

Groundwater Availability Modeling Gulf Coast Aquifer

Cindy Ridgeway, P.G.

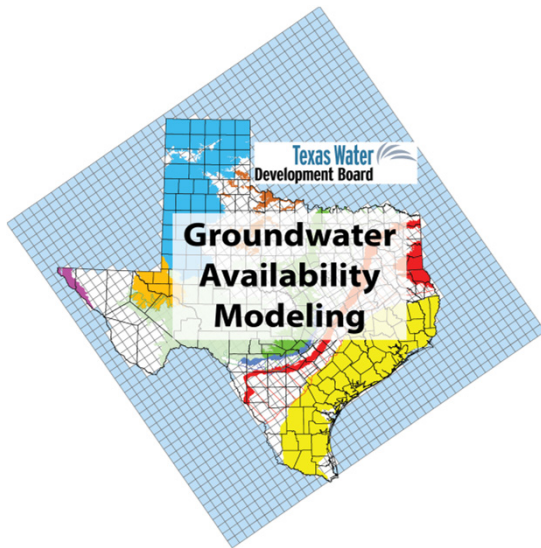
Manager

Groundwater Availability Model (GAM) Program

Stakeholder Advisory Forum (SAF) #1

Corpus Christi, Texas

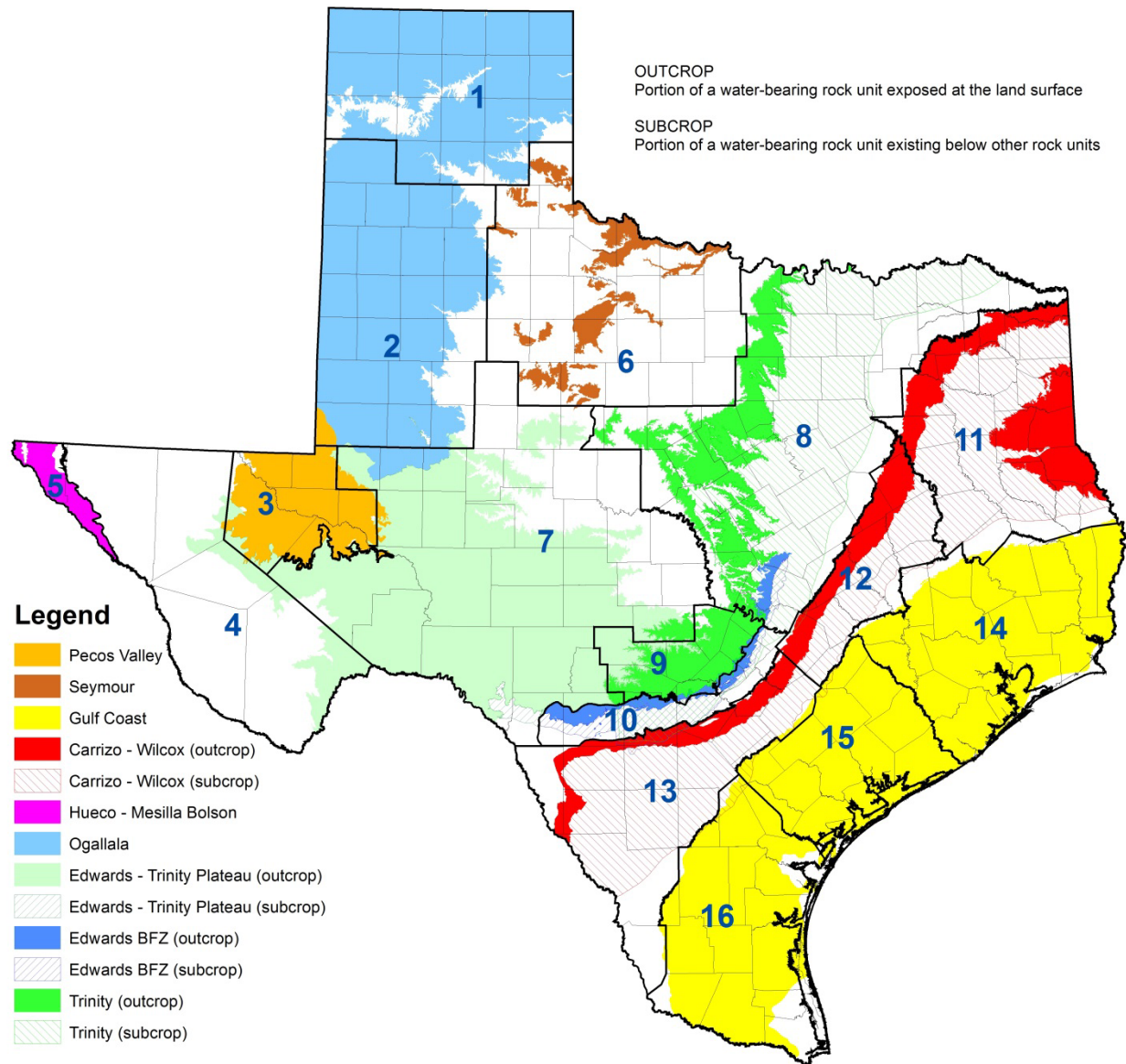
June 17th, 2014



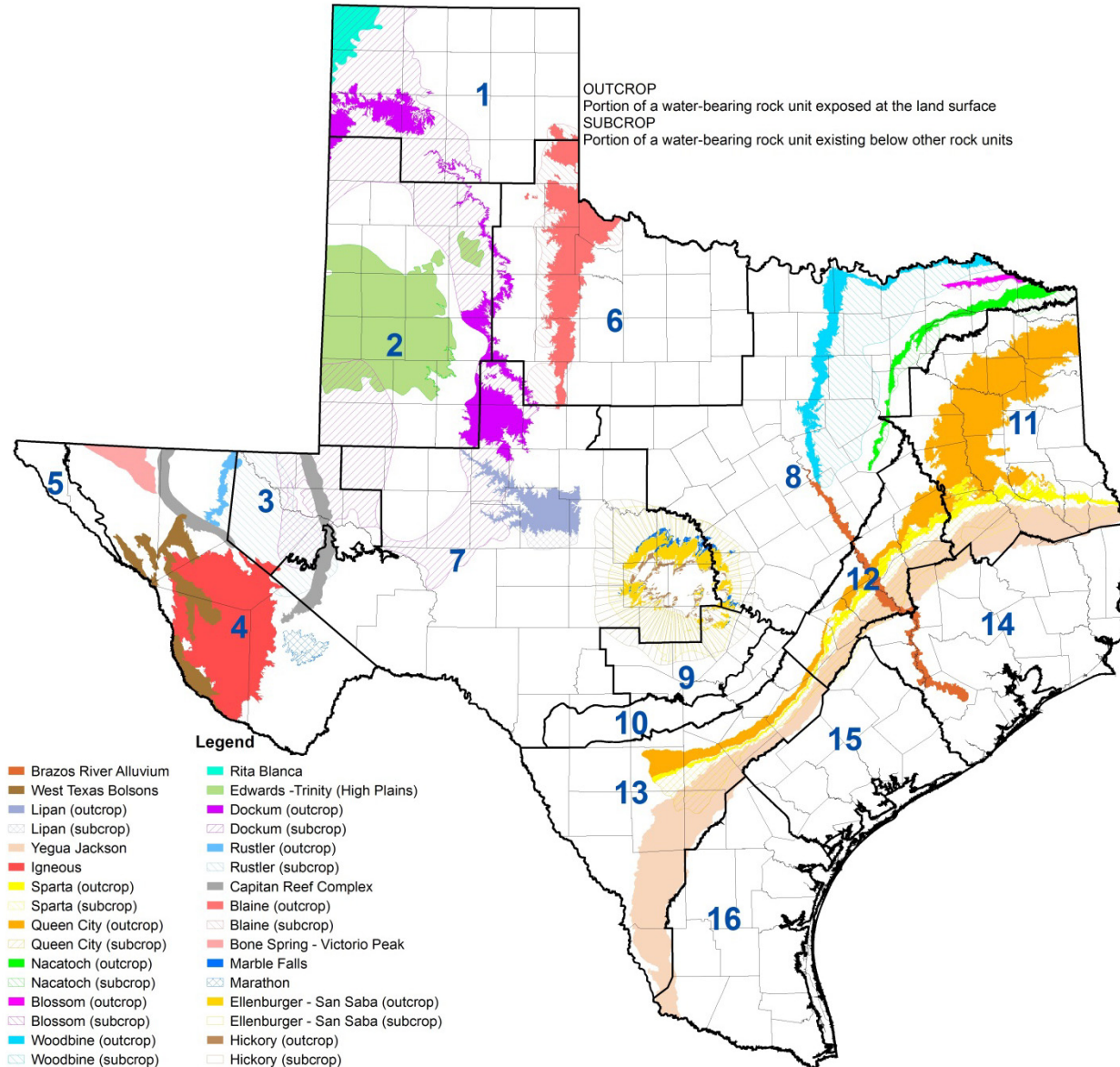
Disclaimer

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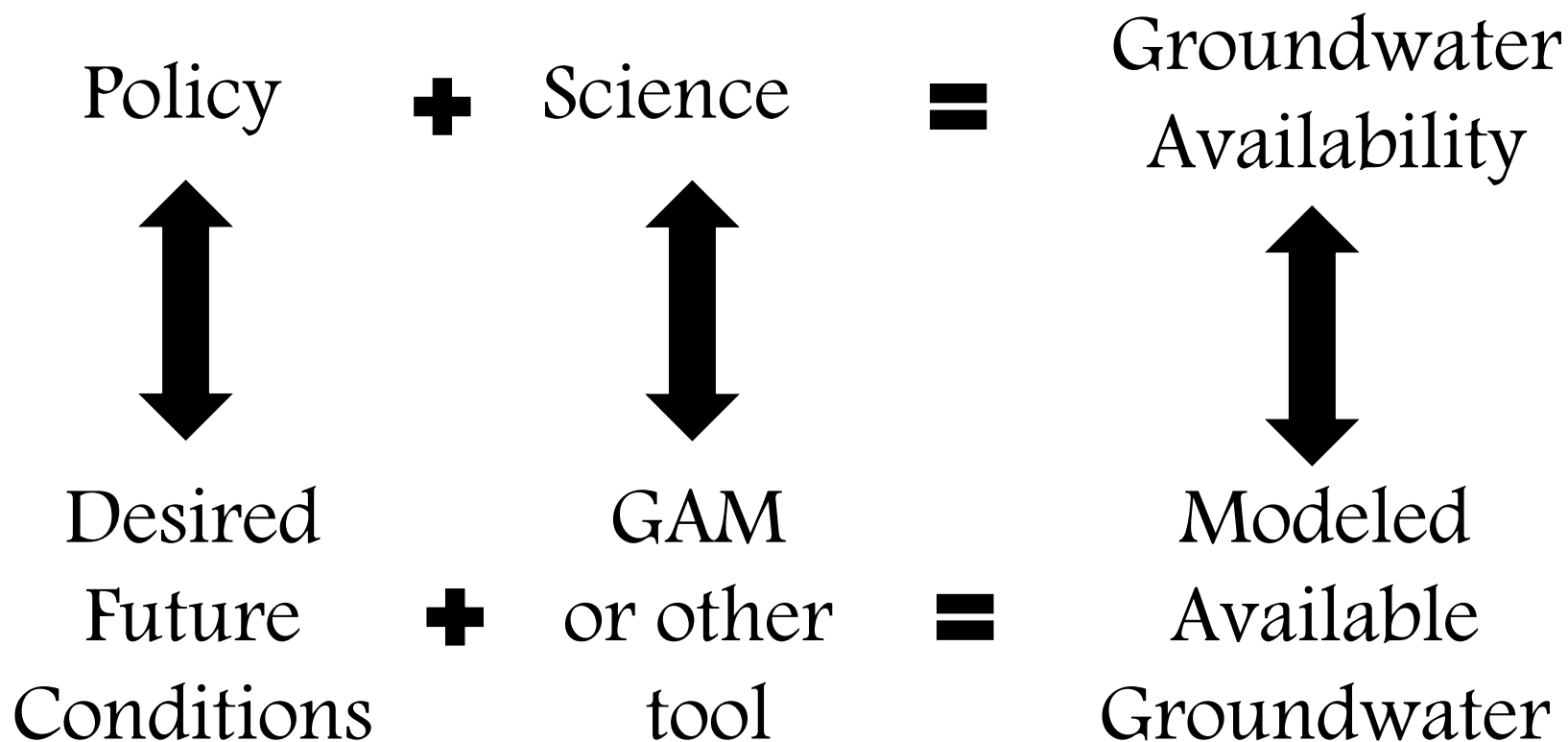
Major Aquifers



