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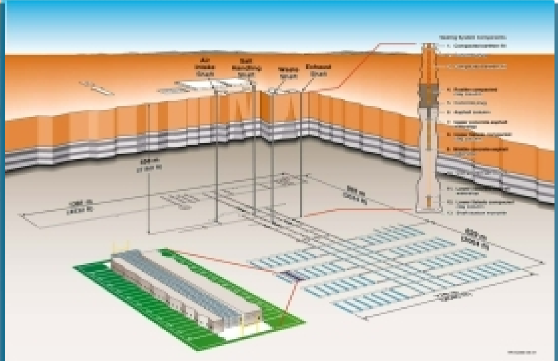
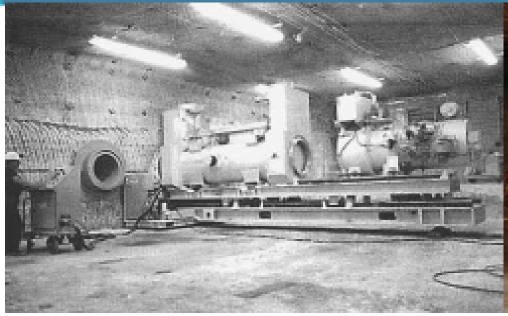
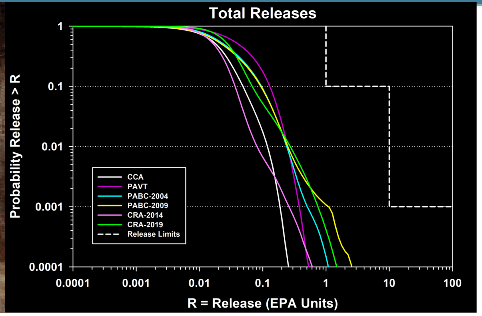
Sandia National Laboratories

Impact of inventory changes on the Waste Isolation Pilot Plant Performance Assessment







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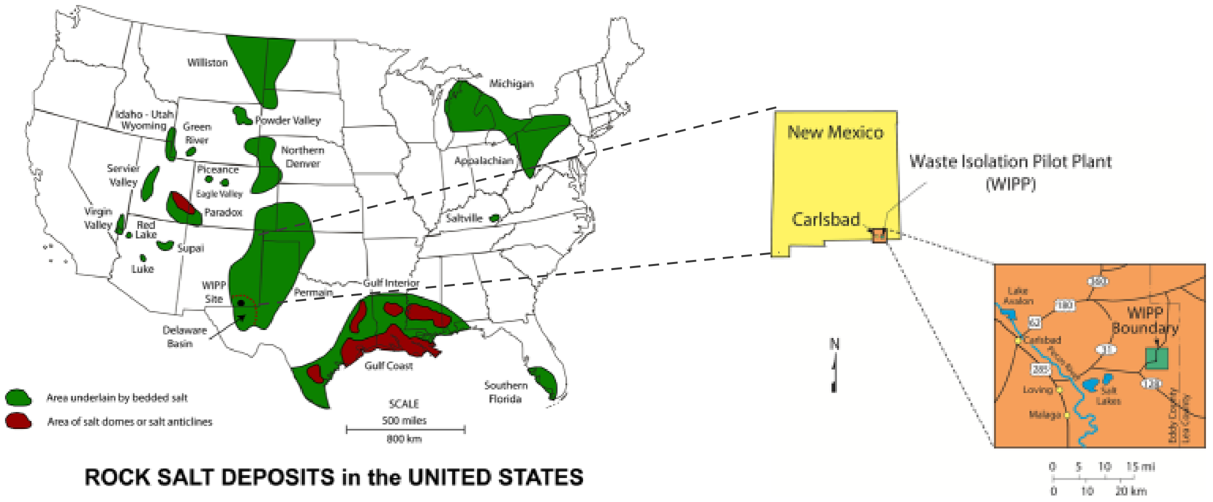
The Waste Isolation Pilot Plant (WIPP)

WIPP is a permanent disposal facility for transuranic (TRU) waste

- Located in southeast New Mexico
- Created by the Land Withdrawal Act (Congress, 1996)
- Owned by U.S. Department of Energy (DOE)
- Certified by U.S. Environmental Protection Agency (EPA)
- Defense-related TRU waste is emplaced in a salt formation deep underground
- Post-closure regulatory compliance is demonstrated via Performance Assessment (PA)



