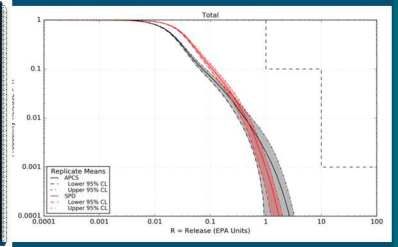
SAND2019-3538PE

Sandia's Role in "Dilute and Dispose": Presentation to Dr. Brent Park Deputy Administrator, Defense Nuclear Nonproliferation, NNSA



PRESENTED BY

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BOTTOM-LINE MESSAGES

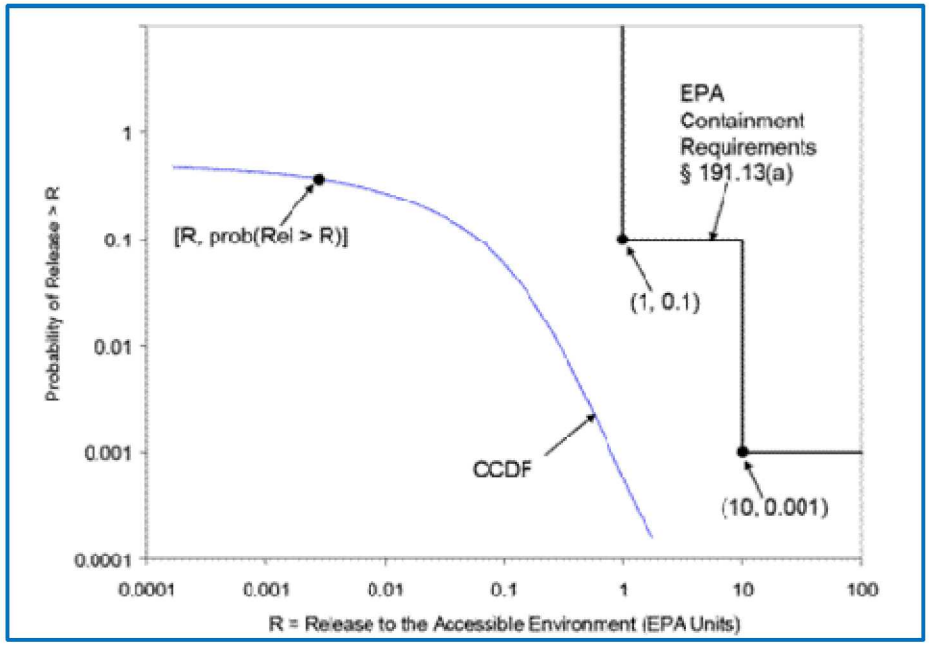
- Initially Sandia became involved in "Dilute and Dispose" as part of NNSA's response to proponents of MOX (Mixed Oxide reactor fuel)
- Sandia's involvement in "Dilute and Dispose" has persisted since January, 2016
- Dilute and dispose has been declared the "preferred alternative" for an inventory of non-pit plutonium (~ 6 MT) – "belongs" to DOE/EM
- Sandia assessed the impact on WIPP's long-term performance from bringing to WIPP the 6 MT inventory
- Dilute and dispose is under study as an alternative for a larger inventory of weapons-grade (i.e., pit) plutonium (up to 42.2 MT) – "belongs" to NNSA
- Sandia has now assessed the impact on WIPP's long-term performance of potentially bringing to WIPP an additional 42.2 MT to WIPP for disposal
- Sandia is currently partnered with Oak Ridge National Laboratory to advise NNSA on the potential for packaging surplus plutonium without neutron poison

BRIEFING CONTENT

- WIPP
- Post-closure criticality
- Surplus plutonium
- Dilute and dispose
- Sandia's involvement
- Activity still underway

