SAND2009-4501P

Overview of Groundwater Monitoring

KRMC Training Program

Module 3: Overview of Operational Programs

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Introduction

- Groundwater monitoring at WIPP originally began as part of site characterization
- Over time, the monitoring focus shifted to providing data for development and calibration of groundwater models
- Currently, monitoring is conducted for performance confirmation and to support continuing hydrologic investigations

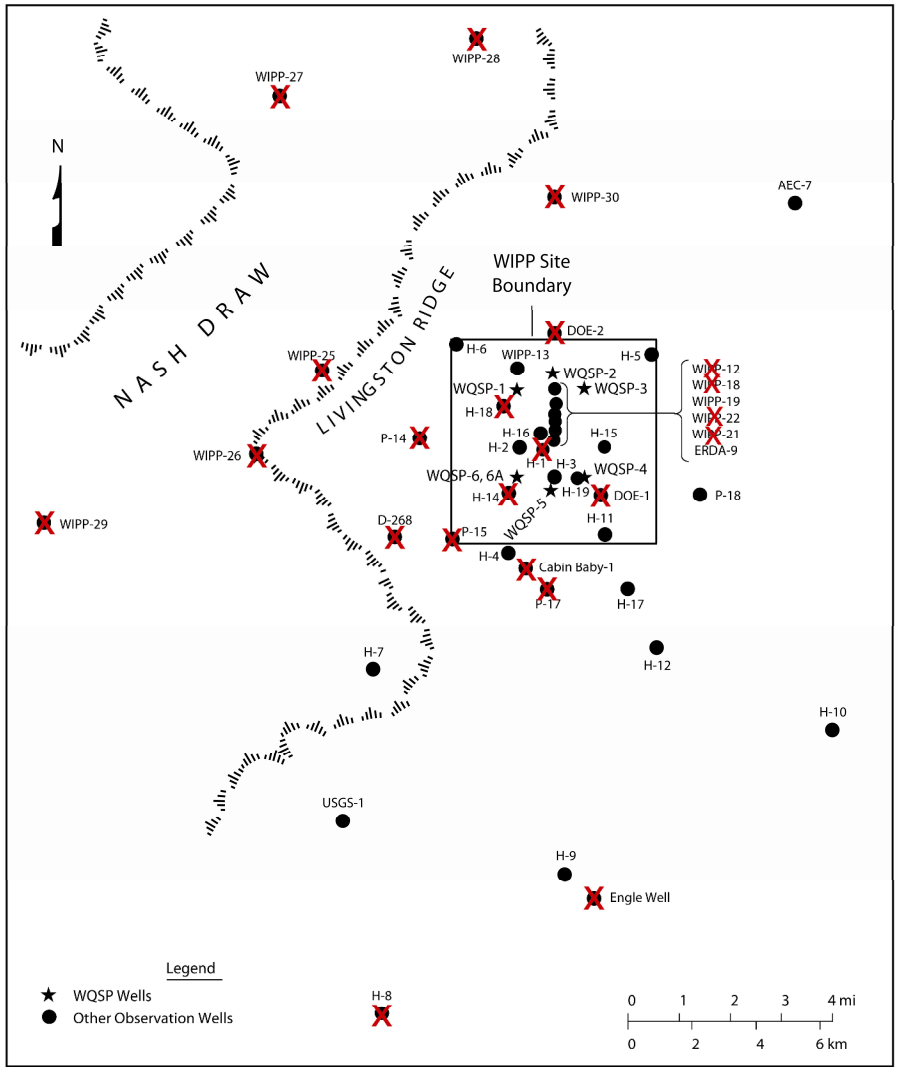
Groundwater Monitoring

- Groundwater monitoring is largely focused on the Culebra
- Water levels measured since 1977
- Different parties have monitored over different periods:
  - 1977-1983: USGS (spotty/intermittent)
  - 1983-1989: SNL (monthly and more frequently in association with tests)
  - 1988-date: WRES (monthly)
  - 1995-1996: SNL (spotty, in association with tests)
  - 2002-date: SNL (began in association with tests, now widespread monthly coverage)
- Beginning in 2002, gradual instrumentation of nearly all wells with Trolls that make hourly pressure readings

Monitoring Network

- The Culebra monitoring network has changed significantly over the past 14 years
- The network that existed up to 1995 was not designed for monitoring, but simply developed as wells were drilled for a variety of separate studies
- Until 1995, all wells were cased with steel
- Steel-cased wells degrade in brine environments and ultimately have to be plugged and abandoned
- Since 1995, all new wells have been constructed of either fiberglass or PVC
- The current network is the result of an optimization study focused on providing data needed for performance assessment modeling

Current Status of 1995 Culebra Well Network



- 26 well locations remain in network
- 22 former locations are no longer monitored

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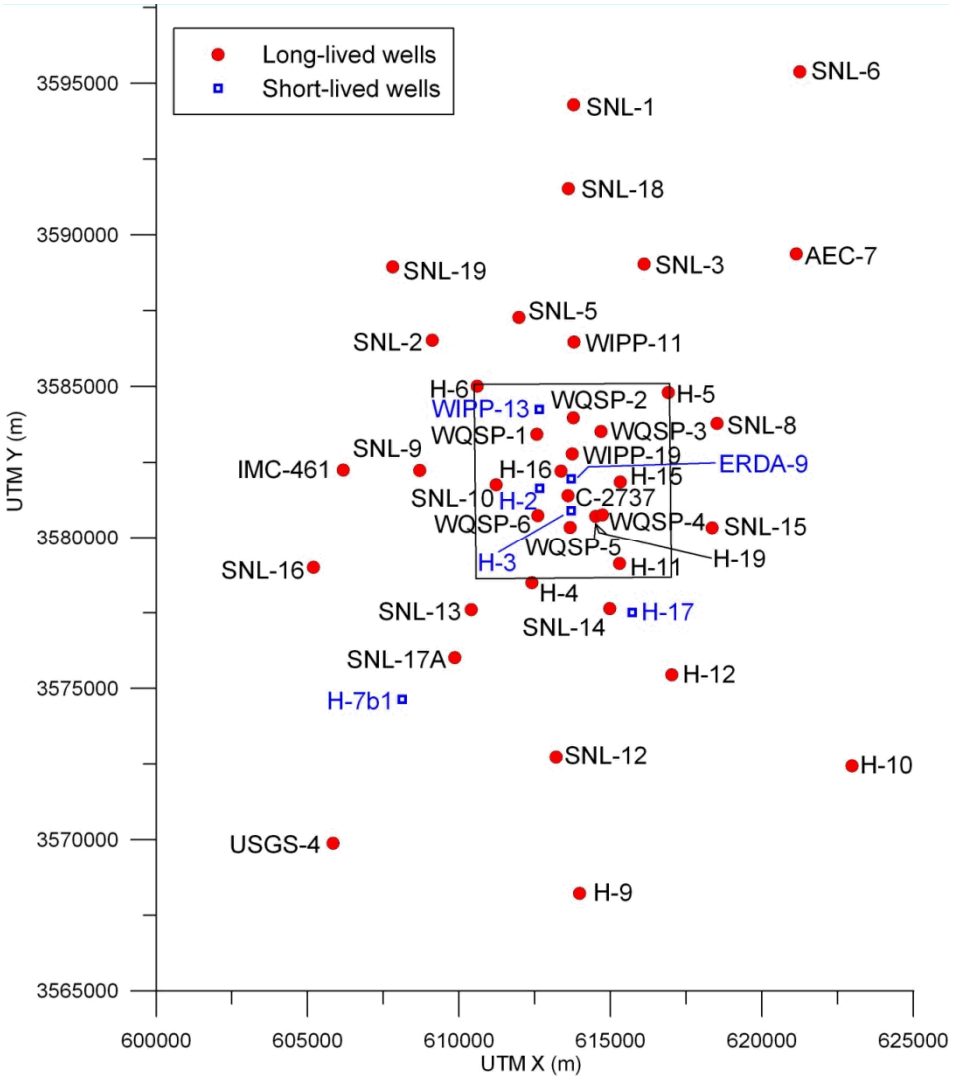
Current Culebra Well Network



