Practical Considerations for CCR Facility Design, Operations, and Maintenance

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CONFERENCE: 2017 World of Coal Ash – (www.worldofcoalash.org)

KEYWORDS: CCR, landfill, design, operations, and maintenance

INTRODUCTION

This paper conveys a range of practical design, operations, and maintenance considerations for coal combustion residual (CCR) landfills highlighting what works and what could be improved to the benefit of owners, operators, and design engineers working with similar facilities. These considerations are based on observation program results of fifteen facilities in three states. This paper discusses the use of an observation plan to document current conditions and confirm that infrastructure and operations and maintenance practices are functioning as designed and intended.

LANDFILL OBSERVATIONS

Amec Foster Wheeler has been conducting landfill observations at CCR facilities since 2014. Initially, the frequency and intensity of the observations were tailored to the operational status (active or closed) and the intensity of waste management activities. Observations ranged from twice per year to once every two years. In October 2015, the Environmental Protection Agency (EPA) issued a final rule to regulate CCR surface impoundments and landfills making annual inspections of active landfills a requirement. The final EPA rule (CCR Rule) from Title 40 of the United States Code of Federal Regulation (CFR), part 257, subpart D, section 257.84(b) requires the following:

“(b) Annual inspections by a qualified professional engineer.

(1) Existing and new CCR landfills and any lateral expansion of a CCR landfill must be inspected on a periodic basis by a qualified engineer to ensure the design, construction, operation, and maintenance of the CCR unit is consistent with recognized and generally accepted good engineering standards. The inspections must, at a minimum, include:

- *(i)* *A review of available information regarding the status and condition of the CCR unit, including, but not limited to, files available in the operating record (e.g., the results of inspections by a qualified person, and results of previous annual inspections); and* *(ii) A visual inspection of the CCR unit to identify signs of distress or malfunction of the CCR unit.*

(2) Inspection report. The qualified professional engineer must prepare a report following each inspection that address the following:

(i) Any changes in geometry of the structure since the previous annual inspection;
(ii) The approximate volume of CCR contained in the unit at the time of the inspection;
(iii) Any appearances of an actual or potential structural weakness of the CCR unit, in addition to any existing conditions that are disrupting or have the potential to disrupt the operation and safety of the CCR unit; and
(iv) Any other change(s) which may have affected the stability or operation of the CCR unit since the previous annual inspection."

While landfill observations at CCR facilities were happening as a best management practice prior to its promulgation, the CCR Rule has since been the basis for annual landfill observations and reporting. Though not required by the CCR Rule, Amec Foster Wheeler also conducted observations of closed and inactive landfills and structural fills at the request of the client. This paper will explore several aspects of, and lessons learned from conducting the observation program.

OBSERVATION PROGRAM DESIGN

Since there are numerous landfills subject to observation under the CCR Rule, it was envisioned that several teams of observers may be needed to meet the reporting deadline. The team identified that having a consistent approach and consistent team members would benefit the program. Maintaining continuity within the program could avoid differing opinions of the conditions observed, shorten the site learning curve, and result in valuable site to site comparisons of operations and maintenance practices.

The importance of the observation team members having familiarity with the site they are observing, and also having a general understanding of landfill operations, was also identified. Additionally, it would be beneficial to the program to have continuity of the team members from site to site and year to year in order to take advantage of members' knowledge of historical observations and other landfill projects.

Executing and reporting of the observations comes down to scheduling, preparing, and implementing. While a master schedule of observations was prepared during the planning stages, our experience has been that the actual observation dates will change depending on the availability of other stakeholders. Preparing for the observation means first reviewing existing documents such as record drawings, open work orders (of operations and maintenance activities), past observation reports, permits, and operations plans. Preparing the tools (e.g., tablet, hand-held GPS, software) needed to document the observation comes next. Building a checklist of landfill features to observe from drawings and plans allows the team to focus the observations and confirm that pertinent items have been identified prior to starting the observation. Without a checklist, whether hard copy or digital, the team may have a difficult time recalling the measures, features, equipment, and practices that need to be observed and recorded.