WIPP

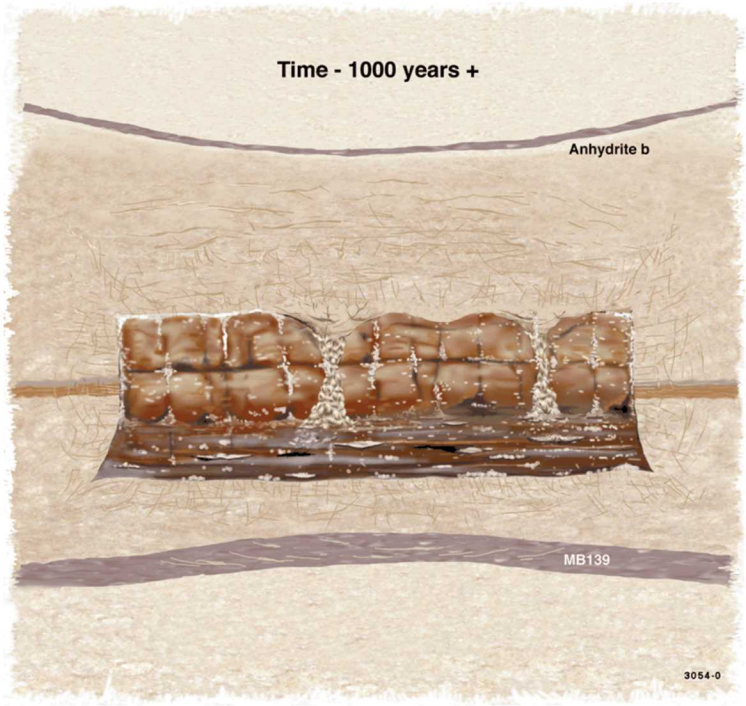
- Per 40 CFR 191.13(a): "WIPP must be designed to provide reasonable expectation that cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events will be less than these release limits:
  - Less than 1 chance in 10 of exceeding 1 EPA unit
  - Less than 1 chance in 1000 of exceeding 10 EPA units"



- EPA Unit: A normalized measure of releases based on the concept that residual risks allowed by the release standard would be comparable to the risks that future populations would encounter if the uranium ore used to produce the wastes emplaced at WIPP had not been mined to begin with
- Sandia estimates cumulative releases using a suite of computer codes and calculations known as performance assessment, simulations that are informed by scientific studies in geochemistry, rock mechanics, and geohydrology

POST-CLOSURE CRITICALITY

- At present, WIPP contains about 5.7 MT of plutonium
- Most TRU waste containers may not contain more than 200 ^{239}Pu Fissile Gram Equivalents per container
- A relatively new container – the Criticality Control Overpack (CCO) – can be loaded to a limit of 380 ^{239}Pu Fissile Gram Equivalents (FGE) per container
- Down-blended surplus Pu will come to WIPP in CCO containers
- WIPP is located in bedded salt; salt creeps, encasing the radioactive waste placed therein
- The forces applied by this creep closure can compress the waste containers and bring their contents close together



- Containers loaded to lower FGE limits are at little-to-no risk of allowing a post-closure criticality event to occur
- Post-closure criticality questions have been posed about the CCOs, however, given their higher concentration of plutonium
- We chose ORNL to perform the post-closure criticality assessment for our impact assessment

SURPLUS PLUTONIUM

- Several inventories of plutonium have been declared excess to US needs:
  - Pu scrap and residues, 3.2 MT (mostly from Rocky Flats, already disposed of at WIPP)
  - Surplus, non-pit Pu, 5.1 MT (added in 2016 to the WIPP-bound inventory)
  - Surplus, non-pit Pu, 0.9 MT (allowance for future non-pit Pu disposal, also in the WIPP-bound inventory)
  - Weapons-grade Pu, 34.0 MT (proposed to be diluted and disposed of at WIPP)
  - Other pit Pu, 7.1 MT (residual of pit Pu declared in 2007 to be excess to US defense needs, may also be diluted and disposed of at WIPP)
  - Surplus, non-pit Pu, 1.1 MT (to be dispositioned at SRS or disposed of at WIPP)
- "Surplus" Pu slated to come to WIPP in the future = 6 MT (per ROD signed in 2016)
- "Surplus" Pu that may come to WIPP if dilute and dispose is identified as the preferred alternative in an expected future ROD (in the 2021-2022 timeframe) ≈ 42 MT
- The intent is for processing of the 6 MT coming to WIPP to provide prove-in for the processing future excess plutonium inventories; the process lines will be at SRS
- Pu Oxide that is downblended with adulterant is the waste form that is prepared for shipment to WIPP

