[67] on local roads (Table 9-1). Noise from these trucks includes engine and braking noise, which can be disruptive to the communities through which they are passing,[68] and trucks frequently passing through rural communities may pose additional disturbance from roadway congestion. To compare the disturbance of trucking noise and congestion between closure options, I used the average daily number of truck passes for trucks carrying earthen fill and geosynthetic material to the construction site (Table 9-1). The number of passes of trucks hauling ash from the ash basin to the landfill was not considered because these trucks do not leave BCSS. For CIP, it is estimated that a total of 22,140 truck passes would occur at locations along the transportation corridor over the 76-month course of trucking activities, for an average of 11 passes per day, or one truck every 54 minutes assuming a 10-hour work day.[69] Excavation closure averages 8 truck passes per day for 138 months, or one truck every 1 hour and 15 minutes. In the hybrid closure, there would be 10 trucks per day, which is 1 per hour assuming a 10-hour work day. These results and their relative differences (as the ratio to CIP closure) are summarized for all closure options in Table 9-3.

9.2.2 Traffic Accidents

Traffic accidents are assumed to be a function of the total number of offsite road miles driven by construction trucks (NHTSA 2016). CIP closure requires approximately 324,000 miles of driving, excavation closure requires approximately 378,000 miles of driving, and hybrid closure requires approximately 285,000 miles of driving. The difference in distance driven between the excavation and hybrid options is equivalent to more than 4 trips around the earth. Table 9-3 summarizes the results for all disturbances considered.

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67 Twenty-ton dump trucks, or similar vehicles for bulk transport, are assumed to be the primary vehicles that will be involved in transporting materials during closure construction activities.

68 A typical construction dump truck noise level is approximately 88 decibels 50 ft. from the truck. (https://www.fhwa.dot.gov/ENVIRONMENT/noise/construction_noise/handbook/handbook09.cfm)

69 All closure options assume 10-hour work days, 6-day work weeks, and 26 working days per month.

Table 9-3. Comparative metrics for increased noise, congestion, and traffic accidents

	Months of trucking	Noise and congestion		Traffic Accidents	
		Average truck passes per day	Ratio to CIP	Total offsite road miles driven	Ratio to CIP
CIP	76	11	1	324,180	1
Excavation	138	8	0.7	378,245	1.2
Hybrid	88	10	0.9	284,700	0.9

9.3 NEBA – Minimize Human Disturbance

From these analyses, no meaningful health risk is expected from diesel exhaust emissions under any closure option, but the closure options are expected to produce different levels of community disturbance in the form of noise, traffic congestion, and risk of traffic accidents.

I used the number of trucks per day passing[70] a receptor along a near-site transportation corridor to examine the differences in noise and traffic congestion under the closure options. I compared the increase in the average number of trucks hauling earthen fill, geosynthetic material, and other materials under the closure options to the current number of truck passes for the same receptor. I specified a baseline, or current, level of truck passes on the transportation corridor, and the number of truck passes per day under the closure options were derived directly from the trucking projections and implementation schedules provided by Duke Energy.

A baseline estimate of trucking passes per day for transportation corridors near BCSS was derived from North Carolina Department of Transportation (NCDOT) data of annual average daily traffic (AADT) at thousands of locations across the state[71] and the proportion of road miles

70 Truck passes per day is calculated as the total number of loads required to transport earthen fill, geosynthetic material, and other materials multiplied by two to account for return trips. The resulting total number of passes is then divided evenly among the total construction time multiplied by 26 working days per month.

71 Annual average daily traffic (AADT) values are derived from counts of axle pairs in every lane travelling in both directions using a pneumatic tube counter. At each monitoring station, raw data is collected for two days, and these raw counts are adjusted using axle and seasonal correction factors to estimate the AADT. AADT results are compared to historical values at the same location and values at nearby stations to provide temporal and spatial quality assurance. AADT data and a mapping application user interface are available online (http://ncdot.maps.arcgis.com/apps/webappviewer/index.html?id=5f6fe58c1d90482ab9107ccc03026280)

driven by large trucks in Stokes County.[72] Based on the assumed 94-truck-per-day baseline level and the number of truck trips per day from Duke Energy's closure projections, all options would have an impact of 12% or less (CIP = 12%, excavation = 9%, hybrid = 11%) on noise and congestion. I input these percent impacts to the risk-ranking matrix (Table 5-4) along with the total duration of trucking activities (6 years CIP; 12 years excavation; 7 years hybrid) to evaluate which of the closure options best minimizes human disturbances (Table 9-4).

I evaluated risk of traffic accidents by comparing the average number of annual offsite road miles driven between closure options relative to a baseline estimate of the current road miles driven.[73] I chose a baseline of 27.4 million annual truck road miles for Stokes County, North Carolina, based on the reported total vehicle miles traveled in Stokes County (NCDMV 2017) multiplied by the county average 7% contribution of trucks to total AADT (NCDOT 2015). I used the increase in truck miles driven over baseline in the closure options as a surrogate for the potential increase in traffic accidents.

Using the 27.4-million-truck-miles baseline assumption, CIP closure has a 0.19% impact, the excavation closure has a 0.12% impact, and hybrid closure has a 0.14% impact. All closures have a relative risk rating of <5%. These relative risk ratings appear to be insensitive to lower assumed baseline annual truck miles (see Appendix E for sensitivity analysis); reducing the baseline assumption to the statewide minimum number of truck miles driven per year (6.2 million truck miles in Hyde County) does not appreciably increase the expected percent impact and relative risk rating and, by extension, the estimated risk of traffic accidents. Results are summarized in the NEBA framework (Table 9-4) within the objective of minimizing disturbance to humans during closure.

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[72] A value of 1,300 AADT was chosen as a baseline value for all vehicle traffic by identifying potential transportation routes to and from the BCSS ash basin and selecting the AADT station along the route that currently has the lowest traffic and would experience the greatest proportional increase in trucking traffic from ash basin closure. The baseline AADT value (1,300) was then multiplied by the county average of large truck traffic volume (7%) to derive an estimated 94 passes per day along the most sensitive portion of the transportation corridor to and from BCSS (Appendix E).

[73] The difference of baseline miles and closure option miles was divided by the baseline miles and multiplied by 100 to get a percent impact.

Table 9-4. Summary of relative risk ratings for attributes that characterize potential hazards to communities during remediation activities. Darker shading and higher codes indicate greater impact.

Objective	Minimize Human Disturbance		
Hazard	Noise and Traffic Congestion	Traffic Accidents	Air Pollution
Potentially Affected Populations	Local Residents/Visitors	Local Residents/Visitors	Reasonable Maximum Exposure
Scenario			
Baseline	baseline	baseline	baseline
CIP	**3B**	**3A**	**--**
Excavation	**4B**	**4A**	**--**
Hybrid	**3B**	**3A**	**--**

"--" indicates "no meaningful risk."

All closure options create risk and disturbance to human populations. While the excavation closure option produces comparable impacts to CIP and hybrid closures on a daily or annual basis, the impacts occur for twice as long as those for CIP closure, resulting in a greater cumulative impact (risk rating 4 compared to 3) from excavation closure based on the trucking projections and implementation schedules provided by Duke Energy (2018b) [74]

All closure options support safe air quality from diesel truck emissions along the transportation routes, and each creates comparable levels of disturbance and risk that could adversely impact community safety on a daily or annual basis; however, these impacts occur for a substantially longer period under the excavation closure option (12 years for excavation closure compared to 6 and 7 years for CIP and hybrid closures, respectively). Thus, CIP and hybrid closure better

[74] Sensitivity analyses exploring different assumptions and subsequent effects to relative risk ratings are provided in Appendix E.

satisfy the third objective of ash basin closure—to minimize risk and disturbance to humans from closure.

10 Conclusion 4: Hybrid and excavation closures minimize environmental disturbance.

Environmental services are derived from ecological processes or functions that have value to individuals or society, with provision of a healthy environment to humans being one of the most essential environmental services. Environmental services that support human health include functions to purify freshwater, provide food, supply recreational opportunities, and contribute to cultural values (MEA 2005). For example, forests provide habitat for deer that are hunted for food; surface water supports fish populations that are food for bald eagles, a previously threatened and endangered species highly valued by our society;[75] and soil and wetlands purify groundwater and surface water, respectively, by adsorbing contaminants. Central to weighing the net environmental benefits of the closure options under consideration here is understanding how they differentially impact the variety of environmental services at the site and in the area.

BCSS, though an industrial site, supports a diversity of habitats that provide environmental services. Figure 10-1 illustrates the types of habitats at the site. The ash impoundment provides habitat that supports birds and mammals; the open water habitat of the impoundment also removes solids from surface water by providing a low-flow environment in which ash particles and other solids can settle into the sediment before the treated water can enter the Broad River. The onsite forest provides biodiversity protection in the form of foraging, shelter, and breeding habitat for birds and mammals, among other types of organisms; watershed protection; landscape beauty; and carbon sequestration (Bishop and Landell-Mills 2012). Beyond BCSS, the Belews Creek Reservoir and the Dan River provide aquatic habitat that supports a variety of fish and aquatic life (Brown and Derwort 2014; Duke Energy 2016), which then provide food for birds and mammals.

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[75] Bald eagles were taken off the federal list of threatened and endangered species in 2007 (https://www.fws.gov/midwest/eagle/).

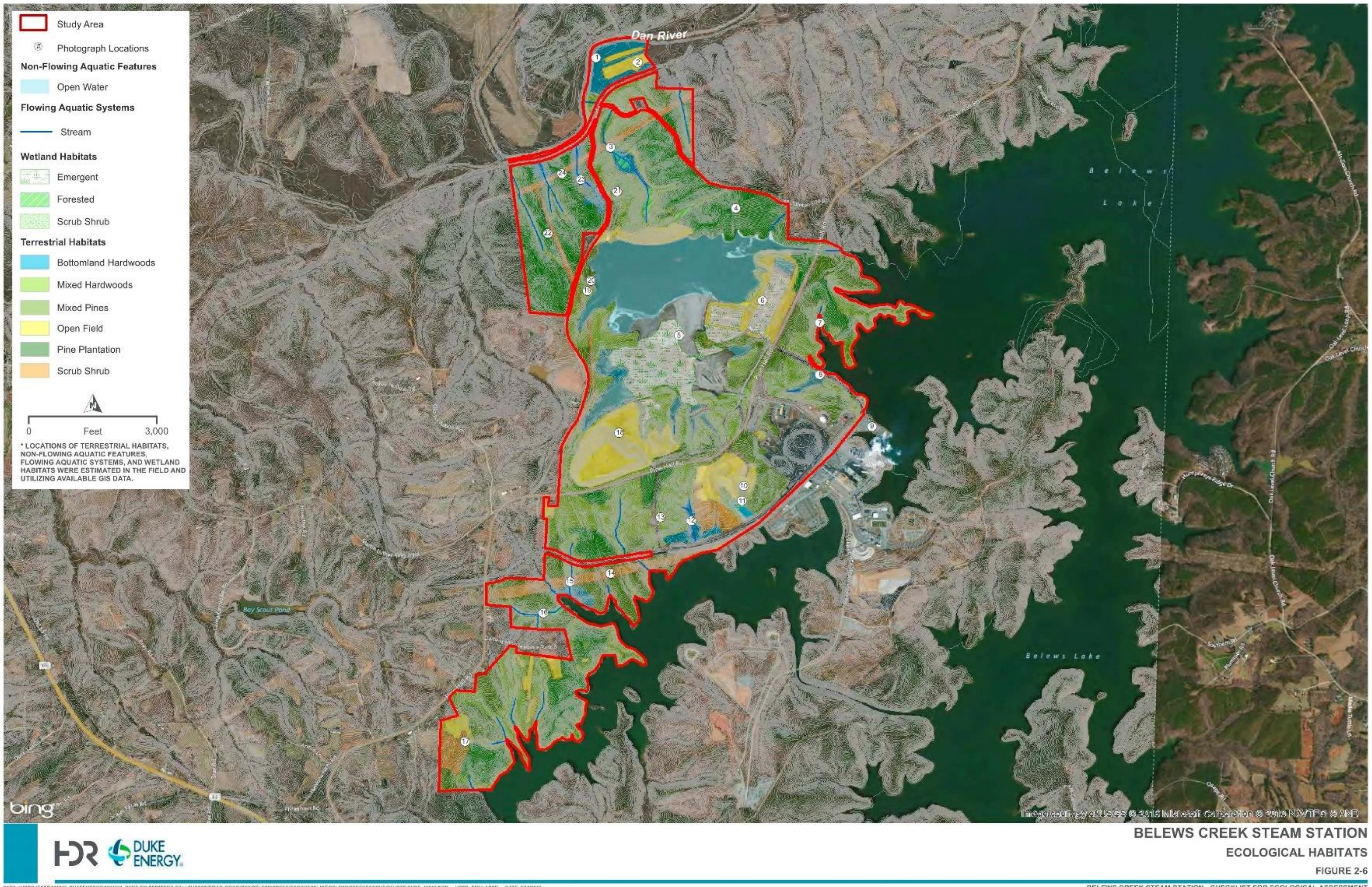

Figure 10-1. Map of habitat types currently present at BCSS.
Reproduced from CAP-2 Appendix F, Figure 2-6 (HDR 2016).

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Plants serve a vital ecosystem role by converting solar energy and carbon dioxide into food (for themselves) and oxygen. Plants then become food for other organisms. As such, "plants provide the energy and air required by most life forms on Earth."[76] NPP represents a measure of the mass of chemically fixed carbon produced by a plant community during a given period and reflects the rate at which different ecosystems are able to sequester carbon. Given the foundational role of primary production in supporting ecological food webs and healthy air, NPP is a good surrogate for environmental services provided by different habitat types (Efroymson et al. 2003). For example, the annual NPP of a temperate forest habitat is approximately 2.5 times higher than for temperate grasslands or freshwater ecosystems (Ricklefs 2008). By multiplying the acres of habitat type by NPP, NPP becomes a single metric by which to compare the different levels of environmental services impacted by ash basin closure.[77]

The fourth objective for ash basin closure, to minimize environmental disturbance, is represented by the environmental services protection of biodiversity and natural beauty. For purposes of the NEBA, these considerations were evaluated based on differences in habitat-derived services estimated from the NPP of impacted habitat acres under the closure options.

10.1 Hybrid and excavation closure produce net gains in environmental services.

Regardless of the closure option, habitat and habitat-derived environmental services will be altered. CIP closure requires removing existing habitat within the footprint of the ash basin, possible temporary removal of forest habitat to create a borrow pit to source earthen materials for the cap, and restoring the ash basin with grass cap habitat. Excavation closure and onsite landfilling require temporary loss and future modification of existing habitats within the footprint of the ash basin; permanent conversion of some forest habitat to create additional landfill capacity; temporary removal of forest habitat to create a borrow pit to source earthen materials for fill material for the landfill cap; restoring the ash basin with a mixture of grass cap,

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76 https://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD17A2_M_PSN

77 I used rates of NPP by stand age from He et al. (2012, Figure 2c.) for mixed forests as the basis for establishing NPP of onsite wooded habitats and used relative rates of NPP from Ricklefs (2008) to scale NPP for other habitat types.

open field, and forest habitat; and restoring the new landfill capacity with grass cap. The hybrid option requires temporary loss and future modification of existing habitats within the footprint of the ash basin and temporary loss of forest habitat at the borrow site. All closure options include restoration of the ash basin footprint, but the collateral losses of habitat, the differences in service levels of restored habitat, and the timelines for recovery of the habitats vary substantially. This makes it challenging to appreciate the net gain or loss of environmental services. To address this challenge, I used a habitat equivalency analysis (HEA) to quantify the differences in environmental services resulting from each closure option.

HEA is an assessment method widely used in NRDA to facilitate restoration scaling for environmental services (Dunford et al. 2004; Desvousges et al. 2018; Penn undated). Numerous damage assessment restoration plans based on the use of HEA can be found on the U.S. Fish and Wildlife Service[78] and NOAA[79] websites and include sites such as the St. Lawrence River near Massena, New York; Onondaga Lake near Syracuse, New York; and LaVaca Bay in Texas. As Desvousges et al. (2018) describe, use of HEA has expanded in recent years beyond its original applications for NRDA to address environmental service losses from other causes such as forest fires and climate change. As the authors note, HEA has also been used as an assessment tool in NEBA applications, such as evaluating the effects of transmission line routing on habitats of greater sage-grouse (*Centrocercus urophasianus*), a proposed threatened species.

The objective of HEA is to estimate the amount of compensatory services necessary to equal the value of the services lost because of a specific release or incident. The method calculates debits based on services lost because of resource losses and credits for services gained due to resource gains. The latter are often scaled to compensate for, or offset, the loss in services. A discount rate is used to standardize the different time intervals in which the debits and credits occur, so the services are usually expressed in terms of discounted acre-years of equivalent habitat, or DSAYs (Dunford et al. 2004; Desvousges et al. 2018; Penn undated).

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[78] www.doi.gov/restoration

[79] www.darrp.noaa.gov

The HEA methodology was used here to estimate changes in environmental service levels that will accrue under closure options. Environmental services currently provided by the site will be eliminated when the ash basin is closed. After closure is complete, there will be a new level of environmental services provided as habitat is restored. Since post-closure habitats may differ from those that currently occur onsite, future services could be greater or less than what occurs at present. Similarly, land used as a borrow area or converted to landfill, as per the closure options, will also impact the net level of services, as services currently provided by those habitats may be reduced. The environmental service losses and gains from onsite and offsite habitats must be considered together when determining the overall net effect of a closure option.

A common ecological metric is required to make comparisons between service gains and losses from various habitat types. For purposes of this evaluation, I used annual NPP as the metric to standardize across habitat types. In terms of habitats currently occurring on the site, wooded areas have the highest NPP, so that is used as the basis for defining service level, and the service levels for other habitat types (open fields, open water) are expressed as a proportion of that baseline service. Based on He et al. (2012), and assuming a tree stand age of 50 years, NPP would be approximately 6.4 tons of carbon per hectare per year (6.4 t C/ha/yr) in wooded areas onsite. Based on relative rates of NPP from Ricklefs (2008), the NPP for open field and open water habitats would be approximately 40% of the temperate forest rate. To prevent overestimation of NPP in open water areas of the ash basin that may not provide the same level of NPP as natural freshwater habitats (perhaps from limited abundance or diversity of vegetation), I assumed that open water areas of the ash basin produce NPP that is 25% that of natural ecosystems.[80] Therefore, I applied a four-fold habitat quality factor to scale NPP at these open water areas of the ash basin to approximately 10% of the rate for wooded habitats. Deforested land for borrow areas was assumed to be reforested after closure was complete under

[80] I observed open water areas of the ash basin that supported aquatic vegetation but do not know the extent of vegetation in the open water areas of the ash basin. Thus, I made a conservative assumption (i.e., one that reduces the present value of the habitat) that these areas of the ash basin provide a reduced level of NPP compared to natural open freshwater areas.

CIP and hybrid closures but permanently converted to grass cap under excavation closure. The grass cap on landfill was given a service value of 8%,[81] as was done for CIP.

For each closure option, I used the acreage of existing habitat types and the level of service of that habitat type to establish a baseline level of service. Based on the timelines for the various closure options, a HEA was conducted to calculate the net change in service flow of the closure area over the next 150 years at a 3% discount rate.[82] Similarly, a HEA was run to calculate the net change in environmental services deriving from areas used either as borrow or for landfill. Because NPP standardizes service levels across habitat types, the DSAY estimates for all affected habitats can be summed to calculate the net service gain/loss associated with each closure option. In addition to the assumptions identified above, several other assumptions were made to support the HEA, which are described in Appendix D.

Results of the HEA are presented in Table 10-1[83] and indicate that both excavation and hybrid closure of the ash basin at BCSS result in a net gain in NPP services. Conversely, CIP will result in a net loss of environmental services due primarily to the reduced NPP services provided by the grass cap that will replace all of the existing habitats in the ash basin. This factor adversely affects the environmental services provided by the impacted habitat such that environmental services produced after closure will not compensate for the service losses resulting from the closure. Hybrid closure produces the largest net gain in environmental services because of the amount of forested land that will be restored both onsite and at the area used for borrow, whereas excavation closure only returns the landfill area to a grass cap.

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81 An open field provides a relatively lower NPP service level than forest habitat (40% of forest NPP; Ricklefs 2008), and since a grass cap requires periodic maintenance mowing, for purposes of the HEA it was assumed never to reach a level of NPP service equivalent to an open field. Grass cap was assumed to have 20% of the NPP service level for open field, which is 8% of forest NPP.

82 Environmental services in future years are discounted, which places a lower value on benefits that will take longer to accrue. The basis for this is that humans place greater value on services in the present and less value on services that occur in the future.

83 A full description of the methods, assumptions, results, and sensitivity analyses for the HEA are provided in Appendix D.

Table 10-1. Summary of NPP DSAYs for CIP, excavation, and hybrid ash basin closure options

		CIP	Excavation	Hybrid
Ash basin losses				
	Grass Cap	−25	−24	−25
	Open water	−470	−443	−470
	Wetland	−801	−754	−801
	Broadleaf forest	−182	−170	−182
	Needle leaf forest	−9	−8	−9
	Shrub-scrub	−13	−13	−13
	Total losses	−1,500	−1,411	−1,500
Ash basin post-closure gains				
	Grass cap	520		257
	Open field		110	99
	Wetland		68	61
	Broadleaf forest		2,002	1,093
	Needle leaf forest		1,515	826
	Shrub-scrub		204	183
	Wetland forest		27	15
	Total gains	520	3,926	2,534
Landfill/borrow losses				
	Forest loss to landfill/borrow	−392	−2,278	−362
	Open field loss to landfill/borrow			
	Total losses	−392	−2,278	−362
Landfill/borrow post-closure gains				
	Land reforested	264		237
	Land restored to grass cap		126	
	Total gains	264	126	237
Net Gain/Loss per Option		**−1,107**	**361**	**908**

Note: DSAYs for specific habitat types are reported here rounded to the nearest whole number. As such, the net gain/loss per option differs slightly from the sum of the individual DSAYs reported in the table.

10.2 NEBA – Minimize Environmental Disturbance

The impact of the closure options on environmental services was computed as the percentage difference in DSAYs produced by the closure option and the absolute value of the DSAY losses. The DSAY losses represent the NPP services that would have been produced by the site, borrow areas, and landfills but for the project closure. The DSAY gains represent the NPP services restored after project closure plus any future gains realized from existing habitats before remediation begins. The sum of DSAY losses and gains represents the net change of NPP services for the project resulting from closure. Dividing the net DSAYs by the absolute value of the DSAY losses provides a percentage of the impact. From these calculations, the CIP closure will have a 59% impact, while excavation and hybrid closure will have no net adverse impact on NPP services and will, in fact, increase net NPP services (Table 10-2). These percent impacts were input to the risk-ranking matrix (Table 5-4) along with the duration of the closure activities (6 years CIP; 12 years excavation; 7 years hybrid) to visualize, within the NEBA framework, which of the closure options best minimizes environmental disturbances (Table 10-3).

Table 10-2. Percent impact of ash basin closure options. Closure options that produce a net gain in ecosystem services are assumed to have a 0% negative impact.

	CIP	Excavation	Hybrid
DSAY Losses[a]	1,892	3,690	1,862
DSAY Gains	784	4,051	2,769
Percent Impact (%)	59%	0%	0%

[a] Absolute value of DSAY losses is equivalent to baseline services of the affected habitat, but for the closure.

Table 10-3. Summary of relative risk ratings for habitat changes that affect provision of environmental services. Darker shading and higher codes indicate greater impact.

Objective	Minimize Environmental Disturbance
Hazard	Habitat Change
Attribute	DSAYs
Scenario	
Baseline	baseline
CIP	**3D**
Excavation	**--**
Hybrid	**--**

"--" indicates "no meaningful risk."

Within the objective of minimizing environmental disturbance from closure, my analyses indicate that both hybrid and excavation closures produce a net benefit in habitat-derived environmental services; however, CIP closure, as currently defined, decreases habitat-derived environmental services.[84] Thus, hybrid and excavation closures better satisfy the fourth objective of ash basin closure—to minimize risk and disturbance to the local environment from closure.

[84] Note, however, that the environmental services lost due to the currently designed CIP closure could be offset (see discussion in Section 11) by a suitable reforestation project that would then result in all closure options producing no net loss of habitat-derived environmental services in the HEA model.

11 Conclusion 5: Hybrid closure maximizes environmental services.

Identifying environmental actions that maximize environmental services (the fifth objective for ash basin closure) is a function of NEBA (Efroymson et al. 2003, 2004) and the overarching objective that encompasses each of the other four objectives and all of the environmental services that have been considered to this point. Table 11-1 summarizes the relative risk ratings for all attributes and objectives. Impacts to environmental services considered in this NEBA focused on key community-relevant concerns. Risk to construction workers from construction operations, risks to local and global populations from increased greenhouse gas emissions, and “wear-and-tear” damage to roadways from trucking were not estimated. Each of these risks, however, would scale with the duration, frequency, and intensity of construction operations.

Sensitivity analyses of the specifications of the NEBA framework show that the specific relative risk ratings presented in this NEBA can change depending on how baseline is defined (see Appendix E). The purpose of the risk matrix, and the risk ratings that result from it, is to consolidate the results from a variety of different analyses for a variety of different data types and attributes into a single framework for comparative analysis. It is imperative, however, to consider the underlying information used to develop the risk ratings to interpret the differences between closure options, particularly when percent impacts or durations of closure options are similar but receive different risk ratings.

As noted in Section 5, NEBA analysis provides an opportunity to better understand the net environmental benefits of possible closure options. If Duke Energy’s preferred closure option for reasons not considered in the NEBA does not best maximize environmental services to the local community as currently defined, the NEBA results provide insight into how environmental services could be improved for that closure option. For instance, if Duke Energy’s preferred closure option for BCSS is CIP closure but the HEA results for the currently defined CIP closure option estimate a net environmental service loss of 1,107 DSAYs, Duke Energy could consider incorporating into an updated CIP closure plan for BCSS a mitigation project that compensates for the net environmental service losses projected from the currently defined CIP closure option. As an example, if Duke Energy started a reforestation project outside of the ash basin in 2022 (when onsite preparation of the ash basin begins), the reforestation project would gain 24.3 DSAYs/acre over the lifetime of the site (150 years in the HEA), requiring a 45.5 acre project to compensate for the 1,107 DSAY loss projected in the HEA. Re-analysis of the HEA component of the NEBA for the updated possible closure options would then result in no net environmental losses (as NPP services) from habitat alteration of the basin under any closure option.

From the closure options considered and the analyses presented in this report, which are based on a scientific definition of risk acceptability and include no value weighting, a hybrid closure best maximizes environmental benefits compared to excavation or CIP closures because it offers equivalent protection of human and ecological health from CCR exposure, results in less disturbance to the local community over time compared to excavation closure, and produces a net increase in habitat-derived environmental services. Thus, among the closure options considered as currently defined, hybrid closure best satisfies the fifth objective of ash basin closure—to maximize local environmental services.

Table 11-1. NEBA for closure of the ash basin at BCSS.
Darker shading and higher alphanumeric codes indicates greater impact.

Objective	**Protect Human Health from CCR**							**Protect Ecological Health from CCR**					**Minimize Human Disturbance**			**Minimize Environmental Disturbance**
Hazard	Exposure to CCR							Exposure to CCR					Noise and Traffic Congestion	Traffic Accidents	Air Pollution	Habitat Change
Potentially Affected Populations	Local Residents/Visitors	Onsite Construction Workers	Offsite Recreational Swimmers	Offsite Recreational Waders	Offsite Recreational Boaters	Offsite Recreational Fishers	Offsite Subsistence Fishers	Fish Populations	Aquatic Omnivore Birds (mallard)	Aquatic Piscivore Birds (great blue heron)	Aquatic Herbivore Mammals (muskrat)	Aquatic Piscivore Mammals (river otter)	Local Residents/Visitors	Local Residents/Visitors	Reasonable Maximum Exposure	DSAYs
Scenario																
Baseline	--	--	--	--	--	--	--	--	--	--	--	--	baseline	baseline	baseline	baseline
CIP	--	--	--	--	--	--	--	--	--	--	--	--	**3B**	**3A**	--	**3D**
Excavation	--	--	--	--	--	--	--	--	--	--	--	--	**4B**	**4A**	--	--
Hybrid	--	--	--	--	--	--	--	--	--	--	--	--	**3B**	**3A**	--	--

"--" indicates "no meaningful risk."

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Appendix A

Curriculum Vitae of Dr. Ann Michelle Morrison, Sc.D.

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Ann Michelle Morrison, Sc.D.

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Professional Profile

Dr. Morrison has over 20 years of experience evaluating the relationship between anthropogenic contamination and health effects to aquatic life and humans. Dr. Morrison specializes in natural resource damage assessment (NRDA), environmental causal analysis, and assessments of water quality conditions. Dr. Morrison has provided scientific consultation regarding the design of field studies for NRDA, and she has worked closely with legal counsel during scientific assessments and settlement negotiations with state and federal trustees. Dr. Morrison has performed detailed technical assessments of injuries to aquatic resources, including vegetation, benthic infauna, fishes, shellfishes, and corals. She has also developed site-specific sediment toxicity thresholds based on the empirical relationships of chemical concentrations to biological effects. She has provided expert testimony concerning injury to aquatic resources and the net environmental benefits of remediation alternatives.

Projects she has been involved with have concerned oil spills, sewage releases, heavy metal contamination, and various industrial and municipal facilities that have generated complex releases to the environment. Dr. Morrison applies statistical tools and weight-of-evidence approaches to delineate exposure zones, predict the likelihood of contamination events, evaluate net environmental benefits, and assess causation. She uses a broad knowledge of aquatic life and human health to assess risk and injury to these populations.

Academic Credentials & Professional Honors

Sc.D., Environmental Health, Harvard University, 2004

M.S., Environmental Health, Harvard University, 2001

B.S., Biology, Rhodes College, 1997

Prior Experience

Senior Scientist, Sole Proprietor, Morrison Environmental Data Services, 2004–2007

Data Analyst, ETI Professionals, 2005

Scientist, NIH Toxicology Training Grant, Harvard School of Public Health, 2000–2004

Guest Student, Woods Hole Oceanographic Institution, Stegeman Lab, 2001–2004

Science Intern, Massachusetts Water Resources Authority, 03-05/2000, 10/2000-10/2001

Research technician, Bermuda Biological Station for Research, Inc., Benthic Ecology Research Program (BERP), Bermuda, 01/1998-09/1999, 06-08/2000

Research Intern, Bermuda Biological Station for Research, Inc., Benthic Ecology Research Program (BERP), Bermuda, 05/1997-12/1997

NSF Research Experience for Undergraduates Fellowship, Bermuda Biological Station for Research, Inc., Benthic Ecology Research Program (BERP), Bermuda, 08-11/1996

Professional Affiliations

American Chemical Society — ACS

Society for Risk Analysis — SRA

Society of Environmental Toxicology and Chemistry — SETAC

North Atlantic Chapter of SETAC

Publications

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Morrison AM, Palmquist K, Kashuba R. Baseline in the Open-Access and “Big Data” Era. Law Seminars International. Washington, D.C. March 1, 2018.

Palmquist K, Morrison AM, Edwards ME. Addressing white hat bias: Lessons from environmental litigation. Society of Environmental Toxicology and Chemistry (SETAC) North America 38th Annual Meeting, Minneapolis, MN. November 12–16, 2017.

Palmquist KR, Ginn TC, Morrison AM, Boehm PD. 2017. Addressing Spatial Data Gaps in Deep-sea Benthic Sediment Sampling Following a Large-Scale Oil Spill. Battelle Sediment Conference in New Orleans, LA.

Morrison AM. The Science. Natural Resource Damages 101. Law Seminars International. Washington, D.C. March 9, 2016.

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Smith SR, Grayston LM, Stanley AM, Webster G, McKenna SA. CARICOMP coral reef monitoring: A comparison of continuous intercept chain and video transect techniques. Scientific Aspects of Coral Reef Assessment, Monitoring and Management, National Coral Reef Institute (NCRI), Nova Southeastern University, Ft. Lauderdale, FL. 1999.

Project Experience

Dr. Morrison has been involved in numerous complex projects relating to environmental contamination and potential risk to humans and biological resources in the affected environment.

Risk Assessments and Natural Resource Assessments

Expert witness concerning net environmental benefits from coal ash closure alternatives at two coal ash plants in North Carolina. *Roanoke River Basin Association v. Duke Energy Progress,* LLC, United States District Court, Middle District of North Carolina, Case No. 1:16-cv-607 and *Roanoke River Basin Association v. Duke Energy Progress,* LLC, United States District Court, Middle District of North Carolina, Case No. No. 1:17-cv-452.

Expert witness concerning potential damages to terrestrial and aquatic resources, including coral reefs, endangered sea turtles, fish and shellfish, and seagrass beds, resulting from a coastal development project on the Caribbean island of Nevis. Anne Hendricks Bass vs. Director of Physical Planning, Development Advisory Committee, and Caribbean Development Consultant Limited. Eastern Caribbean Supreme Court, in the High Court of Justice Saint Christopher and Nevis, Nevis Circuit, Civil Case No. NEVHCV2016/0014.

Expert witness concerning potential impacts to California fishery populations from the Refugio oil spill. Andrews et al. v. Plains All American Pipeline, L.P. et al. United States District Court, Central District of California, Wester Division, Case No. 2:15-cv-04113-PSG-JEM.

Provided analysis and technical support in Florida v. Georgia United States Supreme Court case that considered questions of causation relative to alleged adverse ecological changes in downstream river and bay populations.

Conducted a comprehensive review of an environmental impact assessment of potential impacts to coral reefs from a proposed dairy farm development in Hawaii.

Provided scientific support for the Deepwater Horizon NRDA in the Gulf of Mexico.

Developed a cooperative NRDA field study in the offshore waters of the Gulf of Mexico to collect sediment samples for analysis of chemistry, toxicology, and benthic infauna.

Expert witness concerning alleged injuries to aquatic resources from disposal of bauxite ore processing wastes for the case: Commissioner of the Department of Planning and Natural Resources, Alicia V. Barnes, et al. v. Virgin Islands Alumina Company et al. District Court of the Virgin Islands, Division of St. Croix, Civil Case No. 2005-0062.

Developed decision management products for beach water quality stakeholders using statistical data analysis tools such as receiver operating characteristic (ROC) curves and Bayesian networks to improve public beach advisories related to elevated fecal bacteria.

Developed net environmental benefit analysis (NEBA) for a lead contaminated river. This analysis used site-specific data to evaluate the costs and benefits of two different remediation options that were being considered. The NEBA was successfully used by the client to negotiate a higher remediation goal than original proposed by the state Department of Environmental Protection.

Performed ROC curve analyses of site-specific polycyclic aromatic hydrocarbon (PAH) toxicity data to assess the relationship between PAH concentration and toxicity at three ecological risk assessment projects in Wisconsin. The curves were used to identify site-specific toxicity thresholds for PAH concentration in sediment that were indicative of various zones of toxicity (no toxicity, low toxicity, and high toxicity), with very limited misidentification of sediments.

Provided research support to calculate site-specific no-observed-adverse-effect level (NOAEL) and lowest-observed-adverse-effect level (LOAEL) concentrations for mammals and birds for use in a baseline ecological risk assessment in Wisconsin.

Performed ROC curve analysis of national mercury toxicity data to assess the relationship between mercury concentration and toxicity. The curves were also used to identify a threshold mercury concentration for sediment that indicates likely toxicity, with very limited misidentification of sediments that are not toxic.

Assembled and analyzed data and reviewed remedial investigations to conduct a screening-level ecological risk assessment for sediment, surface water, and groundwater for a site in Connecticut. The chemicals considered were total petroleum hydrocarbons (TPH), metals, and PAHs.

Reviewed species lists and created summary descriptions of organisms that could be potentially impacted by dam construction on a high-altitude river in the Caribbean. This information was important to develop the risk assessment from dam construction.

Researched the toxicity of malathion to fish to support a technical review of the National Marine Fisheries biological opinion for the registration of pesticides containing malathion.

Ecological and Toxicity Studies

Conducted surveys to assess the health of coral reefs, seagrass beds, and mangrove swamps in the nearshore environment of Bermuda. Projects included area-wide habitat surveys as well as targeted sites potentially impacted by a heavy metals dump, hot water effluent from an incinerator, sedimentation from cruise ship traffic, and chronic release of raw sewage. In addition to ecological surveys, water quality was assessed through measurements of trace metals in water, sediment, and coral tissue.

Surveyed juvenile coral recruitment in the Florida Keys to evaluate if marine protected areas (MPAs) provide a benefit to coral recruitment.

Studied cytochrome P450 family enzymes, including CYP51 and CYP1, examining their sensitivity to environmental chemicals and their evolution through molecular biology and biochemistry approaches.

Environmental Forensics Projects

Performed document review, information management, and technical writing for numerous complex projects that dealt with historical petroleum contamination and multiple site owners in several types of environmental media.

Reviewed documents, assembled data, and researched metal concentrations associated with crude oil and railroads in support of a Superfund project in Oklahoma.

Examined the correlation of multiple contaminants (PAHs, metals) with polychlorinated biphenyl (PCB) congeners at a historically contaminated site in Alabama to identify the likely origins of the PCB contamination.

Performed statistical analysis to determine source contribution in a chemical fingerprinting case at a Superfund site in Washington that involved hydrocarbons in water, sediment, and groundwater.

Human Health Projects

Organized, managed, and simplified a complex database of field sampling reports for a litigation case in Louisiana regarding human air exposure to PAHs.

Performed data analysis and document review for a Superfund site in Oklahoma. The analyses used hydrocarbon chromatograms and limited PAH and metal data to identify the likely sources of contamination.

