

**COAL ASH DISPOSITION**  
**The Alternative for North Carolina**

**Technical Report No. 14-083**

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**Blue Ridge Environmental Defense League**

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*Esse quam videri*

## Preface

Shortly after the coal ash dump discharge into the Dan River on February 2, 2014, more than a few elected officials and advocacy groups began calling for removal of the ash from plant sites to double-lined landfills. However, present solid waste landfills were never designed for the hazards presented by coal ash and are not suitable. Municipal solid waste is a mixture of household garbage and commercial waste, and presently permitted landfills do a poor job of coping with these materials, let alone waste which presents special hazards. Coal ash is the toxic residue left after combustion in a power plant. Coal ash presents special problems because of its toxic nature and requires a specialized solution to prevent the spread of toxic heavy metals and other compounds into the air, soil and water. Recognizing this, and in consultation with our members living downstream from the spill and near solid waste dumps, the Blue Ridge Environmental Defense League set out to find a solution to the immediate problem of what to do with coal ash from Duke Energy's Dan River power plant and, ultimately, thirteen other coal-fired power plants with ash dumps extending across North Carolina from the mountains to the coast.

As a first step, based on the principles of fairness, equity and environmental justice, the Blue Ridge Environmental Defense League Board of Directors Executive Committee on March 14, 2014 adopted the following resolution:

**RESOLVED:** That no coal ash waste should be transferred from power plant sites to solid waste landfills.

**FURTHER BE IT RESOLVED:** That storage of coal ash by electric power plant operators should be done at plant sites but in a manner which would isolate it from surface water, groundwater and airborne dispersion.

With this sound footing, the League authorized this report for the purpose of educating elected officials and other decision makers, the news media and other opinion leaders, and advocacy groups and the general public.

*It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us, we were all going direct to Heaven, we were all going direct the other way...*

Charles Dickens, *A Tale of Two Cities*

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## Executive Summary

Fly ash is the dry residue from burning of coal captured by the pollution control devices. Bottom ash is the residue which collects in the bottom of the boiler during the coal burning process. Both types of ash are laced with toxic elements, including arsenic, chromium, lead, selenium and mercury. Also, radioactive strontium and uranium remain after the burning process and are concentrated in the ash.

During the early 1990s, implementation of the new Subtitle D regulations prompted widespread closure of traditional unlined landfills and a flurry of new double-lined landfills relying on a layer of clay and a layer of plastic. The double liners were thought to provide protection from contamination of groundwater. However, the fatal flaw of solid waste landfills is that they are subject to natural forces which make leakage and contamination inevitable.

Assurances by solid waste landfill regulators and commercial companies that waste is safely contained and managed by a double-lined landfill are false. Impartial experts agree that liner failure is inevitable, regardless of the liner type. That all liners will eventually fail is not in dispute. The only question is: How long will it take?

The inherent injustice of transporting toxic waste from a power plant site to a waste dump is currently the subject of a Civil Rights lawsuit. The solution to the coal ash problem cannot be the transfer of liability from the generator of the waste to the public. Nor can it be the infringement of community well-being.

Getting coal ash out of the impoundments near rivers and lakes must be done as rapidly as possible but to a more secure site within the power plant operators' responsibility.

A study by the Electric Power Research Institute confirms that combustion of coal tends to concentrate many toxic elements in the bottom and fly ash. High levels of toxic and radioactive elements in coal ash make the deposition of the ash on cropland, roads, airport runways and other methods unacceptable. Needless and life-threatening contamination of the environment would be the result. Therefore, these methods are also unacceptable ways of dealing with the coal ash problem.

As an alternative, we propose that the ash be stored by the power plant operators onsite but in a manner which would isolate it from surface water, groundwater and the air. One method involves the use of cylindrical concrete tanks. Such concrete vaults are used commercially for waste sludge and liquids. The mixture includes cement, fly ash, and slag which is put into the concrete vaults where it hardens. Such vaults may be as large as 120,000 square feet, approximately two football fields in size. They are modular, allowing for expansion as the need arises.

The Blue Ridge Environmental Defense League opposes the transfer the coal ash pollution problem from the private power company to municipal landfills, affecting communities already exposed to the risk of contamination caused by waste dumping. Blue Ridge Environmental

Defense League policy calls for the closing of such landfills, and the promotion of Zero Waste. Dumping ash in landfills would prolong the mega-dump problem and make it worse.

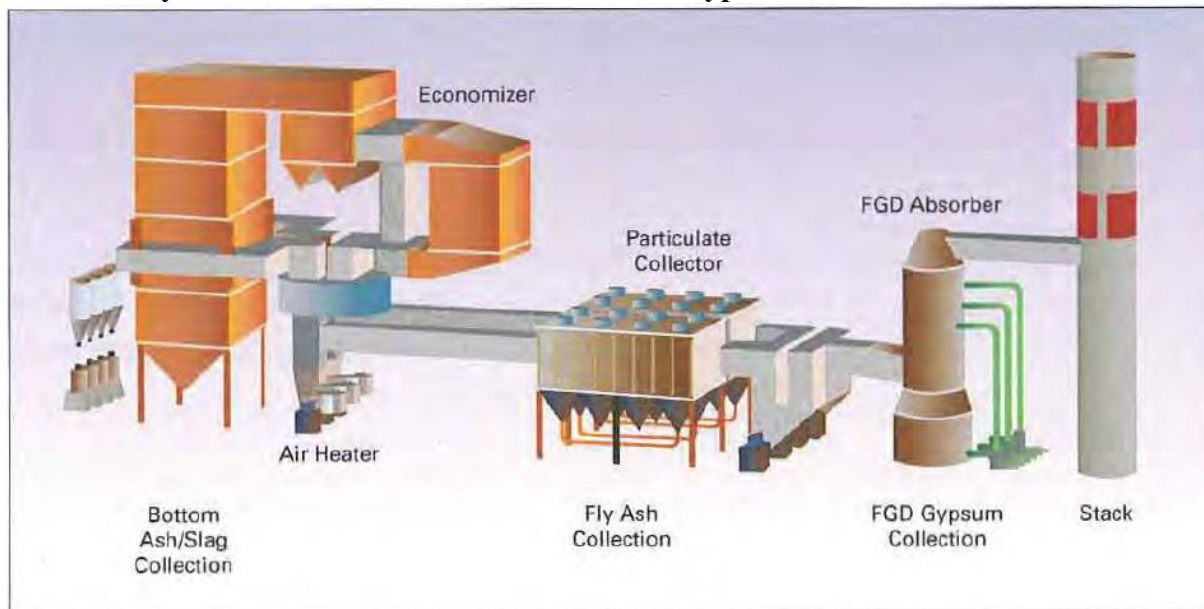
### **Hazards of Coal Ash**

The two types of waste residue from the combustion of coal are fly ash and bottom ash.

