U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Human Intrusion

Presented to:
NRC/DOE Technical Exchange on Total System Performance Assessment (TSPA) for Yucca Mountain
San Antonio, Texas

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June 7, 2000

YUCCA MOUNTAIN PROJECT

Outline

- **Regulatory Basis**
- **Conceptual Model**
- **Implementation in TSPA-SR**

Documentation for Site Recommendation

- **SRCR**
  - **Volume 1: Sections 4.3.2.3, 4.4.3, 4.4.4.3**
  - **Volume 2: Sections 3.3.2, 3.4.10.4**
- **TSPA-SR**
  - **Sections 4.4, 5.3.4**

Regulatory Basis

- **Proposed 10 CFR 963**
  - **From Section 963.16(a)(2)**
    - **"Consistent with applicable NRC regulations regarding a stylized human intrusion case, DOE will conduct a total system performance assessment to evaluate the ability of a geologic repository to limit radiological exposures in a stylized limited human intrusion case."**
  - **From Supplementary Information (p. 67064)**
    - **"It is anticipated that NRC would conform its proposed licensing regulation at 10 CFR part 63 with to the final EPA radiation protection standards, as necessary and appropriate**

Regulatory Assumptions

NRC Base Assumptions (from 10 CFR 63)	EPA Additional and/or Conflicting Assumptions (from 40 CFR 197)	Conceptualization for TSPA-SR
Assumed intrusion is a drilling event	Assumed intrusion is acute and inadvertent	Inadvertent drilling event
Drilling result is a single, nearly vertical borehole that penetrates a waste package and extends down to the SZ	Borehole penetrates a degraded waste package	Single vertical borehole from surface through a single waste package to SZ
Borehole properties are based on current practices for resource exploration	Borehole results from exploratory drilling for ground water	Borehole diameter consistent with resource exploration
A separate consequence analysis is required, identical to the performance assessment, except for the occurrence of the specified human intrusion scenario	Unlikely natural processes and events are not included, but analysis could include disturbances by other processes or events which are likely to occur	Intrusion borehole is applied to nominal case.

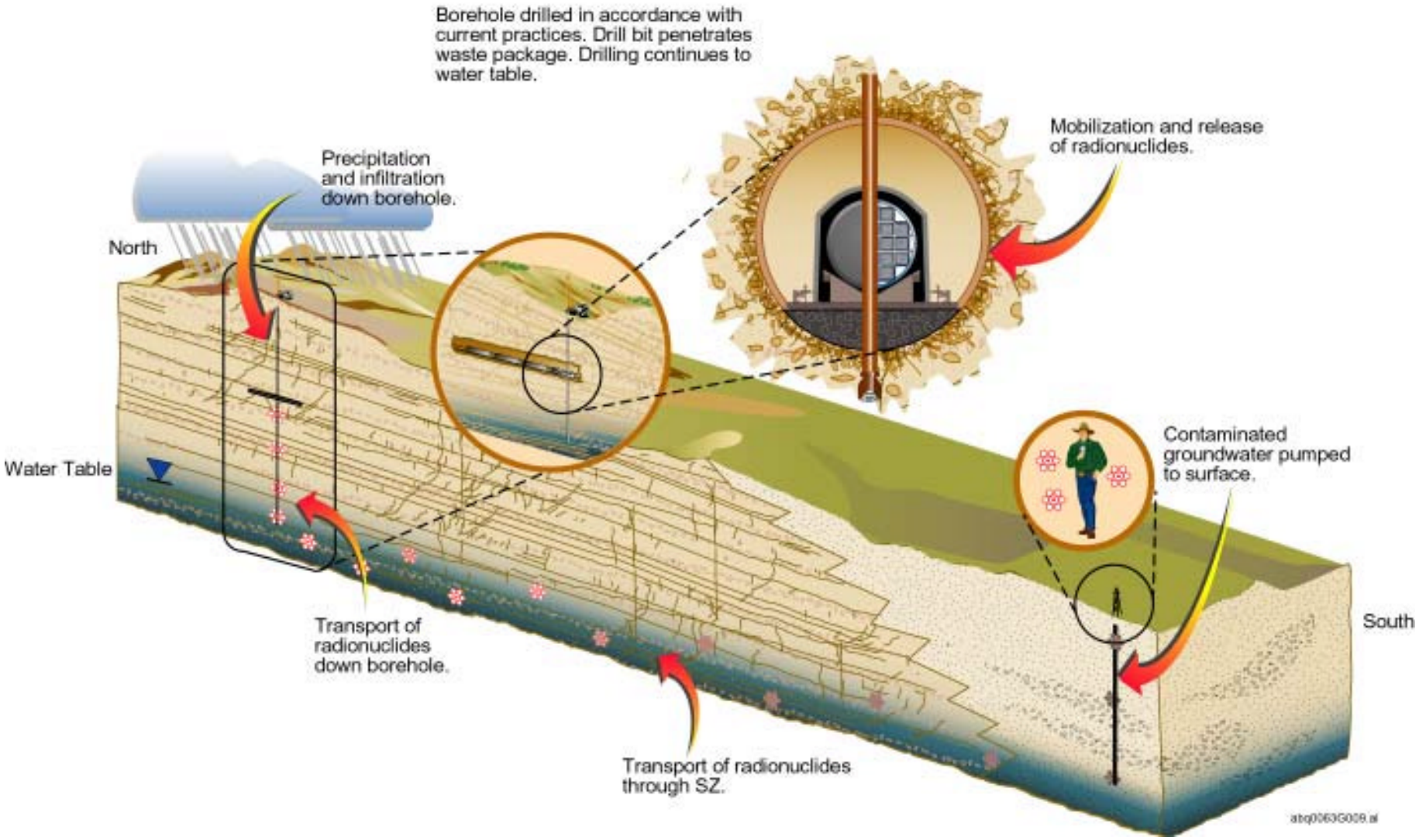
Regulatory Assumptions
(continued)