Researched and compiled screening-level human health inhalation toxicity values for refinery-related gases for an overseas project.

Developed a questionnaire and related database for industrial hygiene surveys to support regulatory compliance for a highly specialized industry.

Appendix B

Human Health and Ecological Risk Assessment Summary Update for Belews Creek Steam Station

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

SUMMARY UPDATE

For

BELEWS CREEK STEAM STATION
3195 PINE HALL ROAD
BELEWS CREEK, NC 27009

NOVEMBER 2018

PREPARED FOR

DUKE ENERGY CAROLINAS, LLC
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1.0 INTRODUCTION

This update to the Belews Creek Steam Station (BCSS or Site) human health and ecological risk assessment incorporates results from sampling events conducted March 2015 through July 2018. The samples were collected from surface water, sediment, and groundwater. This update was performed in support of a Net Environmental Benefits Analysis. As set forth below in detail, this updated risk assessment concludes that: (1) the BCSS ash basin does not cause any material increase in risks to human health for potential human receptors located on-Site or off-Site; and (2) the BCSS ash basin does not cause any material increase in risks to ecological receptors.

The original 2016 risk assessment was a component of the Corrective Action Plan Part 2 pertaining to BCSS (HDR, 2016). To assist in corrective action decision making, the risk assessment characterized potential effects on humans and wildlife exposed to naturally occurring elements, often associated wth coal ash, present in environmental media. Corrective action is to be implemented with the goal of ensuring future site conditions remain protective of human health and the environment, as required by the 2014 North Carolina General Assembly Session Law 2014-122, Coal Ash Management Act (CAMA). The risk assessment was updated as part of the 2017 Comprehensive Site Assessment (CSA) Update report (SynTerra, 2017). This update follows the methods of the 2016 risk assessment (HDR, 2016) and is based on U.S. Environmental Protection Agency (USEPA) risk assessment guidance (USEPA, 1989; 1991; 1998).

Areas of wetness (AOWs), or seeps, are not subject to this risk assessment update. AOWs associated with engineered structures, also referred to as "constructed seeps," are being addressed in National Pollutant Discharge Elimination System (NPDES) permits. Other AOWs (non-constructed seeps) are now addressed under a Special Order by Consent (SOC) issued by the North Carolina Environmental Management Commission (EMC SOC WQ S18-004). Many AOWs are expected to reduce in flow or be eliminated after decanting. The SOC requires that any seeps remaining after decanting must be addressed with a corrective action plan that must "protect public health, safety, and welfare, the environment, and natural resources" (EMC SOC WQ S18-004, 2. d.).

This risk assessment update includes results from samples of surface water, sediment, and groundwater collected since the 2017 CSA update. New information regarding groundwater flow and the treatment of source areas other than the ash basin has resulted in refinement of exposure pathways and exposure areas. The Conceptual Site Models (CSMs) (**Figures 1 and 2**) reflect potentially complete exposure pathways with potential risks, and ecological exposure areas are depicted in **Figure 3**. Human health risks were evaluated Site-wide and in adjacent areas, so no exposure area figure is provided. Changes to the CSMs include:

- Exposure to coal combustion residual (CCR) constituents by Site workers is considered incomplete, because Duke Energy maintains strict health and safety requirements and training. The use of personal protective equipment (*e.g.*, boots, gloves, safety glasses) and other safety behaviors exhibited by Site workers limits exposure to CCR constituents.

- The number of ecological exposure areas was reduced from five to two, as depicted in **Figure 3**. Other ecological exposure areas evaluated in the 2016 risk assessment were eliminated because they are not influenced by groundwater migration from the ash basin.

- Surface water sampling and sediment sampling of Belews Lake and the Dan River allow for direct assessment of those areas, rather than using AOW data as a surrogate. Although groundwater monitoring and modeling indicate CCR constituents have not migrated to Belews Lake and the Dan River, there is evidence that migration to Belews Lake from a seep designated S-06 has occurred. The flow from S-06 to Belews Lake is negligible in comparison to the volume of the lake, and is expected to be reduced or eliminated under the SOC.

Results from samples of surface water, sediment, and groundwater were compared with human health and ecological screening values (**Attachments 1 and 2**) to identify constituents of potential concern (COPCs) for further review. Exposure point concentrations (EPCs) were calculated for COPCs (**Attachments 3 and 4**) to incorporate into human health and ecological risk models. Results of risk estimates (**Attachments 5 and 6**) are summarized below.

2.0 SUMMARY OF RISK FINDINGS

2.1 Human Health

There is no exposure to residential receptors at or near BCSS because there are no complete exposure pathways. Potential receptors off-Site are recreational users of the Dan River and Belews Lake, including swimmers, waders, boaters, and fishers. However, background concentrations of the same elements also present similar risks not associated with the ash basin to the same potential receptors.

- Boater, swimmer, and wader exposure scenarios
  - There is no material increase in cancer risks for the boater, swimmer, and wader exposure scenarios attributable to the ash basin. Incorporating arsenic concentrations in sediment samples and hexavalent chromium concentrations in surface water samples collected since the 2017 CSA update produced modeled potential carcinogenic risks under the boater, swimmer, and wader scenarios. However, arsenic and hexavalent chromium concentrations in upgradient surface water and sediment samples were similar to EPCs used in risk calculations, and when substituted for EPCs, also indicated potential risks. For example, the concentration of arsenic in sediments from the Dan River background location was as much as 3.6 mg/kg. The hexavalent chromium surface water concentration was as much as 0.064 μg/L in the Dan River upstream of the ash basin, and 0.029 μg/L at the Belews Lake background location. When substituted into the human health risk models, these concentrations measured upstream of the ash basin also resulted in modeled risks under the exposure conditions evaluated.
  - No evidence of non-carcinogenic risks for recreational swimmer, wader, or boater exposure scenarios was identified.
- Fisher exposure scenario
  - As stated above, there is no material increase in cancer risks for the fisher exposure scenario attributable to the ash basin. Hexavalent chromium concentrations in surface water produced modeled results of potential carcinogenic risks under the recreational and subsistence fishing exposure scenarios.[1] However, hexavalent chromium concentrations in upgradient

[1] For conservative estimation of hexavalent chromium concentrations in fish tissue, the recreational and subsistence fisher exposure models used in this risk assessment assume a hexavalent chromium

surface water were similar to EPCs used in risk calculations, and when substituted for EPCs in the model, also indicated potential risks. There is, therefore, no material increase in cancer risks attributable to the ash basin.

- No evidence of non-carcinogenic risks from consumption of fish from Belews Lake was identified – for either the recreational or subsistence fisher scenarios. Fish tissue concentrations were modeled from detected surface water concentrations.

- Based upon limited data, potential non-carcinogenic risks were modeled for the recreational fisher potentially exposed to thallium detected in the Dan River upstream of NPDES Outfall 003. However, the modeled concentration of thallium in fish tissue is likely overestimated. Thallium was detected in only five (5) of 37 samples (14 percent detection frequency) collected from the Dan River. The maximum thallium concentration of 1.1 μg/L was used as the EPC because there were fewer than six detections. Risk estimates from fish consumption are based on CCR constituent concentrations in fish tissue modeled from concentrations detected in surface water. There is not likely to be any material increase in non-carcinogenic risks for the recreational fisher scenario.

- Potential non-carcinogenic risks from consumption of fish containing cobalt, thallium, and zinc (modeled from surface water concentrations) were modeled for the subsistence fisher on the Dan River. Subsistence fishing, defined by USEPA (2000) as ingestion of 170 grams (0.375 pounds) of fish per day, has not been identified on the Dan River or near the Site.[2] But even if there were subsistence fishers using these water bodies, there would be no material increase in risks to them posed by the ash basin. The cobalt EPC is within "background" conditions of the Dan River. The cobalt EPC used in risk calculations was 1.55 μg/L, compared with a

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bioconcentration factor (BCF) of 200 (NRCP, 1996). Bioconcentration is the process by which a chemical is absorbed by an organism from the ambient environment through its respiratory and dermal surfaces (Arnot and Gobus, 2006). The degree to which bioconcentration occurs is expressed as the BCF. Published BCFs for hexavalent chromium in fish can be as low as one, suggesting that potential bioconcentration in fish is low (USEPA, 1980; 1984; Fishbein, 1981; ATSDR, 2012). The conservative BCF of 200 used here likely overestimates the hexavalent chromium concentration in fish tissue.

[2] To put the fish ingestion rate into context, a 170 gram per day fish meal is approximately equal to six ounces or approximately five fish sticks per meal (see http://gortons.com/product/original-batter-tenders); it is assumed that the subsistence fisher catches this amount of fish in the local water body and has such a fish meal once per day, every day for years.

maximum cobalt concentration of 1.79 μg/L measured in the Dan River upstream of ash basin. Thus, the ash basin does not materially increase the background level of risks associated with cobalt. Further, as noted above, risks associated with modeled thallium in fish tissue are likely overestimated. As stated in previous versions of the risk assessment, the fisher exposure scenarios overestimate risks based on exposure model assumptions of bioconcentration and fish consumption rates. Neither cobalt, thallium, nor zinc appreciably concentrates in fish tissue. Finally, the average concentration of zinc in the Dan River was well below surface water standards.

The updated risk assessment found no evidence of risks associated with exposure to groundwater by Site workers. Trespasser exposure to AOWs was not evaluated because AOWs are addressed in the SOC. There is, therefore, no material increase in risks associated with onsite exposure scenarios.

2.2 Ecological

There is no evidence of ecological risks associated with the Dan River (Exposure Area 1) or Belews Lake (Exposure Area 3).

- In practice, ecological risks are quantified by comparing an average daily dose (ADD) of a constituent to a toxicity reference value (TRV) for a given wildlife receptor. The ratio of the ADD and TRV is the hazard quotient (HQ), where an HQ less than unity (1) indicates no evidence of risks. TRVs are generally no-observed-adverse-effects-levels (NOAEL) or a lowest-observed-adverse-effects-levels (LOAEL) from toxicity studies published in scientific literature.

- No HQs based on LOAELs exceeded unity for the wildlife receptors (mallard duck, great blue heron, muskrat, river otter) exposed to surface water and sediments.

- One HQ based on a NOAEL of aluminum was 2.0 for the muskrat. The modeled risk is negligible. Moreover, the model likely overstates any real risk. Aluminum occurs naturally in soil, sediment and surface water in this area. For example, the aluminum concentration in the Dan River surface water upstream of the Site was as much as 3.9 mg/L, and the concentration in sediment was 16,000 mg/kg. Comparatively, the aluminum EPCs used in the risk assessment were 2 mg/L in surface water and 27,000 mg/kg in sediments. Per the U.S. Geological Survey (USGS), aluminum is the third most abundant element following oxygen and silicon in the Earth's crust (USGS, 2018).

In summary, the BCSS ash basin does not cause any increase in risks to ecological receptors.

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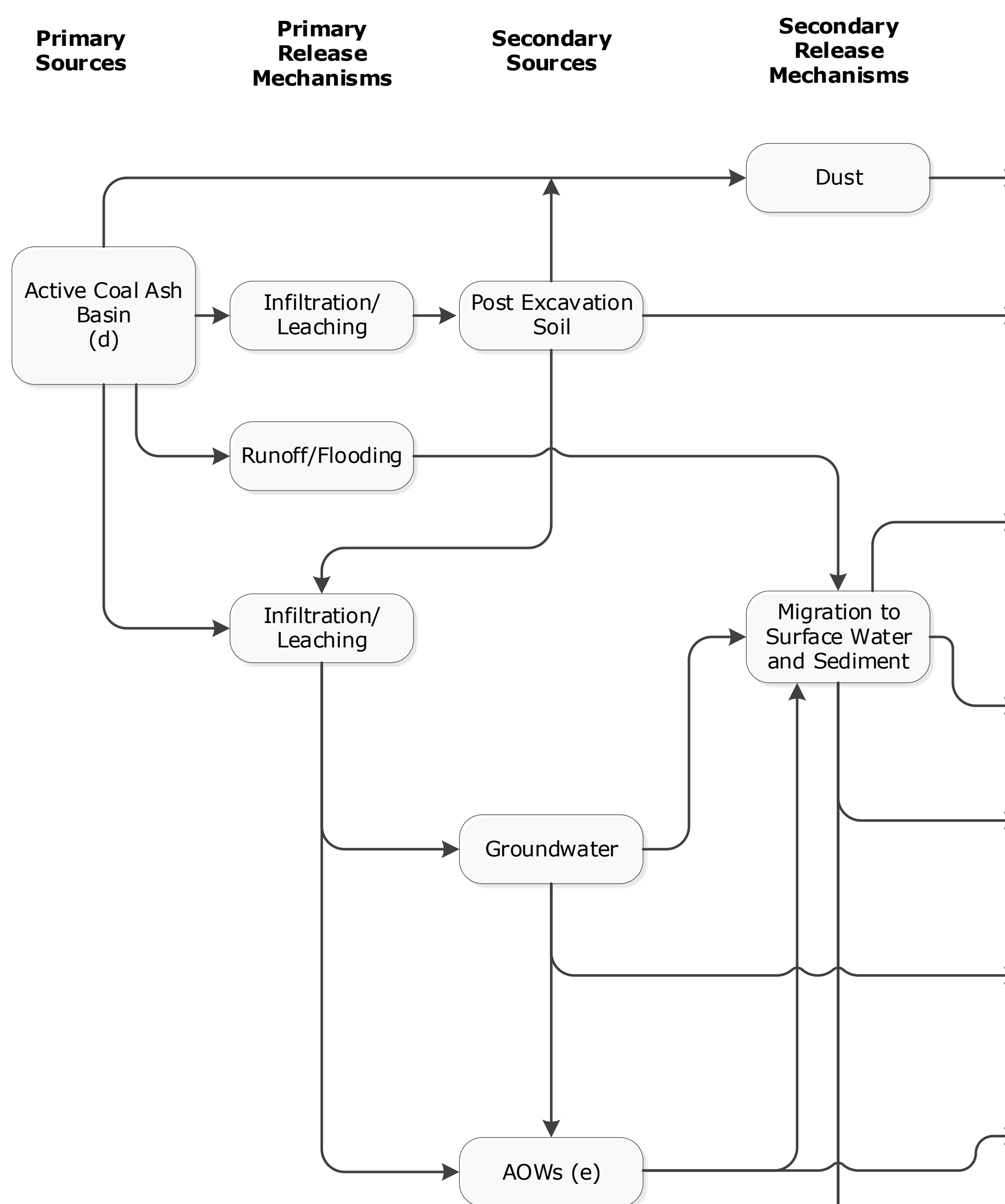
FIGURES



Potential Exposure Media	Potential Exposure Route	Current/ Future Off-Site Resident Adult/Child	Current/ Future On-Site Recreational Trespasser	Current/ Future Off-Site Recreational Swimmer	Current/ Future Off-Site Recreational Wader	Current/ Future Off-Site Recreational Boater	Current/ Future Off-Site Recreational / Subsistence Fisher	Current/ Future On-site Commercial/ Industrial Worker	Current/ Future On-Site Construction Worker
		Human Receptors							
Outdoor Air	Inhalation	O	O	O	O	O	O	O	O
Soil Remaining Post-Excavation (f)	Incidental Ingestion	O	O	O	O	O	O	O	O
	Dermal Contact	O	O	O	O	O	O	O	O
Surface Water (Off-site) (d)	Drinking Water Use (g)	O	O	O	O	O	O	O	O
	Incidental Ingestion	O	O	●(h)	●(h)	O	O	O	O
	Dermal Contact	O	O	●	●	O	●	O	O
Sediment (Off-site) (d)	Incidental Ingestion	O	O	●	●	O	O	O	O
	Dermal Contact	O	O	●	●	O	O	O	O
Fish Tissue (e)	Ingestion	O	O	O	O	O	●	O	O
Groundwater (f)	Drinking Water Use (b)	O	O	O	O	O	O	O	O
	Incidental Ingestion	O	O	O	O	O	O	O	O(i)
	Dermal Contact	O	O	O	O	O	O	O	O(i)
AOW Water (On-site)	Dermal Contact	O	O	O	O	O	O	O	O
AOW Soil (On-site)	Dermal Contact	O	O	O	O	O	O	O	O
Surface Water (On-site) (f)	Incidental Ingestion	O	O	O	O	O	O	O	O
	Dermal Contact	O	O	O	O	O	O	O	O
Sediment (On-site) (f)	Incidental Ingestion	O	O	O	O	O	O	O	O
	Dermal Contact	O	O	O	O	O	O	O	O

NOTES

● Potentially complete exposure pathway based on results of 2018 risk assessment update.

O Pathway evaluated and found incomplete/insignificant.

(a) The ash basin, closed Pine Hall Road Landfill, and the chemical pond are present onsite as part of the steam station.

(b) Areas of wetness (AOWs) are addressed in the Special Order by Consent (SOC) and not evaluated in the risk assessment update at this time.

(c) Post-excavation soils are the materials remaining beneath the ash basins after excavation. There is no potentially complete pathway from coal ash in basins to upland soils.

(d) The Dan River upstream of outfall 003 and Belews Lake along the shore east of the site.

(e) Concentration of COPC in fish tissue modeled from surface water concentration.

(f) Site-wide data are used to evaluate on-site exposure.

(g) Belews Lake is a source of public drinking water i.e., WS-IV, water is treated before use. There are no private residences located hydraullically downgradient of on-site groundwater.

(h) Incidental surface water ingestion assumed only to occur for receptors for the swimming and wading scenarios.

(i) Groundwater exposure evaluated in the risk assessment update, although an incomplete exposure pathway for construction worker.

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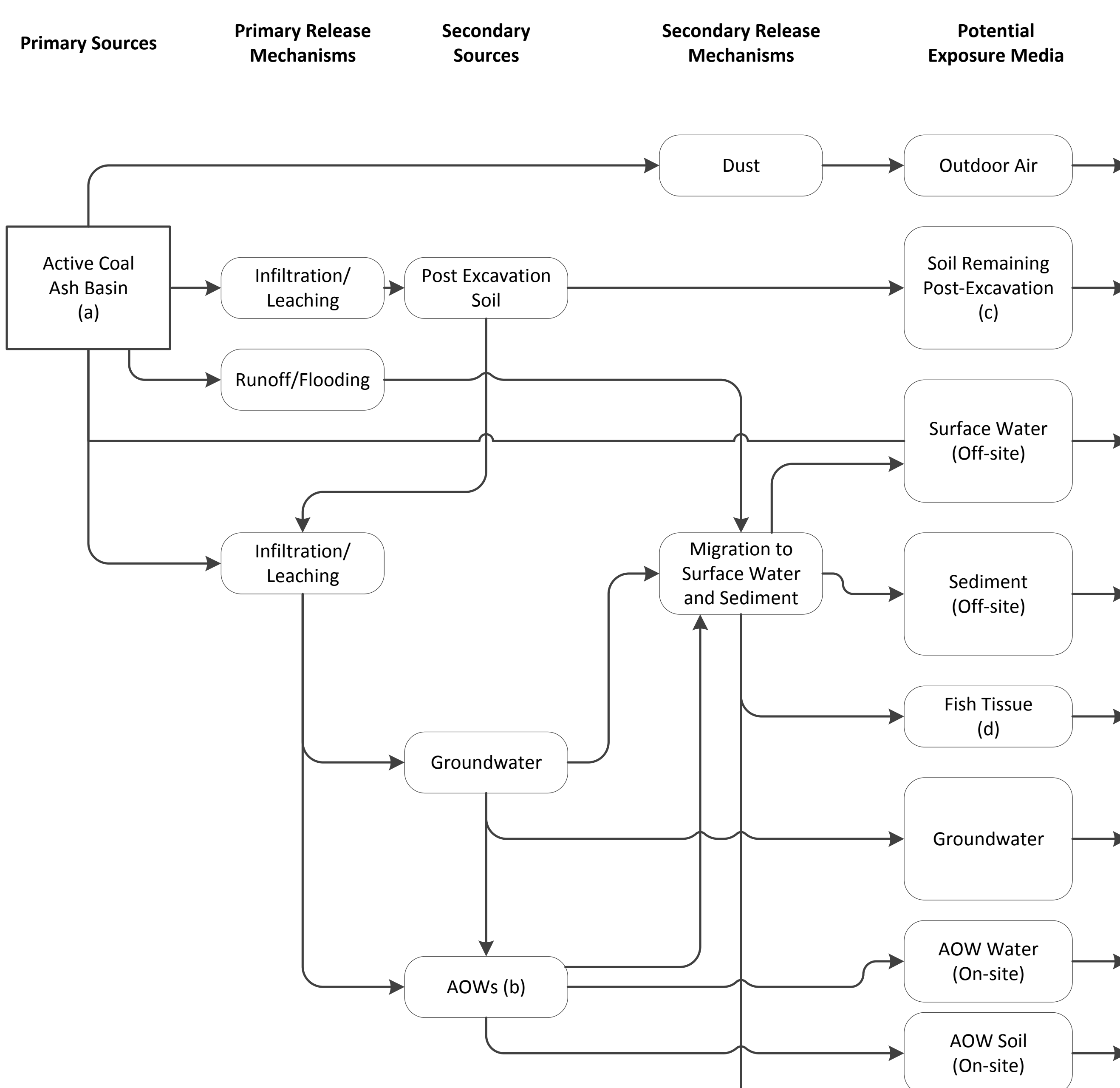
FIGURE 1
HUMAN HEALTH RISK ASSESSMENT
CONCEPTUAL SITE MODEL
BELEWS CREEK STEAM STATION
BELEWS CREEK, NORTH CAROLINA



Potential Exposure Media	Potential Exposure Route	AQUATIC RECEPTORS: Fish	AQUATIC RECEPTORS: Benthic Invertebrates	AQUATIC RECEPTORS: Avian: Mallard (Omnivore)	AQUATIC RECEPTORS: Avian: Great Blue Heron (Piscivore)	AQUATIC RECEPTORS: Mammal: Muskrat (Herbivore)	AQUATIC RECEPTORS: Mammal: River Otter (Piscivore)	TERRESTRIAL RECEPTORS (f): Avian: Robin (Omnivore)	TERRESTRIAL RECEPTORS (f): Avian: Red-Tailed Hawk (Carnivore)	TERRESTRIAL RECEPTORS (f): Mammal: Meadow Vole (Herbivore)	TERRESTRIAL RECEPTORS (f): Mammal: Red Fox (Carnivore)
Outdoor Air	Inhalation	○	○	○	○	○	○	○	○	○	○
Soil Remaining Post-Excavation (c)	Plant/Incidental Ingestion	○	○	○	○	○	○	○	○	○	○
	Direct Contact	○	○	○	○	○	○	○	○	○	○
Surface Water (Off-site)	Ingestion	○	○	○	○	○	○	○	○	○	○
	Direct Contact	●(e)	●(e)	○	○	○	○	○	○	○	○
Sediment (Off-site)	Plant/Incidental Ingestion	○	○	○	○	○	○	○	○	○	○
	Direct Contact	○	●(e)	○	○	○	○	○	○	○	○
Fish Tissue (d)	Ingestion	○	○	○	○	○	○	○	○	○	○
Groundwater	Ingestion	○	○	○	○	○	○	○	○	○	○
	Direct Contact	○	○	○	○	○	○	○	○	○	○
AOW Water (On-site)	Ingestion	○	○	○	○	○	○	○	○	○	○
AOW Soil (On-site)	Plant/Incidental Ingestion	○	○	○	○	○	○	○	○	○	○
Surface Water (On-site)	Ingestion	○	○	○	○	○	○	○	○	○	○
	Direct Contact	○	○	○	○	○	○	○	○	○	○
Sediment (On-site)	Plant/Incidental Ingestion	○	○	○	○	○	○	○	○	○	○
	Direct Contact	○	○	○	○	○	○	○	○	○	○

NOTES

- ● Potentially complete exposure pathways based on results of the 2018 risk assessment update.
- ○ Pathway evaluated and found incomplete/insignificant.
- (a) The ash basin, closed Pine Hall Road Landfill, and the chemical pond are present onsite as part of the steam station.
- (b) Areas of wetness (AOWs) are addressed in the Special Order by Consent (SOC) and not evaluated in the risk assessment update at this time.
- (c) Pathway incomplete as long as ash remains in place; re-evaluation upon excavation (if conducted) may be warranted.
- (d) Concentration of COPC in fish tissue modeled from surface water concentration.
- (e) Based on screening against aquatic life criteria.
- (f) Exposure to terrestrial receptors was not evaluated because AOWs are addressed in the SOC.

CSM reflects exposure pathways evaluated quantitatively in the risk assessment.

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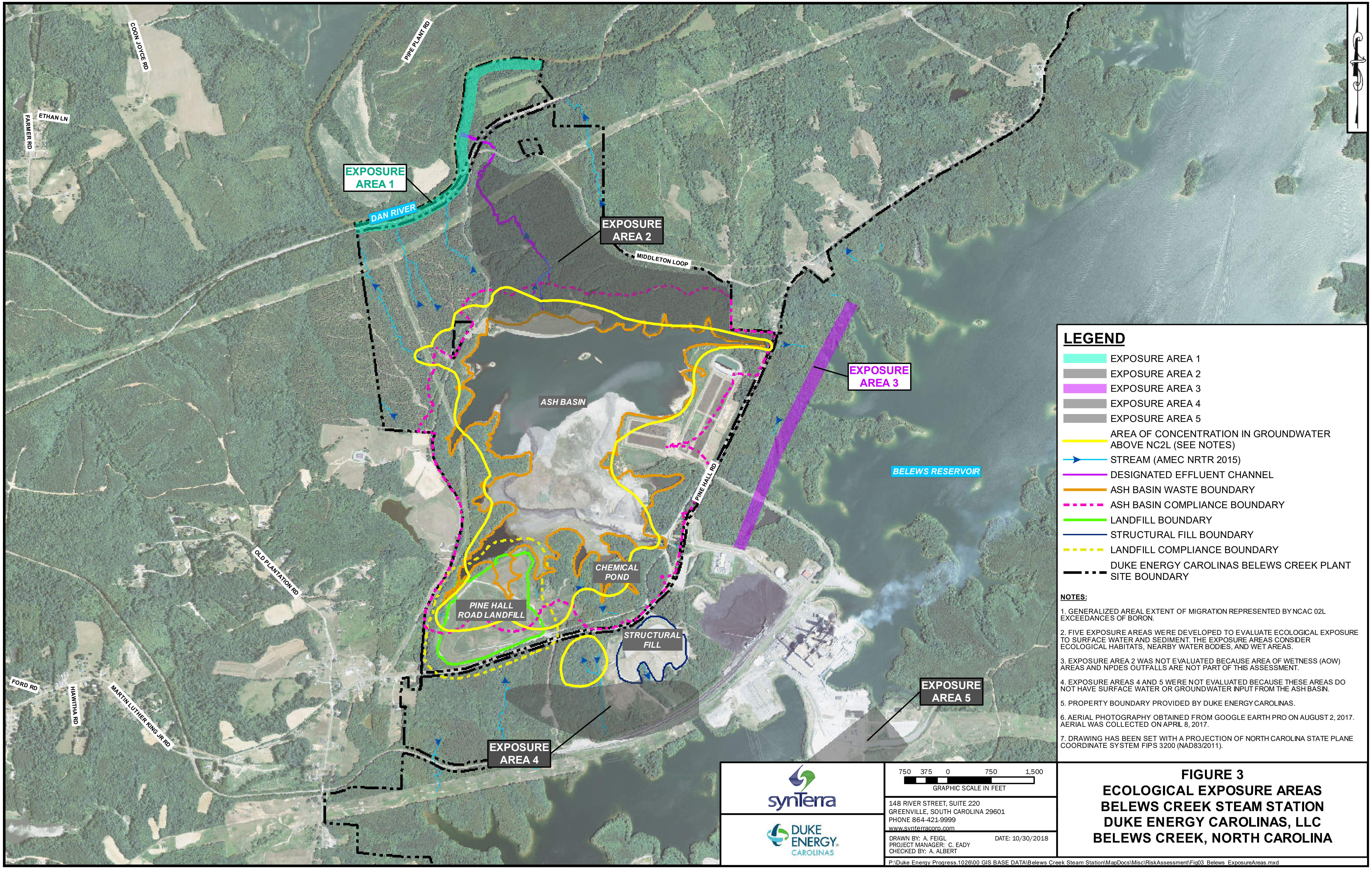
FIGURE 2
ECOLOGICAL RISK ASSESSMENT
CONCEPTUAL SITE MODEL
BELEWS CREEK STEAM STATION
BELEWS CREEK, NORTH CAROLINA



LEGEND

- EXPOSURE AREA 1
- EXPOSURE AREA 2
- EXPOSURE AREA 3
- EXPOSURE AREA 4
- EXPOSURE AREA 5
- AREA OF CONCENTRATION IN GROUNDWATER ABOVE NC2L (SEE NOTES)
- STREAM (AMEC NRTR 2015)
- DESIGNATED EFFLUENT CHANNEL
- ASH BASIN WASTE BOUNDARY
- ASH BASIN COMPLIANCE BOUNDARY
- LANDFILL BOUNDARY
- STRUCTURAL FILL BOUNDARY
- LANDFILL COMPLIANCE BOUNDARY
- DUKE ENERGY CAROLINAS BELEWS CREEK PLANT SITE BOUNDARY

NOTES:

1. GENERALIZED AREAL EXTENT OF MIGRATION REPRESENTED BY NCAC 02L EXCEEDANCES OF BORON.
2. FIVE EXPOSURE AREAS WERE DEVELOPED TO EVALUATE ECOLOGICAL EXPOSURE TO SURFACE WATER AND SEDIMENT. THE EXPOSURE AREAS CONSIDER ECOLOGICAL HABITATS, NEARBY WATER BODIES, AND WET AREAS.
3. EXPOSURE AREA 2 WAS NOT EVALUATED BECAUSE AREA OF WETNESS (AOW) AREAS AND NPDES OUTFALLS ARE NOT PART OF THIS ASSESSMENT.
4. EXPOSURE AREAS 4 AND 5 WERE NOT EVALUATED BECAUSE THESE AREAS DO NOT HAVE SURFACE WATER OR GROUNDWATER INPUT FROM THE ASH BASIN.
5. PROPERTY BOUNDARY PROVIDED BY DUKE ENERGY CAROLINAS.
6. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON AUGUST 2, 2017. AERIAL WAS COLLECTED ON APRIL 8, 2017.
7. DRAWING HAS BEEN SET WITH A PROJECTION OF NORTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3200 (NAD83/2011).

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DRAWN BY: A. FEIGL DATE: 10/30/2018
PROJECT MANAGER: C. EADY
CHECKED BY: A. ALBERT

FIGURE 3
ECOLOGICAL EXPOSURE AREAS
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC
BELEWS CREEK, NORTH CAROLINA

P:\Duke Energy Progress.1026\00 GIS BASE DATA\Belews Creek Steam Station\MapDocs\Misc\RiskAssessment\Fig03_Belews_ExposureAreas.mxd

ATTACHMENTS

TABLE 1-1
HUMAN HEALTH SCREENING - SEDIMENT - DAN RIVER
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Analyte	CAS	Number of Samples	Frequency of Detection	Range of Detection (mg/kg)		Concentration Used for Screening (mg/kg)	NC PSRG Residential Health Screening Level (hh) (mg/kg)	Residential Soil RSL (a) HI = 0.2 (mg/kg)	NC PSRG Industrial Health Screening Level (hh) (mg/kg)	Industrial Soil RSL (a) HI = 0.2 (mg/kg)	Residential Screening Value Used (mg/kg)	Industrial Screening Value Used (mg/kg)	Residential COPC?	Industrial COPC?
				Min.	Max.									
Aluminum	7429-90-5	5	5	4,050	27,000	27,000	15,000	15,400	100,000	220,000	15,000	100,000	Y	N
Antimony	7440-36-0	5	0	ND	ND	ND	6.2 (m)	6.2 (m)	94 (m)	94 (m)	6.2	94	N	N
Arsenic	7440-38-2	5	4	0.4	5.8	5.8	0.68 (h)	0.68 (h, jj)	3 (h)	3 (h, jj)	0.68	3	Y	Y
Barium	7440-39-3	5	5	34	100	100	3,000	3,000	44,000	44,000	3,000	44,000	N	N
Beryllium	7440-41-7	5	5	0.22	1.6	1.6	32	32	460	460	32	460	N	N
Boron	7440-42-8	5	0	ND	ND	ND	3,200	3,200	46,000	46,000	3,200	46,000	N	N
Cadmium	7440-43-9	5	3	0.022	0.023	0.023	14	14.2	200	196	14	200	N	N
Chromium (Total)	7440-47-3	5	5	8.4	28	28	24,000 (n)	24,000 (n)	100,000 (n)	360,000 (n)	24,000	100,000	N	N
Cobalt	7440-48-4	5	4	2.8	8.9	8.9	4.6	4.6	70	70	4.6	70	Y	N
Copper	7440-50-8	5	5	3.2	12	12	620	620	9,400	9,400	620	9,400	N	N
Lead	7439-92-1	5	4	3.1	13	13	400	400 (jj)	800	800 (jj)	400	800	N	N
Manganese	7439-96-5	5	5	90.4	190	190	360	360	5,200	5,200	360	5,200	N	N
Mercury	7439-97-6	5	1	0.01	0.01	0.01	4.6 (o)	4.6 (o)	3.1 (o)	70 (o)	4.6	3.1	N	N
Molybdenum	7439-98-7	5	0	ND	ND	ND	78	78	1,200	1,160	78	1,200	N	N
Nickel	7440-02-0	5	5	3.3	13	13	300 (p)	300 (p)	4,400 (p)	4,400 (p)	300	4,400	N	N
Selenium	7782-49-2	5	0	ND	ND	ND	78	78	1,200	1,160	78	1,200	N	N
Strontium	7440-24-6	5	5	3	8.9	8.9	9,400	9,400	100,000	140,000	9,400	100,000	N	N
Thallium	7440-28-0	5	4	0.071	0.25	0.25	0.16 (q)	0.156 (q)	2.4 (q)	2.4 (q)	0.16	2.4	Y	N
Vanadium	7440-62-2	5	5	12	51	51	78	78	1,160	1,160	78	1,160	N	N
Zinc	7440-66-6	5	5	14	43	43	4,600	4,600	70,000	70,000	4,600	70,000	N	N

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HEG Checked by: ARD

Notes:

AWQC - Ambient Water Quality Criteria
CAMA - Coal Ash Management Act
North Carolina Session Law 2014-122, http://www.ncleg.net/Sessions/2013/Bills/Senate/PDF/S729v7.pdf
CAS - Chemical Abstracts Service
CCC - Criterion Continuous Concentration
CMC - Criterion Maximum Concentration
COPC - Constituent of Potential Concern
DENR - Department of Environment and Natural Resources
DHHS - Department of Health and Human Services
ESV - Ecological Screening Value
HH - Human Health
HI - Hazard Index
IMAC - Interim Maximum Allowable Concentration
MCL - Maximum Contaminant Level
mg/kg - milligrams/kilogram
NA - Not Available
NC - North Carolina
NCAC - North Carolina Administrative Code
ORNL - Oak Ridge National Laboratory
PSRG - Preliminary Soil Remediation Goal
Q - Qualifier
RSL - Regional Screening Level
RSV - Refinement Screening Value
SMCL - Secondary Maximum Contaminant Level
SSL - Soil Screening Level
su - Standard units
µg/L - micrograms/liter
USEPA - United States Environmental Protection Agency
WS - Water Supply
< - Concentration not detected at or above the reporting limit
j - Indicates concentration reported below Practical Quantitation Limit (PQL) but above Method Detection Limit (MDL) and therefore concentration is estimated

(a) - USEPA Regional Screening Levels (May 2018). Values for Residential Soil, Industrial Soil, and Tap Water. HI = 0.2. Accessed October 2018.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed October 2018.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.

(c) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. March 2018. Accessed October 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf

(d) - DHHS Screening Levels. Department of Health and Human Services, Division of Public Health, Epidemiology Section, Occupational and Environmental Epidemiology Branch. http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=24814087&name=DLFE-112704.pdf

(e) - North Carolina 15A NCAC 02L .0202 Groundwater Standards & IMACs. http://portal.ncdenr.org/c/document_library/get_file?uuid=1aa3fa13-2c0f-45b7-ae96-5427fb1d25b4&groupId=38364
Amended April 2013.

(f) - North Carolina 15A NCAC 02B Surface Water and Wetland Standards. Amended January 1, 2015.
http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/subchapter%20b%20rules.pdf
WS standards are applicable to all Water Supply Classifications. WS standards are based on the consumption of fish and water.
Human Health Standards are based on the consumption of fish only unless dermal contact studies are available.
For Class C, use the most stringent of freshwater (or, if applicable, saltwater) column and the Human Health column.
For a WS water, use the most stringent of Freshwater, WS and Human Health. Likewise, Trout Waters and High Quality Waters must adhere to the most stingent of all applicable standards.

(g) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018 Update.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf

(h) - Value applies to inorganic form of arsenic only.

