Shallow Infiltration and the Initiation of Fracture Flow at Yucca Mountain, Nevada

Alan L. Flint
U.S. Geological Survey
Mercury, NV

June 26, 1995

Goal of the infiltration study

Provide the upper boundary conditions for numerical models that are realistically variable in time and space.

Methods chosen to meet that goal (Milestones)

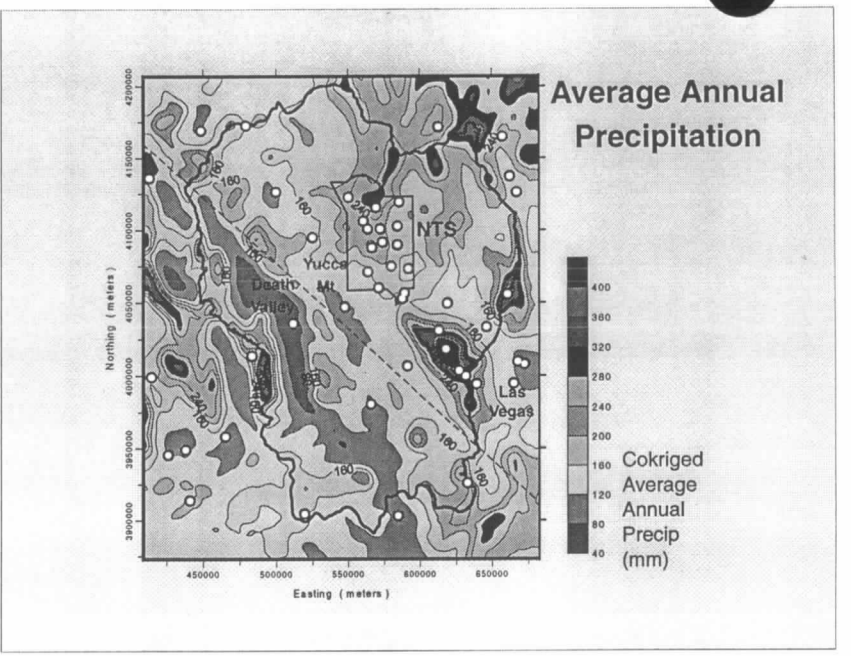
- **Develop a map of current net infiltration based on field measurements (10 yr avg.)**
- **Develop a numerical model based on deterministic and stochastic processes that can reproduce that map**
- **Model past and future climate scenarios with changeable soil, vegetation and atmospheric conditions**

