USGS
science for a changing world

Overview of Recent Groundwater Activities and Studies of the USGS Texas Water Science Center

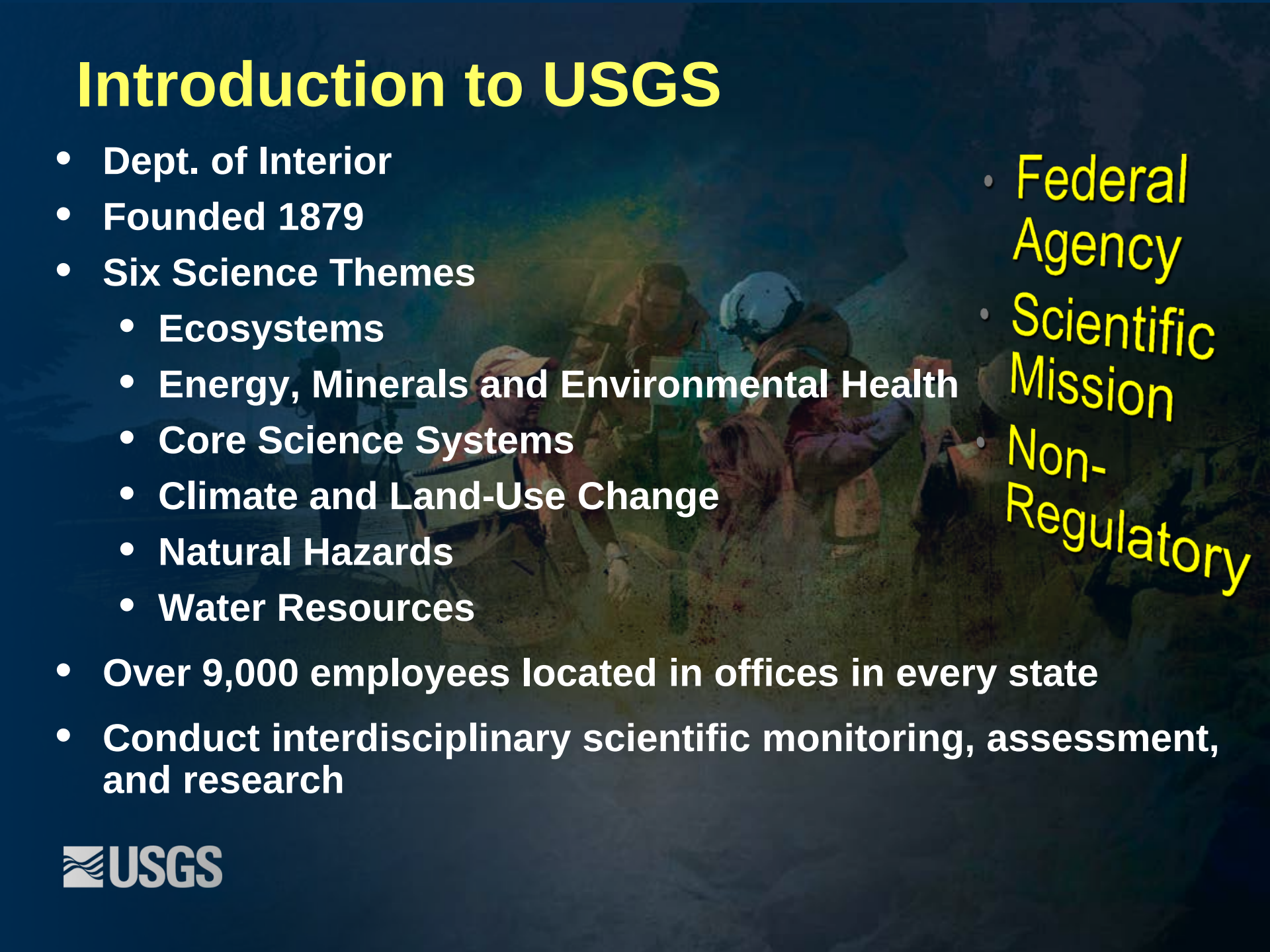
Jonathan V. Thomas
Geophysicist

Texas Groundwater Protection Committee
July 15, 2015

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

Introduction to USGS

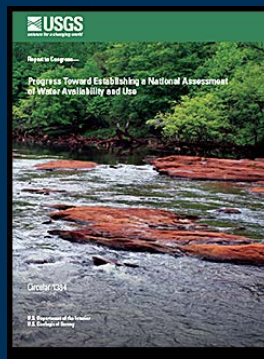
- Dept. of Interior
- Founded 1879
- Six Science Themes
  - Ecosystems
  - Energy, Minerals and Environmental Health
  - Core Science Systems
  - Climate and Land-Use Change
  - Natural Hazards
  - Water Resources
- Over 9,000 employees located in offices in every state
- Conduct interdisciplinary scientific monitoring, assessment, and research



USGS

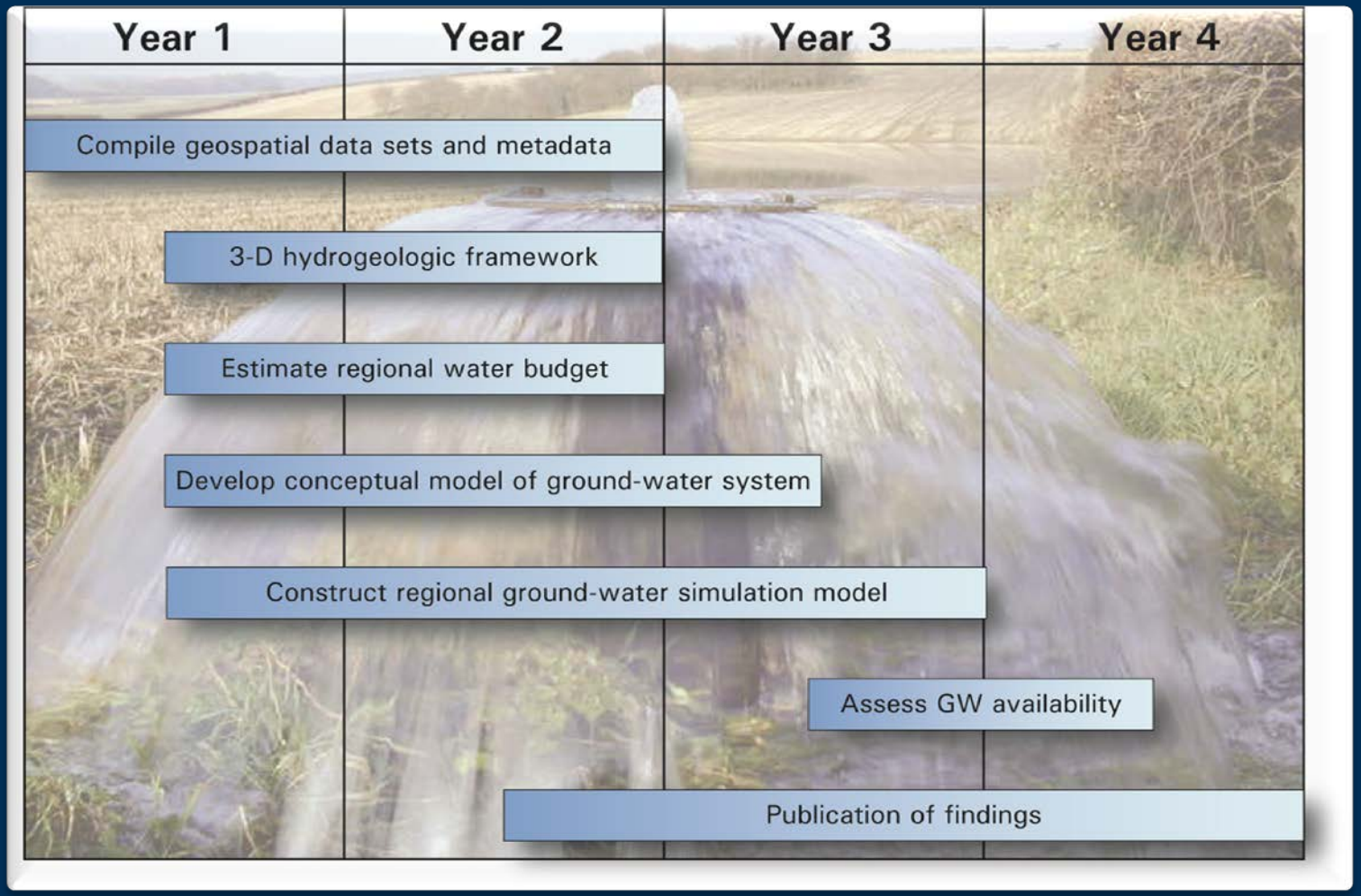
National Groundwater Activities

- **USGS Office of Groundwater**
- **Groundwater data is stored in the National Water Information System (NWIS)**
- **Water Census**
  - Availability and use
  - Brackish water
  - National Water-Quality Assessment Program
  - National GW Networks



Regional Availability Assessments

Emphasize integrated use of monitoring data, ground-water modeling, and other existing information to assess status of system in context of complete water budget (recharge, discharge, flow, and storage)



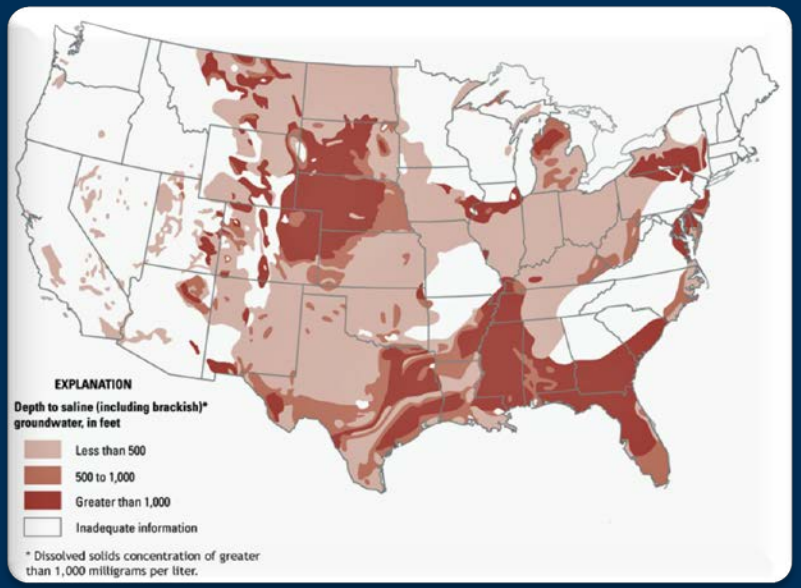
USGS

Brackish GW Assessment

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

Major Study Components (2013-2016)

- Compile existing information
- Describe dissolved-solids concentrations, other chemical characteristics
- Ability of aquifers to yield water
- Horizontal and vertical extents
- Current brackish use
- Make maps
- Identify data gaps



USGS

National Water-Quality Assessment (NAWQA)

- Assess quality of freshwater resources and how quality changes over time (status and trends)
- Evaluate how human activities and natural factors, such as land use and climate change, affect quality (understand causes)
- Determine effects of contaminants on quality (assess effects)
- Predict effects of human activities, climate change, and management strategies on quality (forecast)

USGS

NAWQA Groundwater Quality Assessments

- Approach

- Synoptic monitoring networks
  - *monitoring, domestic, and public supply wells*

- Time-series sampling
  - *continuous monitoring and periodic sampling*

- Modeling – multiple types & scales
  - *flow, transport, statistical*

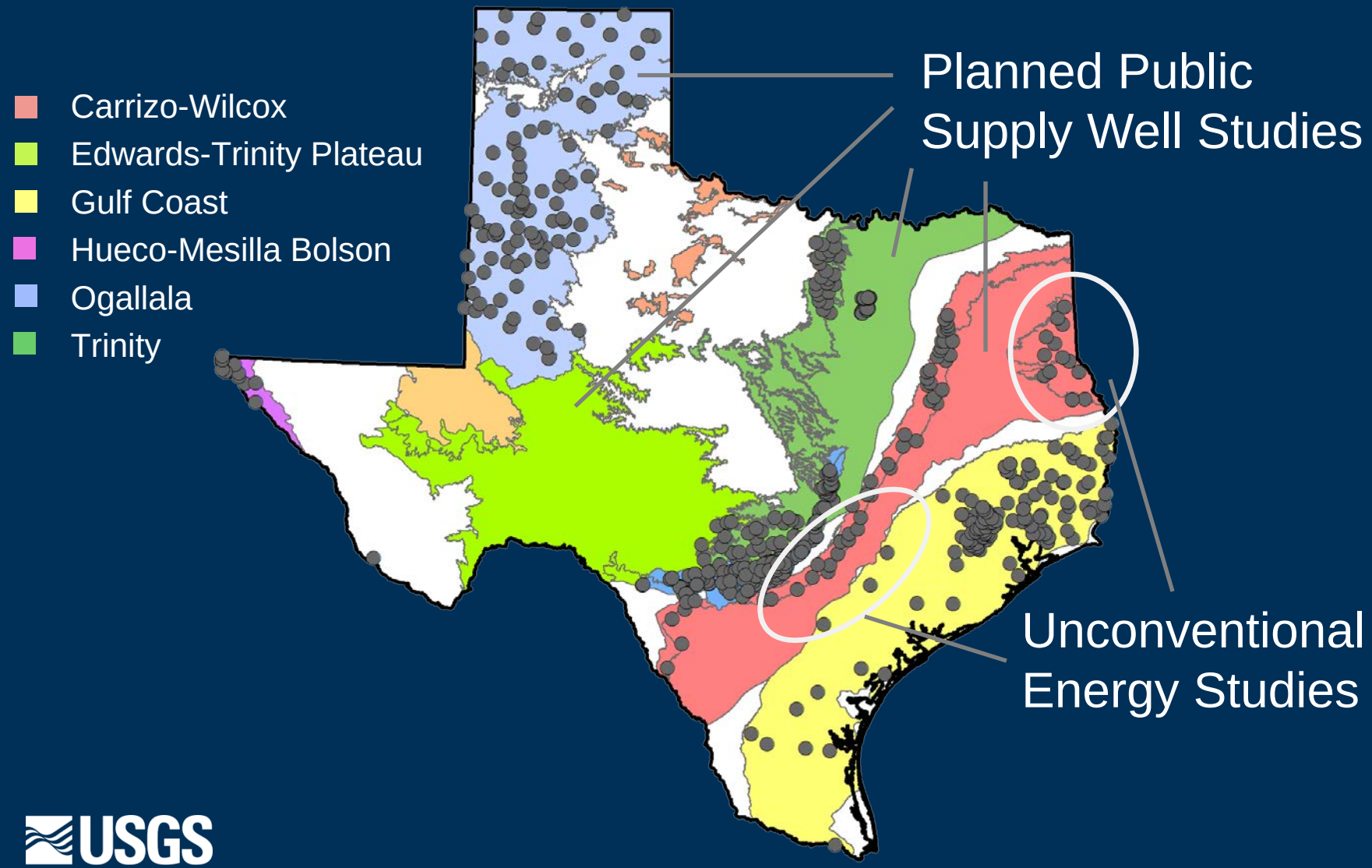
USGS

NAWQA Routine Analytes

Field Measurements	*Dissolved oxygen, pH, Specific conductance, Temperature, Alkalinity, Turbidity, Water Level*
Basic Suite	*Major Ions, Nutrients, Dissolved Organic Carbon (DOC), Trace Elements*
Pesticides	*Pesticides and degradates (200+)*
VOCs	*Volatile Organic Compounds (90+ VOCs)*
Pharmaceuticals	*Human Health Pharmaceuticals, Hormones*
Radionuclides	*Radon, Radium (-224, -226, -228), Polonium-210, Lead-210, Gross alpha and beta*
Microbial Indicators	*Total coliform, E. coli, Enterococci, Somatic and F-Specific Coliphage*
Hydrocarbons (energy studies)	*C1-C6 Hydrocarbons (methane, ethane, propane, butane, pentane, hexane); Carbon and Hydrogen isotopes of methane*
Age-Dating	*Tritium, Helium, SF6, Dissolved Gases,14C and 13C, Oxygen & Deuterium isotopes*