Fly ash is the dry residue from burning of coal captured by the pollution control devices. These fine particulates are trapped by pollution control devices required by most air quality agencies to reduce visible emissions. Fly ash is of lighter weight and smaller size than bottom ash, in a range of 1 to 100 microns, with a median of 20-25 microns (also micrometer or  $\mu\text{m}$ , one thousandth of a millimeter,  $1 \times 10^{-6}$  meter, about 0.000039 inches). Toxic elements which become volatile in the combustion process, such as selenium and arsenic, become attached to these fine particulates.<sup>1</sup>

Bottom ash is the residue which collects in the bottom of the boiler during the coal burning process. Heavier and larger than fly ash, bottom ash has the consistency of sand or gravel, with a size ranging from 0.1 to 50 millimeters. After combustion, bottom ash is typically mixed with water for transfer via sluice pipe from the power plant, then de-watered and stored.

### **Fly Ash and Bottom Ash Collection at a Typical Coal-fired Power Plant<sup>2</sup>**



Toxic constituents of coal ash vary according to the type of coal burned— lignite, subbituminous, bituminous and anthracite, the sulfur content, the methods of pollution control— cyclones, bag houses and electrostatic precipitators, and whether it is fly ash or bottom ash. Other factors

<sup>1</sup> *Coal Ash Disposal Manual: Third Edition*. EPRI, Palo Alto, CA: 1995. TR-104137

<sup>2</sup> Illustration from: "Coal Ash: Characteristics, Management and Environmental Issues," Electric Power Research Institute (EPRI), Technical Update "Coal Combustion Products" Environmental Issues, September 2009

affecting the ash include ammonia-based nitrogen oxide (NO<sub>x</sub>) control, carbon injection for mercury control, and sodium-based sulfur trioxide (SO<sub>3</sub>) control. (SO<sub>3</sub> is the major contributor to acid rain and sulfuric acid emissions from power plants). A detailed study of ash revealed the following:<sup>3</sup>

The concentrations of As, Cd, Hg, Mo, Ni, and Pb in fly ash are related to the S content of the coal. Generally, those feed coals with a high S content contain higher concentrations of these elements. The concentrations of these elements are also greater for baghouse fly ash compared to ESP fly ash for the same station. The S content of fly ash from high S coal is 0.1% for pulverized ESP fly ash and 7% for baghouse fly ash from the fluidized bed, indicating that most of the S is captured by fly ash in the fluidized bed. The baghouse fly ash from the fluidized bed has the highest content of Cd, Hg, Mo, Pb, and Se, indicating that CaO, for the most part, captures them. Arsenic is captured by calcium-bearing minerals and hematite, and forms a stable complex of calcium or a transition metal of iron hydroxy arsenate hydrate  $[(M^{2+})_2Fe_3(AsO_4)_3(OH)_4 \cdot 10H_2O]$  in the fly ash. Most elements in fly ash have enrichment indices of greater than 0.7 indicating that they are more enriched in the fly ash than in the feed coal, except for Hg in all ESP ashes. Mercury is an exception; it is more enriched in baghouse fly ash compared to ESP.

A study by the Electric Power Research Institute confirms that combustion of coal tends to concentrate many toxic elements in the bottom and fly ash. The EPRI analysis compared the concentrations of 28 elements found in natural soil and rock to levels detected in bottom ash and fly ash. Chromium is more highly concentrated in bottom ash. Lead and mercury are more highly concentrated in fly ash. Also, the study indicated that uranium and strontium were highly concentrated in both bottom ash and fly ash as compared to naturally occurring soil levels. The relative concentrations above natural soil levels for six elements are listed in the table below. The EPRI study did not have data on the various radioactive isotopes of strontium and uranium.

Element	Fly ash concentration above soil level	Bottom ash concentration above soil level	Natural soil median level mg/kg (ppm)
Arsenic	1,914 %	69 %	7
Chromium	184 %	901 %	57.5
Lead	737 %	104 %	15
Mercury	148 %	--	0.105
Strontium	548 %	337 %	260
Uranium	273 %	214 %	2.55

Appendix A to this report contains the EPRI data listing all twenty-eight coal ash elements they analyzed and compared to the levels found in natural rock and soil in milligrams per kilogram (ppm).

<sup>3</sup> Corrigendum to "Characteristics and composition of fly ash from Canadian coal-fired power plants" Fariborz Goodarzi [Fuel 85 (10611) (2006) 1418627] *Fuel*, Volume 85, Issues 17618, December 2006, Pages 2683-2684, accessed 3/20/14 at <http://www.sciencedirect.com/science/article/pii/S0016236105004643>

The presence of high levels of toxic and radioactive elements in coal ash makes the deposition of the ash on cropland, roads, airport runways and other methods of using the material largely a means of dispersing the harmful substances into the air, soil and water. Needless and life-threatening contamination of the environment would be the result. Therefore, these methods are unacceptable ways of dealing with the problems created by the burning of coal.

### *Aquatic Impacts*

The tons of coal ash from the recent spill site near Eden, NC, are responsible for the death of a huge number of aquatic organisms in the Dan River: fish, mussels, clams, frogs and turtles. One biologist described it as "a graveyard." Water birds, raptors, mammals and reptiles will also be affected by the bioaccumulation of selenium in the food chain. Although selenium is an essential trace element, it is toxic at high levels. An elevated level of selenium in the river water also interferes with the development of fish larvae, and bioaccumulation of selenium has been known to wipe out whole species.<sup>4</sup>

Dr. Dennis Lemly, Professor of Biology at Wake Forest University, provided the following description of how selenium in coal ash can harm fish:<sup>5</sup>

In concentrations that are too high, selenium leaves fish with deformities that include misshapen spines; "craniofacial" defects of the mouth, jaw and gill cover; fin irregularities; unnatural accumulations of fluids and chronic swelling; and eye problems that include cataracts and protruding eyeballs.

Dr. Lemly added that a high level of selenium also renders fish unable to reproduce and that, if selenium contamination is prolonged, the species can be eliminated from the area.

### **Coal Ash Clean Up: A Tale of Two Cities**

#### *Kingston, Tennessee*

On December 22, 2008, a dike failed at the TVA Kingston Fossil Plant in Roane County, Tennessee, releasing 5.4 million cubic yards of coal ash sludge. The failure of containment structures at the plant's onsite Class II landfill caused the disaster. Eight years before the break, the Tennessee Department of Environment and Conservation's Solid Waste Management Division had issued TVA a Class II landfill permit as part of a plan to close the plant's nearby settling pond which discharged waste water into the Emory and Clinch rivers.

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<sup>4</sup> *Aquatic Hazard of Selenium Releases From Coal Mining in the Mud River Ecosystem, West Virginia*, Lemly D, April 17, 2008, accessed 3/18/14 at <http://www.wvhighlands.org/PDFs/LemlyEx6.pdf>

<sup>5</sup> Email to L. Zeller from Anne Cockrell, "Information/Concerns to Share about the Dan River Coal Ash Spill," March 9, 2014. Dr. Lemly, a Research Associate Professor of Biology at Wake Forest University and a U.S. Forest Service Cooperator, has published 47 research articles on selenium toxicity to fish and wildlife, as well as the reference book *Selenium Assessment in Aquatic Ecosystems*. He has consulted on selenium pollution issues ranging from power plant waste in Australia to mountaintop removal coal mining in West Virginia.

