Overview of Data and Modeling Considerations for Engineered Features

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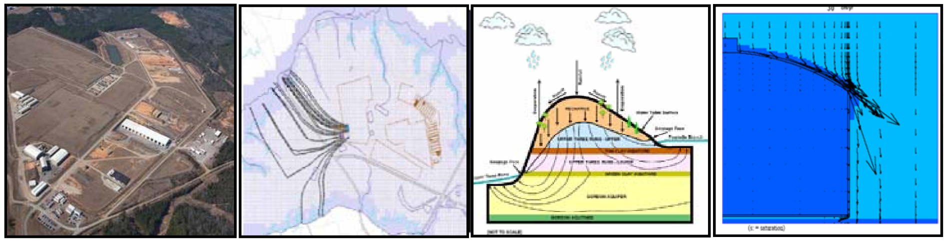
13 July 2009



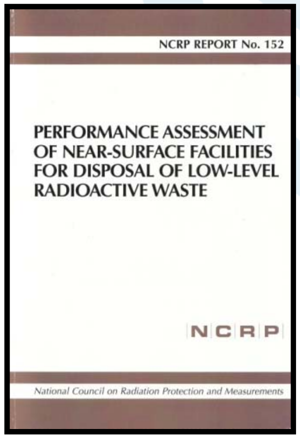
Performance Assessment Community of Practice

Salt Lake City, Utah USA

SRNL-MS-2009-00128-S

Background

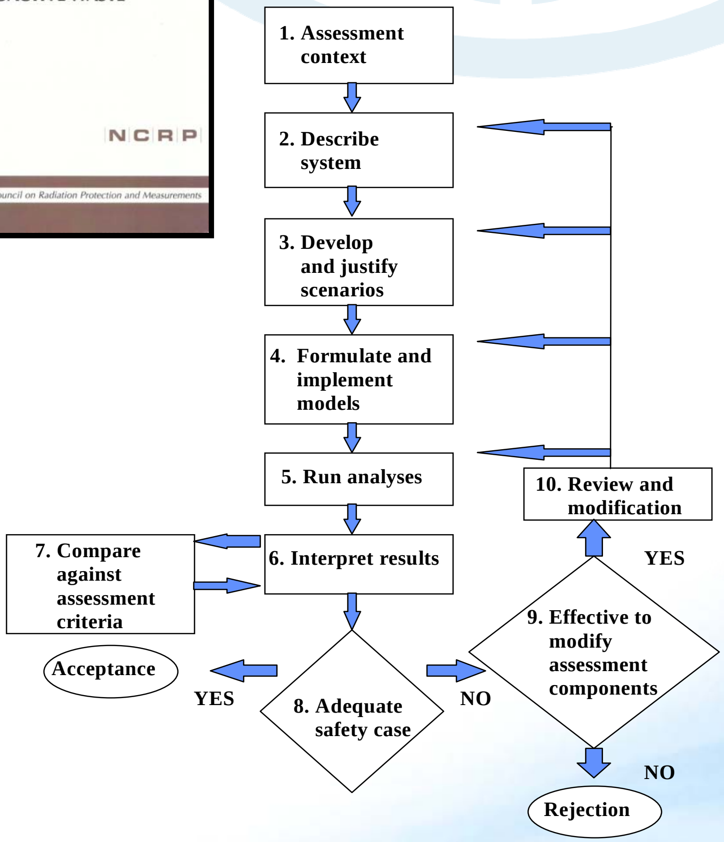
- **Performance (Safety) Assessment (PA) process has a long history of successful use around the world**
- **Relatively good agreement about general methodology, technical approaches continually evolving**
- **Healthy tension between programmatic and scientific interests (realism and conservative-bias)**
- **Uncertainties associated with complex systems over long time frames are the primary challenge (Safety Case)**


