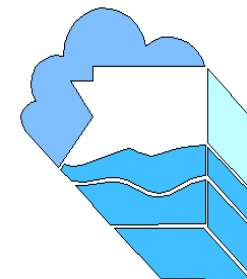


Risk Analysis of Pumping Impacts on Simulated Groundwater Flow in the Santa Cruz AMA

**Keith Nelson
Arizona Department of Water Resources**

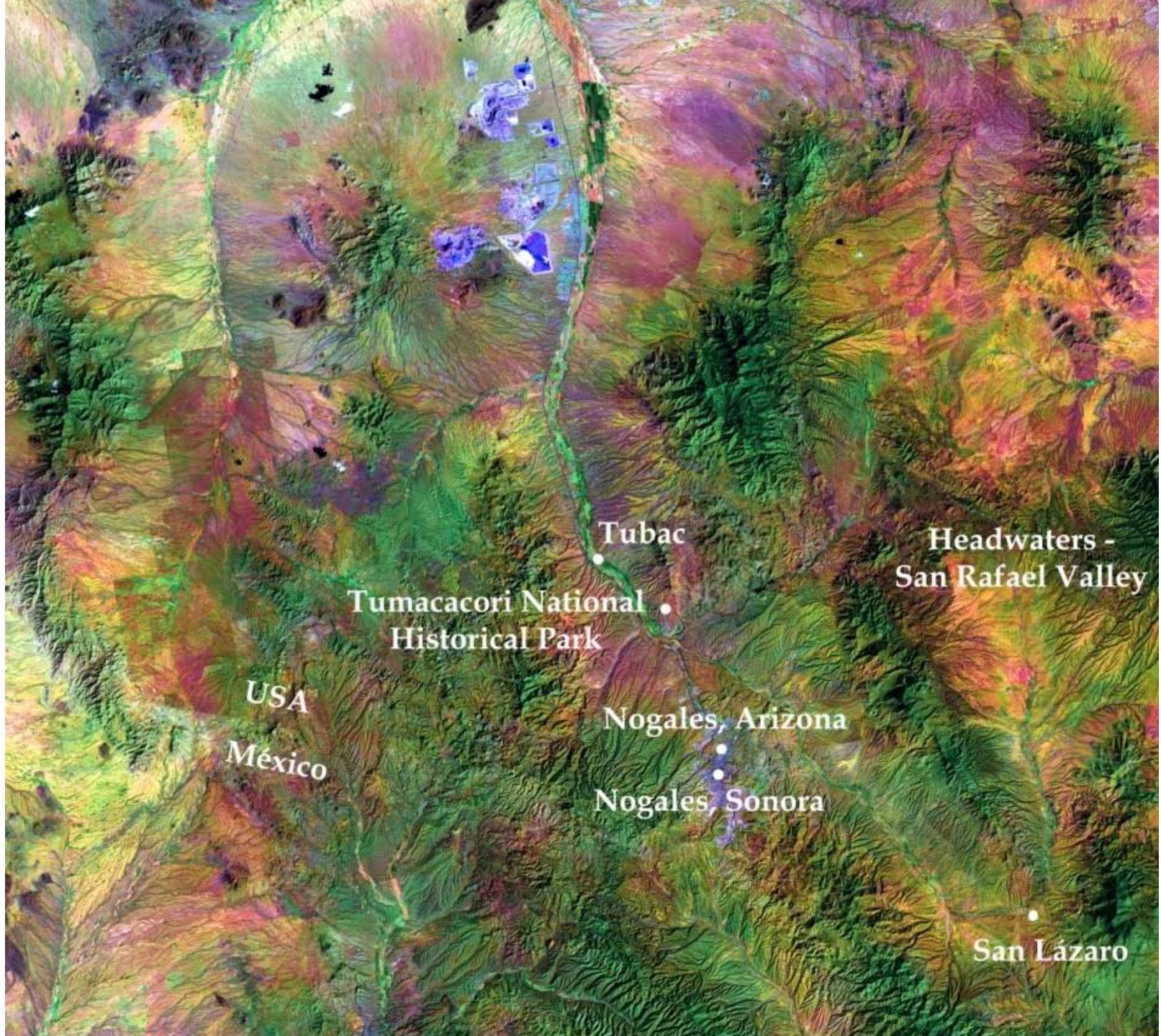


**ARIZONA
DEPARTMENT
OF WATER
RESOURCES**

- **Overview of Hydrology
(Upper Santa Cruz)**
- **Hydrologic Models**
 - **Stochastic Streamflow Model**
 - **Groundwater Flow Models**
 - **Combining Streamflow and
Groundwater Flow Models**
- **Risk Analysis Example**

Santa Cruz AMA Goals § 45-562C:

- 1) “Maintain Safe-Yield Conditions”
- 2) “Prevent local water tables from experiencing long-term declines”



Tubac

Tumacacori National
Historical Park

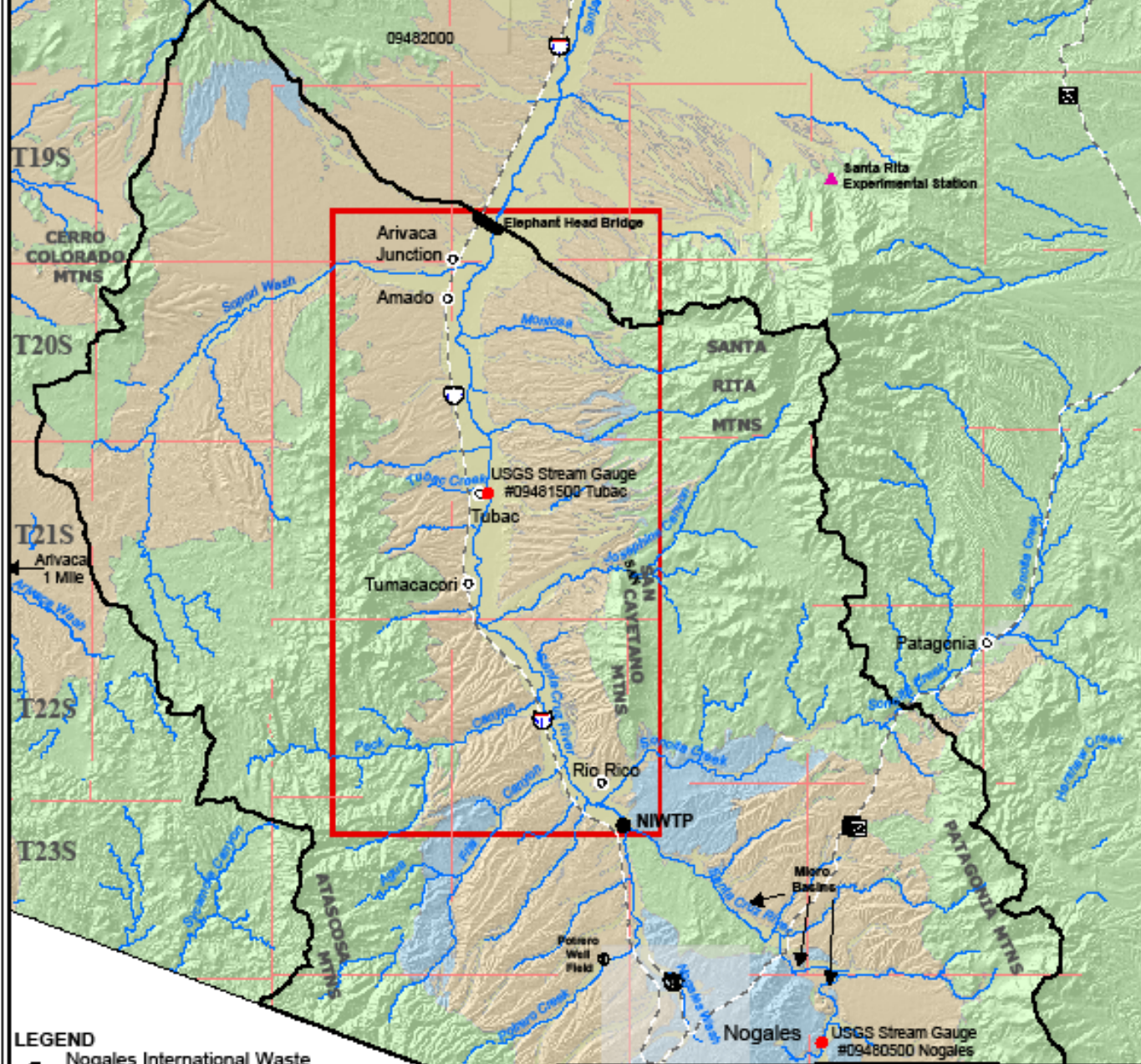
Headwaters -
San Rafael Valley

USA
México

Nogales, Arizona

Nogales, Sonora

San Lázaro



LEGEND

- Nogales International Waste Water Treatment Plant
- USGS Stream Gauge
- City and Town
- Road
- Stream