In Tennessee a Class II Disposal Facility is:<sup>6</sup>

a landfill which receives waste which is generated by one or more industrial or manufacturing plants and is used or to be used for the disposal of solid waste generated by such plants, which may include industrial wastes, commercial wastes, institutional wastes, farming wastes, bulky wastes, landscaping and land clearing wastes, construction/demolition wastes, and shredded automotive tires. Additionally a Class II disposal facility may also serve as a monofill for ash disposal from the incineration of municipal solid waste.

The state standards for a coal-ash fill project require:<sup>7</sup>

- (I) A geologic buffer of at least three feet with a maximum saturated conductivity of  $1 \times 10^{-6}$  centimeters per second between the base of the fill and the seasonal high water table of the uppermost unconfined aquifer or the top of the formation of a confined aquifer, or such other protection as approved by the Commissioner taking into account site specific coal ash and soil characteristics, ambient groundwater quality, and projected flows in and around the site; and
- (II) A ground water monitoring program approved by the department that reports sampling results to the department at least once each year. If sampling results indicate that the fill area has caused the ground water protection standards to be exceeded, the owner or operator of the facility shall commence an assessment monitoring program in accordance with regulations adopted by the board and carry-out all corrective measures specified by the Commissioner.

The Class II landfill at TVA's Kingston Fossil Plant failed with catastrophic consequences for the residents of Roane County, Tennessee.

On January 12, 2009, three weeks after the disaster, the Tennessee Department of Environment and Conservation issued an administrative legal order<sup>8</sup> which required TVA to:

1. Prevent movement of contaminated materials into waters of the state,
2. Cooperate with the state's comprehensive review of all the utility's coal ash impoundments in the state,
3. Submit to the state all documents relevant to understanding the cause of the containment failure within 20 days,
4. Cooperate fully with and support the state's investigation into the failure,
5. Submit a corrective action plan within 45 days,
6. After review, furnish any additional requested by the state at a meeting with state officials,

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<sup>6</sup> Rules of Tennessee Department of Environment and Conservation, Solid Waste Management, Chapter 0400-11-01.01(3)(b)

<sup>7</sup> Rules of Tennessee Department of Environment and Conservation, Solid Waste Management, Chapter 0400-11-01.02(2)(a)(2)(viii)

<sup>8</sup> Commissioner's Order, Case No. OGC09-0001, In the Matter of Tennessee Valley Authority, Division of Water Pollution Control, Tennessee Department of Environment and Conservation, James H. Fyke, Commissioner, January 12, 2009



7. Implement the corrective action plan according to a schedule determined by the state,
8. Submit all data gathered during the corrective action,
9. Perform any additional actions directed by the state,
10. Submit written reports on performance, results and additional work needed, and
11. Pay all costs associated with the state's investigation and oversight.

The State of Tennessee was the sole authority regarding this emergency plan, but it did not relieve the utility of other obligations under state or federal law, nor did it prevent the state from pursuing civil or criminal action against the company. TDEC did assess a civil penalty of \$11.5 million from TVA.

Over 3.5 million cubic yards of ash spilled into the Emory River was removed by mechanical and hydraulic dredge and shipped to an EPA-approved Arrowhead Landfill in Uniontown, Alabama. The dredging was completed in May 2010 and the last shipment of ash was in December 2010.<sup>9</sup>

#### *Uniontown, Alabama*

The citizens of Uniontown had opposed the Arrowhead Landfill since it was constructed in 2003. The landfill was permitted by the Alabama Department of Environmental Management (ADEM) to accept the municipal, industrial and "special" wastes from 16 states. Uniontown is in Perry County, Alabama, about 350 miles from Kingston, Tennessee. Perry County's population is 68 percent African-American. Uniontown, the community nearest the Arrowhead Landfill, is 88 percent African-American.

The Arrowhead Landfill was permitted by the state to accept the municipal, industrial and "special" waste from 16 states.<sup>10</sup>

The Arrowhead Landfill, located in Uniontown, AL (population 1,775) was permitted by ADEM to dispose of nearly all the coal ash removed from Harriman as a result of the TVA spill (4 million tons). Instead of using protective management techniques, the ash was dumped in mounds as high as 60 feet with nothing covering them. From the front porch of several Uniontown homes, residents have only mounds of coal ash from TN to gaze upon and air contaminated by the dust to breathe. The dumped ash rises above the tree line and is within 100 feet of their front steps.

With the arrival of coal ash, the situation in Uniontown deteriorated. Residents living near the waste dump reported a noxious, nauseating smell from coal ash waste. Also, they reported fugitive ash dust covering their homes and automobiles.

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<sup>9</sup> "Ash Slide at TVA Kingston Fossil Plant," Tennessee Department of Environment and Conservation, website accessed March 22, 2014 at <http://www.tn.gov/environment/kingston/index.shtml>

<sup>10</sup> "A Toxic Inheritance: An Alabama community inherits America's worst coal ash spill," Earthjustice blog accessed 3/21/14 at <http://earthjustice.org/features/campaigns/a-toxic-inheritance>

The inherent injustice of transporting toxic waste from the largely white community in Roane County, Tennessee to a majority black community is currently the subject of a Civil Rights lawsuit brought by Earthjustice and a local attorney:<sup>11</sup>

In December of 2013, Earthjustice attorneys informed the EPA's Office of Civil Rights that Earthjustice would be representing six Alabama residents in a civil rights complaint under Title VI of the Civil Rights Act of 1964, which prohibits recipients of federal funds, including state agencies, from taking actions or implementing policies that have unjustified disproportionate adverse effect on the basis of race. The complaint is against the Alabama Department of Environmental Management for reissuing and modifying the landfill's permit without proper and readily enforceable protections of public health.

At the time of this report, the case is unresolved and awaits adjudication; no hearing date has been set.

### **Eden, North Carolina: *In Harm's Way***

On February 2, 2014, in the third largest coal ash disaster in history, Duke Energy's Dan River Steam Station released a torrent of toxic sludge into the Dan River near Eden, North Carolina. The story made national and world news that day, but the disaster was an accident waiting to happen. Ample warnings were there. Regulatory officials in North Carolina were aware of excessive groundwater contamination. Risks to residents from coal ash impoundments were known to the company and state and federal officials. Yet nothing was done.

The Dan River flows 214 miles through North Carolina and Virginia. It arises in Patrick County, Virginia and crosses into North Carolina at Stokes County, flows east into Rockingham County, veers back into Virginia and then reenters North Carolina and flows into Caswell County, then back into Mecklenburg County, Virginia where it empties into the John H. Kerr Reservoir, also known to North Carolinians as Kerr Lake and to Virginians as Buggs Island Lake. The Kerr Reservoir is formed by a dam on the Roanoke River, which flows east into Lake Gaston.