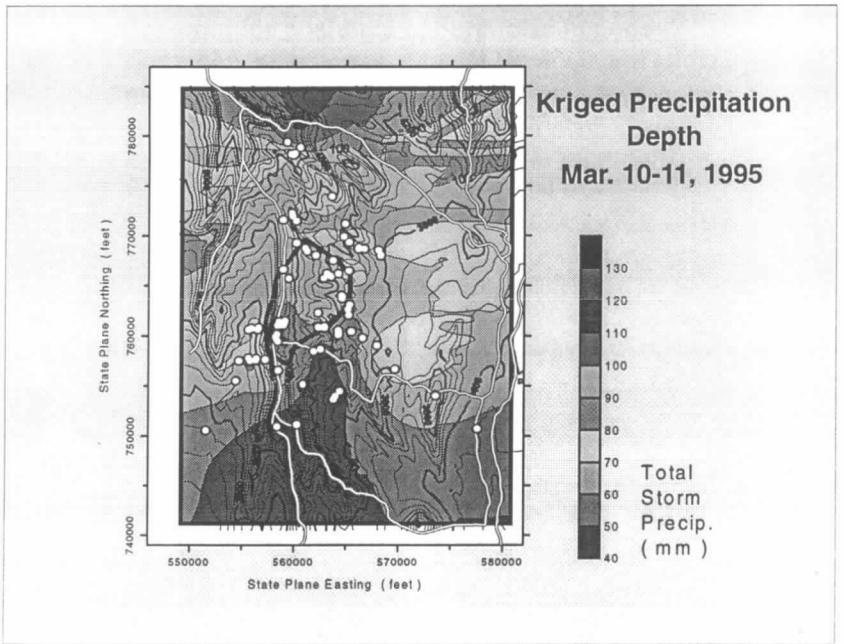
Objectives of this presentation

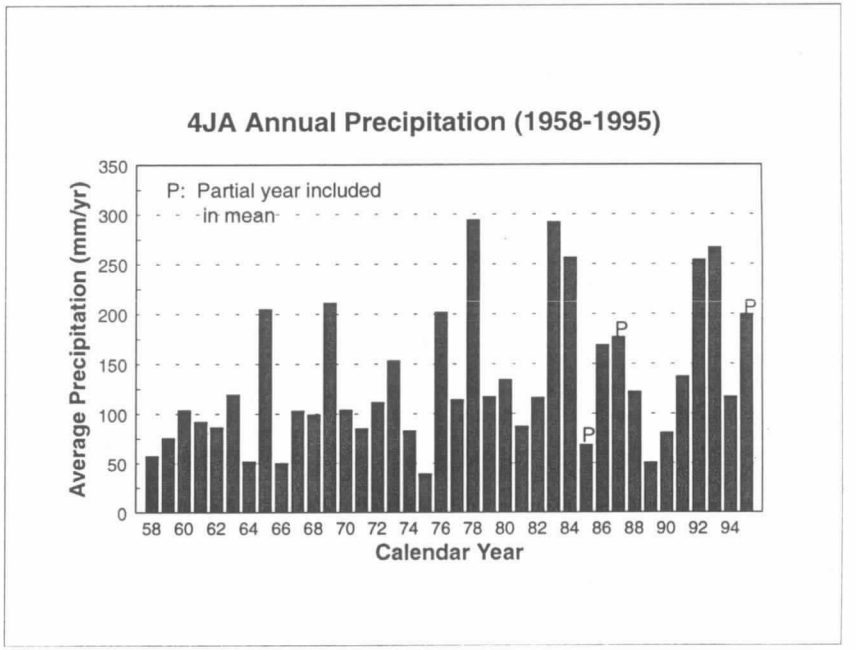
- **Present the meteorological conditions that existed during collection of the infiltration data sets.**
- **Present an overview of the field data that was used to develop the current conceptual model of net infiltration at Yucca Mountain.**
- **Present the current conceptual model of net infiltration at Yucca Mountain.**
- **Present the methods chosen to extrapolate point measurements of infiltration to the new areal extent of the 3-D site scale model.**

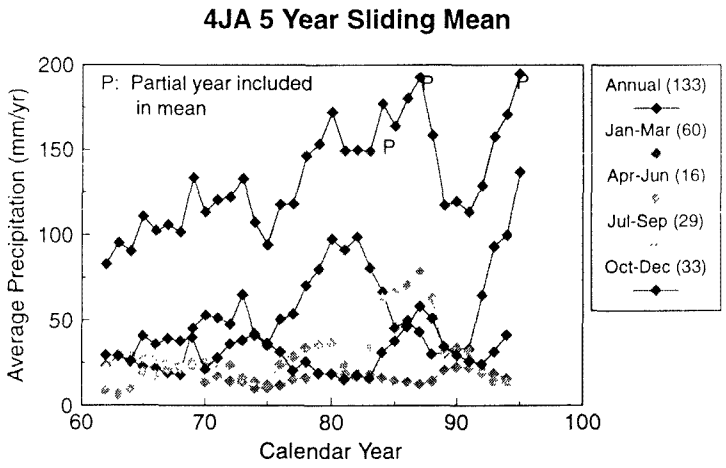
Data set

- Large temporal and spatial precipitation data set
- 90 neutron-access boreholes, 6-67 meters deep
- Topographic positions of boreholes include ridgetops, sideslopes, alluvial terraces and alluvial channels
- Monthly readings of volumetric water content, at 0.1 m depth intervals, for between 3 and 9 years







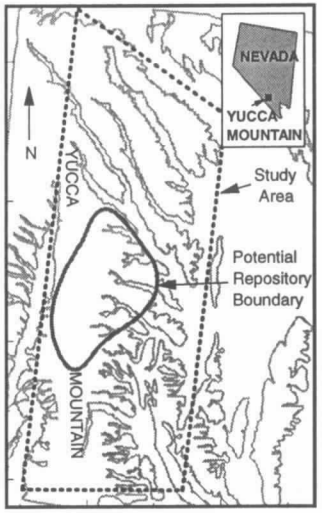


Site Description

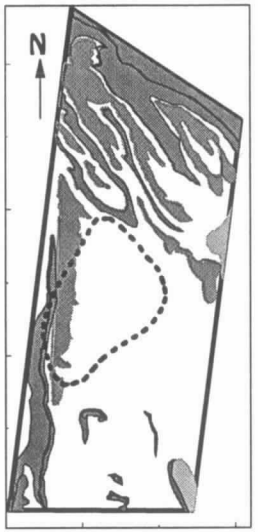
- Arid environment, average precipitation 170 mm/yr
- Volcanic tuffs, nonwelded/bedded to welded
- Varying thicknesses of alluvial/colluvial deposits
- Faulted and fractured bedrock with highly eroded and variable surfaces

