Brazos River Alluvium Aquifer Groundwater Availability Model (GAM)

Stakeholder Advisory Meeting #1

College Station, TX

January 22, 2014

Texas Water Development Board

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Outline

- **Introduction**
  - The Brazos River Alluvium Aquifer GAM team
  - Study Objectives
  - General Introduction to the GAM program
- Background
  - Basics of groundwater flow
  - Numerical groundwater modeling and the GAMs
- Brazos River Alluvium Aquifer overview
- Key model aspects
- Request for Data
- GAM schedule

Project Team & Responsibilities

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- Texas corporation with 30 scientists and engineers in Austin
- International reputation in numerical modeling
- Lead on 11 other Texas GAMs and support (revisions, updates, recalibration) on 4 others

- Prime contractor
- Project management and technical coordination
- Technical lead for all tasks

Bureau of Economic Geology

- Premier geologic research organization in Texas
- Technical contributions on 6 GAM projects
- Unique expertise in aquifer recharge, ET, and hydrostratigraphy

Senior technical input and review

Brazos River Authority

- Unique knowledge of the Brazos River and hydrologic conditions
- Comprehensive database of hydrologic information on the Brazos River Basin

Senior technical input and review

Freese and Nichols

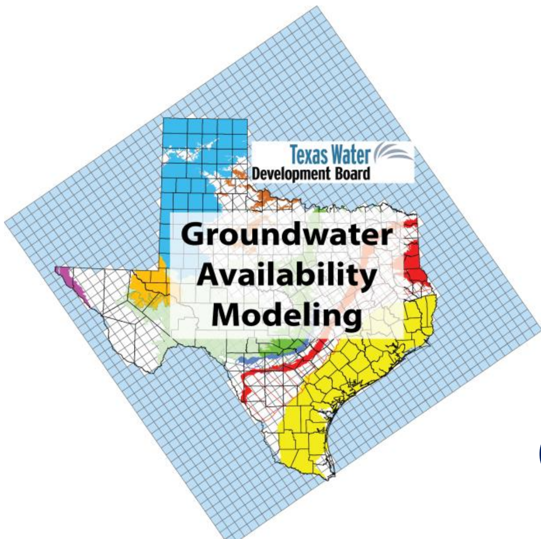
- Nearly 120 years of water-related experience in Texas
- Member of team that developed Brazos River basin WAM
- Completion of multiple hydrologic studies in the Brazos River Basin

Technical input on surface water/groundwater interaction and pumping

Study Objectives

- Improve the conceptualization of the surface water/groundwater interaction in the Brazos River Alluvium Aquifer
- Provide tool for assessing desired future condition of the aquifer (DFC)/ modeled available groundwater (MAG) that is consistent with joint planning of the underlying aquifers
- Provide groundwater model/tools suitable for eventual conversion to integrated surface water/groundwater model

Groundwater Availability Modeling



Cindy Ridgeway

Contract Manager

Brazos River Alluvium Aquifer Groundwater Availability Model (GAM)

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Groundwater Availability Modeling (GAM) Program

- Purpose: to develop tools that can be used to help Groundwater Conservation Districts, Regional Water Planning Groups, and others understand and manage their groundwater resources.
- Public process: you get to see how the model is put together.
- Freely available: models are standardized, thoroughly documented. Reports available over the internet.
- Living tools: periodically updated.

What is Groundwater Availability?

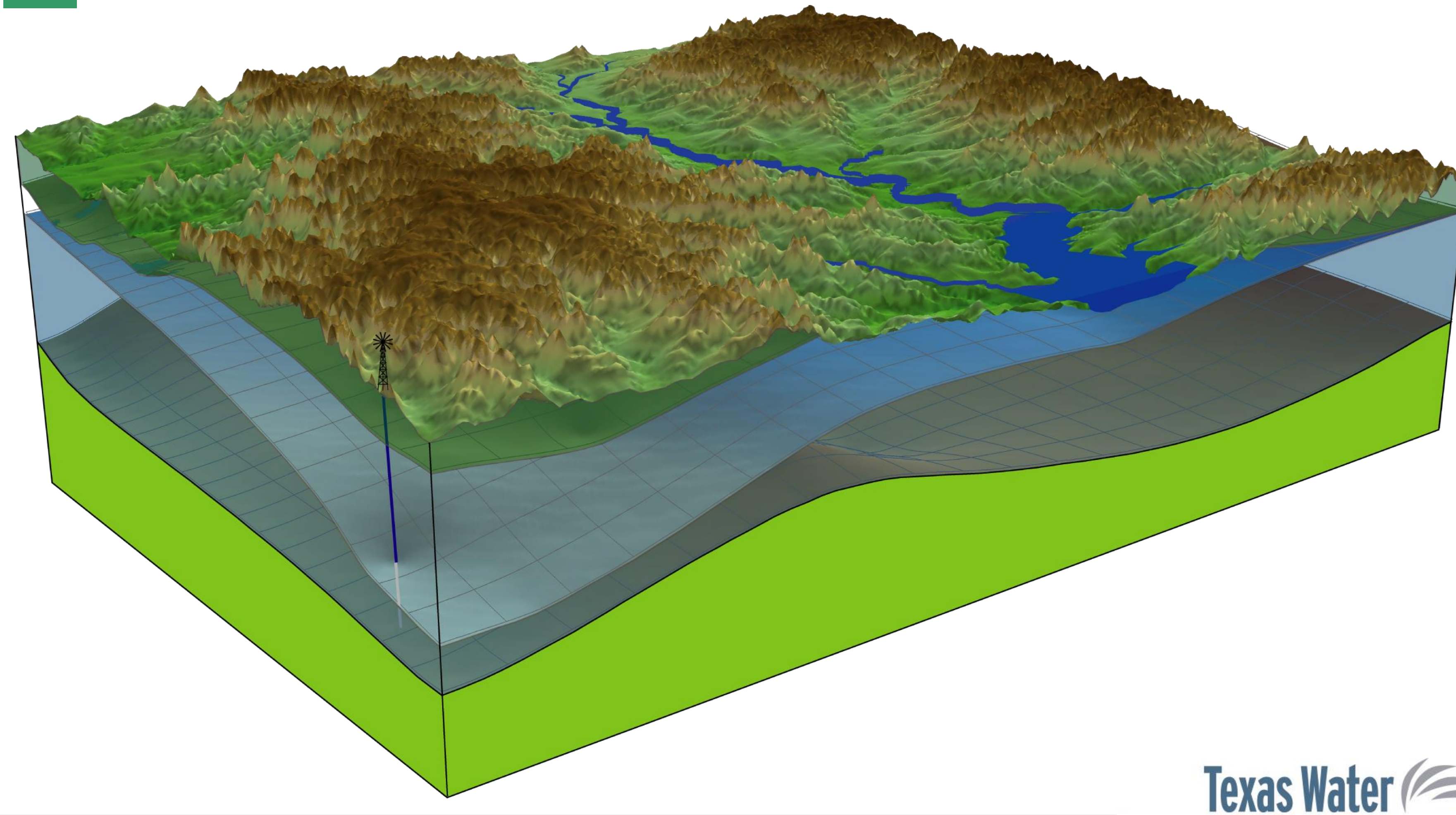
Policy + Science = Groundwater Availability

↓ ↓ ↓

Desired Future Conditions + GAM or other tool = Modeled Available Groundwater

Goal: informed decision-making

Groundwater Model



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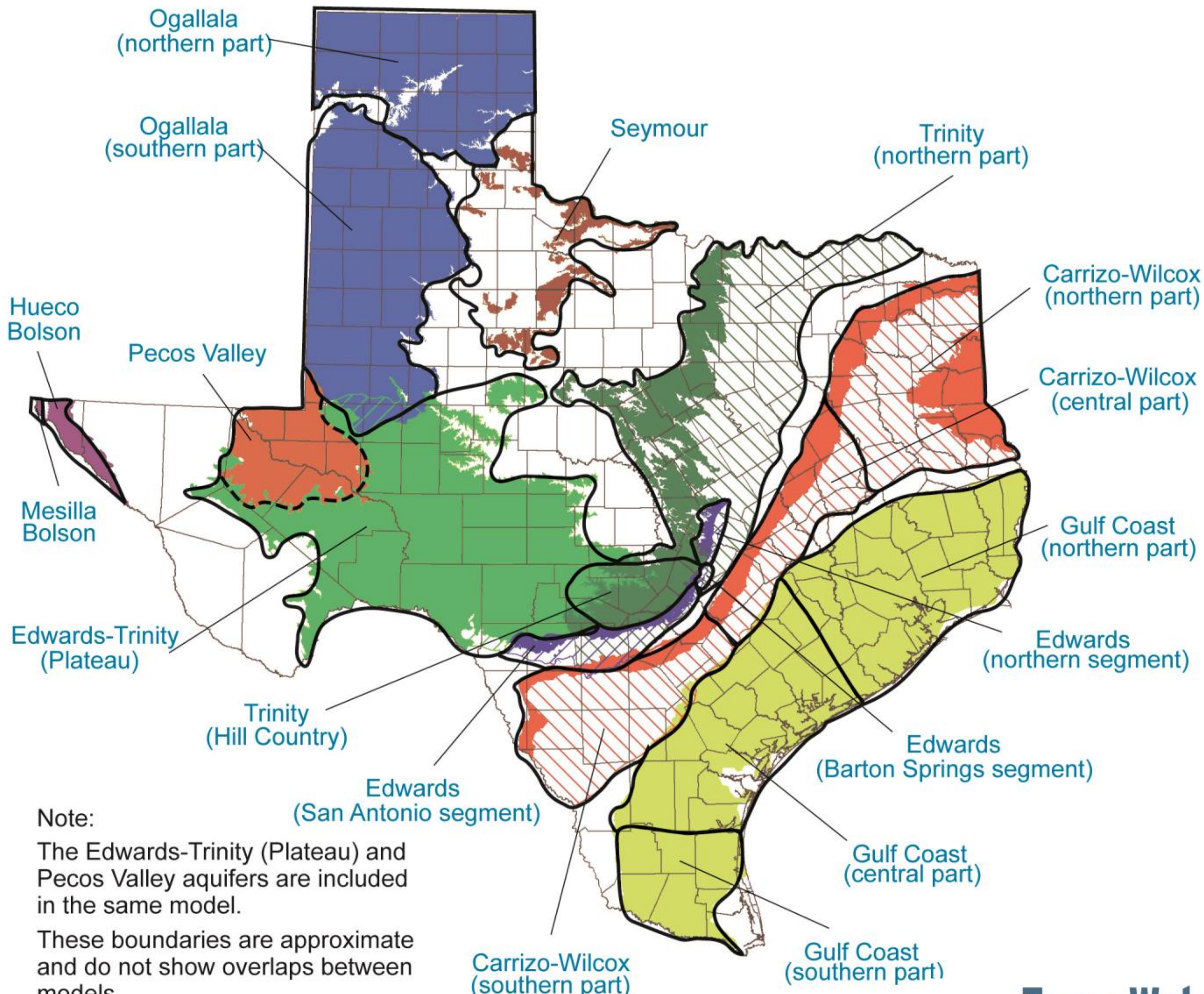
Major Aquifers



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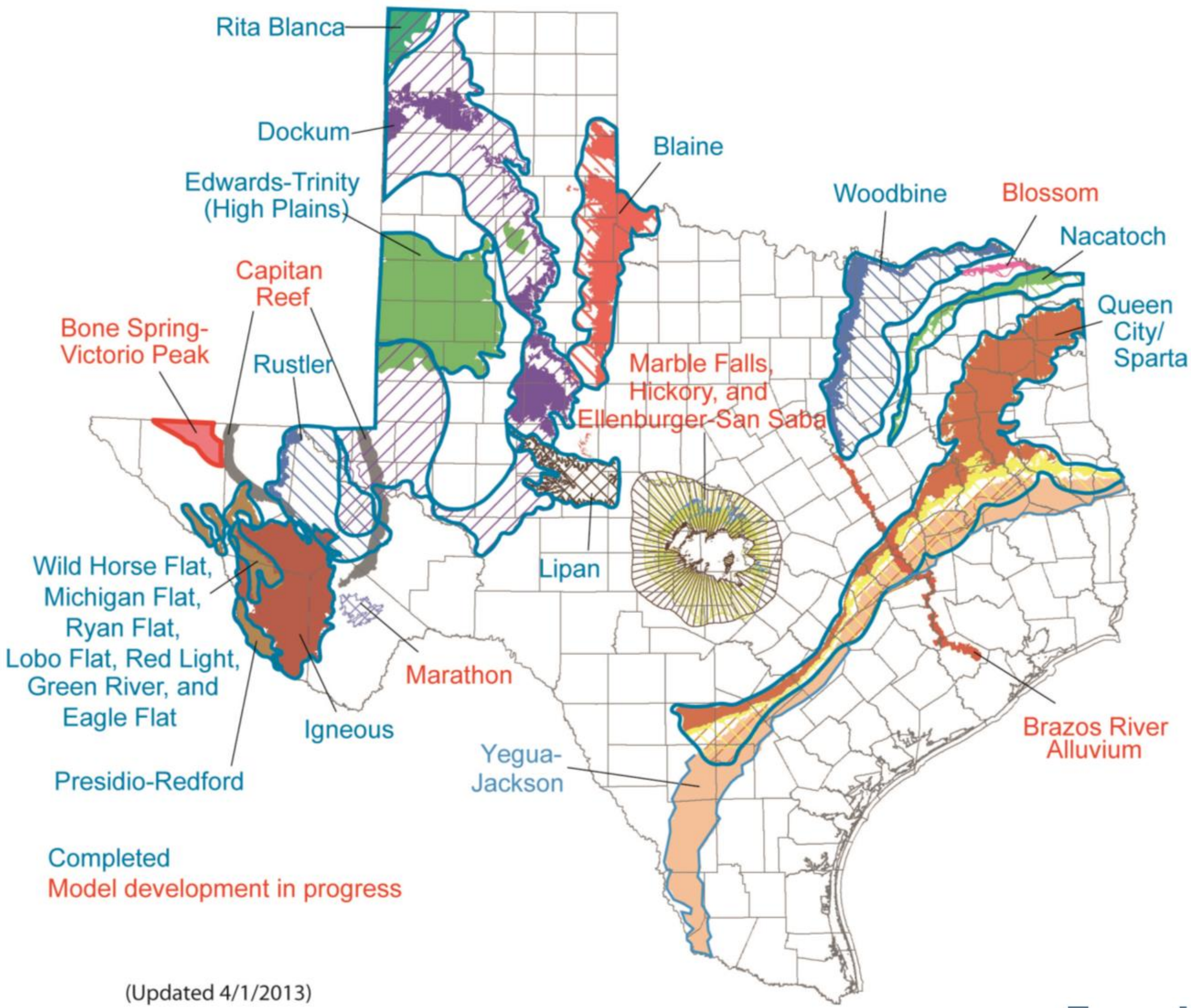
Minor Aquifers