As in all things we do, safety is the first priority, and performing a landfill observation is certainly no exception. A health and safety plan (HASP) is prepared prior to the observation and reviewed with those participating. Observations around active disposal operations require awareness between those on foot and those driving and operating equipment.

In order to report on the design, operations, and maintenance of the landfill per the CCR Rule, it is important to conduct a thorough observation. The categories of measures, features, equipment, and practices included in the observation reports are geometry, volume, vegetation, erosion, stormwater management, leachate management system, and record keeping. As the facilities are observed annually, the reports are a record of landfill conditions that can be used to evaluate the design, operations, and maintenance practices of a facility.

As an industry, it benefits us to share our lessons learned and identify the measures and practices that should be sustained, as well as, those that can be improved. Drawing on previous project experience and dozens of landfill observations, the authors will now review some practical considerations for the design, operations, and maintenance of CCR landfills that are of interest to CCR landfill operators, owners, and consultants.

DESIGN

The major intent of landfill design and operations is waste containment, that is keeping the waste isolated from the environment (i.e., prevent the transmission of contact water into the groundwater table) and keeping stormwater separated from the waste (i.e., run-on and run-off control). The following points explore this design intent from the perspective of an engineer's landfill observation.

1. Berms and benches are geometric features incorporated into many landfill designs for stormwater runoff control on slopes. Tack-on berms are attractive to owners and designers because the berms do not impact landfill airspace; however, tack-on berms have been observed to pose greater risks for drainage and maintenance problems than benches (see Figure 1). In designing tack-on berms, it is important to keep the following observations in mind:

Figure 1

   a. Tack-on berms with shallow longitudinal slopes can lead to ponding and local berm instability at low points.
   b. Tack-on berms with steep back slopes are tough to construct and difficult to maintain vegetative cover.

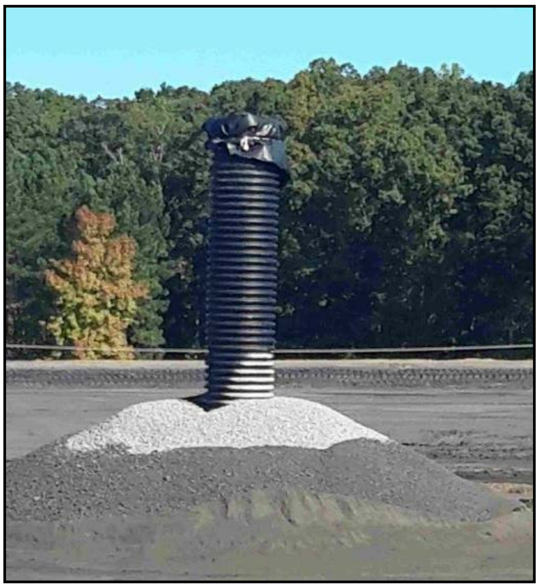
2. Downdrain, or slope drain pipes are designed to transport stormwater from higher elevations on the landfill (e.g., top deck) to a lower elevation, such as a perimeter channel. The following observations should be considered when designing the type of pipe and joint used for a downdrain, or whether to use an alternative to pipe, such as a lined open channel.
   a. Bell and spigot pipes, whether exposed or buried, have been observed to separate at the joints (see Figure 2). Leaking water at these joints can cause piping of the underlying soil and erosion of the slope.

Figure 2

   b. The transition from top deck channel or overland flow into pipe inlets may be prone to erosion and stormwater flow bypassing the inlet.
   c. Steep slopes increase stormwater velocity, thus requiring adequate discharge stabilization/anchoring and potential flow redirection into perimeter channels.

3. Chimney drains have become a common design feature at many landfills. Often consisting of a vertical perforated pipe connected to a perforated horizontal base pipe, the chimney drain network conveys contact water from the active landfill area to the leachate collection system. It is important to design chimney drains with following observations in mind:
   a. Use clean filter media, such as stone and bottom ash, around the pipe to minimize clogging and stormwater ponding (see Figure 3).
   b. Place covers on the stick-up pipe ends to prevent dropped objects and stone from entering the chimney drain (see Figure 3).

