Wet Impoundment Stabilization, Consolidation, and Landfill Development: The Best Alternative to Dig and Haul Propositions is In-situ Stabilization and Vertical Expansion.

Russell B. Stapp

1 Remedial Construction Services, L.P. (RECON), 9977 West Sam Houston Pkwy N. Suite 100, Houston, TX 77064

CONFERENCE: 2015 World of Coal Ash – (www.worldofcoalash.org)

KEYWORDS: In-situ stabilization, low solids stabilization, deep soil mixing, beneficial use

I. INTRODUCTION

Coal combustion residuals (CCRs) are the byproducts of coal combustion during power generation and require special attention to handling. Recent regulatory changes promulgated by the U.S. Environmental Protection Agency (EPA) require coal combustion facility managers to change their materials handling procedures of CCRs. Managers must now consider alternatives to wet impoundment storage i.e. traditional transportation and disposal approach to others that ideally do not disrupt plant operations and are cost-effective. Historically, utilities managers would use traditional transport and disposal methods, however, traditional transport and disposal is costly, provides transportation risks, and draws criticism from environmental non-governmental organizations (ENGOs).

This paper will briefly review the current CCR management practices, provide an overview of the new regulations, discuss various CCR handling methods that meet the new regulations and propose a best value alternative that offers CCR managers saving of 15% to 65% over the traditional CCR handling methods (depending on the project variables such as, but not limited to: the distance to landfill, depth of DSM, cost of new on site landfill development and local regulations) to manage CCRs in the new regulatory environment.

II. OVERVIEW OF CURRENT CCR MANAGEMENT PRACTICES

Current CCR Management Practices
CCR management practices vary from plant-to-plant. Each coal fired unit may have different combustion conditions, combust different fuel sources, and collect the CCR by a different technology; therefore, each utility’s fleet of plants may have a different management strategy for its CCRs.

Some CCRs are quite valuable and create a significant revenue source for a utility or generating plant. Unfortunately, before CCR beneficial use became a more widely accepted practice, millions of tons of CCRs were wet sluiced into ponds for storage and management. While most CCR is no longer wet sluiced, some facilities have yet to perform dry conversion which will indeed become a requirement in short order due the regulations. Currently, many millions of tons of CCRs are stored in ponds and impoundments. While it is hard to discern the exact total tonnages stored, it is estimated that at this time the number of impoundments ranges from 700-725 and approximately 27,000 cumulative surface acres of impoundments.

Current CCR management practice is to maintain the storage unit’s walls and dykes to mitigate and eliminate failures. Some plants have closed wet impoundments and maintain dry storage areas that will need amendments to meet regulatory requirements, including possible retrofit of liners, monitoring wells and ELG prevention protocols. The biggest challenge now with the regulations is how to best manage the CCR ponds and ameliorate risk.

**Risks Associated with Current Practices**

The risks associated with current ash management practices are numerous and can have an impact on surrounding communities. Concerns about leaching, windblown ash, and improper disposal offer a lot of critiques from surrounding communities and public perception is a powerful factor in how coal ash is viewed and handled. While the majority of criticisms are public relations campaigns driven by media agendas and ENGOs, significant events have occurred, specifically the TVA’s Kingston Fossil Plant coal ash spill and the Duke Energy Dan River coal ash spill. While these events were related to the design, civil engineering or maintenance failures of the storage units in which the ash was stored rather than CCRs per se, both events were a public relations nightmare for all involved and advanced discussions about the storage of coal ash at a local, state, and national level.

The TVA spill was the catalyst for the current administration’s drive to shut down coal units using a back door strategy. If CCRs could be deemed a hazardous material under Subtitle C of RCRA, then federal oversight would take control of regulation and enforcement activity of CCRs, ultimately constraining by-product management and
recycling efforts. If power plants could not dispense or store CCRs in a non-Subtitle C approved storage facility, then the plant would necessarily cease operations due to congestion and storage limitations.

However, the incessant claim that CCRs are hazardous is refuted by toxicity characteristic leaching procedure (TCLP) or synthetic precipitate leachate procedure (SPLP). The data, as a general rule, does not meet the definition of “hazardous” under RCRA limits and therefore the EPA has finally ruled accordingly in December of 2014. There are, however, cases of documented spikes in metals in down gradient wells which are considered contamination by the EPA. The regulatory requirements for impoundments and run-off migration are specifically set forth in the new regulations to prevent further risk of metals migration to protect human health and safety and environmental impacts.

