Alternative Final Cover System Demonstrations and the Associated Benefits

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ABSTRACT

The Coal Combustion Residuals (CCR) Rule allows the use of alternative final cover (AFC) systems for closure of CCR units, provided that certain engineering demonstrations can be made regarding the anticipated performance of the selected AFC system. At many site locations, the use of an appropriately designed AFC system offers equivalent environmental performance to the prescriptive cover system with significant benefits in terms of cost, effectiveness of soil resource usage, and sustainability. Designing an AFC system and demonstrating that its performance is equivalent or superior to the performance of the prescriptive cover system is typically a site-specific process. This paper discusses common approaches, techniques, considerations, and possible outcomes of AFC system demonstrations, with a focus on actual demonstrations that have been completed and the associated benefits that are being realized.

BACKGROUND

A final cover system is constructed during closure of a waste containment facility (or a portion of a waste containment facility) for the primary purpose of limiting the percolation of water into the waste mass below. The Coal Combustion Residuals (CCR) Rule includes requirements for closure of landfills and surface impoundments containing
CCRs when waste is left in place. The default, or prescriptive, final cover system specified in the CCR Rule is characterized by the following minimum requirements:

- The permeability of the final cover system must be less than or equal to the permeability of the liner system and any natural subsoils and no greater than $1 \times 10^{-5}$ centimeters per second (cm/s)
- An earthen infiltration layer at least 45 cm (18 inches) thick must be included to minimize percolation into the underlying CCR material
- An earthen erosion layer at least 15 cm (6 inches) thick must be included to minimize erosion by wind and water and sustain native plant growth
- The disruption of final cover system integrity must be minimized through use of a stable design that accommodates settling and subsidence

Use of the term “permeability” in the first requirement can lead to some confusion because a final cover system and a liner system may include multiple components (e.g. a geomembrane and a compacted soil layer) that have varying individual permeability properties and work in combination to limit percolation. The interpretation taken for this paper is that “permeability” refers to the rate of percolation through the entire final cover system or liner system, not a single component. This view is supported by the reference in the CCR Rule preamble to 62 FR 40710, which notes: “The purpose of the performance standard is to reduce the possibility of the ‘bathtub effect’ which can lead to ground-water contamination. The ‘bathtub effect’ occurs when more liquid enters the [unit] than escapes causing the [unit] to fill with liquid.” This interpretation has commonly been taken since the early 1990s to address similar imprecision in regulations pertaining to municipal solid waste landfills.

The CCR Rule allows the use of alternative final cover (AFC) systems for closure of landfills and surface impoundments containing CCRs, provided that several engineering demonstrations can be made regarding the expected performance of the selected AFC system. At many sites, the use of an appropriately designed AFC system offers equivalent environmental performance to the prescriptive cover system with significant benefits in terms of cost, effectiveness of soil resource usage, and sustainability. The following are the engineering demonstrations that need to be made regarding the anticipated performance of the selected AFC system:

- The AFC system design includes an infiltration layer that provides an equivalent reduction in percolation to the infiltration layer specified for the prescriptive cover system
- The AFC system design includes an erosion layer that provides equivalent protection from wind and water erosion to the erosion layer specified for the prescriptive cover system
• The disruption of final cover system integrity is minimized through use of a stable AFC system design that accommodates settling and subsidence

A confounding factor for some facilities is the reality that a different set of final cover system requirements often exists simultaneously under the purview of a state regulatory agency. Final cover system designs prescribed in the applicable state regulations or approved by the state regulatory agency may not meet the prescriptive final cover system requirements of the CCR Rule and would therefore classify as AFC systems under the CCR Rule. For many active CCR units where good engineering practice of concurrent/progressive closure is being employed, the final cover system may already be in place over portions of the CCR unit. In this case, the engineering demonstrations noted above would need to be made successfully to avoid retrofitting or augmenting the already-constructed final cover system.

The engineering demonstrations required under the CCR Rule for AFC systems are most often made using a set of calculations and/or through modeling. The calculation or modeling effort required to demonstrate equivalent reduction in percolation between the prescriptive final cover system and the AFC system is typically the most involved and complex of the engineering demonstrations. The primary reason is that the modeling requires in-depth and site-specific understanding of the soil resources, revegetation characteristics, and climate at the CCR unit. Unsaturated flow analysis that uses industry-recognized soil-atmosphere modeling software, like HYDRUS or UNSAT-H, is typically employed.