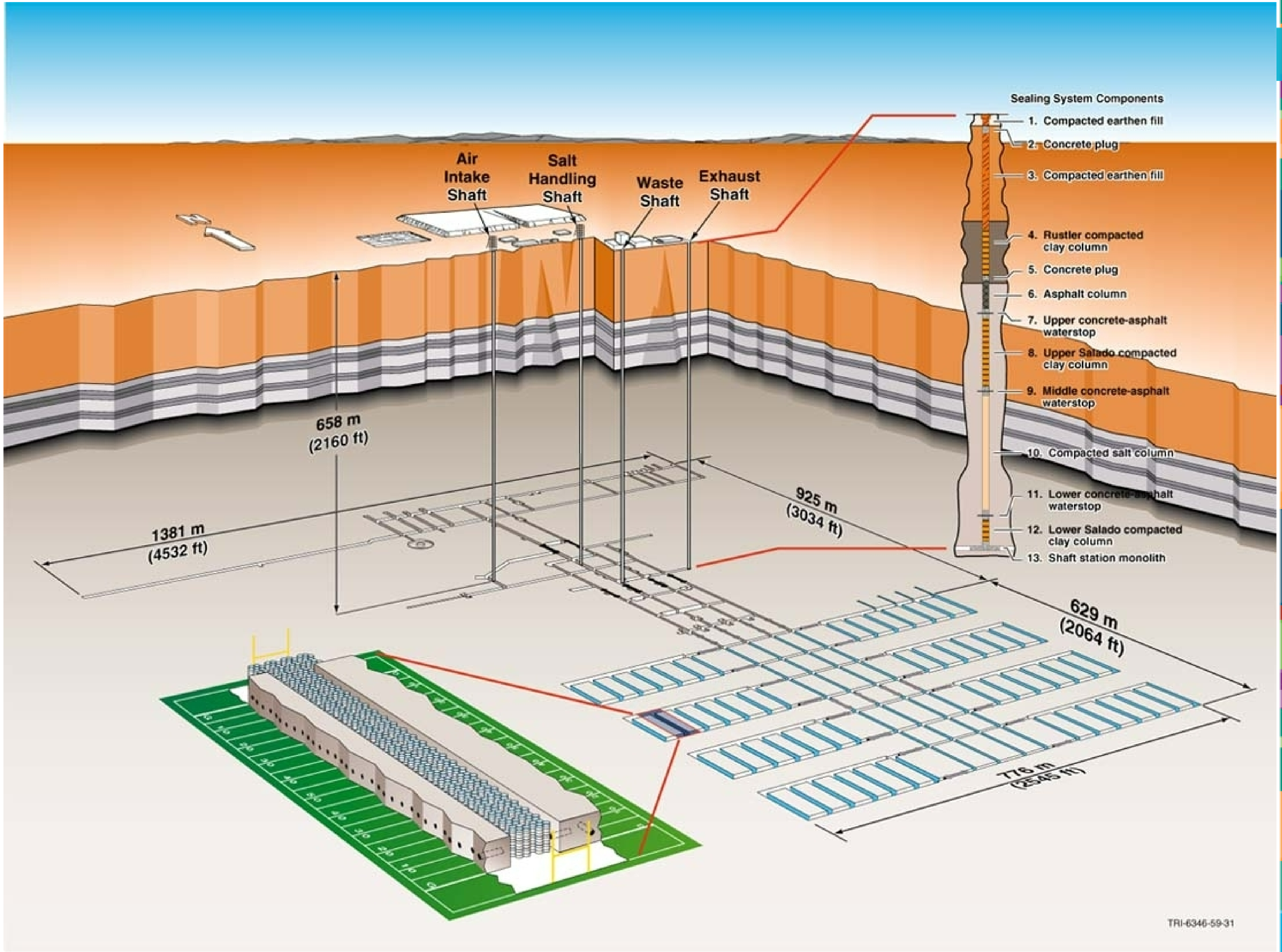
WIPP Layout

The WIPP is located in the Salado formation.

The Salado contains thick salt beds. An important aspect of the Salado salt is the self healing (creep closure) expected over time.

At the WIPP site the Salado is approximately 600 m thick.

The WIPP is at a depth of 658 m, roughly 400 m below the top of the Salado formation.



Normalized Release

- WIPP releases are measured relative to the initial waste inventory.
- The WIPP is a repository for TRU waste, for which its "unit of waste" is defined as the amount of waste containing 10^6 curies of alpha-emitting TRU radionuclides with half-lives greater than 20 years.
- The unit of waste is also called the waste unit factor (WUF) and is defined as follows:

$$f_w = \frac{\sum_i W_i}{10^6 \text{ Ci}}$$

Where f_w is the WUF, and
W_i is the activity in Ci for alpha-emitting TRU radionuclides having half-lives greater than 20 years.

