Hydrologic Evolution of The San Pedro River - Present and Emergent Conservation Issues

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The San Pedro Riparian National Conservation Area

Public Law 100-696

- Enacted November 18, 1988
- The Act is cited as the "Arizona-Idaho Conservation Act of 1988"

Introduction

- Purpose: Provide General Background and Understanding of Water and Related Issues in the San Pedro River National Conservation Area.

- Presenter: Southeastern Arizona Native, University of Arizona Graduate (B.S in Watershed Management – College of Agriculture, School of Renewable Natural Resources).

- Thirty-Five Years Experience.
- Known For Holistic Sustainable Watershed Approaches.

Topics of Discussion

- Water Facts
- Location
- Origin
- Watershed Parameters
- Historic Changes
- Hydrologic Changes
- Present And Emergent Issues
- Foreseeable Future
- Questions

Water Facts

- Earth's surface is 75% water
- Water recycles in CLOSED system (hydrologic cycle)
- Human Body = 65% water (by weight)
- Your blood = 83% water
- $H_2O = (2)H_1 + (1)O_{16}$ = 18 Atomic Weight
- ***WATER = LIFE !!***

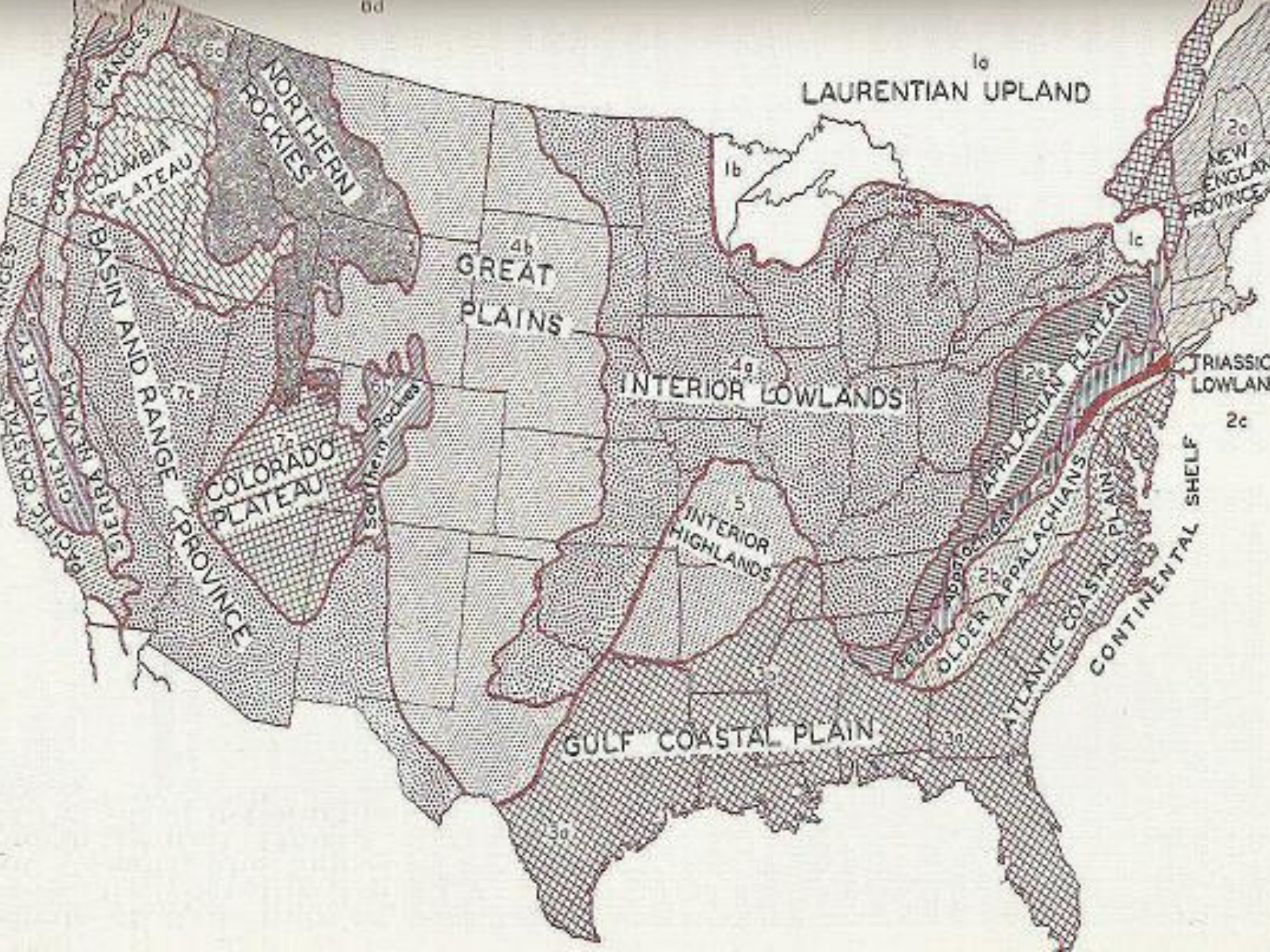
Days You Can Survive Without Water
(With No Physical Activity)

- 10 Days
- 7 Days
- 2 Days

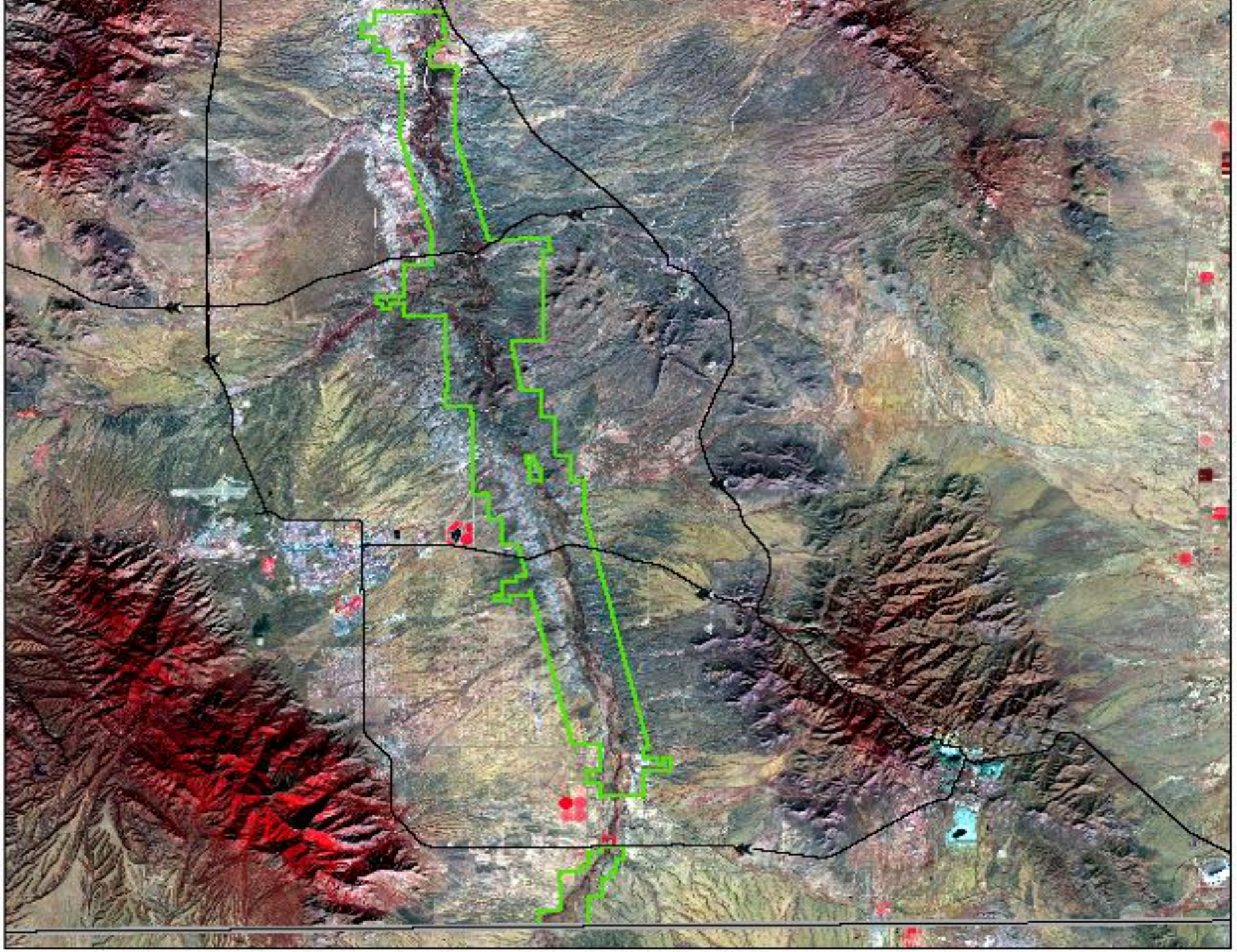
- 50° F.
- 90° F.
- 120° F.

Location

- Basin and Range Physiographic Province of North America.
- Tributary to Gila River.
- Headwaters: In Mexico, Mountainous, relatively steep terrain.
- Southeast corner of Arizona rising about 1 inch/year.

