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International PA Approaches and Practical Considerations for Implementation

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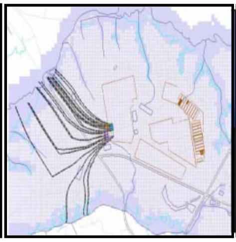
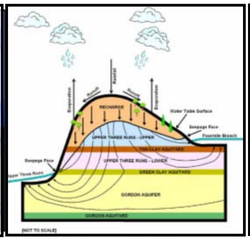
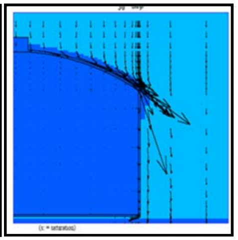

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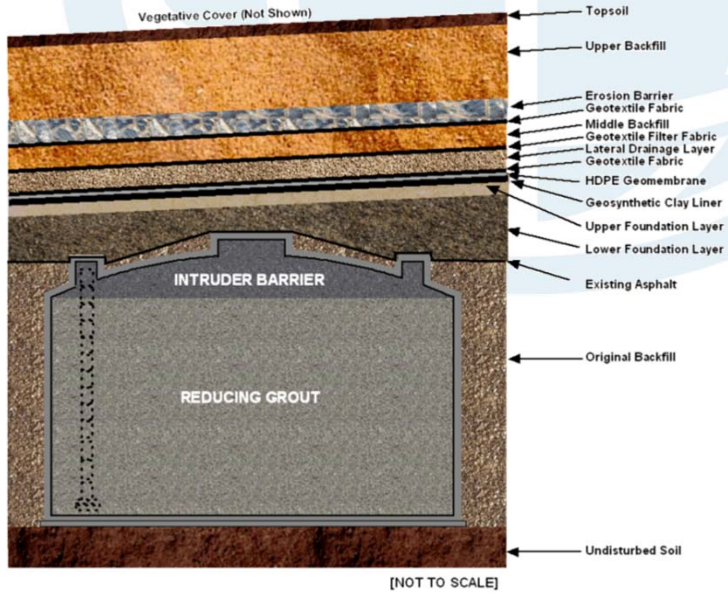
Introduction

- **Quantitative assessments considering protection of future individuals for very long time frames (hundreds or thousands of years) are relatively unique to radioactive waste disposal**
- **Emphasis on understanding roles and functions of barriers in context of system behavior rather than exact predictions**
- **Highlight recent international recommendations and guidance with some historical perspective on scenario development**



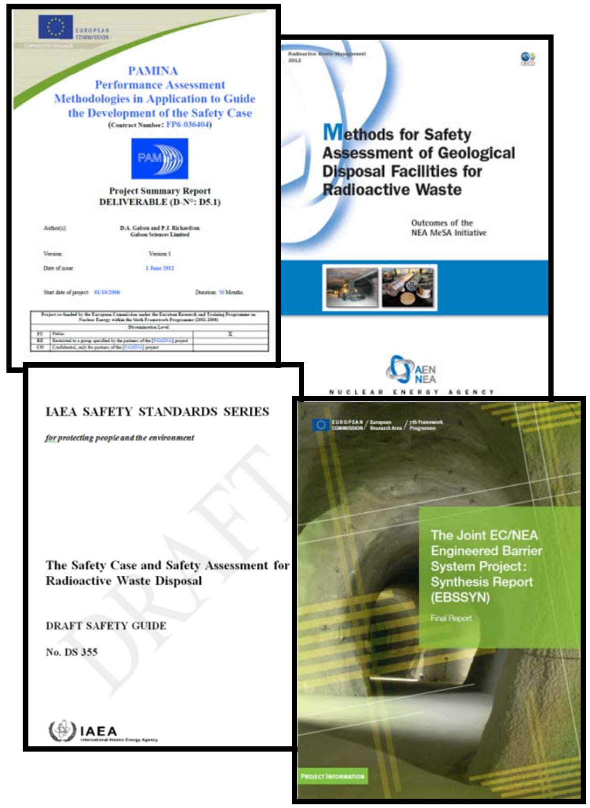
Contents

- **Performance Assessment (PA) Guidance and Recommendations**
- **Considerations related to Scenario Development**
- **Considerations related to Modeling**