- 38 wells are either of recent, non-steel construction or will be replaced when they fail
- 6 steel-cased wells are currently not expected to be replaced when they fail and must be plugged and abandoned

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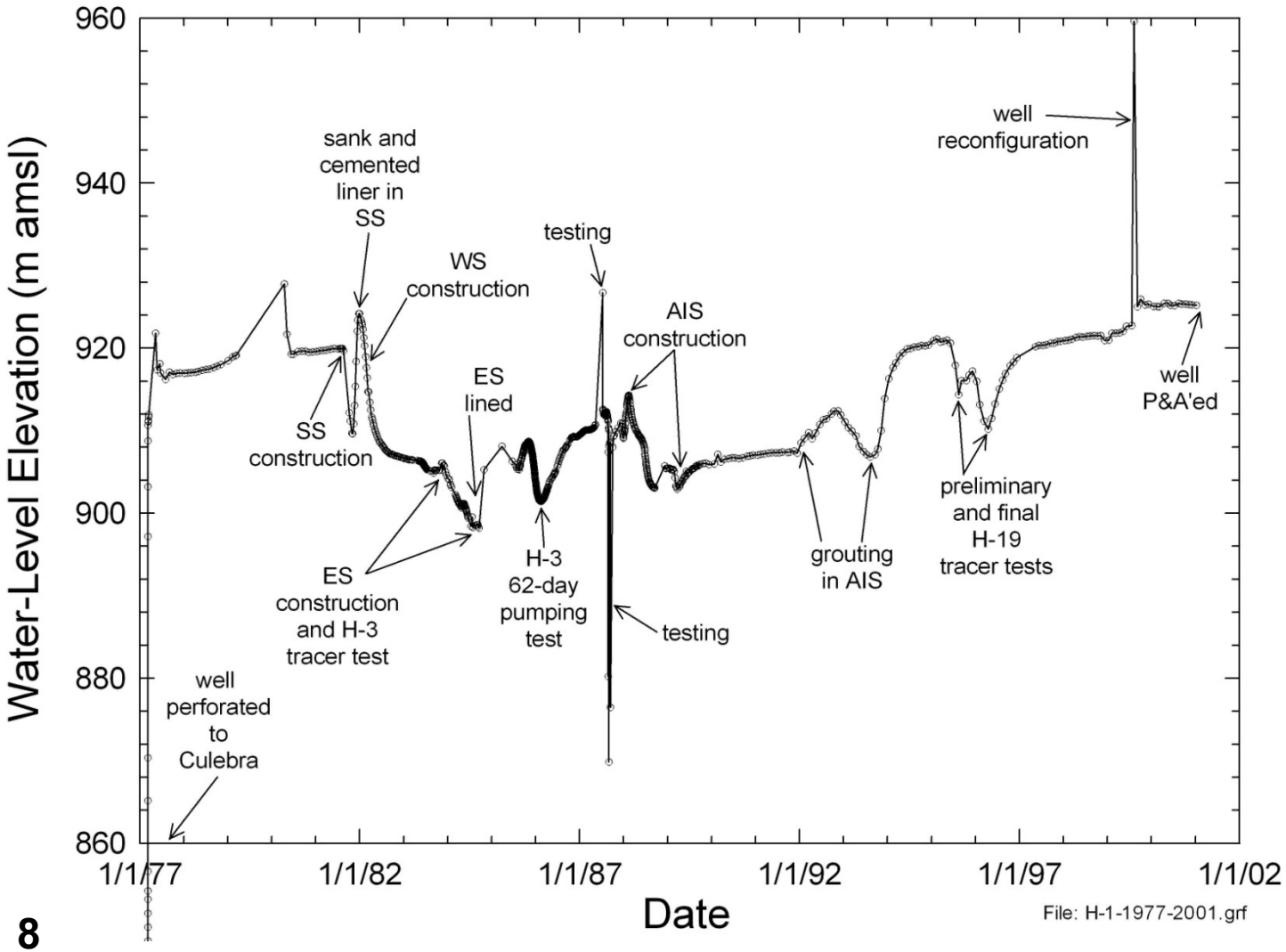
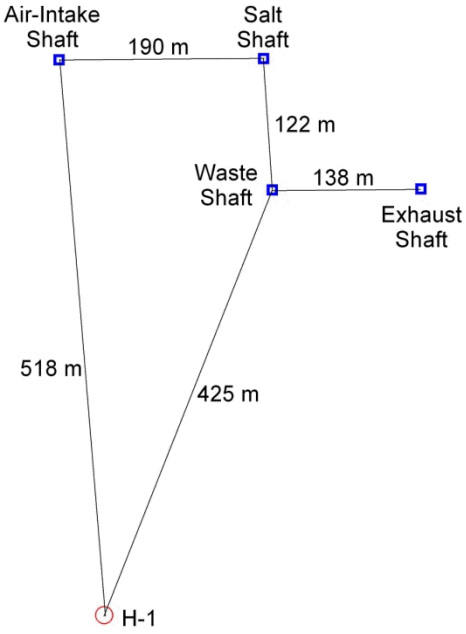
Monitoring Observations

- Many fluctuations in water levels caused by WIPP shaft construction, leakage into shafts, and hydraulic testing
- General rise in water levels over last 2-3 decades
- Spikes in water level from one month to the next with rapid fall-off related to nearby oil and gas drilling
- Water levels in karstic Nash Draw respond to rainfall—head changes then propagate diffusively toward the WIPP site