NCRP REPORT No. 152

PERFORMANCE ASSESSMENT OF NEAR-SURFACE FACILITIES FOR DISPOSAL OF LOW-LEVEL RADIOACTIVE WASTE

NCRP

National Council on Radiation Protection and Measurements



Courtesy: IAEA

Broader Applications for Performance Assessment

- **PA traditionally focused on disposal**
- **More challenging D&D, Remediation, Tank Closure, etc. assessments becoming PA-like**
  - Need to take credit for more engineered features
- **Demonstrated need for**
  - Improved sharing of information regarding approaches that have been used for engineered features
  - Advances in modeling approaches for engineered features

SRNL™ Office of Environmental Management safety ❖ performance ❖ cleanup ❖ closure

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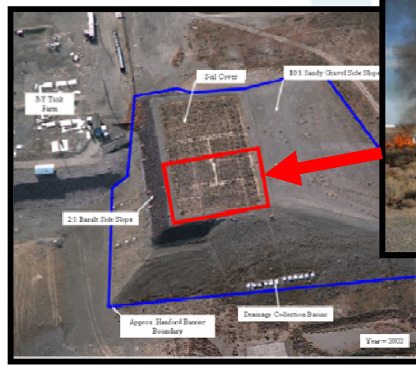
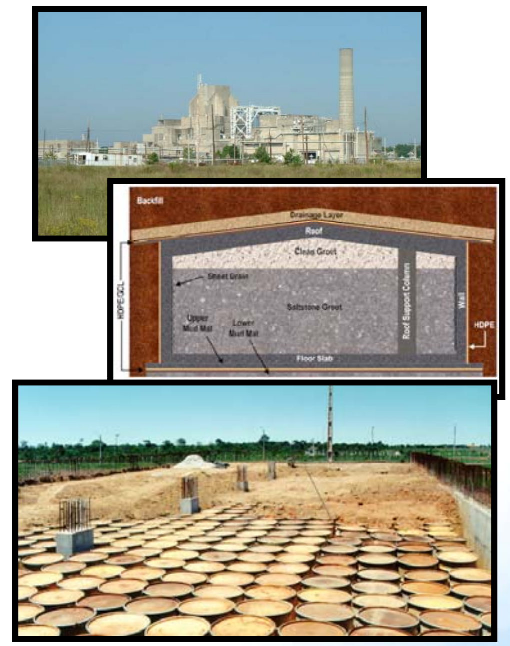
- **Consideration of Engineered Features within the Graded and Iterative Approach**
- **Example Applications**

Diversity of Engineered Features





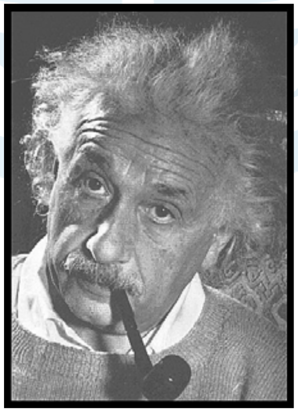
Consideration of Engineered Features in Graded and Iterative Approach

Graded and Iterative Philosophy

Efficient use of resources balancing conservative-bias and realism; and programmatic and scientific interests

General Thought Process

- **Identify radionuclides, pathways and scenarios of key concern (simplified screening)**
- **Conduct basic calculations with *conservative-bias* to identify key contributors to dose (assessment)**
- **Evaluate potential effectiveness of different engineered features as a barrier for radionuclides of concern (sensitivity analysis)**
  - Physical and chemical performance
- **Collect data, refine models to address features expected to provide most benefit, repeat as needed**
- **Detailed calculations/data are also used as support for simplified models (process-level)**



"Everything should be made as simple as possible, but not simpler"

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Role of Engineered Materials in Iterative Approach

