Extension of the WIPP Performance Assessment using Modern 3D Modeling Tools

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Waste Isolation Pilot Plant—WIPP

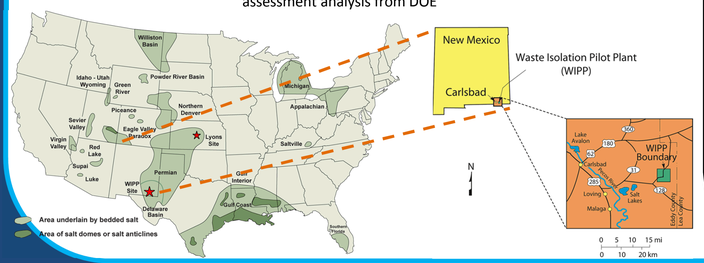
WIPP is the nation's only deep geologic repository for nuclear waste:
- Permanent disposal site for defense-generated transuranic (TRU) waste
- 2,150 feet deep
- 6.2 million cubic feet of disposal capacity

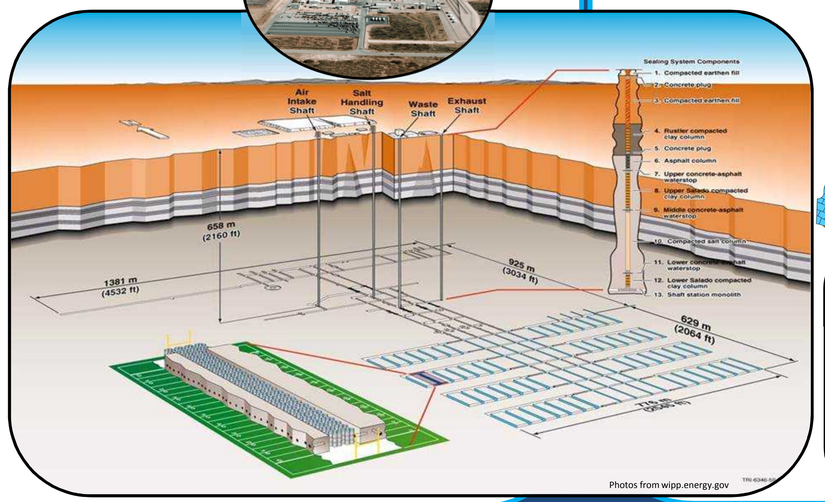
Located in southeast New Mexico:
- Semiarid region, little potable water, no significant aquifers
- Geology and hydrology provide primary isolation

Defense-generated TRU waste:
- Contaminated radioactive and hazardous elements
- Clothing, tools, rags, debris, residues, disposable items
- Less than one percent liquid by volume

Operated by U. S. Department of Energy (DOE)

Long-term performance regulated by U. S. Environmental Protection Agency (EPA)
- Requires periodic recertification, which is supported by performance assessment analysis from DOE





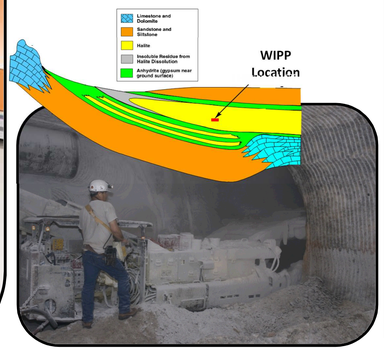
Keys to the WIPP Safety Case

Bedded Salt Host Rock

1. Natural barrier that isolates waste
2. Extremely low permeability
3. High thermal conductivity
4. Creeping behavior
5. Easily mined
6. Geologically stable for more than 200 million yr.
7. Plastic-like quality
8. Self-healing (ability to encapsulate waste)

WIPP Safety Case

1. Conservative with respect to cumulative releases
2. Includes undisturbed and disturbed (i.e., inadvertent intrusion) scenarios
3. Assumes current drilling rate persists for 10,000 yr.
4. Relevant features, events, and processes (FEPs) identified
5. Development of scenarios was iterative and rigorous
6. PA parameter values based on exp. data, expert judgement, or expert elicitation
7. Thorough quality assurance (QA) program
8. Conceptual models peer reviewed by independent panel as part of certification



Regulatory Requirements

1. **Containment requirements** (40 CFR Part 191, Subpart B, Section 191.13):
   - Cumulative radionuclide release limits to the accessible environment over 10,000 yr.
   - Performance assessments to show "reasonable expectation" of compliance
   - Include substantial uncertainties in projecting disposal system performance
   - Releases limits based on estimated dose caused by hypothetical in-situ U ore body
2. **Assurance requirements** (40 CFR Part 191, Subpart B, Section 191.14):
   - Active and passive institutional controls
   - Post-disposal monitoring
   - Natural and engineered barriers
   - Consideration of the presence of resources
   - Some accommodation for waste removal
3. **Individual protection requirements** (40 CFR Part 191, Subpart B, Section 191.15):
   - Undisturbed performance shall not cause annual effective dose >15 mrem
4. Groundwater Protection Requirements (40 CFR Part 191, Subpart C):
   - Limit releases to ground water to no more than Safe Drinking Water Act standards (40 CFR Part 141)

WIPP Performance Assessment Calculations

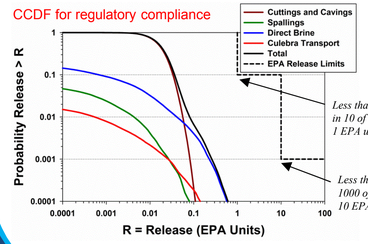
WIPP PA is a probabilistic framework to estimate the future performance of the repository system that:
- calculates releases to the accessible environment over 10,000 years.
- uses a collection of site-specific FEPs, scenarios, conceptual models, and process models.
- explicitly includes both epistemic and aleatory uncertainty.
- considers undisturbed and disturbed scenarios

CCDF for mean total releases is the measure of WIPP compliance with EPA release limits.

