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

Saturated Zone Process Components

Presented to:
Nuclear Waste Technical Review Board

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YUCCA MOUNTAIN PROJECT

Topics of Discussion

- **New data and analyses**
- **Unquantified uncertainties**
- **Multiple Lines of Evidence**
- **Analysis of newly published 40 CFR Part 197 Standard**

New Data and Analyses

- **New Data**
  - **Lithology of Nye County wells**
  - **Hydraulic head and water level elevations**
- **New Field Test Results**
  - **Alluvial Testing Complex (ATC) hydraulic measurements**
  - **Preliminary ATC single-well tracer test results**
- **New Model Analyses**
  - **Alternate conceptual model for Large Hydraulic Gradient**
  - **Alternate representation of Solitario Canyon Fault**
  - **Sensitivity analysis for cooler repository design**
  - **Dispersion and matrix diffusion analyses**

Nye County Lithology

Purpose

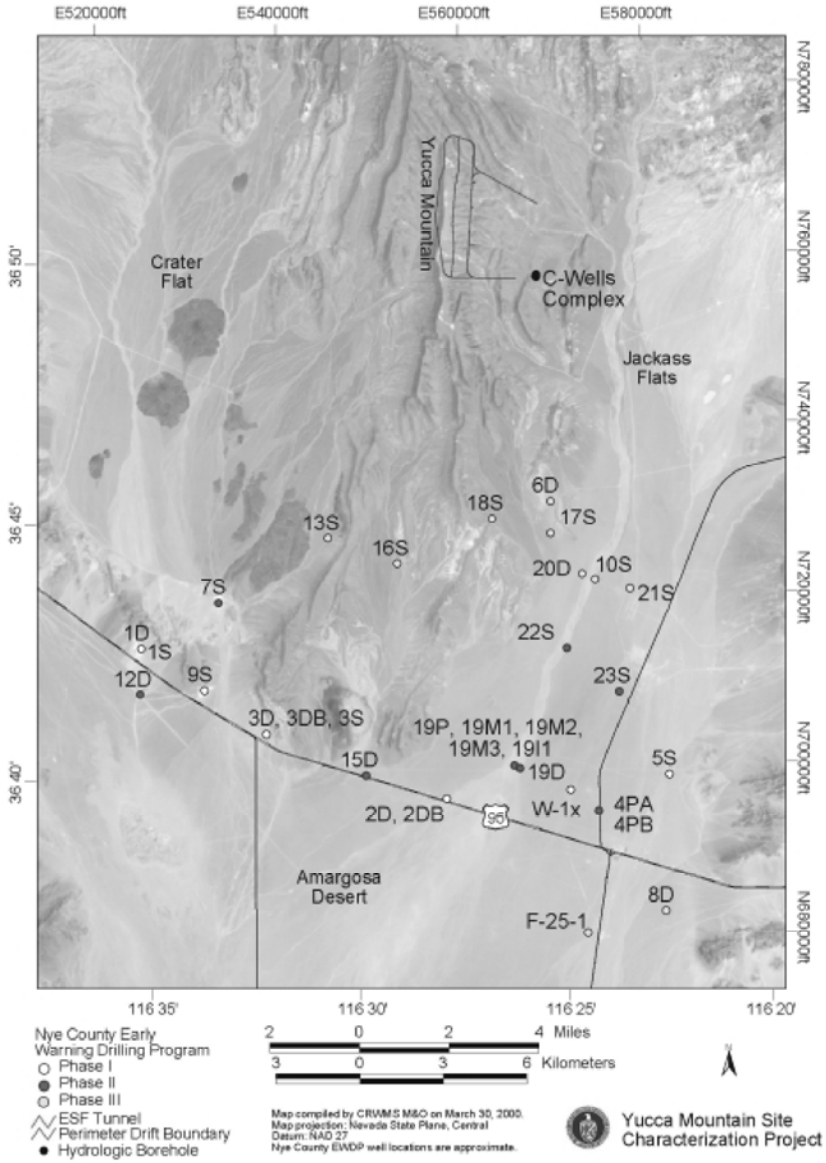
- Data will reduce the uncertainty in the amount of alluvium encountered along the flowpath from the potential repository

Results

- NC-EWDP-02D: >800 ft of saturated alluvium from the water table
- NC-EWDP-19D1: >400 ft of saturated alluvium underlain by volcanic rocks

Conclusions

- At least some of the pathway to 20 km will be through alluvium
- Wells drilled to the north will reduce uncertainty further