(i) - Value is the Secondary Maximum Contaminant Level.
https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals

TABLE 1-1
HUMAN HEALTH SCREENING - SEDIMENT - DAN RIVER
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

(j) - Value for Total Chromium.
(k) - Copper Treatment Technology Action Level is 1.3 mg/L.
(l) - Lead Treatment Technology Action Level is 0.015 mg/L.
(m) - RSL for Antimony (metallic) used for Antimony.
(n) - Value for Chromium (III), Insoluble Salts used for Chromium.
(o) - RSL for Mercuric Chloride used for Mercury.
(p) - RSL for Nickel Soluble Salts used for Nickel.
(q) - RSL for Thallium (Soluble Salts) used for Thallium.
(r) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(s) - Value for Inorganic Mercury.
(t) - Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.
(u) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(v) - Chloride Action Level for Toxic Substances Applicable to NPDES Permits is 230,000 µg/L.
(w) - Applicable only to persons with a sodium restrictive diet.
(x) - Los Alamos National Laboratory ECORISK Database. http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php
(y) - Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. Used effects range low (ER-L) for chronic and effects range medium (ER-M) for acute.
(z) - MacDonald, D.D.; Ingersoll, C.G.; Smorong, D.E.; Lindskoog, R.A.; Sloane, G.; and T. Bernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters. Florida Department of Environmental Protection, Tallahassee, FL. Used threshold effect concentration (TEC) for the ESV and probable effect concentration (PEC) for the RSV.
(aa) - Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario.
(bb) - Los Alamos National Laboratory ECORISK Database. September 2017. http://www.lanl.gov/environment/protection/eco-risk-assessment.php (µg/kg dw)
(cc) - Great Lakes Initiative (GLI) Clearinghouse resources Tier II criteria revised 2013. http://www.epa.gov/gliclearinghouse/
(dd) - Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2. http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf
(ee) - USEPA. Interim Ecological Soil Screening Level Documents. Accessed October 2018. http://www2.epa.gov/chemical-research/interim-ecological-soil-screening-level-documents
(ff) - Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf)
(gg) - Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf)
(hh) - North Carolina Preliminary Soil Remediation Goals (PSRG) Table. HI = 0.2. September 2015. http://portal.ncdenr.org/c/document_library/get_file?uuid=0f601ffa-574d-4479-bbb4-253af0665bf5&groupId=38361
(ii) - As part of the water quality evaluation conducted under the CSA, pH was measured and is reported as a metric data set. The pH comparison criteria are included as ranges as opposed to single screening values. pH is not typically included as part of a risk assessment based on potential toxic effects, therefore; pH was not investigated further as a category 1 COPC. Water quality relative to pH will be addressed as a component of water quality monitoring programs for the site.
(jj) - Hazard Index = 0.1

TABLE 1-2
HUMAN HEALTH SCREENING - SEDIMENT - BELEWS LAKE
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Analyte	CAS	Number of Samples	Frequency of Detection	Range of Detection (mg/kg)		Concentration Used for Screening (mg/kg)	NC PSRG Residential Health Screening Level (hh) (mg/kg)	Residential Soil RSL (a) HI = 0.2 June 2015 (mg/kg)	NC PSRG Industrial Health Screening Level (hh) (mg/kg)	Industrial Soil RSL (a) HI = 0.2 June 2015 (mg/kg)	Residential Screening Value Used (mg/kg)	Industrial Screening Value Used (mg/kg)	Residential COPC?	Industrial COPC?
				Min.	Max.									
Aluminum	7429-90-5	13	13	3,010	28,000	28,000	15,000	15,400	100,000	220,000	15,000	100,000	Y	N
Antimony	7440-36-0	13	4	0.16	0.5	0.5	6.2 (m)	6.2 (m)	94 (m)	94 (m)	6.2	94	N	N
Arsenic	7440-38-2	13	11	0.37	12	12	0.68 (h)	0.68 (h,jj	3 (h)	3 (h,jj)	0.68	3	Y	Y
Barium	7440-39-3	13	13	19.3	175	175	3,000	3,000	44,000	44,000	3,000	44,000	N	N
Beryllium	7440-41-7	13	11	0.22	3.5	3.5	32	32	460	460	32	460	N	N
Boron	7440-42-8	13	2	2.5	3.1	3.1	3,200	3,200	46,000	46,000	3,200	46,000	N	N
Cadmium	7440-43-9	13	7	0.014	0.081	0.081	14	14.2	200	196	14	200	N	N
Chromium (Total)	7440-47-3	13	13	2.2	29	29	24,000 (n)	24,000 (n)	100,000 (n)	360,000 (n)	24,000	100,000	N	N
Cobalt	7440-48-4	13	9	1.4	19.3	19.3	4.6	4.6	70	70	4.6	70	Y	N
Copper	7440-50-8	13	13	3.4	35.7	35.7	620	620	9,400	9,400	620	9,400	N	N
Lead	7439-92-1	13	12	3.1	14.3	14.3	400	400 (jj)	800	800 (jj)	400	800	N	N
Manganese	7439-96-5	13	13	24	670	670	360	360	5,200	5,200	360	5,200	Y	N
Mercury	7439-97-6	13	4	0.0075	0.066	0.066	4.6 (o)	4.6 (o)	3.1 (o)	70 (o)	4.6	3.1	N	N
Molybdenum	7439-98-7	13	3	0.62	5.1	5.1	78	78	1,200	1,160	78	1,200	N	N
Nickel	7440-02-0	13	13	1.1	17.4	17.4	300 (p)	300 (p)	4,400 (p)	4,400 (p)	300	4,400	N	N
Selenium	7782-49-2	13	4	0.49	6.1	6.1	78	78	1,200	1,160	78	1,200	N	N
Strontium	7440-24-6	13	13	2.2	21.1	21.1	9,400	9,400	100,000	140,000	9,400	100,000	N	N
Thallium	7440-28-0	13	7	0.077	0.28	0.28	0.16 (q)	0.156 (q)	2.4 (q)	2.4 (q)	0.16	2.4	Y	N
Vanadium	7440-62-2	13	13	8.5	80	80	78	78	1,160	1,160	78	1,160	Y	N
Zinc	7440-66-6	13	13	8.1	76.4	76.4	4,600	4,600	70,000	70,000	4,600	70,000	N	N

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HEG Checked by: ARD

Notes:

AWQC - Ambient Water Quality Criteria
CAMA - Coal Ash Management Act
North Carolina Session Law 2014-122, http://www.ncleg.net/Sessions/2013/Bills/Senate/PDF/S729v7.pdf
CAS - Chemical Abstracts Service
CCC - Criterion Continuous Concentration
CMC - Criterion Maximum Concentration
COPC - Constituent of Potential Concern
DENR - Department of Environment and Natural Resources
DHHS - Department of Health and Human Services
ESV - Ecological Screening Value
HH - Human Health
HI - Hazard Index
IMAC - Interim Maximum Allowable Concentration
MCL - Maximum Contaminant Level
mg/kg - milligrams/kilogram
NA - Not Available
NC - North Carolina
NCAC - North Carolina Administrative Code
ORNL - Oak Ridge National Laboratory
PSRG - Preliminary Soil Remediation Goal
Q - Qualifier
RSL - Regional Screening Level
RSV - Refinement Screening Value
SMCL - Secondary Maximum Contaminant Level
SSL - Soil Screening Level
su - Standard units
µg/L - micrograms/liter
USEPA - United States Environmental Protection Agency
WS - Water Supply
< - Concentration not detected at or above the reporting limit
j - Indicates concentration reported below Practical Quantitation Limit (PQL) but above Method Detection Limit (MDL) and therefore concentration is estimated

(a) - USEPA Regional Screening Levels (May 2018). Values for Residential Soil, Industrial Soil, and Tap Water. HI = 0.2. Accessed October 2018.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed October 2018.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(c) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. March 2018. Accessed October 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
(d) - DHHS Screening Levels. Department of Health and Human Services, Division of Public Health, Epidemiology Section, Occupational and Environmental Epidemiology Branch. http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=24814087&name=DLFE-112704.pdf
(e) - North Carolina 15A NCAC 02L .0202 Groundwater Standards & IMACs. http://portal.ncdenr.org/c/document_library/get_file?uuid=1aa3fa13-2c0f-45b7-ae96-5427fb1d25b4&groupId=38364
Amended April 2013.
(f) - North Carolina 15A NCAC 02B Surface Water and Wetland Standards. Amended January 1, 2015.
http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/subchapter%20b%20rules.pdf
WS standards are applicable to all Water Supply Classifications. WS standards are based on the consumption of fish and water.
Human Health Standards are based on the consumption of fish only unless dermal contact studies are available.
For Class C, use the most stringent of freshwater (or, if applicable, saltwater) column and the Human Health column.
For a WS water, use the most stringent of Freshwater, WS and Human Health. Likewise, Trout Waters and High Quality Waters must adhere to the most stingent of all applicable standards.
(g) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018 Update.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(h) - Value applies to inorganic form of arsenic only.
(i) - Value is the Secondary Maximum Contaminant Level.
https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals
(j) - Value for Total Chromium.
(k) - Copper Treatment Technology Action Level is 1.3 mg/L.
(l) - Lead Treatment Technology Action Level is 0.015 mg/L.
(m) - RSL for Antimony (metallic) used for Antimony.
(n) - Value for Chromium (III), Insoluble Salts used for Chromium.
(o) - RSL for Mercuric Chloride used for Mercury.
(p) - RSL for Nickel Soluble Salts used for Nickel.
(q) - RSL for Thallium (Soluble Salts) used for Thallium.

TABLE 1-2
HUMAN HEALTH SCREENING - SEDIMENT - BELEWS LAKE
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

(r) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(s) - Value for Inorganic Mercury.
(t) - Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.
(u) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(v) - Chloride Action Level for Toxic Substances Applicable to NPDES Permits is 230,000 µg/L.
(w) - Applicable only to persons with a sodium restrictive diet.
(x) - Los Alamos National Laboratory ECORISK Database. http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php
(y) - Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. Used effects range low (ER-L) for chronic and effects range medium (ER-M) for acute.
(z) - MacDonald, D.D.; Ingersoll, C.G.; Smorong, D.E.; Lindskoog, R.A.; Sloane, G.; and T. Bernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters. Florida Department of Environmental Protection, Tallahassee, FL. Used threshold effect concentration (TEC) for the ESV and probable effect concentration (PEC) for the RSV.
(aa) - Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario.
(bb) - Los Alamos National Laboratory ECORISK Database. September 2017. http://www.lanl.gov/environment/protection/eco-risk-assessment.php (µg/kg dw)
(cc) - Great Lakes Initiative (GLI) Clearinghouse resources Tier II criteria revised 2013. http://www.epa.gov/gliclearinghouse/
(dd) - Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2. http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf
(ee) - USEPA. Interim Ecological Soil Screening Level Documents. Accessed October 2018. http://www2.epa.gov/chemical-research/interim-ecological-soil-screening-level-documents
(ff) - Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf)
(gg) - Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf)
(hh) - North Carolina Preliminary Soil Remediation Goals (PSRG) Table. HI = 0.2. September 2015. http://portal.ncdenr.org/c/document_library/get_file?uuid=0f601ffa-574d-4479-bbb4-253af0665bf5&groupId=38361
(ii) - As part of the water quality evaluation conducted under the CSA, pH was measured and is reported as a metric data set. The pH comparison criteria are included as ranges as opposed to single screening values. pH is not typically included as part of a risk assessment based on potential toxic effects, therefore; pH was not investigated further as a category 1 COPC. Water quality relative to pH will be addressed as a component of water quality monitoring programs for the site.
(jj) - Hazard Index = 0.1

TABLE 1-3
HUMAN HEALTH SCREENING - SURFACE WATER - DAN RIVER
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Analyte	CAS	Number of Samples	Frequency of Detection	Range of Detection (µg/L)		Concentration Used for Screening (µg/L)	15A NCAC 02L .0202 Standard (e) (µg/L)	15A NCAC 02L .0202 IMAC (e) (µg/L)	15A NCAC 02B Water Supply (WS) (f) (µg/L)	15A NCAC 02B Human Health (HH) (f) (µg/L)	USEPA AWQC Consumption of Water and Organism (b) (µg/L)	USEPA AWQC Consumption of Organism Only (b) (µg/L)	Federal MCL/ SMCL (c) (µg/L)	Tap Water RSL HI = 0.2 (a) (µg/L)	Screening Value Used (µg/L)	COPC?
				Min.	Max.											
Aluminum	7429-90-5	38	38	50.4	5,100	5,100	NA	NA	NA	NA	NA	NA	50 to 200 (i)	4,000	50	Y
Antimony	7440-36-0	39	1	0.6	0.6	0.6	1	NA	NA	NA	5.6	640	6	1.56 (m)	1	N
Arsenic	7440-38-2	39	14	0.13	2.5	2.5	10	NA	10	10	0.018 (h)	0.14 (h)	10	0.052 (h, jj)	10	N
Barium	7440-39-3	39	39	17.7	135	135	700	NA	1,000	NA	1,000	NA	2,000	760	700	N
Beryllium	7440-41-7	39	8	0.011	0.28	0.28	NA	4	NA	NA	NA	NA	4	5	4	N
Boron	7440-42-8	39	11	26	12,400	12,400	700	NA	NA	NA	NA	NA	NA	800	700	Y
Cadmium	7440-43-9	39	1	0.25	0.25	0.25	2	NA	NA	NA	NA	NA	5	1.84	2	N
Chromium (Total)	7440-47-3	38	27	0.2	6.76	6.76	10	NA	NA	NA	NA	NA	100	4,400 (n)	10	N
Chromium (VI)	18540-29-9	35	30	0.028	0.63	0.63	NA	NA	NA	NA	NA	NA	NA	0.035 (jj)	0.035	Y
Cobalt	7440-48-4	39	19	0.1	7.8	7.8	NA	1	NA	NA	NA	NA	NA	1.2	1	Y
Copper	7440-50-8	39	30	0.57	5	5	1,000	NA	NA	NA	1,300	NA	1,300 (k)	160	1,000	N
Lead	7439-92-1	39	26	0.12	4.16	4.16	15	NA	NA	NA	NA	NA	15 (l)	15 (jj)	15	N
Lithium	7439-93-2	2	2	0.68	0.76	0.76	NA	NA	NA	NA	NA	NA	NA	8	8	N
Manganese	7439-96-5	39	39	24.1	1,660	1,660	50	NA	200	NA	50	100	50 (i)	86	50	Y
Mercury	7439-97-6	39	38	9.27E-04	0.0127	0.0127	1	NA	NA	NA	NA	NA	2	1.14 (o)	1	N
Molybdenum	7439-98-7	39	11	0.1	38.4	38.4	NA	NA	NA	NA	NA	NA	NA	20	20	Y
Nickel	7440-02-0	38	15	0.42	10.9	10.9	100	NA	25	NA	610	4,600	NA	78 (p)	100	N
Selenium	7782-49-2	39	4	0.35	8.3	8.3	20	NA	NA	NA	170	4,200	50	20	20	N
Strontium	7440-24-6	39	39	29	885	885	NA	NA	NA	NA	NA	NA	NA	2,400	2,400	N
Thallium	7440-28-0	39	5	0.029	1.1	1.1	0.2	NA	NA	NA	0.24	0.47	2	0.04 (q)	0.2	Y
Vanadium	7440-62-2	39	39	0.31	12.4	12.4	NA	NA	NA	NA	NA	NA	NA	17.2	17	N
Zinc	7440-66-6	39	22	3.9	219	219	1	NA	NA	NA	7,400	26,000	5,000 (i)	1,200	1	Y

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted.

Prepared by: HEG Checked by: HES

Notes:

AWQC - Ambient Water Quality Criteria
CAMA - Coal Ash Management Act
North Carolina Session Law 2014-122,
http://www.ncleg.net/Sessions/2013/Bills/Senate/PDF/S729v7.pdf
CAS - Chemical Abstracts Service
CCC - Criterion Continuous Concentration
CMC - Criterion Maximum Concentration
COPC - Constituent of Potential Concern

DENR - Department of Environment and Natural Resources
DHHS - Department of Health and Human Services
ESV - Ecological Screening Value
HH - Human Health
HI - Hazard Index
IMAC - Interim Maximum Allowable Concentration
MCL - Maximum Contaminant Level
mg/kg - milligrams/kilogram

NA - Not Available
NC - North Carolina
NCAC - North Carolina Administrative Code
ORNL - Oak Ridge National Laboratory
PSRG - Preliminary Soil Remediation Goal
Q - Qualifier
RSL - Regional Screening Level
RSV - Refinement Screening Value

SMCL - Secondary Maximum Contaminant Level
SSL - Soil Screening Level
su - Standard units
µg/L - micrograms/liter
USEPA - United States Environmental Protection Agency
WS - Water Supply
< - Concentration not detected at or above the reporting limit

TABLE 1-3
HUMAN HEALTH SCREENING - SURFACE WATER - DAN RIVER
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

(a) - USEPA Regional Screening Levels (May 2018). Values for Residential Soil, Industrial Soil, and Tap Water. HI = 0.2. Accessed October 2018.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed October 2018.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(c) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. March 2018. Accessed October 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
(d) - DHHS Screening Levels. Department of Health and Human Services, Division of Public Health, Epidemiology Section, Occupational and Environmental
Epidemiology Branch. http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=24814087&name=DLFE-112704.pdf
(e) - North Carolina 15A NCAC 02L .0202 Groundwater Standards & IMACs. http://portal.ncdenr.org/c/document_library/get_file?uuid=1aa3fa13-2c0f-45b7-ae96-5427fb1d25b4&groupId=38364
Amended April 2013.
(f) - North Carolina 15A NCAC 02B Surface Water and Wetland Standards. Amended January 1, 2015.
http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/subchapter%20b%20rules.pdf
WS standards are applicable to all Water Supply Classifications. WS standards are based on the consumption of fish and water.
Human Health Standards are based on the consumption of fish only unless dermal contact studies are available.
For Class C, use the most stringent of freshwater (or, if applicable, saltwater) column and the Human Health column.
For a WS water, use the most stringent of Freshwater, WS and Human Health. Likewise, Trout Waters and High Quality Waters must adhere to the most stingent of all applicable standards.
(g) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018 Update.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(h) - Value applies to inorganic form of arsenic only.
(i) - Value is the Secondary Maximum Contaminant Level.
https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals
(j) - Value for Total Chromium.
(k) - Copper Treatment Technology Action Level is 1.3 mg/L.
(l) - Lead Treatment Technology Action Level is 0.015 mg/L.
(m) - RSL for Antimony (metallic) used for Antimony.
(n) - Value for Chromium (III), Insoluble Salts used for Chromium.
(o) - RSL for Mercuric Chloride used for Mercury.
(p) - RSL for Nickel Soluble Salts used for Nickel.
(q) - RSL for Thallium (Soluble Salts) used for Thallium.
(r) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(s) - Value for Inorganic Mercury.
(t) - Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and
CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.
(u) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(v) - Chloride Action Level for Toxic Substances Applicable to NPDES Permits is 230,000 µg/L.
(w) - Applicable only to persons with a sodium restrictive diet.
(x) - Los Alamos National Laboratory ECORISK Database. http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php
(y) - Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.
NOAA Technical Memorandum NOS OMA 52. Used effects range low (ER-L) for chronic and effects range medium (ER-M) for acute.
(z) - MacDonald, D.D.; Ingersoll, C.G.; Smorong, D.E.; Lindskoog, R.A.; Sloane, G.; and T. Bernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for
Florida Inland Waters. Florida Department of Environmental Protection, Tallahassee, FL. Used threshold effect concentration (TEC) for the ESV and probable effect concentration (PEC) for the RSV.
(aa) - Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario.
(bb) - Los Alamos National Laboratory ECORISK Database. September 2017. http://www.lanl.gov/environment/protection/eco-risk-assessment.php (µg/kg dw)
(cc) - Great Lakes Initiative (GLI) Clearinghouse resources Tier II criteria revised 2013. http://www.epa.gov/gliclearinghouse/
(dd) - Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2.
http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf
(ee) - USEPA. Interim Ecological Soil Screening Level Documents. Accessed October 2018. http://www2.epa.gov/chemical-research/interim-ecological-soil-screening-level-documents
(ff) - Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf)
(gg) - Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf)
(hh) - North Carolina Preliminary Soil Remediation Goals (PSRG) Table. HI = 0.2. September 2015. http://portal.ncdenr.org/c/document_library/get_file?uuid=0f601ffa-574d-4479-bbb4-253af0665bf5&groupId=38361
(ii) - As part of the water quality evaluation conducted under the CSA, pH was measured and is reported as a metric data set. The pH comparison criteria are included as ranges as opposed to single screening values. pH is not typically included
as part of a risk assessment based on potential toxic effects, therefore; pH was not investigated further as a category 1 COPC. Water quality relative to pH will be addressed as a component of water quality monitoring programs for the site.
(jj) - Hazard Index = 0.1

TABLE 1-4
HUMAN HEALTH SCREENING - SURFACE WATER - BELEWS LAKE
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Analyte	CAS	Number of Samples	Frequency of Detection	Range of Detection (µg/L)		Concentration Used for Screening (µg/L)	15A NCAC 02L .0202 Standard (e) (µg/L)	15A NCAC 02L .0202 IMAC (e) (µg/L)	15A NCAC 02B Water Supply (WS) (f) (µg/L)	15A NCAC 02B Human Health (HH) (f) (µg/L)	USEPA AWQC Consumption of Water and Organism (b) (µg/L)	USEPA AWQC Consumption of Organism Only (b) (µg/L)	Federal MCL/ SMCL (c) (µg/L)	Tap Water RSL HI = 0.2 (a) (µg/L)	Screening Value Used (µg/L)	COPC?
				Min.	Max.											
Aluminum	7429-90-5	58	45	53	1,820	1,820	NA	NA	NA	NA	NA	NA	50 to 200 (i)	4,000	50	Y
Antimony	7440-36-0	60	5	0.1	0.14	0.14	1	NA	NA	NA	5.6	640	6	1.56 (m)	1	N
Arsenic	7440-38-2	60	26	0.19	1.07	1.07	10	NA	10	10	0.018 (h)	0.14 (h)	10	0.052 (h,jj)	10	N
Barium	7440-39-3	60	60	13.9	75	75	700	NA	1,000	NA	1,000	NA	2,000	760	700	N
Beryllium	7440-41-7	60	11	0.014	0.11	0.11	NA	4	NA	NA	NA	NA	4	5	4	N
Boron	7440-42-8	60	55	25.4	144	144	700	NA	NA	NA	NA	NA	NA	800	700	N
Cadmium	7440-43-9	60	1	0.126	0.126	0.126	2	NA	NA	NA	NA	NA	5	1.84	2	N
Chromium (Total)	7440-47-3	58	19	0.097	1.55	1.55	10	NA	NA	NA	NA	NA	100	4,400 (n)	10	N
Chromium (VI)	18540-29-9	54	23	0.025	0.18	0.18	NA	NA	NA	NA	NA	NA	NA	0.035 (jj)	0.035	Y
Cobalt	7440-48-4	60	19	0.01	0.19	0.19	NA	1	NA	NA	NA	NA	NA	1.2	1	N
Copper	7440-50-8	60	50	0.3	5.5	5.5	1,000	NA	NA	NA	1,300	NA	1,300 (k)	160	1,000	N
Lead	7439-92-1	60	12	0.037	0.49	0.49	15	NA	NA	NA	NA	NA	15 (l)	15 (jj)	15	N
Lithium	7439-93-2	5	2	0.3	0.35	0.35	NA	NA	NA	NA	NA	NA	NA	8	8	N
Manganese	7439-96-5	60	60	5.1	145	145	50	NA	200	NA	50	100	50 (i)	86	50	Y
Mercury	7439-97-6	60	54	3.21E-04	0.00275	0.00275	1	NA	NA	NA	NA	NA	2	1.14 (o)	1	N
Molybdenum	7439-98-7	60	51	1.05	2.34	2.34	NA	NA	NA	NA	NA	NA	NA	20	20	N
Nickel	7440-02-0	58	7	0.17	1	1	100	NA	25	NA	610	4,600	NA	78 (p)	100	N
Selenium	7782-49-2	60	18	0.25	0.63	0.63	20	NA	NA	NA	170	4,200	50	20	20	N
Strontium	7440-24-6	60	60	28	90	90	NA	NA	NA	NA	NA	NA	NA	2,400	2,400	N
Thallium	7440-28-0	60	12	0.016	0.051	0.051	0.2	NA	NA	NA	0.24	0.47	2	0.04 (q)	0.2	N
Vanadium	7440-62-2	60	59	0.32	3.85	3.85	NA	NA	NA	NA	NA	NA	NA	17.2	17	N
Zinc	7440-66-6	60	8	3.8	23.8	23.8	1	NA	NA	NA	7,400	26,000	5,000 (i)	1,200	1	Y

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted.

Prepared by: HEG Checked by: HES

Notes:

AWQC - Ambient Water Quality Criteria
CAMA - Coal Ash Management Act
North Carolina Session Law 2014-122,
http://www.ncleg.net/Sessions/2013/Bills/Senate/PDF/S729v7.pdf
CAS - Chemical Abstracts Service
CCC - Criterion Continuous Concentration
CMC - Criterion Maximum Concentration
COPC - Constituent of Potential Concern
DENR - Department of Environment and Natural Resources
DHHS - Department of Health and Human Services
ESV - Ecological Screening Value
HH - Human Health
HI - Hazard Index
IMAC - Interim Maximum Allowable Concentration
MCL - Maximum Contaminant Level
mg/kg - milligrams/kilogram
NA - Not Available
NC - North Carolina
NCAC - North Carolina Administrative Code
ORNL - Oak Ridge National Laboratory
PSRG - Preliminary Soil Remediation Goal
Q - Qualifier
RSL - Regional Screening Level
RSV - Refinement Screening Value
SMCL - Secondary Maximum Contaminant Level
SSL - Soil Screening Level
su - Standard units
µg/L - micrograms/liter
USEPA - United States Environmental Protection Agency
WS - Water Supply
< - Concentration not detected at or above the reporting limit

TABLE 1-4
HUMAN HEALTH SCREENING - SURFACE WATER - BELEWS LAKE
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

(a) - USEPA Regional Screening Levels (May 2018). Values for Residential Soil, Industrial Soil, and Tap Water. HI = 0.2. Accessed October 2018.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed October 2018.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(c) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. March 2018. Accessed October 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
(d) - DHHS Screening Levels. Department of Health and Human Services, Division of Public Health, Epidemiology Section, Occupational and Environmental
Epidemiology Branch. http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=24814087&name=DLFE-112704.pdf
(e) - North Carolina 15A NCAC 02L .0202 Groundwater Standards & IMACs. http://portal.ncdenr.org/c/document_library/get_file?uuid=1aa3fa13-2c0f-45b7-ae96-5427fb1d25b4&groupId=38364
Amended April 2013.
(f) - North Carolina 15A NCAC 02B Surface Water and Wetland Standards. Amended January 1, 2015.
http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/subchapter%20b%20rules.pdf
WS standards are applicable to all Water Supply Classifications. WS standards are based on the consumption of fish and water.
Human Health Standards are based on the consumption of fish only unless dermal contact studies are available.
For Class C, use the most stringent of freshwater (or, if applicable, saltwater) column and the Human Health column.
For a WS water, use the most stringent of Freshwater, WS and Human Health. Likewise, Trout Waters and High Quality Waters must adhere to the most stingent of all applicable standards.
(g) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018 Update.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(h) - Value applies to inorganic form of arsenic only.
(i) - Value is the Secondary Maximum Contaminant Level.
https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals
(j) - Value for Total Chromium.
(k) - Copper Treatment Technology Action Level is 1.3 mg/L.
(l) - Lead Treatment Technology Action Level is 0.015 mg/L.
(m) - RSL for Antimony (metallic) used for Antimony.
(n) - Value for Chromium (III), Insoluble Salts used for Chromium.
(o) - RSL for Mercuric Chloride used for Mercury.
(p) - RSL for Nickel Soluble Salts used for Nickel.
(q) - RSL for Thallium (Soluble Salts) used for Thallium.
(r) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(s) - Value for Inorganic Mercury.
(t) - Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and
CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.
(u) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(v) - Chloride Action Level for Toxic Substances Applicable to NPDES Permits is 230,000 µg/L.
(w) - Applicable only to persons with a sodium restrictive diet.
(x) - Los Alamos National Laboratory ECORISK Database. http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php
(y) - Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.
NOAA Technical Memorandum NOS OMA 52. Used effects range low (ER-L) for chronic and effects range medium (ER-M) for acute.
(z) - MacDonald, D.D.; Ingersoll, C.G.; Smorong, D.E.; Lindskoog, R.A.; Sloane, G.; and T. Bernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for
Florida Inland Waters. Florida Department of Environmental Protection, Tallahassee, FL. Used threshold effect concentration (TEC) for the ESV and probable effect concentration (PEC) for the RSV.
(aa) - Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario.
(bb) - Los Alamos National Laboratory ECORISK Database. September 2017. http://www.lanl.gov/environment/protection/eco-risk-assessment.php (µg/kg dw)
(cc) - Great Lakes Initiative (GLI) Clearinghouse resources Tier II criteria revised 2013. http://www.epa.gov/gliclearinghouse/
(dd) - Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2.
http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf
(ee) - USEPA. Interim Ecological Soil Screening Level Documents. Accessed October 2018. http://www2.epa.gov/chemical-research/interim-ecological-soil-screening-level-documents
(ff) - Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf)
(gg) - Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf)
(hh) - North Carolina Preliminary Soil Remediation Goals (PSRG) Table. HI = 0.2. September 2015. http://portal.ncdenr.org/c/document_library/get_file?uuid=0f601ffa-574d-4479-bbb4-253af0665bf5&groupId=38361
(ii) - As part of the water quality evaluation conducted under the CSA, pH was measured and is reported as a metric data set. The pH comparison criteria are included as ranges as opposed to single screening values. pH is not typically included
as part of a risk assessment based on potential toxic effects, therefore; pH was not investigated further as a category 1 COPC. Water quality relative to pH will be addressed as a component of water quality monitoring programs for the site.
(jj) - Hazard Index = 0.1

TABLE 1-5
HUMAN HEALTH SCREENING - GROUNDWATER
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Analyte	CAS	Number of Samples	Frequency of Detection	Range of Detection (µg/L)		Concentration Used for Screening (µg/L)	15A NCAC 02L .0202 Standard (e) (µg/L)	15A NCAC 02L .0202 IMAC (e) (µg/L)	DHHS Screening Level (d) (µg/L)	Federal MCL/ SMCL (c) (µg/L)	Tap Water RSL HI = 0.2 (a) (µg/L)	Screening Value Used (µg/L)	COPC?
				Min.	Max.								
Aluminum	7429-90-5	869	655	11	11,700	11,700	NA	NA	3,500	50 to 200 (i)	4,000	3,500	Y
Antimony	7440-36-0	1,153	428	0.095	10.1	10.1	1	NA	1	6	1.56 (m)	1	Y
Arsenic	7440-38-2	1,189	976	0.041	134	134	10	NA	10	10	0.052 (h,jj)	10	Y
Barium	7440-39-3	1,198	1,116	2.5	1,510	1,510	700	NA	700	2,000	760	700	Y
Beryllium	7440-41-7	1,053	726	0.01	13.9	13.9	NA	4	4	4	5	4	Y
Boron	7440-42-8	1,200	559	25	18,100	18,100	700	NA	700	NA	800	700	Y
Cadmium	7440-43-9	1,189	425	0.021	3.8	3.8	2	NA	2	5	1.84	2	Y
Chromium (Total)	7440-47-3	1,175	955	0.098	289	289	10	NA	10	100	4,400 (n)	10	Y
Chromium (VI)	18540-29-9	712	571	0.0088	96	96	NA	NA	0.07	NA	0.035 (jj)	0.07	Y
Cobalt	7440-48-4	1,053	979	0.01	413	413	NA	1	1	NA	1.2	1	Y
Copper	7440-50-8	996	722	0.12	215	215	1,000	NA	1,000	1,300 (k)	160	1,000	N
Lead	7439-92-1	1,189	626	0.022	11.8	11.8	15	NA	15	15 (l)	15 (jj)	15	N
Lithium	7439-93-2	412	408	0.37	322	322	NA	NA	NA	NA	8	8	Y
Manganese	7439-96-5	1,005	916	2.6	21,300	21,300	50	NA	200	50 (i)	86	50	Y
Mercury	7439-97-6	1,198	146	0.05	0.79	0.79	1	NA	1	2	1.14 (o)	1	N
Molybdenum	7439-98-7	1,053	730	0.065	56.1	56.1	NA	NA	18	NA	20	18	Y
Nickel	7440-02-0	982	748	0.16	139	139	100	NA	100	NA	78 (p)	100	Y
Selenium	7782-49-2	1,189	353	0.14	79	79	20	NA	20	50	20	20	Y
Strontium	7440-24-6	862	855	2.5	15,900	15,900	NA	NA	2,100	NA	2,400	2,100	Y
Thallium	7440-28-0	1,153	518	0.015	3.9	3.9	0.2	NA	0.2	2	0.04 (q)	0.2	Y
Vanadium	7440-62-2	853	723	0.064	47.2	47.2	NA	NA	0.3	NA	17.2	0.3	Y
Zinc	7440-66-6	1,005	700	0.0033	583	583	1	NA	1	5,000 (i)	1,200	1	Y

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HEG Checked by: ARD

Notes:

AWQC - Ambient Water Quality Criteria
CAMA - Coal Ash Management Act
North Carolina Session Law 2014-122,
http://www.ncleg.net/Sessions/2013/Bills/Senate/PDF/S729v7.pdf
CAS - Chemical Abstracts Service
CCC - Criterion Continuous Concentration
CMC - Criterion Maximum Concentration
COPC - Constituent of Potential Concern
DENR - Department of Environment and Natural Resources
DHHS - Department of Health and Human Services
ESV - Ecological Screening Value
HH - Human Health
HI - Hazard Index
IMAC - Interim Maximum Allowable Concentration
MCL - Maximum Contaminant Level
mg/kg - milligrams/kilogram
NA - Not Available
NC - North Carolina
NCAC - North Carolina Administrative Code
ORNL - Oak Ridge National Laboratory
PSRG - Preliminary Soil Remediation Goal
Q - Qualifier
RSL - Regional Screening Level
RSV - Refinement Screening Value
SMCL - Secondary Maximum Contaminant Level
SSL - Soil Screening Level
su - Standard units
µg/L - micrograms/liter
USEPA - United States Environmental Protection Agency
WS - Water Supply
< - Concentration not detected at or above the reporting limit
j - Indicates concentration reported below Practical Quantitation Limit (PQL) but above Method Detection Limit (MDL) and therefore concentration is estimated

TABLE 1-5
HUMAN HEALTH SCREENING - GROUNDWATER
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

(a) - USEPA Regional Screening Levels (May 2018). Values for Residential Soil, Industrial Soil, and Tap Water. HI = 0.2. Accessed October 2018.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed October 2018.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.

(c) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. March 2018. Accessed October 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf

(d) - DHHS Screening Levels. Department of Health and Human Services, Division of Public Health, Epidemiology Section, Occupational and Environmental Epidemiology Branch. http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=24814087&name=DLFE-112704.pdf

(e) - North Carolina 15A NCAC 02L .0202 Groundwater Standards & IMACs. http://portal.ncdenr.org/c/document_library/get_file?uuid=1aa3fa13-2c0f-45b7-ae96-5427fb1d25b4&groupId=38364
Amended April 2013.

(f) - North Carolina 15A NCAC 02B Surface Water and Wetland Standards. Amended January 1, 2015.
http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/subchapter%20b%20rules.pdf
WS standards are applicable to all Water Supply Classifications. WS standards are based on the consumption of fish and water.
Human Health Standards are based on the consumption of fish only unless dermal contact studies are available.
For Class C, use the most stringent of freshwater (or, if applicable, saltwater) column and the Human Health column.
For a WS water, use the most stringent of Freshwater, WS and Human Health. Likewise, Trout Waters and High Quality Waters must adhere to the most stingent of all applicable standards.

(g) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018 Update.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf

(h) - Value applies to inorganic form of arsenic only.

(i) - Value is the Secondary Maximum Contaminant Level.
https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals

(j) - Value for Total Chromium.

(k) - Copper Treatment Technology Action Level is 1.3 mg/L.

(l) - Lead Treatment Technology Action Level is 0.015 mg/L.

(m) - RSL for Antimony (metallic) used for Antimony.

(n) - Value for Chromium (III), Insoluble Salts used for Chromium.

(o) - RSL for Mercuric Chloride used for Mercury.

(p) - RSL for Nickel Soluble Salts used for Nickel.

(q) - RSL for Thallium (Soluble Salts) used for Thallium.

(r) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.

(s) - Value for Inorganic Mercury.

(t) - Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µ/gL and 12.82 µ/gL, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.

(u) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.

(v) - Chloride Action Level for Toxic Substances Applicable to NPDES Permits is 230,000 µ/gL.

(w) - Applicable only to persons with a sodium restrictive diet.

(x) - Los Alamos National Laboratory ECORISK Database. http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php

(y) - Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.
NOAA Technical Memorandum NOS OMA 52. Used effects range low (ER-L) for chronic and effects range medium (ER-M) for acute.

(z) - MacDonald, D.D.; Ingersoll, C.G.; Smorong, D.E.; Lindskoog, R.A.; Sloane, G.; and T. Bernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters. Florida Department of Environmental Protection, Tallahassee, FL. Used threshold effect concentration (TEC) for the ESV and probable effect concentration (PEC) for the RSV.

(aa) - Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario.

(bb) - Los Alamos National Laboratory ECORISK Database. September 2017. http://www.lanl.gov/environment/protection/eco-risk-assessment.php (µg/kg dw)

(cc) - Great Lakes Initiative (GLI) Clearinghouse resources Tier II criteria revised 2013. http://www.epa.gov/gliclearinghouse/

(dd) - Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2.
http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf

(ee) - USEPA. Interim Ecological Soil Screening Level Documents. Accessed October 2018. http://www2.epa.gov/chemical-research/interim-ecological-soil-screening-level-documents

(ff) - Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf)

(gg) - Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf)

(hh) - North Carolina Preliminary Soil Remediation Goals (PSRG) Table. HI = 0.2. September 2015. http://portal.ncdenr.org/c/document_library/get_file?uuid=0f601ffa-574d-4479-bbb4-253af0665bf5&groupId=38361

(ii) - As part of the water quality evaluation conducted under the CSA, pH was measured and is reported as a metric data set. The pH comparison criteria are included as ranges as opposed to single screening values. pH is not typically included as part of a risk assessment based on potential toxic effects, therefore; pH was not investigated further as a category 1 COPC. Water quality relative to pH will be addressed as a component of water quality monitoring programs for the site.

