Groundwater Availability Modeling (GAM) for the Southwest Carrizo-Wilcox Aquifer

A Presentation to:

Stakeholder Advisory Forum

San Antonio River Authority

April 24th, 2001

Duke Engineering & Services
A Duke Energy Company

Southwest Carrizo-Wilcox Aquifer GAM Team

- Duke Engineering & Services, Inc.
- Freese and Nichols
- Parsons Engineering Science
- Waterstone
- Senior Technical Experts
  - Dr. Graham Fogg (UC—Davis)
  - Dr. Steven Gorelick (Stanford)

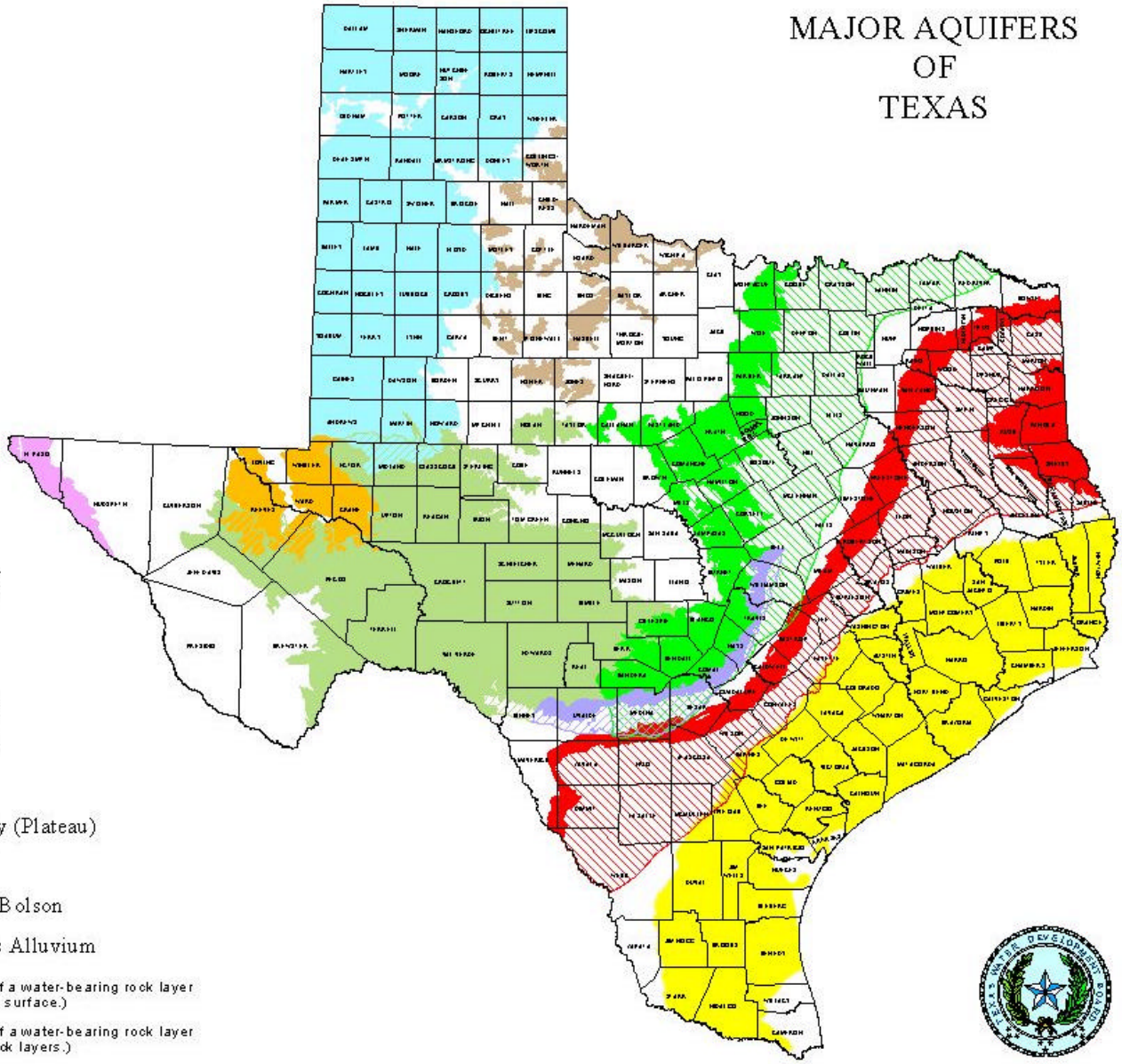
Subcontractor Support Roles

- Freese and Nichols
  - Groundwater demand and pumping
  - Recharge—Groundwater/surface water interaction
  - Stakeholder communication
- Parsons Engineering Science
  - Geographic Information Systems (GIS)
  - Water quality
- Waterstone
  - Modeling support

Outline

- Review of GAM Objectives and Expectations
- Introduction to Groundwater Modeling
- Southwest Carrizo-Wilcox Aquifer
- Modeling Approach for Carrizo-Wilcox Aquifer

MAJOR AQUIFERS OF TEXAS



EXPLANATION

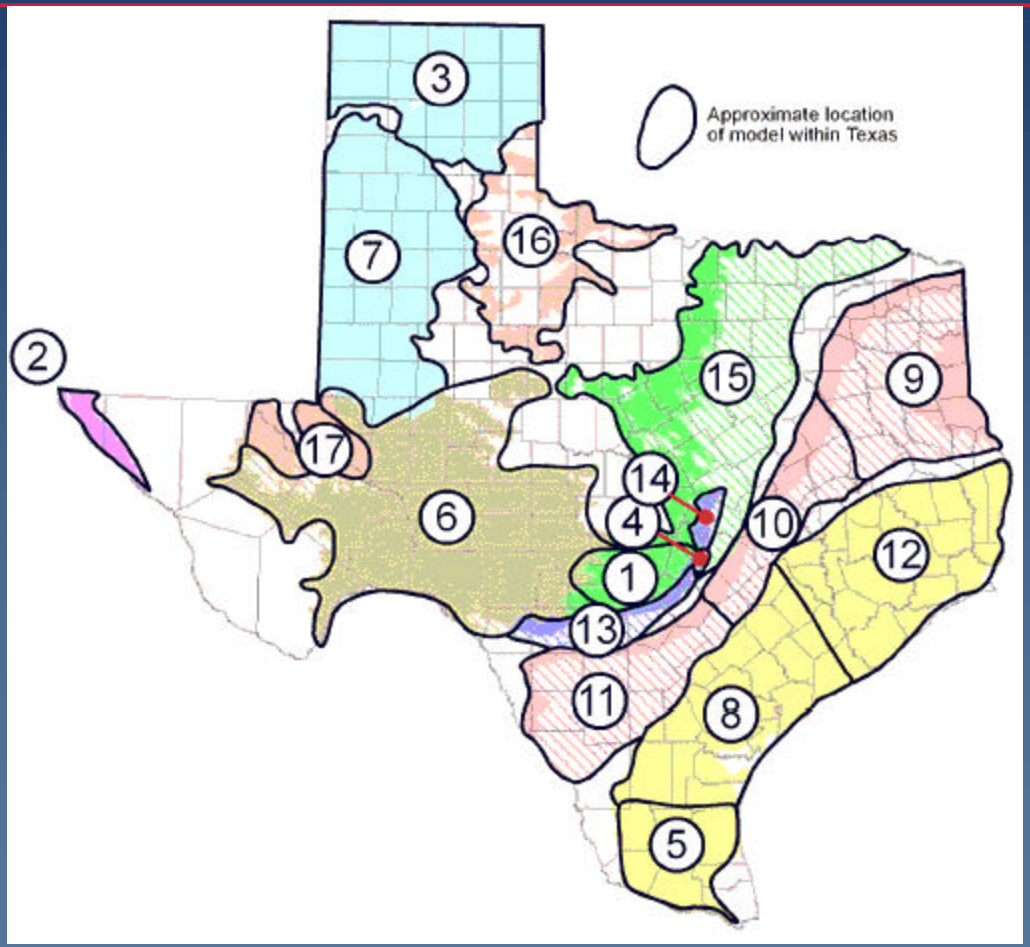
- Ogallala
- Gulf Coast
- * Edwards (BFZ)
- * Carrizo-Wilcox
- * Trinity
- * Edwards-Trinity (Plateau)
- Seymour
- Hueco-Mesilla Bolson
- Cenozoic Pecos Alluvium

OUTCROP (That part of a water-bearing rock layer which appears at the land surface.)

* DOWNDIP (That part of a water-bearing rock layer which dips below other rock layers.)