NRC Base Assumptions (from 10 CFR 63)	EPA Additional and/or Conflicting Assumptions (from 40 CFR 197)	Conceptualization for TSPA-SR
Borehole is not adequately sealed to prevent infiltrating water	Natural degradation processes gradually modify the borehole, the result is no more severe than the creation of a ground water flow path from the crest of Yucca Mountain through the repository and to the water table	Infiltration and transport through the borehole assumes an instantaneously degraded borehole, with properties similar to a fault pathway
Hazards to the drillers or to the public from material brought to the surface by the assumed intrusion should not be considered	Only consider releases through the borehole to the SZ. Consider releases which occur gradually through air and water pathways, not suddenly as with direct removal	Groundwater is only pathway considered

Regulatory Assumptions
(continued)

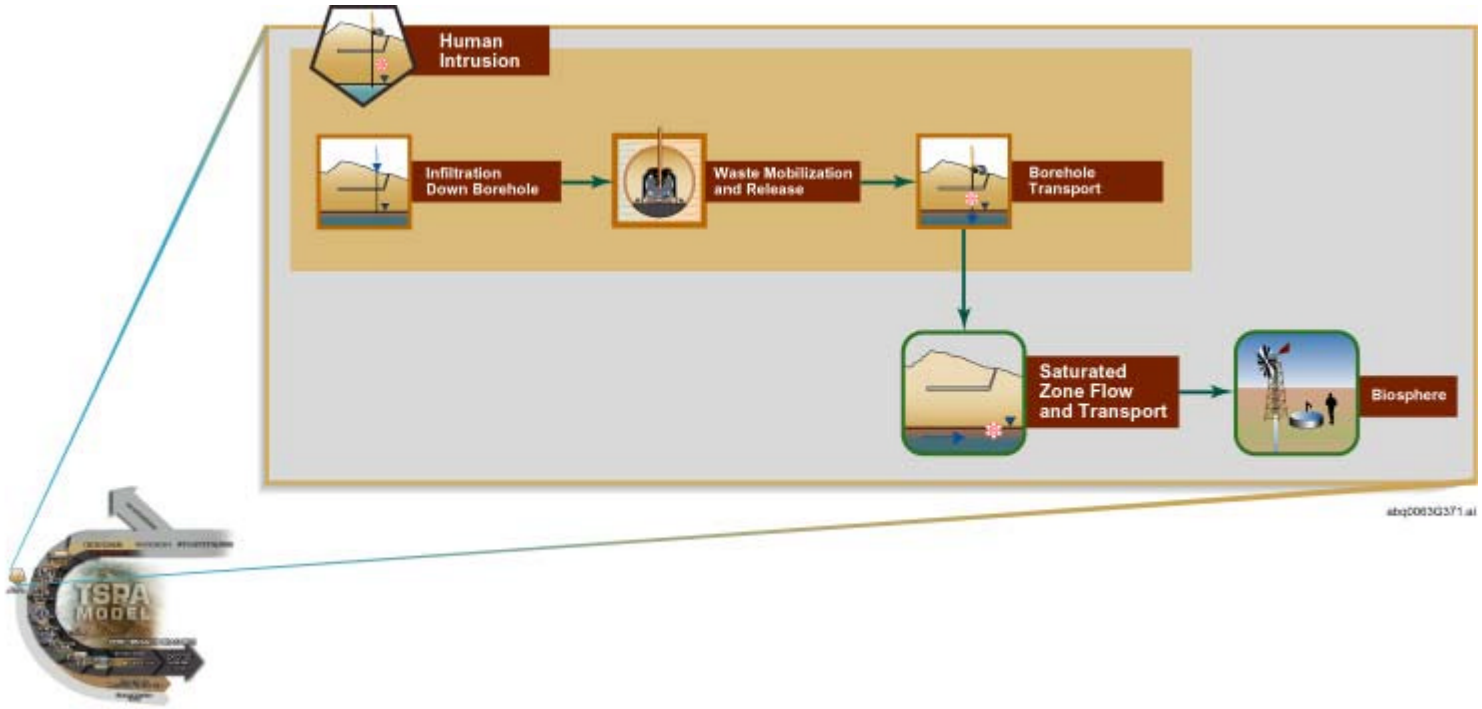
NRC Base Assumptions (from 10 CFR 63)	EPA Additional and/or Conflicting Assumptions (from 40 CFR 197)	Conceptualization for TSPA-SR
Intrusion occurs 100 years after closure	Intrusion time should take into account the earliest time after disposal that a waste package could degrade sufficiently that current drilling techniques could lead to waste package penetration without recognition by the drillers	Several intrusion times analyzed (100, 5000, 10000 years) *DOE Guidance:* *Assume > 10,000 years*
Peak dose not to exceed 25 mrem/yr in the first 10,000 years	(1) Peak dose not to exceed 15 mrem/yr in the first 10,000 years OR (2) Analyze in EIS (no quantitative limit) if intrusion occurs after 10,000 years	Does not affect model *DOE Guidance :* *Use EPA Alternative (2)*

