THE ROLE OF GEOLOGY AT THE PROPOSED YUCCA MOUNTAIN NUCLEAR WASTE REPOSITORY

Overview of the Storage of High-Level Nuclear Waste at Yucca Mountain

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HISTORY

1957 – National Academy of Sciences convenes a meeting of scientists and engineers to consider the permanent disposition of long-lived highly radioactive wastes from commercial nuclear power reactors and nuclear weapons production.

The general conclusion was that it could be disposed in mines built in deep salt deposits that were 200 to 300 million years old. The rationale was that the salt deposits had survived without being dissolved by groundwater, meaning it had been isolated from the near-surface environment for its entire history. And salt is plastic – it flows slowly to fill any voids, so it will encapsulate any waste in a mined opening. Closure rates in salt mines can be on the order of inches per year.

Various government programs searching for geologic disposal sites failed primarily because there was no statutory mandate authorizing the search for such a politically unacceptable facility.

1977 – The U.S. General Accounting Office suggested the search be widened to include the sites of Atomic Energy Defense Facilities – regardless of the rock types available there. The rationale was that states with these facilities would have less political opposition to such an activity.

Locations at the Nevada Test Site were examined but were rejected for various reasons including conflicts with the NTS mission – nuclear weapons testing.

But Yucca Mountain was considered an acceptable location, being adjacent to the southwest corner of NTS on land held by the Bureau of Land Management and the Air Force.

Yucca Mountain is a N-S trending ridge of volcanic tuff easily accessible from NTS. The National Academy of Sciences was asked whether volcanic tuff could be an acceptable host rock, and the answer was that there is <u>no</u> generic reason why it would <u>not</u> be acceptable.

GEOLOGIC DISPOSAL CONCEPT - 1980

Final Environmental Impact Statement – Management of Commercially Generated Radioactive Waste, October 1980

Geologic disposal is the disposal of radioactive wastes in conventionally mined repositories deep within the geologic formations of the earth.

Included is the concept of multiple barriers to provide a series of independent barriers to the release of radionuclides to the biosphere.

Multiple barriers fall in two categories: 1) geologic, or natural; 2) engineered.

Geologic barriers are expected to provide isolation for at least 10,000 years after the waste is emplaced, and probably will provide isolation for millennia thereafter.

Engineered barriers are designed to assure total containment within the disposal package throughout the initial period during which most of the intermediate-lived fission products decay. This period might be as long as 1,000 years.

Tectonic stability and non-communicating hydrologic regime combine with rock properties to maintain repository strength and isolation integrity.

1982 – The Nuclear Waste Policy Act of 1982 was passed by Congress, establishing deep geologic disposal as the national policy for highly radioactive waste from nuclear weapons production and used nuclear fuel from commercial nuclear power reactors.

The NWPA established a screening process for recommendation of repository sites that applied factors from a required set of guidelines that would qualify or disqualify a site for repository development. "Such guidelines shall specify detailed geologic considerations that shall be primary criteria for the selection of sites in various geologic media."

Nine sites in six states that the Department of Energy had been studying before the NWPA were found to be "potentially acceptable."

Texas – 2 sites in bedded salt on private land
Utah – 2 sites in bedded salt on Public land
Louisiana – 1 site in a salt dome on private land
Mississippi – 2 sites in salt domes on private land
Washington – 1 site in volcanic basalt on the DOE Hanford Reservation
Nevada – 1 site in volcanic tuff on Public, DOE, and Department of Defense land

1986 – The DOE, using the site screening guidelines, selected 3 sites with 3 different rock types as "candidate" repository sites for detailed study: Deaf Smith County, Texas; Hanford, Washington; and Yucca Mountain, Nevada.

The NWPA screening process, following site characterization, would have one of these three sites recommended by the Secretary of Energy to the President for approval to be the subject of a license application to the Nuclear Regulatory Commission for development of a repository.

1987 – Congress amended the Nuclear Waste Policy Act to make the Yucca Mountain site the only candidate site for characterization and recommendation for development as a repository. It also deferred the ongoing NWPA screening process for sites for a second repository. Claimed reasons: a)site screening behind schedule, b) estimated cost to characterize a single site escalated from $80 million to $1 billion. Real and undenied reason: POLITICS.

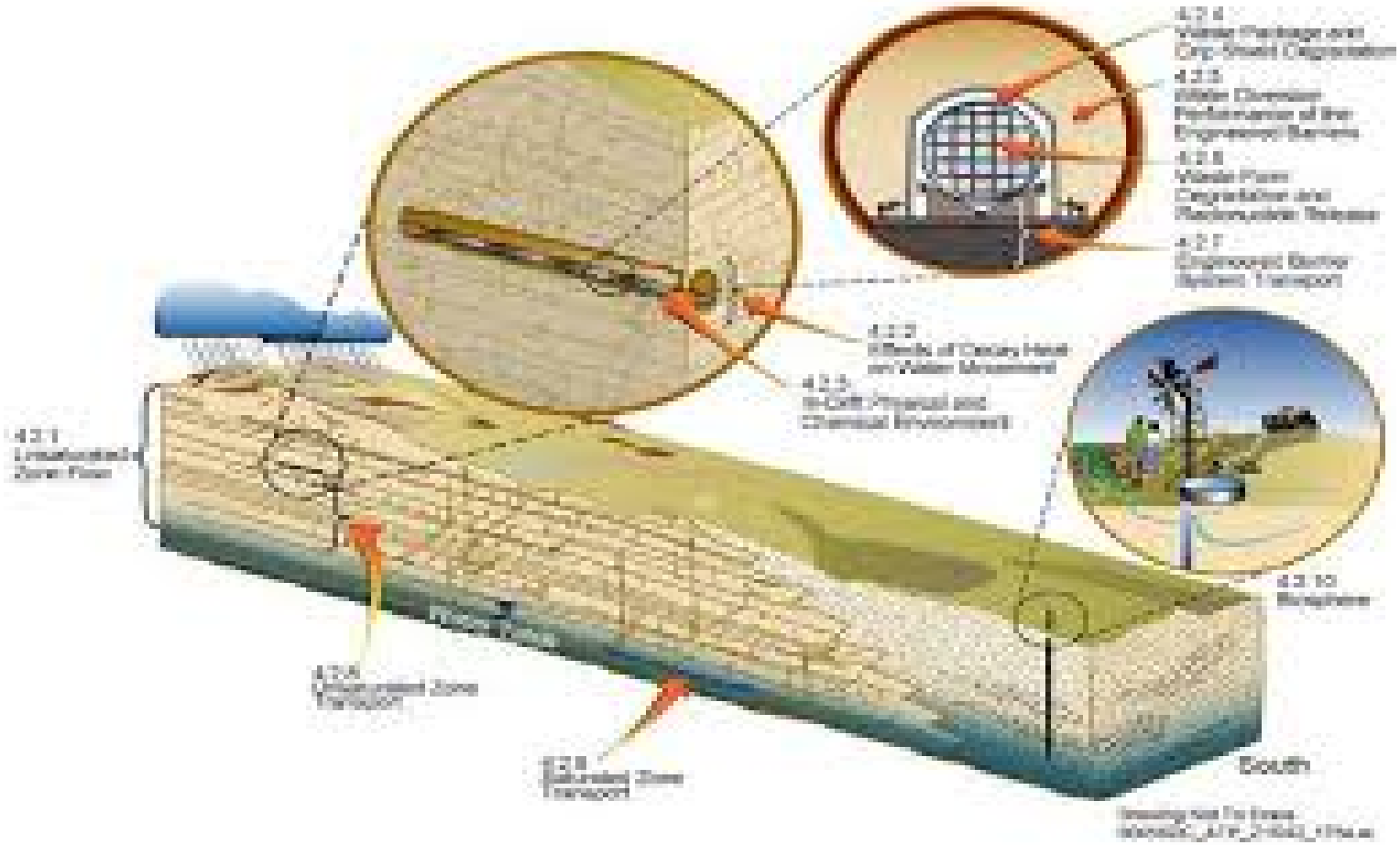
1992 – Site characterization work at Yucca Mountain indicated that projected radionuclide releases would exceed the EPA Radiation Protection Standard for geologic repositories within the 10,000 year regulatory period. DOE efforts to have EPA relax its standard failed, so Congress instructed EPA, in the Energy Policy Act of 1992, to write a new "reasonable" health, or dose based radiation protection standard specific to a Yucca Mountain repository. The new standard was to be written consistent with a study to be done by the National Academy of Sciences (NAS) on the Technical Bases for a Yucca Mountain Standard.

