WM2007

Radionuclide Transport from Yucca Mountain and Inter-basin Flow in Death Valley

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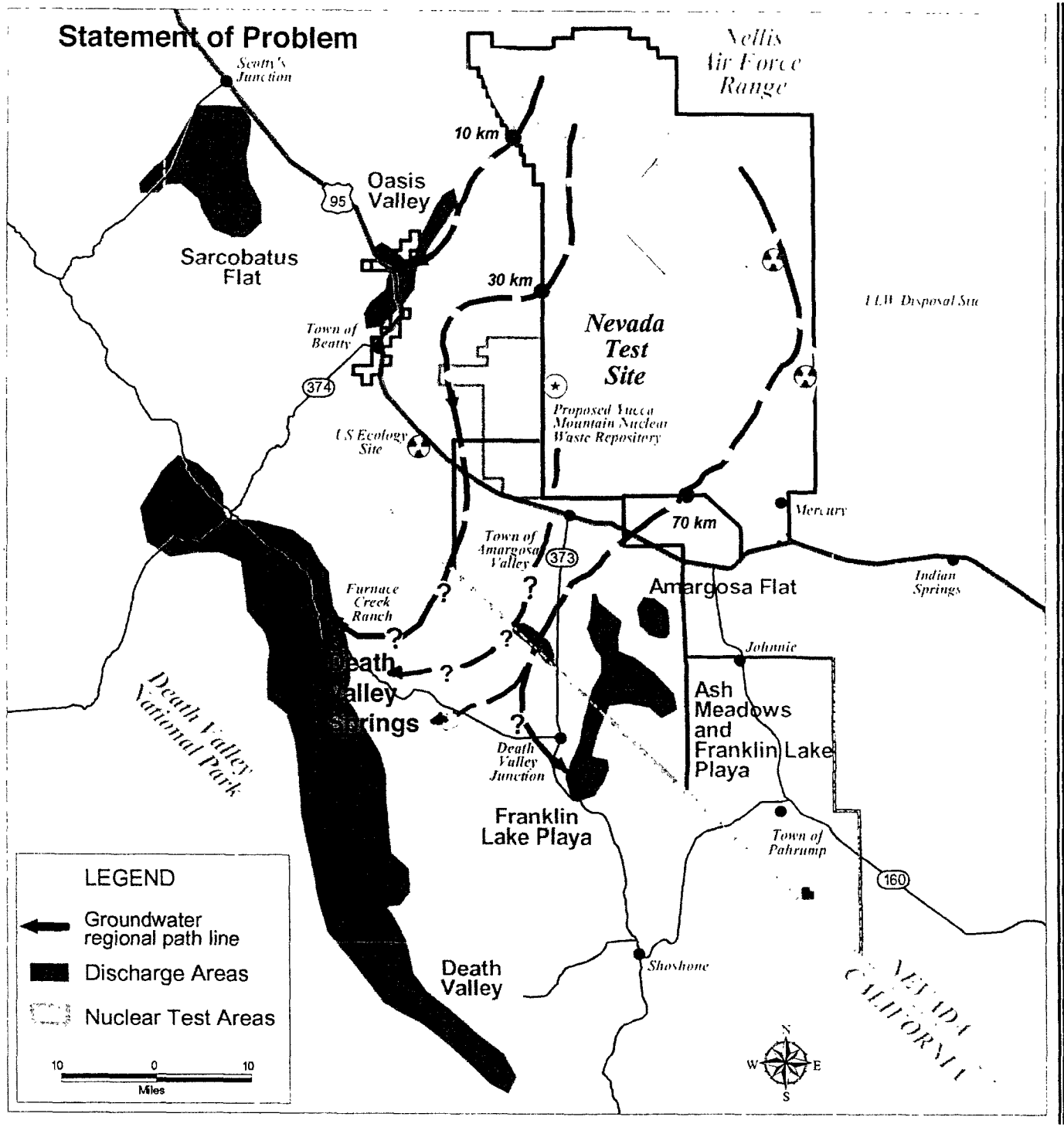
The HYDRODYNAMICS Group, LLC

Studies in Mass & Energy Transport in the Earth


Statement of Problem
Scotty's Junction
Nellis Air Force Range
10 km
Oasis Valley
95
Sarcobatus Flat
30 km
Nevada Test Site
LLW Disposal Site
Town of Beatty
374
Proposed Yucca Mountain Nuclear Waste Repository
US Ecology Site
70 km
Mercury
Town of Amargosa Valley
373
Indian Springs
Amargosa Flat
Furnace Creek Ranch
Johnnie
Death Valley Springs
Ash Meadows and Franklin Lake Playa
Death Valley National Park
Death Valley Junction
Franklin Lake Playa
Town of Pahrump
160
LEGEND
Groundwater regional path line
Discharge Areas
Nuclear Test Areas
10 0 10
Miles
Death Valley
Shoshone
NEVADA
CALIFORNIA
N
W
E
S

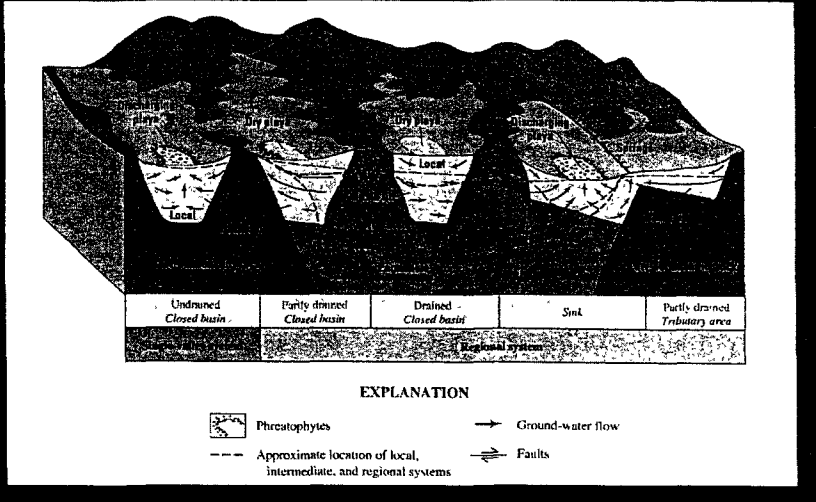
Inyo County Concerns

- Radioactive nuclide transport through the LCA into the Death Valley springs.
- Degradation of the upper gradient in the LCA impact on Furnace Creek spring flows, and on the potential of inducing radioactive nuclide transport from Yucca Mountain.

Winograd/Thordarson Inter-basin Flow Conceptual Model

CASE FOR INTER-BASIN FLOW

- Tertiary tuffs underlain by Massive Sequence of Paleo-carbonate rock.
- Paleo-carbonate rock represent a highly permeable aquifer.
- Paleo-carbonate aquifers have a significant upward gradient.
- Surface expressions of the Paleo-carbonate aquifer manifested in major spring systems.

