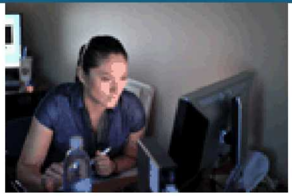
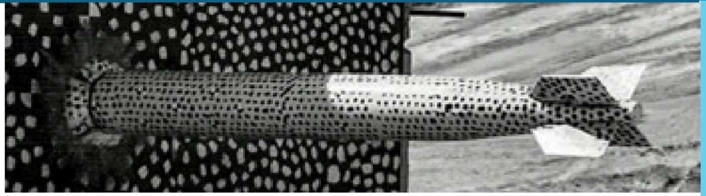
SAND2020-0916PE

WIPP PA Overview





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Long-Term Regulatory Requirements and Criteria

- Regulatory requirements guide the WIPP PA framework.
  - 40 CFR 191: Standards for TRU disposal (SNF and HLW standards also)
  - 40 CFR 194: WIPP-specific rules for certification and re-certification
  - The WIPP must be designed to provide *reasonable expectation* that cumulative releases of radionuclides to the accessible environment for 10,000 years after closure from all significant processes and events shall be less than specified *release limits*
- Recertification required every 5 years

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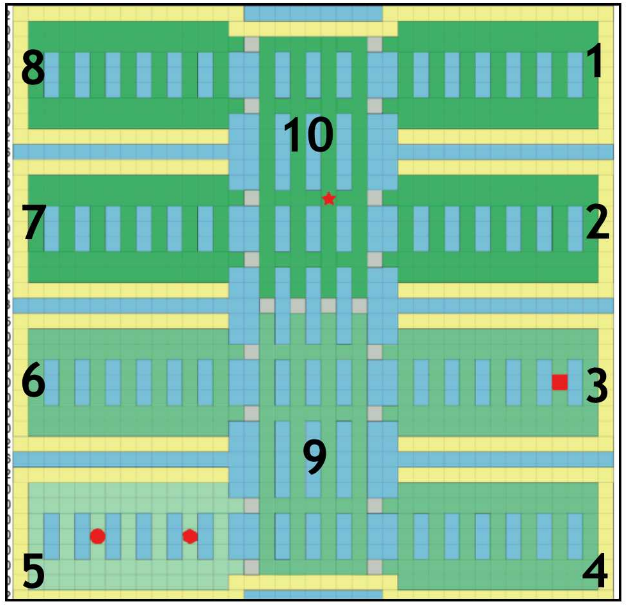

Regulatory Requirements (1)

- <u>Reasonable expectation</u>: Regulations acknowledge substantial uncertainties

- <u>10,000 years</u>: PA must represent behavior for entire regulatory time period

- <u>Significant processes and events</u>: PA must include all of these, including the possibility of inadvertent human intrusion

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Regulatory Requirements (2)

- Releases are not measured as a dose (e.g., Sv)
- Releases are measured in normalized "EPA units"
  - Approximately 10,000 EPA units at closure
- EPA unit is defined in part by total initial inventory
- EPA compliance limits are based on EPA units
- Greater initial inventory allows a greater activity release in Ci

TABLE 1—RELEASE LIMITS FOR CONTAINMENT REQUIREMENTS

[Cumulative releases to the accessible environment for 10,000 years after disposal]

Radionuclide	Release limit per 1,000 MTHM or other unit of waste (see notes) (curies)
Americium-241 or -243	100
Carbon-14	100
Cesium-135 or -137	1,000
Iodine-129	100
Neptunium-237	100
Plutonium-238, -239, -240, or -242	100
Radium-226	100
Strontium-90	1,000
Technetium-99	10,000
Thorium-230 or -232	10
Tin-126	1,000
Uranium-233, -234, -235, -236, or -238	100
Any other alpha-emitting radionuclide with a half-life greater than 20 years	100
Any other radionuclide with a half-life greater than 20 years that does not emit alpha particles	1,000

Table from 40 CFR 191

$$R = \sum \frac{Q_i}{L_i}\left(\frac{1\times10^6\, curies}{C}\right)$$

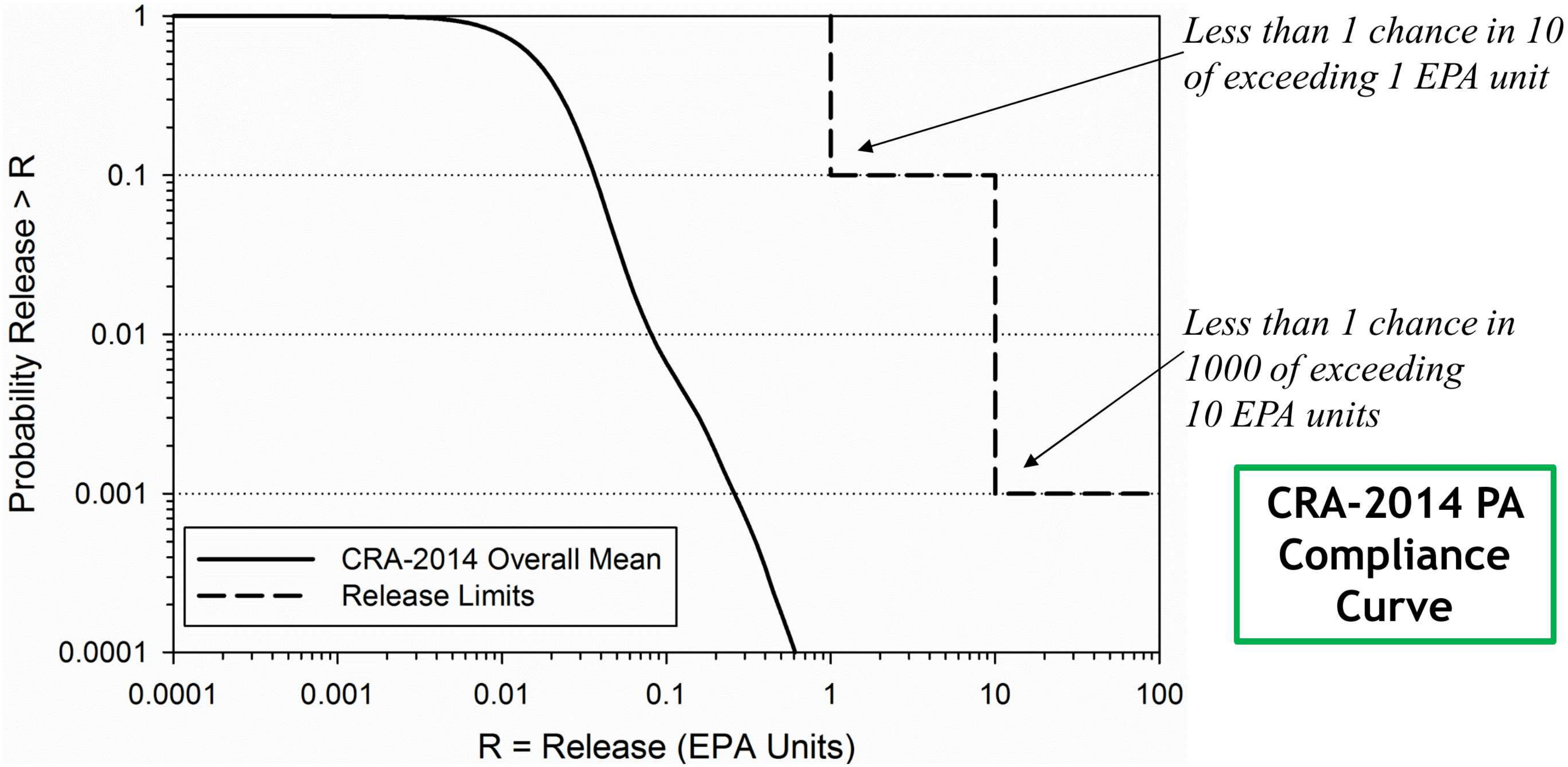
R = Normalized release in "EPA units"
Q_i = 10,000-year cumulative release (in curies) of radionuclide i
L_i = Release Limit for radionuclide i
C = Total initial transuranic inventory (in Ci of α-emitters w/half-lives > 20 years)