The Dan River Steam Station's coal ash was stored in two impoundments covering 39 acres with a capacity of 664 acre-feet. The embankments and dikes constructed over a fifty-eight year period had created the hazardous situation which ended with an eruption of over 35 million gallons of ash and contaminated water into the Dan River. A report issued over three years ago by the Environmental Integrity Project, Earthjustice and Sierra Club concluded<sup>12</sup>:

Voluntary groundwater monitoring at Duke Energy's Dan River Steam Station's coal ash ponds has detected levels of chromium, iron, lead, manganese, silver, and sulfate that exceed state groundwater standards and federal Maximum Contaminant Levels (MCLs) and Secondary MCLs (SMCLs). Dan River Steam Station has two unlined coal ash ponds as well as an unlined dry ash landfill. Fifteen years of sporadic voluntary monitoring beginning in November 1993 indicates that there is on-site groundwater

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<sup>11</sup> *Ibid.*

<sup>12</sup> *In Harm's Way: Lack of Federal Coal Ash Regulations Endangers Americans And Their Environment*, Jeff Stant, August 26, 2010, accessed 3/18/14 at <http://earthjustice.org/sites/default/files/files/report-in-harms-way.pdf>

contamination that is likely migrating outside of the state-designated compliance boundary for Dan River's CCW impoundments. EPA ranked both wet CCW ponds at Dan River Steam Station as high hazard surface impoundments, meaning that their failure will probably cause loss of life (USEPA, 2009).

The *In Harm's Way* investigators reported 39 new cases of contamination caused by improperly disposed coal combustion waste, including Dan River. These reports were in addition to similar cases of contamination found at scores of other sites and catalogued during the previous decade by the US Environmental Protection Agency, bringing the total number of known sites contaminated by coal ash waste to 167 in 34 states.

The Dan River Steam Station chapter of *In Harm's Way* is attached to this report as Appendix B.

### **Landfills Are Not Acceptable for Coal Ash**

During the mid-20<sup>th</sup> Century open pit waste dumps and trash heaps gave way to sanitary landfills which covered the waste with earthen caps to solve the problems of rodents, insects and odors. But the underground environment and consequent anaerobic decomposition of the waste introduced new problems: methane gas and toxic liquid leachate. To solve these problems, Congress enacted the Resource Conservation and Recovery Act in 1976.<sup>13</sup> Subtitle D of RCRA is a section of the law which governs municipal solid waste landfills accepting so-called non-hazardous waste; i.e., household garbage and commercial solid waste. RCRA Subtitle C governs hazardous wastes.<sup>14</sup>

The solid waste program, under RCRA Subtitle D, encourages states to develop comprehensive plans to manage nonhazardous industrial solid waste and municipal solid waste, sets criteria for municipal solid waste landfills and other solid waste disposal facilities, and prohibits the open dumping of solid waste.

The hazardous waste program, under RCRA Subtitle C, establishes a system for controlling hazardous waste from the time it is generated until its ultimate disposal in effect, from cradle to grave.

RCRA (Resource Conservation and Recovery Act) regulates solid waste. Generally, solid wastes are any discarded materials which are not hazardous. Specific definitions and exclusions are located primarily in Title 40 Part 261 of the Code of Federal Regulations. Municipal solid waste landfills may accept household waste, non-hazardous sludge, industrial solid waste, and construction and demolition debris. Municipal solid waste landfills must comply with federal regulations at 40 CFR Part 258, Subtitle D. RCRA also regulates hazardous waste; that is, wastes which are ignitable, corrosive, reactive or toxic. The regulations are located primarily in

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<sup>13</sup> 42 U.S.C. §6901 et seq. (1976). The Solid Waste Disposal Act (42 U.S.C. 6901-6992k) consists of title II of Public Law 89-627 and the amendments made by subsequent enactments. This Act is popularly referred to as the Resource Conservation and Recovery Act, after the short title of the law that amended the Solid Waste Disposal Act in its entirety in 1976 (P.L. 94-6580).

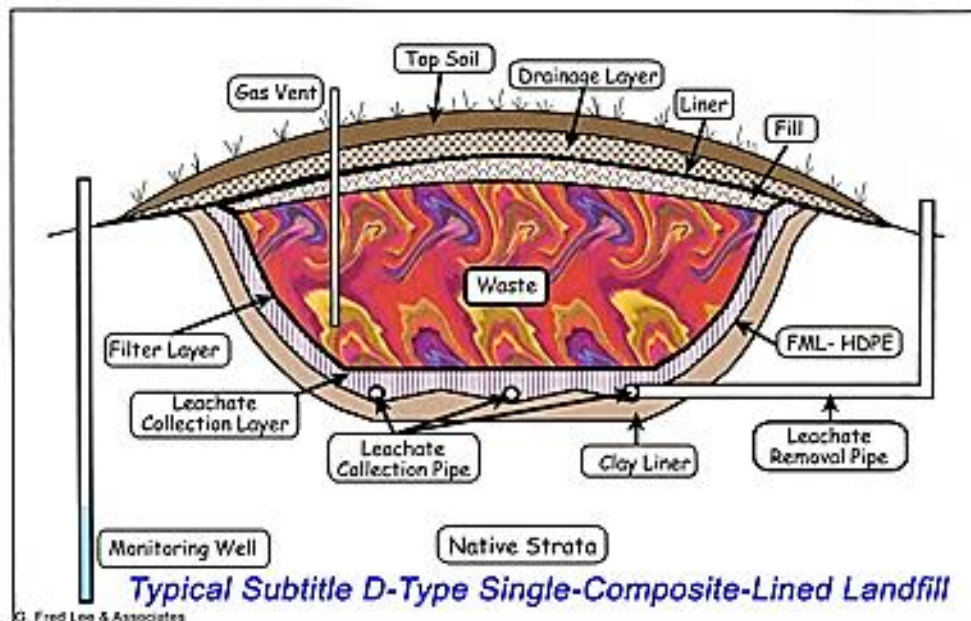
<sup>14</sup> "History of RCRA," EPA website accessed 3/22/14 at <http://www.epa.gov/waste/laws-regs/rcrahistory.htm>

Title 40 of the Code of Federal Regulations at Part 261, Subpart C. There are twenty-one Subtitle C hazardous waste landfills in the United States, identified by the US Environmental Protection Agency for disposal of RCRA Subtitle C hazardous waste. Pursuant to 40 CFR §261.4(b)(4), "Fly ash waste, bottom ash waste, slag waste, and flue gas emission control waste, generated primarily from the combustion of coal or other fossil fuels..." is solid waste.

In 1988, the US EPA altered Subtitle D regulations because single composite liners for landfills would not prevent groundwater pollution. But the new double-lined landfills permitted by North Carolina and most other state waste management agencies under Subtitle D suffer from a combination of technological cross-purposes, regulatory short-sightedness and public relations hyperbole.