The EPA general Standard that would be violated by a Yucca Mountain repository did not contemplate the unique repository design, based on the geology of Yucca Mountain, where waste would be emplaced in the rock about 800 feet below ground, but still about 800 feet above the water table. The radionuclide release that would exceed the release standard would be carbon-14 in the form of carbon dioxide gas that would be inhaled by an exposed individual at the ground surface.

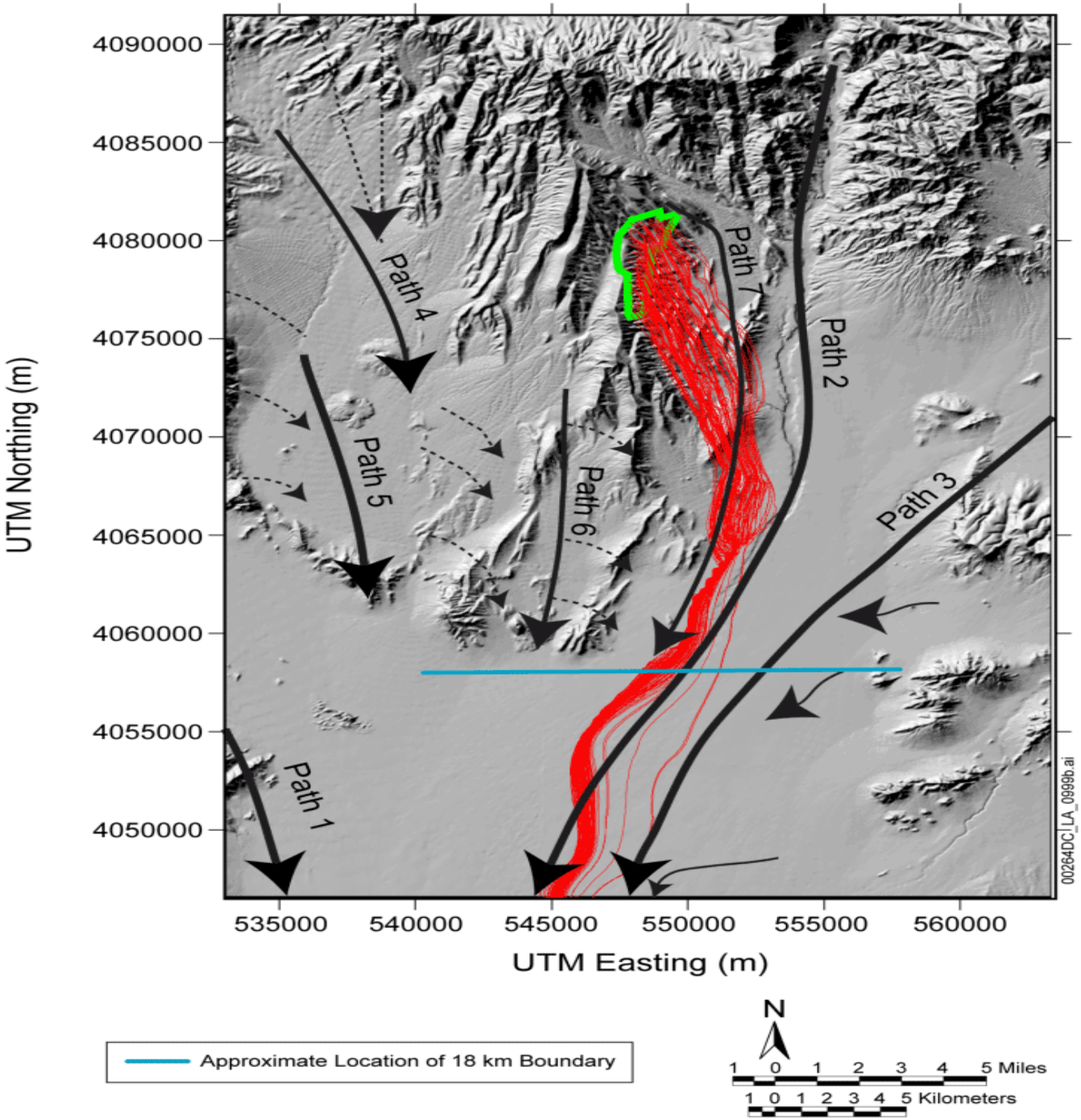
1995 - The NAS Technical Bases report concluded that a risk, or dose based standard, rather than a radionuclide release based standard is reasonable for a Yucca Mountain repository where the waste would be placed above the water table in the unsaturated zone. The report also concluded that the regulatory period should include the time at which the maximum radiological risk to the public is expected to occur from repository releases.

DOE models indicated the time of maximum risk was far later than the 10,000 year period in the original EPA Standard. And, the NAS report concluded that given the geologic characteristics of the Yucca Mountain site, a regulatory period of 1 million years is appropriate and implementable for compliance determination using a Total System Performance Assessment (TSPA) model to calculate expected doses through the regulatory period.

Precipitation will infiltrate the mountain through fractures, contact the waste, and carry contaminants down to the water table. Groundwater flowing beneath the waste buried in Yucca Mountain will carry the radionuclides released from the repository to the accessible environment.