Hydraulic Head and Water Level Data

Purpose

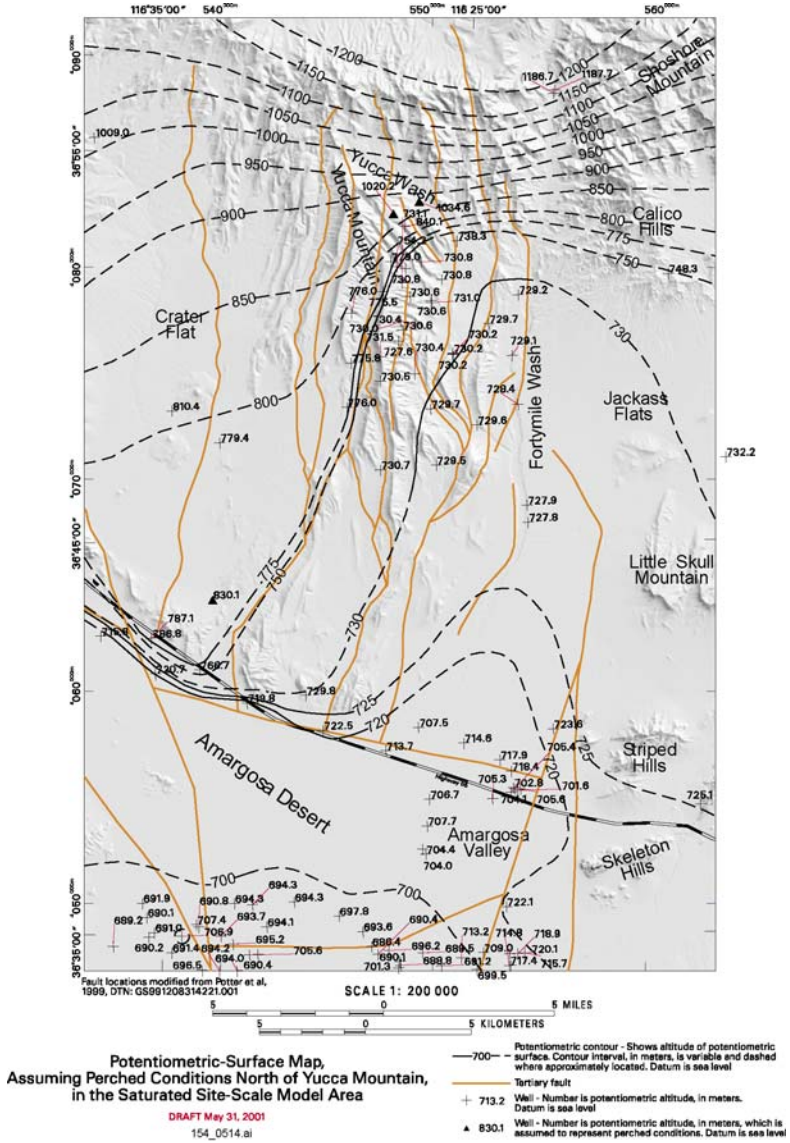
- Provide information for determining flow path directions

Results

- New water level data from Nye County Wells
- NC-EWDP-2D and 2DB:
  - Head in volcanic rocks: 706 m
  - Head in underlying carbonate aquifer: 715 m

Conclusions

- Potentiometric contours are relatively unchanged with the new data
- Further confirmation of the upward gradient from the carbonate aquifer



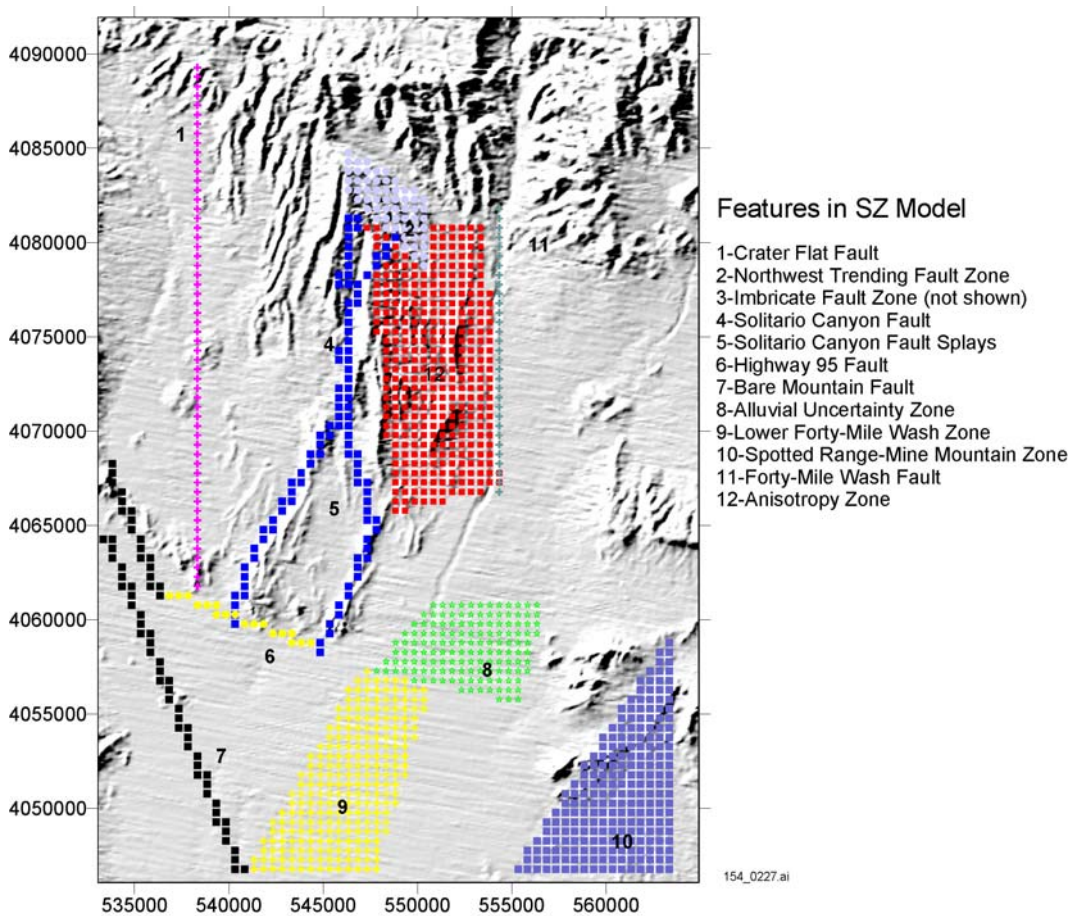
Alternate Conceptual Model - Large Hydraulic Gradient