Culebra Water-Level Response in H-1 to WIPP Activities





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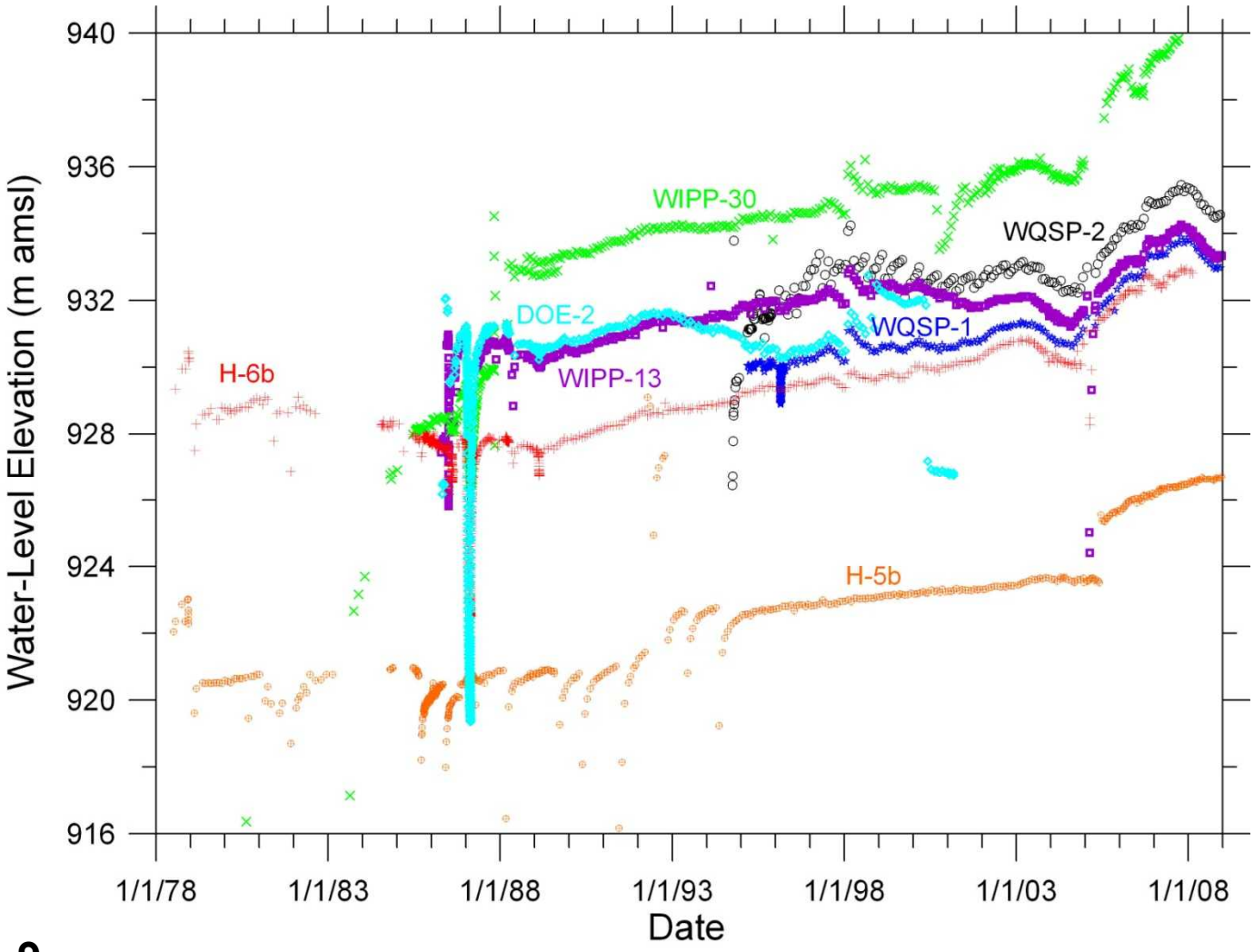
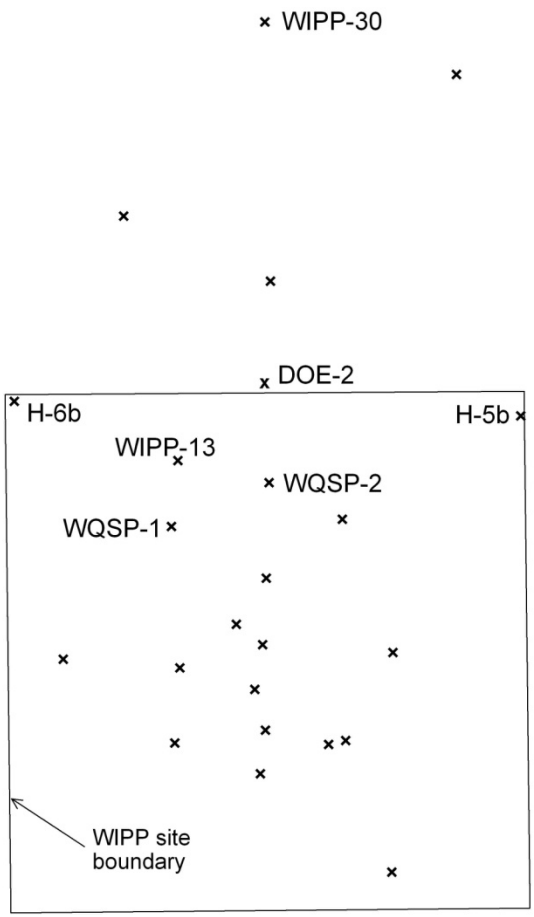
Culebra Long-Term Water-Level Trends (1)





