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# Ground water level monitoring at Yucca Mountain — A programmatic summary

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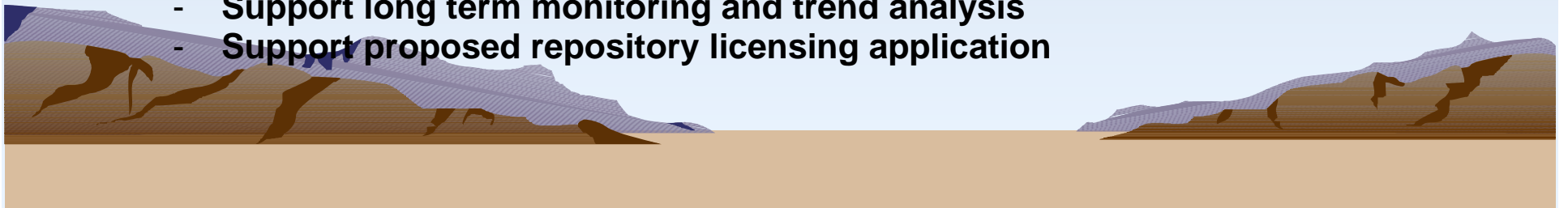
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# Ground Water Level Monitoring at Yucca Mountain A Programmatic Summary

H. Scott Page

Harry Reid Center for Environmental Studies at UNLV

- **Conducted Under Cooperative Agreement with DOE**
- **Carried out by NSHE personnel under NSHE/DOE approved QA program**
- **Initiated July 2001 after program transfer from USGS**
- **Scope**
  - **Confirmatory study supporting previously gathered information**
  - **Measure levels on established network of monitoring wells**
  - **Submit data annually**
- **Objectives**
  - **Provide measurements of known accuracy and precision**
  - **Use manual and electronic equipment**
  - **Provide quality assured data**
  - **Contribute to hydrological understanding**
  - **Support refinement of potentiometric surface**
  - **Provide data for regional flow model**
  - **Fulfill State of Nevada permit conditions**
  - **Monitor transient events such as seismically induced fluctuations and precipitation-related phenomena**
  - **Support long term monitoring and trend analysis**
  - **Support proposed repository licensing application**