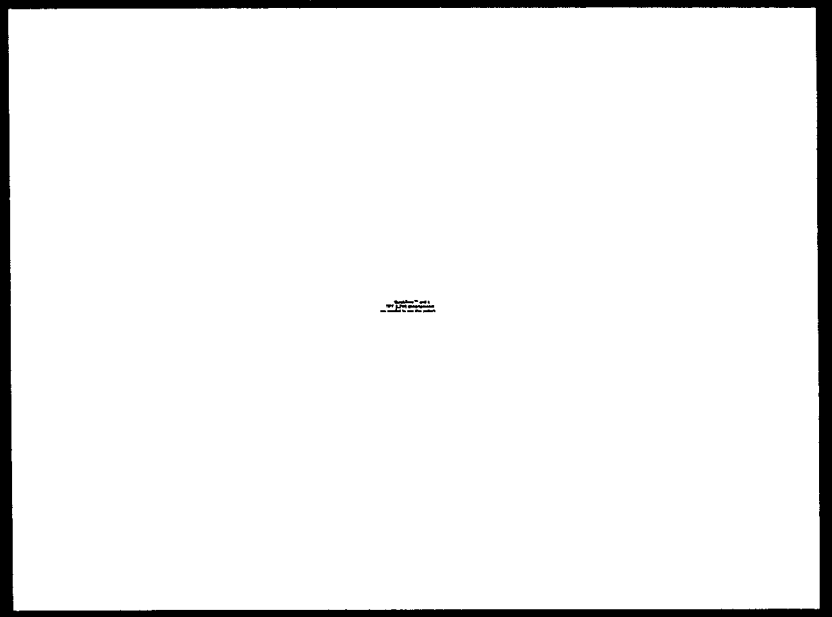


EVIDENCE FOR INTER-BASIN FLOW

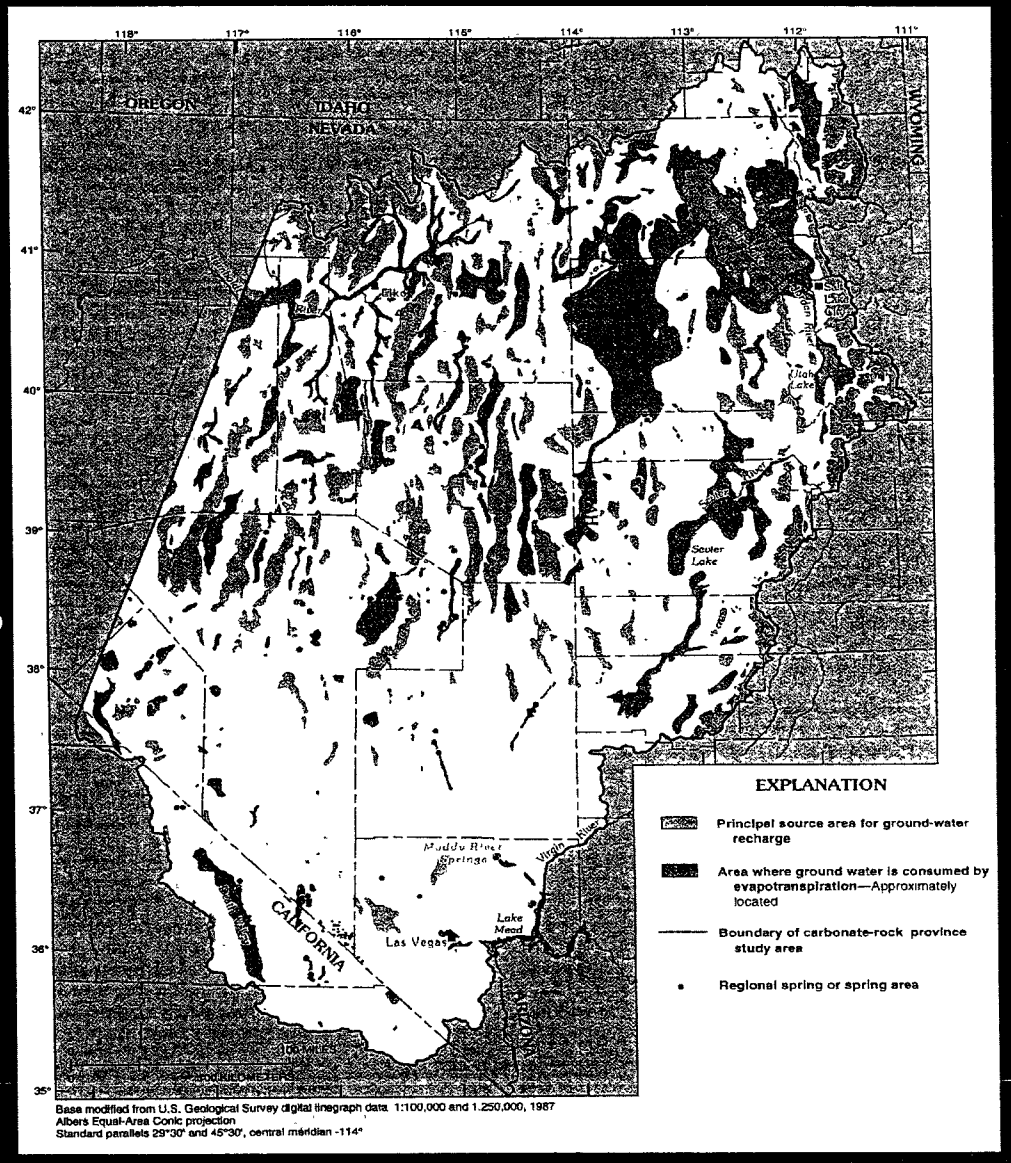
- Geochemistry of carbonate springs and well waters.
- Borehole and geophysical survey data.
- Results of groundwater numerical models

Approach to Problem

- Inyo County's Work Plan
  - Exploratory Drilling
  - Geochemical Analysis
  - Numerical Modeling
- Specific Approach
  - Isolate Paleo-carbonate in USGS regional model
  - Developed Simplified Paleo-Carbonate Model of Sub-Region
  - Evaluate groundwater travel times.