Regulatory Requirements (3)

Total release Complementary Cumulative Distribution Function (CCDF) curve is the measure of compliance

Releases are compared to regulatory release limits

Log-Log scale



CRA-2014 PA Compliance Curve

FEPs and Scenario Development

- Features, events, and processes (FEPs) are screened in/out in PA models
  - If P(event) < 10^{-4} in 10^4 y, don't consider
  - Low consequence or beneficial FEPs also screened out
  - Also be screened by regulatory mandate
- Potential release scenarios are developed for FEPs that are "screened-in"
- WIPP PA considers multiple scenarios
  - Undisturbed case (base-case)
  - Inadvertent drilling intrusion from the surface
  - Release through high permeability features to the Land Withdrawal Boundary

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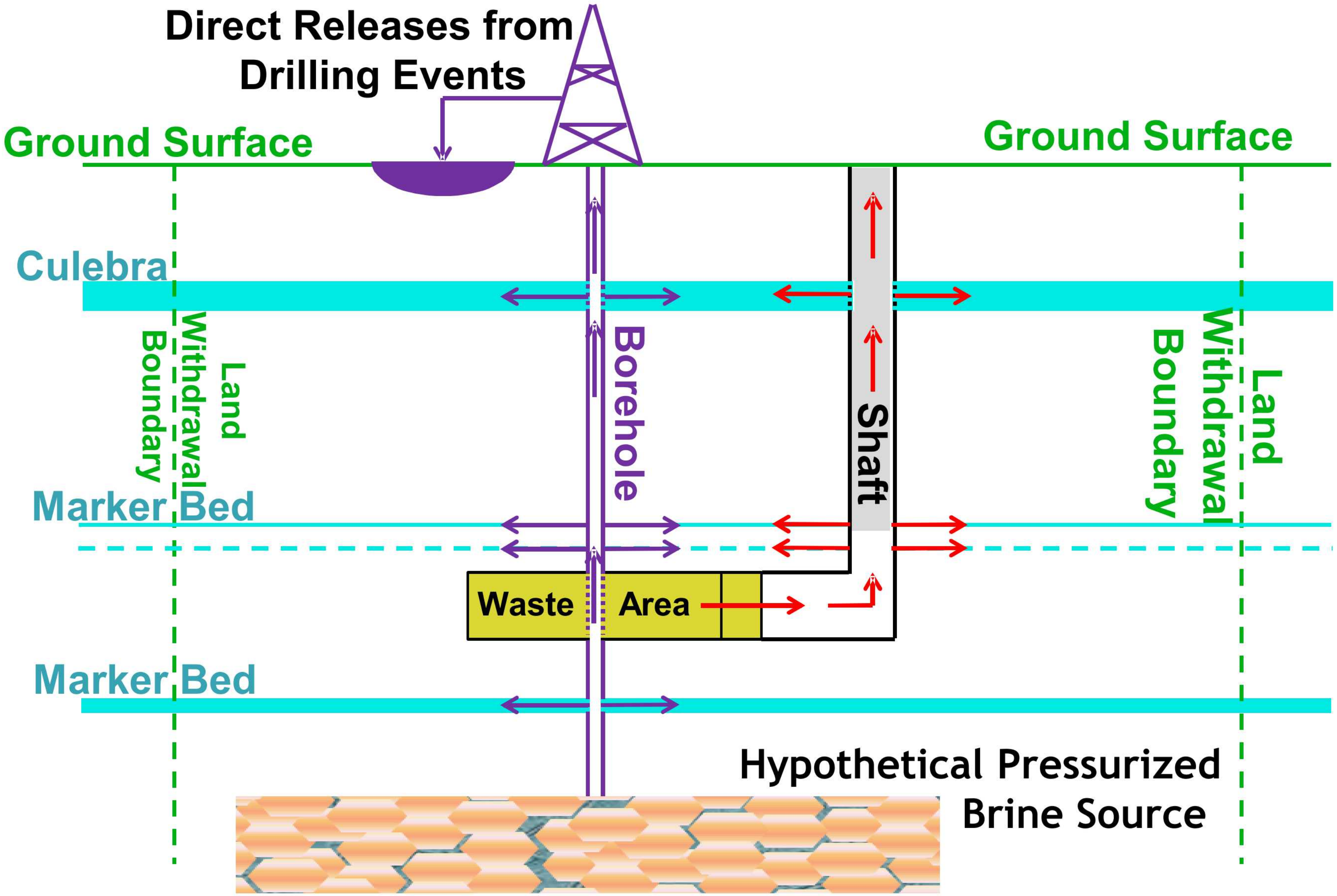
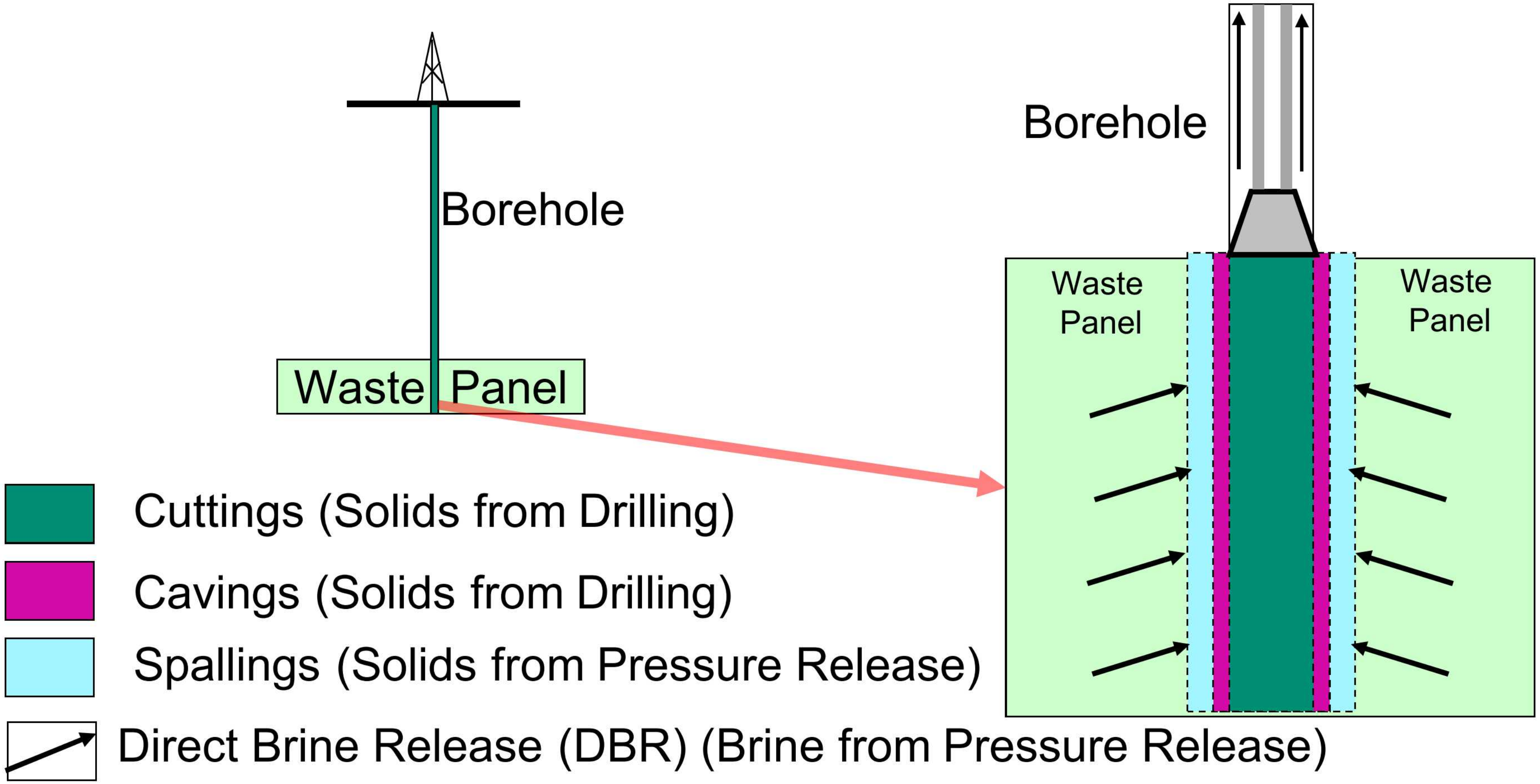
Release Pathways in WIPP PA



