So, You’ve Built a Landfill for Your Ash Pond Closure, Now What? (Lessons Learned During CCR Landfill Operations)

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CONFERENCE: 2019 World of Coal Ash (www.worldofcoalash.org)

KEYWORDS: CCR landfill operations, CCR surface impoundment closure

ABSTRACT

Coal Combustion Residual (CCR) landfills constructed to store CCRs from an ash basin closure (closure landfill) have different operational considerations than CCR landfills constructed to store CCRs generated during active power production (generation landfill). Most notably, closure landfills accept wetter ash at a faster disposal rate than generation landfills.

Critical Best Management Practices for operating closure landfills include exterior sideslope grade control, interim cover placement methods, Run-On and Run-Off Control Plan compliance, managing contact water at the operational face, moisture control and conditioning, and engineering and construction quality assurance (CQA) oversight. The best management practices benefit the landfill owner by maximizing airspace utilization, reducing risk of exterior sideslope re-work, and reducing the risk of an environmental release.

BACKGROUND

A new on-site CCR landfill was constructed in the southeastern United States at a power generating facility with a retired coal-fired power plant. The landfill supports closure of two on-site unlined CCR surface impoundments and two on-site unlined CCR fills. The landfill has three cells and a total permitted airspace of 2,150,000 cubic yards. Landfill operations for Cell 1 began in May 2017, Cell 2 in October 2017, and Cell 3 in April 2018. Closure of the on-site CCR surface impoundments and fills is anticipated to be completed by the end of 2019.

Unlike a CCR landfill that has been constructed for an active coal-fired power plant (generation landfill), this landfill has been constructed to support CCR unit closure
(closure landfill) and does not support an active waste stream. A closure landfill can be expected to receive high moisture waste at a faster rate and have a shorter operational lifetime (years instead of decades) when compared to a generation landfill. Based on our on-going landfiling experience, the following best management practices should be utilized to address the unique challenges posed by operating a closure landfill.

ROLES AND RESPONSIBILITIES

Multiple stakeholders including the Owner, Operator, Engineer, and Regulators have a role in the success of the facility. A clear definition of roles and responsibilities at the start of landfill operations is important to define expectations and prevent miscommunication during landfiling. The roles and responsibilities can be defined in a RACI matrix where R is responsible entity, A is actionable entity (the entity that performs the task), C is consulted entity, and I is informed entity. The RACI matrix should define responsibilities vital to the success of the project including waste quantity tracking, airspace tracking, internal and external (regulatory) reporting, and development of filling plans.

Key stakeholders should have frequent meetings to discuss progress and potential issues. For this site, the Owner, Operator, and Engineer attend weekly landfill operations meetings.

EXTERIOR SIDESLOPES

Grade control of exterior sideslopes is very important for any landfill, but especially for a closure landfill. Overfilling can cause a landfill to have unstable sideslopes or exceed its permitted capacity, and underfilling can cause a loss in airspace. Due to the rapid pace of waste placement, grading errors that are not quickly identified and corrected can become compounded as waste is placed, making corrective actions difficult and costly to perform.

Best Management Practice – Top of Ash Grading Plan

A top of ash grading plan should be developed to facilitate control of exterior sideslopes. The Operator can use GPS-controlled equipment to achieve the designed top of ash grading plan with a relatively high degree of confidence. The top of ash grading plan for most of the landfill footprint is developed by utilizing a standard vertical offset from the final cover grades (i.e. two feet of final cover plus one foot of interim cover = 3 feet vertical offset). Landfill features such as slope access roads, stormwater drainage features, and perimeter tie-in configurations may require a non-standard vertical offset and should be evaluated and incorporated into the top of ash grading plan.
For this site, the Engineer developed the top of ash grading plan and provided the plan to the Operator. The Operator then provided their machine file input back to the Engineer for concurrence. This process allowed both parties to confirm that the top of ash grading plan was in the appropriate horizontal and vertical coordinate system, and in a format that both parties can utilize (i.e. AutoCAD and machine files).

Best Management Practice – Monthly or Quarterly Landfill Surveys

State regulatory requirements for landfills usually require annual surveys for reporting purposes. The landfill surveying frequency should be increased to monthly or quarterly for closure landfills due to the rapid pace of waste placement. Frequent surveys are useful for the following reasons:

1. Early identification of slope grade or elevation errors when compared to the approved top of ash grading plan;
2. Confirmation of amount of waste placed and remaining airspace available;
3. Comparison to volume of material removed from the ash basin to achieve an airspace utilization factor or shrinkage rate; and
4. Confirmation of Run-On and Run-Off Control System Plan storage requirements.