Management of CCRs today consists of wet storage, dry storage, and beneficial use. Beneficial use has been a growing sector for utilities as they have realized the financial benefit and safe application of management for CCRs within the past 20 years. Another large segment of beneficial use is in the mine reclamation sector which is supported by many states interested and vested in surface mine reclamation. Currently the Department of Interior (DOI) and Office of Surface Mining and Reclamation (OSM) have the regulatory oversight of this market. The new CCR regulations deferred this oversight to OSM which may in fact limit this application. If the OSM chooses to limit or eliminate the use of CCRs in surface mine reclamation, there will be a significant impact on the power plants that utilize this option. However, some utility’s risk management teams have stopped using CCRs in large scale mine reclamation and mass stabilization due to language set forth in the initial regulations issued by the EPA in May 2010.

Some utilities today are employing the practice of “dig and haul” operations that simply excavate and remove CCRs from existing wet impoundments to be placed in newly developed lined landfills, municipal fills, or quarry/mine placement. While this is certainly a sure fire method to mitigate risk with a wet impoundment, it is not without its own risks and public relations pressures from communities (driven by ENGOs). There are risks in over-road hauling due to roadway spills, traffic congestion, accidents, and NIMBY (not in my back yard) resistance. Equally as important as the transportation risk is the cost associated with the trucking and disposal of each cubic yard to an offsite landfill where tipping fees can be a premium especially if the utility has minimal leverage.

III. REGULATORY CHANGES AND THEIR AFFECTS ON CCR MANAGEMENT

U.S. EPA CCR Regulatory Highlights
On December 19, 2014, the U.S. EPA administrator signed the Disposal of Coal Combustion Residuals (CCR) from Electric Utilities final rule. The final rule was a result of extensive study of the effects of coal ash on public health and the environment and comprehensive study on the effects of coal ash on the national regulations finalized by the EPA provide a stringent set of requirements for the safe disposal of CCRs that are meant to reduce the risks to human health and the environment. The final rule creates national minimum criteria for existing and new CCR landfills and existing and new CCR surface impoundments. The rule addresses the lateral expansion of landfills and impoundments, including location restrictions, design and operating criteria, groundwater monitoring and corrective actions, closure requirements, post closure, record keeping, and appropriate public notifications. It requires that any existing unlined CCR surface impoundment that is “contaminating groundwater above applicable groundwater protections standards stop receiving CCRs and retrofit with a liner or close the impoundment.”

The rule also requires the closure of any CCR landfill or impoundment that cannot meet the location restrictions or structural integrity requirements. This will certainly cause many utilities to consider closing any CCR facility that may cause undue PR and risk (i.e. litigation, unfounded or with merit) and if suitable, seek available cost effective alternatives. Lastly, the CCR rule requires that those surface impoundments that no longer receive CCRs after the effective date of the rule, but still maintain water and CCRs, be subject to all regulatory requirements unless the owner or operators dewater and install a final applicable cover (federal, state, or county EPD approved cover) no later than three years from the publication of final ruling.

The final rule will apply to all CCRs generated by North American electric utility providers and independent power producers (IPP). However, it does not apply to CCR producers that are not utilities or IPPs, such as industrial plants, universities and hospitals. An example where the rule would not apply would be paper mill facilities that produce as much as 60,000 tons per year of CCRs. These facilities have their own coal-fired plant providing energy and steam to the manufacturing facility. The EPA does not provide a compelling reason why these CCRs units are exempt for the CCR regulations.

Each State will define its own CCR rules that must meet the minimum standards set forth by EPA. While legally compelled to implement EPA minimums, some states may set CCR guidelines that are above minimum EPA standards. The state of North Carolina due to the high profile Duke issues is leading the way in development of state standards and in-place stability options.

1 http://www.epa.gov/epawaste/nonhaz/industrial/special/fossil/index.htm
US EPA December 19, 2014 Final Rule Time Line Summary (related to in-situ stabilization)

**Six to Twelve Months from Date of Promulgation –**

**Structural Integrity Requirements**
- Rule requires structural integrity requirements and currently EPA lists at least 45 units considered high hazard.

**Operating criteria – requirements starting 6 months after rule**
- Operating criteria addresses the day to day operations of the CCR units to protect public health and environment from units. Included are fugitive dust, run-on and run-off controls (ELG) for landfills to minimize the amount of water entering the unit, erosion control, discharge and creation of landfill leachate, and the prevention of run off to surface waters. The unit must have controls in place to prevent overtopping from flood flows. RECON has expertise to attack all of these opportunities with the utility and engineering design firms as the general contractor.