South


CAUTION


UTM Northing (m)
4090000
4085000
4080000
4075000
4070000
4065000
4060000
4055000
4050000
535000
540000
545000
550000
555000
560000
UTM Easting (m)
Path 1
Path 2
Path 3
Path 4
Path 5
Path 6
Path 7
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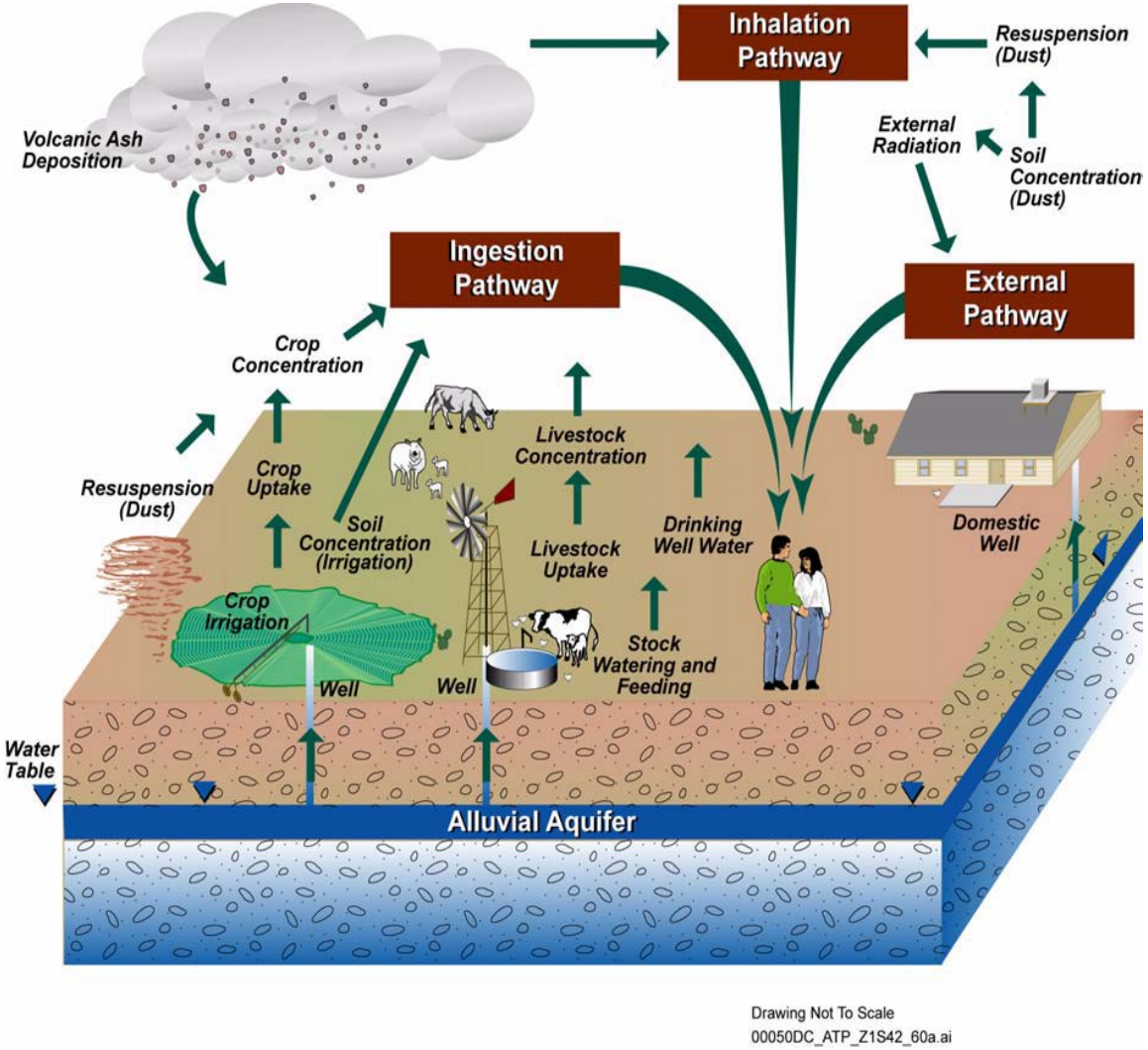
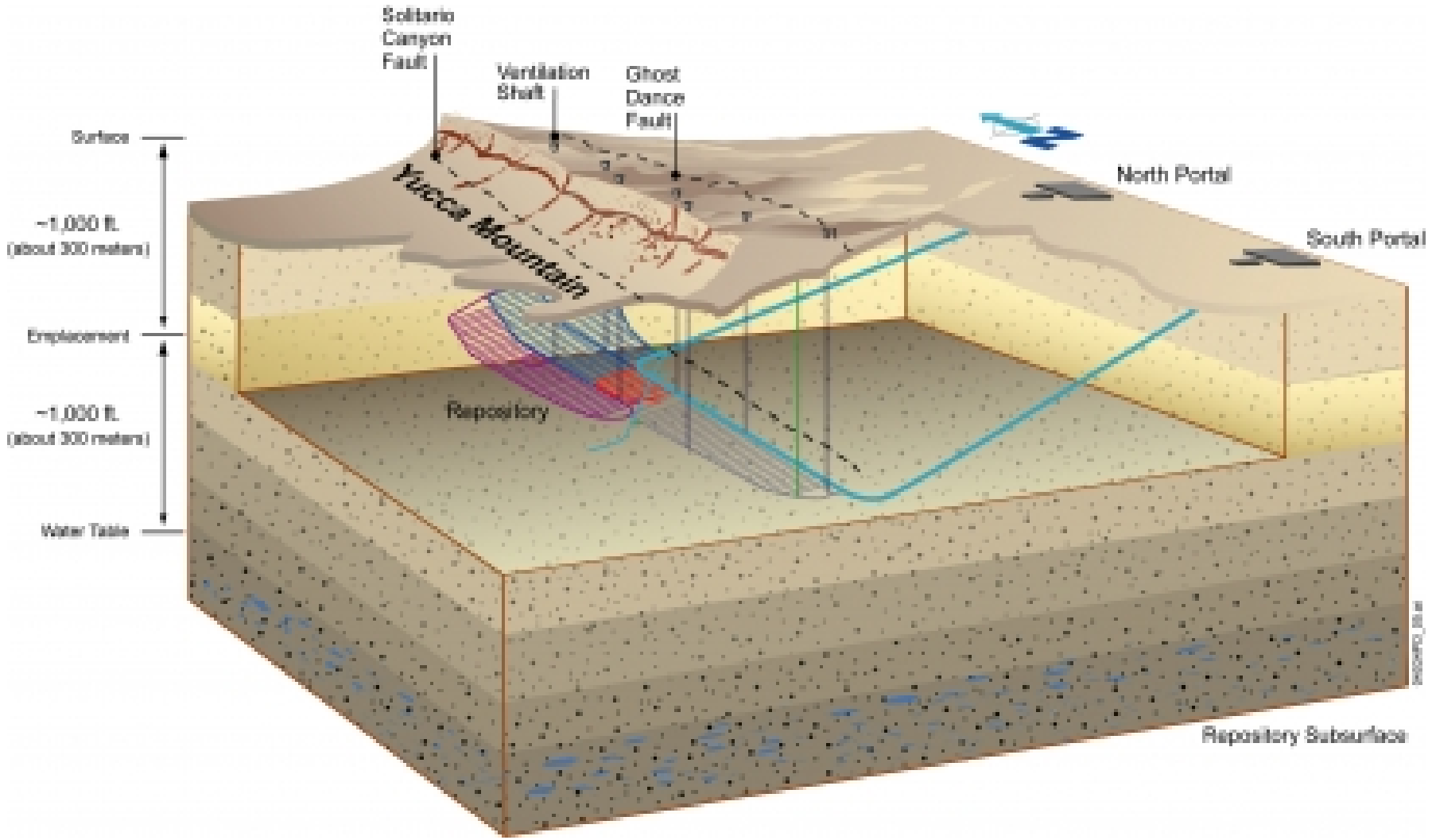
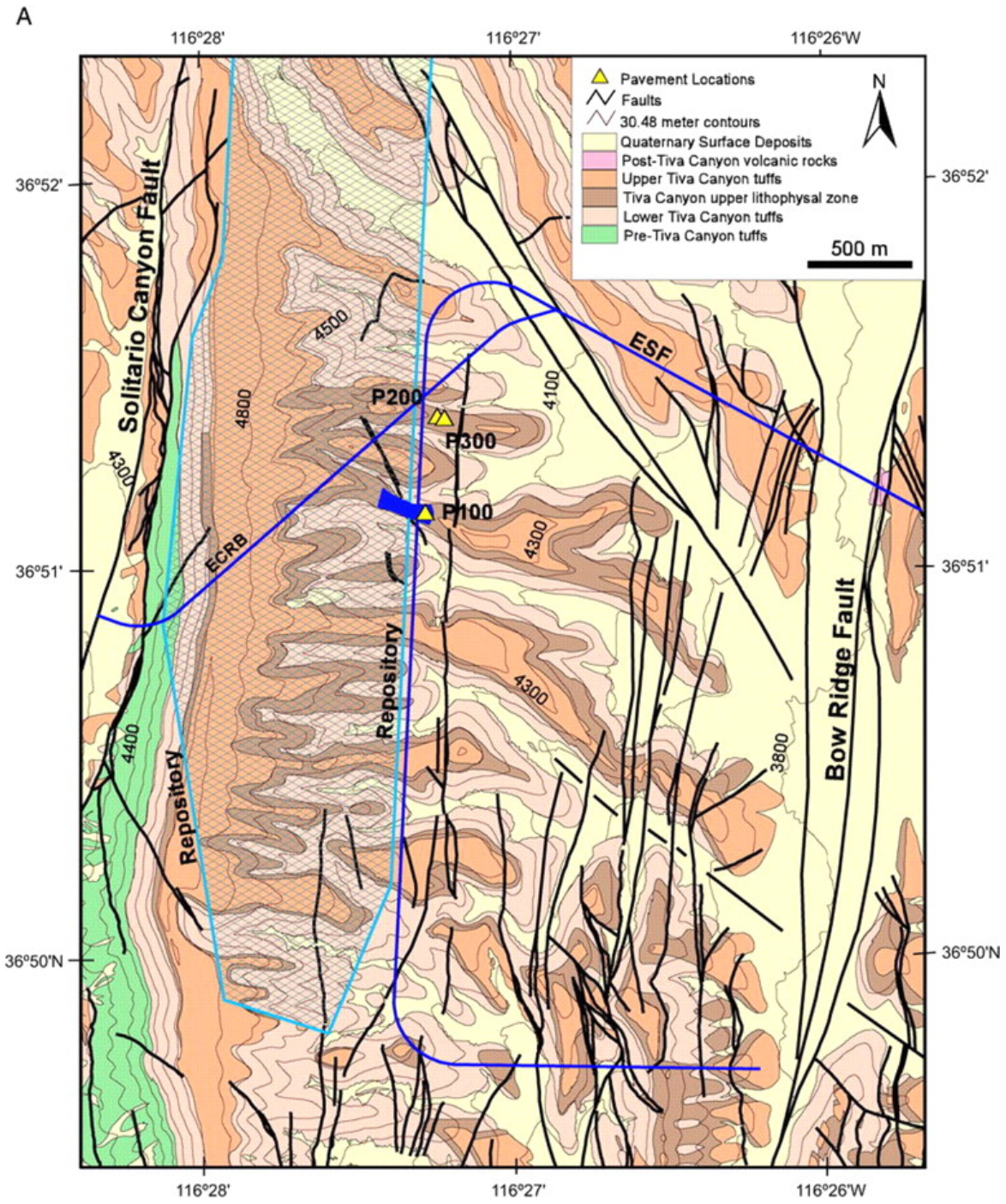
Approximate Location of 18 km Boundary
N
1 0 1 2 3 4 5 Miles
1 0 1 2 3 4 5 Kilometers