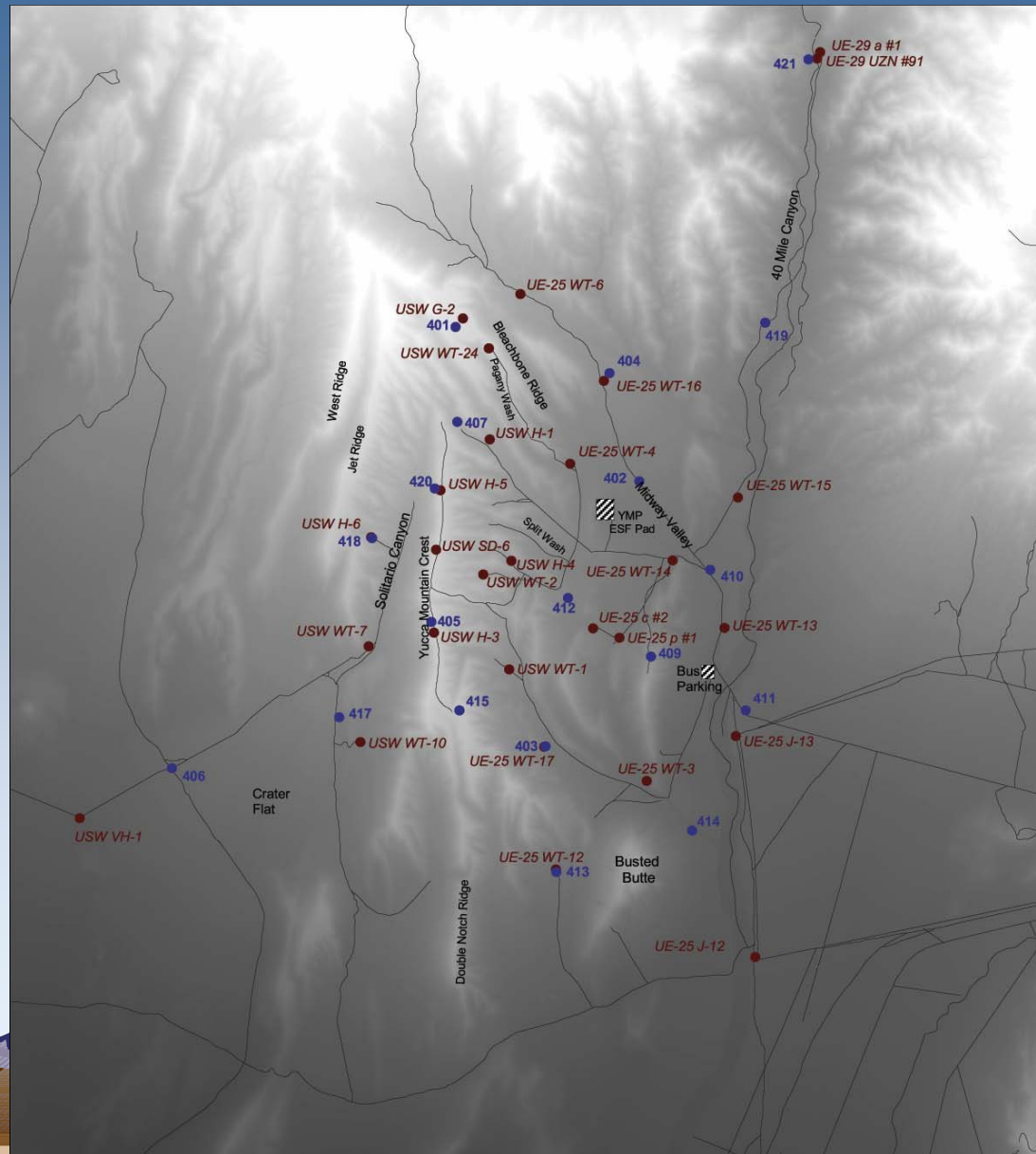


# Monitoring Network Description

- Twenty-eight surface-base boreholes with about 30 usable monitoring ports
- Areas 25 and 29 on Nevada Test Site
- Bureau of Land Management public land west of NTS (Crater Flat)
- Depth-to-water range: 604 - 2510 feet below ground surface
- Flow systems monitored:
  - 24 boreholes in volcanic rock
  - 3 boreholes in alluvium/colluvium
  - 1 borehole in carbonate rock
  - 3 boreholes have multiple access tubes
  - 'WT' wells in upper volcanics
  - 'H' wells in multi-interval/deeper volcanics
  - Special purpose wells:
    - › C-Well Complex – borehole to borehole scale
    - › J-Wells – drinking water
    - › VH-1 – Crater Flats volcanics
    - › p1 – underlying Paleozoic carbonate aquifer



# Hydrologic Monitoring Sites Near Yucca Mountain



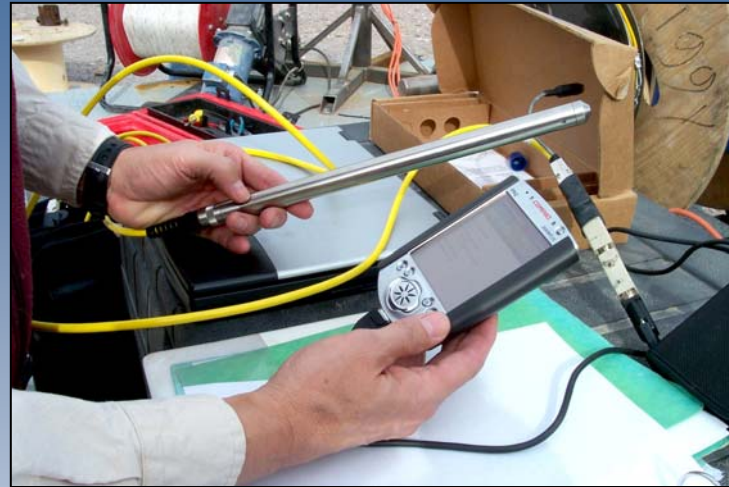
# Ground Water Level Measurement Equipment

- **Powered electric tapes**
  - 3000-foot weight electrical cable graduated 0.01-ft increments
  - Variable speed electric motor with light/electric sounder
  - Calibrated biennially
  - Routine monitoring of most volcanic flow system boreholes
- **Hand held steel tape**
  - 100-foot graduated survey add tape
  - First two feet graduated in 0.01-ft increments with water sensitive coating
  - Not subject to operational variability/non-calibrated
- **Reference Steel Tape**
  - 2,800-foot NIST calibrated survey tape graduated 0.01-ft increments
  - Reference standard for all other equipment calibrations
- **Digital Pressure-Temperature Transducers**
  - Barometrically compensated pressure-temperature sensor with integrated silicon strain gauge, on-board datalogger-microprocessor, 1MB data storage, clock, internal power