Minor Aquifers



What is Groundwater Availability ?



Goal: informed decision-making

Regional Water Planning Process

Existing
Water
Supplies

—

Projected
Water
Demand

=

Surplus (+) or
Need (-) for
Water



GAM
& other
tools



Water Use
Survey
& Estimation

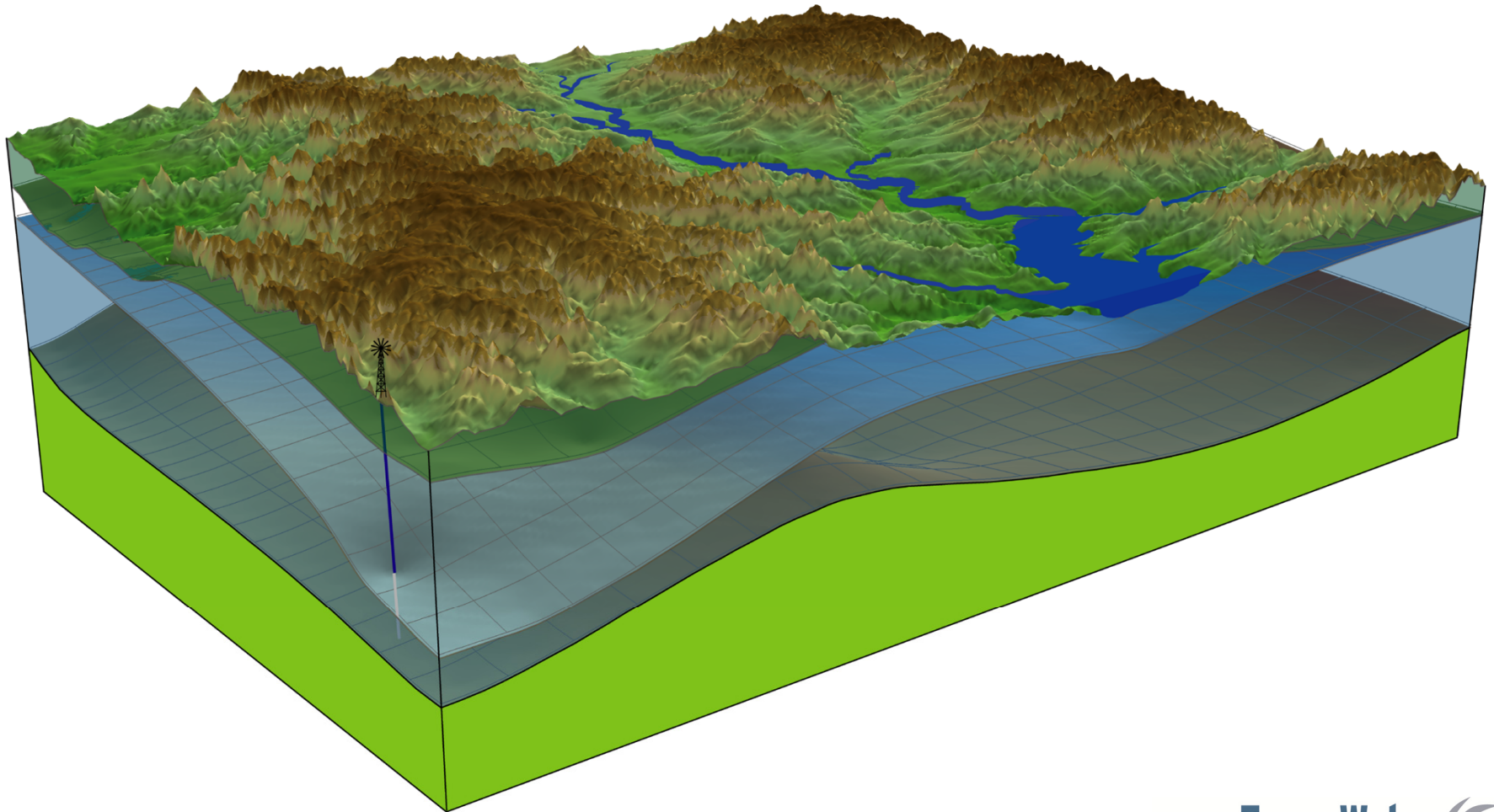


Water
Management
Strategies

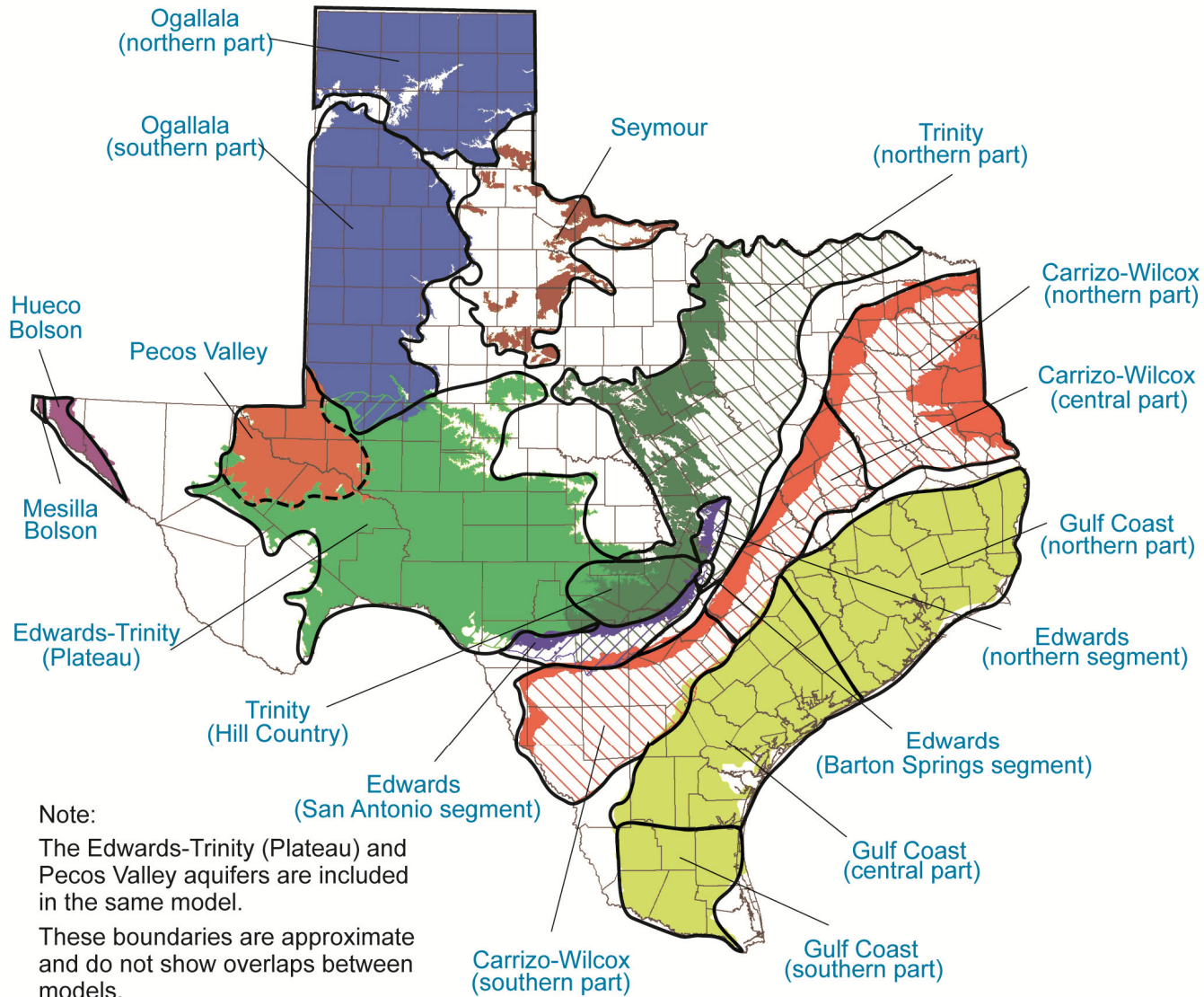
GAM Program

- ❖ Purpose: 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: standardized, thoroughly documented , with the reports available over the internet
- ❖ Living tools: periodically updated