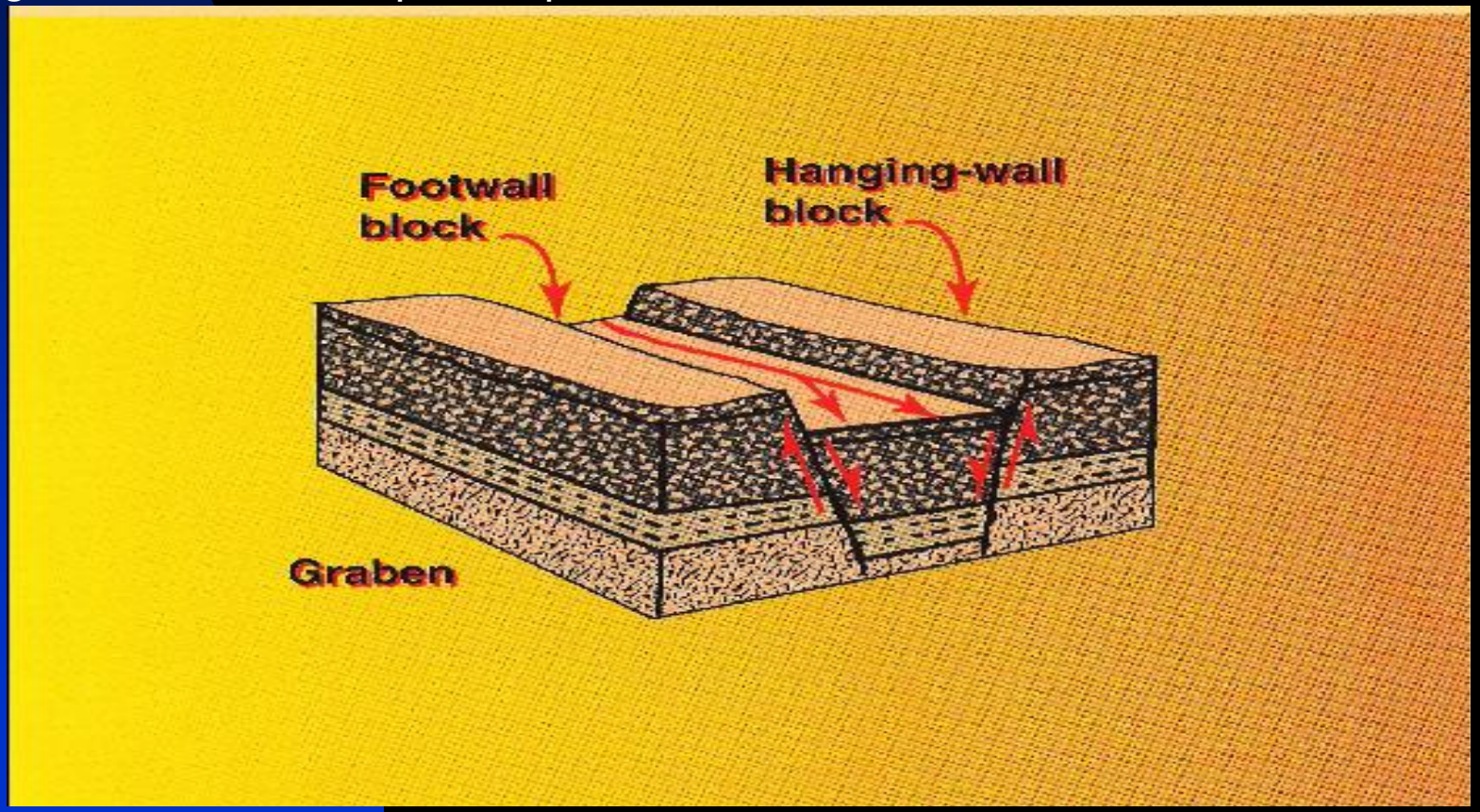


LAURENTIAN UPLAND
1a
1b
1c
2a
2b
2c
NEW ENGLAND PROVINCE
TRIASSIC LOWLAND
CONTINENTAL SHELF
ATLANTIC COASTAL PLAIN
OLDER APPALACHIANS
APPALACHIAN PLATEAU
GULF COASTAL PLAIN
INTERIOR HIGHLANDS
INTERIOR LOWLANDS
GREAT PLAINS
NORTHERN ROCKIES
COLUMBIA PLATEAU
CASCADE RANGES
BASIN AND RANGE PROVINCE
COLORADO PLATEAU
Southern Rockies
PACIFIC COASTAL RANGES
GREAT VALLEY
SIERRA NEVADAS



Origin

- Geologic structural trough formed by block faulting = **GRABEN**
- Mountains and consolidated basin fill composed of Precambrian to Tertiary aged strata.
- **Graben** filling with sediments from mountains. (Older Alluvium = regional aquifer).
- Younger alluvium = floodplain aquifer.



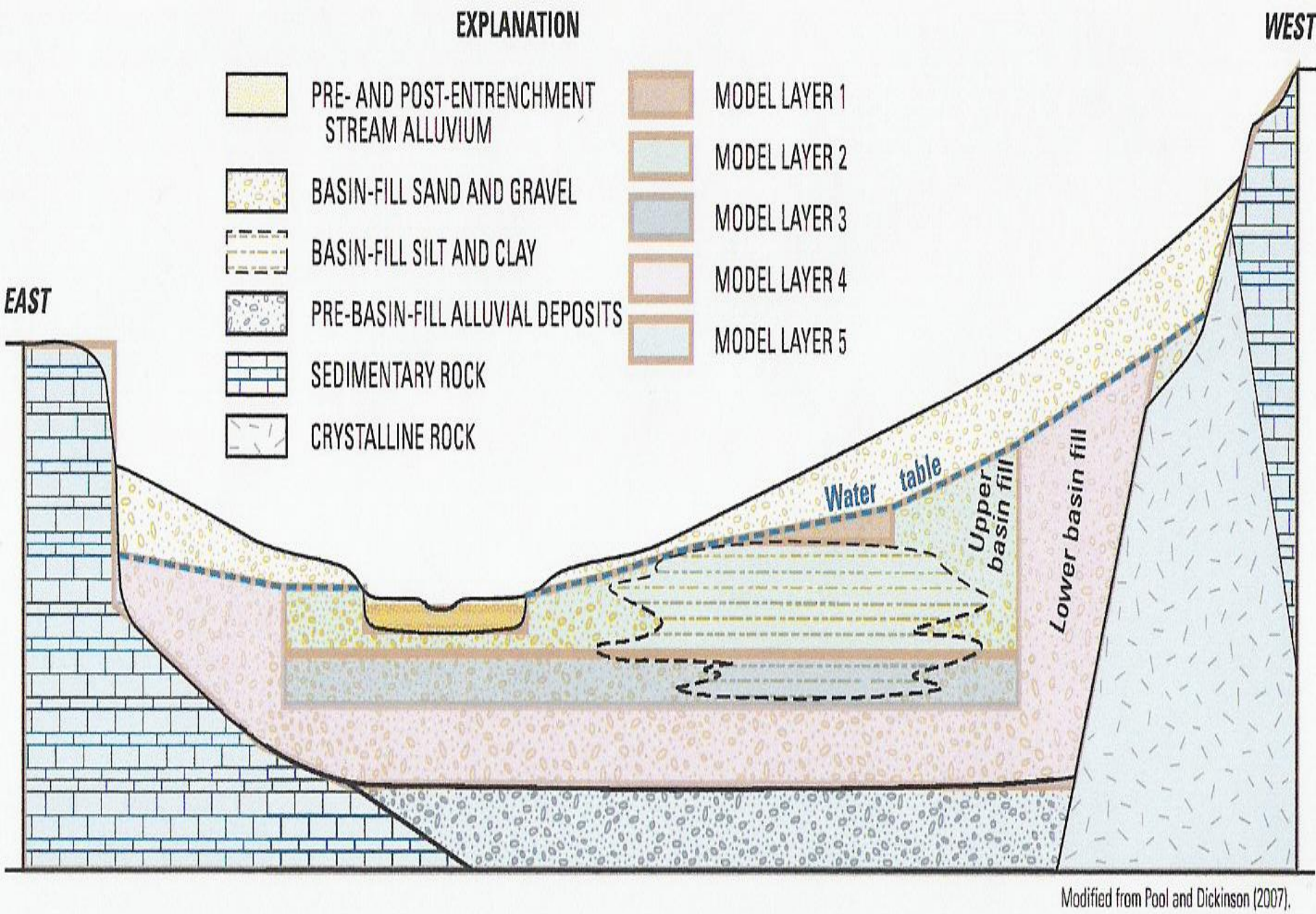
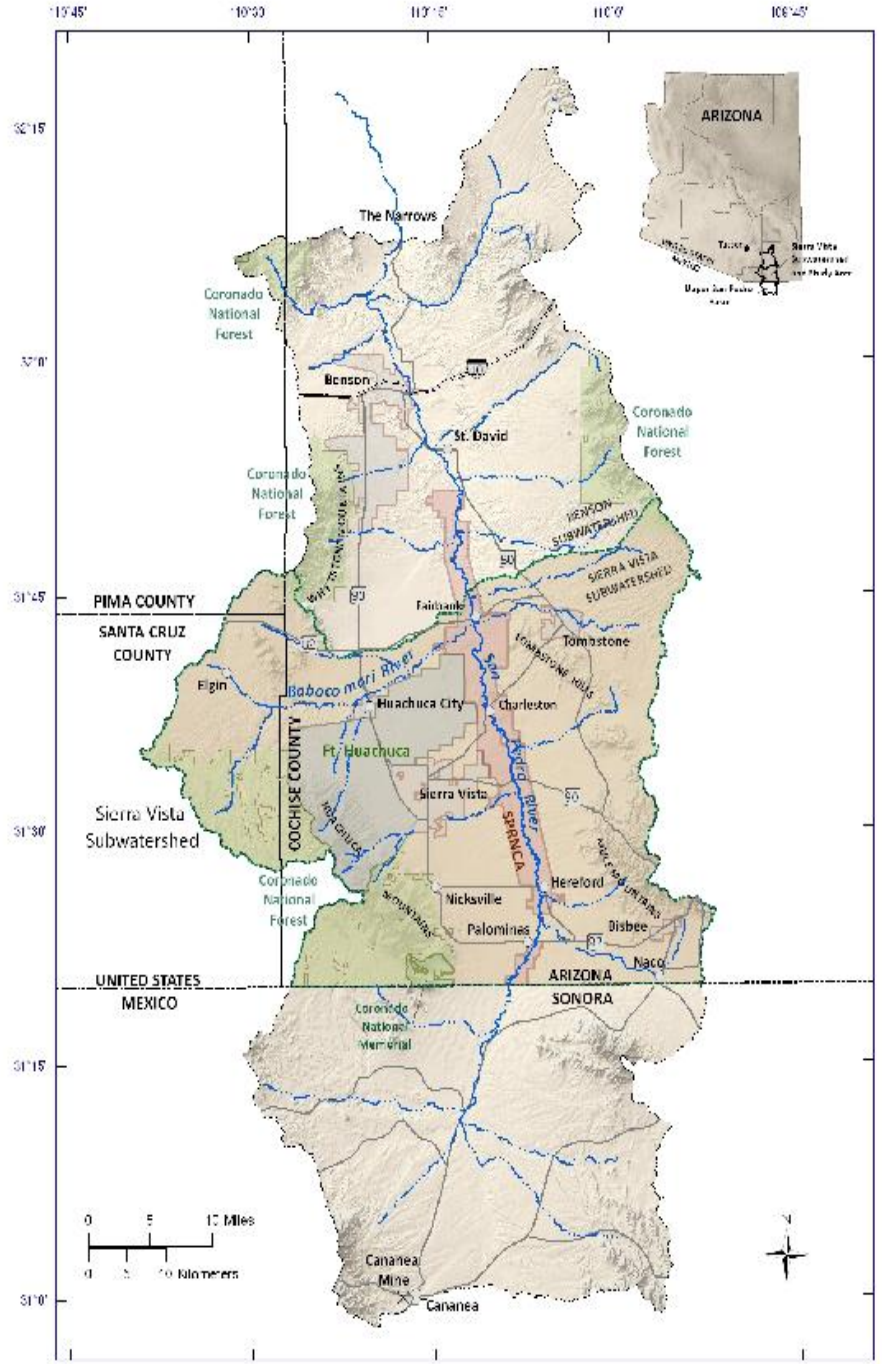


