Adaptive Management of Ground Water Resources to Help Insure Long-Term Sustainability

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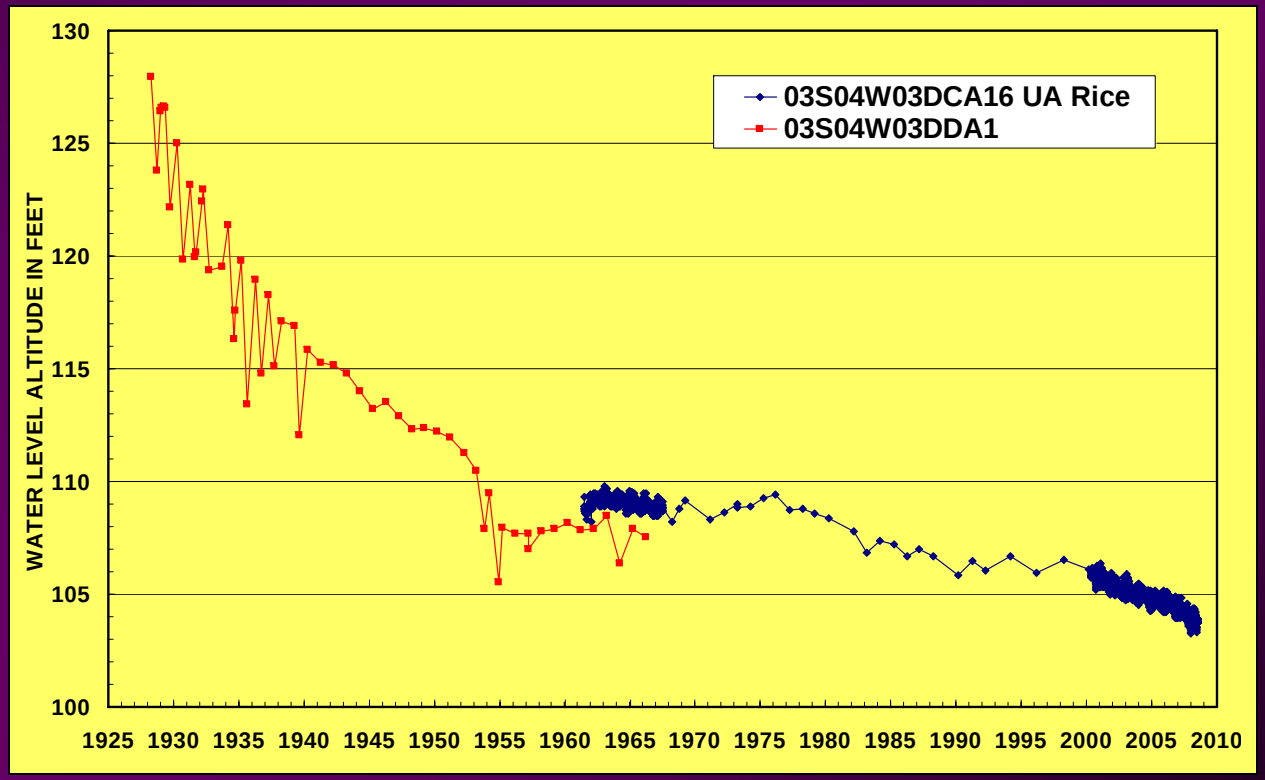
U.S. Department of the Interior
U.S. Geological Survey

Arkansas USGS Ground-Water Data--Collection, Quality Assurance, Management, and Provision



Are Data Important?

The only way to figure out what is happening to our planet is to measure it,

and this means tracking changes decade after decade

and pouring over the records.

(From Ralph Keeling)

Long-term data are fundamental to the resolution of many of the most complex problems dealing with ground-water availability and sustainability.

Significant periods of time—years to decades—typically are required to collect water-level data needed to assess the effects of climate variability, to monitor the effects of regional aquifer development, or to obtain data sufficient for analysis of water-level trends.

Enhanced understanding of the ground-water-flow system and data limitations identified by calibrating ground-water models provide insights into the most critical needs for collection of future water-level data. Unfortunately, this second step of using ground-water models to help improve future water-level monitoring is rarely taken.

USGS

Ground Water Quantity and Quality Data and Water-Use Data

- Long-term collection of high-quality data using Nationally consistent, Nationally validated methodologies
- Numerous cooperators and a continuum of scales from site to regional to National
- Local presence ensures relevance, representativeness, and usefulness
- Data are provided via the National Water Information System, the Web, peer-reviewed reports, and customized, cooperator-defined formats

USGS

Quality Assurance and Data Validation

- Coordinated at the National level by USGS Office of Ground Water and Office of Water Quality
- Stringent and exhaustive development and continual assessment of data collection and data management protocols
- Three-year Discipline reviews

USGS

Office of Ground Water

Water Science Center Reviews

-multidiscipline teams to conduct technical reviews of Water Science Center
-scheduled onsite at approximately 3-year intervals

Purpose
"to ensure that all offices produce hydrologic data and information that meet USGS standards, to assess overall strengths and weaknesses of the technical program, and to make recommendations for improvement"

Quality Assurance and Technical Procedures
Technical Memoranda
Quality-Assurance Plan for District Ground-Water Activities (OFR 97.11)
Technical Procedures
Database Management
Handheld Data Collection

USGS

Arkansas Ground-Water Level Program

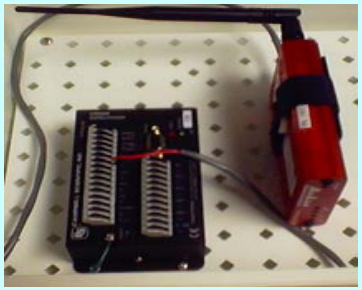
GW levels in major aquifers

- Water levels measured alternating years between Sparta and Alluvial Aquifers- over 300 wells measured
- Potentiometric map report published every two years

Real-time ground-water levels

- 21 wells statewide
- Web accessible:

http://ar.water.usgs.gov/



USGS

Real-Time Ground-Water Levels

USGS

USGS Internal Access

Water Resources

ar.water.usgs.gov

Real-Time Data for Arkansas: Ground Water -- 12 site(s) found

PROVISIONAL DATA SUBJECT TO REVISION

Updated 2006-03-21 14:39:31 US/Eastern

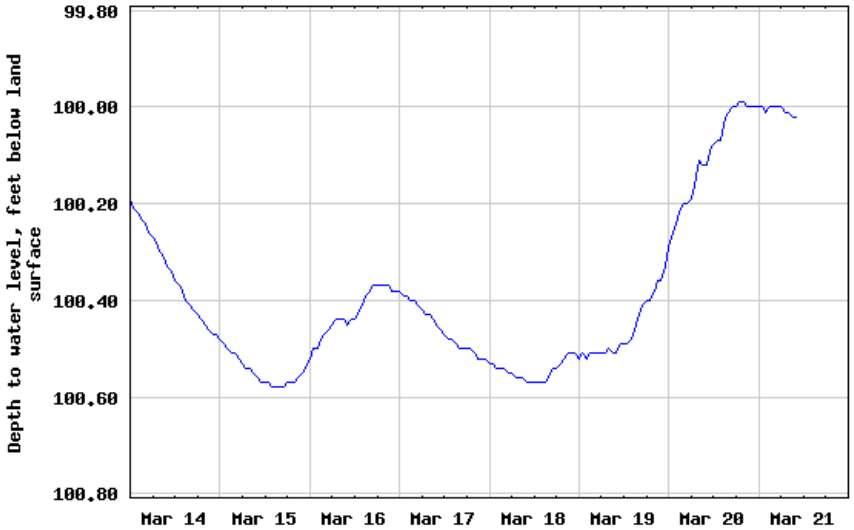
--- Predefined displays --- | Arkansas Ground-Water Table | Group table by | County | Select sites by number or name | go

Customize table to display other real-time parameters

Station Number	Station name	Date/Time	Depth to water level, feet below LSD	Elev-ation, feet above NGVD
Arkansas County				
342649091251916	03S04W03DCA16 Rice Research Center	03/21 10:00	100.02	--
Columbia County				
331609093144902	17S21W11DCC2 Magnolia	03/21 10:00	276.81	--
Lonoke County				
345057091525601	03N08W32ABB1 UAPB Lonoke Farm	03/21 12:00	118.32	--
Montgomery County				
343726093481801	01S26W29DCC1 Oden Forestry Well	03/21 13:15	59.93	--
Stone County				
355927092122401	16N12W25DCB1 Webb Cabin	03/16 21:00	66.95	--
Union County				
331104092380201	18S15W03DAB1 Welcome Center	03/21 10:00	360.32	--
331256092483702	17S17W25DBA2 Airport	03/21 10:00	346.44	--
331354092322401	17S14W22BAB1 Union School	03/21 10:00	305.48	--
331438092411901	17S15W18DBB1 Monsanto	03/21 10:00	320.78	--
332205092433001	16S16W02ABC1 Smackover	03/21 10:00	165.64	--

USGS

USGS 342649091251916 03S04W03DCA16 Rice Research Center



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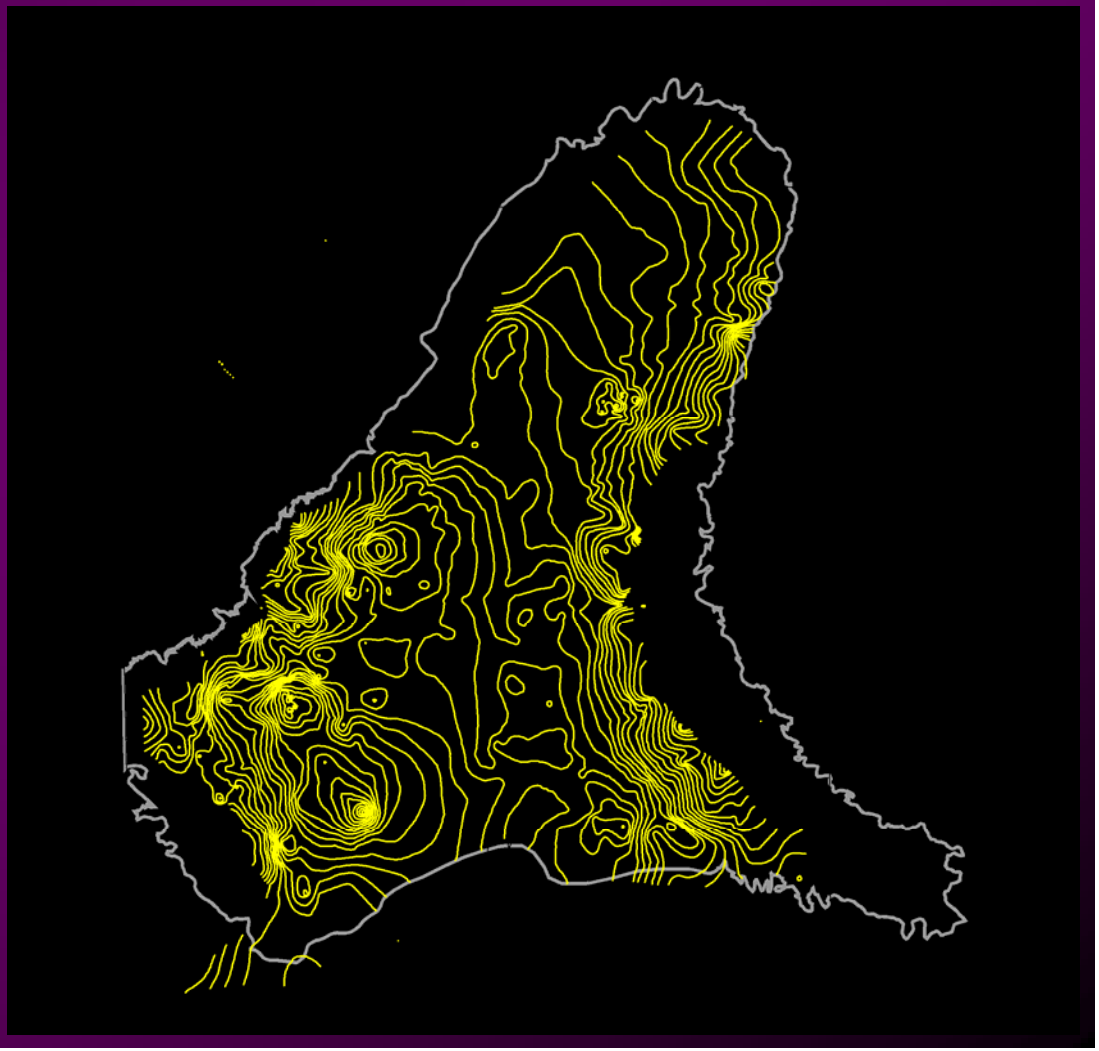
Potentiometric Surface in the Sparta-Memphis Aquifer of the Mississippi Embayment, Spring 2007

By T.P. Schrader

Scientific Investigations Map 3014

Multi-State Coordinated Water-level measurement and mapping



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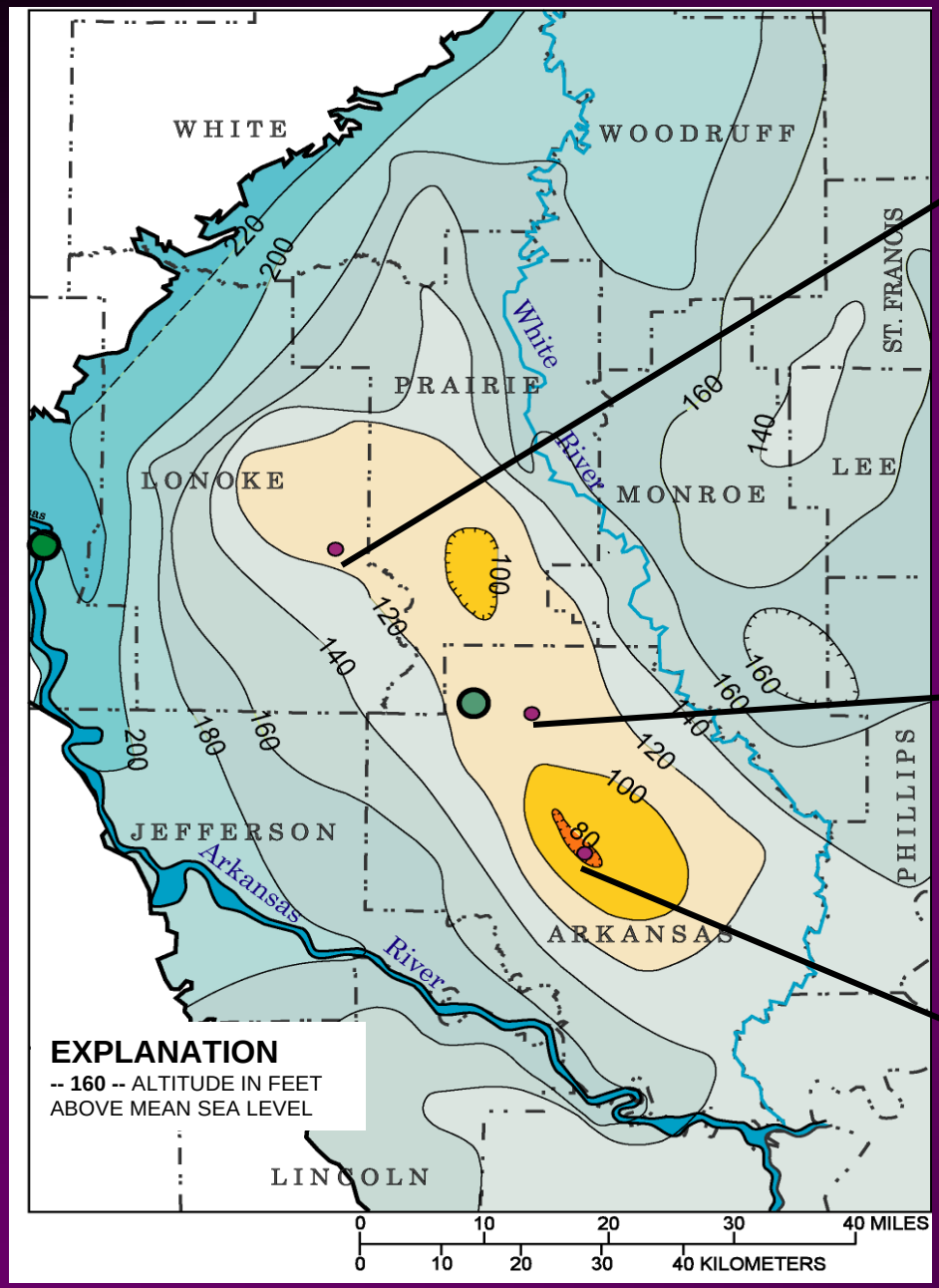
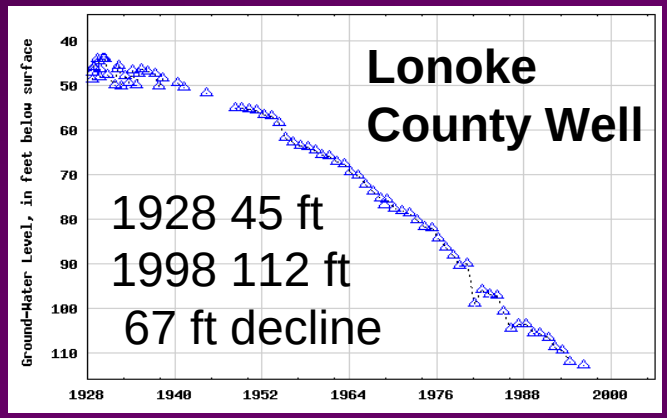
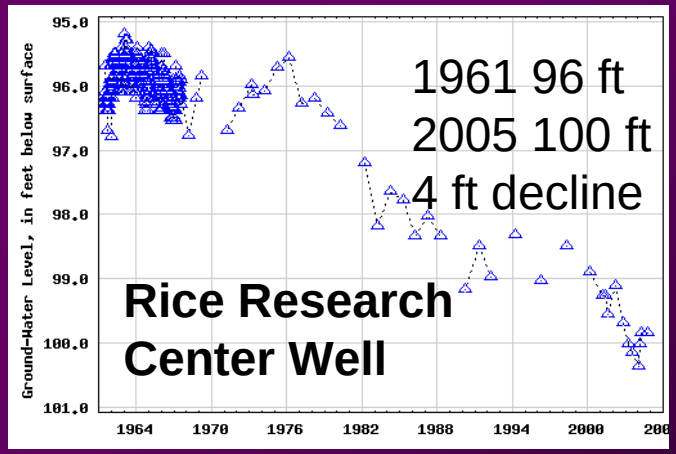
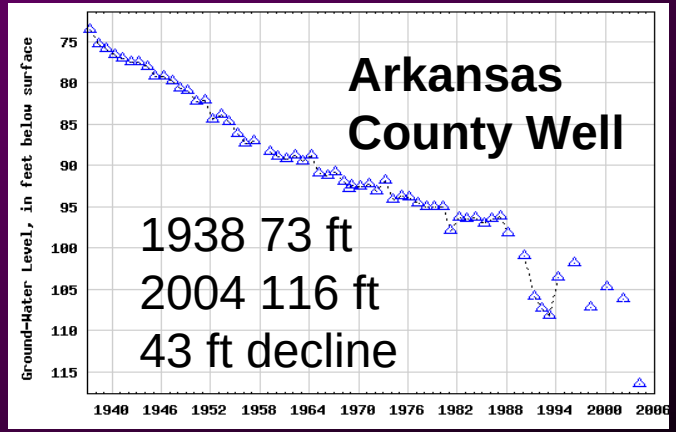

WHITE
WOODRUFF
ST. FRANCIS
PRAIRIE
LONOKE
MONROE
LEE
PHILLIPS
JEFFERSON
ARKANSAS
LINCOLN
White River
Arkansas River
220
200
180
160
140
120
100
80
EXPLANATION
-- 160 -- ALTITUDE IN FEET ABOVE MEAN SEA LEVEL
0 10 20 30 40 MILES
0 10 20 30 40 KILOMETERS


Lonoke County Well
1928 45 ft
1998 112 ft
67 ft decline
Ground-Water Level, in feet below surface
40 50 60 70 80 90 100 110
1928 1940 1952 1964 1976 1988 2000