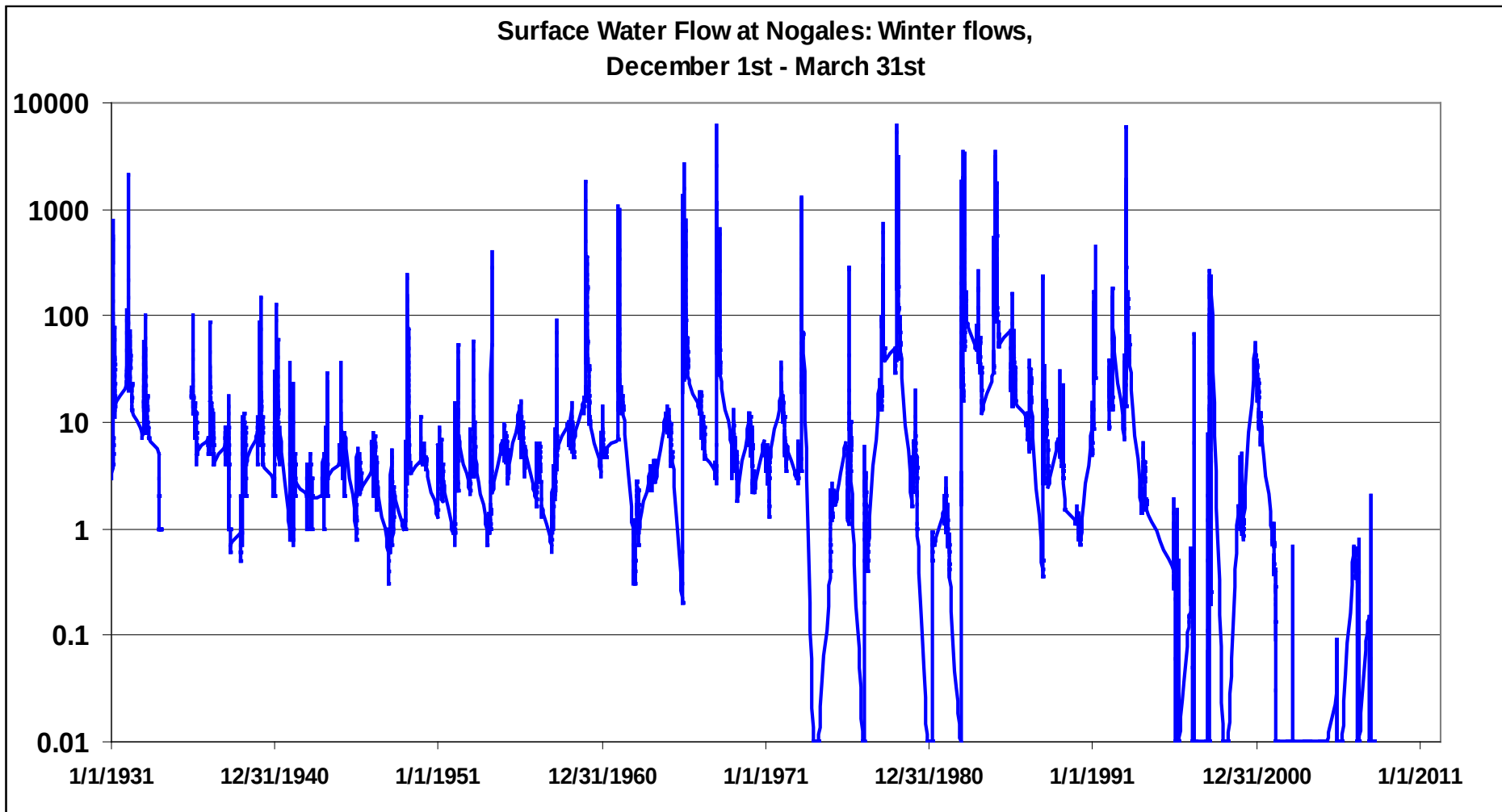
Scale
0 3 6 Miles



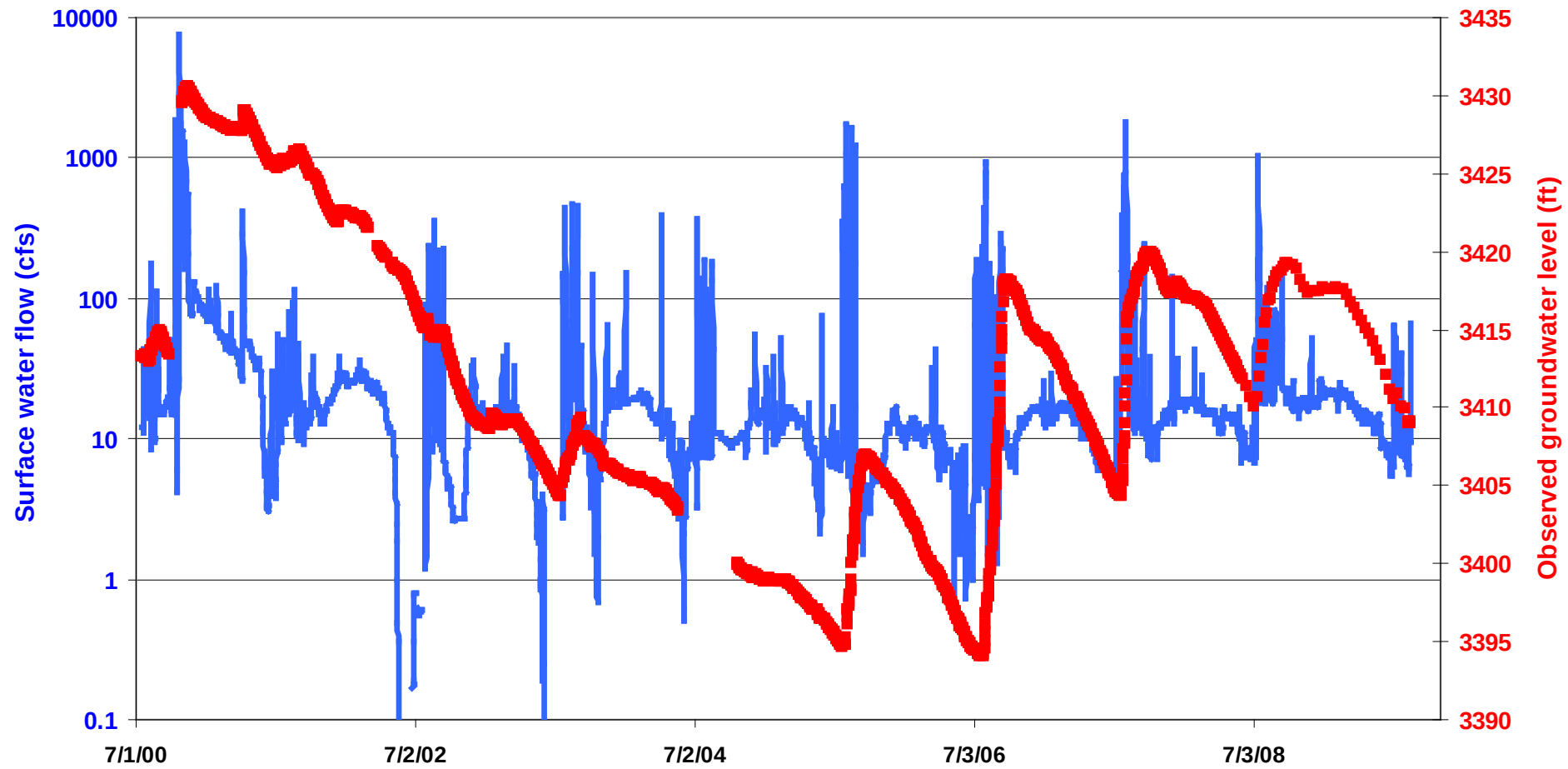




Supply Side: Baseflow Capture (?) at Nogales gauge

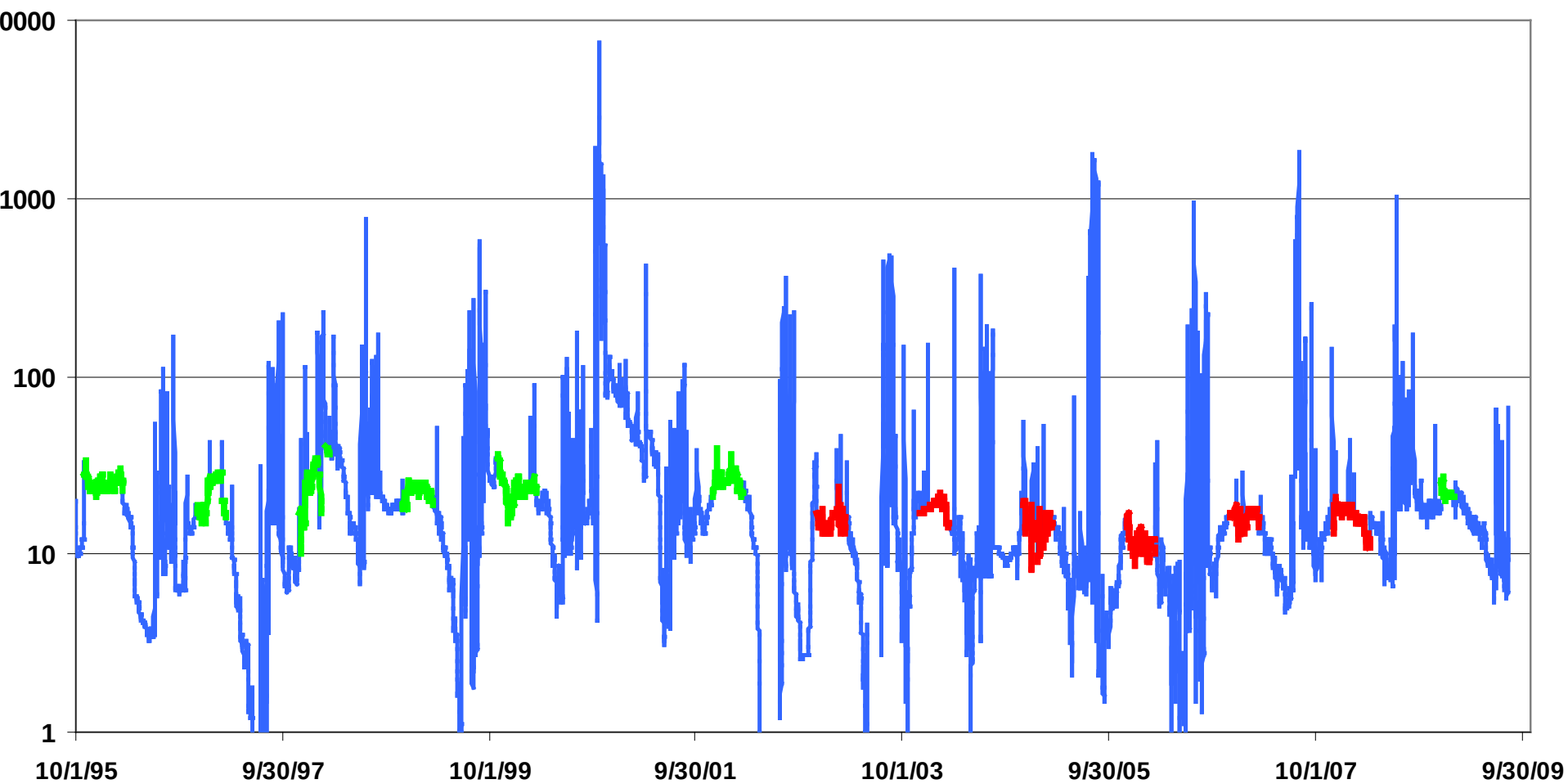