**Eighteen Months after Promulgation –**

**Location Restrictions**
- Include restrictions related to placement above upper most aquifers, in wetlands, in fault areas, in seismic impact zones, and in unstable areas. Owners must demonstrate that the impoundments meet these requirements, through engineering enhancements and if they cannot must begin closure activity. RECON has the competency to provide seismic stability and aquifer protection among other specific need for stability requirements.

**Closure and Post Closure Requirements**
- Closure of CCR unit is triggered in 3 ways:
  1. When the unit does not meet the location standards or engineering amendments cannot bring the unit into compliance.
  2. If the unlined unit is contaminating water above the minimum groundwater protection standard.
  3. If the CCR unit cannot demonstrate that it meets the minimum safety standards for structural integrity.
- When the unit receives the final CCR for storage or when the unit has taken the last shipment of CCR for beneficial use. The unit must begin closure within 30 days of last utilization.
• For idled units, the owner or operator has a two year window of inactivity and then must begin closure unless the owner or operator can provide compelling evidence or demonstrate that the unit will be utilized.

**Beginning Thirty Months after Rule Promulgation –**

**Protection of Groundwater**

• Provision requires owner/operator of CCR unit to install monitoring wells. If monitoring indicates constituents above limits, owner operator must immediately begin remediation practices (slurry walls). If unit is unlined, owner must begin closure procedures.

**Inactive Units - 3 years after rule**

• Inactive units that have ceased receiving CCRs by the effective date of the rule (6 months) if they have water and contain CCR’s. If the units complete closure by dewatering and capping within 3 years then no further action of the rule will apply to the closed unit.

**Beneficial Use and Mine Reclamation**

Beneficial use of industrial materials has the potential to provide economic benefits and avoid negative environmental impacts associated with the acquisition and processing of waste byproducts. The final rule does not regulate or exclude CCRs for beneficial use applications; it only defines beneficial use and states the differences:

“EPA has defined beneficial use of CCR that meets particular guidelines: (1) CCR must provide a functional benefit; (2) The CCR must replace a virgin material, conserving the natural resources that would otherwise need to be obtained through practices such as extractions; (3) The CCR must meet relevant product specifications, regulatory standards when available and when standards are not available, the CCR must not be used in excess quantities; and (4) When un-encapsulated use of CCR involving placement on land of 12,400 tons or more in non-roadway applications, the user must demonstrate and keep records, provide records of documentation upon request that any environmental releases to ground water, surface water, soil and air are comparable or lower than those made form analogous products made without CCR’s or that the environmental release to groundwater, surface water, soil and air will be at
or below relevant regulatory and health-based benchmarks for human and ecological receptors during use.“2

The use of CCRs in mine reclamation is not addressed by EPA in the CCR regulatory action. The EPA states that it will work with the Department of Interior (DOI) to address placement of CCR in mine fills in separate regulatory actions in coordination with and directions from the DOI’s Office of Surface Mining Reclamation and Enforcement.

IV. A BETTER CCR MANAGEMENT ALTERNATIVE

Innovative CCR beneficial use solutions can help utilities implement an ash management strategy that provides economic benefits, avoids negative environmental impacts and public criticisms. By engaging in beneficial use practices, utilities can convert waste materials to a product or raw material. Beneficial use also helps utilities save on transportation and disposal (T&D) costs and mitigate transportation risks. This white paper is intended to demonstrate to the utility industry that the alternative beneficial use approach for in-situ impoundment stabilization and demonstrate how RECON’s approach can provide utilities with solutions that are economical (saving between 15% to 65% over some other methods and may vary significantly due to site location and other associated factors), can neutralize ENGOs and community objections, and can provide an extended operating life cycle of the plant. Some utilities are trying to recover CCR materials currently stored in ponds by applying creative solutions to reclaim the byproduct and processing of the materials to make viable cement replacement products. However, the majority of CCRs in storage ponds have no market value and must be removed and taken to landfills. These landfills may be utility owned or public landfills that will accept the byproduct at very costly tipping fees that may range from $25.00 to $50.00 per ton depending on region.

Through twenty five years of industry experience in geotechnical and environmental projects, RECON has created patented technology (LSS®) to dry, stabilize, and convert wet, seismically unstable sites to valuable industrial property. RECON has determined that these patented reagents or other standard pozzolanic reactions are applicable to stabilizing CCRs creating encapsulated by-products resulting in dry, solid monoliths that can support further commercial development. The depth of solidification may be from 4 feet to full depth stability. This is achieved through applying RECON’s LSS® technology or pozzolanic properties of the stored CCRs with specialized equipment required for deep soil mixing (DSM).