1961 96 ft
2005 100 ft
4 ft decline
Rice Research Center Well
Ground-Water Level, in feet below surface
95.0 96.0 97.0 98.0 99.0 100.0 101.0
1964 1970 1976 1982 1988 1994 2000


Arkansas County Well
1938 73 ft
2004 116 ft
43 ft decline
Ground-Water Level, in feet below surface
75 80 85 90 95 100 105 110 115
1940 1946 1952 1958 1964 1970 1976 1982 1988 1994 2000 2006

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Water-Quality Data

Hot Springs, Arkansas Thermal Spring Recharge Studies

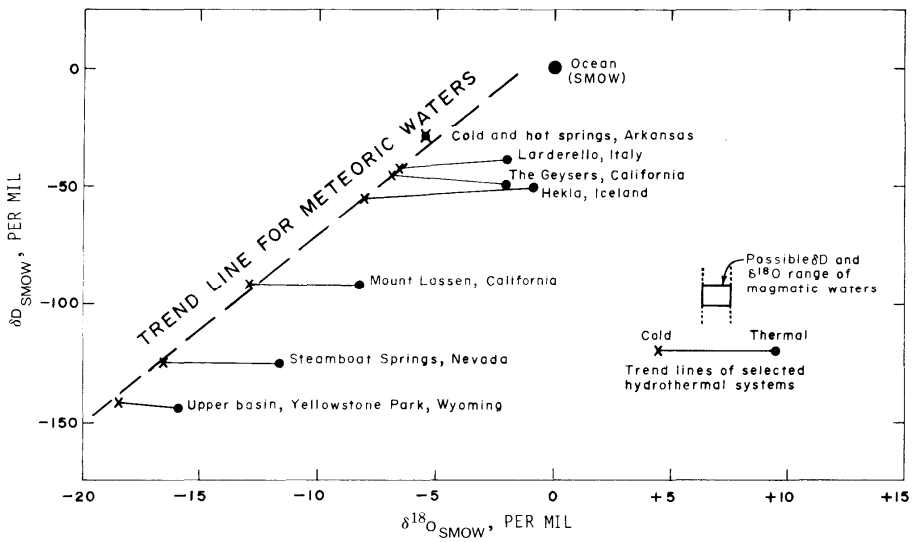


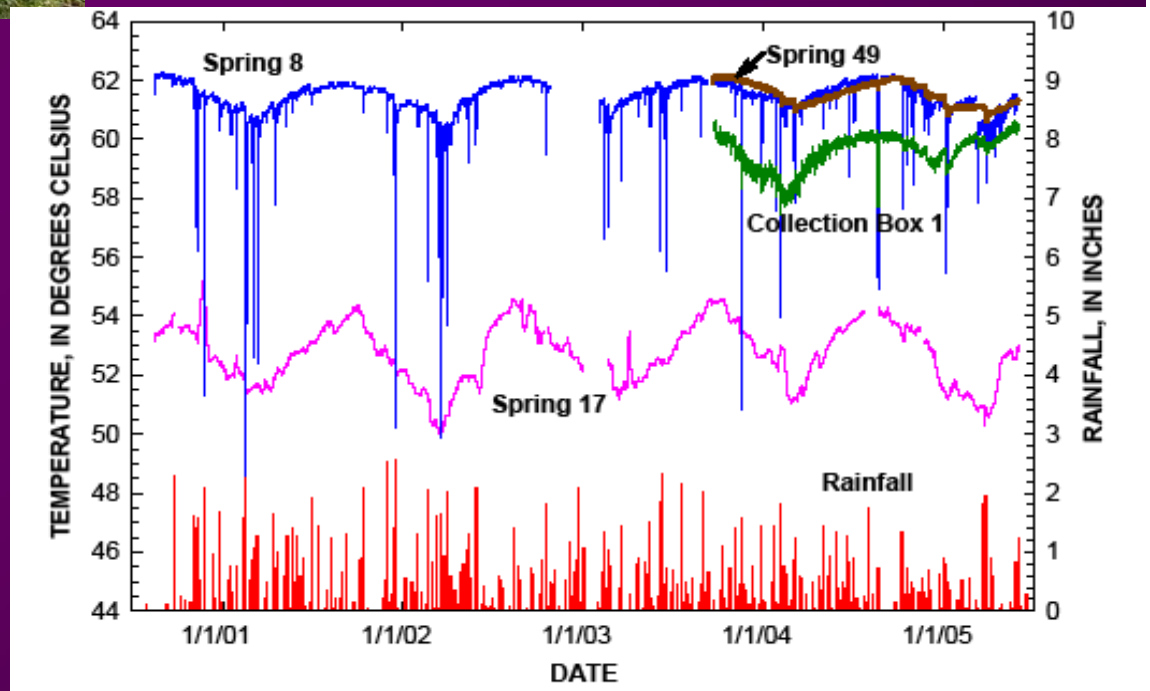
FIGURE 7.—Comparison of isotopic composition of waters from the cold and hot springs of Arkansas and of hydrothermal waters elsewhere (after White and others, 1973, fig. 1).

Stable Isotope Data

USGS

Hot Springs Recharge Studies

Thermal Spring Temperature Data



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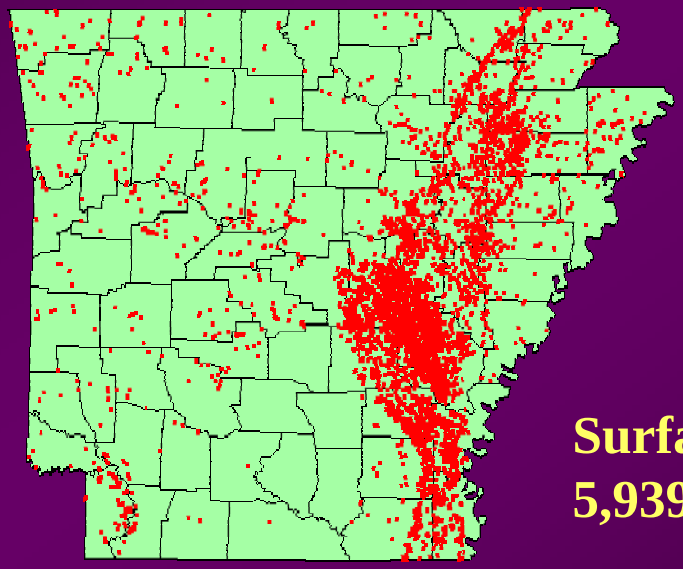
Water Use Data Reporting

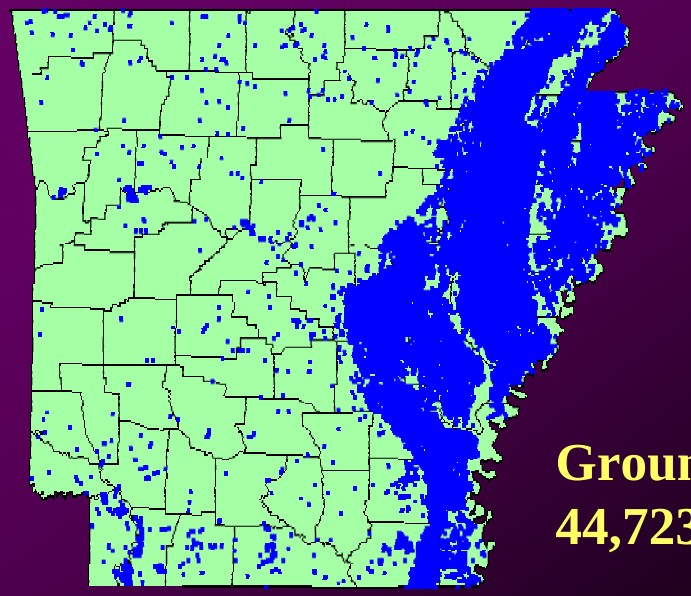
State requires reporting:

- **SW users >1 ac-ft/yr**
- **GW users > 50,000 gal/day**



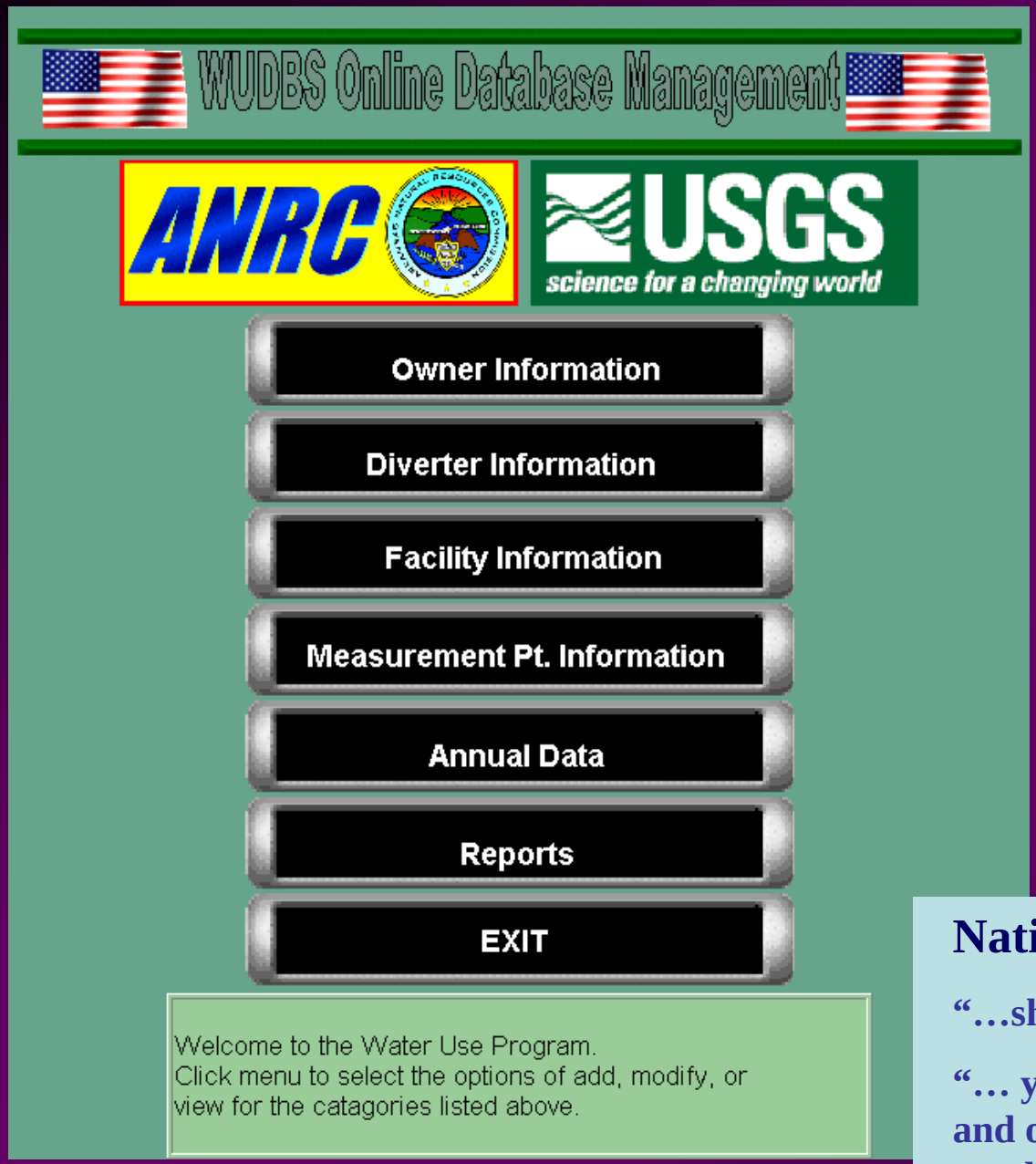
Surface water: 5,939 sites

USGS Cooperative program with Arkansas Natural Resources Commission since 1983



Ground water: 44,723 sites

USGS



Arkansas Water Use

In 2001

Water-use database accessible via the *Web*

- Data entry and retrieval functions
- GIS enabled interface

National Research Council review:

"…shows really what can be done."

"… your work is an example to be emulated and our report is going to have that emphasis."

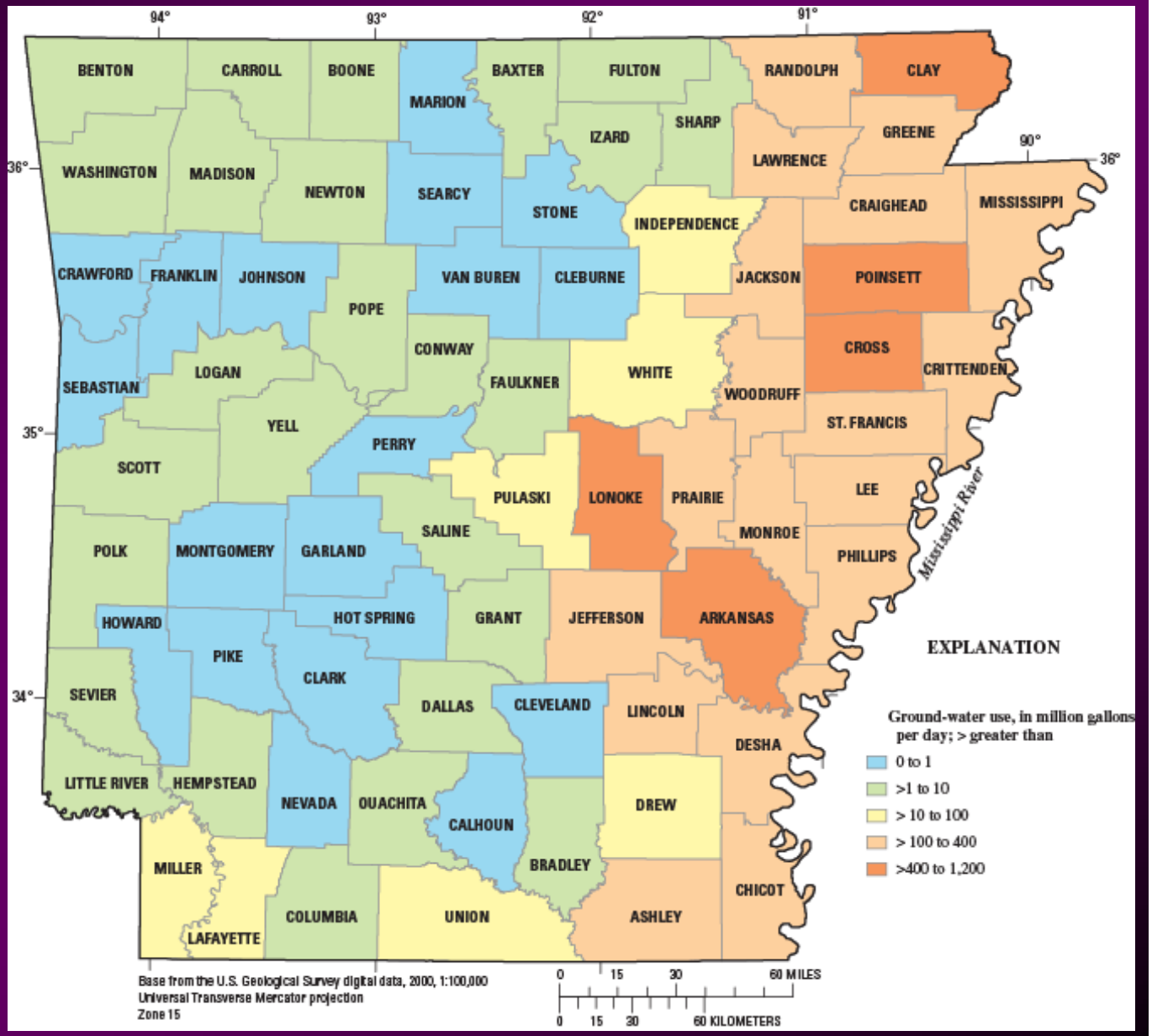
USGS

Arkansas 2005 Ground-Water Use

- Arkansas' total water-use about 11,455 million gallons of water per day (Mgal/d)

  66% ground water
  34% surface water

- Arkansas is the 4th largest user of GW in the US (CA, TX, and NE)



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Surface-Water Data Collection

115 Continuous Streamflow Gages

87 Rainfall Stations

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USGS NWISWeb Database

National Water Information System (NWIS)

Total monitoring sites	1.4 million
Real-time sites	9,300
Daily streamflow values	200 million
Ground-water levels	7.5 million
Water-quality samples	4.3 million
Water-quality analyses	68 million

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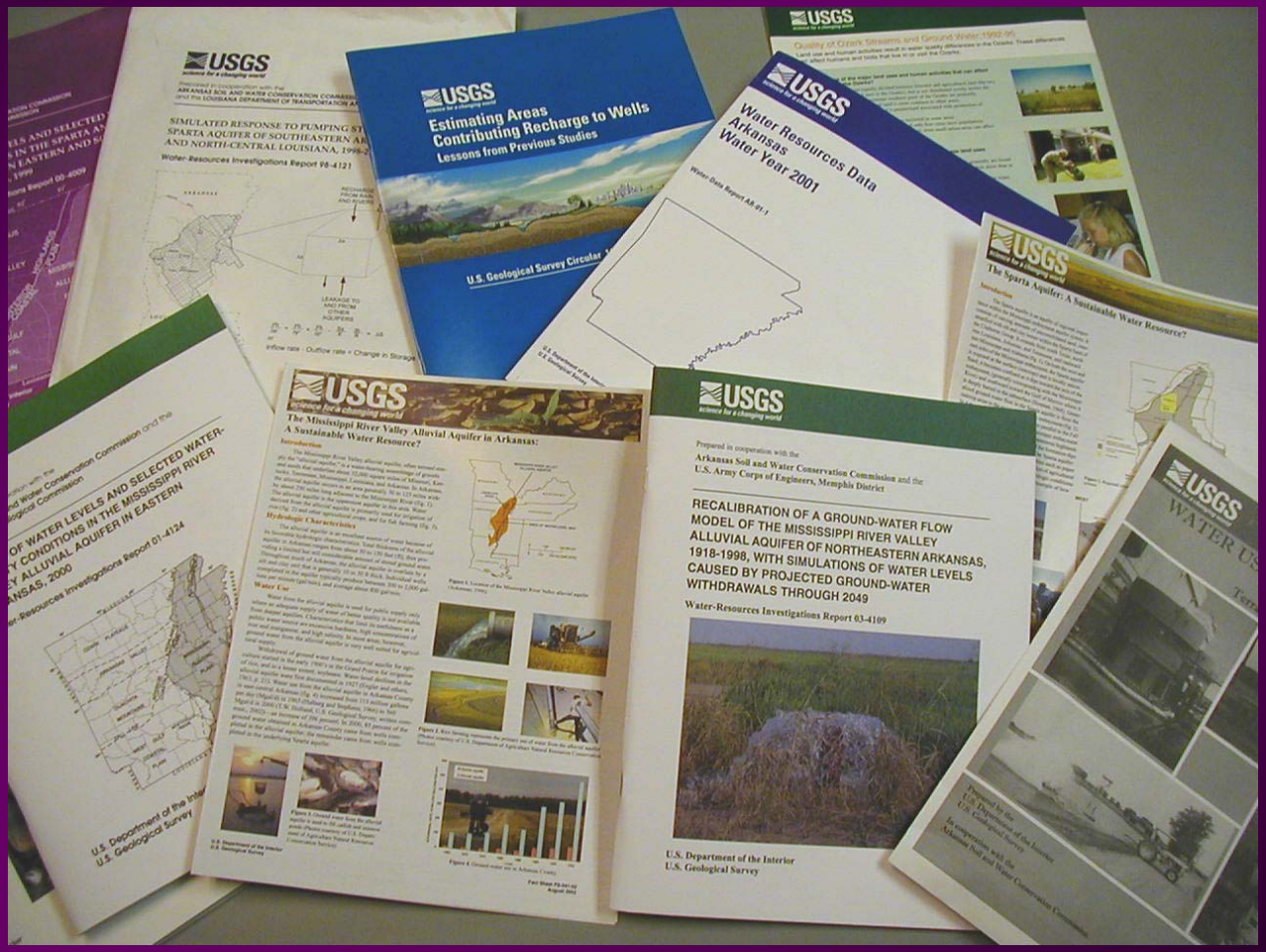
Peer-Reviewed Reports