<u>Figure 3</u>



   c. Specify appropriate pipe materials for the burial depth of the chimney drains.
   d. Follow the adopted Run-on/Run-off Control Plan (ROROCP) for stick-up height and drainage area requirements.

4. The geocomposite drainage layer in a landfill cover system will typically outlet at intermediate locations along the slope and at the toe of the slope into a perimeter channel. Whichever discharge scheme is chosen, the following observations should inform the design:
   a. Work with the owner to decide if uniformly spaced outlets (pipes) or a continuous outlet is better suited for the site.

   b. When pipe outlets are used, place concrete pads around the outlet and visually mark the outlets; otherwise, erosion and vegetation over time can make the outlets difficult to see or locate.
   c. Ensure that record drawings accurately reflect the outlet locations so that personnel can use the drawings to verify the outlets were evaluated during observations.

5. Designers specify various types of stormwater inlets around landfills. Drop inlets and some version of an open-end pipe (e.g., flared end section) are the most common inlets observed. The designer must keep in the mind the application and location of the inlet because clogging of drop inlet grates and ponded water at open-end inlets are often observed.

6. Use of a raincover for non-contact stormwater segregation from the leachate collection system must take the volume of stormwater and pump capacity into account during the design phase. An undersized pump, unplanned volume of stormwater, or unexpected run-on/run-off control issue increases the potential for contact water mixing and possible leachate release.

7. Design of drainage transitions – grass slope to concrete ditch, tack-on berm to exposed membrane, ditch to riprap – needs to minimize the paths for erosion and void creation. These transitions should be special emphasis areas during landfill observations.

8. Side slopes of perimeter stormwater channels should be 3 horizontal to 1 vertical (3H:1V) or shallower because steeper slopes are difficult to mow and sustain vegetation.

9. Leachate manifolds can be designed to be above or below ground. Many of the below ground manifolds observed have had water intrusion at one time or another like that shown in Figure 4 below. Water intrusion is a drawback of a below ground installation that a designer should mitigate by grading stormwater runoff away from the manifold. An above ground manifold may allow the owner to detect any potential contact water leaks without having to discern if it is stormwater runoff. However, secondary containment for contact water leaks may be easier to address with a below ground vault versus measures needed for an above ground manifold.

   The designer also needs to design adequate space for maintenance of the leachate system components, such as changing valves, flow meters, leachate sampling, and maintaining pumps.

Figure 4

OPERATIONS

Landfill operations may be conducted directly by the owner, by an owner's contractor, or some combination of the two. In addition to CCR placement, operations include the day-to-day activities necessary to maintain compliance with state and federal regulations, protect the environment, and foster a safe working climate. The following points explore various operational issues from the perspective of an engineer's landfill observation.

1. Maintaining accurate record drawings allows landfill operators, owners, and observers to confirm they are looking for the right structures in the right places. Depending only on permit drawings can sometimes pose problems when a certain structure cannot be found and its installation or deletion was not accurately recorded. For example, the locations of edge of liner/waste markers are dependent on surveyed information, especially when offsets have been used.

2. The facility's operating record (e.g., permits, drawings, Operations Plan, inspection logs, and leachate monitoring information) should be reviewed periodically to check for missing or outdated information and updated if applicable.

3. If a soil berm is used around the top deck/active face of the landfill for wind screening and contact water containment, it needs at least two things:
    a. Good compaction control, which also infers appropriate soil selection.

   b. The ground surface inside of the berm should be graded away from the berm to reduce potential for ponding water against the berm that could contribute to seepage and berm erosion.

4. Truck, or wheel, washes are important to housekeeping due to the potential for tracking ash and gypsum onto unlined areas such as paved station roads. Truck washes experience much wear and tear and have been observed to experience long down times while waiting on parts or solutions to recurring maintenance issues. The use of water trucks to wash down areas of tracked ash and gypsum is considered a standard and effective housekeeping practice, especially when a truck wash is out of service.