GAM Models

- Ongoing:
  - Carrizo-Wilcox (9-11)
  - Ogallala south (7)
  - Gulf Coast central (8)
  - Gulf Coast north (12)
  - Lower Rio Grande (5)
  - Edwards Trinity (6)
- Completed:
  - Trinity HC (1)
  - Hueco Bolson (2)
  - Ogallala north (3)
  - Edwards - BS (4)



GAM Objectives

- Provide reliable and timely information on GW availability to ensure adequate supplies or recognize inadequate supplies through 2050
- Develop realistic and scientifically accurate GW flow models representing the physical characteristics of the aquifer and incorporating the relevant processes
- The models are designed to assess GW availability through 2050 based on current projections of groundwater demands

GAM Expectations

- Result in standardized, thoroughly documented, and publicly available numerical groundwater flow models and supporting data
- Include substantial stakeholder input to insure the models address the relevant water-resources issues of each aquifer
- Provide an integrated tool for the assessment of water management strategies for state planners, RWPGs, and GCDs

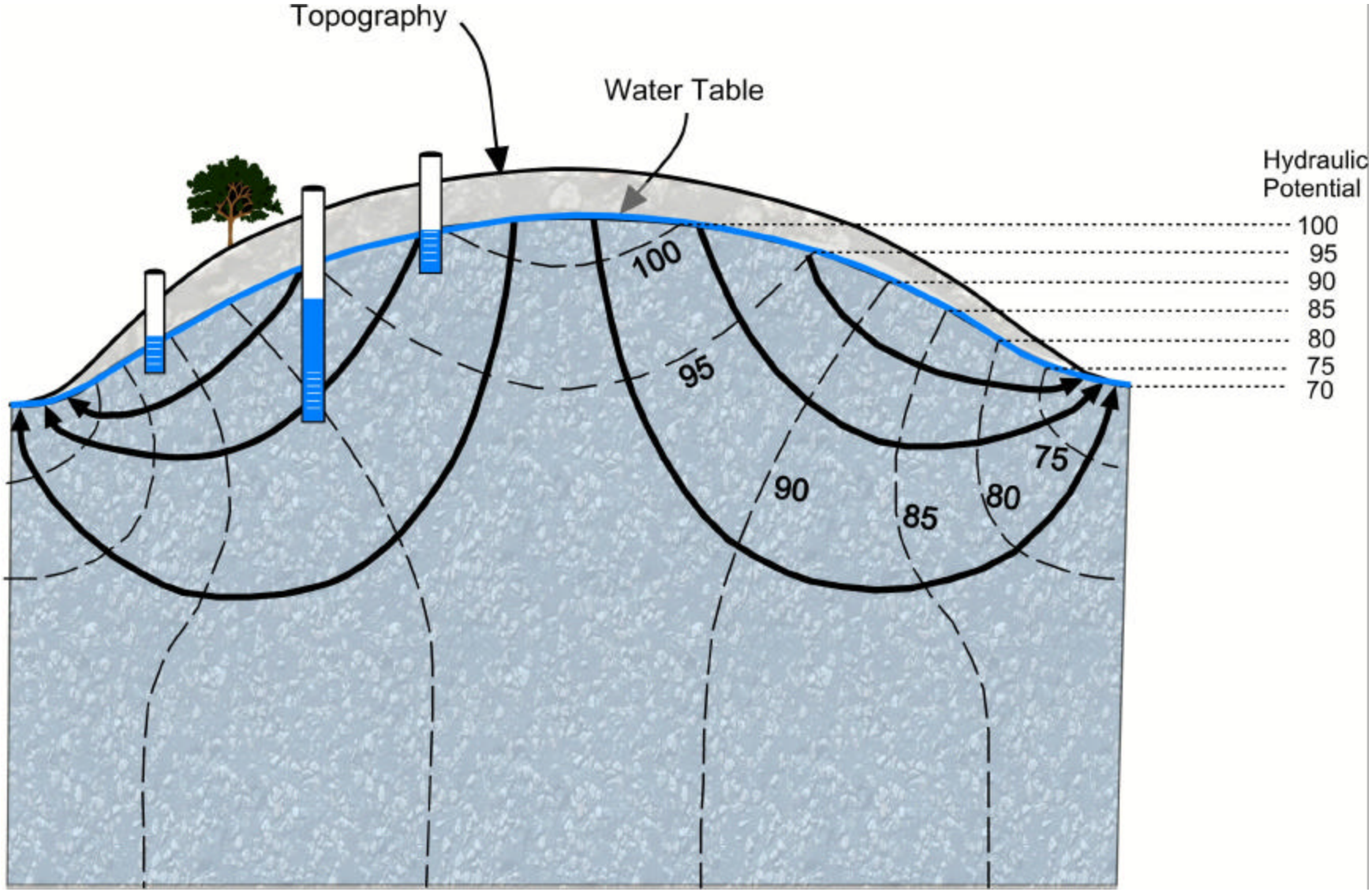
GAM Expectations (cont.)

- The GAM models will build and improve upon previous models
- The GAM models use established computer software and meet the GAM standards developed by TWDB and GAM TAG
- The models will be publicly available and the standardization will allow easy use and update of the model and input data ("living tools")
- Access: http://www.twdb.state.tx.us/GAM/

Why are GW Flow Models Needed?

- In contrast to surface water, groundwater flow is difficult to observe
- Aquifers are typically complex in terms of spatial extent and hydrogeological characteristics
- A groundwater model provides the only means for integrating available data for the prediction of groundwater flow at the scale of interest

Schematic Cross Section of GW Flow

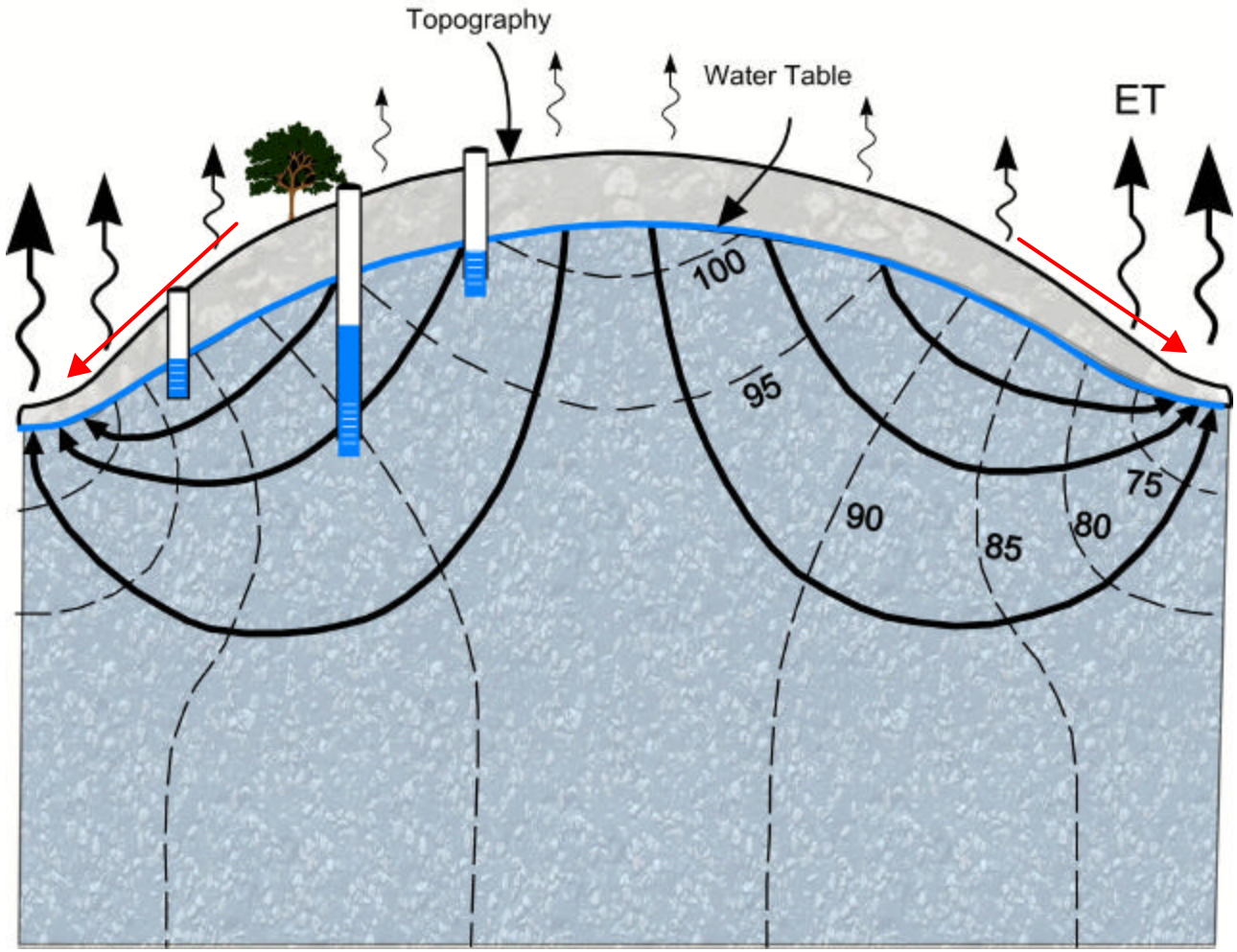


Principles of GW Flow

- The primary observable quantity describing groundwater flow is the water level as measured in a well
- The water-level expressed as elevation is termed the hydraulic head
- GW flows from high hydraulic heads to low heads
- The water table is a subdued replica of the topography
- The difference in hydraulic head between adjacent wells describes the direction of GW flow
- The difference in hydraulic head (gradient) and the physical properties of the aquifer material define volumetric flow rates within the aquifer