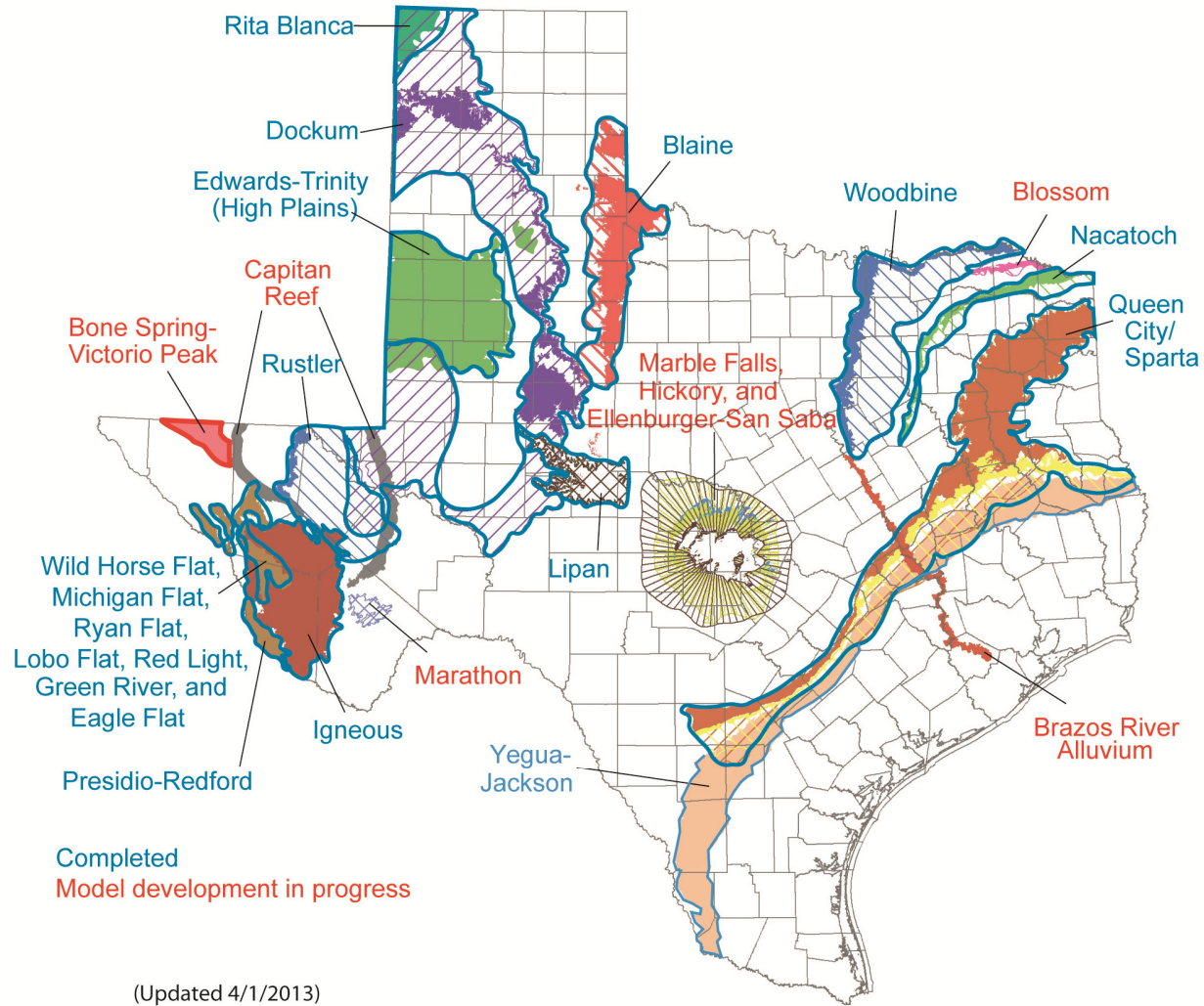
Groundwater Model



Major Aquifers- GAMs



Minor Aquifers- GAMs



How we use Groundwater Models

Texas Water Code, § 36.1071 (h)

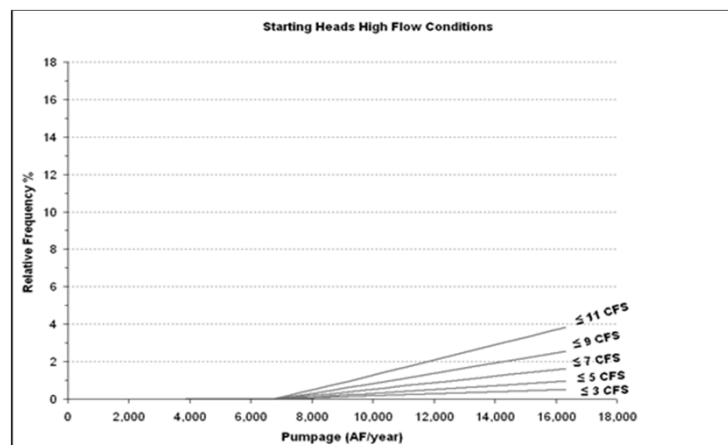
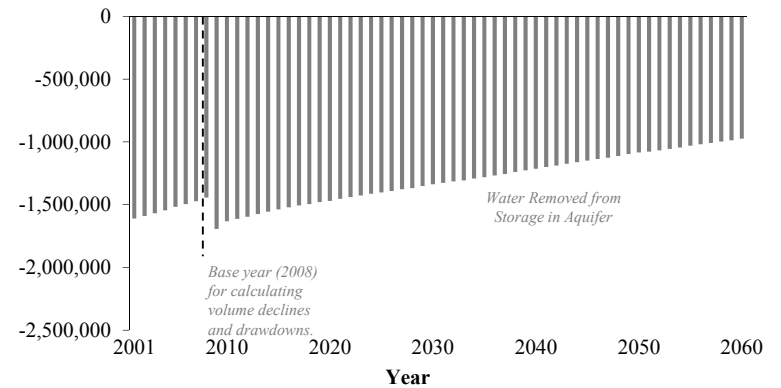
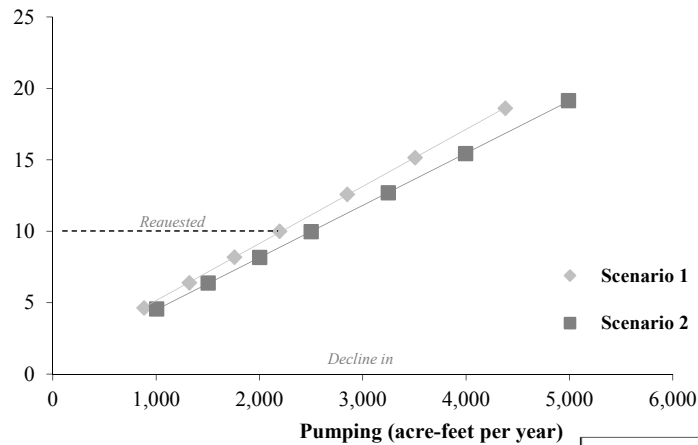
Inform groundwater districts about historical conditions in the aquifer

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

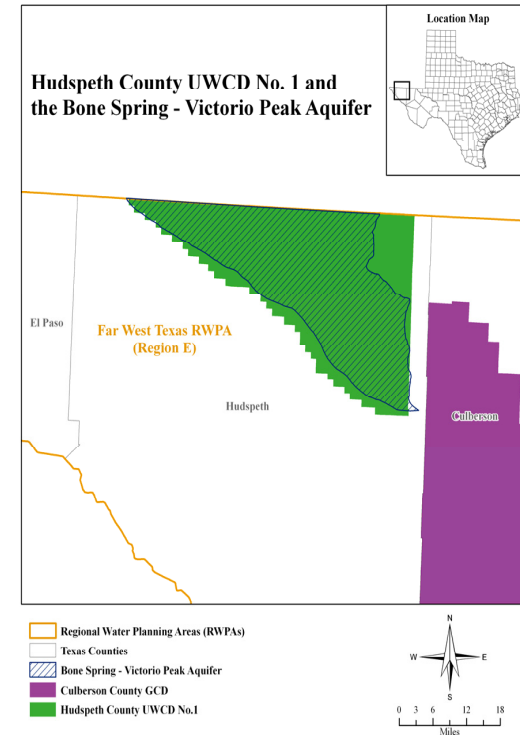


How we use Groundwater Models

Texas Water Code, § 36.1084 (b)

Develop modeled available groundwater based on desired future conditions

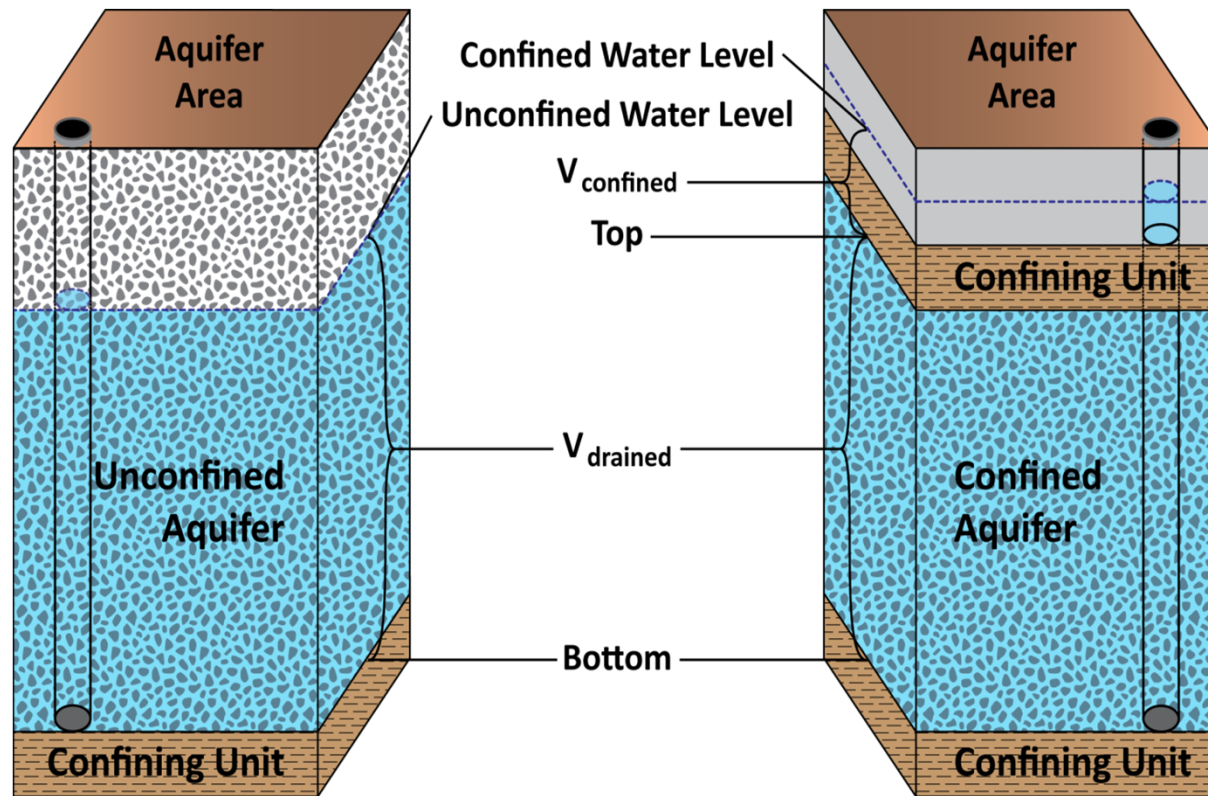
County	Regional Water Planning Area	Basin	Year					
			2010	2020	2030	2040	2050	2060
Hudspeth	E	Rio Grande	101,429	101,429	101,429	101,429	101,429	101,429



How we use Groundwater Models

Texas Water Code, § 36.108 (d) (3)

Estimating total recoverable storage for explanatory reports



Stakeholder Advisory Forums (SAF)

- ❖ Input, data, feedback during model development
- ❖ Updates on progress of the model
- ❖ Improve understanding on use of the model

SAF presentations and associated minutes posted at

http://www.twdb.state.texas.us/groundwater/models/gam/gma15_16/gma15_16.asp

TWDB Home > Groundwater > Models > Groundwater Availability
Models > Gulf Coast Aquifer System GAM for GMAs 15 and 16

Groundwater Availability Modeling Gulf Coast Aquifer

Rohit R. Goswami, Ph.D.