USGS

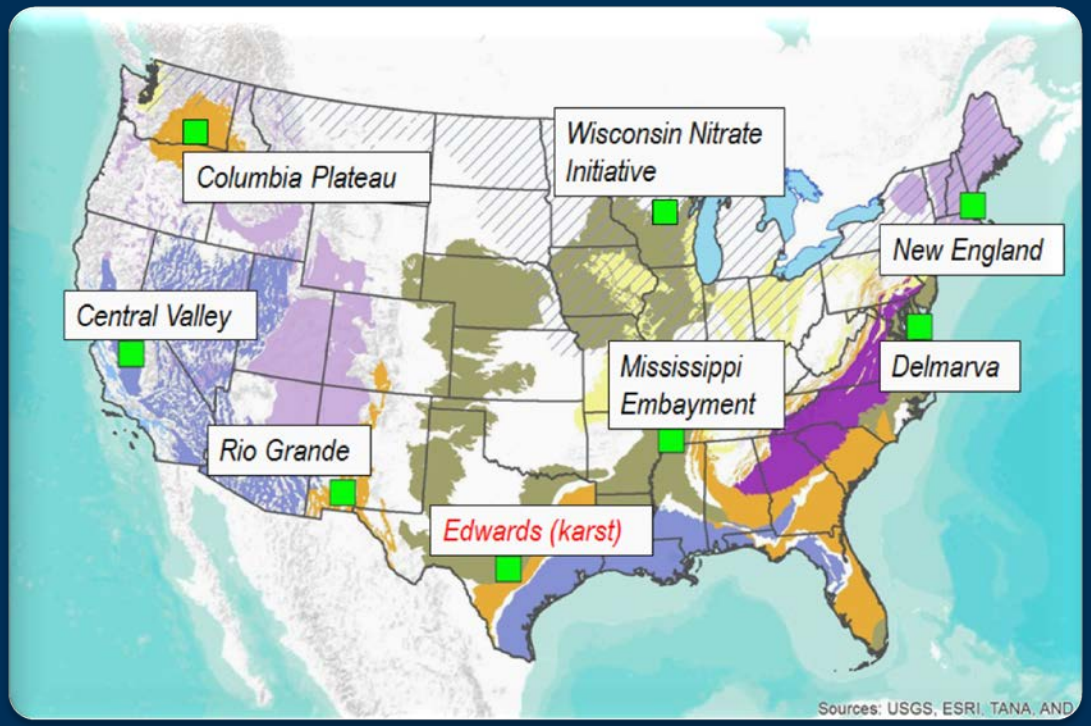
NAWQA Groundwater Sites



USGS

NAWQA Extended Trends Network (ETN)

- Expand understanding of what timescales water quality changes
- Contribute to strategies for best management practices
- Develop baseline measurements
- 8 networks across nation
- **Karst Edwards aquifer example**



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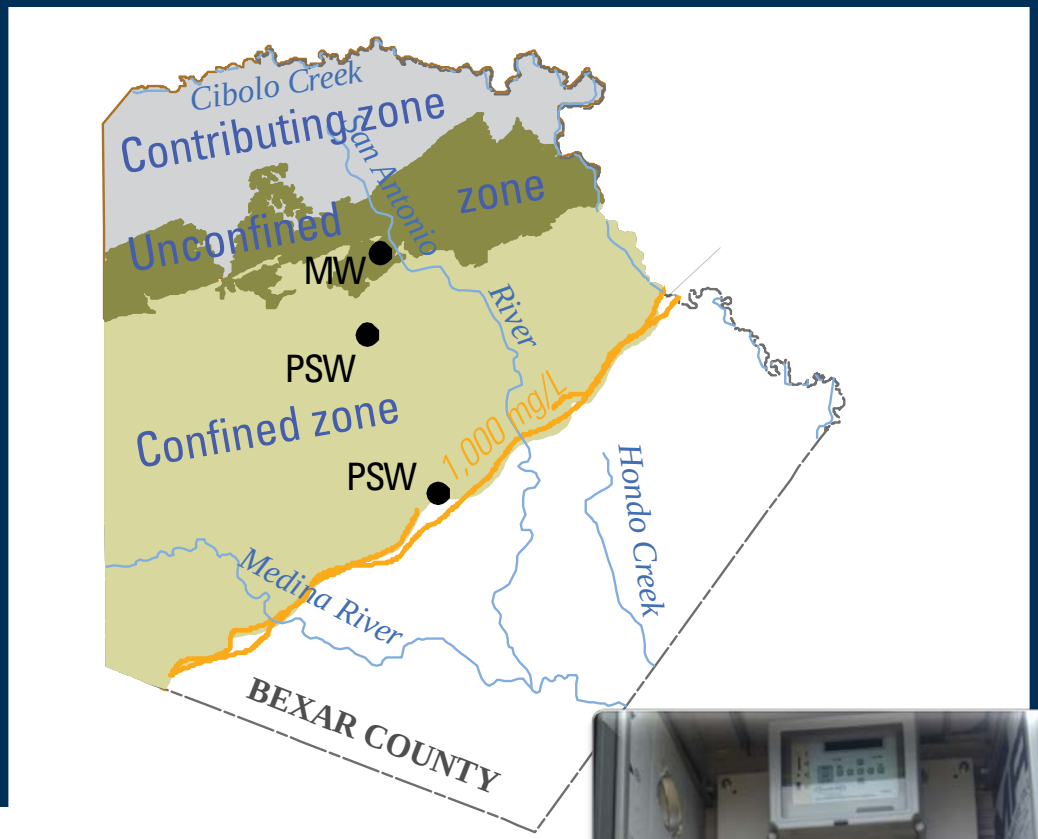
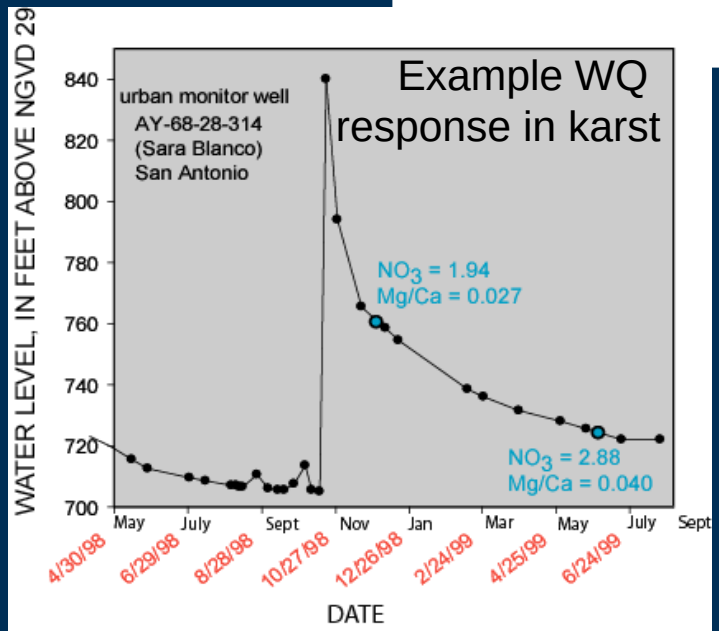
NAWQA Edwards ETN

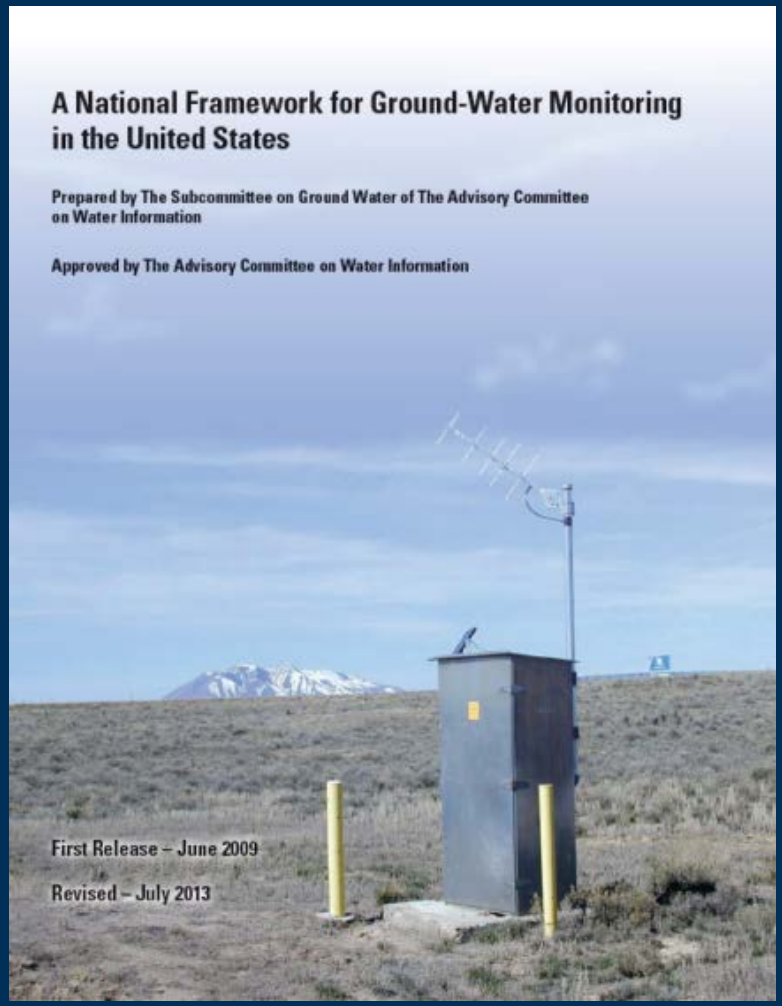
- 3-well network upgradient recharge zone to confined aquifer
- Sites selected: 1 Monitor Well (MW) (upgradient); 2 Public Supply Wells (PSW)
- Continuous monitoring of pH, temp, SC, DO
- Discrete sampling (6x/yr) for nutrients, major ions, trace elements, organics, isotopes, age tracers





National GW Monitoring Network

- Design for a collaborative National GW Monitoring Network
- Inventoried Federal and State monitoring programs
- Guidance for Field Methods
- Guidance for Minimum Data Elements, Standards, & Mgmt
- Implementation Plan and Recommendations
- Publication in 2009, revised 2013
- Texas – Advisory Committee on Water Information, Pilot (Texas Water Development Board, Texas Commission on Environmental Quality)



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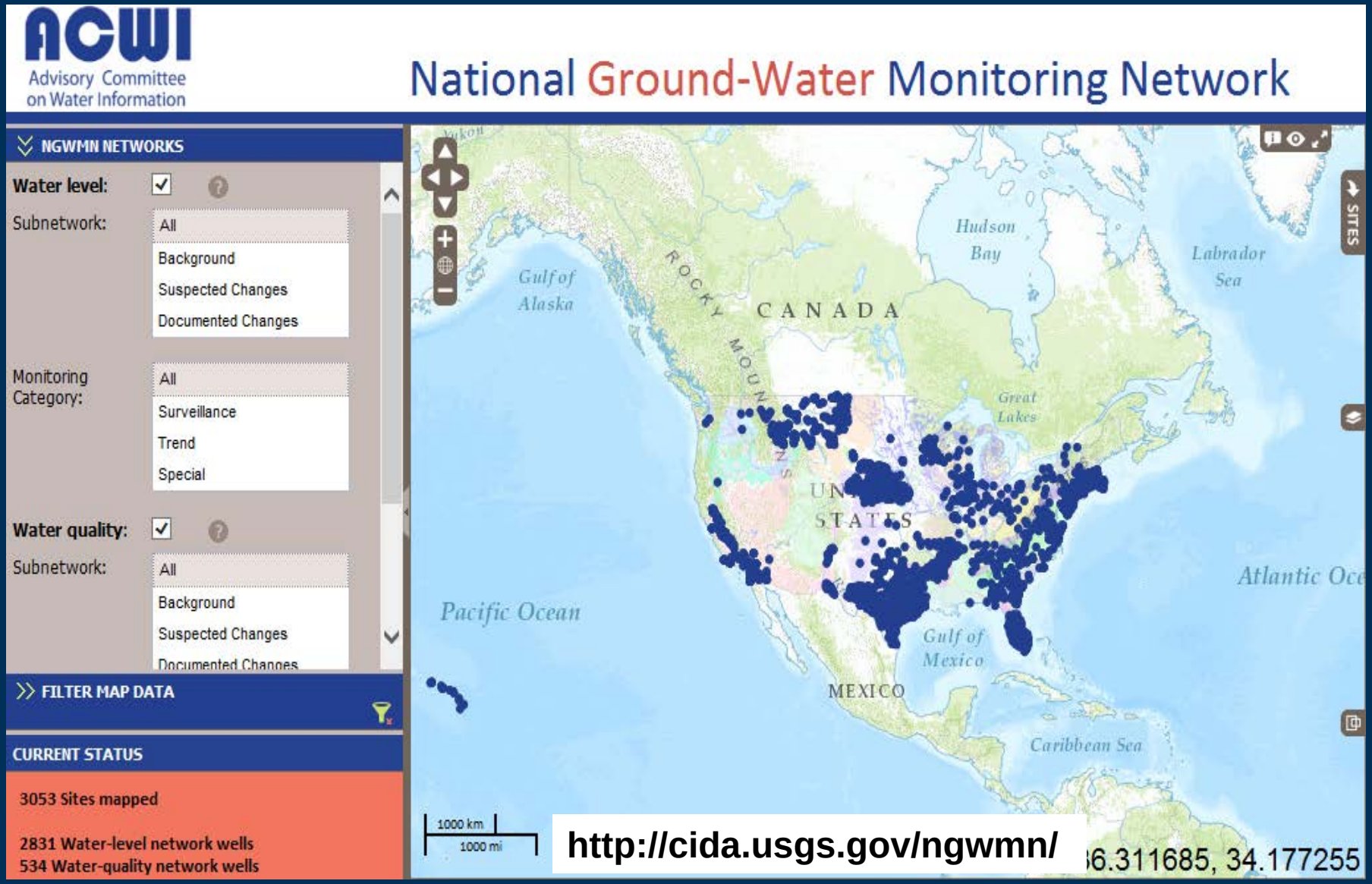
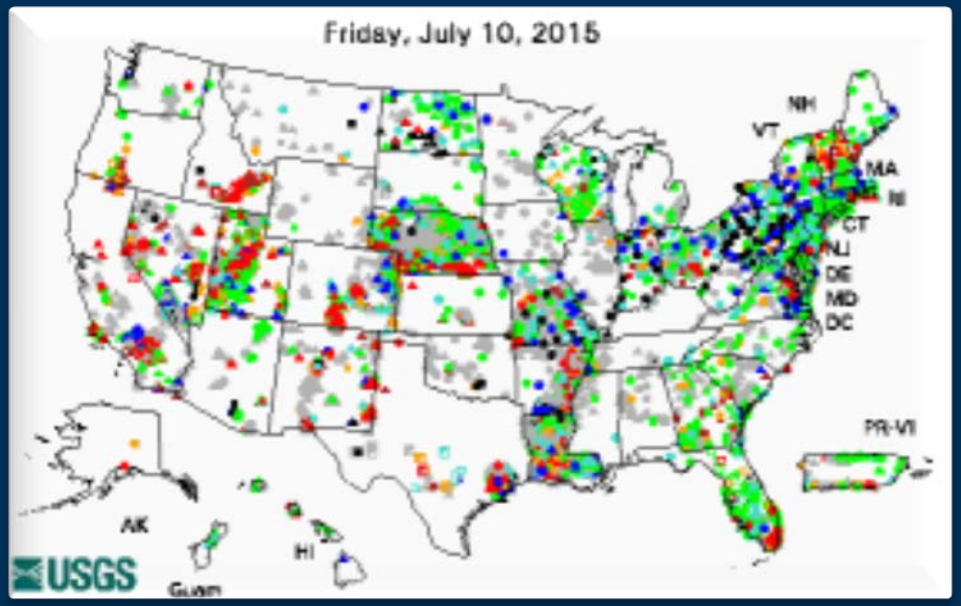
National Groundwater Monitoring Network Portal