(jj) - Hazard Index = 0.1

TABLE 2-1
ECOLOGICAL SCREENING - SEDIMENT - DAN RIVER - EXPOSURE AREA 1
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Analyte	CAS	Number of Samples	Frequency of Detection	Range of Detection (mg/kg)		Concentration Used for Screening (mg/kg)	USEPA Region 4 Sediment Screening Values (g) (mg/kg)				Screening Value Used (mg/kg)	COPC?
				Min.	Max.		ESV		RSV			
Aluminum	7429-90-5	5	5	4,050	27,000	27,000	25,000	(x)	58,000	(x)	25,000	Y
Antimony	7440-36-0	5	0	ND	ND	ND	2	(y)	25	(y)	2	N
Arsenic	7440-38-2	5	4	0.4	5.8	5.8	9.8	(z)	33	(z)	9.8	N
Barium	7440-39-3	5	5	34	100	100	20	(z)	60	(z)	20	Y
Beryllium	7440-41-7	5	5	0.22	1.6	1.6	NA		NA		NA	N
Boron	7440-42-8	5	0	ND	ND	ND	NA		NA		NA	N
Cadmium	7440-43-9	5	3	0.022	0.023	0.023	1	(z)	5	(z)	1	N
Chromium (Total)	7440-47-3	5	5	8.4	28	28	43.4	(z)	111	(z)	43.4	N
Chromium (III)	16065-83-1	1	1	8.4	8.4	8.4	NA		NA		NA	N
Cobalt	7440-48-4	5	4	2.8	8.9	8.9	50	(aa)	NA	(aa)	50	N
Copper	7440-50-8	5	5	3.2	12	12	31.6	(z)	149	(z)	31.6	N
Lead	7439-92-1	5	4	3.1	13	13	35.8	(z)	128	(z)	35.8	N
Manganese	7439-96-5	5	5	90.4	190	190	460	(bb)	1,100	(bb)	460	N
Mercury	7439-97-6	5	1	0.01	0.01	0.01	0.18	(z)	1.1	(z)	0.18	N
Molybdenum	7439-98-7	5	0	ND	ND	ND	NA		NA		NA	N
Nickel	7440-02-0	5	5	3.3	13	13	22.7	(z)	48.6	(z)	22.7	N
Selenium	7782-49-2	5	0	ND	ND	ND	0.8	(bb)	1.2	(bb)	0.8	N
Strontium	7440-24-6	5	5	3	8.9	8.9	NA		NA		NA	N
Thallium	7440-28-0	5	4	0.071	0.25	0.25	NA		NA		NA	N
Vanadium	7440-62-2	5	5	12	51	51	NA		NA		NA	N
Zinc	7440-66-6	5	5	14	43	43	121	(z)	459	(z)	121	N

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HES Checked by: HEG

Notes:

AWQC - Ambient Water Quality Criteria
CAMA - Coal Ash Management Act
North Carolina Session Law 2014-122, http://www.ncleg.net/Sessions/2013/Bills/Senate/PDF/S729v7.pdf
CAS - Chemical Abstracts Service
CCC - Criterion Continuous Concentration
CMC - Criterion Maximum Concentration
COPC - Constituent of Potential Concern
DENR - Department of Environment and Natural Resources
DHHS - Department of Health and Human Services
ESV - Ecological Screening Value
HH - Human Health
HI - Hazard Index
IMAC - Interim Maximum Allowable Concentration
MCL - Maximum Contaminant Level
mg/kg - milligrams/kilogram
NA - Not Available
NC - North Carolina
NCAC - North Carolina Administrative Code
ORNL - Oak Ridge National Laboratory
PSRG - Preliminary Soil Remediation Goal
Q - Qualifier
RSL - Regional Screening Level
RSV - Refinement Screening Value
SMCL - Secondary Maximum Contaminant Level
SSL - Soil Screening Level
su - Standard units
µg/L - micrograms/liter
USEPA - United States Environmental Protection Agency
WS - Water Supply
< - Concentration not detected at or above the reporting limit
j - Indicates concentration reported below Practical Quantitation Limit (PQL) but above Method Detection Limit (MDL) and therefore concentration is estimated

TABLE 2-1
ECOLOGICAL SCREENING - SEDIMENT - DAN RIVER - EXPOSURE AREA 1
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

(a) - USEPA Regional Screening Levels (May 2018). Values for Residential Soil, Industrial Soil, and Tap Water. HI = 0.2. Accessed October 2018.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed October 2018.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(c) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. March 2018. Accessed October 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
(d) - DHHS Screening Levels. Department of Health and Human Services, Division of Public Health, Epidemiology Section, Occupational and Environmental Epidemiology Branch. http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=24814087&name=DLFE-112704.pdf
(e) - North Carolina 15A NCAC 02L .0202 Groundwater Standards & IMACs. http://portal.ncdenr.org/c/document_library/get_file?uuid=1aa3fa13-2c0f-45b7-ae96-5427fb1d25b4&groupId=38364
Amended April 2013.
(f) - North Carolina 15A NCAC 02B Surface Water and Wetland Standards. Amended January 1, 2015.
http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/subchapter%20b%20rules.pdf
WS standards are applicable to all Water Supply Classifications. WS standards are based on the consumption of fish and water.
Human Health Standards are based on the consumption of fish only unless dermal contact studies are available.
For Class C, use the most stringent of freshwater (or, if applicable, saltwater) column and the Human Health column.
For a WS water, use the most stringent of Freshwater, WS and Human Health. Likewise, Trout Waters and High Quality Waters must adhere to the most stingent of all applicable standards.
(g) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018 Update.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(h) - Value applies to inorganic form of arsenic only.
(i) - Value is the Secondary Maximum Contaminant Level.
https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals
(j) - Value for Total Chromium.
(k) - Copper Treatment Technology Action Level is 1.3 mg/L.
(l) - Lead Treatment Technology Action Level is 0.015 mg/L.
(m) - RSL for Antimony (metallic) used for Antimony.
(n) - Value for Chromium (III), Insoluble Salts used for Chromium.
(o) - RSL for Mercuric Chloride used for Mercury.
(p) - RSL for Nickel Soluble Salts used for Nickel.
(q) - RSL for Thallium (Soluble Salts) used for Thallium.
(r) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(s) - Value for Inorganic Mercury.
(t) - Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.
(u) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(v) - Chloride Action Level for Toxic Substances Applicable to NPDES Permits is 230,000 µg/L.
(w) - Applicable only to persons with a sodium restrictive diet.
(x) - Los Alamos National Laboratory ECORISK Database. http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php
(y) - Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. Used effects range low (ER-L) for chronic and effects range medium (ER-M) for acute.
(z) - MacDonald, D.D.; Ingersoll, C.G.; Smorong, D.E.; Lindskoog, R.A.; Sloane, G.; and T. Bernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters. Florida Department of Environmental Protection, Tallahassee, FL. Used threshold effect concentration (TEC) for the ESV and probable effect concentration (PEC) for the RSV.
(aa) - Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario.
(bb) - Los Alamos National Laboratory ECORISK Database. September 2017. http://www.lanl.gov/environment/protection/eco-risk-assessment.php (µg/kg dw)
(cc) - Great Lakes Initiative (GLI) Clearinghouse resources Tier II criteria revised 2013. http://www.epa.gov/gliclearinghouse/
(dd) - Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2.
http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf
(ee) - USEPA. Interim Ecological Soil Screening Level Documents. Accessed October 2018. http://www2.epa.gov/chemical-research/interim-ecological-soil-screening-level-documents
(ff) - Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf)
(gg) - Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf)
(hh) - North Carolina Preliminary Soil Remediation Goals (PSRG) Table. HI = 0.2. September 2015. http://portal.ncdenr.org/c/document_library/get_file?uuid=0f601ffa-574d-4479-bbb4-253af0665bf5&groupId=38361
(ii) - As part of the water quality evaluation conducted under the CSA, pH was measured and is reported as a metric data set. The pH comparison criteria are included as ranges as opposed to single screening values. pH is not typically included as part of a risk assessment based on potential toxic effects, therefore; pH was not investigated further as a category 1 COPC. Water quality relative to pH will be addressed as a component of water quality monitoring programs for the site.

TABLE 2-2
ECOLOGICAL SCREENING - SURFACE WATER - DAN RIVER - EXPOSURE AREA 1
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Analyte	CAS	Number of Samples	Frequency of Detection	Range of Detection (µg/L)		Concentration Used for Screening (µg/L)	15A NCAC 2B Freshwater Aquatic Life Acute (f) (µg/L)		15A NCAC 2B Freshwater Aquatic Life Chronic (f) (µg/L)		USEPA Region 4 Freshwater Acute Screening Values (g) (µg/L)		USEPA Region 4 Freshwater Chronic Screening Values (g) (µg/L)		USEPA AWQC (b) CMC (acute) (µg/L)		USEPA AWQC (b) CCC (chronic) (µg/L)		Screening Value Used (µg/L)	COPC?
				Min.	Max.		Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved		
Aluminum	7429-90-5	38	38	50.4	5,100	5,100	NA	NA	NA	NA	750 (b)	NA	87 (b)	NA	750	NA	87	NA	87	Y
Antimony	7440-36-0	39	1	0.6	0.6	0.6	NA	NA	NA	NA	900 (cc)	NA	190 (cc)	NA	NA	NA	NA	NA	190	N
Arsenic	7440-38-2	39	14	0.13	2.5	2.5	NA	340	NA	150	340 (b, h)	NA	150 (b, h)	NA	340 (h)	NA	150 (h)	NA	150	N
Barium	7440-39-3	39	39	17.7	135	135	NA	NA	NA	NA	2000 (cc)	NA	220 (cc)	NA	NA	NA	NA	NA	220	N
Beryllium	7440-41-7	39	8	0.011	0.28	0.28	NA	65	NA	6.5	31 (r, cc)	NA	3.6 (r, cc)	NA	NA	NA	NA	NA	4	N
Boron	7440-42-8	39	11	26	12,400	12,400	NA	NA	NA	NA	34,000 (cc)	NA	7,200 (cc)	NA	NA	NA	NA	NA	7200	Y
Cadmium	7440-43-9	39	1	0.25	0.25	0.25	NA	NA	NA	NA	1.1 (r)	NA	0.16 (r)	NA	NA	1.8 (r)	0.27 (r)	NA	0.16	Y
Chromium (Total)	7440-47-3	39	28	0.2	6.76	6.76	NA	NA	50	NA	1,022 (n, r)	NA	48.8 (n, r)	NA	NA	NA	NA	NA	50	N
Chromium (VI)	18540-29-9	37	31	0.028	0.63	0.63	NA	16	NA	11	16	NA	11	NA	NA	16	NA	11	11	N
Cobalt	7440-48-4	39	19	0.1	7.8	7.8	NA	NA	NA	NA	120 (cc)	NA	19 (cc)	NA	NA	NA	NA	NA	19	N
Copper	7440-50-8	39	30	0.57	5	5	NA	NA	NA	NA	7.3 (r)	NA	5.16 (r)	NA	NA	NA	NA	NA	5.16	N
Lead	7439-92-1	39	26	0.12	4.16	4.16	NA	NA	NA	NA	33.8 (r)	NA	1.32 (r)	NA	NA	65.0 (r)	NA	2.5 (r)	1	Y
Lithium	7439-93-2	2	2	0.68	0.76	0.76	NA	NA	NA	NA	910 (cc)	NA	440 (cc)	NA	NA	NA	NA	NA	440	N
Manganese	7439-96-5	39	39	24.1	1,660	1,660	NA	NA	NA	NA	1,680 (cc)	NA	93 (cc)	NA	NA	NA	NA	NA	93	Y
Mercury	7439-97-6	39	38	0.00093	0.0127	0.0127	NA	NA	0.012	NA	1.4 (b, s)	NA	0.77 (b, s)	NA	NA	1.4 (s)	NA	0.77 (s)	0.012	Y
Molybdenum	7439-98-7	39	11	0.1	38.4	38.4	NA	NA	NA	NA	7,200 (cc)	NA	800 (cc)	NA	NA	NA	NA	NA	800	N
Nickel	7440-02-0	39	16	0.41	10.9	10.9	NA	NA	NA	NA	261 (r)	NA	29 (r)	NA	NA	470 (r)	NA	52 (r)	29	N
Selenium	7782-49-2	39	4	0.35	8.3	8.3	NA	NA	5	NA	20 (cc)	NA	5 (cc)	NA	NA	NA	NA	NA	5	Y
Strontium	7440-24-6	39	39	29	885	885	NA	NA	NA	NA	48,000 (cc)	NA	5,300 (cc)	NA	NA	NA	NA	NA	5300	N
Thallium	7440-28-0	39	5	0.029	1.1	1.1	NA	NA	NA	NA	54 (cc)	NA	6 (cc)	NA	NA	NA	NA	NA	6	N
Vanadium	7440-62-2	39	39	0.31	12.4	12.4	NA	NA	NA	NA	79 (cc)	NA	27 (cc)	NA	NA	NA	NA	NA	27	N
Zinc	7440-66-6	39	22	3.9	219	219	NA	NA	NA	NA	67 (r)	NA	67 (r)	NA	120 (r)	NA	120 (r)	NA	67	Y

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HES Checked by: HEG

Notes:

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BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC - Constituent of Potential Concern NA - Not Available

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(e) - North Carolina 15A NCAC 02L .0202 Groundwater Standards & IMACs. http://portal.ncdenr.org/c/document_library/get_file?uuid=1aa3fa13-2c0f-45b7-ae96-5427fb1d25b4&groupId=38364
Amended April 2013.
(f) - North Carolina 15A NCAC 02B Surface Water and Wetland Standards. Amended January 1, 2015.
http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/subchapter%20b%20rules.pdf
WS standards are applicable to all Water Supply Classifications. WS standards are based on the consumption of fish and water.
Human Health Standards are based on the consumption of fish only unless dermal contact studies are available.
For Class C, use the most stringent of freshwater (or, if applicable, saltwater) column and the Human Health column.
For a WS water, use the most stringent of Freshwater, WS and Human Health. Likewise, Trout Waters and High Quality Waters must adhere to the most stingent of all applicable standards.
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https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(h) - Value applies to inorganic form of arsenic only.
(i) - Value is the Secondary Maximum Contaminant Level.
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(j) - Value for Total Chromium.
(k) - Copper Treatment Technology Action Level is 1.3 mg/L.
(l) - Lead Treatment Technology Action Level is 0.015 mg/L.
(m) - RSL for Antimony (metallic) used for Antimony.
(n) - Value for Chromium (III), Insoluble Salts used for Chromium.
(o) - RSL for Mercuric Chloride used for Mercury.
(p) - RSL for Nickel Soluble Salts used for Nickel.
(q) - RSL for Thallium (Soluble Salts) used for Thallium.
(r) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(s) - Value for Inorganic Mercury.
(t) - Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.
(u) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(v) - Chloride Action Level for Toxic Substances Applicable to NPDES Permits is 230,000 µg/L.
(w) - Applicable only to persons with a sodium restrictive diet.
(x) - Los Alamos National Laboratory ECORISK Database. http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php
(y) - Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. Used effects range low (ER-L) for chronic and effects range medium (ER-M) for acute.
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(aa) - Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario.
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(ff) - Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf)
(gg) - Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf)
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TABLE 2-3
ECOLOGICAL SCREENING - SEDIMENT - BELEWS LAKE - EXPOSURE AREA 3
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Analyte	CAS	Number of Samples	Frequency of Detection	Range of Detection (mg/kg)		Concentration Used for Screening (mg/kg)	USEPA Region 4 Sediment Screening Values (g) (mg/kg)				Screening Value Used (mg/kg)	COPC?
				Min.	Max.		ESV		RSV			
Aluminum	7429-90-5	7	7	3,010	19,000	19,000	25,000	(x)	58,000	(x)	25000	N
Antimony	7440-36-0	7	3	0.16	0.5	0.5	2	(y)	25	(y)	2	N
Arsenic	7440-38-2	7	5	0.37	12	12	9.8	(z)	33	(z)	10	Y
Barium	7440-39-3	7	7	19.3	46	46	20	(z)	60	(z)	20	Y
Beryllium	7440-41-7	7	5	0.22	3.5	3.5	NA		NA		NA	N
Boron	7440-42-8	7	0	ND	ND	ND	NA		NA		NA	N
Cadmium	7440-43-9	7	5	0.014	0.081	0.081	1	(z)	5	(z)	1	N
Chromium (Total)	7440-47-3	7	7	2.2	16	16	43.4	(z)	111	(z)	43	N
Chromium (III)	16065-83-1	2	2	2.2	5.2	5.2	NA		NA		NA	N
Cobalt	7440-48-4	7	3	1.4	14	14	50	(aa)	NA	(aa)	50	N
Copper	7440-50-8	7	7	3.4	11	11	31.6	(z)	149	(z)	31.6	N
Lead	7439-92-1	7	6	3.1	12	12	35.8	(z)	128	(z)	35.8	N
Manganese	7439-96-5	7	7	24	90	90	460	(bb)	1,100	(bb)	460	N
Mercury	7439-97-6	7	1	0.0075	0.0075	0.0075	0.18	(z)	1.1	(z)	0.18	N
Molybdenum	7439-98-7	7	0	ND	ND	ND	NA		NA		NA	N
Nickel	7440-02-0	7	7	1.1	6	6	22.7	(z)	48.6	(z)	22.7	N
Selenium	7782-49-2	7	1	0.49	0.49	0.49	0.8	(bb)	1.2	(bb)	0.8	N
Strontium	7440-24-6	7	7	2.2	9.1	9.1	NA		NA		NA	N
Thallium	7440-28-0	7	5	0.077	0.26	0.26	NA		NA		NA	N
Vanadium	7440-62-2	7	7	8.5	62	62	NA		NA		NA	N
Zinc	7440-66-6	7	7	8.1	35	35	121	(z)	459	(z)	121	N

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: TCP Checked by: HES

Notes:

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TABLE 2-3
ECOLOGICAL SCREENING - SEDIMENT - BELEWS LAKE - EXPOSURE AREA 3
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

(a) - USEPA Regional Screening Levels (May 2018). Values for Residential Soil, Industrial Soil, and Tap Water. HI = 0.2. Accessed October 2018.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed October 2018.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(c) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. March 2018. Accessed October 2018.
https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
(d) - DHHS Screening Levels. Department of Health and Human Services, Division of Public Health, Epidemiology Section, Occupational and Environmental
Epidemiology Branch. http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=24814087&name=DLFE-112704.pdf
(e) - North Carolina 15A NCAC 02L .0202 Groundwater Standards & IMACs. http://portal.ncdenr.org/c/document_library/get_file?uuid=1aa3fa13-2c0f-45b7-ae96-5427fb1d25b4&groupId=38364
Amended April 2013.
(f) - North Carolina 15A NCAC 02B Surface Water and Wetland Standards. Amended January 1, 2015.
http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/subchapter%20b%20rules.pdf
WS standards are applicable to all Water Supply Classifications. WS standards are based on the consumption of fish and water.
Human Health Standards are based on the consumption of fish only unless dermal contact studies are available.
For Class C, use the most stringent of freshwater (or, if applicable, saltwater) column and the Human Health column.
For a WS water, use the most stringent of Freshwater, WS and Human Health. Likewise, Trout Waters and High Quality Waters must adhere to the most stingent of all applicable standards.
(g) - USEPA Region 4. 2018. Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018 Update.
https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(h) - Value applies to inorganic form of arsenic only.
(i) - Value is the Secondary Maximum Contaminant Level.
https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals
(j) - Value for Total Chromium.
(k) - Copper Treatment Technology Action Level is 1.3 mg/L.
(l) - Lead Treatment Technology Action Level is 0.015 mg/L.
(m) - RSL for Antimony (metallic) used for Antimony.
(n) - Value for Chromium (III), Insoluble Salts used for Chromium.
(o) - RSL for Mercuric Chloride used for Mercury.
(p) - RSL for Nickel Soluble Salts used for Nickel.
(q) - RSL for Thallium (Soluble Salts) used for Thallium.
(r) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(s) - Value for Inorganic Mercury.
(t) - Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and
CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.
(u) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(v) - Chloride Action Level for Toxic Substances Applicable to NPDES Permits is 230,000 µg/L.
(w) - Applicable only to persons with a sodium restrictive diet.
(x) - Los Alamos National Laboratory ECORISK Database. http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php
(y) - Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.
NOAA Technical Memorandum NOS OMA 52. Used effects range low (ER-L) for chronic and effects range medium (ER-M) for acute.
(z) - MacDonald, D.D.; Ingersoll, C.G.; Smorong, D.E.; Lindskoog, R.A.; Sloane, G.; and T. Bernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for
Florida Inland Waters. Florida Department of Environmental Protection, Tallahassee, FL. Used threshold effect concentration (TEC) for the ESV and probable effect concentration (PEC) for the RSV.
(aa) - Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario.
(bb) - Los Alamos National Laboratory ECORISK Database. September 2017. http://www.lanl.gov/environment/protection/eco-risk-assessment.php (µg/kg dw)
(cc) - Great Lakes Initiative (GLI) Clearinghouse resources Tier II criteria revised 2013. http://www.epa.gov/gliclearinghouse/
(dd) - Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2.
http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf
(ee) - USEPA. Interim Ecological Soil Screening Level Documents. Accessed October 2018. http://www2.epa.gov/chemical-research/interim-ecological-soil-screening-level-documents
(ff) - Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf)
(gg) - Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf)

TABLE 2-4
ECOLOGICAL SCREENING - SURFACE WATER - BELEWS LAKE - EXPOSURE AREA 3
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Analyte	CAS	Number of Samples	Frequency of Detection	Range of Detection (µg/L)		Concentration Used for Screening (µg/L)	15A NCAC 2B Freshwater Aquatic Life Acute (f) (µg/L)		15A NCAC 2B Freshwater Aquatic Life Chronic (f) (µg/L)		USEPA Region 4 Freshwater Acute Screening Values (g) (µg/L)		USEPA Region 4 Freshwater Chronic Screening Values (g) (µg/L)		USEPA AWQC (b) CMC (acute) (µg/L)		USEPA AWQC (b) CCC (chronic) (µg/L)		Screening Value Used (µg/L)	COPC?
				Min.	Max.		Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved		
Aluminum	7429-90-5	38	31	53	487	487	NA	NA	NA	NA	750 (b)	NA	87 (b)	NA	750	NA	87	NA	87	Y
Antimony	7440-36-0	39	2	0.11	0.12	0.12	NA	NA	NA	NA	900 (cc)	NA	190 (cc)	NA	NA	NA	NA	NA	190	N
Arsenic	7440-38-2	39	15	0.42	1.07	1.07	NA	340	NA	150	340 (b, h)	NA	150 (b, h)	NA	340 (h)	NA	150 (h)	NA	150	N
Barium	7440-39-3	39	39	13.9	75	75	NA	NA	NA	NA	2000 (cc)	NA	220 (cc)	NA	NA	NA	NA	NA	220	N
Beryllium	7440-41-7	39	6	0.014	0.027	0.027	NA	65	NA	6.5	31 (r, cc)	NA	3.6 (r, cc)	NA	NA	NA	NA	NA	4	N
Boron	7440-42-8	39	34	49.7	144	144	NA	NA	NA	NA	34,000 (cc)	NA	7,200 (cc)	NA	NA	NA	NA	NA	7200	N
Cadmium	7440-43-9	39	1	0.126	0.126	0.126	NA	NA	NA	NA	1.1 (r)	NA	0.16 (r)	NA	NA	1.8 (r)	NA	0.72 (r)	0.16	N
Chromium (Total)	7440-47-3	39	10	0.12	0.7	0.7	NA	NA	50	NA	1,022 (n, r)	NA	48.8 (n, r)	NA	NA	NA	NA	NA	50	N
Chromium (VI)	18540-29-9	37	16	0.025	0.18	0.18	NA	16	NA	11	16	NA	11	NA	NA	16	NA	11	11	N
Cobalt	7440-48-4	39	11	0.01	0.19	0.19	NA	NA	NA	NA	120 (cc)	NA	19 (cc)	NA	NA	NA	NA	NA	19	N
Copper	7440-50-8	39	31	0.86	5.5	5.5	NA	NA	NA	NA	7.3 (r)	NA	5.16 (r)	NA	NA	NA	NA	NA	5	Y
Lead	7439-92-1	39	7	0.048	0.49	0.49	NA	NA	NA	NA	33.8 (r)	NA	1.32 (r)	NA	NA	65 (r)	NA	2.5 (r)	1	N
Lithium	7439-93-2	4	2	0.3	0.35	0.35	NA	NA	NA	NA	910 (cc)	NA	440 (cc)	NA	NA	NA	NA	NA	440	N
Manganese	7439-96-5	39	39	5.1	145	145	NA	NA	NA	NA	1,680 (cc)	NA	93 (cc)	NA	NA	NA	NA	NA	93	Y
Mercury	7439-97-6	39	35	4.09E-04	0.00275	0.00275	NA	NA	0.012	NA	1.4 (b, s)	NA	0.77 (b, s)	NA	NA	1.4 (s)	NA	0.77 (s)	0.01	N
Molybdenum	7439-98-7	39	32	1.05	2.34	2.34	NA	NA	NA	NA	7,200 (cc)	NA	800 (cc)	NA	NA	NA	NA	NA	800	N
Nickel	7440-02-0	39	5	0.17	0.48	0.48	NA	NA	NA	NA	261 (r)	NA	29 (r)	NA	NA	470 (r)	NA	52.0 (r)	29	N
Selenium	7782-49-2	39	9	0.25	0.43	0.43	NA	NA	5	NA	20 (cc)	NA	5 (cc)	NA	NA	NA	NA	NA	5	N
Strontium	7440-24-6	39	39	50	90	90	NA	NA	NA	NA	48,000 (cc)	NA	5,300 (cc)	NA	NA	NA	NA	NA	5300	N
Thallium	7440-28-0	39	7	0.016	0.048	0.048	NA	NA	NA	NA	54 (cc)	NA	6 (cc)	NA	NA	NA	NA	NA	6	N
Vanadium	7440-62-2	39	38	0.32	1.29	1.29	NA	NA	NA	NA	79 (cc)	NA	27 (cc)	NA	NA	NA	NA	NA	27	N
Zinc	7440-66-6	39	4	3.8	20.5	20.5	NA	NA	NA	NA	67 (r)	NA	67 (r)	NA	120 (r)	NA	120 (r)	NA	67	N

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: TCP Checked by: HES

Notes:
AWQC - Ambient Water Quality Criteria
CAMA - Coal Ash Management Act
North Carolina Session Law 2014-122, http://www.ncleg.net/Sessions/2013/Bills/Senate/PDF/S729v7.pdf
CAS - Chemical Abstracts Service
CCC - Criterion Continuous Concentration
CMC - Criterion Maximum Concentration
DENR - Department of Environment and Natural Resources
DHHS - Department of Health and Human Services
ESV - Ecological Screening Value
HH - Human Health
HI - Hazard Index
IMAC - Interim Maximum Allowable Concentration
MCL - Maximum Contaminant Level
mg/kg - milligrams/kilogram
NC - North Carolina
NCAC - North Carolina Administrative Code
ORNL - Oak Ridge National Laboratory
PSRG - Preliminary Soil Remediation Goal
Q - Qualifier
RSL - Regional Screening Level
RSV - Refinement Screening Value
SMCL - Secondary Maximum Contaminant Level
su - Standard units
µg/L - micrograms/liter
USEPA - United States Environmental Protection Agency
WS - Water Supply
< - Concentration not detected at or above the reporting limit
j - Indicates concentration reported below Practical Quantitation Limit (PQL) but above Method Detection Limit (MDL) and therefore concentration is estimated

TABLE 2-4
ECOLOGICAL SCREENING - SURFACE WATER - BELEWS LAKE - EXPOSURE AREA 3
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC - Constituent of Potential Concern   NA - Not Available   SSL - Soil Screening Level

(a) - USEPA Regional Screening Levels (May 2018). Values for Residential Soil, Industrial Soil, and Tap Water. HI = 0.2. Accessed October 2018.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed October 2018.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table
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https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf
(d) - DHHS Screening Levels. Department of Health and Human Services, Division of Public Health, Epidemiology Section, Occupational and Environmental
Epidemiology Branch. http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=24814087&name=DLFE-112704.pdf
(e) - North Carolina 15A NCAC 02L .0202 Groundwater Standards & IMACs. http://portal.ncdenr.org/c/document_library/get_file?uuid=1aa3fa13-2c0f-45b7-ae96-5427fb1d25b4&groupId=38364
Amended April 2013.
(f) - North Carolina 15A NCAC 02B Surface Water and Wetland Standards. Amended January 1, 2015.
http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/subchapter%20b%20rules.pdf
WS standards are applicable to all Water Supply Classifications. WS standards are based on the consumption of fish and water.
Human Health Standards are based on the consumption of fish only unless dermal contact studies are available.
For Class C, use the most stringent of freshwater (or, if applicable, saltwater) column and the Human Health column.
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https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf
(h) - Value applies to inorganic form of arsenic only.
(i) - Value is the Secondary Maximum Contaminant Level.
https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals
(j) - Value for Total Chromium.
(k) - Copper Treatment Technology Action Level is 1.3 mg/L.
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(m) - RSL for Antimony (metallic) used for Antimony.
(n) - Value for Chromium (III), Insoluble Salts used for Chromium.
(o) - RSL for Mercuric Chloride used for Mercury.
(p) - RSL for Nickel Soluble Salts used for Nickel.
(q) - RSL for Thallium (Soluble Salts) used for Thallium.
(r) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(s) - Value for Inorganic Mercury.
(t) - Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and
CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.
(u) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of mg/L.
(v) - Chloride Action Level for Toxic Substances Applicable to NPDES Permits is 230,000 µg/L.
(w) - Applicable only to persons with a sodium restrictive diet.
(x) - Los Alamos National Laboratory ECORISK Database. http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php
(y) - Long, Edward R., and Lee G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.
NOAA Technical Memorandum NOS OMA 52. Used effects range low (ER-L) for chronic and effects range medium (ER-M) for acute.
(z) - MacDonald, D.D.; Ingersoll, C.G.; Smorong, D.E.; Lindskoog, R.A.; Sloane, G.; and T. Bernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for
Florida Inland Waters. Florida Department of Environmental Protection, Tallahassee, FL. Used threshold effect concentration (TEC) for the ESV and probable effect concentration (PEC) for the RSV.
(aa) - Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario.
(bb) - Los Alamos National Laboratory ECORISK Database. September 2017. http://www.lanl.gov/environment/protection/eco-risk-assessment.php (µg/kg dw)
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(dd) - Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2.
http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf
(ee) - USEPA. Interim Ecological Soil Screening Level Documents. Accessed October 2018. http://www2.epa.gov/chemical-research/interim-ecological-soil-screening-level-documents
(ff) - Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf)
(gg) - Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants:
1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf)
(hh) - North Carolina Preliminary Soil Remediation Goals (PSRG) Table. HI = 0.2. September 2015. http://portal.ncdenr.org/c/document_library/get_file?uuid=0f601ffa-574d-4479-bbb4-253af0665bf5&groupId=38361

TABLE 3-1
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
HUMAN HEALTH - SEDIMENT - DAN RIVER
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Constituent	Reporting Units	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean Detected Concentration	UCL Selected	UCL	Exposure Point Concentration (mg/kg)
Aluminum	mg/kg	5	5	4,050	27,000	9,850	---	---	27000
Arsenic	mg/kg	5	4	0.4	5.8	1.973	---	---	5.8
Cobalt	mg/kg	5	4	2.8	8.9	4.625	---	---	8.9
Thallium	mg/kg	5	4	0.071	0.25	0.118	---	---	0.25

Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise note

Prepared by: HEG Checked by: ARD

Notes:

---: Calculations were not performed due to lack of samples

Mean - Arithmetic mean

mg/kg - milligrams per kilogram

ND - Not Determined

UCL - 95% Upper Confidence Limit

(a)- Mean calculated by ProUCL using the Kaplan-Meier (KM) estimation method for non-detect values: only given for datasets with FOD less than 100% and that met the minimum sample size and FOD requirements for use with ProUCL; see note (b).

(b)- Sample size was greater than or equal to 10 and the number of detected values was greater than or equal to 6, therefore, a 95% UCL was calculated by ProUCL. The UCL shown is the one recommended by ProUCL. If more than one UCL was recommended, the higher UCL was selected. ProUCL, version 5.0

(c) - 0 is defined as a number of samples analyzed or the frequency of detection among samples.

(d) - The 95% UCL values are calculated using the ProUCL software (V. 5.0; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernable), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002b). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical distribution of the data set. ProUCL will calculate a 95% UCL where there are 3 or more total samples with detected concentrations. Where too few samples or detects are available, the maximum detected concentration is used as the EPC.

TABLE 3-2
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
HUMAN HEALTH - SEDIMENT - BELEWS LAKE
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Constituent	Reporting Units	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean Detected Concentration	UCL Selected	UCL	Exposure Point Concentration
Aluminum	mg/kg	13	13	3,010	28,000	14,521	95% Student's-t UCL	18,279	18279
Arsenic	mg/kg	13	11	0.37	12	3.761	95% KM Bootstrap t UCL	7.818	7.818
Cobalt	mg/kg	13	9	1.4	19.3	8.867	95% KM (t) UCL	10.78	10.78
Manganese	mg/kg	13	13	24	670	146.1	95% Adjusted Gamma UCL	266.7	266.7
Thallium	mg/kg	13	7	0.077	0.28	0.167	95% KM (t) UCL	0.22	0.22
Vanadium	mg/kg	13	13	8.5	80	39.82	95% Student's-t UCL	51.62	51.62

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HEG Checked by: ARD

Notes:

---: Calculations were not performed due to lack of samples

Mean - Arithmetic mean

mg/kg - milligrams per kilogram

ND - Not Determined

UCL - 95% Upper Confidence Limit

(a)- Mean calculated by ProUCL using the Kaplan-Meier (KM) estimation method for non-detect values: only given for datasets with FOD less than 100% and that met the minimum sample size and FOD requirements for use with ProUCL; see note (b).

(b)- Sample size was greater than or equal to 10 and the number of detected values was greater than or equal to 6, therefore, a 95% UCL was calculated by ProUCL. The UCL shown is the one recommended by ProUCL. If more than one UCL was recommended, the higher UCL was selected. ProUCL, version 5.0

(c) - 0 is defined as a number of samples analyzed or the frequency of detection among samples.

(d) - The 95% UCL values are calculated using the ProUCL software (V. 5.0; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernable), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002b). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical distribution of the data set. ProUCL will calculate a 95% UCL where there are 3 or more total samples with detected concentrations. Where too few samples or detects are available, the maximum detected concentration is used as the EPC.

TABLE 3-3
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
HUMAN HEALTH - SURFACE WATER - DAN RIVER
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Constituent	Reporting Units	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean Detected Concentration	UCL Selected	UCL	Exposure Point Concentration	Exposure Point Concentration (mg/L)
Aluminum	µg/L	38	38	50.4	5,100	1,436	95% Adjusted Gamma UCL	2,030	2030	2.03
Boron	µg/L	39	11	26	12,400	2,835	97.5% KM (Chebyshev) UCL	3,619	3619	3.619
Chromium (VI)	µg/L	35	30	0.028	0.63	0.0803	95% KM (Chebyshev) UCL	0.155	0.155	0.000155
Cobalt	µg/L	39	19	0.1	7.8	1.557	Gamma Adjusted KM UCL	1.483	1.483	0.001483
Manganese	µg/L	39	39	24.1	1,660	126.1	95% Chebyshev (Mean, Sd) UCL	314.6	314.6	0.3146
Molybdenum	µg/L	39	11	0.1	38.4	9.038	97.5% KM (Chebyshev) UCL	11.59	11.59	0.01159
Thallium	µg/L	39	5	0.029	1.1	0.522	---	---	1.1	0.0011
Zinc	µg/L	39	22	3.9	219	22.81	95% KM (Chebyshev) UCL	40.42	40.42	0.04042

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HEG Checked by: HES

Notes:

---: Calculations were not performed due to lack of samples

Mean - Arithmetic mean

mg/L - milligrams per liter

µg/L - micrograms per liter

ND - Not Determined

UCL - 95% Upper Confidence Limit

(a)- Mean calculated by ProUCL using the Kaplan-Meier (KM) estimation method for non-detect values: only given for datasets with FOD less than 100% and that met the minimum sample size and FOD requirements for use with ProUCL; see note (b).

(b)- Sample size was greater than or equal to 10 and the number of detected values was greater than or equal to 6, therefore, a 95% UCL was calculated by ProUCL. The UCL shown is the one recommended by ProUCL. If more than one UCL was recommended, the higher UCL was selected. ProUCL, version 5.0

(c) - 0 is defined as a number of samples analyzed or the frequency of detection among samples.

(d) - The 95% UCL values are calculated using the ProUCL software (V. 5.0; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernable), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002b). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical distribution of the data set. ProUCL will calculate a 95% UCL where there are 3 or more total samples with detected concentrations. Where too few samples or detects are available, the maximum detected concentration is used as the EPC.

