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Hydrogeology Associated with the Waste Isolation Pilot Plant (WIPP)

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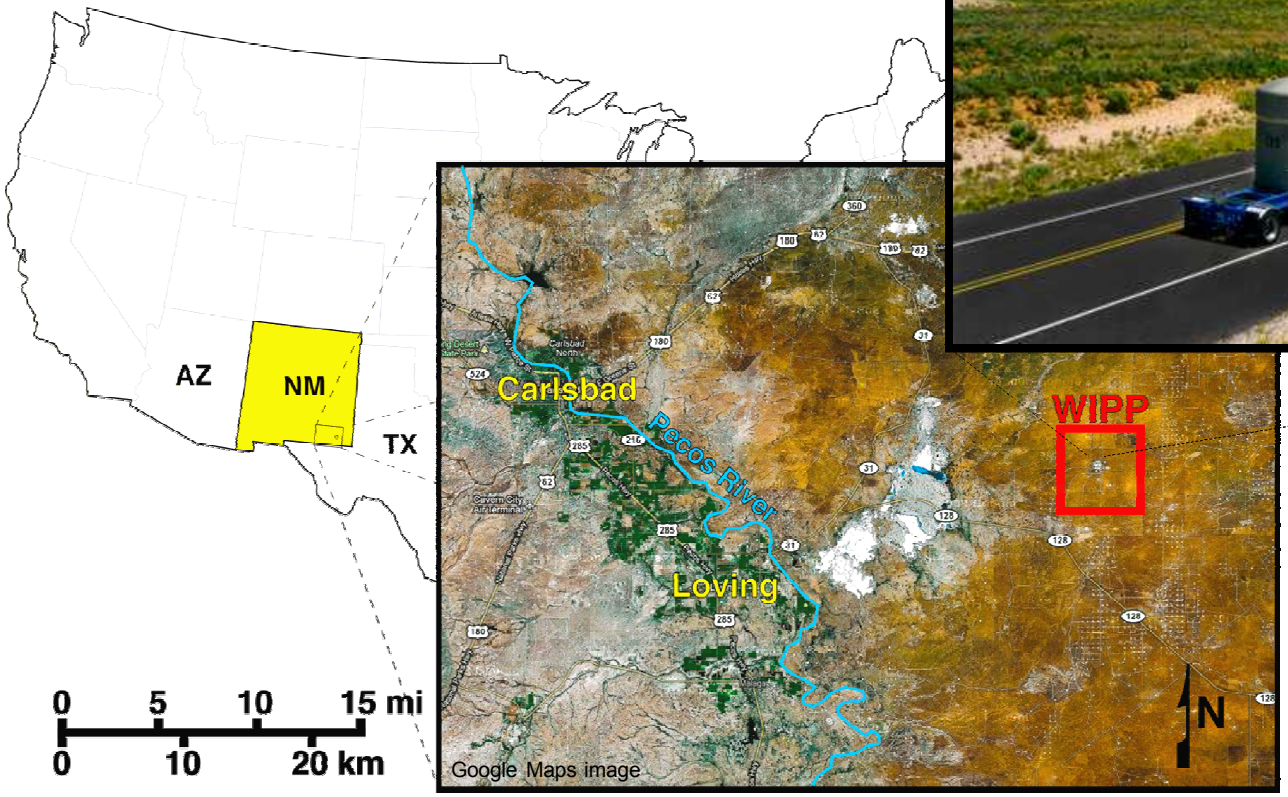
Waste Isolation Pilot Plant (WIPP)

- Transuranic (TRU) waste permanent underground geologic repository



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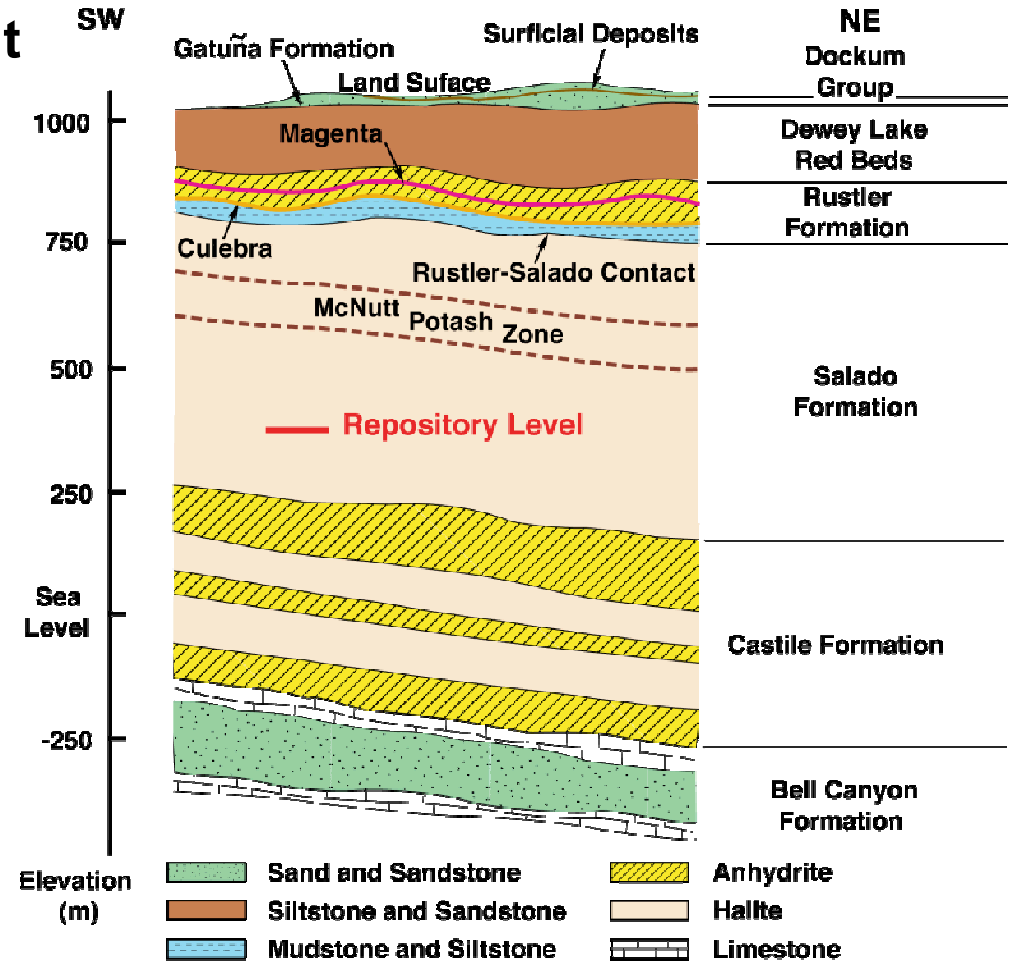
WIPP Hydrogeology