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USGS
science for a changing world

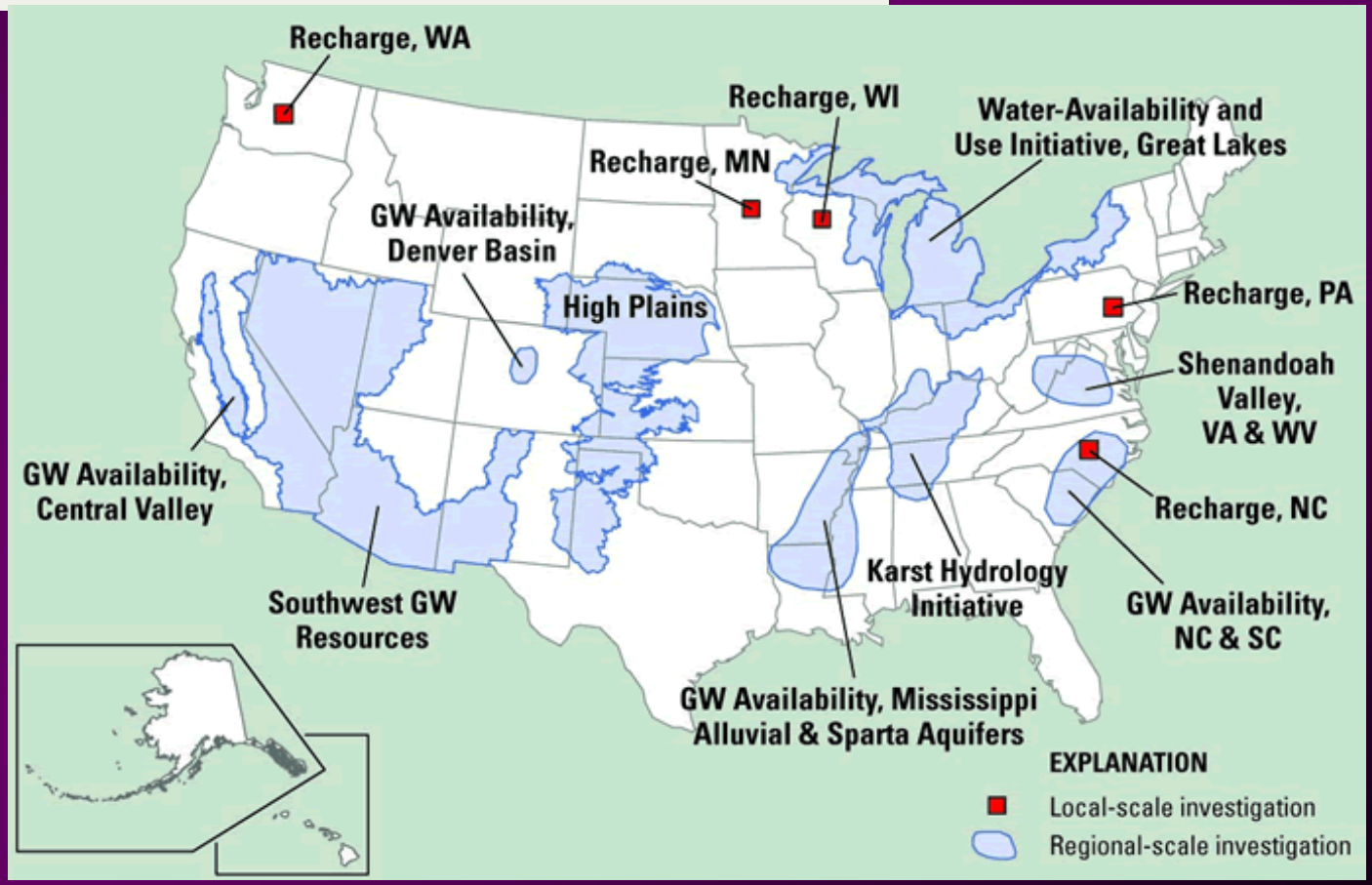
Ground-Water Resources Program (GWRP)

Home

http://water.usgs.gov/ogw/gwrp/

Program Mission

The Ground-Water Resources Program's mission is to provide objective scientific information and develop interdisciplinary understanding necessary to help assure the availability of the Nation's ground-water resources.



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Water for America—
a Water Census

"The United States has a strong need for an ongoing census of water that describes the status of our Nation's water resource at any point in time and identifies trends over time."

National Science and Technology Council report,
"A Strategy for Federal Science and Technology to Support Water Availability and Quality in the United States."

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In the next decade, the Nation will have a new appraisal for water availability. In the FY 2009 Budget, the President has requested funds for an initiative to:

- Conduct a nationwide assessment of water availability
- Proceed with regional-scale studies
- Cooperate with State and local government in selected focused areas
- Cooperate with States to map the geologic framework of aquifers,
- Modernize the Nation's 7,000 streamgages

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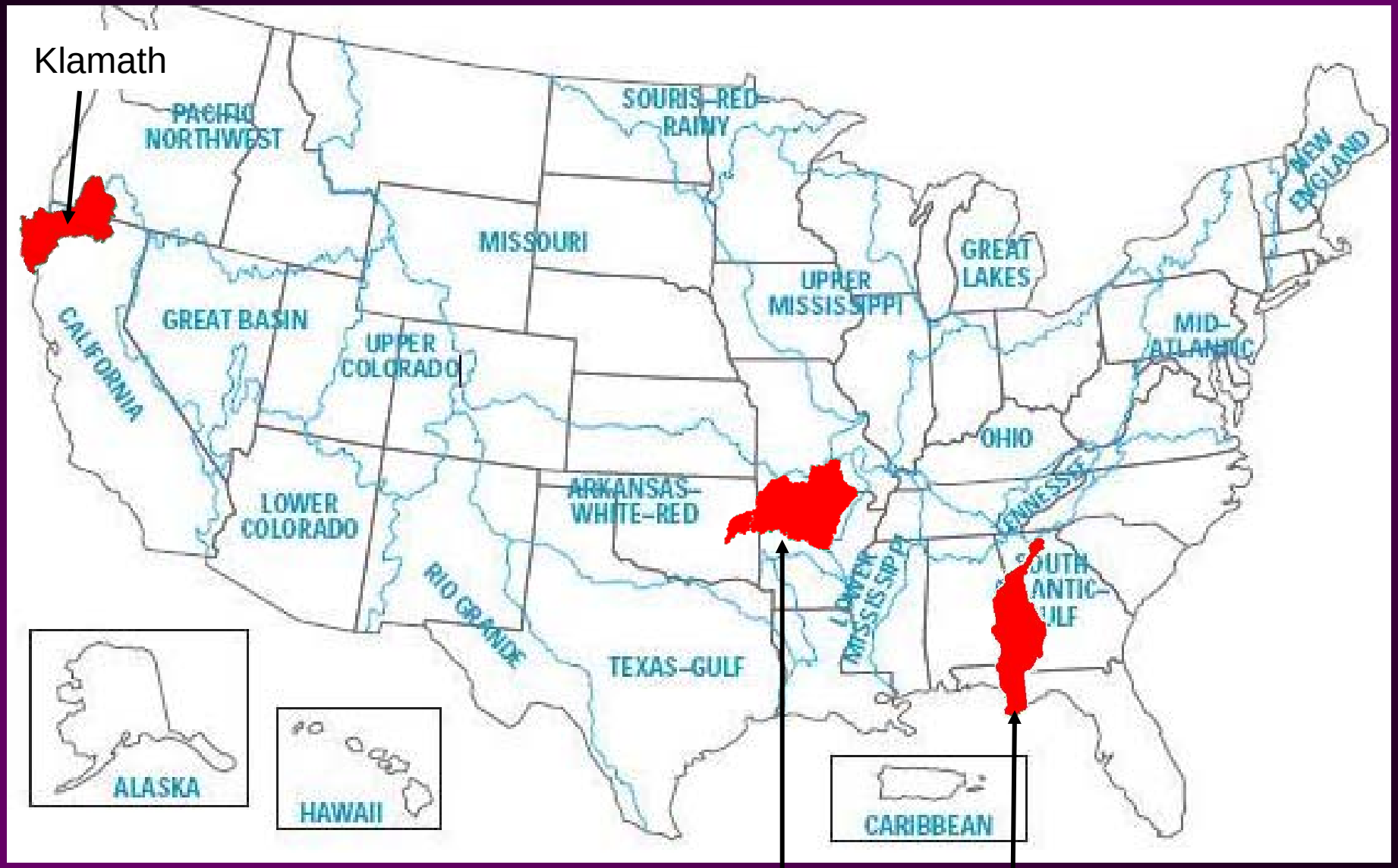
Focus Area Study Candidates



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Regional Ground-Water Models—Key Water Management Tools

Fitzpatrick, D.J., Kilpatrick, J.M., and McWreath, Harry, 1990, Geohydrologic characteristics and simulated response to pumping stresses in the Sparta aquifer in east-central Arkansas: U.S. Geological Survey Water-Resources Investigations Report 88- 4201, 50 p.

McWreath, H.C., III, Nelson, J.D., and Fitzpatrick, D.J., 1991, Simulated response to pumping stresses in the Sparta aquifer, northern Louisiana and southern Arkansas: Louisiana Department of Transportation and Development Water Resources Technical Report No. 51, 51 p.

Kilpatrick, J.M., 1992, Simulated response to future pumping in the Sparta aquifer, Union County, Arkansas: U.S. Geological Survey Water-Resources Investigations Report 91-4161, 25 p.

Hays, P.D., Lovelace, J.K., and Reed, T.B., 1998, Simulated response to pumping stress in the Sparta aquifer of southeastern Arkansas and north-central Louisiana, 1998-2027: U.S. Geological Survey Water-Resources Investigations Report 98-4121, 25 p.

Hays, P.D., 2000,
Sustainable-yield estimation for the Sparta aquifer in Union County, Arkansas, U.S. Geological Survey Water-Resources Investigations Report 99-4274.

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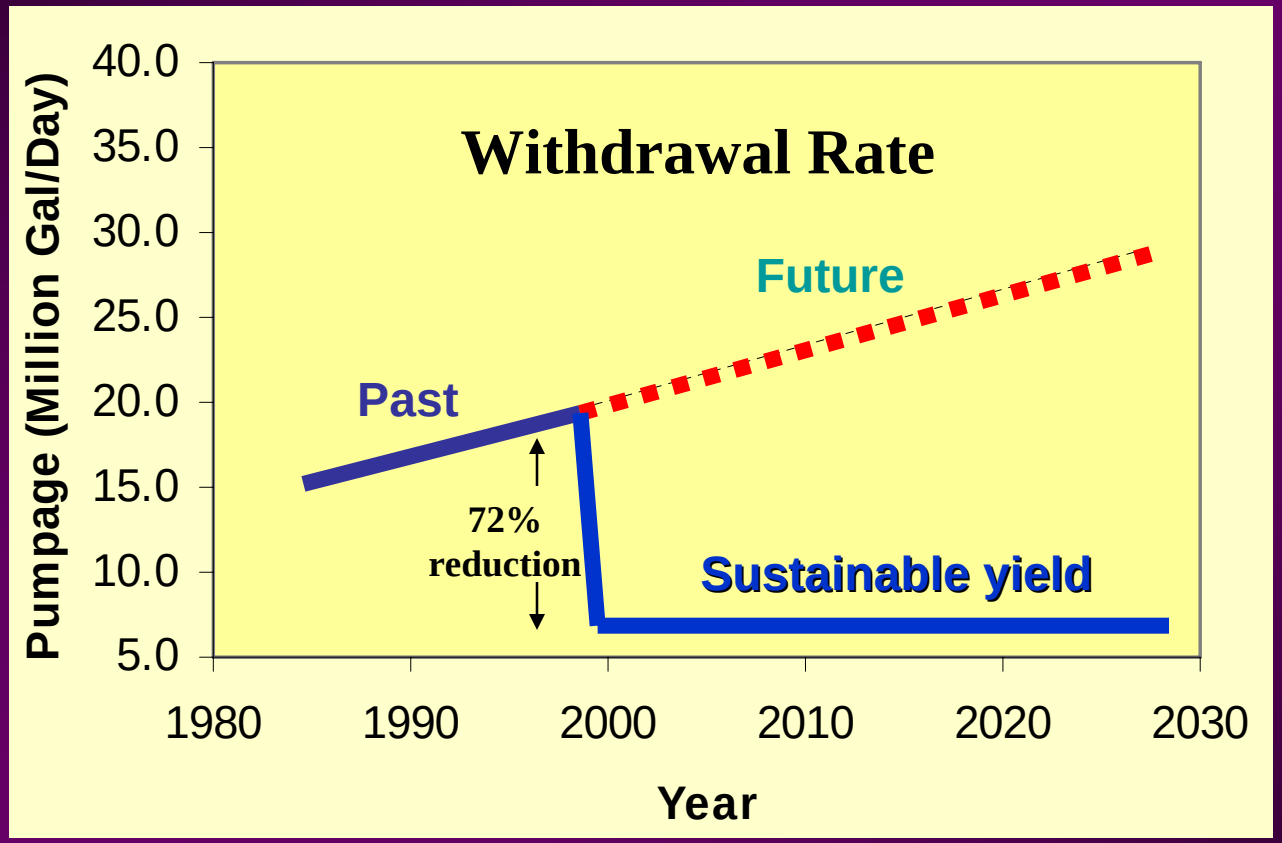
Sparta Aquifer Sustainable Yield Model Results



reduce by 72% of the 1997 withdrawal rate

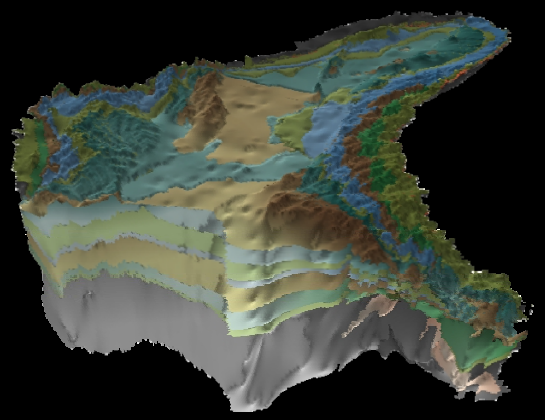
USGS

Conclusions

- Long-term, consistent data needed for understanding ground water and development of effective management approaches and tools
- Multiple partners required to fund data collection
- USGS data are fully available to public via web
- Effective ground-water management unfeasible without reliable data

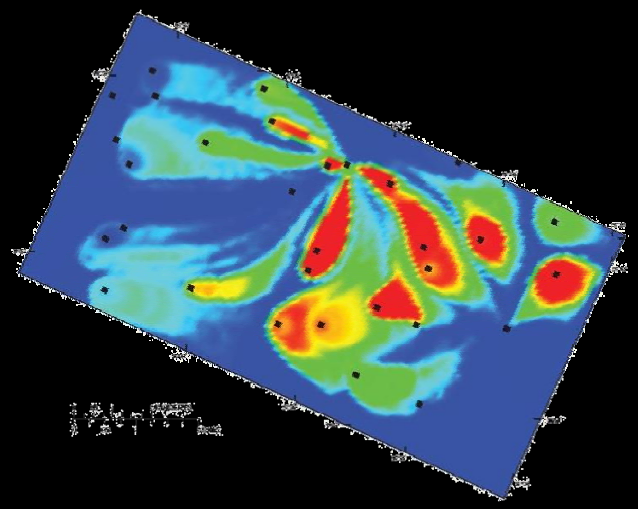
USGS

Systems modeling:
Case studies



Mississippi Embayment Regional Aquifer Study (MERAS)

Transport of Anthropogenic and Natural Contaminants (TANC)



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Mississippi Embayment Regional Aquifer Study (MERAS)

-Designed to address ground-water availability questions at a regional level and provide boundaries for local scale models

-Major component of study – hydrogeologic framework interpretation and archive

-Data driven

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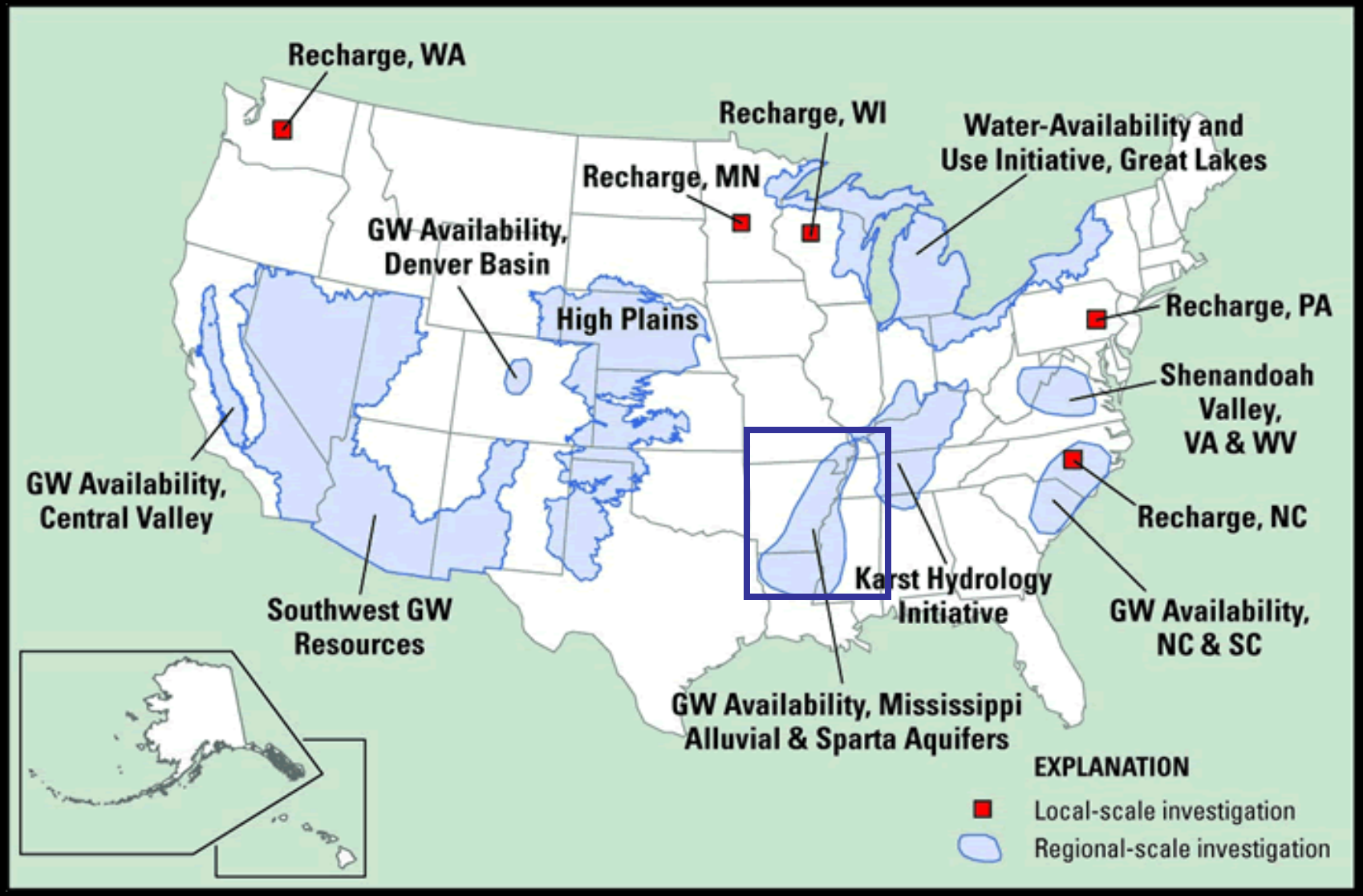
The big picture