TABLE 3-4
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
HUMAN HEALTH - SURFACE WATER - BELEWS LAKE
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Constituent	Reporting Units	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean Detected Concentration	UCL Selected	UCL	Exposure Point Concentration	Exposure Point Concentration (mg/L)
Aluminum	µg/L	58	45	53	1,820	193.1	95% KM (Chebyshev) UCL	315	315	0.315
Chromium (VI)	µg/L	54	23	0.025	0.18	0.061	KM H-UCL	0.0448	0.0448	0.0000448
Manganese	µg/L	60	60	5.1	145	26.18	95% Chebyshev (Mean, Sd) UCL	43.67	43.67	0.04367
Zinc	µg/L	60	8	3.8	23.8	10.61	95% KM (t) UCL	6.004	6.004	0.006004

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HEG Checked by: HES

Notes:

---: Calculations were not performed due to lack of samples

Mean - Arithmetic mean

mg/L - milligrams per liter

µg/L - micrograms per liter

ND - Not Determined

UCL - 95% Upper Confidence Limit

(a)- Mean calculated by ProUCL using the Kaplan-Meier (KM) estimation method for non-detect values: only given for datasets with FOD less than 100% and that met the minimum sample size and FOD requirements for use with ProUCL; see note (b).

(b)- Sample size was greater than or equal to 10 and the number of detected values was greater than or equal to 6, therefore, a 95% UCL was calculated by ProUCL. The UCL shown is the one recommended by ProUCL. If more than one UCL was recommended, the higher UCL was selected. ProUCL, version 5.0

(c) - 0 is defined as a number of samples analyzed or the frequency of detection among samples.

(d) - The 95% UCL values are calculated using the ProUCL software (V. 5.0; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernable), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002b). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical distribution of the data set. ProUCL will calculate a 95% UCL where there are 3 or more total samples with detected concentrations. Where too few samples or detects are available, the maximum detected concentration is used as the EPC.

TABLE 3-5
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
HUMAN HEALTH - GROUNDWATER
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Constituent	Reporting Units	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean of Detected Concentration	UCL Selected	UCL	Exposure Point Concentration	Exposure Point Concentration (mg/L)
Aluminum	µg/L	869	655	11	11,700	497	95% KM (Chebyshev) UCL	526.3	526.3	0.5263
Antimony	µg/L	1,153	428	0.095	10.1	0.782	95% KM (Chebyshev) UCL	0.555	0.555	0.000555
Arsenic	µg/L	1,189	976	0.041	134	4.404	95% KM (Chebyshev) UCL	5.134	5.134	0.005134
Barium	µg/L	1,198	1,116	2.5	1,510	95.07	95% KM (Chebyshev) UCL	107.9	107.9	0.1079
Beryllium	µg/L	1,053	726	0.01	13.9	1.296	95% KM (Chebyshev) UCL	1.205	1.205	0.001205
Boron	µg/L	1,200	559	25	18,100	3161	95% KM (Chebyshev) UCL	1915	1915	1.915
Cadmium	µg/L	1,189	425	0.021	3.8	0.501	95% KM (Chebyshev) UCL	0.285	0.285	0.000285
Chromium (Total)	µg/L	1,175	955	0.098	289	5.194	95% KM (Chebyshev) UCL	6.462	6.462	0.006462
Chromium (VI)	µg/L	712	571	0.0088	96	1.497	95% KM (Chebyshev) UCL	2.404	2.404	0.002404
Cobalt	µg/L	1,053	979	0.01	413	12.63	95% KM (Chebyshev) UCL	15.91	15.91	0.01591
Lithium	µg/L	412	408	0.37	322	29.93	95% KM (Chebyshev) UCL	40.22	40.22	0.04022
Manganese	µg/L	1,005	916	2.6	21,300	1002	95% KM (Chebyshev) UCL	1239	1239	1.239
Molybdenum	µg/L	1,053	730	0.065	56.1	3.484	95% KM (Chebyshev) UCL	3.217	3.217	0.003217
Nickel	µg/L	982	748	0.16	139	8.228	95% KM (Chebyshev) UCL	8.178	8.178	0.008178
Selenium	µg/L	1,189	353	0.14	79	5.848	95% KM (Chebyshev) UCL	2.811	2.811	0.002811
Strontium	µg/L	862	855	2.5	15,900	243	95% KM (Chebyshev) UCL	366.7	366.7	0.3667
Thallium	µg/L	1,153	518	0.015	3.9	0.256	95% KM (Chebyshev) UCL	0.179	0.179	0.000179
Vanadium	µg/L	853	723	0.064	47.2	1.608	95% KM (Chebyshev) UCL	1.958	1.958	0.001958
Zinc	µg/L	1,005	700	0.0033	583	19.14	95% KM (Chebyshev) UCL	18.45	18.45	0.01845

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HEG Checked by: ARD

Notes:

---: Calculations were not performed due to lack of samples

ND - Not Determined

Mean - Arithmetic mean

UCL - 95% Upper Confidence Limit

mg/L - milligrams per liter

µg/L - micrograms per liter

(a)- Mean calculated by ProUCL using the Kaplan-Meier (KM) estimation method for non-detect values: only given for datasets with FOD less than 100% and that met the minimum sample size and FOD requirements for use with ProUCL; see note (b).

(b)- Sample size was greater than or equal to 10 and the number of detected values was greater than or equal to 6, therefore, a 95% UCL was calculated by ProUCL. The UCL shown is the one recommended by ProUCL. If more than one UCL was recommended, the higher UCL was selected. ProUCL, version 5.0

(c) - 0 is defined as a number of samples analyzed or the frequency of detection among samples.

(d) - The 95% UCL values are calculated using the ProUCL software (V. 5.0; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernable), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002b). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical distribution of the data set. ProUCL will calculate a 95% UCL where there are 3 or more total samples with detected concentrations. Where too few samples or detects are available, the maximum detected concentration is used as the EPC.

TABLE 4-1
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
ECOLOGICAL - SEDIMENT - DAN RIVER - EXPOSURE AREA 1
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Constituent	Reporting Units	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean Detected Concentration	UCL Selected	UCL	Exposure Point Concentration
Aluminum	mg/kg	5	5	4,050	27,000	9,850	---	---	27000
Barium	mg/kg	5	5	34	100	52.44	---	---	100

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HES Checked by: HEG

Notes:

---: Calculations were not performed due to lack of samples

Mean - Arithmetic mean

mg/kg - milligrams per kilogram

UCL - 95% Upper Confidence Limit

(a)- Sample size was greater than or equal to 10 and the number of detected values was greater than or equal to 6, therefore, a 95% UCL was calculated by ProUCL. The UCL shown is the one recommended by ProUCL. If more than one UCL was recommended, the higher UCL was selected. ProUCL, version 5.0

(b) - 0 is defined as a number of samples analyzed or the frequency of detection among samples.

(c) - The 95% UCL values are calculated using the ProUCL software (V. 5.0; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernable), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in “Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites” (USEPA, 2002b). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical distribution of the data set. ProUCL will calculate a 95% UCL where there are 3 or more total samples with detected concentrations. Where too few samples or detects are available, the maximum detected concentration is used as the EPC.

TABLE 4-2
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
ECOLOGICAL - SURFACE WATER - DAN RIVER - EXPOSURE AREA 1
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Constituent	Reporting Units	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean Detected Concentration	UCL Selected	UCL	Exposure Point Concentration	Exposure Point Concentration (mg/L)
Aluminum	µg/L	38	38	50.4	5,100	1,436	95% Adjusted Gamma	2,030	2030	2.03
Boron	µg/L	39	11	26	12,400	2,835	97.5% KM (Chebyshev)	3,619	3619	3.619
Cadmium	µg/L	39	1	0.25	0.25	0.25	---	---	0.25	0.00025
Lead	µg/L	39	26	0.12	4.16	1.407	95% KM (t)	1.283	1.283	0.001283
Manganese	µg/L	39	39	24.1	1,660	126.1	95% Chebyshev (Mean, Sd)	314.6	314.6	0.3146
Mercury	µg/L	39	38	0.00093	0.0127	0.0039	95% GROS Adjusted Gamma	0.00504	0.00504	0.00000504
Selenium	µg/L	39	4	0.35	8.3	5.538	---	---	8.3	0.0083
Zinc	µg/L	39	22	3.9	219	22.81	95% KM (Chebyshev)	40.42	40.42	0.04042

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: HES Checked by: HEG

Notes:

---: Calculations were not performed due to lack of samples

µg/L - micrograms per liter

Mean - Arithmetic mean

UCL - 95% Upper Confidence Limit

mg/L - milligrams per liter

(a)- Sample size was greater than or equal to 10 and the number of detected values was greater than or equal to 6, therefore, a 95% UCL was calculated by ProUCL. The UCL shown is the one recommended by ProUCL. If more than one UCL was recommended, the higher UCL was selected. ProUCL, version 5.0

(b) - 0 is defined as a number of samples analyzed or the frequency of detection among samples.

(c) - The 95% UCL values are calculated using the ProUCL software (V. 5.0; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernable), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002b). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical distribution of the data set. ProUCL will calculate a 95% UCL where there are 3 or more total samples with detected concentrations. Where too few samples or detects are available, the maximum detected concentration is used as the EPC.

TABLE 4-3
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
ECOLOGICAL - SEDIMENT - BELEWS LAKE - EXPOSURE AREA 3
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Constituent	Reporting Units	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean Detected Concentration	UCL Selected	UCL	Exposure Point Concentration
Arsenic	mg/kg	7	5	0.37	12	3.694	---	---	12
Barium	mg/kg	7	7	19.3	46	29.09	---	---	46

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: TCP Checked by: HES

Notes:

---: Calculations were not performed due to lack of samples

Mean - Arithmetic mean

mg/kg - milligrams per kilogram

UCL - 95% Upper Confidence Limit

(a)- Sample size was greater than or equal to 10 and the number of detected values was greater than or equal to 6, therefore, a 95% UCL was calculated by ProUCL. The UCL shown is the one recommended by ProUCL. If more than one UCL was recommended, the higher UCL was selected. ProUCL, version 5.0

(b) - 0 is defined as a number of samples analyzed or the frequency of detection among samples.

(c) - The 95% UCL values are calculated using the ProUCL software (V. 5.0; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernable), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002b). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical distribution of the data set. ProUCL will calculate a 95% UCL where there are 3 or more total samples with detected concentrations. Where too few samples or detects are available, the maximum detected concentration is used as the EPC.

TABLE 4-4
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
ECOLOGICAL - SURFACE WATER - BELEWS LAKE - EXPOSURE AREA 3
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Constituent	Reporting Units	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Mean Detected Concentration	UCL Selected	UCL	Exposure Point Concentration	Exposure Point Concentration (mg/L)
Aluminum	µg/L	38	31	53	487	124.9	KM H-UCL	131.1	131.1	0.1311
Copper	µg/L	39	31	0.86	5.5	1.412	95% KM (BCA)	1.573	1.573	0.001573
Manganese	µg/L	39	39	5.1	145	31.26	95% Chebyshev (Mean, Sd)	56.84	56.84	0.05684

* Data evaluated includes data from 2015 to 2nd quarter 2018, unless otherwise noted

Prepared by: TCP Checked by: HES

Notes:

---: Calculations were not performed due to lack of samples

µg/L - micrograms per liter

Mean - Arithmetic mean

UCL - 95% Upper Confidence Limit

mg/L - milligrams per liter

(a)- Sample size was greater than or equal to 10 and the number of detected values was greater than or equal to 6, therefore, a 95% UCL was calculated by ProUCL. The UCL shown is the one recommended by ProUCL. If more than one UCL was recommended, the higher UCL was selected. ProUCL, version 5.0

(b) - 0 is defined as a number of samples analyzed or the frequency of detection among samples.

(c) - The 95% UCL values are calculated using the ProUCL software (V. 5.0; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernable), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002b). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical distribution of the data set. ProUCL will calculate a 95% UCL where there are 3 or more total samples with detected concentrations. Where too few samples or detects are available, the maximum detected concentration is used as the EPC.

TABLE 5-1
SUMMARY OF ON-SITE GROUNDWATER EPC/RBC COMPARISON
CONSTRUCTION - CONSTRUCTION WORKER (ADULT)
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Ash Basin-Groundwater	Risk Ratio	
		Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	9.6E+04	nc	9.6E+04	nc	0.5	0.000005	nc
Antimony	7440-36-0	1.7E+01	nc	1.7E+01	nc	0.001	0.00003	nc
Arsenic	7440-38-2	2.9E+01	4.5E+02	2.9E+01	nc	0.005	0.0002	nc
Barium	7440-39-3	5.0E+03	nc	5.0E+03	nc	0.1	0.00002	nc
Beryllium	7440-41-7	4.8E+02	nc	4.8E+02	nc	0.001	0.00000	nc
Boron	7440-42-8	1.9E+04	nc	1.9E+04	nc	2	0.00010	nc
Cadmium	7440-43-9	1.0E+01	nc	1.0E+01	nc	0.0003	0.00003	nc
Chromium, Total	7440-47-3	8.6E+03	nc	8.6E+03	nc	0.006	0.0000007	nc
Chromium (VI)	18540-29-9	2.8E+01	7.6E+01	2.8E+01	nc	0.002	0.00009	nc
Cobalt	7440-48-4	3.3E+02	nc	3.3E+02	nc	0.02	0.0000	nc
Lithium	7439-93-2	NA				0.04	NA	nc
Manganese	7439-96-5	2.2E+03	nc	2.2E+03	nc	1	0.001	nc
Molybdenum	7439-98-7	4.8E+02	nc	4.8E+02	nc	0.003	0.00001	nc
Nickel	7440-02-0	1.0E+03	nc	1.0E+03	nc	0.008	0.00001	nc
Selenium	7782-49-2	4.8E+02	nc	4.8E+02	nc	0.003	0.00001	nc
Strontium	7440-24-6	1.9E+05	nc	1.9E+05	nc	0.4	0.000002	nc
Thallium	7440-28-0	NA				0.0002	NA	nc
Vanadium	7440-62-2	9.6E+02	nc	9.6E+02	nc	0.002	0.00000	nc
Zinc	7440-66-6	3.1E+04	nc	3.1E+04	nc	0.02	0.000001	nc
					Cumulative Risk		**0.001**	**0.00E+00**

Prepared by: HHS Checked by: VTV

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index
NA - No toxicity value available; remedial goal not calculated

Exposure Routes Evaluated

Incidental Ingestion	Yes
Dermal Contact	Yes
Ambient Vapor Inhalation	No

Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-2
SUMMARY OF OFF-SITE SEDIMENT EPC/RBC COMPARISON
RECREATIONAL SWIMMER - CHILD, ADOLESCENT, and ADULT
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Belews Lake Sediment	Risk Ratio	
		Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis	Exposure Point Concentration (mg/kg)	Non-Cancer	Cancer
Aluminum	7429-90-5	1.2E+07	nc	1.2E+07	nc	18279	0.002	nc
Arsenic	7440-38-2	1.5E+03	1.4E+03	1.4E+03	c	8	0.005	5.4E-03
Cobalt	7440-48-4	3.7E+03	nc	3.7E+03	nc	11	0.003	nc
Manganese	7439-96-5	1.7E+06	nc	1.7E+06	nc	267	0.0002	nc
Thallium	7440-28-0	1.2E+02	nc	1.2E+02	nc	0.2	0.0018	nc
Vanadium	7440-62-2	6.1E+04	nc	6.1E+04	nc	52	0.0008	nc
					Cumulative Risk		**0.01**	**5.4E-03**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - remedial goal based on non-cancer hazard index

Exposure Routes Evaluated

Incidental Ingestion	Yes
Dermal Contact	Yes
Particulate Inhalation	No
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-3
SUMMARY OF OFF-SITE SURFACE WATER EPC/RBC COMPARISON
RECREATIONAL SWIMMER - CHILD, ADOLESCENT, and ADULT
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Belews Lake Surface Water	Risk Ratio	
		Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	1.1E+03	nc	1.1E+03	nc	0.3	0.0003	nc
Chromium (VI)	18540-29-9	3.3E-01	2.0E-02	2.0E-02	c	0.00004	0.0001	2.3E-03
Manganese	7439-96-5	4.1E+01	nc	4.1E+01	nc	0.04	0.001	nc
Zinc	7440-66-6	3.4E+02	nc	3.4E+02	nc	0.01	0.00002	nc
						Cumulative Risk	**0.002**	**2.3E-03**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index
NA - No toxicity value available; remedial goal not calculated

Exposure Routes Evaluated

Incidental Ingestion	Yes
Dermal Contact	Yes
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-4
SUMMARY OF OFF-SITE SEDIMENT EPC/RBC COMPARISON
RECREATIONAL WADER - CHILD, ADOLESCENT, and ADULT
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Belews Lake Sediment	Risk Ratio	
		Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis	Exposure Point Concentration (mg/kg)	Non-Cancer	Cancer
Aluminum	7429-90-5	1.2E+07	nc	1.2E+07	nc	18279	0.002	nc
Arsenic	7440-38-2	3.2E+03	3.6E+03	3.2E+03	nc	8	0.002	2.4E-03
Cobalt	7440-48-4	3.7E+03	nc	3.7E+03	nc	11	0.003	nc
Manganese	7439-96-5	1.7E+06	nc	1.7E+06	nc	267	0.0002	nc
Thallium	7440-28-0	1.2E+02	nc	1.2E+02	nc	0.2	0.002	nc
Vanadium	7440-62-2	6.1E+04	nc	6.1E+04	nc	52	0.0008	nc
					Cumulative Risk		**0.010**	**2.4E-03**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index

Exposure Routes Evaluated

Incidental Ingestion	Yes
Dermal Contact	Yes
Particulate Inhalation	No
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-5
SUMMARY OF OFF-SITE SURFACE WATER EPC/RBC COMPARISON
RECREATIONAL WADER - CHILD, ADOLESCENT, and ADULT
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Belews Lake Surface Water	Risk Ratio	
		Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	1.2E+03	nc	1.2E+03	nc	0.3	0.0003	nc
Chromium (VI)	18540-29-9	9.5E-01	8.3E-02	8.3E-02	c	0.00004	0.00005	5.4E-04
Manganese	7439-96-5	9.0E+01	nc	9.0E+01	nc	0.04	0.0005	nc
Zinc	7440-66-6	3.6E+02	nc	3.6E+02	nc	0.01	0.00002	nc
					Cumulative Risk		**0.001**	**5.4E-04**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
No toxicity value available; remedial goal not calcul
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index

Exposure Routes Evaluated

Incidental Ingestion Yes
Dermal Contact Yes
Ambient Vapor Inhalation No
Target Hazard Index (per Chemical) 1E+00
Target Cancer Risk (per Chemical) 1E-04

TABLE 5-6
SUMMARY OF OFF-SITE SURFACE WATER EPC/RBC COMPARISON
RECREATIONAL BOATER - RECREATIONAL BOATER (ADULT)
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Belews Lake Surface Water	Risk Ratio	
		Non-Cancer	Cancer	Final	Basis	Exposure Point Concentration	Non-Cancer	Cancer
		(mg/L)	(mg/L)	(mg/L)		(mg/L)		
Aluminum	7429-90-5	5.6E+04	nc	5.6E+04	nc	0.3	0.00001	nc
Chromium (VI)	18540-29-9	2.1E+00	9.8E-01	9.8E-01	c	0.00004	0.00005	4.6E-05
Manganese	7439-96-5	3.1E+02	nc	3.1E+02	nc	0.04	0.0001	nc
Zinc	7440-66-6	2.8E+04	nc	2.8E+04	nc	0.01	0.0000002	nc
					Cumulative Risk		**0.0002**	**4.6E-05**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index
NA - No toxicity value available; remedial goal not calculated

Exposure Routes Evaluated

Incidental Ingestion	No
Dermal Contact	Yes
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-7
SUMMARY OF OFF-SITE SURFACE WATER EPC/RBC COMPARISON
RECREATIONAL FISHER - RECREATIONAL FISHER (ADULT)
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Belews Lake Surface Water	Risk Ratio	
		Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	5.6E+04	nc	5.6E+04	nc	0.3	0.00001	nc
Chromium (VI)	18540-29-9	2.1E+00	9.8E-01	9.8E-01	c	0.00004	0.00005	4.6E-05
Manganese	7439-96-5	3.1E+02	nc	3.1E+02	nc	0.04	0.0001	nc
Zinc	7440-66-6	2.8E+04	nc	2.8E+04	nc	0.01	0.0000002	nc
						Cumulative Risk	**0.0002**	**4.6E-05**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index

Exposure Routes Evaluated

Incidental Ingestion	No
Dermal Contact	Yes
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-8
SUMMARY OF FISH TISSUE EPC/RBC COMPARISON
FISHER - RECREATIONAL(ADULT AND ADOLESCENT)
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration - Fish Tissue								Lowest Non-Cancer RBC Value	Lowest Cancer RBC Value	BCF (unitless)	Risk-Based Concentration - Surface Water				Belews Lake Surface Water	Risk Ratio	
		Adult				Adolescent (a)													
		Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis	Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis				Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	4.6E+03	nc	4.6E+03	nc	5.8E+03	nc	5.8E+03	nc	4.6E+03	nc	2.7	1.7E+03	nc	1.7E+03	nc	0.3	0.0002	nc
Chromium (VI)	18540-29-9	1.4E+01	6.4E+00	6.4E+00	c	1.7E+01	2.7E+00	2.7E+00	c	2.7E+00	2.7E+00	200	1.4E-02	1.4E-02	1.4E-02	c	0.00004	0.003	0.003
Manganese	7439-96-5	6.4E+02	nc	6.4E+02	nc	8.1E+02	nc	8.1E+02	nc	6.4E+02	nc	2.4	2.7E+02	nc	2.7E+02	nc	0.04	0.0002	nc
Zinc	7440-66-6	1.4E+03	nc	1.4E+03	nc	1.7E+03	nc	1.7E+03	nc	1.4E+03	nc	2059	6.7E-01	nc	6.7E-01	nc	0.01	0.01	nc
																	Cumulative Risk	**0.01**	**3.3E-03**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked b

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index

BCF - Bioconcentration Factor
Surface water RBC = Fish Tissue RBC / BCF

Exposure Routes Evaluated

Ingestion	Yes

Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-9
SUMMARY OF FISH TISSUE EPC/RBC COMPARISON
FISHER - SUBSISTENCE (ADULT AND CHILD)
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration - Fish Tissue								Lowest Non-Cancer RBC Value	Lowest Cancer RBC Value	BCF (unitless)	Risk-Based Concentration - Surface Water				Belews Lake	Risk Ratio	
		Adult				Child (a)													
		Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis	Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis				Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	4.7E+02	nc	4.7E+02	nc	1.5E+02	nc	1.5E+02	nc	1.5E+02	nc	2.7	5.7E+01	nc	5.7E+01	nc	0.3	0.01	nc
Chromium (VI)	18540-29-9	1.4E+00	6.6E-01	6.6E-01	c	4.6E-01	3.6E-02	3.6E-02	c	4.6E-01	3.6E-02	200	2.3E-03	1.8E-04	1.8E-04	c	0.00004	0.02	0.2
Manganese	7439-96-5	6.6E+01	nc	6.6E+01	nc	2.1E+01	nc	2.1E+01	nc	2.1E+01	nc	2.4	8.9E+00	nc	8.9E+00	nc	0.04	0.005	nc
Zinc	7440-66-6	1.4E+02	nc	1.4E+02	nc	4.6E+01	nc	4.6E+01	nc	4.6E+01	nc	2059	2.2E-02	nc	2.2E-02	nc	0.01	0.3	nc
																	Cumulative Risk	**0.3**	**2.5E-01**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked I

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - remedial goal based on non-cancer hazard index
There is no evidence of that subsistence fishing occurs in Belews Lake.
NA - No toxicity value available; remedial goal not calculated
NC - Not Calculated
BCF - Bioconcentration Factor
Surface water RBC = Fish Tissue RBC / BCF

Exposure Routes Evaluated
Ingestion Yes

Target Hazard Index (per Chemical) 1E+00
Target Cancer Risk (per Chemical) 1E-04

TABLE 5-10
SUMMARY OF OFF-SITE SEDIMENT EPC/RBC COMPARISON
RECREATIONAL SWIMMER - CHILD, ADOLESCENT, and ADULT
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Dan River	Risk Ratio	
		Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis	Exposure Point Concentration (mg/kg)	Non-Cancer	Cancer
Aluminum	7429-90-5	1.2E+07	nc	1.2E+07	nc	27000	0.002	nc
Arsenic	7440-38-2	1.5E+03	1.4E+03	1.4E+03	c	6	0.004	4.0E-03
Cobalt	7440-48-4	3.7E+03	nc	3.7E+03	nc	9	0.002	nc
Thallium	7440-28-0	1.2E+02	nc	1.2E+02	nc	0.3	0.002	nc
					Cumulative Risk		**0.011**	**4.0E-03**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - remedial goal based on non-cancer hazard index
NC - Not Calculated
ND- Not Detected.

Exposure Routes Evaluated

Incidental Ingestion	Yes
Dermal Contact	Yes
Particulate Inhalation	No
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-11
SUMMARY OF OFF-SITE SURFACE WATER EPC/RBC COMPARISON
RECREATIONAL SWIMMER - CHILD, ADOLESCENT, and ADULT
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Dan River	Risk Ratio	
		Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	1.1E+03	nc	1.1E+03	nc	2	0.002	nc
Boron	7440-42-8	2.2E+02	nc	2.2E+02	nc	4	0.02	nc
Chromium (VI)	18540-29-9	3.3E-01	2.0E-02	2.0E-02	c	0.0002	0.0005	7.9E-03
Cobalt	7440-48-4	3.5E-01	nc	3.5E-01	nc	0.001	0.004	nc
Manganese	7439-96-5	4.1E+01	nc	4.1E+01	nc	0.3	0.01	nc
Molybdenum	7439-98-7	5.4E+00	nc	5.4E+00	nc	0.01	0.002	nc
Thallium	7440-28-0	NA	nc	NA	nc	0.001	NA	nc
Zinc	7440-66-6	3.4E+02	nc	3.4E+02	nc	0.04	0.0001	nc
					Cumulative Risk		**0.03**	**7.9E-03**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
COPC - Chemical of potential concern
NA - No toxicity value available; remedial goal not calculated
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index

Exposure Routes Evaluated

Incidental Ingestion	Yes
Dermal Contact	Yes
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-12
SUMMARY OF OFF-SITE SEDIMENT EPC/RBC COMPARISON
RECREATIONAL WADER - CHILD, ADOLESCENT, and ADULT
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Dan River	Risk Ratio	
		Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis	Exposure Point Concentration (mg/kg)	Non-Cancer	Cancer
Aluminum	7429-90-5	1.2E+07	nc	1.2E+07	nc	27000	0.002	nc
Antimony	7440-36-0	4.9E+03	nc	4.9E+03	nc	ND	NC	nc
Arsenic	7440-38-2	3.2E+03	3.6E+03	3.2E+03	nc	6	0.002	1.80E-03
Cobalt	7440-48-4	3.7E+03	nc	3.7E+03	nc	9	0.002	nc
Thallium	7440-28-0	1.2E+02	nc	1.2E+02	nc	0.3	0.002	nc
					Cumulative Risk		**0.0045**	**1.80E-03**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:

COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index

NA - No toxicity value available; remedial goal not calculated
NC - Not Calculated
ND- non-detect

Exposure Routes Evaluated

Incidental Ingestion	Yes
Dermal Contact	Yes
Particulate Inhalation	No
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-13
SUMMARY OF OFF-SITE SURFACE WATER EPC/RBC COMPARISON
RECREATIONAL WADER - CHILD, ADOLESCENT, and ADULT
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Dan River	Risk Ratio	
		Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	1.2E+03	nc	1.2E+03	nc	2	0.002	nc
Boron	7440-42-8	2.4E+02	nc	2.4E+02	nc	4	0.02	nc
Chromium (VI)	18540-29-9	9.5E-01	8.3E-02	8.3E-02	c	0.0002	0.0002	1.9E-03
Cobalt	7440-48-4	3.6E-01	nc	3.6E-01	nc	0.001	0.004	nc
Manganese	7439-96-5	9.0E+01	nc	9.0E+01	nc	0.3	0.003	nc
Molybdenum	7439-98-7	5.9E+00	nc	5.9E+00	nc	0.01	0.002	nc
Thallium	7440-28-0	NA	nc	NA	nc	0.001	NC	nc
Zinc	7440-66-6	3.6E+02	nc	3.6E+02	nc	0.04	0.0001	nc
					Cumulative Risk		**0.03**	**1.9E-03**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index
NA - No toxicity value available; remedial goal not calculated
NC - Not Calculated

Exposure Routes Evaluated

Incidental Ingestion	Yes
Dermal Contact	Yes
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-14
SUMMARY OF OFF-SITE SURFACE WATER EPC/RBC COMPARISON
RECREATIONAL BOATER - RECREATIONAL BOATER (ADULT)
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Dan River	Risk Ratio	
		Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	5.6E+04	nc	5.6E+04	nc	2	0.00004	nc
Boron	7440-42-8	1.1E+04	nc	1.1E+04	nc	4	0.0003	nc
Chromium (VI)	18540-29-9	2.1E+00	9.8E-01	9.8E-01	c	0.0002	0.0002	1.6E-04
Cobalt	7440-48-4	4.2E+01	nc	4.2E+01	nc	0.001	0.00004	nc
Manganese	7439-96-5	3.1E+02	nc	3.1E+02	nc	0.3	0.001	nc
Molybdenum	7439-98-7	2.8E+02	nc	2.8E+02	nc	0.01	0.00004	nc
Thallium	7440-28-0	NA				0.001	NA	nc
Zinc	7440-66-6	2.8E+04	nc	2.8E+04	nc	0.04	0.000001	nc
					Cumulative Risk		**0.002**	**1.6E-04**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index
NA - No toxicity value available; remedial goal not calculated

Exposure Routes Evaluated

Incidental Ingestion	No
Dermal Contact	Yes
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-15
SUMMARY OF OFF-SITE SURFACE WATER EPC/RBC COMPARISON
RECREATIONAL FISHER - RECREATIONAL FISHER (ADULT)
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration				Dan River	Risk Ratio	
		Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	5.6E+04	nc	5.6E+04	nc	2	0.00004	nc
Boron	7440-42-8	1.1E+04	nc	1.1E+04	nc	4	0.0003	nc
Chromium (VI)	18540-29-9	2.1E+00	9.8E-01	9.8E-01	c	0.0002	0.0001	1.6E-04
Cobalt	7440-48-4	4.2E+01	nc	4.2E+01	nc	0.001	0.00004	nc
Manganese	7439-96-5	3.1E+02	nc	3.1E+02	nc	0.3	0.001	nc
Molybdenum	7439-98-7	2.8E+02	nc	2.8E+02	nc	0.01	0.00004	nc
Thallium	7440-28-0	NA				0.001	NC	nc
Zinc	7440-66-6	2.8E+04	nc	2.8E+04	nc	0.04	0.000001	nc
					Cumulative Risk		**0.002**	**1.6E-04**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked by:

Notes:

COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index
NA - No toxicity value available; remedial goal not calculated
NC - Not Calculated

Exposure Routes Evaluated

Incidental Ingestion	No
Dermal Contact	Yes
Ambient Vapor Inhalation	No
Target Hazard Index (per Chemical)	**1E+00**
Target Cancer Risk (per Chemical)	**1E-04**

TABLE 5-16
SUMMARY OF FISH TISSUE EPC/RBC COMPARISON
FISHER - RECREATIONAL(ADULT AND ADOLESCENT)
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration - Fish Tissue								Lowest Non-Cancer RBC Value	Lowest Cancer RBC Value	BCF (unitless)	Risk-Based Concentration - Surface Water				Dan River	Risk Ratio	
		Adult				Adolescent (a)													
		Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis	Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis				Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	4.6E+03	nc	4.6E+03	nc	5.8E+03	nc	5.8E+03	nc	4.6E+03	nc	2.7	1.7E+03	nc	1.7E+03	nc	2	0.001	nc
Boron	7440-42-8	9.1E+02	nc	9.1E+02	nc	1.2E+03	nc	1.2E+03	nc	9.1E+02	nc	0.3	3.0E+03	nc	3.0E+03	nc	4	0.0012	nc
Chromium (VI)	18540-29-9	1.4E+01	6.4E+00	6.4E+00	c	1.7E+01	2.7E+00	2.7E+00	c	2.7E+00	2.7E+00	200	1.4E-02	1.4E-02	1.4E-02	c	0.0002	0.01	**0.01**
Cobalt	7440-48-4	1.4E+00	nc	1.4E+00	nc	1.7E+00	nc	1.7E+00	nc	1.4E+00	nc	400	3.4E-03	nc	3.4E-03	nc	0.001	0.4	nc
Manganese	7439-96-5	6.4E+02	nc	6.4E+02	nc	8.1E+02	nc	8.1E+02	nc	6.4E+02	nc	2.4	2.7E+02	nc	2.7E+02	nc	0.3	0.001	nc
Molybdenum	7439-98-7	2.3E+01	nc	2.3E+01	nc	2.9E+01	nc	2.9E+01	nc	2.3E+01	nc	NA	NA	nc	NA	NA	0.01	NC	nc
Thallium	7440-28-0	4.6E-02	nc	4.6E-02	nc	5.8E-02	nc	5.8E-02	nc	4.6E-02	nc	190	2.4E-04	nc	2.4E-04	nc	0.001	**5**	nc
Zinc	7440-66-6	1.4E+03	nc	1.4E+03	nc	1.7E+03	nc	1.7E+03	nc	1.4E+03	nc	NA	NA	nc	NA	NA	0.04	NC	nc
																	Cumulative Risk	**5**	**1.1E-02**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked b

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - Remedial goal based on non-cancer hazard index
NA - No toxicity value available; remedial goal not calculated
NC - Not Calculated
BCF - Bioconcentration Factor
Surface water RBC = Fish Tissue RBC / BCF

Exposure Routes Evaluated
Ingestion Yes

Target Hazard Index (per Chemical) 1E+00
Target Cancer Risk (per Chemical) 1E-04

TABLE 5-17
SUMMARY OF FISH TISSUE EPC/RBC COMPARISON
FISHER - SUBSISTENCE (ADULT AND CHILD)
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

COPC	CAS	Risk-Based Concentration - Fish Tissue								Lowest Non-Cancer RBC Value	Lowest Cancer RBC Value	BCF (unitless)	Risk-Based Concentration - Surface Water				Dan River	Risk Ratio	
		Adult				Child (a)													
		Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis	Non-Cancer (mg/kg)	Cancer (mg/kg)	Final (mg/kg)	Basis				Non-Cancer (mg/L)	Cancer (mg/L)	Final (mg/L)	Basis	Exposure Point Concentration (mg/L)	Non-Cancer	Cancer
Aluminum	7429-90-5	4.7E+02	nc	4.7E+02	nc	1.5E+02	nc	1.5E+02	nc	1.5E+02	nc	2.7	5.7E+01	nc	5.7E+01	nc	2	0.04	nc
Boron	7440-42-8	9.4E+01	nc	9.4E+01	nc	3.1E+01	nc	3.1E+01	nc	3.1E+01	nc	0.3	1.0E+02	nc	1.0E+02	nc	4	0.04	nc
Chromium (VI)	18540-29-9	1.4E+00	6.6E-01	6.6E-01	c	4.6E-01	3.6E-02	3.6E-02	c	4.6E-01	3.6E-02	200	2.3E-03	1.8E-04	1.8E-04	c	0.0002	0.07	**0.86**
Cobalt	7440-48-4	1.4E-01	nc	1.4E-01	nc	4.6E-02	nc	4.6E-02	nc	4.6E-02	nc	400	1.1E-04	nc	1.1E-04	nc	0.001	**13**	nc
Manganese	7439-96-5	6.6E+01	nc	6.6E+01	nc	2.1E+01	nc	2.1E+01	nc	2.1E+01	nc	2.4	8.9E+00	nc	8.9E+00	nc	0.3	0.04	nc
Molybdenum	7439-98-7	2.4E+00	nc	2.4E+00	nc	7.7E-01	nc	7.7E-01	nc	7.7E-01	nc	NA	NA	nc	NA	NA	0.01	NC	nc
Thallium	7440-28-0	4.7E-03	nc	4.7E-03	nc	1.5E-03	nc	1.5E-03	nc	1.5E-03	nc	190	8.1E-06	nc	8.1E-06	nc	0.001	**137**	nc
Zinc	7440-66-6	1.4E+02	nc	1.4E+02	nc	4.6E+01	nc	4.6E+01	nc	4.6E+01	nc	2059	2.2E-02	nc	2.2E-02	nc	0.04	**2**	nc
																	Cumulative Risk	**151**	**8.61E-01**

Prepared by: HHS Checked by: VTV
Updated by: HHS Checked

Notes:
COPC - Chemical of potential concern
c - Remedial goal based on cancer risk
nc - remedial goal based on non-cancer hazard index
There is no evidence of that subsistence fishing occurs in Dan River.
NA - No toxicity value available; remedial goal not calculated
NC - Not Calculated
BCF - Bioconcentration Factor
Surface water RBC = Fish Tissue RBC / BCF

Exposure Routes Evaluated
Ingestion Yes

Target Hazard Index (per Chemical) **1E+00**
Target Cancer Risk (per Chemical) **1E-04**

