# The regulation of coal combustion residuals (coal ash) in the United States: geosynthetic and barriers, an overview

B. Ramsey & B. Betke
*GSE Environmental LLC, Houston TX (bramsey@gseworld.com)*

ABSTRACT: The regulation of coal ash (or as it is technically referred to "coal combustion residuals") has significantly expanded the market for geosynthetics within the United States. Further there is interest in these regulations around the globe in every country using coal as an energy source. These regulations are clearly the result of recent environmental incidents. The regulations call for the increased use of geosynthetic materials in both new and exisiting sites and facilities, both for storage, remediation and stabilization of existing sites. This paper highlights the path to regulation, presents the important factors of the exisiting regulations and discusses the ongoing application of the regulations.

*Keywords: Geosynthetics, coal ash, geomembrane, barriers, regulation*

## 1 INTRODUCTION

Use of geosynthetics in barrier, drainage and stabilization applications of civil engineering is well established. This document is an attempt to "tell the story" of how these materials and recent regulations requiring their use have been promulgated by the United States Environmental Protection Agency (USEPA or EPA). These regulations have been influenced by prior performance of the geosynthetic materials and the clearly demonstrated benefits of geosynthetics in civil engineering. Also, several environmental incidents at sites where geosynthetics and proper engineering technologies were not fully utilized have provided an impetus for regulatory and legal action and indicated the scope and scale of the potential environmental issues and impacts.

## 2 HISTORY AND TIMELINE

The geosynthetics market as a whole and the geomembrane industry in particular received its first large growth spurt with the 1976 U.S. congressional bill that is known as RCRA [The Resource Conservation and Recovery Act]. These regulations were issued in two sections, the first specific to material deemed as hazardous waste, the second addressing the long-term fate of solid waste. Hazardous waste has since become known as "subtitle C" type waste and solid or most commonly household waste has become known by that specific section of the regulations "subtitle D." There is an additional waste stream known as construction and demolition waste or "C& D material" that is not regulated under RCRA but is instead addressed

on a state-by-state or local regulatory basis. The second significant regulatory impact occurred in 1980 with passage of the Comprehensive Environmental Response, Compensation and Liability Act more commonly known as "Superfund." This regulation not only increased demand for geosynthetic materials but helped to spur on large growth in the capping applications, using geosynthetics as surface or near surface barriers to prevent rainwater infiltration.

Now focusing on coal ash and its regulation within the United States. The proper place to begin this review is in calendar year 1980 with the passage by the U.S. Congress of what is known as the "Bevill Amendment," named for former Representative Tom Bevill (D-AL). In passing the law, RCRA was amended by adding section 3001(b)(3)(A)(ii), known as the Bevill exclusion, to exclude "solid waste from the extraction, beneficiation, and processing of ores and minerals" from regulation as hazardous waste under Subtitle C of RCRA., Further, an EPA study of the impact of coal ash on the environment was mandated. This study was completed and published in the Federal Register on May 22, 2000. The report states "The Agency has concluded these wastes do not warrant regulation under subtitle C of RCRA and is retaining the hazardous waste exemption under RCRA section 3001(b) (3) (C). However, EPA has also determined national regulations under subtitle D of RCRA are warranted for coal combustion wastes when they are disposed in landfills or surface impoundments…" However, the EPA determination for subtitle "D" regulation was not heeded and the absence of regulations of coal ash storage continued.

Just before 1 a.m. on Monday, December 22, 2008, a dike containing coal fly ash slurry ruptured at an 0.34 km2 (84-acre) solid waste containment area at the TVA Kingston Fossil Plant in Roane County, Tennessee, USA. An estimated 4,200,000 m3 (1.1 billion U.S. gallons) of coal fly ash slurry was released, subsequent direct clean-up and remediation costs have been estimated at greater than 1.5 billion dollars. This incident, other large scale coal ash spills and other issues with groundwater contamination at or near coal combustion residual storage facilities resulted in the US EPA promulgating regulation of coal ash storage and significant companion actions on the legal, federal congressional and multiple governmental fronts.