- Repository in Salado bedded salt formation
  - >500-m thick salt unit
  - *Immeasurably* low undisturbed permeability from surface
- Human Intrusion required for repository breach
  - High-pressure Castile brine
- Culebra of Rustler Formation
  - Most permeable unit
  - Laterally extensive
  - ~7.5-m thick dolomite
  - Focus of hydrologic testing



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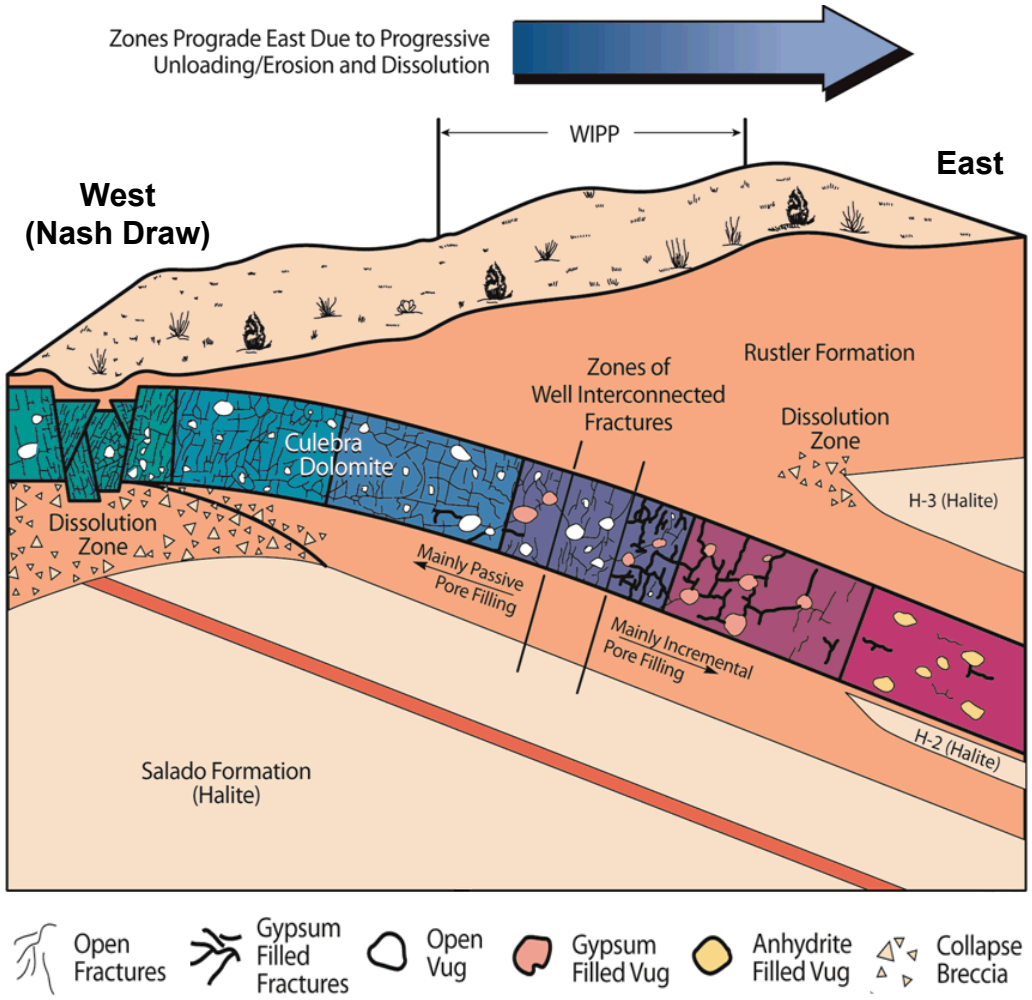
Culebra Conceptual Model



- Two types of processes control Culebra transmissivity (T)
  - Depositional
    - Lateral deposition of sediments or evaporites (mudstone/halite facies)
  - Alteration
    - Fracturing
    - Salado dissolution
    - Fracture in-filling
- High T in West
  - WIPP-26 : -2.9 $\log_{10}$(T) m^2/s
- Low T in east
  - SNL-15 : -12.9 $\log_{10}$(T) m^2/s