Approach

- Replace East-West low-permeability feature with lower permeability rock in the North

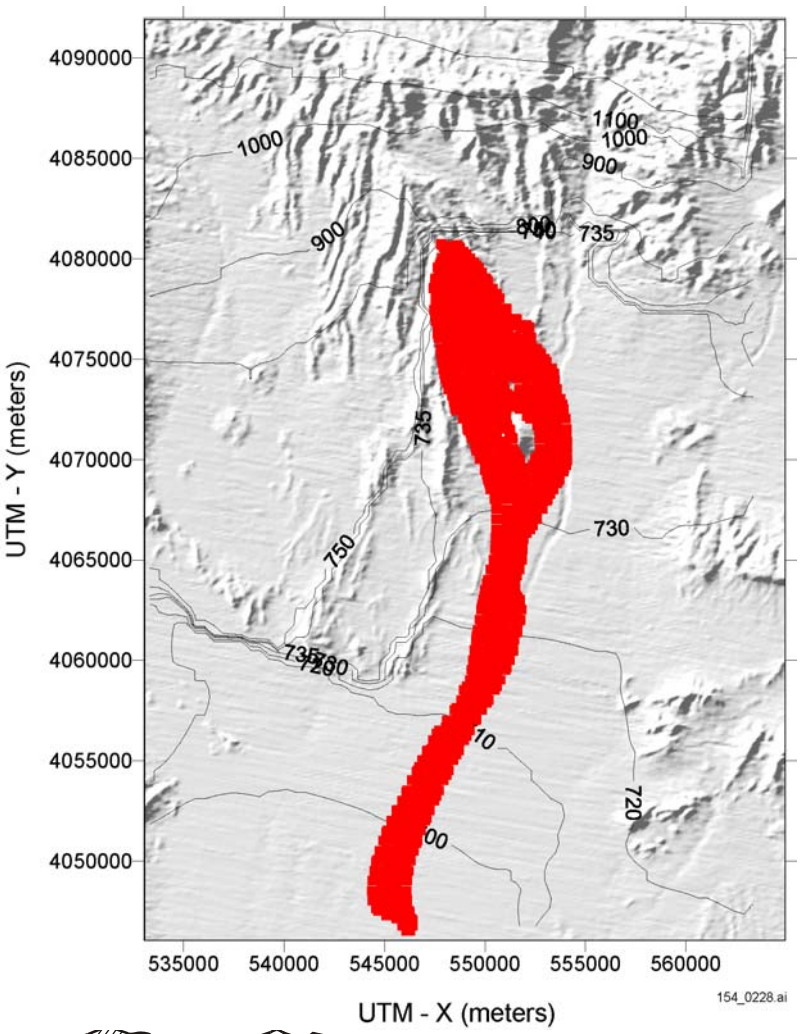
Results

- Generally better calibrations to the head data in the low gradient region in the pathways from the potential repository
- Somewhat more southerly pathlines in the alternate model