TABLE 5-18
RISK ASSESSMENT SUMMARY
BELEWS CREEK STEAM STATION
DUKE ENERGY CAROLINAS, LLC, BELEWS CREEK, NC

Source Table (PRG Tables)	Media	Exposure Pathway	Risk Ratio - Non - cancer	Risk Ratio - Cancer
TABLE 5-1	Groundwater	CONSTRUCTION - CONSTRUCTION WORKER (ADULT)	0.001	0.00E+00
TABLE 5-2	Sediment- Belews Lake Off-Site	OFF-SITE RECREATIONAL SWIMMER - CHILD, ADOLESCENT, and ADULT	0.01	5.45E-03
TABLE 5-3	Surface Water- Belews Lake Off-Site	OFF-SITE RECREATIONAL SWIMMER - CHILD, ADOLESCENT, and ADULT	0.002	2.27E-03
TABLE 5-4	Sediment- Belews Lake Off-Site	OFF-SITE RECREATIONAL WADER - CHILD, ADOLESCENT, and ADULT	0.01	2.42E-03
TABLE 5-5	Surface Water- Belews Lake Off-Site	OFF-SITE RECREATIONAL WADER - CHILD, ADOLESCENT, and ADULT	0.0008	5.39E-04
TABLE 5-6	Surface Water- Belews Lake Off-Site	OFF-SITE RECREATIONAL BOATER - RECREATIONAL BOATER (ADULT)	0.0002	4.57E-05
TABLE 5-7	Surface Water- Belews Lake Off-Site	OFF-SITE FISHER - RECREATIONAL (ADULT AND ADOLESCENT)	0.0002	4.57E-05
TABLE 5-8	Biota (fish)- Belews Lake Off-Site	OFF-SITE FISHER - RECREATIONAL (ADULT AND ADOLESCENT)	0.01	3.32E-03
TABLE 5-9	Biota (fish)- Belews Lake Off-Site	OFF-SITE FISHER - SUBSISTENCE (ADULT AND CHILD)	0.3	2.49E-01
TABLE 5-10	Sediment- Dan River Off-Site	OFF-SITE RECREATIONAL SWIMMER - CHILD, ADOLESCENT, and ADULT	0.01	4.04E-03
TABLE 5-11	Surface Water- Dan River Off-Site	OFF-SITE RECREATIONAL SWIMMER - CHILD, ADOLESCENT, and ADULT	0.03	7.86E-03
TABLE 5-12	Sediment- Dan River Off-Site	OFF-SITE RECREATIONAL WADER - CHILD, ADOLESCENT, and ADULT	0.004	1.80E-03
TABLE 5-13	Surface Water- Dan River Off-Site	OFF-SITE RECREATIONAL WADER - CHILD, ADOLESCENT, and ADULT	0.03	1.86E-03
TABLE 5-14	Surface Water- Dan River Off-Site	OFF-SITE RECREATIONAL BOATER - RECREATIONAL BOATER (ADULT)	0.002	1.58E-04
TABLE 5-15	Surface Water- Dan River Off-Site	OFF-SITE FISHER - RECREATIONAL (ADULT AND ADOLESCENT)	0.002	1.58E-04
TABLE 5-16	Biota (fish)- Dan River Off-Site	OFF-SITE FISHER - RECREATIONAL (ADULT AND ADOLESCENT)	5	1.15E-02
TABLE 5-17	Biota (fish)- Dan River Off-Site	OFF-SITE FISHER - SUBSISTENCE (ADULT AND ADOLESCENT)	151	8.61E-01

Prepared by: HHS Checked by: VTV

Table 1
Exposure Parameters for Ecological Receptors
Ecological Exposure Area 1
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

	Parameter	Body Weight	Food Ingestion Rate	Water Ingestion Rate	Dietary Composition						Home Range	Seasonal Use Factor[j]
					Plants	Mammal/Terr. Vertebrates	Fish	Invertebrates	Birds	Soil		
	Algorithm ID	BW	IR_F	IR_W	P_F	A_M	A_F	A_I	A_B	S_F	HR	SUF
	Units	kg	kg/kg BW/day	L/kg BW/day	%	%	%	%	%	%	hectares	unitless
Ecological Receptors	HERBIVORE											
	Meadow Vole[a]	0.033	0.33	0.21	97.6%	0%	0%	0%	0%	2.4%	0.027	1
	Muskrat[b]	1.17	0.3	0.97	99.3%	0%	0%	0%	0%	0.7%	0.13	1
	OMNIVORE											
	Mallard Duck[c]	1.134	0.068	0.057	48.3%	0%	0%	48.3%	0%	3.3%	435	1
	American Robin[d]	0.08	0.129	0.14	40%	0%	0%	58%	0%	2%	0.42	1
	CARNIVORE											
	Red-Tailed Hawk[e]	1.06	0.18	0.058	0%	91.5%	0%	0%	8.5%	0%	876	1
	Red Fox[g]	4.54	0.16	0.085	6%	89%	0%	2%	0%	3%	1226	1
	PISCIVORE											
	River Otter[h]	6.76	0.19	0.081	0%	0%	100%	0%	0%	0%	348	1
	Great Blue Heron[i]	2.229	0.18	0.045	0%	0%	90%	9.5%	0%	0.5%	227	1

NOTES:

BW - Body Weight
kg - Kilograms
IR - Ingestion Rate
HR - Home Range
SUF - Seasonal Use Factor

P_F - Plant Matter Ingestion Percentage
A_M - Mammal/Terrestrial Vertebrate ingestion percentage
A_F - Fish Ingestion Percentage
A_B - Bird Ingestion Percentage
S_F - Soil Ingestion Percentage

kg/kg BW/day - Kilograms Food per Kilograms Body Weight per Day
L/kg BW/day - Liters Water per Kilogram Body Weight per Day

[a] BW, IR_f, IR_w, P_F, HR from USEPA 1993 (sections 2-328 and 2-329); S_F from Sample and Suter 1994
[b] BW, IR_f, IR_w, P_F, HR from USEPA 1993 (sections 2-340 and 2-341); S_F from TechLaw Inc. 2013; IR_F from Nagy 2001
[c] BW, P_F, A_I, HR from USEPA 1993 (sections 2-43 and 2-45); S_F from Beyer et al. 1994; IR_F from Nagy 2001
[d] BW, P_F, A_I, HR from USEPA 1993 (sections 2-197 and 2-198); S_F from Sample and Suter 1994; IR_F from Nagy 2001
[e] BW, P_F, A_M, A_B, IR_F, HR from USEPA 1993 (sections 2-82 and 2-83)
[f] BW, P_F, A_F, A_M, A_B, HR from USEPA 1993 (sections 2-91 and 2-97); IR_F from Nagy 2001
[g] BW, P_F, A_F, A_I, HR from USEPA 1993 (sections 2-224 and 2-225); S_F from Beyer et al. 1994
[h] BW, IR_w, A_F, HR from USEPA 1993 (sections 2-264 and 2-266); S_F from Sample and Suter 1994; IR_F from Nagy 2001
[i] BW, P_F, A_F, A_I, HR from USEPA 1993 (sections 2-8 and 2-9); S_F from Sample and Suter 1994; IR_F from Nagy 2001
[j] Seasonal Use Factor is set to a default of 1 to be overly conservative and protective of ecological receptors.

Table 2
Toxicity Reference Values for Ecological Receptors
Ecological Exposure Area 1
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

Analyte	TRVs (NOAEL)							
	Aquatic				Terrestrial			
	Mallard Duck (mg/kg/day)	Great Blue Heron (mg/kg/day)	Muskrat (mg/kg/day)	River Otter (mg/kg/day)	American Robin (mg/kg/day)	Red-Tailed Hawk (mg/kg/day)	Meadow Vole (mg/kg/day)	Red Fox (mg/kg/day)
Aluminum[a]	110	110	1.93	1.93	110	110	1.93	1.93
Antimony[a]	NA	NA	0.059	0.059	NA	NA	0.059	0.059
Arsenic[b]	2.24	2.24	1.04	1.04	2.24	2.24	1.04	1.04
Barium[c]	20.8	20.8	51.8	51.8	20.8	20.8	51.8	51.8
Beryllium[a]	NA	NA	0.532	0.532	NA	NA	0.532	0.532
Boron[a, b]	28.8	28.8	28	28	28.8	28.8	28	28
Cadmium[a]	1.47	1.47	0.77	0.77	1.47	1.47	0.77	0.77
Calcium	EN	EN	EN	EN	EN	EN	EN	EN
Chromium, Total[d]	1	1	2740	2740	1	1	2740	2740
Chromium VI (hexavalent)[a]	NA	NA	9.24	9.24	NA	NA	9.24	9.24
Chromium III[a]	2.66	2.66	2.4	2.4	2.66	2.66	2.4	2.4
Cobalt[a]	7.61	7.61	7.33	7.33	7.61	7.61	7.33	7.33
Copper[a]	4.05	4.05	5.6	5.6	4.05	4.05	5.6	5.6
Iron	EN	EN	EN	EN	EN	EN	EN	EN
Lead[b]	1.63	1.63	4.7	4.7	1.63	1.63	4.7	4.7
Magnesium	EN	EN	EN	EN	EN	EN	EN	EN
Manganese[a]	179	179	51.5	51.5	179	179	51.5	51.5
Mercury[e]	3.25	3.25	1.01	1.01	3.25	3.25	1.01	1.01
Molybdenum[a, d]	3.53	3.53	0.26	0.26	3.53	3.53	0.26	0.26
Nickel[a]	6.71	6.71	1.7	1.7	6.71	6.71	1.7	1.7
Potassium	EN	EN	EN	EN	EN	EN	EN	EN
Selenium[a]	0.29	0.29	0.143	0.143	0.29	0.29	0.143	0.143
Sodium	EN	EN	EN	EN	EN	EN	EN	EN
Strontium[a, d]	NA	NA	263	263	NA	NA	263	263
Thallium[a]	NA	NA	0.015	0.015	NA	NA	0.015	0.015
Titanium	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium[a]	0.344	0.344	4.16	4.16	0.344	0.344	4.16	4.16
Zinc[a]	66.1	66.1	75.4	75.4	66.1	66.1	75.4	75.4
Nitrate[d]	NA	NA	507	507	NA	NA	507	507

Table 2 (Cont.)

Analyte	TRVs (LOAEL)							
	Aquatic				Terrestrial			
	Mallard Duck (mg/kg/day)	Heron (mg/kg/day)	Muskrat (mg/kg/day)	River Otter (mg/kg/day)	Robin (mg/kg/day)	Hawk (mg/kg/day)	Meadow Vole (mg/kg/day)	Red Fox (mg/kg/day)
Aluminum[a]	1100	1100	19.3	19.3	1100	1100	19.3	19.3
Antimony[a]	NA	NA	0.59	0.59	NA	NA	0.59	0.59
Arsenic[b]	40.3	40.3	1.66	1.66	40.3	40.3	1.66	1.66
Barium[c]	41.7	41.7	75	75	41.7	41.7	75	75
Beryllium[a]	NA	NA	6.6	6.6	NA	NA	6.6	6.6
Boron[a, b]	100	100	93.6	93.6	100	100	93.6	93.6
Cadmium[a]	2.37	2.37	10	10	2.37	2.37	10	10
Calcium	EN	EN	EN	EN	EN	EN	EN	EN
Chromium, Total[d]	5	5	27400	27400	5	5	27400	27400
Chromium VI (hexavalent)[a]	NA	NA	40	40	NA	NA	40	40
Chromium III[a]	2.66	2.66	9.625	9.625	2.66	2.66	9.625	9.625
Cobalt[a]	7.8	7.8	10.9	10.9	7.8	7.8	10.9	10.9
Copper[a]	12.1	12.1	9.34	9.34	12.1	12.1	9.34	9.34
Iron	EN	EN	EN	EN	EN	EN	EN	EN
Lead[b]	3.26	3.26	8.9	8.9	3.26	3.26	8.9	8.9
Magnesium	EN	EN	EN	EN	EN	EN	EN	EN
Manganese[a]	348	348	71	71	348	348	71	71
Mercury[e]	0.37	0.37	0.16	0.16	0.37	0.37	0.16	0.16
Molybdenum[a, d]	35.3	35.3	2.6	2.6	35.3	35.3	2.6	2.6
Nickel[a]	11.5	11.5	3.4	3.4	11.5	11.5	3.4	3.4
Potassium	EN	EN	EN	EN	EN	EN	EN	EN
Selenium[a]	0.579	0.579	0.215	0.215	0.579	0.579	0.215	0.215
Sodium	EN	EN	EN	EN	EN	EN	EN	EN
Strontium[a, d]	NA	NA	2630	2630	NA	NA	2630	2630
Thallium[a]	NA	NA	0.075	0.075	NA	NA	0.075	0.075
Vanadium[a]	0.688	0.688	8.31	8.31	0.688	0.688	8.31	8.31
Zinc[a]	66.5	66.5	75.9	75.9	66.5	66.5	75.9	75.9
Nitrate[d]	NA	NA	1130	1130	NA	NA	1130	1130

NOTES:

NOAEL - No Observed Adverse Effects Level

LOAEL - Lowest Observed Effects Level

EN - Essential nutrient

NA - Not available

TRV - Toxicity Reference Value

[a] CH2M Hill. 2014. Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site. CHPRC-01311. Revision 2. July. Http://pdw.hanford.gov/arpir/pdf.cfm?accession=0088115

[b] USEPA 2005 EcoSSL

[c] Only a single paper (Johnson et al., 1960) with data on the toxicity of barium hydroxide to one avian species (chicken) was identified by USEPA (2005); therefore, an avian TRV could not be derived and an Eco-SSL could not be calculated for avian wildlife (calculation requires a minimum of three results for two test species). Johnson et al. (1960) reports a subchronic NOAEL of 208.26 mg/kg/d. The NOAEL was multiplied by an uncertainty factor of 0.1 to derive a very conservative TRV of 20.8 mg/kg/d.

[d] Sample et al. 1996

Table 3
Exposure Area and Area Use Factors for Ecological Receptors
Ecological Exposure Area 1
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

Exposure Point	Exposure Area[a] (hectares)	Area Use Factor (AUF)							
		Mallard Duck	Great Blue Heron	Muskrat	River Otter	American Robin	Red-Tailed Hawk	Meadow Vole	Red Fox
Ecological Exposure Area 1	10	2.30%	4.41%	100%	2.87%	100%	1.142%	100%	0.82%

NOTES:
[a] Exposure Area 1 (EA 1) is northwest of the ash basin along Dan River.

Table 4
Exposure Point Concentrations
Ecological Exposure Area 1
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

COPC	CASRN	Aquatic EPCs[a, b]	
		Sediment EPC Used in Risk Assessment[c] (mg/kg)	Surface Water EPC Used in Risk Assessment (mg/L)
Aluminum	7429-90-5	27,000	2.03
Barium	7440-39-3	100	
Boron	7440-42-8		3.62
Cadmium	7440-43-9		0.00025
Lead	7439-92-1		0.0013
Manganese	7439-96-5		0.31
Mercury	7439-97-6		0.000005
Selenium	7782-49-2		0.0083
Zinc	7440-66-6		0.040

Prepared by: TPC Checked by: HES

NOTES:

COPC - Constituent of Potential Concern
CASRN - Chemical Abstracts Service Registration Number
EPC - Exposure Point Concentration

[a] EPCs for Dan River sediment are based on maximum detected values. EPCs for surface water are based on 95% UCL calculations.

[b] EPCs are used for aquatic receptors in the area adjacent to and in Dan River.

[c] Analysis of solids (i.e., soil and sediment) was reported as dry weight.

Table 5
Calculation of Average Daily Doses for Mallard Duck
Ecological Exposure Area 1
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

Analyte	EPC_w COPEC in Water (mg/L)	EPC_s COPEC in Solid (mg/kg)	Slope, or Plant Uptake (BAF)	Intercept	EPC_p Estimated[1] Concentration in Vegetation (mg/kg dry)	Slope, or Invertebrate Uptake (BAF)	Intercept	EPC_i Estimated[2] Concentration in Invertebrates (mg/kg dry)	AVERAGE DAILY DOSE VIA: WATER NIR_w Water Ingestion Rate (L/kg BW/day)	AVERAGE DAILY DOSE VIA: WATER ADD_W Unadjusted Average Daily Dose Water (mg/kg/day)
Aluminum	2.034	27,000	0.0008		21.6000	1		27000.00	0.057	0.116
Barium		100	0.03		3.0000	1		100.00	0.057	0.000
Boron	3.619		1		0.0000	1		0.00	0.057	0.21
Cadmium	0.00025					0.6		0.00	0.057	0.000014
Lead	0.001					0.117		0.00	0.057	0.0001
Manganese	0.315		0.050		0.0				0.057	0.018
Mercury	0.000005					1.136		0	0.057	2.8728E-07
Selenium	0.008					0.7		0	0.057	0.0004731
Zinc	0.040					1.936		0	0.057	0.0023

Analyte	PLANTS/VEGETATION P_f Fraction Diet Plant Matter (percent)	PLANTS/VEGETATION NIR_f Food Ingestion Rate, Wet (kg/kg BW/day)	PLANTS/VEGETATION NIR_p Plant Ingestion Rate, Dry (kg/kg BW/day)	PLANTS/VEGETATION ADD_p Unadjusted Average Daily Dose Plant (mg/kg/day)	INVERTEBRATES A_f Fraction Diet Invertebrates (percent)	INVERTEBRATES NIR_a Invertebrates Ingestion Rate (kg dry/kg BW/day)	INVERTEBRATES ADD_a Unadjusted Average Daily Dose Invertebrates (mg/kg/day)	SOIL S_f Fraction Diet Soil (percent)	SOIL NIR_s Soil Ingestion3 Rate (kg dry/kg BW/day)	SOIL ADD_s Unadjusted Average Daily Dose Soil (mg/kg/day)	BF Bioavailability[3] (percent)	ADD_t Omnivore Intake (mg/kg/day)	SUF Seasonal Use Factor (unitless)	AUF Area Use Factor (Exposure Area/Home Range)	ADD_{tot} Adjusted Total Omnivore Average Daily Dose (mg/kg/day)
Aluminum	48%	0.068	0.0049	0.106415	48%	0.007	195.0934	3.3%	0.00029	7.87644	100%	203.19	1	0.023	4.671084
Barium	48%	0.068	0.0049	0.014780	48%	0.007	0.7226	3.3%	0.00029	0.02917	100%	0.7665	1	0.023	0.017621
Boron	48%	0.068	0.0049	0.000000	48%	0.007	0.0000	3.3%	0.00029	0.00000	100%	0.21	1	0.023	0.004742
Cadmium	48%	0.068	0.0049	0.000000	48%	0.007	0.0000	3.3%	0.00029	0.00000	100%	0.000	1	0.023	0.000000
Lead	48%	0.068	0.0049	0.000000	48%	0.007	0.0000	3.3%	0.00029	0.00000	100%	0.000073	1	0.023	0.000002
Manganese	48%	0.068	0.0049	0.000000	48%	0.007	0.0000	3.3%	0.00029	0.00000	100%	0.02	1	0.023	0.000412
Mercury	48%	0.068	0.0049	0.000000	48%	0.007	0.0000	3.3%	0.00029	0.00000	100%	2.8728E-07	1	0.023	0.000000
Selenium	48%	0.068	0.0049	0.000000	48%	0.007	0.0000	3.3%	0.00029	0.00000	100%	0.0004731	1	0.023	0.000011
Zinc	48%	0.068	0.0049	0.000000	48%	0.007	0.0000	3.3%	0.00029	0.00000	100%	0.00	1	0.023	0.000053

NOTES:

EPC - Exposure Point Concentration
NIR - Normalized Ingestion Rate
ADD - Average Daily Dose
BF - Bioavailability Factor
BAF - Bioaccumulation Factor
BCF - Bioconcentration Factor
SUF - Seasonal Use Factor
AUF - Area Use Factor

[1] Bechtel Jacobs Company 1998a; Baes et al. 1984 (Mo); Environmental Restoration Division - Manual ERD-AG-003 1999; default value of 1 is used for constituents for which a BAF could not be found.

[2] Bechtel Jacobs Company 1998b, Table 2, median BAFs for sediment to benthic invertebrates for As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn; Sample et al. 1998b (earthworms) for Mn; default value of 1 is used for constituents for which a BAF could not be found.

[3] Bioavailability is set to a default of 100% to be conservative and protective of ecological receptors.

Table 6
Calculation of Average Daily Doses for Great Blue Heron
Ecological Exposure Area 1
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

								AVERAGE DAILY DOSE VIA:													
								WATER		FISH				INVERTEBRATES							
	EPC_w	EPC_s		EPC_{fish}			EPC_i	NIR_w	ADD_w	A_f	NIR_f	NIR_a	ADD_a	A_f	NIR_a	ADD_a	BF	ADD_t	SUF	AUF	ADD_{tot}
Analyte	COPEC in Water (mg/L)	COPEC in Solid (mg/kg)	Fish Uptake (BCF)	Estimated[1] Concentration in Fish (mg/kg)	Slope, or Invertebrate Uptake (BAF)	Intercept	Estimated[2] Concentration in Invertebrates (mg/kg dry)	Water Ingestion Rate (L/kg BW/day)	Unadjusted Average Daily Dose Water (mg/kg/day)	Fraction Diet Animal Matter (percent)	Food Ingestion Rate, Wet (kg/kg BW/day)	Fish Ingestion Rate (kg/kg BW/day)	Unadjusted Average Daily Dose (mg/kg/day)	Fraction Diet Invertebrates (percent)	Invertebrates Ingestion Rate (kg dry/kg BW/day)	Unadjusted Average Daily Dose Invertebrates (mg/kg/day)	Bioavailability[3] (percent)	Piscivore Intake (mg/kg/day)	Seasonal Use Factor (unitless)	Area Use Factor (Exposure Area/Home Range)	Adjusted Total Piscivore Average Daily Dose (mg/kg/day)
Aluminum	2.03400	27,000	0.1	0.20	1		2.03	0.045	0.092	90%	0.18	0.162	0.033	10%	0.004	0.0077	100%	0.13	1	0.044	0.006
Barium		100	4	0.00	1		0.00	0.045	0.000	90%	0.18	0.162	0.000	10%	0.004	0.0000	100%	0.00000	1	0.044	0.000
Boron	3.619		1	3.62	1		3.62	0.045	0.163	90%	0.18	0.162	0.586	10%	0.004	0.0136	100%	0.76	1	0.044	0.034
Cadmium	0.00025		50	0.01250	0.6		0.00	0.045	0.000	90%	0.18	0.162	0.002	10%	0.004	0.0000	100%	0.002	1	0.044	0.000
Lead	0.00128		300	0.38	0.117		0.00	0.045	0.000	90%	0.18	0.162	0.062	10%	0.004	0.0000	100%	0.062412	1	0.044	0.003
Manganese	0.3146		400	125.84	0.682	-0.809	0.20	0.045	0.014	90%	0.18	0.162	20.386	10%	0.004	0.0008	100%	20.40	1	0.044	0.899
Mercury	0.000005		63000	0.32	1.136		5.72544E-06	0.045	0.000	90%	0.18	0.0405	0.013	10%	0.004	0.0000	100%	0.013	1	0.044	0.001
Selenium	0.0083		8	0.07	0.7		0.00581	0.045	0.000	90%	0.18	0.0405	0.003	10%	0.004	0.0000	100%	0.003	1	0.044	0.000
Zinc	0.0404		1000.000	40.42	1.936		0.07825312	0.045	0.002	90%	0.18	0.0405	1.637	10%	0.004	0.0003	100%	1.639	1	0.044	0.072

NOTES:

EPC - Exposure Point Concentration
NIR - Normalized Ingestion Rate
ADD - Average Daily Dose
BF - Bioavailability Factor
BAF - Bioaccumulation Factor
BCF - Bioconcentration Factor
SUF - Seasonal Use Factor
AUF - Area Use Factor

[1] Al (Voigt et al. 2015), mean of fish tissue BAFs; Cu (USEPA 1980); Environmental Restoration Division - Manual ERD-AG-003 1999.

[2] Bechtel Jacobs Company 1998b, Table 2, median BAFs for sediment to benthic invertebrates for As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn; Sample et al. 1998b (earthworms) for Mn; default value of 1 is used for constituents for which a BAF could not be found.

[3] Bioavailability is set to a default of 100% to be conservative and protective of ecological receptors.

Table 7
Calculation of Average Daily Doses for Muskrat
Ecological Exposure Area 1
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

						AVERAGE DAILY DOSE VIA:													
						WATER		PLANTS / VEGETATION				SOIL							
	EPC_w	EPC_s			EPC_p	NIR_W	ADD_w	P_f	NIR_f	NIR_p	ADD_p	S_f	NIR_s	ADD_s	BF	ADD_t	SUF	AUF	ADD_{tot}
Analyte	COPEC in Water (mg/L)	COPEC in Solid (mg/kg)	Slope, or Plant Uptake (BAF)	Intercept	Estimated[1] Concentration in Vegetation (mg/kg dry)	Water Ingestion Rate (L/kg BW/day)	Unadjusted Average Daily Dose Water (mg/kg/day)	Fraction Diet Plant Matter (percent)	Food Ingestion Rate, Wet (kg/kg BW/day)	Plant Ingestion Rate, Dry (kg/kg/day)	Unadjusted Average Daily Dose Plant (mg/kg/day)	Fraction Diet Soil (percent)	Soil Ingestion Rate (kg dry/kg BW/day)	Unadjusted Average Daily Dose Soil (mg/kg/day)	Bioavailability[2] (percent)	Herbivore Intake (mg/kg/day)	Seasonal Use Factor (unitless)	Area Use Factor (Exposure Area/Home Range)	Adjusted Total Herbivore Average Daily Dose (mg/kg/day)
Aluminum	2.034	27,000	0.0008		21.6000	0.97	1.97	99%	0.3	0.045	0.96520	1%	0.000273	0.95823	100%	3.90	1	1	3.90
Barium		100	0.03		3.0000	0.97	0.00	99%	0.3	0.045	0.13406	1%	0.000273	0.00355	100%	0.14	1	1	0.14
Boron	3.619		1		0.0000	0.97	3.51	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	3.51	1	1	3.51
Cadmium	0.0003					0.97	0.00	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	0.00	1	1	0.00
Lead	0.0013					0.97	0.00	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	0.00	1	1	0.00
Manganese	0.3146		0.050		0.0	0.97	0.31	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	0.31	1	1	0.31
Mercury	0.000005					0.97	0.00	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	0.00	1	1	0.00
Selenium	0.0083					0.97	0.01	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	0.01	1	1	0.01
Zinc	0.0404					0.97	0.04	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	0.04	1	1	0.04

NOTES:

EPC - Exposure Point Concentration
NIR - Normalized Ingestion Rate
ADD - Average Daily Dose
BF - Bioavailability Factor
BAF - Bioaccumulation Factor
BCF - Bioconcentration Factor
SUF - Seasonal Use Factor
AUF - Area Use Factor

[1] Bechtel Jacobs Company 1998a; Baes et al. 1984 (Mo); Environmental Restoration Division - Manual ERD-AG-003 1999; default value of 1 is used for constituents for which a BAF could not be found.

[2] Bioavailability is set to a default of 100% to be conservative and protective of ecological receptors.

Table 8
Calculation of Average Daily Doses for River Otter
Ecological Exposure Area 1
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

					AVERAGE DAILY DOSE VIA:										
					DRINKING WATER		FISH								
	EPC_w	EPC_s		EPC_{PREY}	NIR_w	ADD_w	P_f	NIR_f	NIR_a	ADD_a	BF	ADD_t	SUF	AUF	ADD_{tot}
Analyte	COPEC in Water (mg/L)	COPEC in Solid (mg/kg)	Fish Uptake (BCF)	Estimated[1] Concentration in Fish (mg/kg)	Water Ingestion Rate (L/kg BW/day)	Unadjusted Average Daily Dose Water (mg/kg/day)	Fraction Diet Animal Matter (percent)	Food Ingestion Rate, Wet (kg/kg BW/day)	Fish Ingestion Rate (kg/kg BW/day)	Unadjusted Average Daily Dose (mg/kg/day)	Bioavailability[2] (percent)	Piscivore Intake (mg/kg/day)	Seasonal Use Factor (unitless)	Area Use Factor (Exposure Area/Home Range)	Adjusted Total Piscivore Average Daily Dose (mg/kg/day)
Aluminum	2.034	27,000	0.1	0.20	0.081	0.165	100%	0.19	0.19	0.0386	100%	0.203	1	0.029	0.005845
Barium		100.0	4	0.00	0.081	0.000	100%	0.19	0.19	0.000	100%	0.000	1	0.029	0.000000
Boron	3.61900		1	3.62	0.081	0.293	100%	0.19	0.19	0.688	100%	0.981	1	0.029	0.028182
Cadmium	0.00025		50	0.01250	0.081	0.000	100%	0.19	0.19	0.00238	100%	0.002	1	0.029	0.000069
Lead	0.00128		300	0.38	0.081	0.000	100%	0.19	0.19	0.073	100%	0.073	1	0.029	0.002104
Manganese	0.31460		400	125.84	0.081	0.025	100%	0.19	0.19	23.91	100%	23.935	1	0.029	0.687790
Mercury	0.000005		63000	0.32	0.081	0.000	100%	0.19	0.19	0.060	100%	0.060	1	0.029	0.001734
Selenium	0.0083		8	0.07	0.081	0.001	100%	0.19	0.19	0.013	100%	0.013	1	0.029	0.000382
Zinc	0.04042		1000.000	40.42	0.081	0.003	100%	0.19	0.19	7.680	100%	7.683	1	0.029	0.220778

NOTES:

EPC - Exposure Point Concentration
NIR - Normalized Ingestion Rate
ADD - Average Daily Dose
BF - Bioavailability Factor
BAF - Bioaccumulation Factor
BCF - Bioconcentration Factor
SUF - Seasonal Use Factor
AUF - Area Use Factor

[1] Al (Voigt et al. 2015), mean of fish tissue BAFs; Cu (USEPA 1980); Environmental Restoration Division - Manual ERD-AG-003 1999.
[2] Bioavailability is set to a default of 100% to be conservative and protective of ecological receptors.

Table 9
Hazard Quotients for COPCs - Aquatic Receptors
Ecological Exposure Area 1
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

Analyte	Wildlife Receptor Hazard Quotient Estimated using the 'No Observed Adverse Effects Level'			
	Aquatic			
	Mallard Duck	Great Blue Heron	Muskrat	River Otter
Aluminum	4.25E-02	5.29E-05	**2.02E+00**	3.03E-03
Barium	8.47E-04		2.66E-03	
Boron	1.65E-04	1.17E-03	1.25E-01	1.01E-03
Cadmium	2.23E-07	6.10E-05	3.15E-04	8.94E-05
Lead	1.03E-06	1.69E-03	2.65E-04	4.48E-04
Manganese	2.30E-06	5.02E-03	5.93E-03	1.34E-02
Mercury	2.03E-09	1.74E-04	4.84E-06	1.72E-03
Selenium	3.75E-05	4.69E-04	5.63E-02	2.67E-03
Zinc	8.01E-07	1.09E-03	5.20E-04	2.93E-03

Analyte	Wildlife Receptor Hazard Quotient Estimated using the 'Lowest Observed Adverse Effects			
	Aquatic			
	Mallard Duck	Great Blue Heron	Muskrat	River Otter
Aluminum	4.25E-03	5.29E-06	2.02E-01	3.03E-04
Barium	4.23E-04		1.83E-03	
Boron	4.74E-05	3.36E-04	3.75E-02	3.01E-04
Cadmium	1.38E-07	3.79E-05	2.43E-05	6.88E-06
Lead	5.16E-07	8.43E-04	1.40E-04	2.36E-04
Manganese	1.18E-06	2.58E-03	4.30E-03	9.69E-03
Mercury	1.78E-08	1.53E-03	3.06E-05	1.08E-02
Selenium	1.88E-05	2.35E-04	3.74E-02	1.78E-03
Zinc	7.96E-07	1.09E-03	5.17E-04	2.91E-03

NOTES:
Hazard Quotients greater than or equal to 1 are highlighted in gray and in boldface.
NM - Not measured due to lack of a Toxicity Reference Value

Table 1
Exposure Parameters for Ecological Receptors
Ecological Exposure Area 3
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

	Parameter	Body Weight	Food Ingestion Rate	Water Ingestion Rate	Dietary Composition						Home Range	Seasonal Use Factor[j]
					Plants	Mammal/Terr. Vertebrates	Fish	Invertebrates	Birds	Soil		
	Algorithm ID	BW	IR_F	IR_W	P_F	A_M	A_F	A_I	A_B	S_F	HR	SUF
	Units	kg	kg/kg BW/day	L/kg BW/day	%	%	%	%	%	%	hectares	unitless
Ecological Receptors	HERBIVORE											
	Meadow Vole[a]	0.033	0.33	0.21	97.6%	0%	0%	0%	0%	2.4%	0.027	1
	Muskrat[b]	1.17	0.3	0.97	99.3%	0%	0%	0%	0%	0.7%	0.13	1
	OMNIVORE											
	Mallard Duck[c]	1.134	0.068	0.057	48.3%	0%	0%	48.3%	0%	3.3%	435	1
	American Robin[d]	0.08	0.129	0.14	40%	0%	0%	58%	0%	2%	0.42	1
	CARNIVORE											
	Red-Tailed Hawk[e]	1.06	0.18	0.058	0%	91.5%	0%	0%	8.5%	0%	876	1
	Red Fox[g]	4.54	0.16	0.085	6%	89%	0%	2%	0%	3%	1226	1
	PISCIVORE											
	River Otter[h]	6.76	0.19	0.081	0%	0%	100%	0%	0%	0%	348	1
	Great Blue Heron[i]	2.229	0.18	0.045	0%	0%	90%	9.5%	0%	0.5%	227	1

NOTES:

BW - Body Weight
kg - Kilograms
IR - Ingestion Rate
HR - Home Range
SUF - Seasonal Use Factor

P_F - Plant Matter Ingestion Percentage
A_M - Mammal/Terrestrial Vertebrate ingestion percentage
A_F - Fish Ingestion Percentage
A_B - Bird Ingestion Percentage
S_F - Soil Ingestion Percentage

kg/kg BW/day - Kilograms Food per Kilograms Body Weight per Day
L/kg BW/day - Liters Water per Kilogram Body Weight per Day

[a] BW, IR_f, IR_w, P_F, HR from USEPA 1993 (sections 2-328 and 2-329); S_F from Sample and Suter 1994
[b] BW, IR_f, IR_w, P_F, HR from USEPA 1993 (sections 2-340 and 2-341); S_F from TechLaw Inc. 2013; IR_F from Nagy 2001
[c] BW, P_F, A_I, HR from USEPA 1993 (sections 2-43 and 2-45); S_F from Beyer et al. 1994; IR_F from Nagy 2001
[d] BW, P_F, A_I, HR from USEPA 1993 (sections 2-197 and 2-198); S_F from Sample and Suter 1994; IR_F from Nagy 2001
[e] BW, P_F, A_M, A_B, IR_F, HR from USEPA 1993 (sections 2-82 and 2-83)
[f] BW, P_F, A_F, A_M, A_B, HR from USEPA 1993 (sections 2-91 and 2-97); IR_F from Nagy 2001
[g] BW, P_F, A_F, A_I, HR from USEPA 1993 (sections 2-224 and 2-225); S_F from Beyer et al. 1994
[h] BW, IR_w, A_F, HR from USEPA 1993 (sections 2-264 and 2-266); S_F from Sample and Suter 1994; IR_F from Nagy 2001
[i] BW, P_F, A_F, A_I, HR from USEPA 1993 (sections 2-8 and 2-9); S_F from Sample and Suter 1994; IR_F from Nagy 2001
[j] Seasonal Use Factor is set to a default of 1 to be overly conservative and protective of ecological receptors.

Table 2
Toxicity Reference Values for Ecological Receptors
Ecological Exposure Area 3
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

Analyte	TRVs (NOAEL)							
	Aquatic				Terrestrial			
	Mallard Duck (mg/kg/day)	Great Blue Heron (mg/kg/day)	Muskrat (mg/kg/day)	River Otter (mg/kg/day)	American Robin (mg/kg/day)	Red-Tailed Hawk (mg/kg/day)	Meadow Vole (mg/kg/day)	Red Fox (mg/kg/day)
Aluminum[a]	110	110	1.93	1.93	110	110	1.93	1.93
Antimony[a]	NA	NA	0.059	0.059	NA	NA	0.059	0.059
Arsenic[b]	2.24	2.24	1.04	1.04	2.24	2.24	1.04	1.04
Barium[c]	20.8	20.8	51.8	51.8	20.8	20.8	51.8	51.8
Beryllium[a]	NA	NA	0.532	0.532	NA	NA	0.532	0.532
Boron[a, b]	28.8	28.8	28	28	28.8	28.8	28	28
Cadmium[a]	1.47	1.47	0.77	0.77	1.47	1.47	0.77	0.77
Calcium	EN	EN	EN	EN	EN	EN	EN	EN
Chromium, Total[d]	1	1	2740	2740	1	1	2740	2740
Chromium VI (hexavalent)[a]	NA	NA	9.24	9.24	NA	NA	9.24	9.24
Chromium III[a]	2.66	2.66	2.4	2.4	2.66	2.66	2.4	2.4
Cobalt[a]	7.61	7.61	7.33	7.33	7.61	7.61	7.33	7.33
Copper[a]	4.05	4.05	5.6	5.6	4.05	4.05	5.6	5.6
Iron	EN	EN	EN	EN	EN	EN	EN	EN
Lead[b]	1.63	1.63	4.7	4.7	1.63	1.63	4.7	4.7
Magnesium	EN	EN	EN	EN	EN	EN	EN	EN
Manganese[a]	179	179	51.5	51.5	179	179	51.5	51.5
Mercury[e]	3.25	3.25	1.01	1.01	3.25	3.25	1.01	1.01
Molybdenum[a, d]	3.53	3.53	0.26	0.26	3.53	3.53	0.26	0.26
Nickel[a]	6.71	6.71	1.7	1.7	6.71	6.71	1.7	1.7
Potassium	EN	EN	EN	EN	EN	EN	EN	EN
Selenium[a]	0.29	0.29	0.143	0.143	0.29	0.29	0.143	0.143
Sodium	EN	EN	EN	EN	EN	EN	EN	EN
Strontium[a, d]	NA	NA	263	263	NA	NA	263	263
Thallium[a]	NA	NA	0.015	0.015	NA	NA	0.015	0.015
Titanium	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium[a]	0.344	0.344	4.16	4.16	0.344	0.344	4.16	4.16
Zinc[a]	66.1	66.1	75.4	75.4	66.1	66.1	75.4	75.4
Nitrate[d]	NA	NA	507	507	NA	NA	507	507

Table 2 (Cont.)