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How we use Groundwater Models

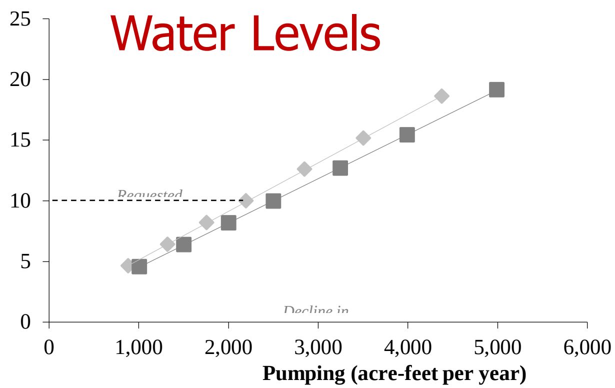
- Texas Water Code, § 36.1071 (h)

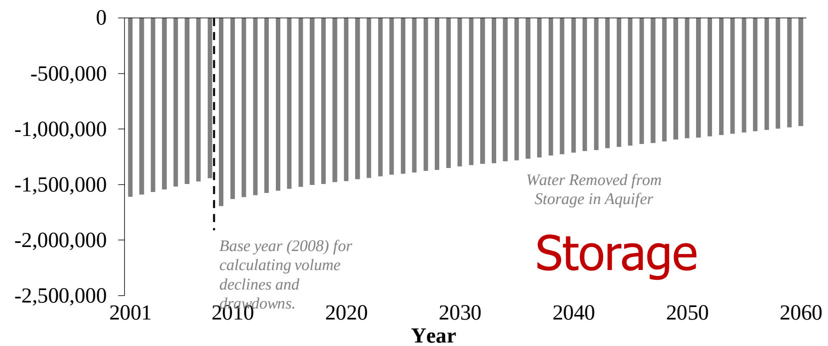
Inform groundwater districts about historical conditions in the aquifer

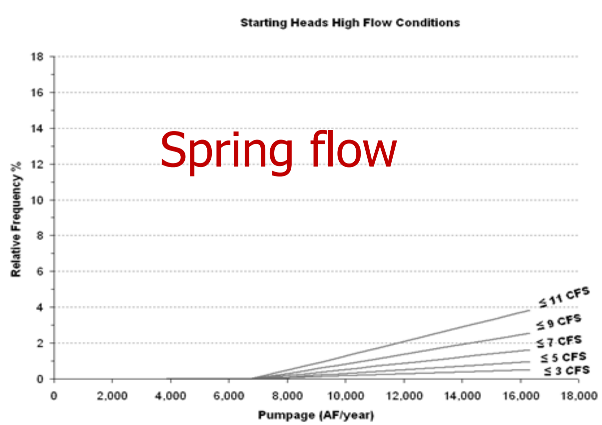
Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	140,509
	Pecos Valley Aquifer	14,115
	Dockum Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	31,222
	Pecos Valley Aquifer	9,804
	Dockum Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	32,993
	Pecos Valley Aquifer	3,441
	Dockum Aquifer	554

How we use Groundwater Models

- Texas Water Code, § 36.108 (d): Assist districts and management areas in determining desired future conditions







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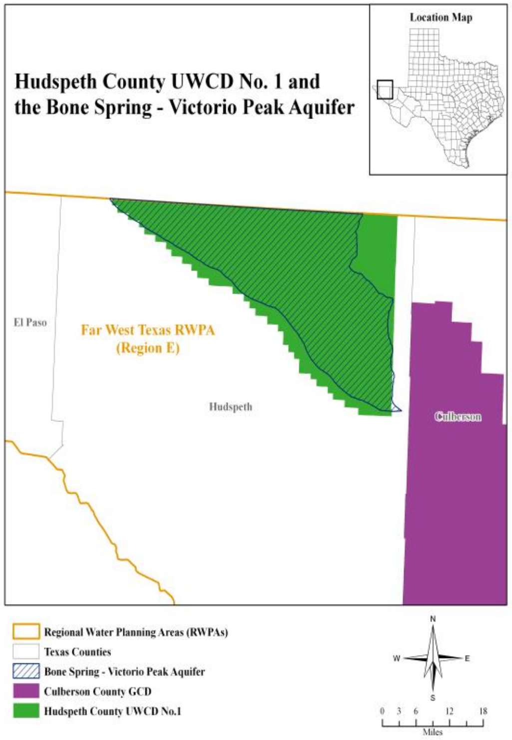
How we use Groundwater Models

- Texas Water Code, § 36.1084 (b): Develop modeled available groundwater based on desired future conditions

County	Regional Water Planning Area	Basin	Year					
			2010	2020	2030	2040	2050	2060
Hudspeth	E	Rio Grande	101,429	101,429	101,429	101,429	101,429	101,429



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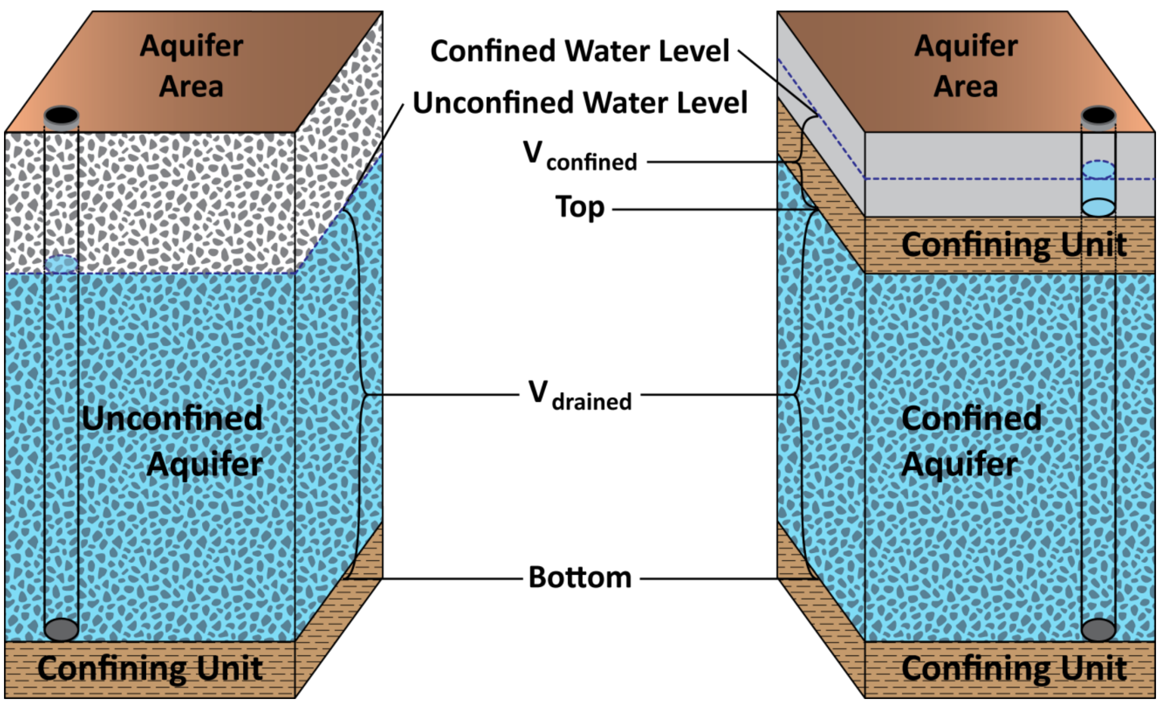
How we use Groundwater Models

- Texas Water Code, § 36.108 (d) (3)

Estimating total recoverable storage for explanatory reports



Stakeholder Advisory Forums

- Provide input and data to assist with model development
- Keep updated about progress of the model
- Understand how the groundwater model can, should, and should not be used

Note: TWDB currently doing field work on geometry of river channel. Contact Mark Wentzel for more information mark.wentzel@twdb.texas.gov

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Disclaimer

The statements contained in this presentation are my current views and opinions and are not intended to reflect the positions of, or information from, the Texas Water Development Board, nor is it an indication of any official policy position of the Board.

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http://www.twdb.texas.gov/groundwater/models/gam/bzrv/bzrv.asp#saf
http://www.twdb.texas.gov/groundwater/index.asp

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Outline

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Early Credits

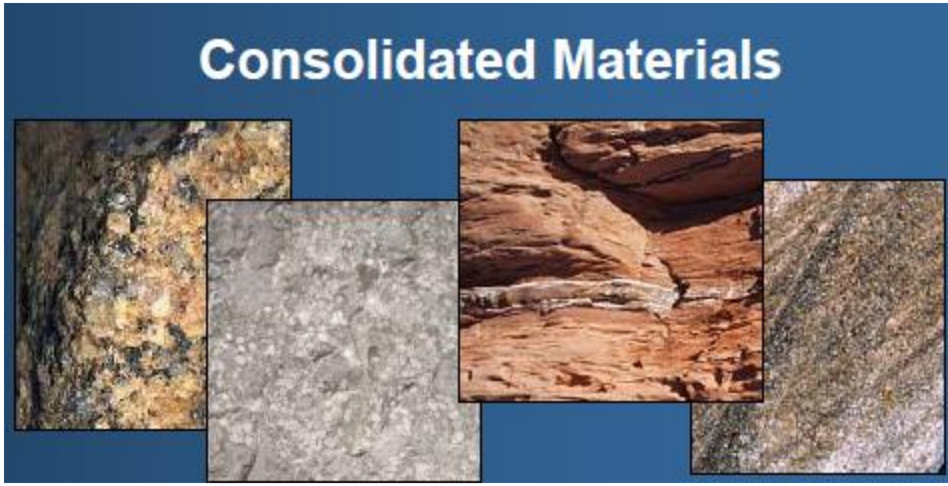
- Thanks and credit to Robert Mace at TWDB for many of the slides in this section

What is an aquifer?

- an aquifer is geologic media that can yield economically usable amounts of water.

DIRT

ROCK

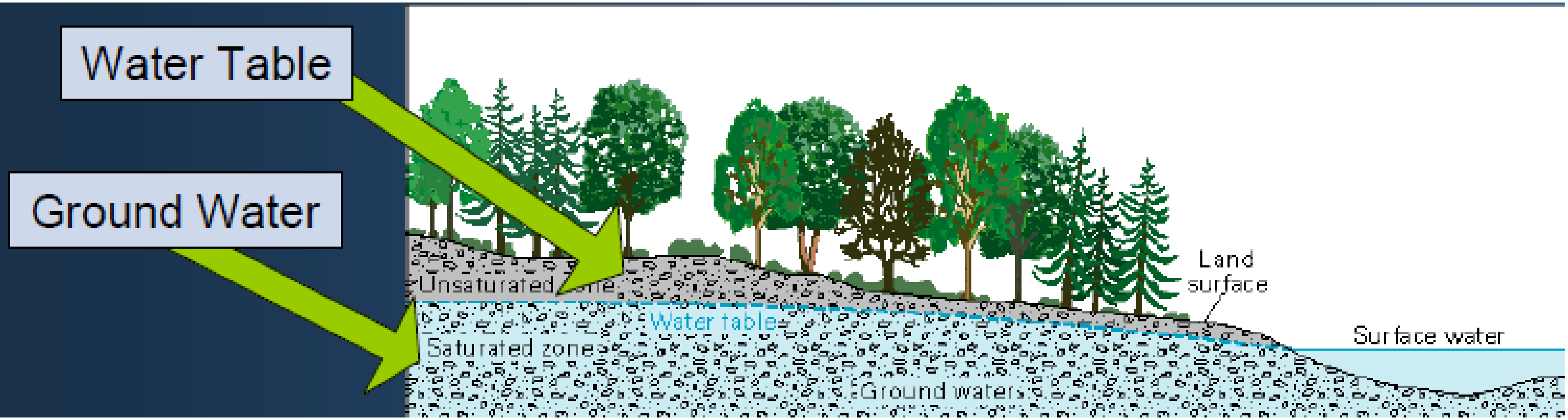


What is an aquitard?