Conceptual Model



Conceptual Model

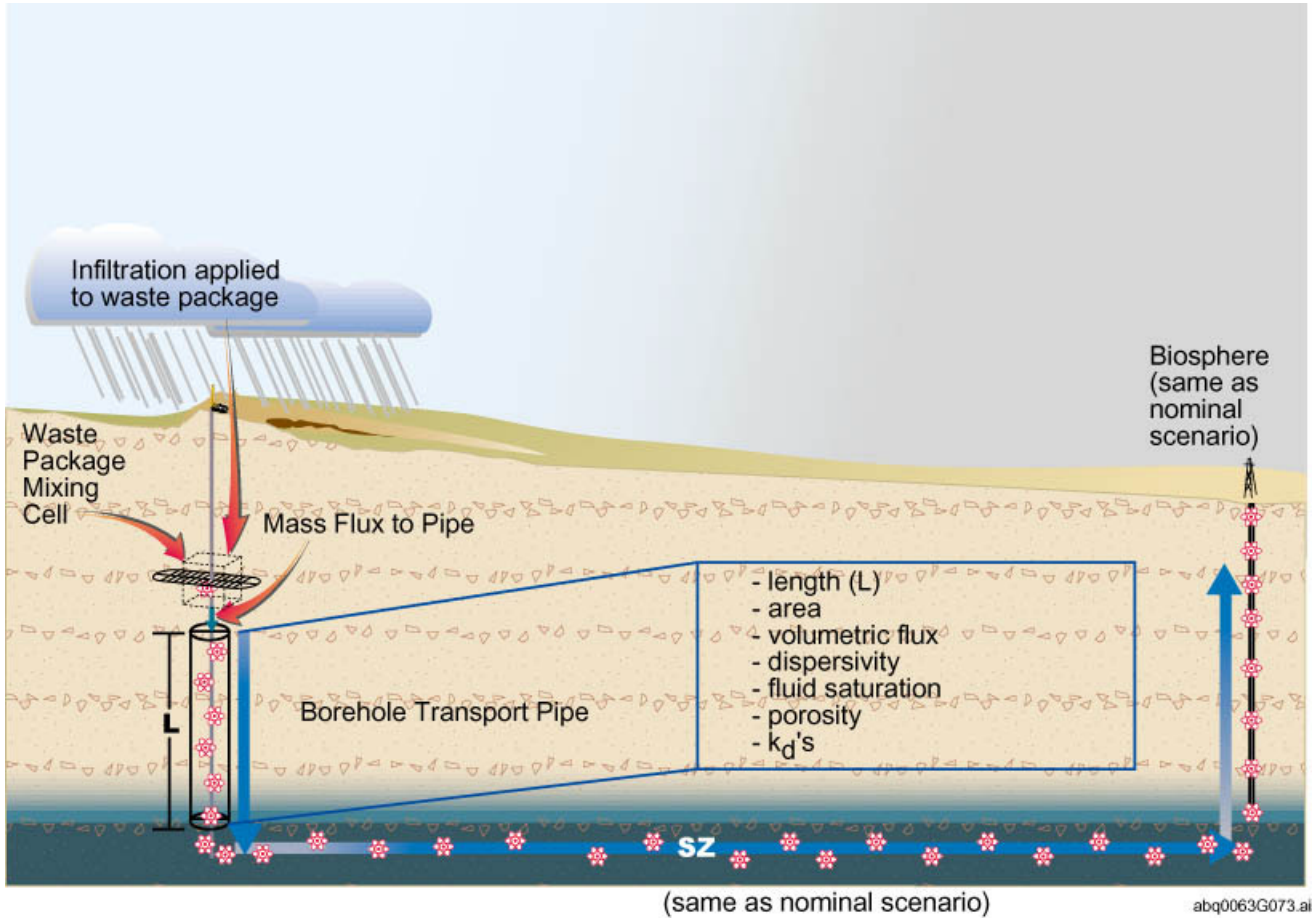
(continued)



