SUMMARY OF *WORKSHOP ON ENGINEERED BARRIER PERFORMANCE RELATED TO LOW-LEVEL RADIOACTIVE WASTE, DECOMMISSIONING, AND URANIUM MILL TAILINGS FACILITIES*

Workshop Dates

August 3–5, 2010

Location

U.S. Nuclear Regulatory Commission (NRC) Headquarters Auditorium,
11545 Rockville Pike, Rockville, Maryland

Attendance

Participants included invited speakers and panelists, Federal and State staff and contractors, selected experts, representatives from Tribes, and NRC technical staff and management (please see Workshop Participants list). The public was welcomed to attend and observe the proceedings of this Category 1 Public Meeting. About 140 workshop registrants were in attendance. In addition, several hundred viewers observed the workshop proceedings remotely via “WebStreaming.”

Workshop Host

NRC’s Offices of Nuclear Regulatory Research (RES) and Federal and State Materials and Environmental Management Programs (FSME) organized this ***Workshop on Engineered Barrier Performance Related to Low-Level Radioactive Waste, Decommissioning, and Uranium Mill Tailings Facilities***. The workshop was coordinated with the States (i.e., Texas, South Carolina, Utah, Colorado, Washington, and New York) and Federal agencies (e.g., U.S. Department of Energy [DOE], U.S. Environmental Protection Agency [EPA], U.S. Department of Agriculture/ Agricultural Research Service [USDA/ARS], U.S. Geological Survey [USGS], and DOE National Laboratories).

Technical Topics

The workshop focused on engineered surface covers and bottom liners designed to isolate waste by impeding surface-water infiltration into the waste systems and mitigating the migration of contaminants from the waste disposal site. Topics included engineered barrier performance, modeling, monitoring, and regulatory experiences at low-level radioactive waste, decommissioning, and uranium mill tailings sites.

Workshop Program

A Workshop Program was provided to the workshop attendees and also to attendees who accessed the workshop remotely over the NRC Public Web site via “WebStreaming” (public), “GoToMeeting” (State regulators) and videoteleconferencing (NRC Regions). The program included a detailed workshop agenda and extended abstracts.

Workshop Objectives

Objectives included:

- Facilitation of communication among Federal and State staff and contractors and selected experts on current engineered barrier issues and technical and regulatory experiences.
- Discussion of lessons learned and approaches for monitoring and modeling.
- Preparation of recommendations to address maintenance of engineered barrier performance over time.
- Identification of topics for future research and the potential need to update technical guidance.

Program Format

In the introductory session, the workshop objectives, technical themes, and topics were presented. This was followed by a presentation on descriptions of the various engineered barrier types by function and design and, finally, an overview of NRC's experience with engineered barrier performance in research, licensing, and regulatory compliance.

Technical Sessions included:

- ***Session 1*** – State and Federal agencies and a Native Tribe presented an overview of their research activities and findings with an emphasis on practical insights on monitoring, modeling, and confirming short- and long-term performance of engineered systems.
- ***Session 2*** – Degradation Processes and Performance Evolution of Engineered Barriers and Covers.
- ***Session 3*** – Experience with Monitoring Devices and Systems Used to Measure Performance.
- ***Session 4*** – Modeling Experiences in Performance Assessment and Evaluation of Performance Monitoring.
- ***Session 5*** – Experience with Model Support and Multiple Lines of Evidence to Gain Confidence in Long-Term Performance.
- ***Session 6*** – Recommendations on Assessing Engineered Barrier Performance, Identifying Future Research Needs, and Improving Guidance Documents.

At the end of each working session, a technical panel of the presenters and selected experts responded to questions. Technical reporters captured significant insights and recommendations from these panelists that were reported during the final session.

Public Comment and Questions:

At the end of each day's sessions, the public was provided an opportunity to make comments or to provide questions.

Observations, Insights, and Recommendations

The observations, insights, and recommendations documented below were made by participants during the workshop proceedings. NRC staff will be studying the usefulness and applicability of the recommendations and insights made.

General

- Facilitated communication between Federal agencies, State regulators, and the technical community; discussed degradation processes and changing performance of engineered barriers, monitoring (short-term), model support (long-term), and modeling of processes within the barriers, especially engineered surface covers; discussed lessons learned and practical examples of performance failures and successes based on field observations.

- General consensus that groups involved with engineered barrier performance need to communicate more frequently and coordinate efforts.