Photo: aerial of Yucca Mountain from Solitario Canyon

Photo: aerial of Yucca Mountain viewing washes



Site Scale Model at Yucca Mountain



Matrix flux in mm/year

PTn	13.40
Rainier Mesa	0.60
Tiva Mod. Welded	0.22
Topopah Welded	0.08
Tiva Welded	0.02

Initiation of Fracture Flow in Arid Land Watersheds

Things to consider:

- Variable depth of alluvium overlying bedrock
- Nature of the fractured bedrock
- Variable matrix porosity of the bedrock
- Variety of topographic positions providing differences in radiation load, soil depth, slope, runoff, run-on
- Timing of precipitation

Pagany Wash

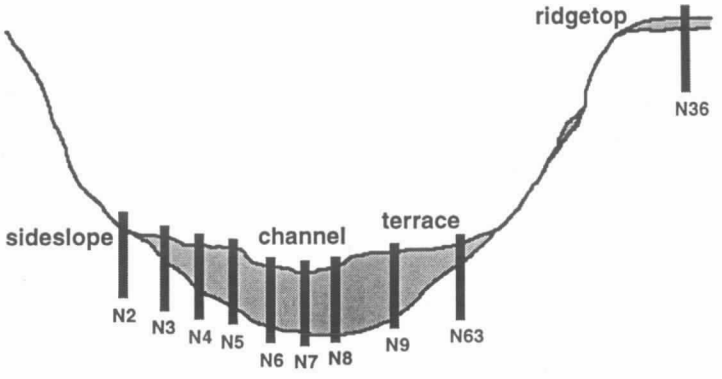


Photo: Neutron logging in channel

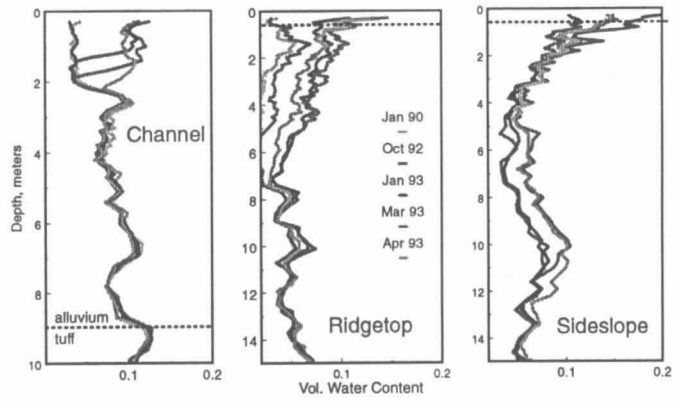
Photo: Channel neutron hole during runoff event