Groundwater Watch

http://groundwaterwatch.usgs.gov/

- Groundwater level network
- Real-time (continuous monitoring)
- Below normal GW levels
- Long-term data
- Climate response
- Springs

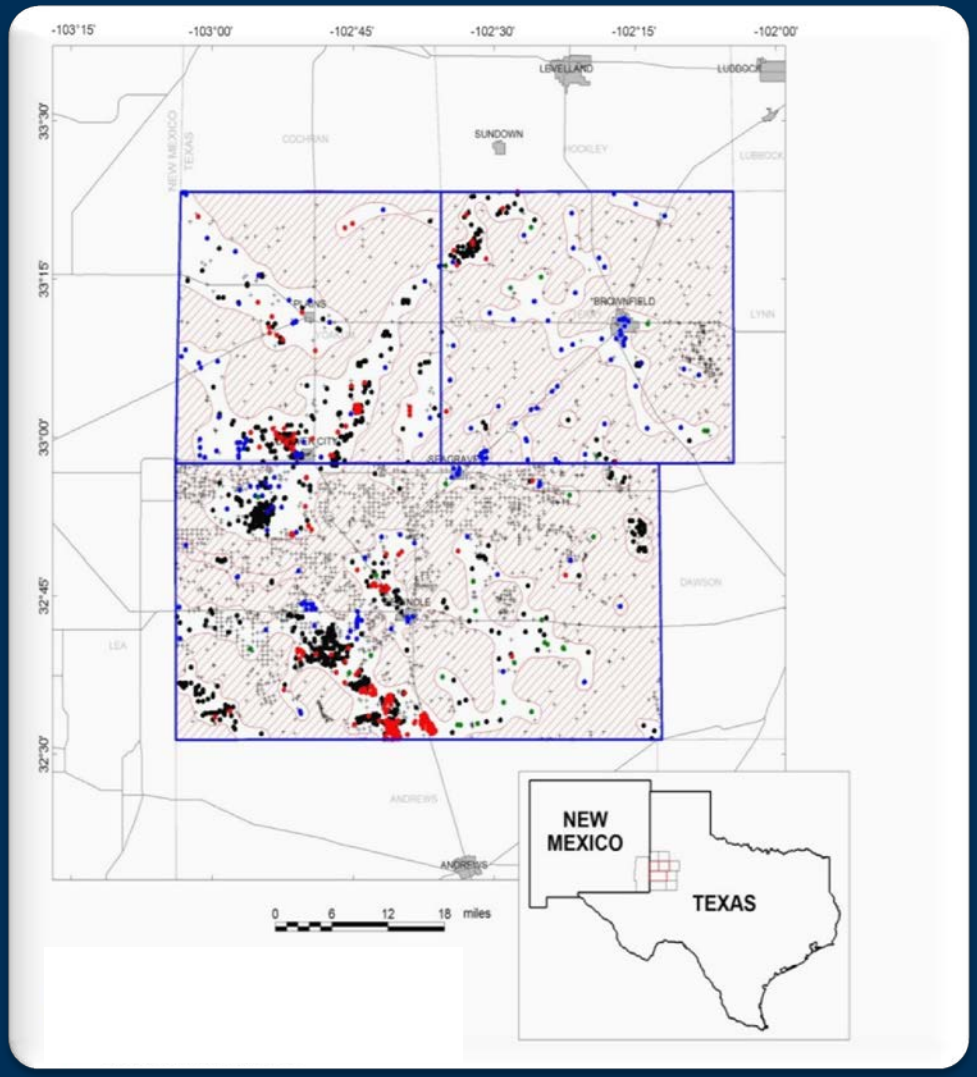


Texas Water Science Center
Selected Studies

USGS

Southern High Plains Study

- Enhance GW system understanding
- GW quantity/quality assessment
- Degradation of the water quality
- Assist with GW management



Sandy Land UWCD, South Plains UWCD, and Llano Estacado UWCD

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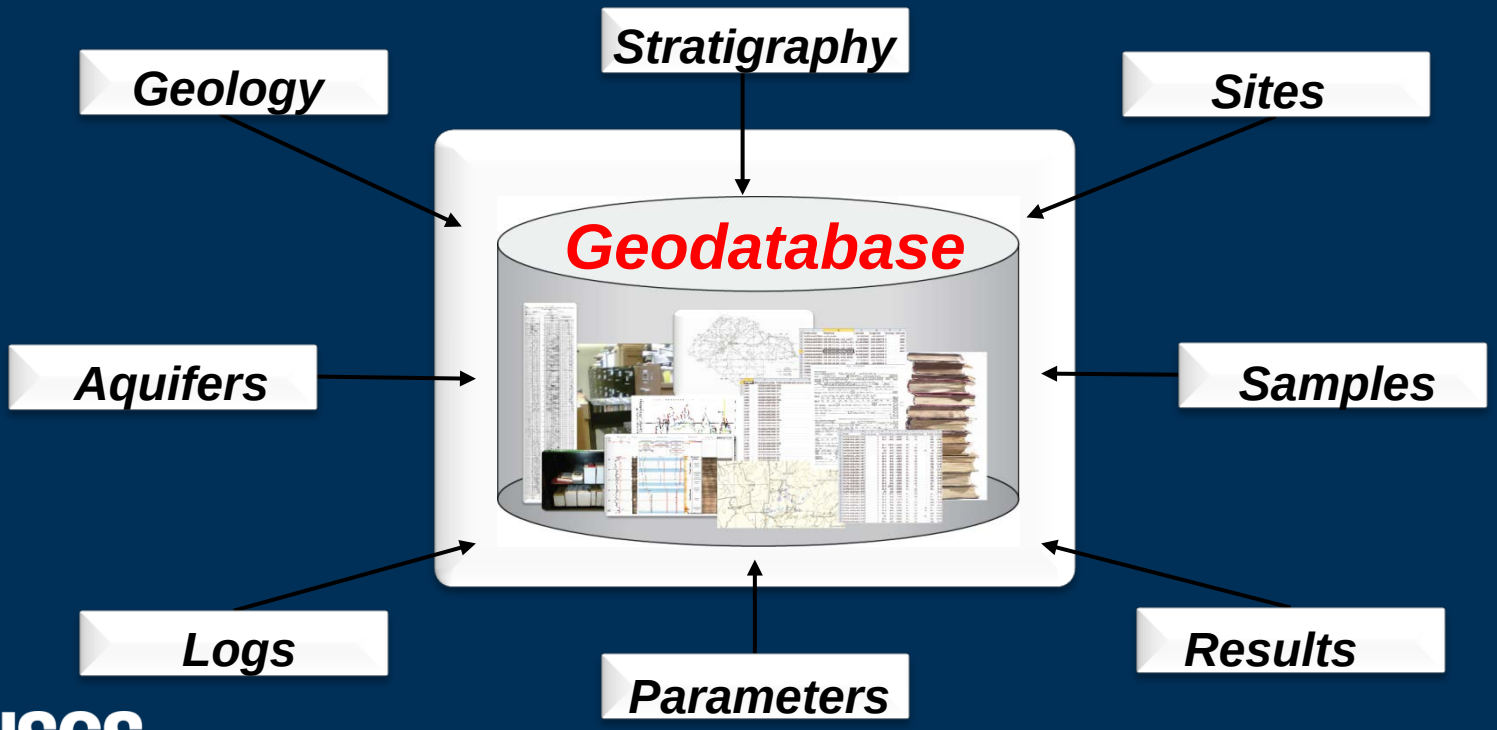
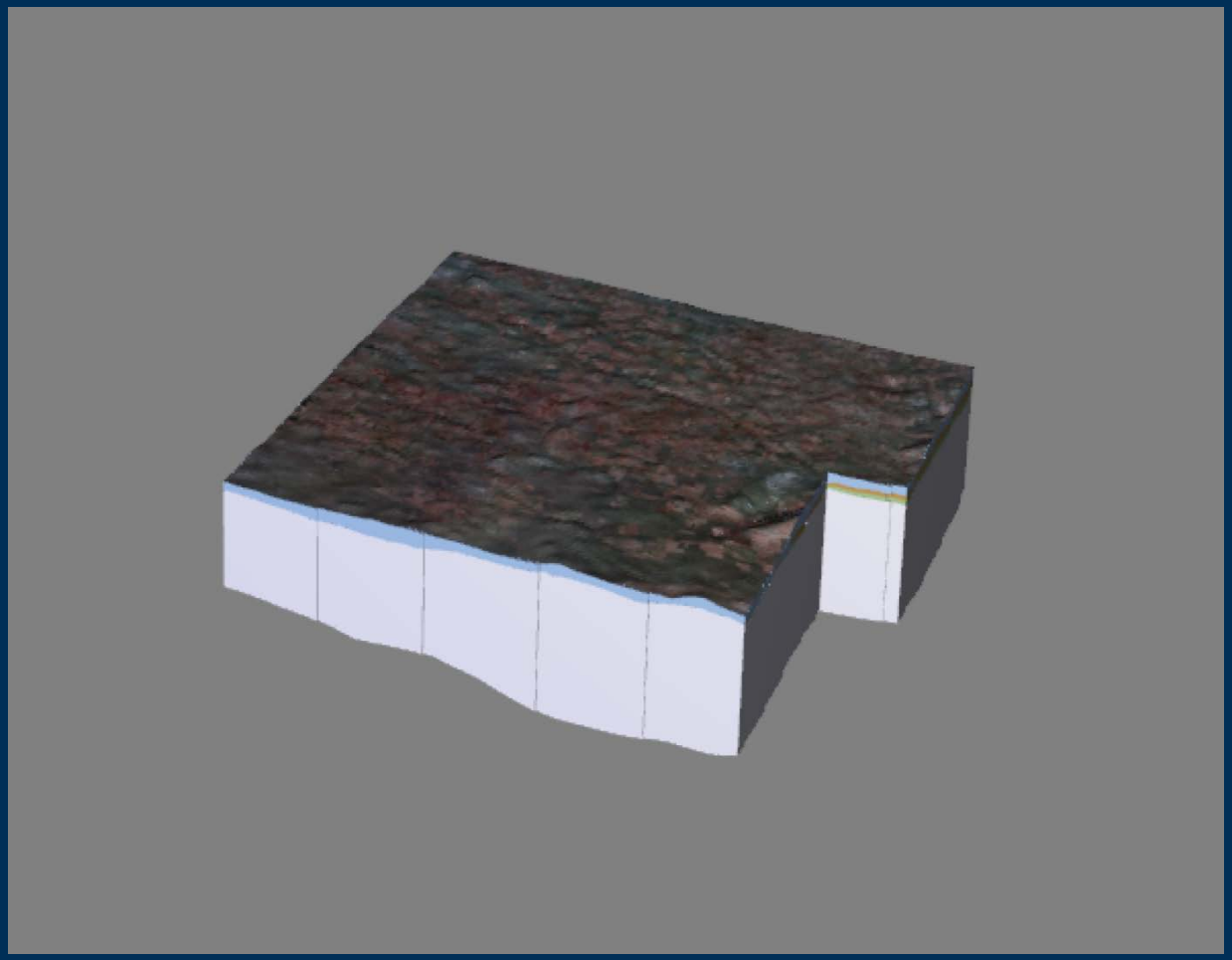
Database Development and Data Compilation

- **Develop database** structure and features
- **Locate and compile** literature and datasets
- **Identify data gaps** to assess additional data collection



USGS

Hydrogeologic Model



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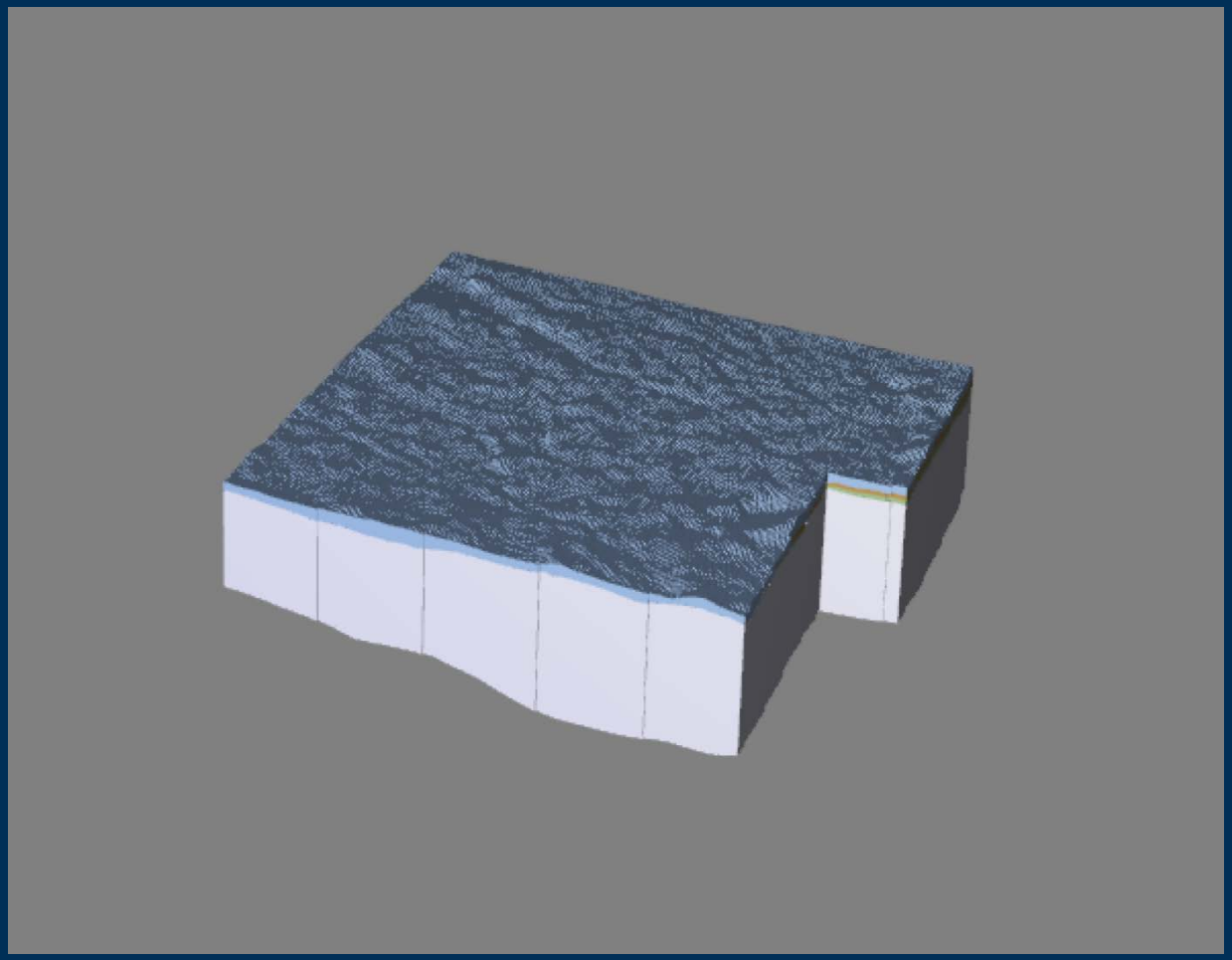