International Recommendations and Guidance

Key Concepts

- *Safety Case*
- *Systems Approach*
- *Safety Functions*
- *Prospective modeling evaluations, not exact predictions*
- *Complementary indicators for long times*
- *Managing uncertainties*

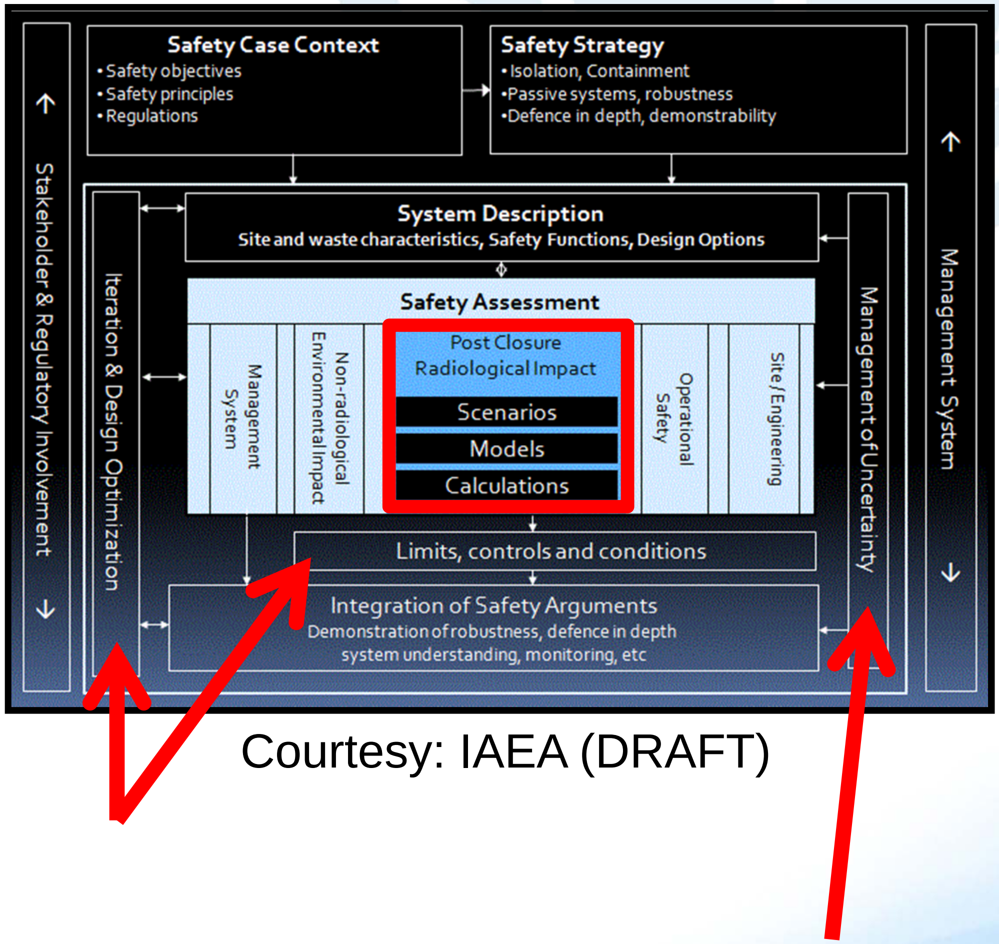


Common Elements

- *Use of probabilistic and deterministic approaches in complementary manner*
- *Combinations of process and system level models*
- *Graded and iterative*
- *Learning and understanding system behavior (sensitivity)*
- *Inform design improvements and waste acceptance criteria*
- *Stylized scenarios*