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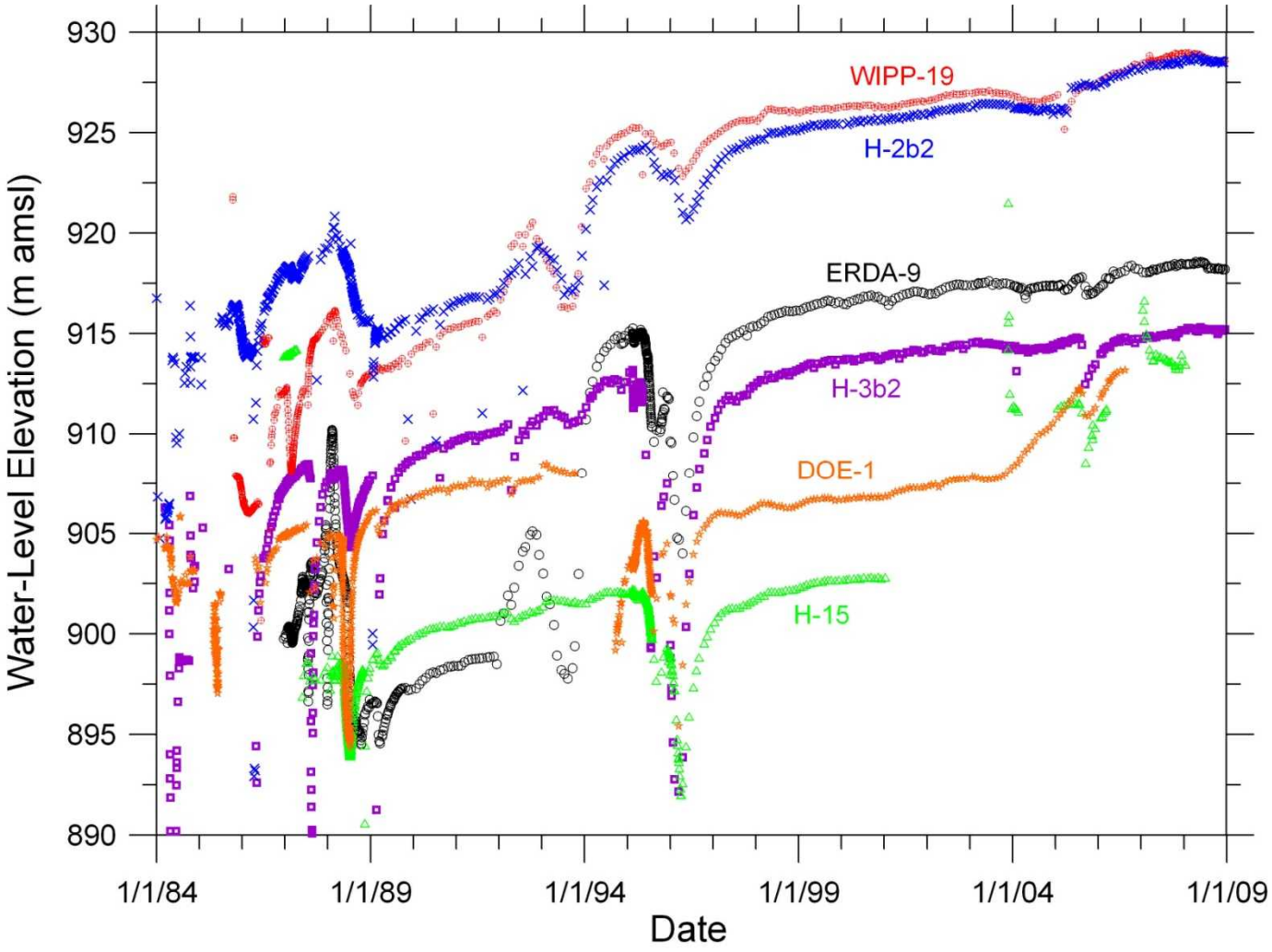
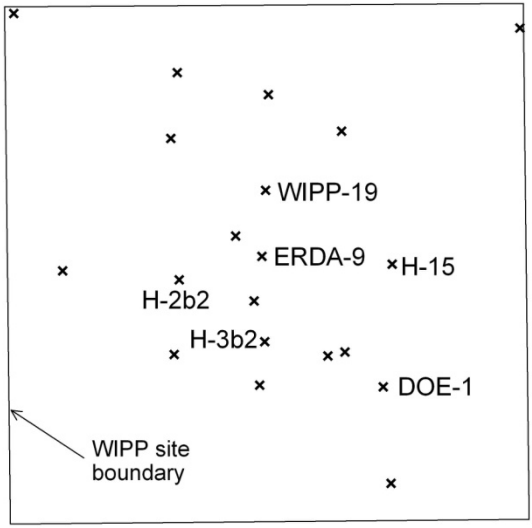
Culebra Long-Term Water-Level Trends (2)





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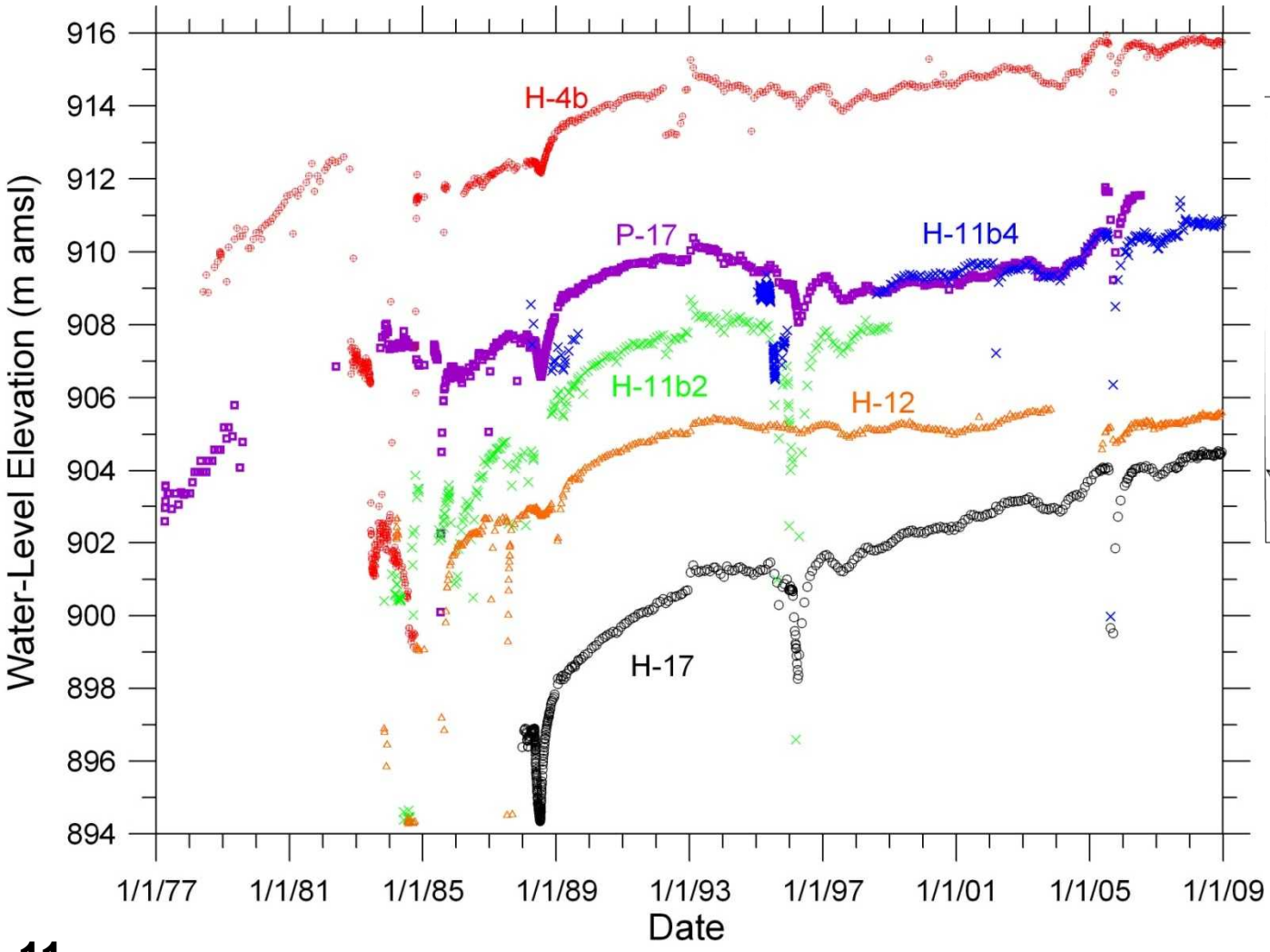
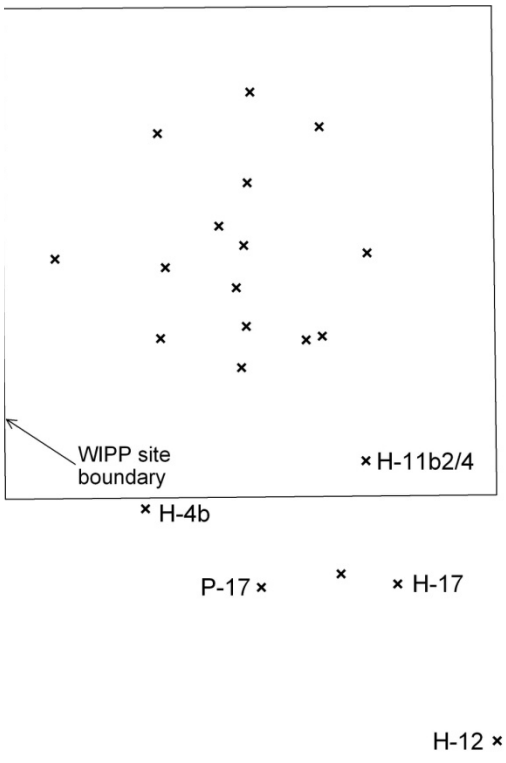
Culebra Long-Term Water-Level Trends (3)