Photo: Neutron hole on terrace

Photo: Neutron hole on sideslope

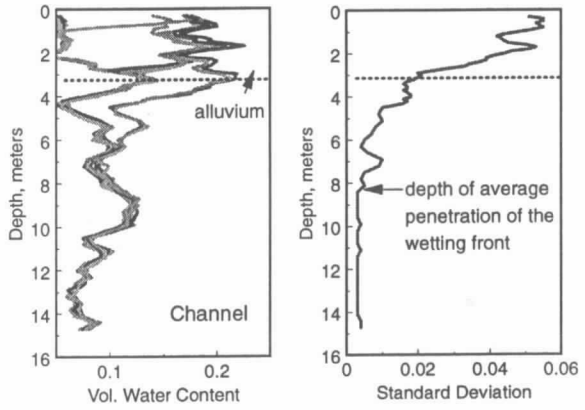
Photo: Neutron hole on ridgetop

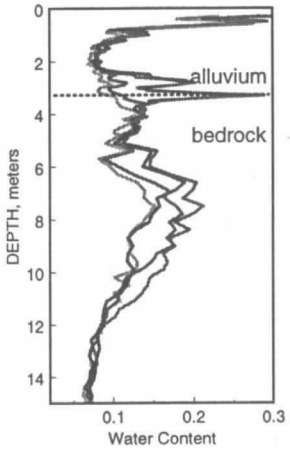
Moisture Profiles



Variation in Water Content

N34, May 1994-May 1995

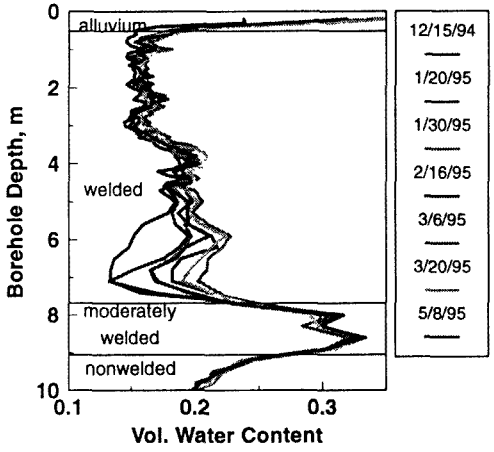




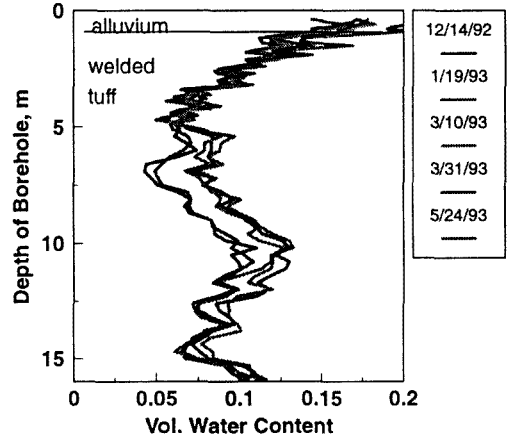
To evaluate the potential for fracture flow:

- Properties of filled and open fractures
- Water potential at the alluvium/tuff interface

