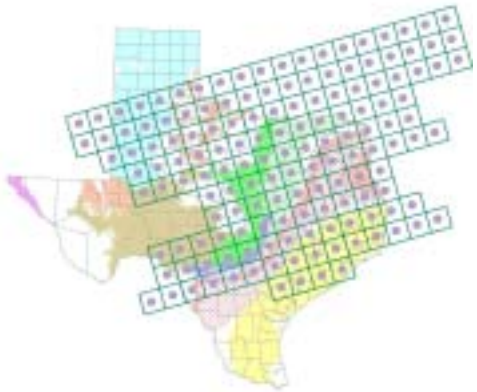
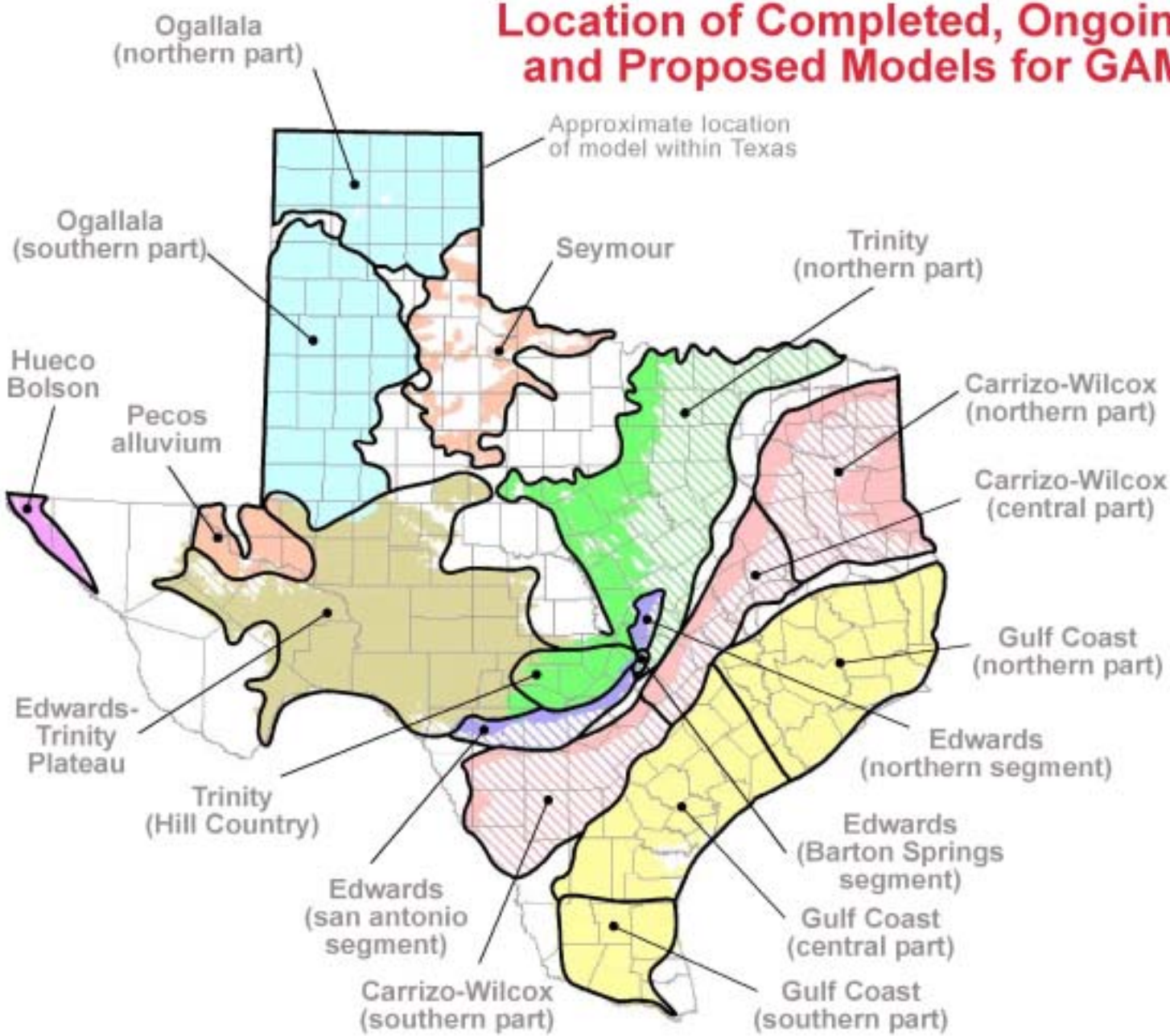


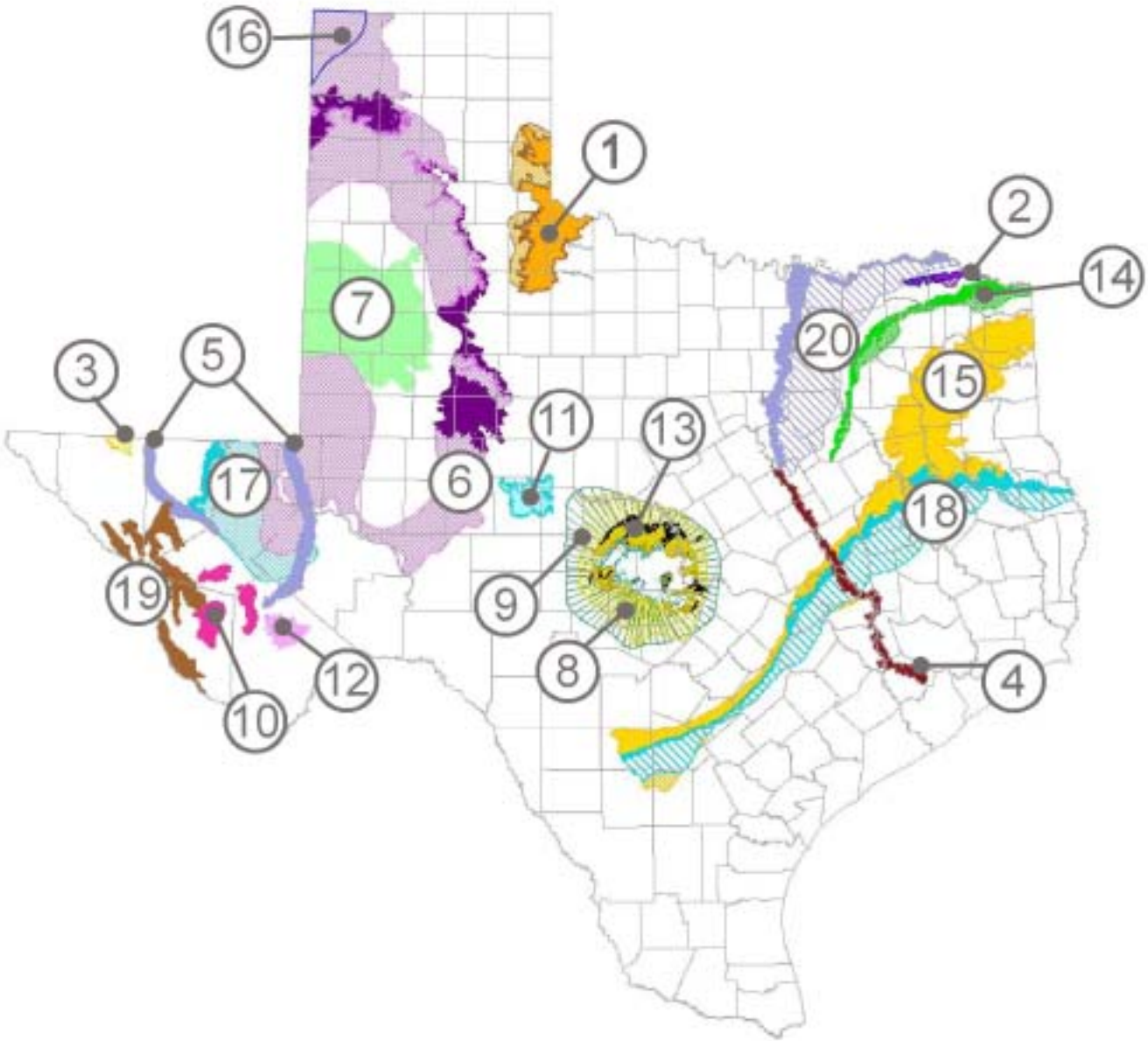
Groundwater Availability Modeling (GAM):

- purpose: to provide reliable and timely information on groundwater availability
- assess adequacy or recognize inadequacy of supplies throughout 50 year planning horizon
- public process
- standardized, thoroughly documented, and available to public over Internet

Location of Completed, Ongoing, and Proposed Models for GAM

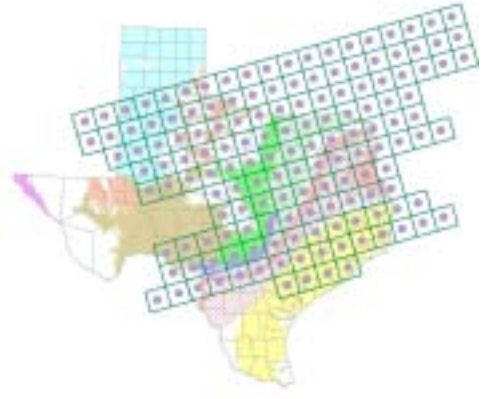


Location of the Minor Aquifers in Texas for GAM

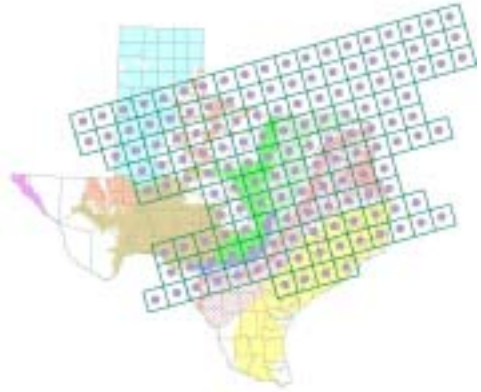


1. Blaine d
2. Blossum n
3. Bone Spring-Victorio Peak n
4. Brazos River alluvium n
5. Capitan Reef n
6. Dockum c,n
7. Edwards-Trinity (High Plains) c
8. Ellenburger-San Saba n
9. Hickory n
10. Igneous n
11. Lipan d
12. Marathon n
13. Marble Falls n
14. Nacatoch n
15. Queen City c
16. Rita Blanca d
17. Rustler n
18. Sparta c
19. West Texas Bolsons d,n
20. Woodbine c

What is a groundwater model?



- a tool to estimate field conditions
- allows effective use of available data and account for complexities
- expands our ability to better understand and manage the water resources
- increases prediction accuracy of future events to a level far beyond “best judgement” decisions



Modeling Protocol

Purpose

Conceptual model

Numerical formulation

Model design

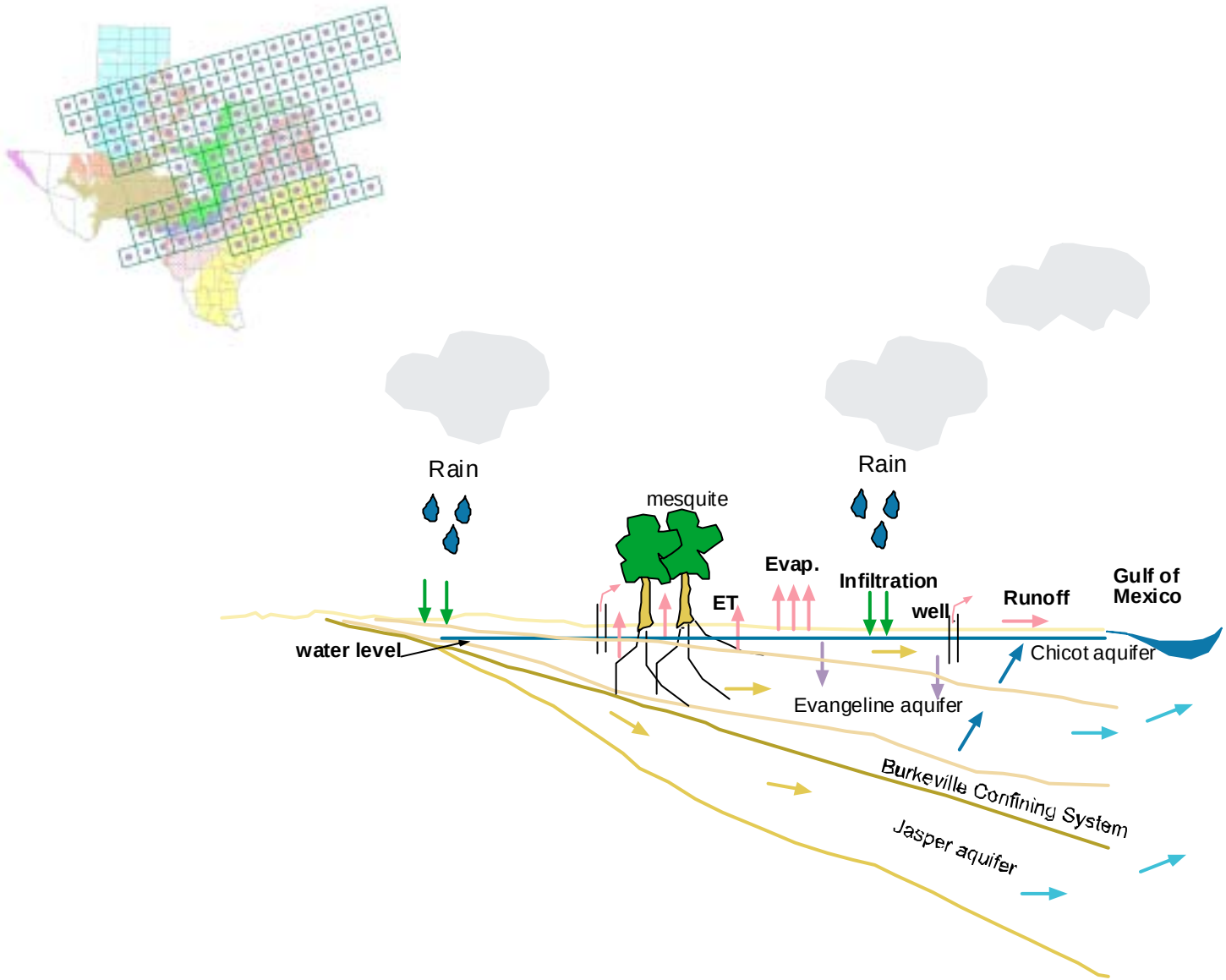
Calibration → Steady-state Model

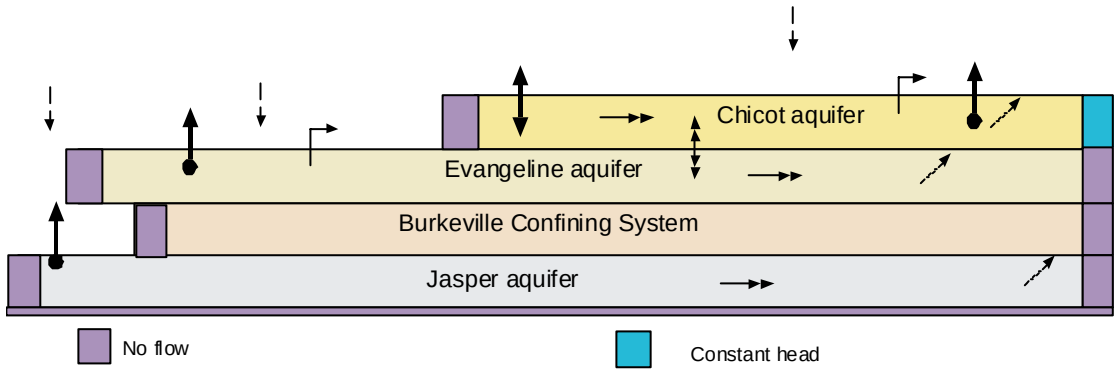
Comparison with field data

Verification → Transient Model (1980-2000)

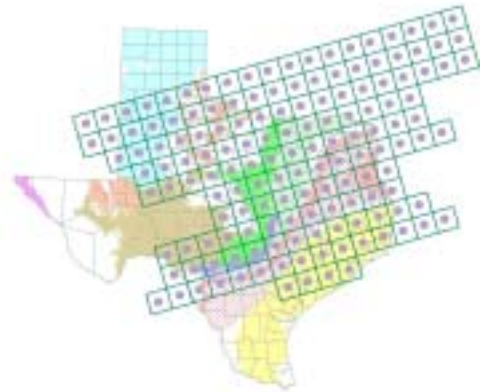
Prediction → Prediction Runs (2000-2050)

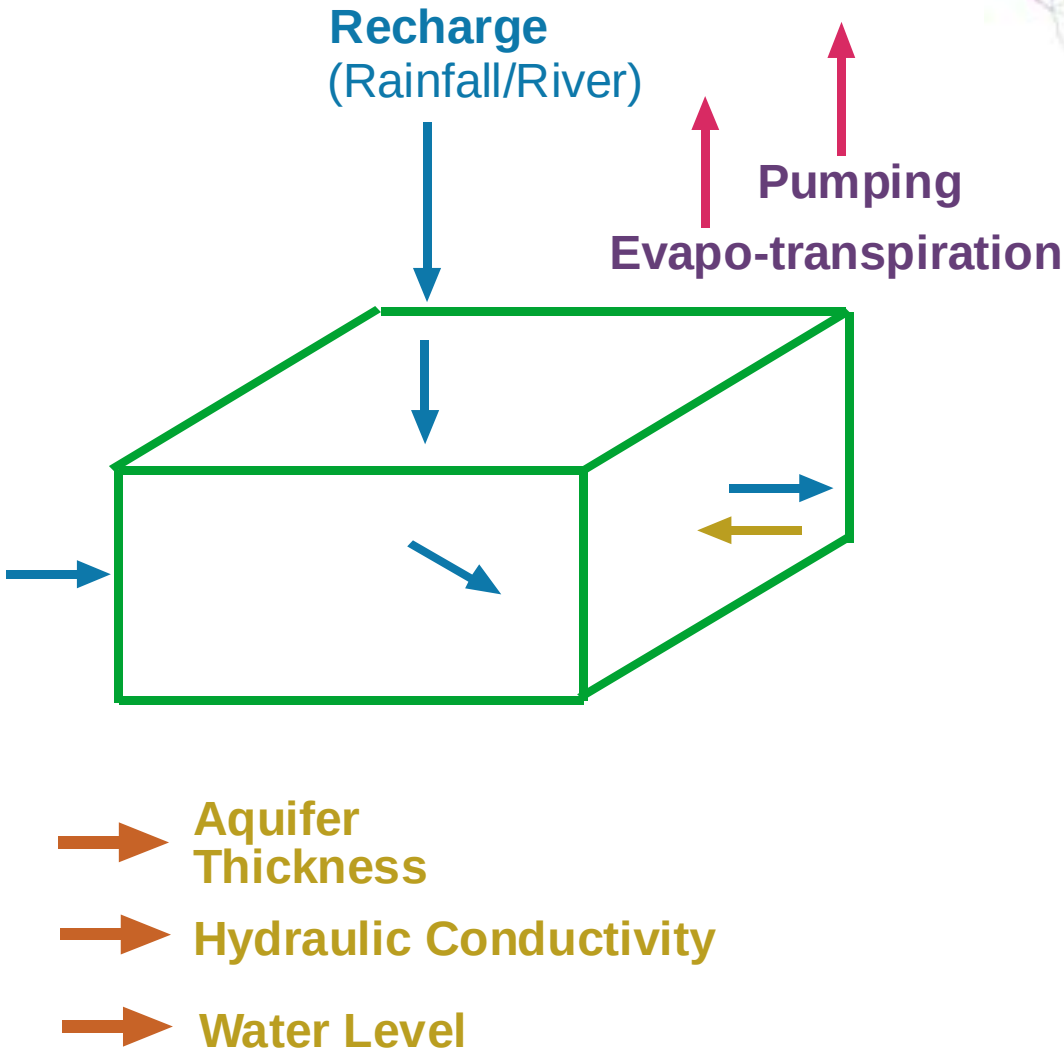
Field data → Postaudit


Rain
Rain
mesquite
Evap.
Infiltration
ET
well
Runoff
Gulf of Mexico
water level
Chicot aquifer
Evangeline aquifer
Burkeville Confining System
Jasper aquifer


Chicot aquifer
Evangeline aquifer
Burkeville Confining System
Jasper aquifer
No flow
Constant head
Recharge
Cross-formational flow
Groundwater-surfacewater interaction
Pumping
Evapo-transpiration
Groundwater flow
Natural discharge