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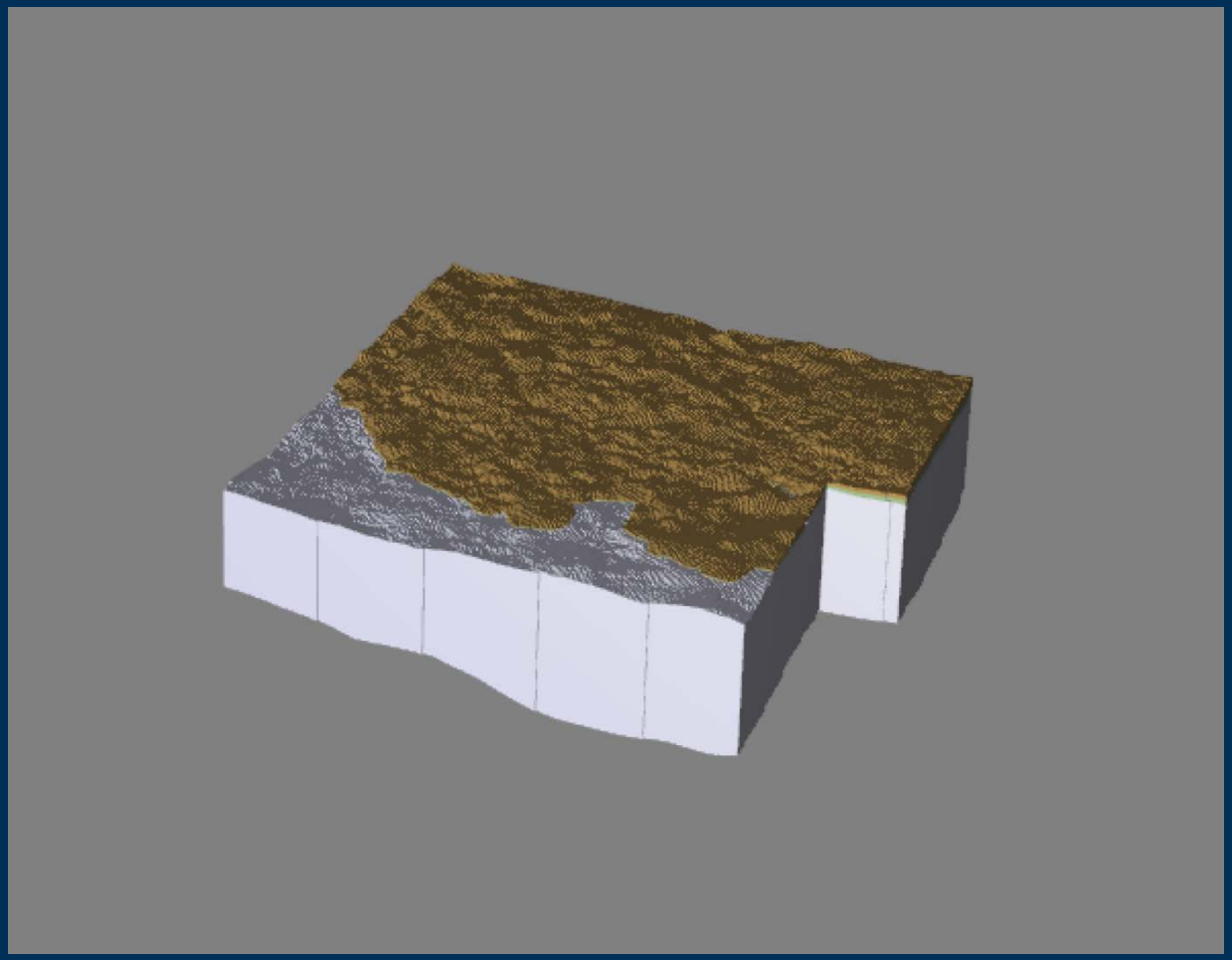
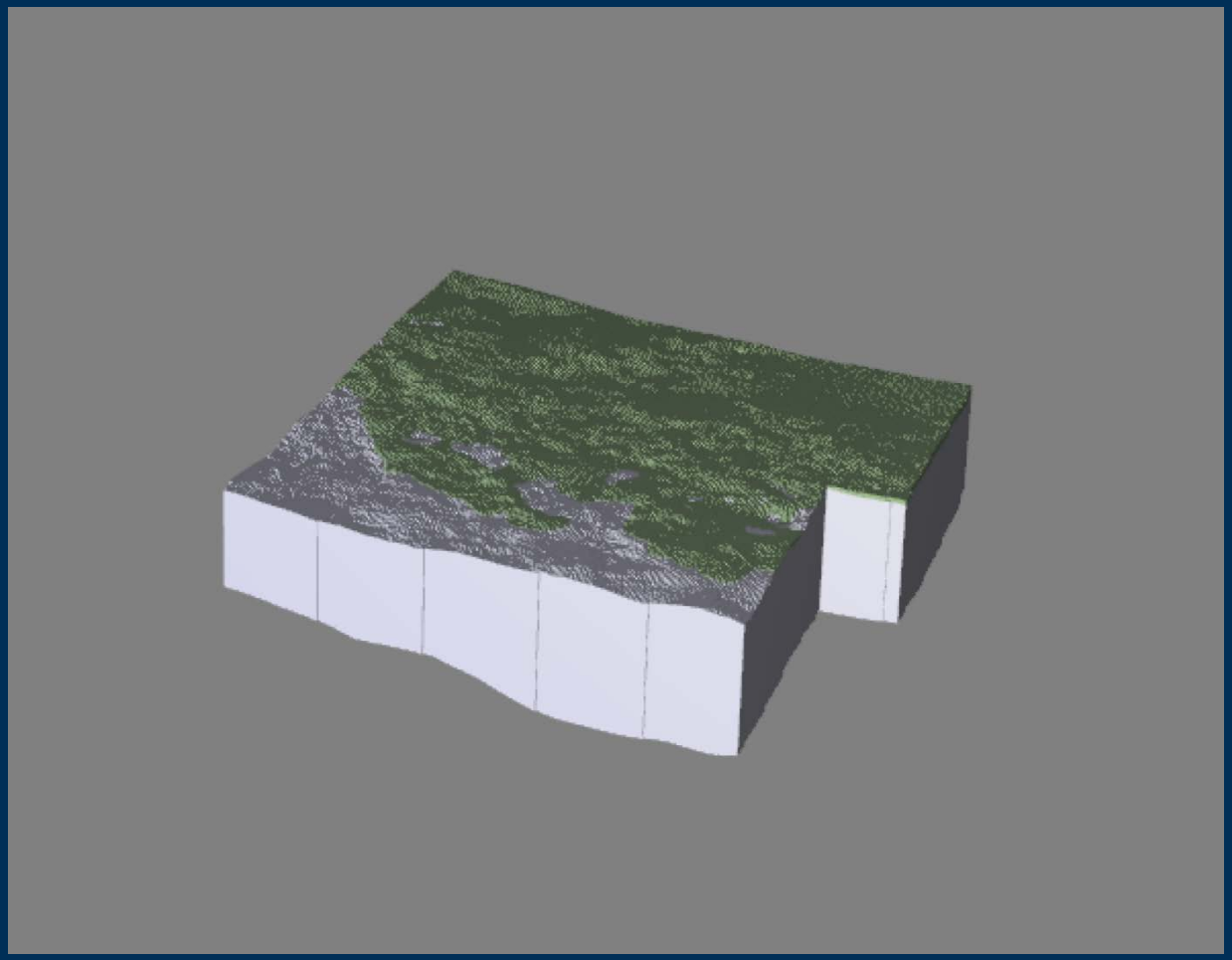


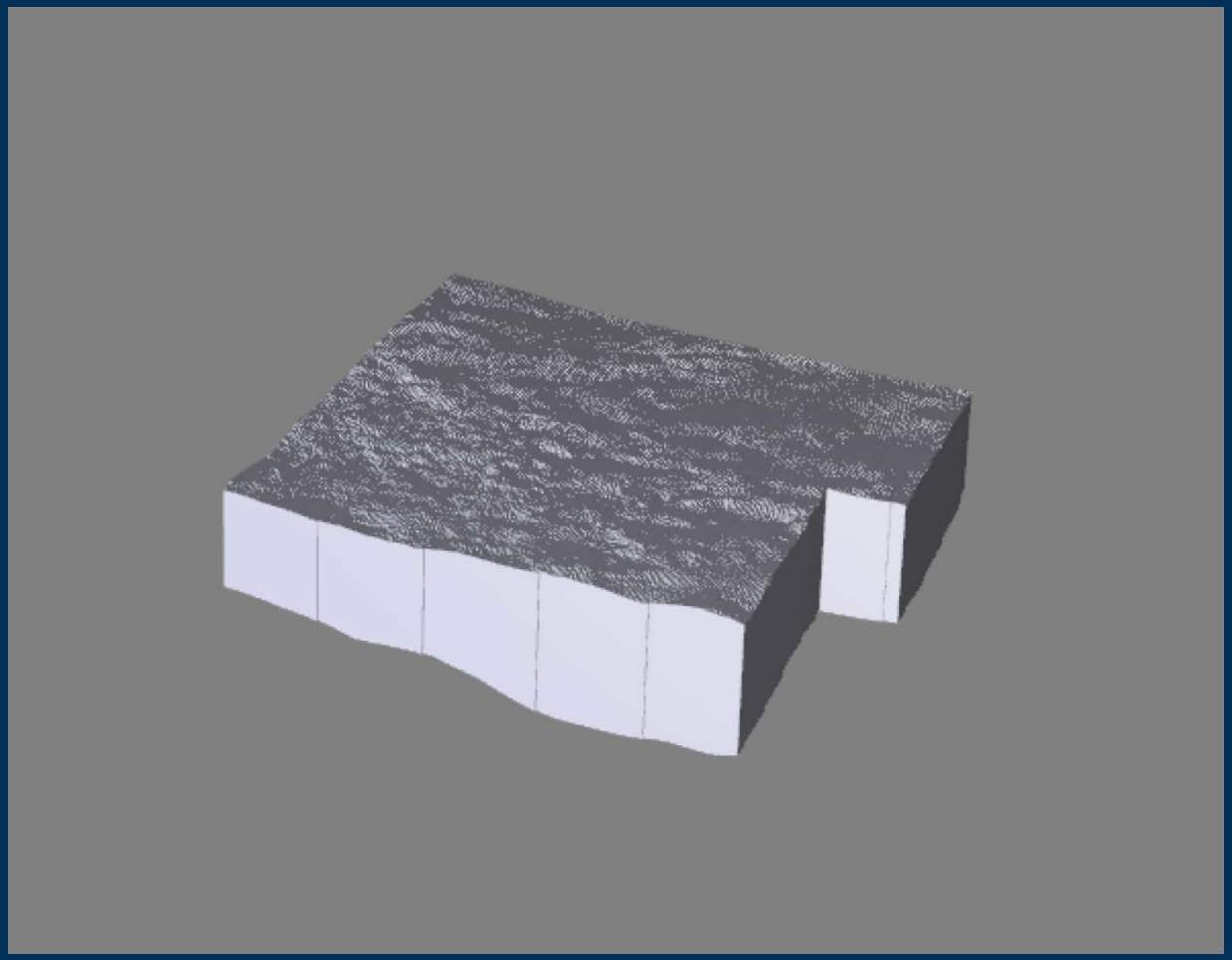
USGS

Hydrogeologic Model



USGS

Hydrogeologic Model



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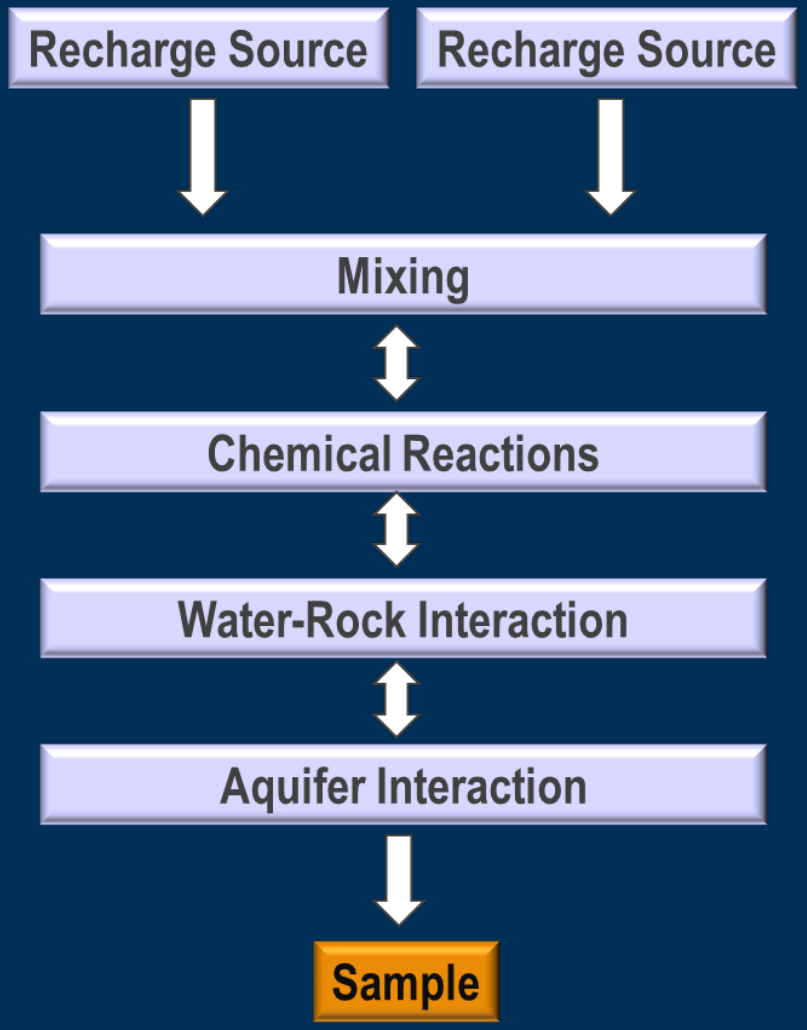
Groundwater Quality and Geochemistry Sampling

- **Chemical characteristics** of the groundwater
- **Identifies geochemical endmembers**
- **Improves understanding** of recharge, discharge, and mixing zones
- Sample results include:
  - Field properties
  - Major ions and trace elements
  - Nutrients and pesticides
  - Isotopes and age tracers