Direct Release Mechanisms

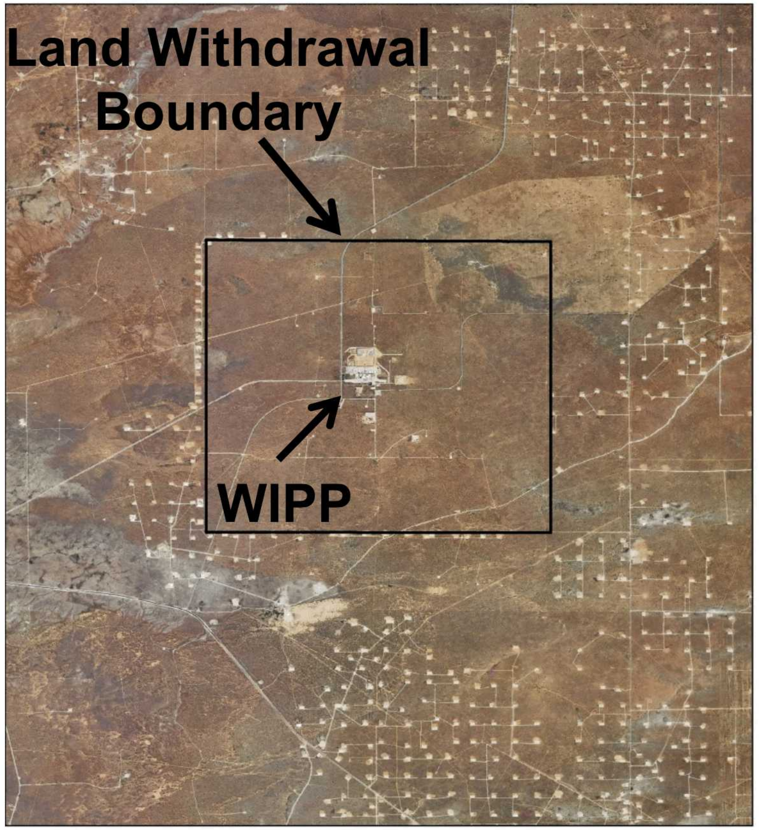
Direct releases dominate total releases

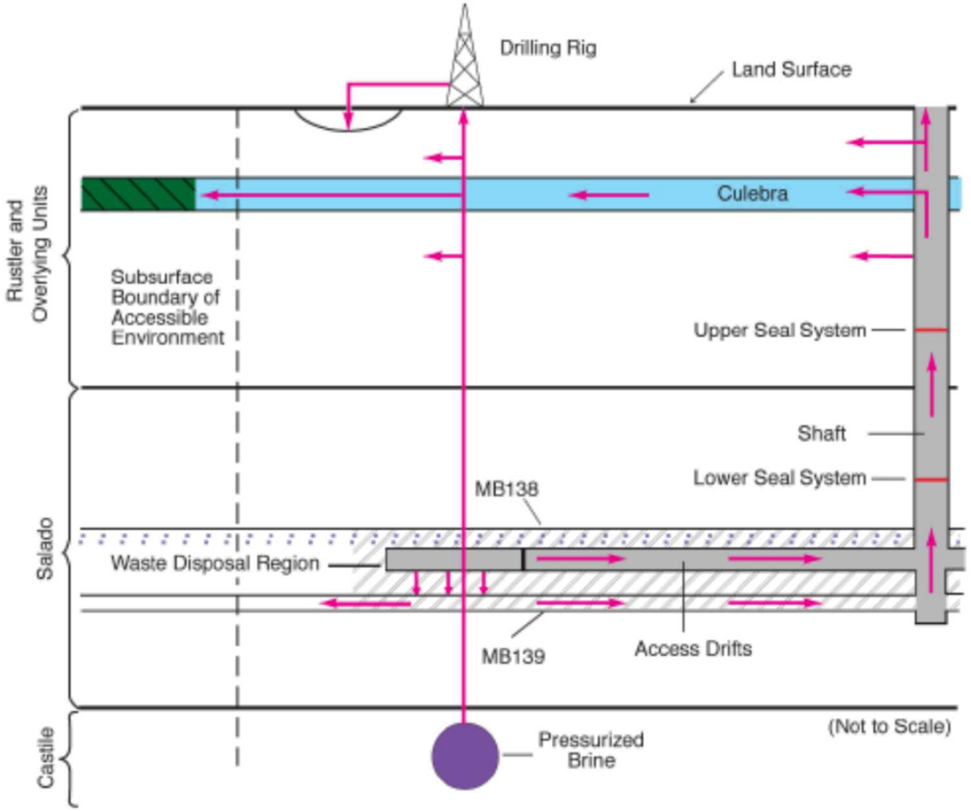
Releases due to inadvertent borehole intrusion



Long-term Release Mechanism

Radionuclide transport through groundwater comprise long-term releases (differ from direct releases)