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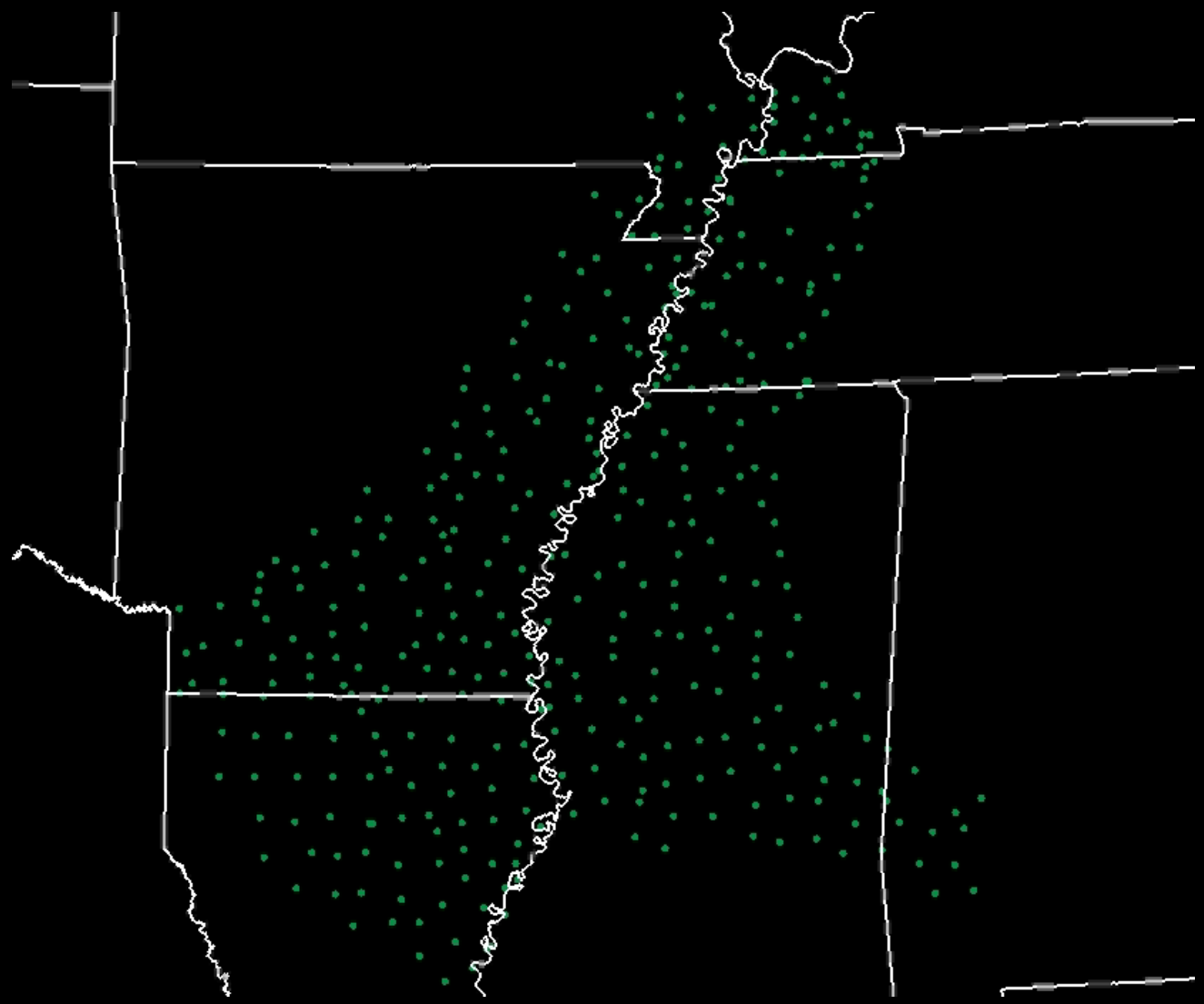
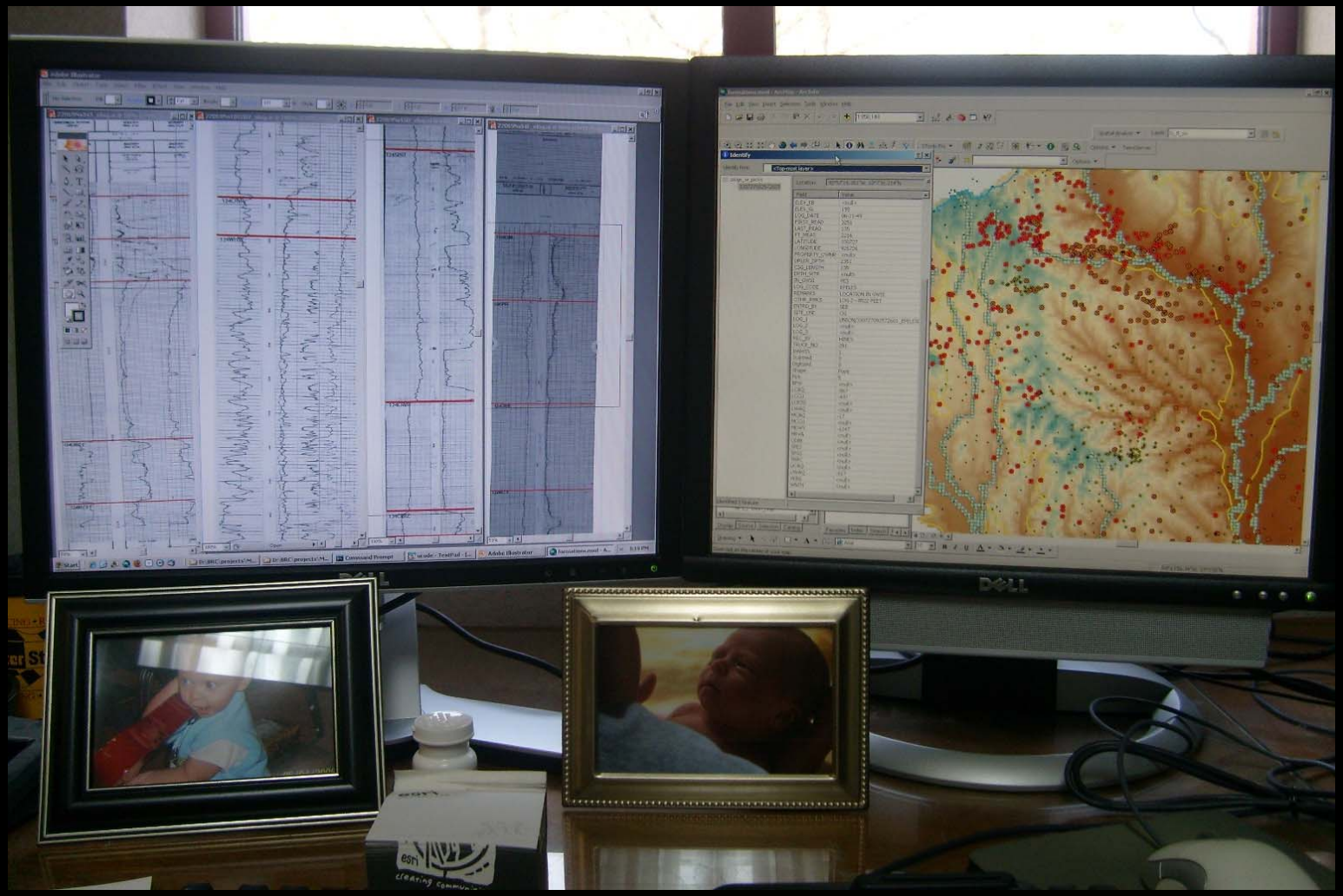
http://water.usgs.gov/ogw/gwrp

Model components

-framework
-water use
-aquifer properties
-observations (streamflow, ground water levels)
-recharge



Framework



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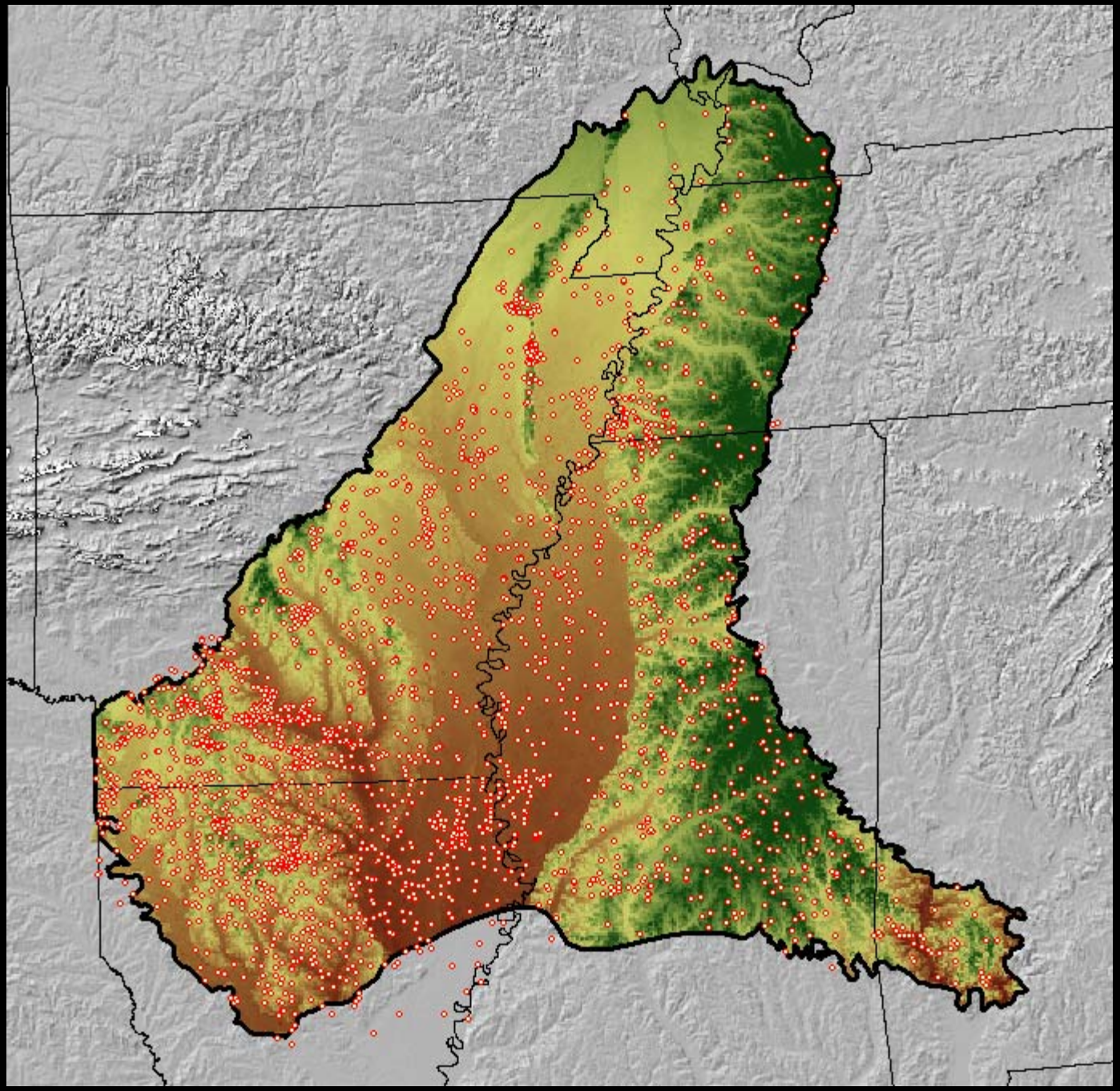
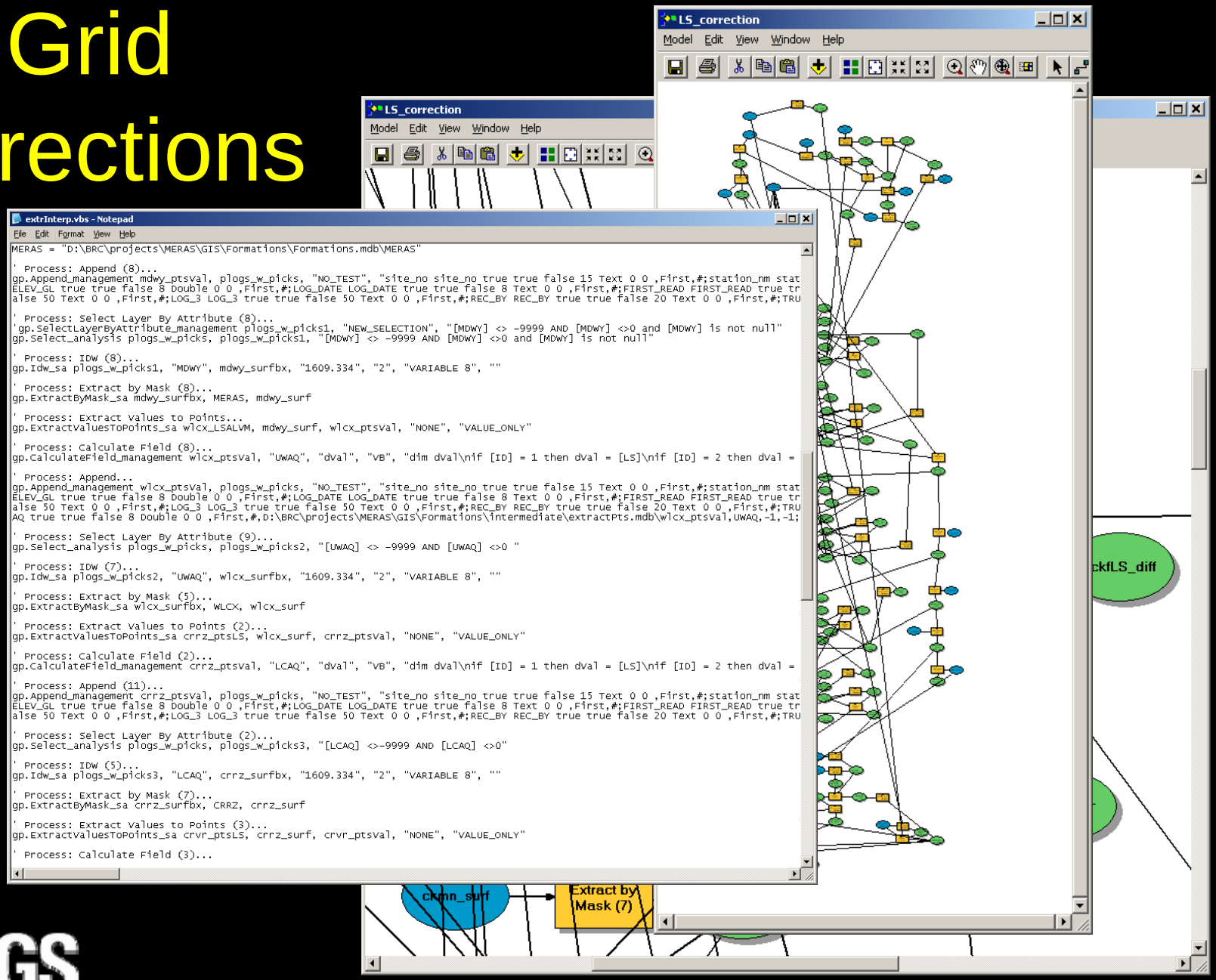
Framework

- 2,700 Geophysical logs
- Interpretive picks
- Digital images



Grid corrections



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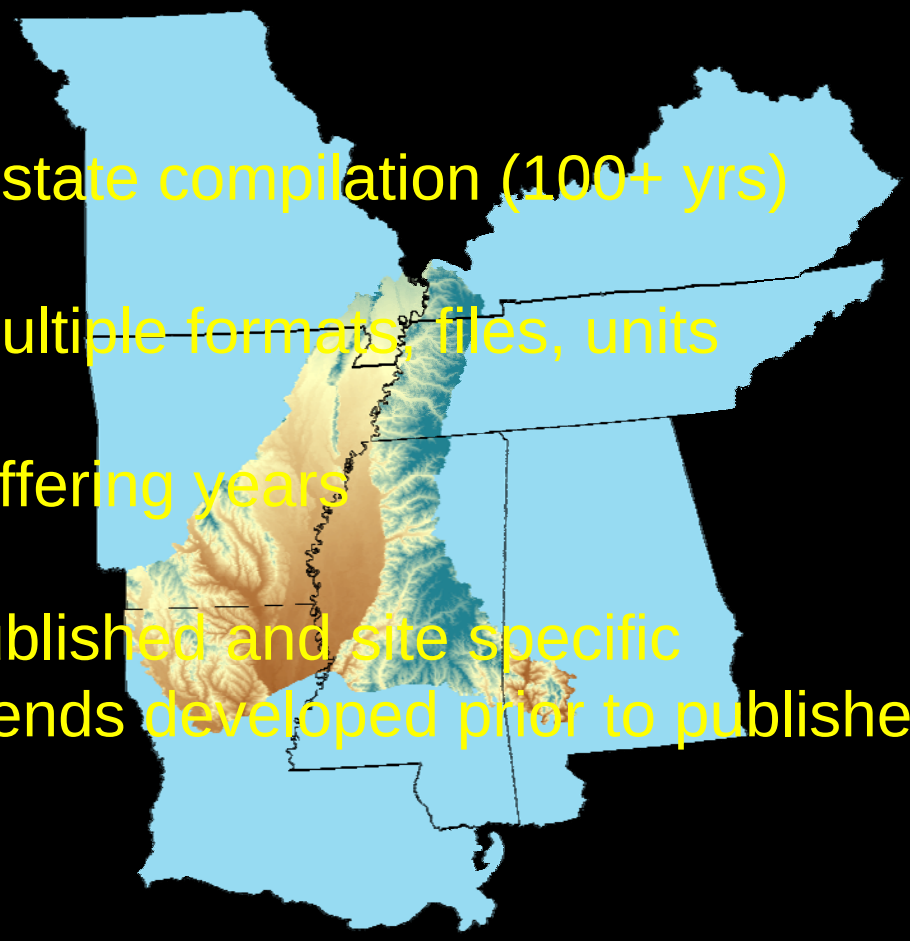
Water use in the embayment

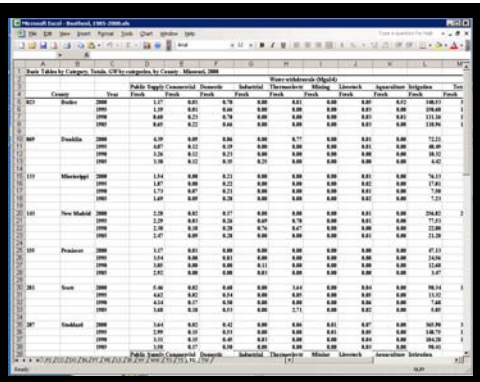


-7 state compilation (100+ yrs)

-multiple formats, files, units

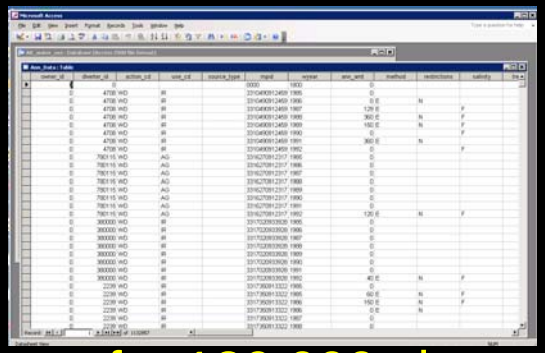
-differing years

Published and site specific
(trends developed prior to published)

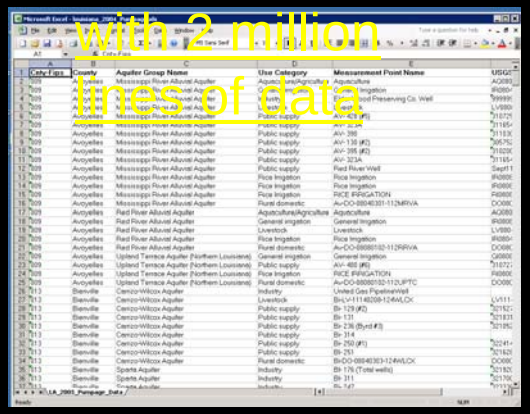


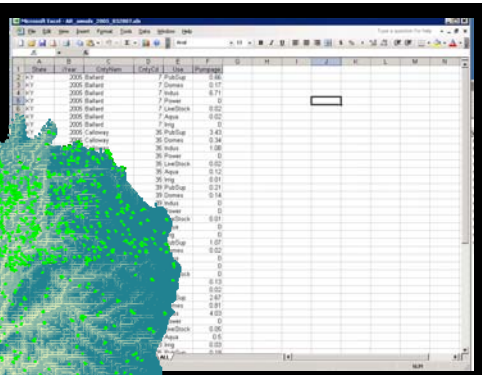
Logic process regarding
-missing well depths
-missing aquifer co
-confining units
-multi-layers
-drawdown co