Precipitation

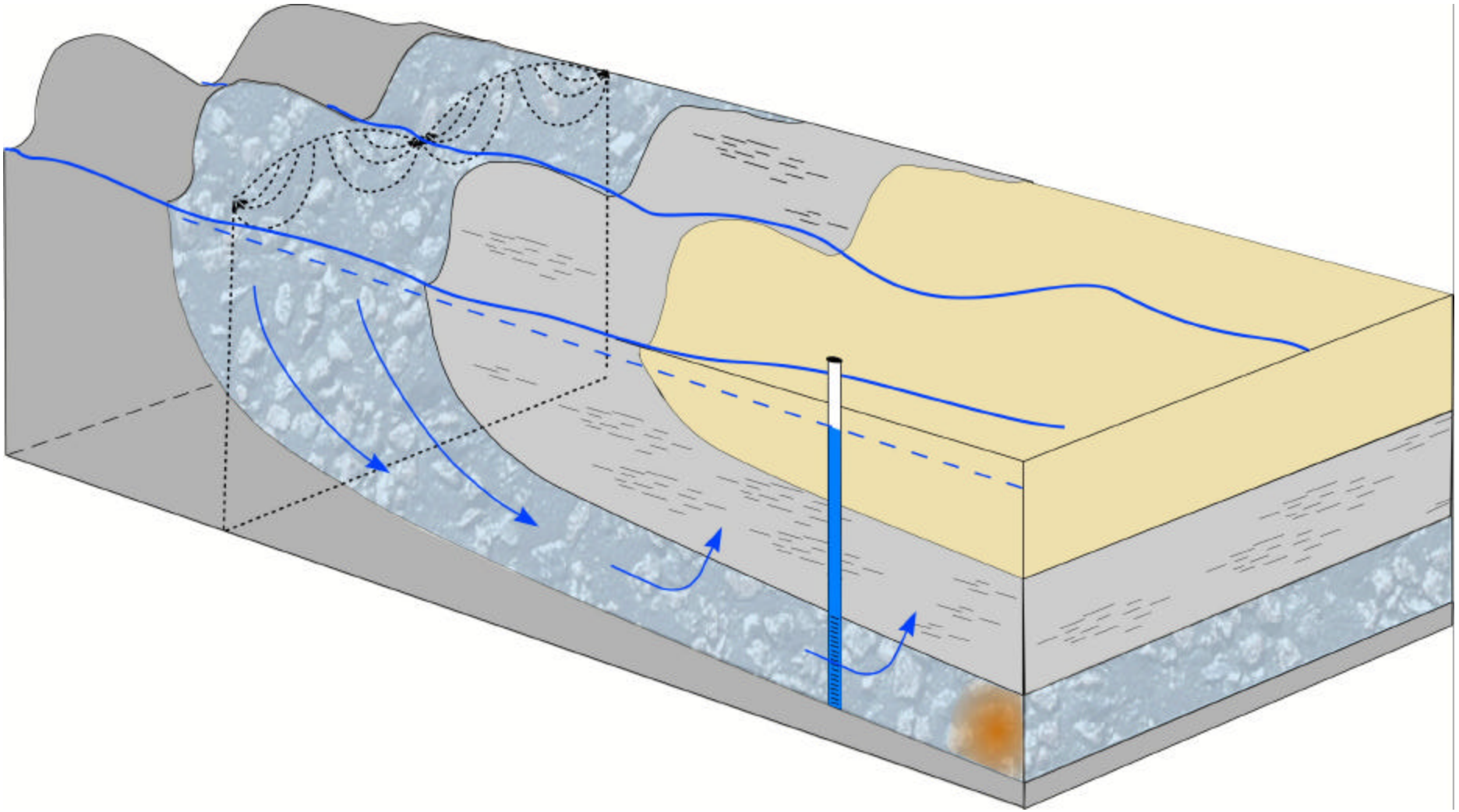
Recharge = P - ET - R



Principles of GW Flow (cont.)

- Recharge is equal to precipitation minus evapotranspiration (ET) and runoff
- Recharge is a function of:
  - precipitation,
  - topography,
  - soil type,
  - soil moisture,
  - geology,
  - depth to water (water level),
  - and evapotranspiration

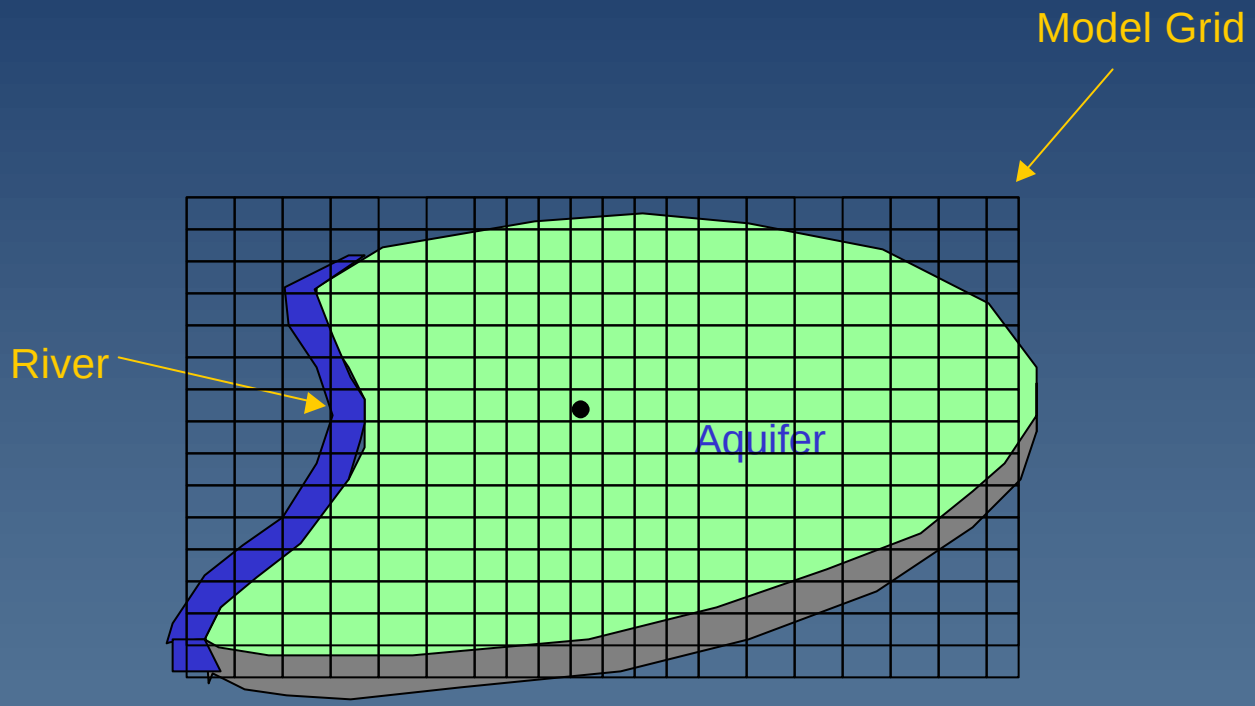
Block Diagram: confined aquifer



Numerical GW Flow Modeling

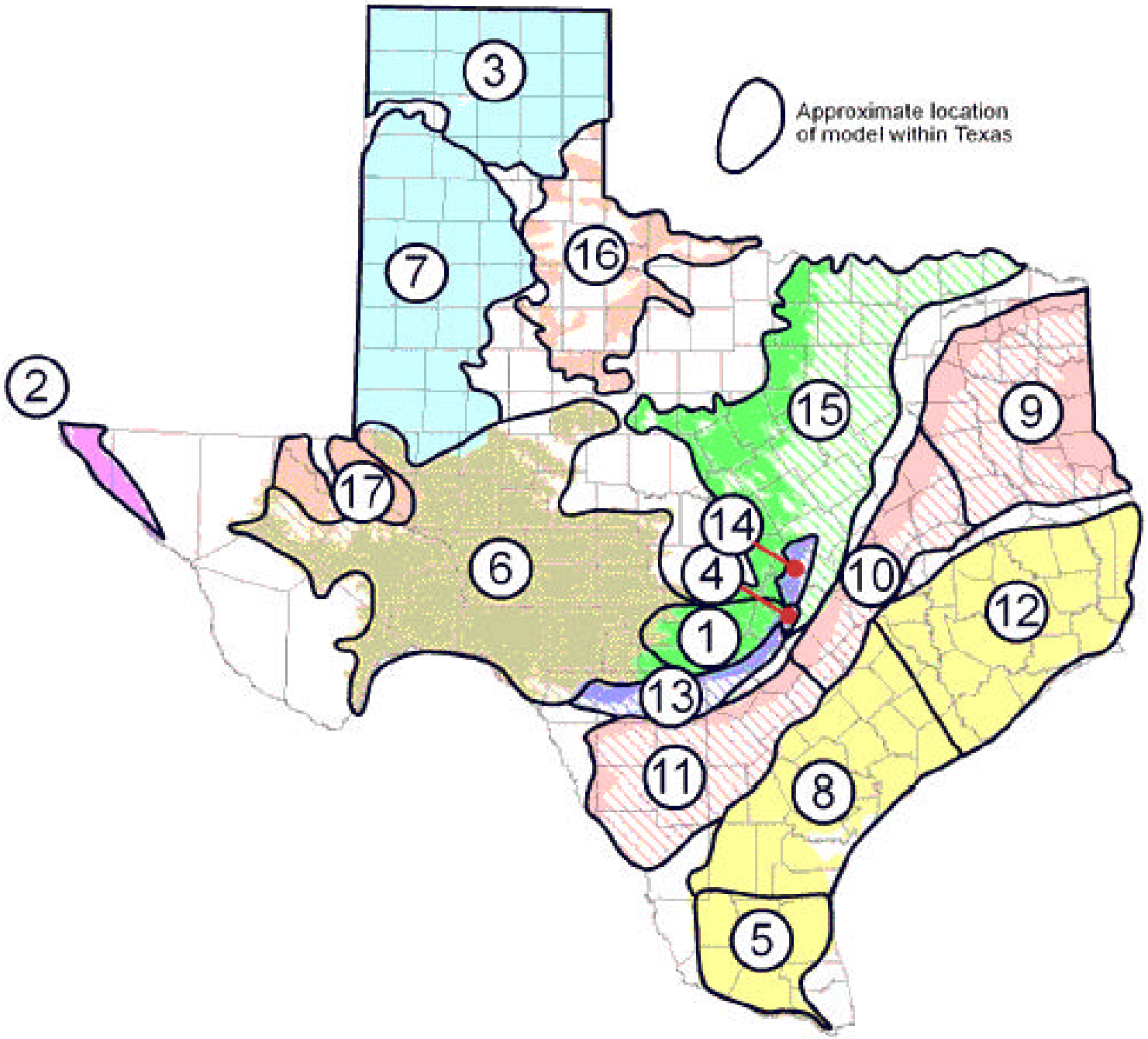
- A numerical groundwater flow model is the mathematical representation of an aquifer
- It uses basic laws of physics that govern groundwater flow
- In the model domain, the numerical model calculates the hydraulic head at discrete locations (grid),
- The calculated model heads can be compared to hydraulic heads measured in wells