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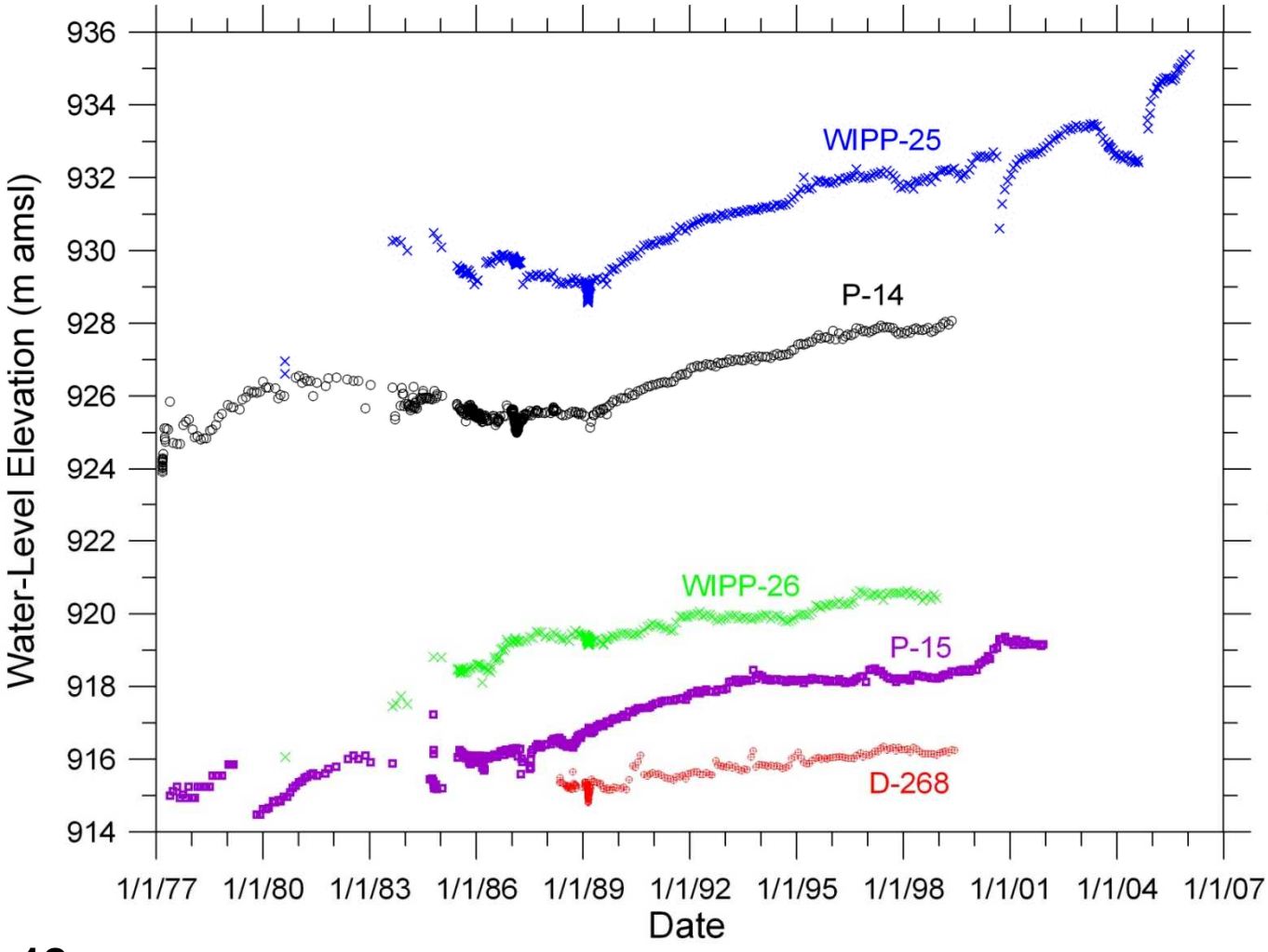
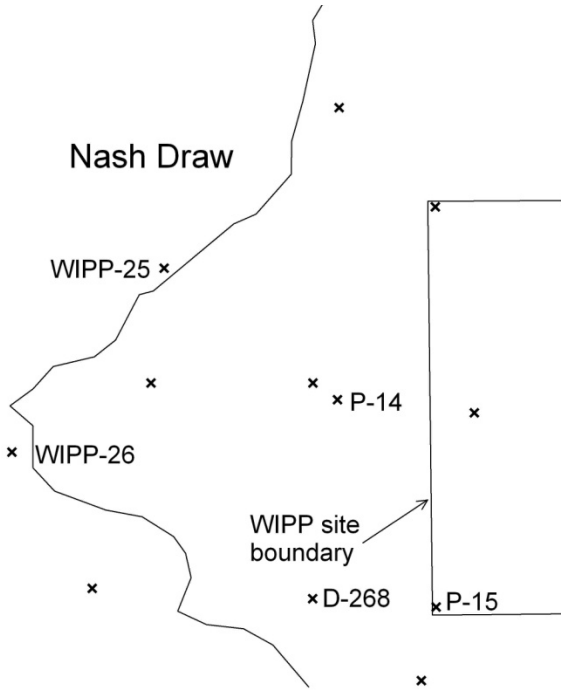
Culebra Long-Term Water-Level Trends (4)