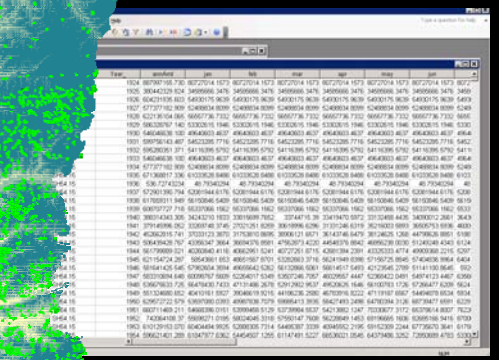
>2,000 line
To combin

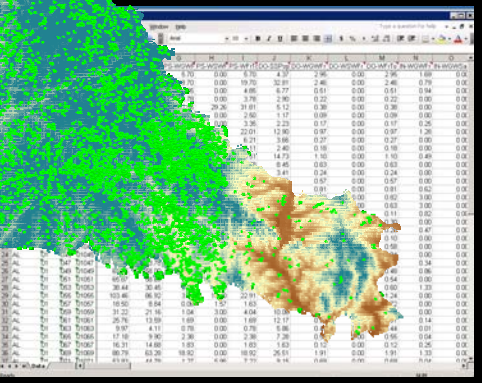


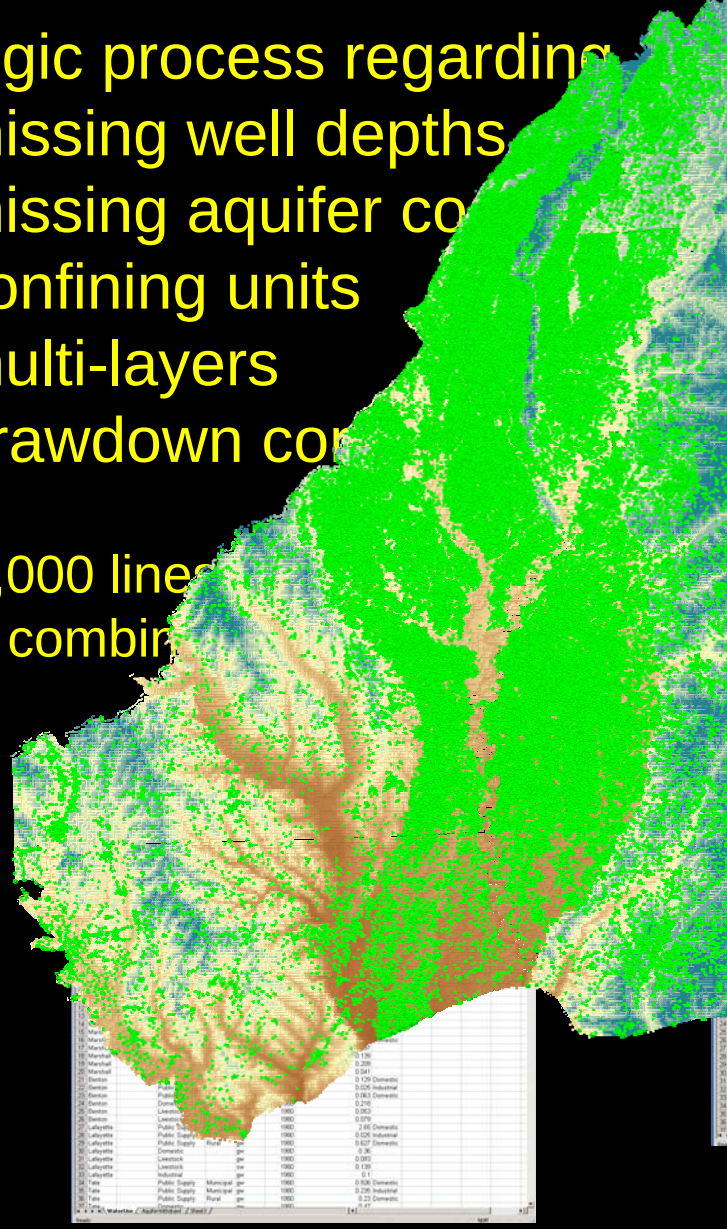
for 130,000 sites
with 2 million
lines of data











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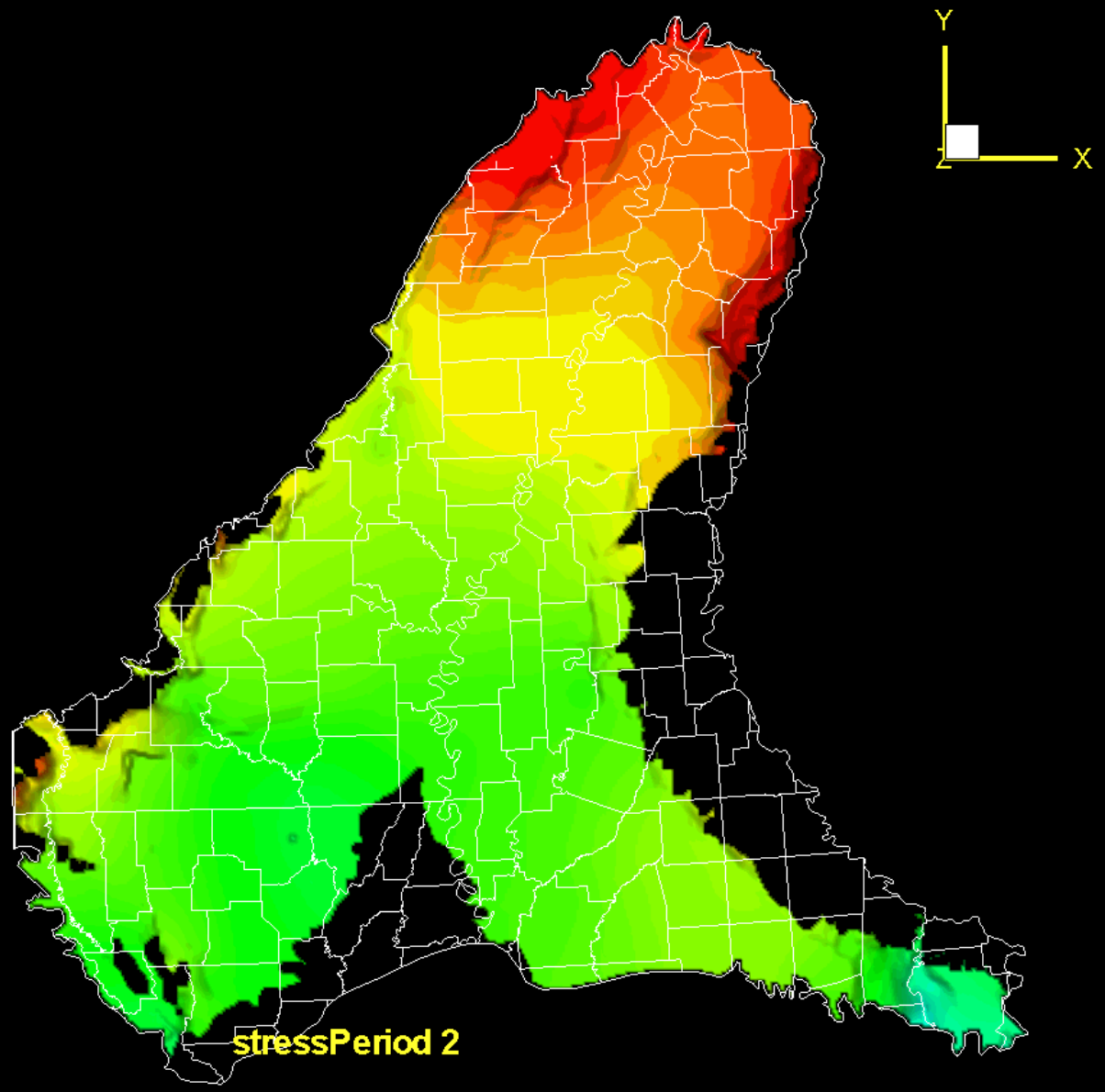
Layer 7 (Sparta/ Memphis)



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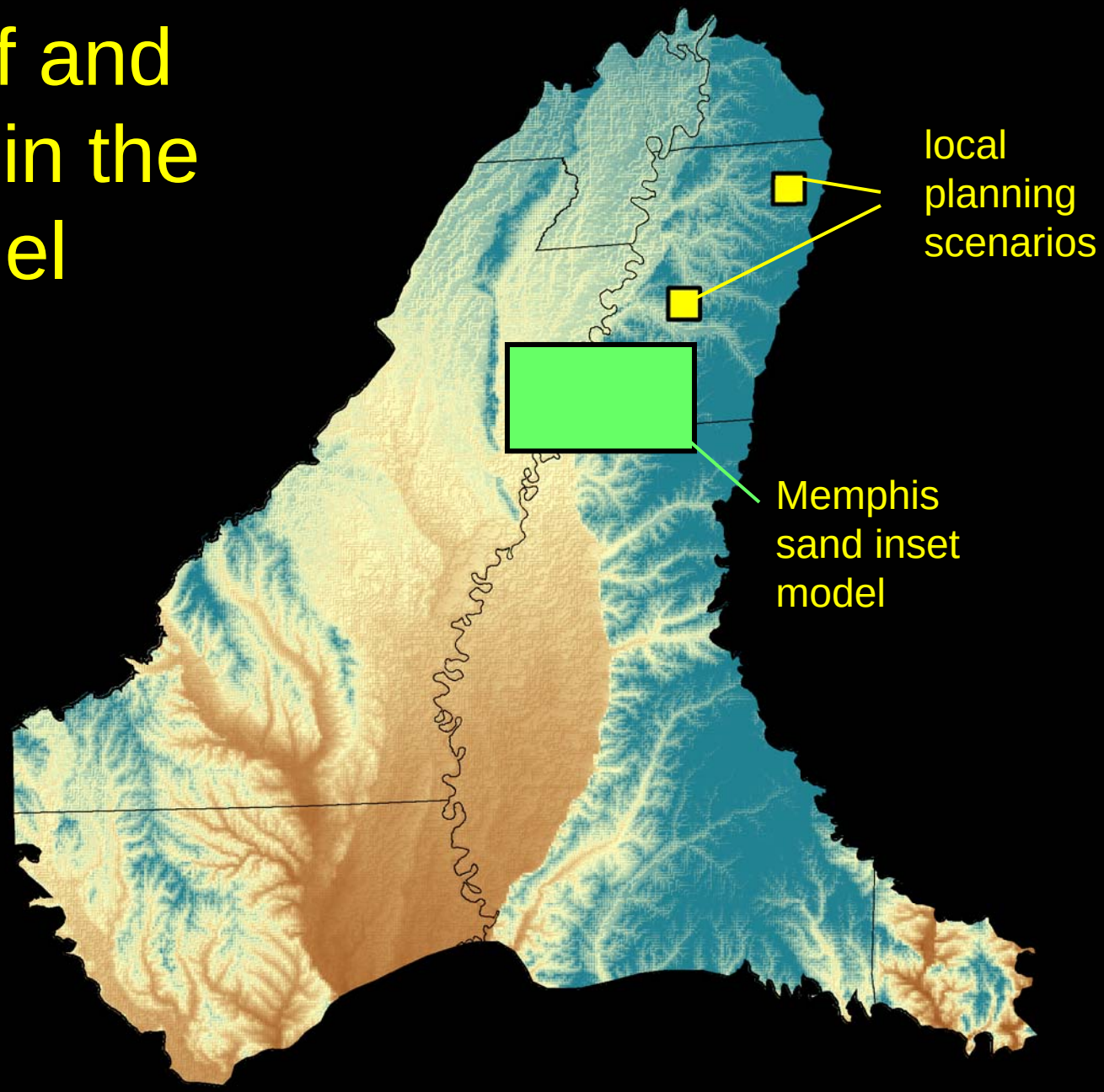
Uses of and interest in the model



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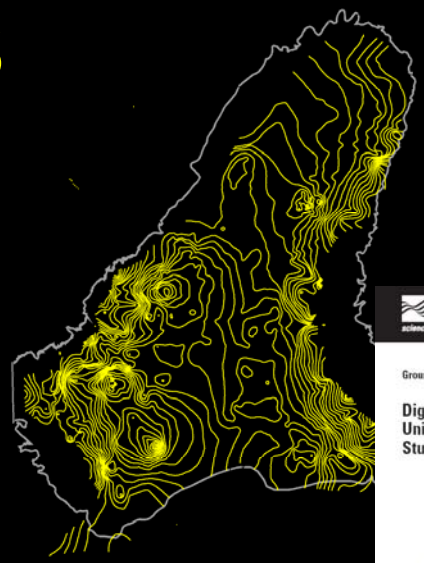
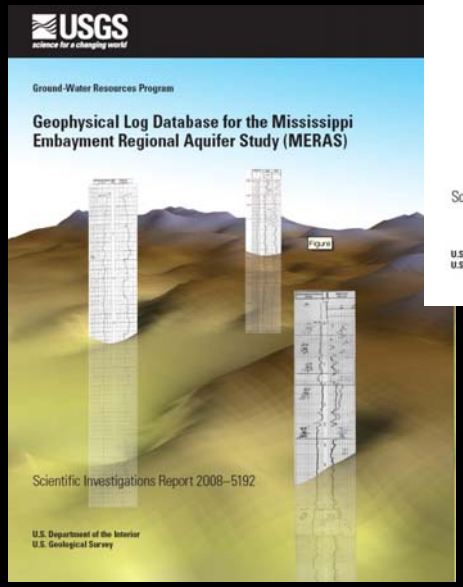
Current products

Sparta/Memphis 07’ water level map



Framework SIR

Geophysical logs online



Online framework

http://ar.water.usgs.gov/meras

MERAS Take-Home Messages

- High value of common dataset structure
- Visualization of data important to stakeholders
- Regional model to answer regional questions, and useful for local-scale studies

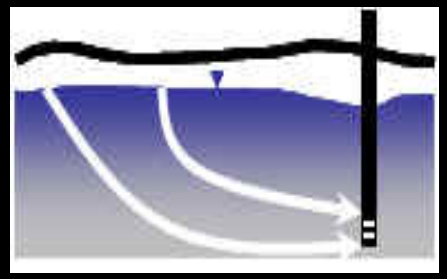
USGS

Study Background

USGS National Water-Quality Assessment (NAWQA) program

NAWQA topical study: Transport of Anthropogenic and Natural Contaminants (TANC) to public supply wells

TANC goal: determine controls on movement of contaminants to public supply wells



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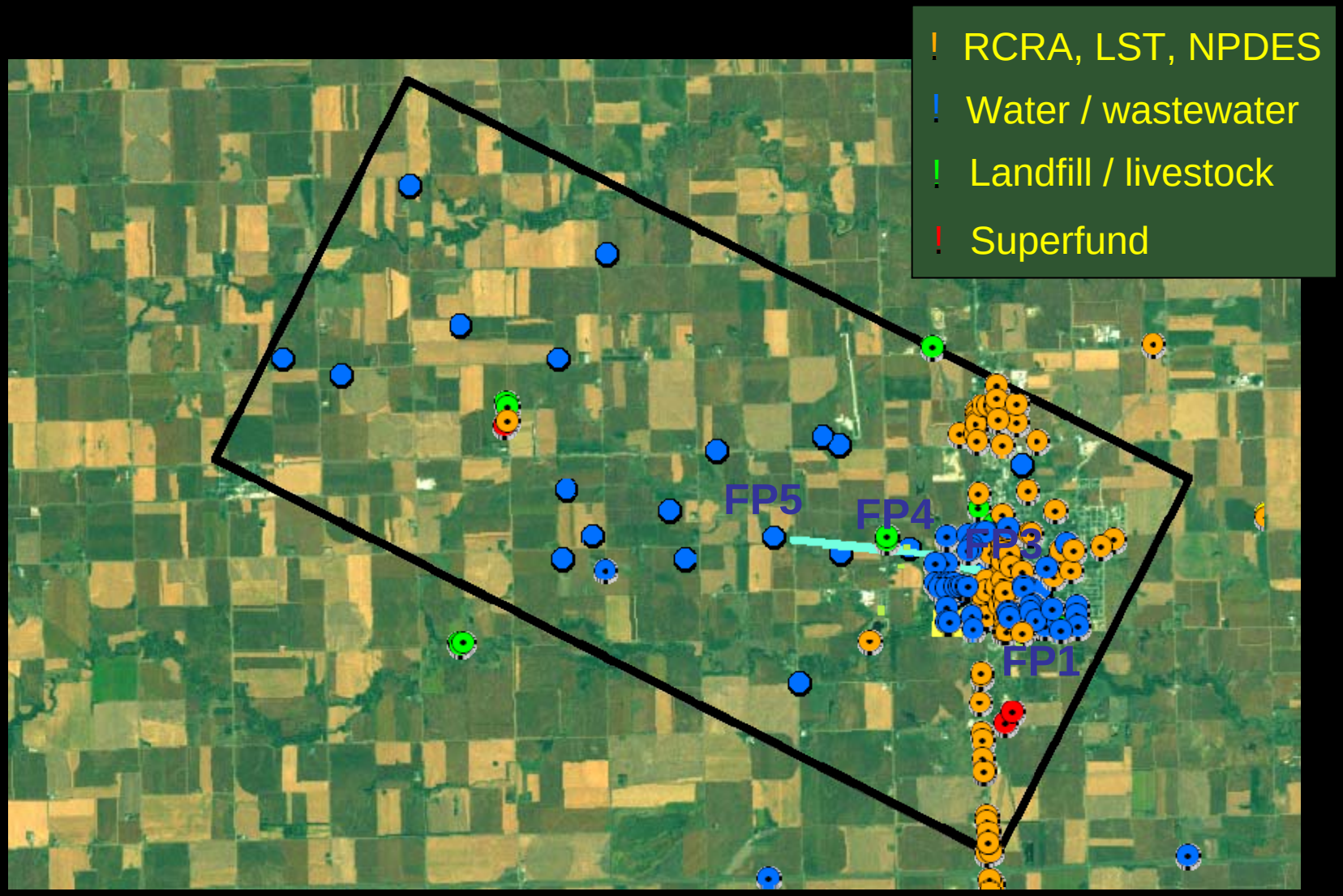
©2005 Google
Pointer 0°00'00.00" N 0°00'00.00" E
Streaming |||||||||| 100%
Eye alt 5142.45 mi
USGS