2 http://www.epa.gov/epawaste/nonhaz/industrial/special/fossil/index.htm
RECON has performed multiple site reclamations at refineries and other industrial sites, including power plants stabilizing over 10,000,000 cubic yards of materials using this technique. Given the new CCR regulations, utilities can benefit greatly by using this in-situ stabilization and capping application, to develop dry impoundments on top of the existing wet impoundments to create usable land for future vertical infrastructure development. RECON has assembled a team to provide the requisite design, engineering and construction services to allow utilities to reclaim the land occupied by wet impoundments while meeting specific local, state and federal regulatory requirements. Most importantly, this application creates more value for a utility by reducing the need for extra land to develop new expensive dry landfills.

A Better Alternative to Current CCR Management: In-Situ Stabilization and Vertical Expansion

In-situ stabilization and vertical expansion is a cost-effective alternative to CCR conditioning and traditional dig and haul removal options because it reduces operating costs for existing landfills, eliminates the requirement to construct a new Greenfield landfill and mitigates the risks of transport and disposal on public roads.

Keeping the CCRs in place on site helps insulate utilities from ENGO targeting and will likely be a preferred method for most state environmental protection division (EPD) regulations. Building a vertical landfill over former CCR impoundments maximizes use of space, thereby reducing the footprint that would be required for new landfills and may be the only alternative to plants that are landlocked or lack acreage for new fills.

Technical Analysis and Engineering Design of In-situ Stabilization

Once it has been determined that the facility meets location requirements as defined in the regulation (such as restrictions on locations include placement above uppermost aquifers, in wetlands, in fault areas, in seismic impact zones, and in unstable areas), an analysis is performed by an engineering consultant to evaluate geotechnical stability, vertical expansion design and dry cell development on the stabilized site to prepare for in-situ stabilization of the impoundment/pond. Representative samples of the pond materials are collected at strategic locations and each sample is characterized for bulk chemistry, physical parameters and TCLP metals present. Once the materials analysis has been completed, mix designs with specific reagents and patented blended materials will be lab-tested to determine appropriate mix designs to achieve the prescribed geotechnical and treatment specifications.
The starting point(s) and a treatment grid size will be selected based on the facility’s operational needs, engineering design team’s recommendation, RECON’s operations team recommended grid size, and on the pond’s size. The operations team will mobilize the required equipment to the initial starting point. Each grid will be cordoned off, if needed to prevent water intrusion and then stabilization activities using the patented reagent blend or pozzolanic reaction, and deep soil mixing will begin. The patented reagent blend will create rapidly drying and cementitious products that will encapsulate and bind any RCRA metals, sulfates and secondary metals of concern. Permeability testing cores, TCLPs and other required QC testing will confirm specification requirements that meet or exceed all CCR regulatory requirements and EPA limitations.

The depth of the stabilization will be dependent on CCR depth, impoundment base, sub-base, and if secondary containment will be required as a final preventative measure. CCRs can be stabilized to the level where the ash is moisture free and well compacted. Initial materials characterization will provide the background data for which depth will be required to meet strength and permeability requirements. Special equipment is required to meet certain depths as required by lab testing criteria. Depths required may be as little as three feet to more than 30 feet to create self-encapsulated, impermeable stable monoliths that can support surface development.

Once the process of stabilization begins, the production rates will be depth dependent. The curing and strength generation will be dictated by specification requirements as defined by the certifying engineering firm and vertical expansion support requirements. If the newly stabilized cell is to receive a clay liner and/or HDPE liner then these liner systems can be placed after required strength is met. Vertical expansion of the cell wall will be in development in conjunction with the newly stabilized cell. If needed, within 30-60 days (or much less if needed) the cell can start receiving dry CCR for deposit and the contractor prepares the second cell for stabilization.

RECON’s Technical Approach to Impoundment Stabilization and Vertical Expansion

RECON has the expertise and specialized equipment fleet to perform wet impoundment stabilization. The following describes the typical project stages that RECON recommends for the vertical development of a dry landfill cell on an existing CCR wet impoundment.
Stage 1: Mass Impoundment Stabilization
RECON begins by removing excess water prior to beginning the stabilization of CCRs. The CCRs are stabilized to increase strength and decrease permeability as required by using RECON’s patented reagent blend in-situ (LSS®) or a utility’s own CCRs, to initiate appropriate pozzolanic reaction to produce a low-cost stabilized monolith base. Once the material is cured, the monolith provides a structural foundation to access heavy equipment on and builds the landfill for the dry CCRs. Vertical wick drains can be installed through the CCRs, if necessary, to provide a means of dewatering and consolidating CCRs based on geotechnical engineering design. Depths of solidification can be modified depending on engineering designs, states’ regulations, and a utility’s internal policy requirements or risk assessment. In some cases, full depth stabilization is not required.