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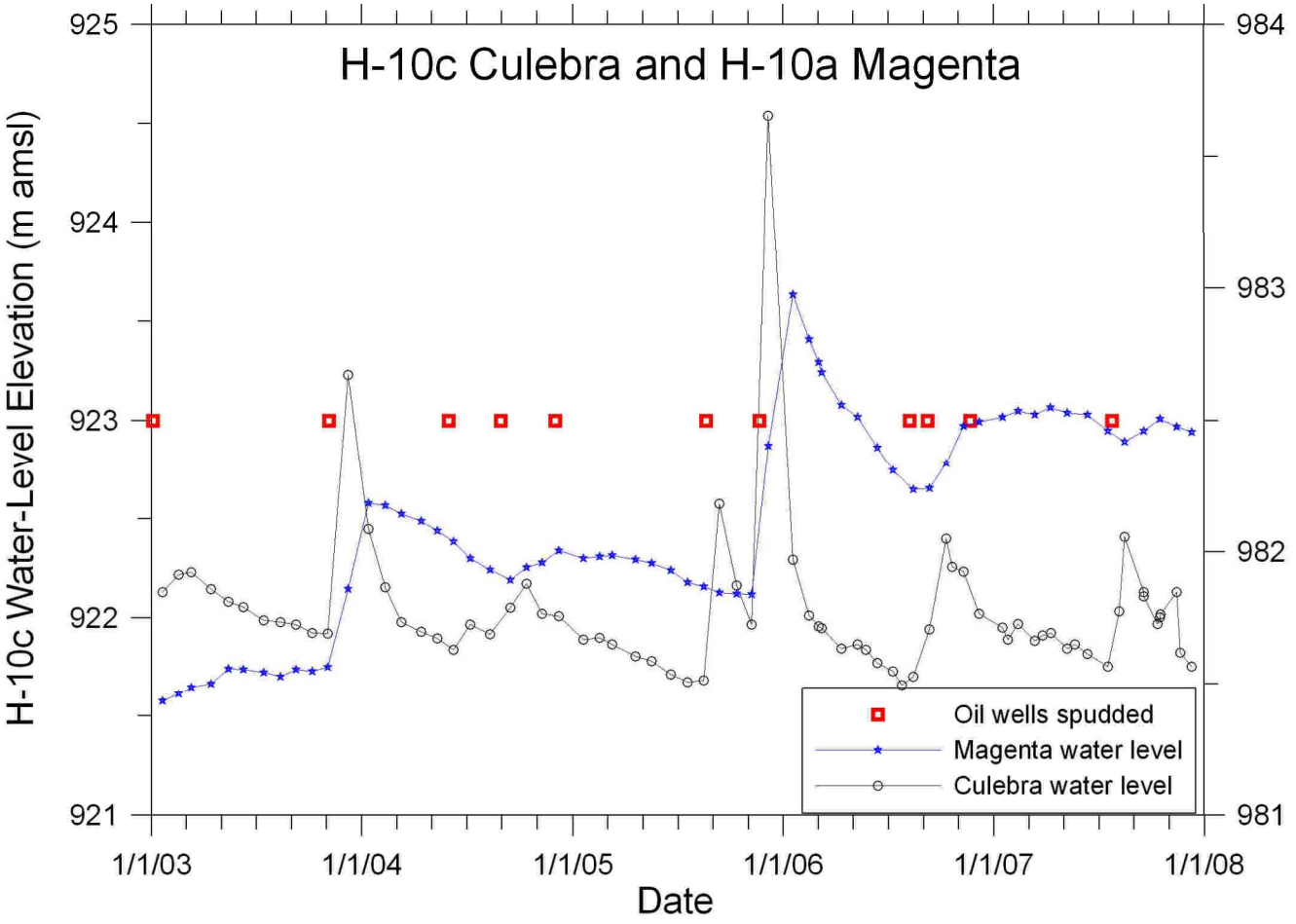
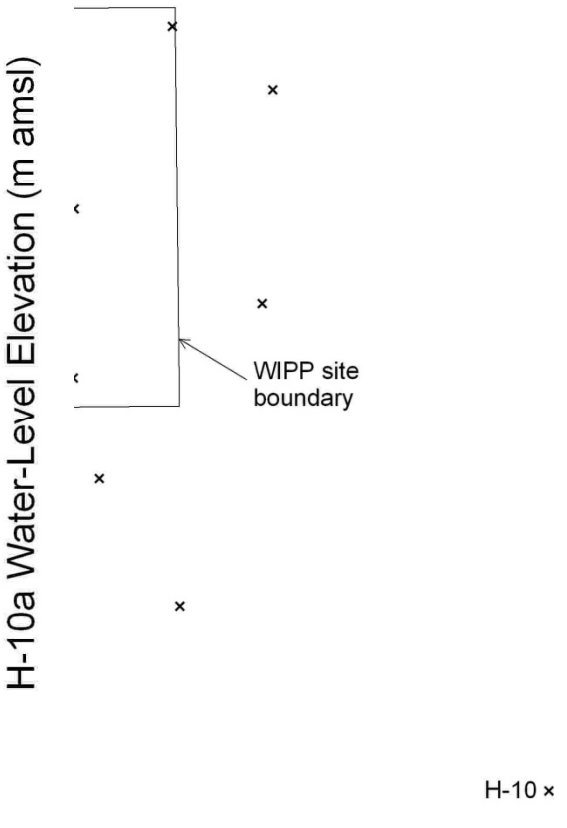
Sudden Water-Level Fluctuations