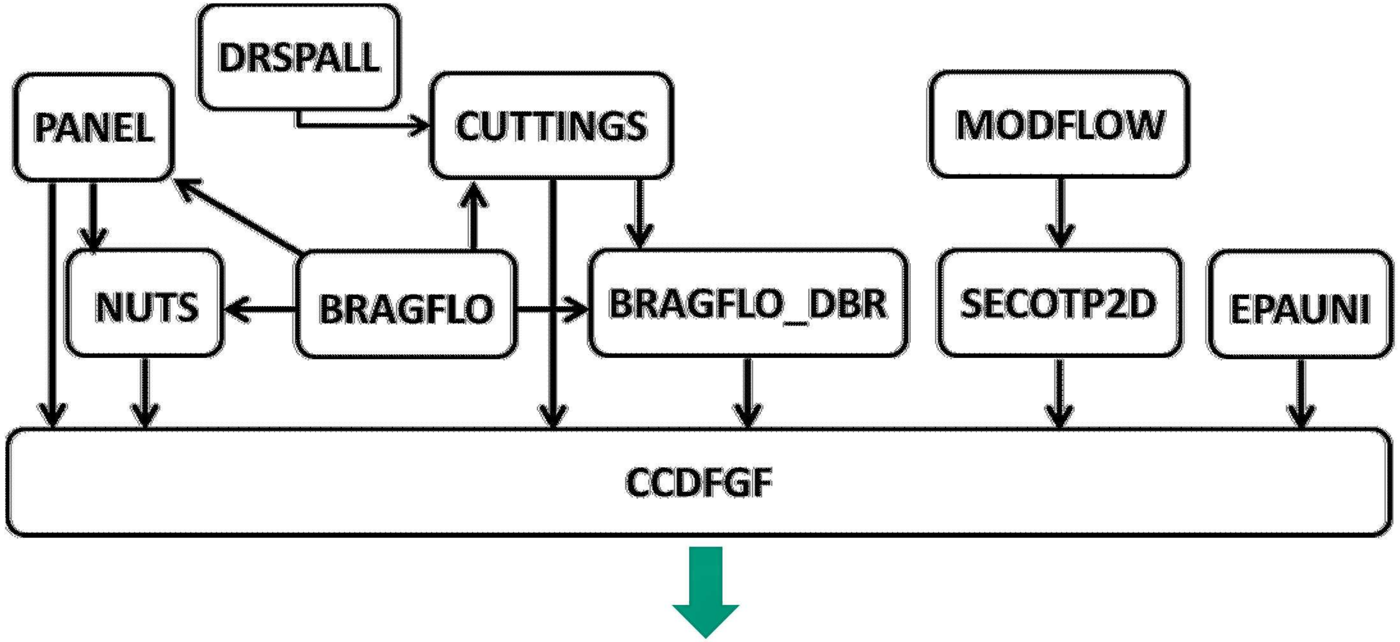




WIPP Performance Assessment

PA calculations include 24 peer-reviewed conceptual models

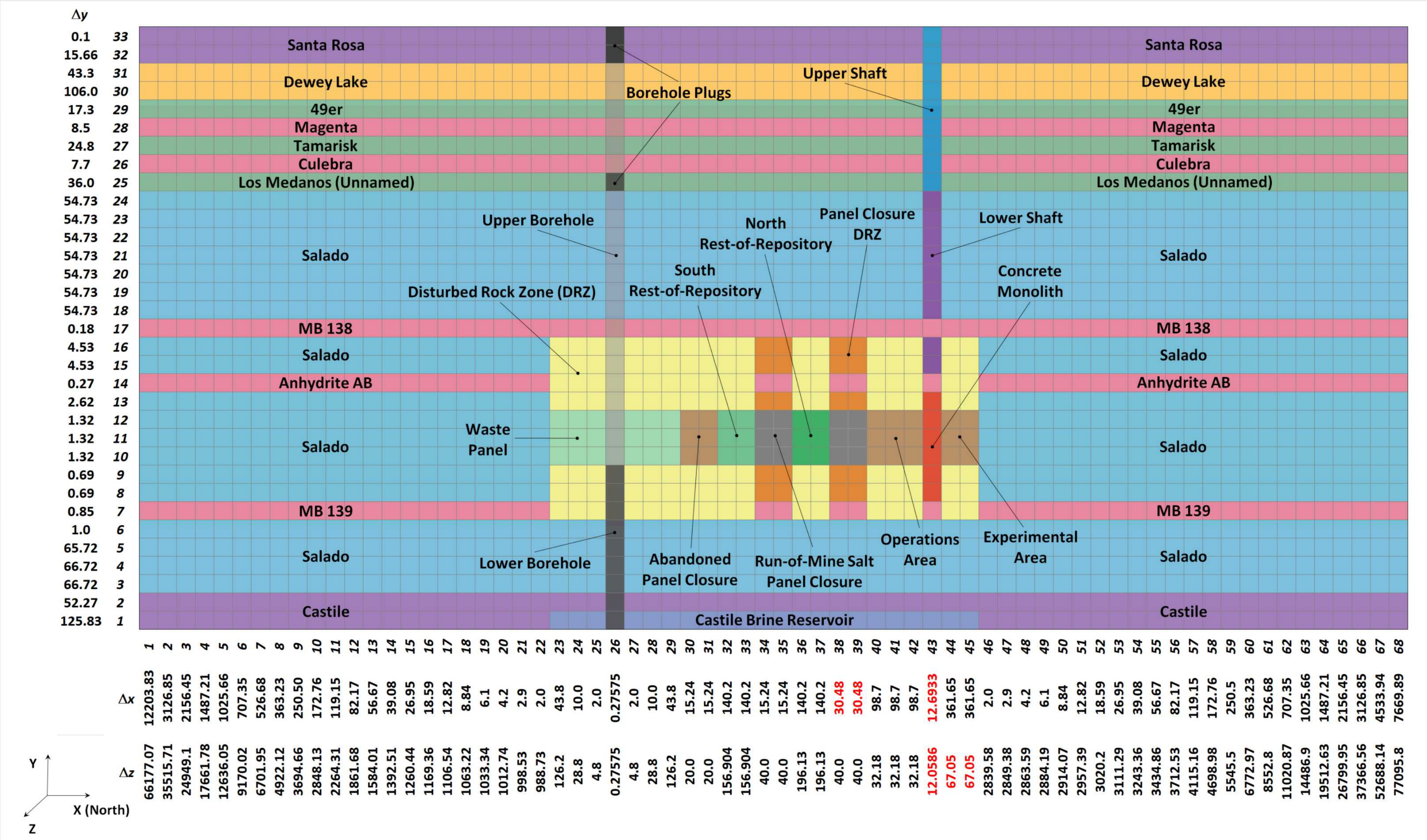
PA uses 10 principal codes and many utility codes



Compliance Curve for Total Normalized Releases

CRA19 BRAGFLO Grid

2-Dimensional "flared" grid used to model flow in and around repository



Current Model Abstraction

3-D repository represented by 2-D flared grid

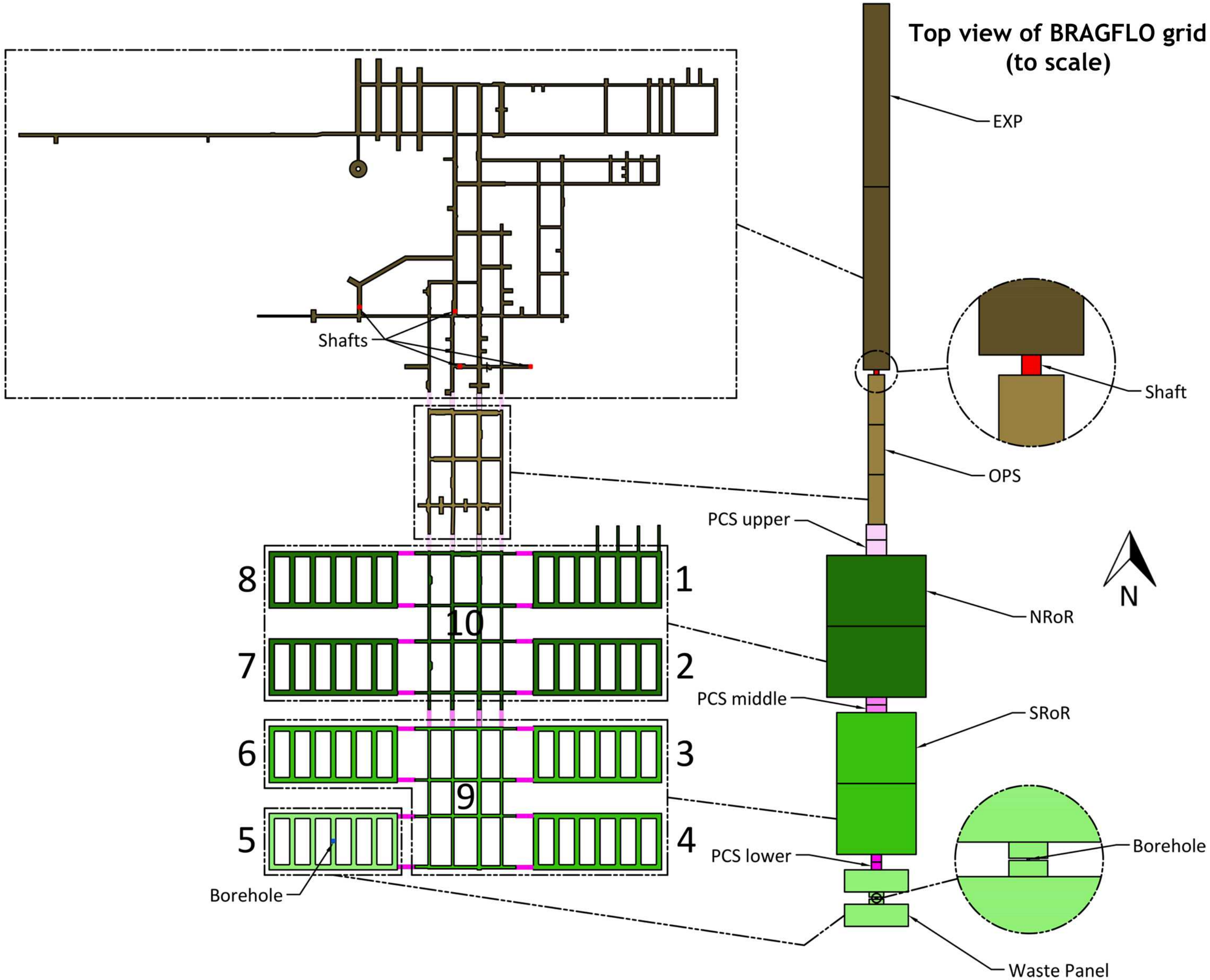
- Radial concentric flow assumption was deemed adequate to predict performance prior to CCA
- Unable to model asymmetry in panel layout

Panels are lumped

- Panel closures in SRoR and NRoR are implied, but not explicitly modeled
- Panel closures between OPS and EXP are combined with panel closures above Panel 10