Figure 2. Generalized hydrogeologic section and extent of numerical model layers, Upper San Pedro basin, United States and Mexico.

Upper San Pedro Watershed

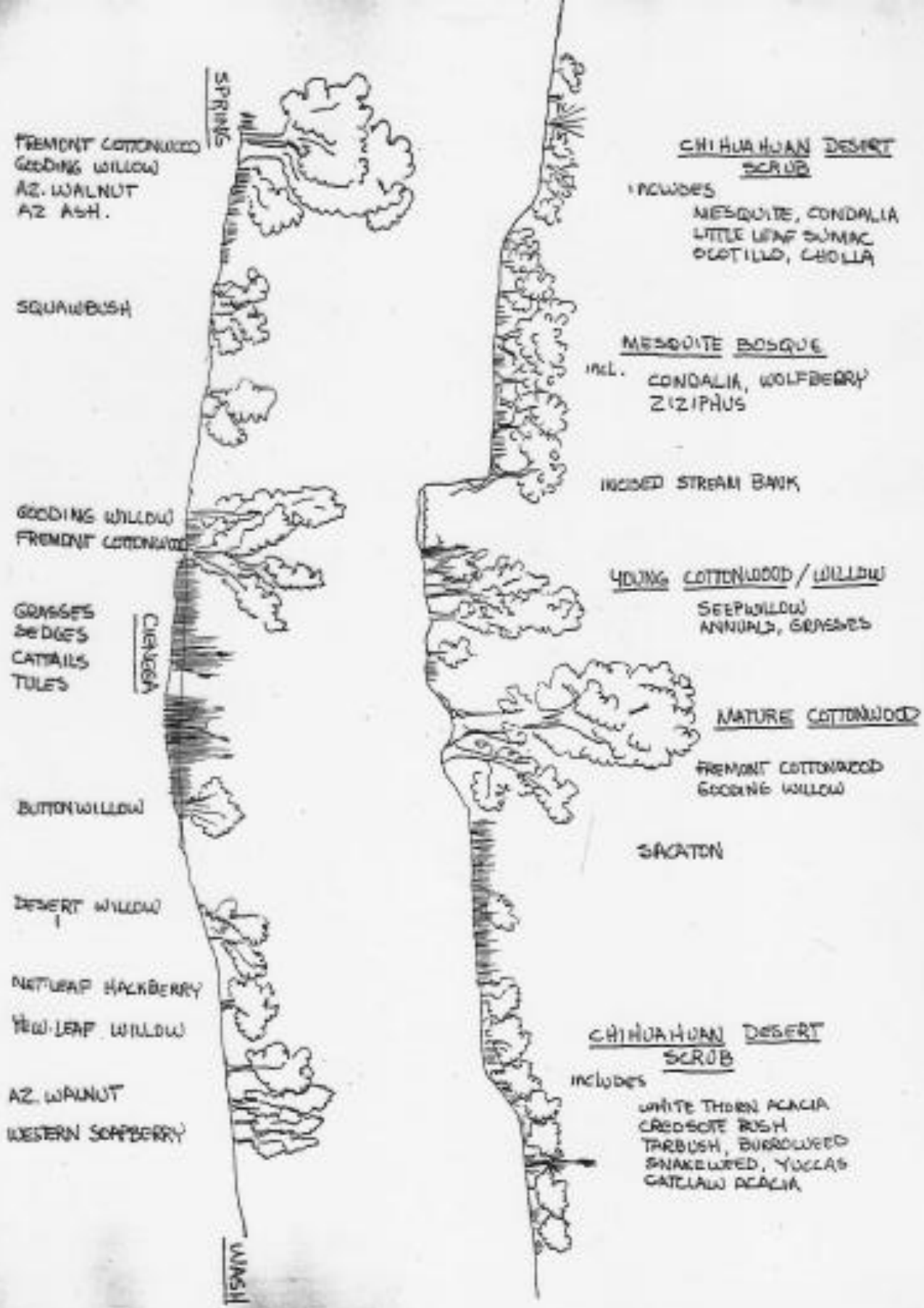


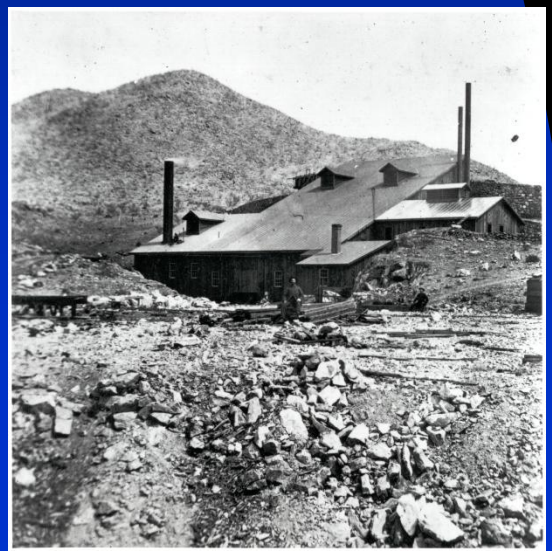
Watershed Parameters

- Area (4,483 Sq. Miles at Winkleman, 696 in Mexico; SV subwatershed = 950 Sq. Miles; 50,000+/- acres in SPRNCA)
- Shape (Dendric)
- Elevation Range (1,920' Winkleman – 5,214' Cananea; 4,275' entering USA) (Miller Peak 9,466')
- Orientation (Flows S > N; 25 miles in Mexico, 125 in USA)
- Average Annual Precipitation (14.24 " @ Sierra Vista, per State Climatologist {1982 – 2009}; 8.5" 2009 subwatershed avg. per Section 321 report)
- Vegetative Communities
- Ground Water Depths (artesian – 600' bls.)
- Climatology Precipitation, (binomial), Temperatures, Winds, Evaporation
- Average Annual Flow (36,950 AFA @ Tombstone gage per ADWR)
- Peak Discharge (102,107 CFS in 1984; @ Tombstone gage per ADWR)

Vegetative Communities

- Mountains: Ponderosa Pine, Fringe Pines.
- Foothills: Oak Woodlands, Chihuahuan Grasslands.
- Alluvial Fans (Bajadas): Chihuahuan Desert.
- Low Lands: Grasslands, Riparian, Aquatic.