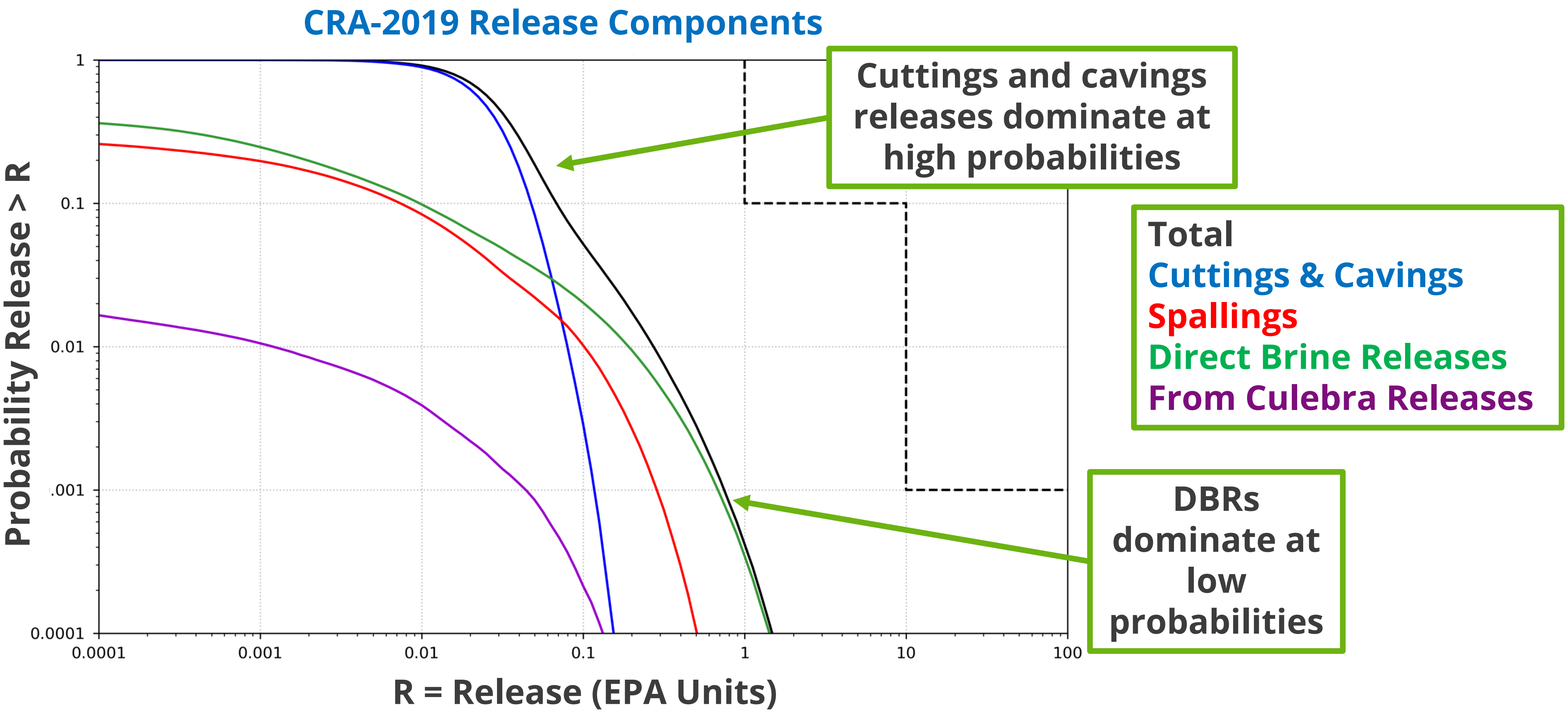
- The normalized release R for TRU waste, in EPA Units, is defined by:

$$R = \left(\frac{1}{f_w}\right) \sum_i \left(\frac{Q_i}{L_i}\right)$$

where Q_i is the cumulative release of radionuclide i to the accessible environment during the 10,000-year period following closure of the repository (Ci), L_i is the release limit for radionuclide i (Ci/unit of waste).

CCDFs for each Release Mechanism

Each Release Component is Quantified by a Complementary Cumulative Distribution Function (CCDF)