Inhalation Pathway
Resuspension (Dust)
Volcanic Ash Deposition
External Radiation
Soil Concentration (Dust)
Ingestion Pathway
External Pathway
Crop Concentration
Livestock Concentration
Resuspension (Dust)
Crop Uptake
Soil Concentration (Irrigation)
Livestock Uptake
Drinking Well Water
Domestic Well
Crop Irrigation
Stock Watering and Feeding
Well
Well
Water Table
Alluvial Aquifer
Drawing Not To Scale
00050DC_ATP_Z1S42_60a.ai

1995 – A 5 mile-long, 25 foot diameter, U-shaped tunnel (Exploratory Studies Facility – ESF) is completed, with a 2.5 mile segment at the repository depth. Fractures in the rock at repository depth are found to contain residue from atmospheric nuclear weapons tests from the 1950s.


Solitario Canyon Fault
Ventilation Shaft
Ghost Dance Fault
Surface
~1,000 ft. (about 300 meters)
Emplacement
~1,000 ft. (about 300 meters)
Water Table
Yucca Mountain
Repository
North Portal
South Portal
Repository Subsurface


A
116°28'
116°27'
116°26'W
36°52'
36°51'
36°50'N
Pavement Locations
Faults
30.48 meter contours
Quaternary Surface Deposits
Post-Tiva Canyon volcanic rocks
Upper Tiva Canyon tuffs
Tiva Canyon upper lithophysal zone
Lower Tiva Canyon tuffs
Pre-Tiva Canyon tuffs
N
500 m
Solitario Canyon Fault
ESF
ECRB
P200
P300
P100
Repository
Repository
Bow Ridge Fault
4500
4800
4300
4100
4300
4300
4400
3800

Finding chlorine – 36 residue caused a significant revision of the conceptual geohydrologic model and design of the repository:

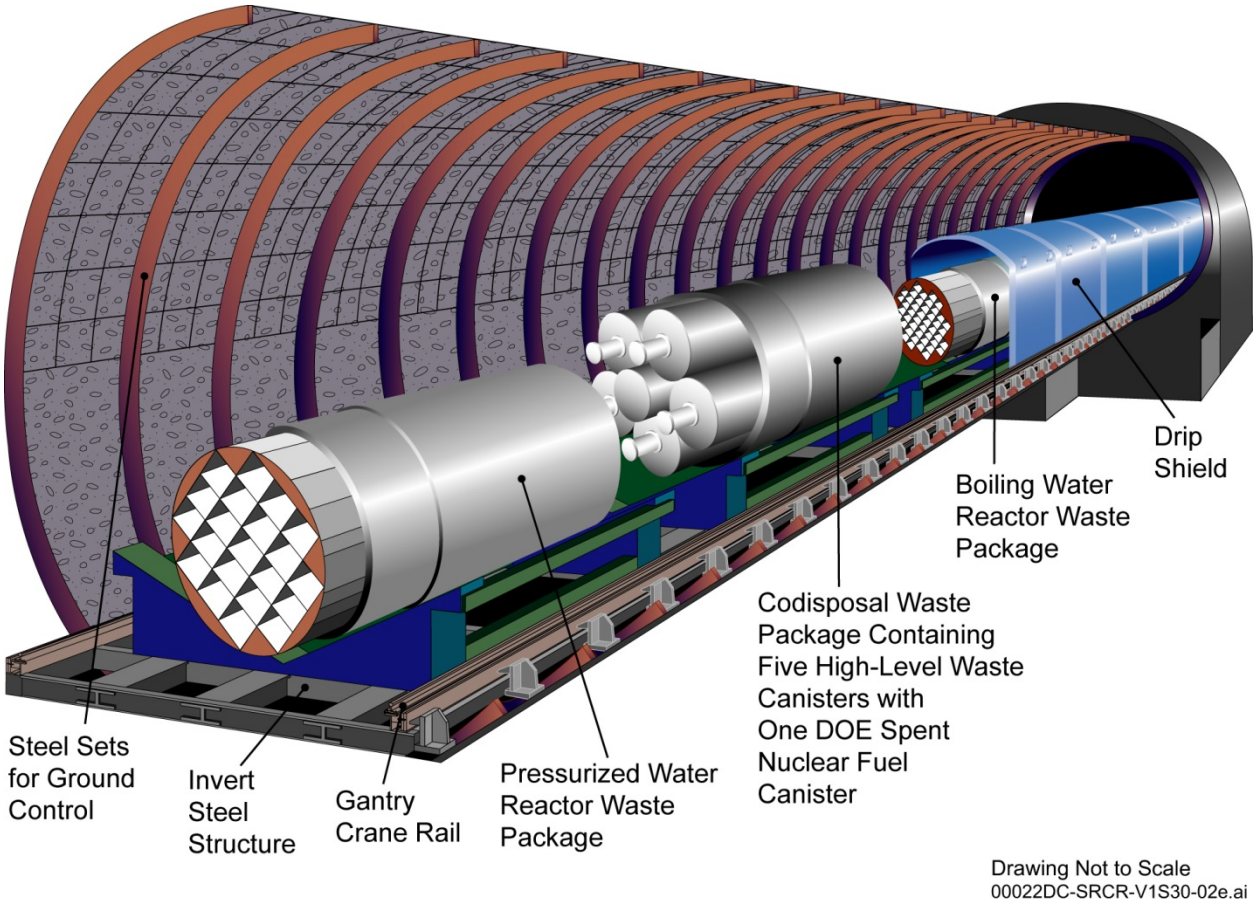
Instead of slow (thousands of years) seepage of precipitation water through the rock pores, infiltrating water moves rapidly downward through fractures and faults.

The chlorine – 36 traveled from the ground surface to the repository horizon and the water table in less than 50 years (more likely in a matter of days associated with heavy rainfall events).

Travel time of infiltrating water to the accessible environment could be on the order of just a few hundred years, or less.

Corrosion resistant waste containers will be needed to prevent early and rapid release of radionuclides to the water table and the accessible environment.

To further delay corrosion of the containers, drip shields will be needed to deflect dripping water from the container surfaces.


Steel Sets for Ground Control
Invert Steel Structure
Gantry Crane Rail
Pressurized Water Reactor Waste Package
Codisposal Waste Package Containing Five High-Level Waste Canisters with One DOE Spent Nuclear Fuel Canister
Boiling Water Reactor Waste Package
Drip Shield
Drawing Not to Scale
00022DC-SRCR-V1S30-02e.ai

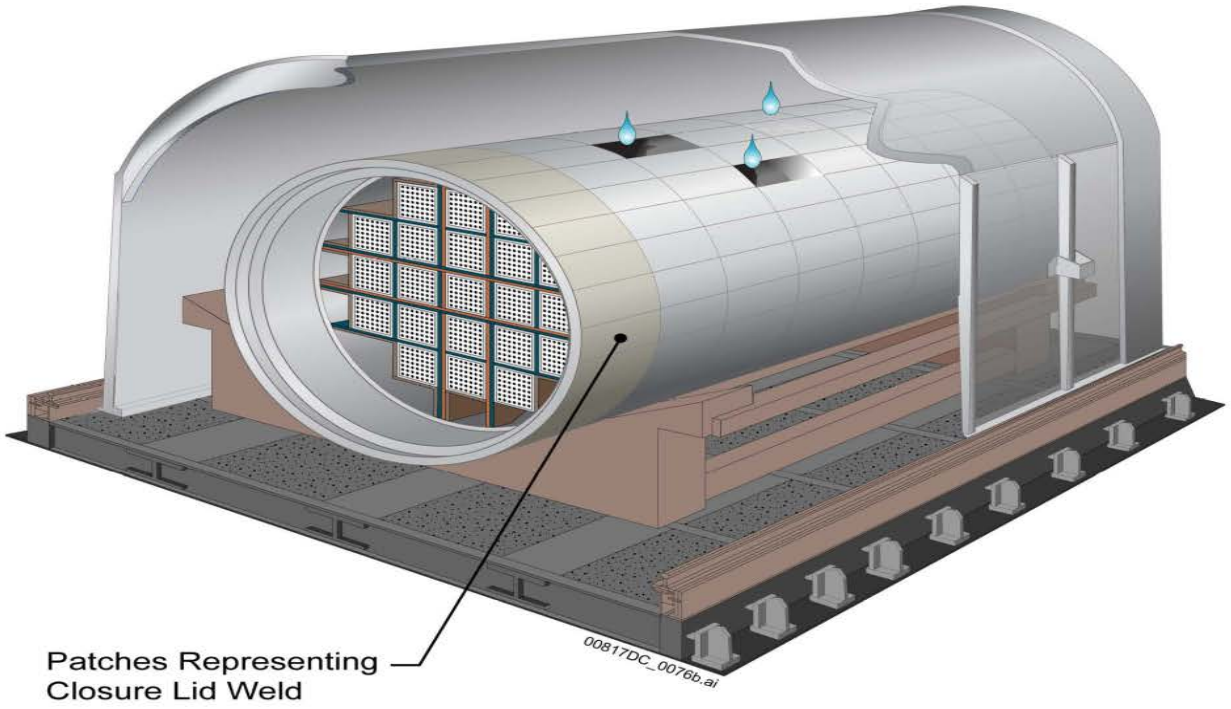
2001 – 2002 DOE Site Recommendation Guidelines, EPA Radiation Protection Standard, and NRC Repository Licensing Rule were revised to be site-specific for a Yucca Mountain repository.