SPRING
FREMONT COTTONWOOD
GOODING WILLOW
AZ. WALNUT
AZ ASH.
SQUAWBUSH
GOODING WILLOW
FREMONT COTTONWOOD
GRASSES
SEDGES
CATTAILS
TULES
CIENEGA
BUTTONWILLOW
DESERT WILLOW
NETLEAF HACKBERRY
YEW-LEAF WILLOW
AZ. WALNUT
WESTERN SOAPBERRY
WASH
CHIHUAHUAN DESERT SCRUB
INCLUDES
MESQUITE, CONDALIA
LITTLE LEAF SUMAC
OCOTILLO, CHOLLA
MESQUITE BOSQUE
INCL.
CONDALIA, WOLFBERRY
ZIZIPHUS
INCISED STREAM BANK
YOUNG COTTONWOOD / WILLOW
SEEPWILLOW
ANNUALS, GRASSES
MATURE COTTONWOOD
FREMONT COTTONWOOD
GOODING WILLOW
TERRACE
CHIHUAHUAN DESERT SCRUB
INCLUDES
WHITE THORN ACACIA
CREOSOTE BUSH
TARBUSH, BURROWEED
SNAKEWEED, YUCCAS
CATCLAW ACACIA



Historic Changes

- **Native American Cultures:**
  - * Paleo (Clovis) – 12,000 B.C. – 300 B.C.
  - * Hohokam – 300 B.C. – 1500 A.D.
- **Spanish:** 1539 De Niza, 1542 Coronado.
- **Mexican:** 1821 (Beginning).
- **Anglo Settlement:** 1825 – 1869, rapid since late 1870's.

  * Oak Woodland Removal: late 1870's, for Mining timbers, charcoal production, Smelting of ores, and fuel wood.

  * Overgrazing: 1539 – 1851; Reintroduction late 1870's.

  * Fire Suppression: Since late 1870's.

  * Beaver Extinction: Fur trapping and Cienegas breached by Army to control Malaria.
- **Climatic Changes:** (precipitation & temperature)
- **Earthquake:** 5/3/1887.

Precipitation Changes Summary

- Large floods after 1870's, preceded by lengthy drought, led to regional riverine entrenchments.

- Frequency of low intensity storms has decreased, while frequency of intermediate and high intensity storms has increased.

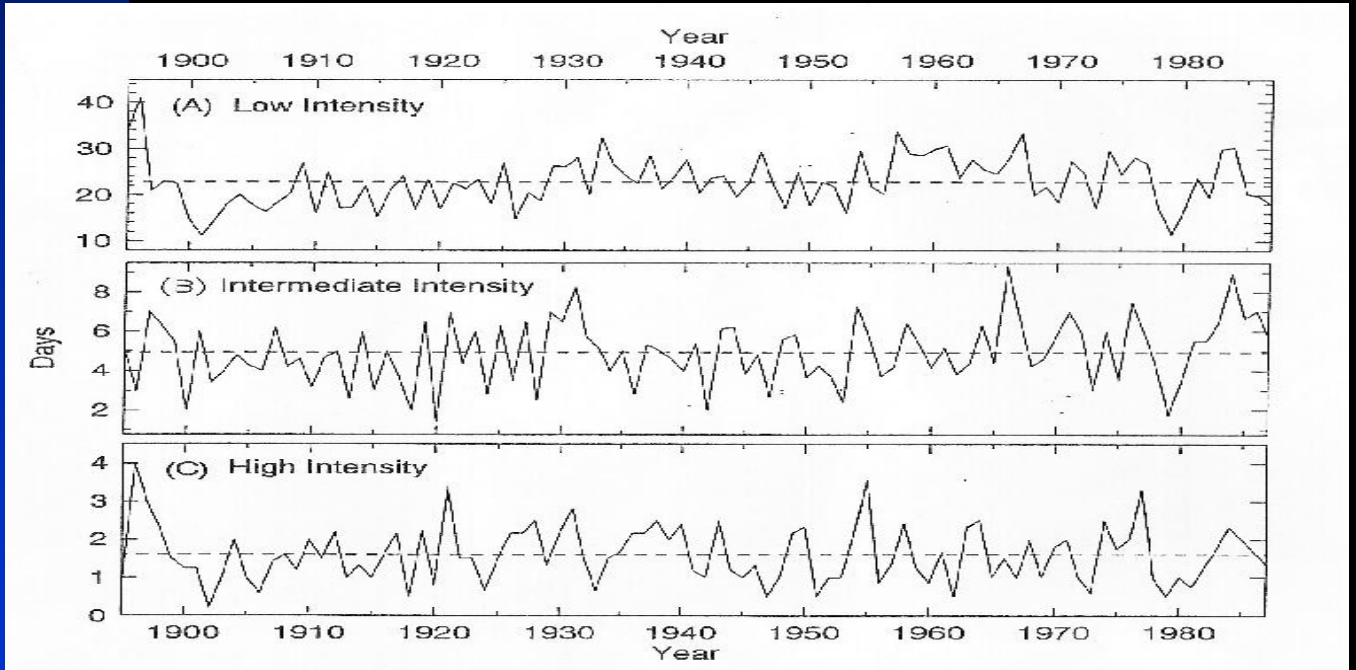
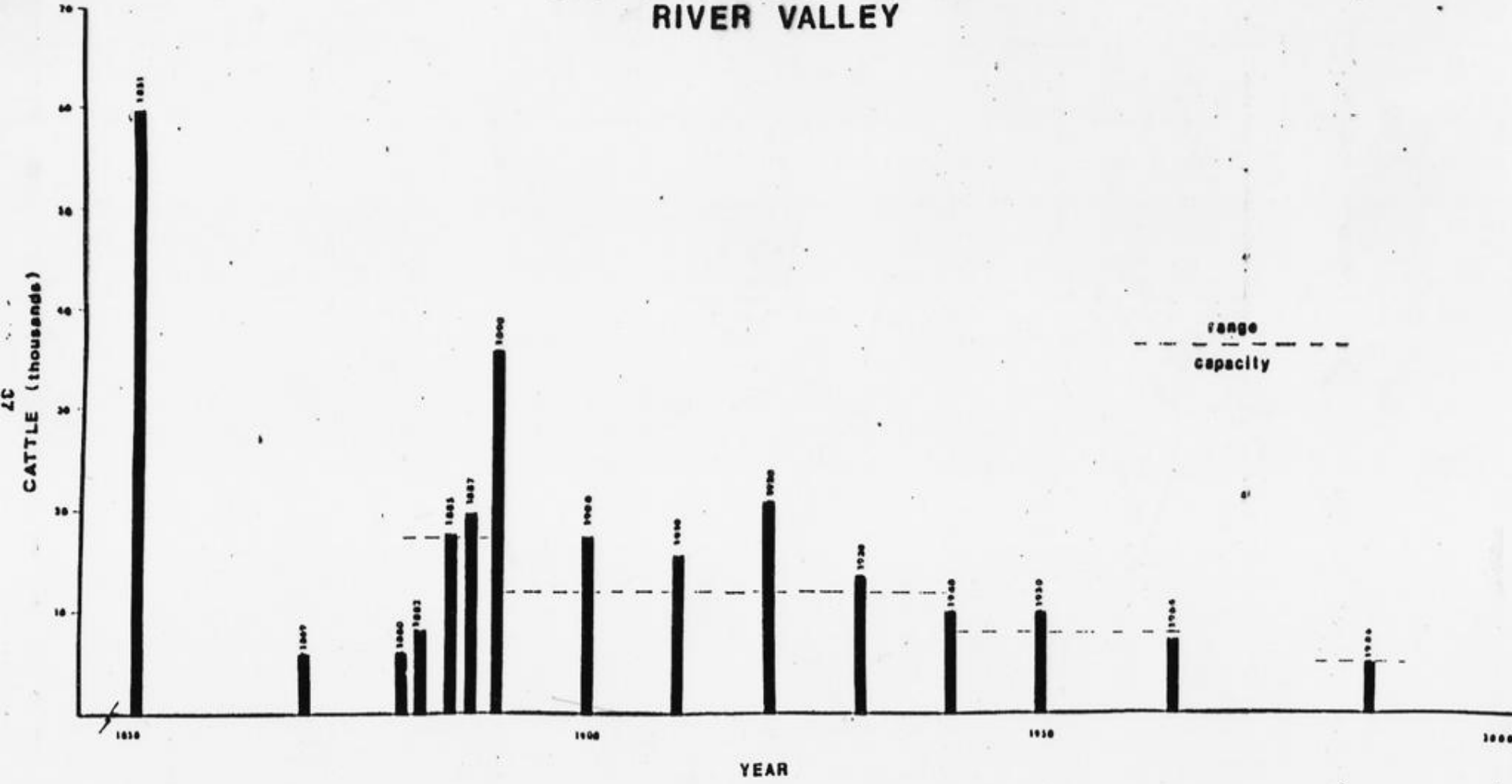