Engineered Features

Waste Form

Container

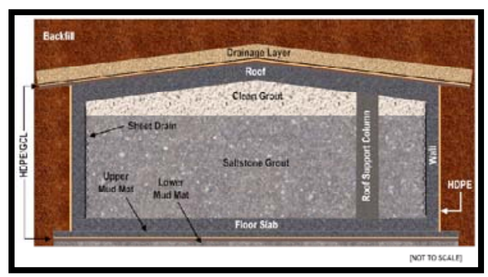
Vault, Liner

Cover

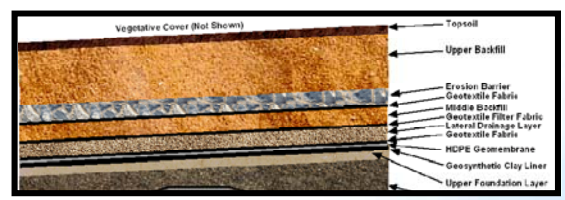
Site

Geochemistry, Permeability

Physical Isolation



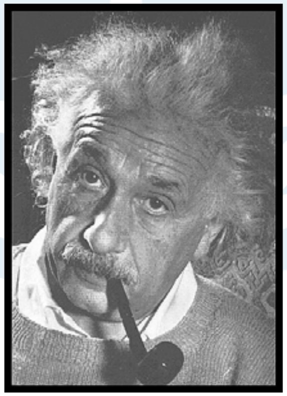
Physical Isolation and Chemical Control

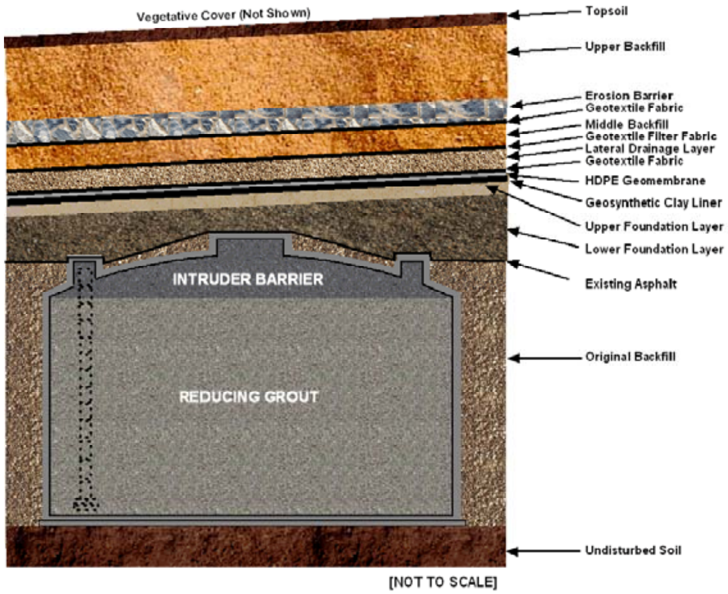


Reduce Infiltration

Complexity and Data Needs

- **Desire to represent more detail and take credit for more features (Operational and Scientific)**
- **Requires more complex models, which require more data with more complexity to defend**
- **Choices between defending realism and conservative-bias**





What is Conservative?

- **Size and distribution of fractures?**
- **Interactions between carbonation, sulfate attack, oxidation, etc. and effects on fracture formation/healing?**
- **Link of cover failure with degradation of cementitious materials?**
- **Fracture effects on oxidation rate of bulk waste?**
- **…**
- **Early cover failure**
- **Early failure of the grout and vault**

Examples

Closure of Reactor Facility

- **Decision whether or not to leave vessel and internals in place**
- **Initial assessment conducted using simplified model suggested that Ni-59 doses were unacceptable and vessel must be removed**
- **Dissolution release mechanism for Ni-59 added to model based on relatively bounding corrosion rate (considered over-conservative)**
- **Updated results showed significant reduction in release and subsequent dose, option to leave vessel in place**

Example Needs: sharing of information, better quantification of releases from activated metal over time

Special Analyses for Waste Disposal

- **Generally applicable disposal limits are developed for all potential wastes and containers expected**
- **Waste streams are identified that exceed generally applicable limits (special waste form or container)**
- **I-129 in Resins and H-3 in solid matrix**
- **H-3 and I-129 are both considered very mobile**
- **Based on the design of the resins, an effective K_d was developed to represent the release of I-129**
- **Containers were designed to limit release of H-3 to an acceptable rate w/o consideration of the matrix**