Relation between Surface water flow and Groundwater Levels



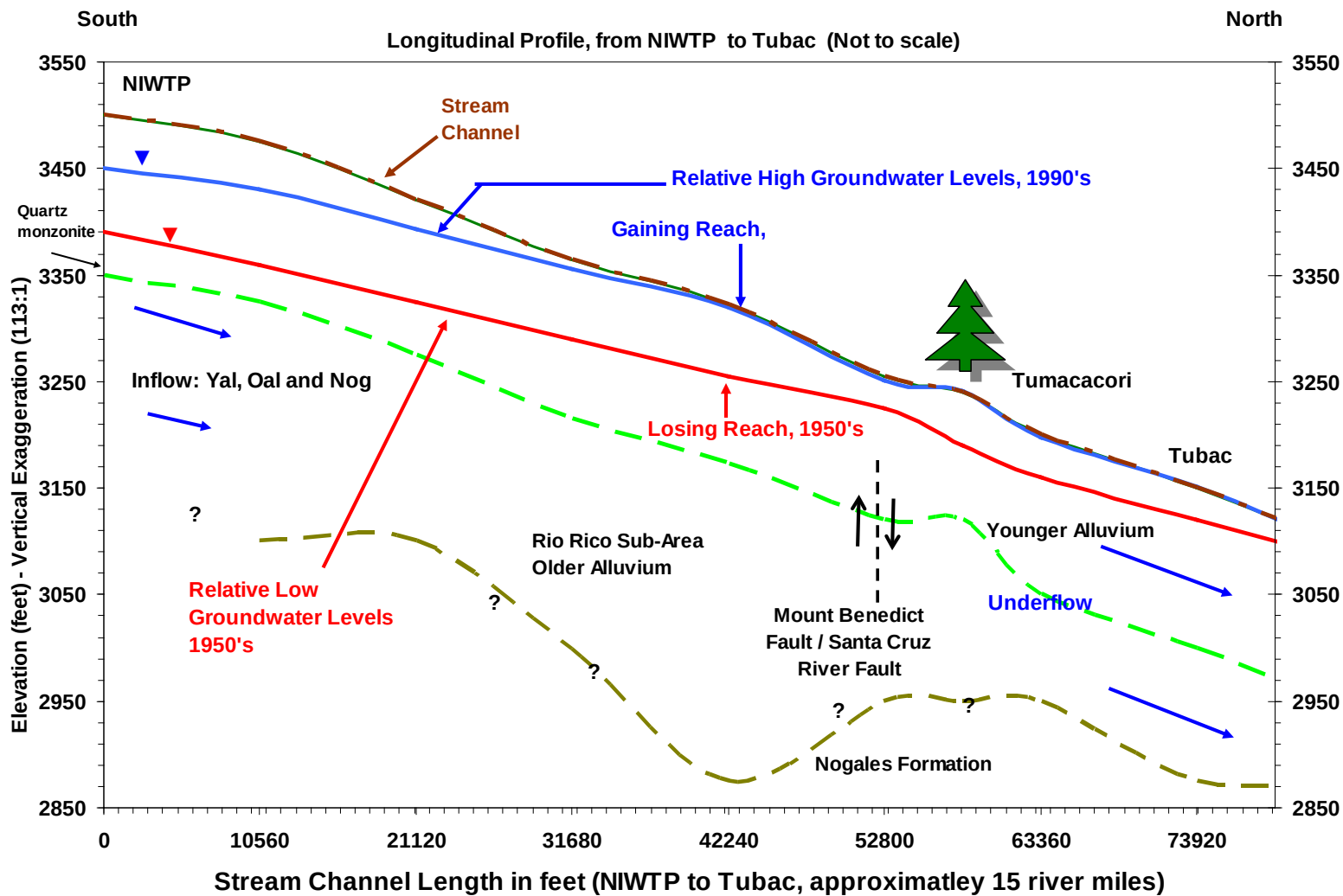
Stream Flow - Santa Cruz River: Baseflow Gaining (green); losing (red)