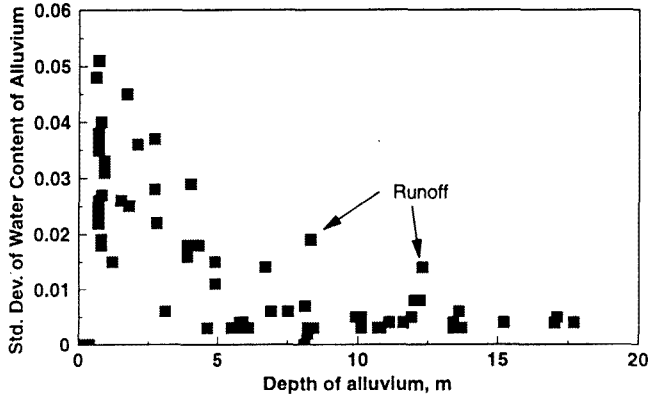
Fracture Flow in N11, Ridgetop



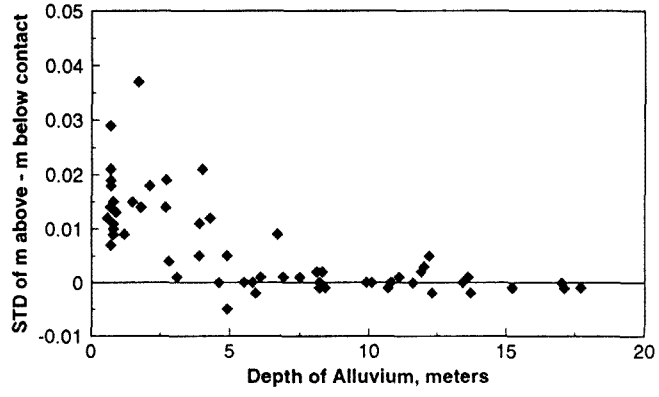
Fracture Flow in N53, Sideslope



Variation in Water Content at the Tuff/Alluvium Contact

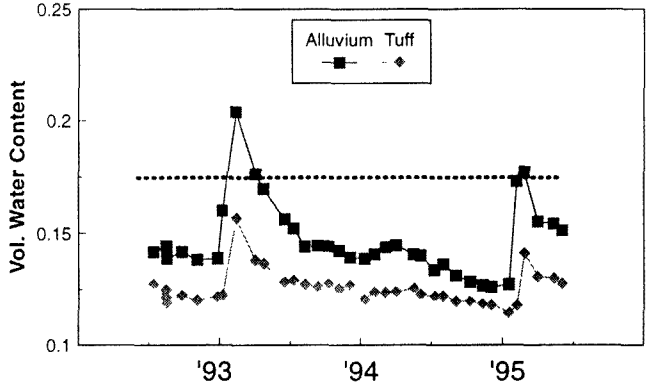


Relative Variation at Tuff/Alluvium Contact



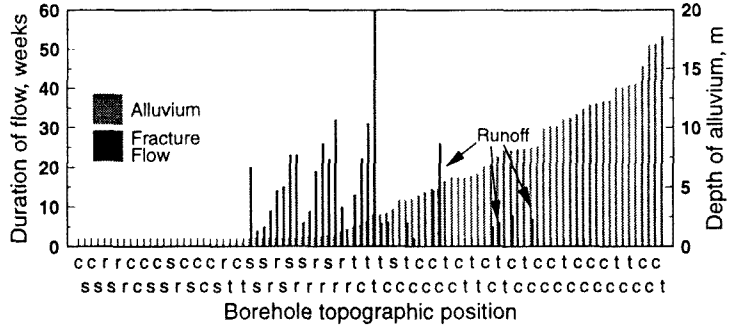
Flux Estimate for N53

18.3 mm/year



Fracture Flow

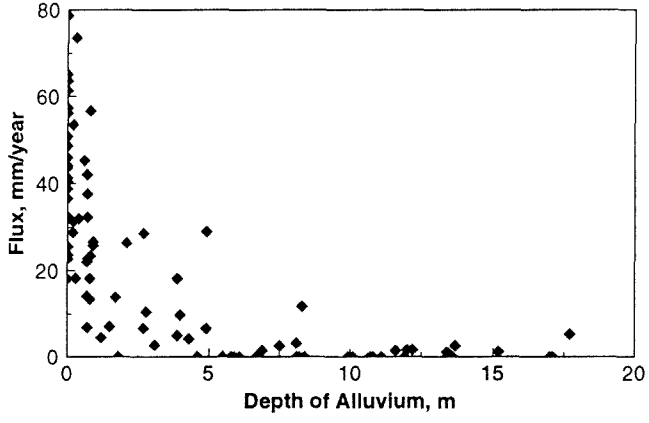
1990-1995



c, Channel, t, Terrace, s, Sideslope, r, Ridgetop

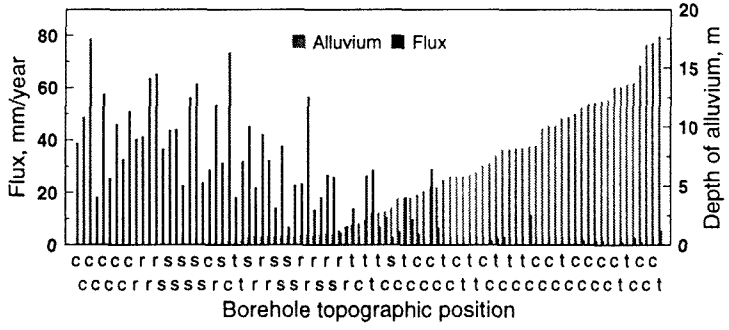
Flux Entering Top Meter of Tuff

1990-1995



Flux through Top Meter of Tuff

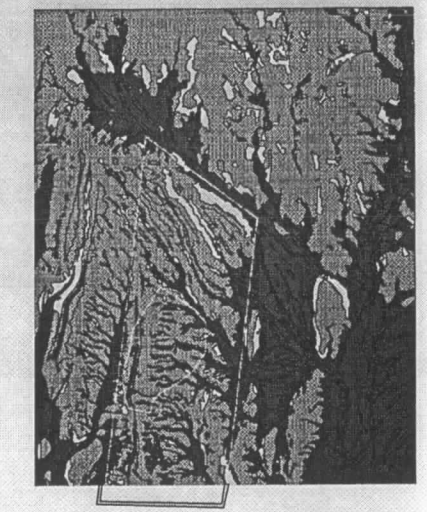
1990-1995



c, Channel, t, Terrace, s, Sideslope, r, Ridgetop

Corrrelation Matrix (r)