Safety Case Concept

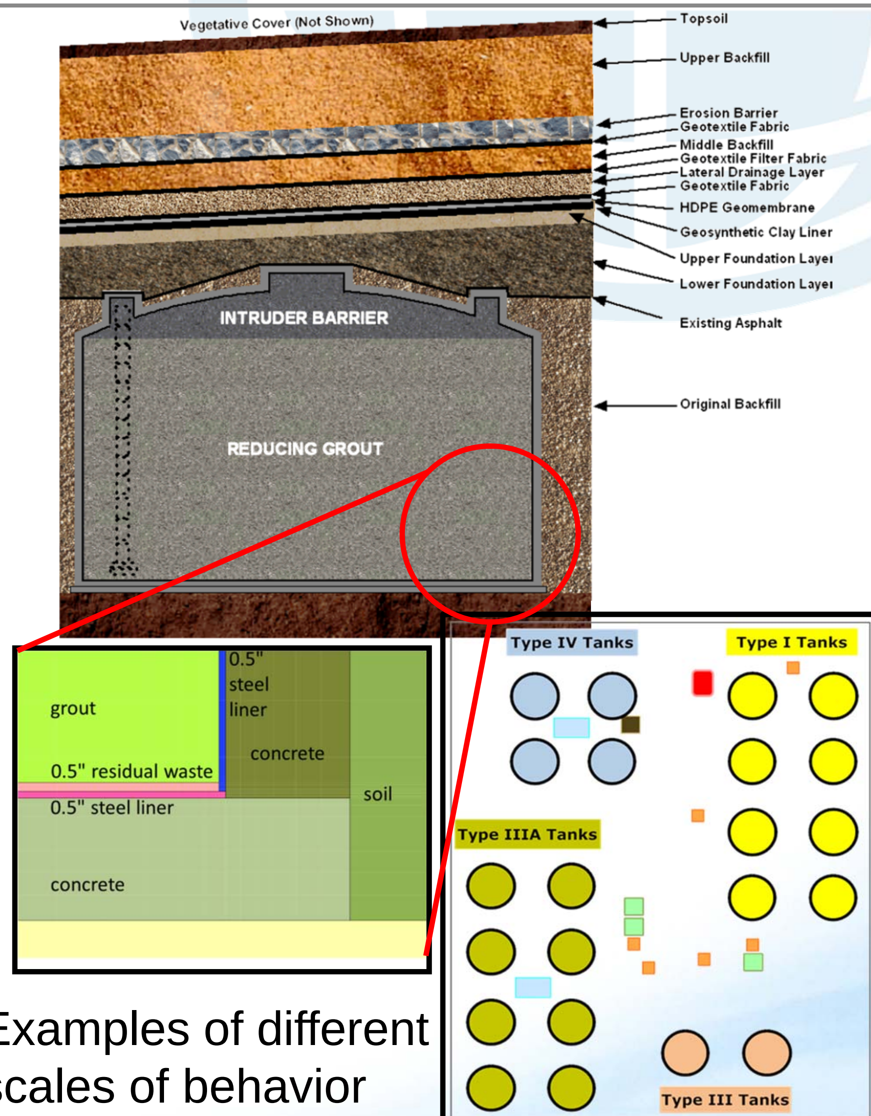
- **Structured view of all components supporting demonstration of safety, PA is only one part of the effort**
- **Provides an effective means to take credit for supporting activities used to build confidence**
- **Highlights links among modeling, design and waste acceptance criteria**
- **Addresses management of uncertainties throughout process (e.g., testing, R&D, monitoring)**



Courtesy: IAEA (DRAFT)

Systems Approach and Safety Functions Concept

- **<u>Systems Approach</u> - Consider behavior of individual features in the context of overall system performance relative to the decision to be made**
- **<u>Safety Functions</u> – Understanding of roles and functions of "barriers" within total system performance perspective**
  - Similarities with NRC barrier analysis concept
- **Often counter-intuitive behavior with multiple "barriers" and/or functions**
- **Top-down, performance-based perspective**