During the early 1990s, implementation of the new Subtitle D regulations prompted widespread closure of traditional unlined landfills and a flurry of new double-lined landfills relying on a layer of clay and a layer of plastic. The double liners were thought to provide protection from contamination of groundwater. However, the fatal flaw of solid waste landfills is that they are subject to natural forces which make leakage and contamination inevitable. For example, on average rodents move over five tons of soil per acre annually. The diagram below illustrates the typical Subtitle D landfill:

**Cross-section of a Subtitle D Landfill**



*Key Problems with the Subtitle D Approach*<sup>15</sup>

- Heavy metals will not "detoxify" in landfill
- All landfill liners eventually leak

<sup>15</sup> "Issues Concerning Impacts of Landfills on Groundwater Quality & Public Health," G. Fred Lee and Associates, most recently accessed 3/22/14 at [http://www.gfredlee.com/Landfill\\_Impacts.html](http://www.gfredlee.com/Landfill_Impacts.html)

- Groundwater monitoring regimens likely to miss finger-plumes of incipient leakage; off-site well pollution may be first indication of failure
- Post-closure care and remediation funding required indefinitely, long-term financial responsibility will be shifted to county, public and local residents

According to Dr. G. Fred Lee:<sup>16</sup>

[T]he typical groundwater monitoring program allowed by regulatory agencies for Subtitle D landfills involving the use of monitoring wells at the point of compliance, which have zones of capture of about one foot, but which are spaced hundreds of feet apart, means that there must be widespread, general failure of the liner system before these monitoring wells can be expected to detect failure. The initial failure of the liner system will not be through general leakage throughout the bottom of the landfill, but will be through holes, rips, tears, or points of deterioration in the plastic sheeting flexible membrane liner. As discussed by Cherry in 1990, the initial liner failures will produce finger-like plumes of leachate that will have a high probability of passing between the monitoring wells and not being detected by them

Lee concludes:

Many of the components of the wastes in Subtitle D landfills will be a threat to pollute groundwaters forever. The liner systems being allowed at best only postpone when groundwater pollution occurs. The groundwater monitoring systems being allowed are largely cosmetic in detecting off-site groundwater pollution before widespread pollution occurs. Anyone who claims otherwise either doesn't understand the basic issues involved, or is deliberately distorting the readily available information on these issues.

The so-called promise of a double-lined landfill to protect groundwater is belied by the limited guarantee offered by manufacturers: "A five year warranty is the typical warranty now offered in the industry."<sup>17,18</sup> Moreover, cleanup costs have not been set aside for the inevitable failures: "The funding that is now provided for closure of Subtitle D landfills is grossly inadequate compared to the funding that will be needed."<sup>19</sup>

The conceptual flaw which undermines the reliability of Subtitle D is illustrated in the following diagram.

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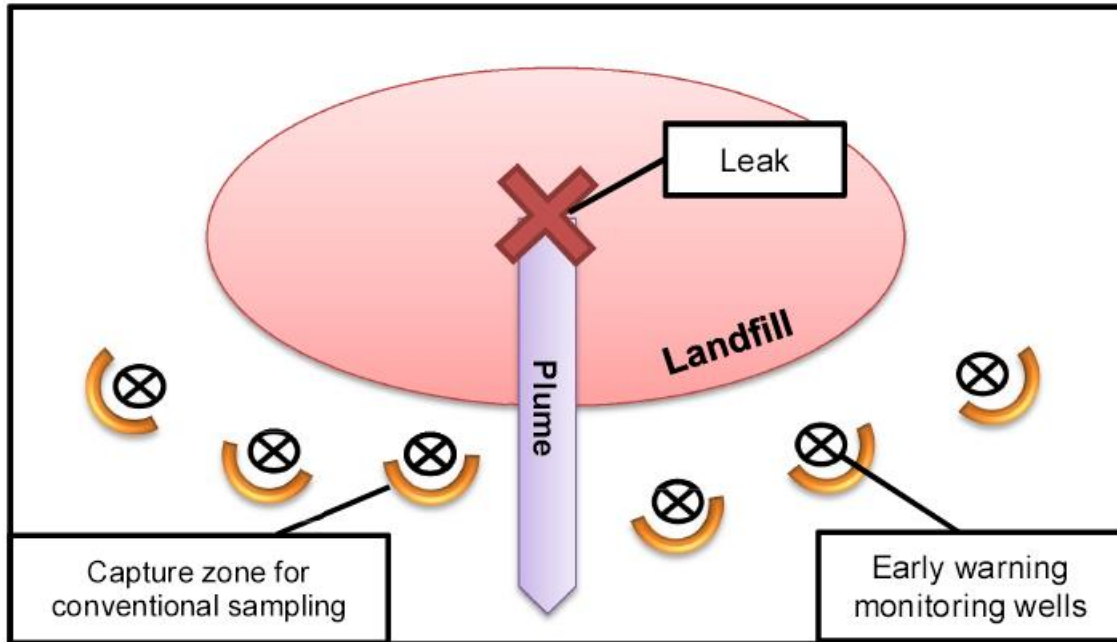
<sup>16</sup> "Detecting Failure of Subtitle D Landfill Liner Systems," G. Fred Lee, PhD, PE, DEE, G. Fred Lee & Associates, El Macero, California, November 1999. Accessed most recently on March 22, 2014 at [http://www.gfredlee.com/detecting\\_failure.pdf](http://www.gfredlee.com/detecting_failure.pdf)

<sup>17</sup> Dever, Raymond J.; Walsh, James J. "Long Term Care for Landfills, More or Less?" SCS Engineers. [www.scsengineers.com](http://www.scsengineers.com). Web. 12 July 2005. Accessed 1 May 2013.

<sup>18</sup> Colorado Lining International, HDPE liner information page. <http://www.coloradolining.com/products/hdpe.htm>

<sup>19</sup> Lee, G. Fred, Jones-Lee, Anne. "Overview of Landfill Post-Closure Issues." G. Fred Lee and Associates. [www.gfredlee.com](http://www.gfredlee.com). Web. Accessed 1 May 2013.

### Schematic Diagram of Subtitle D Solid Waste Landfill Undetected Failure<sup>20</sup>



Monitoring wells which are supposed to detect underground plumes of contamination are placed too far apart to ensure capture of the contamination. Experts who have studied the construction, operation and closure of Subtitle D landfills found that “[G]roundwater monitoring wells spaced hundreds of feet apart...will have a low probability of detecting groundwater polluted by landfill leachate....”<sup>21</sup>

Assurances by solid waste landfill regulators and commercial companies that toxic leachate is safely contained and managed by a double-lined landfill are false. Impartial experts agree that liner failure is inevitable, regardless of the liner type. That all liners will eventually fail is not in dispute. The only question is: How long will it take?

#### *Re-use of Ash Re-introduces Contamination*

Methods of using ash by incorporating it into road building and cement block construction have been tried and the results are unsatisfactory. That the ash becomes immobilized is a common but false claim. Research indicates that contaminants in the ash, heavy metals in particular, are leached from roadways and cement blocks made with ash, endangering the environment and public health. For example, in Newcastle, UK, where ash from a local incinerator had been applied from 1994-1999 on local allotments and paths, hazardous levels of dioxins and heavy metals were found.<sup>22</sup>

<sup>20</sup> Diagram by L. Zeller based on original by Dr. John Cherry

<sup>21</sup> G. Fred Lee; Jones-Lee Anne. “Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste.” G. Fred Lee and Associates. [www.gfredlee.com](http://www.gfredlee.com). Updated February 2013. G. Fred Lee and Associates. Web. Accessed 30 April 2013.