Communication

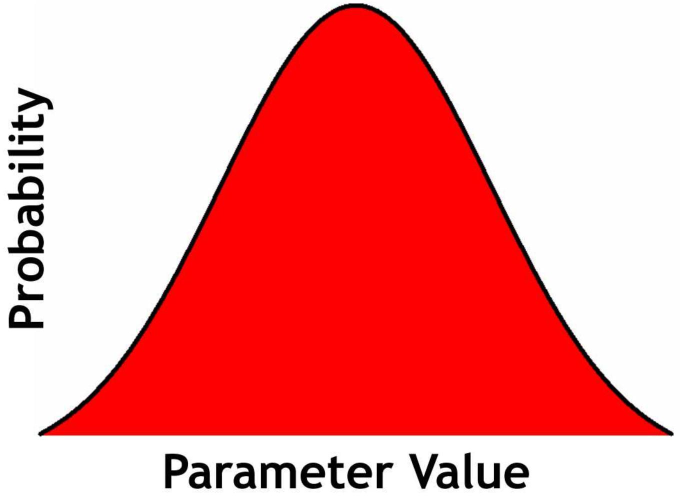
- Flow through waste panel is across the borehole restriction
- Flow from OPS to EXP is across the shaft restriction



Probabilistic Framework: Uncertainty

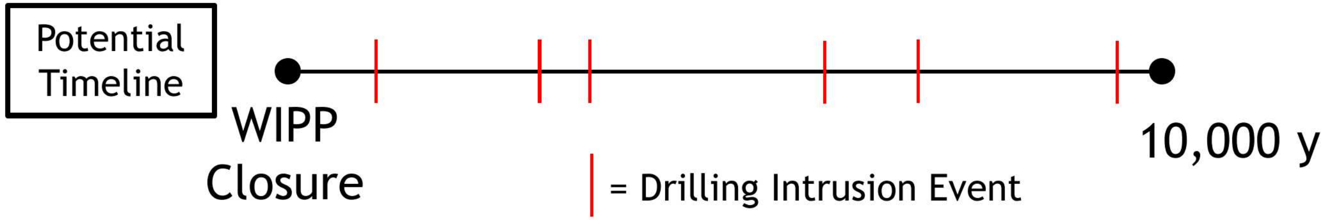
Epistemic (Subjective) Uncertainty

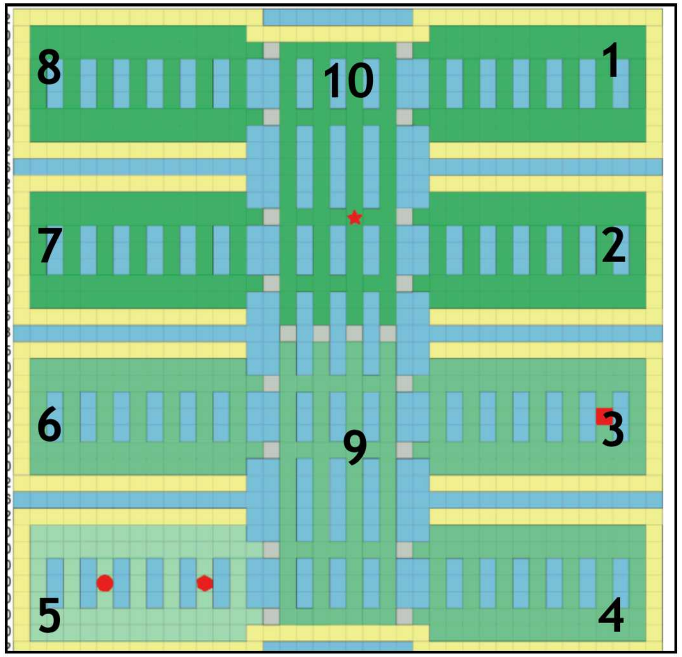
- Arises from a lack of knowledge about parameters that are considered constants
- Parameter values sampled from probability distributions that cover the range of uncertainty
- Examples: permeability, porosity, etc.



Aleatory (Stochastic) Uncertainty

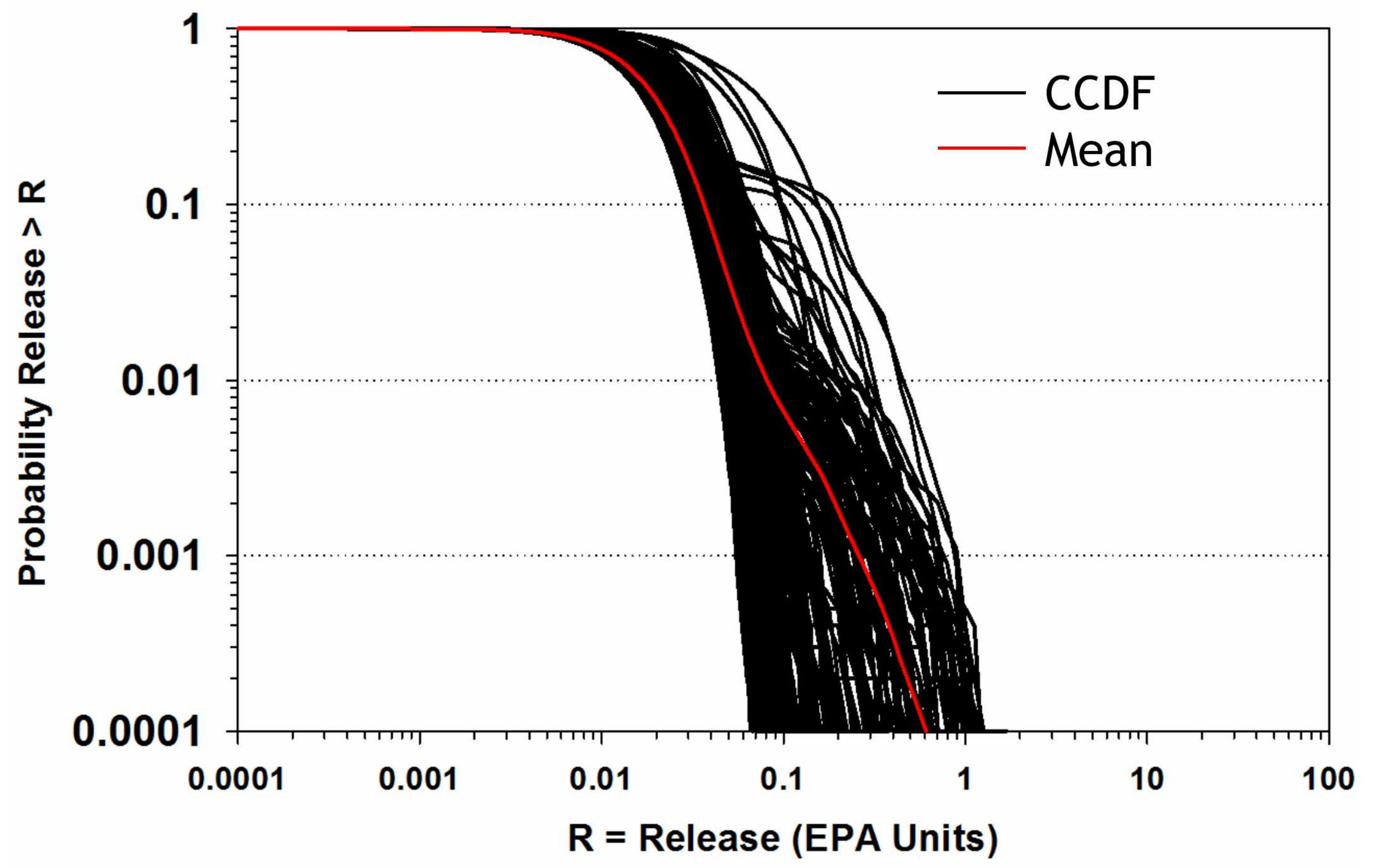
- Arises from a lack of knowledge about future events
- Monte Carlo sampling on possible futures
- Example: Timing and location of future drilling events