	Depth of Penetra -tion	VWC of top meter	VWC of soil above contact	Std. of soil above contact	VWC of tuff below contact	Std. of tuff below contact	Flux through top m of tuff
Radiation	.06	.05	.13	.10	-.08	.13	.12
Slope	-.12	.07	-.11	.42	.11	.44	.54
Aspect	.13	-.09	-.08	-.05	-.23	.18	.19
Elevation	.28	.34	.42	.52	.04	.42	.44
Tuff Porosity	-.03	.36	.29	.22	.55	.20	.36
Fracture Density	.05	-.04	-.21	.03	-.43	-.03	-.03
Depth of alluvium	-.11	-.34	-.21	-.73	-.11	-.58	-.69



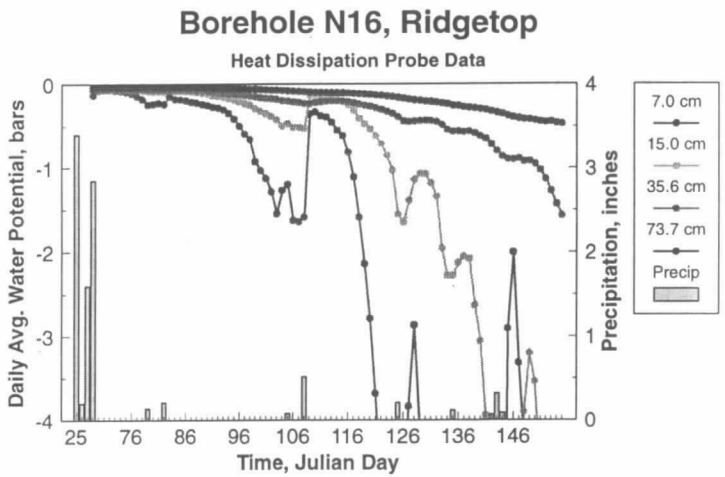
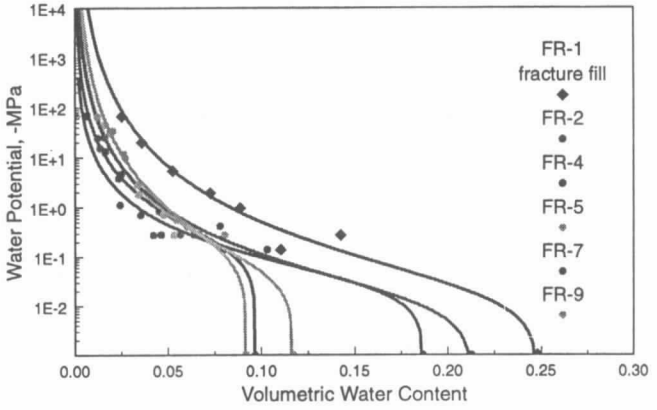