The most efficient and effective barrier system and one that is currently required by regulation is a composite liner system using a primary geomembrane (GMB) liner, most commonly manufactured from High Density Polyethylene (HDPE) with some form of clay, either a compacted clay liner (CCL) or a Geosynthetic Clay Liner (GCL), although other variations exist. This is a direct result of that system being compliant with the United States Environmental Protection Agency (US EPA) Resources Conservation and Recovery Act (RCRA) Subtitle "D" regulations. However, the system(s) have a great history of success as documented by several investigations, most prominently the US EPA study titled "Assessment and Recommendations for Improving the Performance of Waste Containment Systems" by Bonaparte, et.al. Figure 1 illustrates the effectiveness of composite liners as indicated by lower leakage rates.

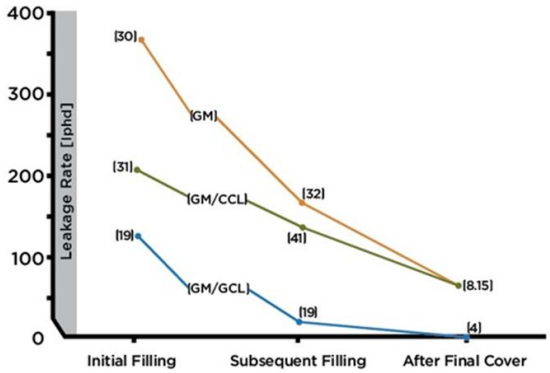

Figure 1. Leakage rates of GMB alone (top) and composite liners (CCL and GCL, respectively) after Bonaparte

After the Kingston spill, on June 21, 2010 the EPA issued a proposed rule for the regulation of coal ash storage. But that statement is factually inaccurate. In the body of the EPA proposal were at least three, perhaps as many as six unique and different regulatory schemes depending on how they were parsed. This confusion, combined with resistance to regulation in some quarters and the possibility of the classification for coal ash as a hazardous waste material resulted in several years of political, legal and governmental review, studies, proposals and evaluations

On October 31, 2011 a spill occurred at a power generation facility owned by a WE Energies located on the shore of Lake Michigan in Oak Creek Wisconsin, USA, south of Milwaukee.

Figure 2: Impacts of the Oak Creek Coal Ash spill (Milwaukee Wisconsin Journal Sentinel Online)

This event resulted in a significant quantity of coal ash being released into Lake Michigan. According to a report published by the State of Wisconsin Department of Natural Resources, the spill was the result of construction of a sediment retaining basin being constructed over old coal ash deposits. *"…the FGD sediment basin would potentially be constructed in coal ash deposits (see figure 5). During construction, ash deposits were found in the western portion of the FGD sediment basin. These deposits were removed and replaced with suitable soil in accordance with the contaminated materials management plan. However, a liner plan was not submitted to the Department when ash deposits were discovered…" "A significant component of the bluff collapse material appears to be the coal ash deposited in a ravine in the 1950s – 1960s*."

On the first and second of February, 2014 at least 30 million kilograms (~ 30,000 tons) of coal ash and stored contaminated water spilled from a closed pond at the Duke Energy power plant in Eden, North Carolina. The coal ash was transported through a failed drainage pipe below the surface impoundment into the Dan River.

Figure 3: The absent ash from the Dan River coal ash storage site (Wikipedia – "Dan River")

The Dan River spill and the subsequent investigations were the impetus for two critically important events with respect to the regulation of coal ash in the US. The first of these occurred on May 14, 2015. Duke Energy pleaded guilty to nine violations of the Clean Water Act (CWA) for illegally discharging pollution from coal ash facilities at five of its coal-fired power plants in North Carolina. The plea and negotiated settlement provided for payment of $68 million in fines and the expenditure of an additional $34 million for environmental and land conservation projects benefitting North Carolina and Virginia. The federal judge in the case characterized the settlement as "the largest federal crime fine in North Carolina history." Settlement documents said the costs would be borne by company shareholders and not passed on to the company's customers.

The Dan River spill also put in motion what may become a precedent-setting legislative response in North Carolina. By September 20, 2014 the General Assembly of NC enacted what is known as the "Coal Ash Management Act of 2014 (NC-CAMA)." While surface water and groundwater pollution from coal combustion residuals (CCR) facilities was already regulated under authority of the CWA, CCR surface impoundments were generally unregulated repositories of solid waste. In North Carolina, like many other states, CCRs in wet impoundment were not considered "solid wastes" and were generally exempt from the state's solid waste disposal regulations. As a result, management practices likely to prevent pollution of water resources from CCR surface impoundments were neither mandated nor consistently applied.

