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Ground water level monitoring at Yucca Mountain — A programmatic summary

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Ground Water Level Monitoring at Yucca Mountain
A Programmatic Summary

H. Scott Page
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- 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 ± 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

UE29 a1 Alluvial Aquifer

Water Level MSL

Date and Time
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 WT10, UE25 WT16, UE29 a1
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