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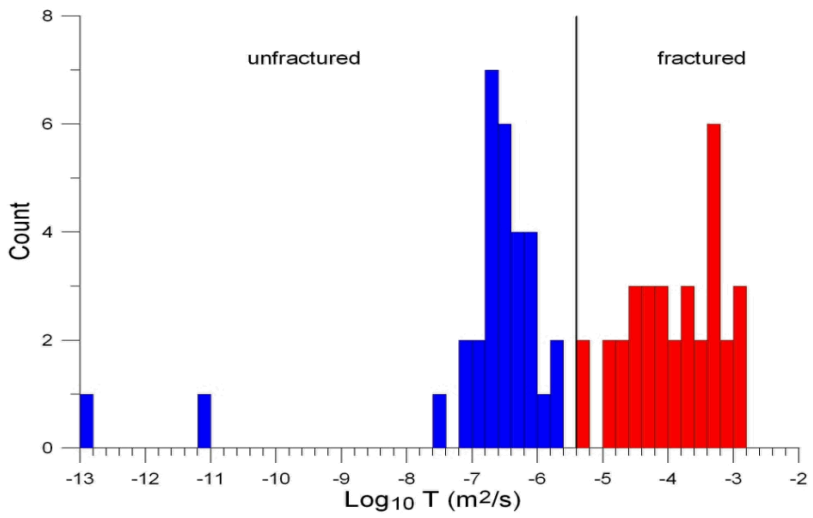
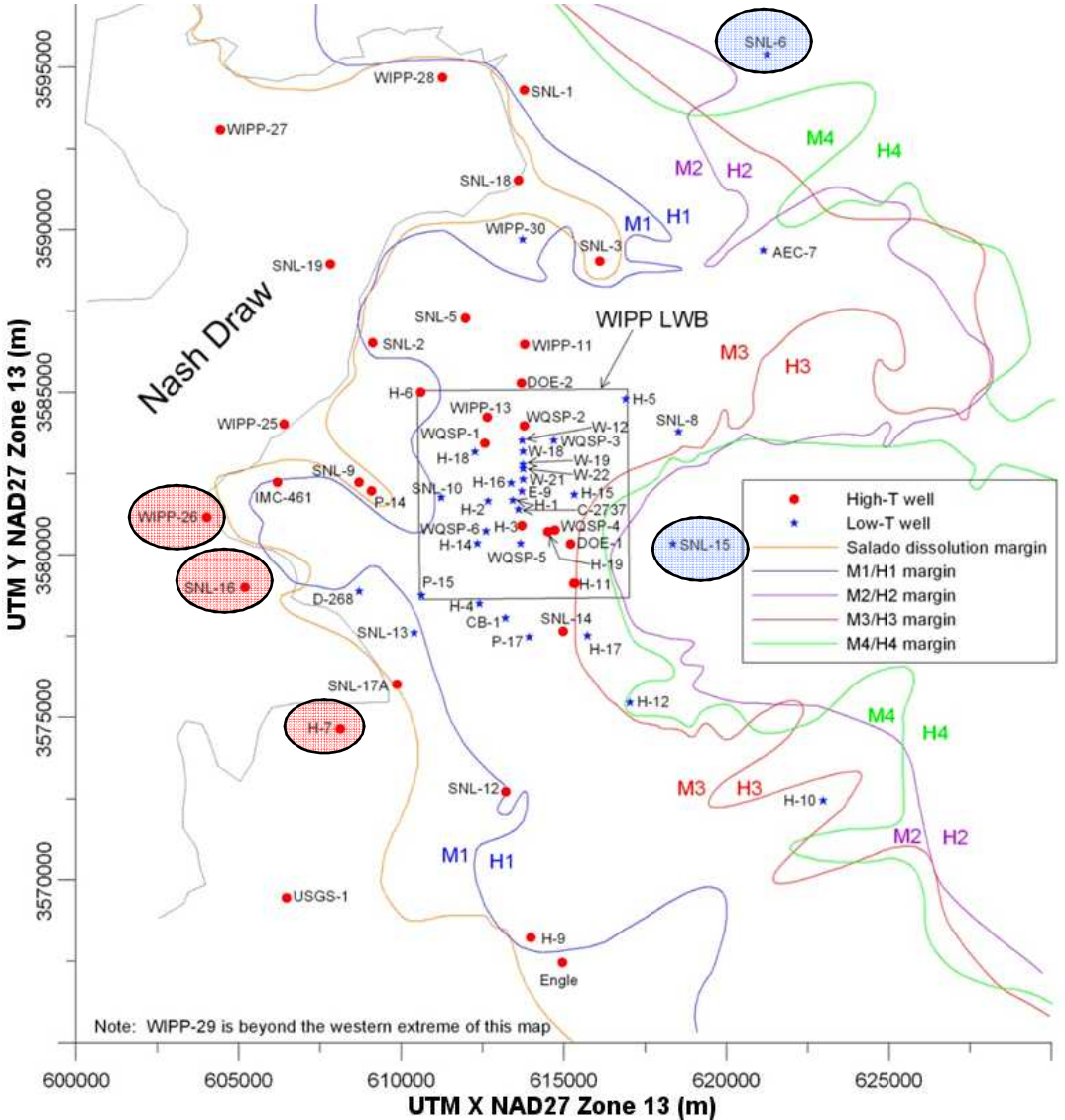
Single-Well Hydraulic Tests

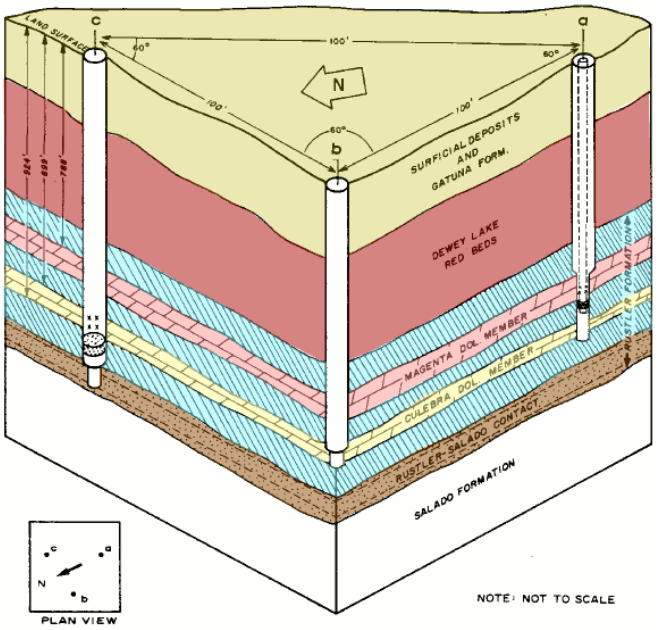
- **>90 tested Culebra locations**
- **Single-well tests show *10 orders of magnitude* variation in T**