<sup>22</sup> Ryder, R.E., “Incinerator Ash is Inert.” ToxCat, 2000. 3(1). Citation 49 accessed 3/23/14 at <http://www.zerowaste.co.nz/assets/Reports/Wastedopportunities.pdf>

## The National Picture

As detailed above, coal ash impoundments a national problem. The following analysis is from a Duke University legal forum.<sup>23</sup>

Consider the following daunting statistics about existing surface impoundments. In the wake of the Kingston spill, the EPA undertook an investigation of existing surface impoundments integrity, finding that 109 of 584 such facilities nationwide had either a "high" or a "significant" hazard potential rating....In addition, 186 of the units were not designed by a professional engineer....Although the impoundments were designed to last for about 40 years, 56 were older than 50 years old and 360 were between 26 and 40 years old....Moreover, 35 units at 25 facilities had already reported releases ranging from minor spills to the massive release at the Kingston facility.

Under the Coal Combustion Residuals Proposed Rule, the US Environmental Protection Agency was to promulgate regulations for coal ash waste.<sup>24</sup>

EPA is proposing to regulate for the first time coal ash to address the risks from the disposal of the wastes generated by electric utilities and independent power producers. EPA is considering two possible options for the management of coal ash for public comment. Both options fall under the Resource Conservation and Recovery Act (RCRA). Under the first proposal, EPA would list these residuals as special wastes subject to regulation under subtitle C of RCRA, when destined for disposal in landfills or surface impoundments. Under the second proposal, EPA would regulate coal ash under subtitle D of RCRA, the section for non-hazardous wastes.

But the EPA's action was forced by events and legal action brought by public interest organizations. The following excerpts are from the EPA Consent Decree of January 29, 2014:

WHEREAS, Plaintiff Appalachian Voices, *et al.*, allege in their complaint that EPA has failed to perform a nondiscretionary duty arising under section 2002(b) of RCRA, 42 U.S.C. § 6912(b), by failing to complete the required review, at least every three years, and revision if necessary, of RCRA subtitle D regulations pertaining to coal combustion residuals;

EPA proposed rule published on June 21, 2010, 75 Fed. Reg. 24,148, EPA proposed, as one regulatory option, to revise its RCRA subtitle D regulations pertaining to coal combustion residuals.

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<sup>23</sup> *The End Game of Deregulation: Myopic Risk Management and the Next Catastrophe*, Thomas O. McGarity & Rena I. Steinzor, Duke Environmental Law and Policy Forum, Fall 2012, Vol. 23:93, Pg. 9, accessed 3/23/14 at <http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1240&context=delpf>

<sup>24</sup> Coal Combustion Residuals Proposed Rule of June 21, 2010, <http://www.epa.gov/osw/nonhaz/industrial/special/fossil/ccr-rule/index.htm>

The EPA Administrator shall, by December 19, 2014, sign for publication in the Federal Register a notice taking final action regarding EPA's proposed revision of RCRA subtitle D regulations pertaining to coal combustion residuals.

Ending the foot-dragging by the federal agency with jurisdiction in this matter is a long-overdue step towards re-regulation for the protection of public health and the environment which is the premise of the Resource Conservation and Recovery Act and other federal laws.

### **The Alternative for North Carolina**

As demonstrated above, RCRA landfills are unsuitable for coal ash, and re-use merely spreads the problem around. So, what other techniques might there be to keep the toxic substances in the ash from escaping into the environment? This chapter will outline possible alternative methods of sequestering coal ash from the water, soil and air. These are now in use and could be employed, perhaps with modification, to the special conditions found in various sites.

Simply stated, one acceptable way to deal with ash is to solidify it with concrete, protect it from weather, and store it above ground. This method has been in use for fifty years.

#### *Saltstone*

The United States Department of Energy has developed a method of isolating hazardous waste at the Savannah River Site in South Carolina known as the "saltstone" process. Production byproducts from decades of defense operations are stored in dozens of million-gallon tanks at SRS. The wastes are a witch's brew of toxic compounds including heavy metals and radioactive compounds. After radioactive substances are removed, the remaining mixture is transferred to the Saltstone Production Facility and mixed with cement, slag, and fly ash to form a grout which is then disposed of in the Saltstone Disposal Facility.

The grout mixture, or slurry, is mechanically pumped into concrete disposal vaults that make up the Saltstone Disposal Facility. The mixture solidifies into a non-hazardous, low-radioactive saltstone waste. When a concrete vault is filled, it is capped with clean concrete to isolate it from the environment. Final closure of the area consists of covering the vaults with engineered closure caps, backfilling with earth and seeding to control water infiltration and erosion. The saltstone plant has been in operation since 1990, processing waste from SRS tank farms (see illustration). Currently there are two vault sizes at the SDF - 60,000 and 120,000 square feet. For comparison, a typical football field including end zones is just over 57,000 square feet. TVA's Kingston Fossil plant had a 244 acre settling pond for ash containment. Duke Energy's Dan River Steam Station has 39 acres of ash impoundment area.



### New Saltstone Disposal Facility Units Under Construction<sup>25</sup>



The Savannah River Site remediation fact sheet states:<sup>26</sup>

Saltstone Disposal Units (SDUs) are permanent disposal units to contain low-activity waste grout produced from solidification of decontaminated non-hazardous salt waste at the Savannah River Site (SRS). These units are cylindrical concrete tanks that are based on a design used commercially for storage of water and other liquids.

The most recently developed unit design, SDU-6, will also be cylindrical but will be built 10 times larger than the others. It will be 375 feet in diameter and 43 feet tall, while units 2, 3 and 5 are 150 feet in diameter and 22 feet tall.



<sup>25</sup> Photographs from Savannah River Remediation öFact Sheet: Saltstone Facilities,ö May 2012 and Sept. 2013

<sup>26</sup> Savannah River Remediation öFact Sheet: Saltstone Facilities,ö Sept. 2013

Testing and analysis by the Department of Energy<sup>27</sup> have concluded that waste disposal in the Saltstone Disposal Facility will not release material above U.S. Environmental Protection Agency drinking water standards. Wells near the edge of the disposal site are used to monitor groundwater to ensure that it meets the applicable standards. The standards are listed in the table below.

**Selected Groundwater Protection Standards Met by the Saltstone Process**

<b>Element</b>	<b>Level</b>	<b>Units</b>	<b>Standard</b>
Arsenic	50	ppb	SDWS
Cadmium	5	ppb	PDWS
Chromium	100	ppb	PDWS
Lead	15	ppb	PDWS
Mercury (elemental)	2	ppb	PDWS
Mercury (methyl)	-	-	background
Molybdenum	-	-	background
Nickel	100	ppb	PDWS
Selenium	50	ppb	PDWS

The Savannah River Site waste undergoing remediation in this manner was about 36.4 million gallons.<sup>28</sup> It is worth noting that this is just about the size of the Dan River coal ash spill in North Carolina.