Implementation in TSPA-SR

- **Human intrusion scenario set up entirely within GoldSim**
- **Human intrusion scenario derives from nominal scenario**
  - **Intrusion borehole replaces nominal unsaturated zone**
  - **Waste package and waste form implementation altered slightly from nominal to consider single WP with drilling damage**
  - **Saturated zone and biosphere same as nominal scenario**
- **Additional model assumptions required**

Implementation in TSPA-SR
(continued)



Implementation - Infiltration Down Borehole

Issue	Key Component(s) Affected	TSPA-SR Implementation
Infiltration into borehole	Infiltration	- Currently assume an infiltration rate of 500 mm/yr, which is larger than the average precipitation and maximum percolation flux for glacial-transition climate. - Conservative value inherently includes possibility of surface water collection basin focusing. - May sample from infiltration map.
Borehole diameter	Infiltration Borehole Transport	- Typical water well has a diameter of 20.3 cm (8 in.)
Seepage into penetrated waste package	Infiltration Waste Mobilization	- Volumetric flux is equivalent to infiltration rate times borehole cross-sectional area. - Volume of drilling fluid is ignored. - No gain or loss of water from UZ - Early-time vaporization is ignored.

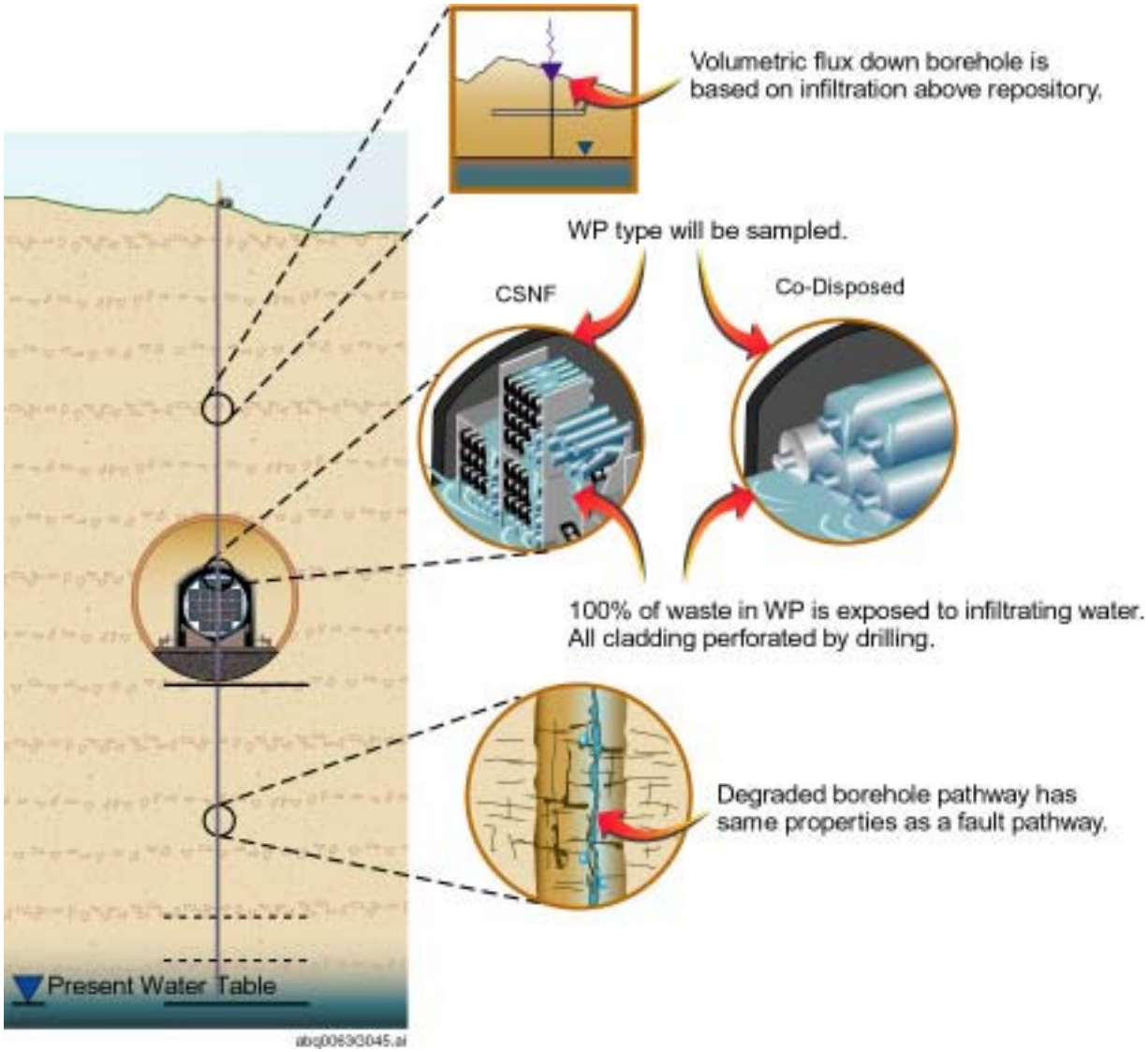
Implementation - Waste Mobilization/Release

Issue	Key Component(s) Affected	TSPA-SR Implementation
Type of WP penetrated	Waste Mobilization	- Sampled from CSNF and CDSP. CDSP is co-disposed DNSF and HLW glass.
Thermal and geochemical conditions in waste package	Waste Mobilization	- Assume temperature and in-package chemistry as calculated in nominal scenario. - This assumes J-13 water and ignores any chemical effects of the drilling fluid.