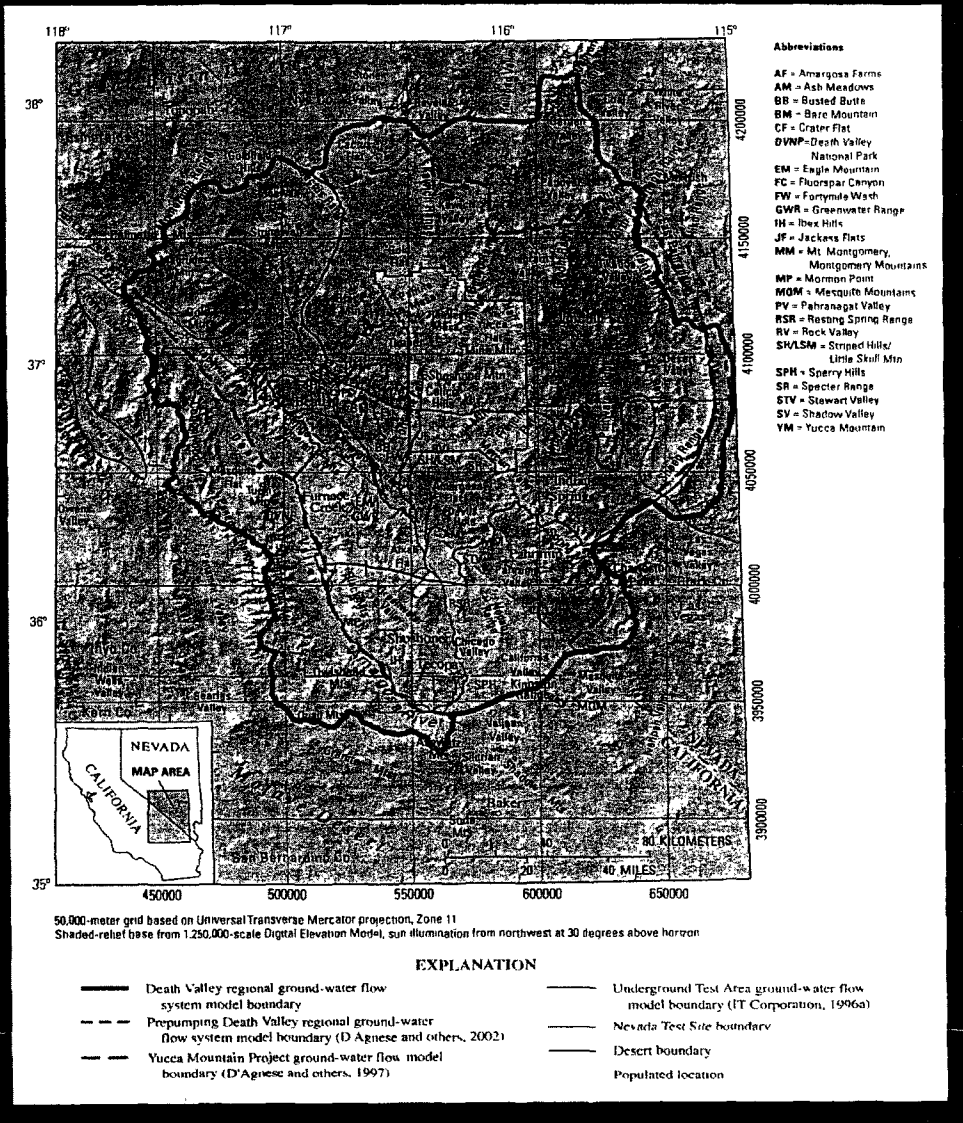


USGS Regional Aquifer System Analysis (RASA): Carbonate Aquifer Terrain Boundary and Features



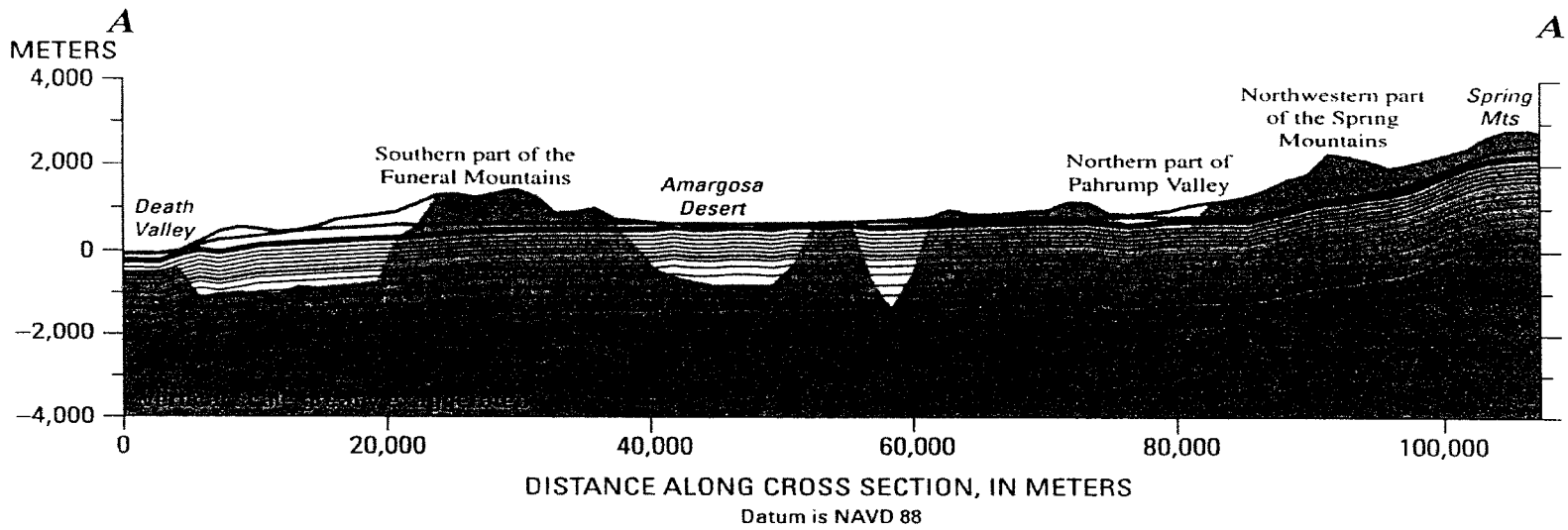
Prudic, et. al., 1995

Map Showing Boundaries of NTS and Death Valley Regional Models



Belcher, et. al., 2004

USGS DV Regional Model
Section Through Southern Funeral Mt. Range



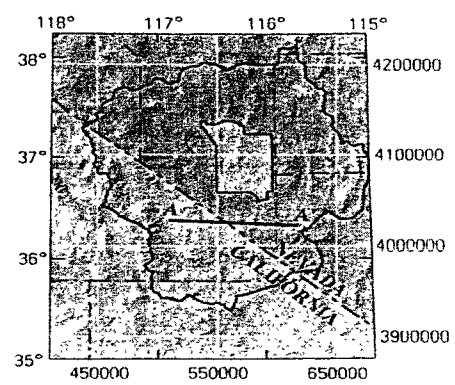
EXPLANATION

Units

- Overlying rocks and sediments
- Carbonate-rock aquifer
- Confining units

- **Land surface**
- **Top of layer 1**— Simulated potentiometric surface
- **Top of layer 10**
- **Top of layer 16**

Location of cross section



Faunt {b} et al. 2004

Cross-section Depicting Relationship of Geology to DV Model Layer Data

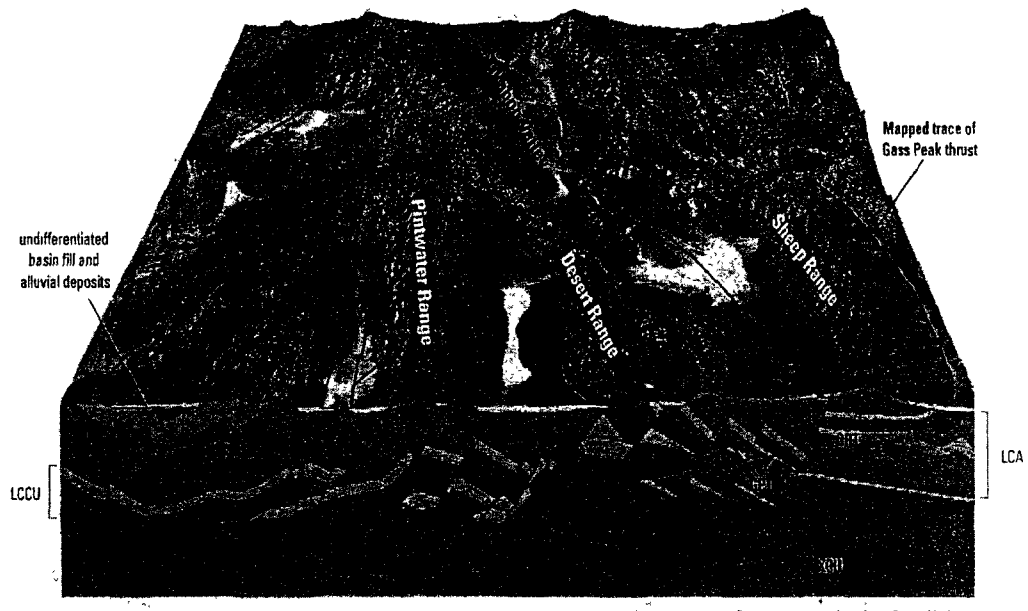
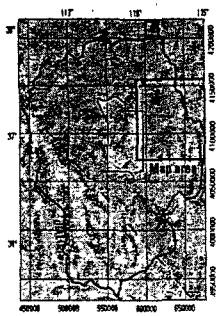


Image is false-color composite combining LANDSAT 5 spectral bands 2, 5, and 7 in RGB (Red-Green-Blue) space. Individual bands were processed to display their full dynamic range. The image was further processed in hue-saturation space to emphasize specific geologic features.