A Model Cell



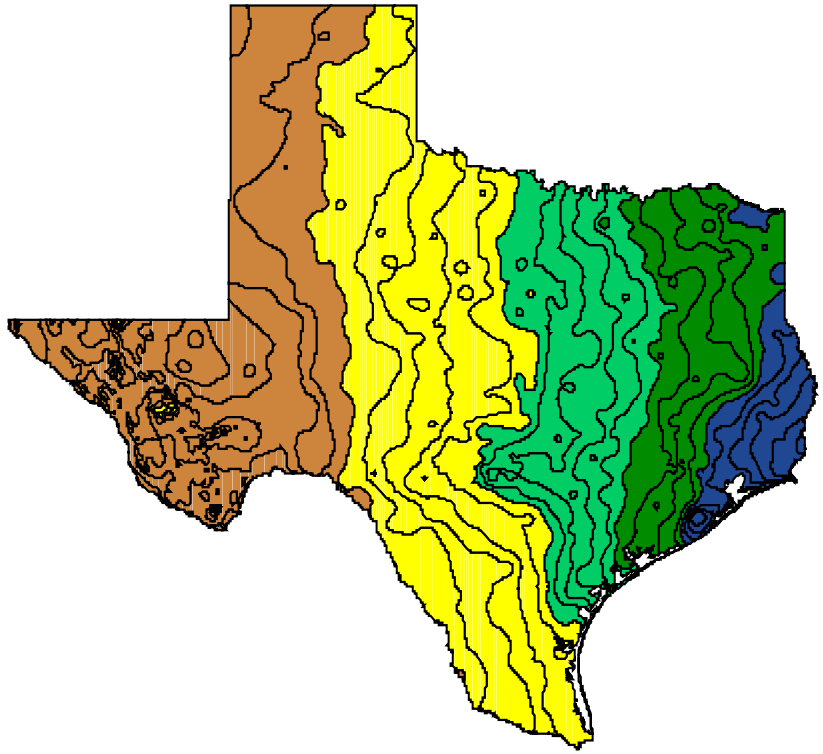

Recharge
(Rainfall/River)
Pumping
Evapo-transpiration
Aquifer
Thickness
Hydraulic Conductivity
Water Level

Recharge

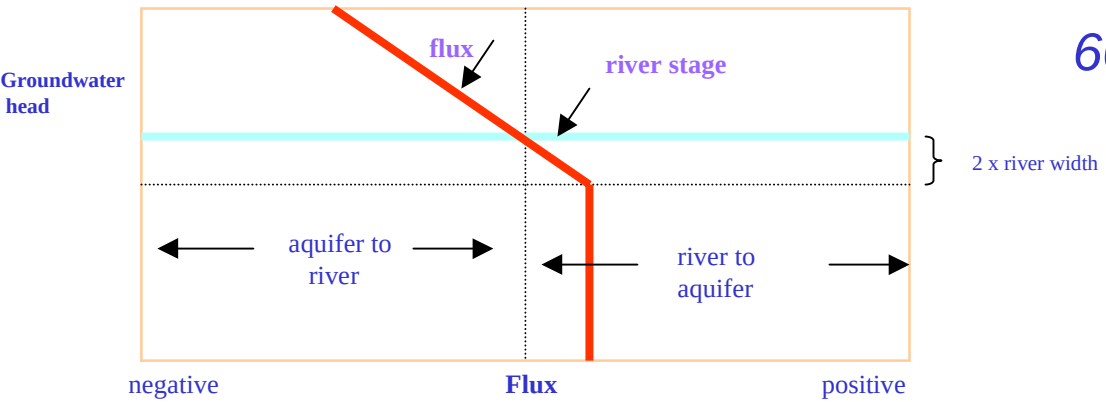
- *diffuse (direct) - precipitation or irrigation*
- *focused or localized - surface depressions, e.g. lakes or playas*
- *indirect recharge - beneath rivers, lakes*

- *recharge rate depends on rainfall, vegetation, soil type, topography*

- *recharge estimation - water budget, surface water techniques, numerical modeling, tracers*



Average annual rainfall map
60 inches in the east to 8 inches in the west



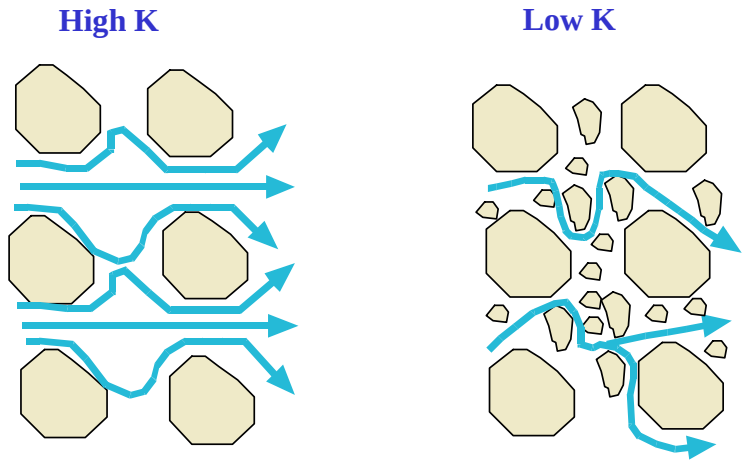
Recharge due to connection between rivers and aquifers
(Bouwer and Madock, 1997)

Recharge for the Gulf Coast aquifer

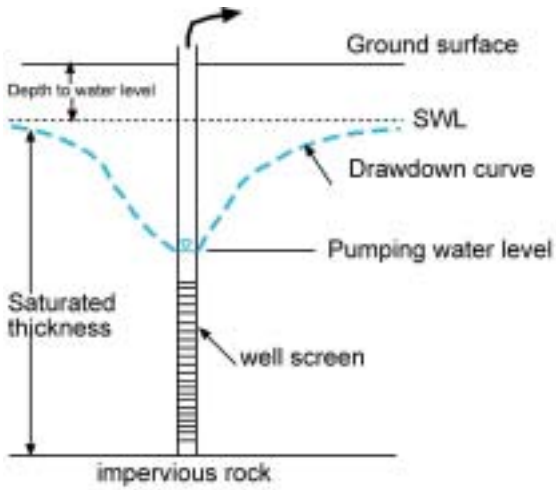
Source	Recharge (in/yr)
Groschen (1985)	0.06
Ryder (1988)	0 to 6
Dutton and Richter (1990)	0.1 to 0.4
Noble and others (1996)	6
Hay (1999)	.00004 to .04
Harden and Associates (2001)	3

Transmissivity

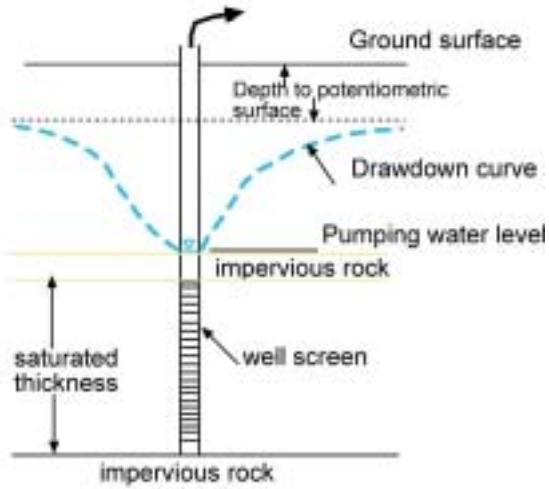
- transmission capability of the entire thickness of the aquifer
(T = KB, hydraulic conductivity aquifer thickness)*
- *hydraulic conductivity (pump test, grain sizes and lab tests)*
- *specific capacity*



Hydraulic conductivity is affected by degree of interconnection between pores



Unconfined aquifer



Confined aquifer

Pumping

- *historical*
- *predictive*

Categories

- *municipal*
- *manufacturing*
- *domestic*
- *irrigation*
- *livestock*

groundwater availability modeling

- ‘Like beauty, groundwater availability is in the eye of the beholder’
- its a combination of policy and science
  - safe yield
  - as a percent of rainfall on outcrop
  - historical pumping
  - systematic depletion


TEXAS WATER DEVELOPMENT BOARD

Quality Scientific Data Collection and Analysis for the Long Term

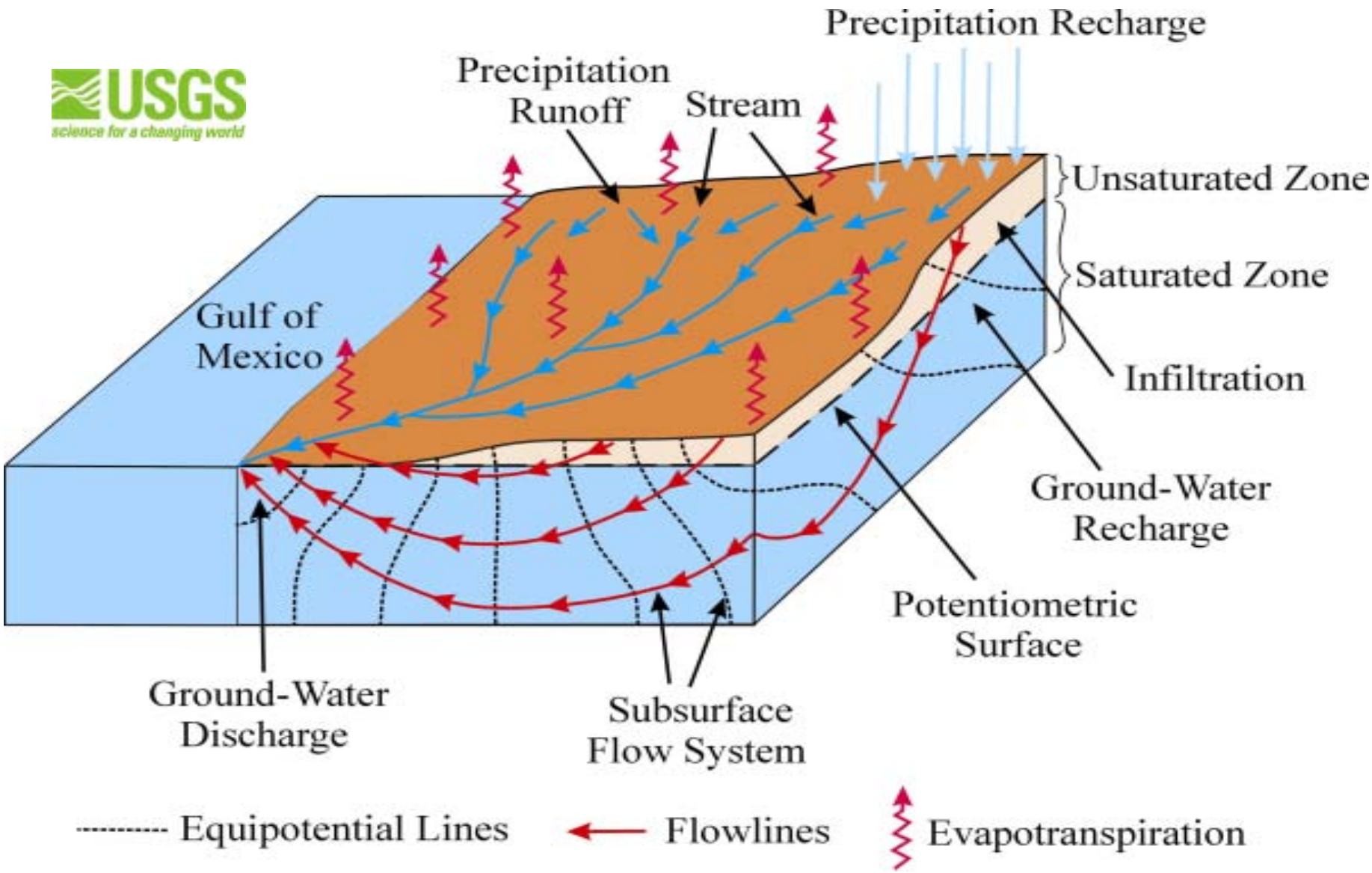
Hydrogeology, Simulation of Ground-Water Flow, and Land-Surface Subsidence in the Chicot, Evangeline, and Jasper Aquifers, Houston Area, Texas

Mark C. Kasmarek & Eric W. Strom

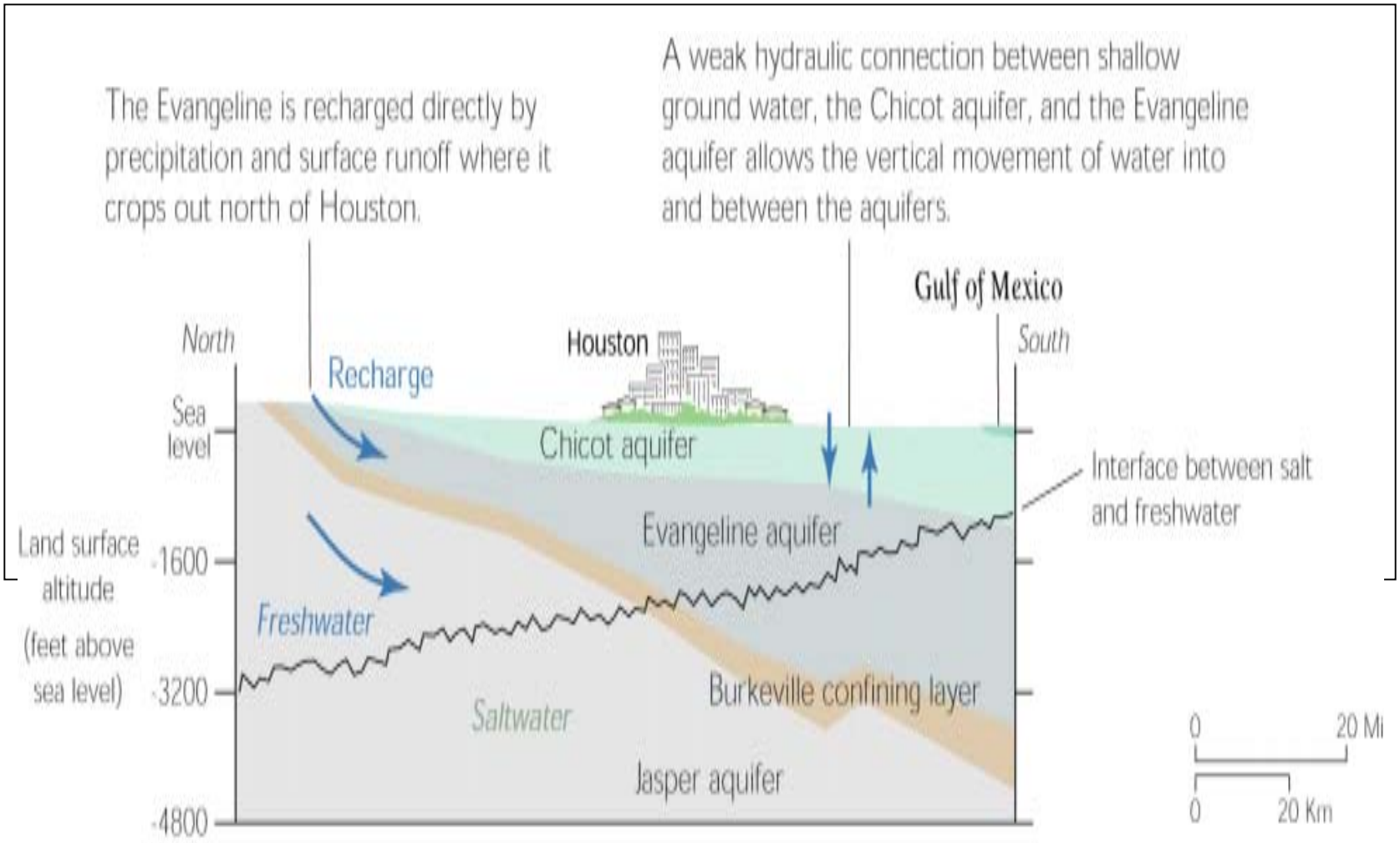
In Cooperation with the Texas Water Development Board and the Harris-Galveston Coastal Subsidence District