For this site, surveys are being conducted on a monthly frequency.

Best Management Practice - Interim Cover Quality Control

During landfill operations, 12 inches of interim soil cover is placed over the waste on exterior sideslopes and tracked in with construction equipment to reduce the quantity of contact water that is generated. The interim cover will subsequently become the subgrade for the geosynthetic final cover system. Technical specifications for geosynthetic cover systems include requirements that the subgrade have a maximum particle size and minimal amount of rutting.

The project team should be aware of the specified subgrade requirements for the final cover system, particularly if the specifications address maximum particle size, and plan accordingly. Soil may need to be imported or screened if the on-site soil is too rocky to meet subgrade specifications in its native state.

For this site, some interim soil cover material is being screened and other material is being obtained from a source that meets the geosynthetic cover system subgrade requirements. The resulting sideslopes are smooth and relatively free of rocks and ruts as shown in the following figure.
CONTACT WATER CONTROL

Contact water is water that has contacted ash, such as at the active face of the landfill, and cannot be released to the environment without treatment. A release of contact water to the environment requires notification of regulatory entities and can result in a Notice of Violation. Due to the rapid pace of waste placement, grading conditions at the active face can change quickly. Adequate contact water storage must be provided within all areas of the active face during all stages of landfill operations.

Best Management Practice - Active Face Perimeter Berm

Contact water should be prevented from draining across the active face to the exterior sideslopes whenever practical to prevent overtopping and leachate seeps. A robust berm around the perimeter of the active face should be constructed and maintained during landfill operations to provide sufficient storage volume for contact water runoff.

A simple soil berm can be constructed around the perimeter of the active face; however, this type of berm is typically not very high, wide, or well-compacted, and could fail due to head pressures from adjacent ponding water. A more robust active face perimeter berm is recommended to reduce the potential for berm failure.
For this site a wide perimeter berm of ash sloping towards the active face (or “racetrack”) is being constructed around the perimeter of the active face. The racetrack consists of two 12-inch lifts of compacted ash with a minimum width of 10 feet. Twelve inches of interim soil cover is placed along the exterior sideslope of the racetrack and a 12-inch soil berm is constructed along the exterior edge of the racetrack to provide three total feet of storage depth when measured from the toe of the berm. The active face perimeter berm is shown in the following figure.

![Figure 2: Active Face Perimeter Berm](image)

**Best Management Practice - Chimney Drains**

Chimney drains are vertical sections of perforated pipe with an aggregate filter that extend from the base of the landfill to the active face. Chimney drains convey contact water from the active face to the leachate collection and removal system. The pipe and aggregate filter are extended vertically as landfill filling progresses.

The chimney drains are located within the interior of the active face. The active face is graded to drain towards the chimney drains. Sometimes a sump is excavated around the chimney drain to increase storage volume. A typical chimney drain is shown in the following figure.
Chimney drains should be adequate in number and spacing to facilitate contact water management control during the entire landfill filling process. Chimney drains should be abandoned by capping with a solid end cap and encapsulating in aggregate before the landfill perimeter encroaches to within a certain distance of the drain. Otherwise, temporarily ponded water at the chimney drain could infiltrate through the perimeter berm and cause a berm failure or leachate seep. For this site, chimney drains are abandoned when they are within 60 horizontal feet of an exterior sideslope.

**Best Management Practice - Run-On and Run-Off Control System Plan Compliance**

The CCR Rule (40 CFR 257.81) requires that the owner or operator of a CCR landfill must design, construct, operate, and maintain:

1. A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and
2. A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.

Control of run-off from the active face is critical to prevent an uncontrolled release of leachate to the environment. A combination of chimney drains and active face perimeter berms are effective methods for achieving run-off control system compliance.
For this site, run-off control compliance is checked monthly. The monthly survey is used to estimate the drainage area and stage-storage curve for each chimney drain. Computer modeling software is used to calculate the volume of runoff for the 25-year, 24-hour storm event. The run-off volume is compared to the stage-storage relationship at each chimney drain location. Sometimes individual chimney drains do not have sufficient capacity to store runoff from the 25-year, 24-hour event. Although not ideal, this condition can be temporarily acceptable if the contact water overflows to another chimney drain that has sufficient capacity to store the additional stormwater volume instead of being released to the environment.

*Best Management Practice – Leachate and Leakage Tracking*

The quantity of leachate, and leakage for double-lined facilities, should be tracked on a monthly basis. The gross quantity of leachate pumped can be divided by the landfill acreage and number of days to obtain a standardized unit of generation (gallons per acre per day).