NC-CAMA materially changed the regulation of CCR surface impoundments in North Carolina. The law required the following actions and set timelines for their completion. Until the enactment of NC-CAMA, nothing in then-existing state or federal law otherwise required any of these actions:

- conversion of utility ash handling practices from wet to dry ash handling;
- cessation of deposition of CCRs in wet impoundments; and the
- closure of all 33 CCR impoundments under prescribed environmental standards.

NC-CAMA required the assessment and prioritization by risk-classification of all 33 CCR impoundments. As of this writing, the NC Department of Environment and Natural Resources (NC-DENR) has completed at least a first "final assessment." All of the CCR impoundments in the state were classified either high or intermediate risks. Under the law CCR impoundments in these classifications must be excavated and remediated. Excavated CCR materials must be beneficially re-used or disposed as a solid waste in landfills or large-scale structural fills.

NC-CAMA also established stricter design, construction and siting standards for large projects using coal ash as fill for construction projects and placed a moratorium on smaller structural fill projects. Essentially, large-scale structural fills are considered disposal units and treated similar to landfills. CCR disposal must be carried out in a landfill that meets the most current standards for industrial landfills, including a composite liner system, leachate collection, groundwater monitoring, and financial assurance. NC-CAMA also provided acceptance of federal standards in the event the federal standards were more stringent.

As the regulations in North Carolina developed, EPA continued its work on federal standards for coal ash facilities. Despite efforts in the US Congress to provide direction to EPA and somewhat consistent with the Consent Decree resulting from the court case with Appalachian Voices, et al, EPA Administrator McCarthy signed on December 19, 2014 "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities (the CCR Rule)" for publication.

This document (the CCR Rule) was ultimately published in the Federal Register April 17, 2015 resulting in an "Effective Date" of October 19, 2015.

One of the fundamental foundations of the newly promulgated CCR Rule was the continuation by EPA of the exclusion of CCR from the list of hazardous wastes. While continuing the exemption, EPA made clear it had not reached a final decision on the Bevill Regulatory Determination. While not listing CCR as a hazardous waste, EPA concluded *"the record is clear that current management of these wastes can present, and in many cases has presented, significant risks to human health and the environment .....* (and) *the current level of risk clearly warrants the issuance of federal standards to ensure consistent management practices and a national minimum level of safety."*

Thus, since CCR is neither a listed nor characteristic hazardous waste it can only be regulated per RCRA subtitle D. Under the applicable sections of RCRA the role of EPA is the establishment of minimum national criteria that apply to CCR facilities. EPA fulfils its role by establishing the criteria and providing technical assistance to states to develop solid waste management practices for each state. In the preamble to the CCR Rule, EPA clarified its role -- *"EPA has no role in the planning and direct implementation of the minimum national criteria or solid waste programs under RCRA subtitle D, and has no authority to enforce the criteria. While Congress developed the statutory structure to create incentives for states to implement and enforce the federal criteria, it does not require them to do so. As a result, subtitle D is also structured to be self-implementing. EPA also may act if the handling, storage, treatment, transportation, or disposal of such wastes may present an imminent and substantial endangerment to health or the environment, pursuant to RCRA section 7003."*

Although EPA lacks authority to enforce the minimum standards, states and/or citizens have access to means to enforce the requirements of the CCR Rule. States may enforce the requirements of the CCR Rule utilizing enforcement authority provided under state law. Both states and citizens may enforce the CCR Rule under the citizen suit authority provided within RCRA (and CWA). To facilitate monitoring and enforcement by citizens EPA included a number of provisions in the CCR Rule requiring public access to owner-proposed actions and operational data.