Groundwater Model Domain

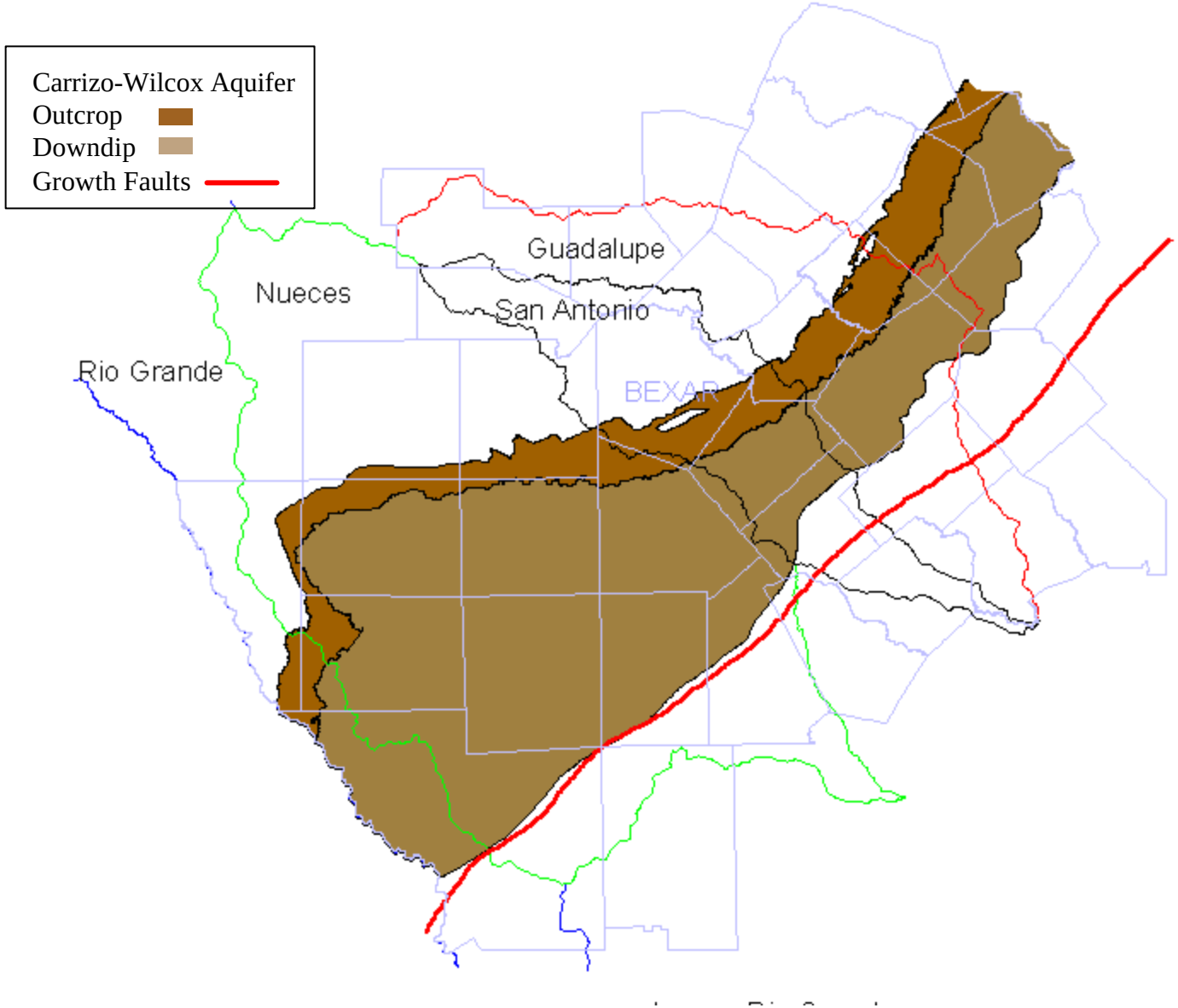


Southwest Carrizo-Wilcox Aquifer

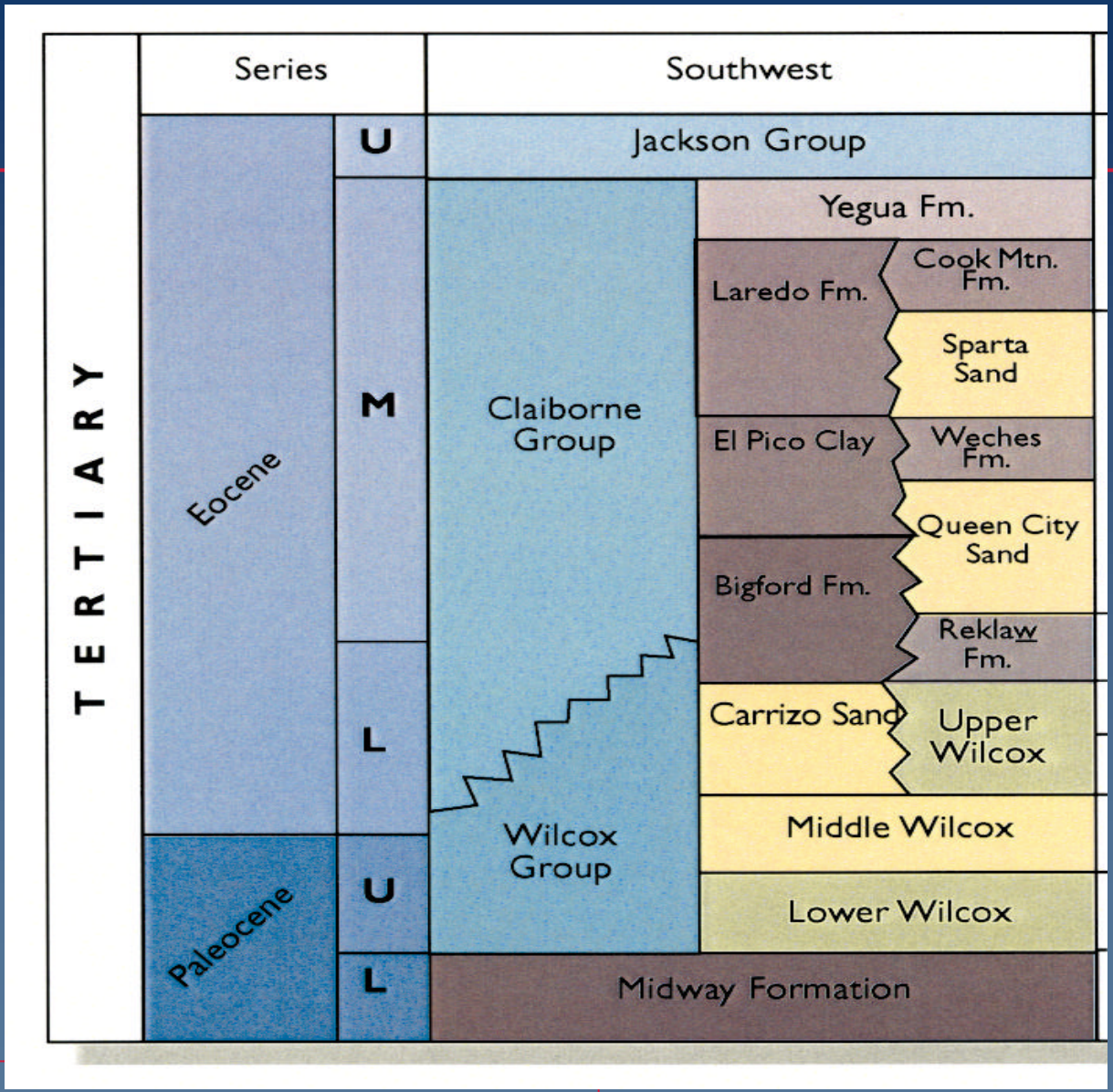
- Location and areal extent
- Coverage of major rivers
- Hydrostratigraphy
- Previous studies