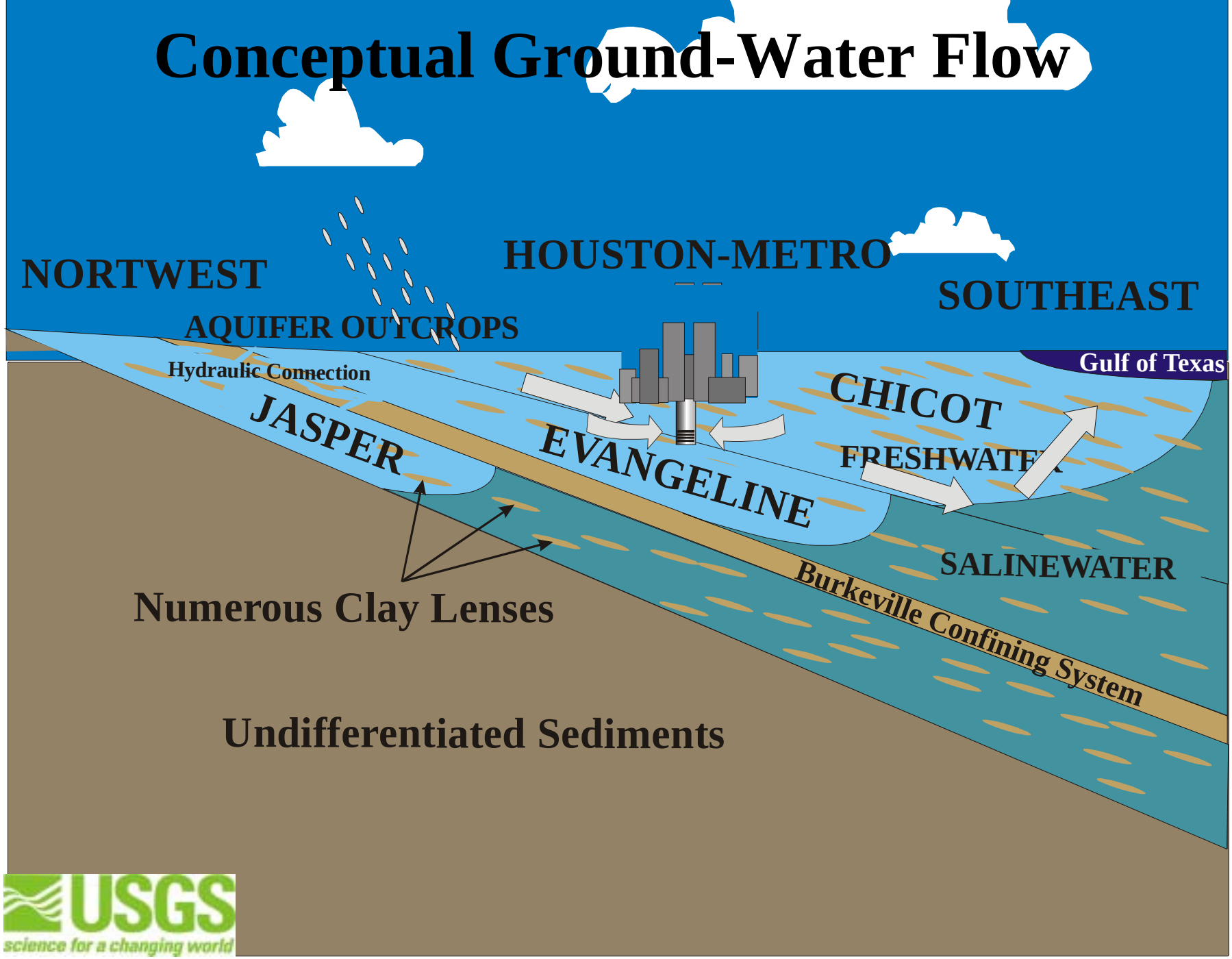
USGS
science for a changing world

Conceptual Chicot Aquifer Flow System

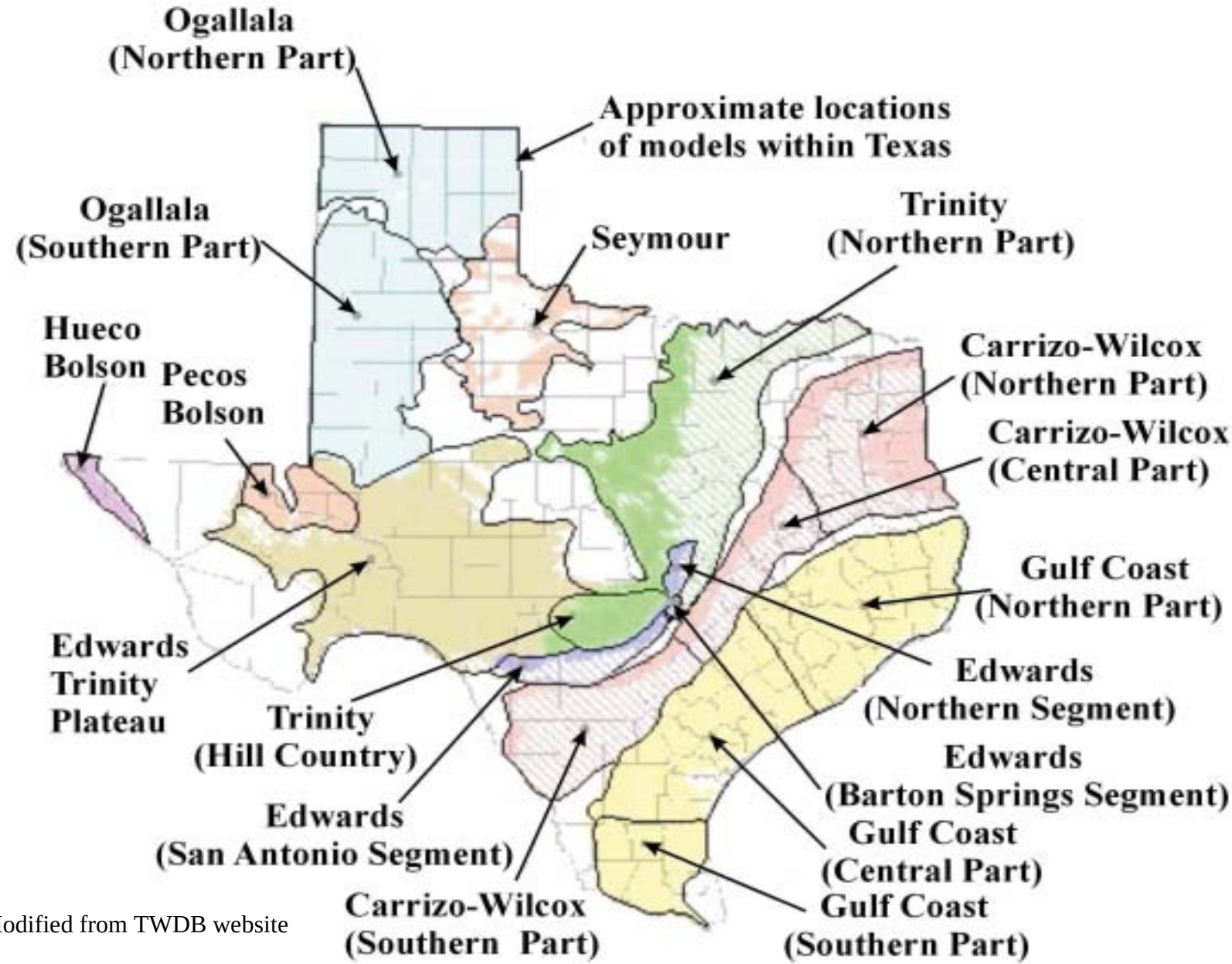


Conceptual Ground-Water Flow



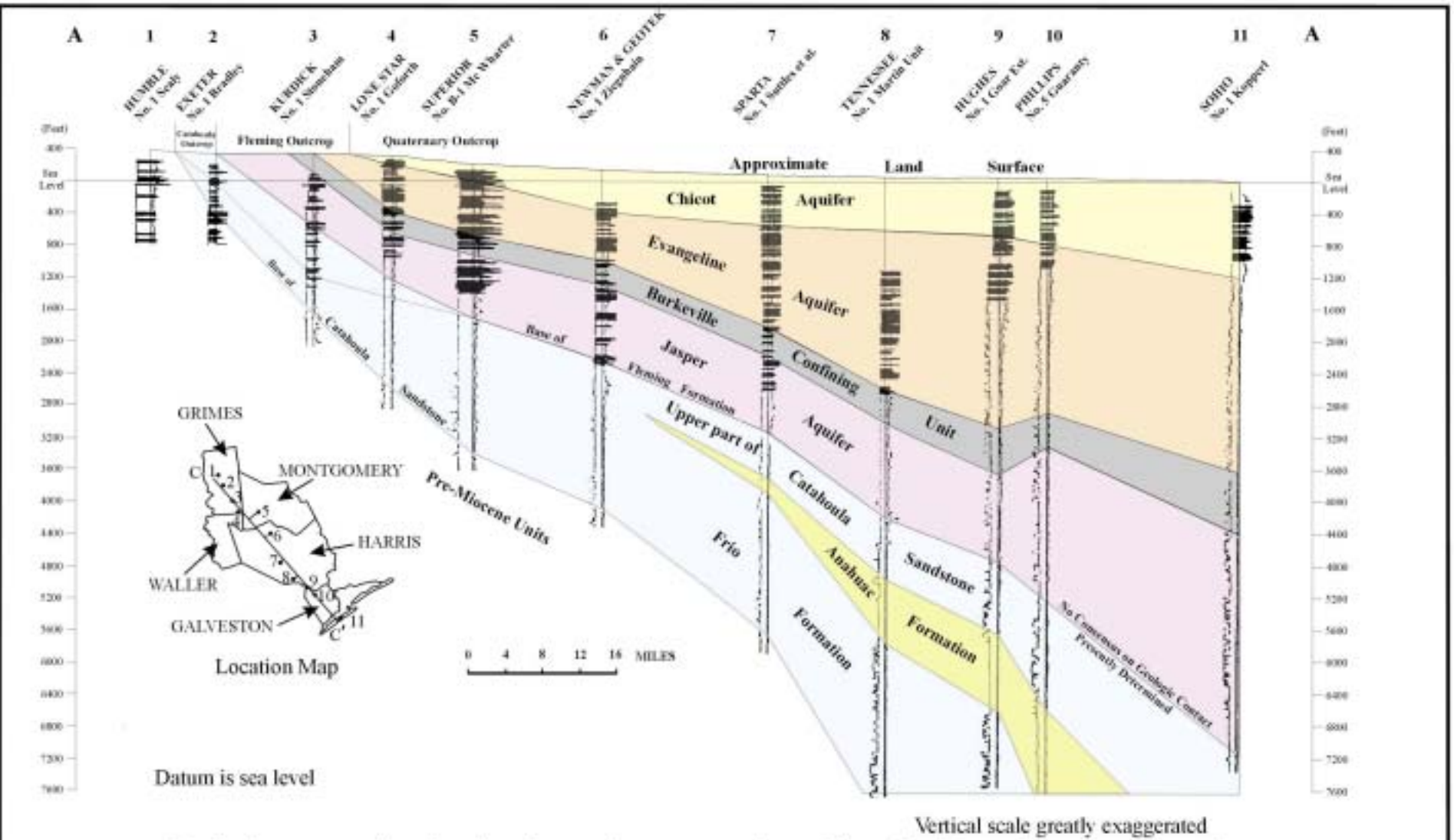

Conceptual Ground-Water Flow
NORTWEST
HOUSTON-METRO
SOUTHEAST
AQUIFER OUTCROPS
Hydraulic Connection
Gulf of Texas
JASPER
EVANGELINE
CHICOT
FRESHWATER
SALINEWATER
Burkeville Confining System
Numerous Clay Lenses
Undifferentiated Sediments
USGS
science for a changing world

TWDB Ground-Water Availability Models in Texas



Modified from TWDB website

Stratigraphic and Hydrologic Sections

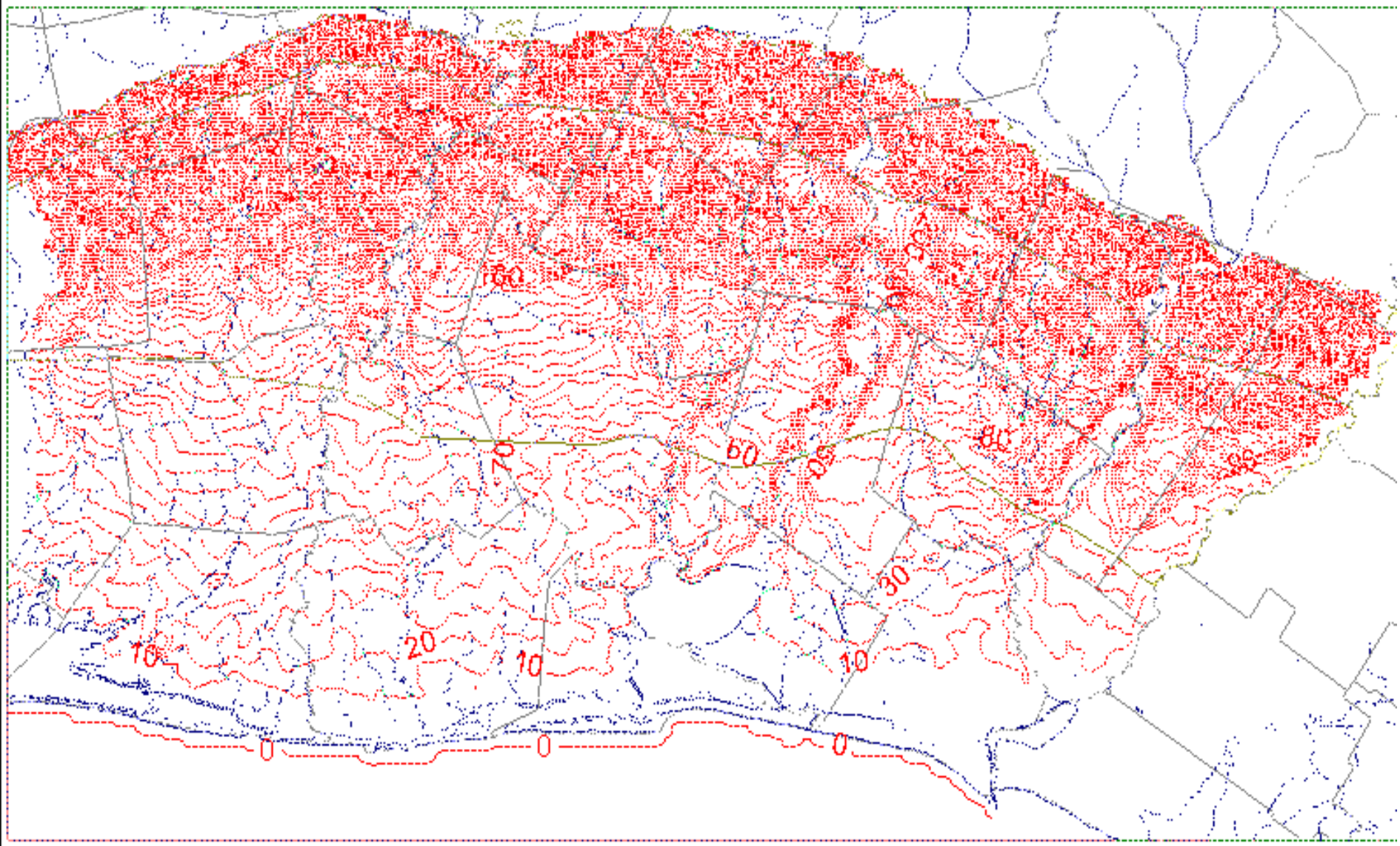


Geologic cross section showing the northwest to southeast dip and relation of stratigraphic and hydrologic units (modified from Baker, 1986).