Inventory Changes

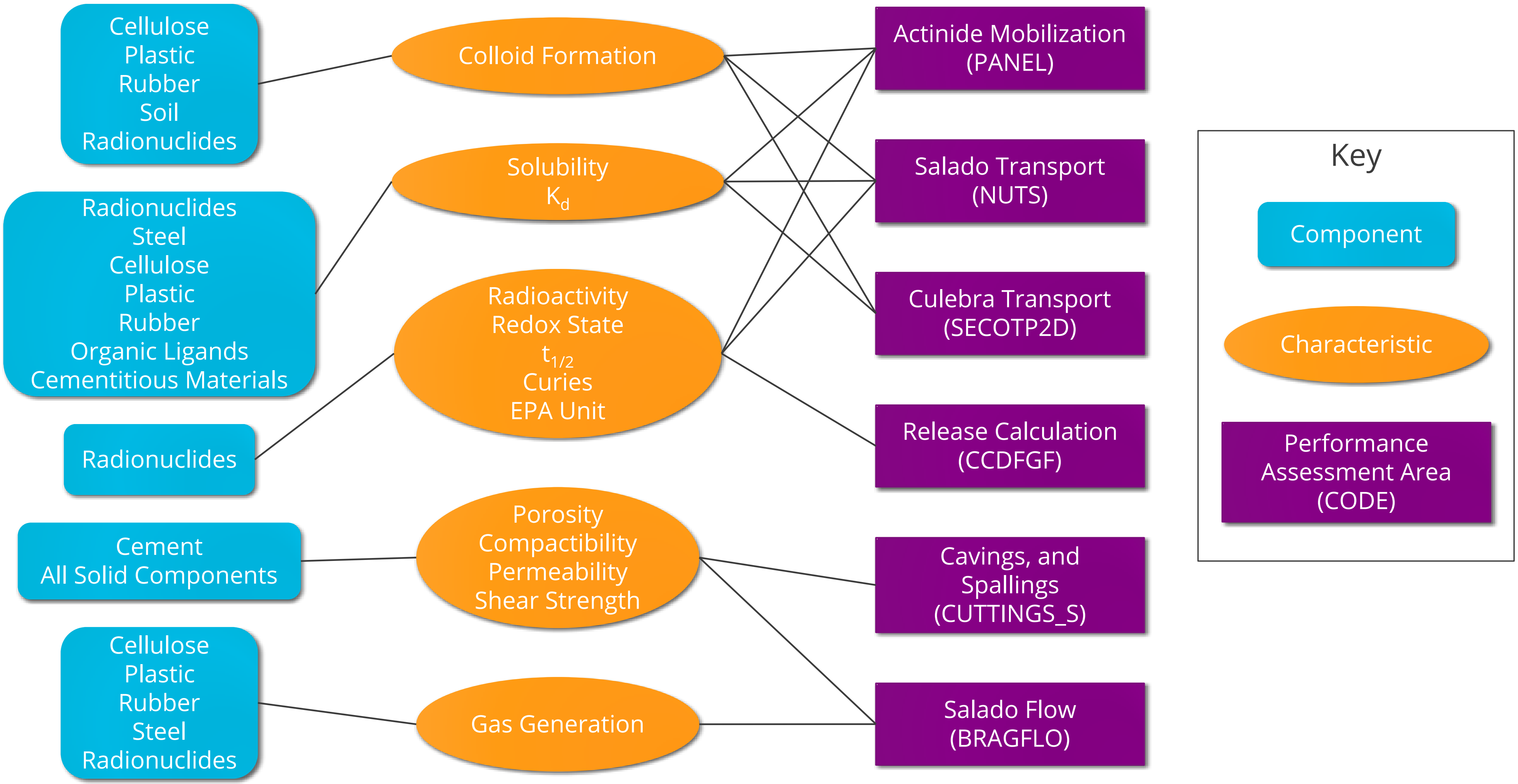
Volume of Record

- WIPP has a legislated capacity of 175,564 m^3 of waste.
- All WIPP PA calculations use an inventory scaled to the legislated capacity.
- Previous PA calculations used the outer container volume for the capacity limit.
- Future PAs will use the inner container volume.
- This is most impactful for pipe overpacks and Criticality Control Overpacks (CCOs).

Surplus Plutonium

- Dilute and dispose process allows for safe disposition of excess nuclear materials at the WIPP.
- The surplus Plutonium waste stream has a higher level of activity than most WIPP waste streams.
- Surplus Plutonium waste is packaged in CCOs, meaning the inclusion of surplus Plutonium has a compounding impacted by the volume of record change.