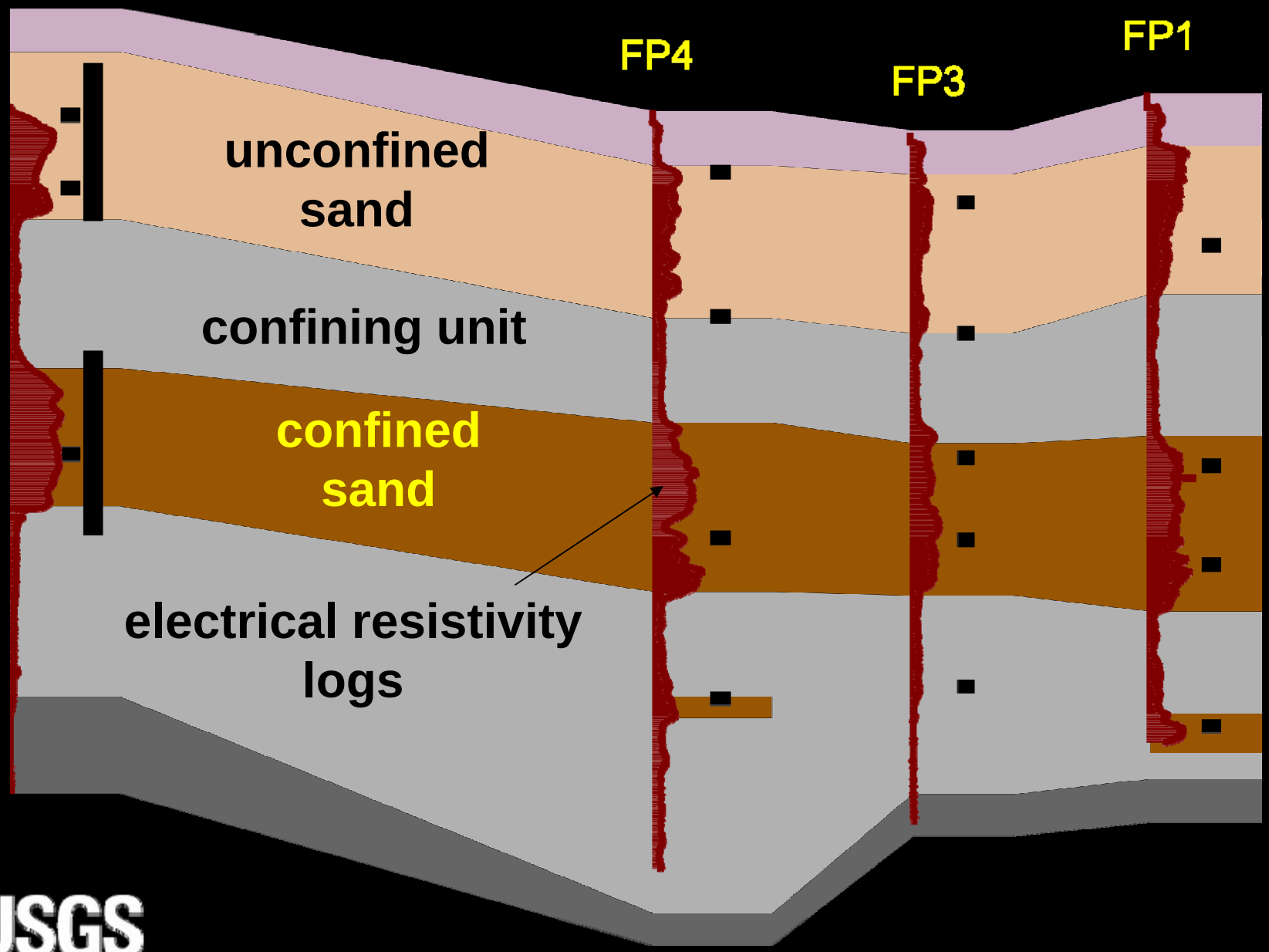


Observation wells

Plans to contain sources

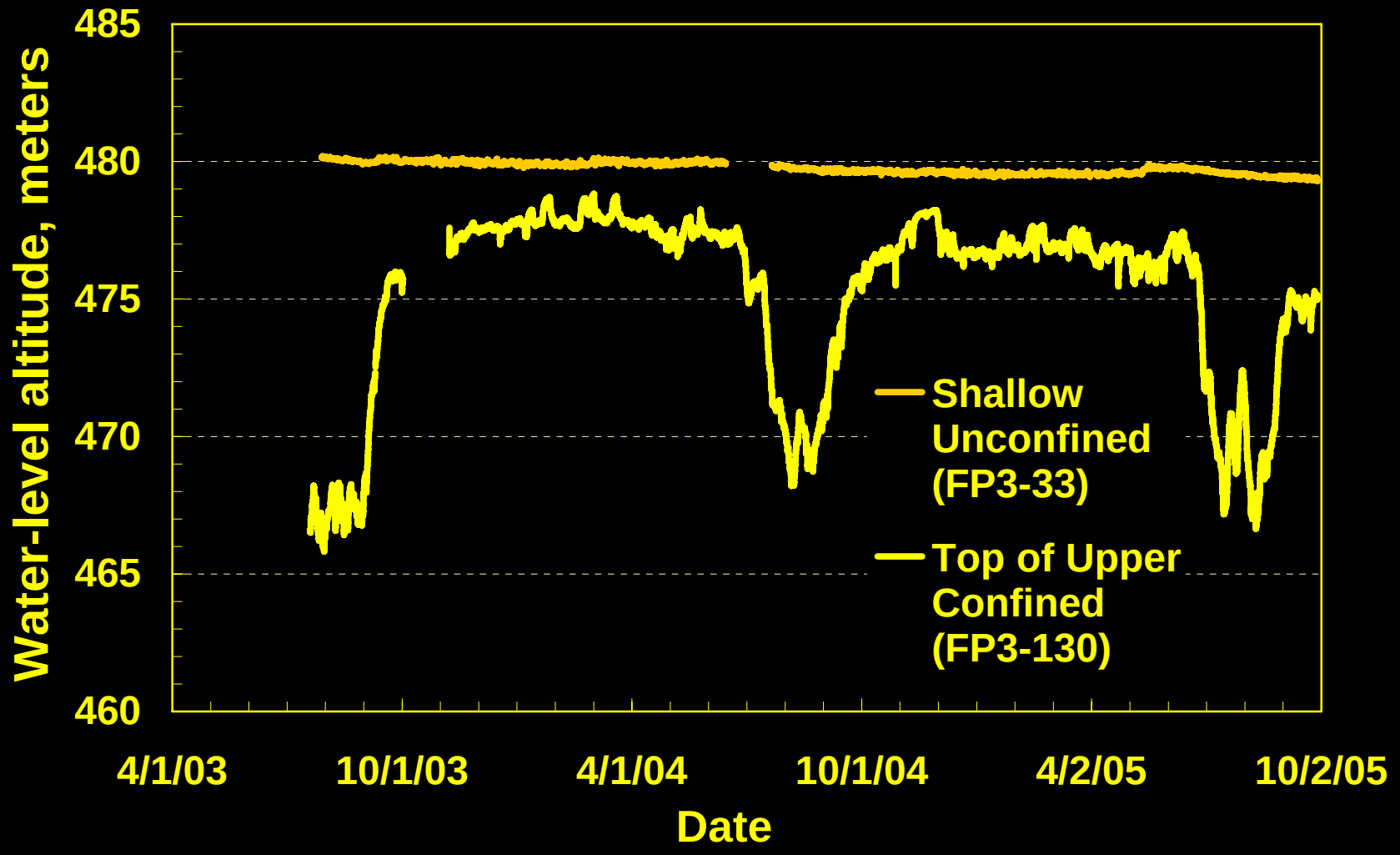
USGS

Hydrogeology



USGS

Confined and unconfined water-levels



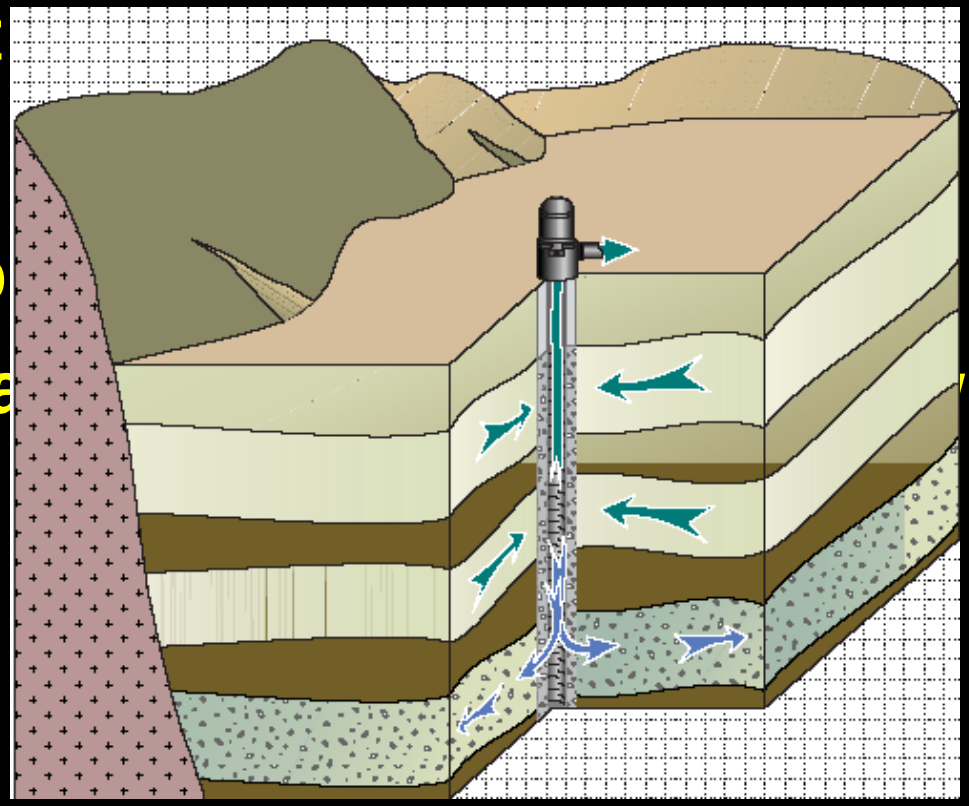
•many wells are commonly screened in unconfined and confined layers

USGS

Transient stresses

•Multi-node wells allow flow through wellbores

- Simulation time
  - Sept
- Seaso
  - Irriga winter

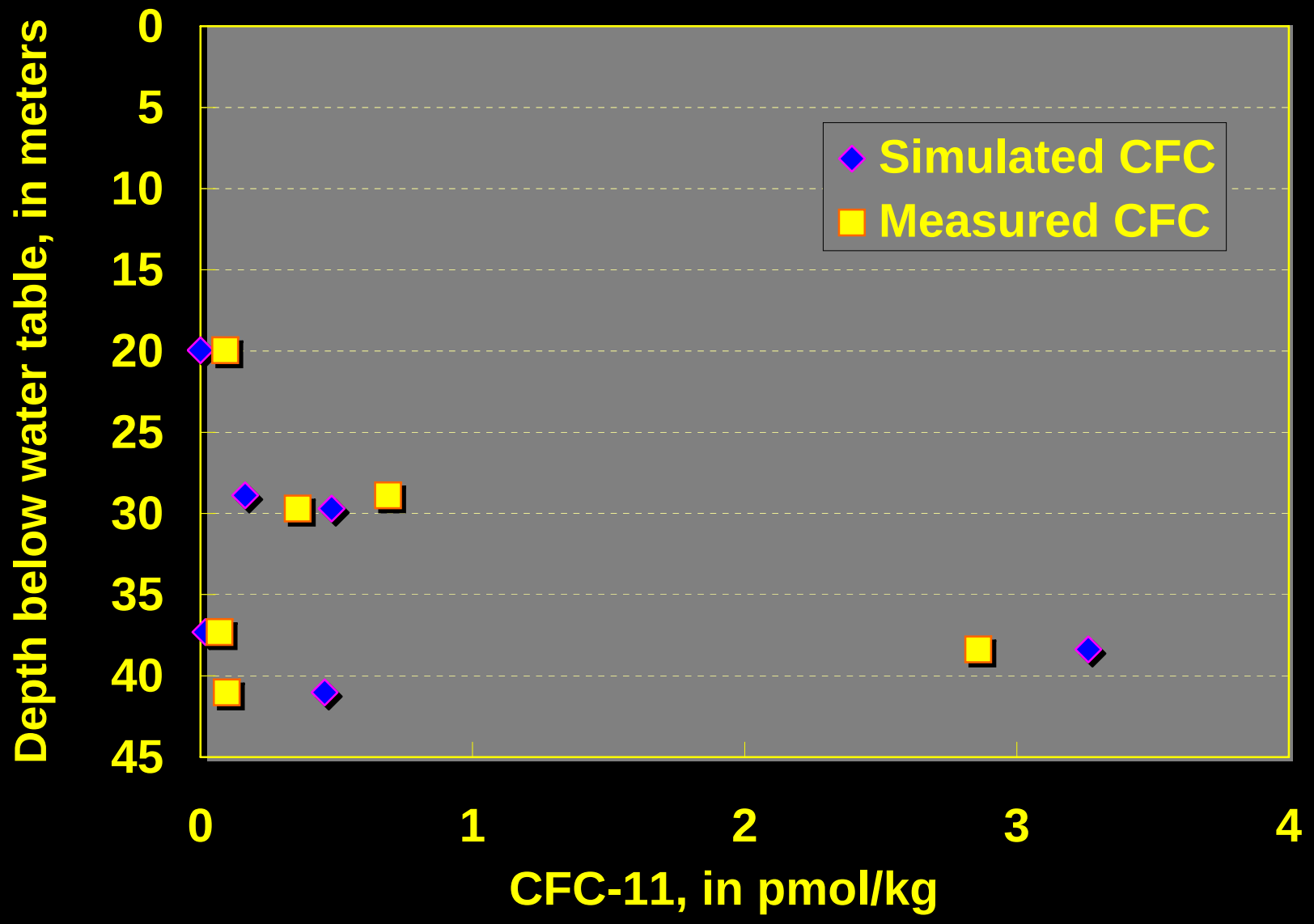


Halford, K.J. and Hanson, R.T., 2002

Age of water vs depth below water table

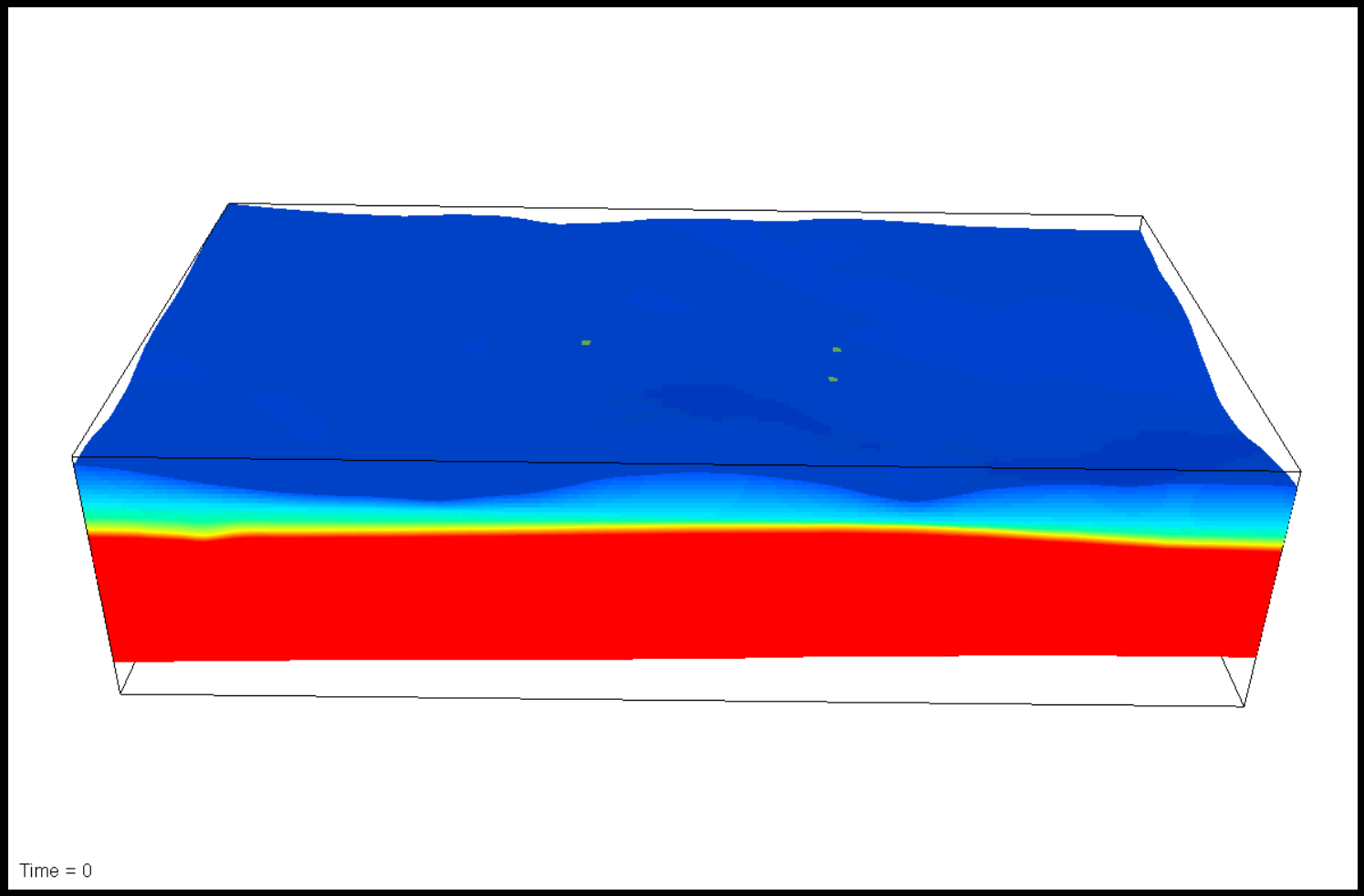
USGS (measured= tritium-helium ages) (unconfined wells only)

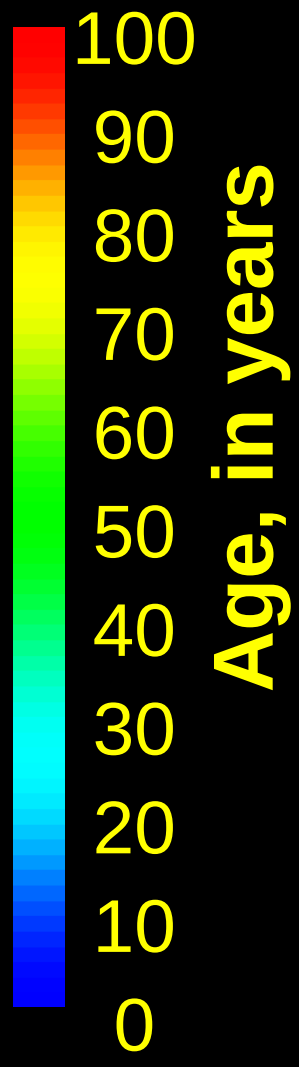
CFC concentration vs depth below water table



(confined wells only)