DILUTE AND DISPOSE

- Pioneered by Rocky Flats (RF) when it undertook site shutdown and clean-up, finished in 2006
- RF plutonium scrap and residue was mixed with a diluent material composed of commercial grade clay granules, silica sand, ferric oxide, and fumed silica; 3.5 MT of plutonium came to WIPP in this down-blended form and was emplaced in waste panels 1 and 2
- Current approach is aimed at processing and shipping to WIPP approximately 6 MT of non-pit plutonium that runs the gamut in terms of purity, concentration, etc., but none of which is considered to be weapons-grade
- The intent for packaging both the non-pit and the pit plutonium, is to achieve a waste form that allows for suspension of safeguards upon loading into WIPP shipping containers

SANDIA'S INVOLVEMENT (1)

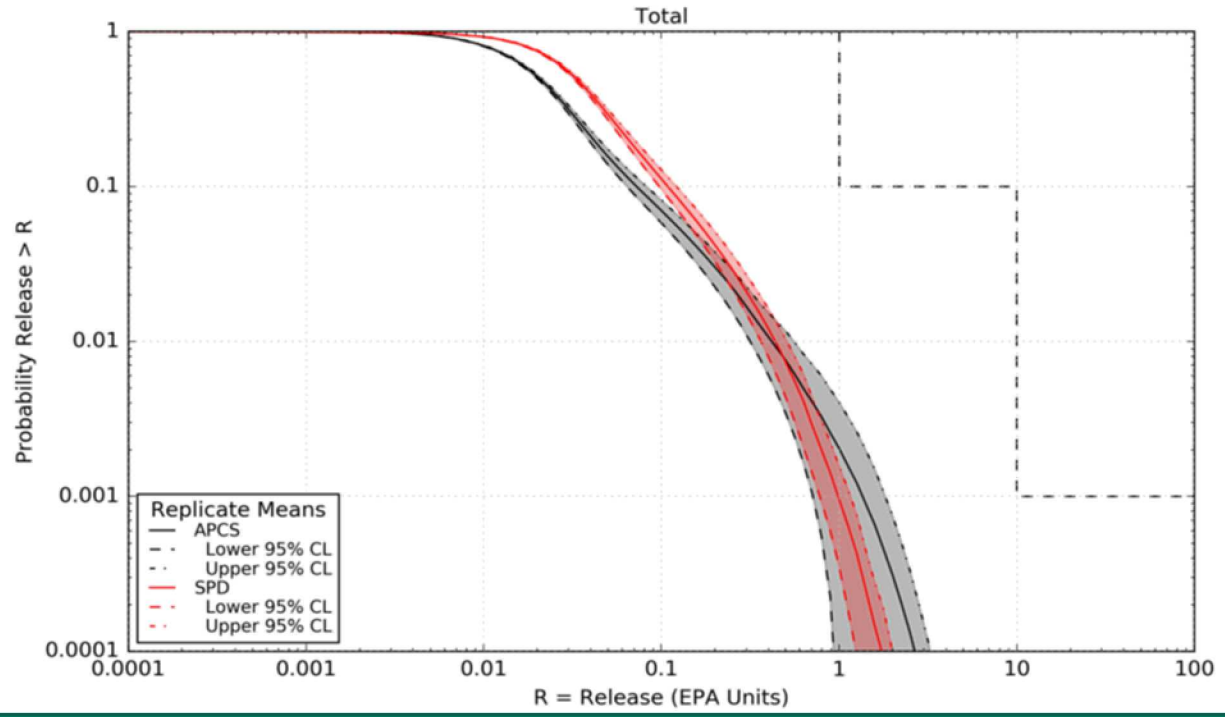
- Responded to request from Senator Heinrich's staff to analyze a Highbridge publication (January 2016)
- Sachiko McAlhany (Senior Technical Advisor, NA-23) contacted DOE/CBFO to see what resources could be applied to the question of post-emplacement criticality and other potential impacts on WIPP related to the dilute and dispose option (January 2016)
- Shared with McAlhany the memo we wrote to respond to the Heinrich staffer's request
- McAlhany indicated that she wanted to rely on Sandia for in-depth technical work on the viability of dilute and dispose within the WIPP context, and asked Sandia to undertake that work for NA-23
- Sandia completed a quick turnaround study on the impact of bringing the 6 MT of non-pit plutonium, in down-blended form, to WIPP for disposal (February 2016)
- Sandia prepared a technical memo to the Manager of DOE/CBFO noting that no negative effects would result from disposing of that inventory of plutonium at WIPP in the anticipated form
- NA-23 engaged Sandia to build on comments made about the High Bridge executive summary document by reviewing and commenting on the full High Bridge report (March 2016)
- Sandia studied the full High Bridge report and reported to NA-23 that we did not find post-closure criticality to be a likely event