3
Approximate location
of model within Texas
7
16
2
15
9
17
14
6
4
10
12
1
13
11
8
5

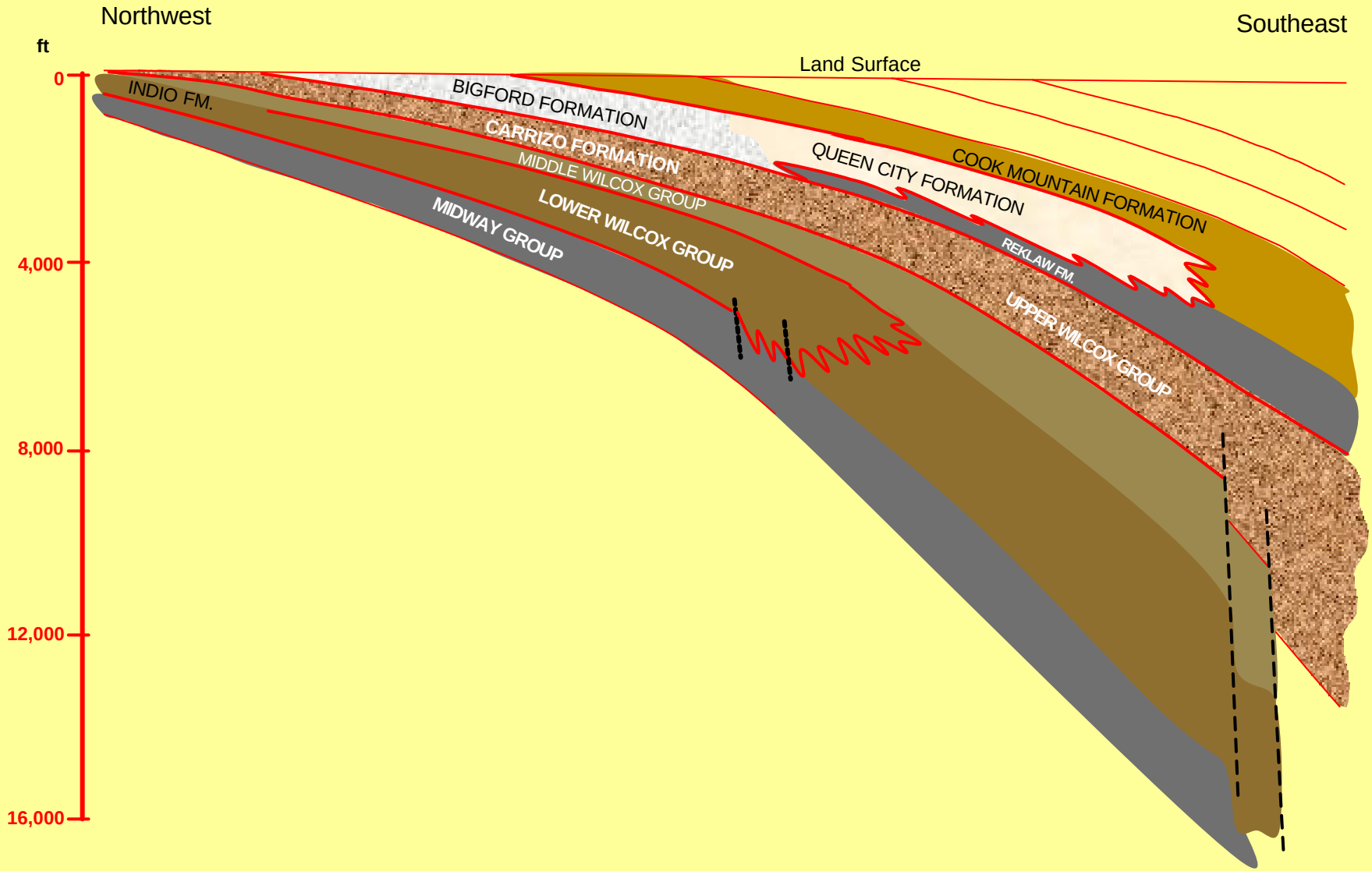
Southwest Carrizo-Wilcox - River Basins



Stratigraphy



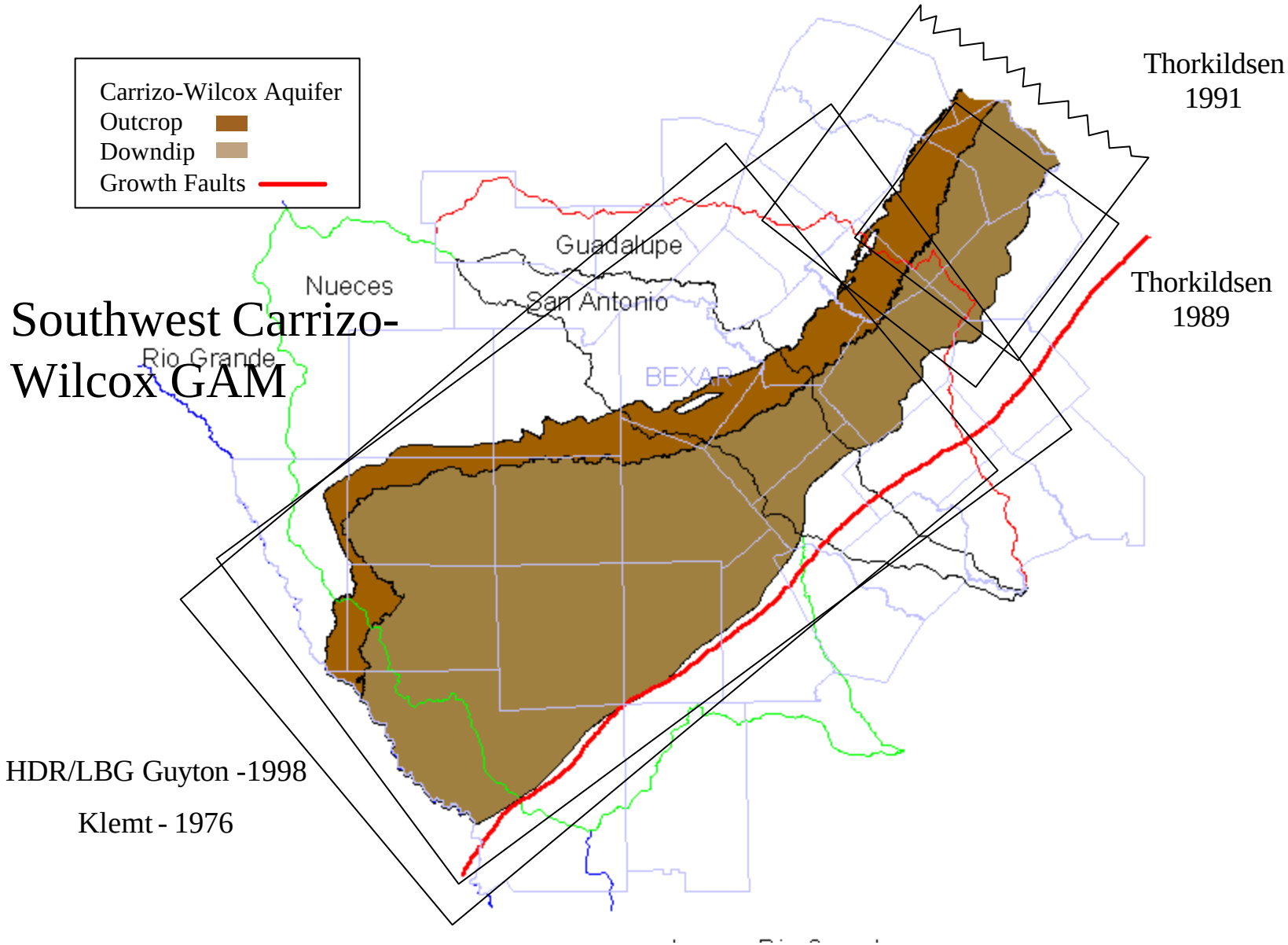
Schematic Cross-Section



Southwest Carrizo-Wilcox Aquifer

- Previous Model Studies:
  - Klemt (1976)
  - Thorkildsen et al. (1989)
  - Thorkildsen and Price (1991)
  - LBG-Guyton and HDR Engineering Inc. (1998)