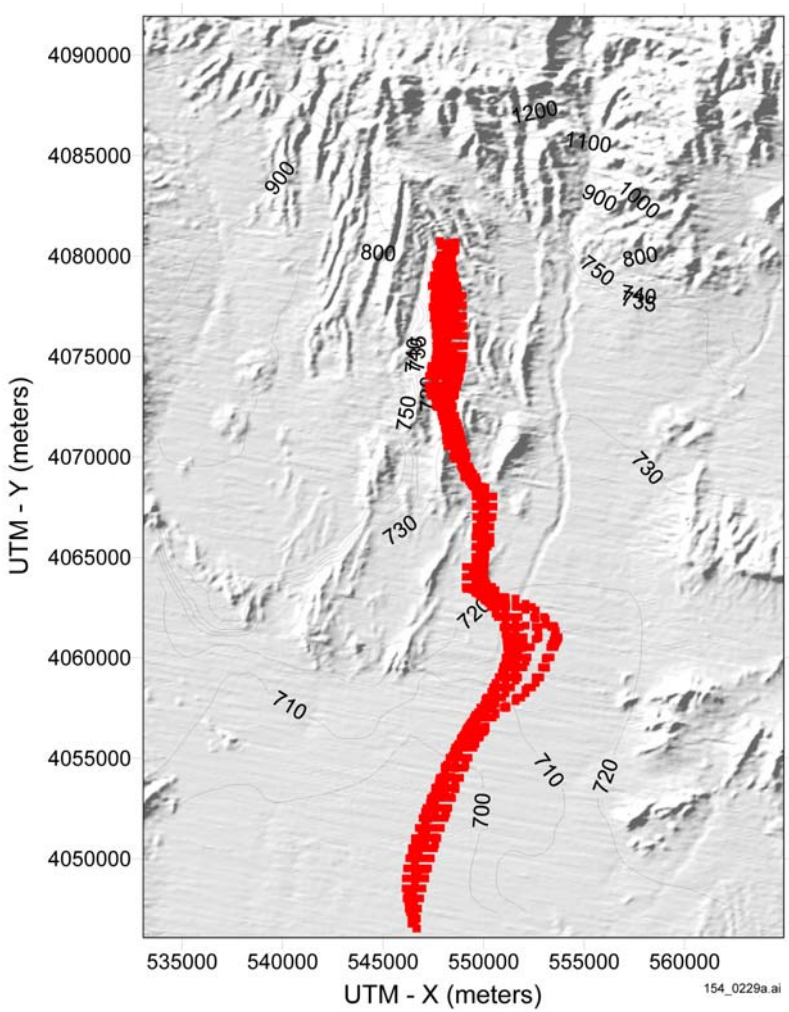


Alternate Conceptual Model - Predicted Pathlines

Original Calibrated Model



Alternate Calibrated Model



Sensitivity Analysis - Cooler Repository Design

Need for Analysis

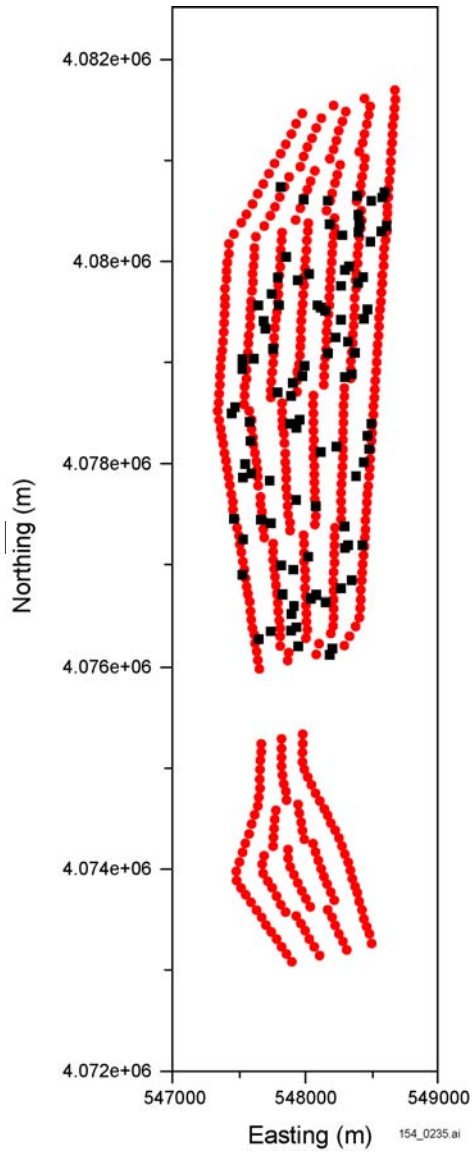
- Cooler repository design may result in larger footprint of potential repository. Impact on SZ paths and travel times must be assessed

Approach

- Compare paths and travel times for releases over larger footprint to previous model results

Conclusion

- No significant impact of a larger repository footprint



Sensitivity Analysis - Cooler Repository Design

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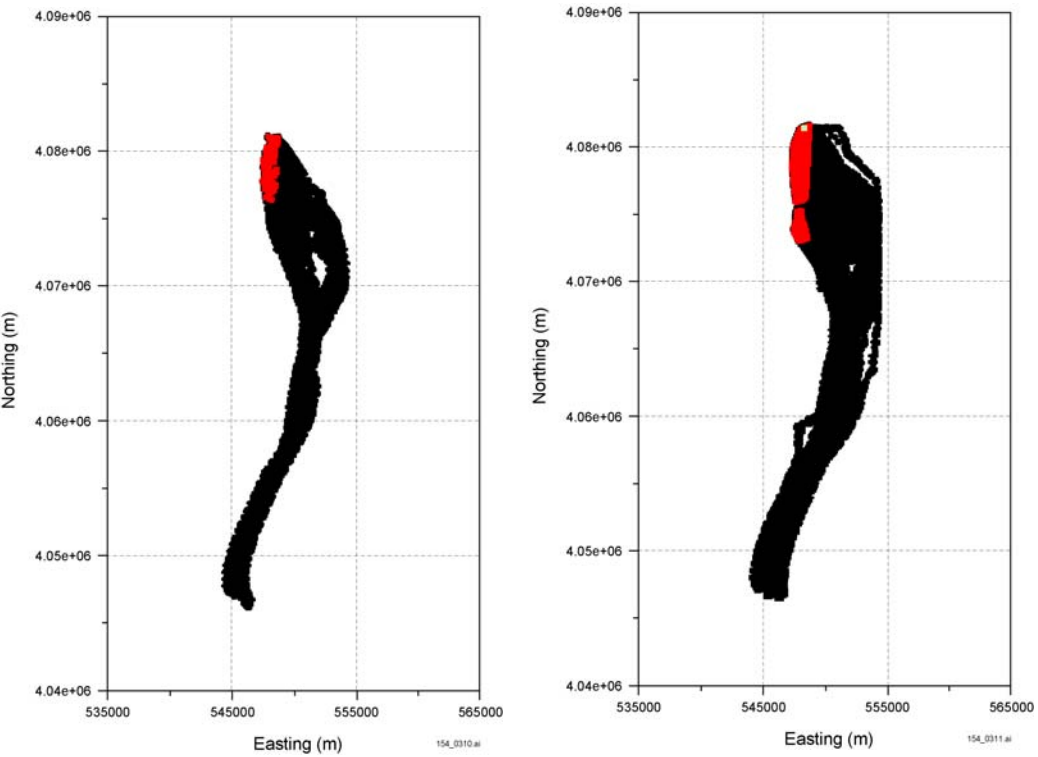
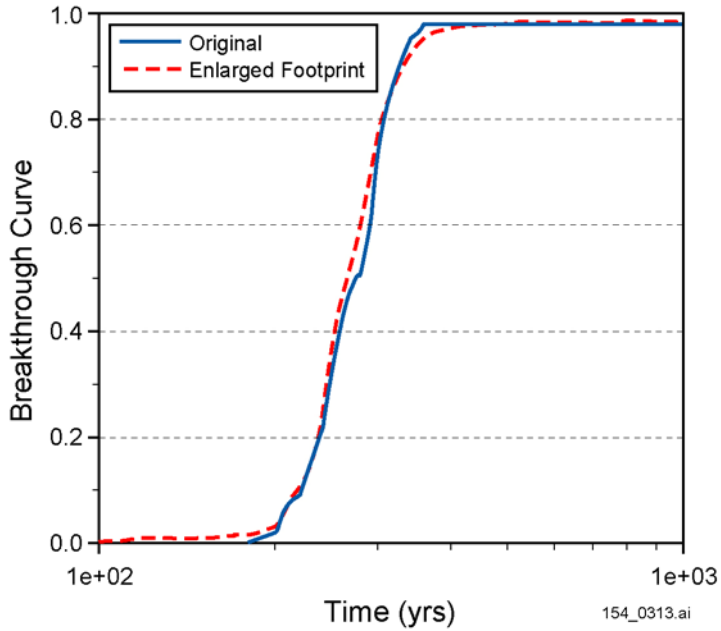
Flowpaths from Potential Repository