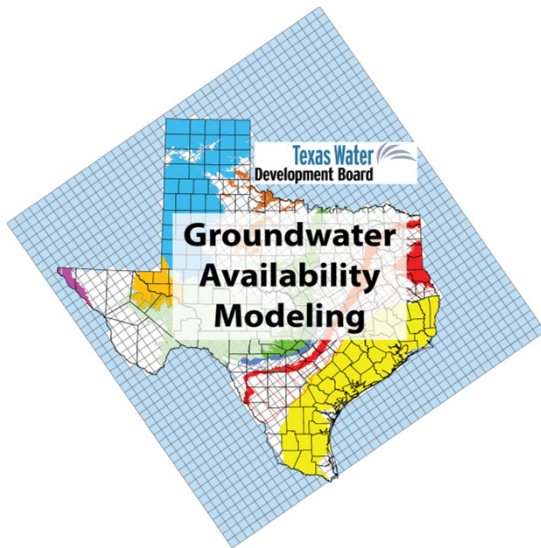
Groundwater Hydrologist

Gulf Coast Aquifer System Groundwater Availability Model (GAM)

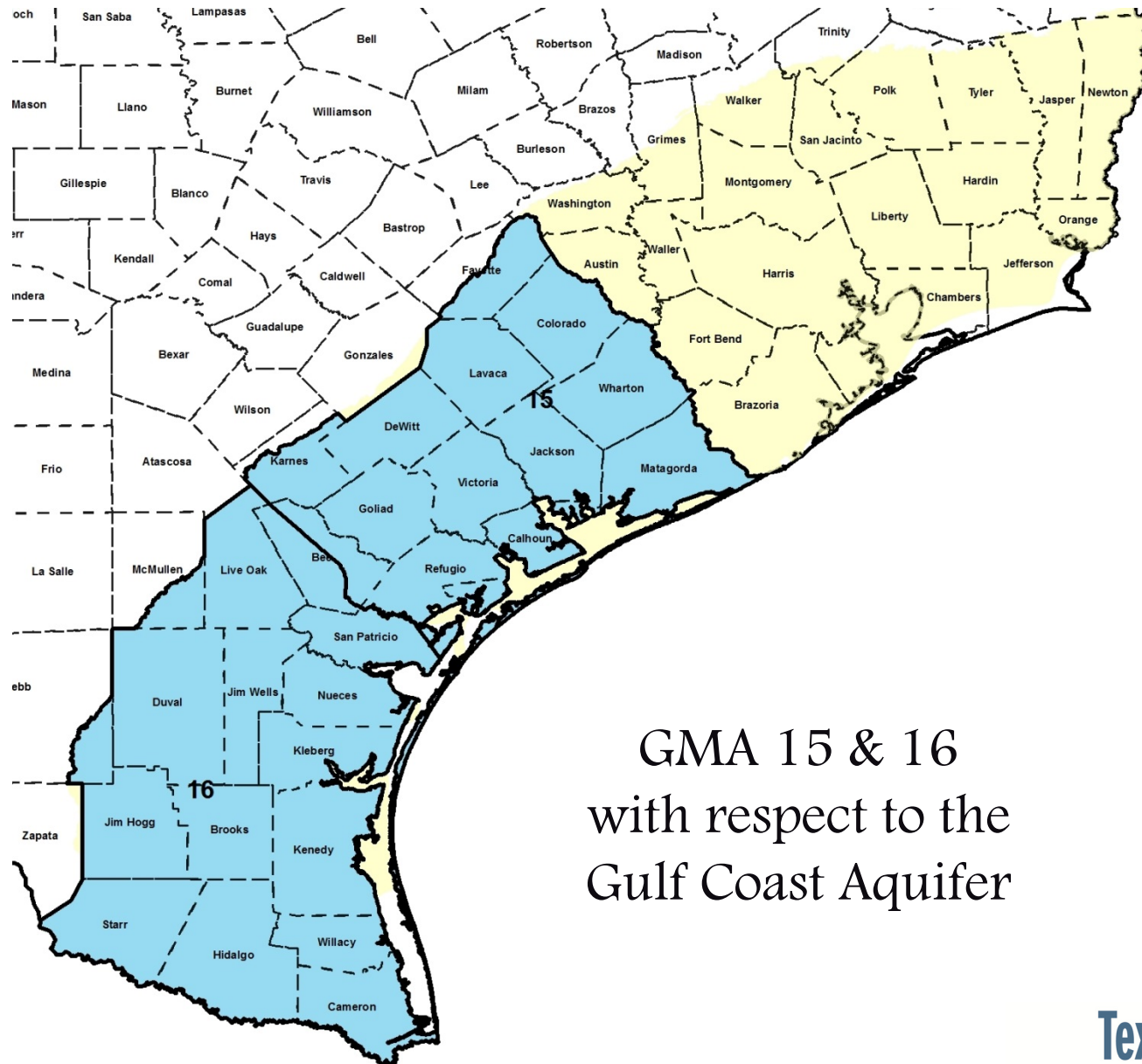
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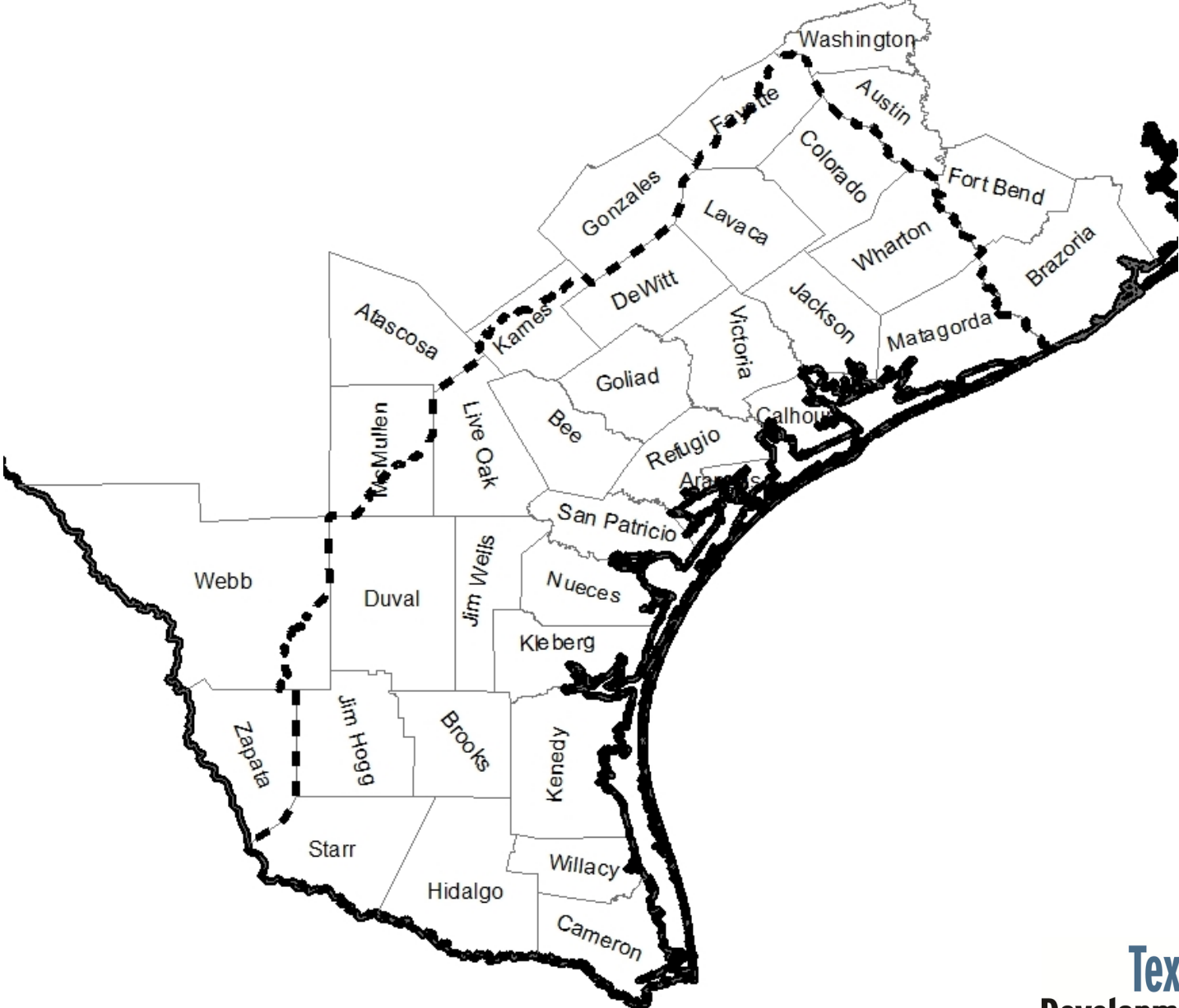