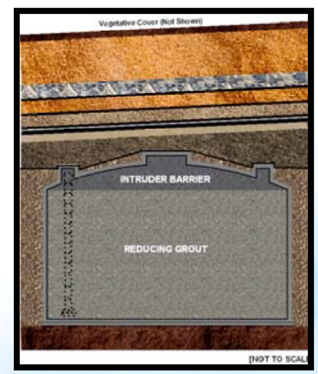
Example Needs: Ability to consider special waste forms as needed

Other Examples

- **First two examples highlighted relatively simple, but common, cases**
- **Numerous more detailed examples will be provided in the presentations during these two days, e.g., taking credit for:**
  - Reduced corrosion of carbon steel encased in cementitious material
  - Changes in physical and chemical properties of cementitious materials over time (permeability, solubilities and distribution coefficients)
  - Reduction capacity of concrete in vault walls to limit access of oxygen to reducing waste form
  - Characterization of tank waste residuals to establish release rates
  - And more…
- **Most improvements are made as a result of sensitivity of the conclusions to that aspect of the system**

Conclusions

- **Engineered Features have proven to be an area of primary concern in PAs and PA-like analyses and provide diverse and interesting challenges for modeling and data collection**
- **Graded and iterative approach with sensitivity analysis is used to focus detailed efforts on specific areas of concern**
  - Choice of which, if any, engineered features to address in more detail is problem-specific
  - Critical choices between developing and defending more complexity and defending conservative-bias
  - Process-level models and data are often used as backup to help defend simplified approaches



QUESTIONS ??