On occasion, field-scale demonstration programs have been used to demonstrate equivalent reduction in percolation between the prescriptive final cover system and the AFC system. This approach is significantly more expensive than the modeling approach, and its use is typically driven by the state regulatory agency (not the CCR Rule) in cases where the agency is skeptical of an engineering demonstration made using the modeling approach. In some scenarios, the higher cost associated with this approach is still worthwhile because of the considerable benefits that may be realized with an AFC system. This paper describes one case history where the modeling approach was used successfully and a second case history where a field demonstration approach was needed to make a successful engineering demonstration.

A vast amount of research has been done to investigate the effectiveness of various types of AFC systems (e.g. Albright et al. 2004, Khire et al. 1999); discussion of that topic is beyond the scope of this paper. Further, this paper does not focus on the category of AFC systems that include the use of geosynthetic material(s) to provide a hydraulic barrier, but rather on soil-only AFC systems, which are suitable primarily in arid and semi-arid environments. The objectives of this paper are to describe some of
the benefits that are possible through the use of AFC systems and to offer two case histories where these benefits are being realized.

POTENTIAL BENEFITS OF ALTERNATIVE FINAL COVER SYSTEMS

The goal of an AFC system is to provide the same protection of the environment as the prescriptive final cover system, while also offering some other benefit(s) that makes the effort associated with demonstrating the appropriateness of the AFC system worthwhile. Some of the potential benefits of AFC systems include:

- More effective and sustainable use of native soil resources
  - On-site or local soils that cannot achieve sufficiently low hydraulic conductivity for use in a compacted soil barrier may still be useful in an AFC system
  - The use of on-site or local soils reduces the need to import soil materials, including truck transport over potentially long distances
  - A more efficient (thinner) cover profile, if possible, or more effective use of on-site or local soils reduces the acreage disturbed to provide borrow materials

- Reduced cover system installation cost
  - Use of a more efficient (thinner) cover profile, if possible, reduces the overall earthwork quantities and costs
  - More effective use of on-site or local soil resources reduces costs associated with importing soils
  - AFC systems usually involve less rigorous moisture conditioning and compaction requirements during soil placement, reducing contractor effort and associated costs
  - AFC systems can often be designed so that an expensive component of a prescriptive cover system is replaced by with a less expensive equivalent component
  - Construction quality assurance (CQA) for AFC systems is typically less involved and less costly

- Simplified CQA
  - If the use of an AFC system can eliminate the need for a geomembrane component, the complexity associated with conformance testing, trial seaming, destructive testing, non-destructive testing, and other geomembrane-related CQA activities is eliminated
  - If the use of an AFC can eliminate the need for a compacted soil barrier, the complexity and potential schedule impacts associated with hydraulic conductivity testing are eliminated (the potential for a failing laboratory hydraulic conductivity test to necessitate uncovering and reworking of an
area that has already been covered during the test turn-around time is a common risk with compacted soil barriers)
- The cruciality of rigorous CQA to achieve adequate environmental performance is often reduced for AFC systems
  - More effective use of available airspace and reduced footprint for future disposal areas
    - A more efficient (thinner) cover profile, if possible, reduces the airspace occupied by the cover system and consequently reduces the footprint needed for future disposal and may even eliminate the need for an expansion or a new disposal facility
    - A reduced footprint for future disposal also reduces land disturbance, permitting effort and costs, and future maintenance costs
  - Simplified construction schedule
    - If the use of an AFC system can eliminate the need for geosynthetic materials, the schedule dependence on material procurement and lead times, conformance testing, and material delivery is eliminated

DEMONSTRATION EXAMPLE #1

The Nucla Station Ash Disposal Facility (the Nucla Facility) accepts CCRs produced at Nucla Generating Station, a 110-megawatt coal-fired electric generating plant owned and operated by Tri-State Generation and Transmission Association (Tri-State). The Nucla Facility is located approximately 5 kilometers (3 miles) southeast of Nucla, Colorado. It is an existing CCR landfill under the CCR Rule and covers a surface area of approximately 25 hectares (61 acres).