Intermediate Results

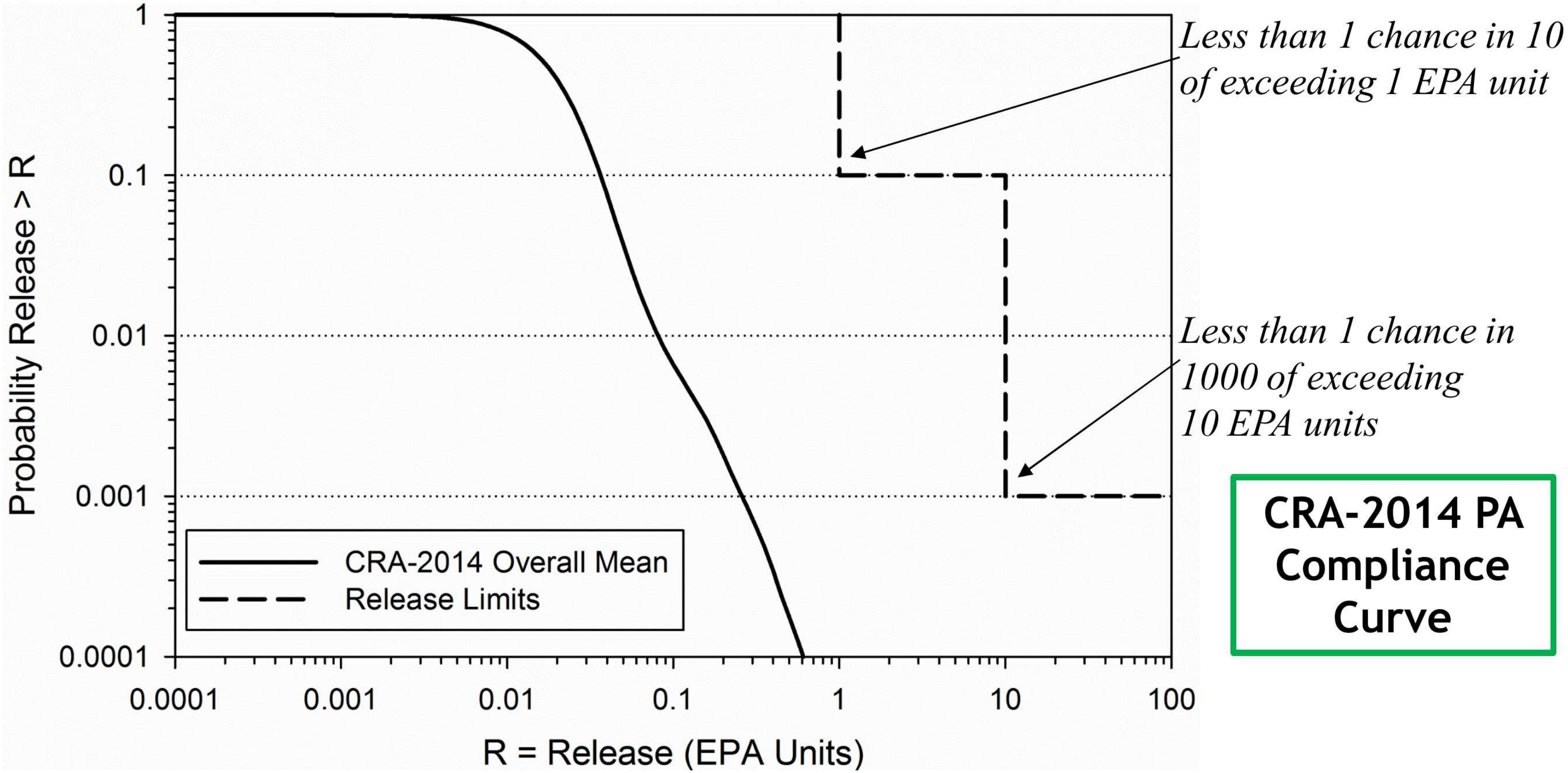
- Complementary Cumulative Distribution Function (CCDF) Curves
- Cumulative releases from 10,000 potential futures for each realization are ordered into a single “horsetail”
- 300 horsetail plots (one for each realization)



Mean Total Release CCDF

Total release Complementary Cumulative Distribution Function (CCDF) curve is the measure of compliance

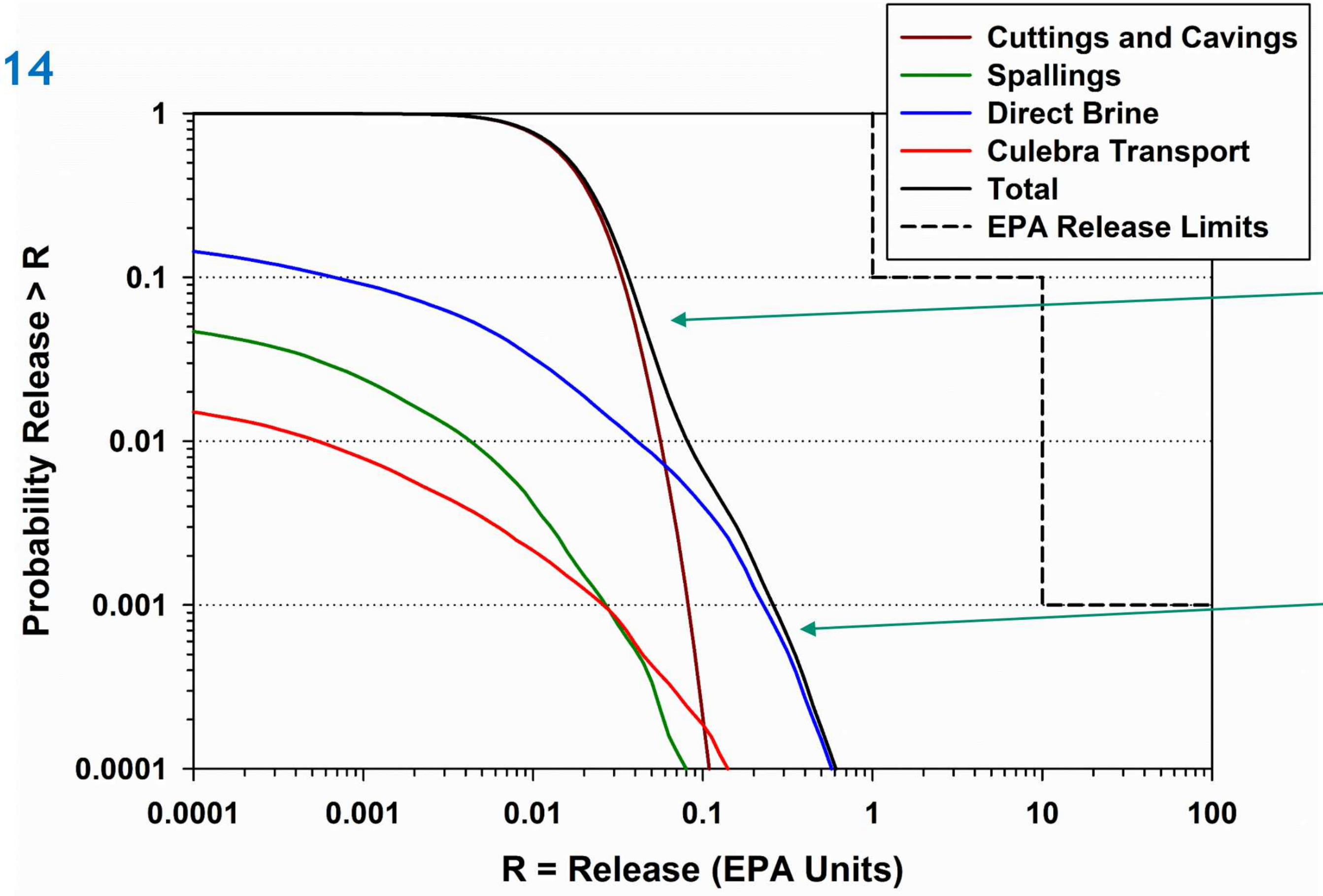
Releases are compared to regulatory release limits