# Yucca Mountain Field Operations



# Quality Assurance: Precision - Accuracy - Error

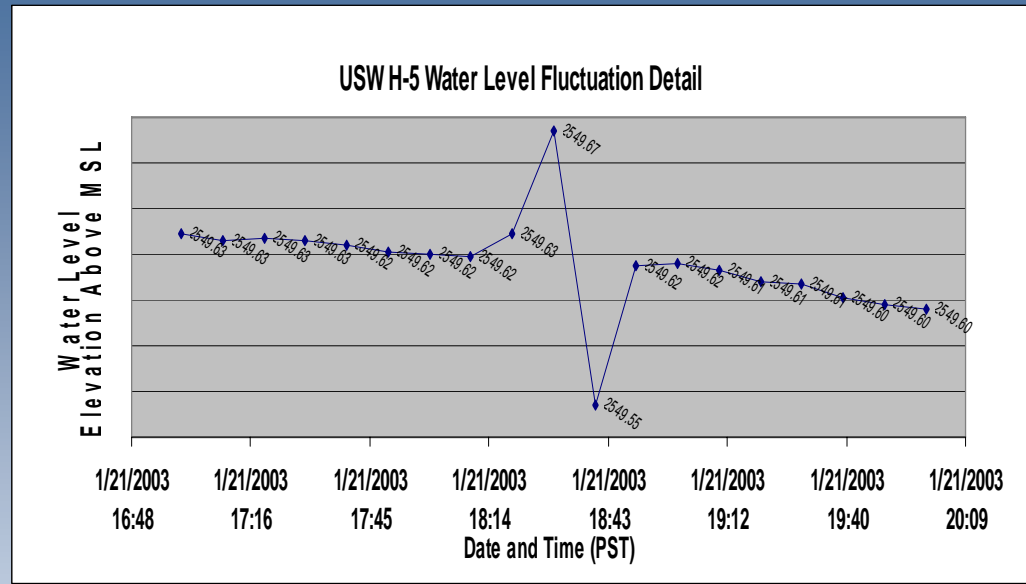
- **Electric Tape**
  - Precision reported to nearest 0.01-ft
  - Accuracy of 99+% relative to Reference Steel Tape over entire measured range
  - Error 0.0004% relative to Reference Steel Tape over entire measured range
- **Hand Held Steel Tape**
  - Precision reported to nearest 0.01-ft
  - Relative Accuracy comparable to electric tape, no absolute accuracy established
  - Error sources qualitatively similar to electric tape, believed to quantitatively similar
- **Digital Pressure Transducer**
  - Precision for 15 PSI sensor is reported to nearest 0.01-ft
  - Accuracy is  $\pm 0.03$  feet over entire measured range for 15 PSIG sensor
  - Error derives from source used to establish sensor reference level for first measurement



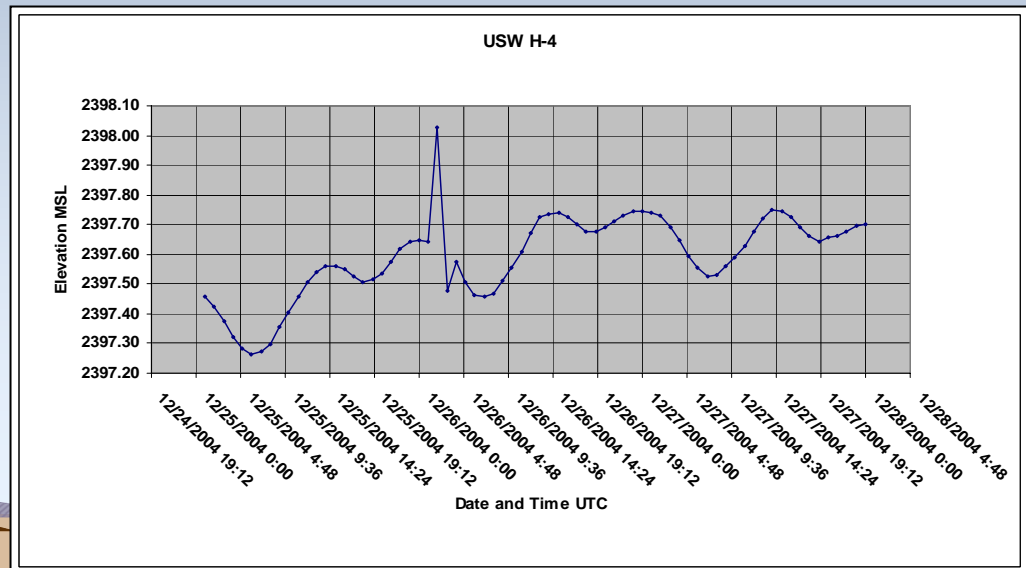
# Significant Observations

## Seismically-Induced Fluctuations

- Alaskan earthquake of Nov 2002, M7.9 near Denali National Park
- 2340 miles from Yucca Mtn
- 16 minute travel time
- 0.73-ft fluctuation