DOE eliminated all qualifying and disqualifying conditions for the Yucca Mountain site, including the disqualifying condition that required groundwater travel time from the repository to the accessible environment be greater than 1,000 years.

EPA established a dose based standard (rather than release based) for protection of the public from radionuclide releases from Yucca Mountain. The standard maintained the 10,000 year regulatory period, contrary to the statutory requirement that it be consistent with the NAS Technical Bases Report recommending 1 million years. This was later remedied by the D.C. Circuit Court of Appeals, but EPA then set a double standard in which an unprecedented high dose to the public was permitted after the first 10,000 years. A lawsuit is pending.

NRC revised its repository licensing rule to rely on TSPA model analysis as the only compliance measure for protection of the public from radionuclide releases. It eliminated subsystem performance requirements such as a requirement for substantially complete radionuclide containment in the repository for at least the first 1,000 years. It also set no requirement that the geologic barrier be primary for waste isolation, and set no limit on the contribution of the engineered barrier protection against loss of waste isolation.

Based on DOE calculations, the Drip Shield is the primary barrier in the Yucca Mountain repository design. If the Drip Shield is not installed, the EPA dose standard to the public is violated 750 years after repository closure.



NOTE: Figure is for illustration purposes only and is not representative of repository postclosure performance.

Figure 6.3.5-4. Schematic of Waste Package Implementation in the Waste Package Degradation Model Showing a Waste Package in a Dripping Environment After a Drip Shield Failure and Patches Degrading from General Corrosion on the Surface of the Waste Package

2002 – The Secretary of Energy recommended the Yucca Mountain to the President for development of a repository. The Site Recommendation included a Final Environmental Impact Statement evaluating the impacts of a Yucca Mountain repository. The President immediately recommended the site to Congress for approval. Congress overrode Nevada's statutory Notice of Disapproval. The NWPA requires that DOE submit a repository license application to the Nuclear Regulatory Commission within 90 days of the final approval of the site by Congress. This did not happen until nearly six years later.

2008 – DOE submits its Yucca Mountain License Application to the Nuclear Regulatory Commission. Nevada has over 220 contentions (single subject objections) admitted for adjudication in a licensing hearing. Other parties bring the total number of contentions to nearly 300. This large number of contentions admitted is unprecedented for any license application ever reviewed by NRC.

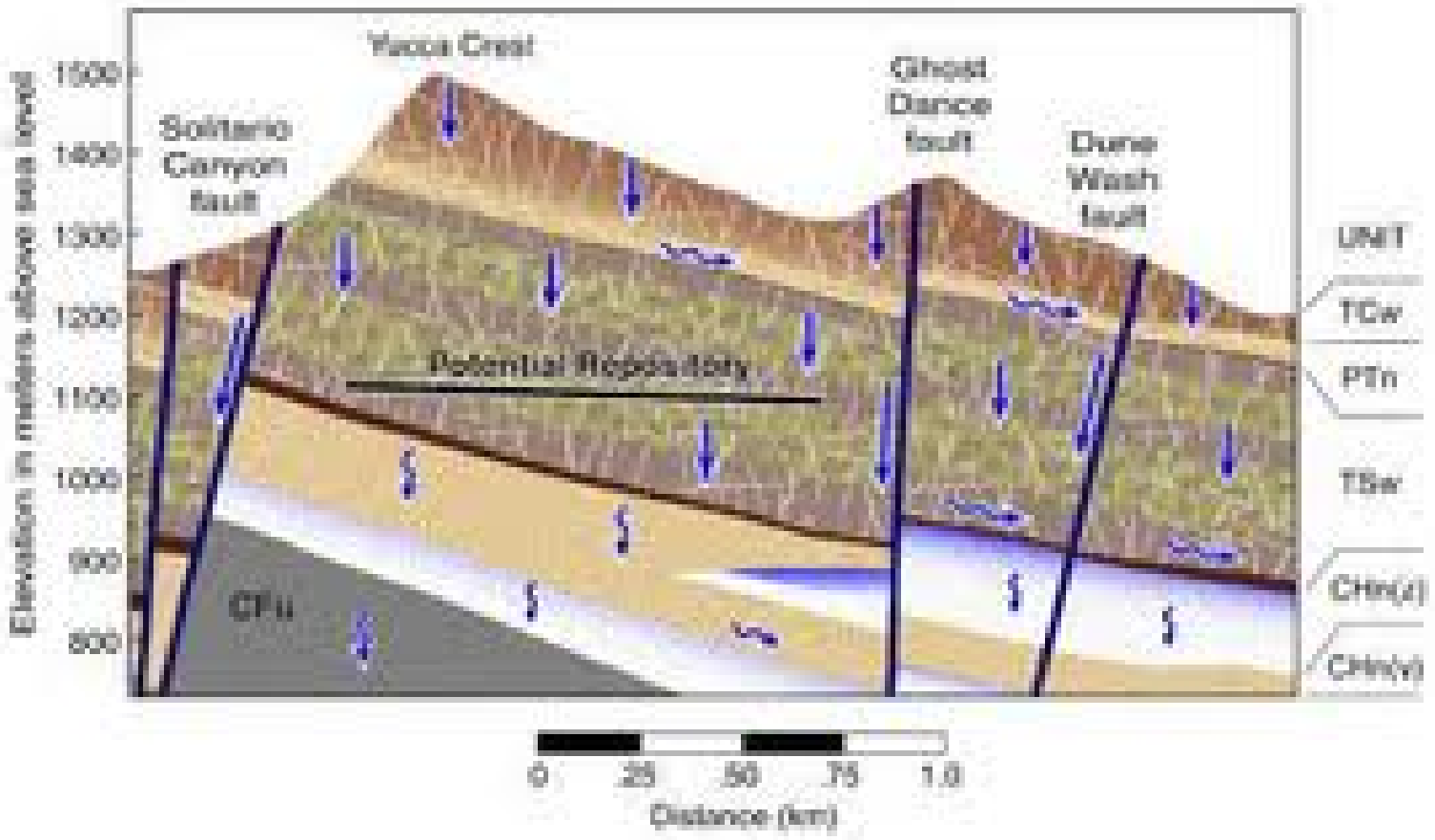
2010 – DOE files motion to withdraw the Yucca Mountain License Application saying that the project is "unworkable." NRC Licensing Board denies the motion based on its reading of the NWPA saying that the NRC must rule on the submitted application.