<---Intensive Drought--->

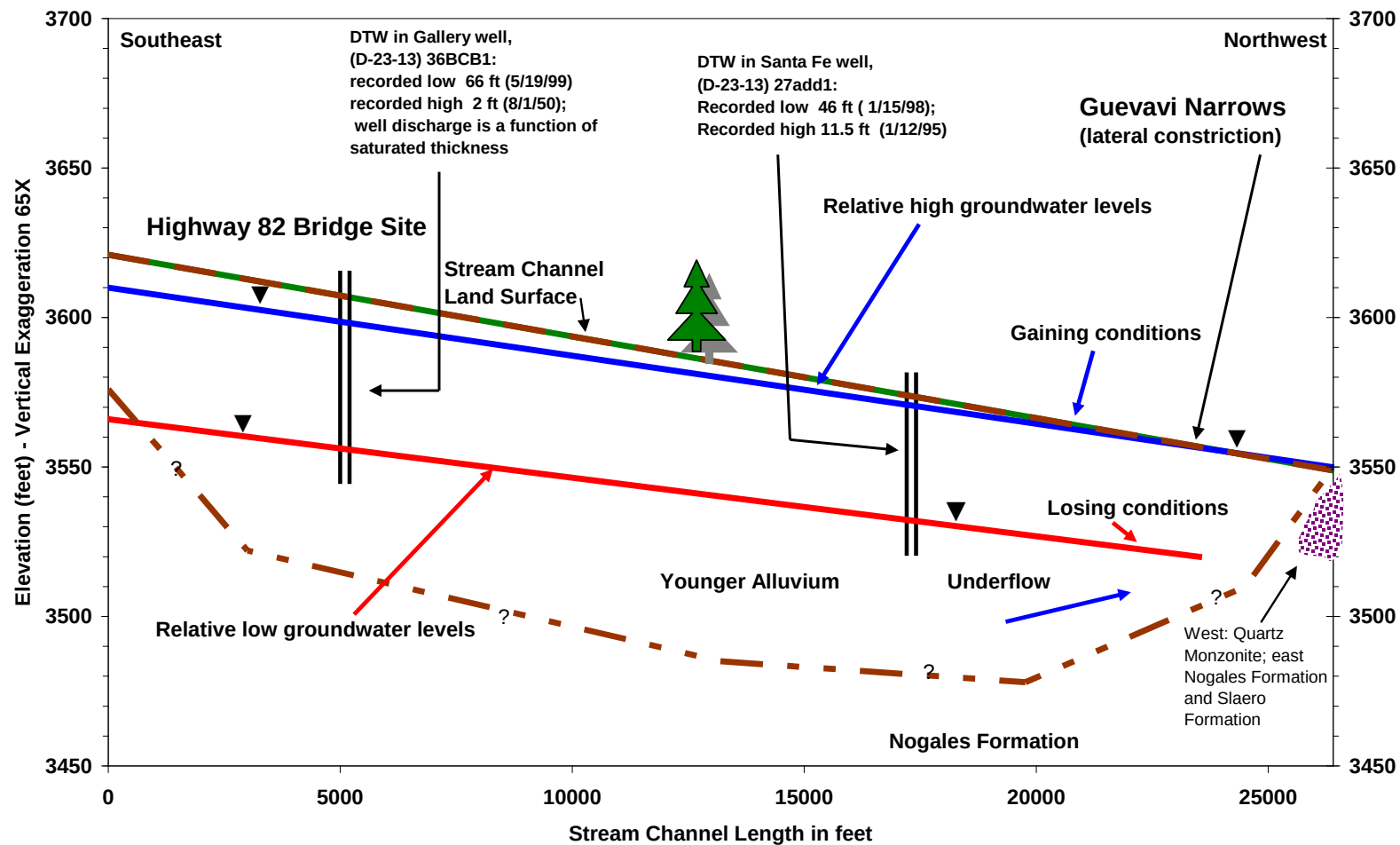


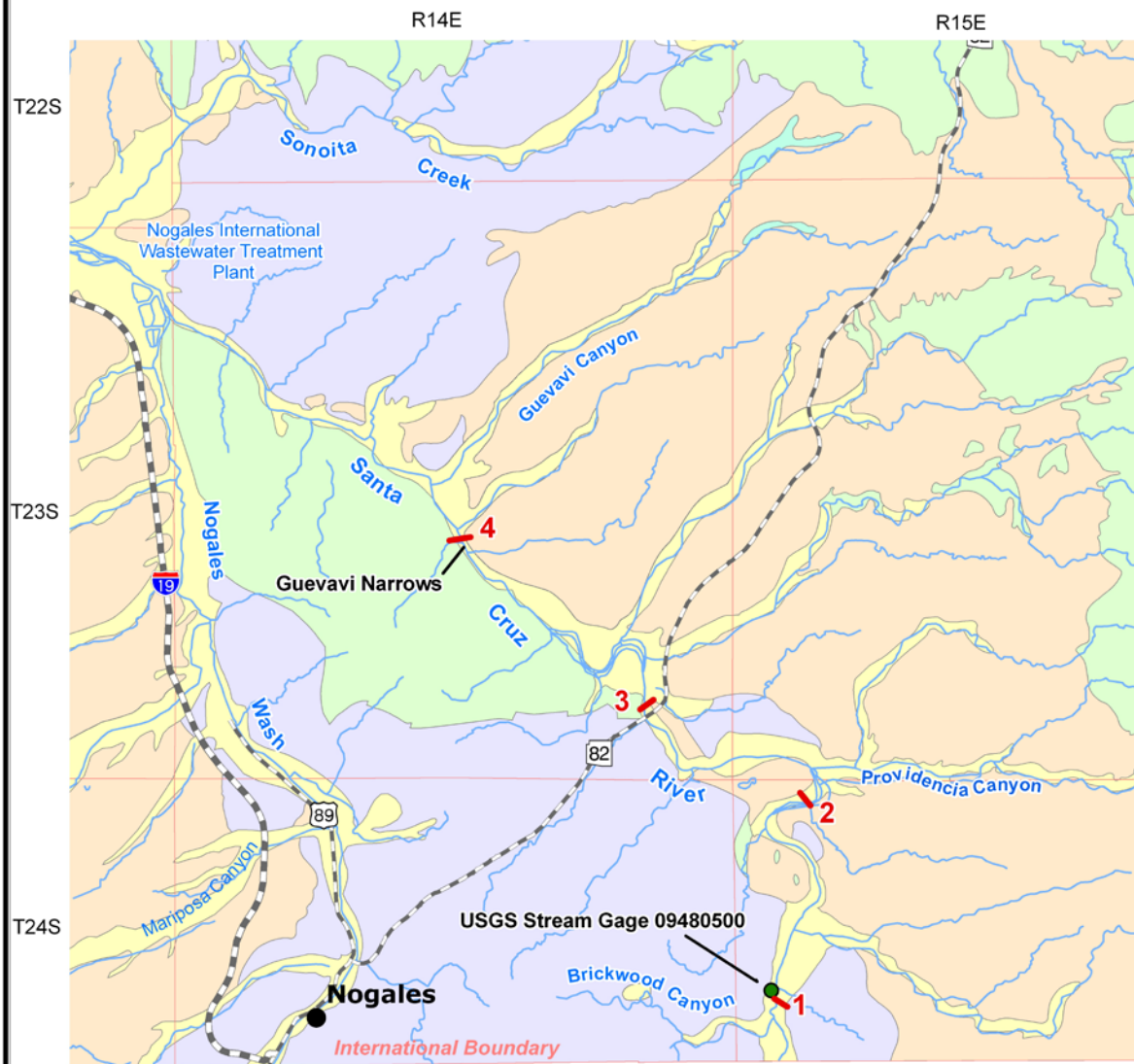
**Baseflow at Guevavi Narrows:
looking southeast, Late May 1998**





Longitudinal Profile, from Highway 82 Bridge to Guevavi Narrows (Not to scale)





ADWR Seepage Measurement Locations

- | | |
|-----------------|--------------------|
| 1. Buena Vista | 3. Highway 82 |
| 2. Kino Springs | 4. Guevavi Narrows |



Surficial Geology

- Nogales Formation
- Older Alluvium

Locations of USGS Gage 09480500



Hydrologic Model

DOS Batch Program
inter-changing modules
~8 hrs on a 2X2.66GHZ; 3G RAM

Stochastic
Stream Model >
Convert to
stream-aquifer BC's

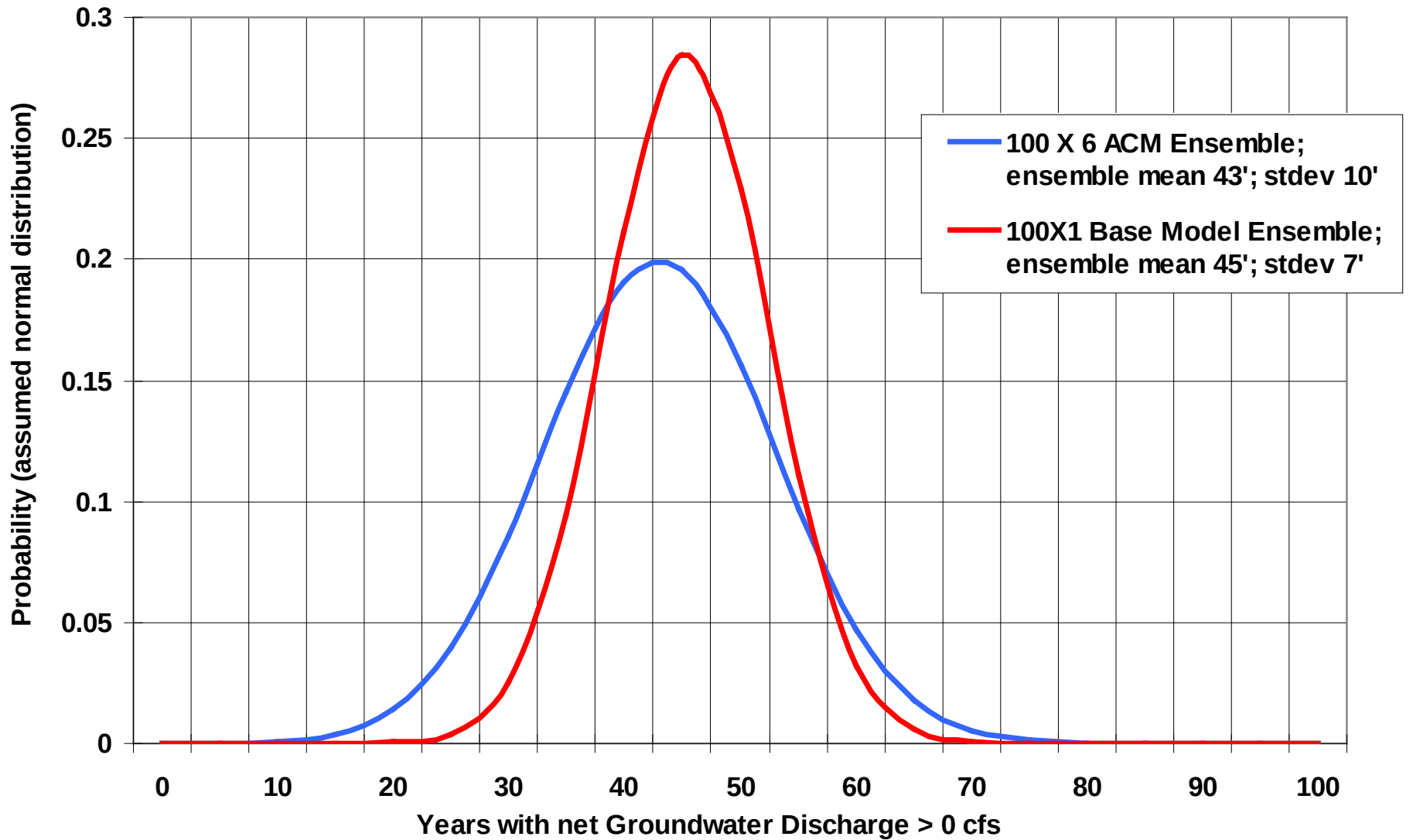
Translate
Stream BC +
Demand >
through 6 ACM's:

Analysis of Simulated
Heads and Flows:
trends; patterns
Inter-arrival stats
(MATLAB; FOXPRO)

Simulated Groundwater Discharge (Baseflow)

(Does not include possible additional uncertainties related to storage (Sy), ET, lateral boundaries, Watershed changes)

**Probability density function: Simulated Flow between NIWTP and Tubac
(Groundwater pumpage = 15,000 acre-feet/year)**

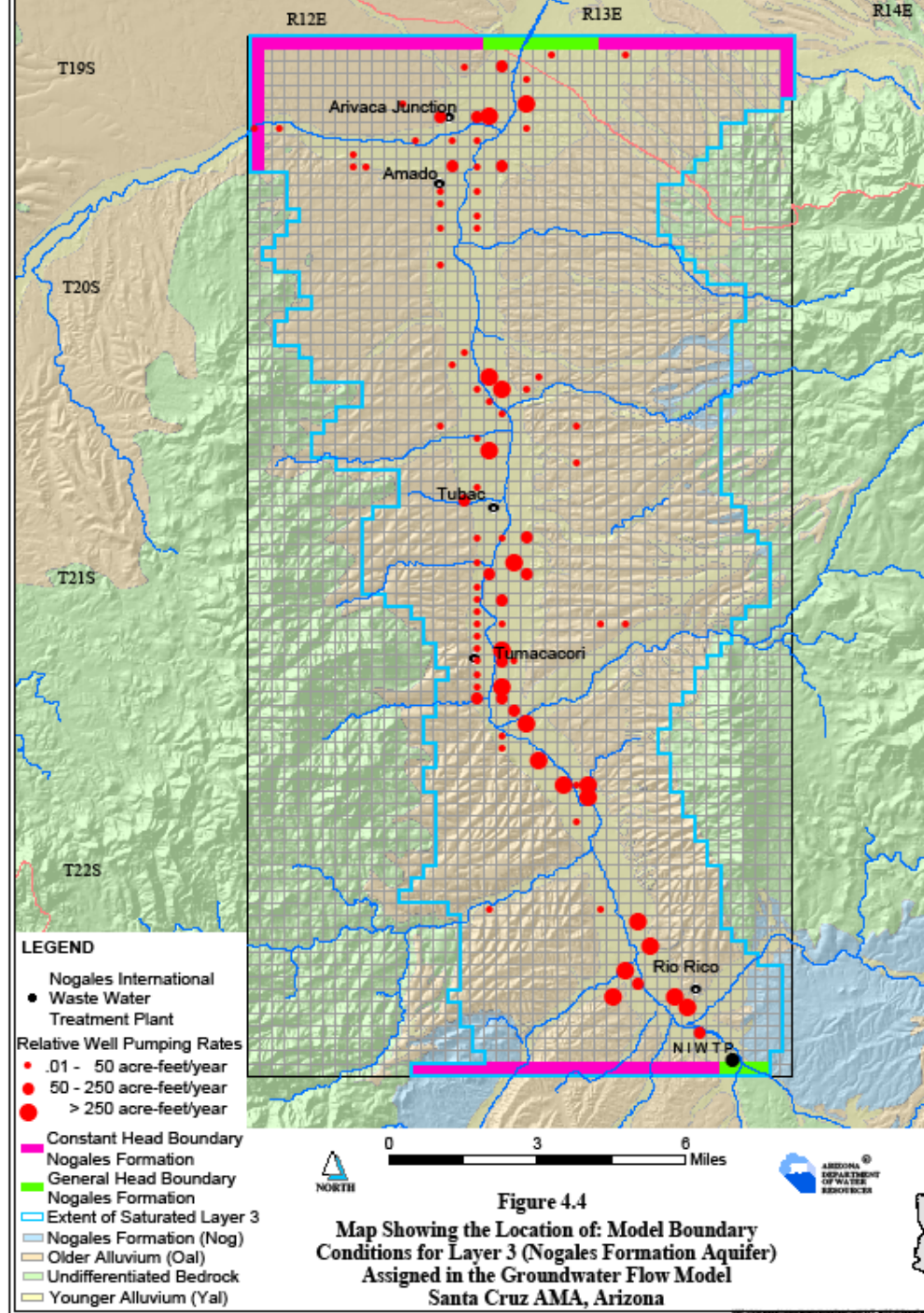


Basecase rate (15K)
Pumping increases/decreases
(11K – 23K) proportional to
Basecase rate at existing loca