Examples of different scales of behavior

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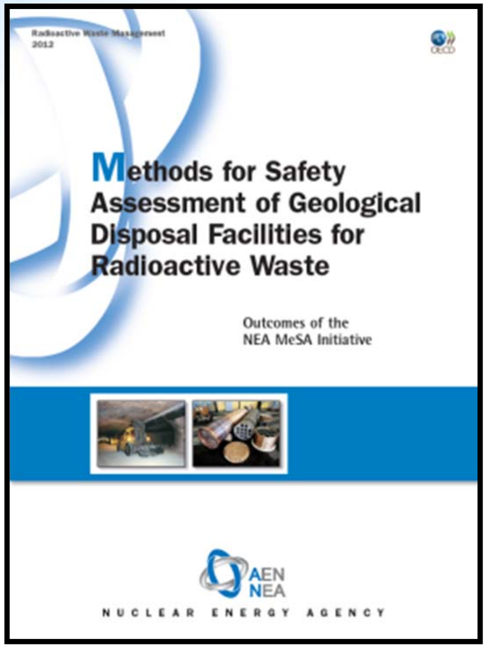
Office of Environmental Management
safety ❖ performance ❖ cleanup ❖ closure

Scenario Development

Historical Perspective

- **80s – FEPs concept introduced**
- **90s – Elaboration on FEPs methodologies, FEPs lists, structured bottom-up approaches**
- **Early 00s – Refinement of structured bottom-up approaches, detail added to FEPs lists, safety functions concept**
- **Late 00s – Safety functions emphasis, top-down supplemented by FEPs input**

Practical Considerations



"*In all programmes, the starting point for the identification of safety-relevant phenomena and uncertainties is the development of a detailed description of the initial state of the system and its subsequent evolution. This description provides the basis for a main scenario, also termed normal evolution, base or reference scenario*."

"*It could be contended that the "top-down" approach described in recent safety assessments is in fact a more accurate representation of the approach that was in reality adopted (though not documented) in earlier safety assessments*." (FEPs based)

"*It could further be contended that "top-down" approaches … are, in fact, better described … as "top-down/bottom-up*"."

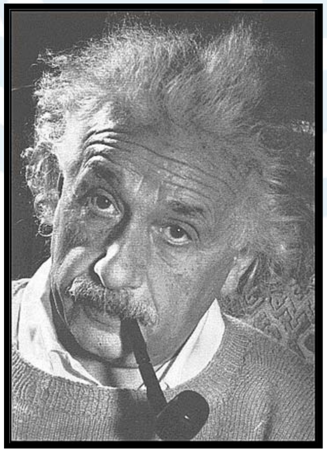
Practical Considerations

- **Need for flexibility in scenario development recognizing the nature of very long term calculations – take advantage of benefits of different approaches (“Top-down/Bottom-up”)**
- **Practical experience reflects a performance-based perspective – learn about behavior, then evaluate comprehensiveness (maintain philosophy of focus on important factors)**
- **Need system perspective, when identifying potentially important safety functions and FEPs – difficult to *a priori* recognize all important interactions**
- **Emphasize the need to integrate efforts rather than having different groups**

Modeling

Graded and Iterative Approach

- **Level of detail based on impact on decision**
- **Multiple levels of detail may be used**
  - **Screening (e.g., spreadsheets)**
  - **System-level (e.g., GoldSim, RESRAD-Offsite, Ecolego, AMBER)**
  - **Process-level (e.g., 2-D, 3-D, Reactive Transport, Geochemistry)**



"*Everything should be made as simple as possible, but not simpler*" – Albert Einstein