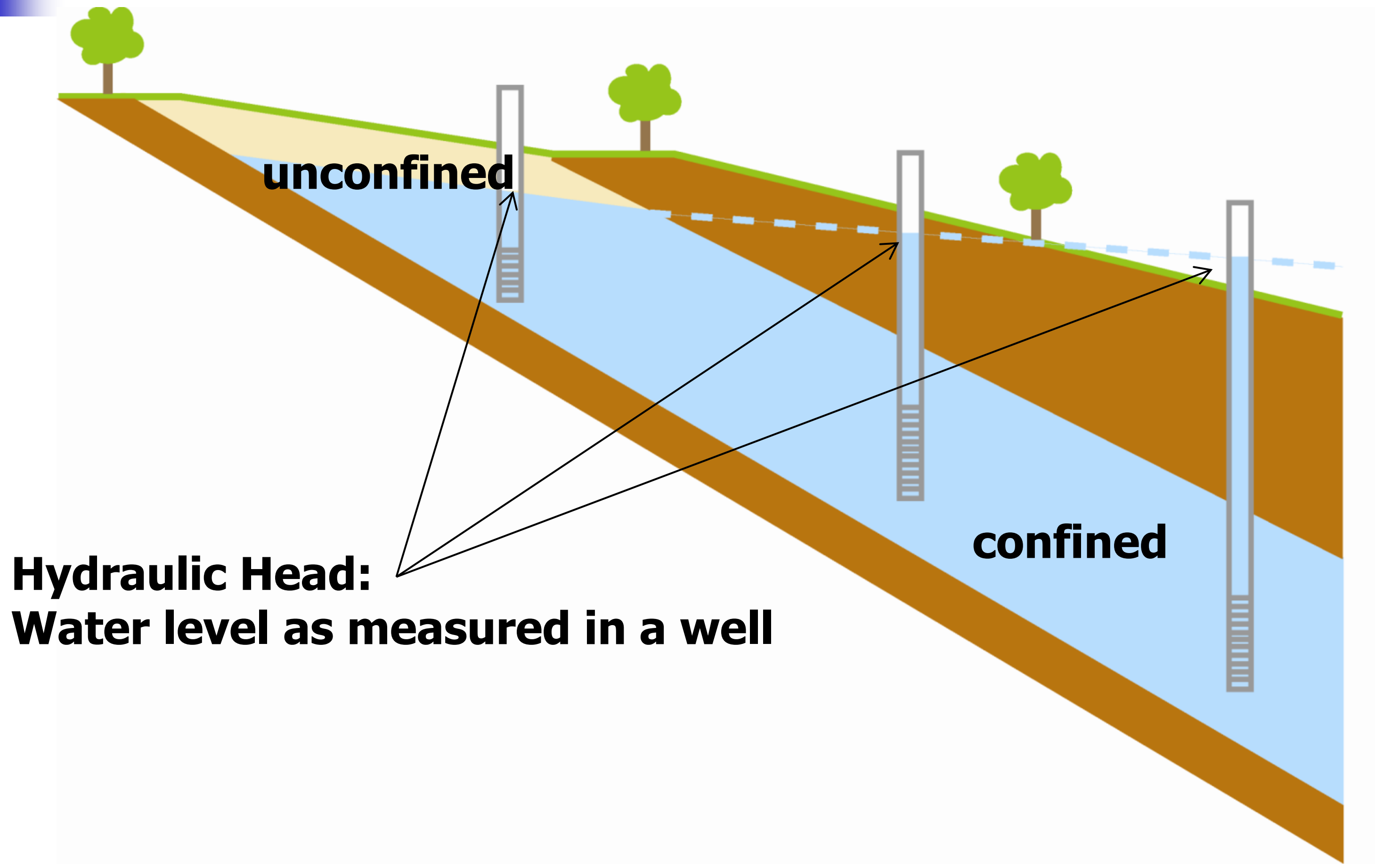
- an aquitard is geologic media that can not yield economically usable amounts of water.
- clay, shale, unfractured dense rocks
- Note: can still transmit water, but s l o w l y

What is a water table?

- A water table is where the saturated zone meets the vadose (unsaturated) zone.
- A water table occurs where the groundwater is under atmospheric pressure



Same aquifer: unconfined and confined



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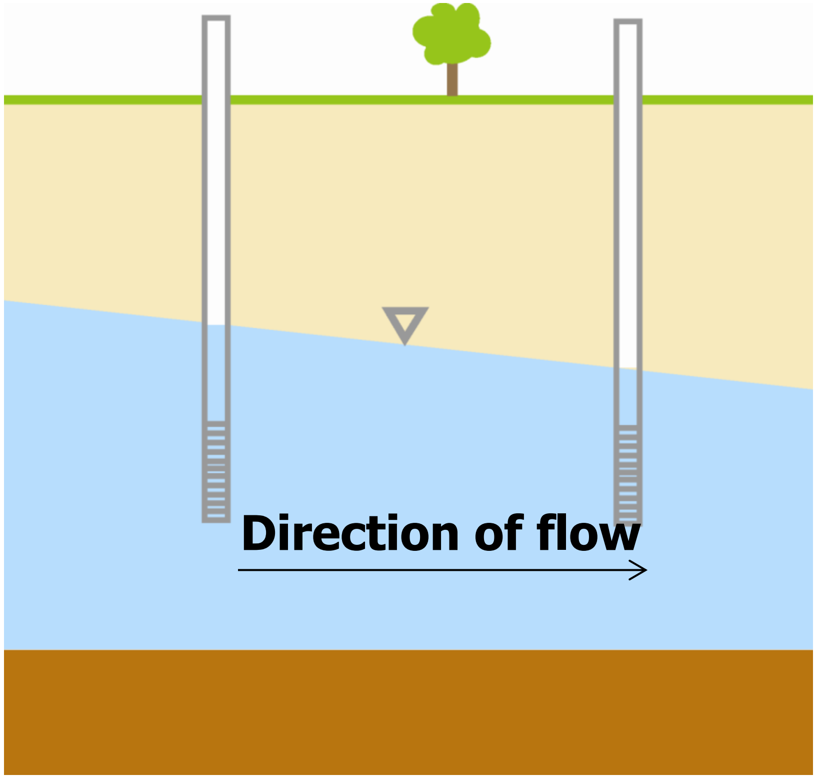
Groundwater Flow

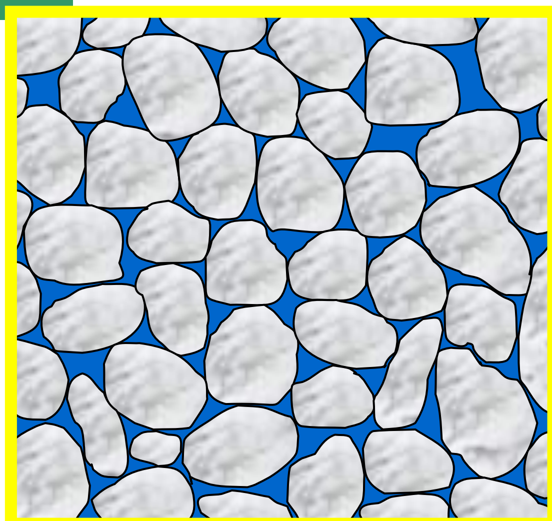
- Groundwater flows from higher potential energy (head) to lower potential energy



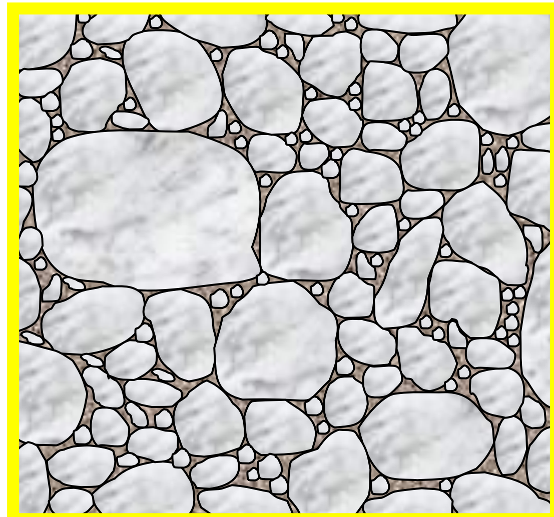
Aquifer Properties

- Hydraulic conductivity – A physical property of the geologic media representing its ability to transmit water (related to permeability and transmissivity)

Aquifer Properties



WELL SORTED
Coarse (sand-gravel)



POORLY SORTED
Coarse - Fine

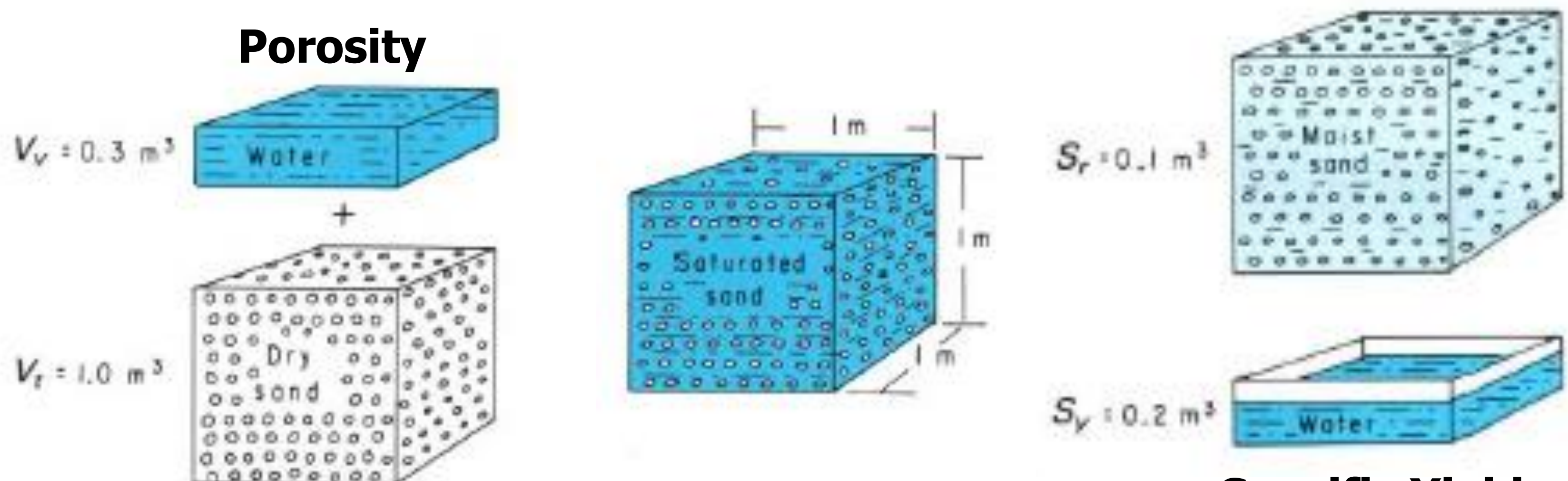
WELL SORTED
Fine (silt-clay)

Permeability and Hydraulic Conductivity

High ⟷ Low

Aquifer Properties

- Specific yield – The volume of water that an unconfined aquifer releases from storage per unit surface area of aquifer per unit decline in water table elevation.