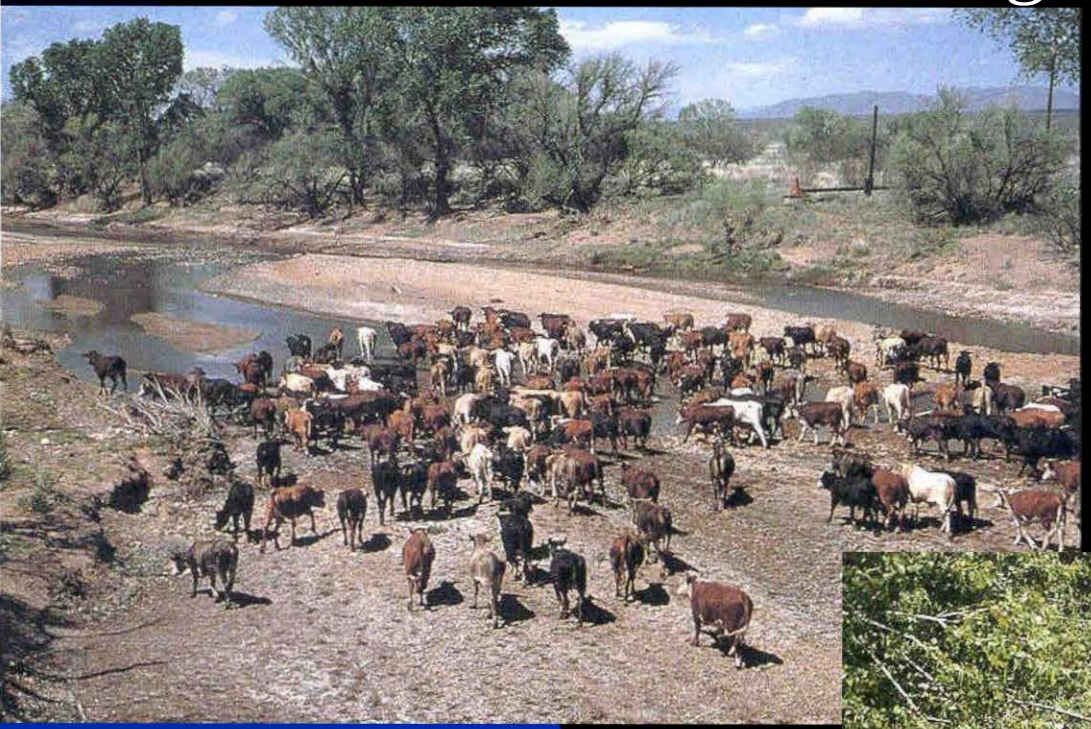
Figure 36. Time series of wet-season rainfall intensity. A) Days annually having low-intensity rainfall, B) intermediate-intensity rainfall, and C) high-intensity rainfall. Dashed line is long-term average.

CATTLE POPULATION OF THE UPPER SAN PEDRO RIVER VALLEY



Sources and Notes: 1851, wild cattle, extrapolations from Bartlett's Reports (Wagoner, 1949); 1869, cattle held on Col. Hooker's ranch until it was abandoned in 1875. No cattle was reported from 1875-1880 (Rodgers, 1965; Wagoner, 1975); 1880, (Wagoner, 1949); 1882, only 3000 cattle were reported on the tax rolls, but Wagoner believes that 8000 head is more realistic (Wagoner, 1949); 1885-1940, Cochise County Tax Rolls, assessed plus 50%, 1950-1964, Assessors Tax Roll, actual assessed (Rodgers, 1965); 1986, estimates based on carrying capacity by section (Swenenson, 1987).

Effects of Grazing Moratorium



Stage 1: Unincised

Stage 2: Rapid downcutting

Stage 3: Channel widening and forming a new flood plain

Stage 4: Channel widened enough to form a new stable channel and flood plain.

THE 1887 EARTHQUAKE
in San Bernardino Valley, Sonora:
Historic accounts and intensity patterns in ARIZONA

by
Susan M. DuBois and Ann W. Smith

Special Paper No. 3

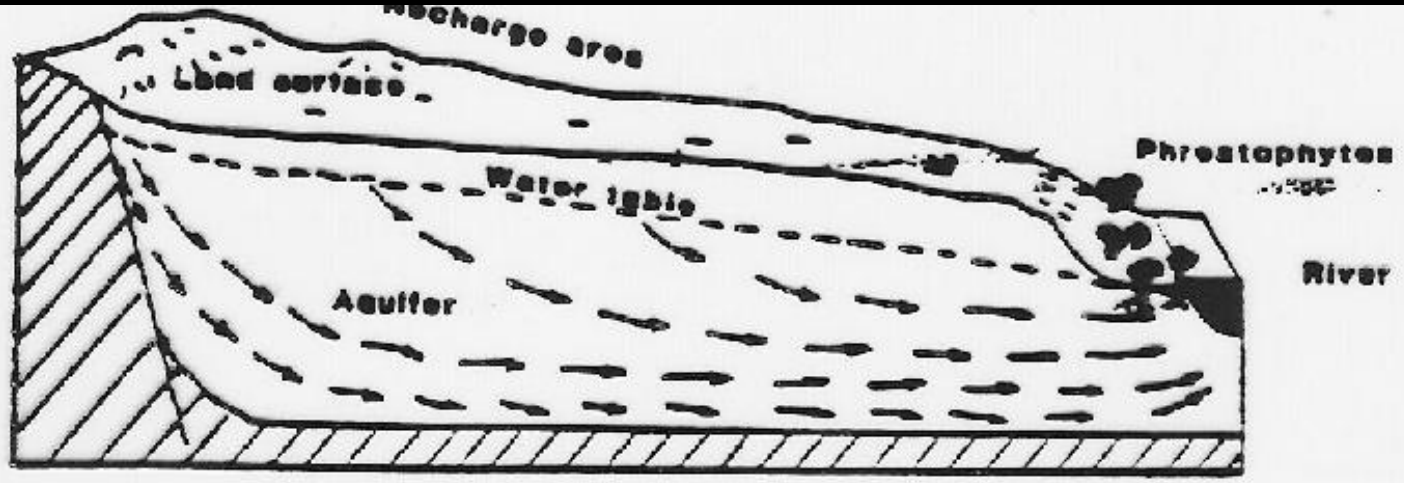
State of Arizona
Bureau of Geology and Mineral Technology
The University of Arizona

Earthquake Summary

- Occurred May 3, 1887; 3:00P.M.,
- Measured 7.2 on Richer Scale,
- Caused by Pitaycachi Fault,
- Epicenter was about 30 miles south of border at Batepito Sonora, (now Colonia Morales).
- Was felt from Mexico City to Albuquerque to Phoenix (where it reportedly rang church bells).
- Water table fluctuations and other hydrologic effects such as appearance and disappearance of springs were reported.

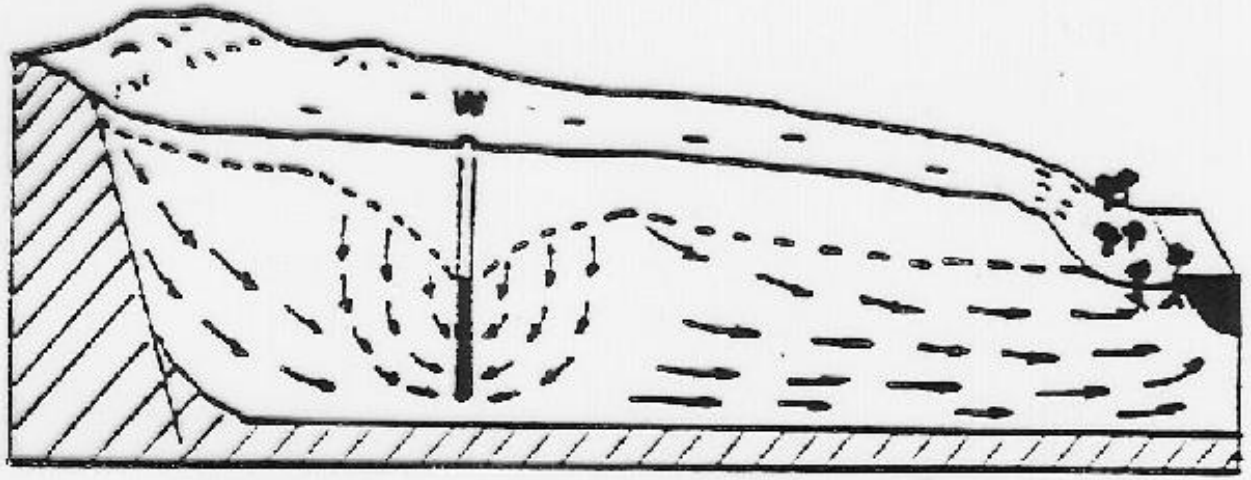
Hydrologic Changes

- **Channel Entrenchment:** 1890 – 1908, Large floods changed system for sluggish cienegas/marshs to faster incised rivers.
- **Channel Widening:** 1908 – 1955.
- **Increased Sinuosity:** continuous; as-needed.
- **Riparian Forests:** Since 1908
- **Stabilization:** 1955
- **Irrigation:** Large parcels with turbine engine pumps 1940's to 60's.
- **Urbanization:** accelerated in 1950's, Boomed in the 1980's, Flood Control channel alterations, and dams.