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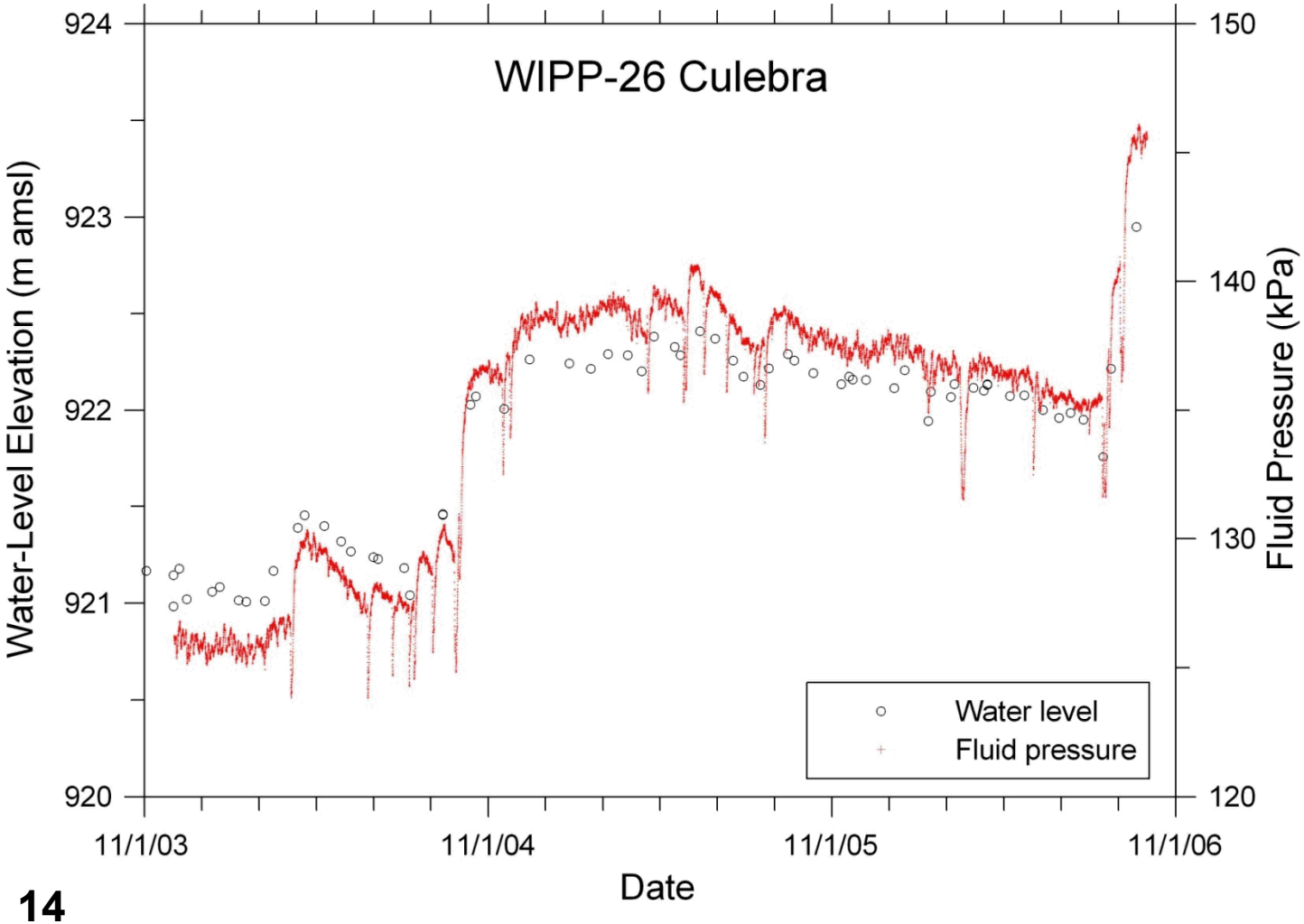
Comparison of Biweekly and Hourly Measurements



In a system not at steady state, hourly measurements are critical to understanding behavior

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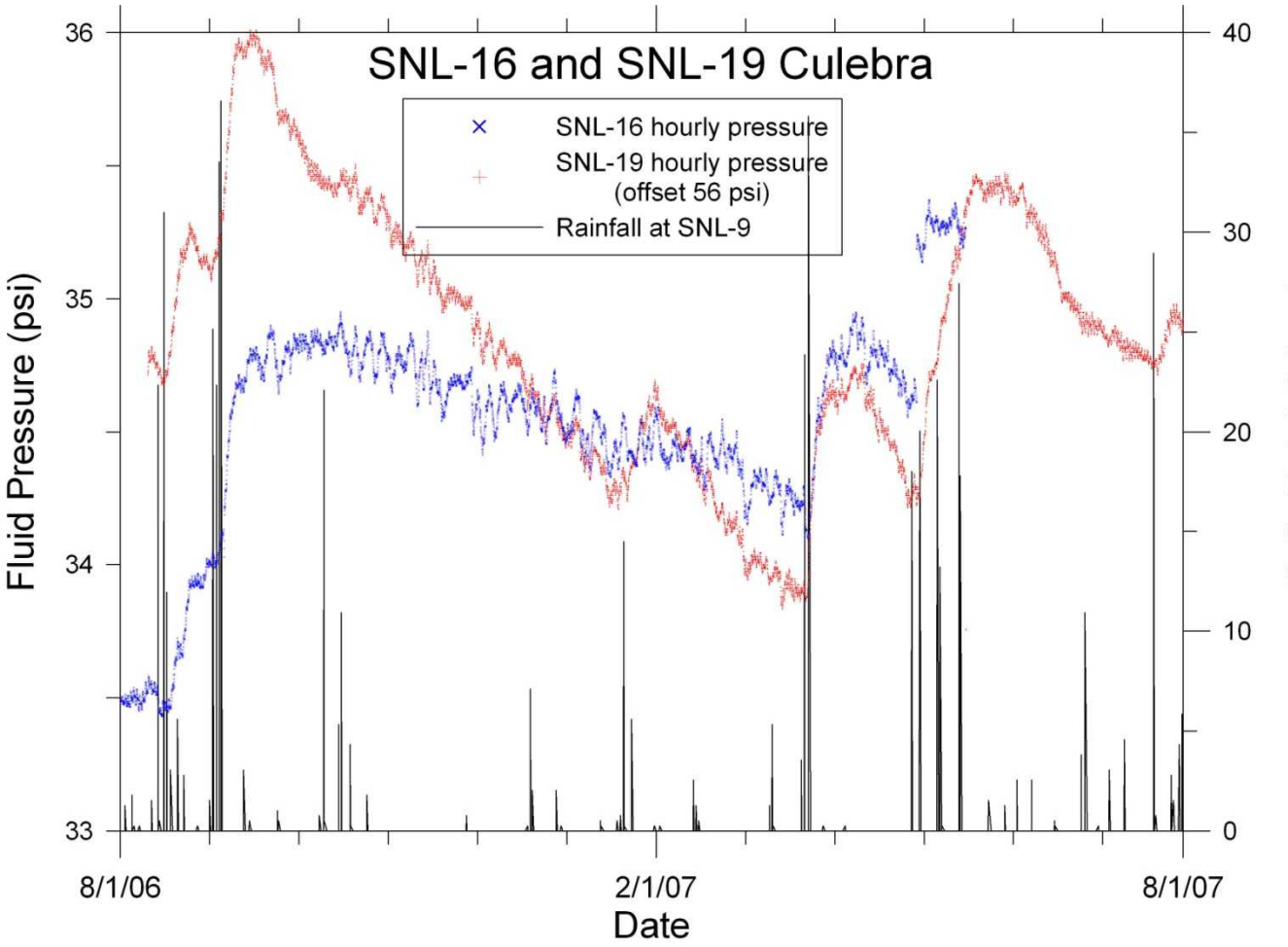
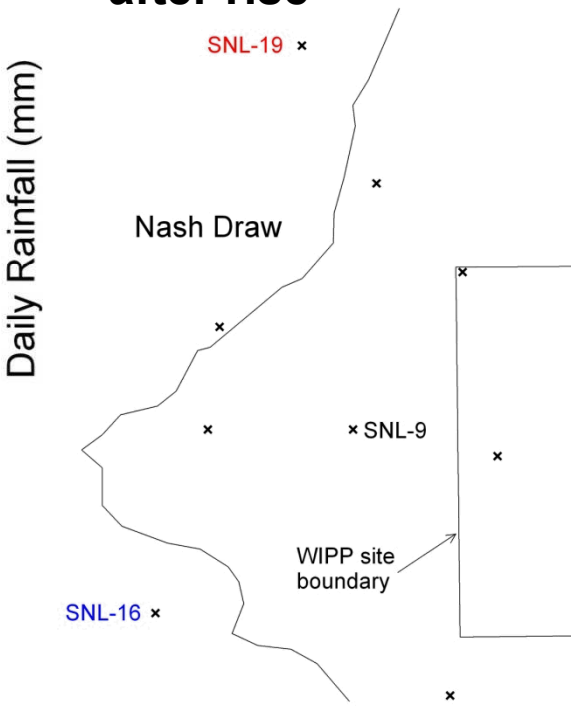
Responses to Rainfall in Karstic Nash Draw