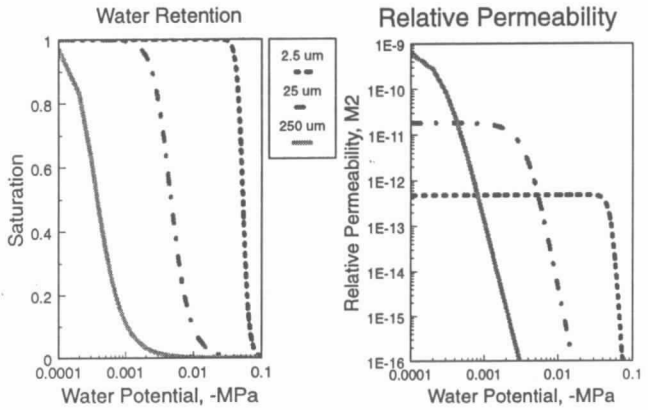
Photo: NRG-5 exposure of fracture fill

Photo: samples of fracture fill material

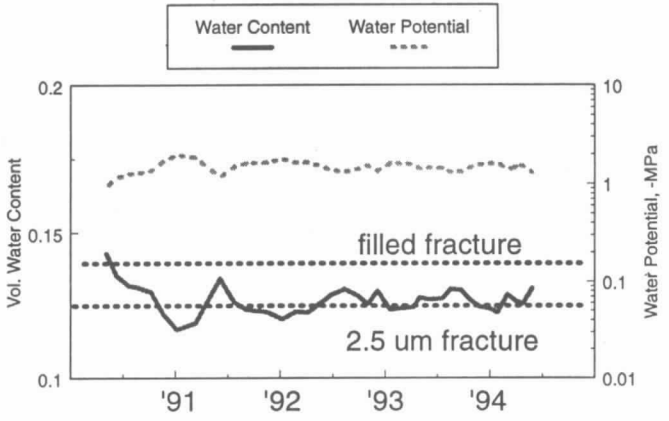
Properties of Fracture Fill



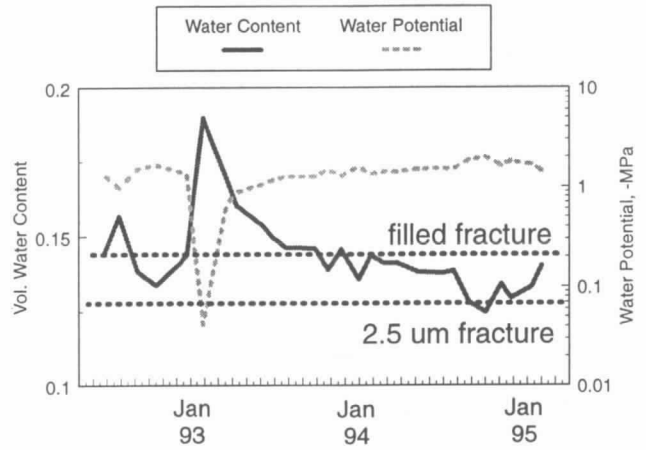
Properties of Fractures



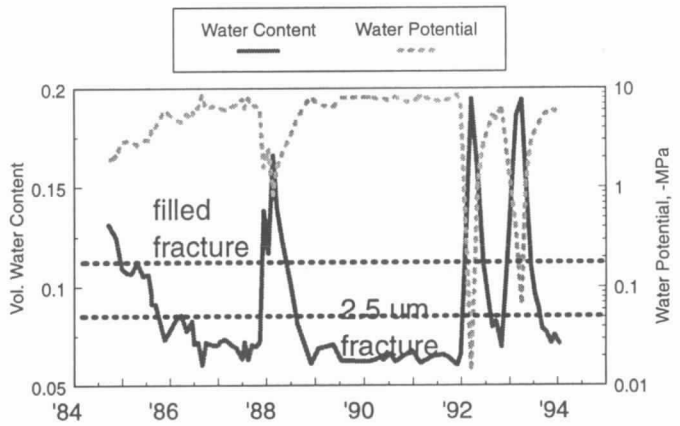
N1 Soil Depth, 8.3 m, Channel



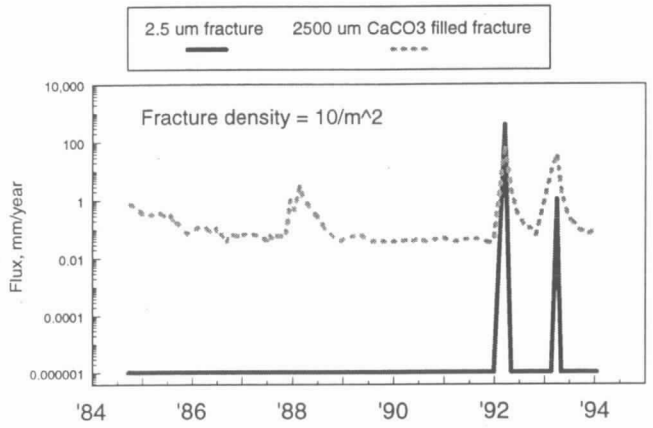
N53 Soil Depth 0.8 m, Sideslope

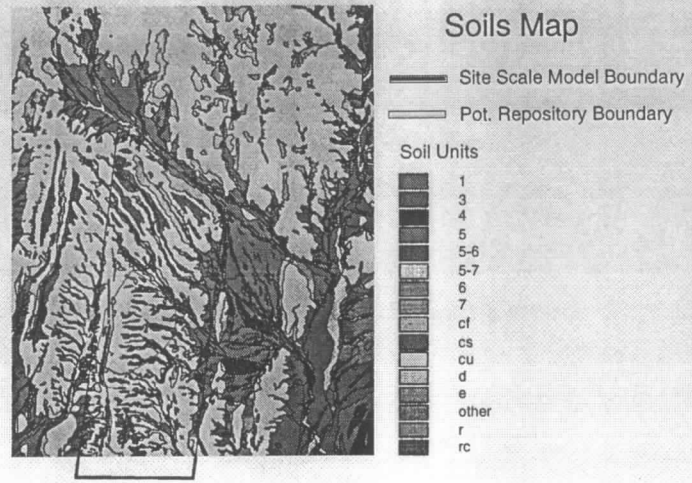


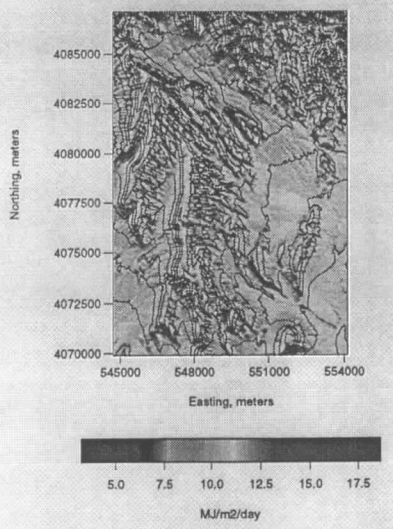
N52 Soil Depth 2.1 m, Channel



Fracture Flow at Tuff/Alluvium Contact



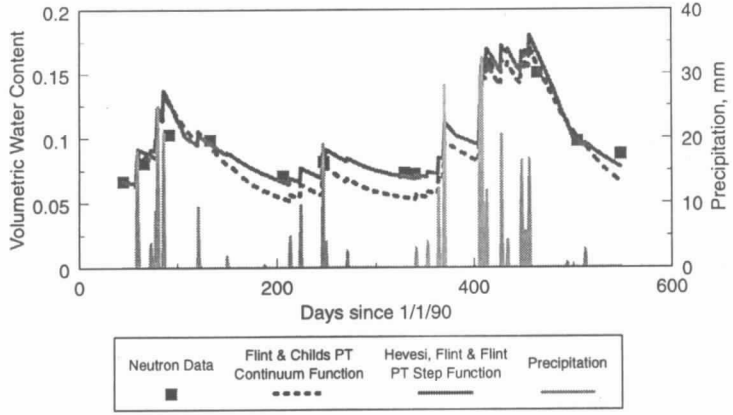