Southwest Carrizo-Wilcox GAM Previous Model Domains



Southwest Carrizo-Wilcox GAM

HDR/LBG Guyton -1998

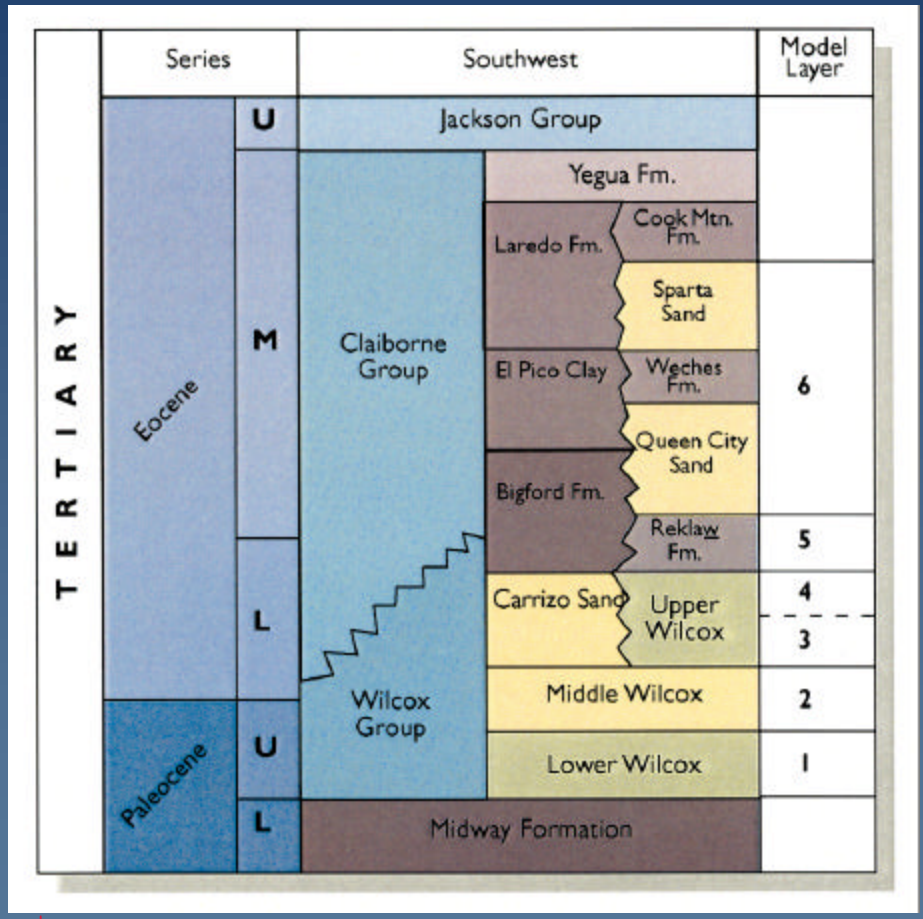
Klemt - 1976

Modeling Approach

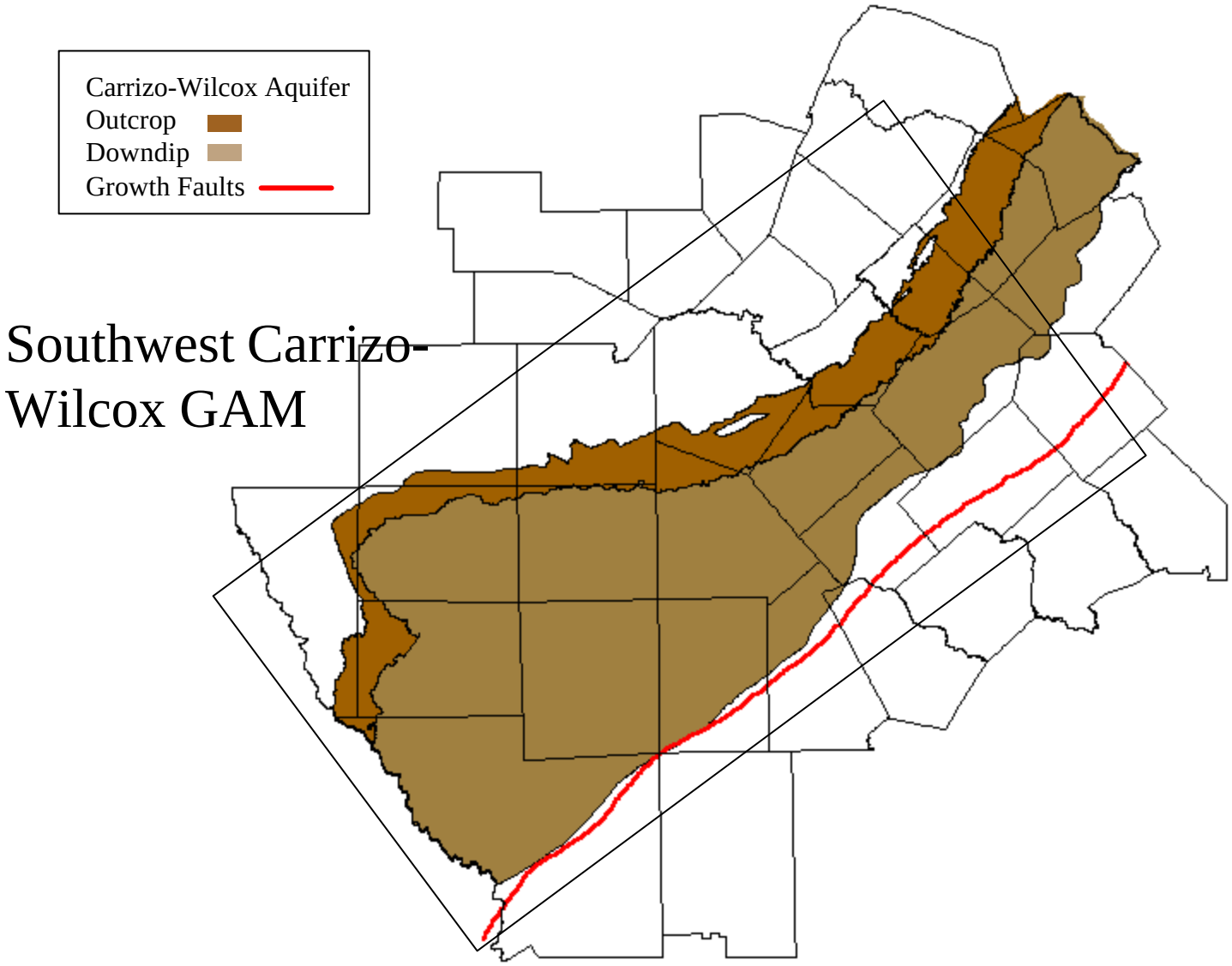
- Hydrostratigraphic layers
- Lateral boundaries
- Overlap and cooperation with adjacent GAM model
- Recharge

Model Layers

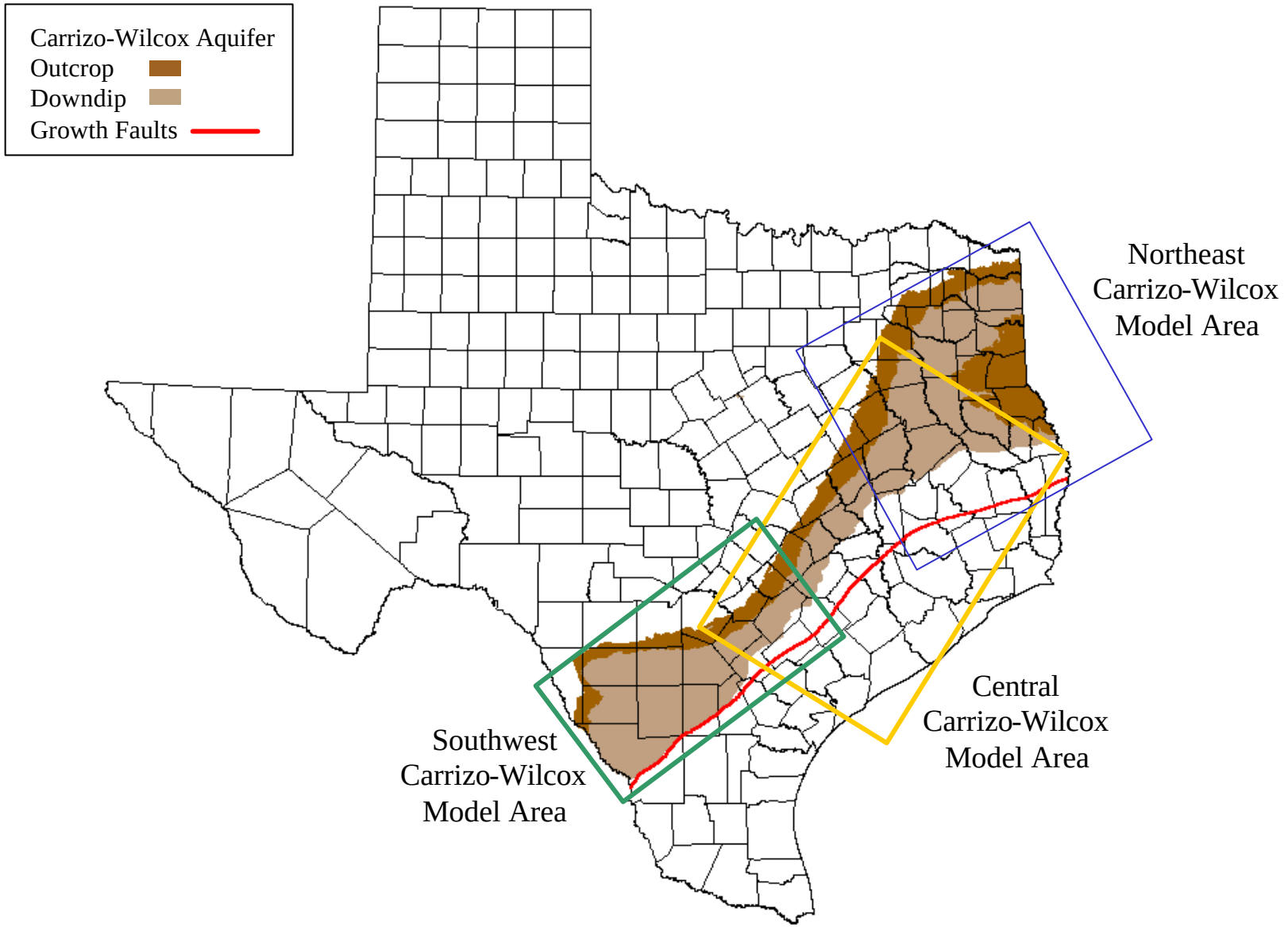
- Total of six layers
  - Carrizo-Upper Wilcox
  - Distinguish Middle and Lower Wilcox
  - Reklaw: major confining unit
  - Shallow aquifers above Reklaw
- West of Frio River:
  - Reklaw → Bigford Fm.
  - Queen City/Weches → Bigford/El Pico
  - Sparta → Laredo Fm.