The Colorado Department of Public Health and Environment (CDPHE) has established guidance for design and construction of water balance cover systems (also known as evapotranspiration or ET cover systems) in Colorado (CDPHE 2013). Water balance cover systems rely on principles of water balance, specifically the capability of soil to store water and native vegetation and evaporation to remove water from the soil cover. Western Colorado has an arid climate that is well-suited for the use of a water balance cover system as an alternative to a conventional cover system with a hydraulic barrier. The final cover system that was in use at the Nucla Facility prior to promulgation of the CCR Rule was a monolithic water balance cover system consisting of at least 76 cm (30 inches) of native soil, which is primarily sandy lean clay. This final cover system had already been constructed over approximately 16 hectares (39 acres) of the Nucla Facility, and Tri-State sought to avoid the substantial cost of retrofitting the final cover system in these areas and to retain the option of using the same final cover system design after the CCR Rule went into effect. This required an AFC system demonstration for CCR Rule compliance.
Golder conducted an evaluation of predicted unsaturated flow and percolation through the prescriptive cover system under the CCR Rule and the water balance cover system, performed as a comparative assessment of hydraulic performance. Unsaturated flow modeling was performed using the one-dimensional soil-atmosphere modeling software HYDRUS-1D (Simunek et al. 2013). The model profile for the prescriptive cover system consisted of (from top to bottom) a 23-cm-thick erosion layer, a 60-cm-thick infiltration layer with saturated vertical hydraulic conductivity equal to $1 \times 10^{-5}$ cm/s (since the native material beneath the Nucla Facility has a hydraulic conductivity greater than $1 \times 10^{-5}$ cm/s), and a 60-cm-thick CCR layer (to establish an appropriate lower boundary condition). The erosion layer was made slightly thicker than required under the CCR Rule for added protection of the relatively steep sideslopes at the Nucla Facility. The model profile for the water balance cover system consisted of (from top to bottom) a 76-cm-thick water storage layer, which combines functionality serving as both the erosion layer (upper 23 cm) and the infiltration layer (lower 53 cm), and a 60-cm-thick CCR layer (to establish the same lower boundary condition as the prescriptive cover profile).
Material properties for the modeling were developed from the results of testing conducted in Golder’s geotechnical laboratory on soils collected at the site. Based on index test results, two soil samples collected from on-site stockpiles were considered representative and appropriate for modeling of the final cover systems. Material properties selected for two different soil samples (and at two different densities for one of the samples) were used in the modeling to help bracket the range of hydraulic performance for different on-site soils. Additional testing was conducted on the two samples, including flexible-wall permeability testing at each density to estimate the saturated vertical hydraulic conductivity of the soils and soil water characteristic curve (SWCC) testing at each density to estimate the unsaturated hydraulic properties of the soils. The SWCC curve provides the laboratory-measured relationship between soil suction and volumetric water content, which is then used to estimate the relationship between volumetric water content and unsaturated hydraulic conductivity. The hydraulic properties of deposited CCRs were estimated based on the particle-size distribution of a sample collected from the Nucla Facility (silty sand under the Unified Soil Classification System, US Department of Agriculture soil texture of loamy sand) and the default properties for loamy sand from the Rosetta database (Schapp et al. 2001). Further details are provided by Golder (2016).

For the soil-atmosphere model, four inputs were required to simulate transpiration by local vegetation: leaf area index (LAI), root distribution with depth, total root depth, and water uptake parameters (critical suction limits), which define the relationship of transpiration with soil suction. Vegetation inputs were developed for the site-specific reclamation seed mix and shrubland plant community. Further details are provided by Golder (2016).

A long-term climate record was developed for the Nucla Facility to provide inputs of precipitation, potential evaporation (PET), and potential transpiration for the soil-atmosphere model. The closest co-located precipitation and PET data record is located at the Nucla Remote Automated Weather Station (RAWS), approximately four miles northwest of the Nucla Facility. However, only a limited climate dataset (less than 18 years of data) existed for this station. As a result, data from the nearby Montrose 2 meteorological station were adjusted to extend the Nucla RAWS dataset based on a linear regression analysis of the overlapping records of these two stations. Following the data reduction, a 112-year period of record was compiled for the Nucla Facility. The range of precipitation over the 112-year climate record indicates an annual average precipitation of 246 millimeters (mm) (9.7 inches) and maximum annual precipitation of 437 mm (17.2 inches). The climate record for the site represents a moisture-limited environment where PET far exceeds precipitation.