- Indonesian earthquake/tsunami of Dec 2004, M8.3+
- 8250 miles from Yucca Mtn
- 20 minute travel time
- 0.39-ft fluctuation

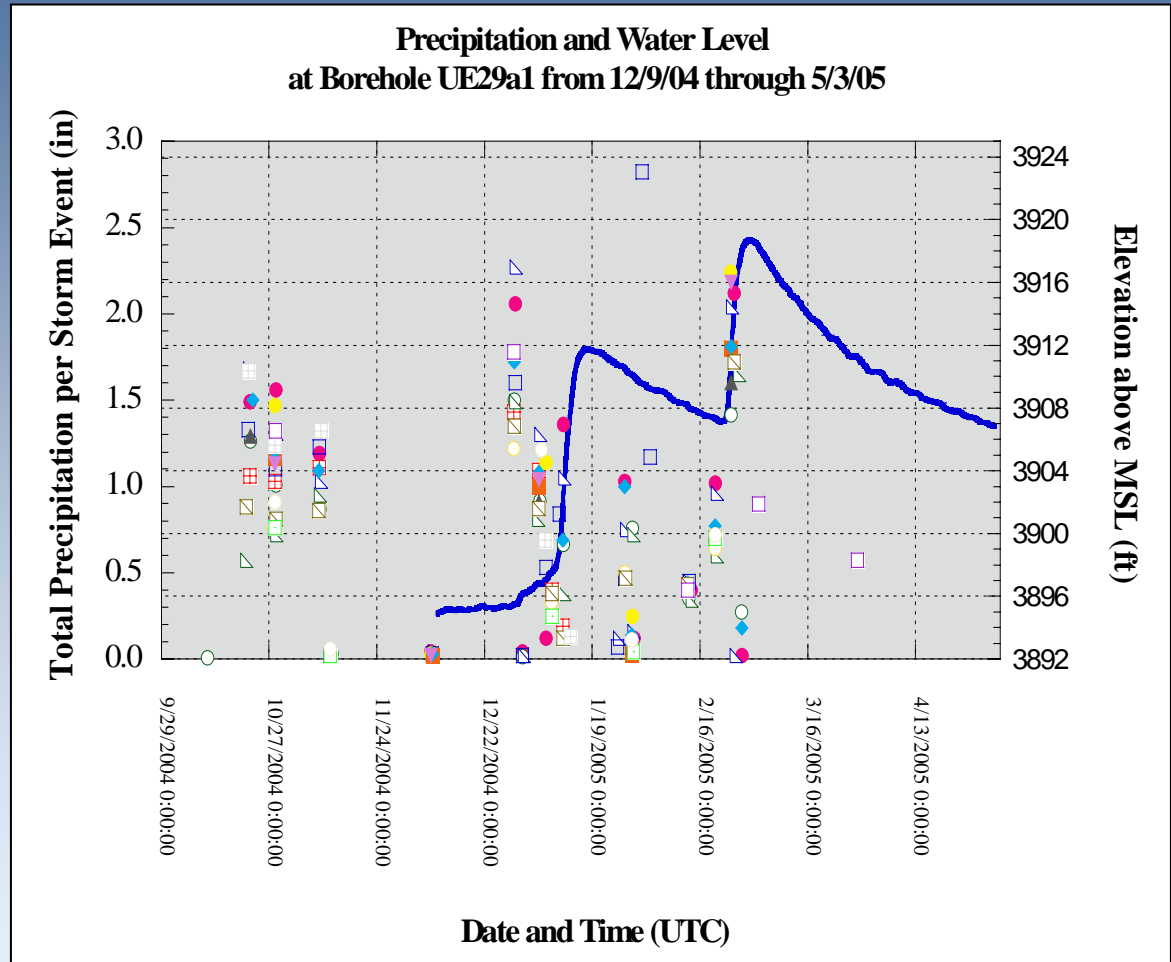




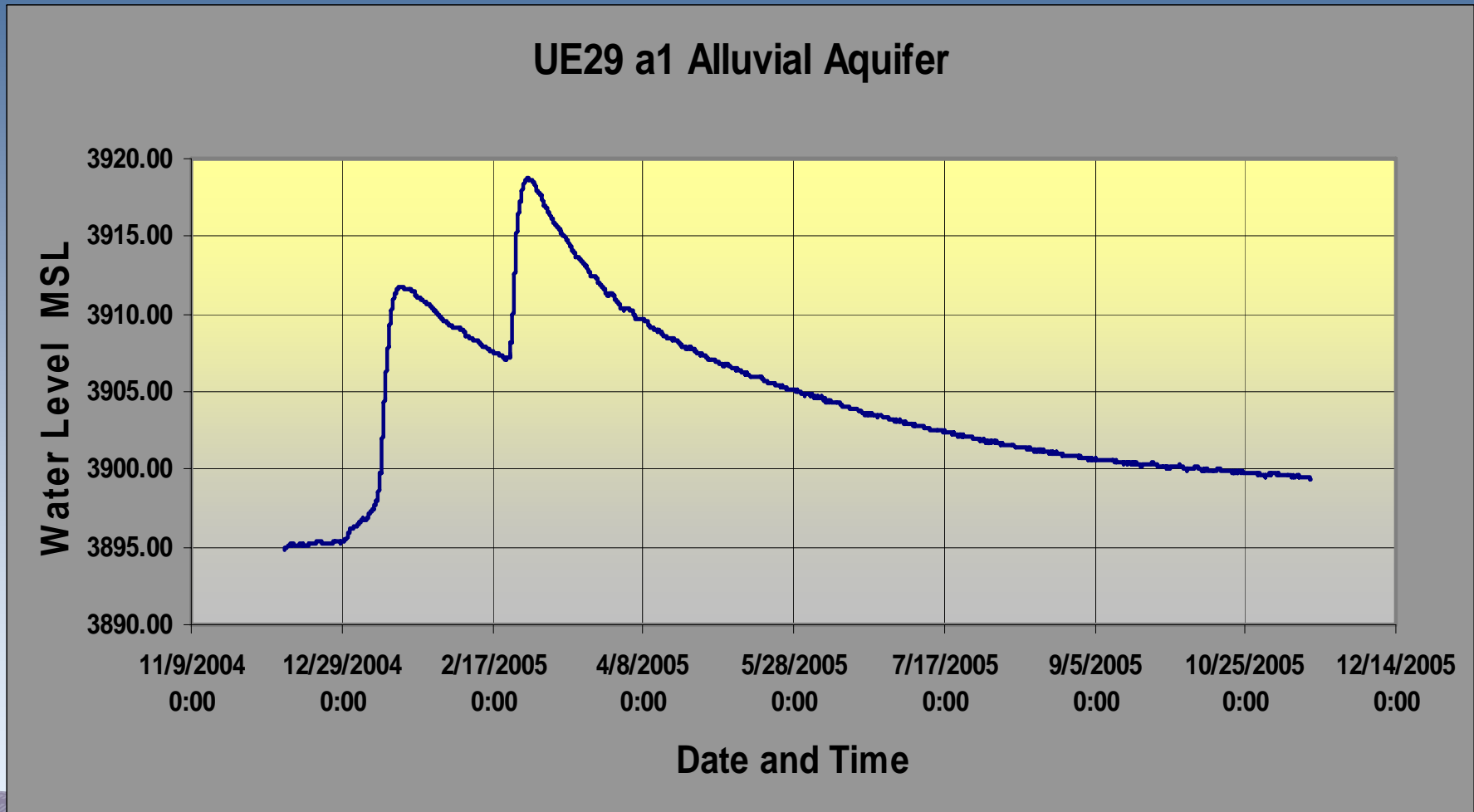
# Significant Observations

## *Fluctuations from Regional Runoff*

- Rapid rise in alluvial boreholes in 40-Mile Wash
- 24-ft rise in 5 months winter of 2005-2005 unprecedented
- Cumulative infiltration and saturated hydraulic conductivity in nearby boreholes could not account for the observed rise
- Rise not direct consequence of precipitation measured by the 17 station network near Yucca Mountain.
- Likely cause:
  - › Precipitation at higher elevations north of the boreholes,
  - › Drainage from larger runoff through the upper Fortymile drainage basin
  - › Large scale USZ lateral flow between alluvial horizons that comprise the canyon and adjacent stream terraces.