Simulated age animation

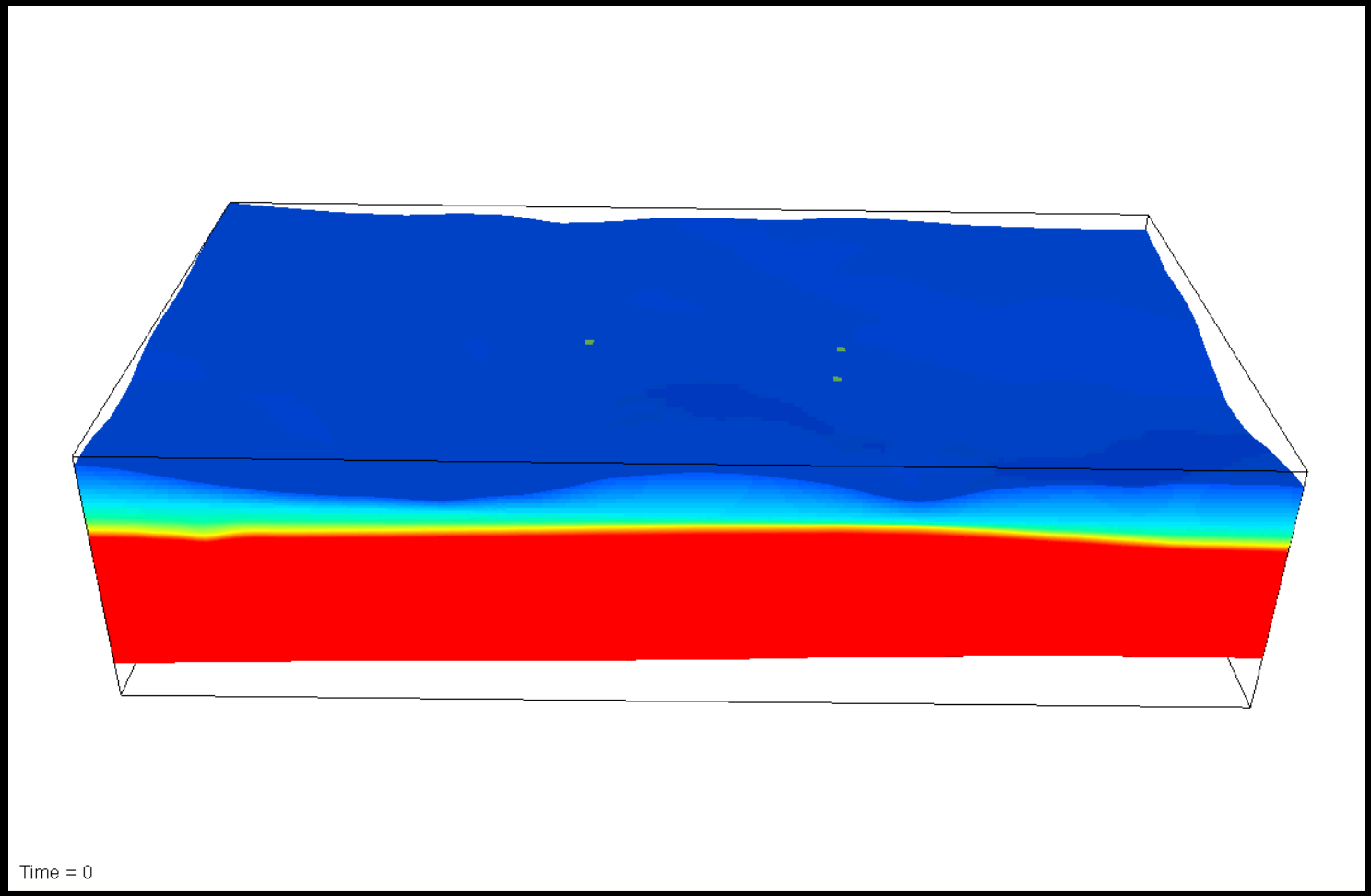


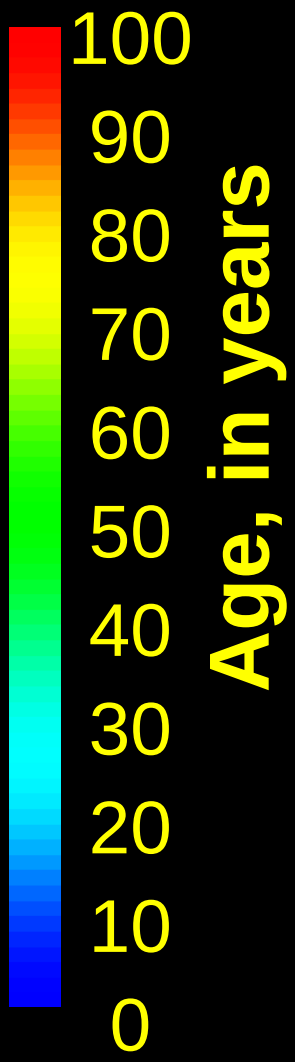


USGS

Cross-sectional view

Simulated age animation





Map view cutaway

TANC Take-Home Messages

- Wellbores drilled through confining units can act as “short circuits”
- Models are able to simulate well-bore flow
- Applicability to other areas – useful tool for water managers

USGS

Using Conjunctive-Use Optimization Strategies to Address Societal Needs for Resource Sustainability

John Czarnecki

U.S. Geological Survey
Arkansas Water Science Center

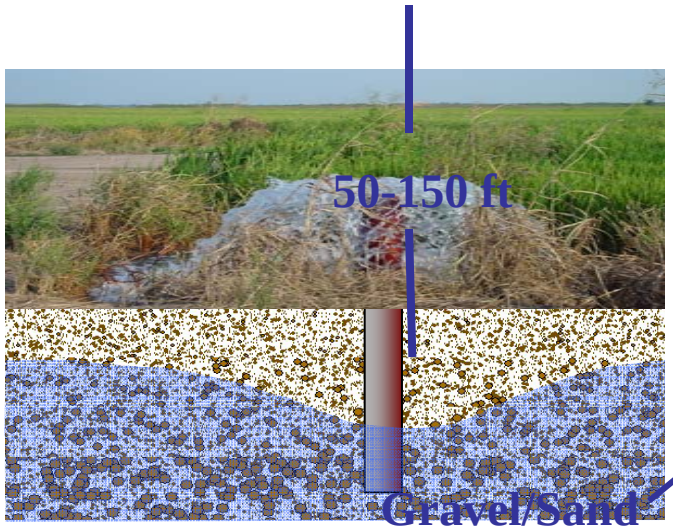
USGS
science for a changing world

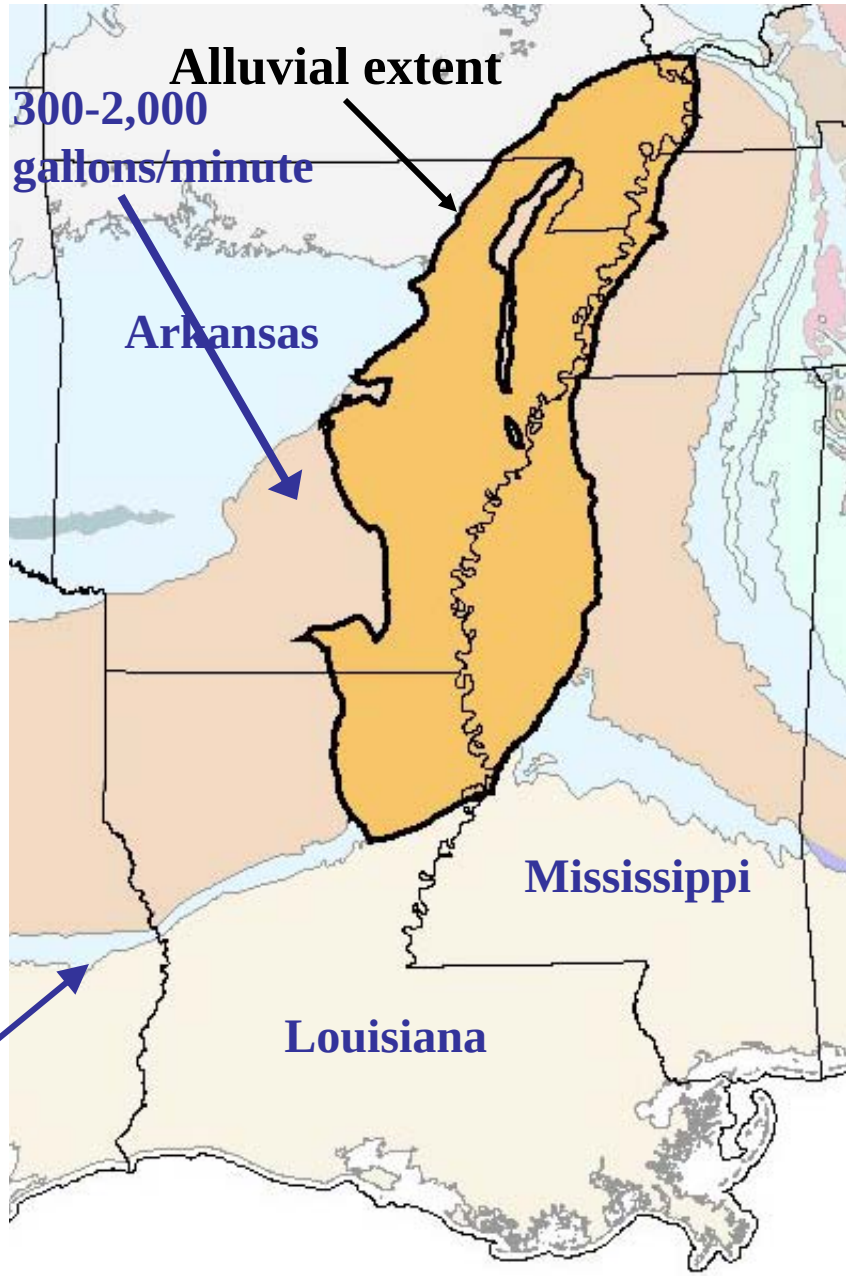
Topics

- Alluvial aquifer in Arkansas
- Water use
- Flow models
- Artificial recharge utilizing constructed wetlands

Alluvial Aquifer

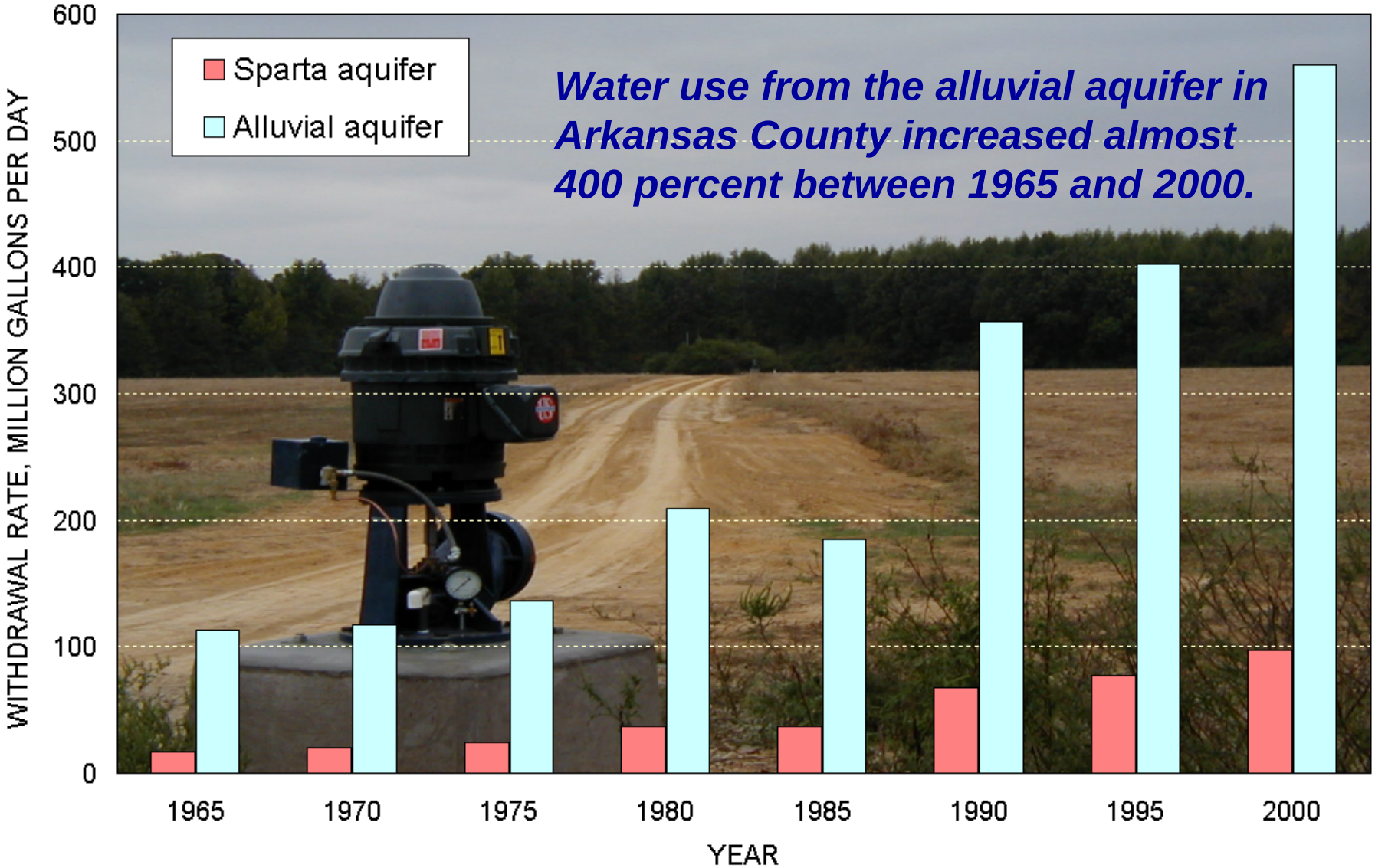
- Agriculture / Irrigation
- Shallow system
- 850 water-level monitor wells (State/USGS cooperative)

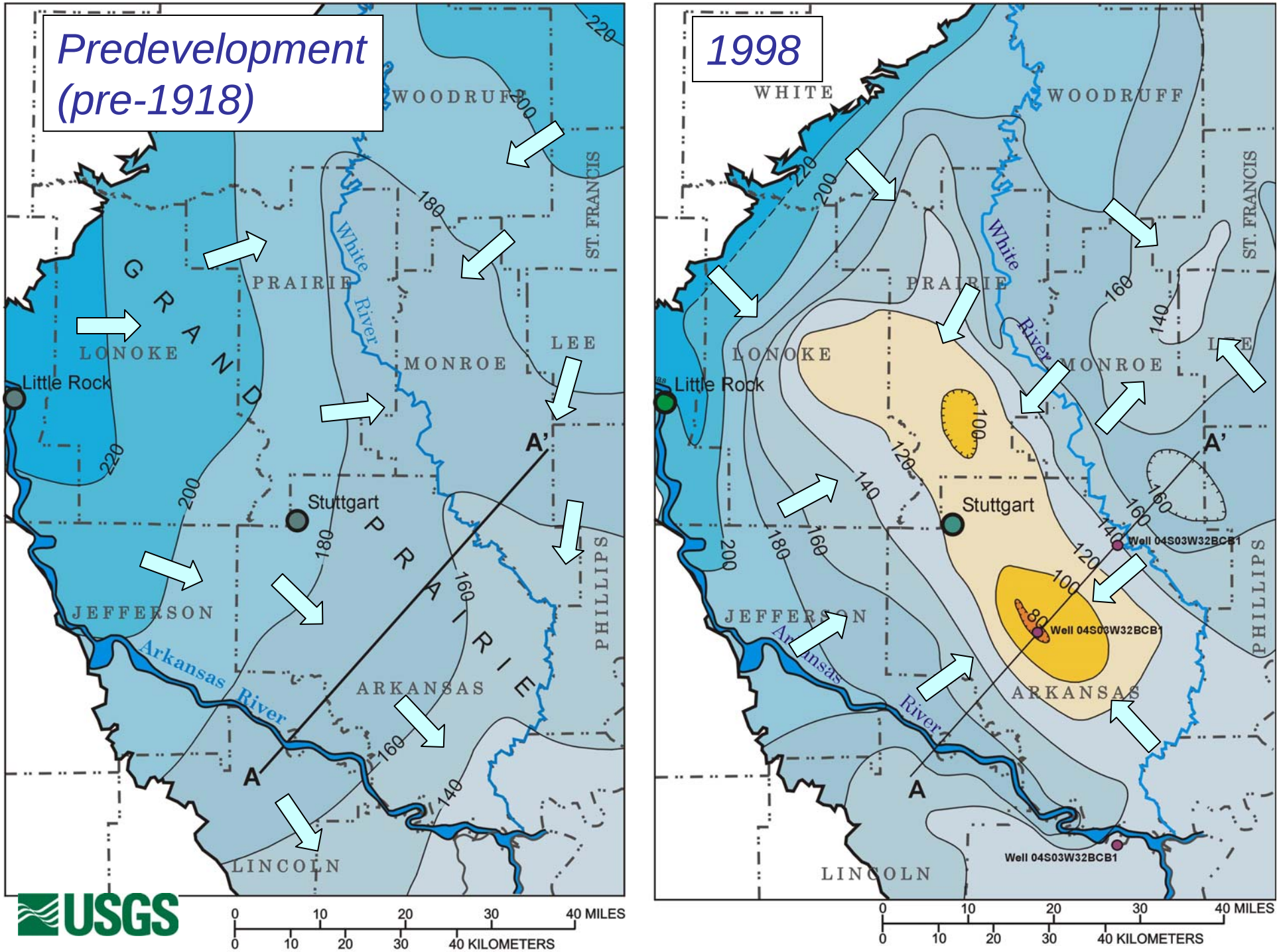




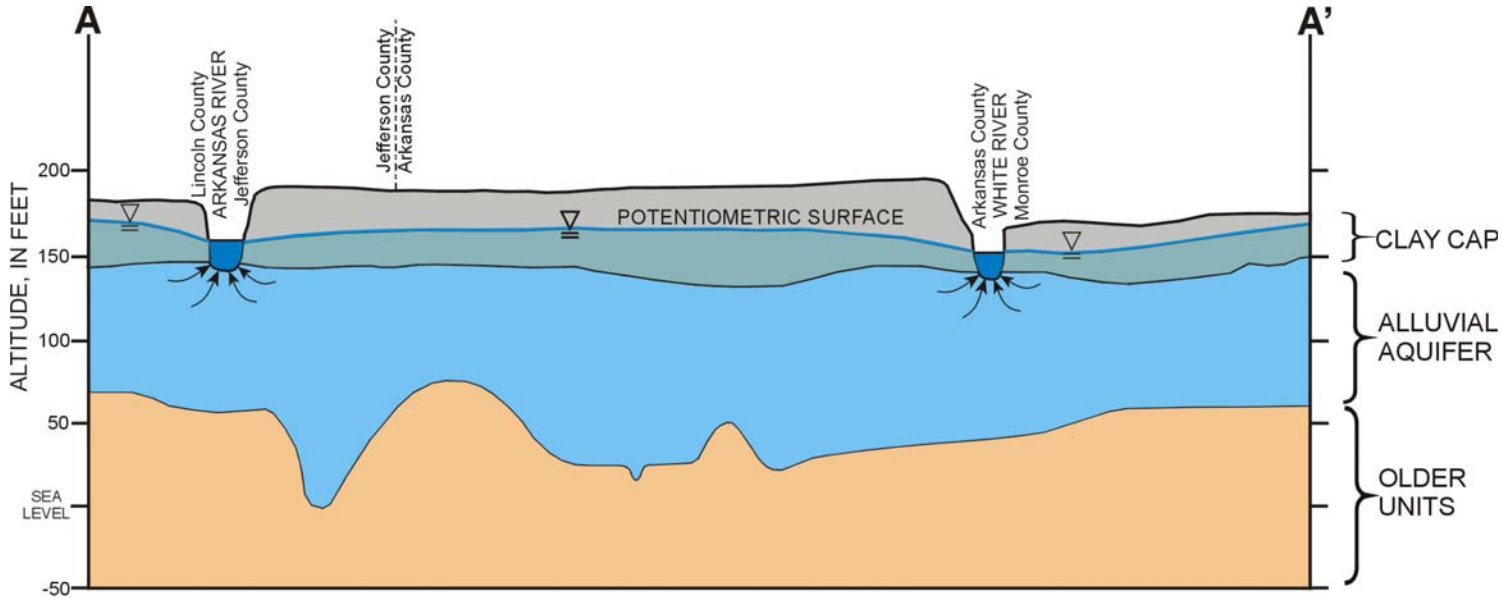
USGS

Ground-water use in Arkansas County

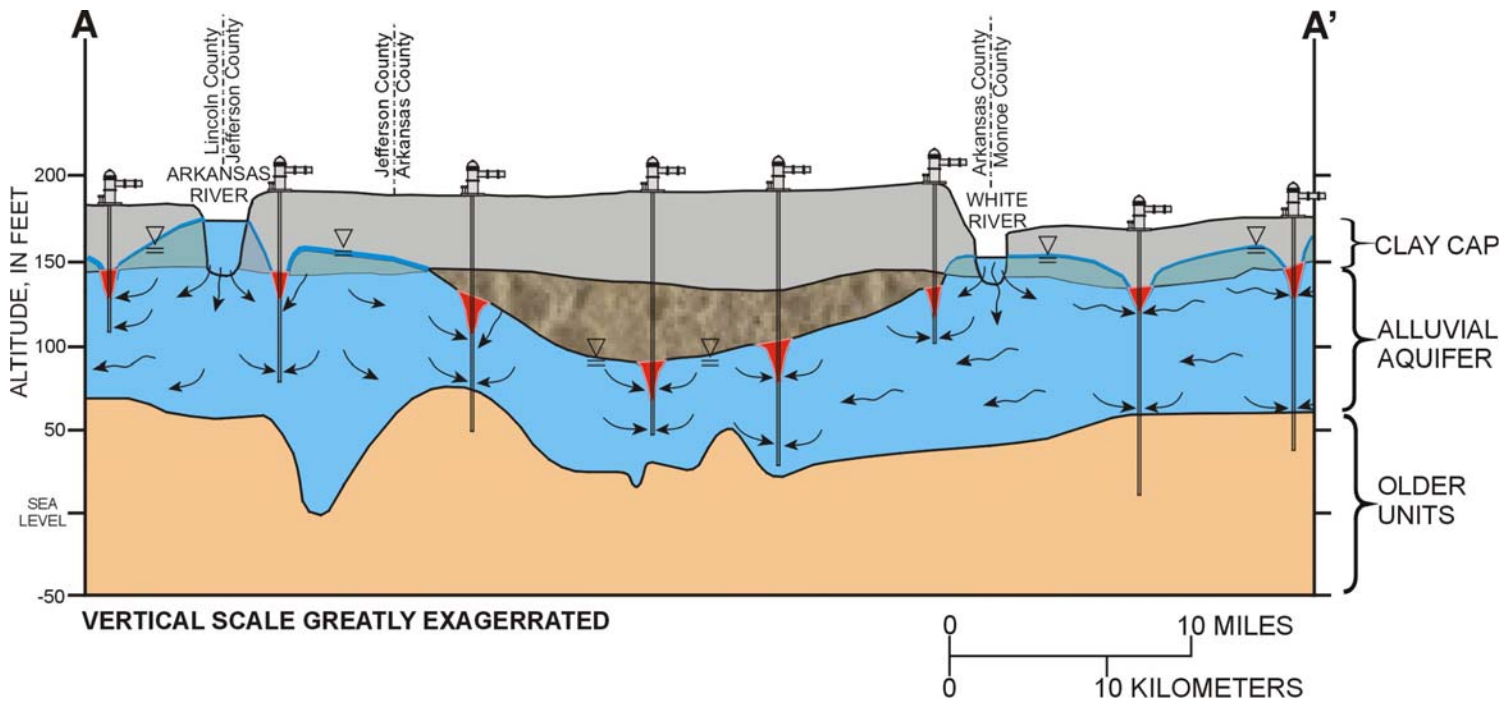



Predevelopment
(pre-1918)
1998
WOODRUFF
WHITE
ST. FRANCIS
PRAIRIE
LONOKE
MONROE
LEE
GRAND PRAIRIE
White River
Little Rock
Stuttgart
JEFFERSON
ARKANSAS
PHILLIPS
LINCOLN
Arkansas River
A
A'
Well 04S03W32BCB1
0 10 20 30 40 MILES
0 10 20 30 40 KILOMETERS
USGS