Predictive simulations were performed for the prescriptive cover system and the water balance cover system using the material properties, vegetation properties, climate inputs, and other model parameters described. Based on results from the simulations,
percolation through each cover system is predicted to be negligibly small – less than 0.25 mm per year (0.01 inches per year) on average – in all model simulations. This is a consequence of PET far exceeding precipitation. Based on the simulation results over the 112-year period of climate record, the predicted water balance fluxes for the prescriptive cover system are approximately the same as the predicted water balance fluxes for the water balance cover system. For the water balance cover system, the water balance fluxes and comparisons of these fluxes to the annual average precipitation at the Nucla Facility are as follows:

- Percolation = < 0.25 mm/year (< 0.01 inches/year) = negligible
- Evaporation = 165 to 180 mm/year (6.5 to 7.1 inches/year) = 67 to 73% of annual average precipitation
- Transpiration = 64 to 81 mm/year (2.5 to 3.2 inches/year) = 26 to 33% of annual average precipitation
- Runoff = < 3 mm/year (< 0.10 inches/year) = ≤ 1% of annual average precipitation
- Change in Storage = minimal = < 1% of annual average precipitation

Demonstrating equivalent protection against wind and water erosion between the AFC system and the prescriptive final cover system was simple in this case. The earthen material used for the erosion layer in the AFC system, which is native soil sourced from on-site stockpiles, would be the same material used for the erosion layer in the prescriptive final cover system. The installation techniques would also be the same. These materials and installation techniques have already been shown to effectively limit erosion on the portions of the Nucla Facility that have been covered. Thus, the erosion layer design for the AFC system meets the CCR Rule requirements to limit wind and water erosion and provide equivalent protection to the erosion layer in the prescriptive final cover system.

Measures that are included in the design of the AFC system to minimize disruption of the integrity of the final cover system and meet the final requirement of the CCR Rule for AFC systems include:

- Compaction of subgrade for the final cover system to establish a firm surface for soil placement and reduce the amount of settlement that will occur after closure
- Establishment of a minimum 2% slope across the top surface to provide positive drainage even if a moderate amount of differential settlement occurs after closure
- Incorporation of surface water controls designed to control runoff from the 100-year, 24-hour storm event and limit long-term soil loss (in combination with vegetation)
- Establishment of appropriate native vegetation on the surface of the final cover system
DEMONSTRATION EXAMPLE #2

Coal Creek Station (CCS) is a 1,200-megawatt coal-fired electric generating plant owned and operated by Great River Energy (GRE). Located approximately 80 kilometers (50 miles) northwest of Bismarck, North Dakota, CCS is North Dakota’s largest electric generation facility. Coal Creek Station has one existing CCR landfill and three existing CCR surface impoundments that are subject to the CCR Rule. The combined surface area of these facilities is approximately 110 hectares (273 acres), so the volume of earthen materials required for closure is considerable.

The North Dakota Department of Health (NDDH) regulates CCR units at the state level in North Dakota. Prior to 2009, the final cover system prescribed by the NDDH for CCR units was a conventional cover system with a compacted soil barrier and a total soil thickness of 152 cm (5 feet). Between February 2004 and December 2006, GRE, Otter Tail Power Company, and Golder conducted an AFC system demonstration project at CCS. Modeled after US Environmental Protection Agency’s (USEPA’s) Alternative Cover Assessment Program (Albright et al. 2004), the objective of the project was to compare the hydraulic performance of three earthen landfill cover system designs by measuring the amount of percolation reaching the base of field-scale (20 meters long by 10 meters wide [66 feet long by 33 feet wide]) lysimeters designed and constructed to represent three different final cover systems. The three final cover systems evaluated are described as:

- **CC5** – The prescriptive cover system with a 61-cm-thick compacted soil barrier and a total soil thickness of 152 cm (5 feet)
- **CC3** – A conventional cover system with a 46-cm-thick compacted soil barrier and a total soil thickness of 91 cm (3 feet)
- **ETC** – A water balance cover system with a total soil thickness of 91 cm (3 feet)

The most significant benefit GRE hoped to derive from the project outcome was to reduce the volume of soil resources (and associated costs) required to construct final cover systems for closure of the CCR units at CCS by reducing the minimum thickness from 152 cm (5 feet) to 91 cm (3 feet). Unsaturated flow modeling performed by Golder using UNSAT-H had shown that the percolation rates through the three final cover systems were equivalent and negligibly low because of the relatively high ratio between PET and precipitation. However, the NDDH considered a 2-foot reduction in minimum cover thickness to be a significant enough change to warrant additional demonstration.