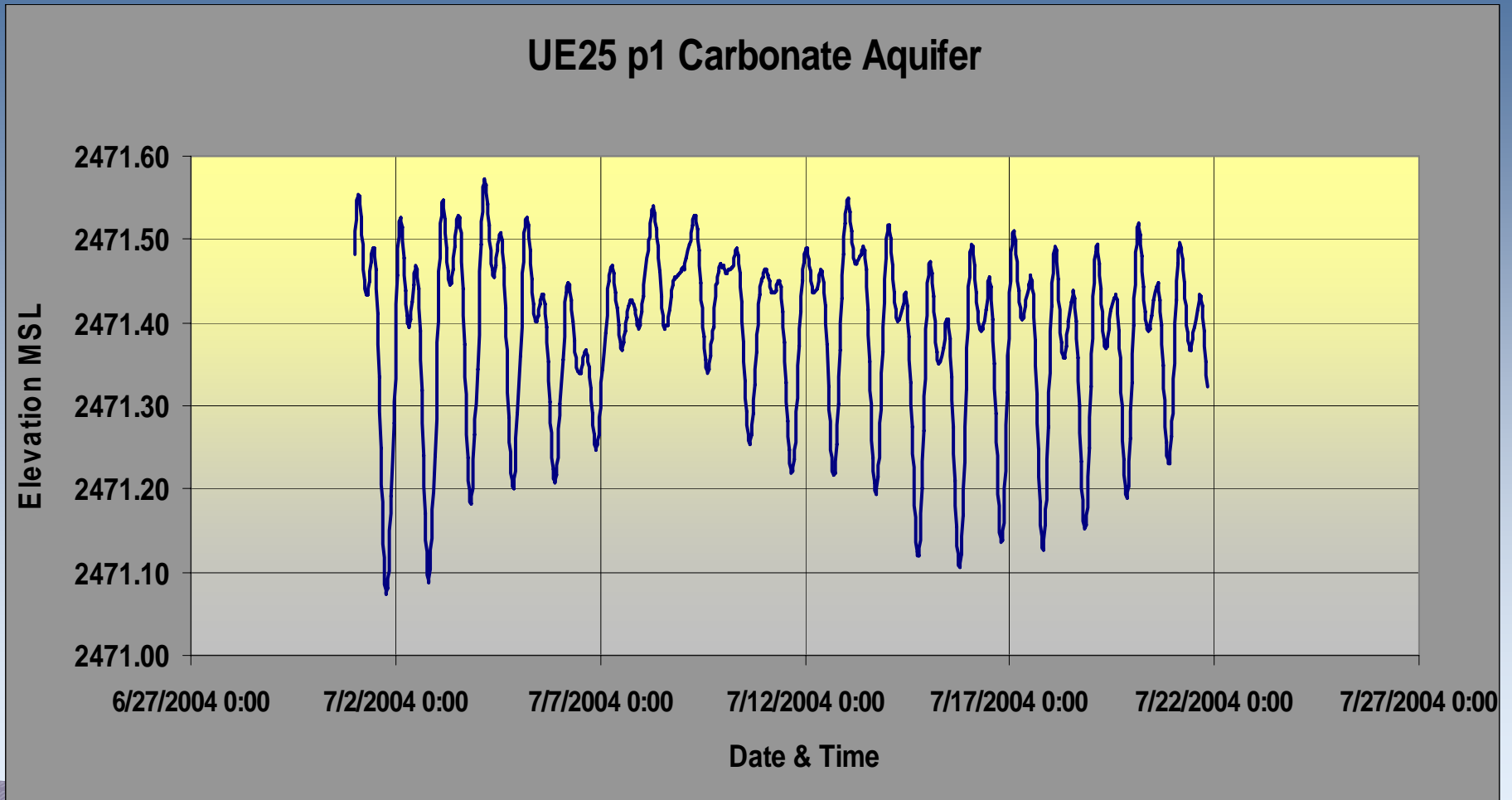


# Significant Observations *Fluctuations from Regional Runoff*



# Significant Observations

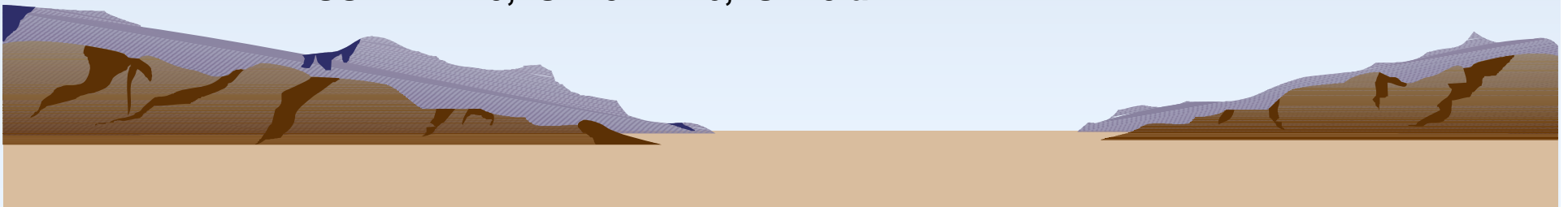
## *Earth Tides: Ground Water Levels From UE25 p1*