Waste Component, associated characteristics, and PA use



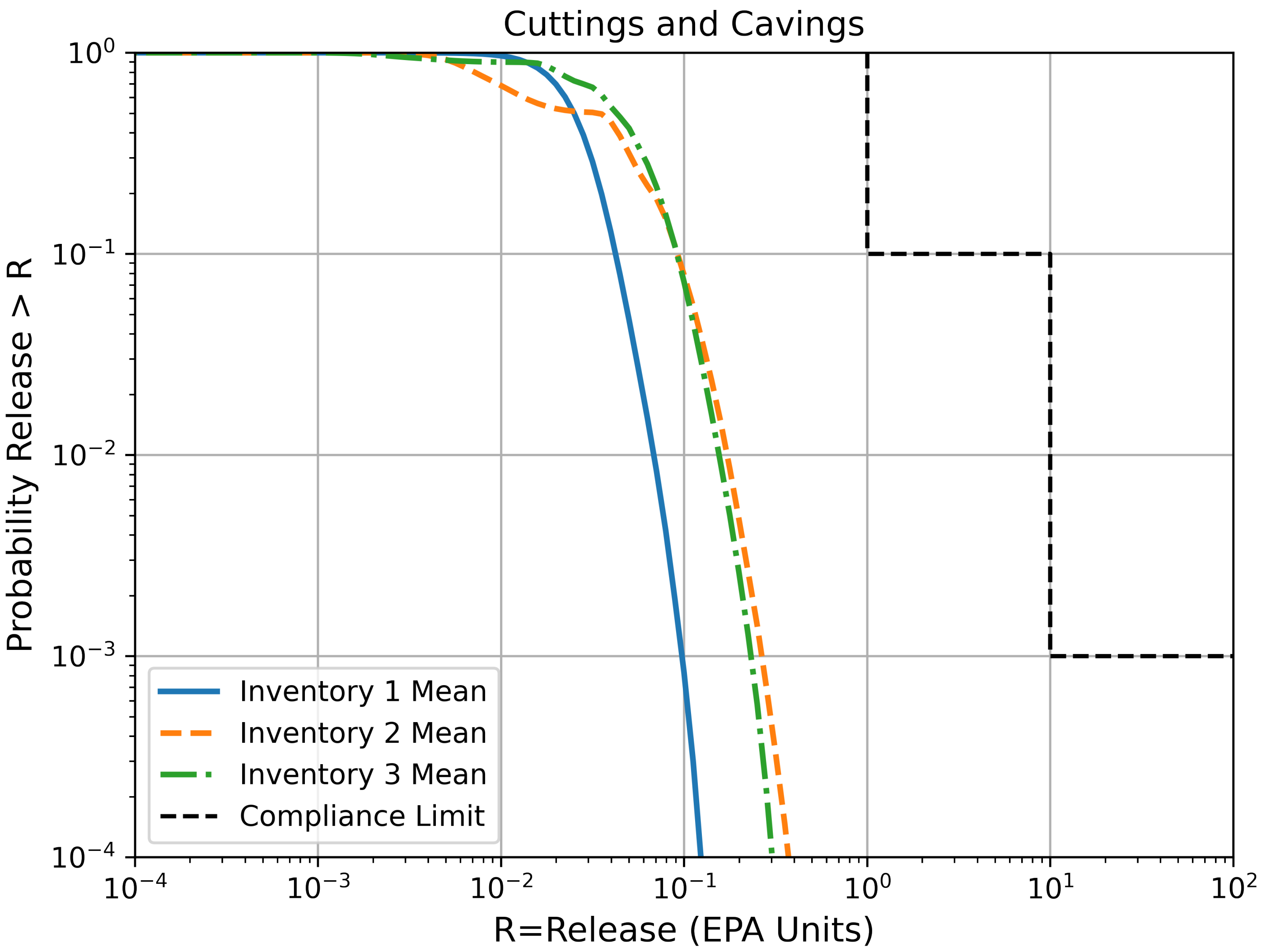
Inventory Impact Study

Three inventories were used to study these impacts:

- Inventory 1 uses the outer container volume and a minimal projected amount of Surplus Pu (6 MT).
- Inventory 2 uses the inner container volume and a larger amount of projected Surplus Pu (13.1 MT).
- Inventory 3 uses the inner container volume and the full amount of projected Surplus Pu (42.2 MT).

Inventory	Activity (*Ci*)	Waste Unit Factor (-)	Iron Mass (*kg*)	CPR Mass (*kg*)	+III Actinide Solubility (*moles/liter*)	+IV Actinide Solubility (*moles/liter*)	+V Actinide Solubility (*moles/liter*)
Inventory 1	6.14×10^{6}	3.30	6.31×10^{7}	1.78×10^{7}	1.90×10^{-7}	5.44×10^{-8}	1.20×10^{-6}
Inventory 2	8.14×10^{6}	7.28	8.32×10^{7}	2.42×10^{7}	1.94×10^{-7}	5.44×10^{-8}	1.18×10^{-6}
Inventory 3	1.98×10^{7}	16.18	1.11×10^{8}	3.56×10^{7}	1.70×10^{-7}	5.44×10^{-8}	9.81×10^{-7}