Gulf Coast Aquifer System Boundaries

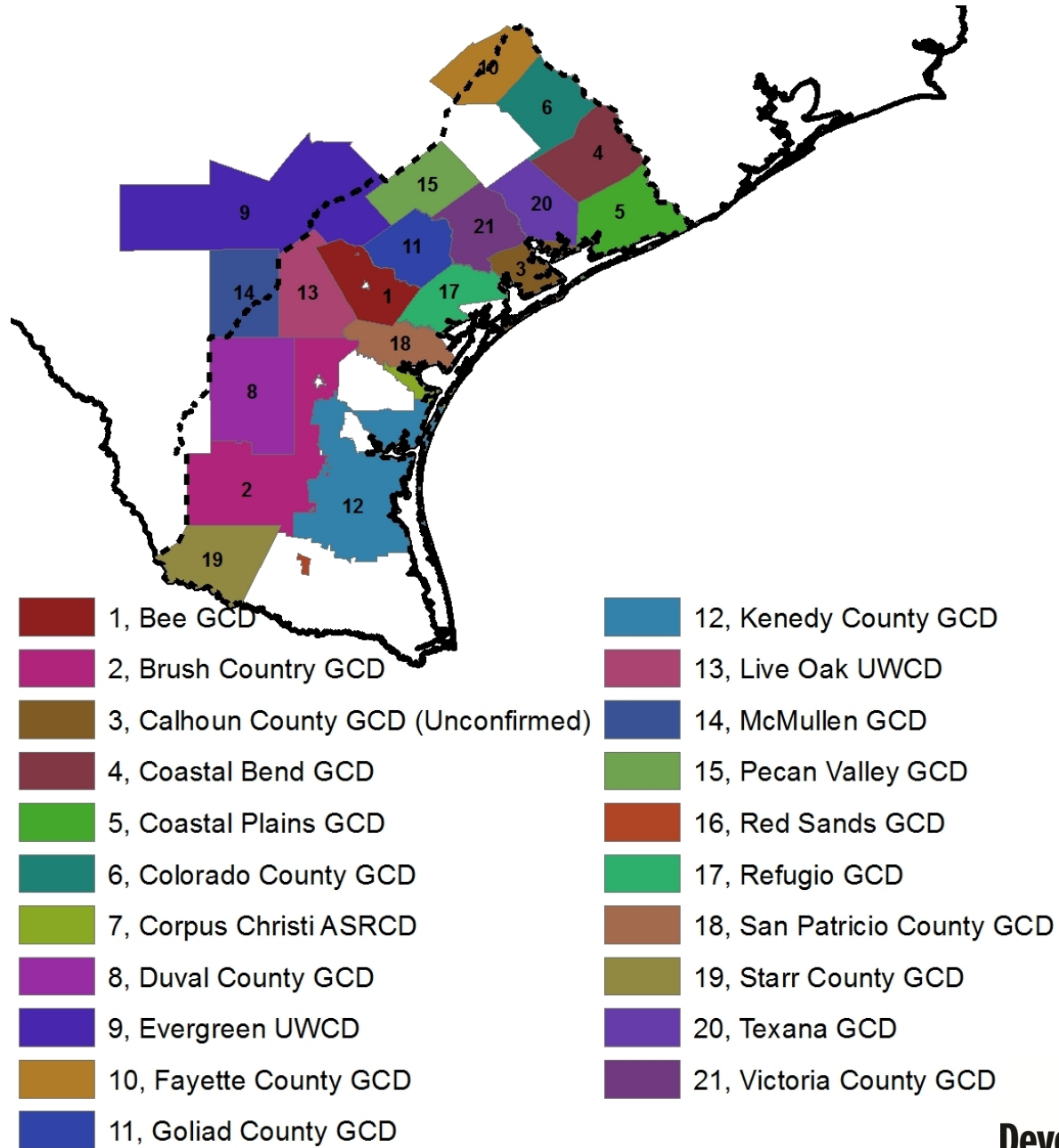


GMA 15 & 16
with respect to the
Gulf Coast Aquifer

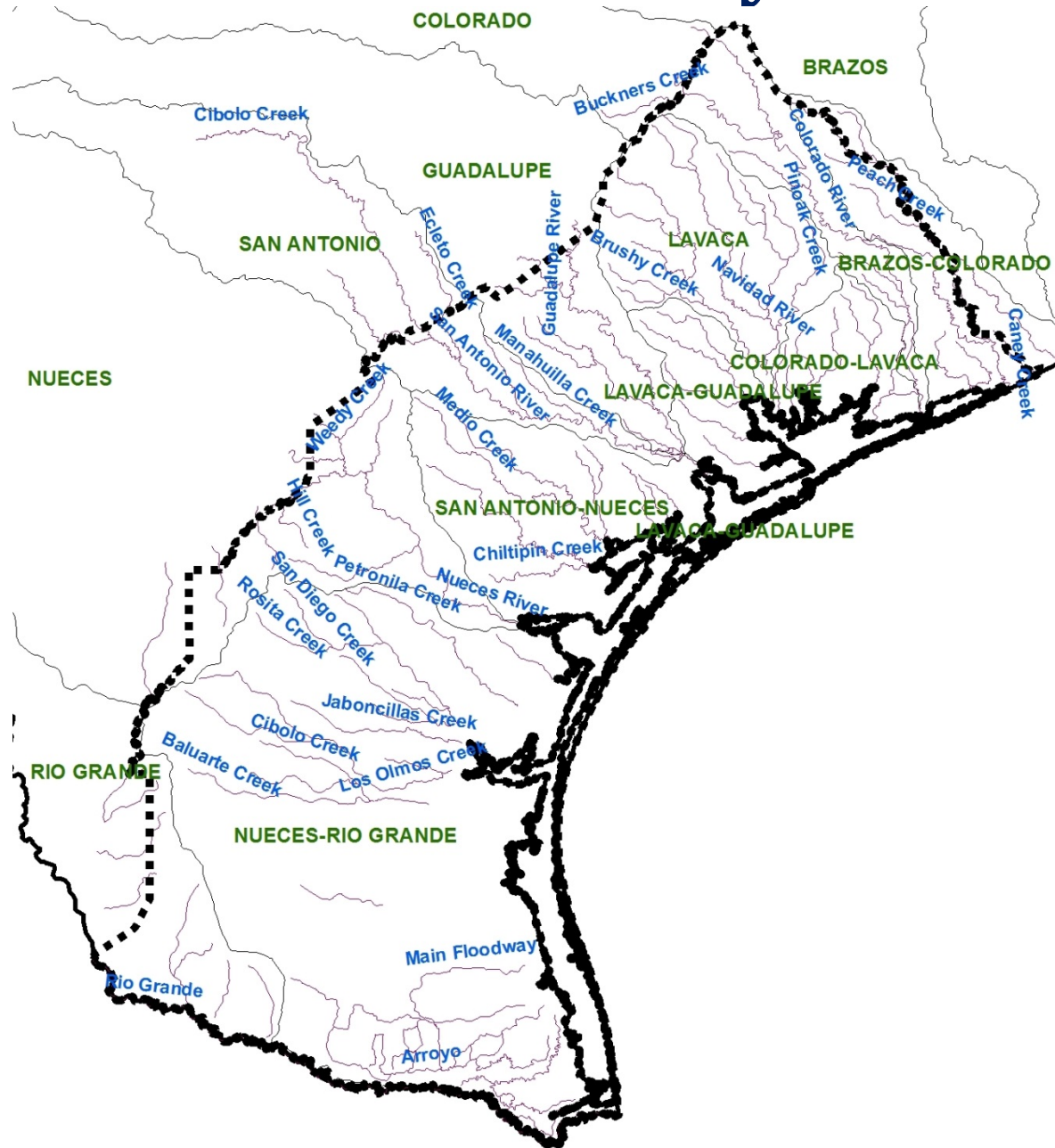
Counties In and Bordering GMA 15 & 16



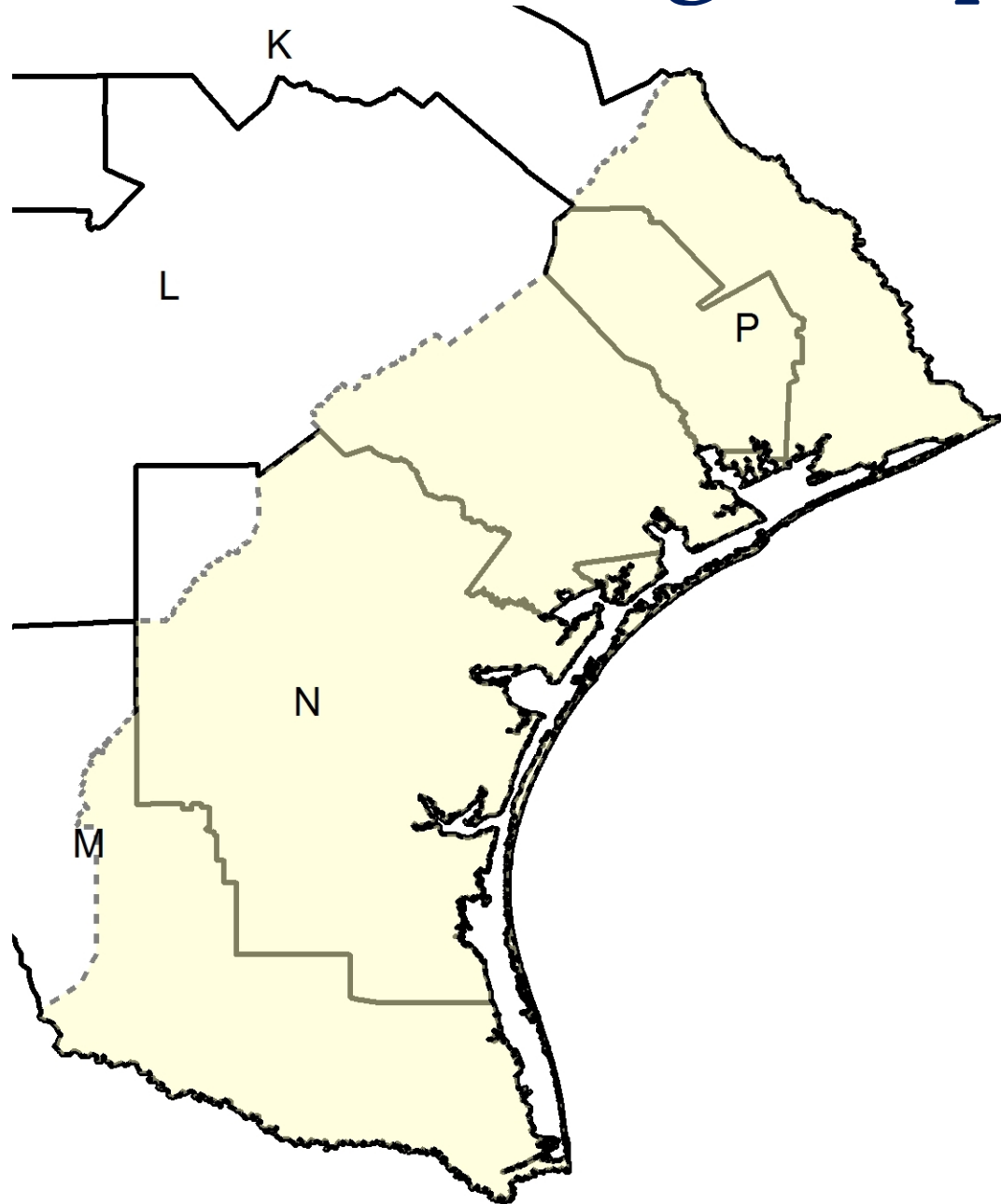
Groundwater Conservation Districts (GCDs)



River Basins and Major Streams



Regional Water Planning Groups (RWPGs)



Groundwater Flow – Definitions

- ❖ Aquifer – Water saturated permeable geologic unit that can transmit significant quantities of water
- ❖ Water table – The level at which water stands in a shallow screened well in an unconfined aquifer
- ❖ Hydraulic head – The water level in a well expressed as an elevation
- ❖ Hydraulic conductivity – A physical property of the geologic media representing its ability to transmit water