Leachate quantity tracking is useful to estimate the facility’s response to rainfall events. This information can be used to prepare a site for adverse weather conditions or for leachate management planning purposes. Anomalies in leachate generation can be caused by weather events, changes in operational practices, or faulty equipment.

For double-lined facilities, leakage generation is quantified separately from leachate generation for comparison to the Response Action Plan. The purpose of the Response Action Plan is to describe the necessary course of action in the event the Initial Response Leakage Rate (IRLR) and/or the Action Leakage Rate (ALR) are exceeded. IRLR exceedances generally require a check of the physical systems (pump and flowmeter), increased monitoring frequency, and regulatory notification. ALR exceedances include the same steps as IRLR exceedances but also include more extensive efforts to find the source of the leakage and can result in premature closure of the landfill.

For this site, leachate and leakage quantities are evaluated monthly. The actual leakage rate is compared to the IRLR and ALR.

**NON-CONTACT WATER CONTROL**

Non-contact water is stormwater that has not contacted ash, such as on landfill exterior sideslopes that have been protected with interim soil cover. Non-contact water can be released to the environment. Non-contact stormwater runoff on the landfill exterior sideslopes should be controlled such that velocities are not erosive. Long uninterrupted sideslopes could permit flows with excessive velocity that erode the interim soil cover and cause a release of ash and/or leachate to the environment. A release of ash or
leachate to the environment requires notification of regulatory entities and could lead to a Notice of Violation. Adequate non-contact water controls must be provided during all stages of landfill operations.

**Best Management Practice - Tack-On Benches and Downdrains**

Tack-on benches are soil berms that are installed along a landfill sideslope to interrupt the slope length and reduce erosion potential. Tack-on benches convey stormwater laterally to downdrains which are installed perpendicular to the slope. Downdrains consist of a pipe or armored channel and are used to convey stormwater from tack-on benches to a perimeter channel. The tack-on benches and downdrains are sized to prevent overtopping of the tack-on benches.

Tack-on benches and downdrains should be installed during landfill operations as construction of the exterior sideslopes progresses. For this site, tack-on benches are installed every 30 vertical feet and downdrains consist of 24-inch dual-walled corrugated HDPE pipe. A typical tack-on bench and slope drain is shown in the following figure:

![Figure 4: Tack-On Bench and Slope Drain](image)

**Best Management Practice - Erosion and Sediment Control Devices**

Supplemental erosion and sediment control (E&SC) devices can be used when features such as temporary access roads prevent construction of tack-on benches or
downdrains, or to protect critical slope areas. For this site, straw wattles are used as a supplemental E&SC device.

LANDFILL OPERATIONS

Operational best management practices should be considered to facilitate two-way traffic and rapid placement of waste material.

*Best Management Practice - Filling Sequencing*

Filling sequences should be developed to define regular grading intervals (i.e. every 30 vertical feet) in the landfill life cycle. Interim filling sequences should address temporary and permanent controls for access, contact water, non-contact water, and chimney drain activation or abandonment. The interim filling sequences should be evaluated by the Engineer for consistency with the top of waste grading plan and adherence to the Run-On and Run-Off Control Plan.

For this site, the Operator is developing five interim filling sequences for review by the Engineer and Owner.

*Best Management Practice - Access*

Temporary and permanent access should be defined for each fill sequence. The landfill should have a slope access road that allows vehicular traffic to travel to the top of the landfill. The slope access road is usually only wide enough to accommodate one-way traffic to conserve airspace. Temporary access routes to accommodate two-way traffic should be considered due to the relatively rapid nature of waste placement in a closure landfill. Contact and non-contact water separation is particularly critical at the ingress and egress points of the active face.

This site has one permanent slope access road. Multiple interim access roads have been constructed, utilized, and abandoned to improve access during the various fill sequences. The access roads are graded with a “hump” at the top of the road to provide contact and non-contact water separation during active landfill operations. Soil is staged at the active face to construct a larger soil berm at the top of the road when landfill operations are not being conducted as shown in the following figure:
Moisture control is important to achieving proper landfill compaction. CCR material recovered during surface impoundment closure is likely to be wet of the material’s optimum moisture content and must be dried out to achieve the compaction specification.

For this site, moisture is controlled at the source of excavation. The ash basins are maintained in a dewatered state by pumping. Stormwater diversion features have been constructed to divert water away from the ash basins. The CCR material is excavated, heaped, and windrowed to decant water.