Predevelopment

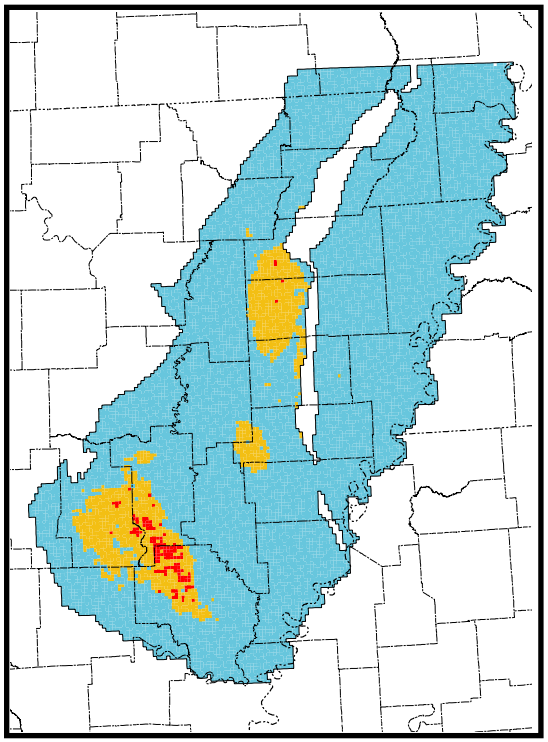


1998



What happens if pumping continues at 1997 rates?

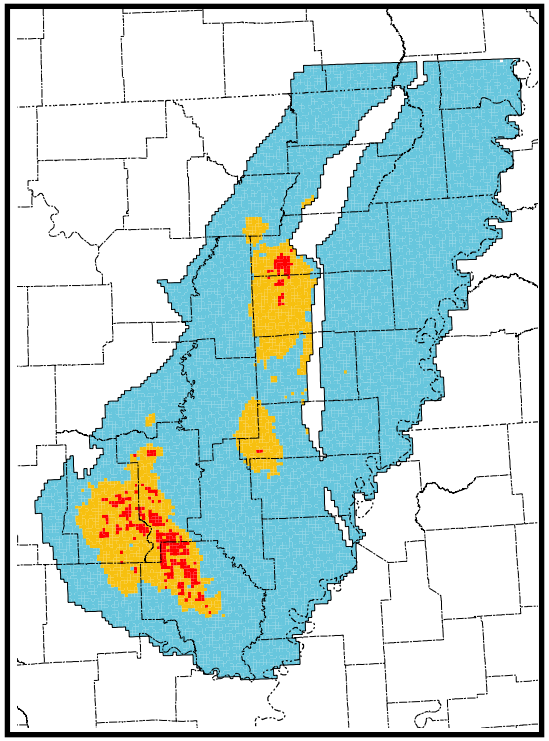
2009



118 dry cells

1,481 cells half depleted

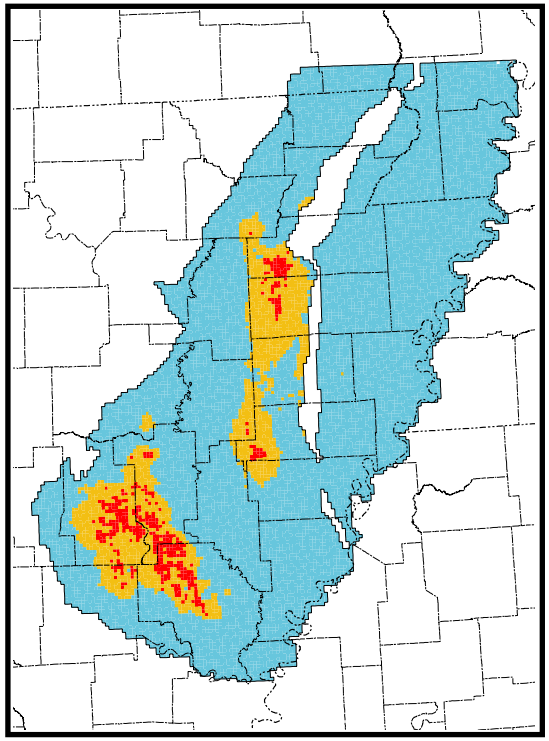
2029



273 dry cells

1,971 cells half depleted

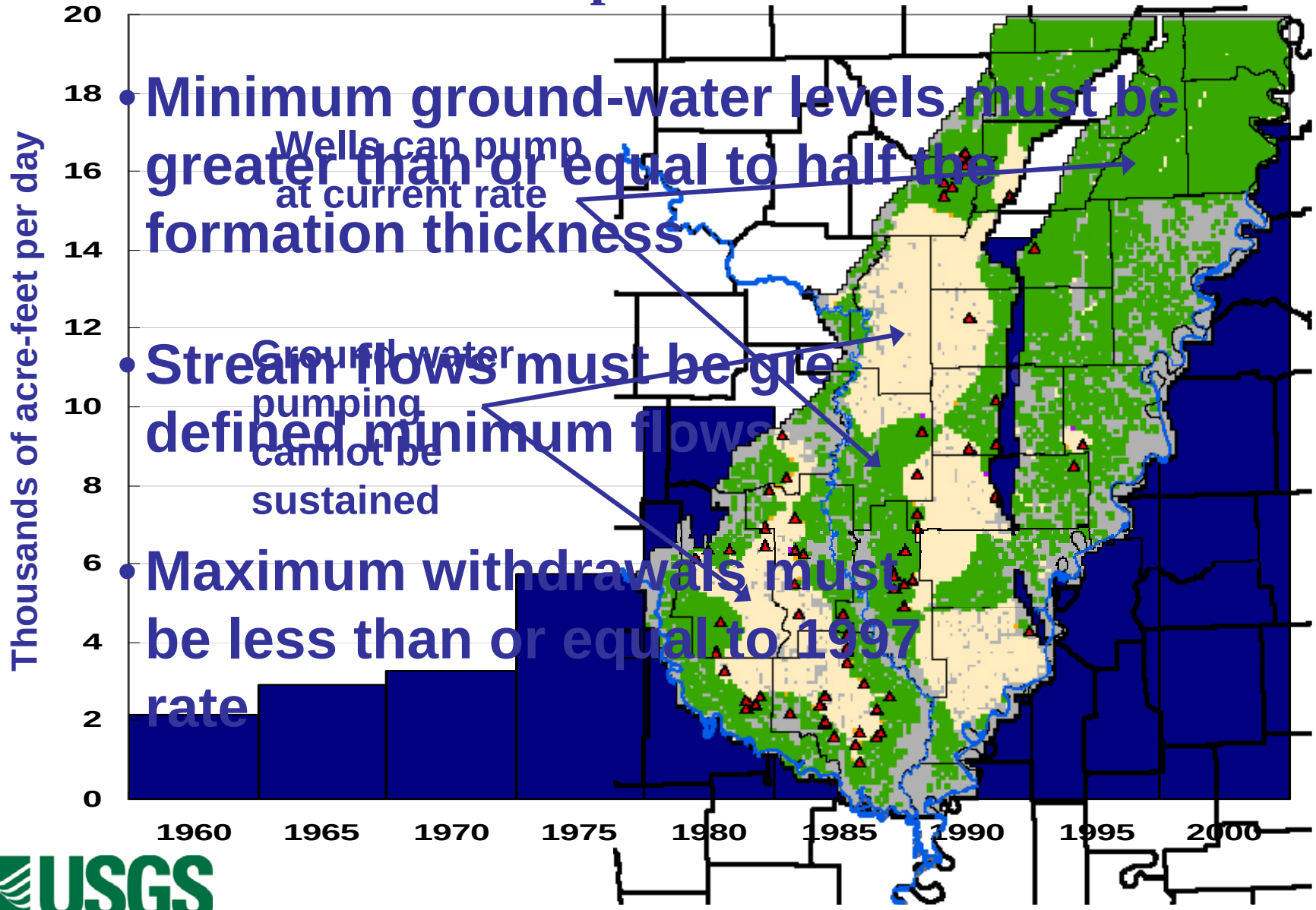
2049



401 dry cells

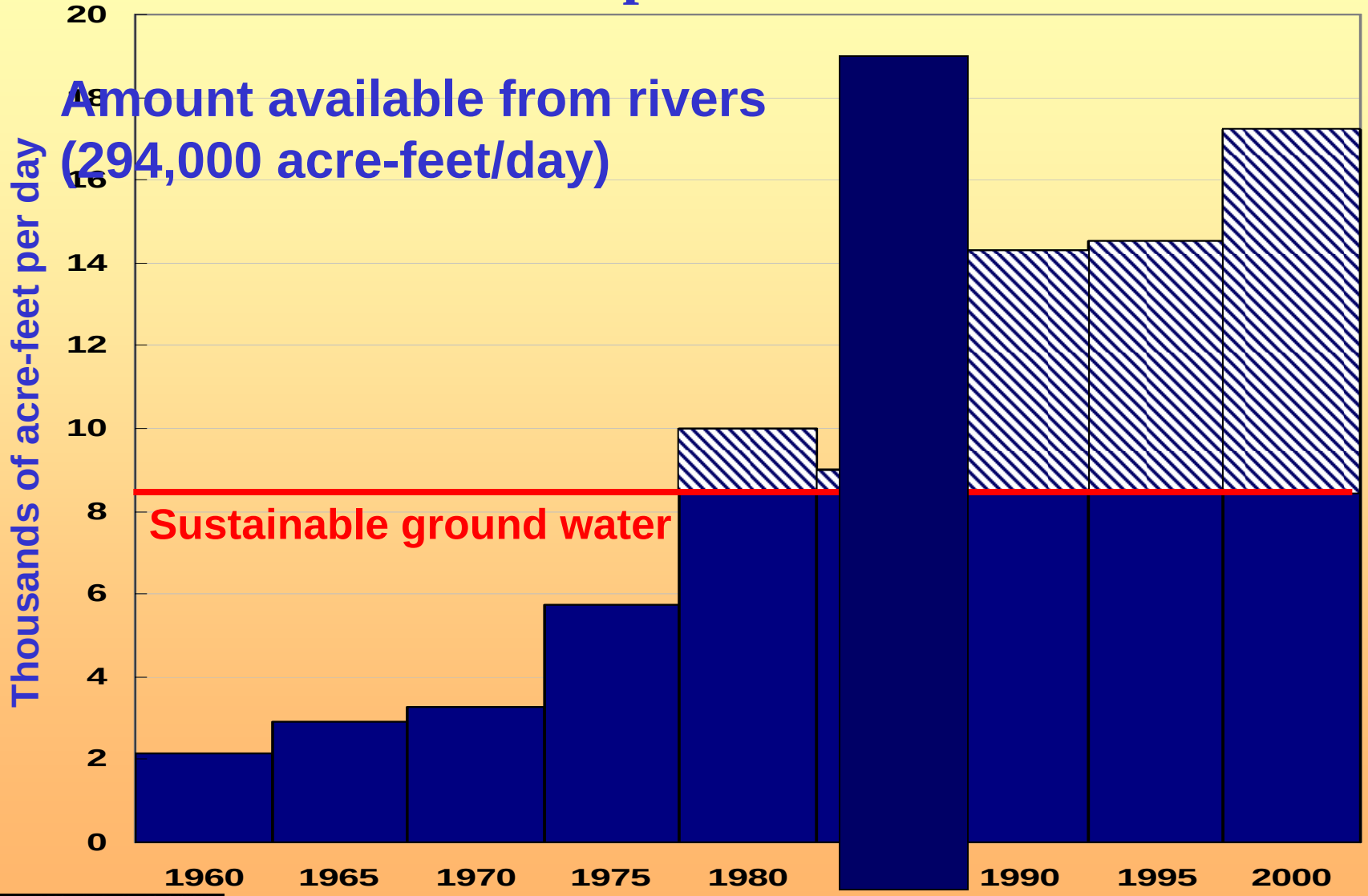
2,195 cells half depleted

North Alluvial Conjunctive-Use Optimization Model – Example Scenario



- Minimum ground-water levels must be greater than or equal to half the formation thickness
- Stream flows must be gre defined minimum flows
- Maximum withdrawals must be less than or equal to 1997 rate

North Alluvial Conjunctive-Use Optimization Model – Example Scenario



Approaches Toward Sustainability

- Conservation
- Surface-water diversions
- On-farm storage
- Artificial recharge

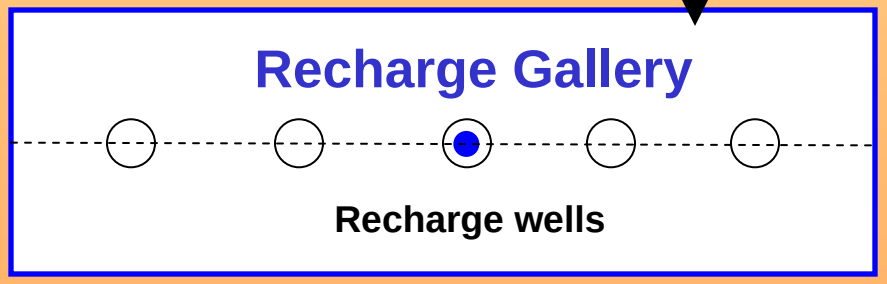
Artificial Recharge in Arkansas

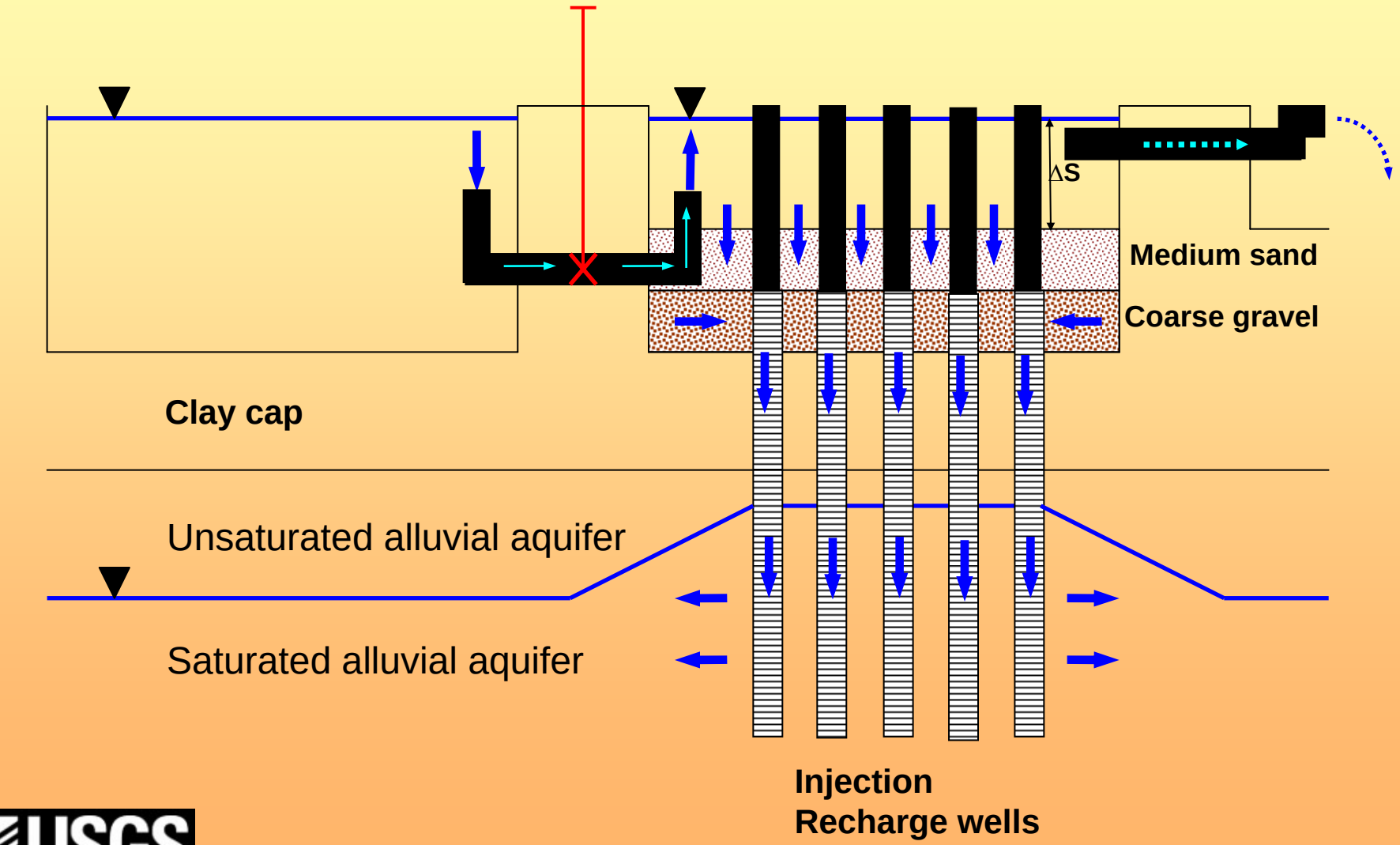
- 1960's: USGS conducts artificial recharge study at Rice Experimental Station
- USGS concludes that recharge could be done at a finite percentage of pumping rate
- Major factors affecting recharge: air entrainment, sediment clogging, chemistry
- Major deterrent: cost of water treatment

Construction of tailwater recovery pit, Lonoke County

Tailwater recovery pond, Lonoke County, Arkansas

Constructed wetland used in series with artificial recharge test system




Constructed Wetland
Recharge Gallery
ΔS
Medium sand
Coarse gravel
Clay cap
Unsaturated alluvial aquifer
Saturated alluvial aquifer
Injection
Recharge wells

Benefits of artificial recharge

- Recharge at 100 gal/minute = 160 acre-feet/year

  (comparable to storage in a tail-water recovery reservoir)
- Subsurface storage minimizes losses from evaporation
- Aquifer storage keeps more land in production
- Constructed wetlands provide wildlife habitat

Summary

- Models show that current water-use from alluvial aquifer is unsustainable
- Surface water could be diverted to meet unmet demand
- Artificial recharge could substantially affect water levels in aquifer and water availability
- If used in conjunction with constructed wetlands, artificial recharge could add to the existing wetlands and wildlife habitat

USGS