- **Rapid responses to individual rain events**
- **Pronounced falloff after rise**



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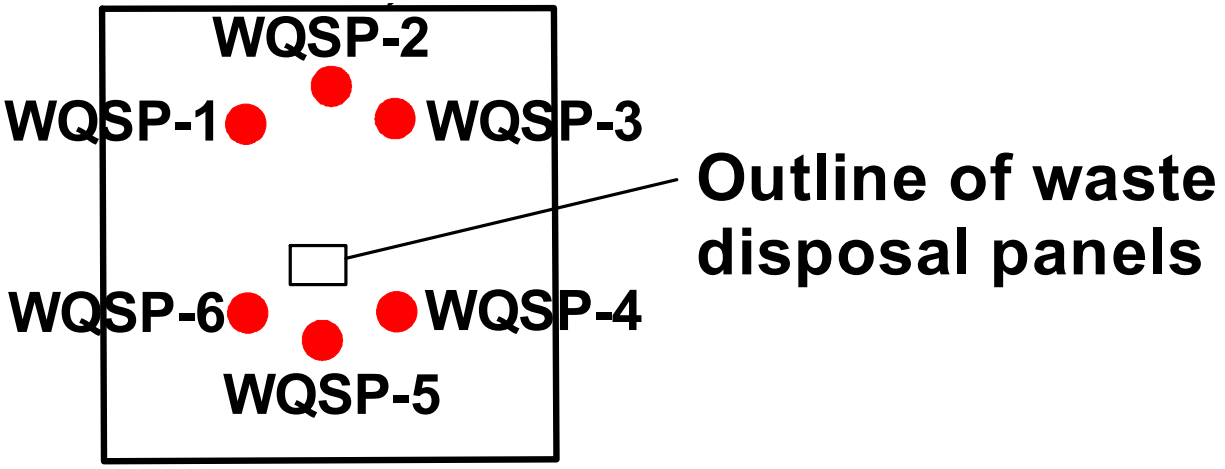
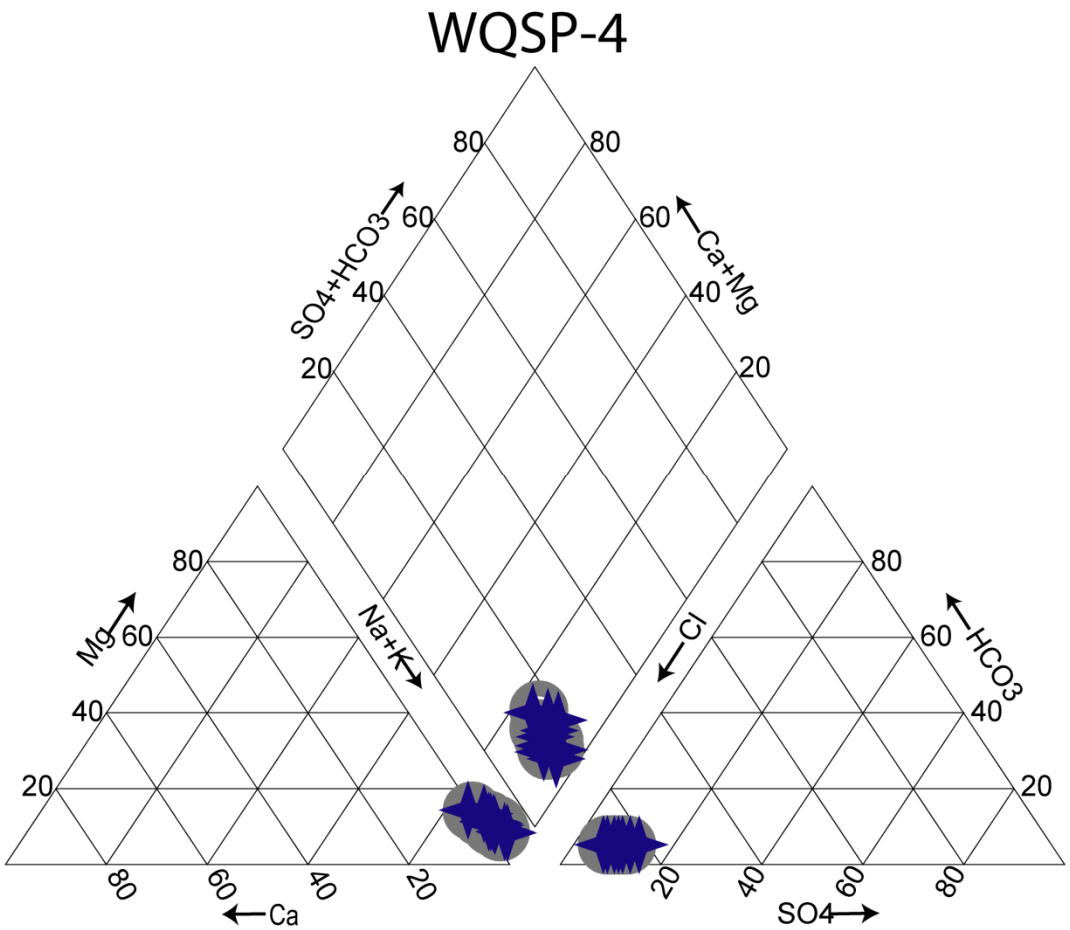
Water-Quality Sampling



- Water-quality samples have been collected from 6 WQSP Culebra wells twice a year since 1995
- Samples are analyzed for major cations (Na^+, Ca^{2+}, Mg^{2+}, K^+) and anions (Cl^-, SO_4^{2-}, HCO_3^-)

Water-Quality Stability



- Piper diagrams show stability of water quality over 13 years of sampling
  - Gray areas show range over first 8 years
  - Blue stars show data from last 5 years
- Stability is consistent with our understanding of flow in the Culebra

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Conclusions

- Culebra heads are continually changing
- Through ~1990, and in 1995-96, many wells were affected by testing, shaft sinking, and other site-characterization activities
- Undisturbed system behavior was observable from ~1997-2003
- Many wells with long historic water-level records have had to be plugged and abandoned
- Extensive new drilling and testing occurred from late 2003 through 2006

Conclusions (2)

- Data collected since 2007 reflect minimal anthropogenic disturbance in the current monitoring network—but water levels are still changing
- Short-term changes related to oil and gas drilling can be expected for the foreseeable future
- Water levels in Nash Draw respond to rainfall
- No static “baseline” conditions can be defined
- Culebra water quality is not changing, consistent with our conceptual understanding of flow rates