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<sup>27</sup> The Savannah River Site is owned by U.S. Department of Energy. The SRS Liquid Waste contract is managed by Savannah River Remediation, a team of companies led by URS Corp. with partners Bechtel National, CH2M Hill and Babcock & Wilcox.

<sup>28</sup> "Technical Evaluation Report for Draft Waste Determination for Salt Waste Disposal," Larry W. Camper, Director, Division of Waste Management and Environmental Protection, US NRC Office of Nuclear Material Safety and Safeguards to Charles E. Anderson, Principal Deputy Assistant Secretary, Office of Environmental Management, U.S. Department of Energy, December 28, 2005

Range 10<sup>th</sup> percentile to 90<sup>th</sup> percentile in bulk composition of fly ash, bottom ash, rock, and soil

Element mg/kg	Fly Ash*	Bottom Ash*	Rock**	Soil***
Aluminum	70,000-140,000	59,000-130,000	9,800-96,000	15,000-100,000
Calcium	7,400-150,000	5,700-150,000	6,000-83,000	1,500-62,000
Iron	34,000-130,000	40,000-160,000	8,800-95,000	7,000-50,000
Silicon	160,000-270,000	160,000-280,000	57,000-380,000	230,000-390,000
Magnesium	3,900-23,000	3,400 - 17,000	700-56,000	1,000-15,000
Potassium	6,200-21,000	4,600 - 18,000	4,000-45,000	4,500-25,000
Sodium	1,700-17,000	1,600 - 11,000	900-34,000	1,000-20,000
Sulfur	1,900-34,000	BDL-15,000	200-42,000	840-1,500
Titanium	4,300-9,000	100-7,200	200-5,400	1,000-5,000
Antimony	BDL-16	All BDL	0.08-1.8	BDL-1.3
Arsenic	22-260	2.6-21	0.50-14	2.0-12
Barium	380-5100	380-3600	67-1,400	200-1,000
Beryllium	2.2-26	0.21-14	0.10-4.4	BDL-2.0
Boron	120-1000	BDL-335	0.2-220	BDL-70
Cadmium	BDL-3.7	All BDL	0.5-3.6	BDL-0.5
Chromium	27-300	51-1100	1.9-310	15-100
Copper	62-220	39-120	10-120	5.0-50
Lead	21-230	8.1-53	3.8-44	BDL-30
Manganese	91-700	85-890	175-1400	100-1,000
Mercury	0.01-0.51	BDL-0.07	0.1-2.0	0.02-0.19
Molybdenum	9.0-60	3.8-27	1.0-16	All BDL
Nickel	47-230	39-440	2.0-220	5-30
Selenium	1.8-18	BDL-4.2	0.60-4.9	BDL-0.75
Strontium	270-3100	270-2000	61-890	20-500
Thallium	BDL-45	All BDL	0.1-1.8	0.20-0.70
Uranium	BDL-19	BDL-16	0.84-43	1.2-3.9
Vanadium	BDL-360	BDL-250	19-330	20-150
Zinc	63-680	16-370	25-140	22-99

BDL - Below Detection Limit

\* Source for most fly ash and bottom ash data is EPRI CP-INFO Database<sup>3</sup>, Beryllium, thallium, mercury (bottom ash only) and boron (bottom ash only) are from the EPRI PISCES Database<sup>6</sup>

\*\* Source for rock data is US Geological Survey National Geochemical database<sup>7</sup>

\*\*\* Source for most soils data is Shacklette and Boerngen (1984)<sup>8</sup>; cadmium and thallium data are from Smith et al (2005)<sup>9</sup>

<sup>3</sup> CP-INFO Database. EPRI: August 5, 2009.

<sup>6</sup> PISCES Database. EPRI: August 5, 2009.

<sup>7</sup> Geochemistry of Rock Samples from the National Geochemical Database. US Geological Survey: 2008. <http://tin.er.usgs.gov/metadata/ngdbrock.html>.

<sup>8</sup> Shacklette, H. and J. Boerngen, 1984. *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States*, US Geological Survey Professional Paper 1270.

<sup>9</sup> Smith, D.; Cannon, W.; Woodruff, L.; Garrett, R.; Klassen, R.; Kilburn, J.; Horton, J.; King, H.; Goldhaber, M.; Morrison, J., 2005. *Major- and Trace-Element Concentrations in Soils from Two Continental-Scale Transects of the United States and Canada*. US Geological Survey Open File Report 2005-1253.

### Entity Company – Location

Duke Energy - Dan River Steam Station  
524 S Edgewood Rd  
Eden, NC 27288  
Rockingham County  
Latitude: 36.489495 Longitude: -79.715427

### Determination

Demonstrated on-site damage to groundwater

### Probable Cause(s)

Leaching of coal combustion waste (CCW) contaminants into groundwater

### Summary

Voluntary groundwater monitoring at Duke Energy's Dan River Steam Station's coal ash ponds has detected levels of chromium, iron, lead, manganese, silver, and sulfate that exceed state groundwater standards and federal Maximum Contaminant Levels (MCLs) and Secondary MCLs (SMCLs). Dan River Steam Station has two unlined coal ash ponds as well as an unlined dry ash landfill. Fifteen years of sporadic voluntary monitoring beginning in November 1993 indicates that there is on-site groundwater contamination that is likely migrating outside of the state-designated "compliance boundary" for Dan River's CCW impoundments. EPA ranked both wet CCW ponds at Dan River Steam Station as "high hazard" surface impoundments, meaning that their failure will probably cause loss of life (USEPA, 2009).





## Test of Proof

Groundwater monitoring found exceedances of groundwater standards, such as North Carolina standards, federal MCLs, and federal SMCLs (Duke Energy and NC DENR, 1993–2009). For example:

- **Chromium** was reported at 0.0611 mg/L in April 2008, over the state groundwater standard of 0.05 mg/L.
- **Iron** exceedances ranged from 0.32 mg/L to 69.73 mg/L between November 1993 and April 2008, the latter being over 232 times the SMCL and state groundwater standard of 0.3 mg/L.
- **Lead** exceedances ranged from 0.01522 mg/L to 0.0392 mg/L between April 1998 and April 2008, the latter being over twice the MCL and state groundwater standard of 0.015 mg/L.
- All recorded **manganese** values exceeded SMCLs and state groundwater standards. Manganese concentrations ranged from 0.32 mg/L to 7.058 mg/L, the latter being over 141 times the SMCL and state groundwater standard of 0.05 mg/L.
- **Silver** was reported at 0.0411 mg/L in April 2008, over twice the state groundwater standard of 0.0175 mg/L.
- **Sulfate** exceedances ranged from 510 mg/L to 560 mg/L between November 1993 and April 1996, more than twice the SMCL and state groundwater standard of 250 mg/L (DENR).

The full extent of the groundwater contamination is unknown. Groundwater testing was only conducted within the boundaries of the CCW impoundment structure because the impoundment extends all the way to the Dan River, making downgradient groundwater monitoring difficult. No off-site monitoring has been conducted.