Specific Yield

From Heath (1983)

Aquifer Properties

- Storativity – The volume of water that a confined aquifer releases from storage per unit surface area of aquifer per unit decline in head.
  - Much smaller than specific yield

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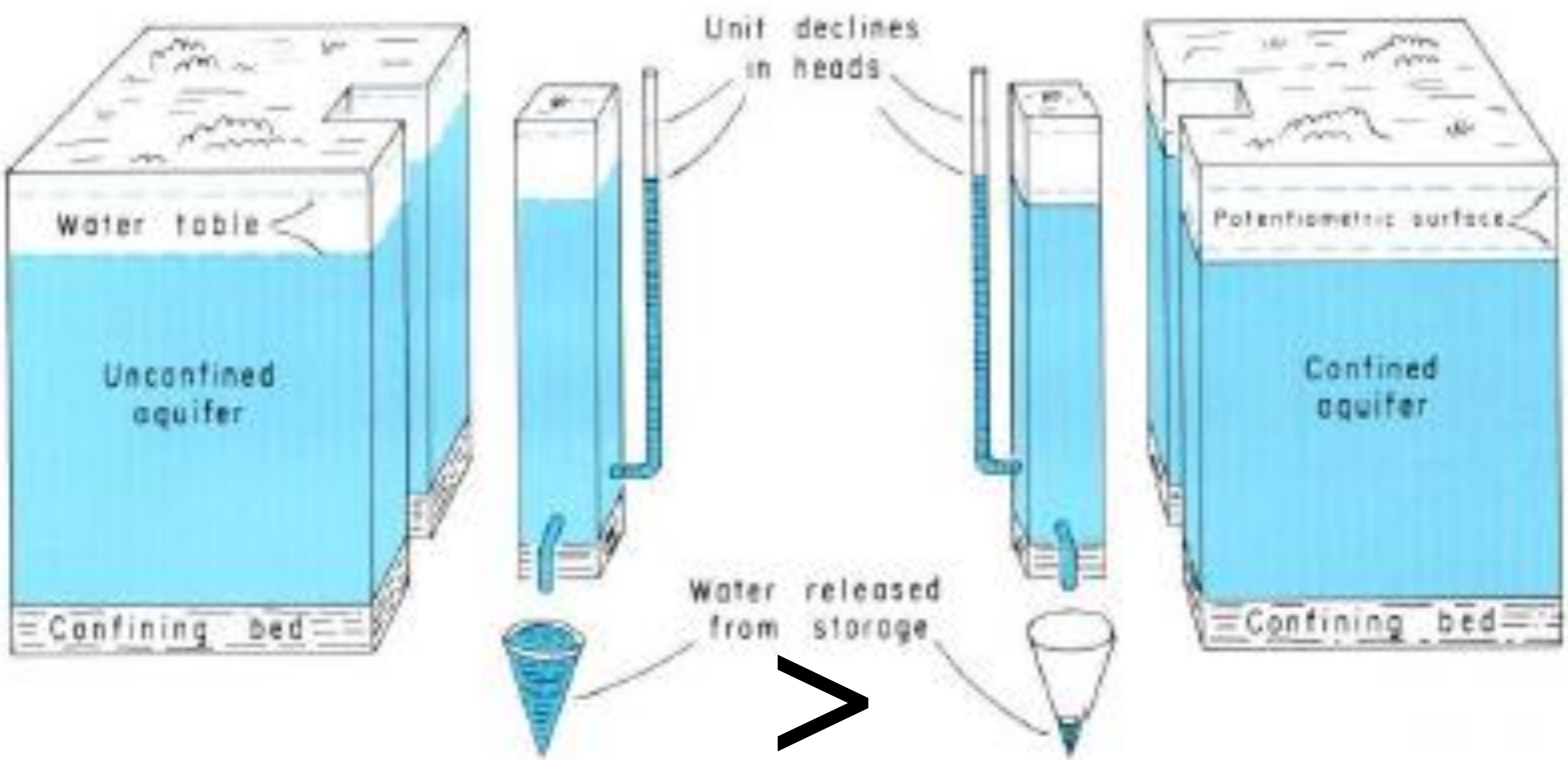
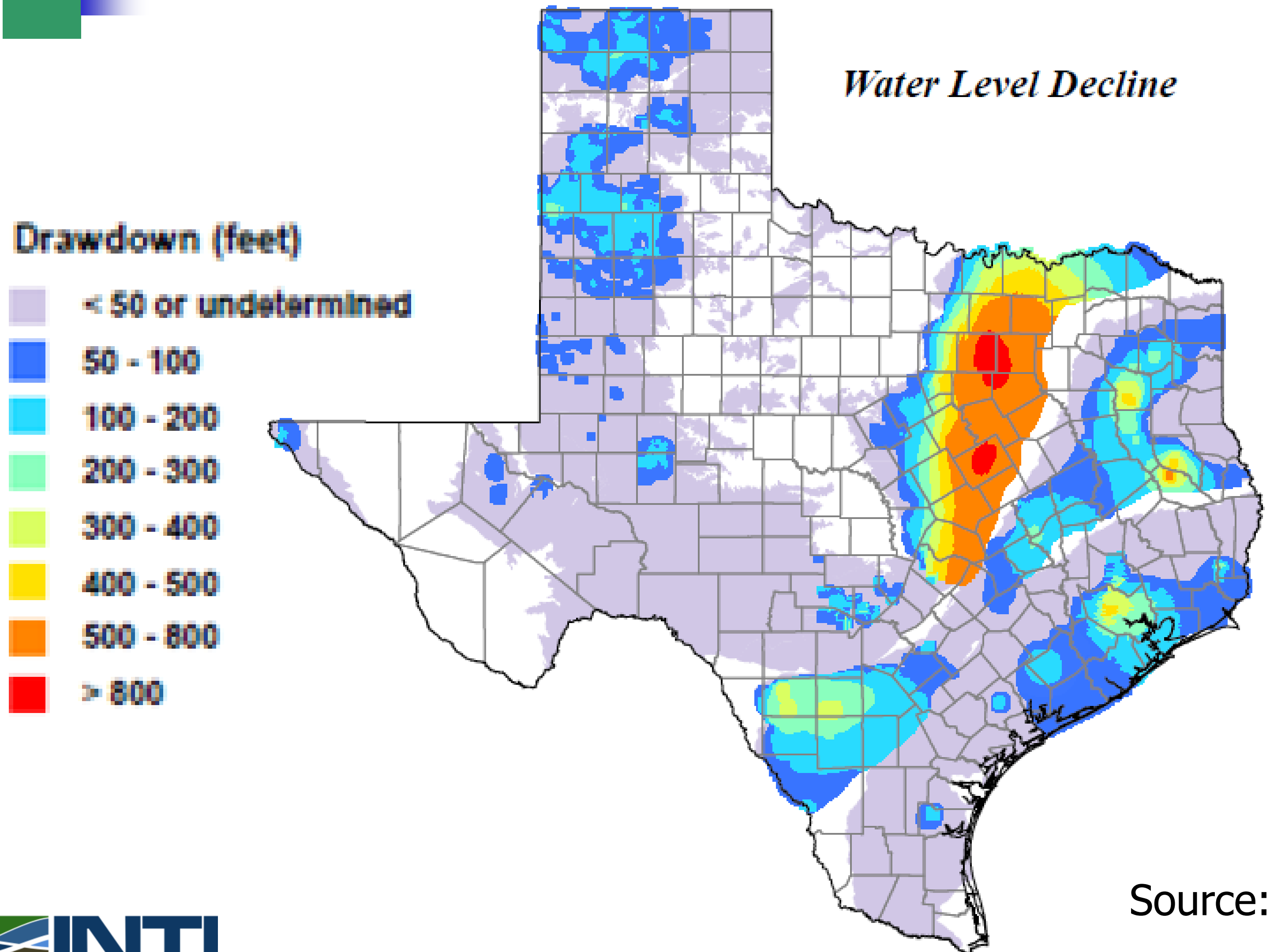
Specific Yield vs. Storativity



From Heath (1983)

Specific Yield vs. Storativity



Source: TWDB

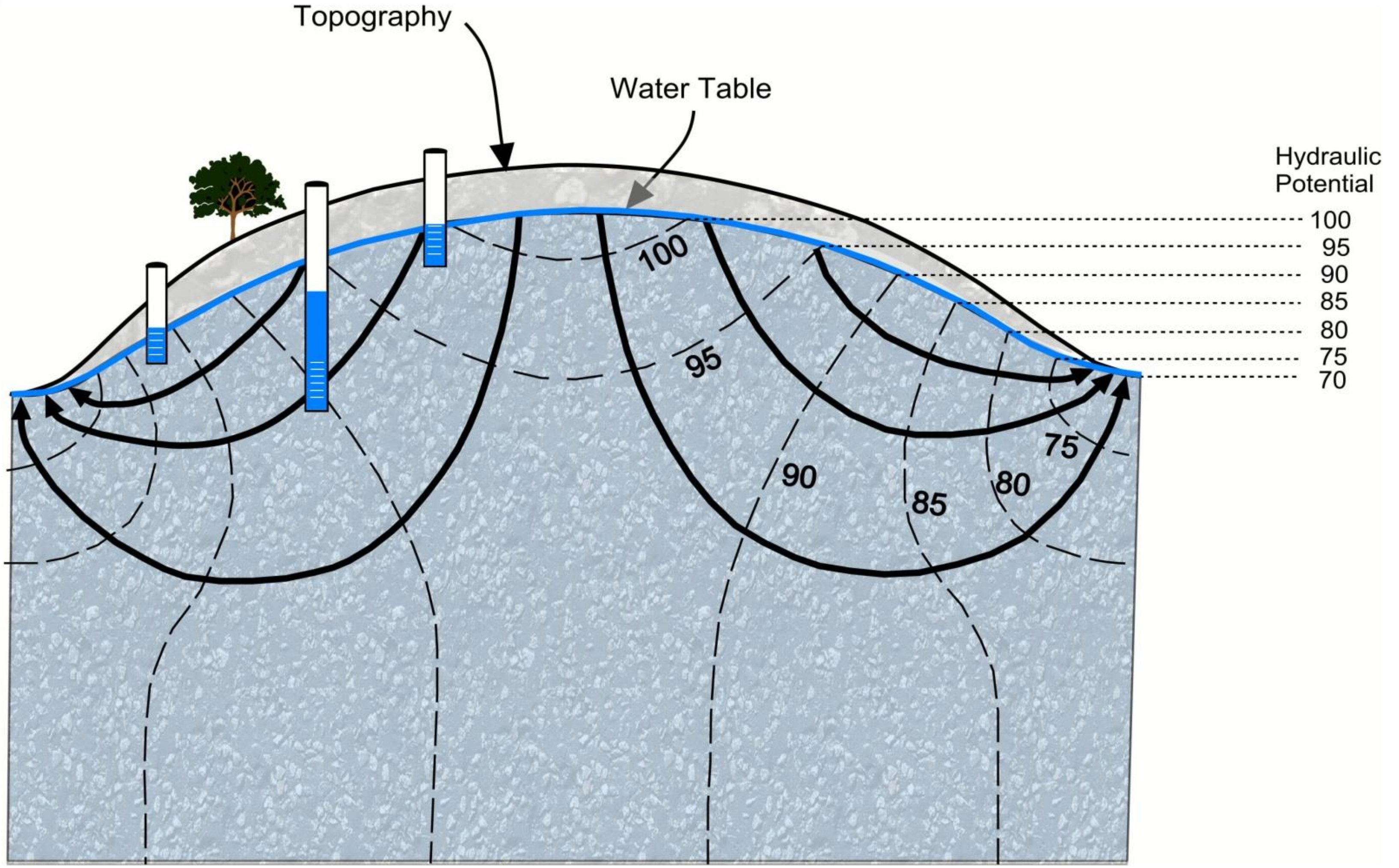
Groundwater Definitions (cont.)

- Recharge – The entry of water to the saturated zone at the water table:

  Recharge = (precipitation + stream loss) minus (runoff + evapotranspiration).

- Cross-formational flow – Groundwater flow between separate geologic formations.
- Stream losses or gains – The water that is either lost or gained through the base of the stream or river.

Schematic Cross Section of Groundwater Flow



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Definition of a Model

Domenico (1972) defined a model as a representation of reality that attempts to explain the behavior of some aspect of reality and is always **less complex** than the real system it represents

Wang & Anderson (1982) defined a model as a tool designed to represent a **simplified** version of reality

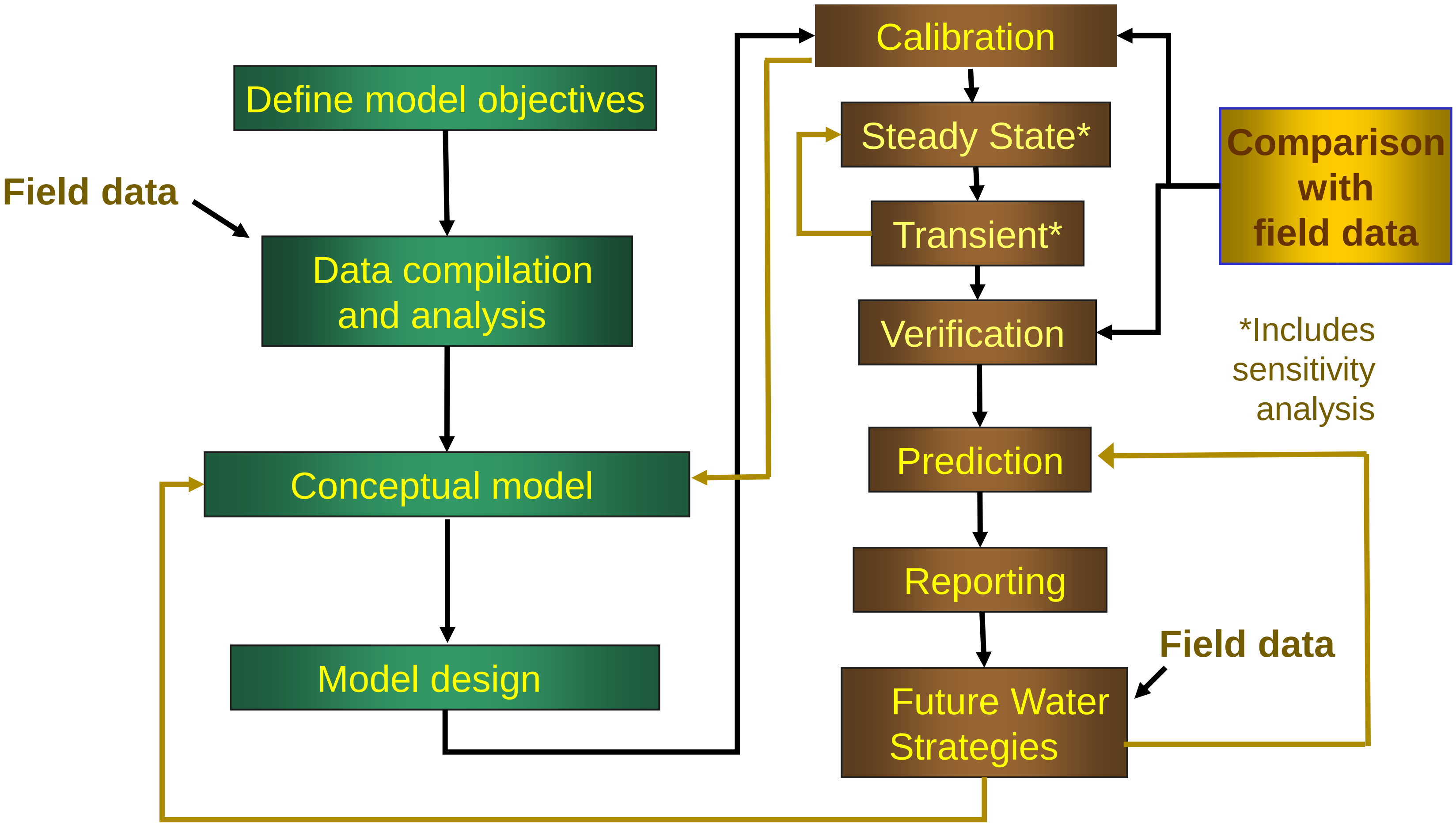
Why Groundwater Flow Models?