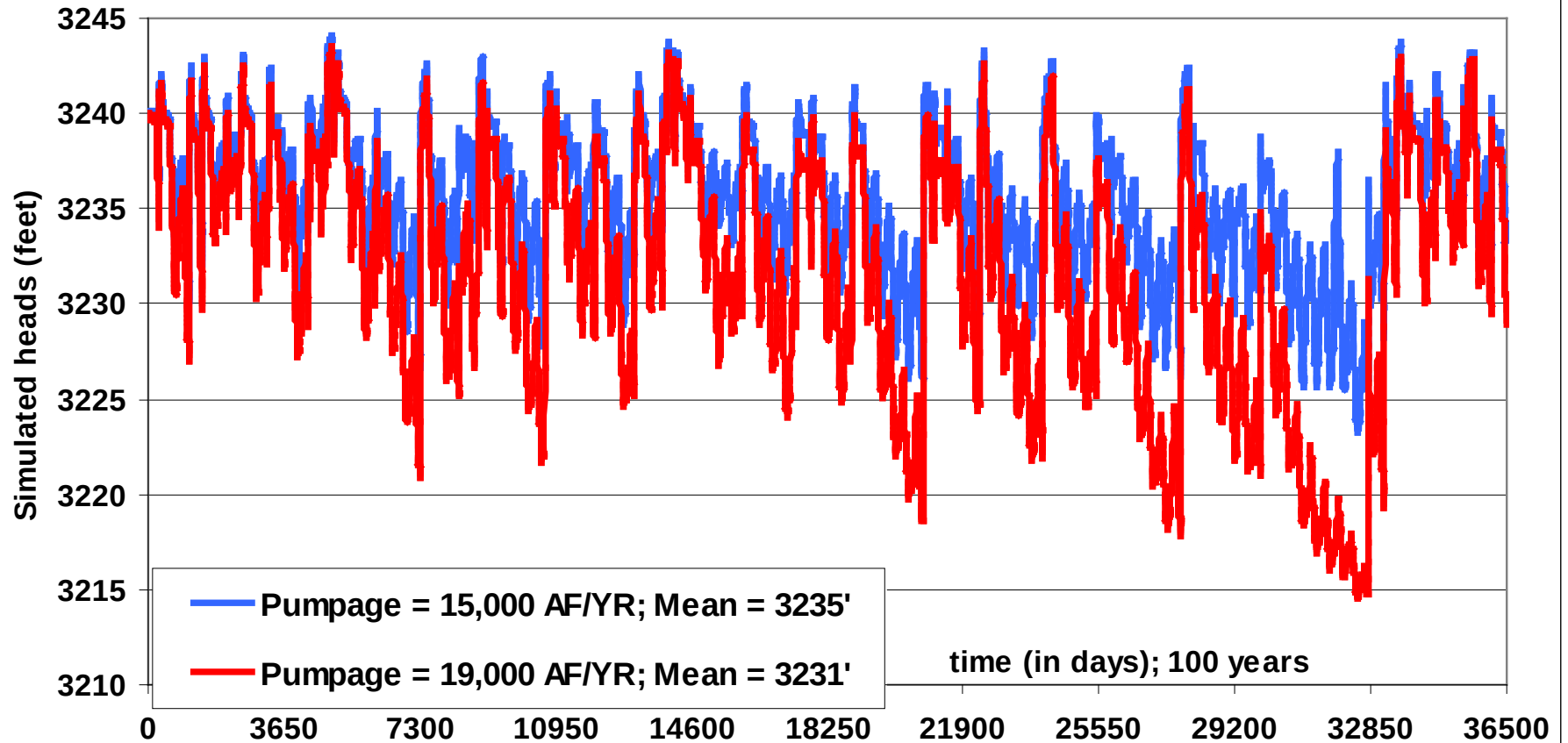
No new demand locations

Incidental Rch fixed

No simulated effluent

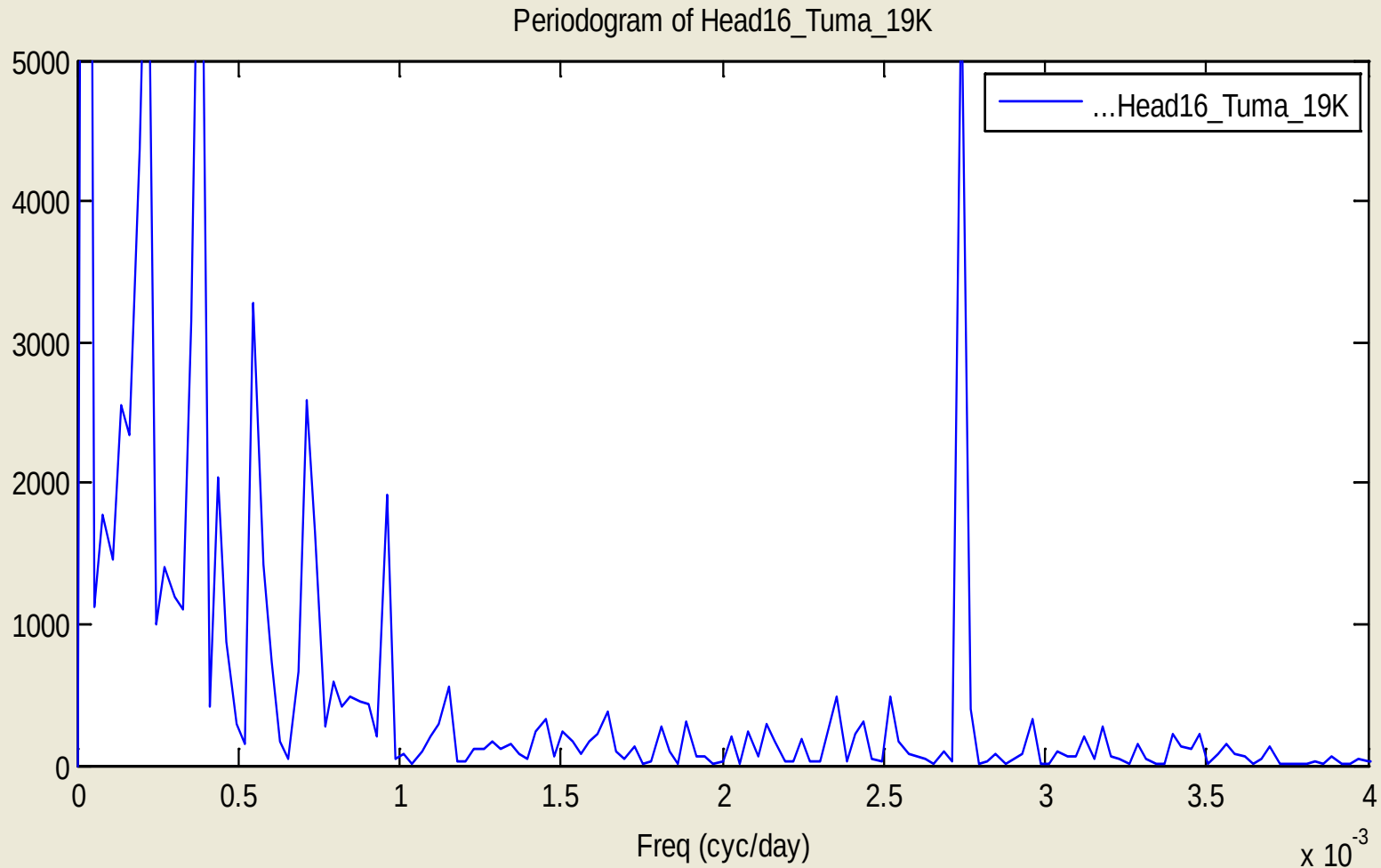


Simulated Heads at Tumacacori: Base Model (shown) Realization #2
Years 1-90 Infrequent Flood Recharge; Years 91-100 Frequent Flood Recharge

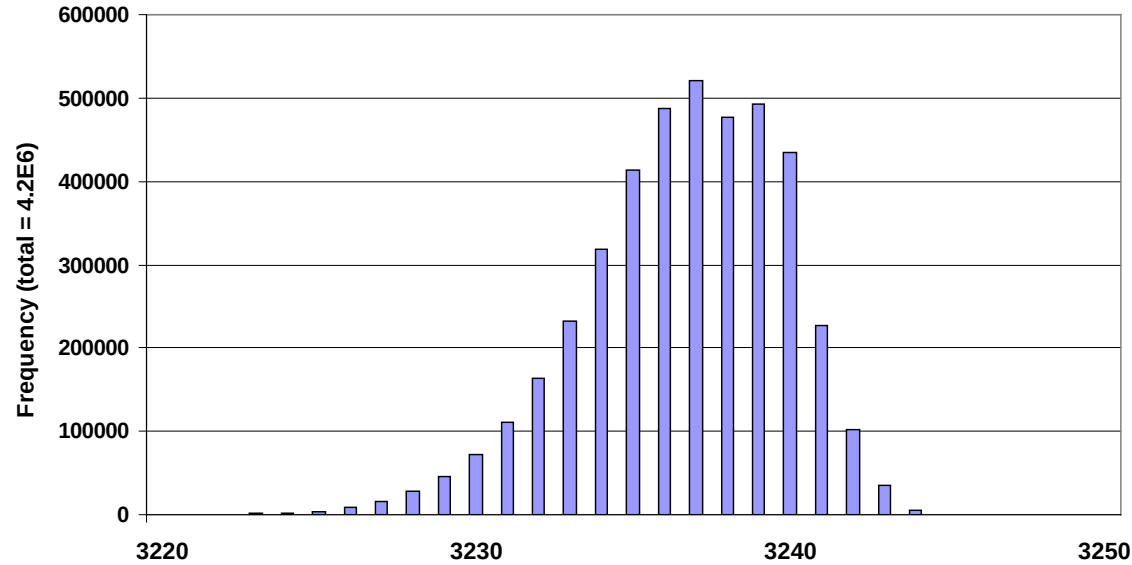


Transform from Time to Frequency domain

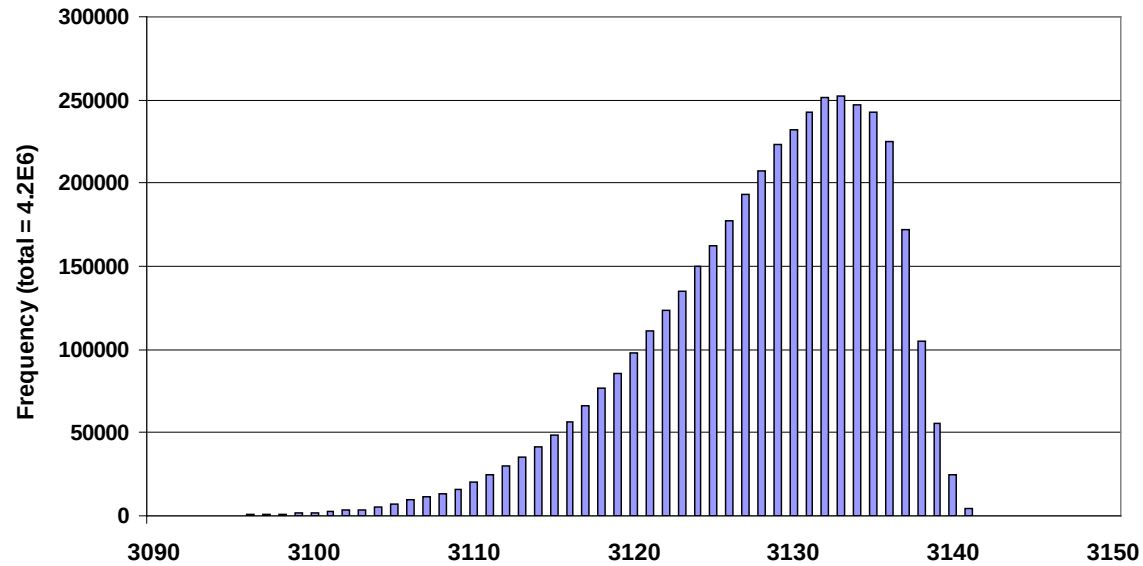
Cycles that show up: 10, 8, 5 and 1 year-period signals