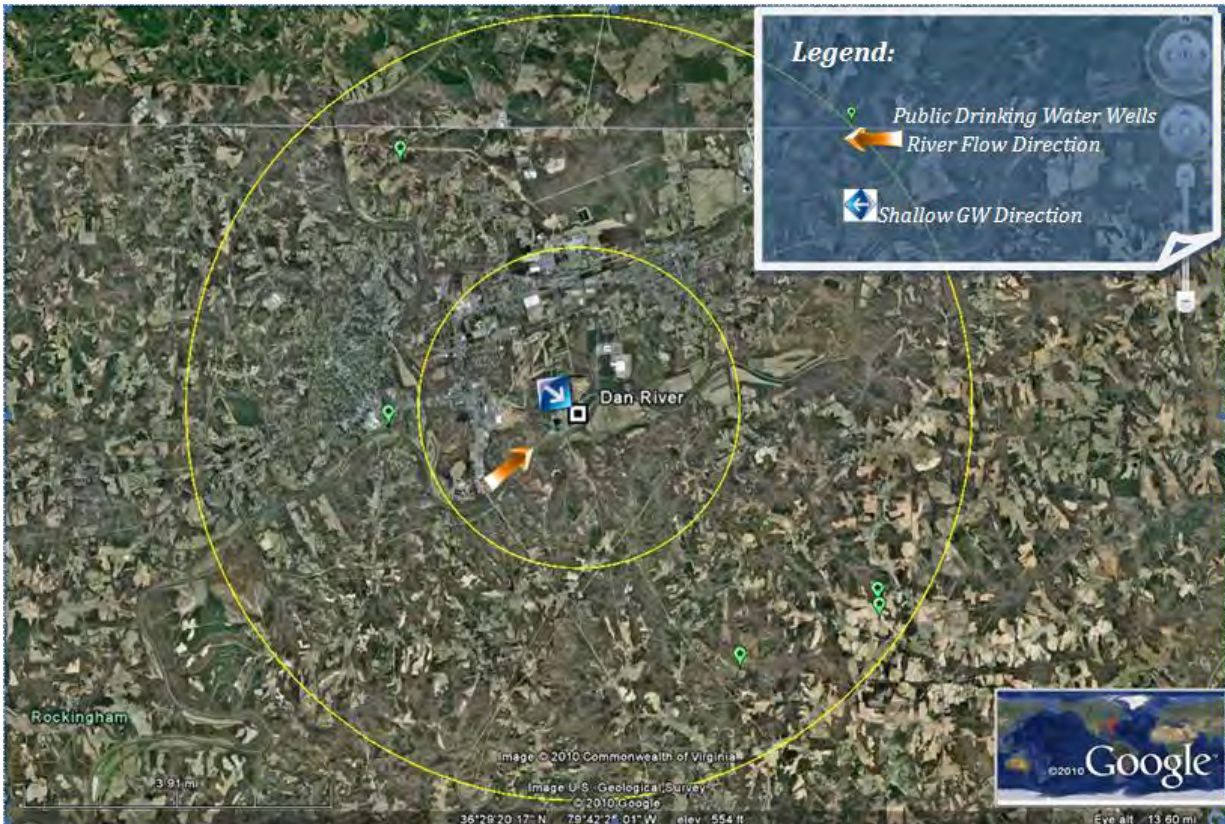
High levels of iron, lead, and manganese in wells presumed to be “background” indicate possible contamination from the on-site dry coal ash storage facilities and warrant further investigation. Groundwater monitoring has only targeted the wet CCW storage site, ignoring the dry CCW landfill.

## Constituents Involved

Chromium, iron, lead, manganese, silver, and sulfate

## At Risk Populations

The Dan River Steam Station is located in a fairly densely populated area. Private well data is supposed to be archived at the county level; however, Rockingham had only an incomplete list of registered wells from the 1970s, without the geospatial data necessary to map wells in relation to the Dan River Steam Station. Although not an exhaustive list, the private well data available showed that there are over a dozen private suburban residences within two miles of the CCW impoundments at Dan River. In addition, public well data available through the North Carolina Department of Natural Resources, shows five public drinking water wells within a five-mile radius of Dan River that serve over 60 citizens.



### Incident and Date Damage Occurred / Identified

Exceedances of groundwater standards were first documented in November 1993

### Regulatory Action

The North Carolina Department of Environment and Natural Resources (DENR) is aware of existing groundwater contamination at levels that exceed state groundwater standards at the Dan River Plant. However, DENR has not required a corrective action plan to restore contaminated groundwater at the Dan River Plant and has no plans to take action to eliminate the source of contamination until it reaches the “compliance boundary.” DENR plans to require groundwater monitoring outside of the compliance boundary upon permit renewal for all coal ash ponds (Henderson, 2010), but this may be difficult in the case of the Dan River Steam Station because its coal ash impoundments abut the Dan River.

Despite evidence of groundwater contamination, DENR has not required Duke Energy to take any remedial action. Under North Carolina law, a company is only required to take cleanup action if contamination is spreading outside of a designated “compliance boundary.” As long as Duke Energy continues to monitor only inside the compliance boundary at the Dan River Plant, they will not produce data sufficient to trigger cleanup.

### Wastes Present

Fly ash, bottom ash, boiler slag, and flue gas emission residuals from the Dan River Steam Station (Duke Energy, 2009)

### Type(s) of Waste Management Unit

Two unlined wet coal ash impoundments and one unlined dry coal ash landfill

### Active or Inactive Waste Management Unit

Two active wet coal ash impoundments and one inactive, capped dry landfill

### Hydrogeologic Conditions

The CCW impoundments abut the Dan River, indicating that shallow off-site groundwater contamination may be diluted. Further hydrogeologic information was unavailable.

### Additional Narrative

The Dan River Steam Station began operation in 1949. The CCW storage impoundment was originally built in 1956, seven years after the plant began operating. The embankment walls were raised in 1967. In 1977, the embankment walls were raised again, and an interior dike was built to divide the impoundment into the two that exist today. It should be noted that the western dike walls of the primary and secondary ash ponds were constructed on top of existing coal ash deposits. The two impoundments together cover 39 acres, with a total storage capacity of 664 acre feet. The impoundments have been periodically dredged and the dredged ash spoils are stored in an unlined dry ash landfill just north of the ponds. The last dredging occurred in 2007. Another dredging is unlikely because the plant is expected to be decommissioned soon.

### Source(s)

Duke Energy & NC DENR. 1993-2008. Dan River Steam Station: Coal Ash Pond Voluntary Monitoring Data.

Duke Energy. 2009. Letter from Richard Kinch, Duke Energy to U.S. Environmental Protection Agency (EPA), Re: CERCLA 104(e) Request for Information (Mar. 25, 2009), available at <http://www.epa.gov/epawaste/nonhaz/industrial/special/fossil/surveys/duke-dan-river.pdf>.

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Powers. 2009. R. Powers. Dan River Ash Basin NPDES Permit NC0003468 Waste Review and Compliance Boundary: Duke Energy – Dan River Steam Station, Rockingham County, North Carolina (Apr. 27 2009).

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