Travel times



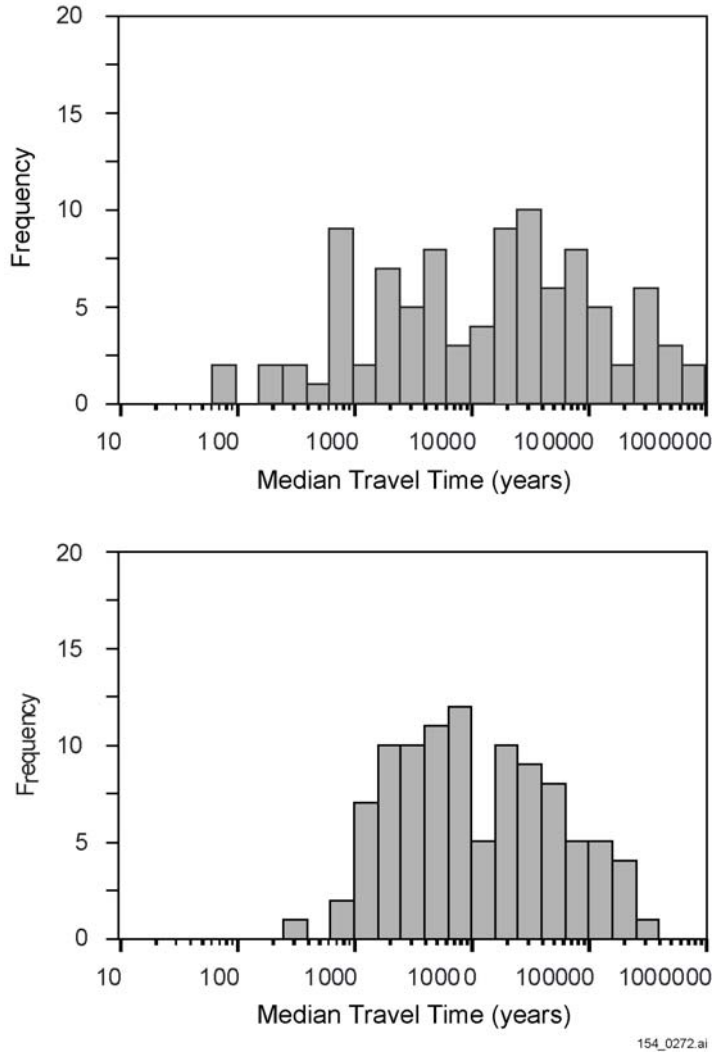
Unquantified Uncertainties

- **Rock Properties**
  - **Bulk density ***
  - **Fracture porosity**
  - **Effective porosity in alluvium**
- **Transport Properties**
  - **Effective diffusion coefficient**
  - **Sorption coefficients ***
  - **Retardation factor for colloid transport in alluvium**
- **Flow Parameters**
  - **Groundwater specific discharge**

*** New Values/Ranges were used in TSPA-SR supplemental analysis**

Unquantified Uncertainties - Np Transport

- **Previously unquantified uncertainties are examined using multiple realizations of the model for the new parameter distributions and comparing the distributions of travel times to the 20 km compliance boundary**
- **Np transport results reflect primarily the narrower range of values for the groundwater specific discharge in the distribution**