Analyte	TRVs (LOAEL)							
	Aquatic				Terrestrial			
	Mallard Duck (mg/kg/day)	Heron (mg/kg/day)	Muskrat (mg/kg/day)	River Otter (mg/kg/day)	Robin (mg/kg/day)	Hawk (mg/kg/day)	Meadow Vole (mg/kg/day)	Red Fox (mg/kg/day)
Aluminum[a]	1100	1100	19.3	19.3	1100	1100	19.3	19.3
Antimony[a]	NA	NA	0.59	0.59	NA	NA	0.59	0.59
Arsenic[b]	40.3	40.3	1.66	1.66	40.3	40.3	1.66	1.66
Barium[c]	41.7	41.7	75	75	41.7	41.7	75	75
Beryllium[a]	NA	NA	6.6	6.6	NA	NA	6.6	6.6
Boron[a, b]	100	100	93.6	93.6	100	100	93.6	93.6
Cadmium[a]	2.37	2.37	10	10	2.37	2.37	10	10
Calcium	EN	EN	EN	EN	EN	EN	EN	EN
Chromium, Total[d]	5	5	27400	27400	5	5	27400	27400
Chromium VI (hexavalent)[a]	NA	NA	40	40	NA	NA	40	40
Chromium III[a]	2.66	2.66	9.625	9.625	2.66	2.66	9.625	9.625
Cobalt[a]	7.8	7.8	10.9	10.9	7.8	7.8	10.9	10.9
Copper[a]	12.1	12.1	9.34	9.34	12.1	12.1	9.34	9.34
Iron	EN	EN	EN	EN	EN	EN	EN	EN
Lead[b]	3.26	3.26	8.9	8.9	3.26	3.26	8.9	8.9
Magnesium	EN	EN	EN	EN	EN	EN	EN	EN
Manganese[a]	348	348	71	71	348	348	71	71
Mercury[e]	0.37	0.37	0.16	0.16	0.37	0.37	0.16	0.16
Molybdenum[a, d]	35.3	35.3	2.6	2.6	35.3	35.3	2.6	2.6
Nickel[a]	11.5	11.5	3.4	3.4	11.5	11.5	3.4	3.4
Potassium	EN	EN	EN	EN	EN	EN	EN	EN
Selenium[a]	0.579	0.579	0.215	0.215	0.579	0.579	0.215	0.215
Sodium	EN	EN	EN	EN	EN	EN	EN	EN
Strontium[a, d]	NA	NA	2630	2630	NA	NA	2630	2630
Thallium[a]	NA	NA	0.075	0.075	NA	NA	0.075	0.075
Vanadium[a]	0.688	0.688	8.31	8.31	0.688	0.688	8.31	8.31
Zinc[a]	66.5	66.5	75.9	75.9	66.5	66.5	75.9	75.9
Nitrate[d]	NA	NA	1130	1130	NA	NA	1130	1130

NOTES:

NOAEL - No Observed Adverse Effects Level

LOAEL - Lowest Observed Effects Level

EN - Essential nutrient

NA - Not available

TRV - Toxicity Reference Value

[a] CH2M Hill. 2014. Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site. CHPRC-01311. Revision 2. July. Http://pdw.hanford.gov/arpir/pdf.cfm?accession=0088115

[b] USEPA 2005 EcoSSL

[c] Only a single paper (Johnson et al., 1960) with data on the toxicity of barium hydroxide to one avian species (chicken) was identified by USEPA (2005); therefore, an avian TRV could not be derived and an Eco-SSL could not be calculated for avian wildlife (calculation requires a minimum of three results for two test species). Johnson et al. (1960) reports a subchronic NOAEL of 208.26 mg/kg/d. The NOAEL was multiplied by an uncertainty factor of 0.1 to derive a very conservative TRV of 20.8 mg/kg/d.

[d] Sample et al. 1996

Table 3
Exposure Area and Area Use Factors for Ecological Receptors
Ecological Exposure Area 3
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

Exposure Point	Exposure Area[a] (hectares)	Area Use Factor (AUF)							
		Mallard Duck	Great Blue Heron	Muskrat	River Otter	American Robin	Red-Tailed Hawk	Meadow Vole	Red Fox
Ecological Exposure Area 3	8.9	2.05%	3.92%	100%	2.56%	100%	1.016%	100%	0.73%

NOTES:

[a] Ecological Exposure Area 3 is to the east of the ash basin and Pine Hall Road. It is comprised of the shoreline of Belews Reservoir.

Table 4
Exposure Point Concentrations
Ecological Exposure Area 3
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

		Aquatic EPCs[a, b]	
COPC	**CASRN**	**Sediment EPC Used in Risk Assessment[c] (mg/kg)**	**Surface Water EPC Used in Risk Assessment (mg/L)**
Aluminum	7429-90-5		0.1311000
Arsenic	7440-38-2	12	
Barium	7440-39-3	46	
Copper	7440-50-8		0.0015730
Manganese	7439-96-5		0.0568400

Prepapred by: TPC Checked by: HES

NOTES:
COPC - Constituent of Potential Concern
CASRN - Chemical Abstracts Service Registration Number
EPC - Exposure Point Concentration
[a] EPCs for Belews Reservoir sediment are based on maximum detected values. EPCs for surface water are based on 95% UCL calculations.
[b] EPCs are used for aquatic receptors in the area adjacent to and in Belews Reservoir. EPCs for terrest
[c] Analysis of solids (i.e., soil and sediment) was reported as dry weight.

Table 5
Calculation of Average Daily Doses for Mallard Duck
Ecological Exposure Area 3
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

Analyte	EPC_w COPEC in Water (mg/L)	EPC_s COPEC in Solid (mg/kg)	Slope, or Plant Uptake (BAF)	Intercept	EPC_p Estimated[1] Concentration in Vegetation (mg/kg dry)	Slope, or Invertebrate Uptake (BAF)	Intercept	EPC_i Estimated[2] Concentration in Invertebrates (mg/kg dry)
Aluminum	0.1311		0.0008		0.0000	1		0.00
Arsenic		12	0.564	-1.992	0.5540	0.143		1.72
Barium		46	0.03		1.3800	1		46.00
Copper	0.0016					1.556		0.00
Manganese	0.0568		0.050					

AVERAGE DAILY DOSE VIA:

Analyte	WATER		PLANTS/VEGETATION				INVERTEBRATES		
	NIR_w Water Ingestion Rate (L/kg BW/day)	ADD_W Unadjusted Average Daily Dose Water (mg/kg/day)	P_f Fraction Diet Plant Matter (percent)	NIR_f Food Ingestion Rate, Wet (kg/kg BW/day)	NIR_p Plant Ingestion Rate, Dry (kg/kg BW/day)	ADD_p Unadjusted Average Daily Dose Plant (mg/kg/day)	A_f Fraction Diet Invertebrates (percent)	NIR_a Invertebrates Ingestion Rate (kg dry/kg BW/day)	ADD_a Unadjusted Average Daily Dose Invertebrates (mg/kg/day)
Aluminum	0.057	0.007	48%	0.068	0.0049	0.000000	48%	0.007	0.0000
Arsenic	0.057	0.00000	48%	0.068	0.0049	0.002730	48%	0.007	0.0124
Barium	0.057	0.000	48%	0.068	0.0049	0.006799	48%	0.007	0.3324
Copper	0.057	0.00009	48%	0.068	0.0049	0.000000	48%	0.007	0.0000
Manganese	0.057	0.003	48%	0.068	0.0049	0.000000	48%	0.007	0.0000

Analyte	SOIL							
	S_f Fraction Diet Soil (percent)	NIR_s Soil Ingestion3 Rate (kg dry/kg BW/day)	ADD_s Unadjusted Average Daily Dose Soil (mg/kg/day)	BF Bioavailability[3] (percent)	ADD_t Omnivore Intake (mg/kg/day)	SUF Seasonal Use Factor (unitless)	AUF Area Use Factor (Exposure Area/Home Range)	ADD_{tot} Adjusted Total Omnivore Average Daily Dose (mg/kg/day)
Aluminum	3.3%	0.00029	0.00000	100%	0.01	1	0.020	0.000153
Arsenic	3.3%	0.00029	0.00350	100%	0.01863	1	0.020	0.000381
Barium	3.3%	0.00029	0.01342	100%	0.3526	1	0.020	0.007214
Copper	3.3%	0.00029	0.00000	100%	0.00	1	0.020	0.000002
Manganese	3.3%	0.00029	0.00000	100%	0.00	1	0.020	0.000066

NOTES:

EPC - Exposure Point Concentration
NIR - Normalized Ingestion Rate
ADD - Average Daily Dose
BF - Bioavailability Factor
BAF - Bioaccumulation Factor
BCF - Bioconcentration Factor
SUF - Seasonal Use Factor
AUF - Area Use Factor

[1] Bechtel Jacobs Company 1998a; Baes et al. 1984 (Mo); Environmental Restoration Division - Manual ERD-AG-003 1999; default value of 1 is used for constituents for which a BAF could not be found.

[2] Bechtel Jacobs Company 1998b, Table 2, median BAFs for sediment to benthic invertebrates for As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn; Sample et al. 1998b (earthworms) for Mn; default value of 1 is used for constituents for which a BAF could not be found.

[3] Bioavailability is set to a default of 100% to be conservative and protective of ecological receptors.

Table 6
Calculation of Average Daily Doses for Great Blue Heron
Ecological Exposure Area 3
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

								AVERAGE DAILY DOSE VIA: WATER		FISH				INVERTEBRATES							
	EPC_w	EPC_s		EPC_{fish}			EPC_i	NIR_w	ADD_w	A_f	NIR_f	NIR_a	ADD_a	A_f	NIR_a	ADD_a	BF	ADD_t	SUF	AUF	ADD_{tot}
Analyte	COPEC in Water (mg/L)	COPEC in Solid (mg/kg)	Fish Uptake (BCF)	Estimated[1] Concentration in Fish (mg/kg)	Slope, or Invertebrate Uptake (BAF)	Intercept	Estimated[2] Concentration in Invertebrates (mg/kg dry)	Water Ingestion Rate (L/kg BW/day)	Unadjusted Average Daily Dose Water (mg/kg/day)	Fraction Diet Animal Matter (percent)	Food Ingestion Rate, Wet (kg/kg BW/day)	Fish Ingestion Rate (kg/kg BW/day)	Unadjusted Average Daily Dose (mg/kg/day)	Fraction Diet Invertebrates (percent)	Invertebrates Ingestion Rate (kg dry/kg BW/day)	Unadjusted Average Daily Dose Invertebrates (mg/kg/day)	Bioavailability[3] (percent)	Piscivore Intake (mg/kg/day)	Seasonal Use Factor (unitless)	Area Use Factor (Exposure Area/Home Range)	Adjusted Total Piscivore Average Daily Dose (mg/kg/day)
Aluminum	0.1311		0.1	0.01	1		0.13	0.045	0.006	90%	0.18	0.162	0.002	10%	0.004	0.0005	100%	0.01	1	0.039	0.000
Arsenic		12	280	0.00	0.143		0.00	0.045	0.000	90%	0.18	0.162	0.000	10%	0.004	0.0000	100%	0.00000	1	0.039	0.000
Barium		46	4	0.00	1		0.00	0.045	0.000	90%	0.18	0.162	0.000	10%	0.004	0.0000	100%	0.00000	1	0.039	0.000
Copper	0.0016		50	0.08	1.556		0.00	0.045	0.000	90%	0.18	0.162	0.013	10%	0.004	0.0000	100%	0.013	1	0.039	0.001
Manganese	0.0568		400	22.74	0.682	-0.809	0.06	0.045	0.003	90%	0.18	0.162	3.683	10%	0.004	0.0002	100%	3.69	1	0.039	0.145

NOTES:

EPC - Exposure Point Concentration
NIR - Normalized Ingestion Rate
ADD - Average Daily Dose
BF - Bioavailability Factor
BAF - Bioaccumulation Factor
BCF - Bioconcentration Factor
SUF - Seasonal Use Factor
AUF - Area Use Factor

[1] Al (Voigt et al. 2015), mean of fish tissue BAFs; Cu (USEPA 1980); Environmental Restoration Division - Manual ERD-AG-003 1999.

[2] Bechtel Jacobs Company 1998b, Table 2, median BAFs for sediment to benthic invertebrates for As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn; Sample et al. 1998b (earthworms) for Mn; default value of 1 is used for constituents for which a BAF could not be found.

[3] Bioavailability is set to a default of 100% to be conservative and protective of ecological receptors.

Table 7
Calculation of Average Daily Doses for Muskrat
Ecological Exposure Area 3
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

						AVERAGE DAILY DOSE VIA:														
						WATER		PLANTS / VEGETATION				SOIL								
	EPC_w	EPC_s			EPC_p	NIR_W	ADD_w	P_f	NIR_f	NIR_p	ADD_p	S_f	NIR_s	ADD_s	BF	ADD_t	SUF	AUF	ADD_{tot}
Analyte	COPEC in Water (mg/L)	COPEC in Solid (mg/kg)	Slope, or Plant Uptake (BAF)	Intercept	Estimated[1] Concentration in Vegetation (mg/kg dry)	Water Ingestion Rate (L/kg BW/day)	Unadjusted Average Daily Dose Water (mg/kg/day)	Fraction Diet Plant Matter (percent)	Food Ingestion Rate, Wet (kg/kg BW/day)	Plant Ingestion Rate, Dry (kg/kg/day)	Unadjusted Average Daily Dose Plant (mg/kg/day)	Fraction Diet Soil (percent)	Soil Ingestion Rate (kg dry/kg BW/day)	Unadjusted Average Daily Dose Soil (mg/kg/day)	Bioavailability[2] (percent)	Herbivore Intake (mg/kg/day)	Seasonal Use Factor (unitless)	Area Use Factor (Exposure Area/Home Range)	Adjusted Total Herbivore Average Daily Dose (mg/kg/day)
Aluminum	0.1311		0.0008		0.0000	0.97	0.13	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	0.13	1	1	0.13
Arsenic		12	0.564	-1.992	0.5540	0.97	0.00	99%	0.3	0.045	0.02476	1%	0.000273	0.00043	100%	0.03	1	1	0.03
Barium		46	0.03		1.3800	0.97	0.00	99%	0.3	0.045	0.06167	1%	0.000273	0.00163	100%	0.06	1	1	0.06
Copper	0.0016					0.97	0.00	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	0.00	1	1	0.00
Manganese	0.0568		0.050		0.0	0.97	0.06	99%	0.3	0.045	0.00000	1%	0.000273	0.00000	100%	0.06	1	1	0.06

NOTES:

EPC - Exposure Point Concentration
NIR - Normalized Ingestion Rate
ADD - Average Daily Dose
BF - Bioavailability Factor
BAF - Bioaccumulation Factor
BCF - Bioconcentration Factor
SUF - Seasonal Use Factor
AUF - Area Use Factor

[1] Bechtel Jacobs Company 1998a; Baes et al. 1984 (Mo); Environmental Restoration Division - Manual ERD-AG-003 1999; default value of 1 is used for constituents for which a BAF could not be found.

[2] Bioavailability is set to a default of 100% to be conservative and protective of ecological receptors.

Table 8
Calculation of Average Daily Doses for River Otter
Ecological Exposure Area 3
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

					AVERAGE DAILY DOSE VIA:										
					DRINKING WATER		FISH								
	EPC_w	EPC_s		EPC_{PREY}	NIR_w	ADD_w	P_f	NIR_f	NIR_a	ADD_a	BF	ADD_t	SUF	AUF	ADD_{tot}
Analyte	COPEC in Water (mg/L)	COPEC in Solid (mg/kg)	Fish Uptake (BCF)	Estimated[1] Concentration in Fish (mg/kg)	Water Ingestion Rate (L/kg BW/day)	Unadjusted Average Daily Dose Water (mg/kg/day)	Fraction Diet Animal Matter (percent)	Food Ingestion Rate, Wet (kg/kg BW/day)	Fish Ingestion Rate (kg/kg BW/day)	Unadjusted Average Daily Dose (mg/kg/day)	Bioavailability[2] (percent)	Piscivore Intake (mg/kg/day)	Seasonal Use Factor (unitless)	Area Use Factor (Exposure Area/Home Range)	Adjusted Total Piscivore Average Daily Dose (mg/kg/day)
Aluminum	0.131		0.1	0.01	0.081	0.011	100%	0.19	0.19	0.0025	100%	0.013	1	0.026	0.000335
Arsenic		12	280	0.00	0.081	0.000	100%	0.19	0.19	0.000	100%	0.000	1	0.026	0.000000
Barium		46	4	0.00	0.081	0.000	100%	0.19	0.19	0.000	100%	0.000	1	0.026	0.000000
Copper	0.002		50	0.08	0.081	0.000	100%	0.19	0.19	0.015	100%	0.015	1	0.026	0.000385
Manganese	0.057		400	22.74	0.081	0.005	100%	0.19	0.19	4.32	100%	4.324	1	0.026	0.110596

NOTES:

EPC - Exposure Point Concentration
NIR - Normalized Ingestion Rate
ADD - Average Daily Dose
BF - Bioavailability Factor
BAF - Bioaccumulation Factor
BCF - Bioconcentration Factor
SUF - Seasonal Use Factor
AUF - Area Use Factor

[1] Al (Voigt et al. 2015), mean of fish tissue BAFs; Cu (USEPA 1980); Environmental Restoration Division - Manual ERD-AG-003 1999.
[2] Bioavailability is set to a default of 100% to be conservative and protective of ecological receptors.

Table 9
Hazard Quotients for COPCs - Aquatic Receptors
Ecological Exposure Area 3
Baseline Ecological Risk Assessment
Duke Energy Carolinas
Belews Creek Steam Station

Analyte	**Wildlife Receptor Hazard Quotient Estimated using the 'No Observed Adverse Effects Level'**			
	Aquatic			
	Mallard Duck	**Great Blue Heron**	**Muskrat**	**River Otter**
Aluminum	1.39E-06	3.04E-06	6.59E-02	1.74E-04
Arsenic	1.70E-04		2.42E-02	
Barium	3.47E-04		1.22E-03	
Copper	4.53E-07	1.24E-04	2.72E-04	6.88E-05
Manganese	3.70E-07	8.07E-04	1.07E-03	2.15E-03

Analyte	**Wildlife Receptor Hazard Quotient Estimated using the 'Lowest Observed Adverse Effects**			
	Aquatic			
	Mallard Duck	**Great Blue Heron**	**Muskrat**	**River Otter**
Aluminum	1.39E-07	3.04E-07	6.59E-03	1.74E-05
Arsenic	9.46E-06		1.52E-02	
Barium	1.73E-04		8.44E-04	
Copper	1.52E-07	4.15E-05	1.63E-04	4.13E-05
Manganese	1.90E-07	4.15E-04	7.77E-04	1.56E-03

NOTES:
Hazard Quotients greater than or equal to 1 are highlighted in gray and in boldface.
NM - Not measured due to lack of a Toxicity Reference Value

Appendix C

Exposure Modeling and Human Health Risk Assessment for Diesel Emissions

Air Dispersion Modeling for BCSS Ash Basin Closure

I used screening models to evaluate the potential for both cancer and non-cancer risks from diesel exhaust emissions due to increased trucking operations related to the closure of the coal ash basin at the Duke Energy Belews Creek Steam Station (BCSS). The calculated cancer and non-cancer risks are associated with increased diesel trucking activity near residential properties that lie along transportation corridors near BCSS. Modelling was conducted for the cap in place (CIP) closure scenario, the excavation closure scenario, and the hybrid closure scenario. Details of these scenarios are provided in the main body of the report.

Emission rates for the fleet of diesel trucks operating as part of closure activities were calculated based on truck activity and emission factors representative of the region from the U.S. Environmental Protection Agency (EPA) Mobile Vehicle Emissions Simulator (MOVES). I estimated airborne concentrations of emitted pollutants using the EPA model AERMOD for atmospheric dispersion and transport. AERMOD is a Gaussian plume model that accounts for the impacts of meteorology and land characteristics on airborne pollutants. Together these tools allowed for the estimation of airborne concentrations of diesel particulate matter (DPM) emitted from passing trucks and subsequent calculation of potential non-cancer health impacts (hazard index [HI]) and cancer risk estimates (excess lifetime cancer risk [ELCR]).

The following sections detail the data and models used in this evaluation, including the meteorological data, trucking operations, emissions calculations, and dispersion modeling. I also include additional discussion of the results and associated uncertainties.

Methodology

Meteorological Data

AERMOD-ready five-year[1] meteorological data sets of hourly surface meteorological data for the years 2012–2016 were generated from the National Weather Service (NWS) Automated Surface Observing System (ASOS) station at the Piedmont Triad International Airport (KGSO) in Greensboro, North Carolina.[2] The Piedmont Triad International Airport is located approximately 22 km from BCSS. I judged this station to be representative of the meteorology in the region of BCSS. Surface parameters applied to the modeling study included wind speed and direction, temperature, pressure, relative humidity, and cloud cover. Twice daily rawinsonde[3] observations of upper air winds and temperatures were also taken from Piedmont Triad International Airport (KGSO), which is the closest upper air sounding site.

The meteorological data were processed using AERMET (v16216) with default options.[4] To better resolve lower wind speeds and avoid overestimating calm conditions, AERMINUTE was also applied.[5] AERSURFACE[6] was used to define the land-use characteristics in the region around the surface observational site (i.e., Piedmont Triad International Airport). The surface

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1 Use of five years of meteorological data is standard in regulatory application of AERMOD (EPA Guideline on Air Quality Models, Section 8.3.1, 2005).

2 Integrated surface hourly weather observations are available at ftp://ftp.ncdc.noaa.gov/pub/data/noaa/. 2-minute average ASOS wind data are available at ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/.

3 A rawinsonde is a device typically carried by weather balloons that collects meteorological and atmospheric data, especially winds.

4 AERMET is an EPA program that will read standard recorded meteorological observations, calculate boundary layer meteorological parameters, and output the data in a format readable by the AERMOD model (U.S. EPA 2016).

5 Because the Piedmont Triad International Airport has an ASOS where 2-minute average wind direction and wind speed data are recorded every minute, it was possible to use AERMINUTE with AERMOD. More frequent measurements of wind data allow for better resolution of wind characteristics.

6 AERSURFACE is the EPA model used to calculate average land-use characteristics. It can read standard databases and calculate the average values of surface roughness, albedo, and Bowen ratios, consistent with EPA recommended methods.

characteristics, which are important when calculating the level of atmospheric dispersion in meteorological modeling, include surface roughness, albedo,[7] and Bowen ratios.[8]

Trucking Operations

Diesel emissions estimates from trucking are based on the number of trucks passing a given receptor location along offsite transportation corridors used during ash basin closure. The total number of truckloads required for transporting earthen fill and geosynthetic materials under the BCSS closure scenarios were projected by Duke Energy (2018). Ash was not transported offsite in any scenario. These truckloads equate to 22,140 total truck passes for the CIP scenario, 28,752 total truck passes for the excavation scenario and 21,972 truck passes for the hybrid scenario. Additional loads of onsite trucks hauling ash, over-excavated soil,[9] and earthen fill were not included. I included only loads hauling earthen fill, geosynthetic materials, and other materials in transportation emissions estimates for all scenarios because trucks hauling ash do not leave the BCSS Plant. Trucks hauling earthen fill are assumed to travel 11 miles one way from the site, and trucks hauling geosynthetic material produced by ARGU America, Inc. are assumed to travel 235 miles one way from Georgetown, South Carolina. Air modeling is conducted for a receptor along the transportation route within the 11-mile radius traveled both by trucks hauling earthen fill and trucks hauling geosynthetic material. Trucks are assumed to travel in round trips, so the number of material loads was doubled to represent the number of truck passes.

AERMOD

The AERMOD modeling system (U.S. EPA 2016) is a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of surface and elevated sources. EPA's "Guideline on Air Quality

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[7] Albedo is the ratio of reflected flux density to incident flux density. It indicates how much incoming energy is absorbed by the land surface. Light surfaces (such as snow) will reflect higher levels of incoming energy.

[8] The Bowen ratio is the ratio of sensible to latent heat fluxes from the earth's surface up into the air. A lower Bowen ratio indicates greater water content in the land surface.

[9] The 12 in. of soil beneath the ash that would also be removed as part of excavation.

Models" (U.S. EPA 2016) identifies AERMOD as the preferred refined dispersion modeling technique for receptors within 50 km of a modeled source.

The latest version of AERMOD (v16216r) was used with default options to conduct the modeling.

Modeled Source and Receptors

AERMOD was configured to simulate an approximately 1-km stretch of road. This road segment was assumed representative of any segment along the proposed transportation corridors. The road emission source was modeled as a continuous distribution of emission along the road due to the passage of multiple trucks. In the cross-road direction, the emissions drop off based on a normal (or Gaussian) distribution. The road emissions were represented using a line of closely spaced volume sources running down the center of the road. Volume sources define the initial pollutant distribution based on an initial release height and the standard deviation of the normal distribution in both the vertical and horizontal directions (sigma-y and sigma-z). The appropriate values for the release height and standard deviations were calculated based on guidance in EPA's Haul Road Working Group Final Report (U.S. EPA 2010).

Transport and dispersion of pollutants away from the road segment may be sensitive to the predominant wind directions at the site and the orientation of the road compared to those predominant wind directions. To fully evaluate the impacts of any road segment, four orientations of the road were considered. Modeled orientations included roads running North/South, East/West, Northeast/Southwest, and Northwest/Southeast. For each modeled road orientation, receptors were included on both sides of the road to represent impacts at distances between 10 and 150 m from the edge of the road. The representative road segments and sampling receptor locations are shown in Figure C-1.

AERMOD was run for the five-year period (2012–2016) defined by the meteorological data. The resulting five-year average dispersion factors were assumed representative of long-term average dispersion of truck roadway emissions along roads in this region.

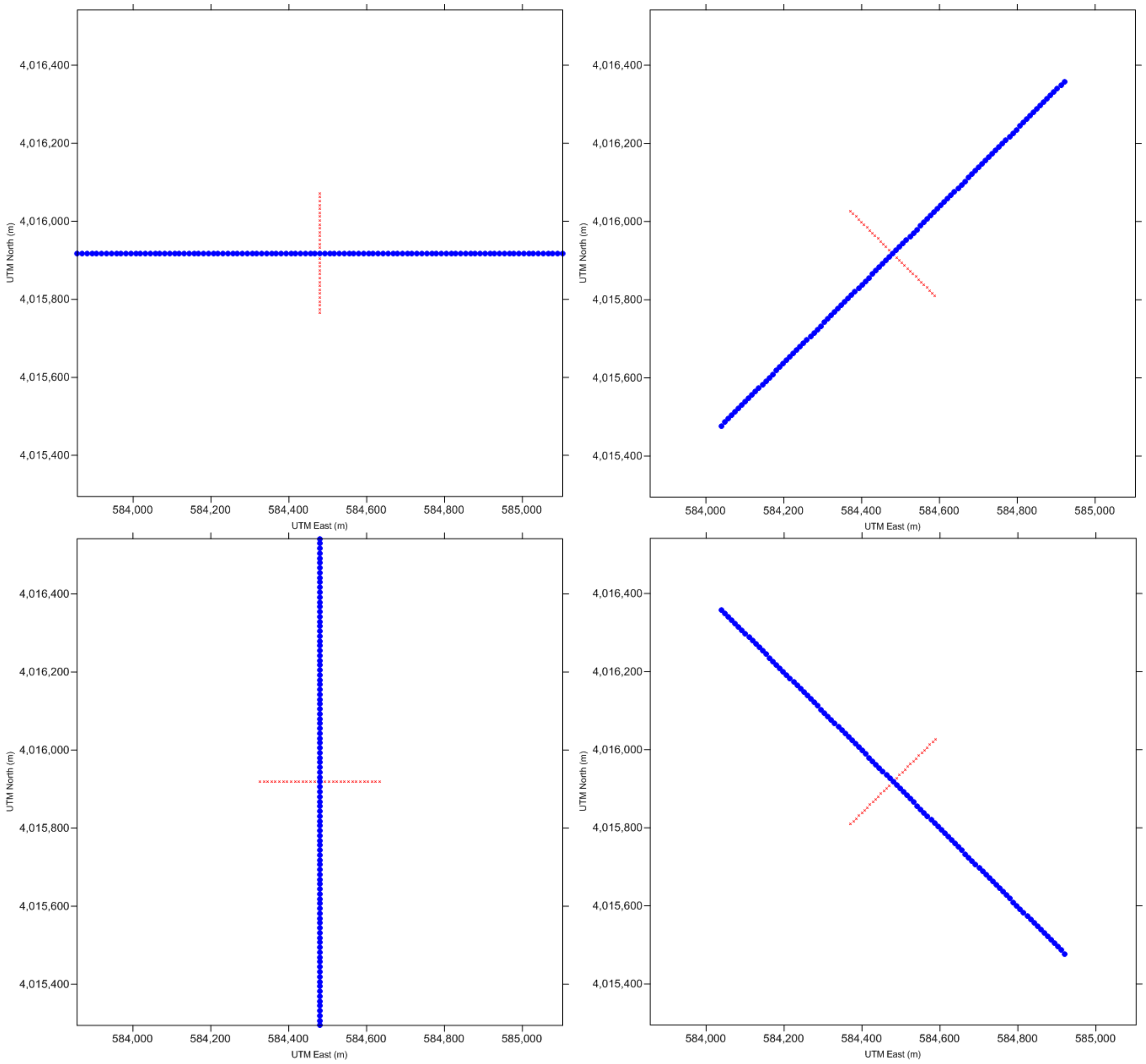

Figure C-1. Location of road sources (blue) and sampling receptors (red) for each of 4 road orientations

Source Emission Rates

Emission rates for mobile sources are typically calculated based on a combination of emission factors and activity rates. The emission factors define the amount of pollutant emitted per unit distance traveled (grams of pollutant per kilometer traveled), and the activity rates define how much activity occurs (i.e., the number of kilometers driven by the vehicles). Emission factors will be specific to the type of vehicle being considered, the model year, the age of the vehicle, and the local climate. For this evaluation, EPA's MOVES model was used to define fleet average emission factors for various years between 2018 and 2050 (2050 is the last year simulated by MOVES) (U.S. EPA 2015). These emission factors are specific to North Carolina and have been selected to represent large, single-unit diesel trucks.

Tailpipe emissions from diesel trucks (DPM) are the subset of PM_{10} of particular interest when evaluating the cancer and non-cancer risk estimates in this analysis. The DPM emission factors generated by MOVES were multiplied by the expected number of trucks under each of the considered scenarios to calculate emission rates for each scenario.

For the cancer risk analysis, emissions were calculated as an average over the regulatory default 70-year residential exposure duration. If the truck activity for a scenario occurs over a shorter period, the duration of the truck activity exposure is factored into the 70-year averaging time (OEHHA 2015). These average emission rates were multiplied by the dispersion factors calculated by AERMOD to predict airborne concentrations. The resulting values were then multiplied by the cancer unit risk factor[10] to quantify cancer risk.

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[10] A "reasonable estimate" for the inhalation unit risk of 3.0×10^{-4} $(\mu g/m^3)^{-1}$ was applied based on California guidelines (OEHHA 2015).

For the non-cancer analysis, airborne concentrations of DPM were calculated and compared to the non-cancer risk threshold of 5 $\mu g/m^3$.[11] In this case, the average concentrations are not tied to a 70-year period and are calculated over the period of operation for each scenario.

[11] North Carolina defers to EPA's chronic non-cancer reference concentration (RfC) for diesel particulate matter of 5 $\mu g/m^3$ based on diesel engine exhaust to estimate risk from diesel emissions (Integrated Risk Information System [IRIS]. U.S. EPA. Diesel engine exhaust).

Uncertainties

A number of uncertainties should be considered when evaluating the modeled results. First, air dispersion modeling is a mathematical calculation of pollutant transport and dispersion and may differ from real world conditions. Typically, for regulatory applications, air dispersion models are expected to predict concentrations within a factor of two (40 CFR Part 51). Longer averaging periods, such as those used in this study, would often have lower uncertainties compared with shorter average periods such as 1-hour or 24-hour averages.

The calculation of emission factors is meant to represent fleet average characteristics. The fleet of trucks used at this specific site may differ from the average values included in MOVES. This may result in higher or lower actual emission rates. Additionally, MOVES includes predictions of future year emission factors based on typical patterns of vehicle turnover and any regulations scheduled to be implemented in future years. Not all future regulations are presently known and future conditions may vary from these estimates.

For the non-cancer risk, an evaluation of the average concentrations was calculated over the actual period of activity, which varies between closure scenarios. For this portion of the evaluation, there was no accounting for how long the emissions were present. The non-cancer risk value is generally considered applicable over a period of approximately eight years. For activities that occur for less than eight years, comparison with this risk value may overstate the actual risk. Correspondingly, for activities that run significantly longer than eight years, there may be sub-periods with higher average concentrations and higher associated non-cancer risk.

Results

Worst-case impacts were calculated for each distance from the modeled road. The worst-case result represents the highest value calculated over the four road orientations. This may not be the same orientation for all distances. For example, a road that runs Northeast/Southwest aligns with the predominant wind direction. This results in higher concentrations for receptors close to the road. For receptors farther away from the edge of the road, the worst case occurs for a Northwest/Southeast road where winds are perpendicular to the road. Worst-case results are reported in Table 9-2 of the main report. The following sections include results for all road orientations and distances from both sides of the road.

Model-estimated cancer risk

ELCR results for the four road orientations and both sides of the road are provided in Table C-1.

Table C-1. ELCR estimates from DPM exposure due to trucking operations associated with closure of the BCSS ash basin under CIP closure, excavation closure, and hybrid closure. Results for each road orientation and distances from both sides of the road (ELCR columns per orientation).

	E-W Run		NE-SW Run		N-S Run		NW-SE Run	
CIP								
10 m	2.4E-09	2.5E-09	3.5E-09	3.3E-09	2.8E-09	2.5E-09	1.9E-09	2.2E-09
20 m	2.3E-09	2.4E-09	2.9E-09	2.6E-09	2.7E-09	2.3E-09	2.0E-09	2.4E-09
30 m	1.9E-09	2.0E-09	2.3E-09	2.1E-09	2.2E-09	1.9E-09	1.7E-09	2.0E-09
40 m	1.6E-09	1.7E-09	1.9E-09	1.7E-09	1.9E-09	1.6E-09	1.5E-09	1.7E-09
50 m	1.4E-09	1.5E-09	1.6E-09	1.4E-09	1.6E-09	1.4E-09	1.3E-09	1.5E-09
60 m	1.3E-09	1.3E-09	1.4E-09	1.3E-09	1.4E-09	1.2E-09	1.1E-09	1.3E-09
70 m	1.1E-09	1.2E-09	1.3E-09	1.1E-09	1.3E-09	1.1E-09	1.0E-09	1.2E-09
80 m	1.0E-09	1.1E-09	1.1E-09	9.8E-10	1.2E-09	9.7E-10	9.4E-10	1.1E-09
90 m	9.4E-10	9.6E-10	1.0E-09	8.8E-10	1.1E-09	8.8E-10	8.6E-10	1.0E-09
100 m	8.7E-10	8.9E-10	9.2E-10	8.0E-10	9.8E-10	8.1E-10	7.9E-10	9.4E-10
110 m	8.1E-10	8.2E-10	8.4E-10	7.3E-10	9.0E-10	7.5E-10	7.4E-10	8.7E-10
120 m	7.6E-10	7.7E-10	7.8E-10	6.7E-10	8.4E-10	6.9E-10	6.9E-10	8.2E-10
130 m	7.1E-10	7.2E-10	7.2E-10	6.2E-10	7.9E-10	6.4E-10	6.5E-10	7.7E-10
140 m	6.7E-10	6.7E-10	6.7E-10	5.7E-10	7.4E-10	6.0E-10	6.1E-10	7.3E-10
150 m	6.3E-10	6.4E-10	6.3E-10	5.3E-10	7.0E-10	5.6E-10	5.8E-10	6.9E-10
Excavation								
10 m	1.7E-09	1.8E-09	2.4E-09	2.3E-09	1.9E-09	1.8E-09	1.3E-09	1.5E-09
20 m	1.6E-09	1.7E-09	2.1E-09	1.8E-09	1.9E-09	1.6E-09	1.4E-09	1.7E-09
30 m	1.4E-09	1.4E-09	1.6E-09	1.5E-09	1.5E-09	1.3E-09	1.2E-09	1.4E-09
40 m	1.2E-09	1.2E-09	1.4E-09	1.2E-09	1.3E-09	1.1E-09	1.0E-09	1.2E-09
50 m	1.0E-09	1.0E-09	1.1E-09	1.0E-09	1.1E-09	9.7E-10	9.1E-10	1.1E-09
60 m	8.9E-10	9.1E-10	1.0E-09	8.8E-10	1.0E-09	8.5E-10	8.1E-10	9.4E-10
70 m	8.0E-10	8.2E-10	8.8E-10	7.7E-10	9.0E-10	7.6E-10	7.2E-10	8.5E-10
80 m	7.2E-10	7.4E-10	7.9E-10	6.9E-10	8.2E-10	6.8E-10	6.6E-10	7.7E-10
90 m	6.6E-10	6.8E-10	7.1E-10	6.2E-10	7.5E-10	6.2E-10	6.0E-10	7.1E-10
100 m	6.1E-10	6.2E-10	6.5E-10	5.6E-10	6.9E-10	5.7E-10	5.6E-10	6.6E-10
110 m	5.7E-10	5.8E-10	5.9E-10	5.1E-10	6.4E-10	5.2E-10	5.2E-10	6.1E-10
120 m	5.3E-10	5.4E-10	5.5E-10	4.7E-10	5.9E-10	4.9E-10	4.9E-10	5.7E-10
130 m	5.0E-10	5.0E-10	5.1E-10	4.3E-10	5.5E-10	4.5E-10	4.6E-10	5.4E-10
140 m	4.7E-10	4.7E-10	4.7E-10	4.0E-10	5.2E-10	4.2E-10	4.3E-10	5.1E-10
150 m	4.4E-10	4.5E-10	4.4E-10	3.7E-10	4.9E-10	4.0E-10	4.1E-10	4.8E-10
Hybrid								
10 m	1.9E-09	2.0E-09	2.7E-09	2.6E-09	2.2E-09	2.0E-09	1.5E-09	1.7E-09
20 m	1.8E-09	1.9E-09	2.3E-09	2.1E-09	2.1E-09	1.8E-09	1.6E-09	1.9E-09
30 m	1.5E-09	1.6E-09	1.8E-09	1.6E-09	1.7E-09	1.5E-09	1.3E-09	1.6E-09
40 m	1.3E-09	1.3E-09	1.5E-09	1.3E-09	1.5E-09	1.3E-09	1.2E-09	1.4E-09
50 m	1.1E-09	1.2E-09	1.3E-09	1.1E-09	1.3E-09	1.1E-09	1.0E-09	1.2E-09
60 m	1.0E-09	1.0E-09	1.1E-09	9.9E-10	1.1E-09	9.6E-10	9.0E-10	1.1E-09
70 m	8.9E-10	9.2E-10	9.9E-10	8.7E-10	1.0E-09	8.5E-10	8.1E-10	9.5E-10
80 m	8.1E-10	8.3E-10	8.8E-10	7.7E-10	9.2E-10	7.7E-10	7.4E-10	8.7E-10
90 m	7.4E-10	7.6E-10	8.0E-10	6.9E-10	8.4E-10	7.0E-10	6.8E-10	8.0E-10
100 m	6.9E-10	7.0E-10	7.3E-10	6.3E-10	7.7E-10	6.4E-10	6.3E-10	7.4E-10
110 m	6.4E-10	6.5E-10	6.6E-10	5.7E-10	7.1E-10	5.9E-10	5.8E-10	6.9E-10
120 m	6.0E-10	6.0E-10	6.1E-10	5.3E-10	6.6E-10	5.5E-10	5.4E-10	6.4E-10
130 m	5.6E-10	5.7E-10	5.7E-10	4.9E-10	6.2E-10	5.1E-10	5.1E-10	6.1E-10
140 m	5.3E-10	5.3E-10	5.3E-10	4.5E-10	5.8E-10	4.7E-10	4.8E-10	5.7E-10
150 m	5.0E-10	5.0E-10	4.9E-10	4.2E-10	5.5E-10	4.5E-10	4.6E-10	5.4E-10

Model-estimated non-cancer risk

HI results for the four road orientations and both sides of the road are provided in Table C-2.