# Significant Observations

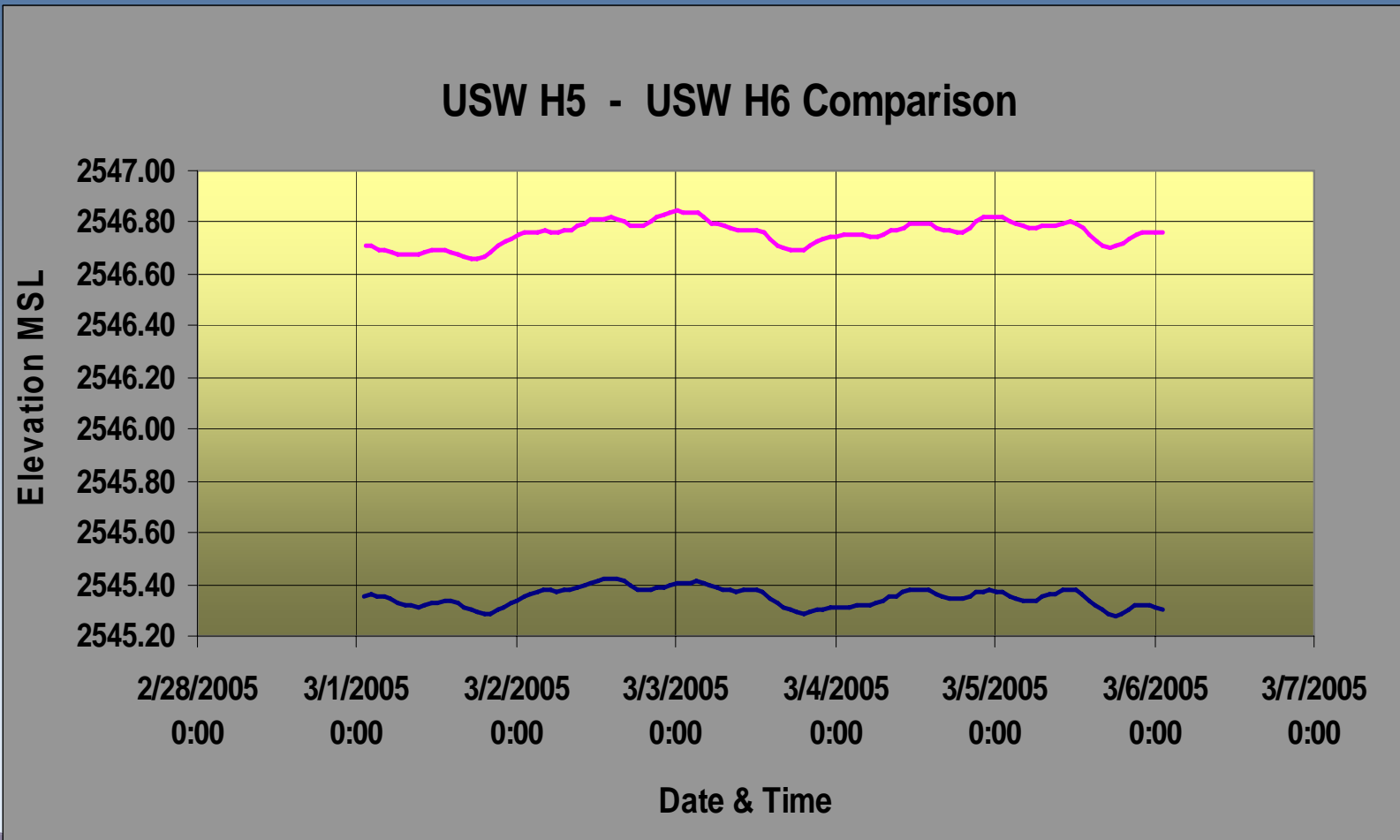
## *Synoptic Data*

- Wide area, simultaneous acquisition at multiple boreholes
- Useful for total flow system understanding
- Synchronized to Zulu Time (GMT)
  - Intercomparison with seismic information
- Hourly sampling except for WT13
- Archived hundreds of thousands of QA measurements
- Nearest 0.01-ft with 0.03 accuracy
- Much of it in overlapping time periods, but not all
- Nine boreholes:
  - WT13, UE25 p1, USW H4, USW H5, USW H6, USW WT2, USW WT 10, UE25 WT16, UE29 a1