EXPLANATION

Mapped and inferred faults
from surface geologic mapping
(from Potter, Sweetkind, and others, 2002)

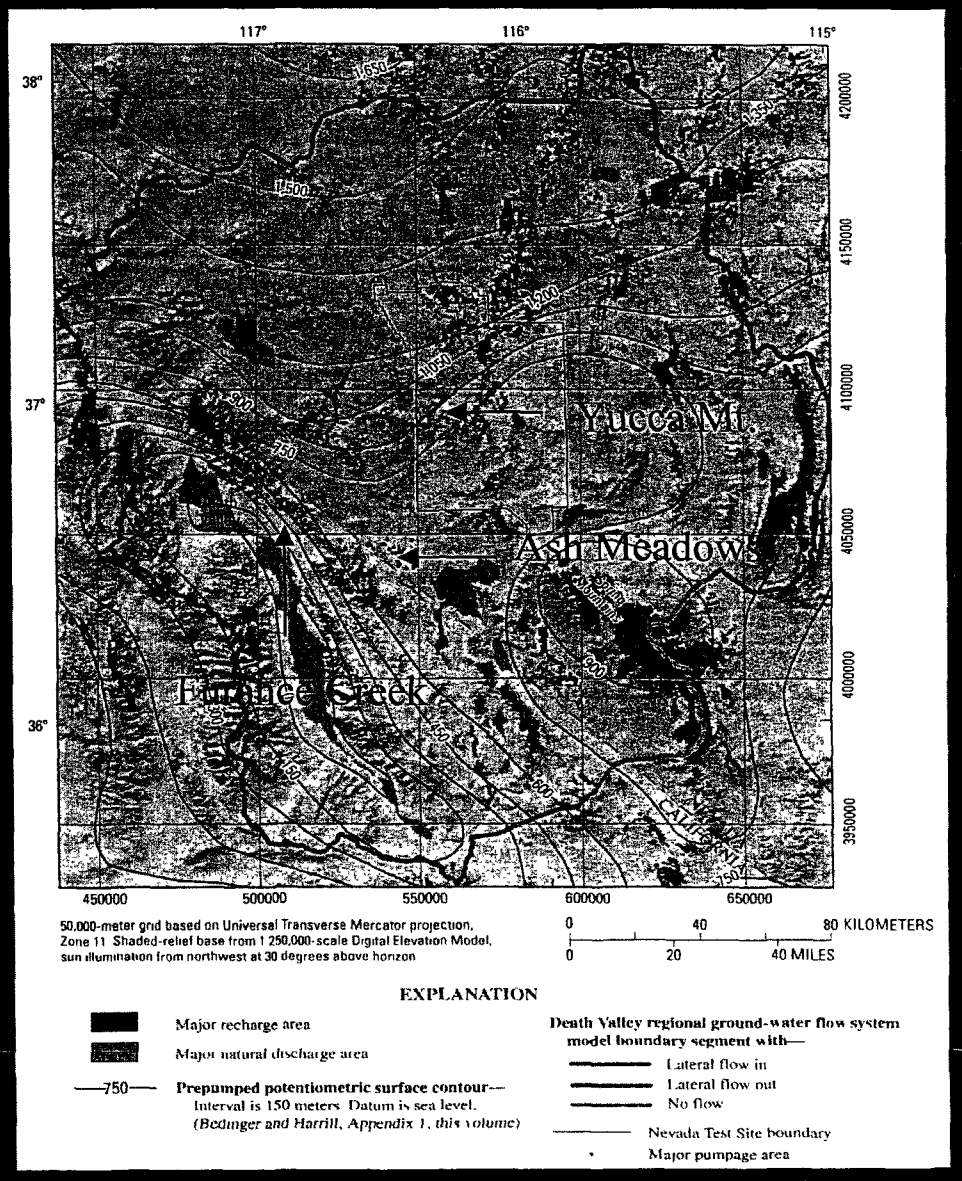
- Strike-slip fault
- Normal fault
- Thrust fault



Cross section geology from Sweetkind, Dickerson, and others (2001) section H-5
View is to the north. GPT, Gass Peak thrust