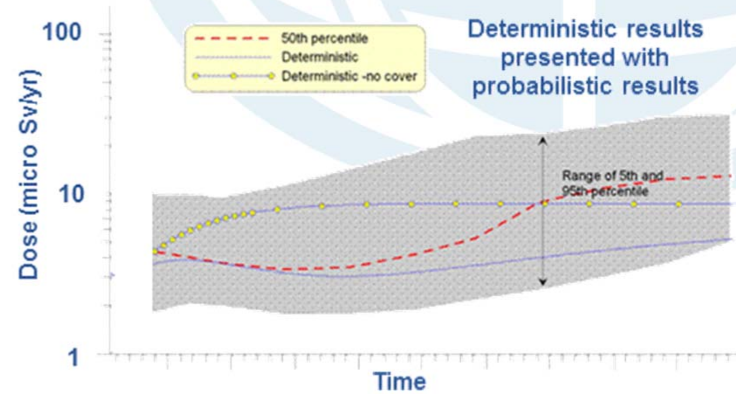
Systems Approach and Sensitivity Analysis

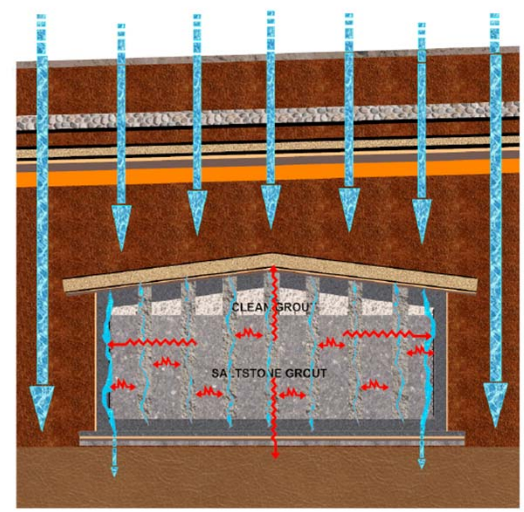
- **Demonstrate understanding and significance of barriers, assumptions and data relative to performance of the system and decision to be made**
- **Use sensitivity analysis and improved understanding to guide iterative approach**

"*The purpose of computing is insight, not numbers*" – Richard Hamming

Abstraction and Level of Modeling Detail

- **General consensus that there are benefits of modeling using complementary combinations of**
  - **Deterministic and probabilistic**
  - **Process- and system-level**
- **Concept of "base", "reference" or "normal evolution" case(s) is common**
- **Need for compromises and simplification to support numerous simulations…** ***importance of conducting numerous simulations***
- **Accommodating and interpreting "What-If", postulated scenarios**





Practical Considerations

- **Learn by Doing – Set up different conceptual models, run a variety of simulations, simplifications are expected**
- **Probabilistic approaches provide broader insights - and require increased effort on development of distributions and typically require simplifications (*and justification*)**
- **Encourage interpretation of results from simplified or abstracted representations (even if not perfect, can gain insights)**
- **Abstraction (simplification) forces you to think about models**
- **Deterministic models provide a means to address details and to evaluate "what-if" cases, also provide technical underpinning for assumptions in simplified models**
- **"What-ifs" are part of the learning process - use caution to avoid postulated "what ifs" being perceived as "expected"**

Summary

- **Requirements to conduct assessments considering very long time frames (hundreds or thousands of years) reflect a relatively unique commitment to considering protection of future generations**
- **PA is a "learning" process with emphasis on identifying and addressing aspects with the most impact on the decision, rather than specifically predicting what will occur (*graded and iterative*)**
- **Informed definition of the system (conceptual model(s)) is an important early step in any long-term assessment effort**
- **Systems approach and safety functions concept have resulted in more popularity of top-down, performance-based scenario development that can be informed by FEPs ("top-down/bottom-up")**
  - How to develop guidance to implement such an approach in a practical manner?
- **Global experience has reinforced the value of using a variety of modeling approaches and numerous simulations to gain insights**

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