SANDIA'S INVOLVEMENT (2)

- Sandia was also asked to prepare a technical document describing what materials would be detrimental to WIPP's long-term performance if they were used in large quantities as down-blending materials in the dilute and dispose approach
- A Sandia technical document examined potential down-blending materials and assessed their impact on WIPP's long-term performance (positive or negative), was given to NA-23 on (August 2016)
- NA-23 chartered a formal assessment of impact on WIPP's long-term performance that might arise should weapons-grade plutonium be down-blended and brought to the repository for disposal (August 2016)
  - Worked with LANL's Carlsbad Operations to develop an inventory of materials that may appear in the waste stream the down-blended, weapons-grade plutonium would represent; they developed the TRU waste inventory information needed for Sandia's performance assessment calculations
  - ORNL began their assessment of post-closure criticality for the down-blended, weapons-grade plutonium waste inventory
  - Sandia initiated geomechanical modeling activities aimed at simulating the interactions between Criticality Control Overpack containers and the surfaces of a disposal room at WIPP as those surfaces deform and creep closed around the waste
  - Sandia also undertook a so-called "external criticality assessment" to gauge the likelihood that Pu would accumulate outside the repository in quantities sufficient to cause a criticality incident
  - Sandia also screened WIPP's Features, Events, and Processes, [natural and human-caused events or occurrences that could affect the long-term performance of the repository] incorporating the conclusions reached by ORNL's and our own criticality assessment studies

SANDIA'S INVOLVEMENT (3)

- Sandia's performance assessment analysis report was delivered to NA-23 in November 2018, as was ORNL's post-closure criticality assessment report
- ORNL concluded that by including 50 grams of neutron poison in the down-blending material a post-closure criticality event could be discounted
- Sandia concluded that if up to 42.2 MT of plutonium, in down-blended form, were added to the inventory emplaced in the WIPP repository, total normalized releases are estimated to fall below the regulatory cumulative release limits that apply to WIPP



Overall Mean CCDFs for Total Normalized Releases with Confidence Interval

ACTIVITY STILL UNDERWAY

- Sandia and ORNL are partnering to investigate how many CCC's without neutron poison would need to come together to achieve criticality and whether the number is likely to be exceeded as a disposal room at WIPP undergoes closure due to salt creep and roof falls
- ORNL analyzed a scenario in which a disposal room collapses from the top and sides resulting in crushed drums and reconfiguration of the pipes inside the drums
- One, two, three, and four columns of CCCs located in the middle of a disposal room were subjected to closure from walls and floor, as well as large blocks of salt dropping from above and were assumed to collapse and form compact clusters surrounded by salt
- ORNL concluded that the collapse of two waste columns (i.e., 11 7-CCC units) forming compact CCC clusters surrounded by salt exceeds the critical limit of 1.
- Sandia is now testing its geomechanical modeling capability to determine if we can model the dynamics in a post-closure disposal room at WIPP to definitively the question about whether the criticality clustering number is likely to be exceeded
- We hope to be able to tell NA-23 by March 1 whether we believe we can model the room and its waste containers discretely enough proceed