Preliminary Water-Table Contours

Contours Range from 0 to 541.5 feet

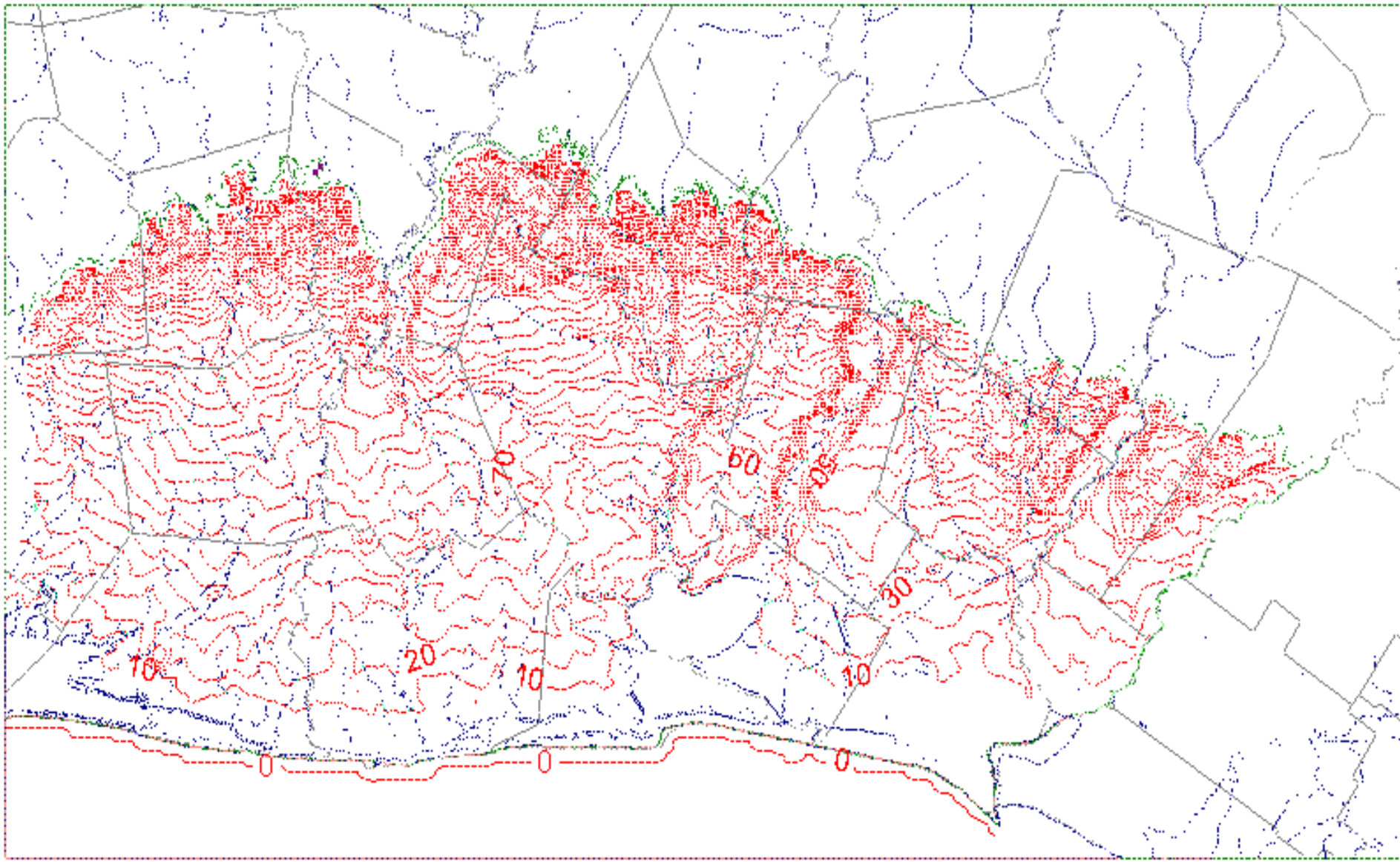
Contour Interval 10 feet



Preliminary Chicot Steady-State Heads

Contours Range from 0 to 421 feet

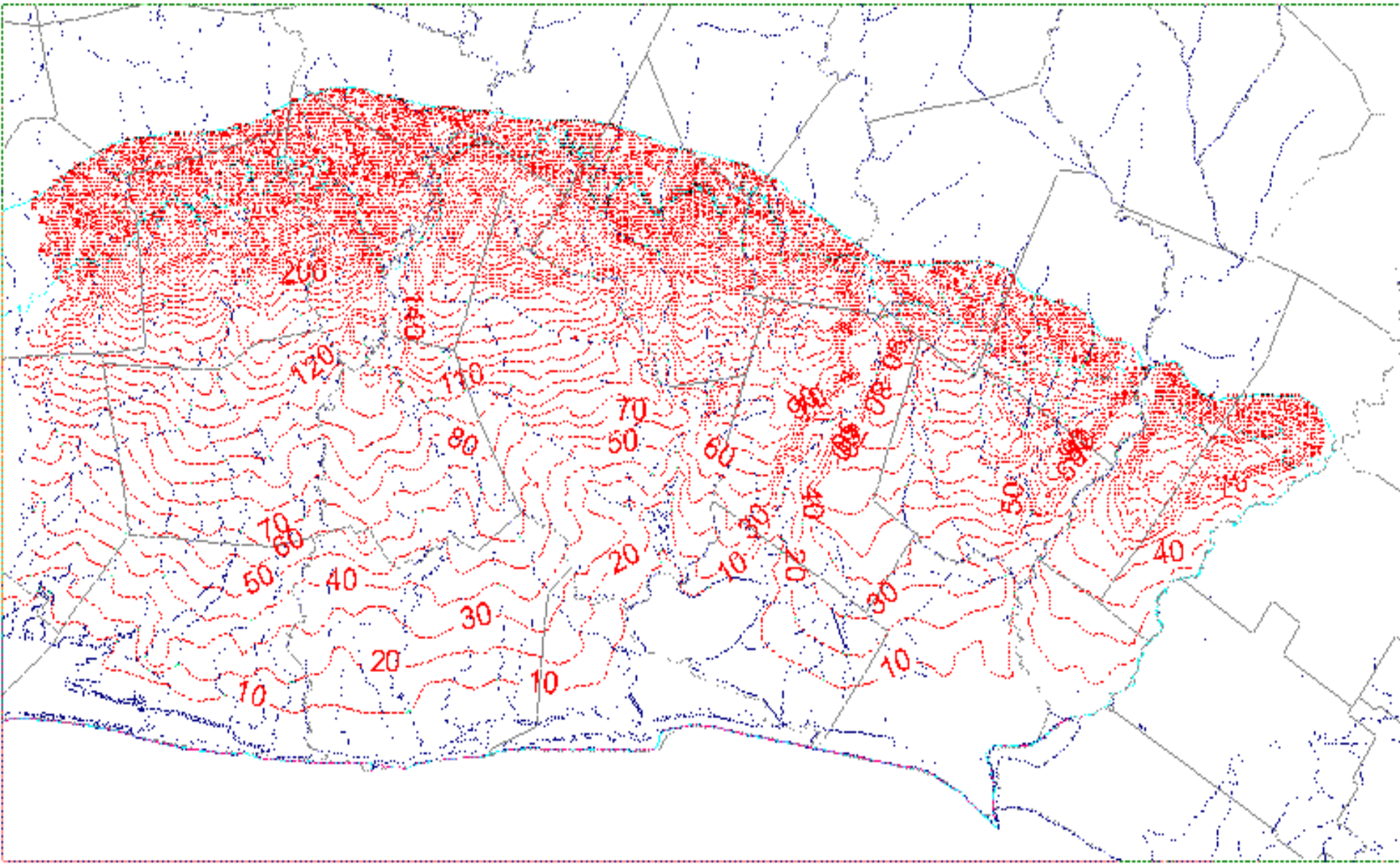
Contour Interval 10 feet



Preliminary Evangeline Steady-State Heads

Contours Range from 0 to 425 feet

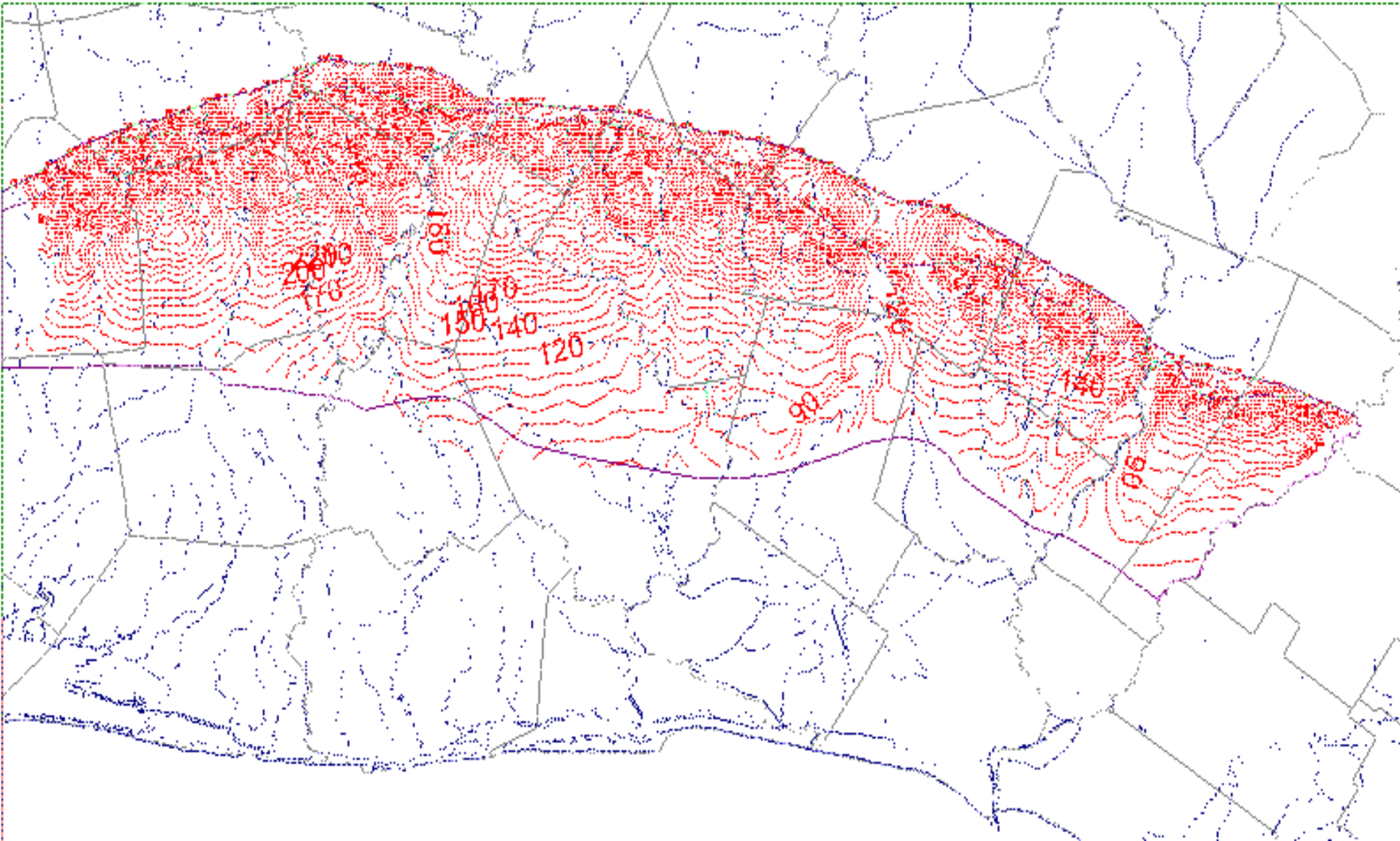
Contour Interval 10 feet



Preliminary Burkeville Steady-State Heads

Contours Range from 52 to 426 feet

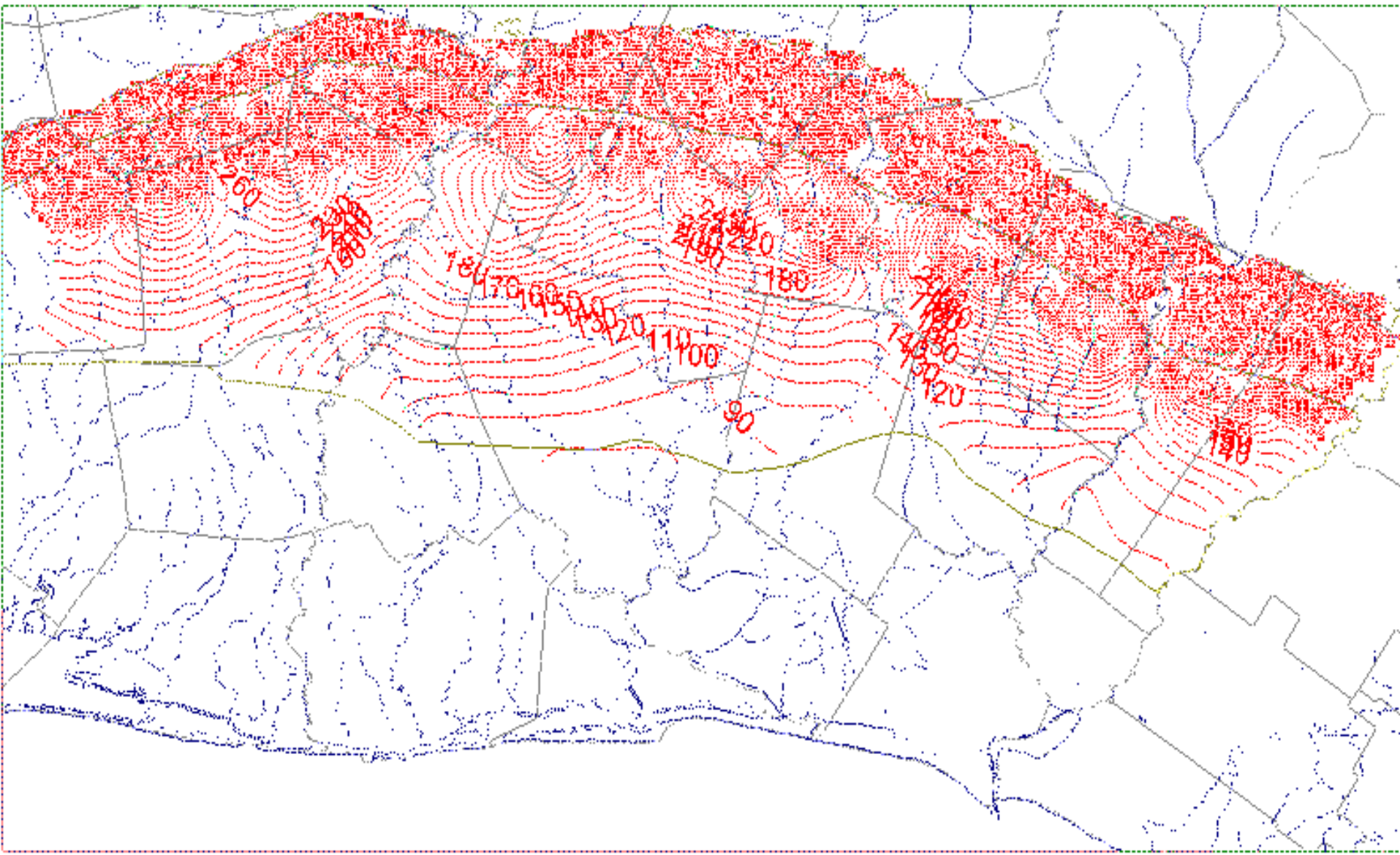
Contour Interval 10 feet



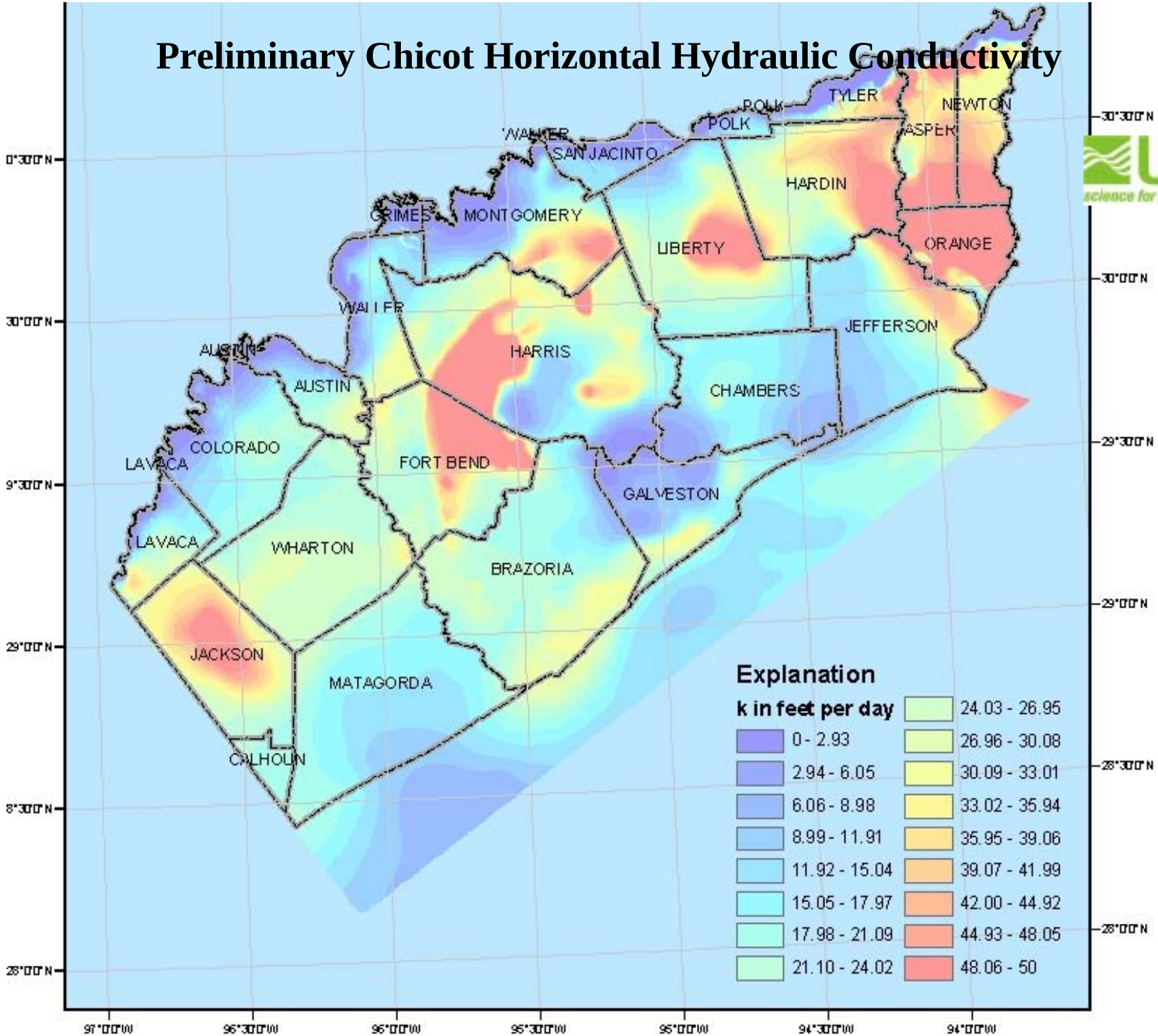
Preliminary Jasper Steady-State Heads

Contours Range from 77.6 to 541.5 feet

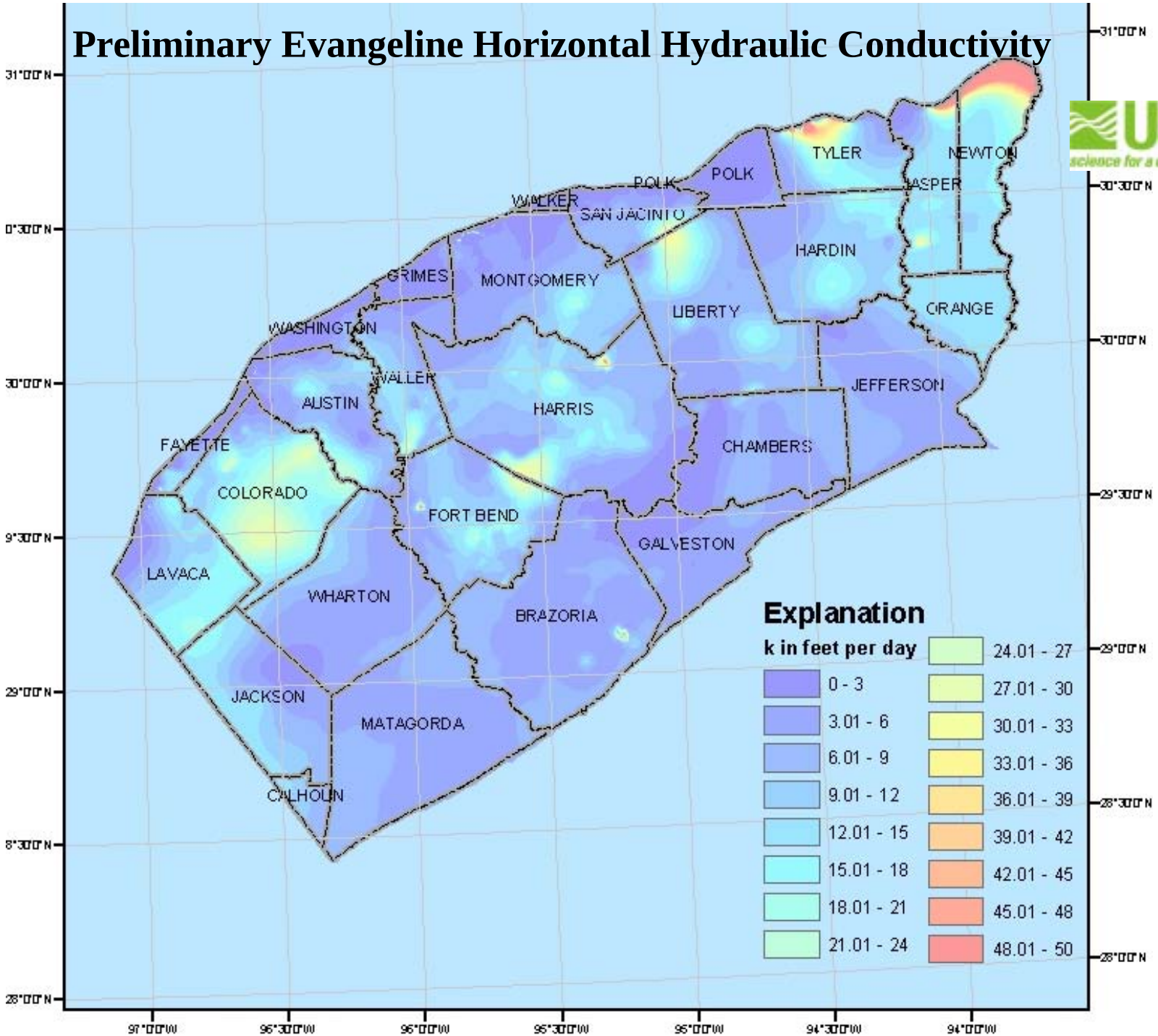
Contour Interval 10 feet



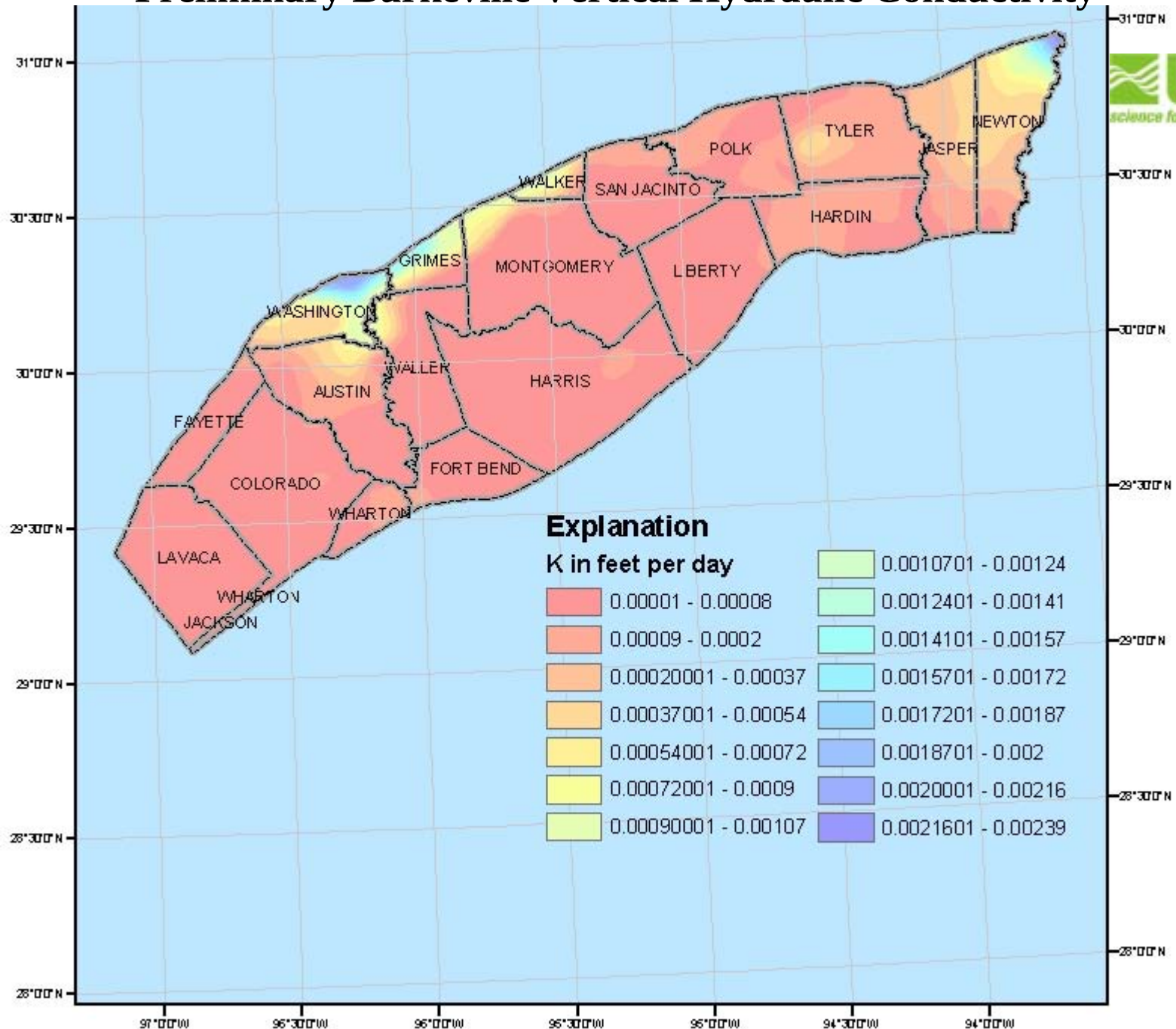
Preliminary Chicot Horizontal Hydraulic Conductivity



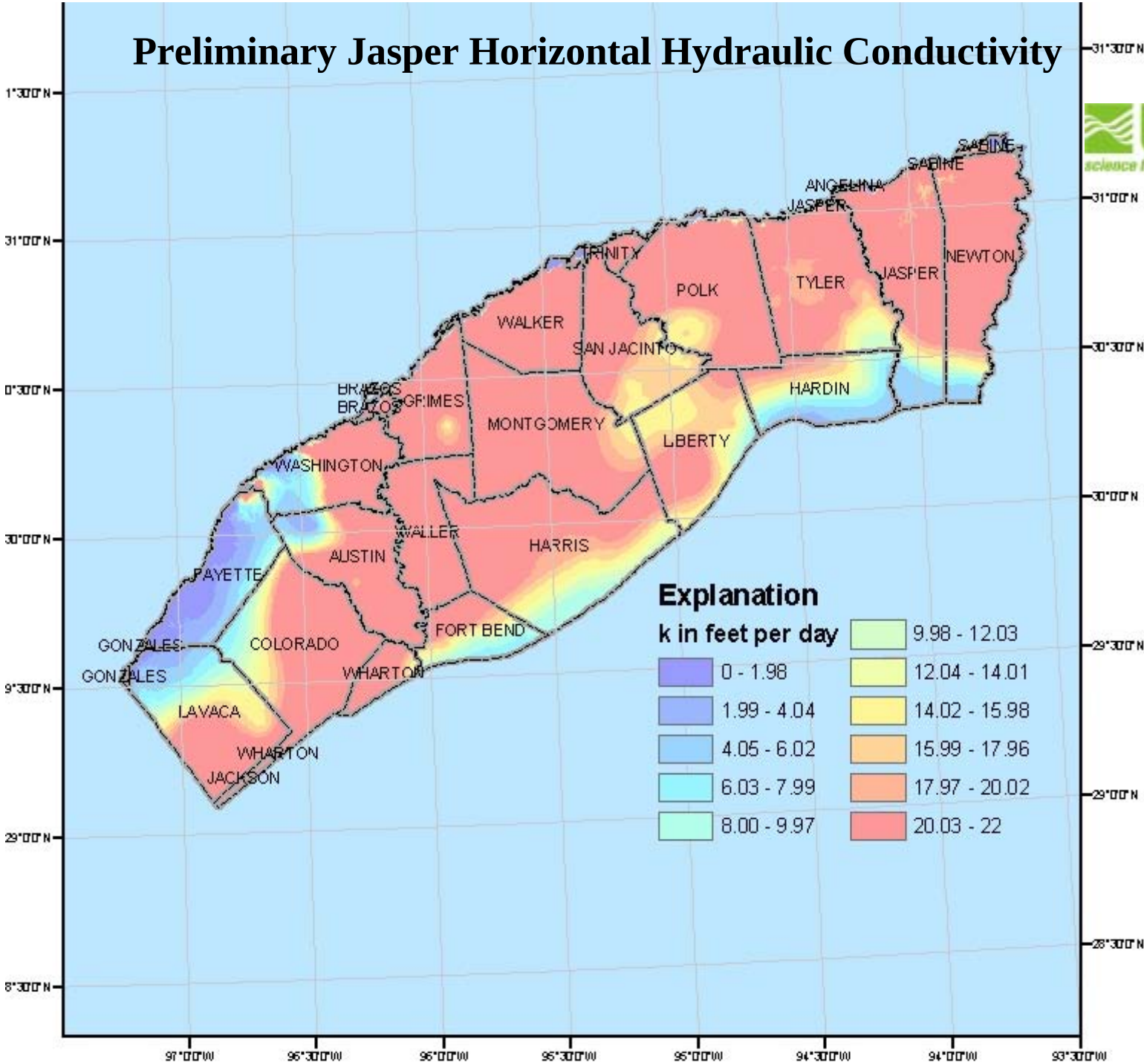
Preliminary Evangeline Horizontal Hydraulic Conductivity