During winter months that are particularly wet, drying agents including lime and cement are being used to achieve the specified moisture content. The addition of drying agents required regulatory approval, geotechnical and leachability laboratory bench-scale testing. Laboratory testing included Standard Proctor compaction testing and SPLP leachability testing. The effects on pH were especially of interest due to effluent limits set by the receiving point of treatment works (POTW). Test pads were also constructed in the field to demonstrate efficacy of contractor means and methods. The application of lime drying agent in the landfill is shown in the following figure.
**Best Management Practice - Waste Placement**

Waste should be placed in the landfill to maintain as large of a working area as possible. This typically requires placing material in 12-inch lifts across the entire working face such that the landfill active face is relatively flat and comes up at a consistent elevation during filling. Top deck grading needs to be higher around the perimeter to facilitate drainage to chimney drains, which are maintained as low points within the interior of the landfill. The active face should be rolled with a smooth-drum roller prior to forecasted rainfall events to promote drainage to the chimney drains and minimize erosion and rilling of the active face.

**REPORTING AND OVERSIGHT**

Adequate construction oversight and reporting is critical to document landfill progress, rapidly identify potential issues and develop solutions, and satisfy permit conditions.

**Best Management Practice - Construction Quality Assurance**

Construction quality assurance (CQA) is important to demonstrate that the landfill waste is being placed and compacted in accordance with project specifications. Landfill permit conditions may require that field density tests (FDTs) be conducted at a specified waste placement interval to demonstrate adequate compaction. Also, there is an intrinsic
benefit to the Owner in monitoring waste placement to maximize compaction and make efficient use of the permitted airspace.

Unlike active-generation landfills which may require infrequent FDTs, closure landfills may require FDTs on a daily basis or several times per week due to the rapid rate of waste placement. For this site, a full-time on-site CQA technician is being utilized to perform the FDTs on a basis of one test per 10,000 cubic yards of waste placed (4 to 5 tests per week), for moisture content testing of pre-processed ash basin CCR, and for general observational purposes. During FDT testing, an initial moisture content is obtained using a hot plate to obtain a preliminary indicator of moisture content. A second sample is dried using the oven method to prevent burn-off of non-water material. The oven method controls for moisture reporting. Additional technicians have been mobilized as necessary to support temporary 24/7 landfill operations to achieve regulatory deadlines for removal of CCRs from the surface impoundments. The results of FDTs, daily observations, and site photographs are documented in daily field reports.

The on-site CQA technician provides a vital link between the Owner, Engineer, and field conditions, and provides early identification of problematic field conditions or operational practices.

Best Management Practice - Laboratory Testing

Standard Proctor laboratory testing is required to provide a reference for FDTs. Different percentages of CCR, soil, and phragmites roots or other vegetation can be expected during closure of CCR units. The addition of drying agents such as lime or cement can further increase the potential number of material combinations. A sufficient number of samples should be collected for Standard Proctor testing to represent the range of site conditions and material combinations.

For this site, Standard Proctor testing is being conducted at an off-site laboratory on a frequency of one test per 50,000 cubic yards of waste placed. A supplemental laboratory testing program was conducted prior to approval of lime as a drying agent. The laboratory testing program included geotechnical testing before and after the addition of drying agents, and SPLP testing to evaluate changes in leachate quality.

Best Management Practice - Reporting

State regulatory requirements for landfills require annual reports. The landfill reporting frequency should be increased to monthly or quarterly due to the rapid pace of waste placement. The reports are useful for the project team to document progress and raise awareness of issues that need to be addressed.
For this site, the Engineer compiles landfill reports on a monthly basis. The reports include the following components:

- Evaluation of landfilled waste quantity including
  - Quantity of waste placed based on survey
  - Estimate of remaining airspace based on survey
  - Comparison of landfill grades to design top of ash grades
- Evaluation of leachate and leakage generation including comparison of leakage generation rate to the Initial Response Leakage Rate (IRLR) and Action Leakage Rate (ALR)
- Summary of landfill operations including
  - Field density test results
  - Laboratory test results
  - Daily field reports
  - Photograph log
- Additional information
  - Monthly Run-On/Run-Off Control Plan compliance check
  - Other supplemental information, such as correspondence with regulatory agencies

CONCLUSIONS

Operation of a closure landfill has the complexities of both operating a landfill and managing a mass grading project, often under difficult schedule constraints. Operations should be conducted to facilitate the total landfill lifecycle, including expansion or closure. Diligent planning, execution, monitoring, and communication between project stakeholders is critical to the success of the project.