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Web Application

- **Display large amounts of data to the public**
- Display a **wide range of data**
  - Stratigrapic Unit Surfaces and Charts
  - Potentiometric Surfaces
  - Water Quality Grids / Points
  - Well Data
  - Base Map Layers
- **View Statistics**
- Export Reports

USGS

Web Application

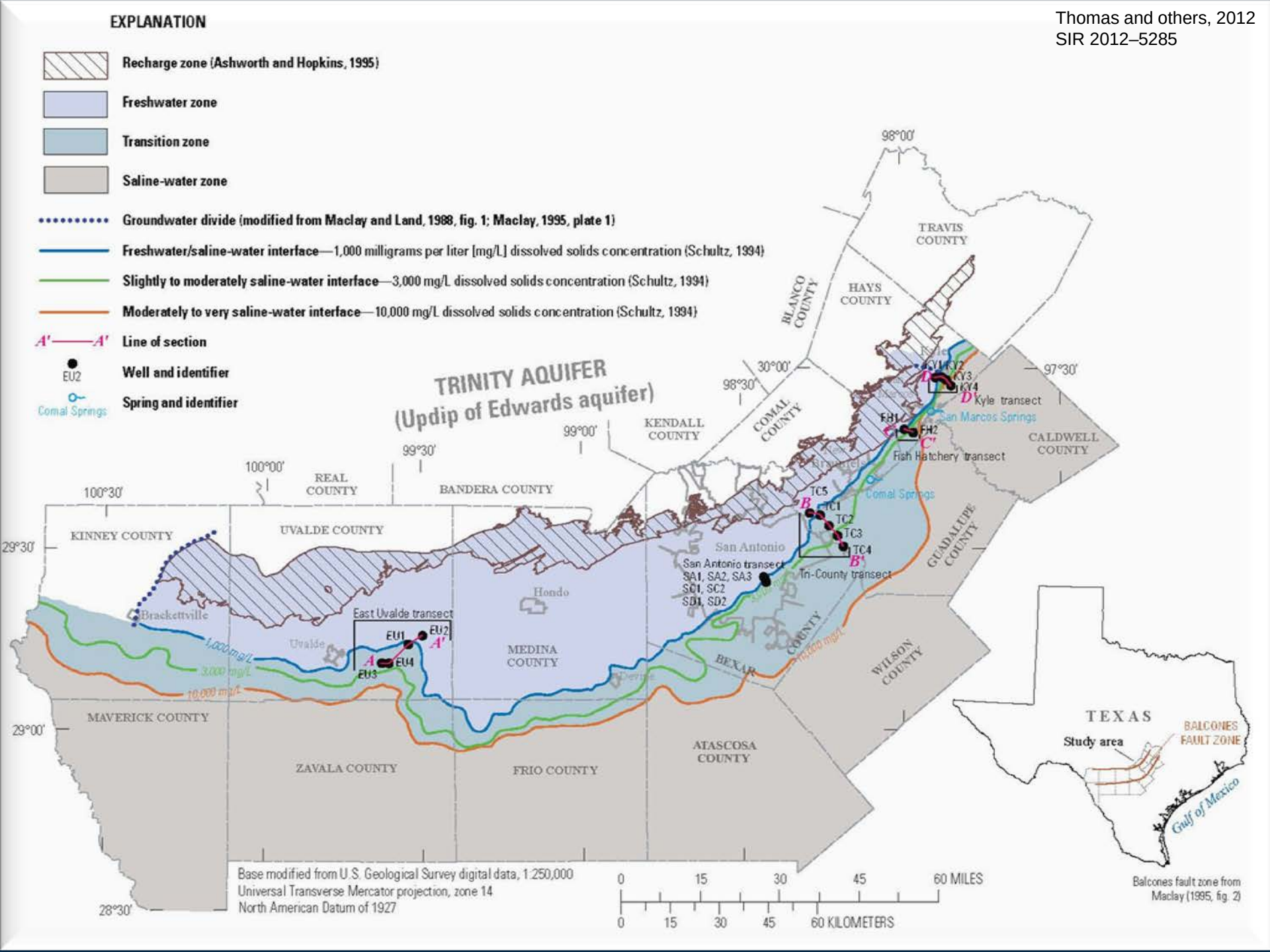
Saline Zone Study

- Freshwater zone of the San Antonio segment of the Edwards Aquifer
  - Utilized as a primary water supply source
  - Bounded to the south and southeast by a saline-water zone
  - Intermediate zone (transition zone) found between the freshwater and saline-water interface

- Concern that saline-water could move into the freshwater zone

USGS

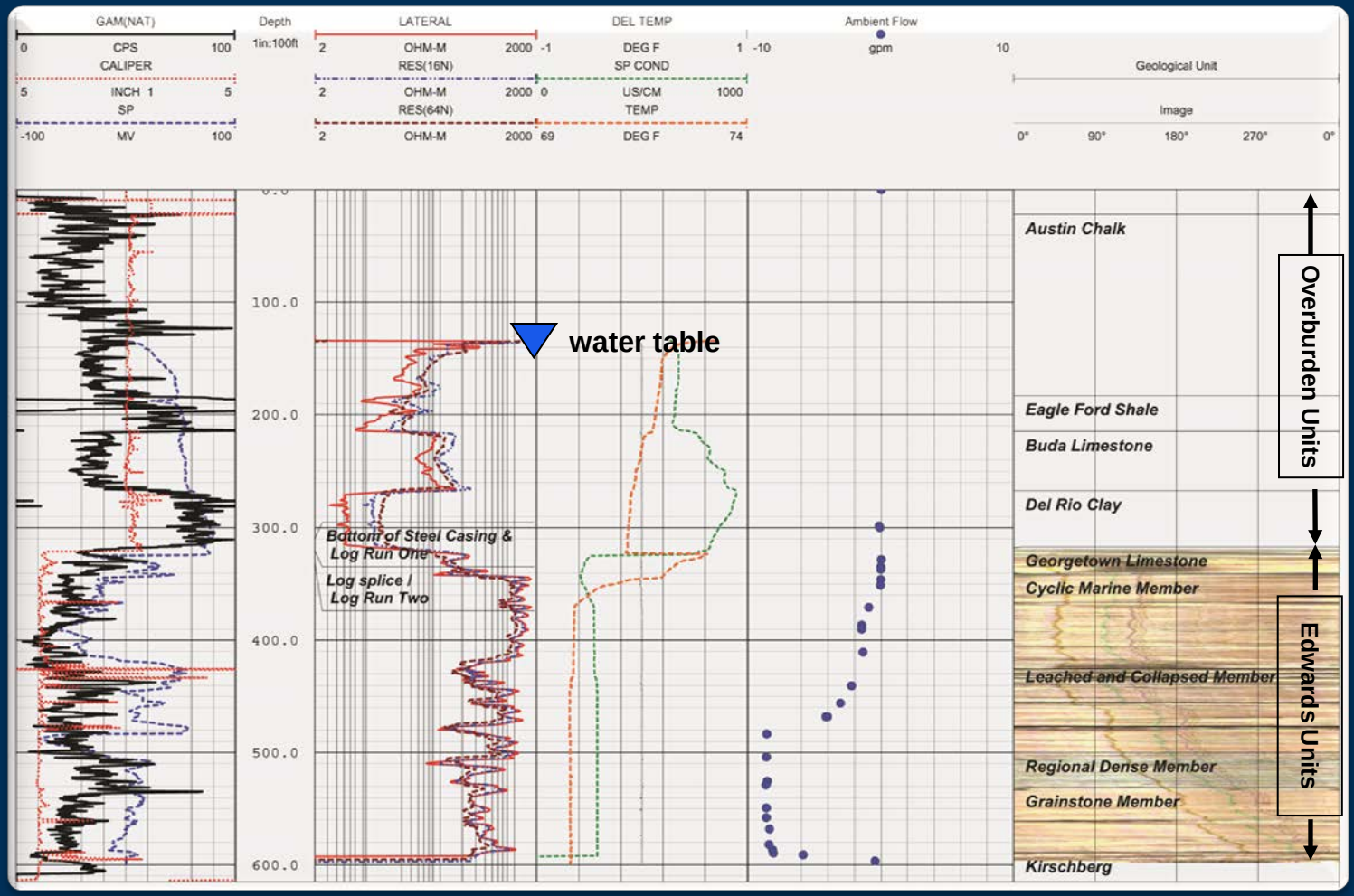
Thomas and others, 2012
SIR 2012–5285



Balcones fault zone from Maclay (1995, fig. 2)

Vertical Borehole Flow and Hydraulic Properties

Z-DED Deep Monitoring Well



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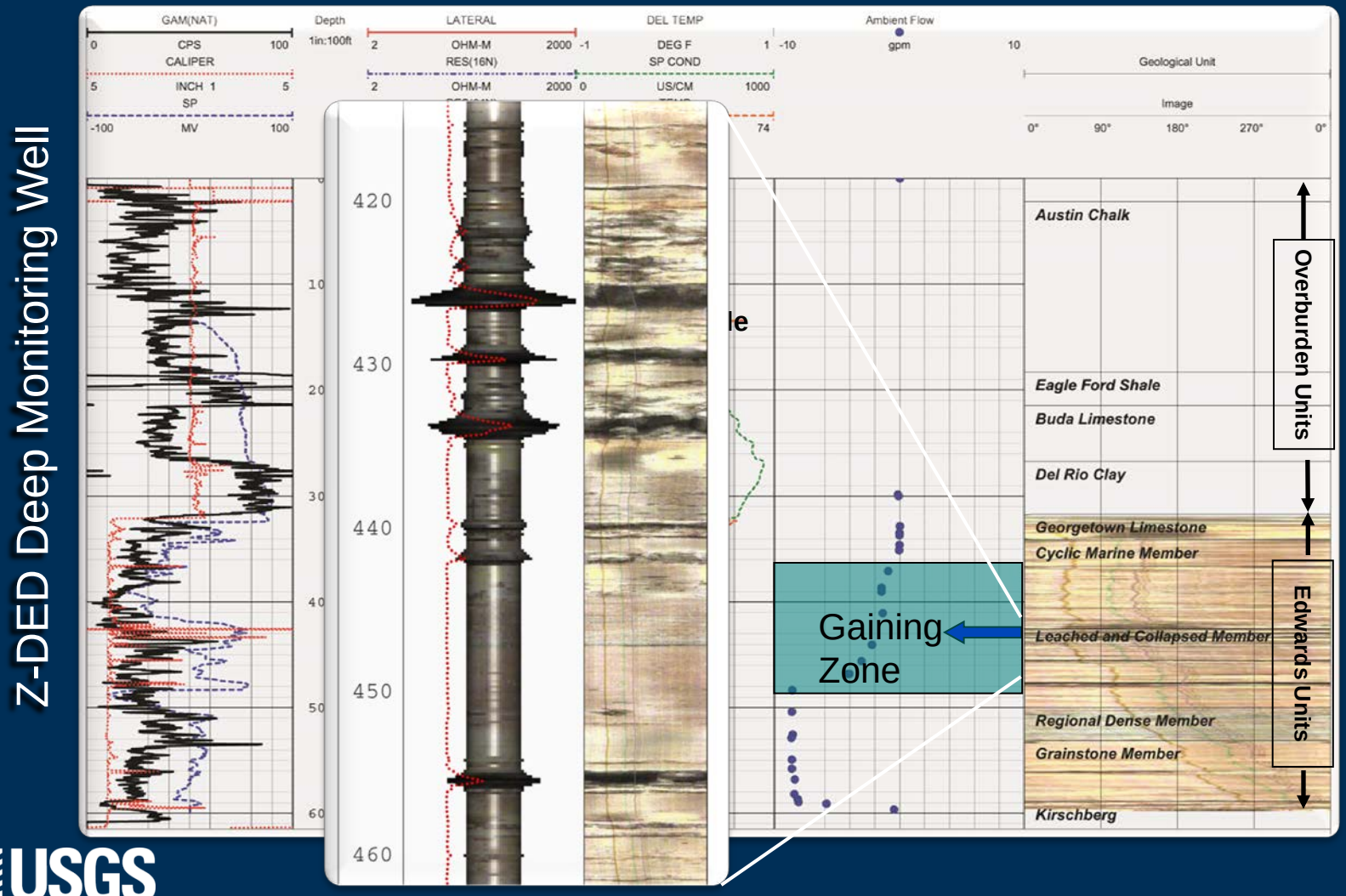

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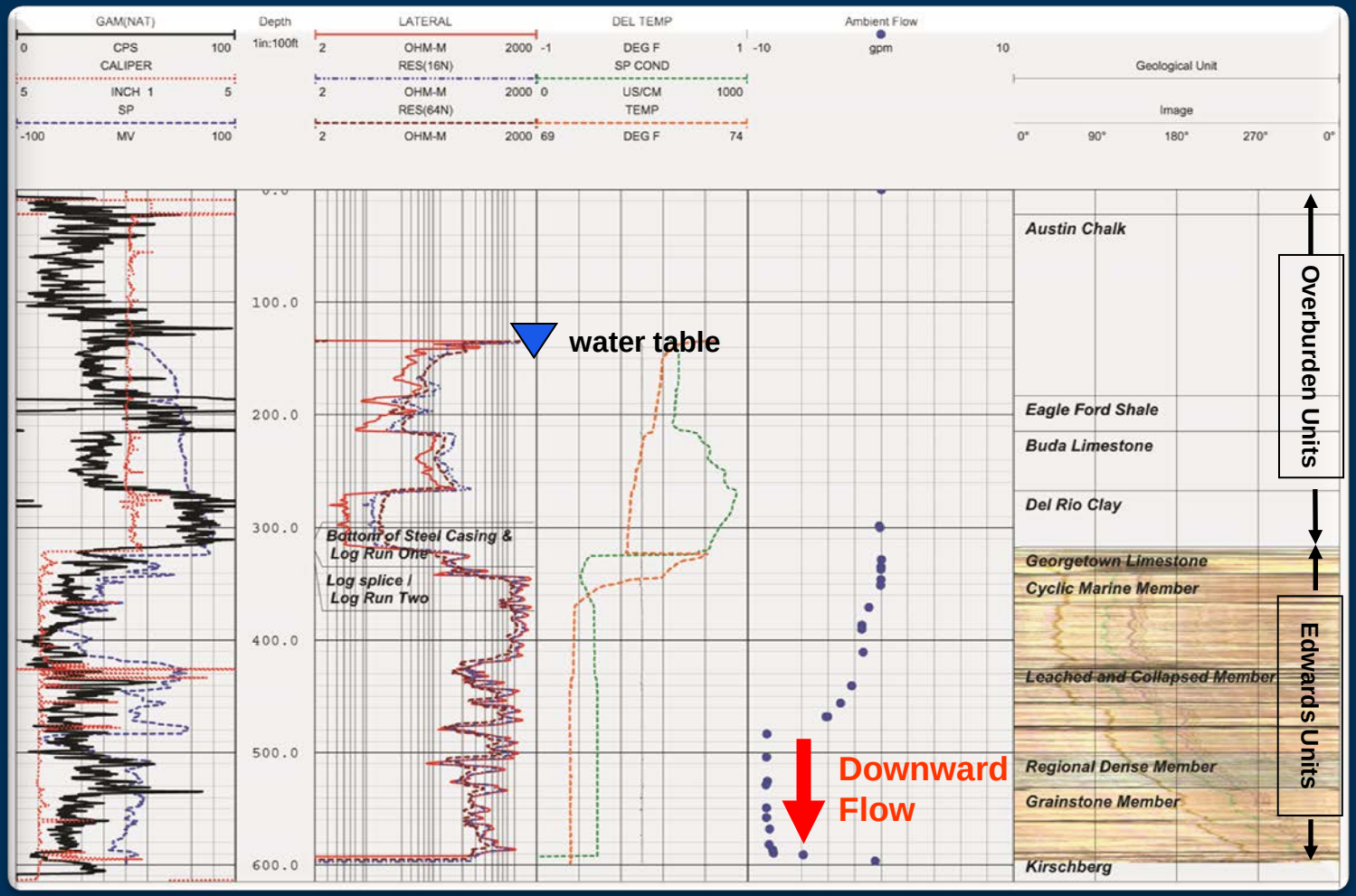