NRC Commissioners suspend the licensing proceeding citing lack of funds to complete the process. It had about $12 million in carry-over funds, and received no new appropriations from Congress.

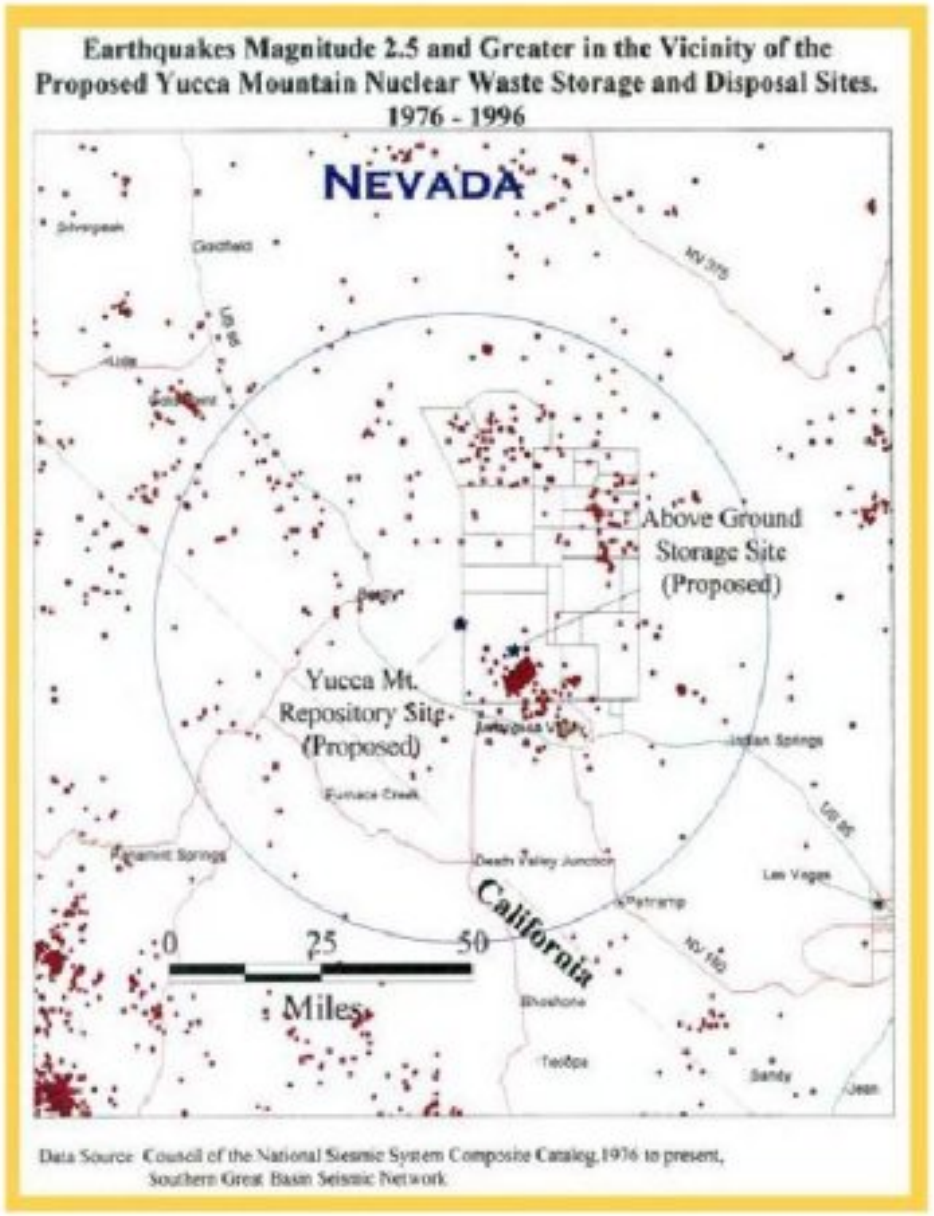
2013 – 2014 Court orders NRC to lift its suspension of the proceeding and continue until funds are consumed.
NRC Staff is writing its Safety Evaluation Report (SER) which is its finding of whether DOE's License Application meets the regulatory requirements for a Construction Authorization. This will be the NRC Staff position in the adjudicatory hearing.

NRC SER on post-closure performance will be out today (10/16/14)