Multiple Lines of Evidence

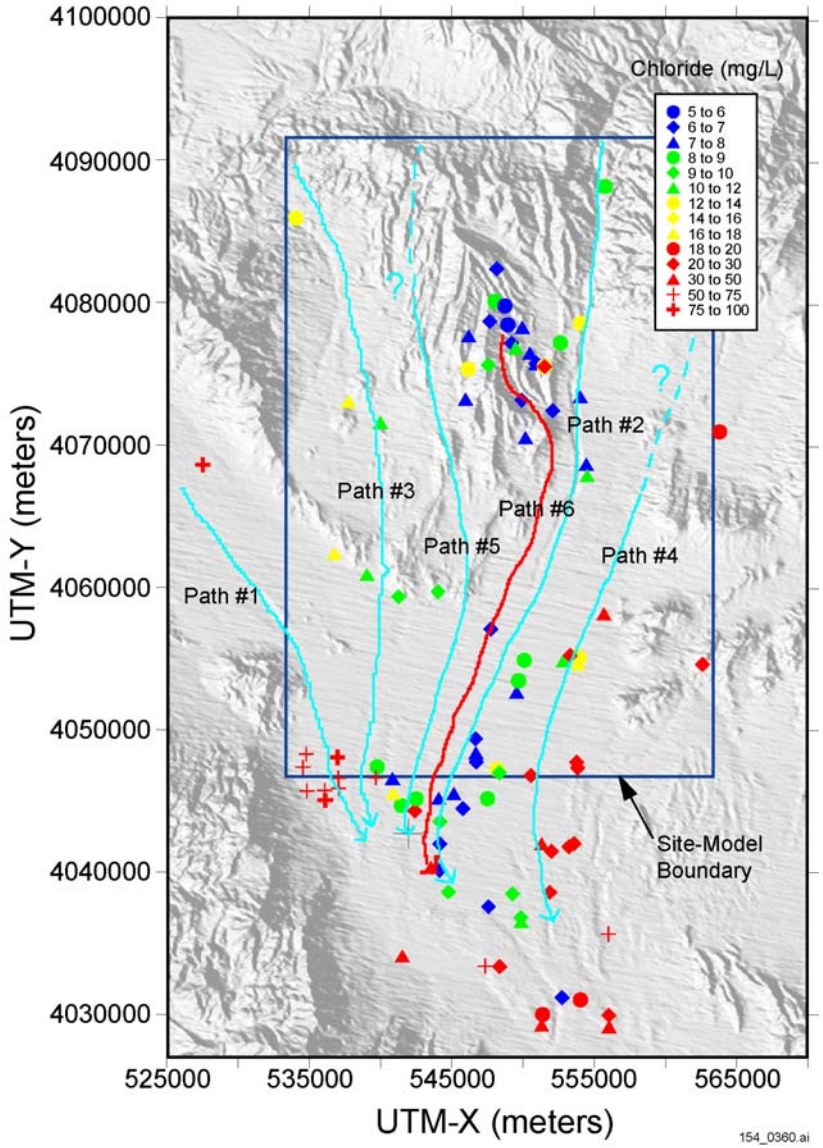
- **Interpretations of Yucca Mountain Data**
  - **Yucca Mountain Hydrochemical and Isotopic Data**
  - **Single-well tracer tests at the ATC**
  - **$^{234}U/^{238}U$ ratios in SZ fluids**
- **Examination of Independent Analyses of the Yucca Mountain SZ**
  - **EPRI flow and transport modeling**
  - **NRC flow and transport studies**
- **Natural and Anthropogenic Analogs (non-YM)**
  - **Uranium migration (mill tailing sites; Pocos de Caldas, Brazil; Alligator Rivers, Australia)**
  - **Radionuclides at other DOE facilities (INEEL, NTS)**

Yucca Mountain Hydrochemical and Isotopic Data

Assumption - trends in the chemical data can be used to delineate large-scale features of the groundwater flow patterns

- **Multiple chemical and isotopic species were used to constrain the flow model (d^2H, $d^{18}O$, Cl^-, SO_4^{2-}, Na^+, Ca^+)**

Conclusion - Flow model results using particle tracking are consistent with the flow patterns deduced from the hydrochemical data



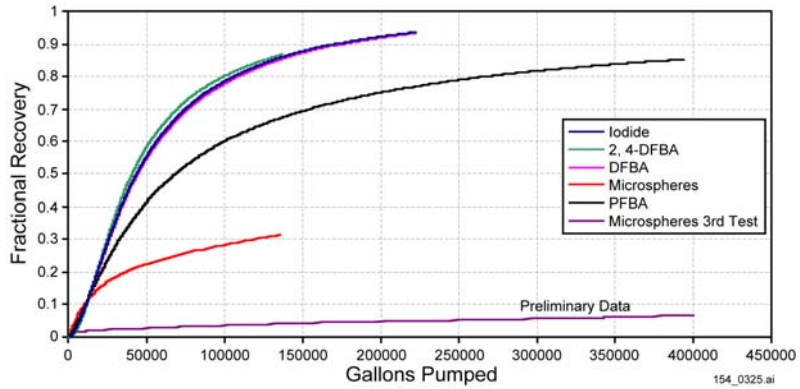
Single-Well Tracer Tests at the ATC

Goal: Validation of porous continuum conceptual model for transport in alluvium

Results: Results are consistent with the conceptual model

- **Dissolved species with different diffusion properties exhibit insignificantly different recoveries (no diffusion into stagnant pore water)**
- **Lower microsphere recoveries and short, temporary spikes after shut-ins are consistent with the filtration model**

Fractional Recoveries of Six Tracers



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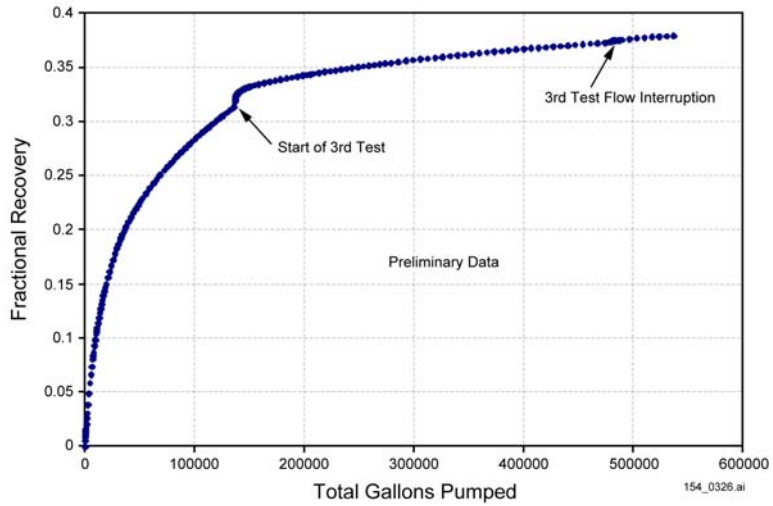