Sweetkind, et. al., 2004

Potentiometric Surface Map of DV Regional Flow System

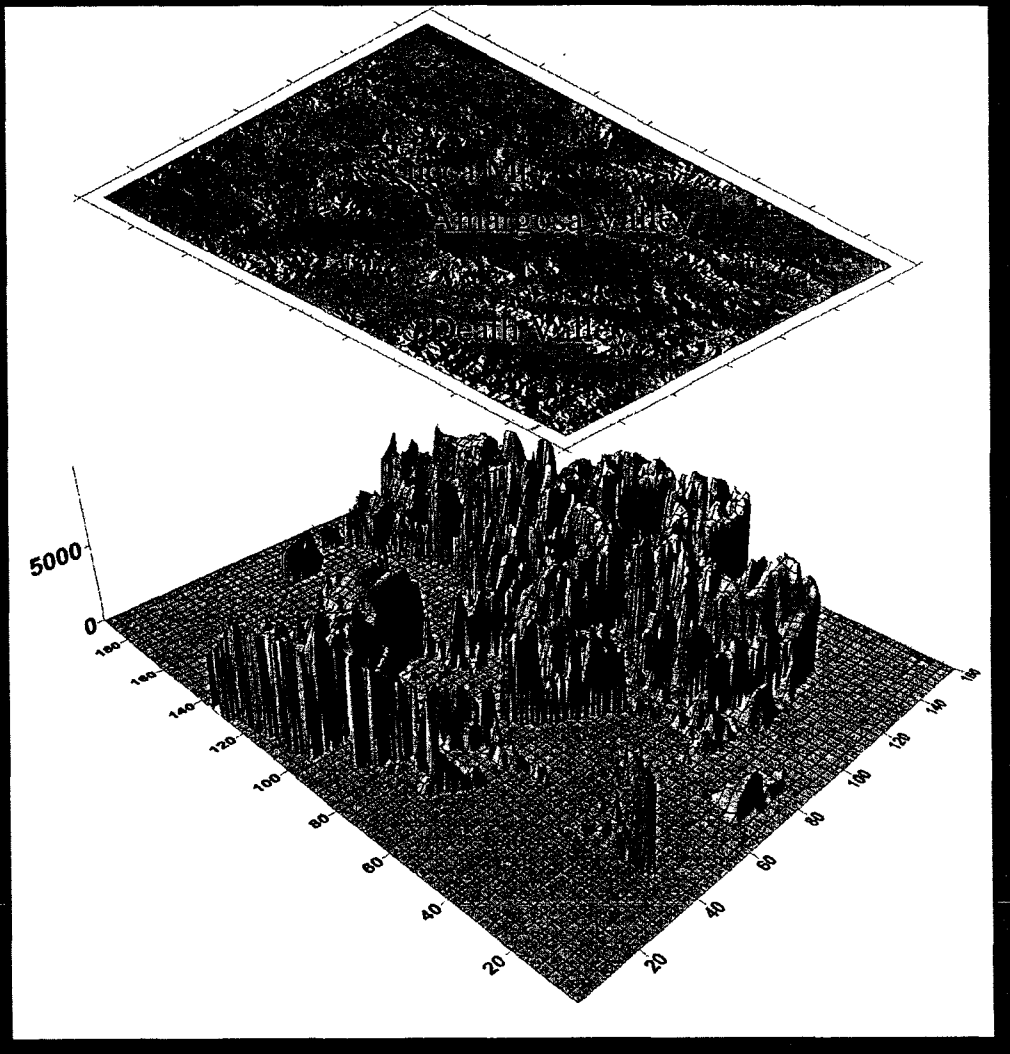


San Juan, et. al., 2004

Distribution of Carbonate Rocks in Death Valley Regional Flow System

Physical Evidence for Hydraulic Connection

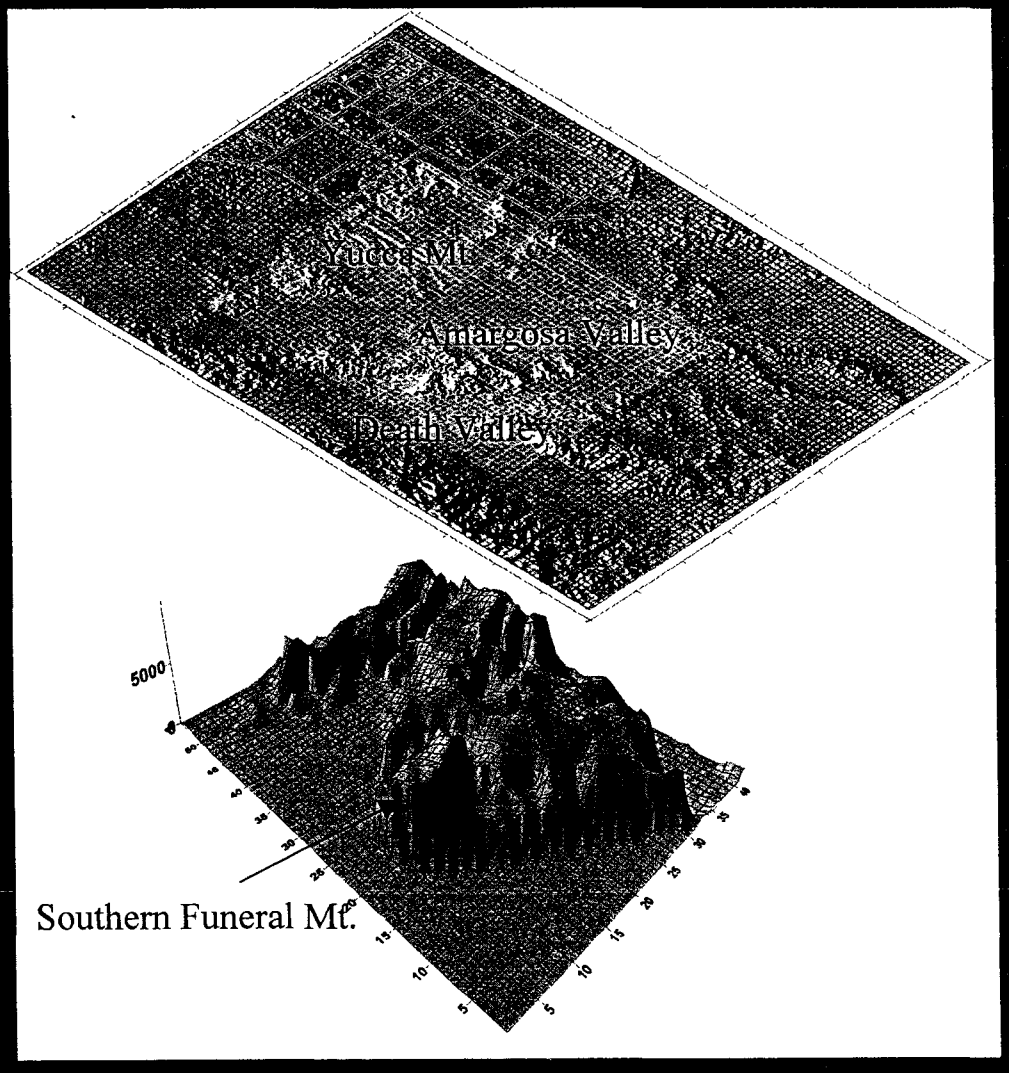
- Over 5,000 m thickness in many areas
- Carbonate underlies Yucca Mt., Amargosa Valley, Southern Funerals Mt.



Boundary of Sub-region Model

Evidence for Hydrualic Connectivity Thru Paleo-carbonates

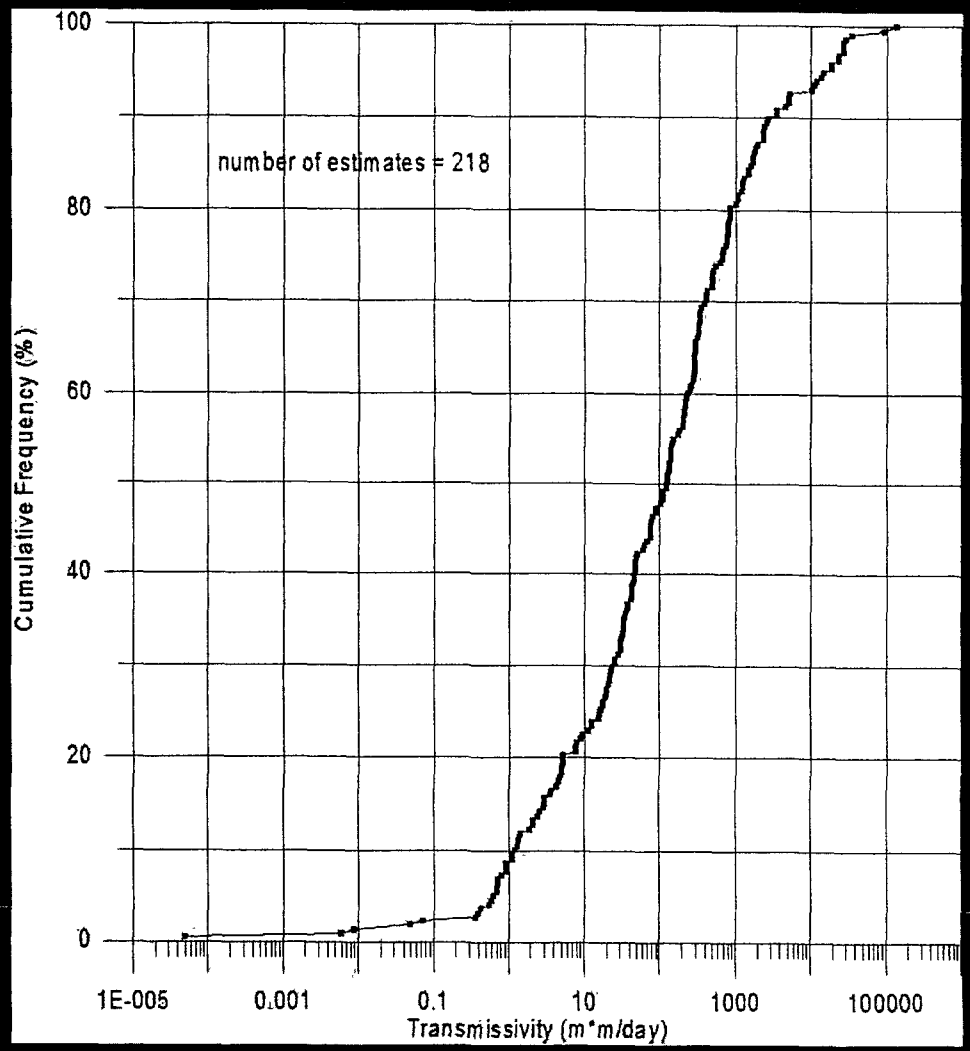
- Vugular and brittle carbonate rocks
- Large open spaces: Caverns (Devil Holes)
- Joints & faults enlarged by dissolution
- Carbonate rocks against carbonates across faults