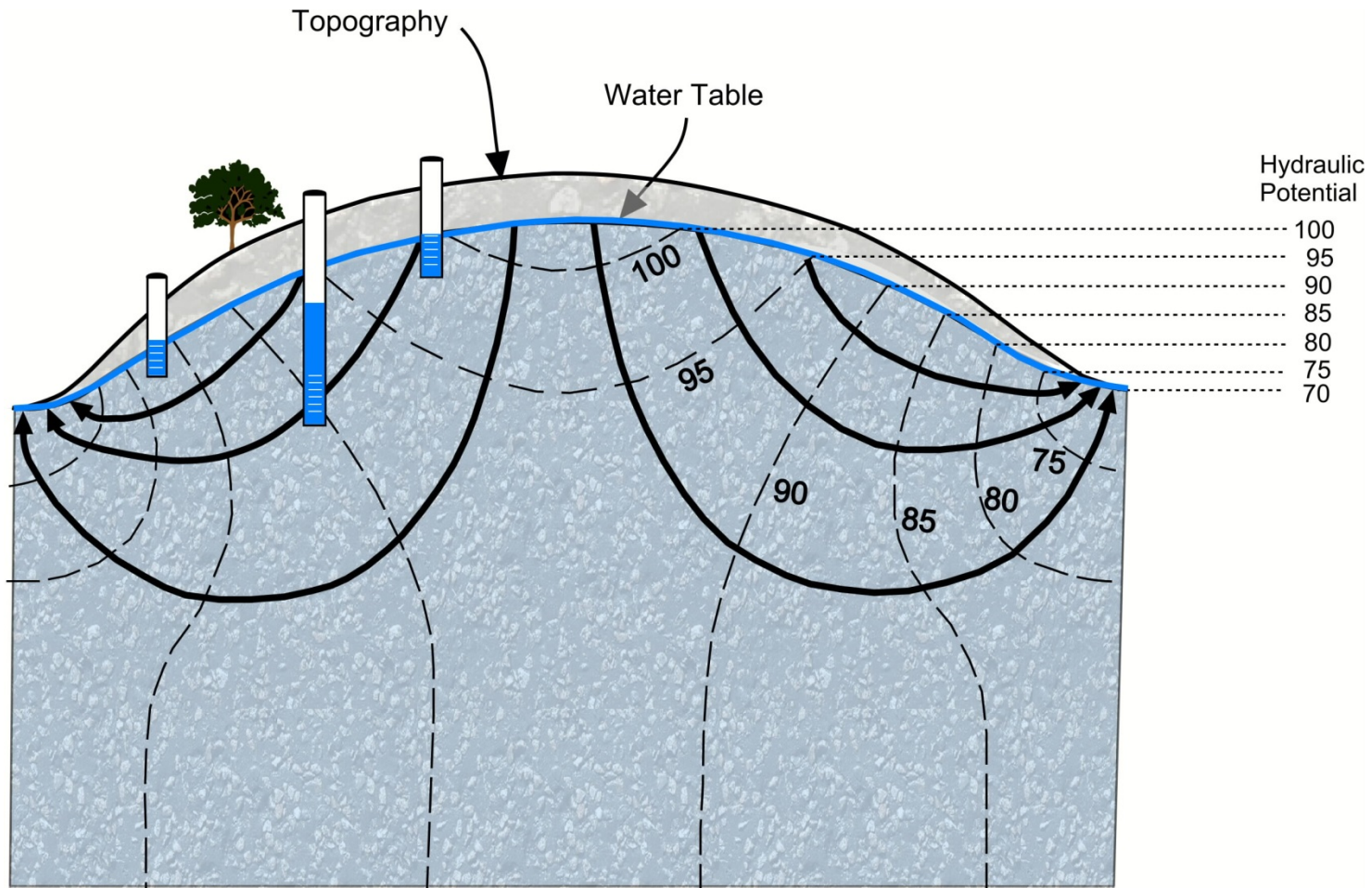
Groundwater Flow – Definitions (cont'd)

- ❖ **Storativity** – The volume of water that a confined aquifer releases from storage per unit surface area of aquifer per unit decline in head
- ❖ **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

Groundwater Flow – Definitions (cont'd)

- ❖ Recharge – The entry of water to the saturated zone at the water table. Recharge equals water inputs at ground surface (precipitation + irrigation) minus water losses (evapotranspiration+runoff)
- ❖ Stream losses or gains – The water that is either lost or gained through the base of the stream

Schematic Cross Section of Groundwater Flow



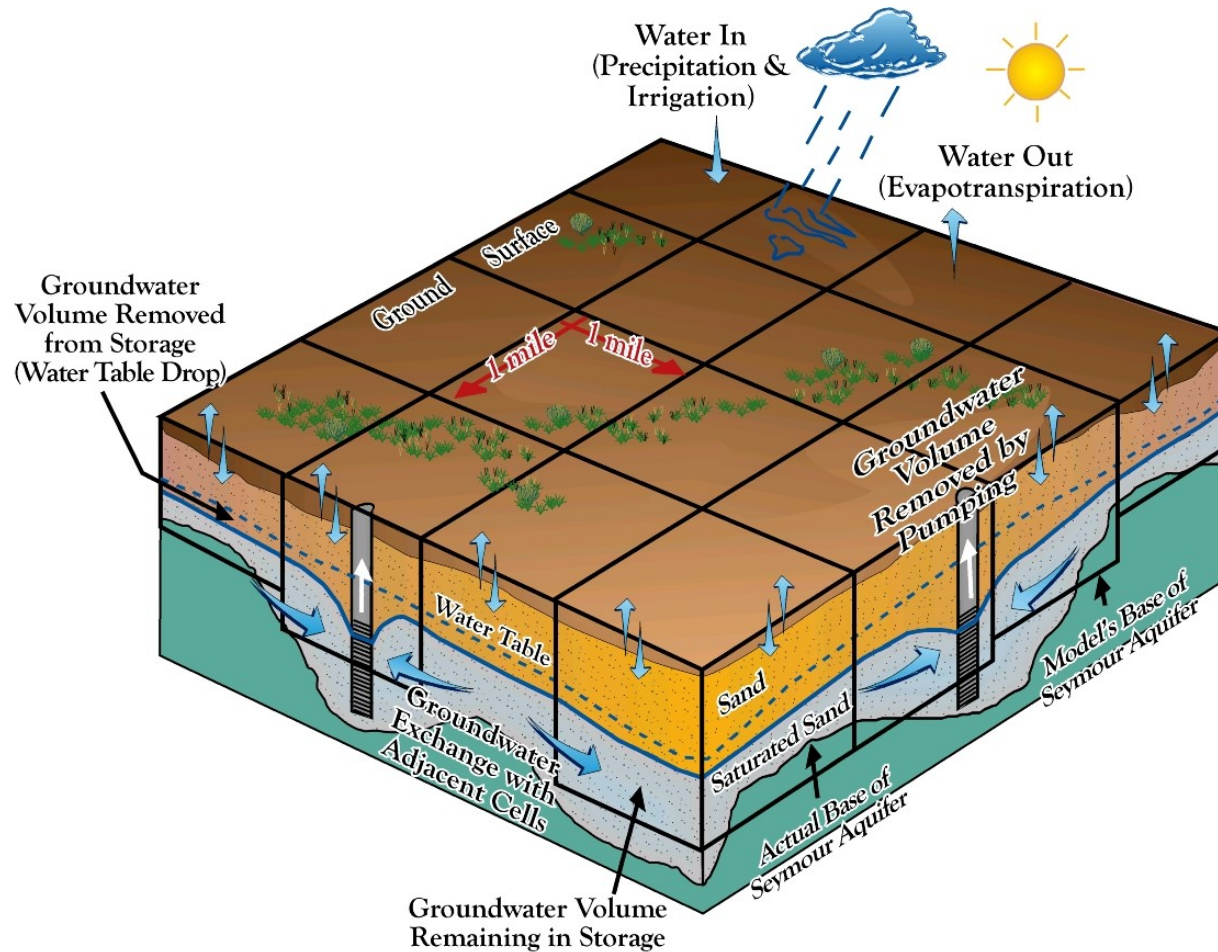
Basic Principles of Groundwater Flow

- ❖ 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
- ❖ Groundwater flows from high hydraulic heads to low heads
- ❖ The water table is typically a subdued replica of the topography

Basic Principles of GW Flow (cont'd)

- ❖ The difference in hydraulic head between adjacent wells describes the direction of GW flow.
- ❖ The thickness and hydraulic conductivity of the aquifer material define volumetric flow rates (e.g., pumping).

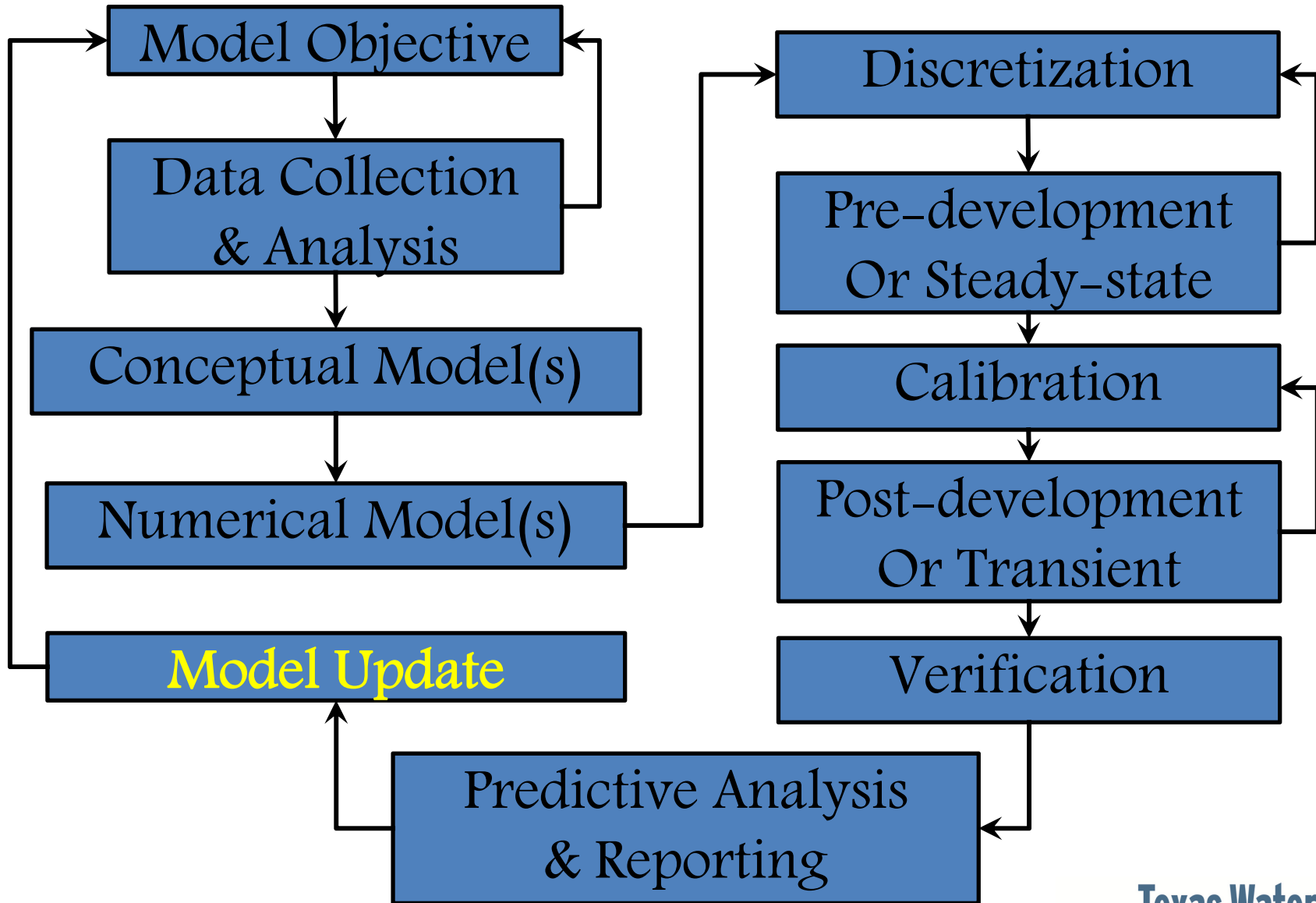
Numerical Groundwater Model – Model Grid Cells & Their Interactions