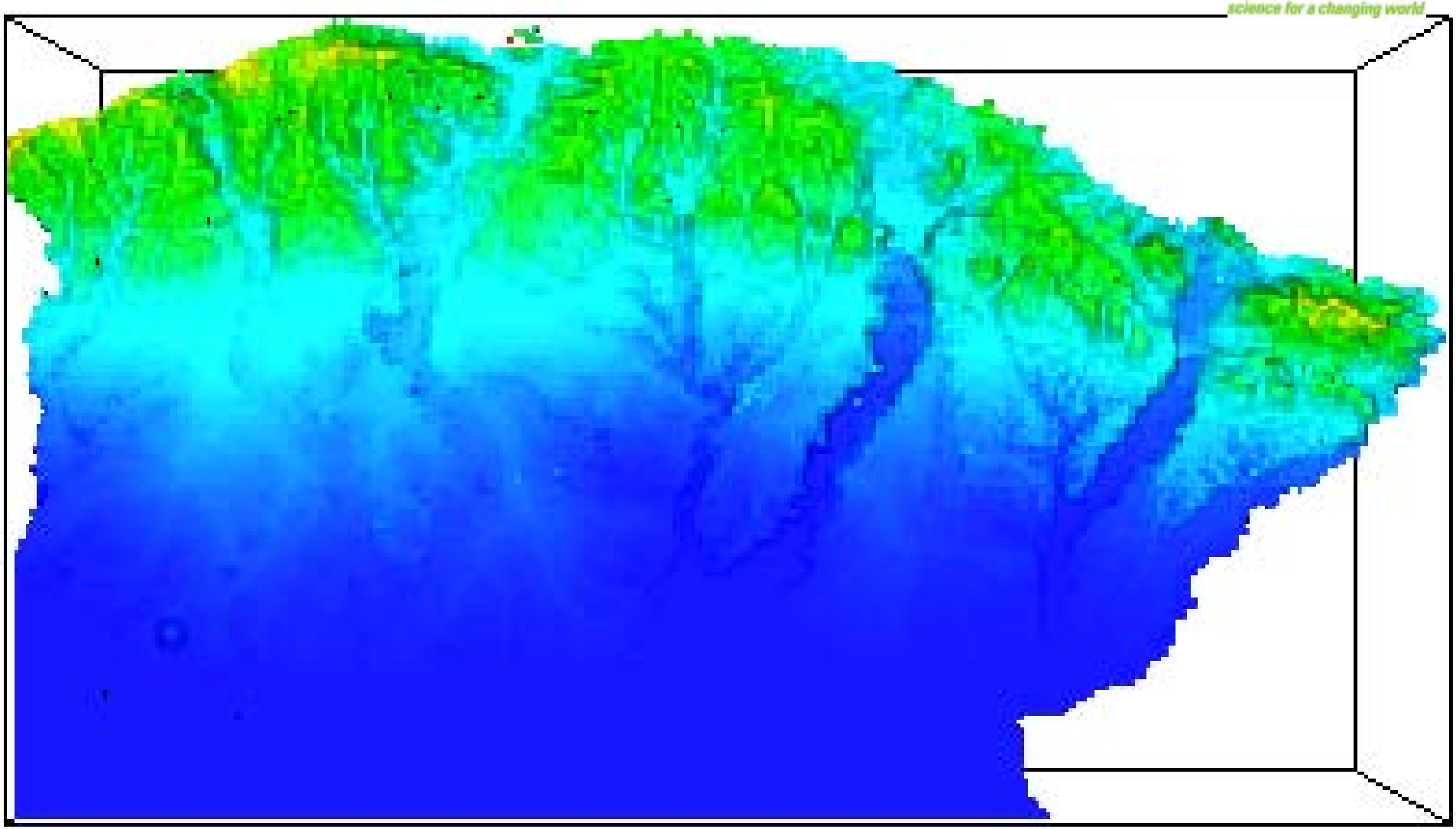
Preliminary Burkeville Vertical Hydraulic Conductivity



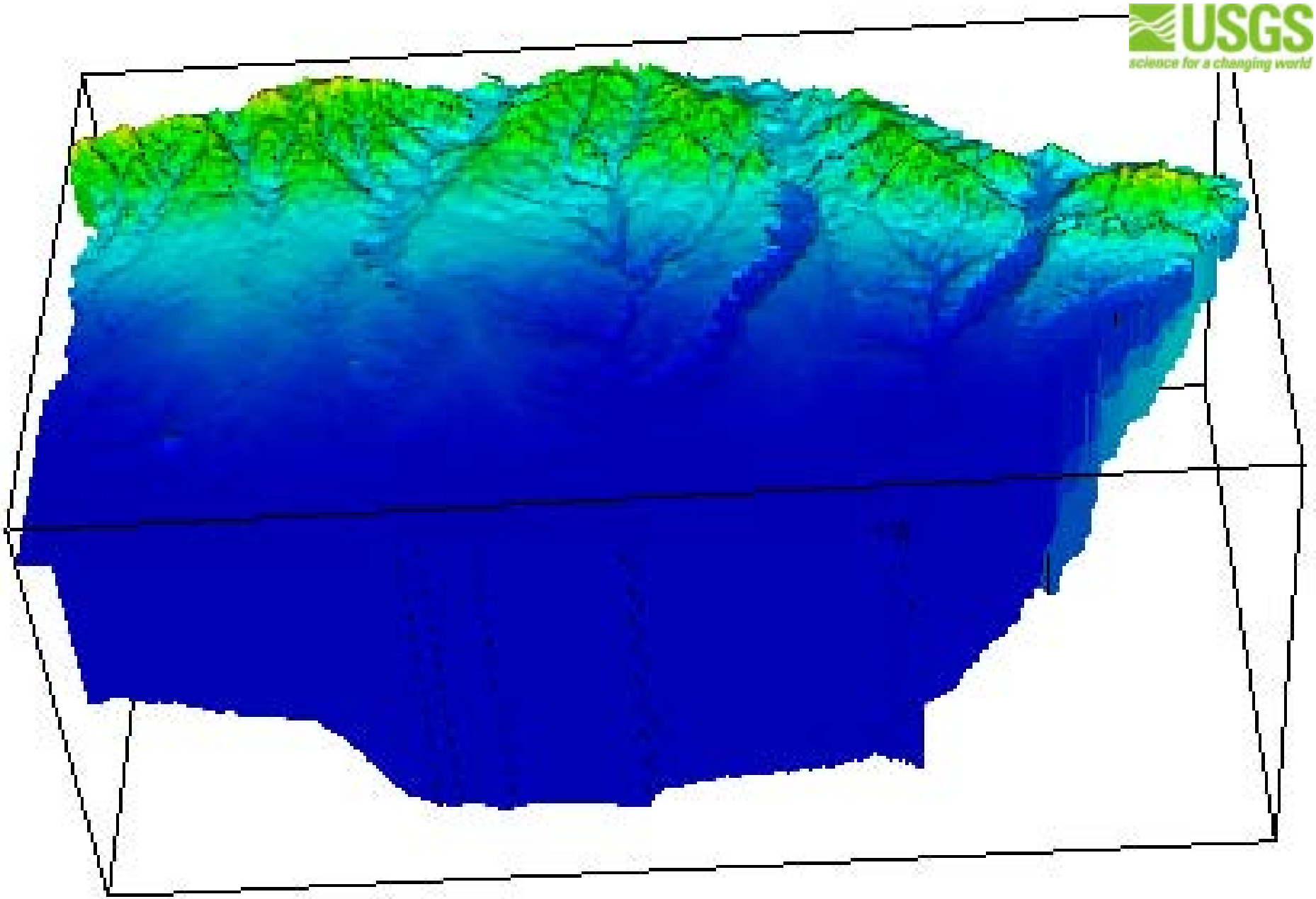
Preliminary Jasper Horizontal Hydraulic Conductivity