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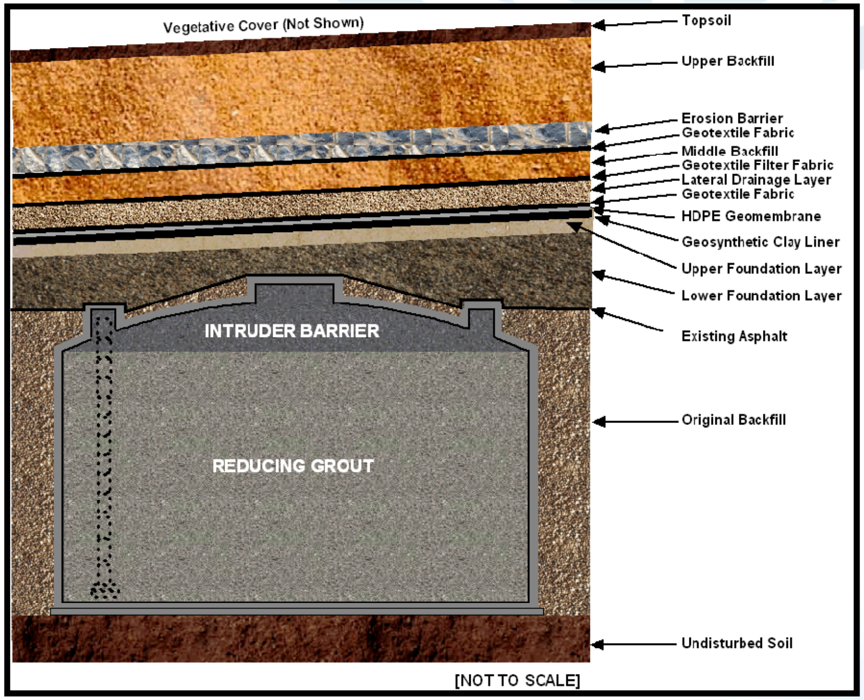
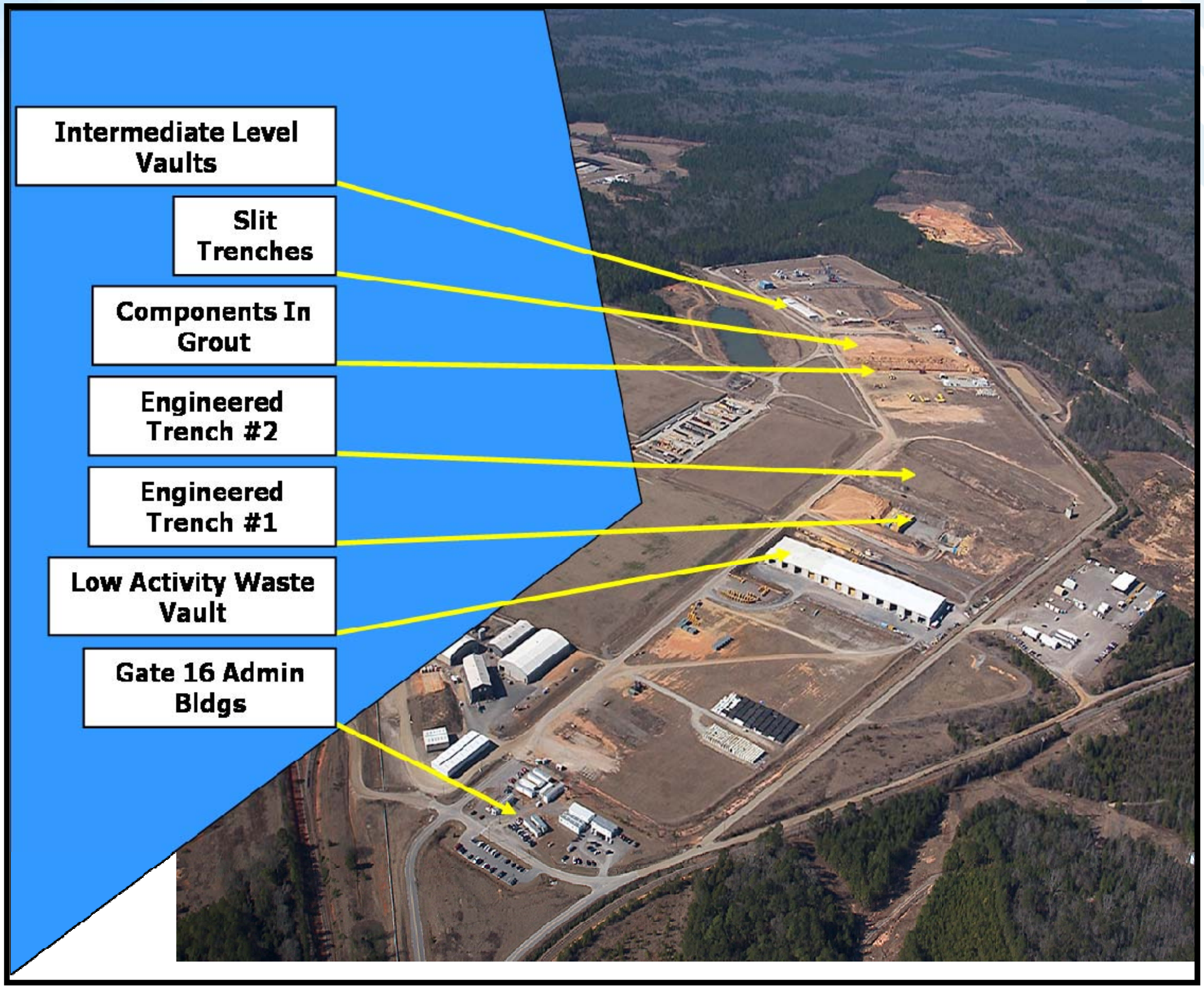
“Source Term” in PA Context – Near Field

- **Waste Form**
  - Contaminant-specific inventory
  - Concentration averaging and location
- **Engineered Features**
  - Native materials (e.g., cover)
  - Cement, metal, synthetic, etc.
- **Physical and chemical properties**
- **Initial condition and evolution over time**



Engineered Features Examples – E-Area Disposal Facility



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