Southern Nevada Water Authority (SNWA)

Transmissivity Spring Valley Model Analysis

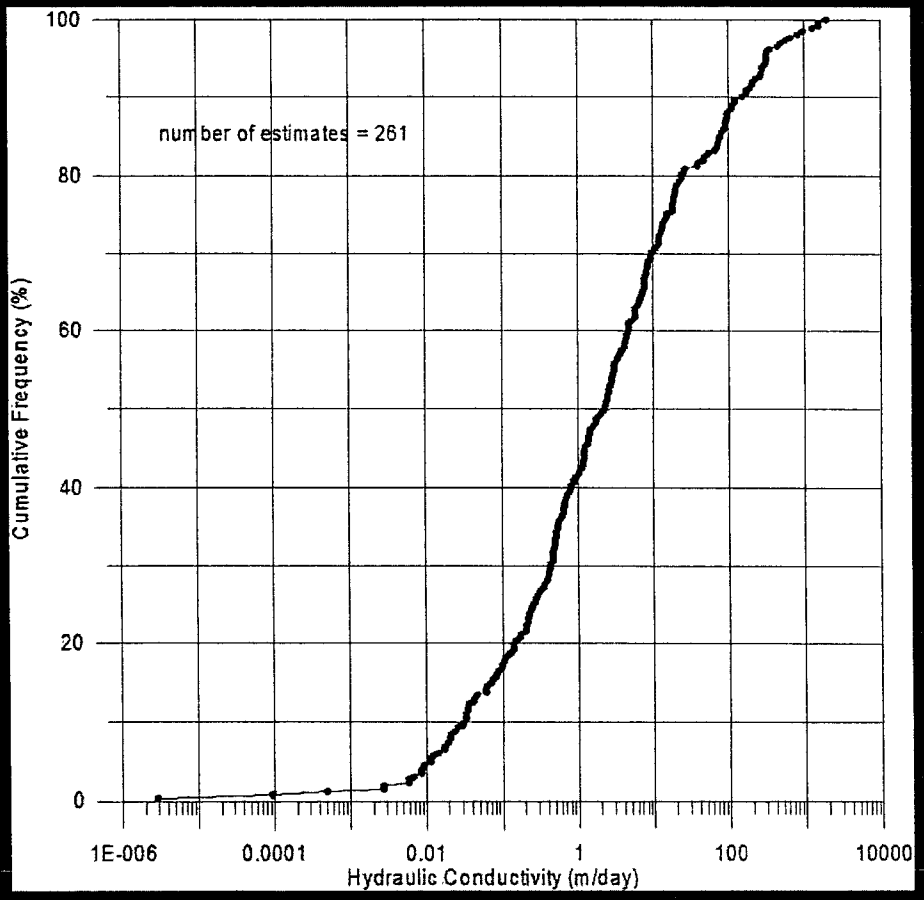
- 85% chance a carbonate well will pump 100 gpm w/100 ft. of drawdown.
- 10% chance a carbonate well will pump 2000 gpm w/100 ft. of drawdown.



Southern Nevada Water Authority (SNWA)

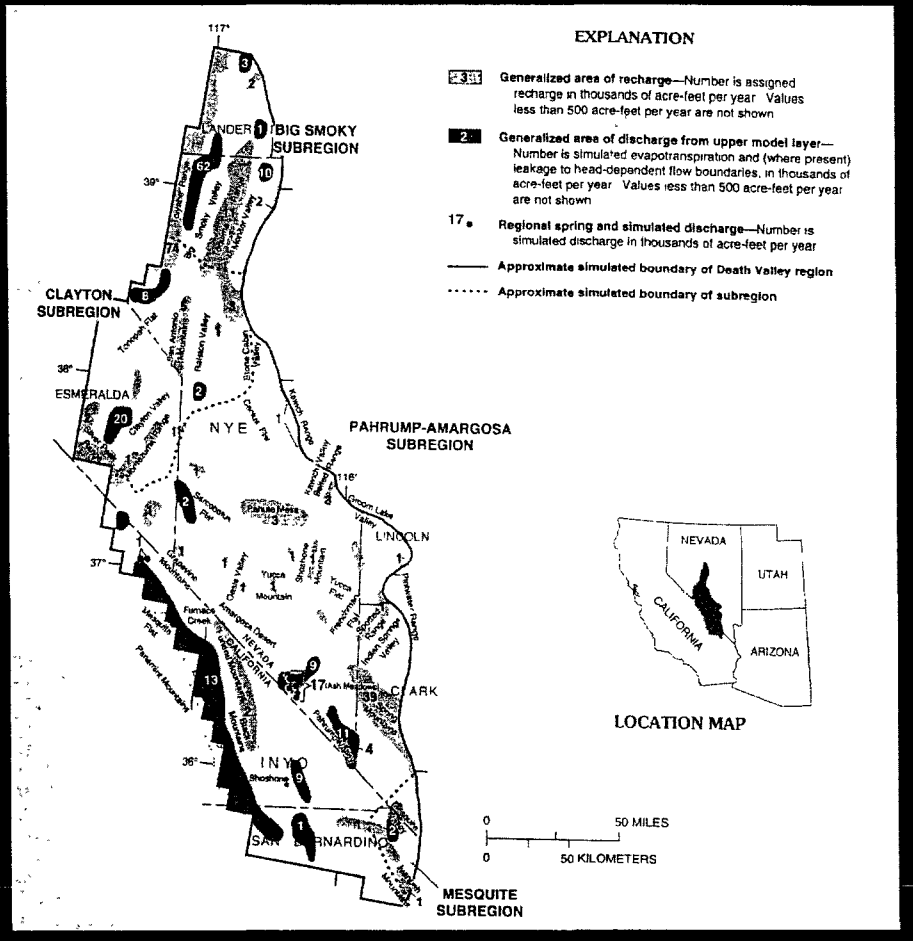
Hydraulic Conductivity Spring Valley Model Analysis

- 85% chance a well can be drilled into the Paleo-carbonate aquifer that will penetrate 30 m of permeable rock that would produce over 100 gpm w/100 ft. of drawdown.



Developed Simplified Paleo-Carbonate Model of Sub-Region

- One layer: Zero-order carbonate model
- Partial isolation-thus good for contaminant flow only.
- Model Input: RASA Model for sub-region plus hydrualic conductivity data from SNWA.