- 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

Numerical Flow Model

- 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 (determined by the grid)
- The calculated model heads can be compared to hydraulic heads measured in wells

Modeling Protocol



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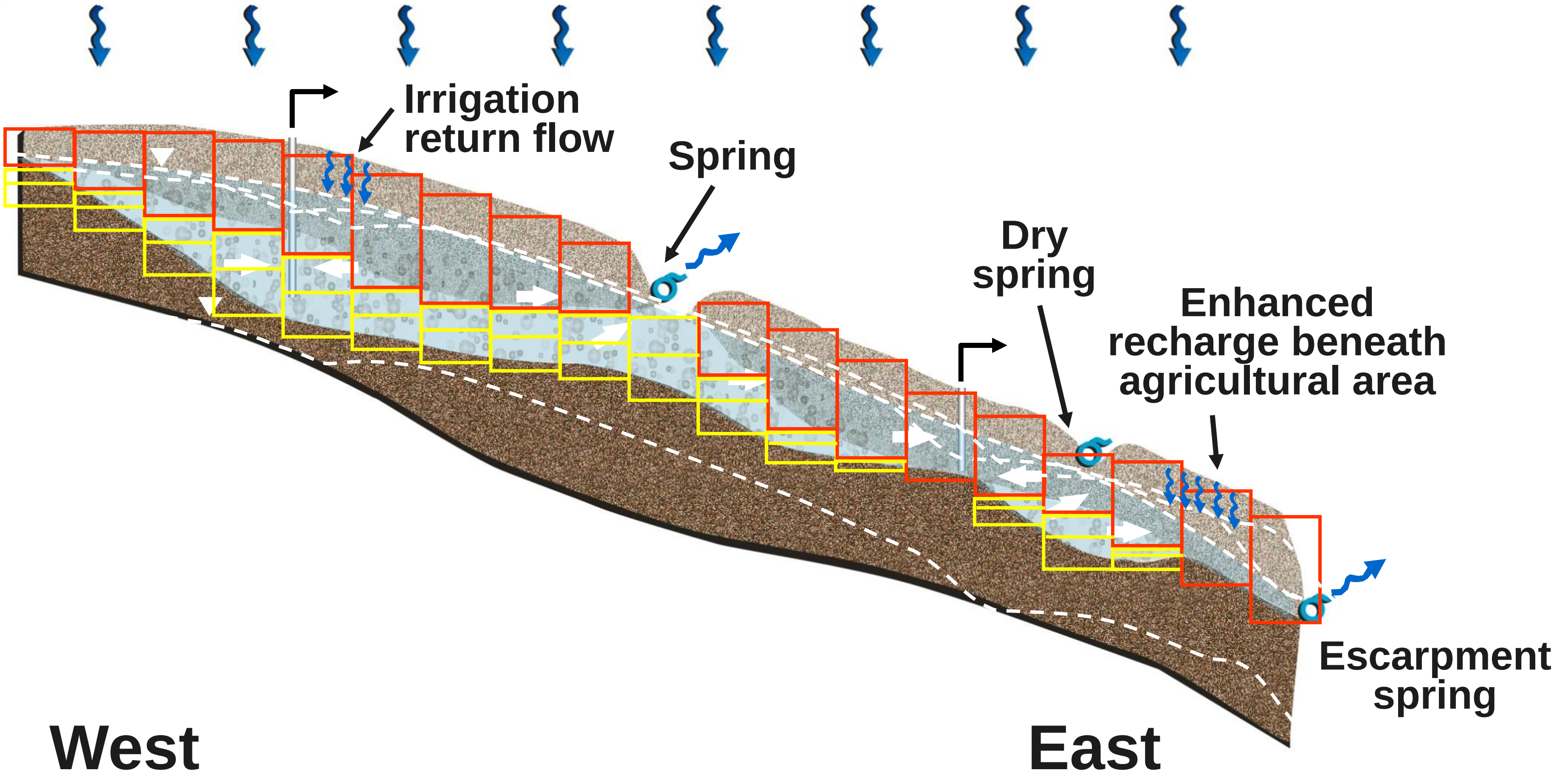
Divide it up into cells
Start with a conceptual model



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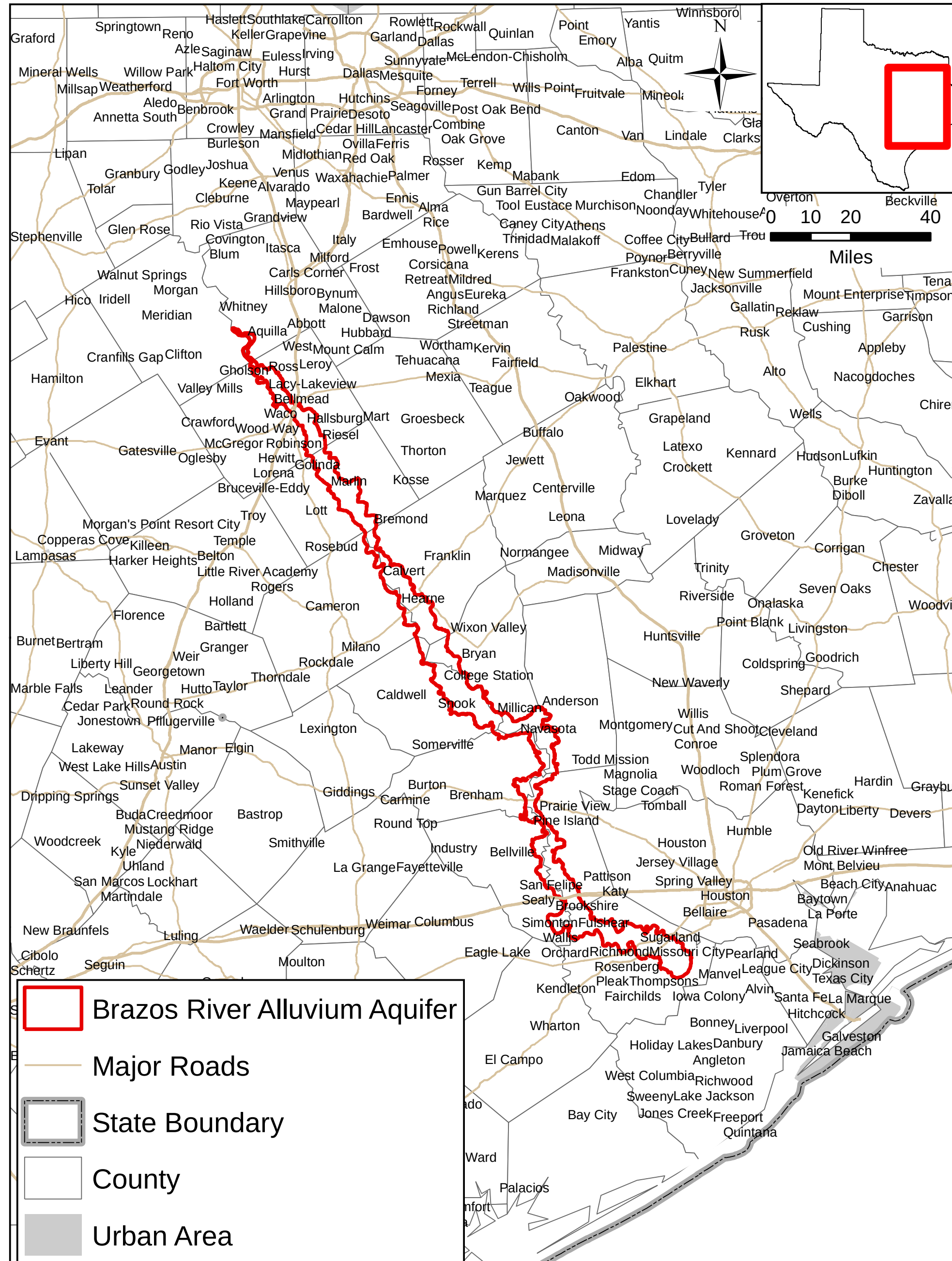
Study Area



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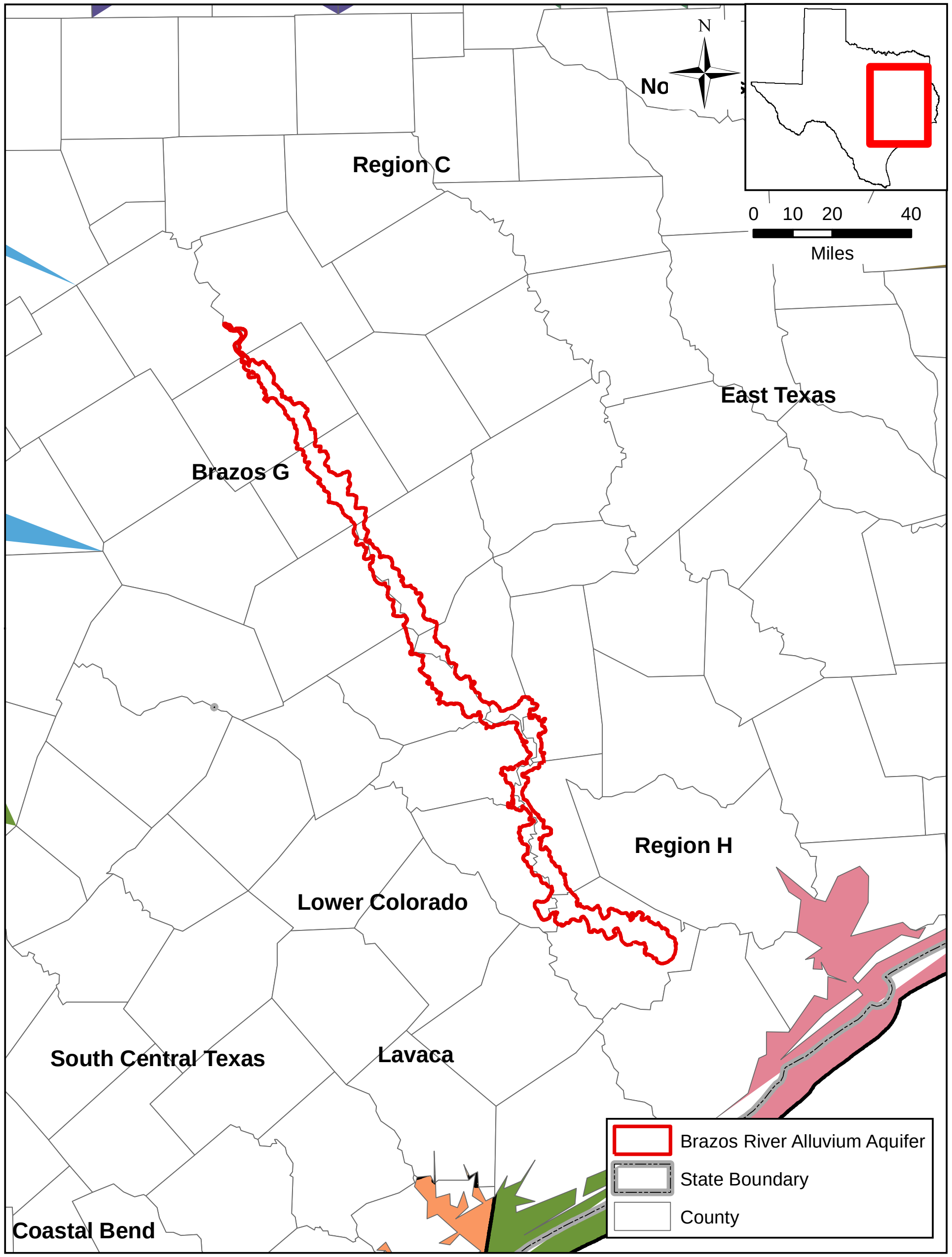
Regional Water Planning Groups