Waste form degradation	Waste Mobilization	- Drilled plug of waste is assumed to be available for immediate dissolution in WP. - Remainder of waste is assumed to have cladding damage from drilling disturbance. - No waste transported directly to SZ.
Dissolution of radionuclides in water	Waste Mobilization	- Infiltrating water can mix with waste in entire waste package. - Solubility is based temperature and in-package chemistry as in nominal scenario. - Colloids are included

Implementation - Borehole Transport

Issue	Key Component(s) Affected	TSPA-SR Implementation
Borehole flow and transport properties	Infiltration Borehole Transport	- Transport simulated in GoldSim 1D pipe. - Properties consistent with UZ fault pathway. - Sorption included - Matrix diffusion ignored
Borehole length	Borehole Transport	- Borehole length from repository to SZ conservatively assumes water level consistent with glacial transition climate.
Borehole location	Infiltration SZ Transport	- Random over repository footprint. - Uncertainty in location is captured in location that radionuclides enter SZ. - Sampling of infiltration would also reflect uncertainty in location.

Summary


Volumetric flux down borehole is based on infiltration above repository.
WP type will be sampled.
CSNF
Co-Disposed
100% of waste in WP is exposed to infiltrating water.
All cladding perforated by drilling.
Degraded borehole pathway has same properties as a fault pathway.
Present Water Table

Summary

- **Stylized scenario based on regulations**
  - **Borehole from surface through single WP to SZ**
  - **NRC and EPA specify different intrusion times**
  - **Separate assessment required**
- **TSPA-SR model**
  - **Derives from nominal scenario model**
  - **Borehole components replace UZ**
  - **Additional technical assumptions required**