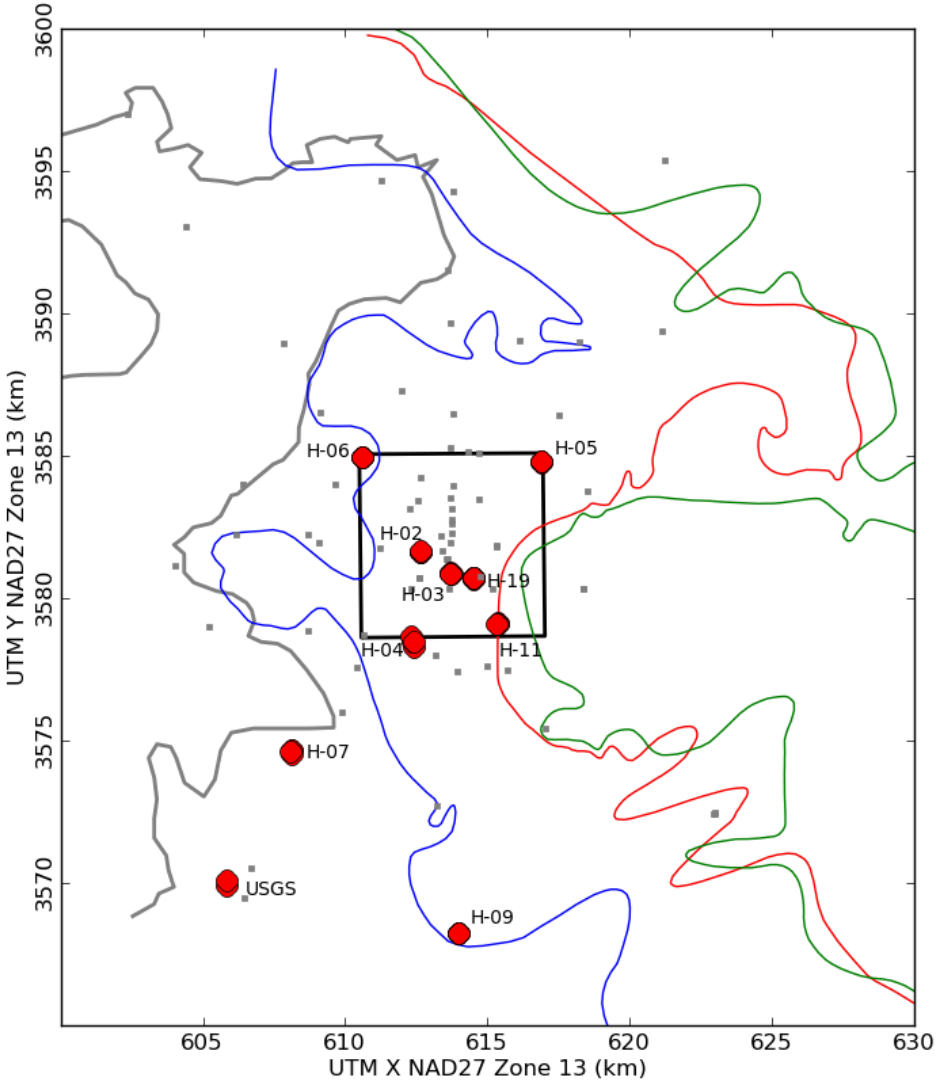




Multi-Well Hydraulic Tests

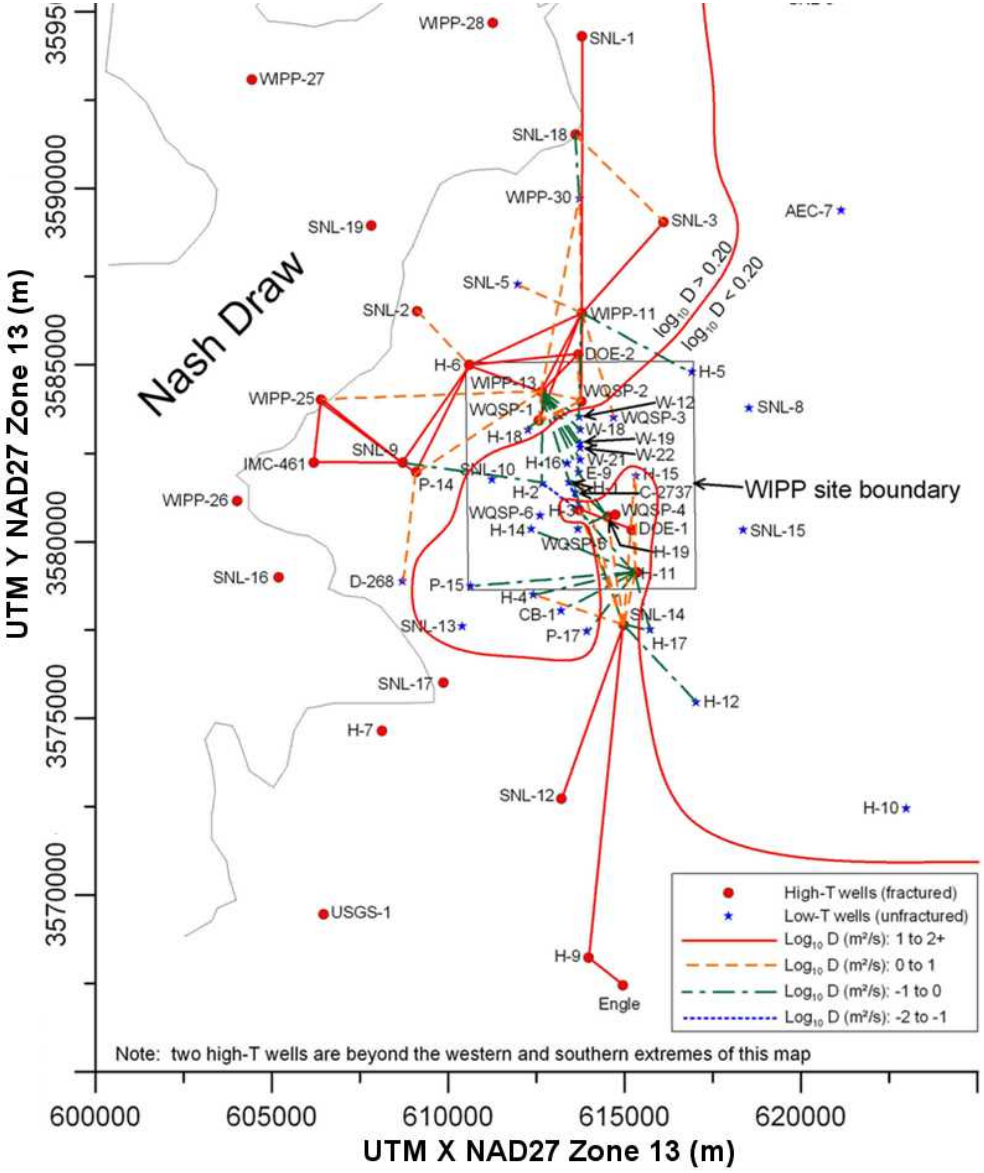
- *20 pad-scale* pumping tests (10-43 m observations)
- Weak pad-scale anisotropy (≤2)
- Only 2 multi-well pads remain
- *Multi-well tests:*
  - *10 pads / 20 tests / 36 wells*

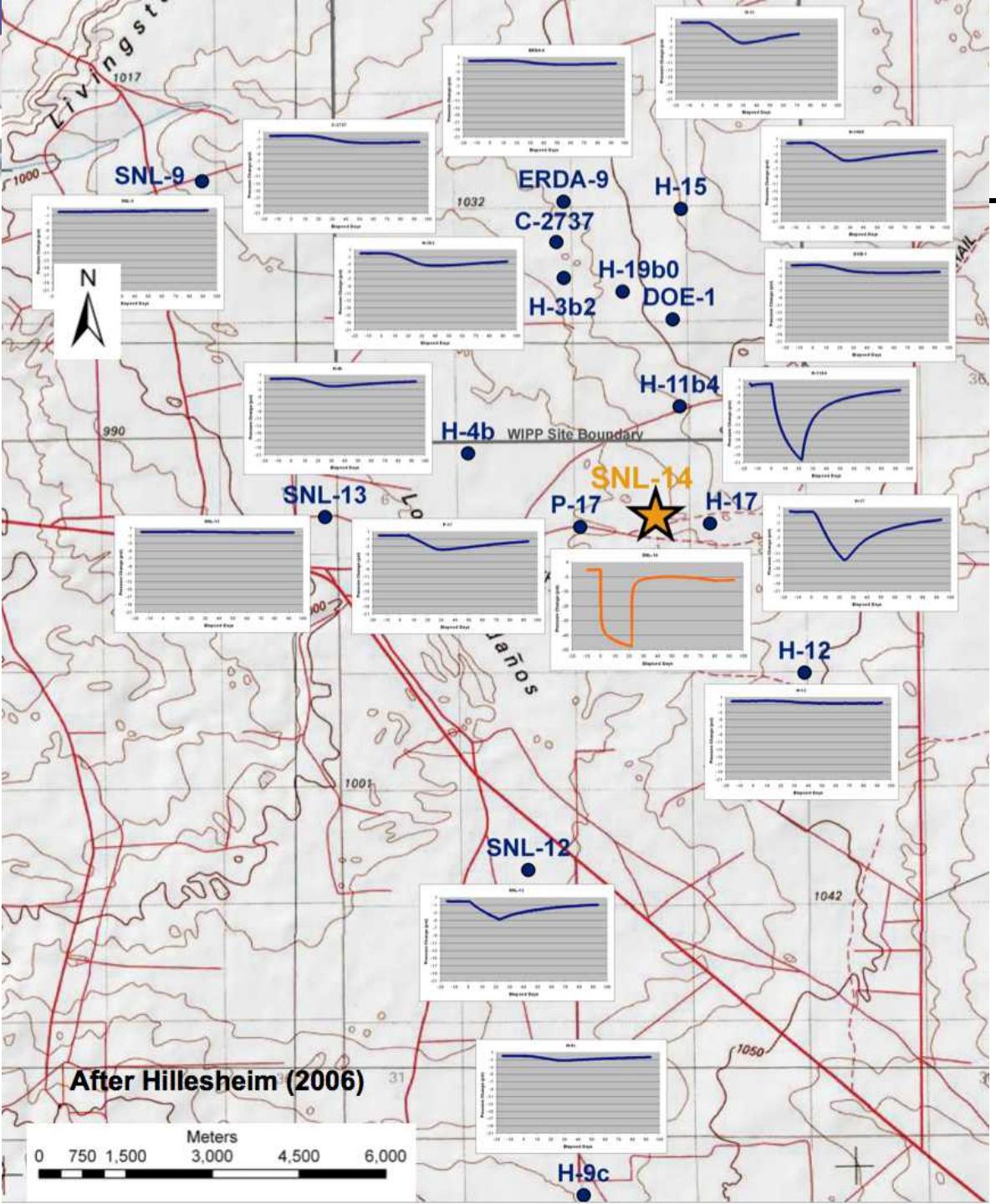




Multi-Pad Hydraulic Tests

- 15 multi-pad pumping tests (responses >395 m away)
  - ≤13 observation wells/test
  - 69 pump/observation pairs
  - Q up to 2.2 L/s (35 gpm)
  - ≤ 63 days of pumping
- Diffusivity (D=T/storativity) used to characterize multi-well response
- Close match to fractured/un-fractured distinction