Map of Computed Steady-State Hydraulic Heads from Yucca Mt. To Death Valley in Carbonate

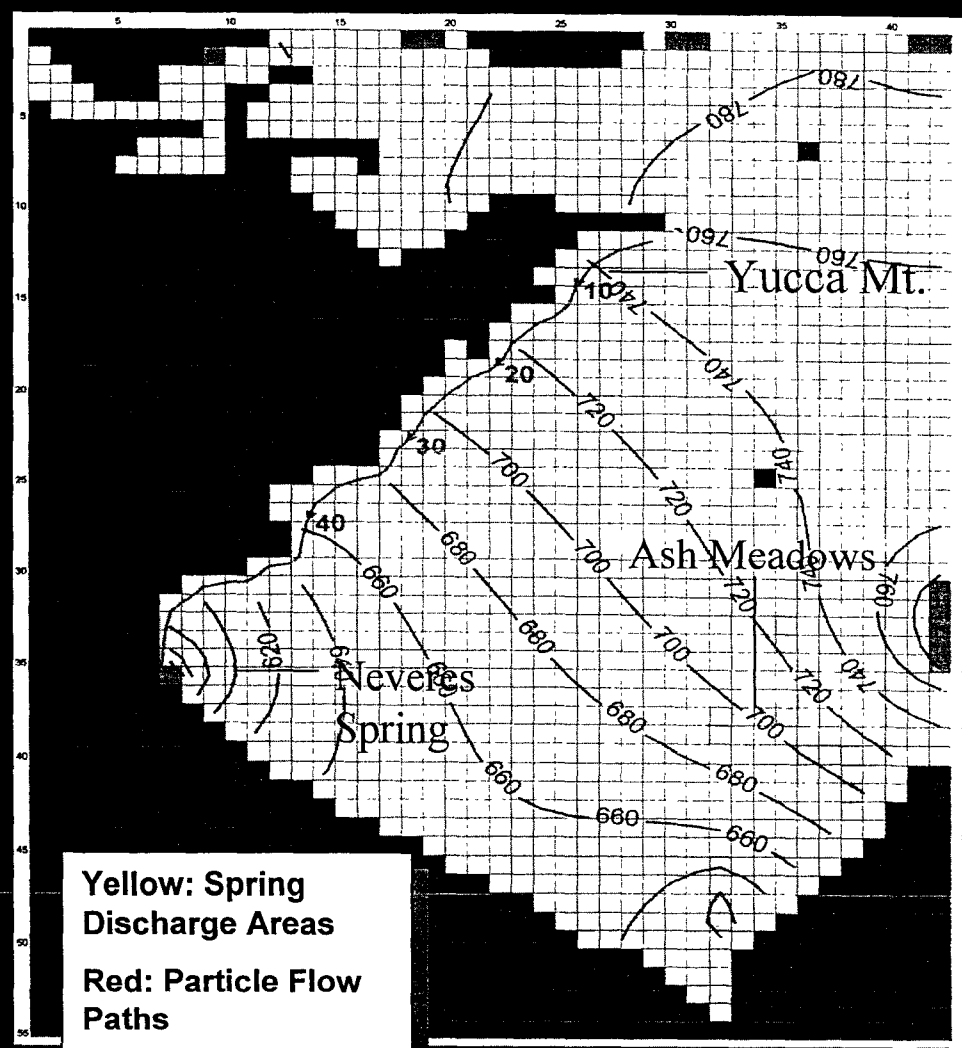
Simple Particle Travel Time Calculation

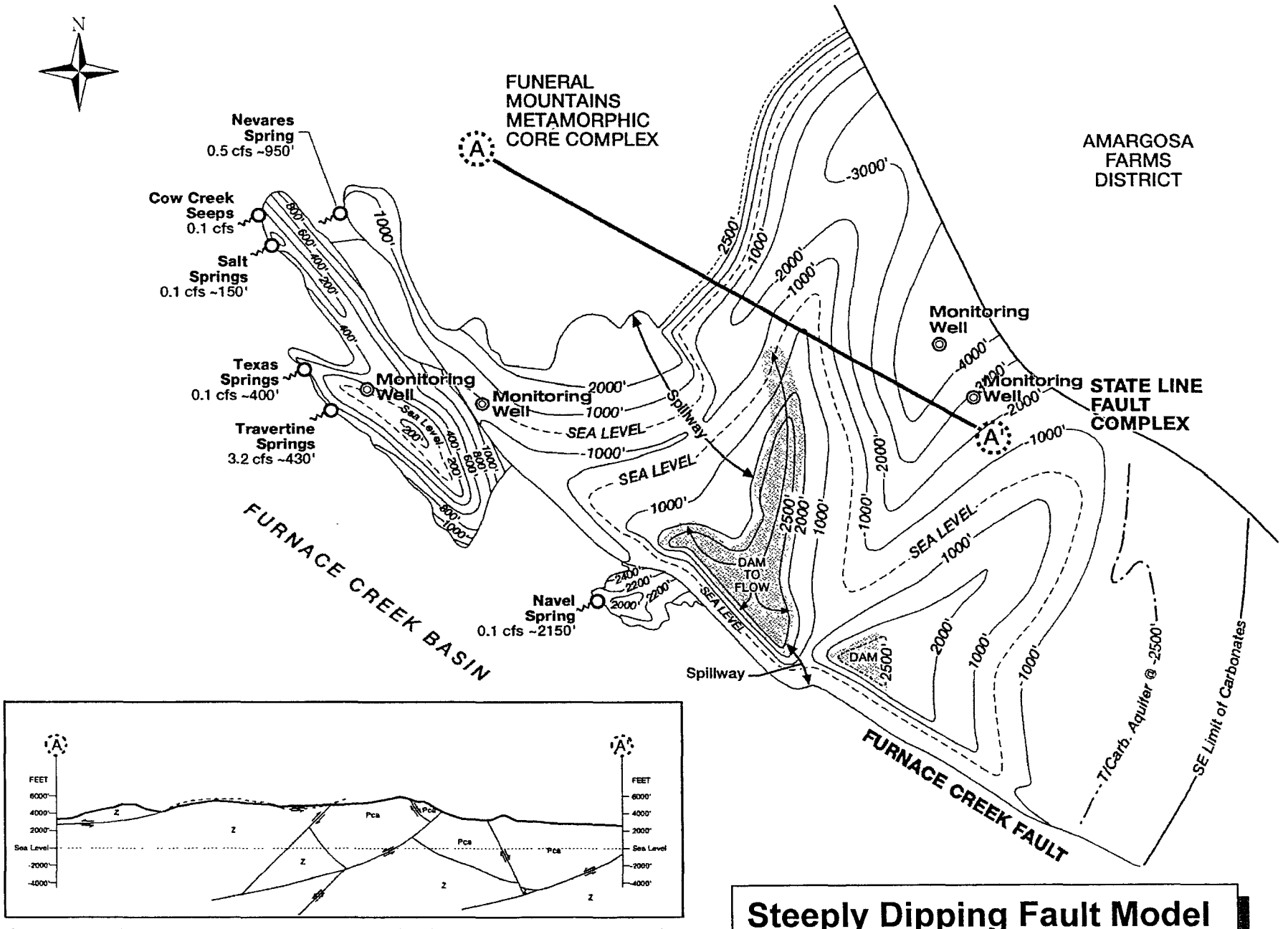
$v = K/\varepsilon\ (\partial h/\partial l)$

- V= velocity
- K= hydraulic conductivity (Transmissivity $59 m^2$/day)
- ε= porosity, 0.1%
- $(\partial h/\partial l)$= gradient

Calculated Travel Time from Yucca Mt. To Death Valley< 50 years.