**Distribution of Simulated Heads at Tumacacori, 100X6 ACM
Assigned Pumpage 15K**

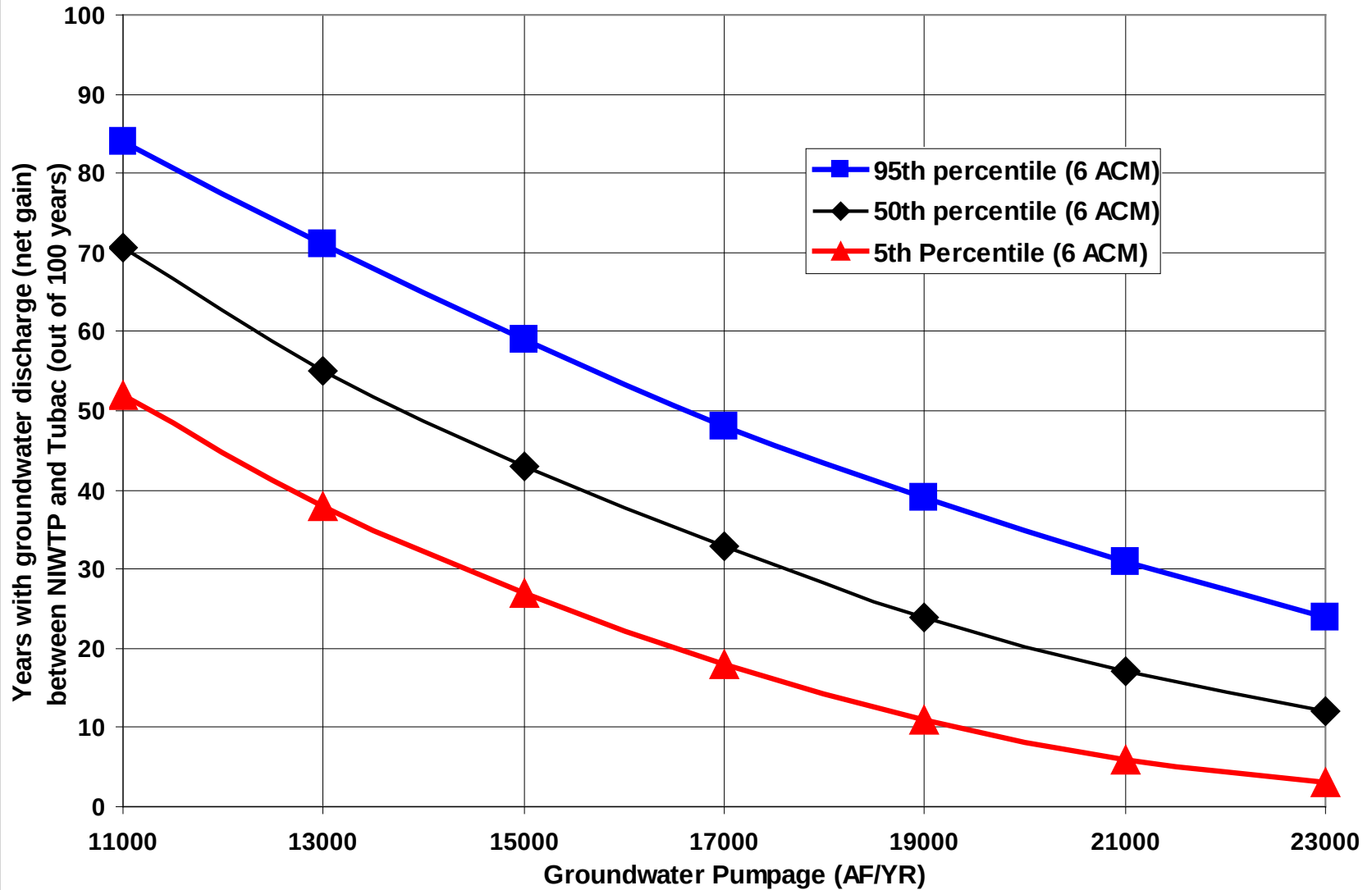


**Distribution of Simulated Heads at Chavez Siding, 100X6 ACM
Assigned Pumpage 15K**

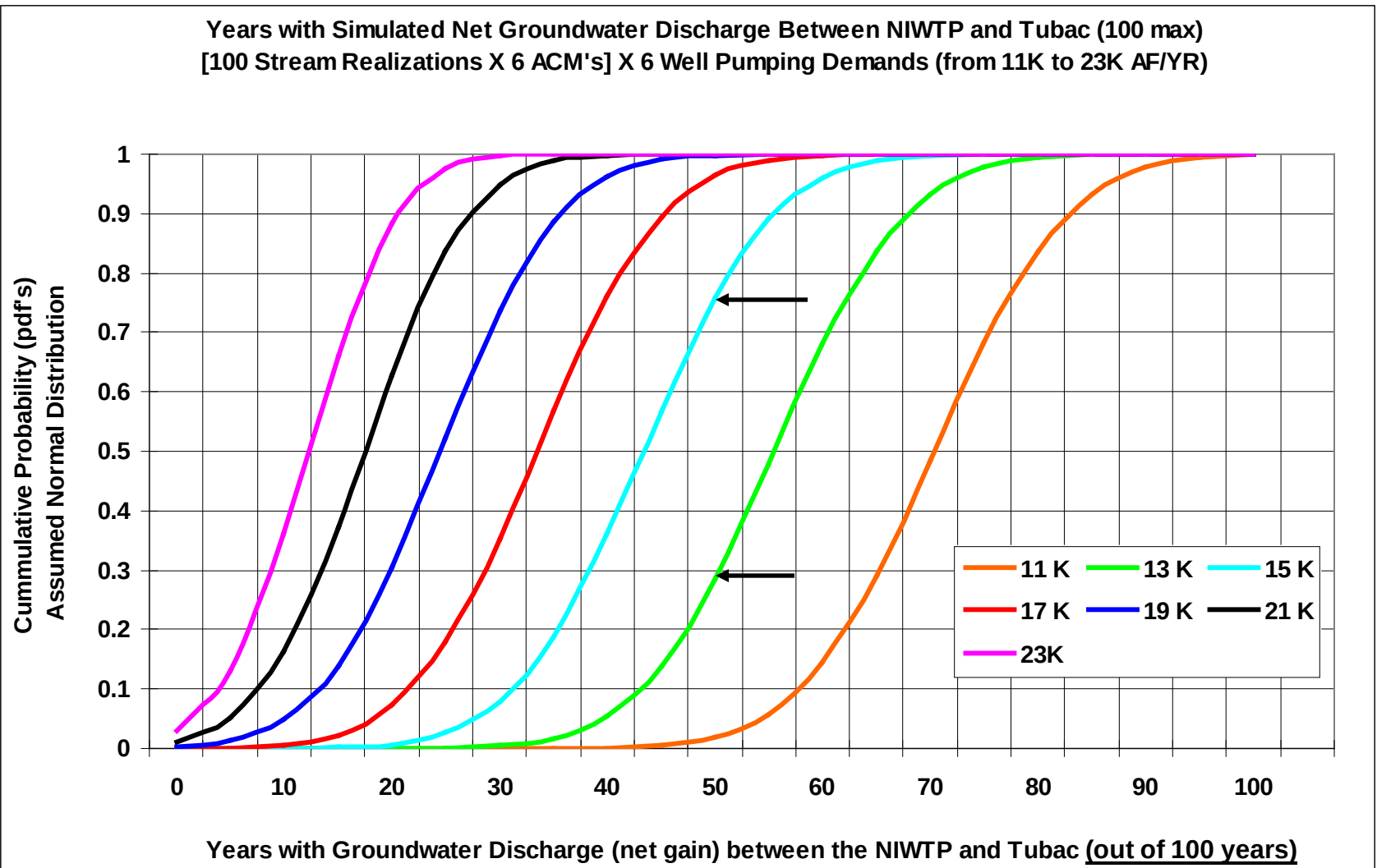


Distribution of simulated head elevation (feet above MSL) for each time step

Relation Between Pumpage and Occurrence of Groundwater Discharge (Gain)