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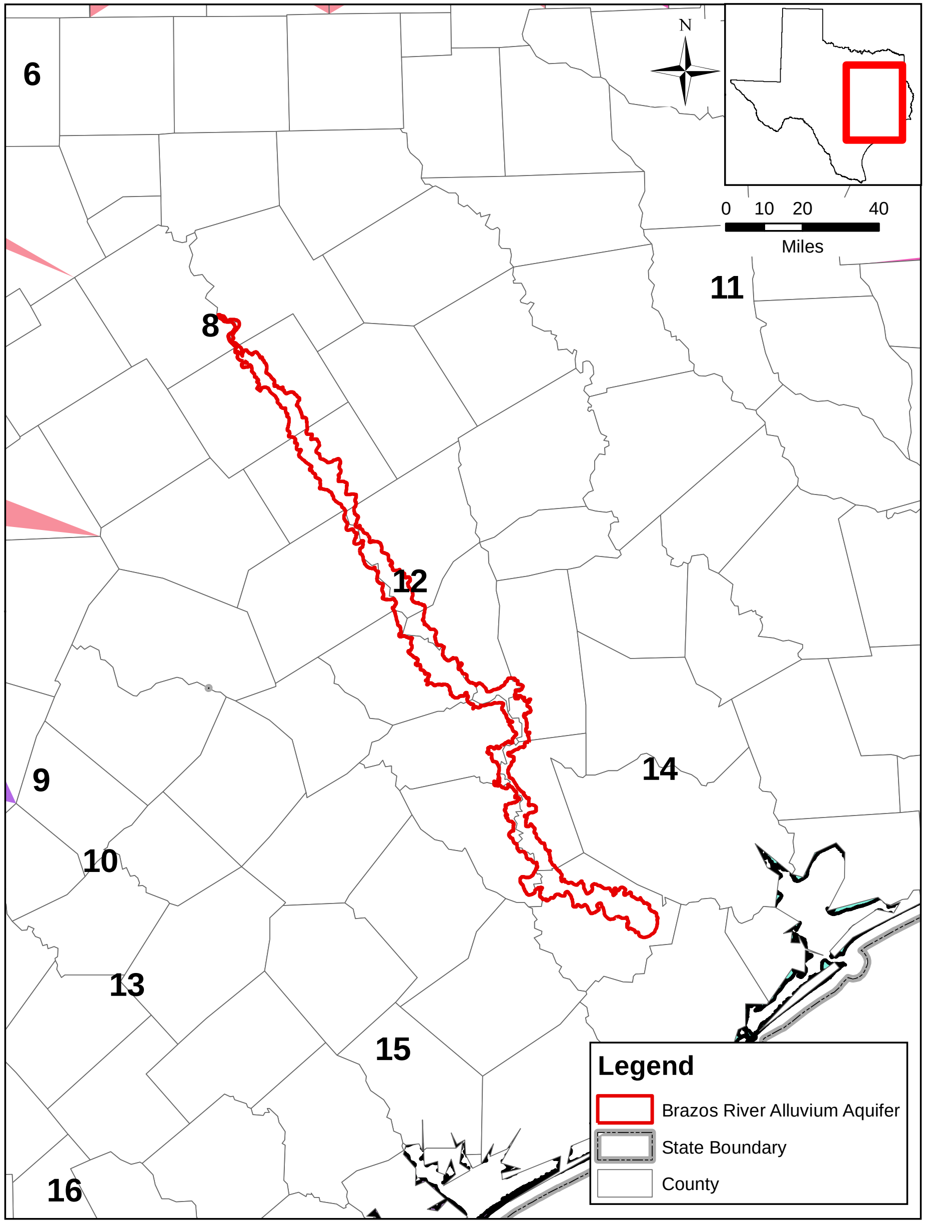
Groundwater Management Areas



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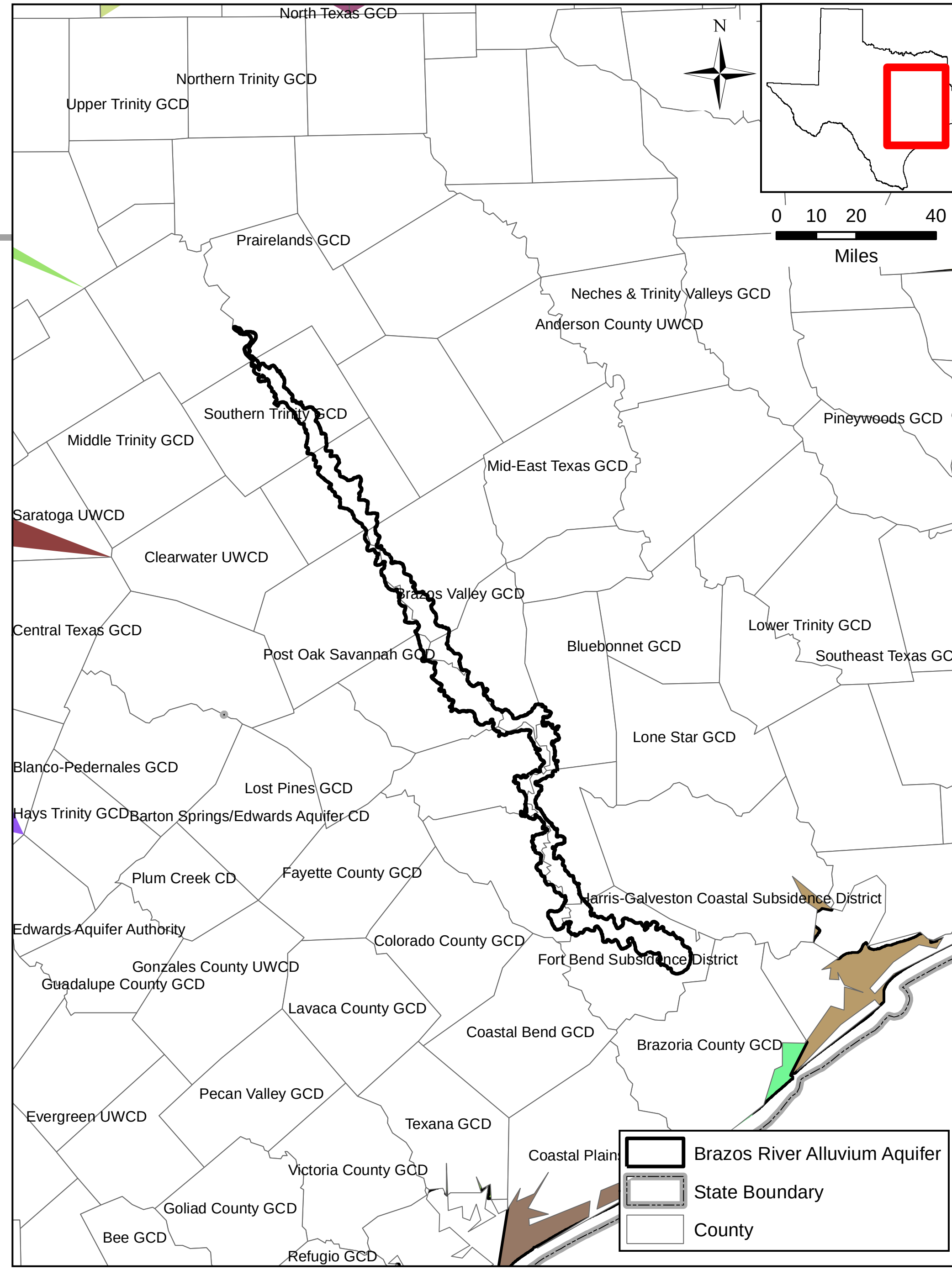
Groundwater Conservation Districts



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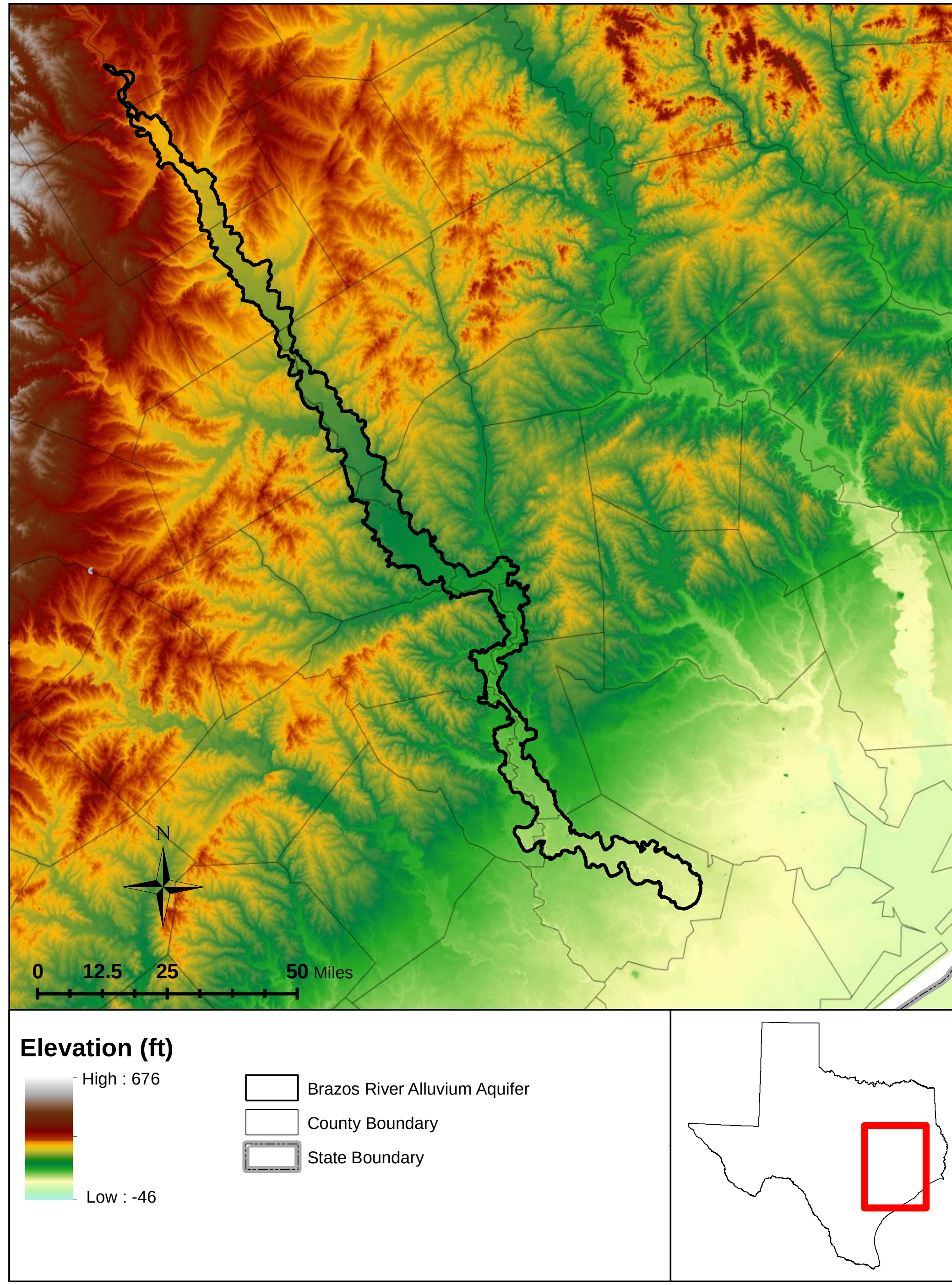
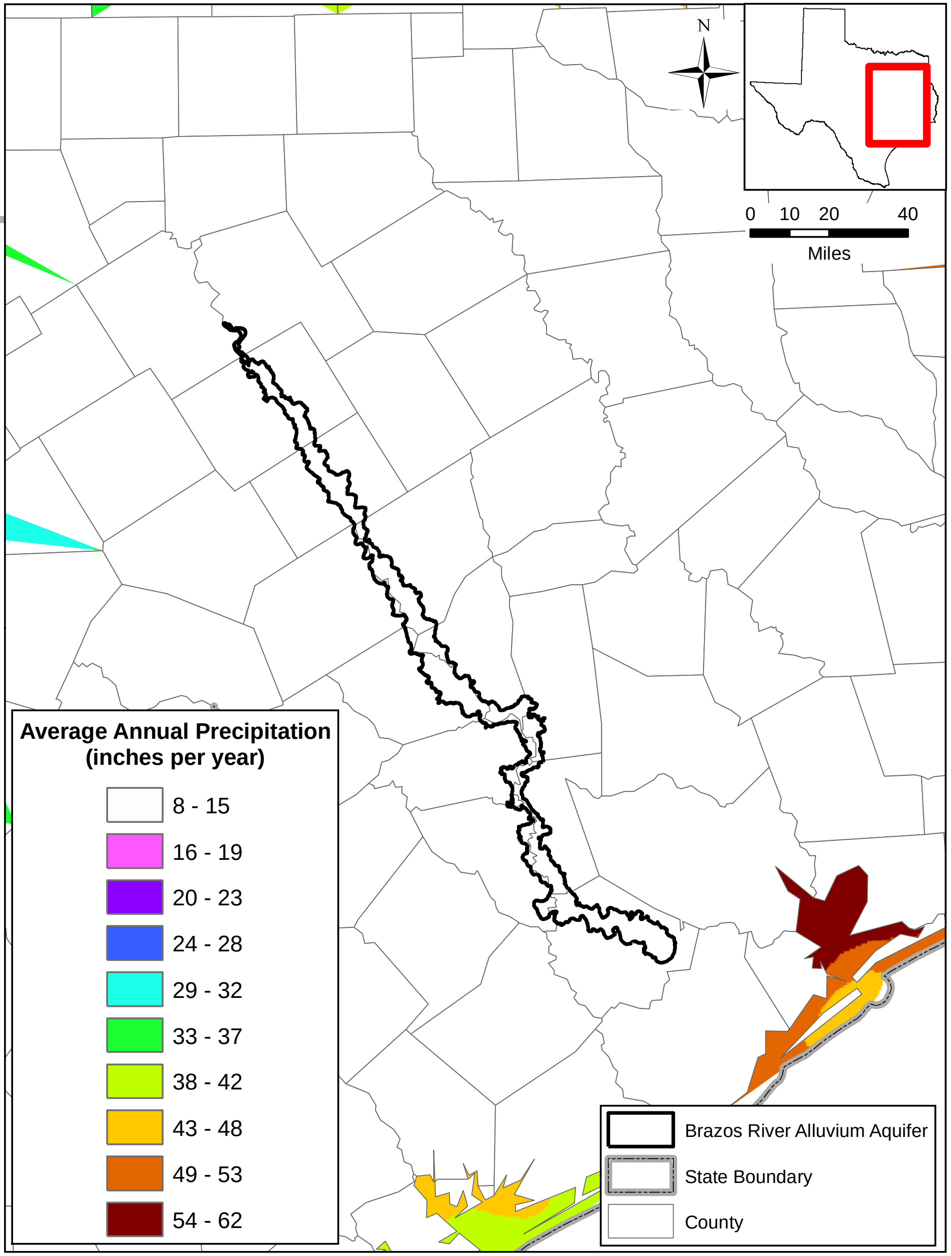
Topography (Feet above mean sea level)