Results – Cuttings and Cavings Releases

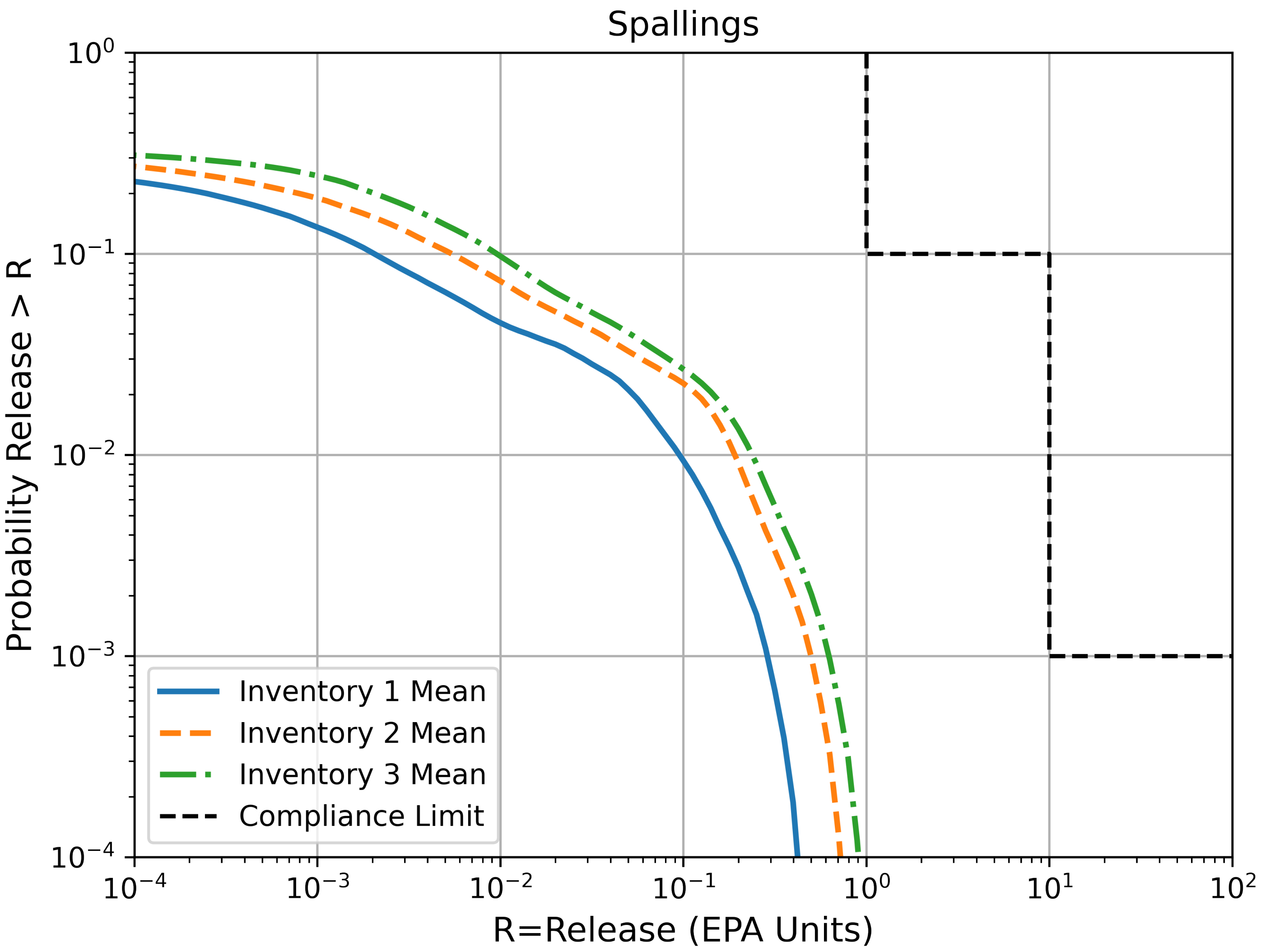


In Inventory 2, the cuttings and cavings CCDF develops a shelf around a 50% probability. 50% probability is roughly the probability that any future has at least one intersection with the Surplus Pu waste stream.

Inventory 3 displays the same shelf at approximately 90% probability due to the increased volume of the Surplus Pu waste stream.

Both inventory 2 and 3 have larger releases in futures that intersect the Surplus Pu waste stream.

Results – Spallings Releases

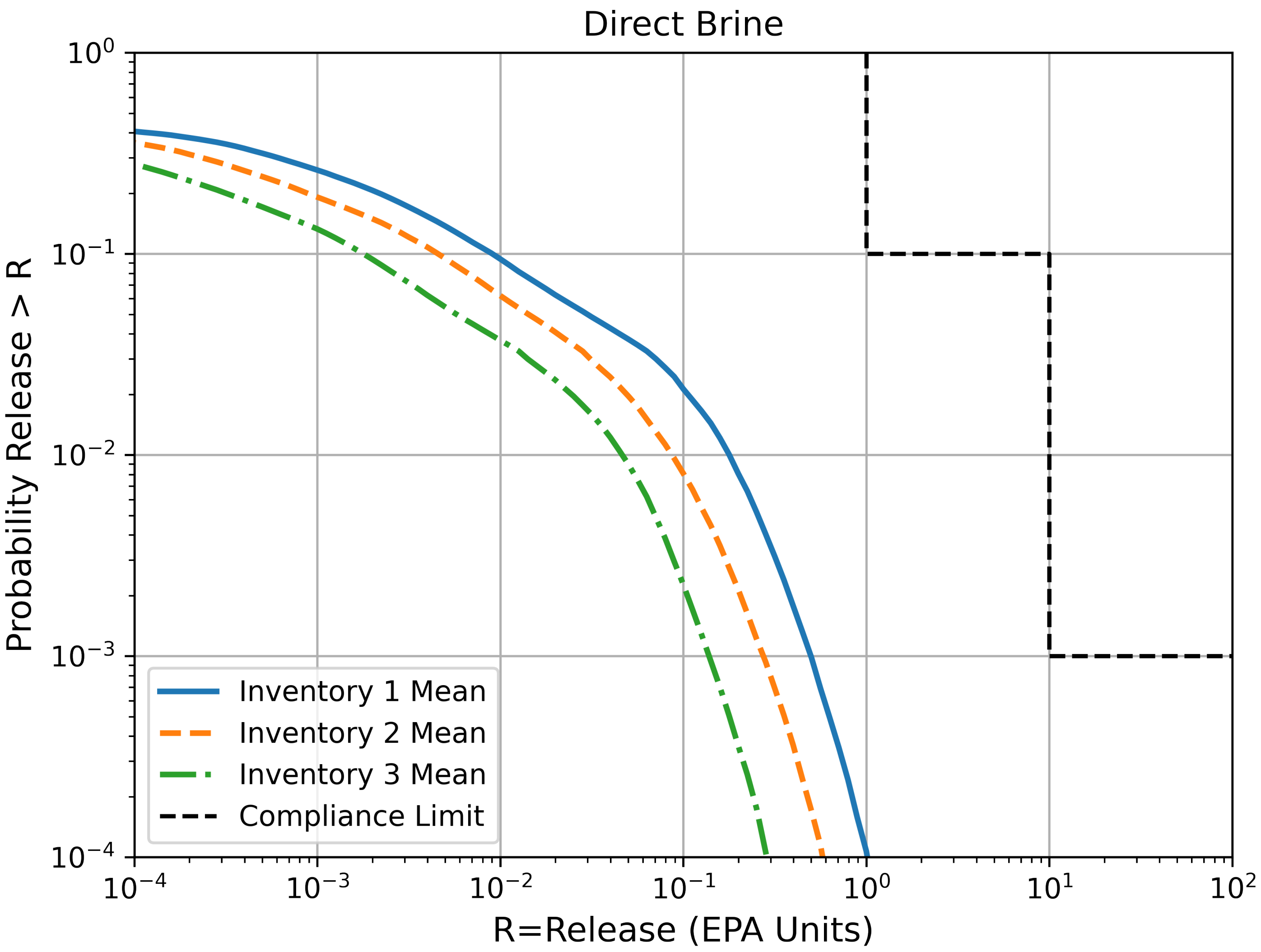


The increase in iron, CPR, and inventory activity increases gas generation, which increases repository pressure leading to larger spallings volumes.