Stage 2: Perimeter Impoundment Stabilization
The perimeter is then reinforced using deep soil mixing techniques to prevent any slip-plane failure potential and meet design requirements for vertical expansion, as specified by clients’ engineering firm.

Stage 3: Constructing the Landfill
Once the wet CCRs have been stabilized and meet all performance criteria, construction of the landfill begins according to engineered design. The landfill’s perimeter dike is raised to increase vertical space and then is followed by the installation of appropriate liners inside the cell. CCR regulations will require well monitoring systems that may include leak detection piping and sumps to monitor possible leaching from new deposits.

Stage 4: Filling the Landfill and Eventual Cap and Cell
After construction of the landfill that meets all requirements of the EPA CCR regulation requirements, it is ready to accept dry CCR deposits. Once the landfill has met its maximum volume (depending on the projected operations of the plant) the landfill is ready to be graded, capped, and revegetated for long-term
maintenance. The surface area can then be beneficially used for recreational purposes, such as a park or laydown yard in case the plant undergoes a major turnaround or expansion.

Quality Control

A very important aspect of any technical application is quality control. In order to meet the specific reagent mix designs, metering equipment will be employed to insure pre-determined upper (UCL) and lower control limits (LCL) are met. Quality control samples will be secured and handled according to soils standards procedures or similar national standard. Each QC sample will be utilized to test for physical strength at prescribed age breaks. Samples will be tested for permeability and SPLP or TCLP at 28 day curing periods to confirm no leaching ability or within acceptable water standard limits.

Cost benefit example:

The Problem- two solutions and one significant cost difference.

- Assume a 25 acre CCR impoundment at a depth of 30 feet.
  - Excavate and haul to newly developed landfill (cost not included) will require removal of 1.2 million yd³ of dewatered CCRs.
    - Cost is approximately $12 million at $10/yd³.
    - The cost of permitting and building the new landfill could increase cost per yard by a magnitude of 3-10 times.

The Best Solution-

- In-situ stabilization with RECON technology/equipment will require a 4-foot mass stabilization with wick drains for 161,000 yd³ at a cost of $5.3 million dollars which solves the same problem of 1.2 million yards of wet CCR’s at a cost of $4.16/yd³.
- The cost of permitting and building a new landfill is deferred.
- The cost differential for this comparison is about 56% savings for in-place stabilization vs. dig and hauls scenarios and reduces transportation risks.
  - Each project will have different requirements and cost structures.
  - State and local regulations may impact requirements and cost,

V. CONCLUSION

Beginning in 2010, the EPA attempted to provide a regulatory scheme to manage CCRs in a more uniform manner and wrestle control of CCR storage enforcement from States. The new regulation issued on December 19, 2014, has enforced the reality to the U.S. coal fired power sector that the use of ponds and impoundments as a standard storage
unit for coal combustion by products is no longer a viable option for managing CCRs. Utilities are seeking alternatives to pond CCR management and storage by preparing for the reality that they must begin pond closures to comply with the new CCR regulations. The costs for the utility to comply with the new regulations are significant whether they result from the engineering and construction of new management systems or litigation mitigation efforts. Regardless of the cost, wet impoundments will cease operations as defined by the timelines outlined in the regulation. As such, now is the time for utilities to seek alternatives and creative solutions to meet these new regulatory requirements.

In situ stabilization and vertical expansion is the best value approach to managing most wet CCR impoundments under the new regulations. RECON has the prerequisite experience, specialized equipment and specific technology to provide a best practices alternative to utilities for wet CCR impoundment closures and management. Over the last 25 years, RECON has developed patented technology to stabilize a wide-latitude of soils, organic and inorganic materials to meet regulatory standards under the 40 CFR Solid Waste regulations. These patented technologies include LSS®, DSM and other mechanical techniques that can cost effectively provide in-situ stabilization of CCRs and allow utilities to consider a vertical expansion approach to solving their CCR management problem. This technically savvy approach is an attractive alternative to dig and haul approaches that may decrease cost by as much as 15% to 65%, while significantly mitigating the risk of spills during transport, community complaints and the cost of new landfill permitting and development.