Pumping 13K: 30% chance gaining conditions will occur less than half of the time



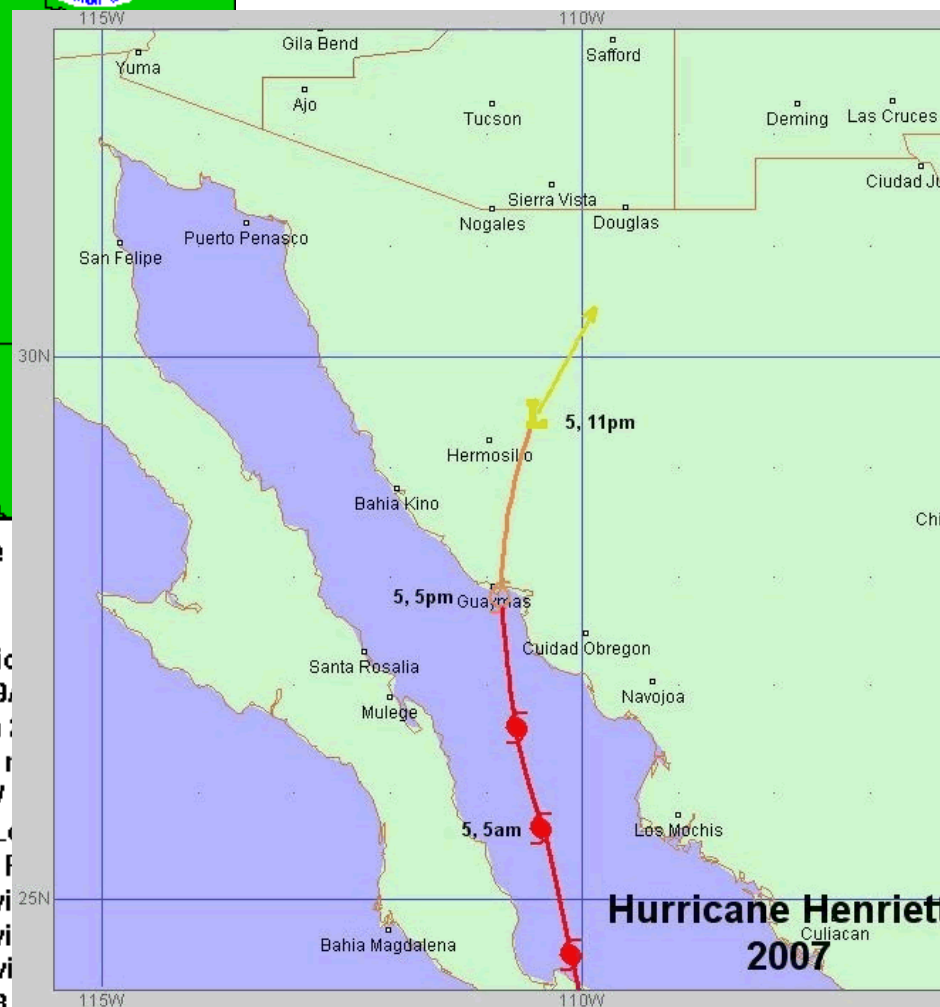
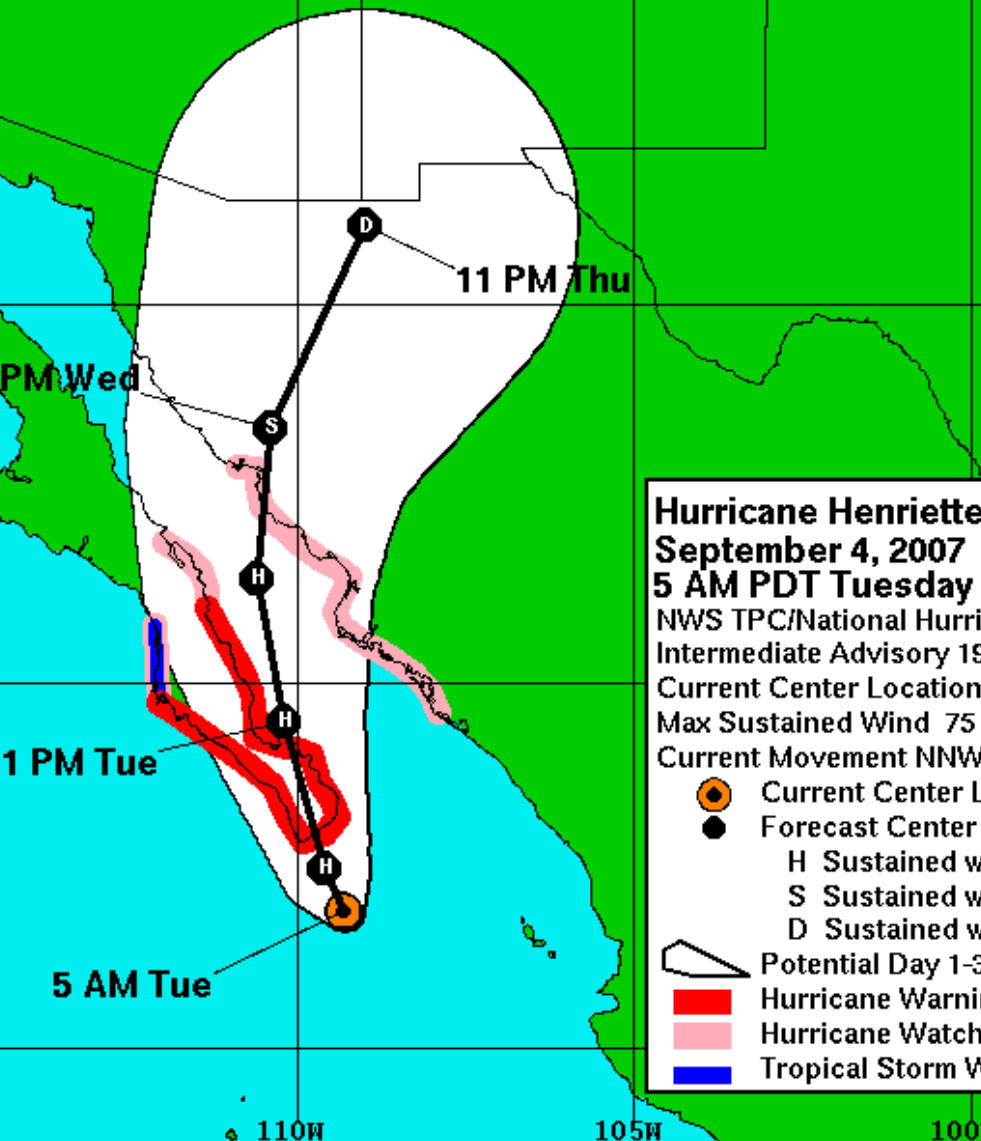
Findings

- Apply models that are not adversely biased!
- Simulate many *plausible* realizations: Will reveal systems central tendencies, etc.,
- Sensitive to Flood Recharge Inter-arrival Periods and Duration periods (trends)
- Sensitive to ACM
- Sensitive to pumping
- Not very sensitive to exact flood rate during any one stress-period

Approx. Distance Scale (Statute Miles)

SM 125 250 375 500

True at 30.00N



Model Forecasts of ENSO from Jul 2009

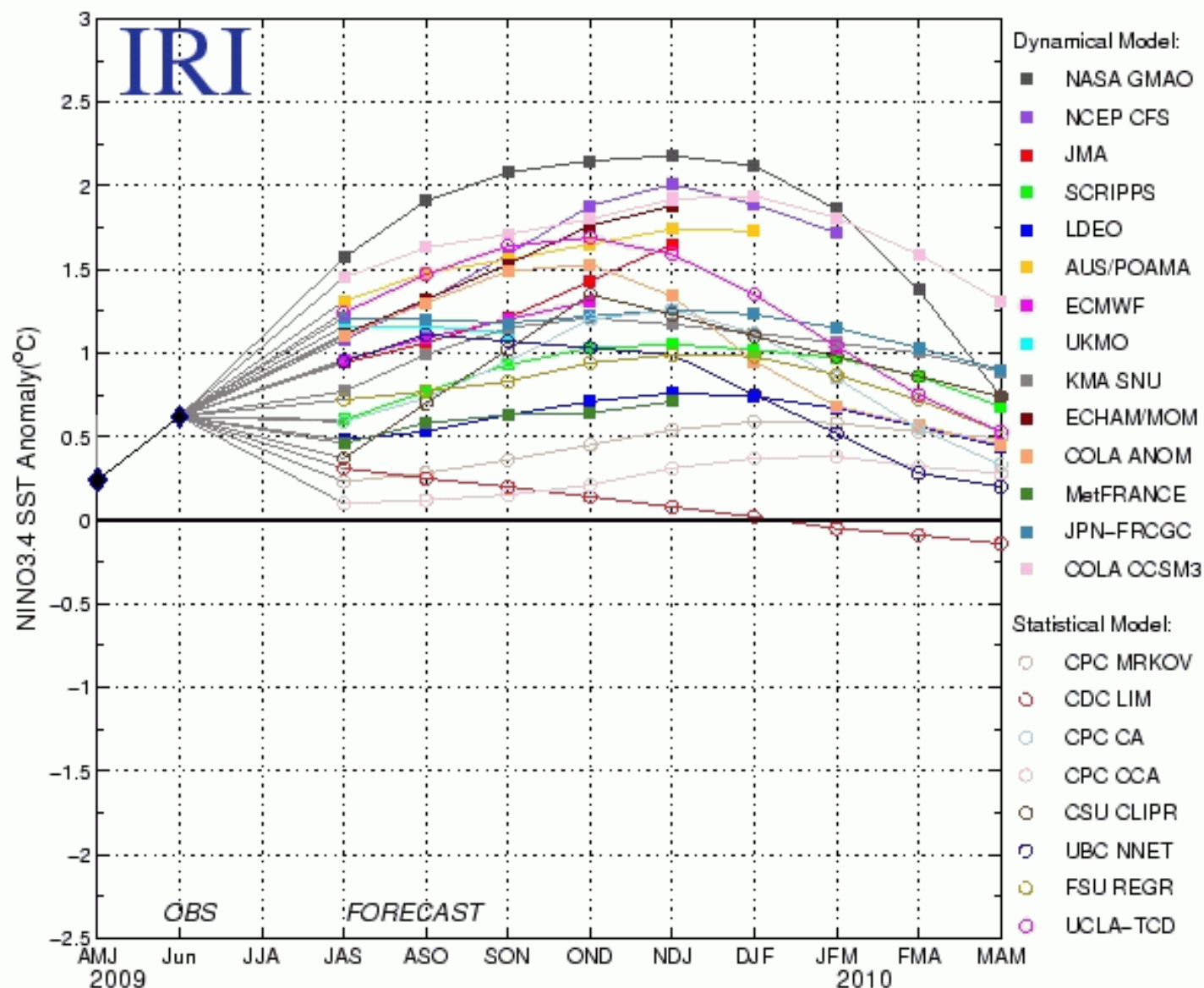


Figure 6. Forecasts of sea surface temperature (SST) anomalies for the Niño 3.4 region (5°N-5°S, 120°W-170°W). Figure courtesy of the International Research Institute (IRI) for Climate and Society. Figure updated 16 July 2009.

Questions?



- Thanks to ADWR Basic Data & Survey Units; Hydrologic Research Center (San Diego); USGS (Tucson); U of A; Santa Cruz AMA GUAC and staff; IBWC; FOSCR; AZ State Parks