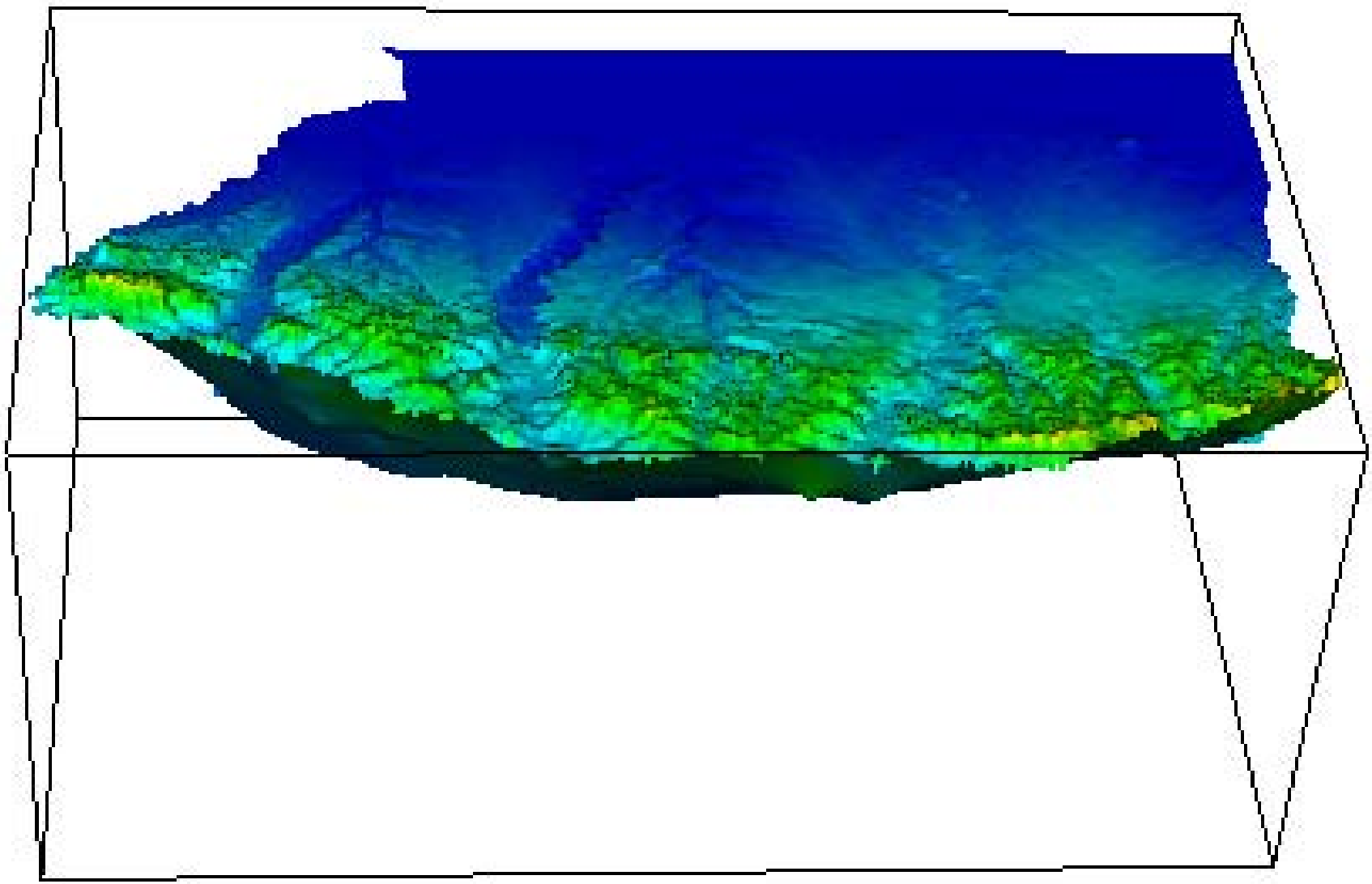
GAM Map View



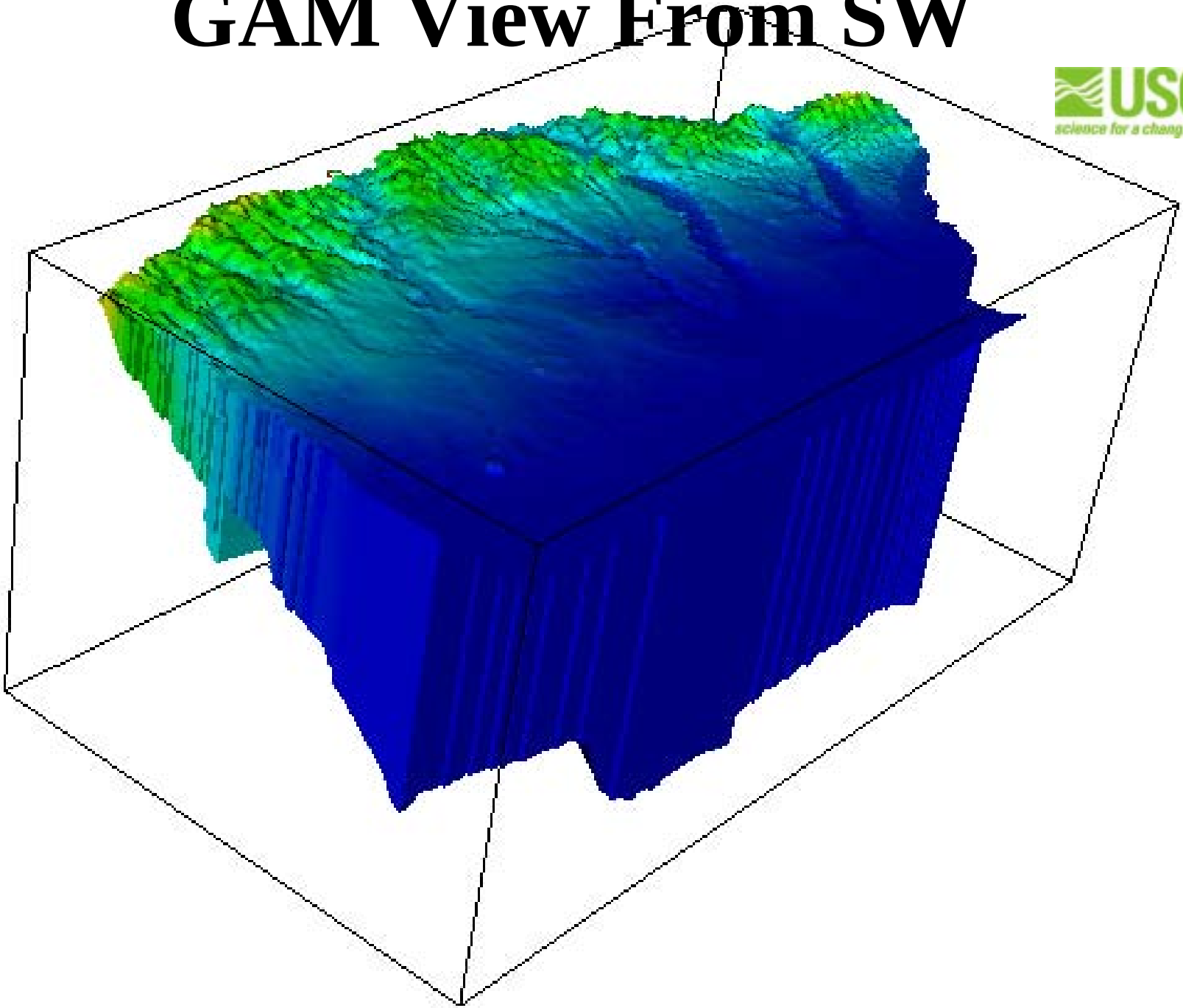
GAM View From Gulf



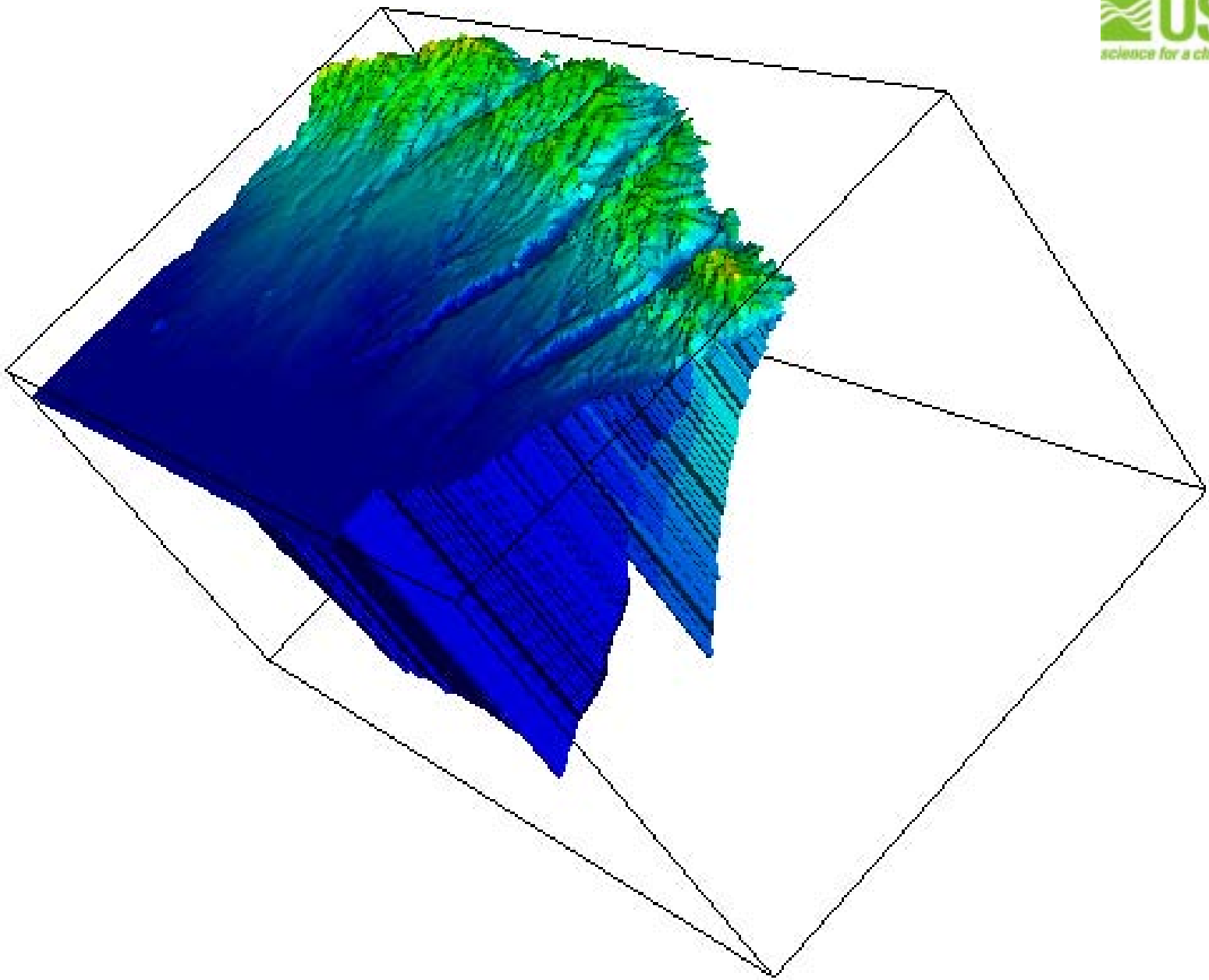
GAM View From North



GAM View From SW

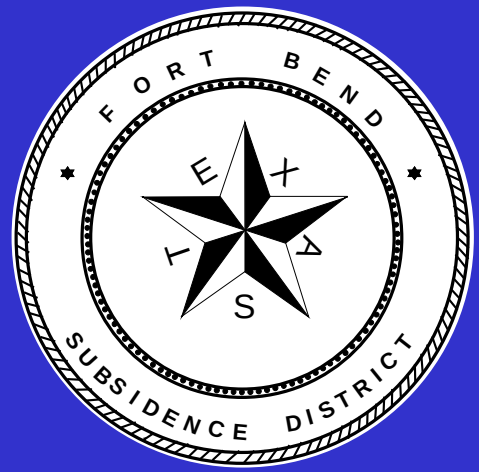


GAM View From SE

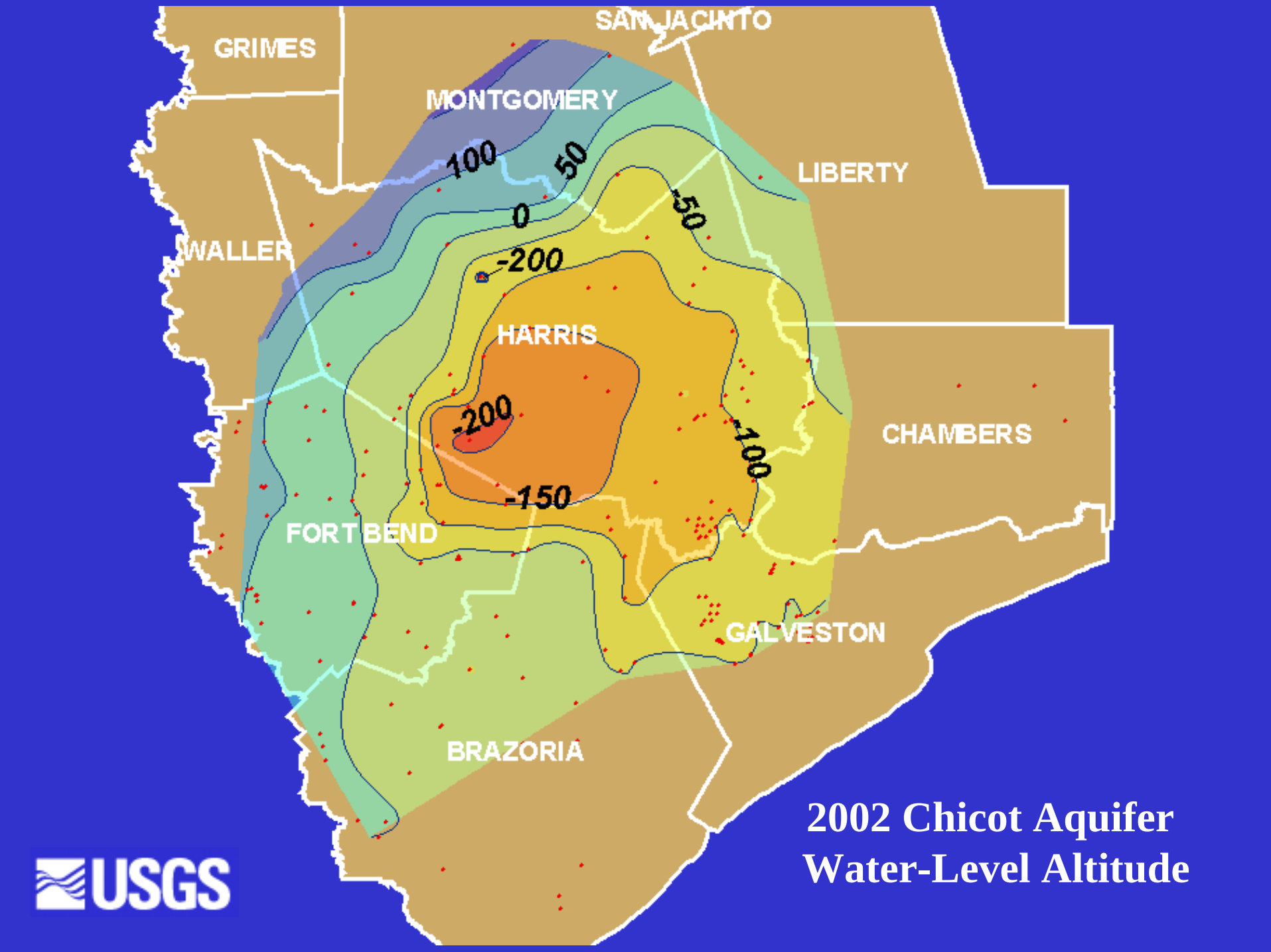


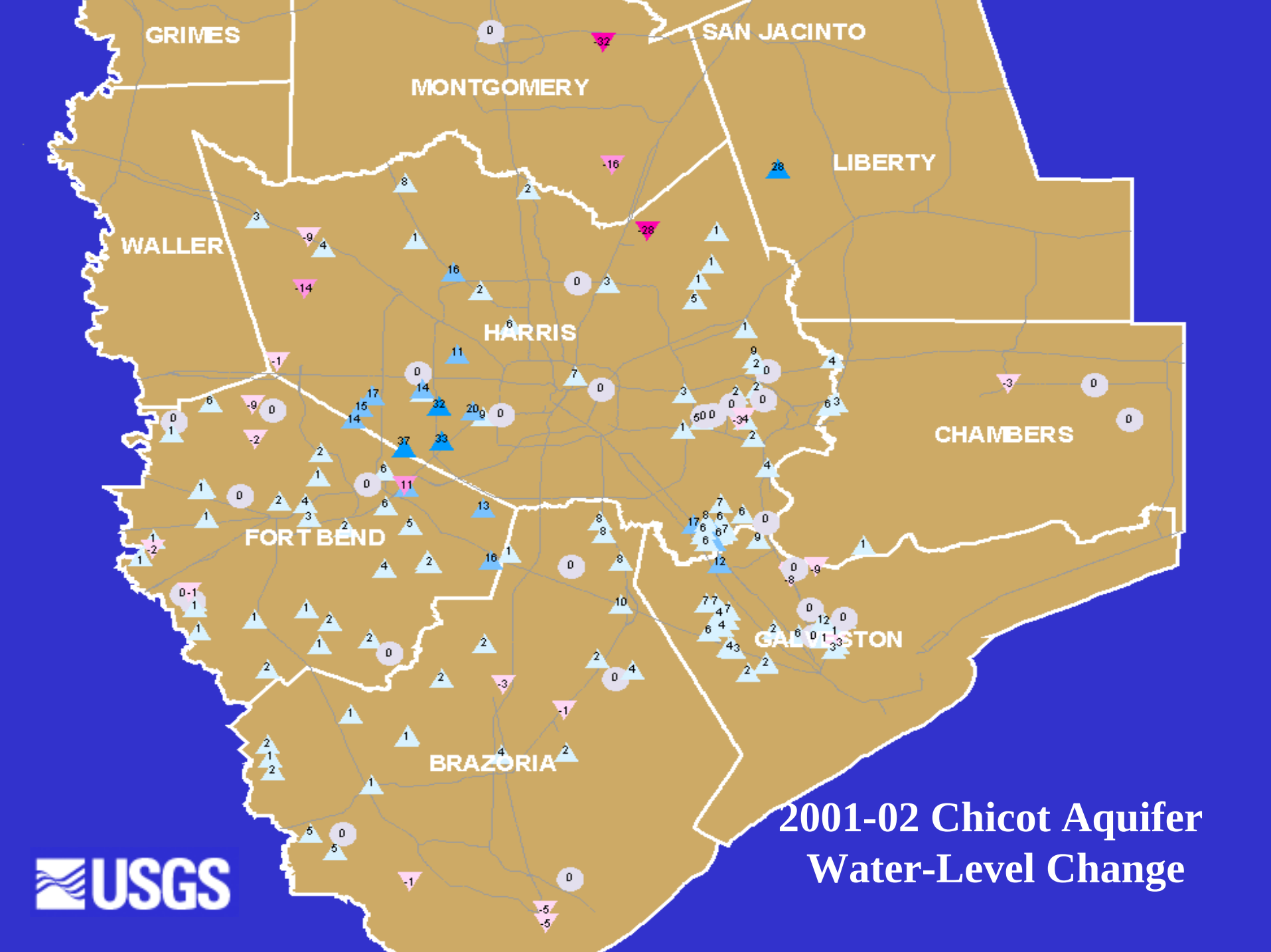
GAM Upper Gulf Coast Aquifer Outcrops

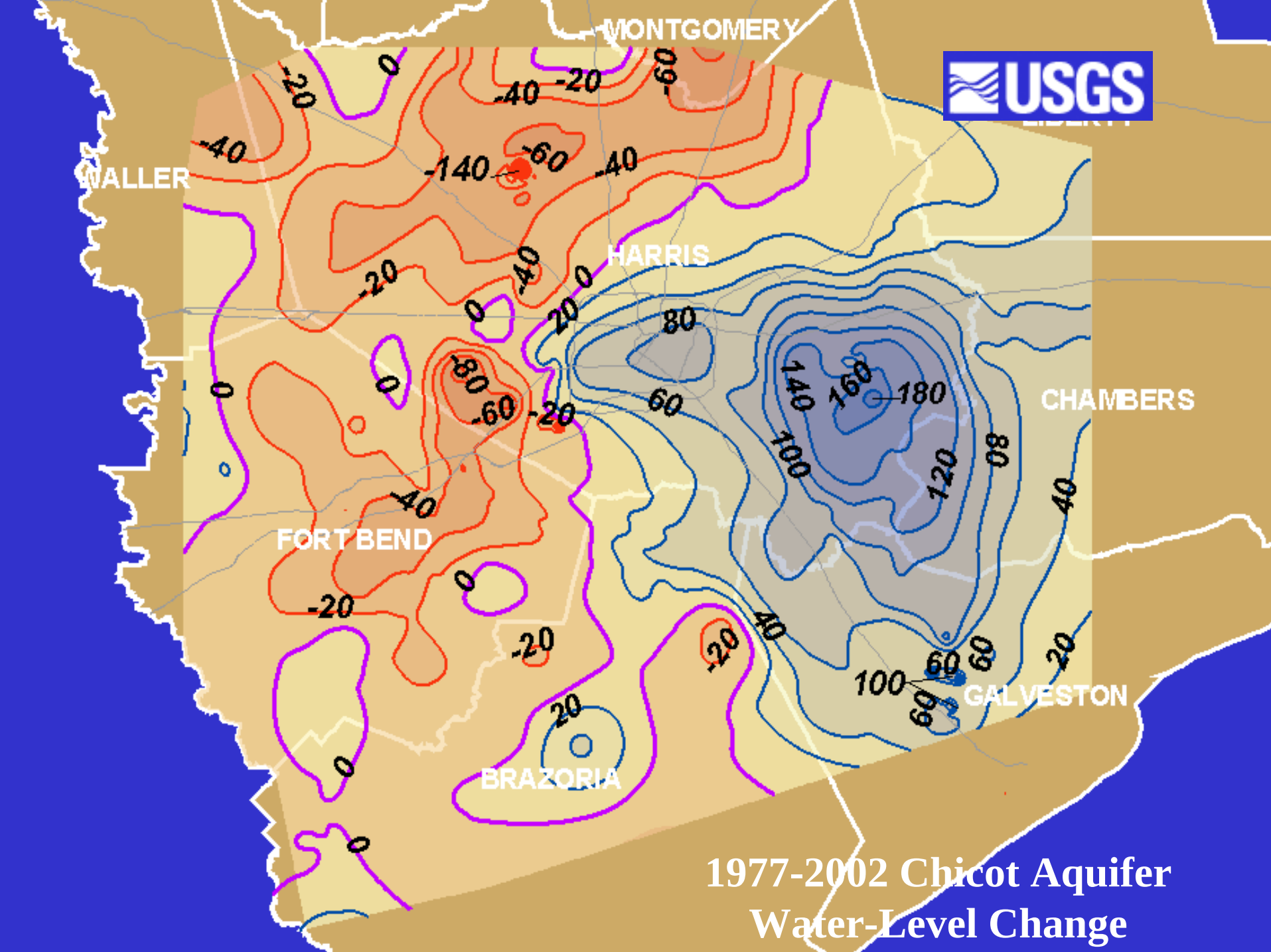
Water-Level Altitudes 2002 and Water-Level Changes in the Chicot, Evangeline, and Jasper Aquifers and Compaction 1973-2001 in the Chicot and Evangeline Aquifers, Houston-Galveston Region, Texas

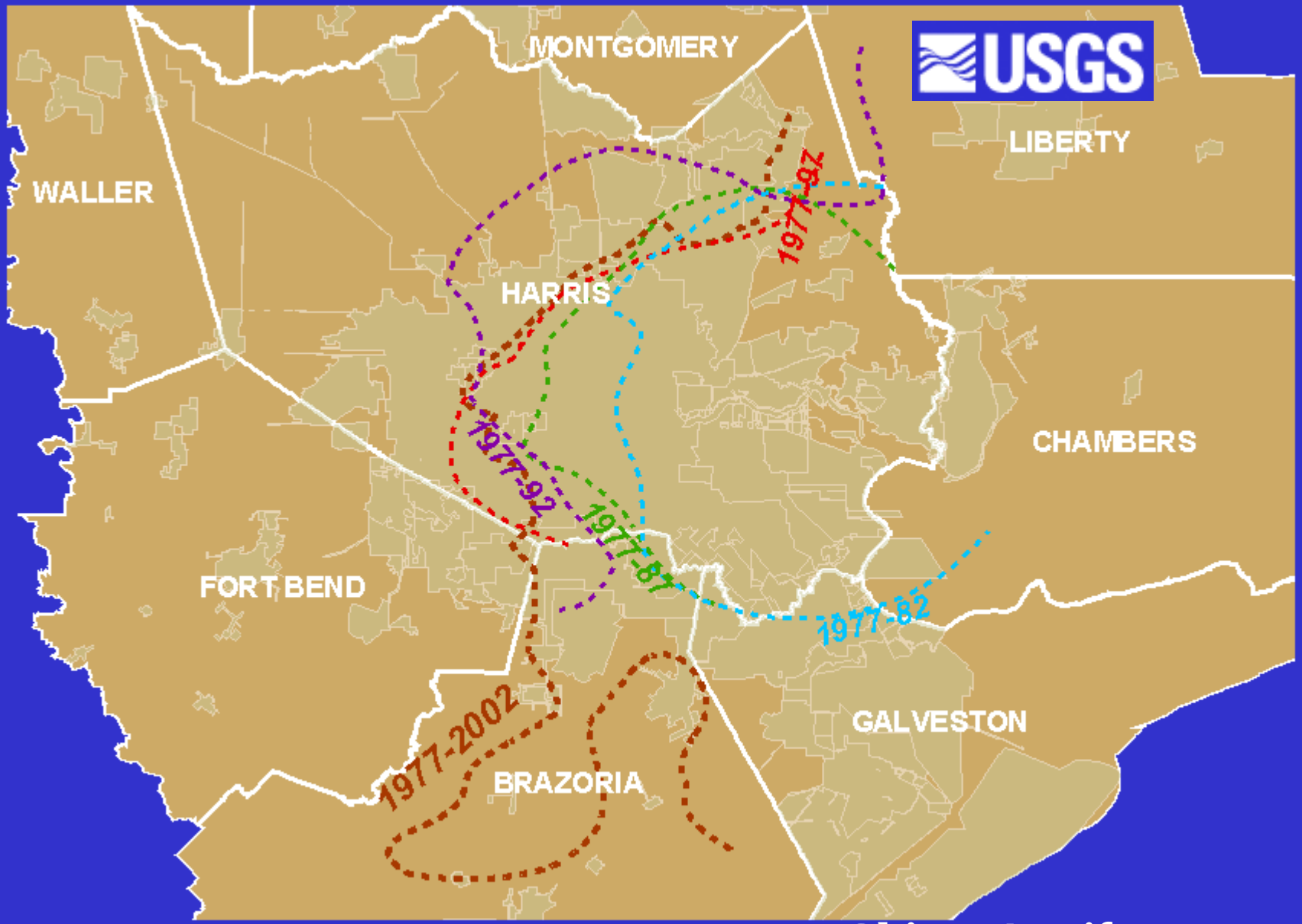


In cooperation with the Harris-Galveston Coastal Subsidence District, City of Houston, and Fort Bend Subsidence District

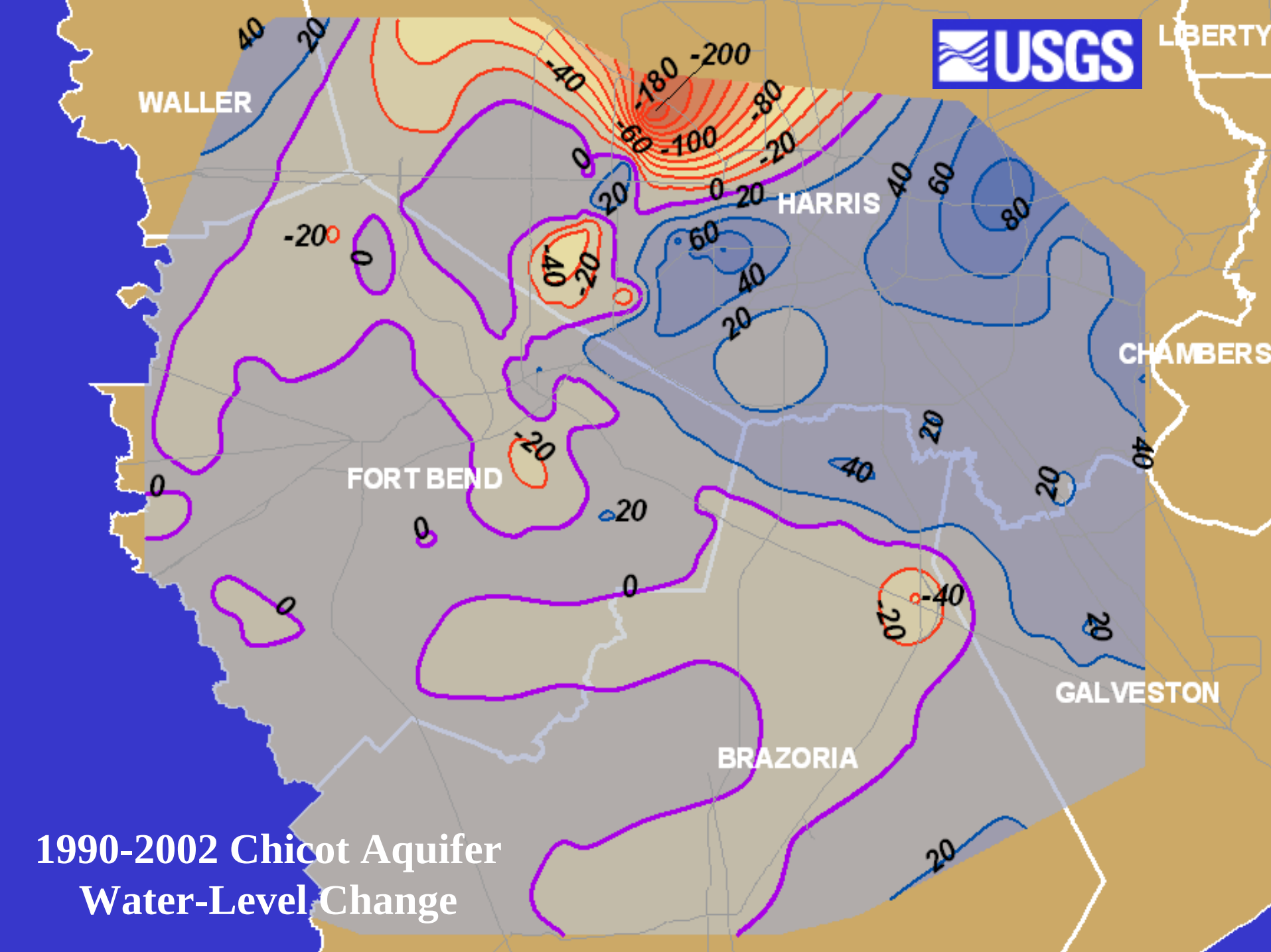

GRIMES
SAN JACINTO
MONTGOMERY
LIBERTY
WALLER
HARRIS
CHAMBERS
FORT BEND
GALVESTON
BRAZORIA
100
50
0
-50
-200
-200
-100
-150
USGS
2002 Chicot Aquifer
Water-Level Altitude


GRIMES
MONTGOMERY
SAN JACINTO
LIBERTY
WALLER
HARRIS
CHAMBERS
FORT BEND
BRAZORIA
GALVESTON
2001-02 Chicot Aquifer
Water-Level Change
USGS


MONTGOMERY
USGS
WALLER
HARRIS
CHAMBERS
FORT BEND
GALVESTON
BRAZORIA
-20
0
-40
-60
-140
40
20
80
60
140
160
180
100
120
08
1977-2002 Chicot Aquifer
Water-Level Change