GRE and Golder constructed a field-scale lysimeter at CCS for each final cover system under evaluation. Earthen material layers having the actual design thicknesses were placed within each lysimeter footprint using full-scale construction equipment and techniques. The base of each lysimeter was sloped to a sump at the downstream end of
the lysimeter and lined with geomembrane. Vertical sidewalls were constructed of geomembrane to create a watertight “bathtub.” The earthen materials were then placed in each geomembrane “bathtub” using equipment and techniques that would typically be employed during construction of a full-scale final cover system. The areas outside of the geomembrane “bathtub” were also backfilled with earthen material to support the sidewalls and keep them vertical. Diversion berms were constructed around the perimeter of each lysimeter to exclude potential run-on from adjacent areas into the lysimeter footprint and to retain runoff originating within the lysimeter footprint. Each lysimeter was vegetated with a prairie grass mixture planned for use on full-scale final cover system installations at the site.

Runoff and percolation from each lysimeter drained through buried plastic collection basins where the flow volumes could be measured using multiple instruments (a tipping bucket flow gauge and a float switch for runoff and percolation, plus a pressure transducer for percolation). Soil volumetric water content sensors and heat dissipation sensors (used to measure soil suction) were installed at various depths and locations within each lysimeter to estimate changes in soil water storage within the cover profile. A precipitation gauge was installed near the lysimeters to measure precipitation occurring at the site. Additionally, a weather station was installed near the lysimeters to measure air temperature, wind speed and direction, relative humidity, and solar radiation.
Monitoring was conducted for a period of four years. Percolation totals and corresponding percolation rates measured between January 1, 2005, and December 31, 2007, a two-year period during which the hydrology of the cover systems had progressed beyond the initial “equilibration” period based on vegetation establishment and surface water runoff patterns, are presented in Table 1.

**Table 1: Alternative Cover Demonstration Project Results**

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Final Cover System</th>
<th>Percolation</th>
<th>Average Percolation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/01/06-12/31/06 (one year)</td>
<td>CC5</td>
<td>0.64 cm</td>
<td>175 liters per hectare per day</td>
</tr>
<tr>
<td></td>
<td>CC3</td>
<td>0.49 cm</td>
<td>134 liters per hectare per day</td>
</tr>
<tr>
<td></td>
<td>ETC</td>
<td>0.29 cm</td>
<td>79 liters per hectare per day</td>
</tr>
<tr>
<td>01/01/07-12/31/07 (one year)</td>
<td>CC5</td>
<td>0.24 cm</td>
<td>66 liters per hectare per day</td>
</tr>
<tr>
<td></td>
<td>CC3</td>
<td>0.10 cm</td>
<td>27 liters per hectare per day</td>
</tr>
<tr>
<td></td>
<td>ETC</td>
<td>0.30 cm</td>
<td>82 liters per hectare per day</td>
</tr>
<tr>
<td>01/01/06-12/31/07 (two years)</td>
<td>CC5</td>
<td>0.88 cm</td>
<td>121 liters per hectare per day</td>
</tr>
<tr>
<td></td>
<td>CC3</td>
<td>0.59 cm</td>
<td>81 liters per hectare per day</td>
</tr>
<tr>
<td></td>
<td>ETC</td>
<td>0.59 cm</td>
<td>81 liters per hectare per day</td>
</tr>
</tbody>
</table>

Results from the project demonstrated that CC3 reduced percolation as effectively as CC5. This demonstration supported a change from CC5 (152-cm-thick conventional cover system) to CC3 (91-cm-thick conventional cover system) as the prescriptive cover system under NDDH regulations as of January 1, 2009. Additionally, the NDDH approved ETC (91-cm-thick water balance cover system) for use at CCS.

In 2015, however, the CCR Rule introduced a new set of challenges to the use of both CC3 and ETC. The CCR units at CCS have composite liner systems (geomembrane over compacted clay). Thus, a demonstration needed to be made that CC3 – even though it is the prescriptive final cover system under state regulations – and ETC meet the AFC design requirements of the CCR Rule, particularly in terms of limiting percolation sufficiently to avoid the “bathtub effect.” That is, the percolation rate through the AFC system must be equivalent to or less than the percolation rate through the liner systems.