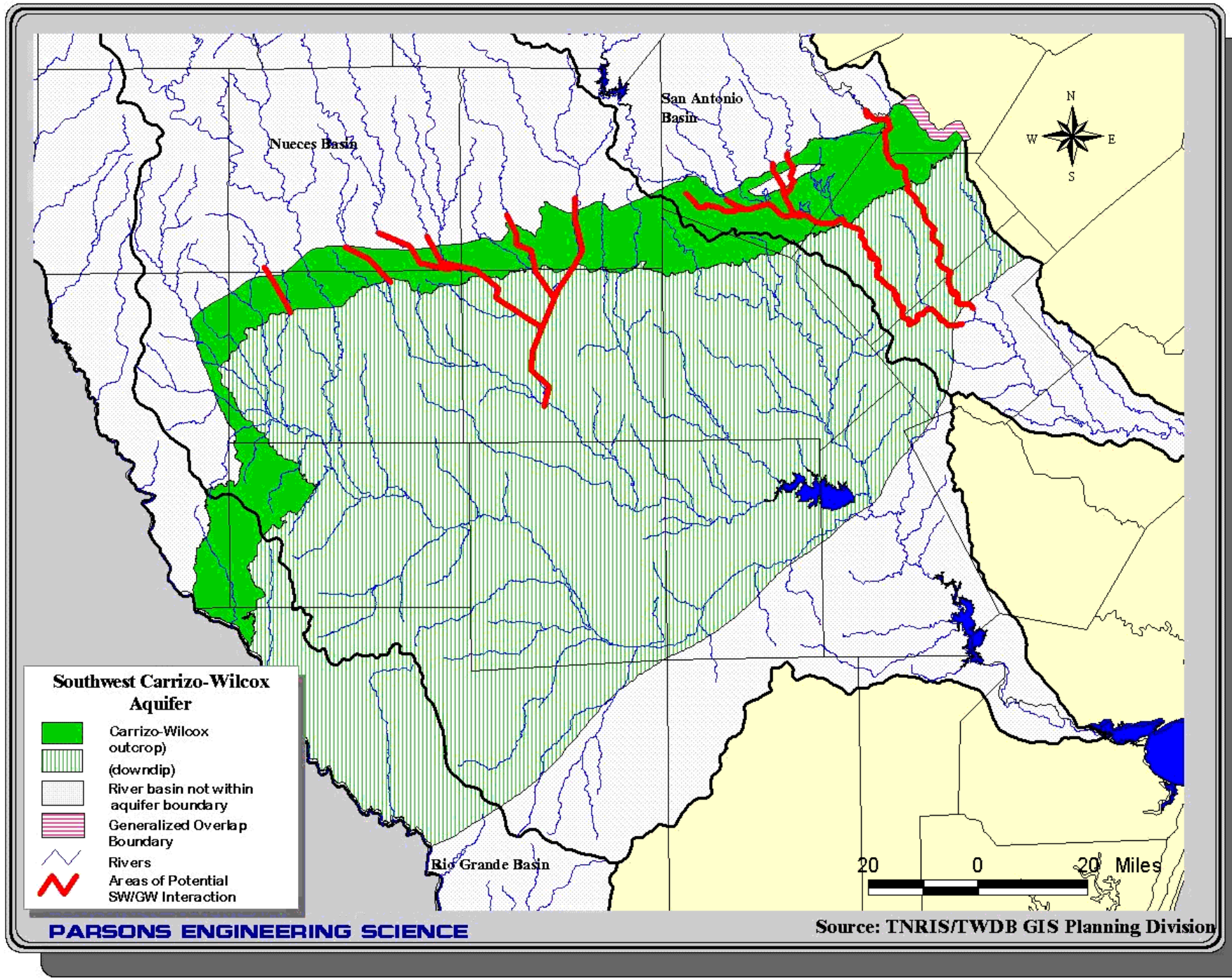


Southwest Carrizo-Wilcox GAM Model Domain

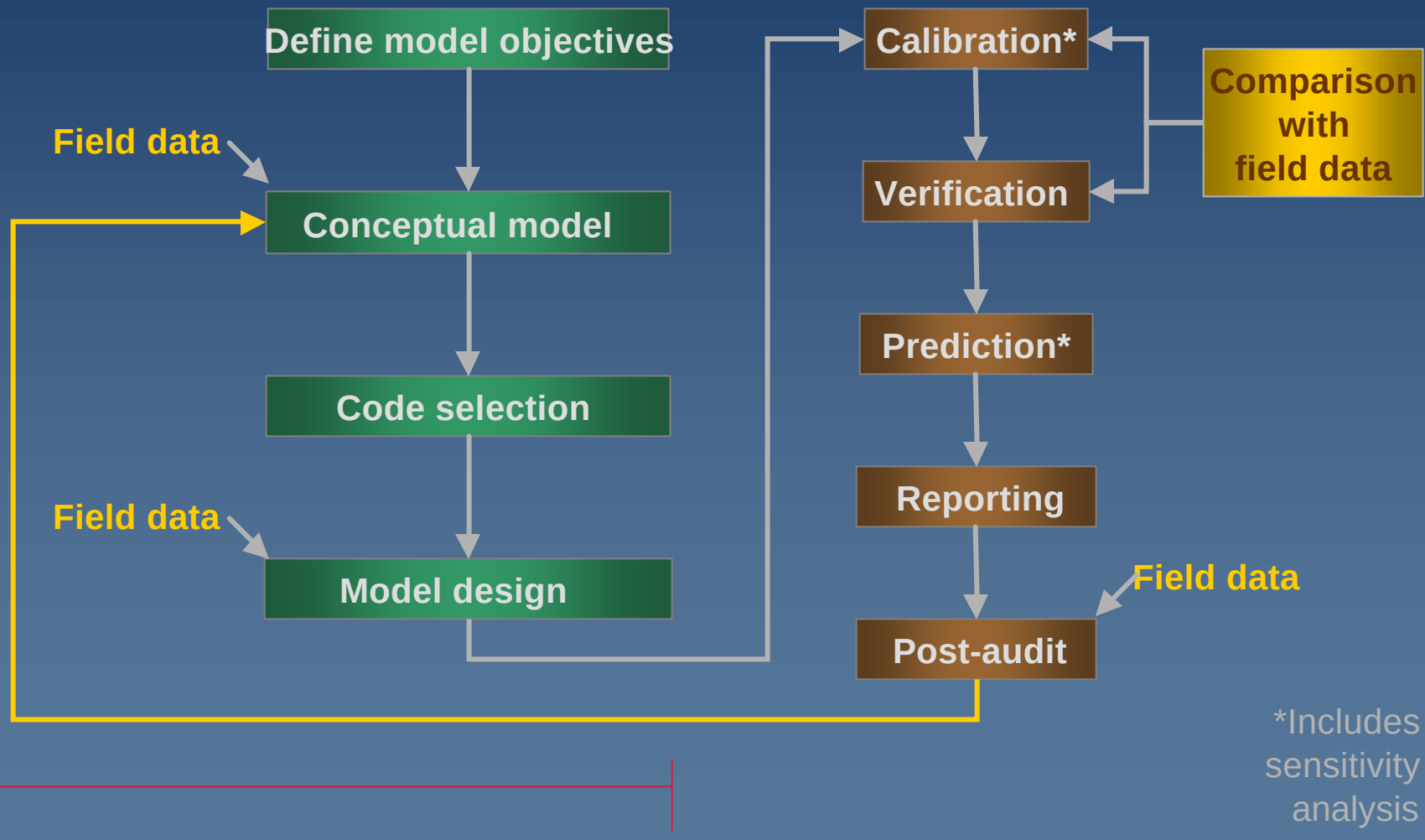


Carrizo-Wilcox GAM Model Domains




San Antonio Basin
Nueces Basin
N
W
E
S
Rio Grande Basin
20
0
20 Miles
Southwest Carrizo-Wilcox Aquifer
Carrizo-Wilcox outcrop)
(downdip)
River basin not within aquifer boundary
Generalized Overlap Boundary
Rivers
Areas of Potential SW/GW Interaction
PARSONS ENGINEERING SCIENCE
Source: TNRIS/TWDB GIS Planning Division

Modeling Protocol



Schedule

2001

- SAF Meeting 1—4/24
- SAF Meeting 2—7/15
- SAF Meeting 3—10/15
- 6/15—Complete conceptual model
- 9/30—Complete model design
- 12/15—Calibrate steady-state mode

2002

- SAF Meeting 4—1/15
- SAF Meeting 5—4/15
- SAF Meeting 6—7/15
- SAF Meeting 7—9/30
- 3/15—Calibrate transient model
- 6/15—Complete model predictions
- 9/30—Prepare draft report
- 12/7—Present SAF Model Seminar

2003

- SAF Meeting 8—1/15
- Deliver Final Product

ATTACHMENT A

NAME	AFFILIATION
Jorge Arroyo	TWDB
Tony Malik	Stockdale
Grant Snyder	URS Greiner Corp.
Carl Lambeck	Stockdale
Graylon Click	Floresville
Bill Klemt	LBG-Guyton
Craig Knapp	Carrizo User
Ray Knapp	Carrizo User
Ned Troshanov	Edwards Aquifer Authority
Linda Perez	Floresville – Carrizo
Christina Perez-Rohl	San Antonio
Bob Harden	R.W. Harden and Assoc.
Marvin Quinney	Wilson County Judge
Diane Savage	Wilson County Water Action Project
Alene Quinney	Stockdale
Robert Handowski	Floresville
Barry Miller	Gonzales County UWCD
John Waugh	San Antonio Water System
Steve Snider	Evergreen UWCD
Genevieve Bohmer	Picosa WSC
Monica K-Flores	Wilson County Water Action Board
Edward Jarzombek	Shady Oaks Water Co.
John Willis	RWPG / Open Forum
Mike Brinkmann	San Antonio Water System
Mary Robinson	Wilson County
Doug Brownlow	Wilson County
John Burke	AQUA Water Supply Corporation
Kevin Morrison	San Antonio Water System
Mike Thuss	Parsons
Susan Roberts	Parsons
Van Kelley	DE&S
Rainer Senger	DE&S
Robert Mace	TWDB
Edward Angle	TWDB

Meeting Minutes for the

First Southern Carrizo-Wilcox Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF) Meeting

April 24, 2001

San Antonio River Authority

San Antonio, Texas

The first Stakeholder Advisory Forum (SAF) Meeting for the Southern Carrizo-Wilcox Groundwater Availability Model (GAM) was held on April 24th from 2:00 until 5:00 PM at the San Antonio River Authority (SARA) Board Room in San Antonio, Texas. Attachment A of these meeting minutes provides a list of all participants who signed up as attending the meeting.