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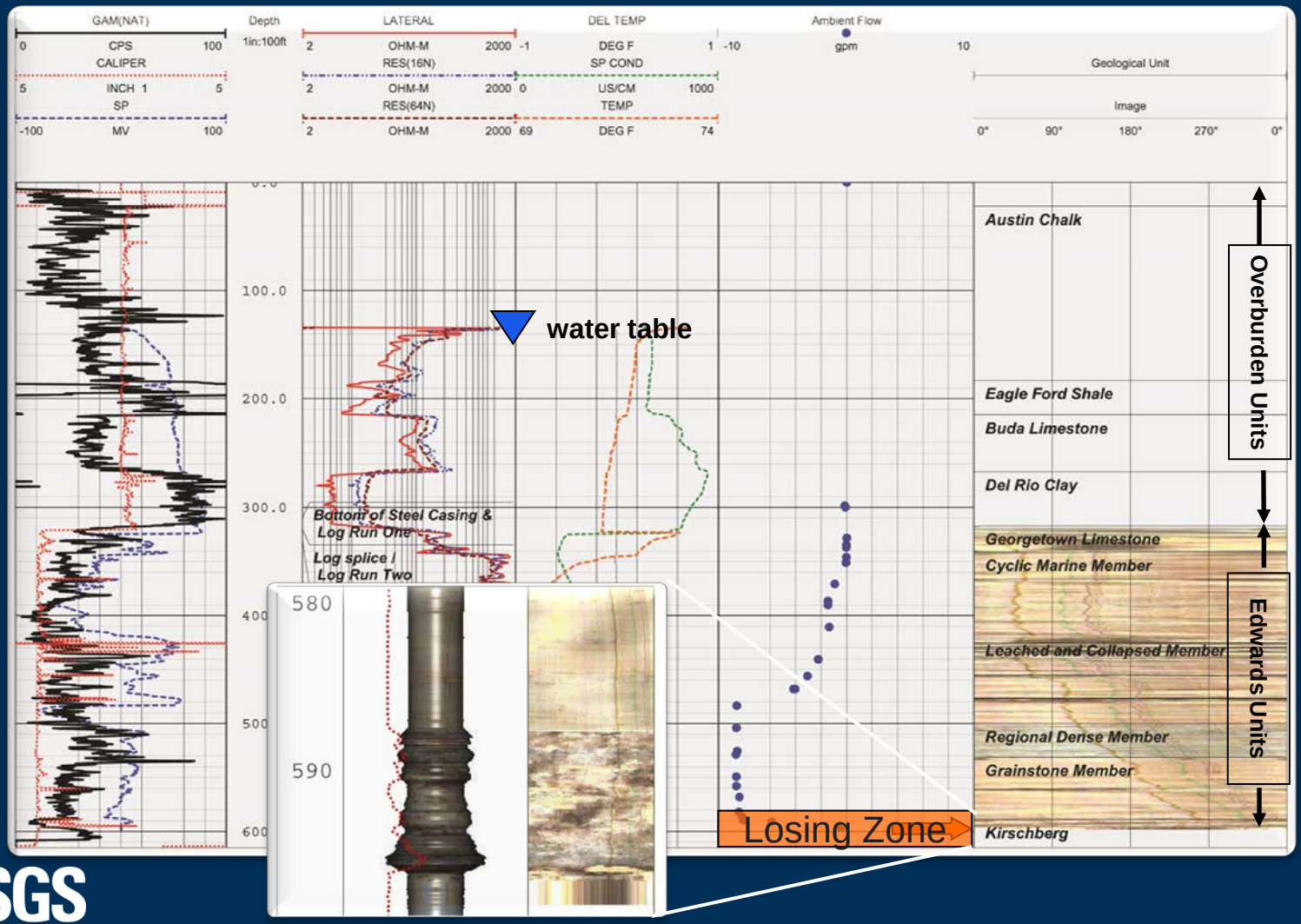
Vertical Borehole Flow and Hydraulic Properties



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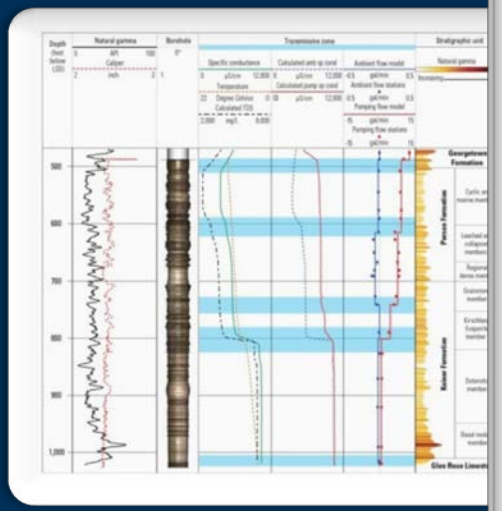
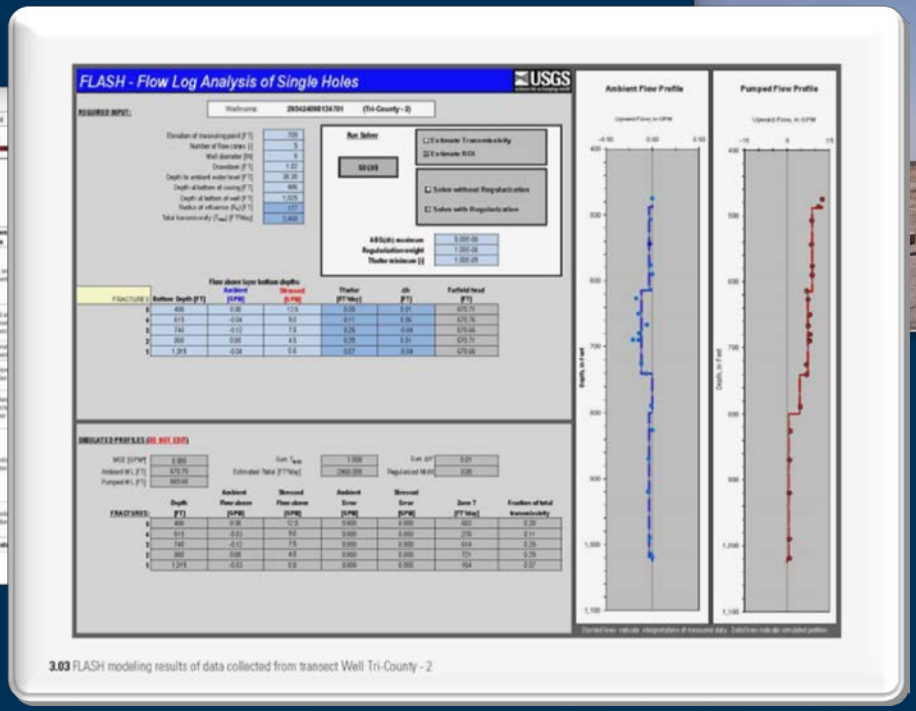
Vertical Borehole Flow and Hydraulic Properties

- FLASH: Flow Log Analysis of Single Holes
  - Total transmissivity/radius of influence
  - Zone transmissivity
  - Delta head values between zones
  - T-factors



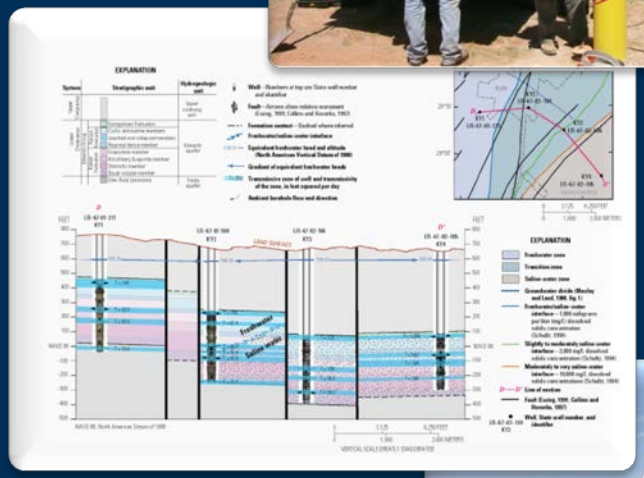


3.03 FLASH modeling results of data collected from transect Well Tri-County - 2

USGS

Equivalent Freshwater Head

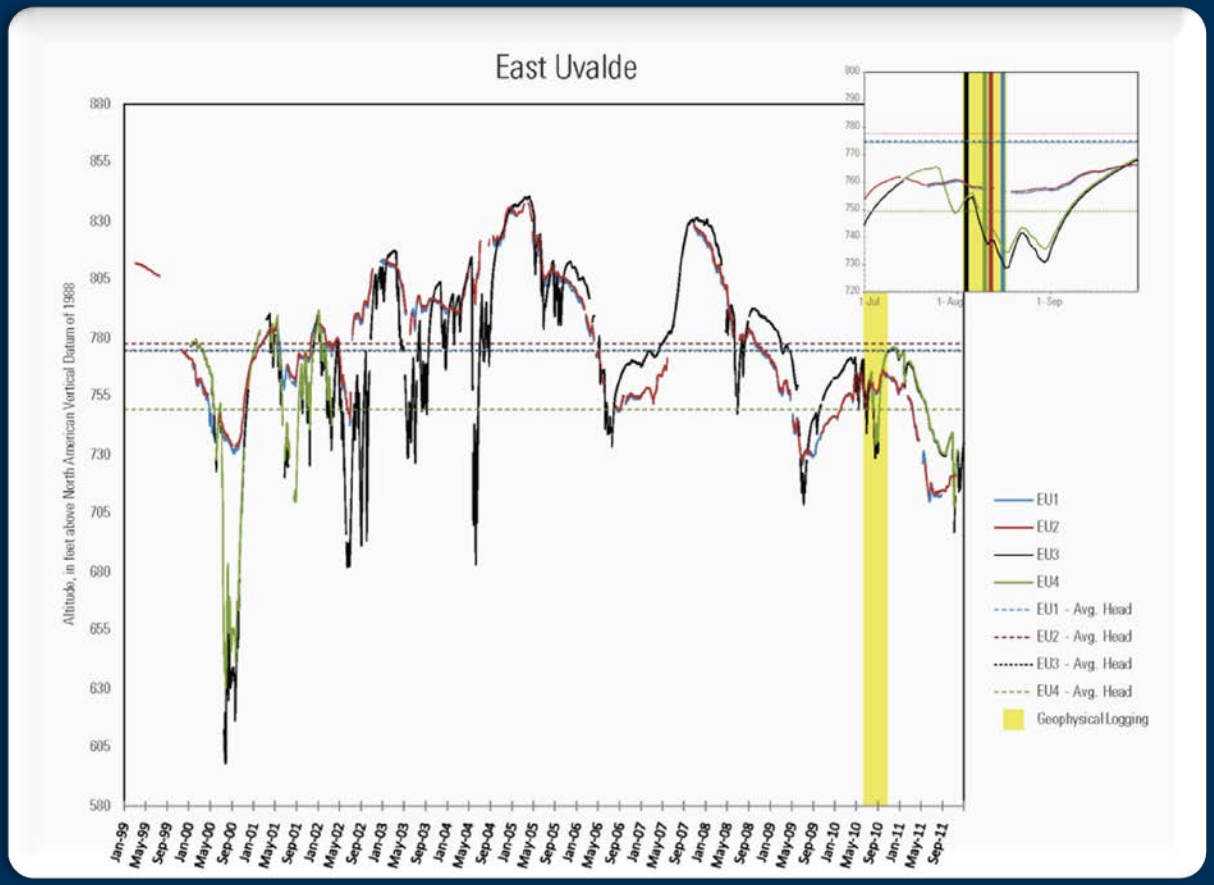
- Field measurements
  - Fluid temperature and conductivity
  - Environmental head
- Calculated variables
  - Fluid density
    - Freshwater
    - Saline-Water
  - $l_f = (\rho_s/\rho_f)(l_s)$
  - $h_f = h_s + (l_f - l_s)$
- Horizontal gradient calculations
- Drawdown corrections



USGS

Borehole Flow and Hydraulic Properties

- Continuous groundwater-level monitoring
- Indicator of **hydraulic connection strength**
- Indicator **horizontal gradient changes**



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Saline Zone Modeling

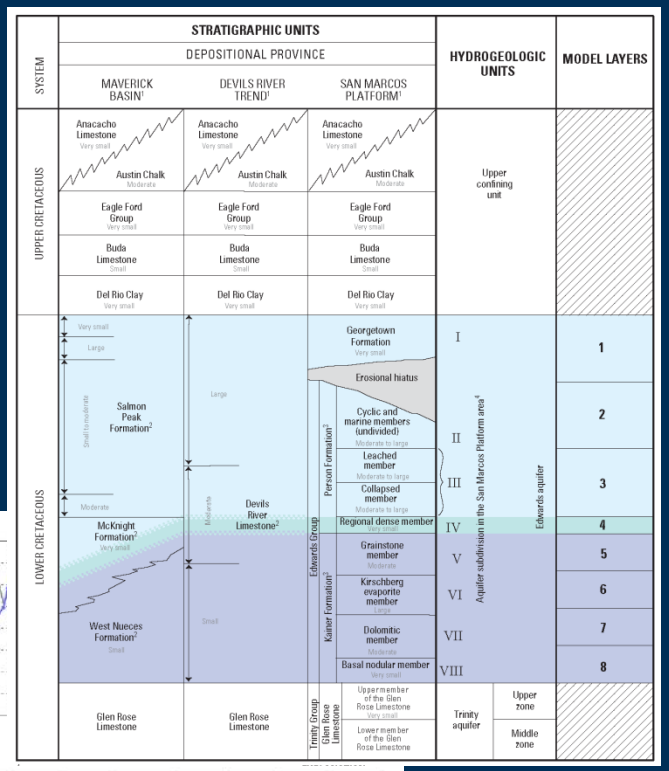
Uncertainty of Drought Conditions (1950-1956) on Brackish-Water Movement within the Edwards Aquifer

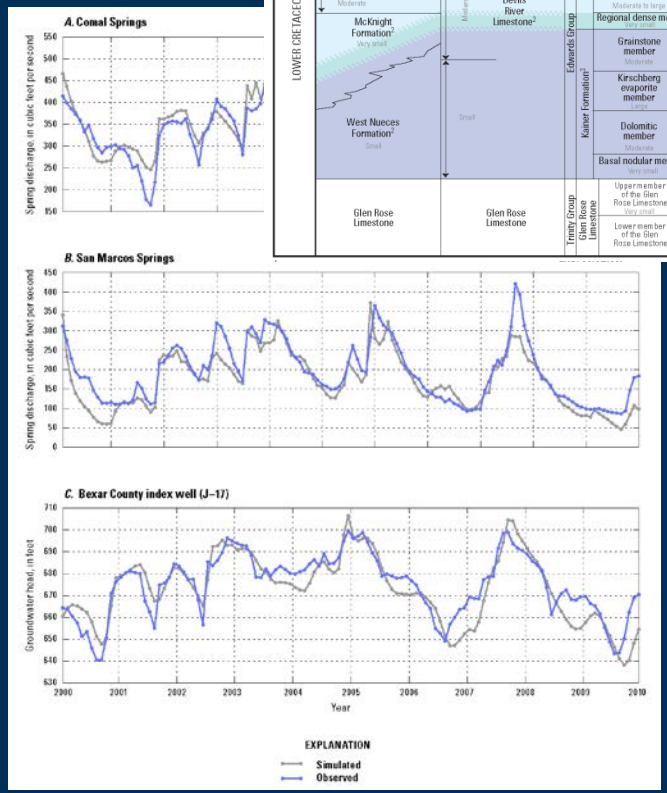
- Repeat of drought of 1950s
- Freshwater and brackish-water flow changes?
- Brackish-water encroachment at production wells?