GAM Specifications (Tentative)

- ❖ Three dimensional (MODFLOW-NWT/USG)
- ❖ Regional scale (Thousands of square miles)
- ❖ Grid spacing (to be decided - 1 square mile ?)
- ❖ Implement
 - ❖ recharge
 - ❖ groundwater/surface water interaction
 - ❖ Pumping
 - ❖ Subsidence ?
- ❖ Calibration to observed water levels, surface water flow, other data where possible or applicable

Modeling Protocol



Model Inputs

- ❖ Top & bottom elevation surfaces for each layer
- ❖ Aquifer Properties:
 - ❖ thickness
 - ❖ hydraulic conductivity (K)
 - ❖ storage parameters
- ❖ Initial water table elevations
- ❖ Recharge
- ❖ Surface water characteristics
- ❖ Pumping

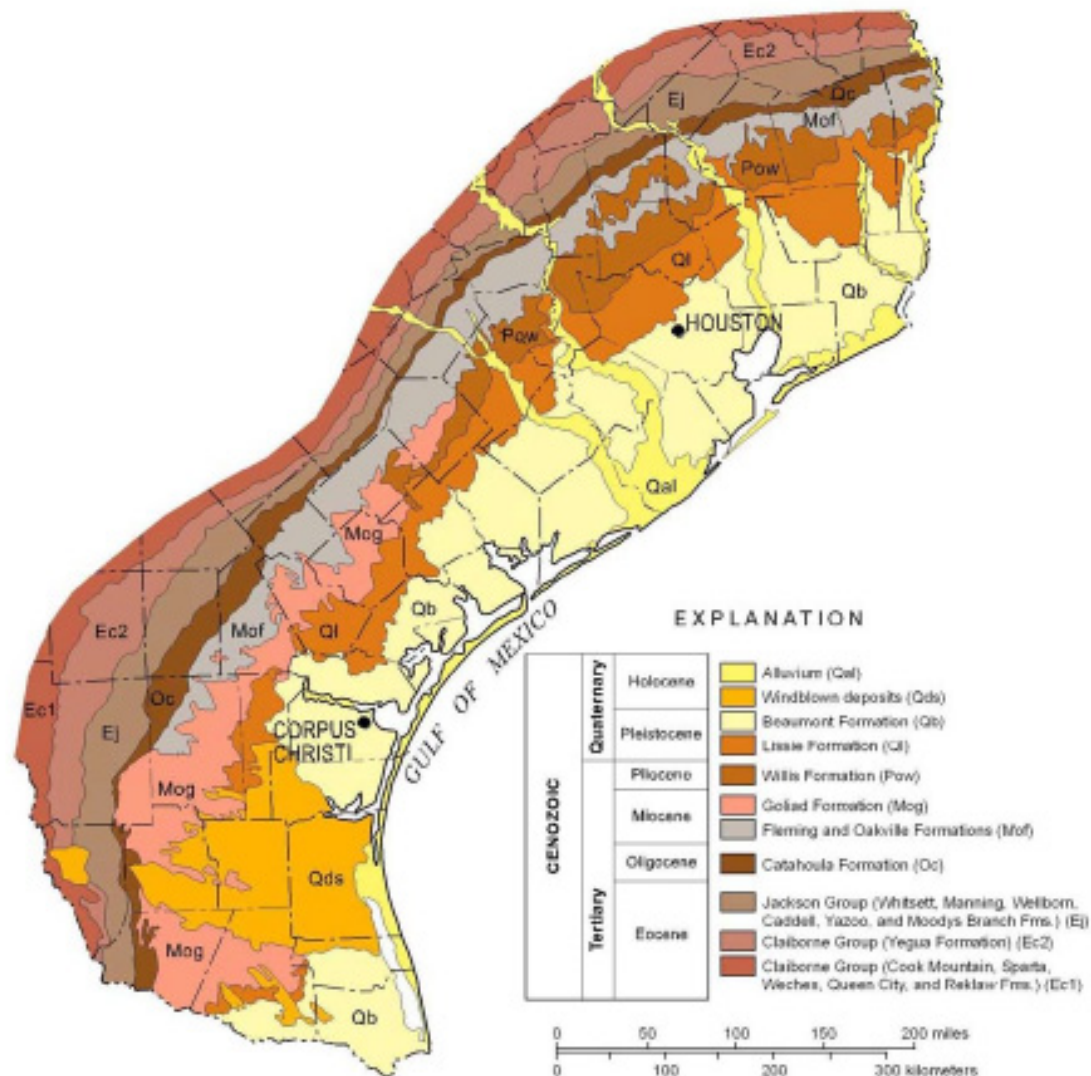
Model Limitations

- ❖ The Gulf Coast aquifer is heterogeneous vertically (clay, silt, sand, gravel) and will be represented by multiple layers.
- ❖ Data available (e.g., geology, wells, pumping) is limited in some regions.
- ❖ The GAM is a tool for making groundwater availability assessments on a regional basis only.
- ❖ The GAM is not capable of predicting aquifer responses at small scales (e.g., individual wells). Such evaluations would require refined model development.

Gulf Coast Aquifer

- ❖ Composed of clay, silt, sand, and gravel. Sands & gravels occur primarily at base.
- ❖ Thickness of the aquifer layers is up to 1000 feet or more

Geologic Map of Texas Coastal Plain



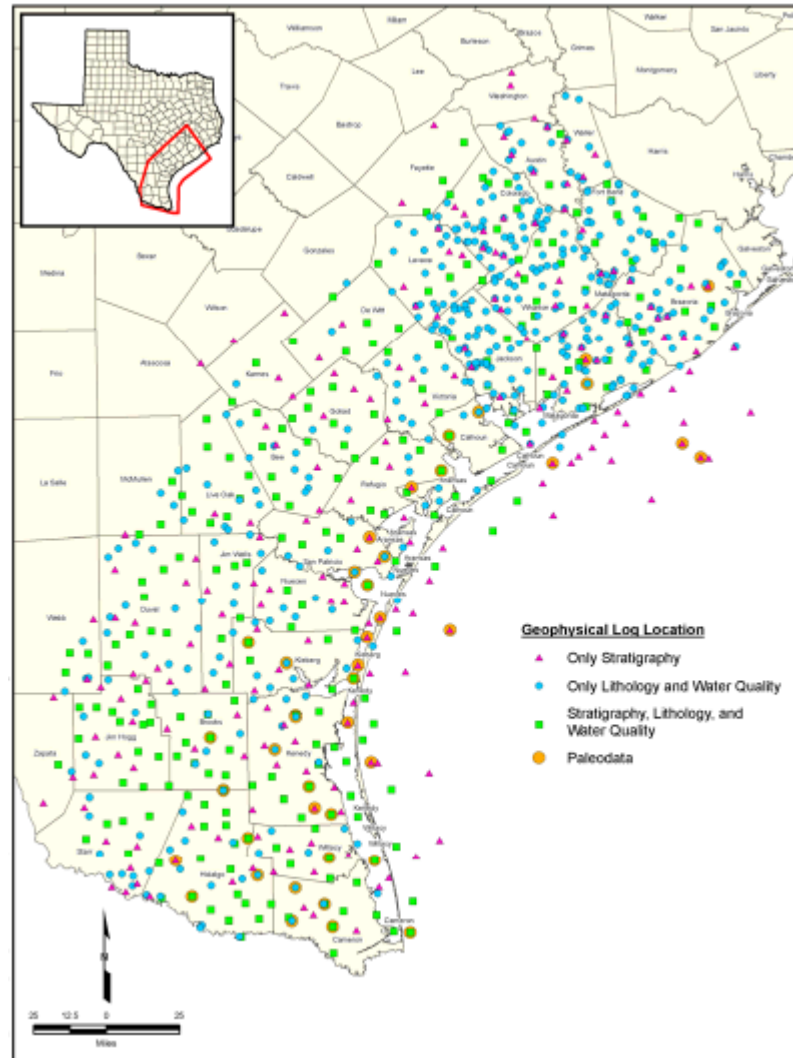
Taken from Barnes (1992)

Stratigraphic and Hydrogeologic Chart of Texas Coastal Plain

ERA	Period		Epoch	Age (M.Y.)	Stratigraphic Unit	Dominant Lithology	Hydrogeologic Unit		
Cenozoic	Quaternary		Holocene	0.02	Alluvium	sand	Alluvium/Beaumont Aquifer	Gulf Coast Aquifer	
			Pleistocene		Beaumont	sand			
	Tertiary	Neogene	Pliocene	1.8	Lissie/Alta Loma	sand	Chicot Aquifer		
				5.3	Willis	sand	Evangeline Aquifer		
					Goliad	sand	Burkeville Aquitard		
			Miocene		Fleming/Lagarto	mud	Jasper Aquifer		
				23.9	Fleming/Oakville	sand	aquitard		
		Paleogene	Oligocene		33.9	Catahoula/Frio/Anahuac	sand and mud		aquitard
					33.9	Vicksburg	mud		aquitard
			Eocene			Jackson	sand and mud		Yegua-Jackson Aquifer
						Yegua	sand and mud		
						Sparta	sand		Queen City-Sparta Aquifer
						Queen City	sand and mud		
						Reklaw	mud		aquitard
				Paleocene		55.8	Upper Wilcox/Carrizo		sand
					Middle Wilcox	mud			
					Lower Wilcox/Simsboro	sand and mud			