- The performance of cover systems evolve toward an equilibrated state more rapidly than originally anticipated (with the exception of geomembranes where the longevity of these components may have been conservatively estimated in earlier research). The alteration or evolution of covers can lead to a transition from a resistive cover to an evapotranspiration cover. The level of monitoring and model support should be risk informed and performance based.

- General alteration of some cover properties observed from that of the designed as-built properties. Exposure to natural environmental conditions caused root intrusion and soil development that increased saturated hydraulic conductivity and soil development that may cause preferential flow in the low-permeability radon barriers.

- The energy of the system and how much energy is required to maintain the engineered system must be considered. The further away it is from equilibrium, the more energy will be required. An energy balance should be calculated similarly to water balance.

- Evapotranspirative or water balance covers can use the pedogenesis processes and establishment of flora and fauna to increase or maintain performance.

- No urgent problem identified with engineered surface covers at Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) sites; however, uranium mill tailings sites need monitoring in the cover, tailings, and below the tailings so there is more of a system approach.

- General consensus of a total systems approach to monitoring and modeling. Engineered covers and liners should not be looked at in isolation from the entire waste disposal system. Graded and iterative approach to identify significant processes and components requiring further detailed modeling and/or monitoring.

Monitoring and Modeling

- Monitoring and modeling is an iterative process. Modeling can focus monitoring by identifying key processes and parameters or disconnects between field observations and model results that could be investigated. Similarly, the results of monitoring provide feedback to refine models and improve the understanding of the system. Monitoring should be driven by the purpose of the project—recognizing that technology exists to monitor almost all components—but the cost of monitoring is often limiting.

- Align level of engineering with the level of risk, the costs of monitoring, the cost of cleanup, and the total system. If the cover or liner is risk significant, then there should be a redundant system.

- Clearly determine the function of each cover component (e.g., plants) to diminish the risk of unintended consequences. The intended function of each component must be clearly defined in addition to the potential risks to the primary function.

- Monitor safety-dependent components of the facility. Integrate internal containment system monitoring to enhance performance. Monitor the containment structure to understand processes and to identify precursors of problems. This approach is more effective than perimeter compliance wells that do not provide an understanding of the processes that impact compliance.

- Monitor ecological/plant processes if they are potentially critical to cover performance.

- Monitor the unsaturated zone within and below the emplaced waste to the regional water table.

- Place monitoring devices within the engineered cover elements to obtain data on water infiltration and gaseous releases.

- Identify methods and guidance for large-scale lysimeter monitoring to quantify preferential fluxes through the cover to the emplaced waste and onto the unsaturated zone and deeper saturated zone below.

- If the engineered barrier performance is important and associated with significant uncertainty, monitor and confirm ground-water releases and radon emissions also for sites with designed-based compliance.

- Use remote sensing to assess environmental conditions indicative of performance.

- Monitor differential settlement and human intrusion and its potential to dramatically alter the cover performance.

- Monitor microbial activity that may affect drainage layers (e.g., biofouling) and geosynthetic performance.

- More information is needed on biotic activity and its relation to the performance of engineered surface covers (i.e., information such as root and burrow penetration depth distribution and the dynamics of ecological succession).

- Codes need to better incorporate ecological succession and climatological changes. Account for episodic rates as well as dynamic disturbances such as fires and changes in biota. All model assumptions and evaluations should generally be made available.

- If risk significant information can be obtained on overall total systems performance, integrate engineered barrier degradation processes into the model.

- Monitor and model the ecosystem with an emphasis on quantifying baseline conditions to model anticipated future human and natural events that may significantly affect performance.

- Identify and test assumptions in performance assessments for past (Title I), present (Title II), and future engineered barrier systems.

- Coupling of hydrology, erosion, and plant succession on the short- and long-term performance of the engineered systems.

- Coupling of monitoring and modeling activities focusing on performance indicators that can be both monitored and modeled.

- Treatment of uncertainty in the prediction of both short- and long-term performance of the engineered system components and surrounding environments.

- Assess conceptual, parameter, and scenario uncertainties with emphasis on alternative conceptual models including features, events and processes that can affect long-term performance.

- Define a screening framework of possible future scenarios. For example, a soil type exposed to particular climatological condition and ecological changes categorized within a range of scenario possibilities. Identify degradation processes affecting performance, e.g., different barrier types for different types of ecologic and climate states.

Model Support

- Continue to improve model support and confidence building activities; this process should not cease after acceptance. Reevaluate every 5 to 10 years to ascertain that design and construction matches expected performance.

- Develop and implement strategies to obtain and evaluate information needed to support both short- and long-term modeling results.