FAULTS AND VOLCANISM



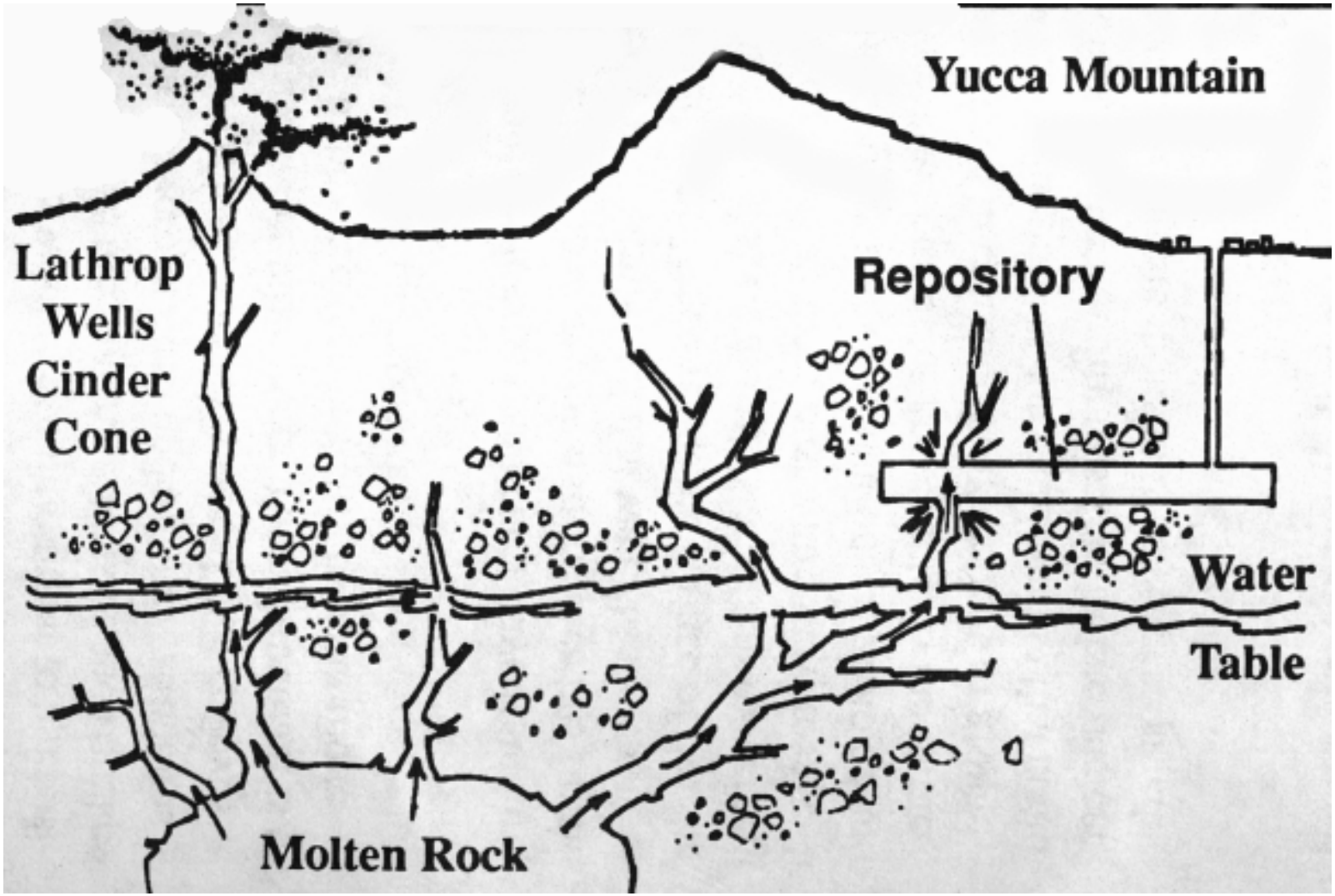
Geologic cross-section with flow patterns

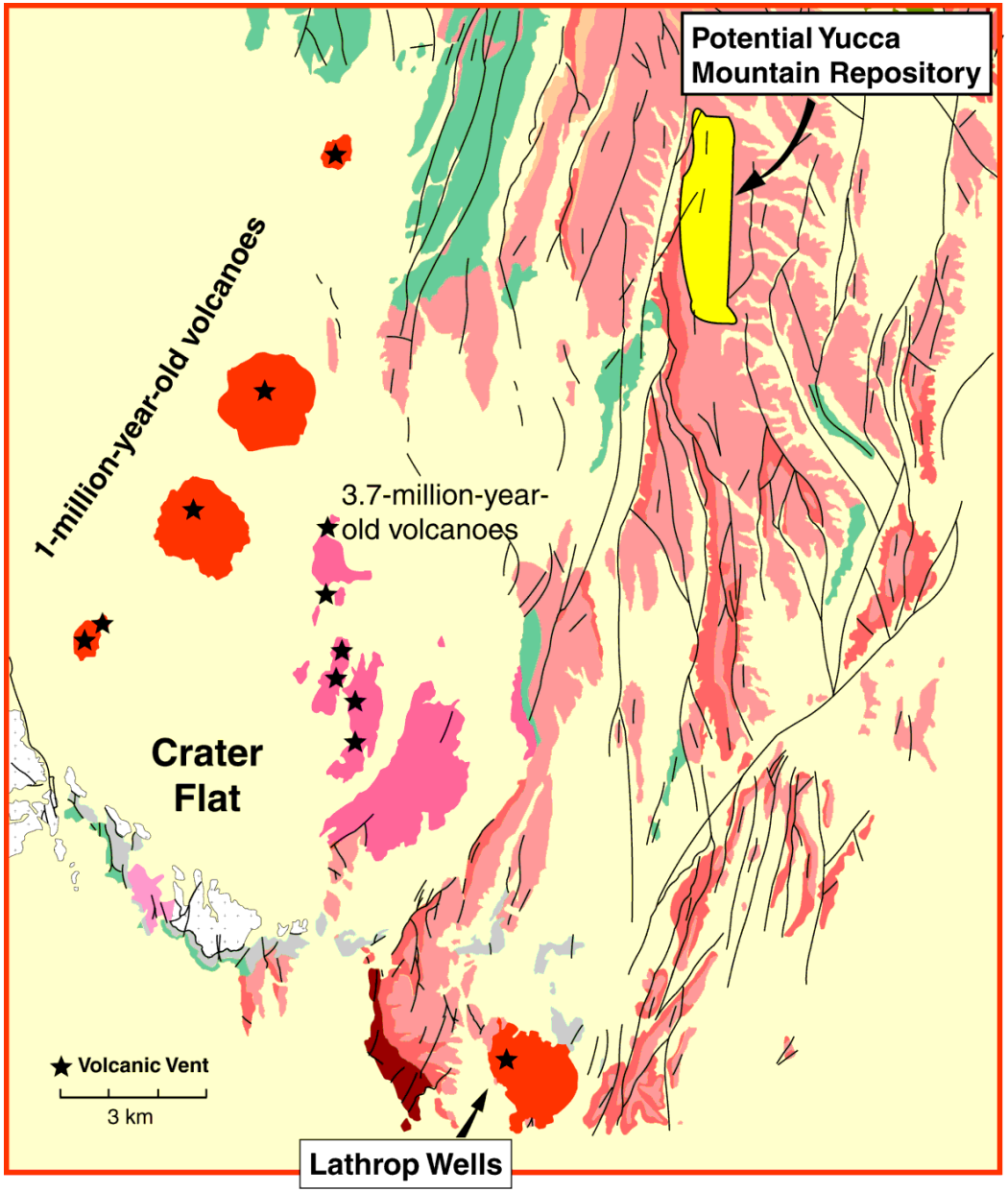


Nevada is the 3rd most earthquake prone state.

A 5.2 quake 8 miles south of Yucca Mt. in 1992 caused over $1 million in damage to DOE's own buildings.


CAUTION


Yucca Mountain
Lathrop
Wells
Cinder
Cone
Repository
Water
Table
Molten Rock


Potential Yucca Mountain Repository
1-million-year-old volcanoes
3.7-million-year-old volcanoes
Crater Flat
Volcanic Vent
3 km
Lathrop Wells

VOLCANISM

Volcanic cones and flows are visible on the surface ranging from 85,000 years to about 4 million years old

Other older magnetic anomalies buried in alluvial valley fill.

Probability of recurrence – Experts differ in their opinions

Range from 1 in 1 million to about 1 in 1 billion/ year

Settled on 1 in 70 million per year for analysis

CONCLUSION