Chicot Aquifer Zero Water-Level Change


USGS
WALLER
HARRIS
LIBERTY
CHAMBERS
FORT BEND
GALVESTON
BRAZORIA
40
20
-40
-180
-200
-80
-60
-100
-20
0
20
60
80
-40
-20
40
20
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0
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-20
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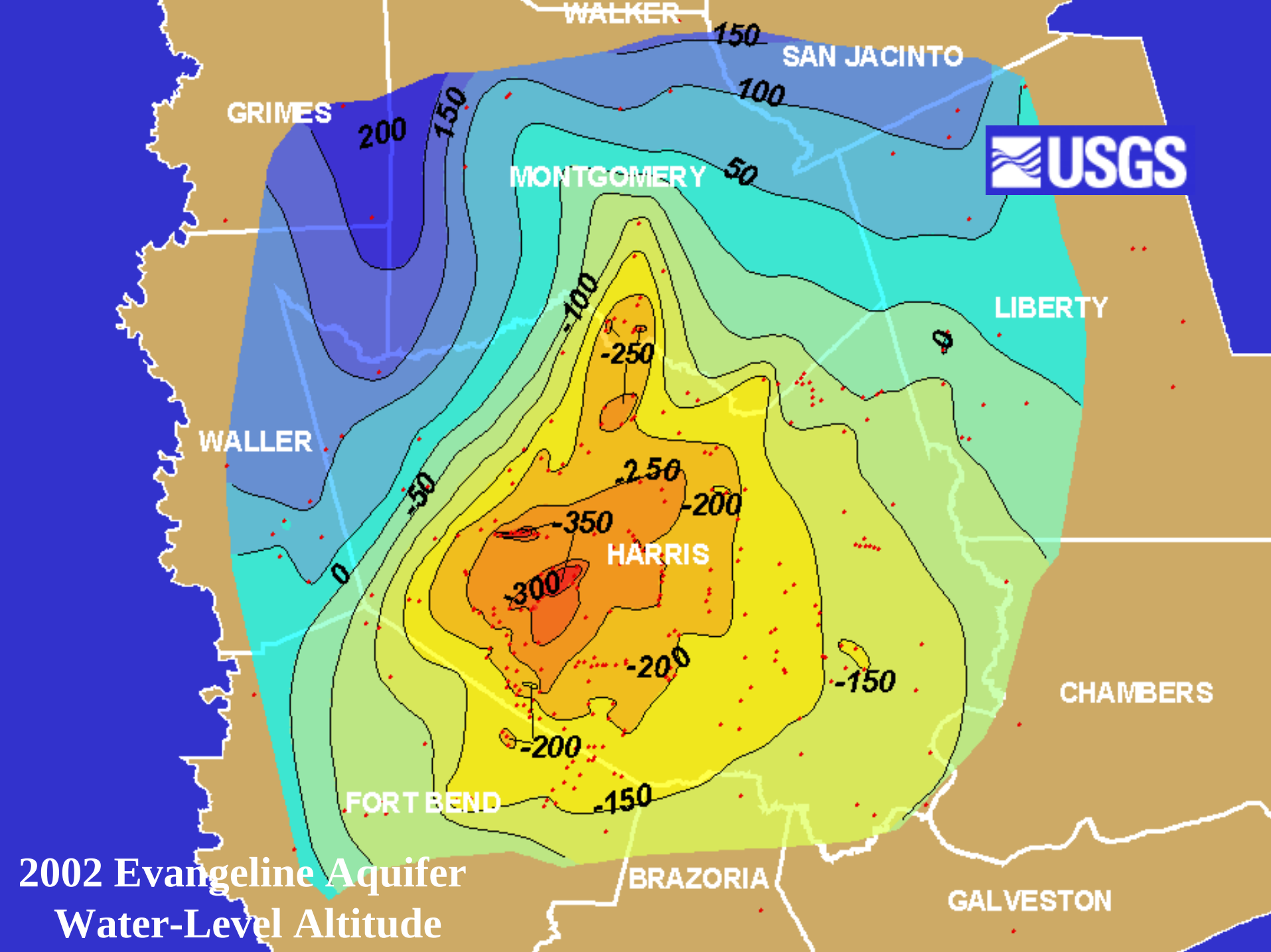
20
1990-2002 Chicot Aquifer
Water-Level Change


WALKER
SAN JACINTO
GRIMES
MONTGOMERY
LIBERTY
WALLER
HARRIS
CHAMBERS
FORT BEND
BRAZORIA
GALVESTON
USGS
150
100
200
150
50
-100
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-50
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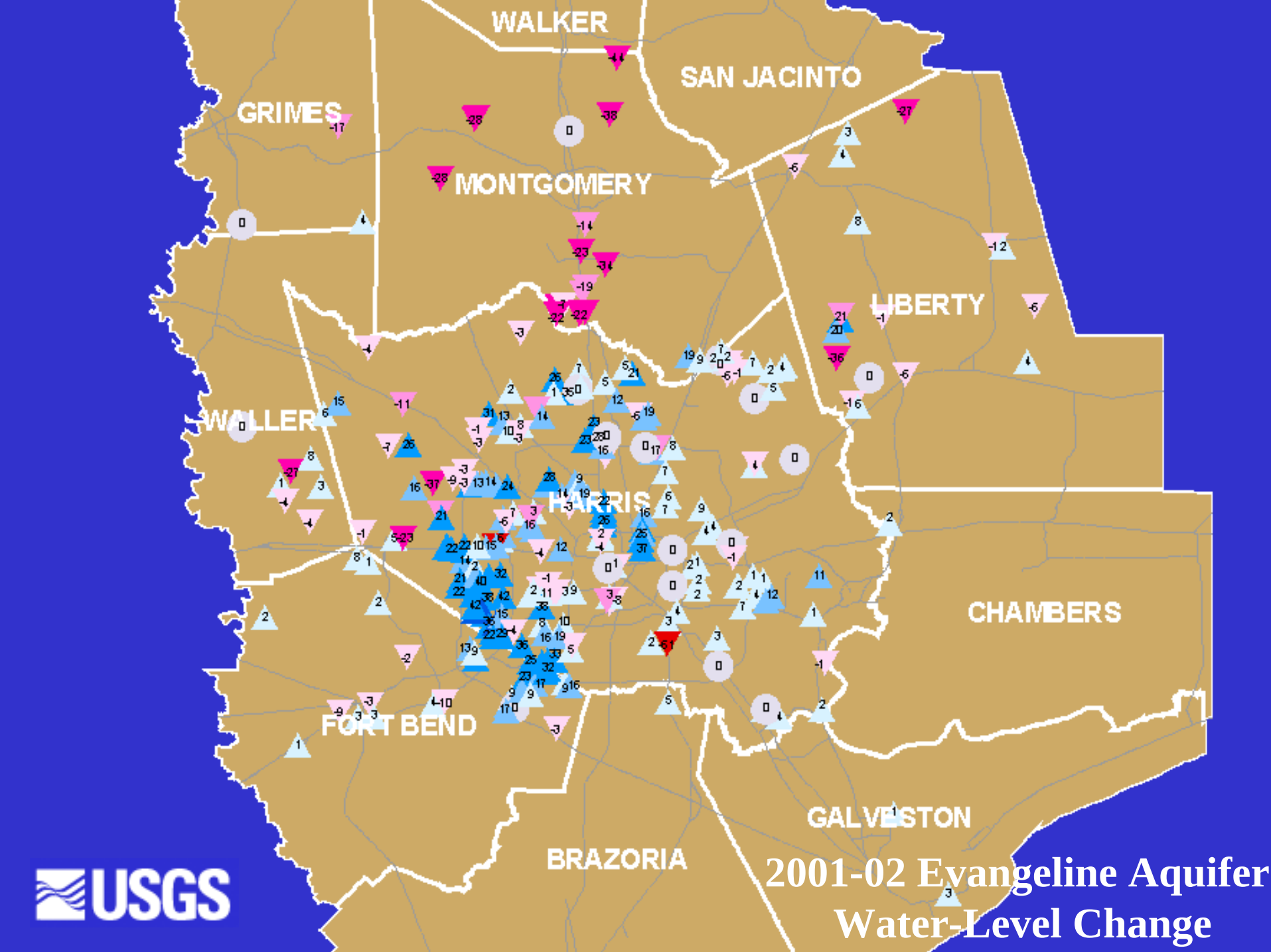
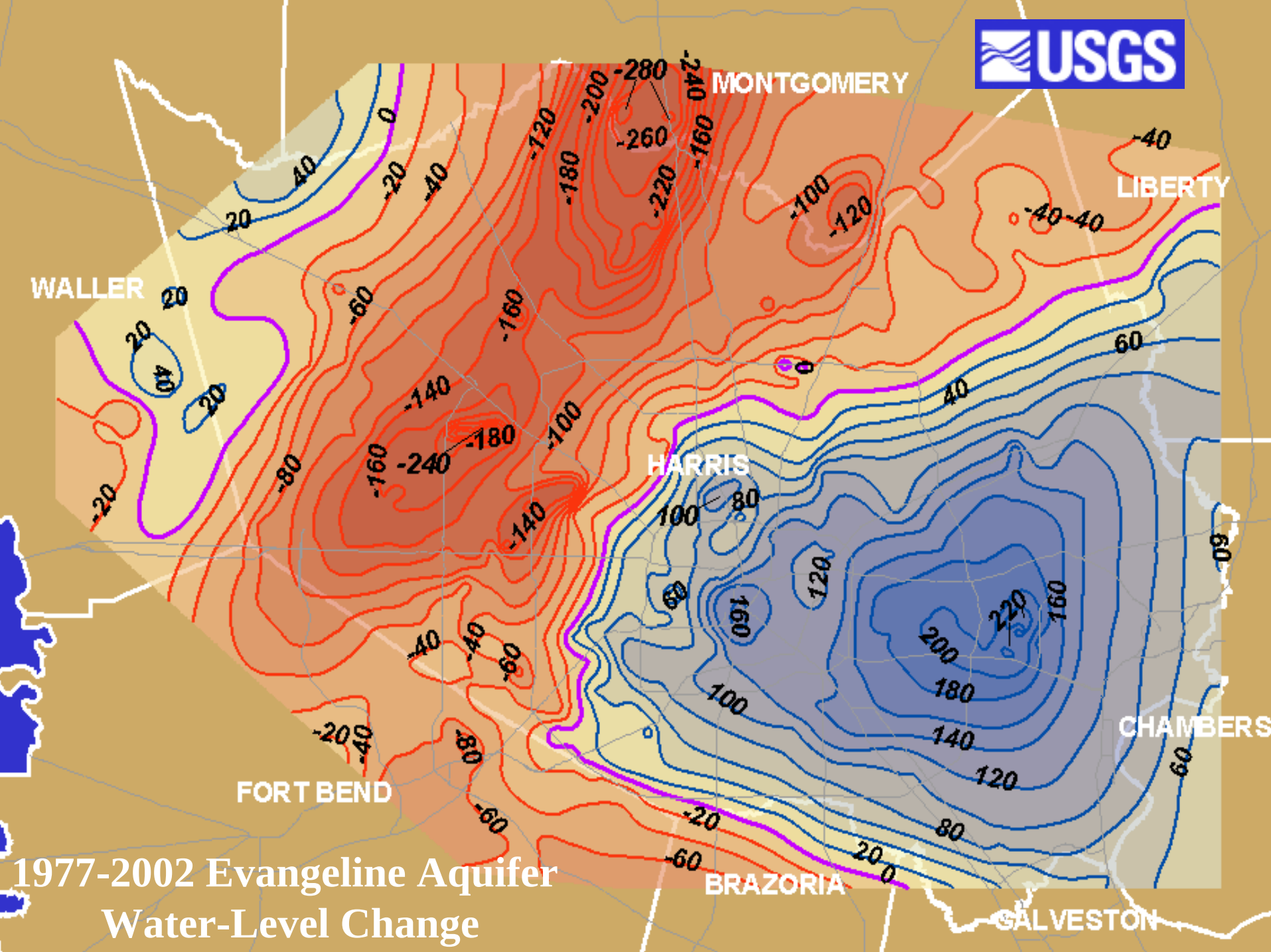
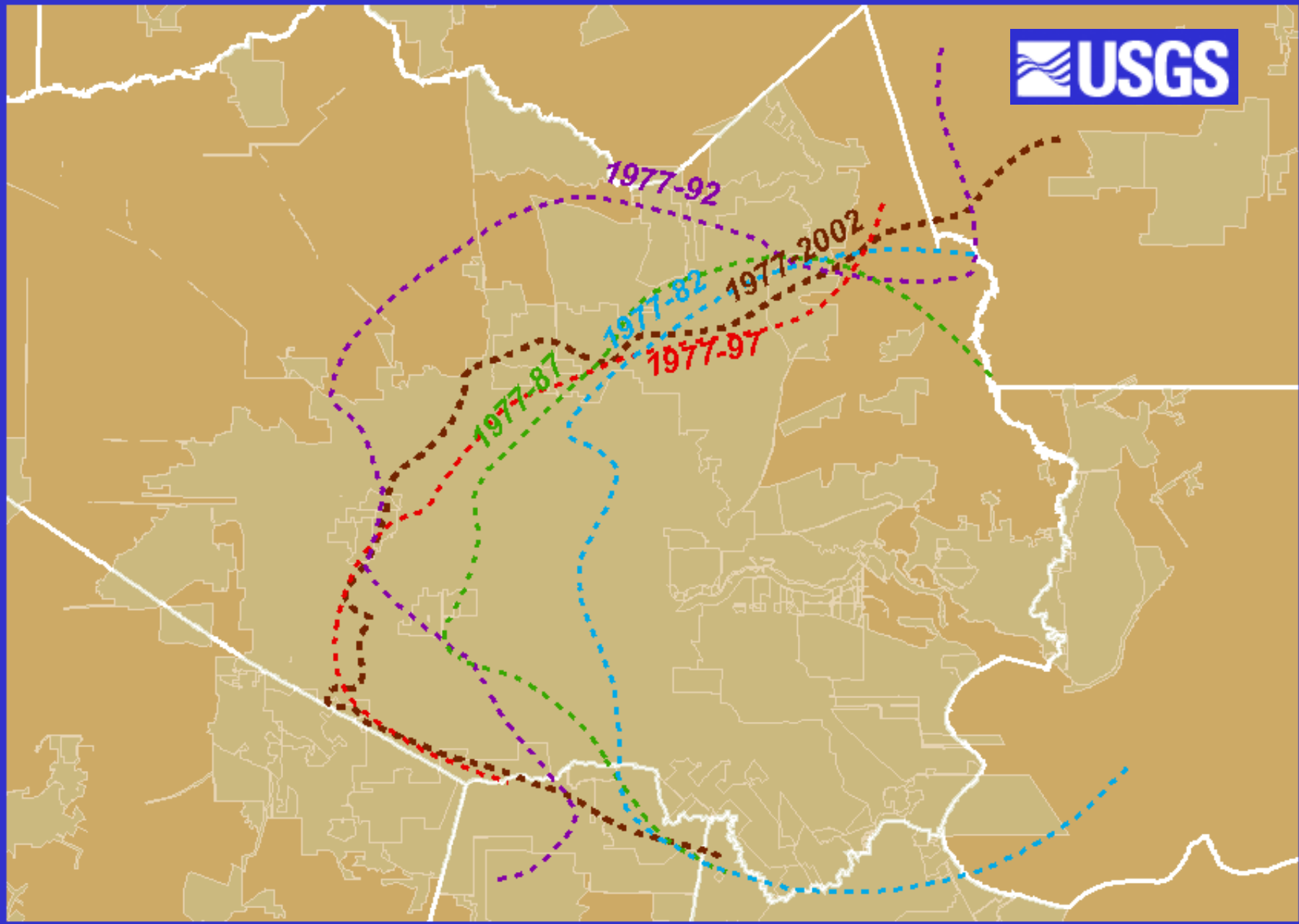
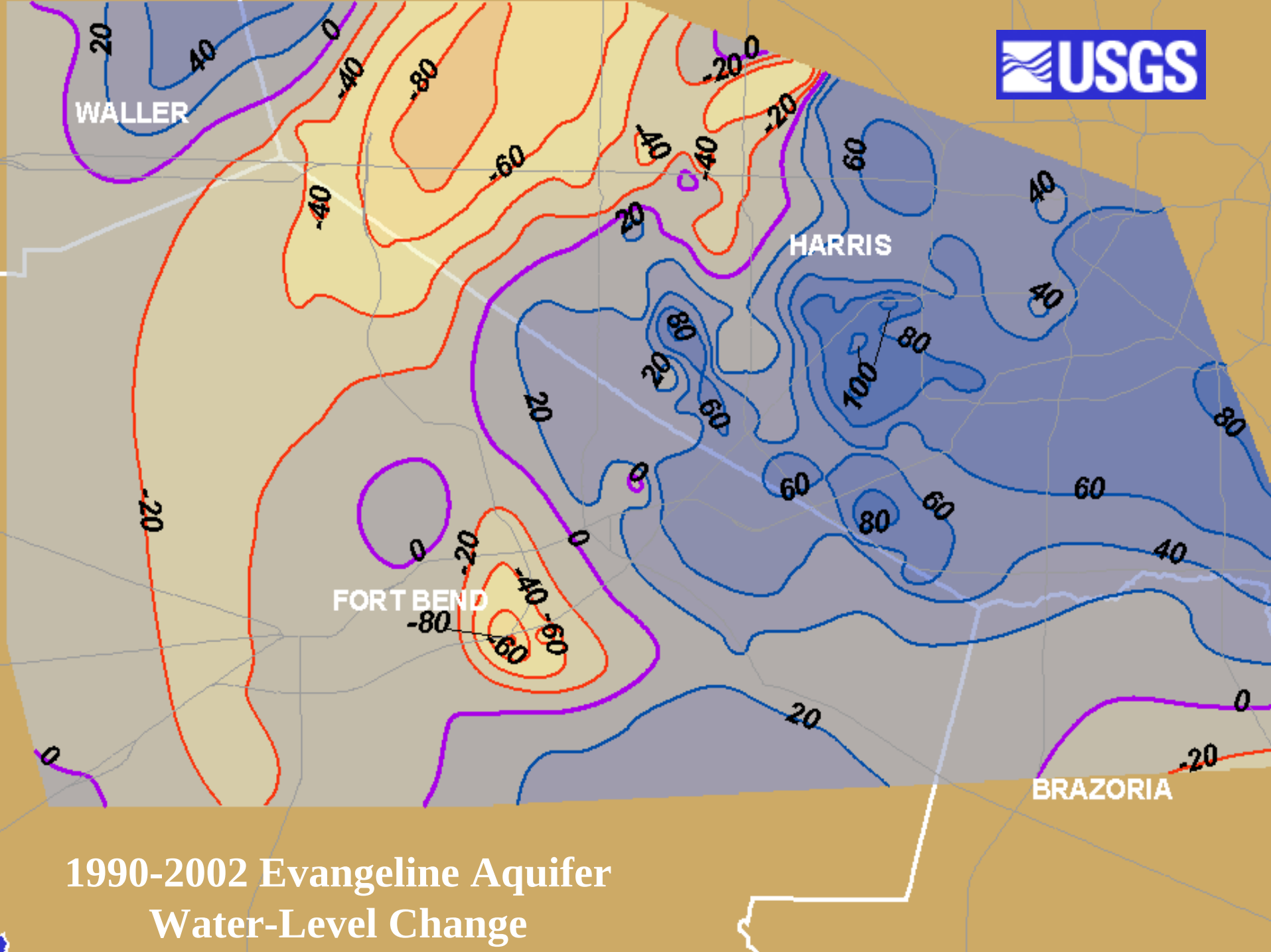
-200
-150
-200
-150
2002 Evangeline Aquifer
Water-Level Altitude


WALKER
SAN JACINTO
GRIMES
MONTGOMERY
LIBERTY
WALLER
HARRIS
CHAMBERS
FORT BEND
GALVESTON
BRAZORIA
USGS
2001-02 Evangeline Aquifer
Water-Level Change

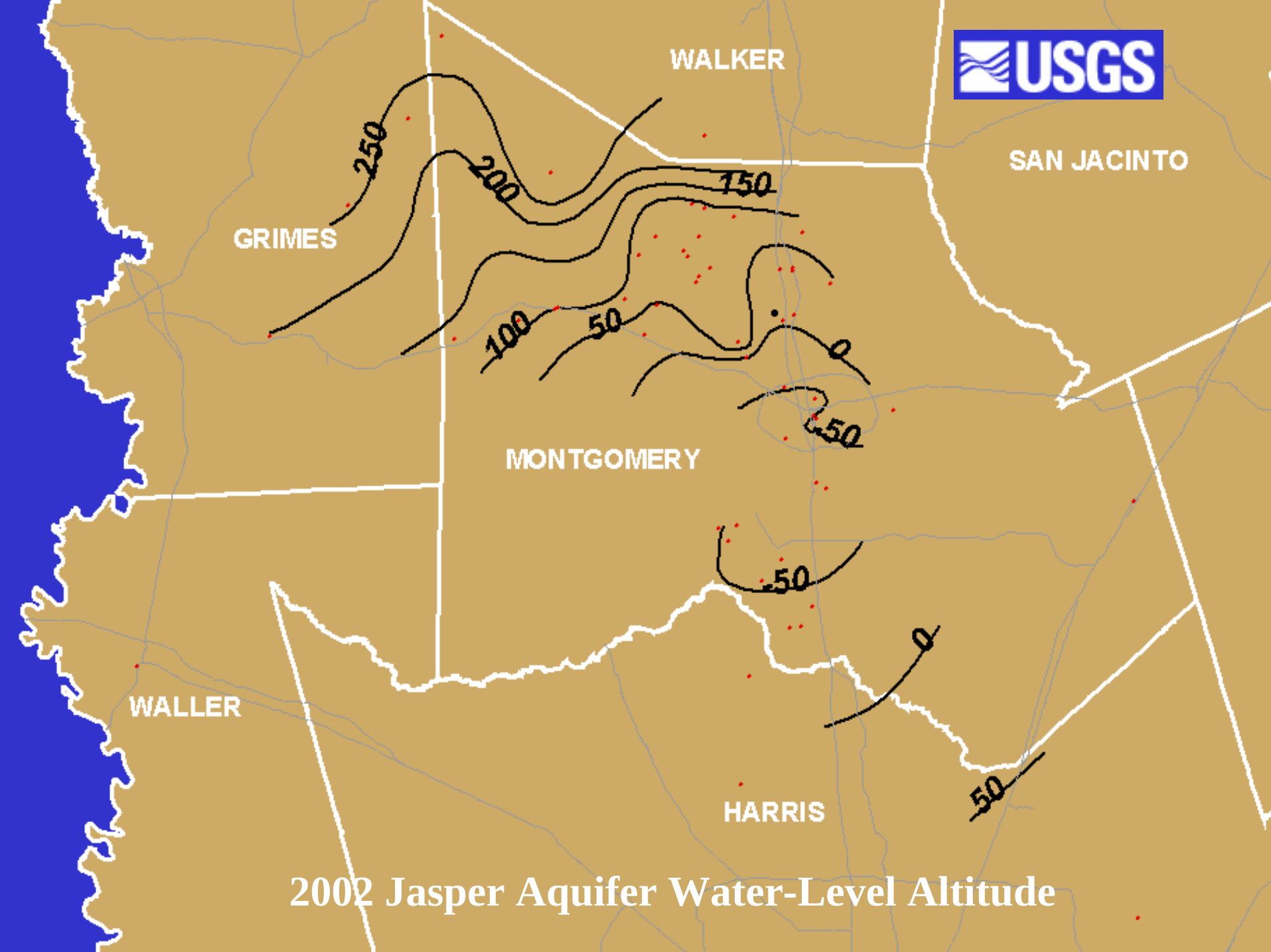

USGS
MONTGOMERY
LIBERTY
WALLER
HARRIS
CHAMBERS
FORT BEND
BRAZORIA
GALVESTON
1977-2002 Evangeline Aquifer
Water-Level Change