# Significant Observations

## *Synoptic Data*

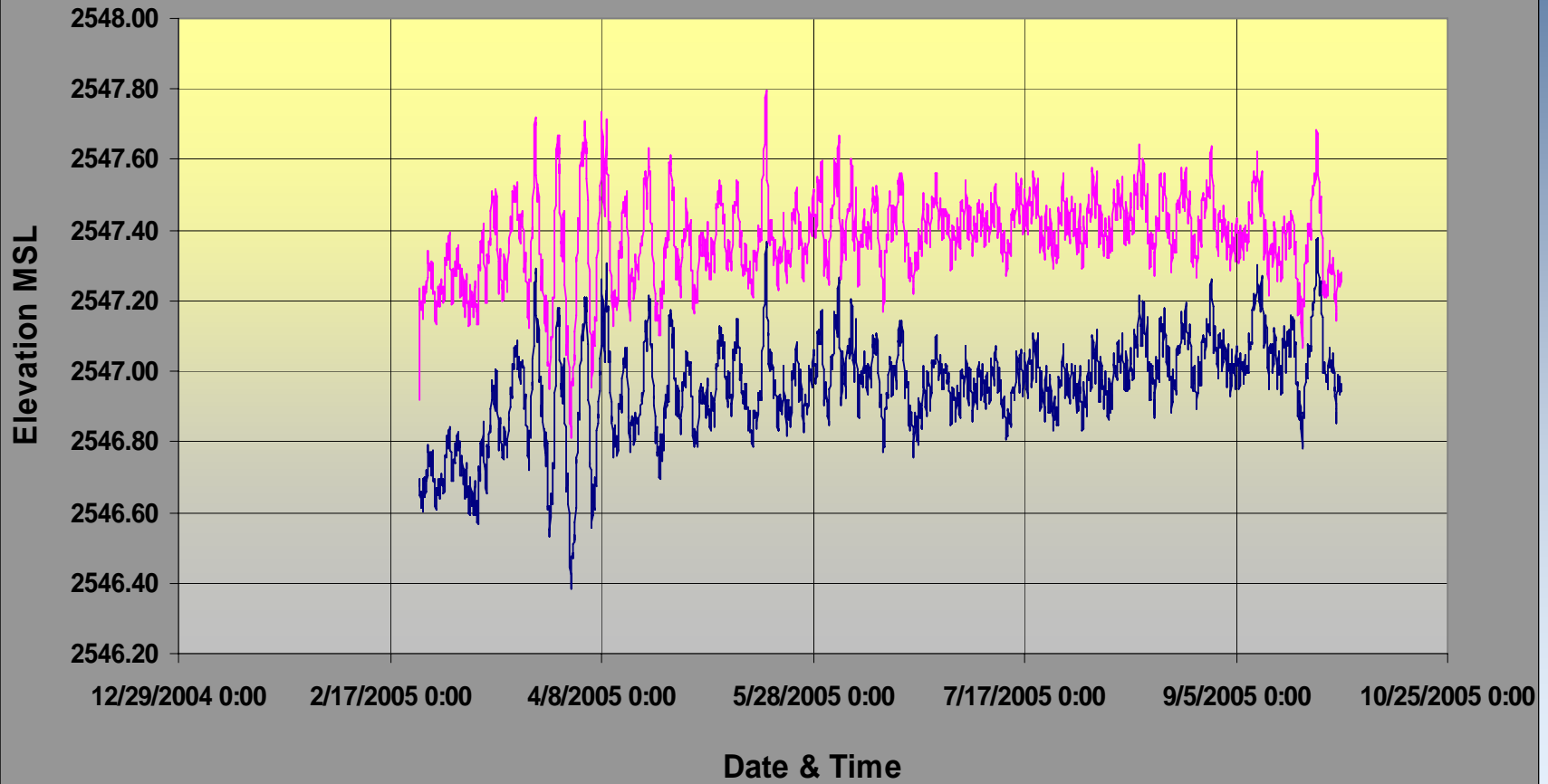




# Significant Observations

## *Synoptic Data*

### USW H6 - USW WT10 Comparison



# Significant Observations

## *Groundwater Water Level Trends: 2001 - 2005*

- Mean fluctuation range in the volcanic, carbonate, and alluvial flow systems period was 2.52 feet
- When effects of the 2004 - 2005 precipitation-induced fluctuations in 3 alluvial system boreholes in Fortymile Wash are removed, mean fluctuation range was 1.33 feet
- Mean beginning-to-end-of-period change from the 2nd Quarter 2001 to the 4th Quarter 2005 was + 0.59 feet
- When effects of the 2004 – 2005 precipitation-induced fluctuations in 3 alluvial system boreholes in Fortymile Wash are removed, mean beginning-to-end-of-period change was + 0.31 feet
- Ground water levels near Yucca Mtn are quite stable



## **The Future: New Initiatives**

- **Support Proposed Saturated Zone Test Program**
  - Nye County, Sandia, Los Alamos, UNLV, others
  - 4,300 ft combination vertical-to-horizontal borehole
  - Proof-of-concept design drill east-to-west near Bow Ridge Fault
  - UNLV to instrument seven observation wells, measure drawdown
- **Update Equipment**
  - Existing electronic systems need replacing to support SZ Test, future measurement program for Yucca Mountain
  - New temp/pressure sensors with 8-10 yr battery life
  - High accuracy, greater reliability, software/firmware improvements
  - Same vendor, similar operational characteristics simplify transition
  - Approximately 14,400 feet of vented communication cable to support SZ test