The increase in surplus Pu also increases long lived radionuclides giving the inventory higher activity through time relative to the initial activity. This leads to larger spallings activity.

These two factors lead to larger spallings releases with the increases inventories.

Results – Direct Brine Releases

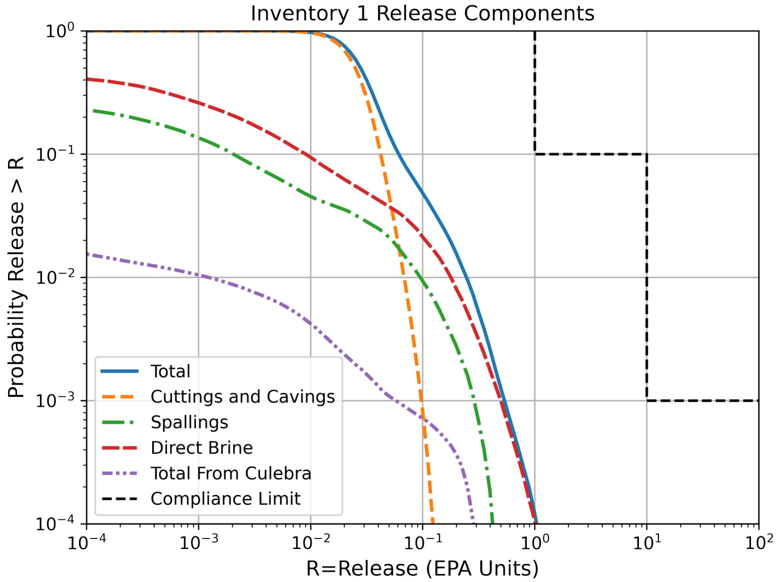


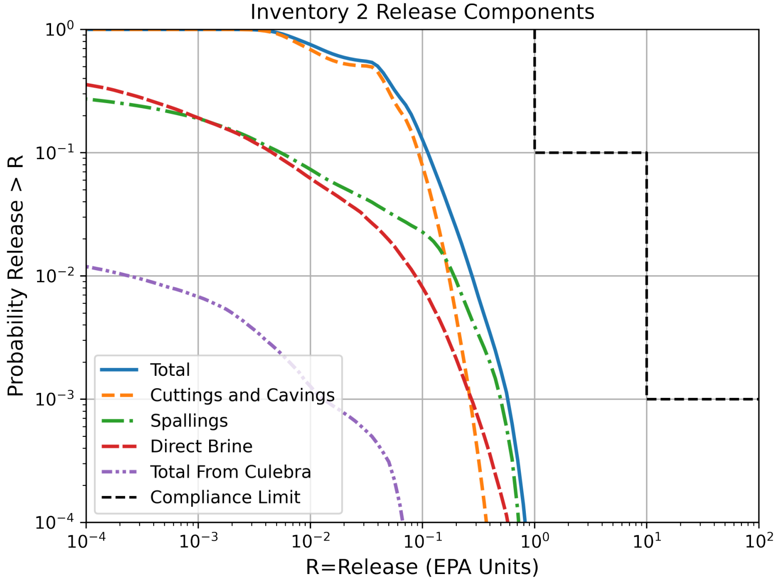
Actinide concentrations in brine tend to be solubility limited, thus when measured relative to the initial waste inventory actinide concentrations decrease with the inventory increases.

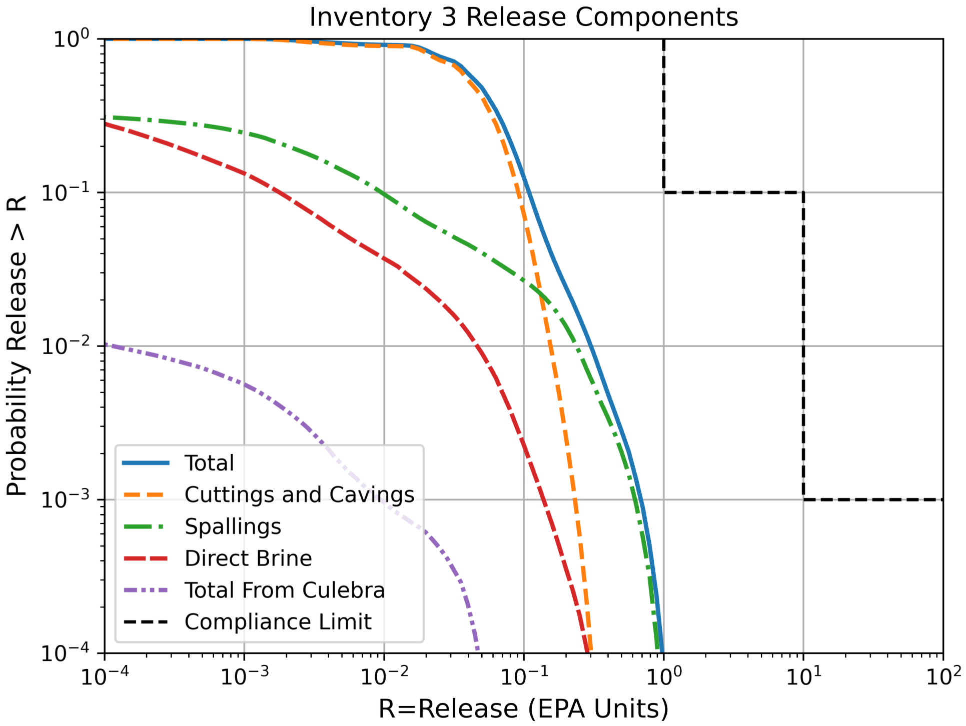
Iron corrosion and brine radiolysis both produce gas and consume brine. These reactions are increased with increasing activity. This leads to an increase in drive for brine releases but a decrease in brine availability for releases.