USGS

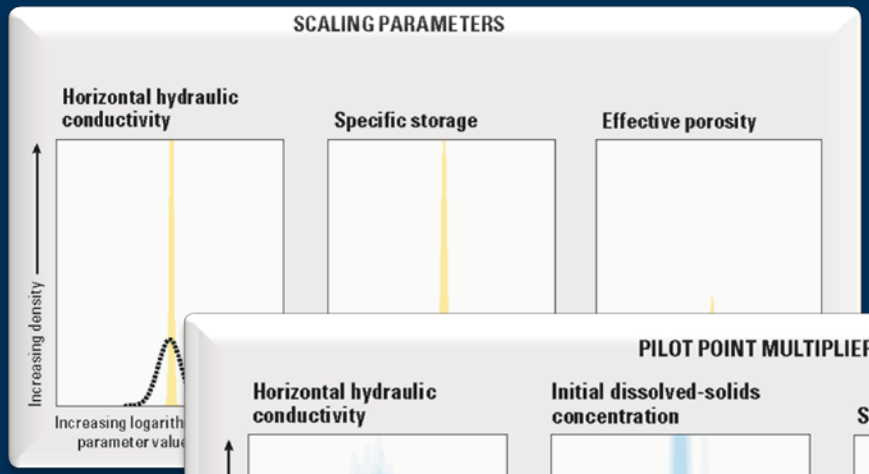
MODFLOW TO SEAWAT

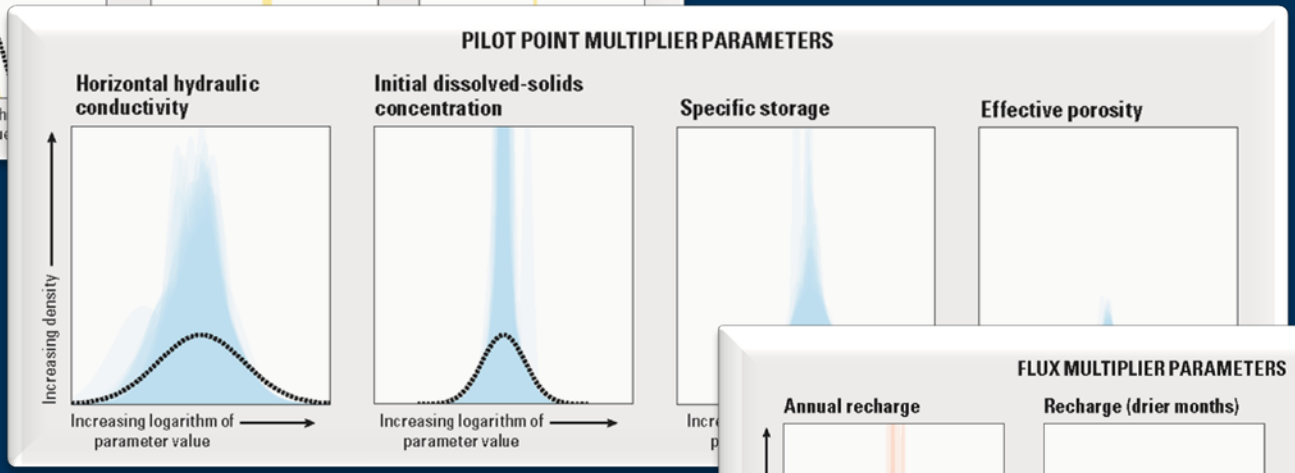
- Density-dependence on dissolved-solids concentrations (SEAWAT) ~ *brackish water*
- 1-layer model to 8-layer model
- Upper (layers 1-3), Middle (layer 4), and Lower (layers 5-8)
- Highly-parameterized inversion with PEST++ for calibration, parameter estimation and uncertainty analysis

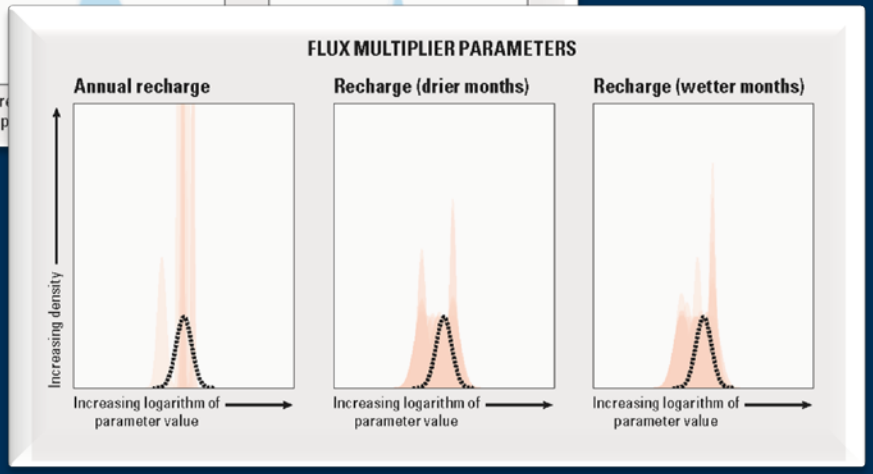




Parameter and Forecast Uncertainty







- Minimal encroachment
- Model assessment

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Example - Subsidence and Groundwater Level Monitoring

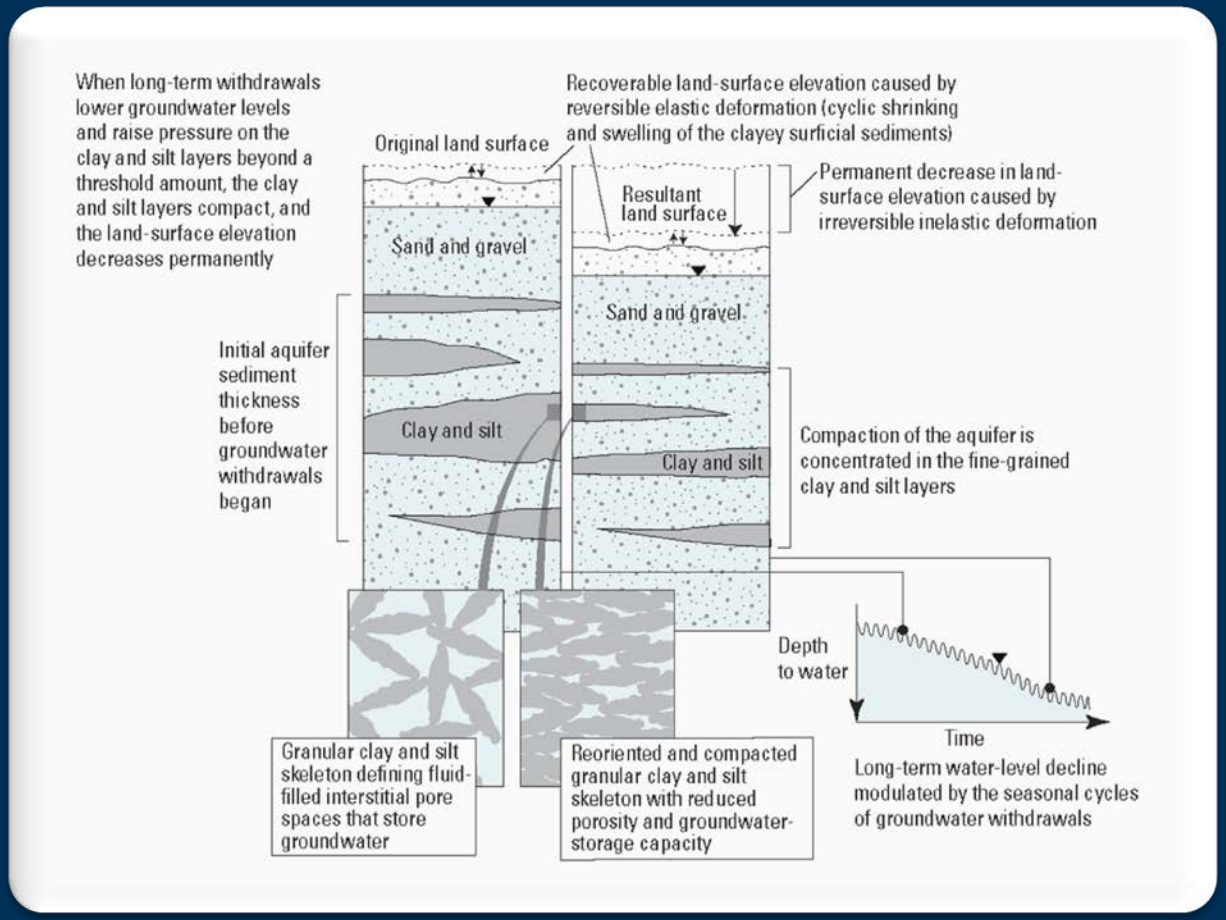
- Use of water-level altitudes to assess and monitor subsidence

- http://pubs.usgs.gov/sim/3337/

USGS

Land-Surface Subsidence Monitoring

- Compaction of subsurface sediments
- Fine-grained clay and silt layers
- Depressured and dewatered units



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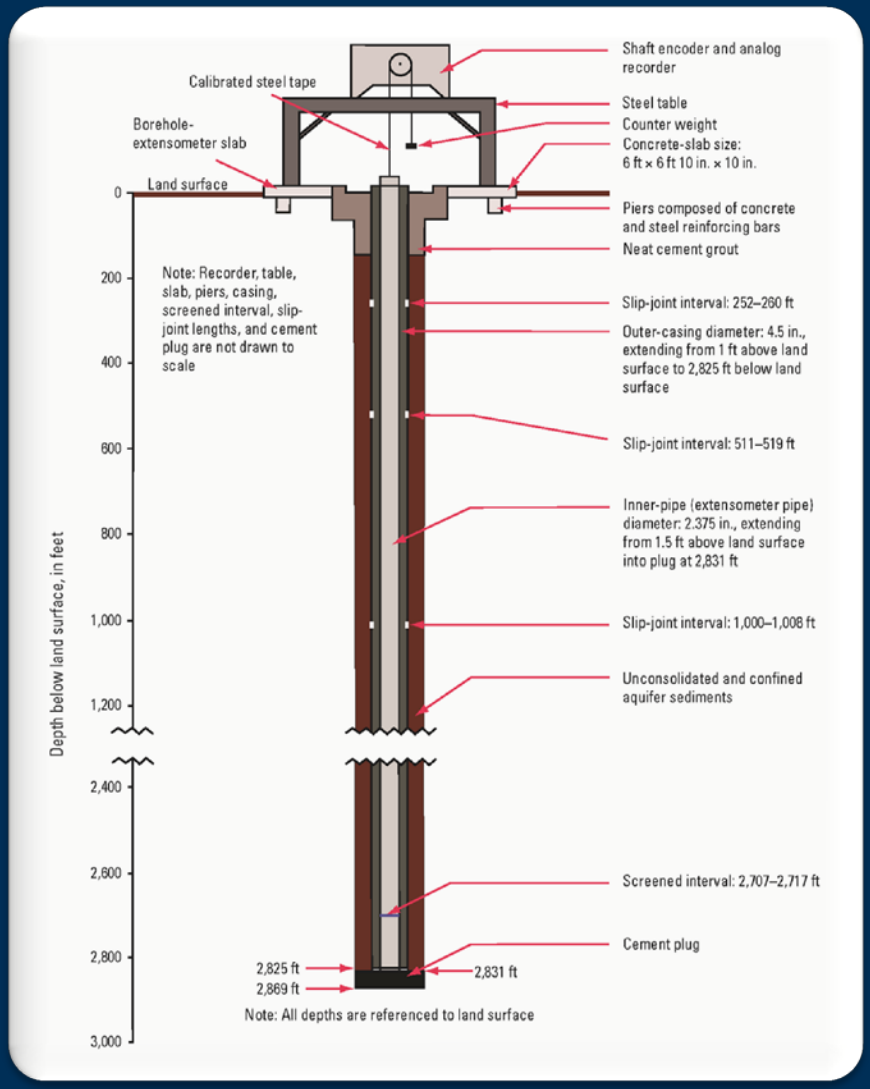

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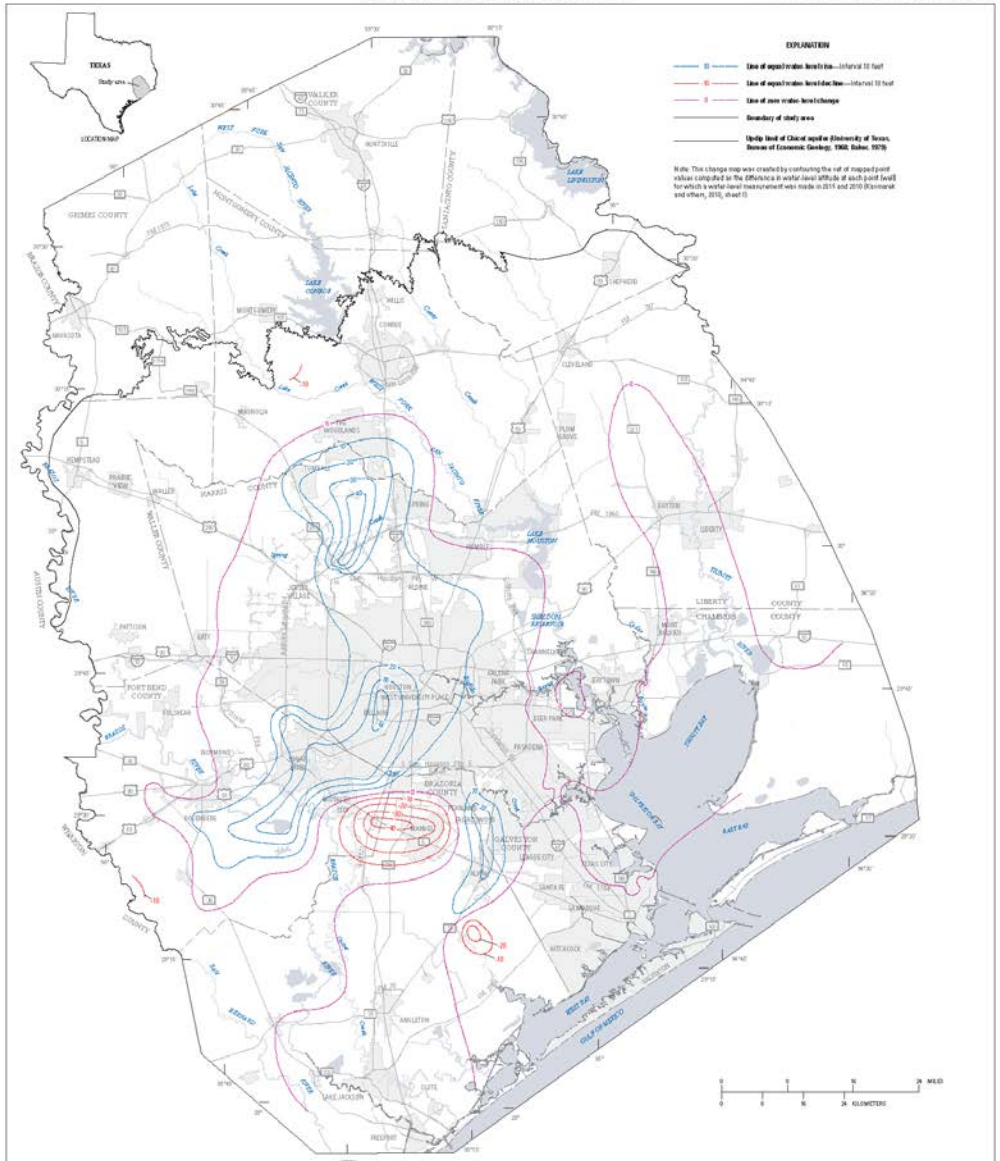
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
HARRIS-GALVESTON SUBSIDENCE DISTRICT,
CITY OF HOUSTON, FORT BEND SUBSIDENCE DISTRICT,
LONE STAR GROUNDWATER CONSERVATION DISTRICT, AND
BRAZORIA COUNTY GROUNDWATER CONSERVATION DISTRICT

SCIENTIFIC INVESTIGATIONS MAP 3337
Approximate water-level changes, Chicot aquifer, 2010–15—SHEET 3 OF 16



Sheet 3. Approximate water-level changes in the Chicot aquifer, Houston-Galveston region, Texas, 2010–15.