5. Evidence of operator training programs (e.g., certified operator and MOLO) should be in the operator records. Some landfill owners may go beyond the regulatory requirements and call for all operations staff to be certified by an accredited landfill training program.

6. Update the ROROCP when changes to the landfill dictate. The owner and engineer should review the changes with the landfill operations personnel.

7. Periodically check for erosion and voids at stormwater flow transitions between differing materials (e.g., grass slope into concrete channel).

8. Phasing and lift sequences, and their associated access roads, should be planned with station production forecasts in order to limit unnecessary operations and maintenance (O&M) expenditures.

9. Obtain any necessary special waste handling or disposal authorizations from the regulatory agency and make contractors and staff aware of those special provisions, e.g., vacuum truck unloading procedures.

10. If CCR materials are being mined out of landfills for beneficial use, it is important to have a mining sequencing plan that the operator can follow. Care must be taken to protect the landfill liner if mining operations approach the bottom of the cell.

11. Conduct periodic surveys and capacity studies in order to track and correct side slope overfill/underfill and maximize airspace utilization.

12. Phased Erosion & Sedimentation Control (E&SC) permits may allow closing of constructed phases and retaining operational stormwater best management practices BMPs. For example, not all BMPs may need to remain in service for the permit to be active, so establish which measures need to be observed and which ones can be closed out without closing out the landfill E&SC permit.

13. Implement regular dust control operations in order to minimize transport of wind-blown ash or gypsum to unlined or non-permitted areas. If CCRs blow onto rain covers, they can get washed or pumped into non-contact water systems.

MAINTENANCE

Maintaining a landfill in good working order is a constant endeavor. Rainfall is the driving force behind much of the CCR landfill maintenance because whether it becomes non-contact or contact water, it has to be effectively managed. Vegetation management on intermediate and final cover soils is a key component to controlling erosion, which in turn benefits stormwater and leachate management efforts. The following points explore several maintenance issues from the perspective of an engineer's landfill observation.

1. Produce and follow a vegetation maintenance and implementation plan. Be careful of slope impacts such as ruts and sloughing from larger, heavier mowing equipment.

2. Diverse vegetation has shown the strongest performance based on several years of landfill observations. Some species, such as lespedeza and bunch grasses, shade or choke-out desirable grasses and may be perennial, thus allowing for and masking erosion at the ground surface despite the initial appearance of thick cover (see Figure 5).

Figure 5

3. Look for evidence of animal burrowing on landfill slopes that can damage cover systems; rain covers also need to be checked periodically for damage by animals.

4. Tears or other damage to rain covers should be repaired as soon as possible so that the underlying leachate collection system is not receiving stormwater and the landfill owner is not unnecessarily treating excess contact water.

5. Test alarm lights and horns on the leachate control panels and test operability of pumps by listening and observing flow meter responses.

6. Keep stormwater features, such as grate inlets and ponds, cleaned out of sediment, vegetation, and debris. If the features have a concrete lining, check the condition of the concrete periodically.

7. Maintain and test backup generators for remote facilities to maintain operability.

8. Maintain contact water/non-contact water separation at access road thresholds and perimeter berms.

CONCLUSION

The value of a regular landfill observation program not only keeps an owner in compliance with Federal regulations, it also serves as a tool for improving design, operations, and maintenance. Having all of the landfill stakeholders (i.e., owner, manager, operator, and consultant) together for a detailed facility observation and operating records review is a significant planning opportunity for engineering and maintenance.

The benefit of observation team member consistency cannot be overstated. The institutional knowledge from having the same personnel conduct the landfill observation year after year is a valuable resource. Having the right technology (e.g., tablets, hand-held GPS units, and GIS software) in your toolbox is important for recording locations of landfill observations year after year. The observation team needs to meet with O&M staff after the observation to review findings and recommendations. The ultimate landfill observation goal is much greater than mere regulatory compliance. The observation program serves as a vehicle for continuous facility improvement, where a successful program enables the landfill owner and operator to make informed decisions about landfill design, operations, and maintenance.