Example

2005 SNL-14 multi-pad pumping test

Q = 30 gpm for 22 days

Response observed up to 9.5 km away

15 wells instrumented with pressure transducers for observing SNL-14 pumping + recovery

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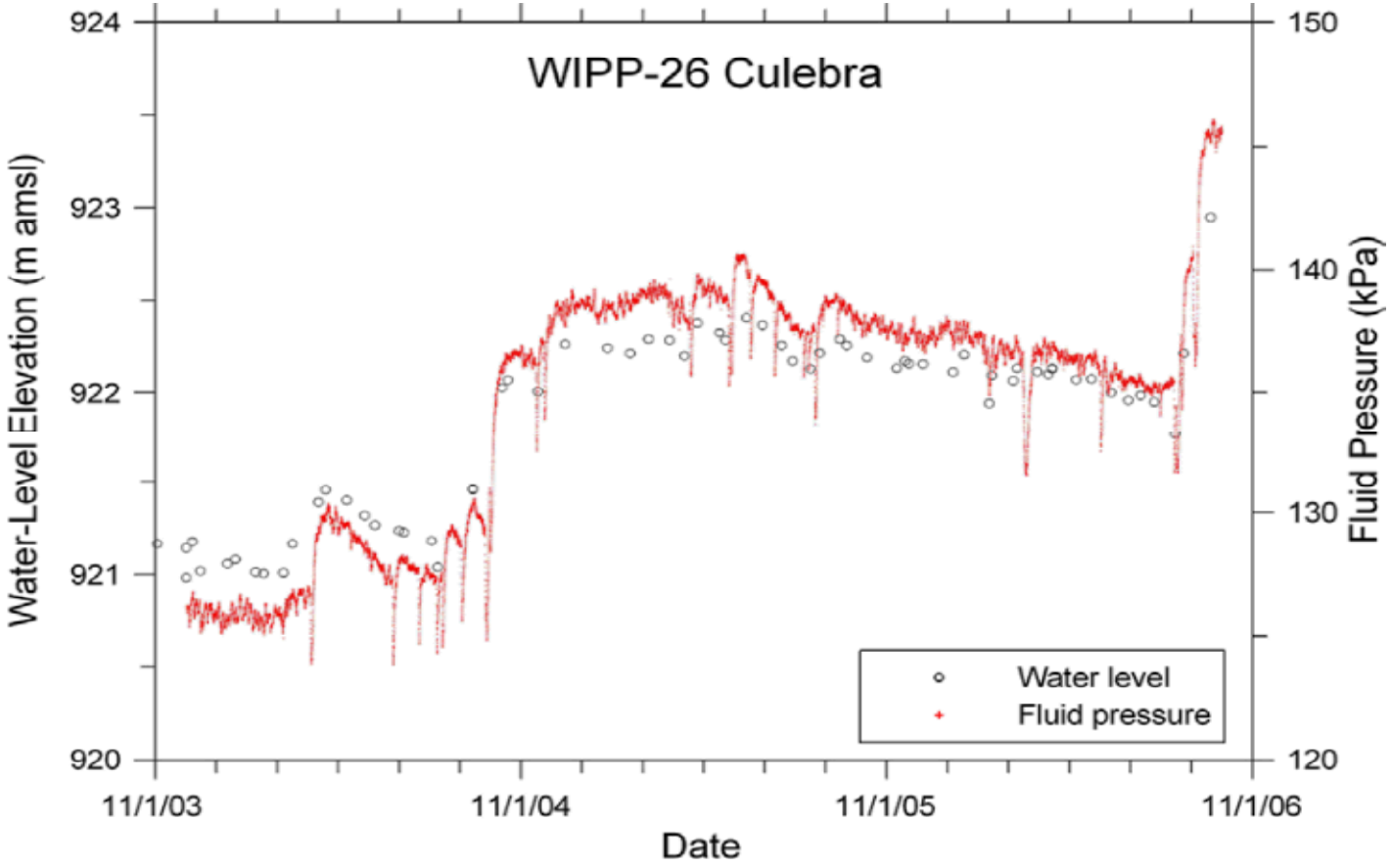
Pressure Head Monitoring

- **Hourly pressure-head vs. monthly water-level data**



From CRA-2009 (DOE, 2009)