As of October 19, 2015, the self-implementing CCR Rule finalized enforceable minimum national criteria owners and operators of CCR disposal facilities must meet to avoid having those facilities treated as "open dumps" under RCRA. The CCR Rule applies to certain CCR facilities located at or serving power plants owned by electric utilities or independent power producers actively producing electricity at those plants. CCR facilities regulated under the CCR Rule include:

- New and existing CCR landfills; and lateral expansions undertaken after the effective date,
- New and existing CCR surface impoundments; and lateral expansions undertaken after the effective date' and
- Inactive" CCR surface impoundments. (In the published version of the CCR Rule EPA elected to create an incentive for more rapid closure of inactive surface impoundments. Owners and operators of inactive CCR surface impoundments dewatered and capped in accordance with the CCR Rule by April of 2018 would be exempt from some of the requirements of the CCR Rule. More about this below.)

With the establishment of the CCR Rule EPA ushered in several firsts regarding CCR facilities across the US:

- Regulation of CCR surface impoundments,
- Uniform minimum standards for landfill liner systems and cover systems,
- Uniform minimum standards for surface impoundment liners and cover systems and
- Regulation of large-scale CCR structural fills as landfills.

EPA also enumerated facilities and activities not covered by the CCR Rule. CCR landfills no longer in use and CCR facilities at power plants which have ceased all electricity production are not covered by the CCR Rule. In addition, the following activities are outside the CCR Rule:

- Beneficial use of CCR,
- Placement of CCR at active or abandoned underground or surface coal mines, and
- Disposal of CCR at municipal solid waste landfills (MSWLF).

After years of assessing the management practices associated with the storage and disposal of CCR, EPA established the minimum criteria documented in the Code of Federal Regulations Title 40 Parts 257.50 through 257.107 (the Code). The criteria are grouped into seven segments of criteria, restrictions and/or requirements the owners and operators of CCR facilities must comply with to establish new facilities, continue to operate existing facilities and close and care for facilities at the end of their useful lives.

1. Locations restrictions

2. Liner design criteria
3. Structural integrity requirements
4. Operating Criteria
5. Groundwater monitoring and corrective action requirements
6. Closure and post-closure care requirements
7. Recordkeeping, notification and internet posting requirements

The market for geosynthetic materials has been significantly expanded by the regulation of additional CCR facilities, the establishment of uniform minimum management practices across the US, the liner design criterion and the closure and post-closure care requirements. Nationwide regulation of CCR surface impoundments for the first time in decades expands the regulated use of geosynthetic materials. While the CCR Rule allows continued operation of existing CCR surface impoundments, it provides criteria for the disposition of the inactive and active fleet of surface impoundments. Time frames for the initiation of closure are established for units no longer harvesting CCR for beneficial use, for units no longer receiving CCR and for units that become temporarily idle. In addition to closures triggered by operational criteria, closures may be triggered by technical criteria contained in the CCR Rule. An owner must initiate closure within six months when a CCR unit:

- Fails to meet established location criteria,
- Contaminates groundwater and is an unlined surface impoundment or
- Fails to demonstrate minimum factors of safety for structural integrity.

Inactive CCR surface impoundments – units which ceased to receive CCR after the October 17, 2015, but still contained water and CCR – were required to meet all applicable regulatory requirements. During the CCR assessment period EPA concluded inactive CCR surface impoundments that had not completed closure consistent with the standards being promulgated posed significant risk. To encourage owners to rapidly close the inactive units to the performance standards in Part 257.102, EPA provided exemption from the remaining requirements (eg groundwater monitoring and post-closure care) of the CCR Rule if an inactive surface impoundment closed by April of 2018 utilizing the processes contained in the CCR Rule.

In respect to inactive surface impoundments, industry groups have challenged EPA's authority to regulate them at all; and environmental groups challenged the exemption from the CCR Rule for inactive CCR surface impoundments appropriately closed by April of 2018. The extent of EPA's authority and the means it employs to establish regulation of activities impacting the environment result from interpretation of the pertinent laws passed by Congress and from the case law emanating from challenges brought to agency interpretations of those laws. Shortly after promulgation of the CCR Rule industry and environmental groups filed a series of challenges to EPA's interpretations of law supporting the recently established CCR regulations. The actions were consolidated to a single case in the United States Court of Appeals.

## 3 CURRENT STATUS

As of this writing, the question of EPA's authority to regulate inactive CCR surface impoundments remains an open issue before the Court. But, April 18, 2016 EPA filed a motion with the Court to vacate the exemptions for rapidly closed inactive CCR surface impoundments because "EPA did not provide notice or opportunity to comment on this exemption

during the rulemaking" – seemingly a procedural reason. There were no objections to EPA's motion, but the Court has yet to accept the motion as of this writing.