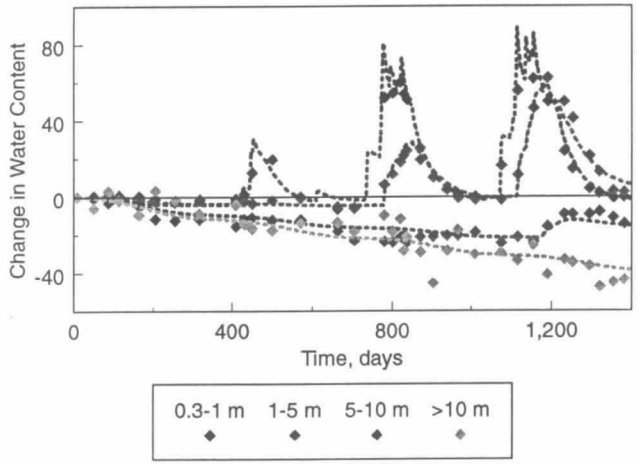
Solar Radiation
Dec. 21

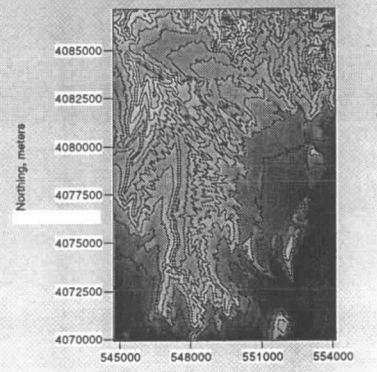
Modeling Surface Water Content

(Average Top Meter of Soil)



Modeling Borehole Data





3-D Site Scale Model

Summary

- The most recent years have been the wettest years on record.
- Near surface fracture flow readily occurs under wetter than average climates.
- Depth of alluvium may be one of the most important factors controlling the temporal and spatial distribution of fracture flow.
- Deterministic and stochastic models may be a viable way to investigate the influence of future climate change.