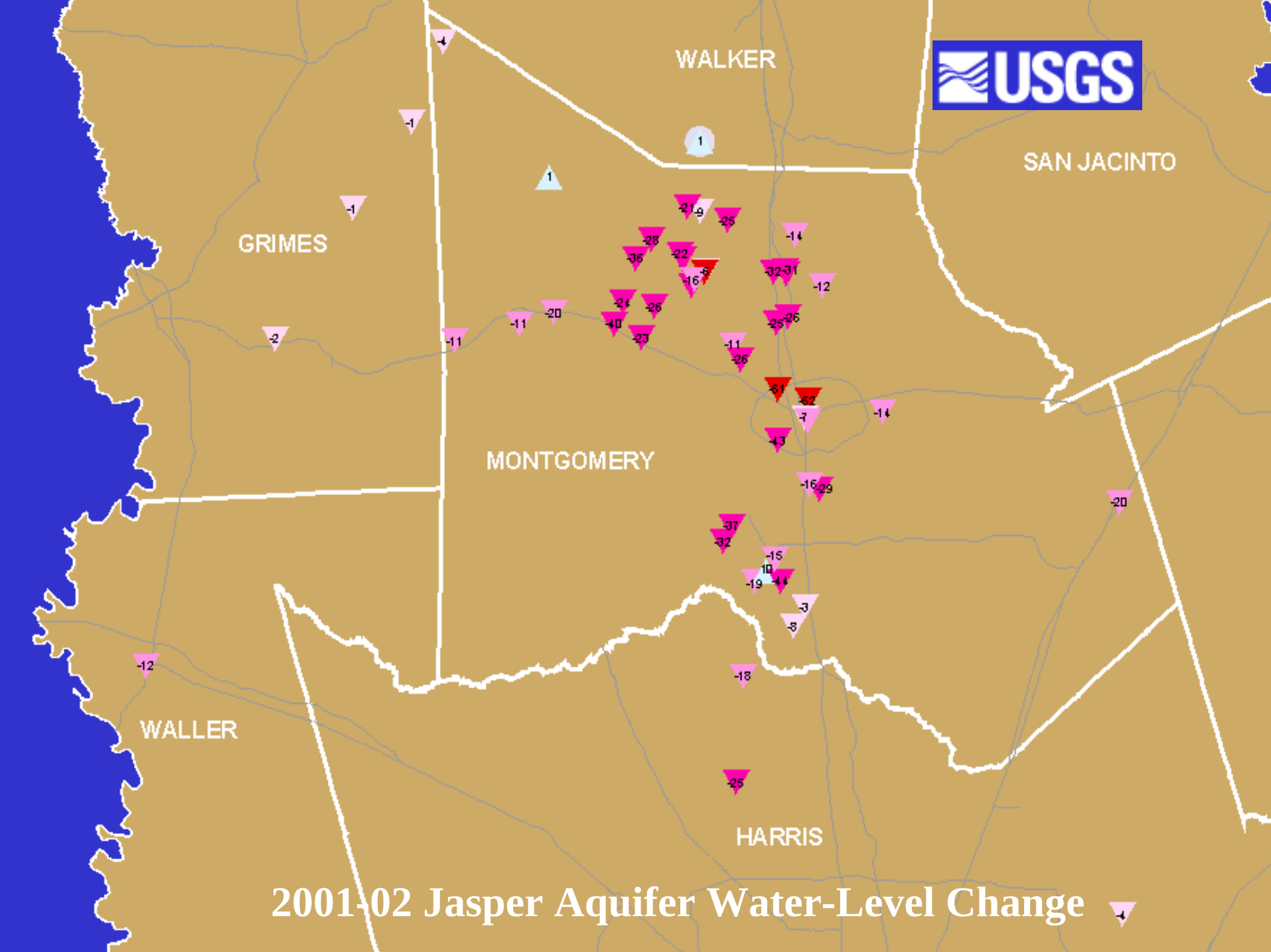
Evangeline Aquifer Zero Water-Level Change

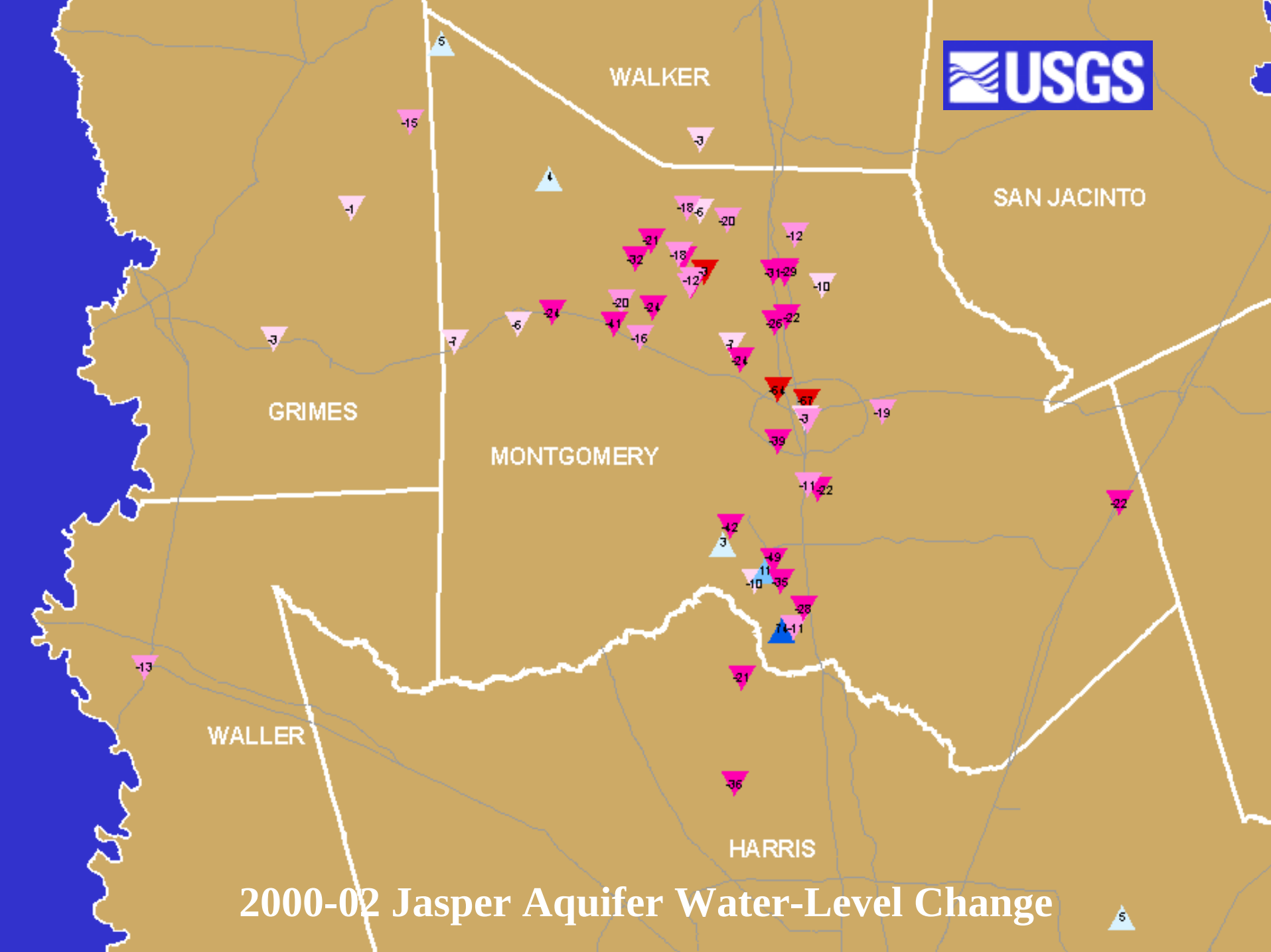


1990-2002 Evangeline Aquifer Water-Level Change



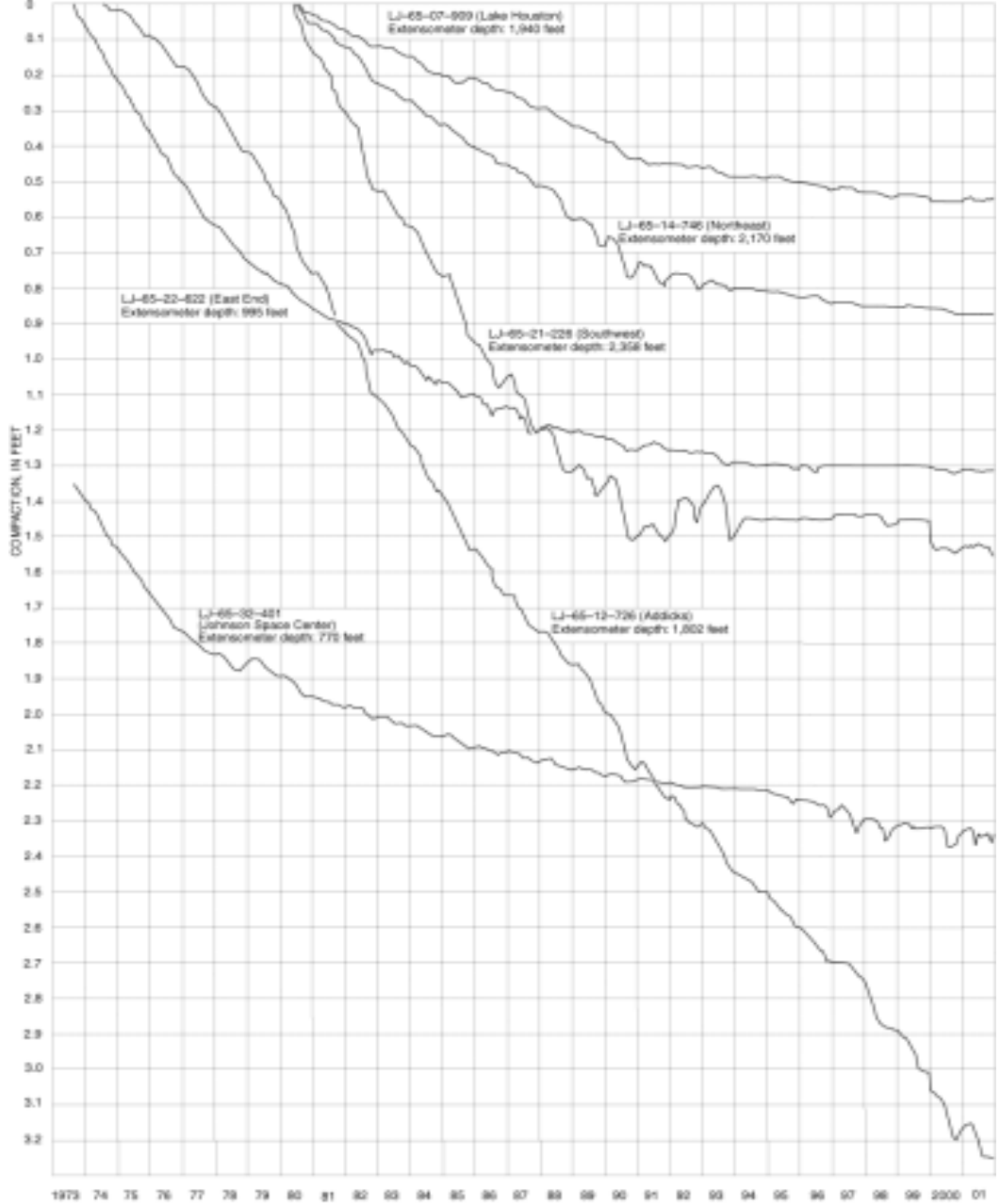
2002 Jasper Aquifer Water-Level Altitude


WALKER
SAN JACINTO
GRIMES
MONTGOMERY
WALLER
HARRIS
USGS
2001-02 Jasper Aquifer Water-Level Change

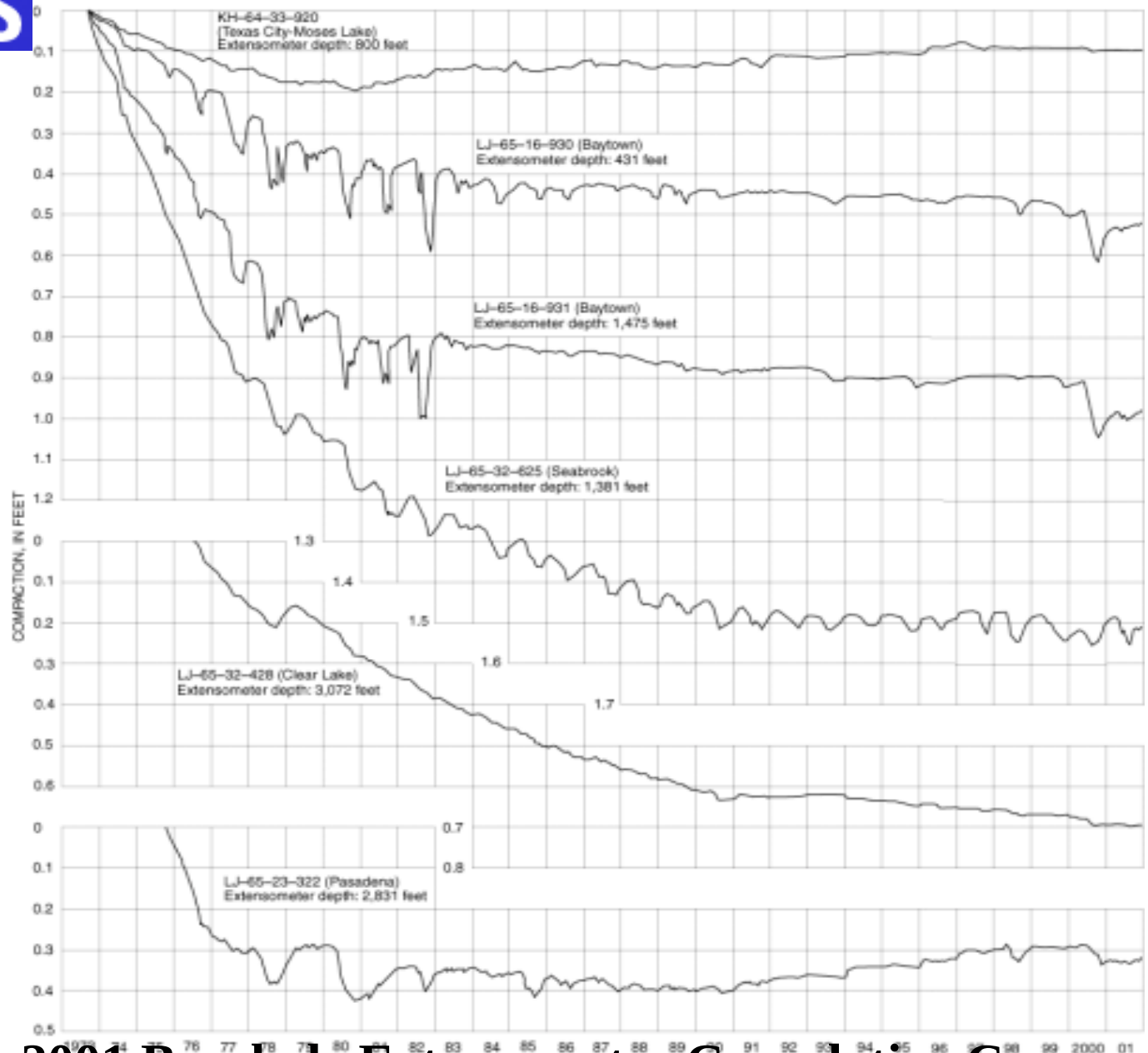


2000-02 Jasper Aquifer Water-Level Change

Borehole Extensometer Site Locations



1973-2001 Borehole Extensometer Cumulative Compaction



1973-2001 Borehole Extensometer Cumulative Compaction

Quality Scientific Data Collection and Analysis for the Long Term

Attendance list at the 4th Stakeholder Advisory Forum for the northern Gulf Coast aquifer Groundwater Availability Model, June 5, 2002

Names	**Affliation**
Ali Chowdhury	Texas Water Development Board
David Huang	City of Houston
H.C. Clarke	Geology Consultant
David Dow	NHCRWA
Alan Hamilton	Ecologist
Bob Rodgers	RWR Associates
Ken Kramer	Sierra Club
David W. Minze	Bluebonnet GWCD
Eric Strom	US Geological Survey
Cary L. Betz	TNRCC
Haskell L. Simon	Region K -Regional Water Planning Group
Wes Meehan	USGS
Marl Lowry	Region K and P Consultant
Joe Broadus	US Geological Survey
John Nelson	LBG-Guyton Associates
Mark C. Kasmarek	US Geological Survey
Robert K. Gabrysch	Consultant Hydrogeologist
Ron Neighbors	Harris-Galveston Coastal Subsidence District
Phil Savoy	Murfee Engineering
David A. Van Dresar	City of Texas City
Tom Michel	Harris-Galveston Coastal Subsidence District

Northern Gulf Coast GAM - 4th SAF Meeting
June 5, 2002
Questions and Answers

Q: Predictive-pumping distribution may not be that accurate and therefore, predictive water levels over the 50-year planning framework may not be valid. Population projection study is needed to estimate where the future population will migrate and where groundwater extraction will occur.

A: We are using the groundwater demand numbers as provided by the RWPGs for making predictive runs. New population projection study may not accurately locate well locations, as wells may not move with the population. We have to start somewhere and the model will be updated, as new data becomes available.

Q: The model may not accurately predict water levels in the areas outside the subsidence district where there is paucity of data. The new Groundwater Districts may not have the financial resources to use the model.

A: There is no denying that additional data can help improve the accuracy of the model. The model however includes the best information available today. On a regional basis, the model should be able to provide answers to various groundwater issues. Numerous wells may be needed to address local groundwater concerns.

The TWDB will help in making different scenario runs at the request of the Groundwater Districts. At this time, there will be no fees for these services and these requests will be handled on first come first served basis.

Q: Does the model include salt water?

A: No, the model does not simulate salt water. MT3D may be incorporated to simulate salt water.

Q: What are the salt concentrations at the down-dip boundaries of the Burkeville Confining System and the Jasper aquifer?

A: 10,000 PPM TDS based on geophysical logs.

Q: What is the steady-state head?

A: Water levels in an aquifer under pre-pumping conditions. Water levels for 1891 were used for constructing the pre-development model.

Q: Can you show recharge for the different outcrop areas?

A: We will report recharge-discharge values when we are done with calibrating the model.

Q: How dispersed is the clay data across the model area?

A: Away from the core, hardly any clay data is present.

Q: How much money is required to run a Groundwater District?

A: One stakeholder reported that TWDB said it might cost as little as $50,000. Another stakeholder reported that you might not be able to hire one professional staff for that amount.

Q: Chapter 376 states that the GW districts shall use the GAM models to estimate groundwater availability.

A: We are developing the GAM models as tools for predicting future water levels. Groundwater availability numbers for the aquifers are decided at the local levels.

Comment: The model is funded by the TWDB, the Harris-Galveston Coastal Subsidence District and the USGS. City of Houston and San Jacinto River Authority was ready to participate but did not make any financial contribution to the study.