The impact of eliminating the exemption has more to do with when closure projects will be executed than if the closure projects will be executed. Geosynthetic materials will be used in roughly the same proportion of projects, but the market impact from closure of inactive CCR surface impoundments will be more extended in time.

Once undertaken or triggered, closure of a surface impoundment may be accomplished via clean closure or waste-in-place closure. The choice of the most appropriate method of closure is left to the owner. If a clean closure is chosen or otherwise mandated (NC), the excavated CCR material must either be beneficially re-used or disposed in a lined landfill/structural fill in accordance with the CCR Rule.

Waste-in-place closures of surface impoundments and landfills are regulated to the same standards. The CCR Rule sets out minimum standards for the design, execution and operation of the cover system. The minimum standards are based upon practices found to contribute to the long term performance of the closed facility. Owners and operators must ensure that closure systems for such CCR facilities will, ***at a minimum***, comply with the performance standards identified at 257.102(d)(1) in the Code:

- *Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere;*
- *Preclude the probability of future impoundment of water, sediment, or slurry;*
- *Include measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period;*
- *Minimize the need for further maintenance of the CCR unit; and*
- *Be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices.*

In an effort to bring emphasis to the long term performance of the cover system, EPA modeled the closure performance standard after Part 265.111 dealing with interim status hazardous waste units. "*Under this performance standard, if the cover system results in liquids infiltration or releases of leachate from the CCR unit, the final cover would not be an appropriate cover."* So, in addition to the meeting the cover system criteria, owners and engineers are required to "account for any condition that may cause the final cover system not to perform as designed." A professional engineer (PE) is required to certify that the cover system design meets both the cover system criteria and the cover system performance standard.

In the CCR Rule, EPA relies on PE certification to performance standards instead of being overly prescriptive as to the cover system design. Engineers and owners may apply a soil cover system, provided the soil infiltration layer has a permeability less than or equal to the bottom liner or natural subsoils at the base of the unit. In any event, the final cover must have a permeability no greater than 1 x 10-5 cm/sec.

While the CCR Rule does not require the use of composite final covers - a geomembrane and a clay component, engineers may conclude composite final cover systems are the best way to meet the performance standard. "*EPA therefore generally recommends that facilities install a composite cover system, rather than a compacted clay barrier, as the composite system has*

*often proven to be more effective (and cost effective) over the long term. For these reasons, EPA also anticipates that composite cover systems will be recommended in many circumstances by qualified Professional Engineers."*

The CCR Rule requires all new CCR units to be designed and constructed with a composite liner (see 257.70). EPA specifically provides for an alternative composite liner – a geomembrane primary liner with a geosynthetic clay secondary liner - provided the alternative composite liner meets the required performance standard and it is certified by a qualified professional engineer. The alternative liner design must be chemically compatible with CCR and leachate and of adequate strength and thickness to prevent failure. *"The overwhelming amount of data supporting the effectiveness of a GM/GCL liner has convinced the Agency that the final rule should allow for some flexibility in composite liner designs. Data indicate that alternatives to the lower component of the composite liner system (e.g., GCLs) are available and can perform at a level equivalent to a compacted soil liner, based on a comparison of their flow rates with two feet of compacted soil with a hydraulic conductivity of no more than 1x10-7 cm/sec."*

The CCR Rule also requires a leachate collection and removal system for landfills designed to maintain less than a 30-centimeter depth of leachate over the composite liner. The leachate collection and removal system must be designed to prevent collapse from the pressure of the CCR and to minimize clogging during the active life and the 30-year post-closure care period.

## 4 CONCLUSIONS

The addition of regulations that mandate the usage of geosynthetics has occurred as a result of poor environmental performance in the storage of CCR, coal ash materials. The regulations and to an additional extent the opinions of the regulatory authors and governmental officials are encouraging the usage of the "best versions" and best geosynthetic design and construction practices for this application. This has expanded the market for geosynthetics in the United States significantly and over time as the final regulatory questions are addressed and litigation winds down the market will continue to expand.

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