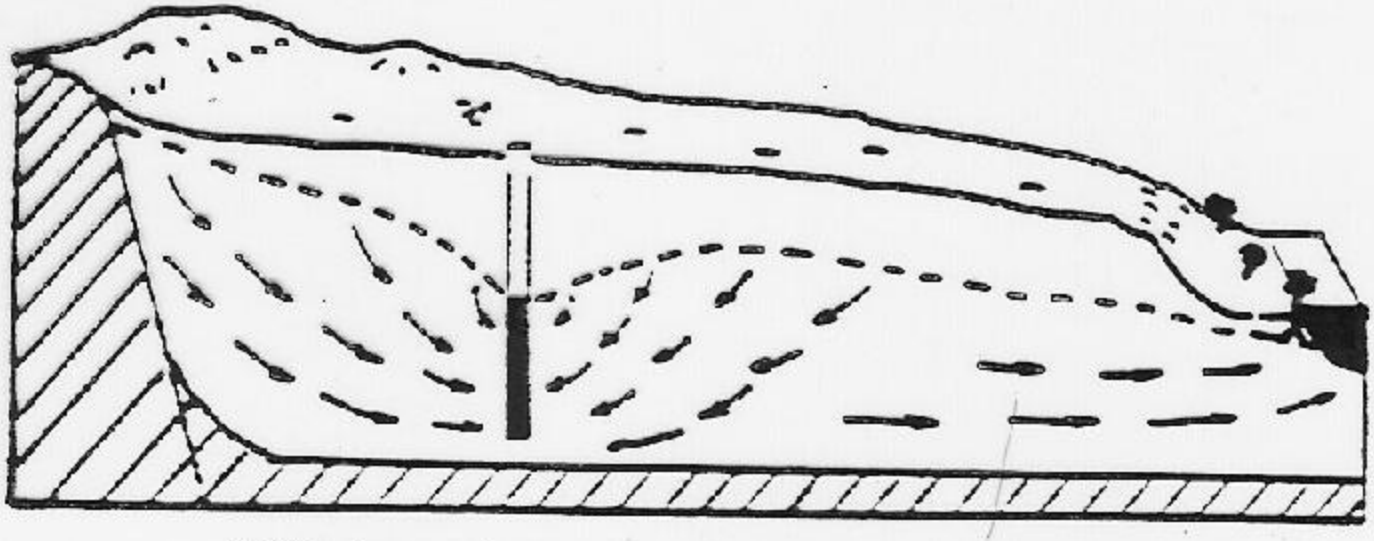


Undeveloped Conditions: Recharge equals discharge

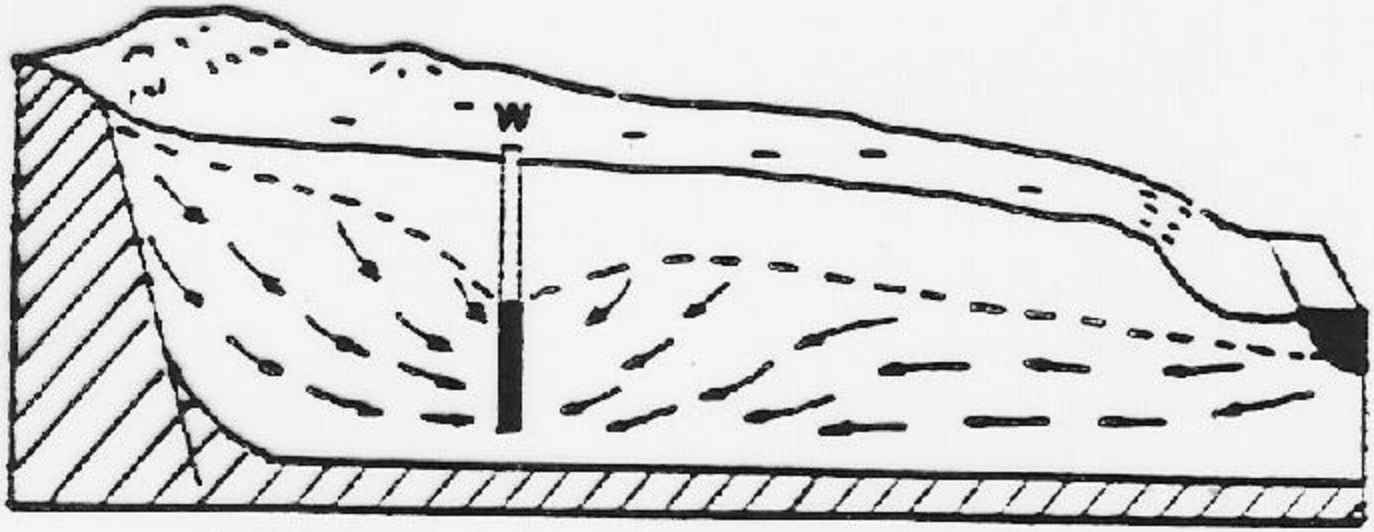
Developed Conditions:



Withdrawal equals reduction in storage

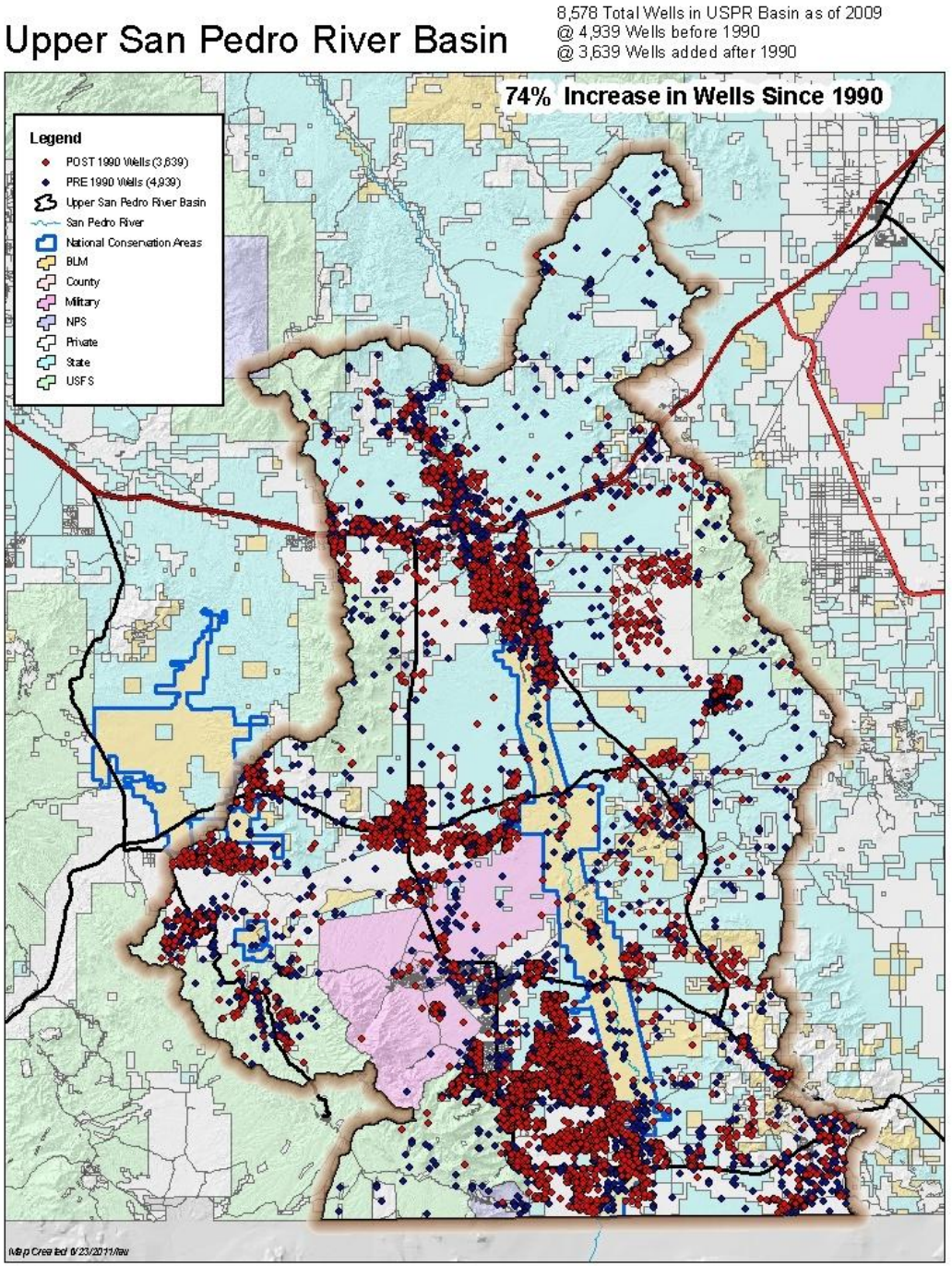


Withdrawal equals reduction in storage
plus reduction in discharge

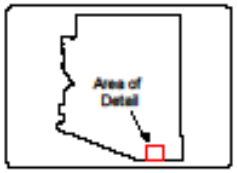


Withdrawal equals reduction in discharge
plus increase in recharge

Wells in the Sierra Vista Subwatershed



Wells approved after 11/18/88 and Groundwater Flow in the Sierra Vista Subwatershed



Groundwater Drawdown (feet) [6]
1940 - 2001

- 0- 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 65

- Wells[1]
- Direction of Groundwater Flow[2]
- Subdivisions with[3] Certificates of Adequacy 1980 - 2002.
- Huachuca water umbel populations[4] from Vernadero inventory results, 2008.
- Huachuca water umbel populations[5] from EEC inventory results, 2007.
- Huachuca water umbel populations[5] from EEC inventory results, 2004.
- Huachuca water umbel populations[5] from EEC inventory results, 2001.
- Huachuca water umbel populations from BLM, 1995 - 1999.
- Wastewater treatment plant
- Roads
- Drainages
- San Pedro River
- San Pedro Riparian National Conservation Area
- Fort Huachuca

Data Sources:

1 - Arizona Department of Water Resources, "Wells 55" CD, January 2010.