$^{234}U/^{238}U$ Ratios in SZ Fluids

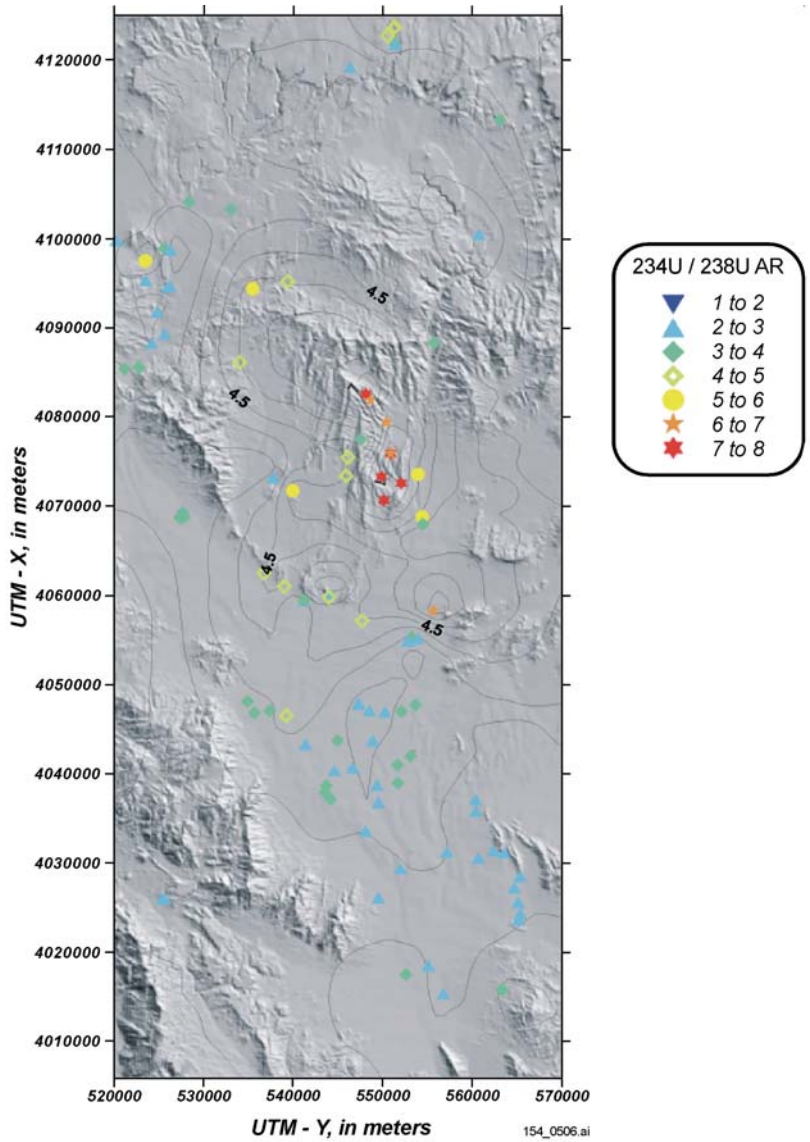
Approach: Distinctive $^{234}U/^{238}U$ ratios in fluids recharging the SZ at Yucca Mountain provide a natural tracer for fluids that potentially will be carrying released radionuclides from the repository

Results

- **The presence of anomalous ratios at Yucca Mountain support the hydrologic isolation and slow movement of the groundwater directly beneath the Mountain**
- **Lower ratios downstream of Yucca Mountain are consistent with dilution due to dispersion and mixing**