The purpose of the first SAF meeting was to introduce interested stakeholders to the purpose of the GAM Program, the basics of groundwater flow and groundwater flow modeling, and the proposed methodology to be used in modeling the Southern Carrizo-Wilcox Aquifer. The presentation material is available at the TWDB GAM website (www.twdb.state.tx.us/gam).

Meeting Introduction: Dr. Robert Mace, TWDB

The meeting was initiated by Dr. Robert Mace of the Texas Water Development Board (TWDB). He stated that the TWDB Groundwater Availability Section is busy developing several models with the goal of modeling all the major aquifers in Texas. Groundwater models are perfect tools to help understand what happens to aquifer water levels if various pumping scenarios are implemented.

The current GAM projects, such as this one for the Southern Carrizo-Wilcox, are focused on developing the tools to be used for groundwater availability assessments. The Groundwater Conservation Districts (GCDs) and Regional Water Planning Groups (RWPGs) will make the decisions regarding resource planning and groundwater availability. It is predicated that the RWPGs use the TWDB GAM unless the RWPG has a better tool or more site-specific information to make the particular assessment.

The SAF is by definition a forum to inform stakeholders on GAM and how the GAMs are being developed. The SAF provides a forum for the discussion of the GAMs as resource planning tools including their capabilities and limitations. The SAF also provides a forum for the TWDB, and their consultants, to receive valuable input from the stakeholders on how the aquifer behaves, what the local issues are, what data are available, and to help in the GAM development.

SAF Presentation: Van Kelley and Rainer Senger, Duke Engineering and Services (DE&S)

After the introduction by Dr. Robert Mace, Van Kelley and Rainer Senger of the Duke Engineering and Services Southern Carrizo-Wilcox Team presented a prepared presentation. The presentation was structured according to the following outline:

1. Review of GAM Objectives and Expectations
2. Introduction to Groundwater Modeling
3. Southwest Carrizo-Wilcox Aquifer
    - Location and Extent
    - Major River Basins
    - Hydrostratigraphy
    - Previous Investigations
4. Approach to Modeling the Southwest Carrizo-Wilcox Aquifer
5. Schedule

The presentation is available on the GAM website (*www.twdb.state.tx.us/gam)*.

Questions and Answers: Open Forum:

Q: How do you determine the size of the model cells?

A: *The model cell size was pre-determined and prescribed by the TWDB to be one square mile. This size represents a balance between the model's ability to predict drawdowns in the vicinity of a well versus the very large size of the model resulting in a large number of model grid cells.*

Q: Is there a printed itinerary for this meeting available today?

A: *No, however the meeting minutes and presentation material will be available on the TWDB GAM Website (www.twdb.state.tx.us/gam).*

Q: Will the conceptual model be fixed, that is truly completed, on 6/15/01 and if so will this be our only venue for input?

A: *No, the schedule presented in the presentation is incorrect in stating that the conceptual model will be completed at that date. It is the intention of the DE&S team to have a draft conceptual model complete and ready for TWDB review in the second half of June. Our next SAF meeting is planned for the middle of July. At that time, the SAF will be able to provide input on the conceptual model which will be presented at that meeting. This will provide adequate time for the GAM development team to incorporate recommendations.*

Q: How flexible is the schedule presented?

A: *The project schedule is prescribed in the GAM contracts and is based upon the TWDB's experience in the Trinity GAM and because there are limits to funding.*

Q: What is the source of your data? Are you drilling new wells?

A: *No, but we will be adding some TWDB aquifer tests into the model database. More information is always welcome; at this time we are mostly working with data compiled by the TWDB. The Trinity GAM is being used as a prototype.*

Q: Please go further on the data. We know that some data is available that did not get into the RWPs.

A: *This is a good point. The TWDB is aware that there may be additional data available that we may not have. To the degree possible, the TWDB wants to collect and use that data.*

Q: What is the link to the Groundwater Conservation Districts (GCDs). How will the information be passed from the GCDs through to the GAM team?

A: *The GCDs are currently providing all test data to the TWDB. It will be up to the team to contact the local cooperatives to incorporate the relevant data into the database currently available to the TWDB.*

Q: What will be the impact of pumping the Edwards on the Carrizo-Wilcox?

A: *We do not really know. This is not a question that can be answered with the Southern Carrizo-Wilcox GAM.*

Q: Is ASR part of the GAM?

A: *Not at this time – but the model can be used to look at the hydraulic aspects of ASR. The model is not being developed to look at any potential water quality issues that may arise from ASR.*

Q: We have a big problem in Wilson County. The RWP showed Wilson County to have a big groundwater surplus, even though regionally water levels have been dropping. Will this model show the impact of pumping on future water levels?

A: *The model can be used to determine if water levels are falling as a result of pumping and also it can be used to evaluate how good the recharge estimates are that are currently being used in the RWP.*

Q: A major water supply project (30,000 acre-feet/yr), the Schertz-Seguin Water Supply Project (SSWSP), is planned. Currently this project is not in the Region L water demand projections. This must be included into the GAM to get a realistic prediction of future groundwater levels. We have many questions related to this well field. How will Atascosa and Wilson Counties be impacted? What will be the impact on recharge?

A: *The GAM contracts require the contractors to use the 2000 to 2050 projected water use as defined in the RWPs. However, the great thing about models is that once you get the hard part done, which is constructing the model (GAM Mission), it is easy and fast to look at a scenario such as the SSWSP.*

Response: That is not good enough, this model must incorporate the SSWSP pumping before the pumping actually begins.

Response: The Evergreen Underground Water Conservation District is working with Region L to include the SSWSP into the RWP.

Q: Where will the information and data used in the model be posted and available for review?

A: *On the TWDB GAM website (www.twdb.state.tx.us/gam).*

Q: The City of Stockdale is listed in the TWDB database as pumping from the Queen City. In fact, the City has been pumping from the Carrizo since 1963. The water level elevation has been dropping seven inches per year. We need to know the potential impact of the SSWSP on our water levels.

A: *The TWDB will correct the aquifer information for the City of Stockdale.*

Q: How fast can we get answers from these models on the impacts of the proposed pumping over the next 50 years?

A: *Once the models are built, we can answer resource allocation questions quickly. The models will not be completed until the beginning of 2003.*

Q: Can you explain what is meant by calibration and verification?

A: *These are modeling terms which have a specific meaning in the context of GAM. To calibrate a model is to adjust the model properties (i.e., hydraulic conductivity, storage), such that the model reproduces measured water levels and stream discharge. This modeling approach is termed the inverse problem and is inherently non-unique. This means that there are more than one set of parameter values that can reproduce observed water levels. Therefore, the calibrated model is used to run in the "forward" mode to see how well the model predicts measured water levels and discharge without modifying model properties. This process is called model validation. In GAM, the model calibration time period is defined to be from 1980 through 1990. The validation time period is defined to be from 1990 through 2000.*

Q: The Evergreen Underground Water Conservation District has an extensive historical database of pumping and water levels. It is considered imperative that the Evergreen database be incorporated into the GAM. Does the GAM team want to use this data.

A: *Yes, we need to get that data.*

Q: How will the data be requested?

A: *TWDB or DE&S will contact Evergreen for the data.*

Q: If you are putting so much weight on the GAM models for the determination of water availability, what is your confidence in the accuracy of the models?

A: *This is a very good question. We build confidence in using our models in the calibration and validation phases. The GAM models are required to be able to fit twenty years of historical data which increases our confidence in using the models for predicting future conditions. Each GAM model requires a sensitivity analysis which provides information on how certain we are of the selected model parameters. The TWDB developed a detailed set of specifications for the GAM models so that they can be used to make long-term future predictions of water levels which may be affected by significant groundwater withdrawals. The GAM models, as currently formulated, will not provide a quantitative uncertainty analysis.*

Q: Do you start at square one or are you using the old models which may be available for the GAM model region.

A: *Yes, we are using information and data from the old models where is still relevant. The GAM models seek to build on the work of previous investigators while developing a standardized tool to be used to assess groundwater availability.*

Q: Our recharge rate estimate is not as high as that used in the Region L RWP. If the estimates in the RWP were correct, water levels would be rising regionally when in fact they are falling.

A: *Recharge in the region is being independently evaluated in the development of the GAM. We will not determine groundwater availability for the RWPGs in the GAM Program.*

Q: Growth is occurring in Wilson and Atascosa Counties which is not properly being represented in the RWP.

A: *This issue must be resolved with Region L.*

Q: Could you provide some type of graphical interface for the water well database which you will be posting on the GAM website.

A: *We will post the database in a pdf format so it is accessible to all.*

Q: Will the GAM contractor look at new technologies or methods of determining recharge rates?

A: *The TWDB has a contractor currently investigating recharge rates for the aquifers that are being modeled.*

Q: Can you make policy decisions based upon the results from this model and report?

A: *No, water resource decisions are between you and your state legislators.*

Q: Will you have some regression models relating water levels with rainfall?

A: *We will be investigating the drivers for water levels fluctuations in the model region, be it pumping or precipitation.*

Q: Is there a way to have the conceptual model available for SAF review prior to the next meeting?

A: *The TWDB and the GAM Team will confer to see what can be done to make this information available to the SAF prior to the meeting.*

Q: What effort will you make to get pumping data from suppliers that do not come forward and provide it.

A: *The TWDB gets a 90 to 95% return rate from our municipal surveys. We will be calling the 5 to 10% who have not come forward.*

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