2 - US Geological Survey,"Hydrogeologic Investigations of the Sierra Vista Subwatershed of the Upper San Pedro Basin, Cochise County, Southeast Arizona", By D.R. Pool and Allissa L. Coes, 1999.

3 - Arizona Department of Water Resources, "Cochise County Water Agency Report 1980 - 2002", 2003.

4 - Vernadero Group 2008. Huachuca Water Umbel (Lilaeopsis schaffneriana recurva), Fort Huachuca Monitoring and San Pedro Riparian NCA Inventory Report; Prepared for: Environmental and Natural Resources Division, U.S. Army Garrison, Fort Huachuca, Arizona. Prepared by: Vernadero Group Inc., Sierra Vista, Arizona. January 8, 2009

5 - EEC 2001, 2004, 2007. Huachuca Water Umbel (Lilaeopsis schaffneriana recurva), Fort Huachuca Monitoring and San Pedro Riparian NCA Inventory Reports; prepared for: Directorate of Installation Support, U.S. Army Garrison, Fort Huachuca, Arizona; prepared by: Engineering and Environmental Consultants, Inc., Sierra Vista, Arizona.

6 - ADWR 1996. Corell, S. W., et al. 1996. A groundwater flow model of the Sierra Vista subwatershed of the Upper San Pedro Basin-southeastern Arizona. Phoenix: Arizona Department of Water Resources, Hydrology Division, Modeling Report No. 10. December 1996.
and
Arizona Department of Water Resources, The Upper San Pedro Basin Active Management Area Review Report, March 2005.
and
Arizona Department of Water Resources, Ground Water Site Inventory Database, October 2004.

* - Subwatershed definition from:
Arizona Department of Water Resources. Preliminary hydrographic survey report for the San Pedro River watershed, Volume 1: General Assessment. Phoenix, Arizona, November 20, 1991.

0 1.25 2.5 5 Miles

Map by Curt Bradley
Center for Biological Diversity, 2/24/10

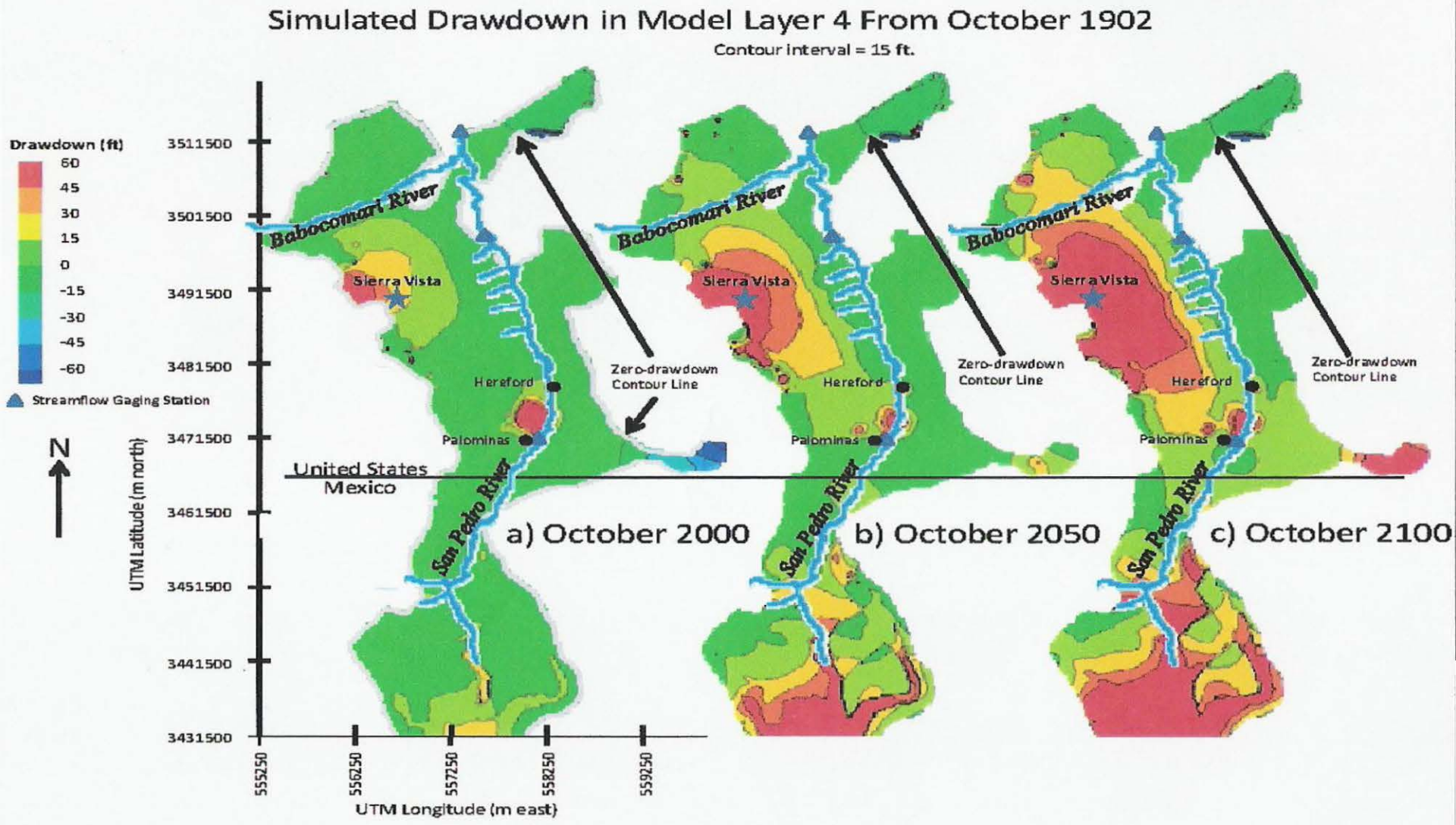
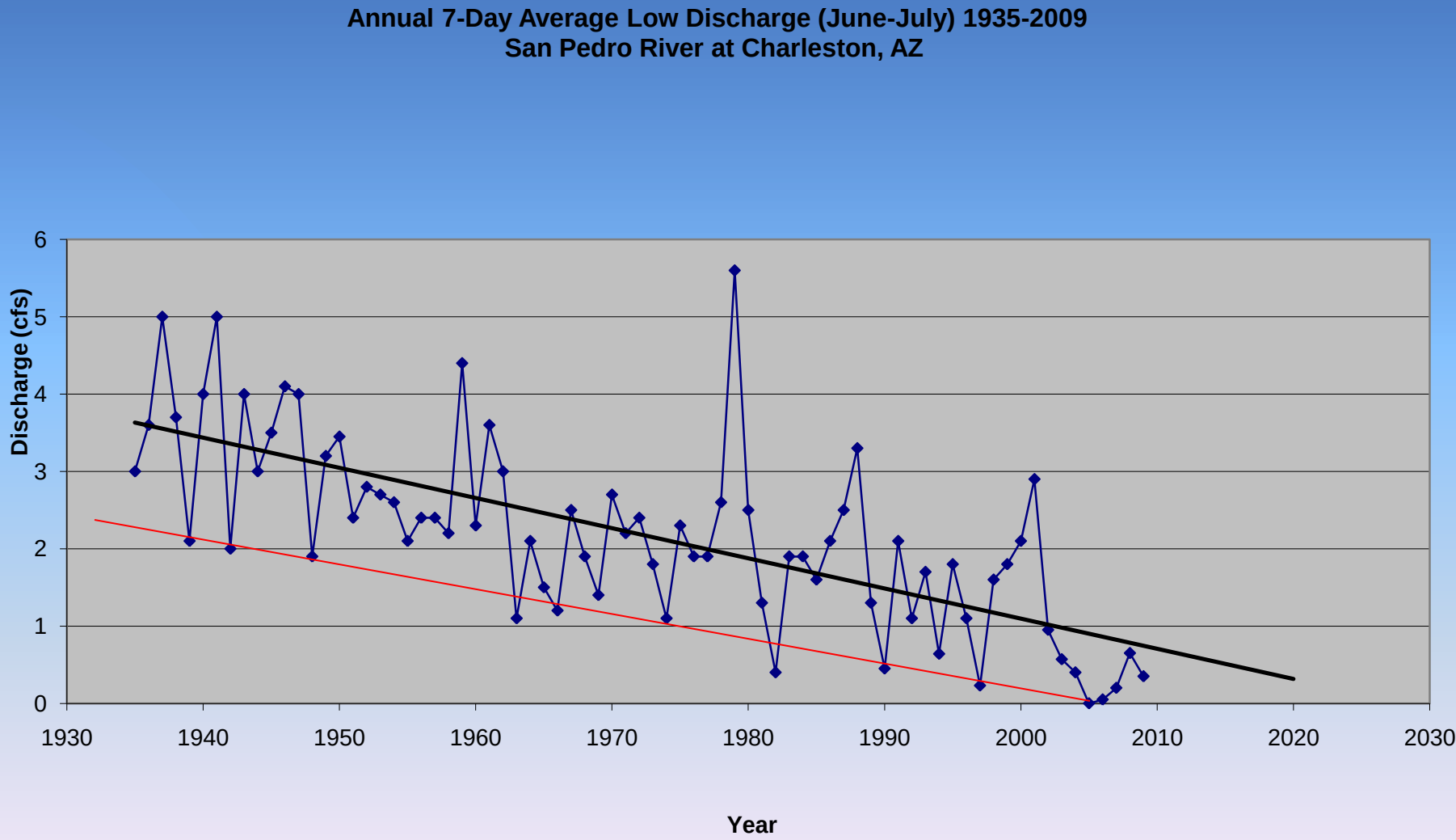
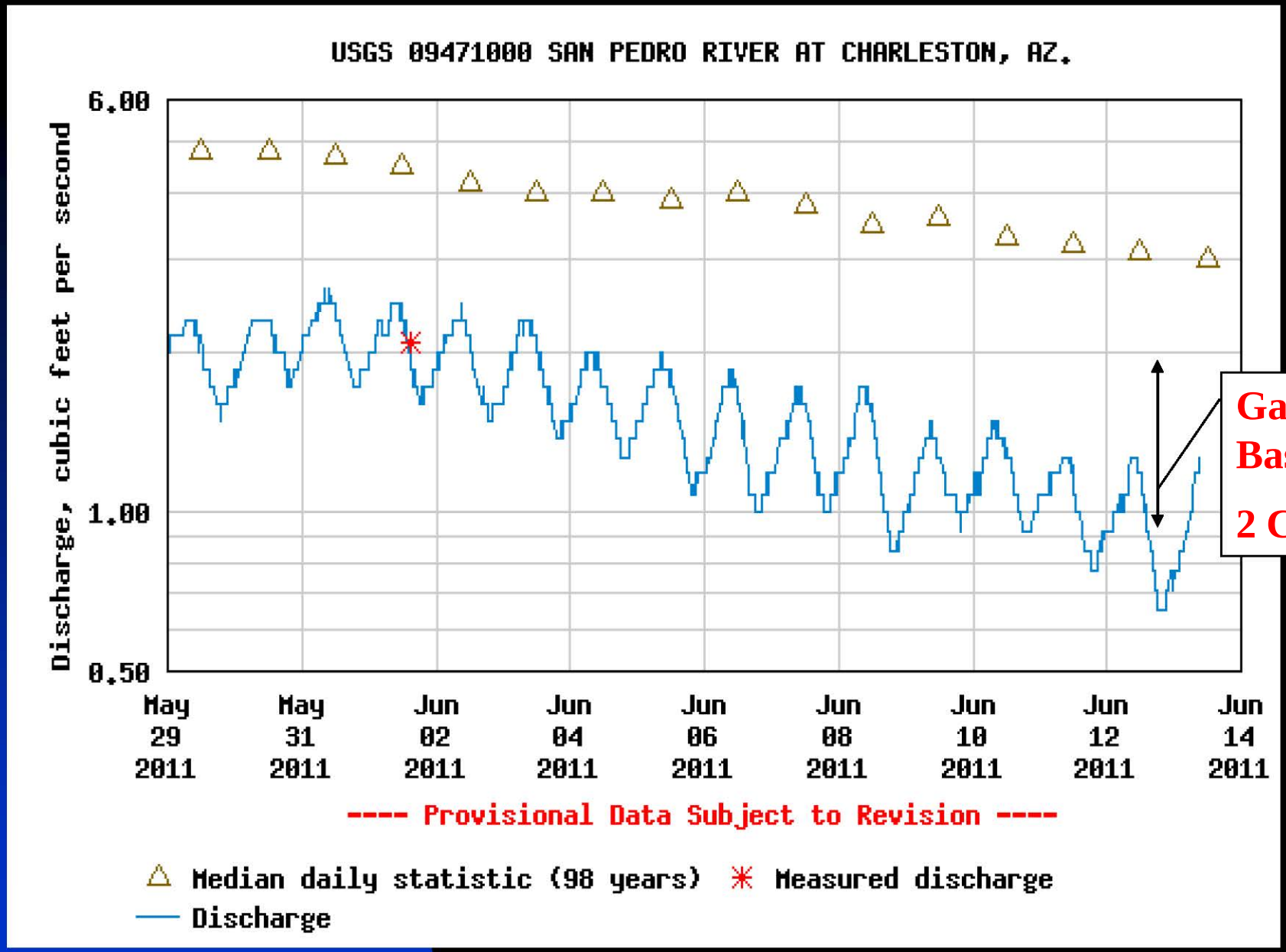