500 years if ε= porosity, 1.0%

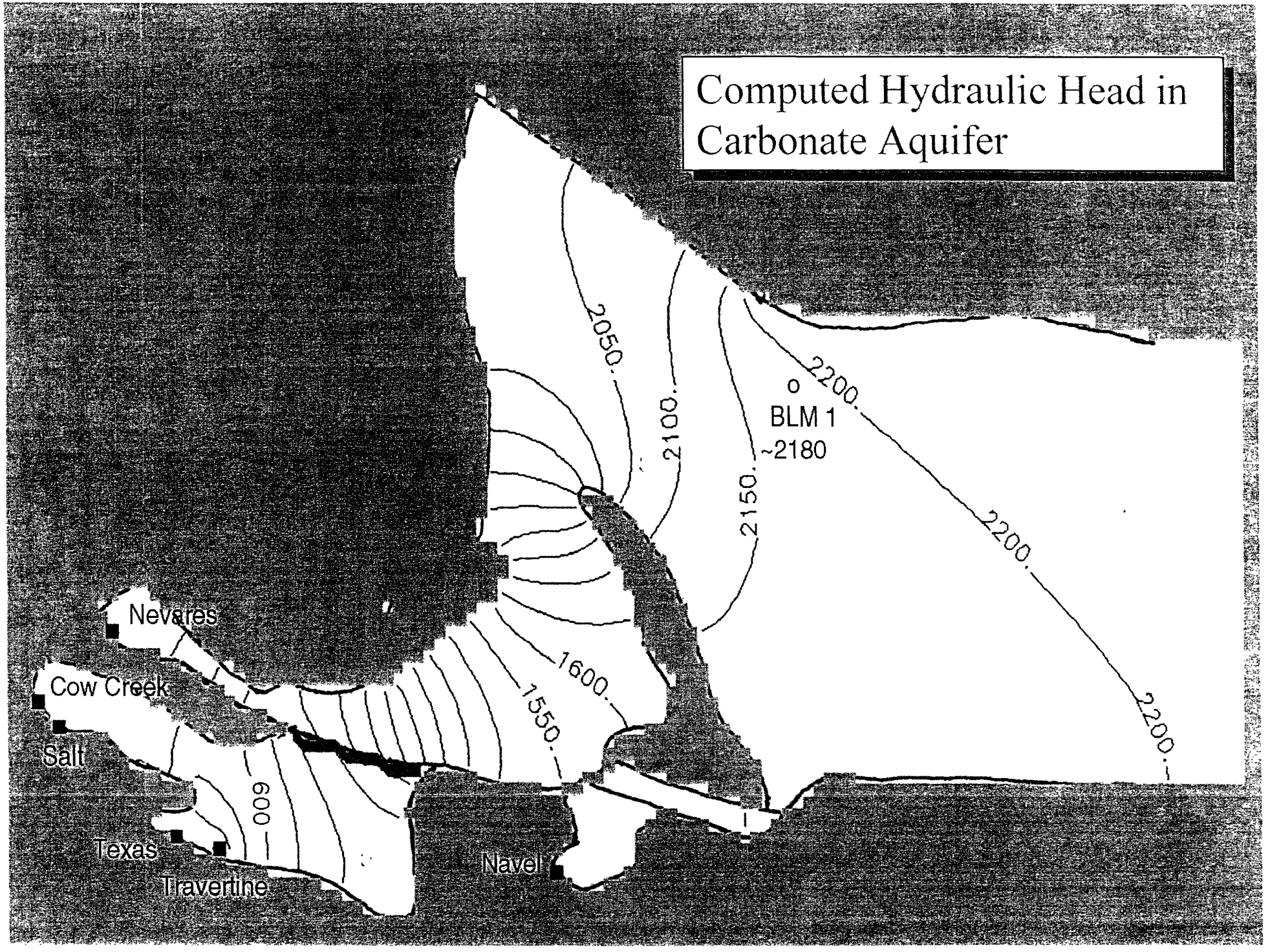




Spillway model, version 2: same as figure 4, except that this is a bounding case in which the thickness of the aquifer at the spillways is maximized.

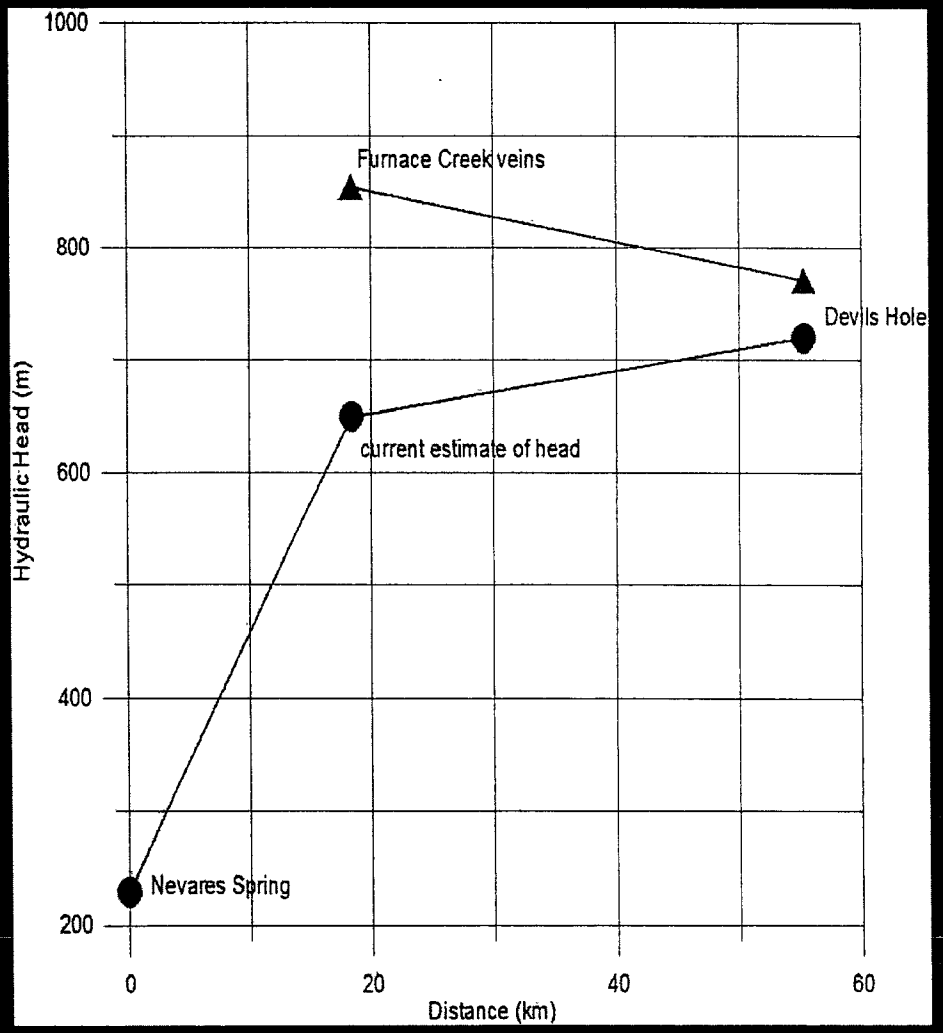
Steeply Dipping Fault Model

Computed Hydraulic Head in Carbonate Aquifer



Hydraulics of Paleo-carbonates

- Important upward gradient-30 m at Well U25p1. Barrier to radionuclide transport at Yucca Mt.
- 800,000 yr. Paleo-deposit had 50 m higher head
  - 1. Reverse of gradient,or
  - 2. Tectonic: uplift rate of 0.25 to 0.3 m/100-yr.
- Significant head change from Devils Hole to Nevares Spring in Death Valley.



What did we learn?

- Paleo-carbonates represent a significant aquifer/water supply to the Yucca Mt.-Amargosa Valley-Death Valley region.
- Paleo-carbonates are connected through the region with thicknesses up to 5,000 m.
- Paleo-carbonates are highly permeability: brittle, faulted, vugular, large cavities.
- USGS RASA model a good representation of Paleo-carbonate aquifer system.
- Hydrodynamics simplified Paleo-carbonate model is a reasonable tool to evaluate groundwater travel time from Yucca Mt. To Death Valley: 50 to 500 years.
- Upward gradient in Paleo-carbonates evident throughout region: Barrier to radionuclide transport.
- Paleo-carbonate a good pathway for radionuclide transport from Yucca Mt.