CCDFs for each Release Mechanism

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

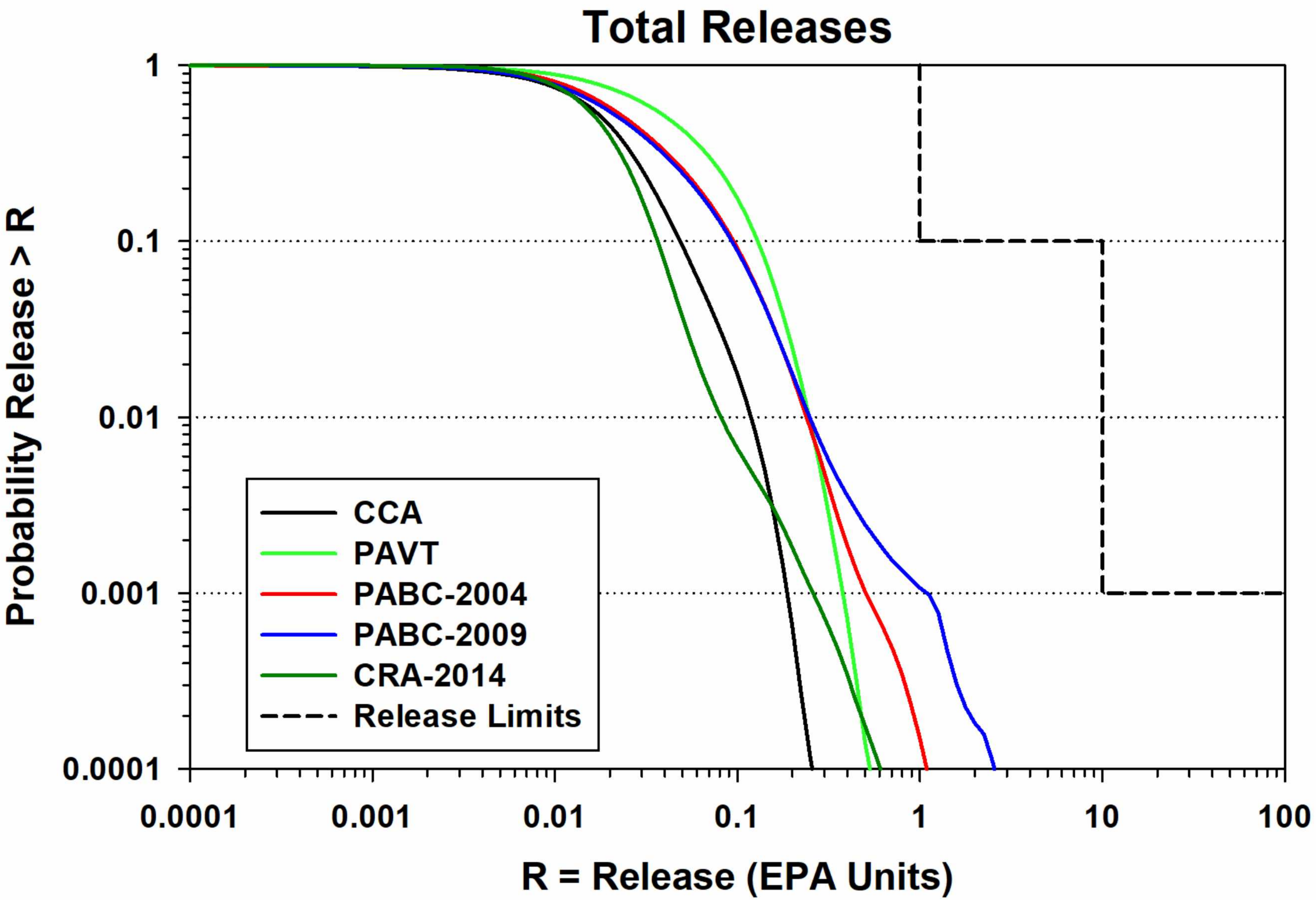
CRA-2014



Cuttings and cavings releases dominate at high probabilities

DBRs dominate at low probabilities

Historical Compliance Calculations



Abandonment of South End of Mine

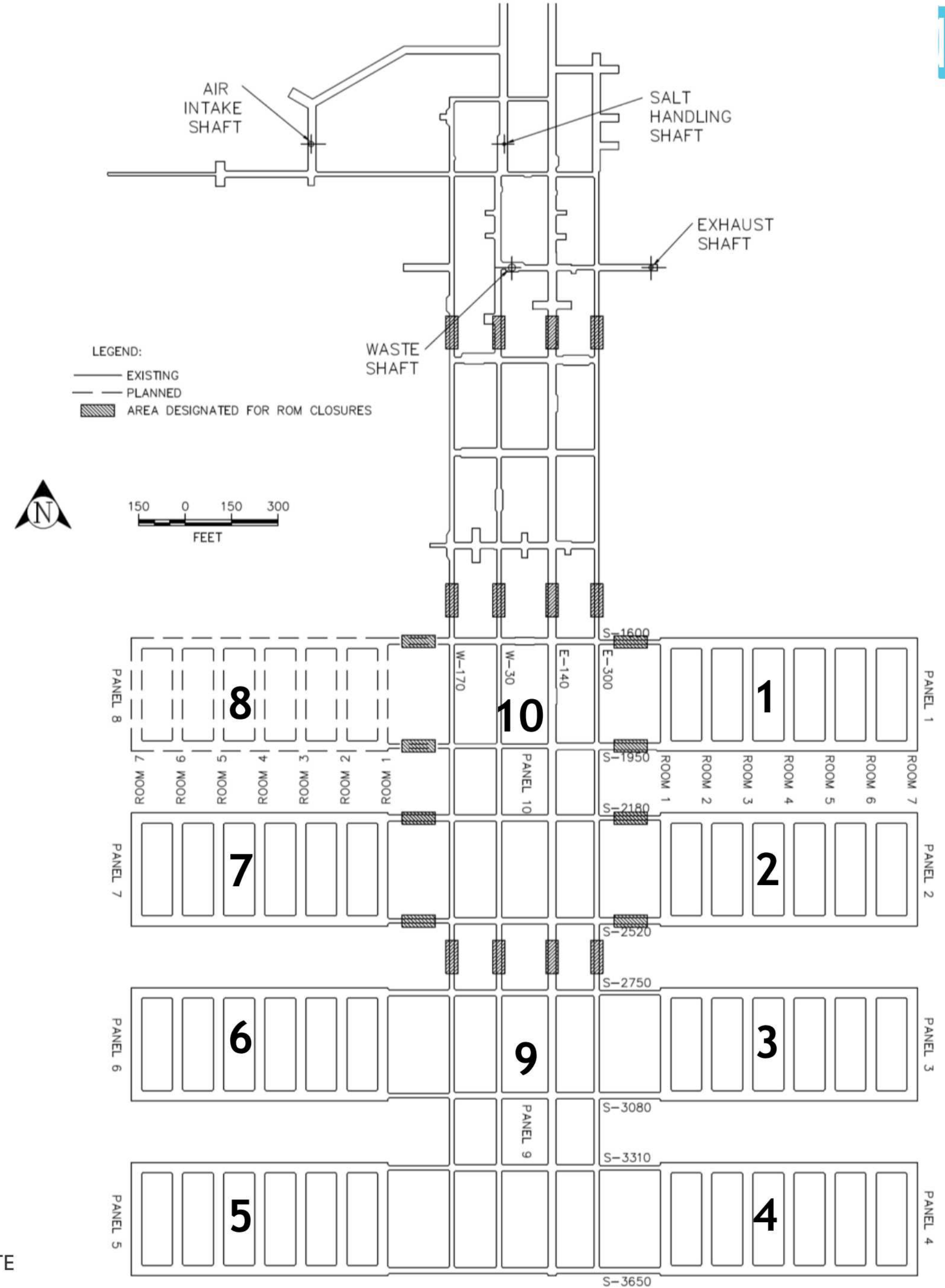
Fire and release events in 2014

Access to south end was limited

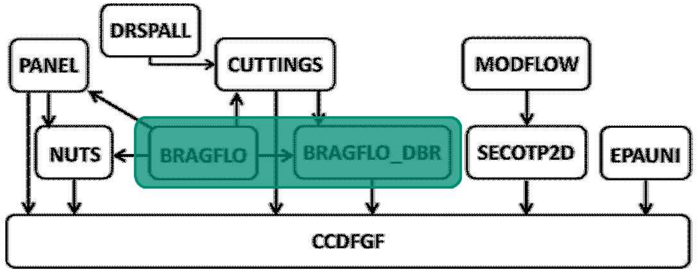
- Ground control maintenance deficiencies resulted in back instability and eventual roof falls