Monthly water levels (dots) not revealing entire picture

Apparent measurement noise revealed to be coherent short-term fluctuations

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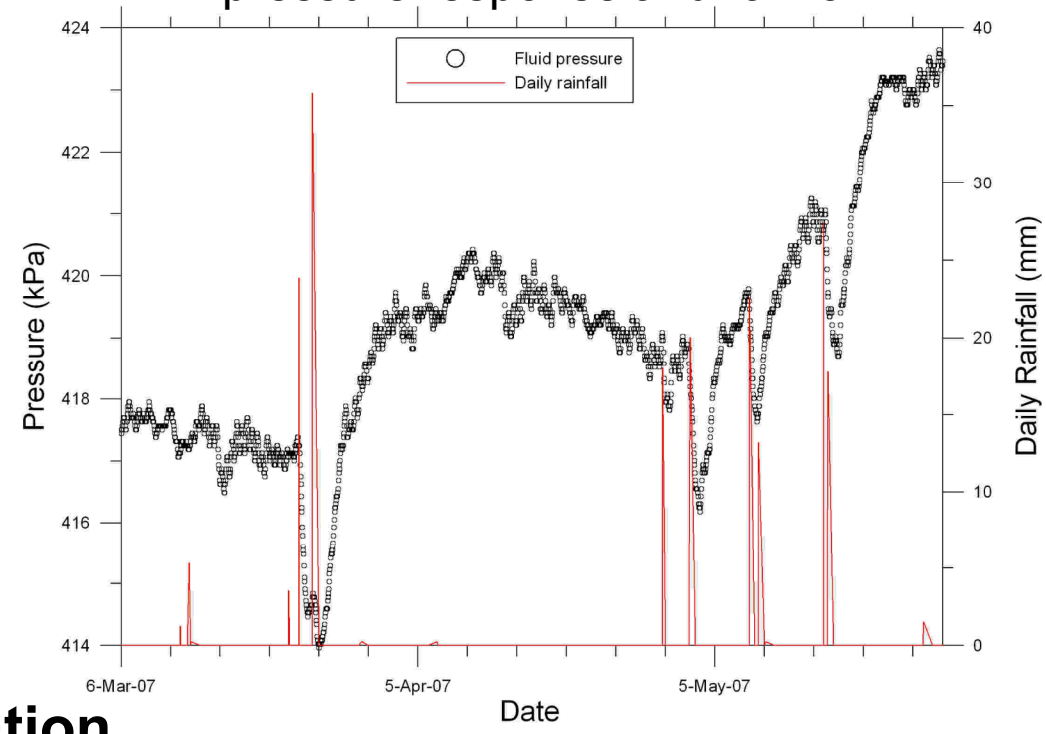
Large-Scale Natural Stimuli "Tests"

- **Multi-pad tests are major effort**
- **Growing database of high-frequency observations.**
- **Natural stimuli have large-scale effects**
  - **Precipitation**
  - **Barometric pressure**
  - **Earth-tides**
  - **Oil/gas/potash drilling**
- ***Free* testing stimuli**
  - **Poor source characterization**
  - **Hard to untangle multiple effects**

IMC-461 (in Nash Draw)
pressure response and rainfall



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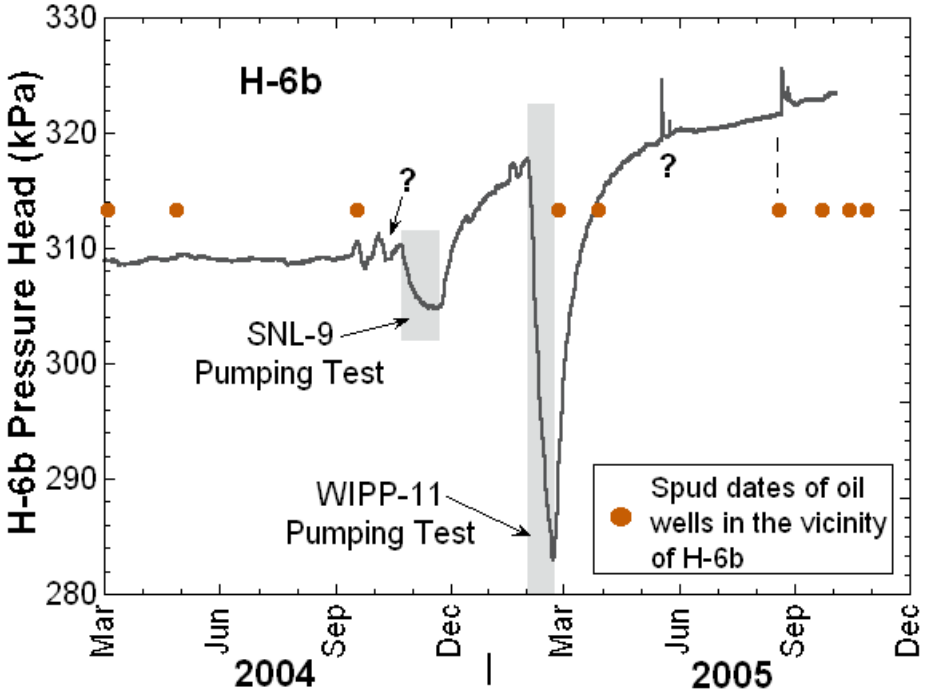
Oil/Gas/Potash Drilling

- Not *natural* stimuli, but pre-existing in basin
- Discrete location/time
- Source influences smaller area (< 5km)
- Sometimes questionable info available regarding spud dates
- Simulation?
  - 2D groundwater flow due to pulse source (easy)