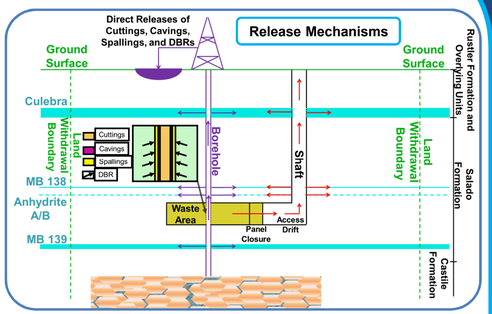
PA calculations have demonstrated compliance for each certification (1996) and recertification (2004, 2009, 2014) submittal

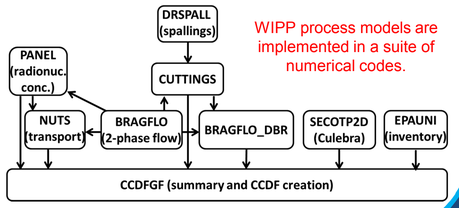
PA continues to be refined and enhanced to ensure longevity into the future.

CCDF for regulatory compliance



Each release component is quantified.





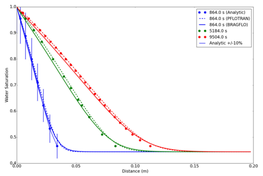
WIPP process models are implemented in a suite of numerical codes.

PA Modernization Effort

PFLOTRAN has capabilities that are new to WIPP PA, including:
- 3-D spatial gridding
- parallel processing
- 2-phase miscible flow
- heat transfer

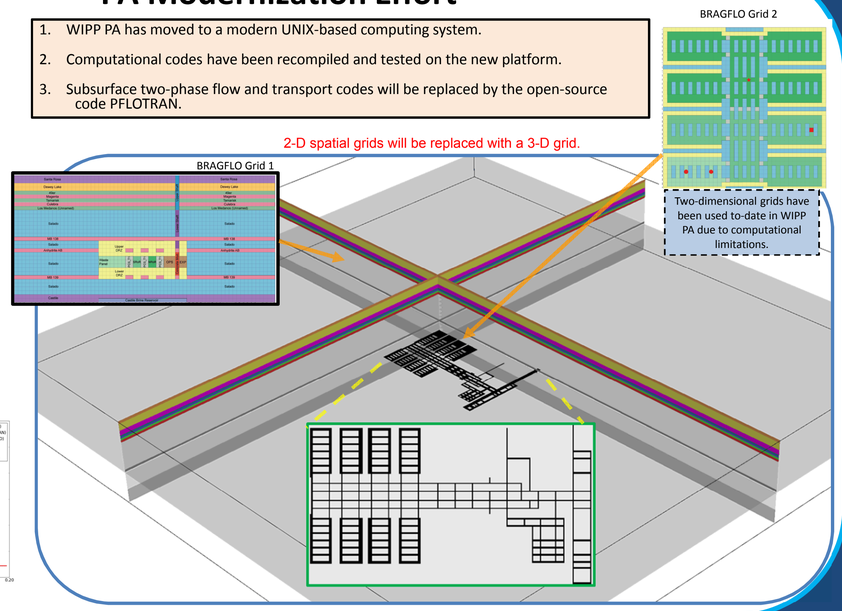
In order to add PFLOTRAN to the list of approved codes for WIPP PA calculations, it must go through the QA process of qualification.

A final critical step to the qualification of PFLOTRAN will be submission of the code to a peer review process, in which the conceptual models implemented in PFLOTRAN will be reviewed by a panel of experts.



Sample test case results.

1. WIPP PA has moved to a modern UNIX-based computing system.
2. Computational codes have been recompiled and tested on the new platform.
3. Subsurface two-phase flow and transport codes will be replaced by the open-source code PFLOTRAN.



Summary

The WIPP PA program is an integral part of the WIPP safety case.
- Predicts long-term repository performance
- Addresses regulatory containment requirements
- Implements conservative assumptions regarding potential radionuclide releases
- Has shown compliance for each recertification of the WIPP

The WIPP PA program is currently driving a modernization effort in three principal areas:

1. **Hardware and OS update**
2. **Code Migration from VMS to Solaris**
3. **Implementation of PFLOTRAN for Subsurface Flow and Transport Calculations**

The result of the modernization effort will be a state-of-the-art subsurface flow and transport capability that will serve WIPP PA into the future.

Acknowledgements

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