- Model support should be risk informed and needs to evolve with different stages of the project and should be specific to each site's characteristics. For example, new material may become available and be used in the actual construction. A need exists for clear feedback between the assumptions that the modeler makes and the construction years later.

- Improve communication between modeler developers and those who provide model support. These communications should be documented in the quality assurance/quality control (QA/QC) program.

- Develop "Catalogue of Natural Analogs" for different climatic and environmental settings throughout the U.S.

- A catalog of analogs could provide insight into ecology, climate, and erosive forces for long time periods and could provide bounding scenarios of reasonable future states. For example, pedogenic carbonates provide analog of a capillary barrier on the order of 10,000 years. Analogs can also assist in characterizing surrounding system by imitating ecology and high evapotranspiration of diverse native vegetation. However, analogs must be used with caution, since unknown analogs may not have survived into the present and past environmental exposure may not be known.

- Soil development will be a function of climate, parent material, topography, biology, and time. Pedogenic features will affect hydraulic processes and plant communities at various scales, both spatially and temporally. The modern landscape provides a record of soil evolution pathways that can support long-term assessments of covers.

- Clay barriers should be built down below the ground instead of above the ground, which would minimize some degradation processes. More information is needed on the relationship between depth of soil (clay) barrier and rate of degradation or changing properties.

- Understanding the geochemical environmental in addition to other attributes is fundamental to designing the cover appropriately.

Processes and Performance

- Performance of current geosynthetics appears promising (potential service life of hundreds of years). However, a paucity of really relevant data exists relating to the effect of low-level waste (LLW) on service life of geomembranes. Impact of radiation is determined by total absorbed dose in the presence or absence of oxygen. If oxygen is available, irradiation can provide the activation energy for oxidation to occur. Service life could be reduced by heat generation, high pH leachate, or irradiation from the waste itself.

- The greatest short-term risk to geomembranes is due to hole formation resulting from construction, activities above the liner, animals, and excessive differential settlement. Typical modes of degradation of geomembranes include oxidation, extraction (e.g., diffusion of antioxidants into the surrounding environmental), biological degradation, UV, and thermal degradation. The most significant short- and long-term ecological degradation processes are root growth and intrusion, plant composition, animal intrusion, and bioturbation of soils.

- QA/QC guidance and confirmatory testing of geosynthetic materials and their installation. Geomembranes are fragile materials and strict QA/QC is critical. Quality construction of cover is important and should be documented in the QA/QC program. The QA/QC pedigree must be robust.

- Erosion/deposition rates are different across a cover. Erosion over the long term is concentrated in gullies that do not uniformly erode over their entire length. Peak erosion depth determines cover failure.

- Although the current state of the landform evolution model software has many drawbacks, it can assist in predicting where the most sensitive parts of the cover are located. Next steps include coupling ecology succession with landform evolution.

Specific

- Many specific recommendations were made during the workshop with regards to monitoring significant components or processes of the barrier system.

- “Bands of armor” can be incorporated in the design of covers using the results of landform evolution modeling to determine the probabilities and locations of gully formation.

- Modular systems of engineered barriers as opposed to a large monolithic design would encourage ground-water recharge between modules and thereby increase dispersive mixing and dilution.

- Recommendation to use geophysical investigations and caution on the limited usefulness, both spatially and temporally, of focusing on point censors and sampling.

- Recommendation to design for catastrophic events. For example, disposal site on ridge top instead of in valley if investigations have shown catastrophic scouring of the valley in the past.

Additional General

- Continue to use a strategy of defense in depth. For example, uranium mill tailings disposal sites use layered tailings with the less radioactive material overlying the more radioactive material, a soil/frost protection layer in addition to radon barrier, and the siltation of the rock covers to provide additional radon protection.

- Institutional controls have been ineffective at some sites. For example, impediments constructed to prevent public access to uranium mill tailings disposal sites were removed and sites were visited by members of the public.

- Recommendations were made by some participants to reconsider the time period of institutional control for LLW disposal sites. Change to a more adaptive and site-specific approach that is more consistent with UMTRCA sites. Would need dedicated funding source for long-term monitoring and to provide for flexible responses and activities.

- Newer guidance is needed on covers, liners, and construction techniques that incorporate new knowledge and techniques. Guidance should be flexibility and allow for change in knowledge, experience, and techniques over time.

- A common data repository is needed for current and future information on engineered barrier performance. This proposed data repository could be a multi-agency effort with ongoing maintenance.

Proceedings

A workshop summary of presentations, significant insights, and recommendations will be posted on the NRC Public Web site as a NUREG/CP publication by December 29, 2010.

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