Source: USGS



Annual Average Precipitation 1981- 2010

Source: Oregon State University PRISM Climate Data Group



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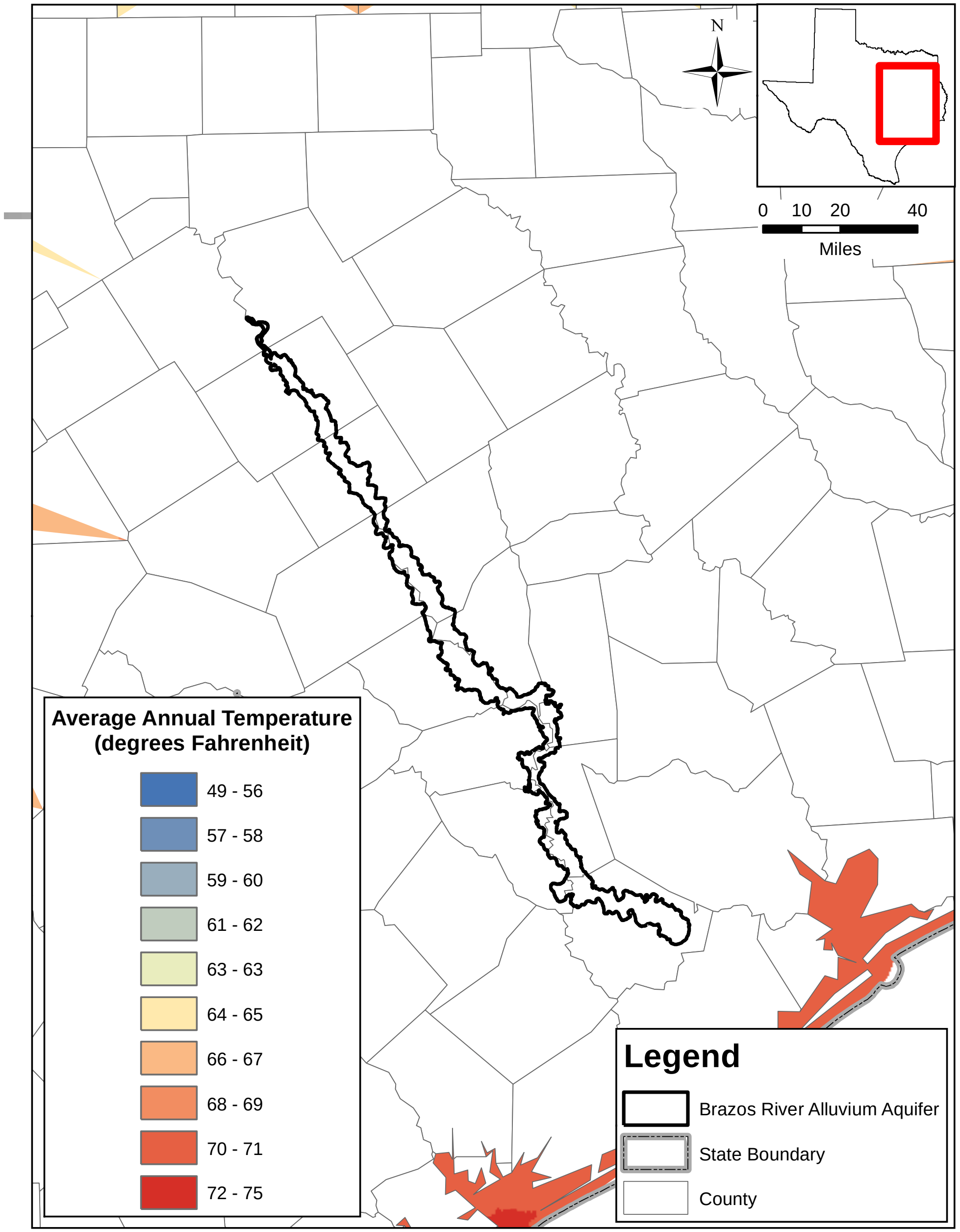
Annual Average Temperature 1981- 2010

Source: Oregon State University PRISM Climate Data Group



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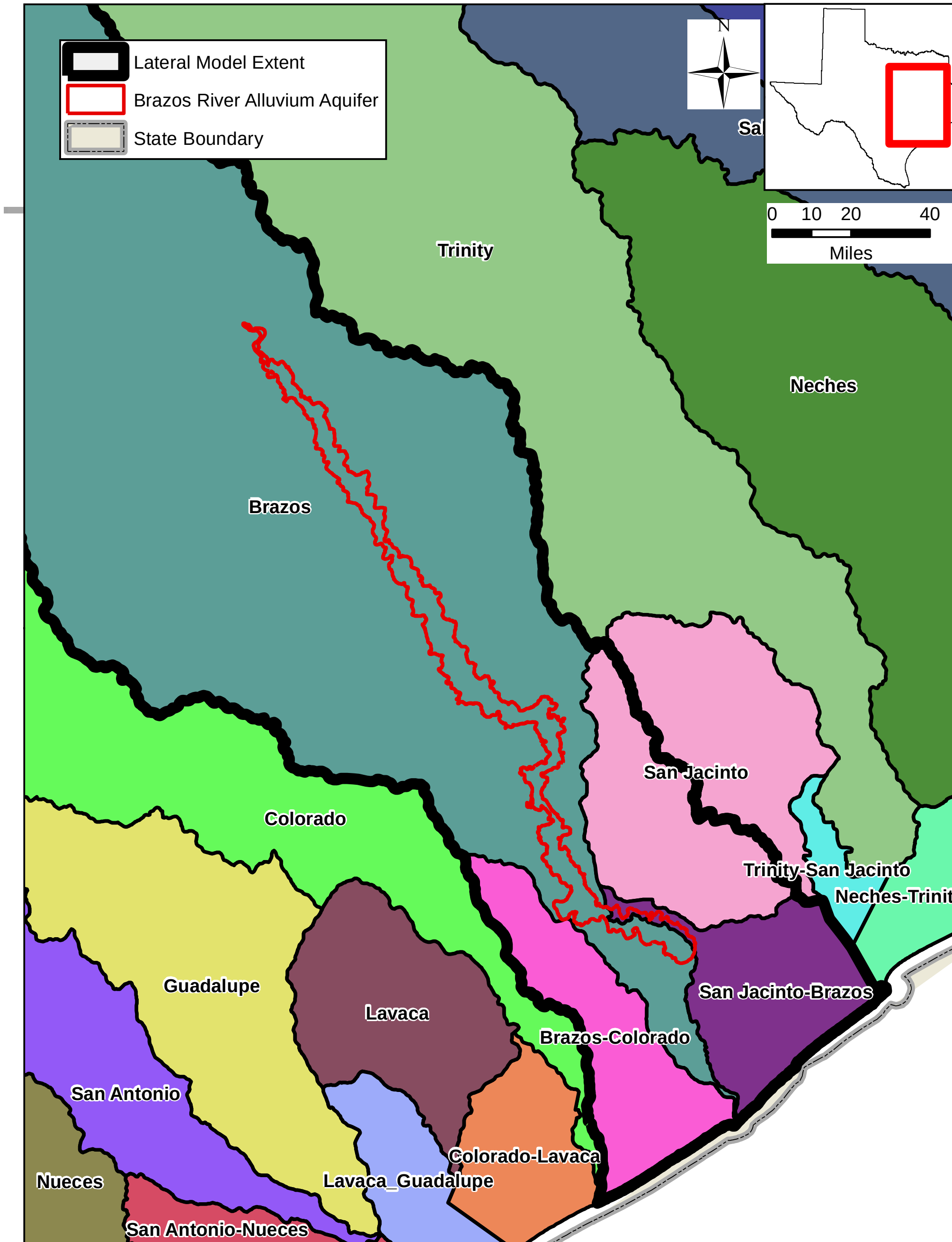
Lateral Model Extent



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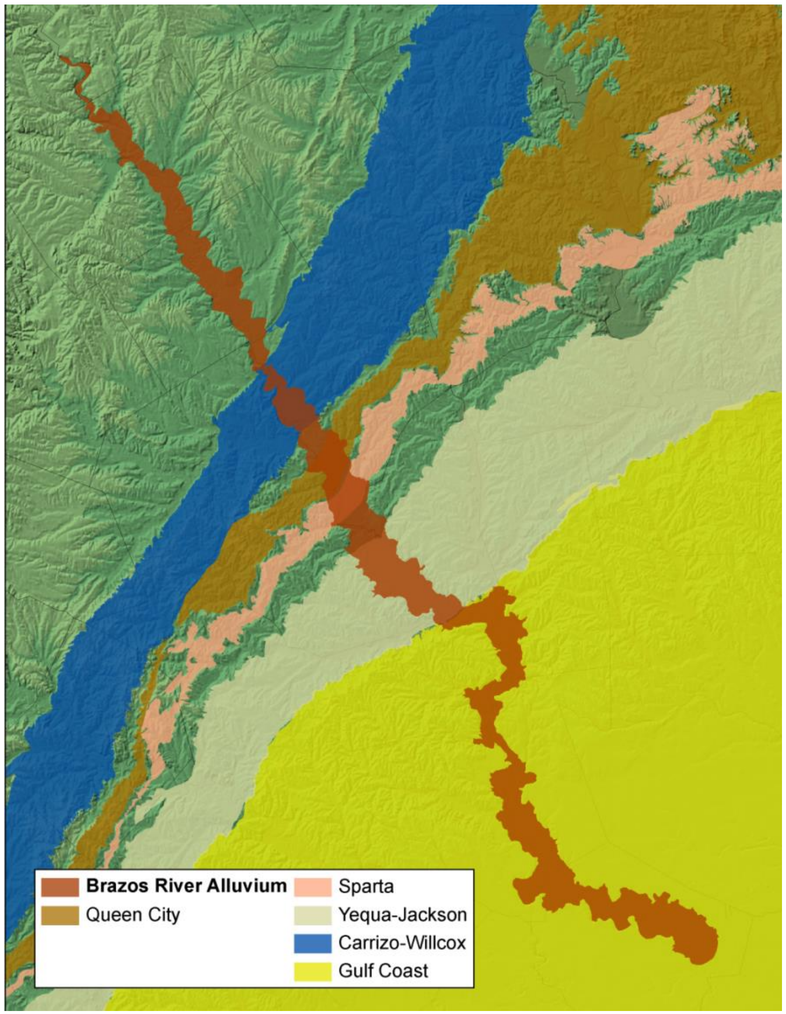
Model Layering



System	Series	Geologic Unit	Aquifer	Model Layer
Quaternary	Holocene	Alluvium	Brazos River Alluvium	**1 and 2**
	Pleistocene	Fluvial terrace deposits	Gulf Coast	**3**
		Beaumont Formation		
		Lissie Formation		
Tertiary	Pliocene	Willis Sand		
	Miocene	Goliad Sand		
		Fleming Formation		
		Oakville Sandstone		
	Oligocene	Catahoula Sandstone		
	Eocene	Jackson Group	Yegua-Jackson	
		Yegua Formation		
		Cook Mountain Formation		
		Sparta Sand	Sparta	
		Weches Formation		
		Queen City Sand	Queen City	
		Reklaw Formation		
		Carrizo Sand	Carrizo-Wilcox	
		Wilcox Group		
	Paleocene	Midway Group		
Cretaceous	Gulfian	Navarro Group		
		Taylor Marl		
		Austin Chalk		
		Eagle Ford Group		
		Grayson Marl		
	Comanchean	Washita Group		
		Fredricksburg Group		