Overall direct brine releases are decreased with the inventory increases.

Release components driving total releases



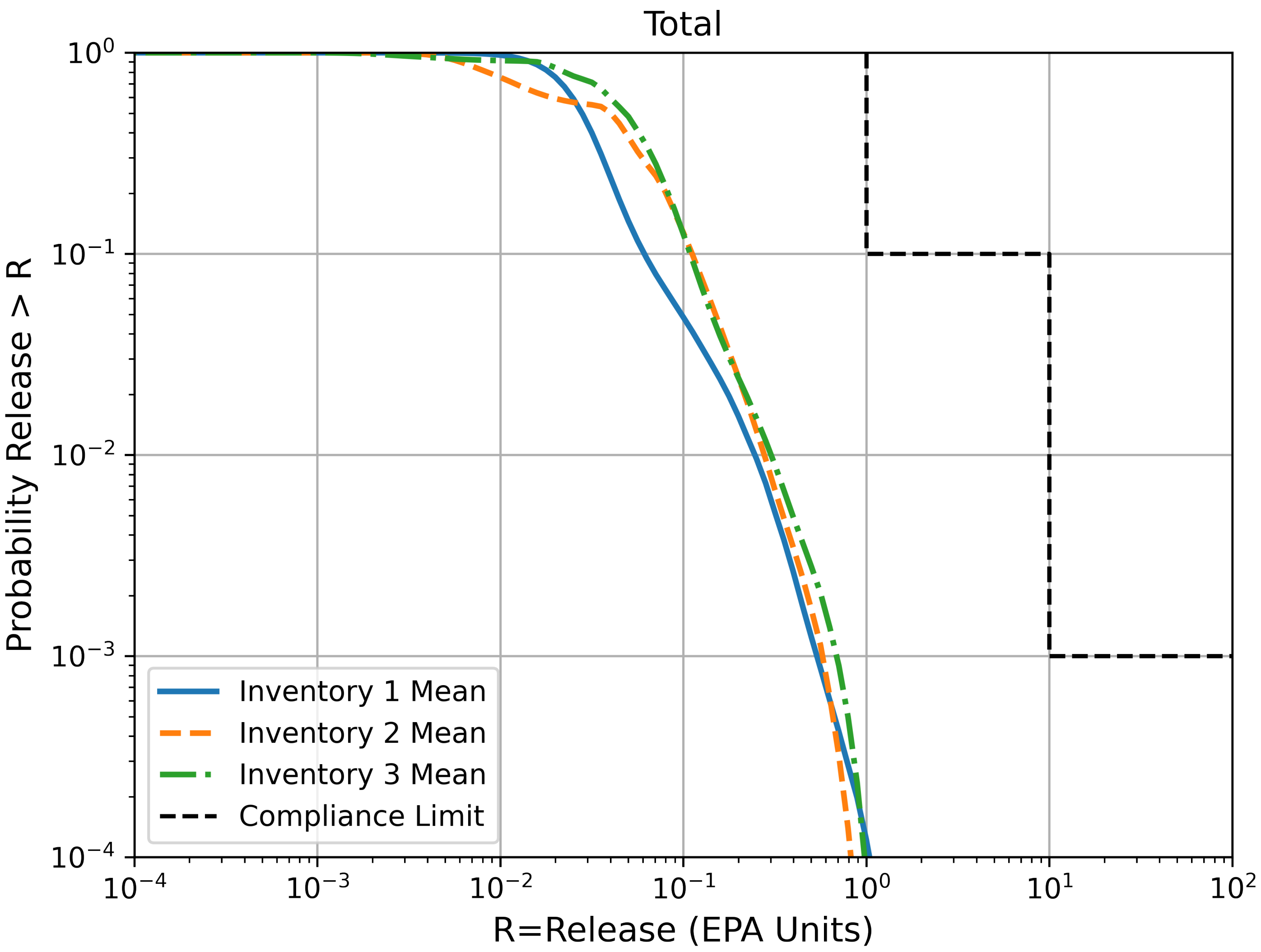




Because actinide concentrations tend to be solubility limited relative to the initial inventory releases in brine (DBRs and Culebra releases) decrease as the initial inventory activity increases.

Due to the presence of high-consequence waste stream intersections, solid releases (Cuttings, cavings, and spallings) increase at low probabilities with increasing surplus Pu inventory.

Conclusions



Long-term performance of the WIPP remains in compliance with dramatic shifts in initial inventory despite changing mechanisms driving total releases.