Table C-2. HI estimates from DPM exposure due to trucking operations associated with closure of the BCSS ash basin under CIP closure, excavation closure, and hybrid closure. Results for each road orientation and distances from both sides of the road (HI columns per orientation).

	E-W Run			NE-SW Run			N-S Run			NW-SE Run	
CIP											
10 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
20 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
30 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
40 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
50 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
60 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
70 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
80 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
90 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
100 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
110 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
120 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
130 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
140 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
150 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
Excavation											
10 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
20 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
30 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
40 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
50 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
60 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
70 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
80 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
90 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
100 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
110 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
120 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
130 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
140 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
150 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
Hybrid											
10 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
20 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
30 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
40 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
50 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
60 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
70 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
80 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
90 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
100 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
110 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
120 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
130 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
140 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000
150 m	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000		0.0000	0.0000

Appendix D

Habitat Equivalency Analysis

Habitat Equivalency Analysis

Habitat equivalency analysis (HEA) was used to estimate changes in environmental service levels under different closure options for the Duke Energy Belews Creek Steam Station (BCSS). The extent of environmental service flows currently provided by ash basin habitats (wooded areas, open field, open water, etc.) and associated sites (borrow/landfill areas) was calculated and compared to service flows provided by post-closure habitats in these areas.

The HEA proceeded in four steps:

1. **Estimate habitat areas:** The acres of different habitat types (e.g., forest, open field, open water, wetland) that would be affected by closure under each closure option (i.e., cap in place [CIP], excavation, and hybrid closures) were estimated from aerial imagery.
2. **Evaluate environmental service levels:** The relative level of environmental services provided by these habitats was estimated in terms of net primary productivity (NPP).
3. **Apply discounting for future services:** The relative levels of environmental services were calculated over time according to the construction implementation schedule developed by Duke Energy (2018) and expressed in units of discounted service acre-years (DSAYs).
4. **Calculate discounted environmental services:** DSAYs were summed across the gains and losses of each habitat type to produce a net gain or loss in environmental service levels for each closure option.

Estimate Habitat Areas

Acreages of current habitat types were calculated from geographic information system (GIS) files provided by Duke Energy that included spatial representations of the current acreage of open field, wetland, wooded area, and open water habitats surrounding the ash basin. The acreages of ash basin to be closed and land converted to landfill or borrow pit were based on information provided by Duke Energy (2018) according to the assumptions below. For the excavation and hybrid closure options, the closure-by-removal portions of the ash basin were assumed to be restored to historical, pre-basin conditions. Historical acreage of forested, open field, and stream habitat types were estimated by measuring aerial photographs provided in the comprehensive site assessment (CSA; SynTerra 2017) using GIS. Not all areas of the current basin footprint were classified into habitats (e.g., bare ground), thus total restored habitat area in the footprints may be larger than the habitat areas assumed to be currently providing services. Historical habitat types were generally classified into forest, open water, and unclassified open areas since not all currently measured habitat types (e.g., scrub-shrub) could be resolved from historical images. Historical areas of forest sub-habitat types were estimated by assuming the current (non-basin) site-wide percentages of broadleaf forest (52%), needleleaf forest (47%), and wetland forest (<1%) applied to the historical ash basin footprint. Historical areas of open but unclassified (as forest or open water) habitat types were estimated by assuming the current site-wide percentages of scrub-shrub (51%), emergent wetland (17%), and open field (33%) applied to the historical ash basin footprint.

Additional assumptions used to calculate habitat areas included:

- Stream habitats in the ash basin were not indicated for BCSS in historical imagery and not included in the NPP services in ash basin restoration.
- Fill material for closure was assumed to be derived from excavation of basin dam features and new, onsite borrow pits. The areal extent of these borrow pits was calculated from the volume (cubic yards) of required earthen fill material, assuming borrow pits would be dug to 15 ft.
- Area lost to borrow pit excavation was assumed to contain forest habitat, which is the predominant non-basin habitat type on the BCSS property.

- Fill material for landfill cap construction under excavation closure was assumed to be taken from the footprint of the newly dug landfill.[1]

Evaluate Environmental Services

NPP was used to standardize environmental services across habitat types. NPP is a measure of how much photosynthesis occurs in an area greater than the amount required by the plants for immediate respiration needs. Fundamentally, NPP is a measure of the energy available to perform environmental services and is a useful currency for comparing habitats (Efroymson et al. 2003). NPP is often referred to in terms of carbon fixation or carbon storage, as the removal of carbon from the atmosphere is a primary reaction of photosynthesis.

Of the habitats currently occurring on the site, deciduous, coniferous, and mixed forested areas have the highest NPP; that is, per acre of forest, photosynthesis fixes more carbon/produces more energy for environmental services (Ricklefs 2008). As such, NPP service levels for all habitat types were normalized to the NPP service level of forested habitat. Specifically, the service levels for all habitat types were expressed as a proportion of the maximum wooded area service level (He et al. 2012).

To compare results between the different closure options, a set of assumptions was used for all options evaluated.

- Figure 22.12 from Ricklefs (2008) was used as the basis for determining relative rates of NPP for different ecosystem types. For this evaluation, temperate forest (woodland) was considered the base habitat with a relative NPP of 100%. Other habitat types were normalized as a proportion of that value based on the relative levels of NPP shown in Ricklefs' Figure 22.12 (2008), using temperate grassland as representative of open fields and freshwater environments as representative of open water.

[1] New landfill area (83 acres) was found to be a sufficient source of fill material (33 acres, assuming such a pit would be dug to 15 ft to meet fill volume requirements) and additional borrow pits were not assumed.

- Based on Ricklefs' Figure 22.12 (2008), NPP values for open field and open water habitats were assumed to be 40% of the forest value. However, because aquatic habitats of the ash basin may not be functionally equivalent to naturally occurring freshwater ecosystems (e.g., less abundant or diverse vegetation), a habitat quality adjustment factor of 4 was applied, lowering the relative NPP value for ash basin open water habitat to 10% of temperate forest NPP.

- Figure 2c from He et al. (2012) was used to estimate NPP of woodland areas based on stand age.
  - The NPP functions for the three forest types (broadleaf, needleleaf, mixed) from Figure 2c of He et al. (2012) were digitized to allow calculation of NPP by stand age. For example, for mixed forests this function shows rapidly increasing NPP up to a maximum at 45 years, after which the NPP declines slightly to level off at approximately 85% of the maximum.
  - All wooded areas currently occurring in the ash basin or on borrow or landfill areas were assumed to be 50 years old, which, based on He et al. (2012), provide approximately 97% of maximum NPP function in the case of broadleaf and mixed forests and 84% for needleleaf forests. Other habitats were normalized from the higher value using the relative rates of NPP described above.

- Baseline levels of service (NPP) in the absence of closure activities were assumed to continue at the current rate for 150 years, accounting for slight changes in wooded area NPP by age as calculated from the NPP function of He et al. (2012).

Apply Discounting for Future Services

HEA applies a discounting function when calculating the amount of environmental services derived from an acre over a year and uses as its metric a discounted service acre-year, or DSAY. Discounting is necessary because environmental services occurring in the future are assumed to be less valuable to people than the same services performed now (Dunford et al. 2004; Desvousges et al. 2018; Penn undated). This allows the environmental services occurring far in the future to be considered on par with contemporary services. Thus, factors determining when closure and remediation begin and the duration of these processes are important parameters of the final DSAY estimate.

I used the closure schedule provided by Duke Energy (2018) to develop timelines for habitat loss and gain under each closure option. For purposes of the HEA, only site preparation, construction, and site restoration times were included. Pre-design and design permitting periods were assumed to have no effect on environmental services. The closure schedule estimated duration of each activity in months; however, since the HEA model calculates DSAYs on an annual basis, the activity durations were rounded up the nearest full year. This has a negligible impact on DSAY estimates.

The following assumptions were then used to standardize timing of activities among the closure options:

- For all options, removal of existing onsite habitats was assumed to occur in the year that construction begins and was assumed to be completed the same year such that no environmental service is provided by the end of the first construction year.
- Environmental services of areas used for borrow or as landfill were assumed to be lost in the year construction starts, and borrow/landfill site preparation was assumed to be complete the same year such that no environmental service is provided by the end of the first construction year.

- Environmental service gains from restoration (ash basin and borrow area) were assumed to begin in the year following completion of construction activities.
- Post-closure habitats were presumed eventually to provide the same level of service as equivalent pre-closure habitats with the following conditions:
  - Forests would be age 0 in the year when restoration was completed and would generate an increasing level of NPP as they grow, following the rates calculated from the NPP curves of He et al. (2012).
  - Restored open field habitat would take five years (based on professional judgement) to reach the baseline relative to forest NPP of 40%, with service levels increasing linearly over that time.
  - Restored wetland and stream habitat would be functionally equivalent to natural freshwater ecosystems and would provide an NPP relative to forests of 40% after five years (based on professional judgement), increasing linearly over that time.
  - Periodic mowing is required to maintain a grass cap, so grass cap was assumed never to reach a level of service equivalent to an open field. Grass cap was assumed to have 20% of the NPP service level for open field, which is 8% of forest NPP. Grass cap was assigned a post-closure service level of 8%, with full service attained in 2 years.
  - Bare ground was assumed to provide no environmental service.
- The base year for discounting is 2019 in all options.
- A discount rate of 3% is applied in all options.
- The HEA is run for 150 years for all closure options.

Calculate Discounted Environmental Services

Calculation of DSAYs is a summation of the discounted losses and gains in service values across habitat types. The net DSAYs calculated for each closure option are reported in Table 10-1 of the main body of this report.

A sensitivity analysis of key parameters (based on professional experience) and assumptions used in the HEA was conducted to evaluate how sensitive the HEA results are to changes in (1) the duration over which the services were evaluated (i.e., 150 years), (2) the assumed relative NPP of ash basin open water and open fields, and (3) habitat created by restoration of borrow areas. The results are discussed in the context of uncertainty in the net environmental benefit analysis (NEBA) in Appendix E.

Appendix E

Net Environmental Benefit Analysis

Net Environmental Benefit Analysis

Net environmental benefit analysis (NEBA) is a structured framework for comparing impacts and benefits to environmental services to support decision-making (Efroymson et al. 2003, 2004). In the NEBA application for the Belews Creek Steam Station (BCSS) ash basin closure, a risk-ranking approach, based on that described by Robberson (2006), was applied. The risk-ranking approach develops alphanumerical estimates of relative risk by closure option and by attribute (e.g., risk to a receptor, change in environmental services), which allows comparison of the relative differences in impact between closure options to a variety of attributes. In this way, tradeoffs can be visualized to inform decision-making.

Risk-Ranking Matrix

The risk-ranking matrix includes two axes that characterize risk. The y-axis shows the level of impact, or risk, to an attribute, and the x-axis shows the duration of the impact (which is directly related to the time to recovery). Both are important to evaluate the relative differences in risk posed by closure options. A moderate level of impact over a long duration can potentially have an overall greater negative impact on the environment than a higher impact over a very short period (Robberson 2006). The pattern of shading of the risk matrix conveys this general principle, though the exact shading of the cells is based on best professional judgement. Robberson (2006) describes darker shading as indicating a higher level of concern over the level of impact to a resource or environmental service. The NEBA matrix developed by the Operational Science Advisory Team-2 (OSAT 2011) used a similar color coding approach to compare risk from further cleanup of oil on beaches of the Gulf of Mexico following the Deepwater Horizon oil spill. The risk-ranking matrix used in the NEBA of closure options for the Belews Creek ash basin is shown in Table E-1.

Table E-1. Risk-ranking matrix for impacts and risk from closure activities. Darker shading and higher codes indicate greater impact.

		Duration of Impact (years)			
		10–15 **(4)**	5–9 **(3)**	1–4 **(2)**	<1 **(1)**
% Impact	No meaningful risk	--	--	--	--
	<5% **(A)**	**4A**	**3A**	**2A**	**1A**
	5–19% **(B)**	**4B**	**3B**	**2B**	**1B**
	20–39% **(C)**	**4C**	**3C**	**2C**	**1C**
	40–59% **(D)**	**4D**	**3D**	**2D**	**1D**
	60–79% **(E)**	**4E**	**3E**	**2E**	**1E**
	>80% **(F)**	**4F**	**3F**	**2F**	**1F**

The percent impact levels (e.g., <5%, 5–19%) were defined based on best professional judgement and regulatory precedent. A <5% impact characterizes a very minor potential or expected impact that may be functionally indistinct from baseline conditions due to uncertainty in metrics or the estimated effects. As such, this level of impact was given no shading, regardless of the duration of impact. Impacts between 5–19% are considered low in the NEBA framework (Efroymson et al. 2003). This impact level was shaded to reflect this low risk. Levels of impact >20% were separated at intervals of 20% based on best professional judgement and consistent with the risk-ranking approach used by Robberson (2006).

Similarly, the categories used to define duration of impact were based on best professional judgment and regulatory precedent. Robberson (2006) defines recovery in <1 year as “rapid,” with shading that indicates a generally low level of concern across the levels of impact. The remaining categories of time in the risk-ranking matrix were divided at roughly 5-year intervals. As Robberson (2006) notes, the exact size of the risk matrix is a function of decisions made about scaling the matrix, which is a function of the closure and remediation being considered and the attributes included in the NEBA. The risk-ranking matrix applied here could have been defined differently. For example, the duration of impact categories could have been expanded to six (e.g., <1 year, 1–3 years, 3–6 years, 6–10 years, 10–15 years, >15 years), which would have changed the alphanumeric risk ratings and perhaps some of the shading of attributes evaluated in the NEBA. The purpose of the risk matrix, and the risk ratings that result from it, is to consolidate the results from a variety of different analyses for a variety of different data types and attributes into a single framework for comparative analysis. It is imperative, however, to consider the underlying information used to develop the risk ratings to interpret the differences between closure options, particularly when percent impacts or durations of closure options are similar but receive different risk ratings. It is inappropriate to assume a risk rating for one attribute is scientifically equivalent to the risk rating of another attribute because the comparative metrics that form the foundation of the risk ratings can be fundamentally different (e.g., a hazard quotient for risk to a bird species is different from discounted service acre-years [DSAYs] for environmental services from a habitat). Thus, the risk ratings in the NEBA matrix permit a relative comparison of impacts between closure options within attributes. Decision-makers can use the NEBA framework to identify the relative impacts of closure options across many different attributes, but the NEBA matrix does not, by design, elevate, or increase the value of, any specific risk or benefit in the framework.

Risk Rating Sensitivity

Uncertainty in a NEBA can be evaluated by examining the uncertainty in the assumptions and analyses used as inputs to the risk-ranking matrix. The following sections examine how differences in assumptions could affect relative risk ratings in the NEBA framework for attributes found to have levels of impact. Attributes for which no meaningful risk was found (e.g., human health risk assessments, ecological health risk assessments) are not included in the following discussion.

Noise and congestion from trucking traffic

I used the number of trucks per day passing[1] a receptor along a near-site transportation corridor as a metric to examine the differences in noise and traffic congestion under the closure options. I

[1] Truck passes per day resulting from trucking activities is calculated as the total number of loads required to transport earthen fill, geosynthetic materials, and other materials multiplied by two to account for return trips. The resulting total number of passes is then divided evenly among the total number of months of trucking time multiplied by 26 working days per month.

compared the increase in truck passes due to hauling earthen fill, geosynthetic material, and other materials under the closure options[2] to the current number of truck passes for the same receptor.

The current (or baseline) number of truck passes was estimated from North Carolina Department of Transportation (NCDOT) annual average daily traffic (AADT) data collected at thousands of locations across the state and the proportion of road miles driven by large trucks in North Carolina. AADT is an estimated daily traffic volume at a specific location, which captures traffic in all lanes traveling in both directions and is assumed to represent typical traffic volume for a year.[3] Not all AADT data, however, differentiate between large trucks such as those to be used in ash basin closure and other traffic such as cars, which is a relevant distinction when considering impacts to communities from increased noise. NCDOT performs vehicle classification[4] on trucking routes to estimate annualized truck percentage to apply to AADT to determine truck AADT (NCDOT 2015). The average annualized truck percentage for Stokes County is 7%.

The precise transportation corridor for trucks travelling to and from BCSS during ash basin closure is unknown; however, likely corridors in the communities local to BCSS can be identified by examining road maps and AADT statistics. BCSS is located on Pine Hall Road (SR1908, Figure E-1). Immediately adjacent to BCSS is NCDOT Station 8401621, which reported 1,400 AADT in 2015. Travelling south from BCSS, Pine Hall Road connects to NC Highway 65 and the town of Belews Creek. Along this route NCDOT Station 8401721 reported 1,300 AADT in 2015, and NCDOT Station 3301780 reported 3,600 AADT in 2017. NCDOT Station 8401622, on nearby SR1921, reported 700 AADT in 2016; however, it is less likely that

[2] Truck trips to haul ash were not included in the estimate for BCSS ash basin closure because trucks hauling ash would not leave the BCSS property and would not affect community receptors along the transportation corridors.

[3] AADT is calculated from two days of traffic counts at each station during weekdays, excluding holidays. Raw monitoring data consists of counts of axle pairs made by pneumatic tube counters that are converted to traffic volume by applying axle correction factors, and expanded to annual estimates by seasonal correction factors. Derived AADT values are checked for quality against nearby stations and historical station-specific values (NCDOT 2015).

[4] Vehicle classification is assigned based on number of axles, space between axles, weight of the first axle, and total weight of the vehicle.

trucks travelling to and from BCSS would use SR1921 since it is a small side road that is not the shortest route to a major transportation corridor. NC 65 appears to be the major transportation route south of BCSS, and NCDOT Station 8400040 on NC 65, approximately 1mile north of the Pine Hall Road intersection, reported 3,600 AADT in 2017. NCDOT Station 3302110 immediately south of Pine Hall Road on NC 65 reported 4,900 AADT in 2017. Alternatively, if ash basin closure trucking travelled to and from BCSS from the north, Pine Hall Road connects to the small town of Pine Hall. Near the town of Pine Hall, NCDOT Station 8401694 reported 1,500 AADT in 2017. Pine Hall Road, to the north and south of BCSS, is sparsely traveled, primarily residentially populated, and likely to be the most impacted by ash basin trucking traffic. To best capture trucking related impacts to sensitive communities along the transportation corridor, I assumed a baseline truck passes per day of 94, which was computed by multiplying 1,300 AADT (2015 estimate from Pine Hall Road NCDOT Station 8401721) by the Stokes County average percent of truck AADT (7.2%; NCDOT 2015).[5]

[5] AADT data are not available for every road or every location along a road. It is possible during closure of the BCSS ash basin that trucks will utilize less traveled roads (i.e., with lower AADT), which would have a lower baseline truck passes per day estimate and result in a higher percent impact from ash basin closure for these sensitive communities; however, by choosing the lowest available AADT estimate from roads within 10 miles of BCSS along the most likely transportation corridors to and from BCSS to a major road (e.g., highway), my analyses have considered sensitive communities that would be more affected by traffic noise and congestion from ash basin closure trucking.

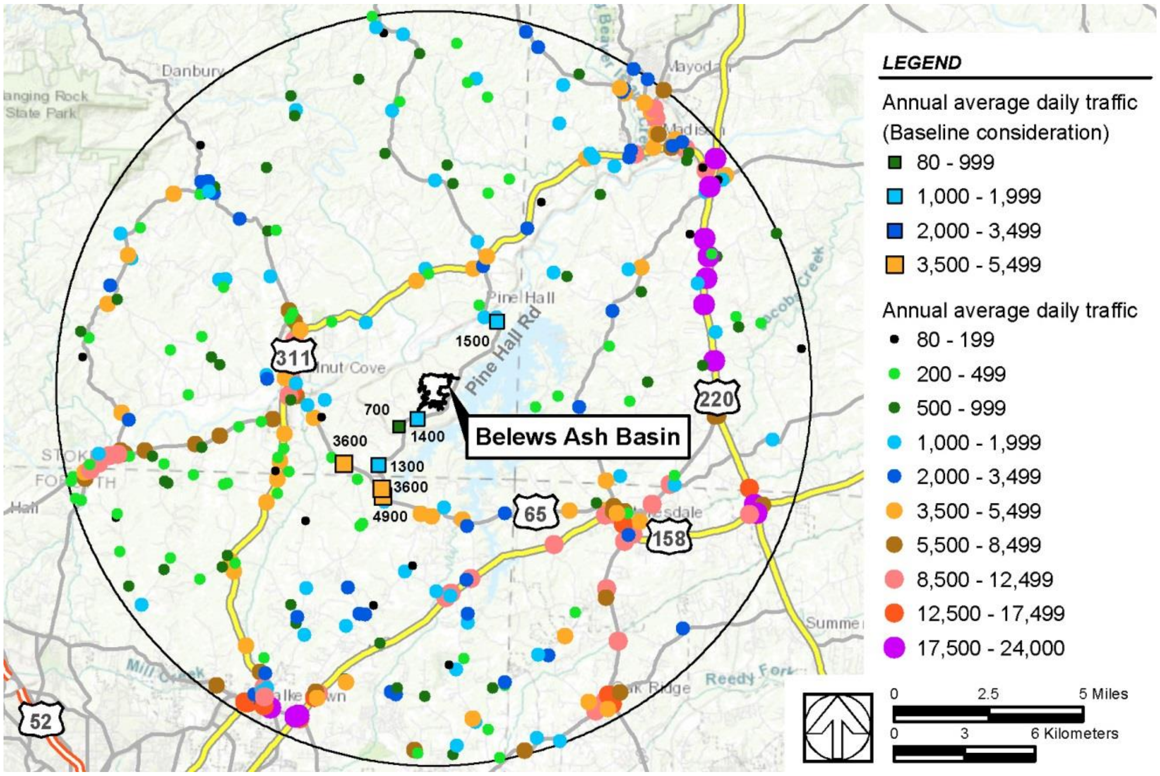

Figure E-1. NCDOT annual average daily traffic (AADT) measurement stations in the vicinity of BCSS. Traffic stations and AADT values considered when determining the baseline number of truck passes are indicated as squares.

The sensitivity of the NEBA relative risk ratings to the baseline assumption of 94 trucks per day was evaluated by calculating relative risk ratings for a range of baseline truck traffic levels, based on the minimum and maximum AADT values for any NCDOT station within a 50-mile radius of the BCSS ash basin, using AADT from the most recent year that data are available for a particular station and assuming 7.2% truck traffic as previously described. Figure E-2 plots the resulting percent impact for closure options along with the resulting relative risk rating across the range of 2 to 10,076 truck passes per day.

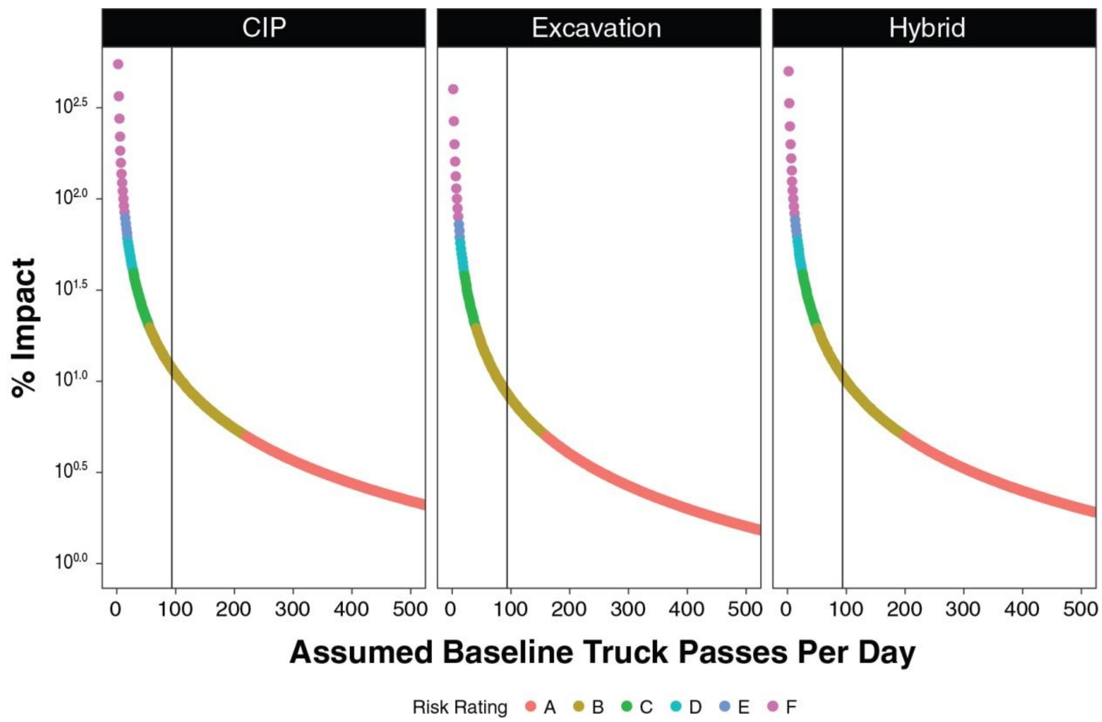

Figure E-2. Sensitivity of NEBA relative risk rating for noise and congestion impacts from trucking operations. The vertical line indicates the assumed baseline 94 truck passes per day. The y-axis is plotted on a log10 scale and the X axis is truncated at 500 to improve visualization.

Using a baseline truck passes per day of 94, all closure options (CIP, excavation, and hybrid) fall into the second lowest relative risk rating (B, 5–19%) for traffic-induced noise and congestion during closure of the BCSS ash basin (Figure E-2). The assigned relative risk ratings may be reduced to the lowest rating (A) if the baseline traffic assumption is increased to 221, 161, and 201 truck passes per day for CIP, excavation, and hybrid closures, respectively, thereby decreasing the relative impact of additional construction traffic. Higher risk ratings would result from a lower baseline truck traffic assumption; decreasing the baseline truck traffic assumption to 55, 40, and 50 truck passes per day would increase the risk rating from B to C for CIP, excavation, and hybrid closures, respectively.

Traffic accidents

I evaluated risk of traffic accidents by comparing the average number of annual offsite road miles driven between closure options relative to a baseline estimate of the current annual road miles driven.[6] I chose a baseline of 27.4 million annual truck road miles based on the reported total vehicle miles traveled in Stokes County, North Carolina (NCDOT 2017) multiplied by the county average 7.2% contribution of trucks to total AADT (NCDOT 2015).

The sensitivity of the NEBA relative risk ratings to the baseline assumption of 27.4 million truck miles per year was evaluated by calculating relative risk ratings for alternative baseline truck mile assumptions derived from the counties in NC with the minimum (Hyde County) and maximum (Mecklenburg County) reported vehicle miles driven, resulting in a sensitivity range estimated from 6.2 million to 641 million truck miles per year. Figure E-3 plots the resulting percent impact for both the CIP and excavation options, along with the resulting relative risk ratings across the range of truck miles per year.

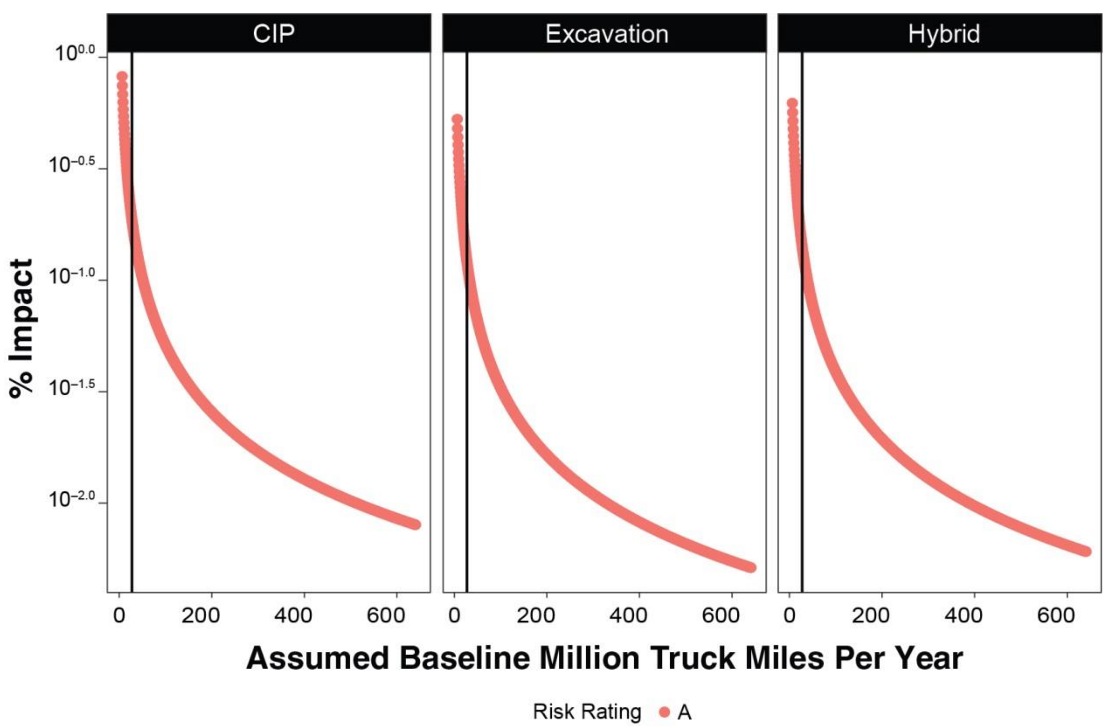

Figure E-3. Sensitivity of NEBA relative risk rating for traffic accidents due to trucking activities. The vertical line indicates the assumed baseline 27.4 million truck miles per year. The y-axis is plotted on a log10 scale to improve visualization.

6 The difference between the baseline miles assumption and the closure assumption was divided by the baseline miles assumption and multiplied by 100 to get a percent impact.

Using the 27.4-million-truck-miles baseline assumption, CIP closure has a 0.19% impact, excavation closure has a 0.12% impact, and hybrid closure has a 0.14% impact. All closure options have a relative risk rating of A (<5%). These relative risk ratings do not appear to be sensitive to lower assumed baseline annual truck miles. The vertical lines in Figure E-3 indicate the location of the baseline assumption. Reducing the baseline assumption to the 6.2 million truck miles minimum increases percent impact to 0.8, 0.53, and 0.62% for the CIP, excavation, and hybrid closure options, respectively, though the risk ratings are unchanged.

Habitat Equivalency Analysis

Uncertainty in the habitat equivalency analysis (HEA) that examined disruption of environmental services from ash basin closure was explored through sensitivity analyses of key assumptions in the HEA. To test sensitivity, I re-ran HEA models with the following changes:

1. Running the HEA for 100 years instead of 150 years.
2. Assuming the open water habitats of the ash ponds provide environmental services at 40% of wooded areas instead of 10%.
3. Assuming open field habitats provide environmental services at 20% of wooded areas instead of 40%.
4. Assuming borrow areas under the CIP and hybrid closure options are restored to open fields, not reforested.

For each sensitivity analysis, all parameters in the base model were held constant except the one parameter varied to understand the sensitivity of the model to each assumption (Table E-2).

Table E-2. Change in DSAYs from base model[a] for key HEA assumptions

Closure Option	100-year model[b]	Ash basin water 40%[c]	Borrow becomes field[d]	Open Field 20%[e]
CIP	39	−1,409	−141	0
Excavation	−75	−1,328	0	−51
Hybrid	−59	−1,409	−126	−46

[a] Base models were run for 150 years, with ash basin open water NPP services at 10%, borrow fields were assumed to become forest (CIP and hybrid closure) or grass cap (excavation), open field NPP services at 40%.
[b] Base models except the HEA was run for 100 years.
[c] Base models except ash basin open water NPP service at 40%.
[d] Base models except borrow pits were assumed to become open field for CIP and hybrid options.
[e] Base models except open field NPP services decreased to 20%.

Running HEAs for 100 years increased net DSAYs slightly for the CIP closure and decreased net DSAYs for both the landfill and hybrid closure options. Increasing the ash basin open water service level to 40% resulted in net negative DSAYs for all options. Assuming borrow areas would be returned to open field resulted in a decrease in net DSAYs for CIP and hybrid closure options; there are no borrow areas in the excavation closure, so there is no net change in DSAYs for that option.

Looking at the change in net DSAYs between the sensitivity models and their base models, the changes in assumptions have relatively consistent effects on net DSAYs. For example, changing ash basin open water services from 10 percent to 40 percent affects all closure options equally, since the same level of service change is applied over the same areal extent (156 acres of open water) in all closure options. Assuming open field services at 20% decreases future services of restored field habitat for the excavation and hybrid options but has no effect on the CIP option since that option has no open field habitat. Changing the service level of borrow acreage habitat after borrow is complete only affects closure options that assume the borrow area will be restored to forested habitat (CIP and hybrid closures). However, since the directionality of net NPP services provided by the closure options does not change under this sensitivity analysis (i.e., hybrid closure and excavation closure have net NPP service gains, while CIP closure results in net NPP service losses), this demonstrates that the model can differentiate between relative differences in NPP service level changes with consistency.

Changes in net DSAYs with changing assumptions may change the relative risk rating applied to a closure option in the NEBA. However, the relative similarity in the how DSAYs change with assumptions between the various closure options and the result that the excavation or hybrid closure option always result in substantially greater net DSAYs than CIP under any sensitivity analysis supports the relative risk ratings for decision support in the NEBA.

Closure Option Assumptions

The following assumptions were used to calculate NEBA input values related to trucking activities and habitat acreages.

- The density of ash was assumed to be 1.2 ash tons/CY.
- Borrow pit acreage required to supply earthen fill and cover material was assumed to be dug to a depth of 15 ft to meet volume requirements. Borrow pits not specifically identified were assumed to contain a mixed forest habitat that would be restored upon closure completion.
- Excavation was assumed to proceed at a rate of 1,000,000 CY/year for all types of excavation material combined including ash, underlying over-excavated or residual soil, and dam and embankment material.
- CIP cover systems were assumed to require two layers of geosynthetic material. New landfill areas were assumed to require five layers of geosynthetic material. Geosynthetic material was assumed to be transported from Georgetown, South Carolina, at a rate of six loads per day, and 3 acres per load.
- Covers/caps for both CIP and landfills were assumed to receive 18 in. of cover soil plus 6 in. of topsoil. New landfills also were assumed to receive 2 ft of liner soil. Topsoil was assumed to come from an offsite commercial facility requiring no additional borrow area.

- Unless otherwise specified, offsite borrow material and topsoil were assumed to be from sources 11 miles away (one way).
- Offsite truck capacity was assumed to be 20 CY of ash or earthen material.
- Working hours were assumed to be 10 hr/day, 6 days/week, and 26 days/month.
- Earthen fill material was assumed to be hauled in at a rate based on 1,000,000 CY/year.
- In excavated areas, 1ft of over-excavation of residual soil was assumed. When restoring these areas, 2 ft of additional soil material plus 6 in. of top soil was assumed necessary to establish vegetative stabilization over the total area.