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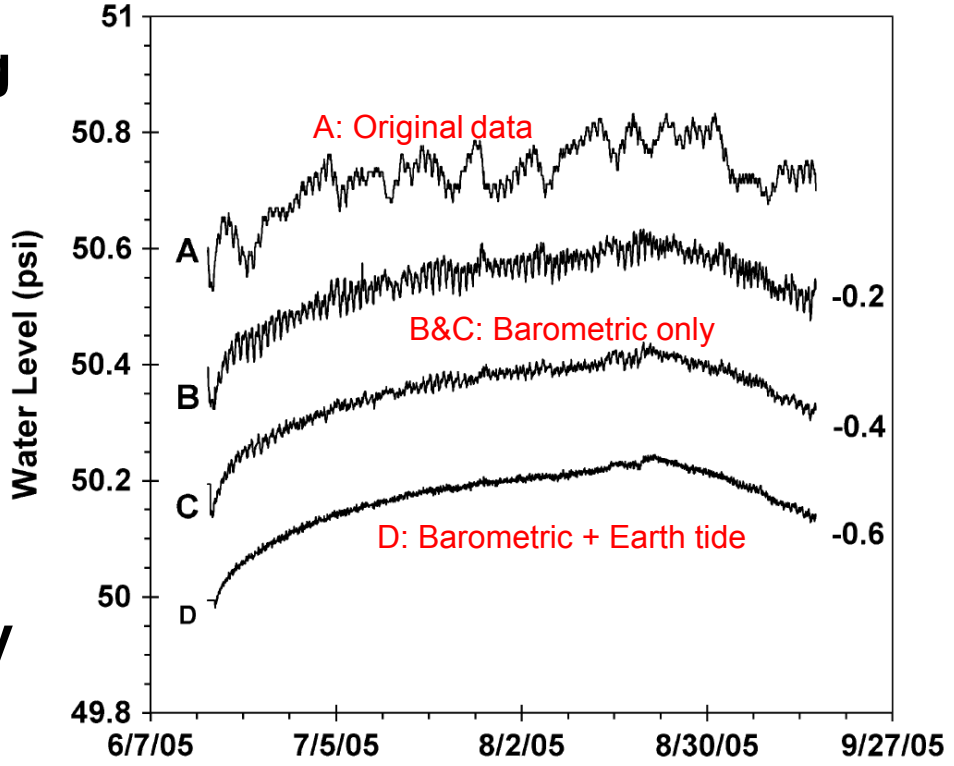
Barometric Pressure & Earth-Tides

- Previously removed to analyze pumping test data
  - Statistical approach (moving average least-squares fit)
- Alternately, use physical model to explain effects
- Estimate:
  - Confined aquifer T and storage parameters
  - vadose zone air permeability
- Source is well defined
- Simulation?
  - 1D vertical pressure wave



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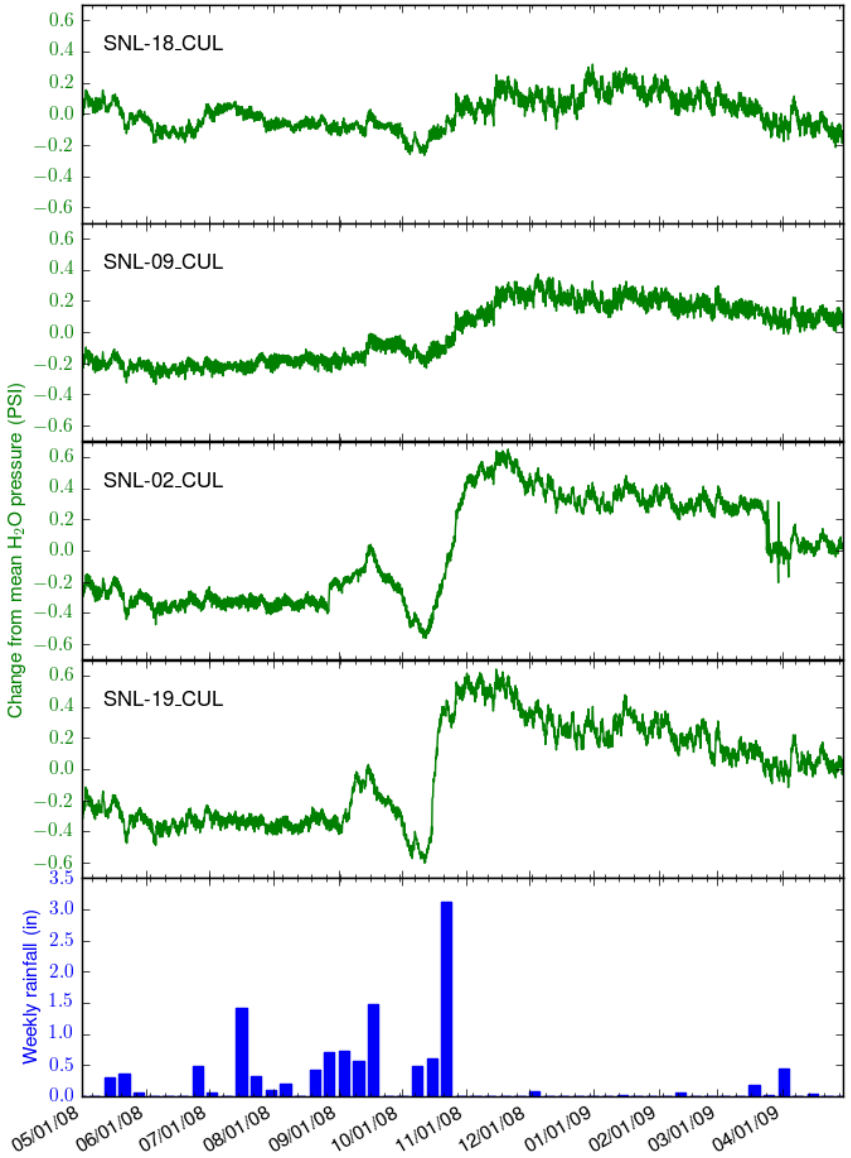
Precipitation

- Rain / water-levels depend on:
  - Precipitation distribution
  - Confined/unconfined
- Nash Draw: unconfined & Rustler karst
- Few major annual storms
- Shallow system dries out between rain events
- Source poorly characterized spatially
- Simulation?
  - 3D infiltration



Summary

- **WIPP Characterization of Culebra has historically focused on well testing**
- **New focus on "data mining" existing and future high-frequency monitoring records**

Stimulus	# Tests	Scale
Single-well pumping	~100	1 m – 10 m
Single-pad multi-well pumping	20	5 m – 50 m
Multi-pad pumping	15	0.4 km – 9.5 km
Oil/Gas/Potash drilling	dozens per year	0.5 km – 4 km ?
Precipitation	2-3 per year	1 km – 30 km ?
Barometric/ Earth tide	continuous	1 km – 30 km ?

- **Testing Culebra at a new scale**