Since it is impractical to directly measure percolation rates through the liner systems of the subject CCR units, a study published by the USEPA (Bonaparte et al. 2002) was judged to be a relevant and defensible source of information for comparative purposes,
based on a literature review conducted by Golder. In this study, the authors conducted a comprehensive review in which they evaluated leak detection system (LDS) flow data from 189 cells at 54 municipal solid waste, hazardous waste, and industrial solid waste landfills located throughout the US. The LDS flow rate is indicative of the permeability of the primary liner system. Primary liner systems in many of the cells consisted of a geomembrane underlain by a compacted soil layer, similar to the liner systems for the subject CCR units. Thus, the measurements of LDS flows from this subset of landfills provides an estimation of the range in percolation rate for composite liner systems like those beneath the subject CCR units (assuming similar hydraulic head conditions, which is likely a conservative assumption for the CCR surface impoundments). LDS flow data from the first two years of the post-closure period were available for 44 different time intervals (each between 2 and 13 months) across 21 cells. The range in average LDS flow rates for these time intervals was between 0 and 313 liters per hectare per day, with an average of 80 liters per hectare per day. This average percolation rate is equivalent to the average two-year percolation rate for CC3 and ETC (see Table 1), signifying that the reduction in percolation rate provided by CC3 and ETC meets the pertinent requirement of the CCR Rule.

As with Demonstration Example #1, the earthen material used for the erosion layer in CC3 or ETC, which is native soil sourced from on-site stockpiles, and the installation techniques would be the same as those used for the erosion layer in the prescriptive final cover system under the CCR Rule. Thus, the erosion layer design for either AFC system meets the CCR Rule requirement to provide equivalent protection against wind and water erosion to the erosion layer in the prescriptive final cover system.

Measures that are included in the design of CC3 and ETC to minimize disruption of the integrity of the final cover system and meet the final requirement of the CCR Rule for AFC systems include:

- Drainage and stabilization of CCRs to reduce the amount of settlement that will occur after closure (applicable to the surface impoundments)
- Compaction of subgrade for the final cover system to establish a firm surface for soil placement and reduce the amount of settlement that will occur after closure
- Establishment of a minimum 3% to 5% slope across the top surface to provide positive drainage even if a moderate amount of differential settlement occurs after closure
- Incorporation of surface water controls designed to control runoff from the 100-year, 24-hour storm event and limit long-term soil loss (in combination with vegetation)
- Implementation of construction quality assurance procedures to verify that installation of the final cover system is completed in accordance with the applicable requirements
• Establishment of appropriate native vegetation on the surface of the final cover system

CONCLUSION

Evaluating the appropriateness and usefulness of an AFC system is a site-specific process that depends on the prescriptive final cover design (to identify whether a significant enough benefit could be realized to make an AFC system demonstration worthwhile), the site climate, the available soil resources, the regulatory environment, and potentially other factors. In certain scenarios, an AFC system demonstration can offer significant benefits (particularly in arid and semi-arid climates).

Tri-State is realizing significant benefits from the AFC system demonstration completed for the Nucla Facility. Tri-State has already placed 16 hectares (39 acres) of CDPHE-approved final cover at the Nucla Facility. While the final cover system would likely not meet all of the requirements for the prescriptive final cover system under the CCR Rule, engineering demonstrations have been made to show that the final cover system already in place does meet the CCR Rule requirements for an AFC system. In doing so, Tri-State has avoided a costly retrofit that may have been needed to establish and document the presence of an infiltration layer with relatively low hydraulic conductivity. As shown in this paper, such a retrofit would have provided no additional environmental benefit despite a significant cost. By using an AFC system, Tri-State is taking advantage of the water storage capabilities of the on-site soils and an arid climate that favors the use of a water balance cover system.

Great River Energy is realizing significant benefits from the AFC system demonstration completed for the CCR units at CCS. A reduction in minimum final cover thickness from 152 cm (5 feet) to 91 cm (3 feet) provides benefits in terms of earthworks construction cost, CQA cost, stewardship of on-site soil resources, sustainability, avoided land disturbance, and increased airspace. Using an AFC system demonstration to avoid the possible need for a geomembrane component in the final cover system (as may be required for the prescriptive cover system under the CCR Rule due to the inclusion of a geomembrane in the liner system) provides benefits in terms of construction cost, CQA cost and complexity, and schedule complexity. These benefits are provided by an AFC system that achieves the same environmental performance as the prescriptive final cover system.

REFERENCES