Base from U.S. Geological Survey digital data, 1:100,000
Universal Transverse Mercator projection, Zone 15
North American Datum of 1927

Water-Level Altitudes 2015 and Water-Level Changes in the Chicot, Evangeline, and Jasper Aquifers and Compaction 1973–2014 in the Chicot and Evangeline Aquifers, Houston-Galveston Region, Texas

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2015

Publications regarding water resources in Texas is available at http://tx.usgs.gov/

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http://dx.doi.org/10.3133/sim3337

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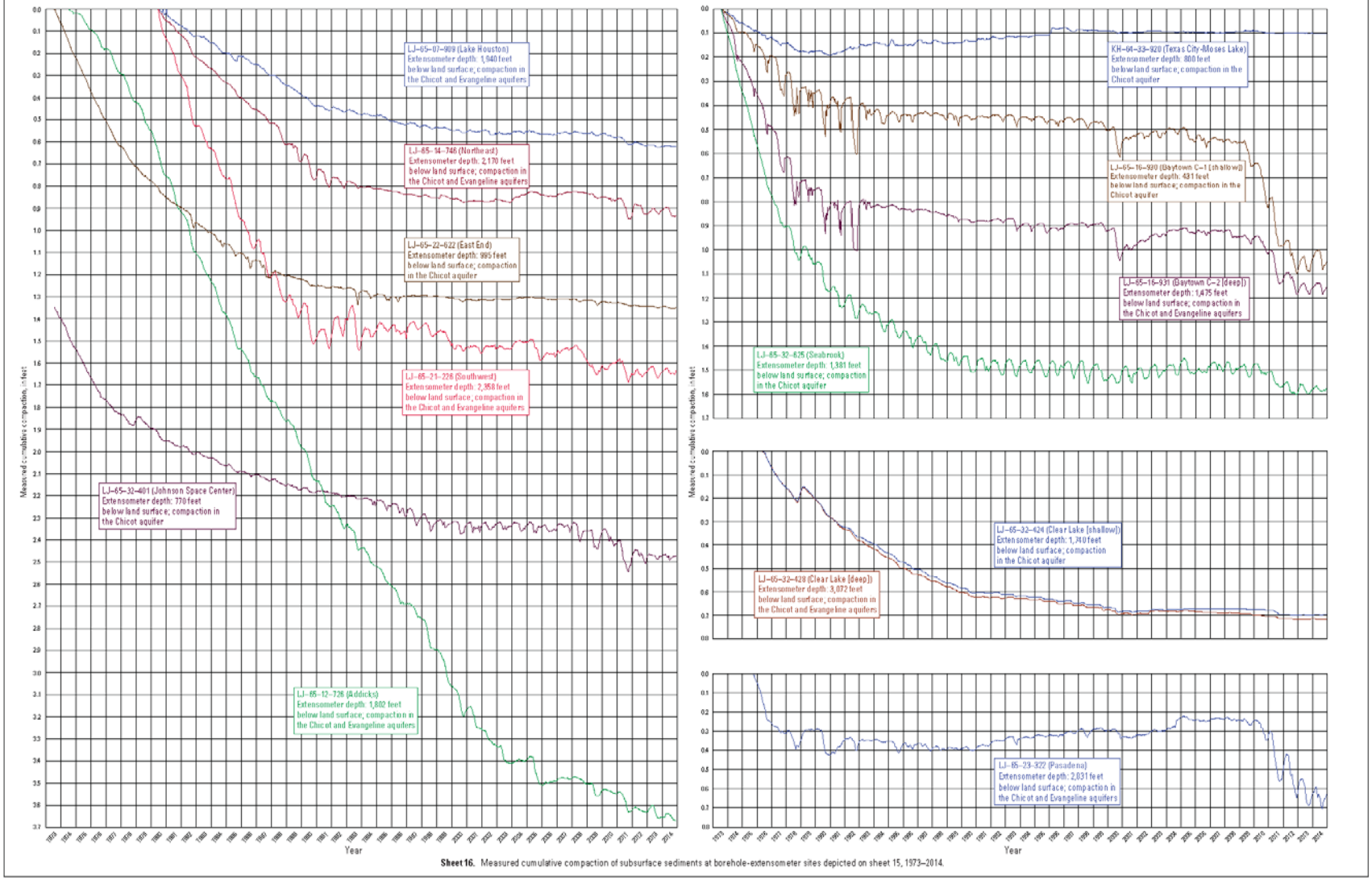
SCIENTIFIC INVESTIGATIONS MAP 3337
Measured cumulative compaction of subsurface sediments, 1973–2014—SHEET 16 OF 16

Kasmarek, M.C., Jason, J.K., Houston, N.A., Johnson, M.R., and Schmidt, T.S., 2015, Water-level altitudes 2015 and water-level changes in the Chicot, Evangeline, and Jasper aquifers and compaction 1973–2014 in the Chicot and Evangeline aquifers, Houston-Galveston region, Texas



Sheet 16. Measured cumulative compaction of subsurface sediments at borehole-extensometer sites depicted on sheet 15, 1973–2014.

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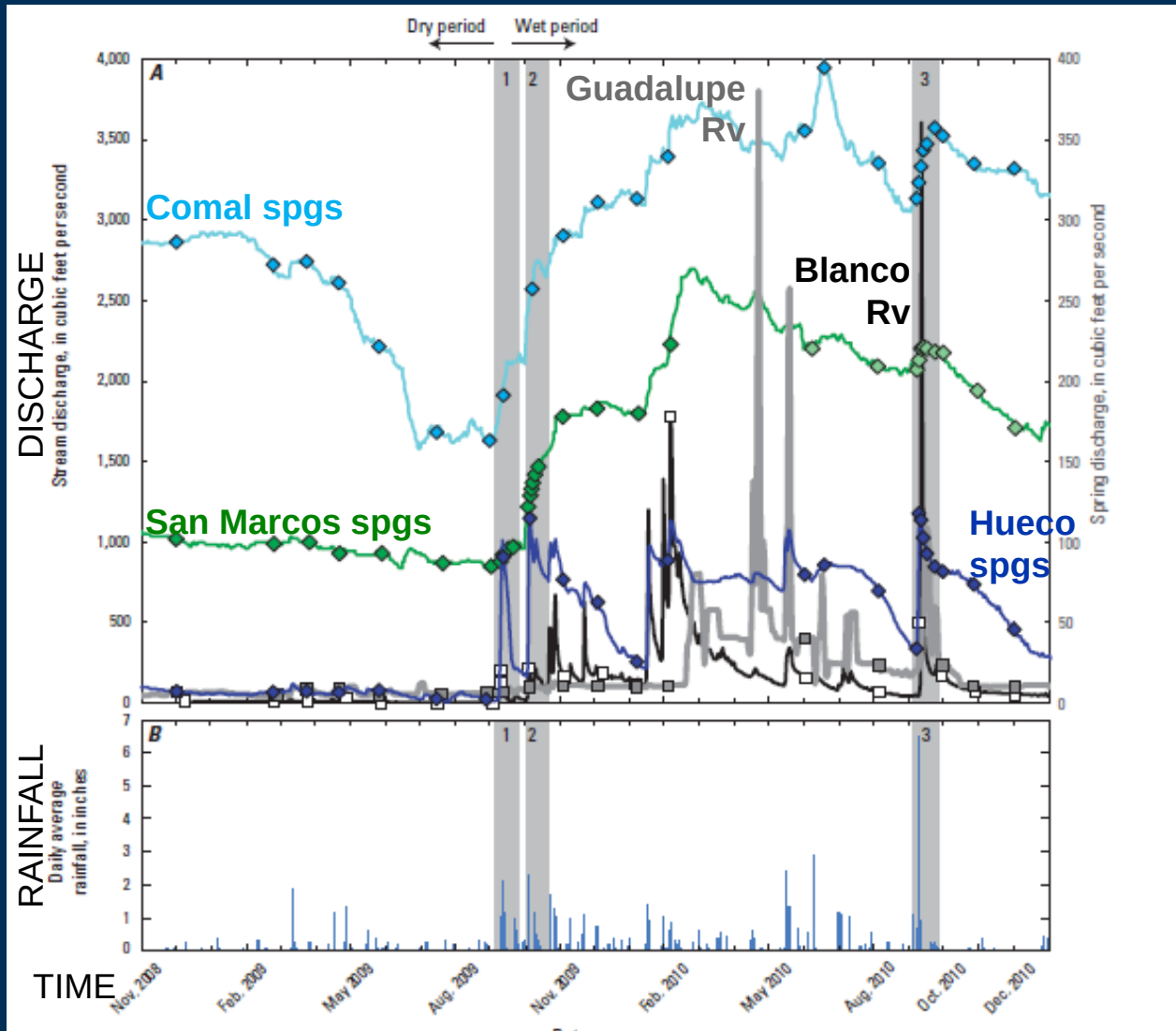
San Marcos Springs

http://pubs.er.usgs.gov/publication/sir20125126

- Source of water to San Marcos springs?
- Does it change over varying hydrologic conditions?



San Marcos Springs

http://pubs.usgs.gov/fs/2013/3080/

Geo-chemical mixing models of spring water with Blanco River water

100 % spring water

100 % surface water

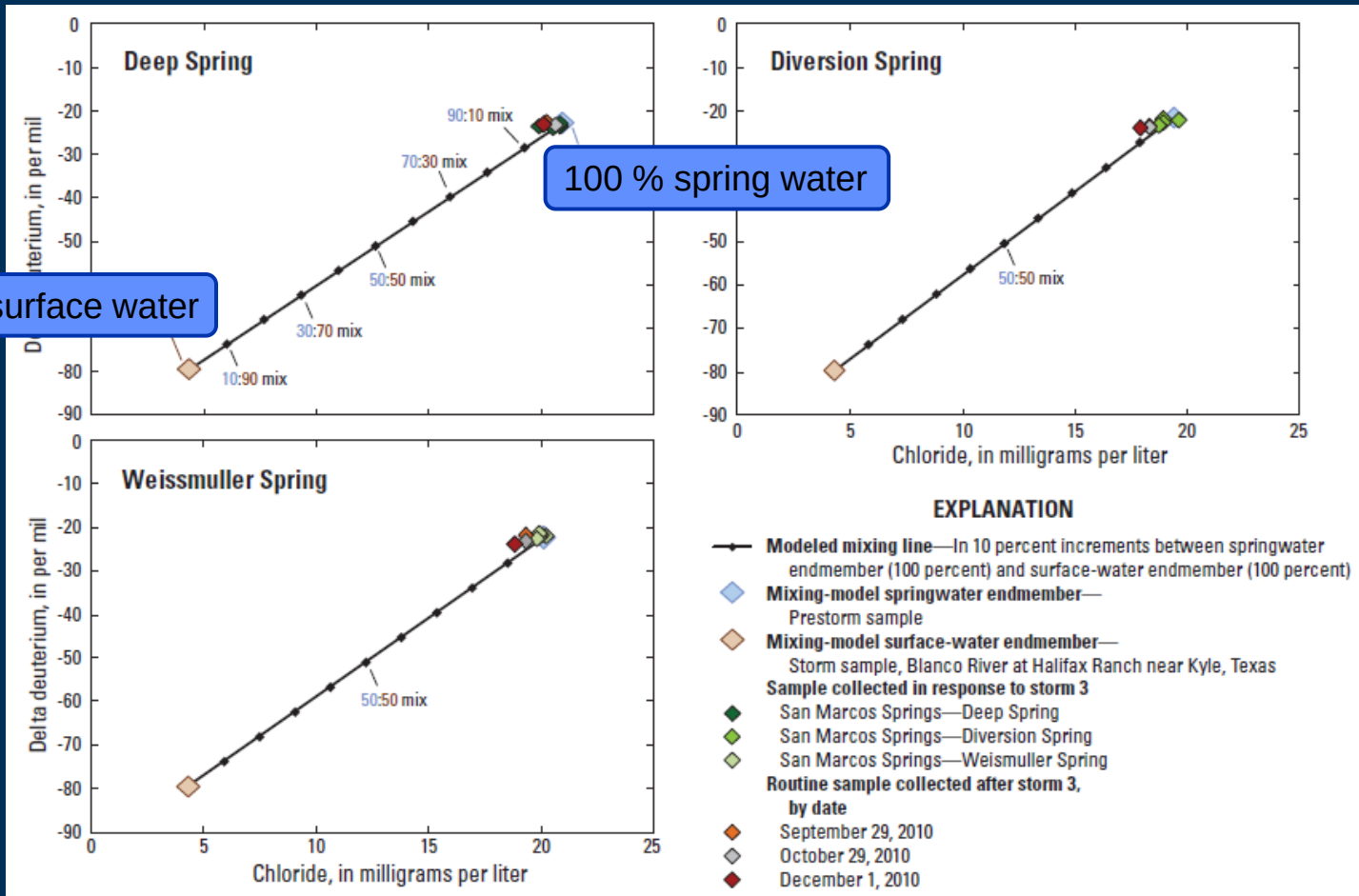


Figure 4. Relation between chloride concentration and deuterium isotopes for two-component mixing models showing proportional mixing between surface-water (stream recharge) and springwater endmembers for San Marcos Springs samples collected immediately following and several months after Tropical Storm Hermine in September 2010.

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Questions?

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