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GAM Model Specifications

- Three dimensional (MODFLOW-NWT)
- Regional scale (1000’s of square miles)
- Grid spacing
  - Maximum 1/8-mile over Brazos River Alluvium
  - Probable increased spacing (≤1-mile) at extents
- Implement
  - recharge
  - groundwater/surface water interaction
  - pumping
- Calibration to observed water levels/fluxes

MODFLOW

- Code developed by the U.S. Geological Survey
- Selected by TWDB for all GAMs
- Handles the relevant processes
- Comprehensive documentation
- Public domain – non-proprietary
- Most widely used groundwater model
  - USGS had 12,261 downloads of MODFLOW computer code in 2000
- Supporting interface programs available
  - Groundwater Vistas to be used in all GAMs
- Using MODFLOW-NWT – most recent standard version

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Key model aspects

- Hydrostratigraphy
- Hydraulic/storage properties
- Surface water/groundwater interaction
- Groundwater production
- Recharge
- Discharge

Hydrostratigraphy

- Basal structure of aquifer based at least partially on Shah and others (2007)
  - Constrained at lateral extents by land surface elevation
- Top of alluvium defined by land surface
- Shallow portions of underlying aquifers represented by an additional model layer
  - Lateral extent of underlying layer based on natural groundwater divides
  - Thickness and hydraulic properties of underlying layer dependent on properties of underlying aquifers

Hydraulic Properties

- Will evaluate transmissivity estimates from Shah and others (2007)
  - Study has spatial gaps particularly in the northwest and southeast portions of the aquifer
- Potential sources for additional hydraulic property estimates
  - TCEQ public water supply records (1 well)
  - Driller's logs with specific capacity information
  - Will perform 2 to 3 additional aquifer tests

Surface Water/Groundwater Interaction

- The Brazos River Alluvium Aquifer is hydraulically connected to the Brazos River along the entire length of the aquifer
- Will improve the characterization of this interaction
  - Interpret/analyze existing synoptic gain-loss studies
  - Calculate long-term baseflow estimates from gage data
  - Estimate local interaction (including bank storage) at several points along the river
  - Perform WAM simulations to determine whether groundwater model results affect reliability estimates for various rights holders

Groundwater Production

- Groundwater production in the aquifer is primarily for irrigation purposes
- Historical production averages 32,000 Acre Feet per Year
- Future production ranges between 35,000 and 45,000 Acre Feet per Year
- Assigning pumping to particular wells will be difficult
- Imagery from National Agricultural Statistics Service program may be used to locate irrigated cropland
- Well location from driller's logs and the TWDB groundwater database will be used to estimate (based on size and production capacity) well locations for production
- Will investigate local declines/recoveries to locate pumping centers

Recharge

- Recharge is a critical component of the water balance
- The aquifer is thin, narrow, and unconfined so recharge is important to maintaining water levels under long-term pumping conditions
- Several potential sources of recharge
  - Areal recharge from precipitation
  - Irrigation return flow
  - Lateral and vertical inflow from underlying formations
  - Surface water bodies (Brazos River and tributaries, reservoirs, and oxbow lakes)

Natural Discharge

- The Brazos River is a major discharge avenue for the groundwater in the Brazos River Alluvium Aquifer
- The Brazos River is also a regional discharge boundary for the underlying regional aquifers
- Much of the aquifer has a quite shallow water table, so groundwater evapotranspiration (ET) will be an important portion of the water balance

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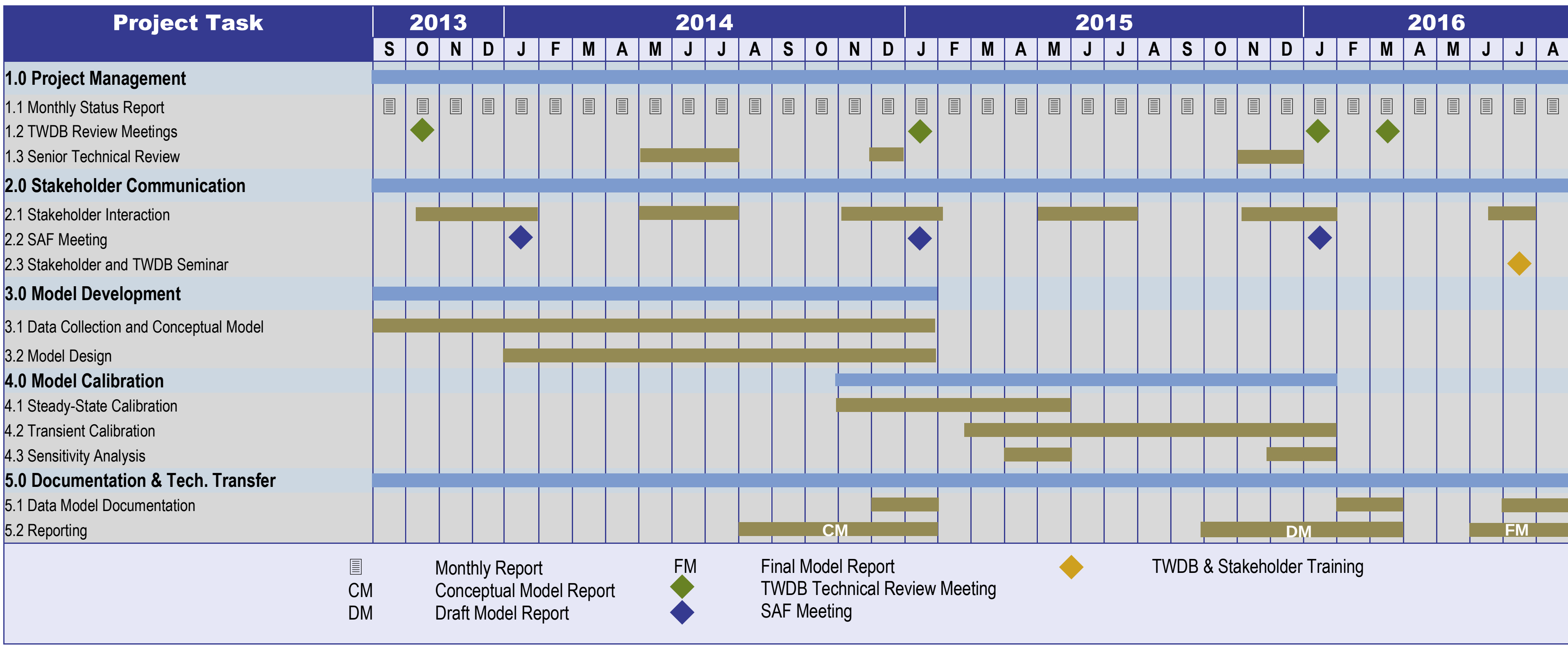
Data Request

- Any un-published data to support the model
  - Geophysical logs
  - Pump tests
  - Water levels
  - Interpreted properties
  - Structural picks
  - Production information
- Leads for local published reports/data
- Data request by February 28, 2014

(please contact us if more time is needed)

Tasks and Proposed Schedule



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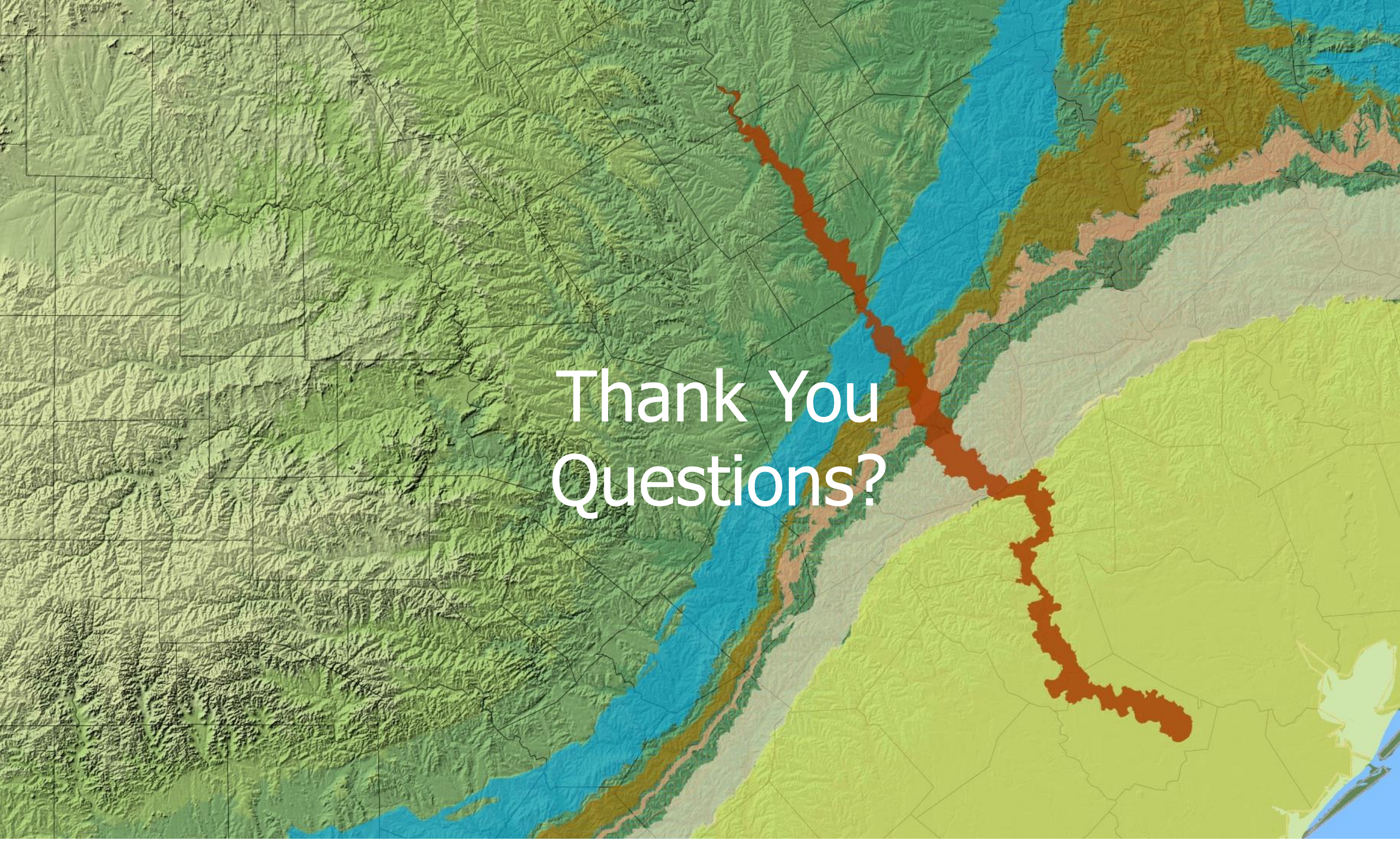
Thank You
Questions?



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Brazos Alluvium Aquifer GAM -- Stakeholder Advisory Forum #1
College Station, January 22, 2014
Questions and Answers

Question: Have there been any studies on the BRAA before?
Answer: Yes, TWDB reports, Hydrostratigraphy by USGS, and County studies

Question: Will water quality be looked at?
Answer: Yes, It is not simulated explicitly, but it is evaluated as part of the conceptual model.

Question: Will historical uses be put into the model?
Answer: Yes, as part of calibration. Estimating pumping is a critical piece of the conceptual model.

Question: What weight will historical permits hold in the study?
Answer: The best information on historical pumping available will be incorporated into the model.

Question: How will surface water/groundwater interaction be estimated?
Answer: We will interpret/analyze existing synoptic gain-loss studies, calculate long-term baseflow estimates from gage data, estimate local interaction (including bank storage) at several points along the river, and perform WAM simulations to determine if results from the groundwater model will affect reliability estimates for water rights holders.

Question: What is the source of the historical pumping estimate?
Answer: This pumping estimate is from the Water Use Survey, but pumping is typically one of the most difficult aspects of the model to characterize. If you have information relevant to pumping, please provide it to us so that the model contains this information.

Question: Can you set up a project specific FTP site?
Answer: Yes, we will do that.

Comment: If you use evapotranspiration in the model, make sure to consider leaching fractions.

Question: Have you used SWAT and can it be used for this study?
Answer: Yes, we've used it and information from existing SWAT runs in the basin can inform estimates of recharge and baseflow. We will not be doing new SWAT modeling as part of this study.

Comment: Dr. Munster (Texas A&M) has studies that may be relevant to this aquifer.

Question: Does recharge get through the Ships clay?
Answer: We will hopefully know more about that as we begin work on the conceptual model.

Name	Organization
Cindy Ridgeway	Texas Water Development Board
Philip Price	Brazos River Authority
Evan Cook	Brazos River Authority
Robert Thompson	Harris-Galveston Subsidence District & Fort Bend Subsidence District
Bobby Bazan	Post Oak Savannah GCD
David Studt	Brazos Valley GCD
Meredith Earwood	Student
Scooter Radcliffe	Southern Trinity GCD
Andrew Worsley	Southern Trinity GCD
Cynthia Lopez	Brazos Valley GCD
Alan M. Day	Brazos Valley GCD
John Melvin	Brazos Valley Groundwater Rights Association
Wade Oliver	INTERA
John Ewing	INTERA