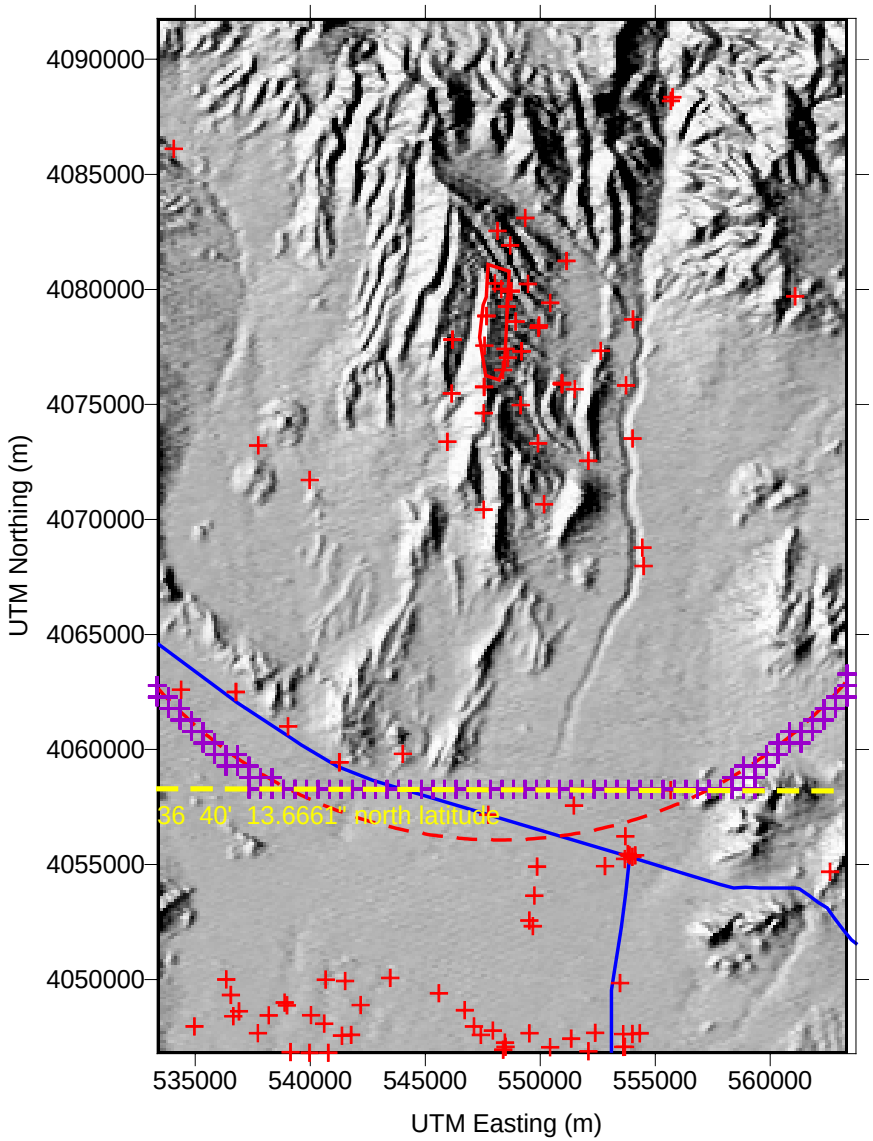
Uncertainties

- **Possible source term from rock dissolution**
- **Mechanism for high ratios in Yucca Mountain fluid is unknown**



Final 40 CFR Part 197 Standard for Yucca Mountain

- **New EPA standard specifies a compliance boundary somewhat closer to the potential repository than assumed for transport analyses performed to date**



Final 40 CFR Part 197 Standard for Yucca Mountain

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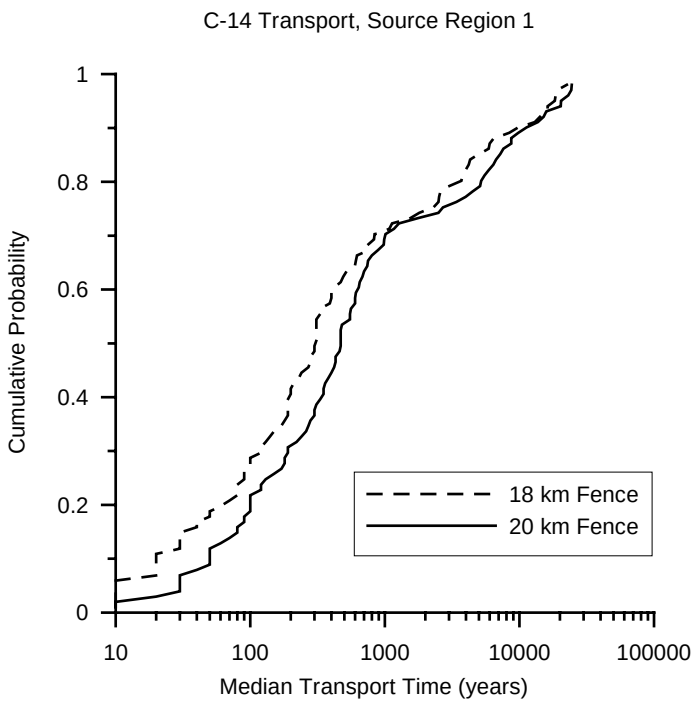
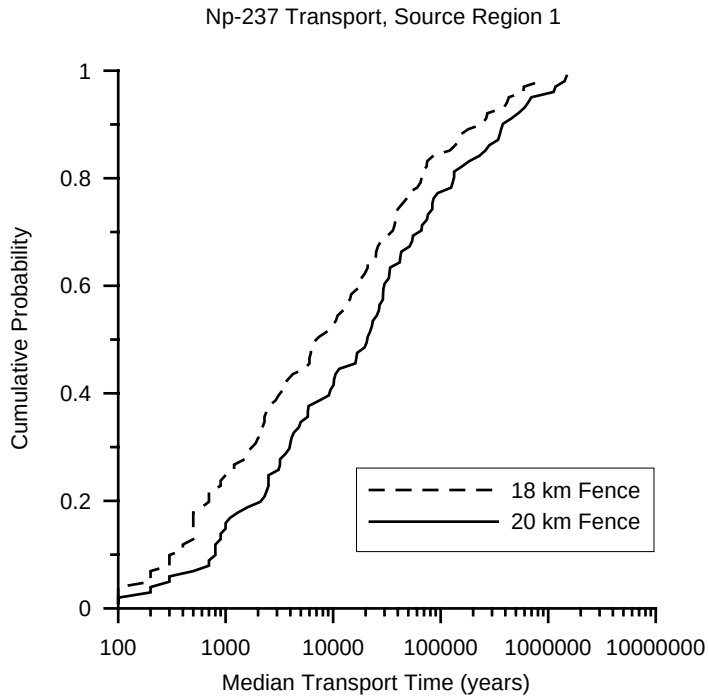
- **New compliance boundary results in somewhat shorter travel times due to shorter flow path length in the alluvium**

^{14}C Travel Time Comparison



^{237}Np Travel Time Comparison



Summary

- Newly collected data in general confirms the previous representation of the SZ in the site-scale model
- New flow model representations allow for a more complete examination of conceptual model uncertainties
- A hypothetical larger repository footprint has very little impact on predicted SZ performance
- Unquantified uncertainties analyses have resulted in somewhat narrower ranges of SZ behavior compared to previous analyses
- Multiple lines of evidence have been investigated to provide independent confirmation of various conceptual models and assumptions
- Newly published regulatory standard for Yucca Mountain prescribes a slightly closer compliance boundary, resulting in somewhat shorter travel times in the SZ