FIGURE 18. SIMULATED CHANGE IN HEAD (DRAWDOWN) (FT.) IN MODEL LAYER 4 (REGIONAL BASIN-FILL AQUIFER) FROM OCTOBER 1902 TO OCTOBER 2000, OCTOBER 2050, AND OCTOBER 2100. AREAS IN DARK RED REPRESENT DRAWDOWN OF 60 FT. OR MORE. BLUE LINE REPRESENTS LOCATION OF RIVERS BUT DOES NOT SIGNIFY THE CONDITION OF PERENNIAL FLOW.



Diminishing Base Flow



Discharge Gap

Fish Species Occurrence in the San Pedro River (Main Stem) from 1850 through 2000

(Adapted from Minckley 1987)

Native Species	1850	1880	1900	1940	1950	1960	1970	1980	2000	Introduced Species
Colorado Squawfish(E)	←	← →	→	→	→	→	→	→	→	Common Carp
Razorback Sucker (E)	←	←		→	→	→	→	→	→	Black Bullhead
Flannelmouth Sucker	←	←		→	→	→	→	→	→	Green Sunfish
Roundtail Chub	←	←		→	→	→	→	→	→	Mosquitofish
Gila Chub (E)	←	←				→	→	→	→	Goldfish
Speckled Dace	←	←	←				→	→	→	Fathead Minnow
Loach Minnow (T)	←	←	←	←	←		→	→	→	Yellow Bullhead
Desert Pupfish (E)	←	←	←	←	←		→	→	→	Channel Catfish
Spikedace (T)	←	←	←	←	←	←	→	→	→	Bluegill
Gila Topminnow (E)	←	←	←	←	←	←	← →	→	→	Largemouth Bass
Sonoran Sucker	←	←	←	←	←	←	←	←	→	Red Shiner
Longfin Dace	←	←	←	←	←	←	←	←	← →	Flathead Catfish
Desert Sucker	←	←	←	←	←	←	←	←	←	??What Next??

BLM placed 21 wells into non-use accounting for 10,000 to 12,000 acre feet of annual ground water pumping used for agricultural purposes (paper right of 18,000 acre feet annually).

- ✓ **Objective was to restore groundwater levels and stream flows.**

BLM also closed all sand & gravel pits and converted some into recharge basins

➢**Restoring of approximately 2,000 acres of abandoned farmlands to native grasslands.**

- **Through mechanical methods.**
- **Through prescribed fire.**
- **Through natural progression & rest. Moratorium on livestock grazing since 1989.**
  - ✓**Objective is to improve upland and near riparian habitats, and to decrease erosion and improve infiltration.**

- **Initiated prescribed fire program for all vegetative communities.** To date over 4,000 acres treated.
- **Annual mowing of fire breaks.**
  - ✓Objectives are to restore native grassland habitat, to improve existing native plant habitats, to eliminate invasive plant species, stimulate recruitment of native plant species, to reduce the threat and severity of natural and human caused fires to the riparian area.

ARIZONA FIREWISE COMMUNITIES™

Reintroduction of Beaver

- Began reintroduction of 15 beaver into the riparian area in 1999 - 2001.
- Approximately 60 beaver inhabit the system today.
  - ✓ Objective is to help stabilize the stream banks, to improve stream bank recharge, retain stream flows for longer durations, to establish new marsh lands or Cienegas, and to reestablish a species removed from the system.

Land & Water Conservation Fund Acquisitions

- Acquisition of over 3,862 acres in conservation easements in the Borderland/gap area near the international border, and ecosystem areas north of I-10.
- Acquisition of fee ownership within the SPRNCA congressional boundary from willing sellers continues as possibilities arise.
- Some acquisitions are processed in partnership with The Nature Conservancy and/or DOD.
  - Objective is to acquire resources within the SPRNCA necessary for long-term management, and acquire interest in land through conservation easements to retire high water uses and manage future development.

Riparian Values

- **ECOLOGICAL EQULIBRIUM AND PRODUCTIVITY**
  - * Game & Fish
  - * Non-Game species
  - * Floral Diversity
  - * Faunal Diversity
  - * Aesthetically Pleasing
  - * Air Quality
- **FAVORABLE HYDROLOGIC CONDITIONS**
  - * Flood Control
  - * Detention/Retention
  - * Extended Base Flows
  - * Increased Recharge
  - * Higher Water Tables
  - * Water Quality
  - * Erosion Protection
  - * Reduced Sediments
  - * Increased Storage
- **ECONOMIC INCENTIVES**
  - * Recreation
  - * Aesthetics
  - * Healthier Environment
  - * Better Quality of Life
  - * Business Opportunities
  - * Reduced Diseconomies

Recent and Emergent Issues

- Murray Springs/EOP
- Pharmaceuticals
- E-Coli Downstream of Babocomari
- Fish Kills
- Monument Fire
- HR 1505

Foreseeable Future

- **Water Quantity** – flow regime, water table.
- **Water Quality** - surface and groundwater.
- Present fluvial system is a result of a series of historic changes and rapid development that has led to significant hydrologic changes. Tomorrow's system will depend on today's land use practices and climatic changes.

Questions?

THANK YOU

Arizona Bureau of Land Management
Tucson Field Office