Worker safety issue identified

- Most effective resolution was to abandon the south end that contains Panels 3, 4, 5, 6, and 9
- Waste was already emplaced in south Panels 3, 4, 5, and 6, but not 9
- Unable to install run-of-mine-salt panel closures (ROMPCS) in Panels 3, 4, 5, and 6



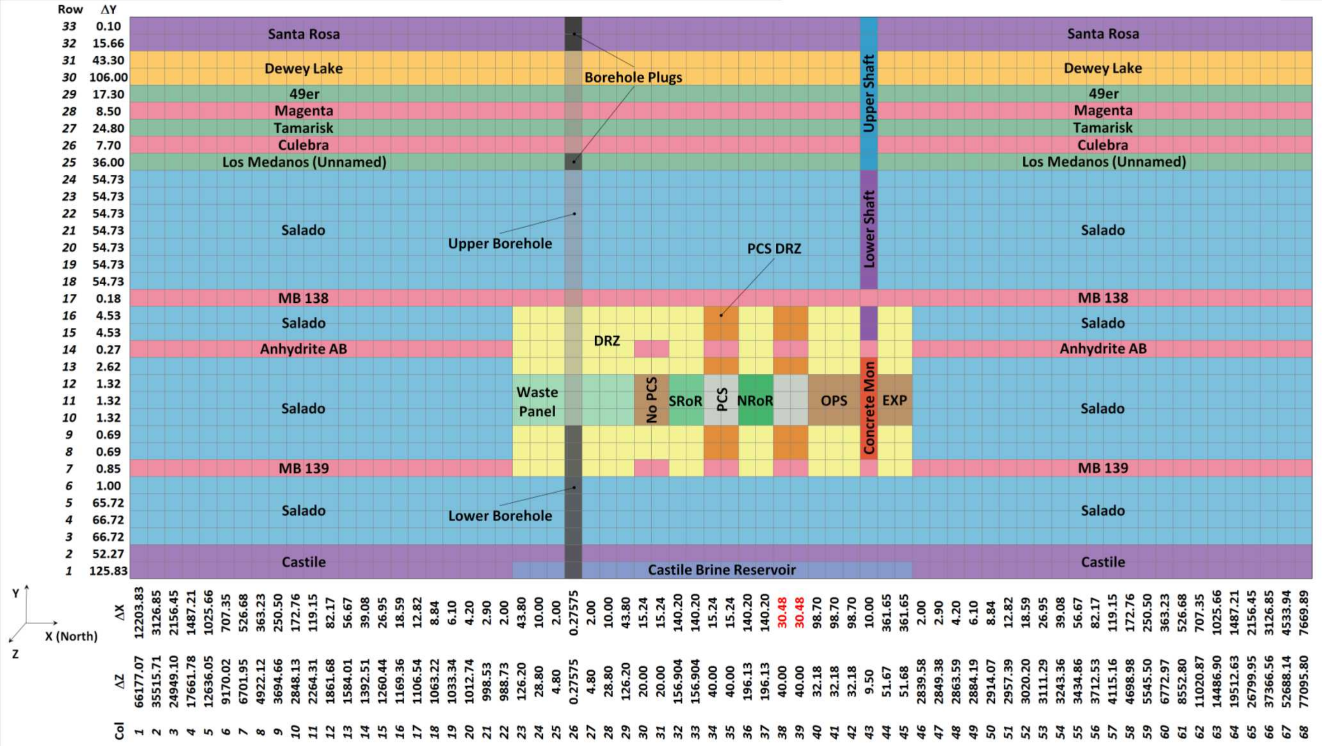
APCS Methodology

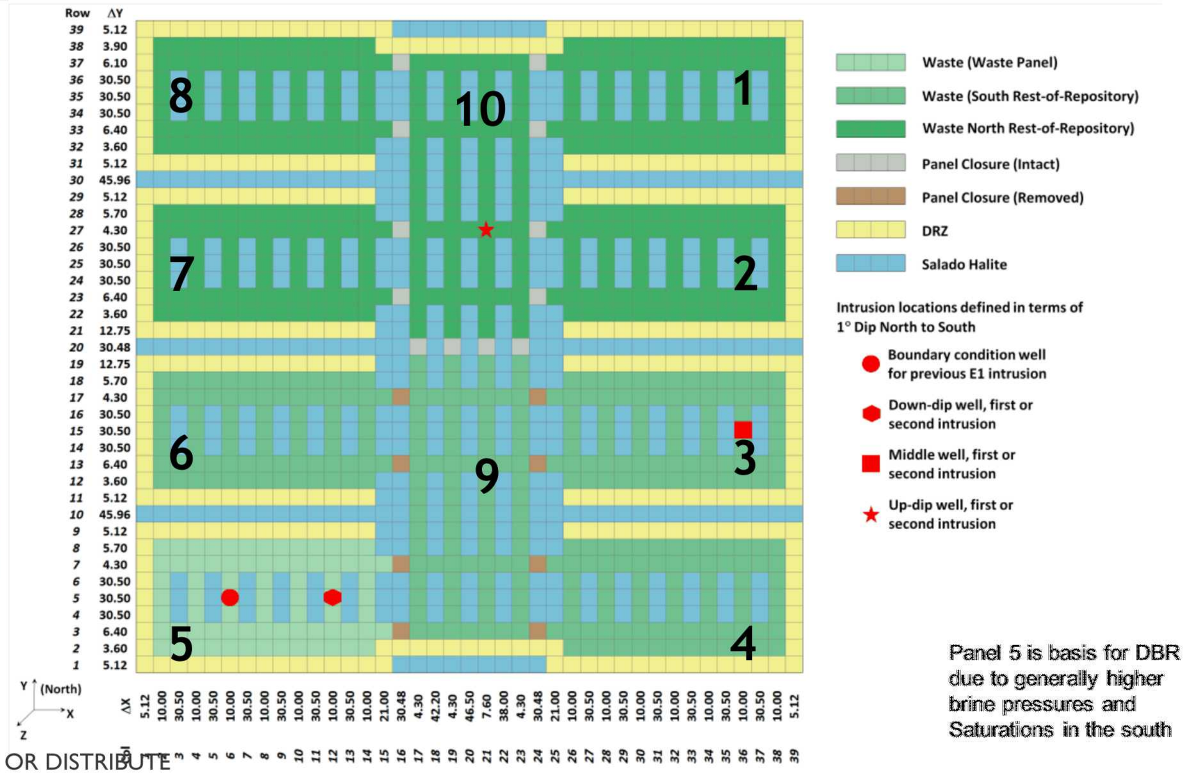


BRAGFLO/BRAGFLO_DBR

- Introduce PCS_NO material (consistent with open area OPS/EXP material parameters) at Time = 0 for the southernmost panel closure in the BRAGFLO grid and for panel closures between Panels 3, 4, 5, 6 and 9 in the BRAGFLO_DBR grid to represent the "abandoned" panel closures

- Waste Panel – Panel 5
- South Rest-of-Repository – Panels 3, 4, 6, 9
- North Rest-of-Repository – Panels 1, 2, 7, 8, 10

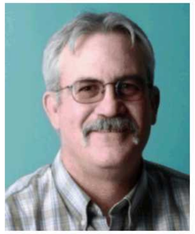




Panel 5 is basis for DBR due to generally higher brine pressures and Saturations in the south

Acknowledgements

WIPP PA is a coordinated effort by many dedicated people.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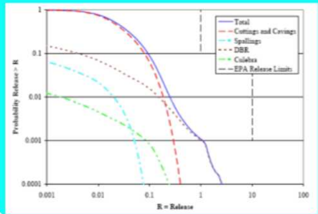
WIPP PA

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