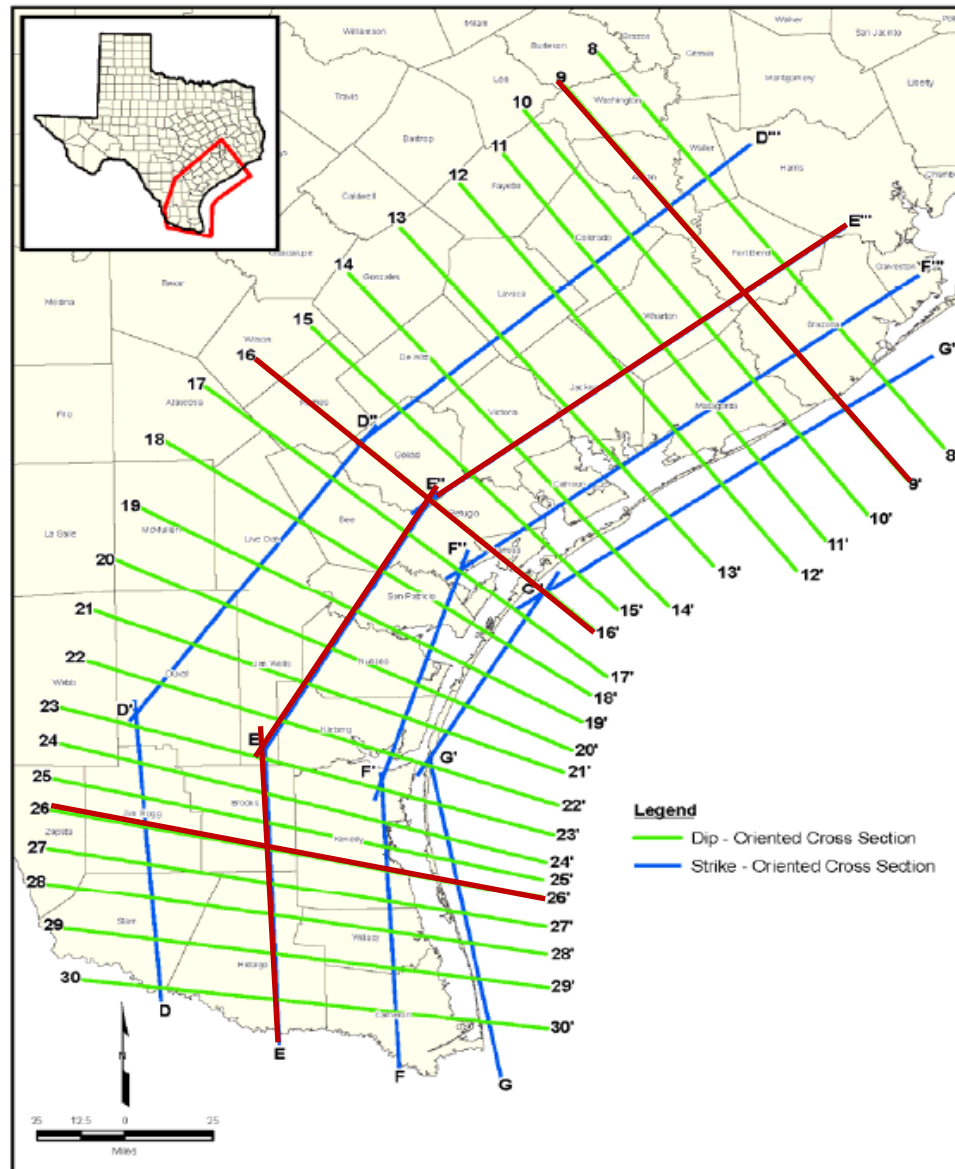
Taken from Young and others (2010); After Galloway and others(1991) and Sharp and others(1991)

Logs Used to Characterize Stratigraphy and Lithology of Gulf Coast Aquifer



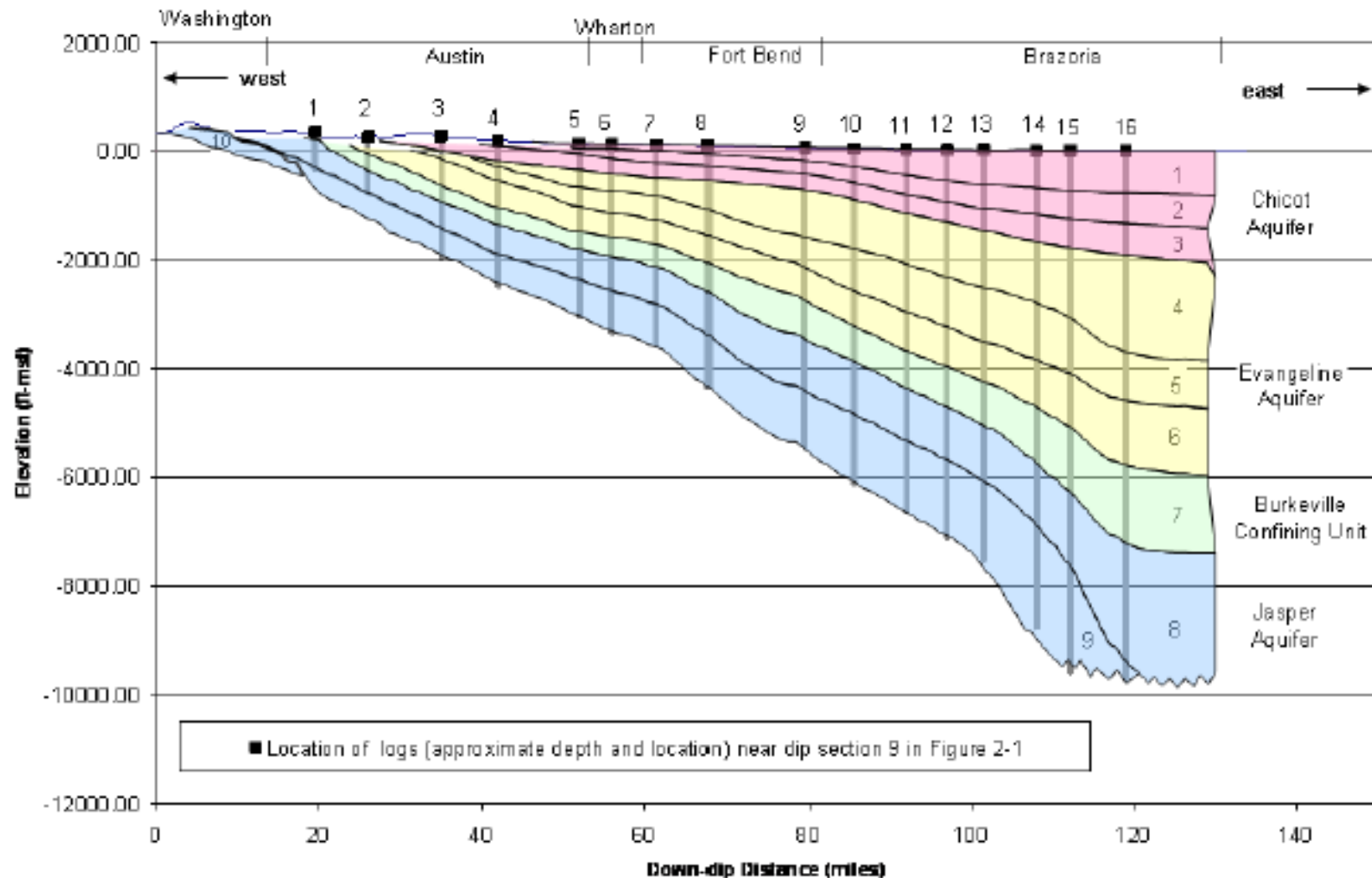
Taken from Young and others (2010)

Cross-sections for Stratigraphic Surfaces



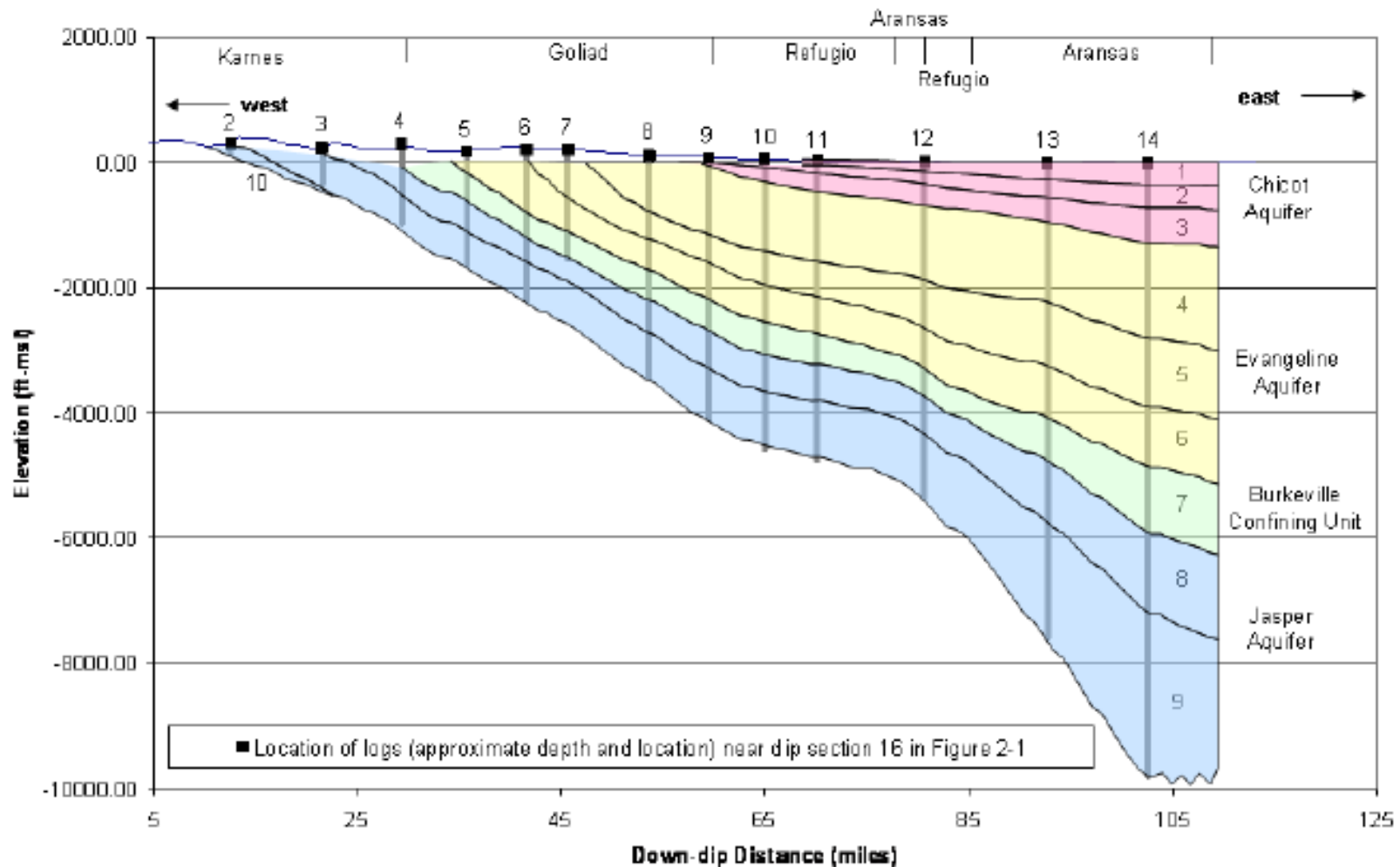
Taken from Young and others (2010)

Cross-sections for Stratigraphic Surfaces



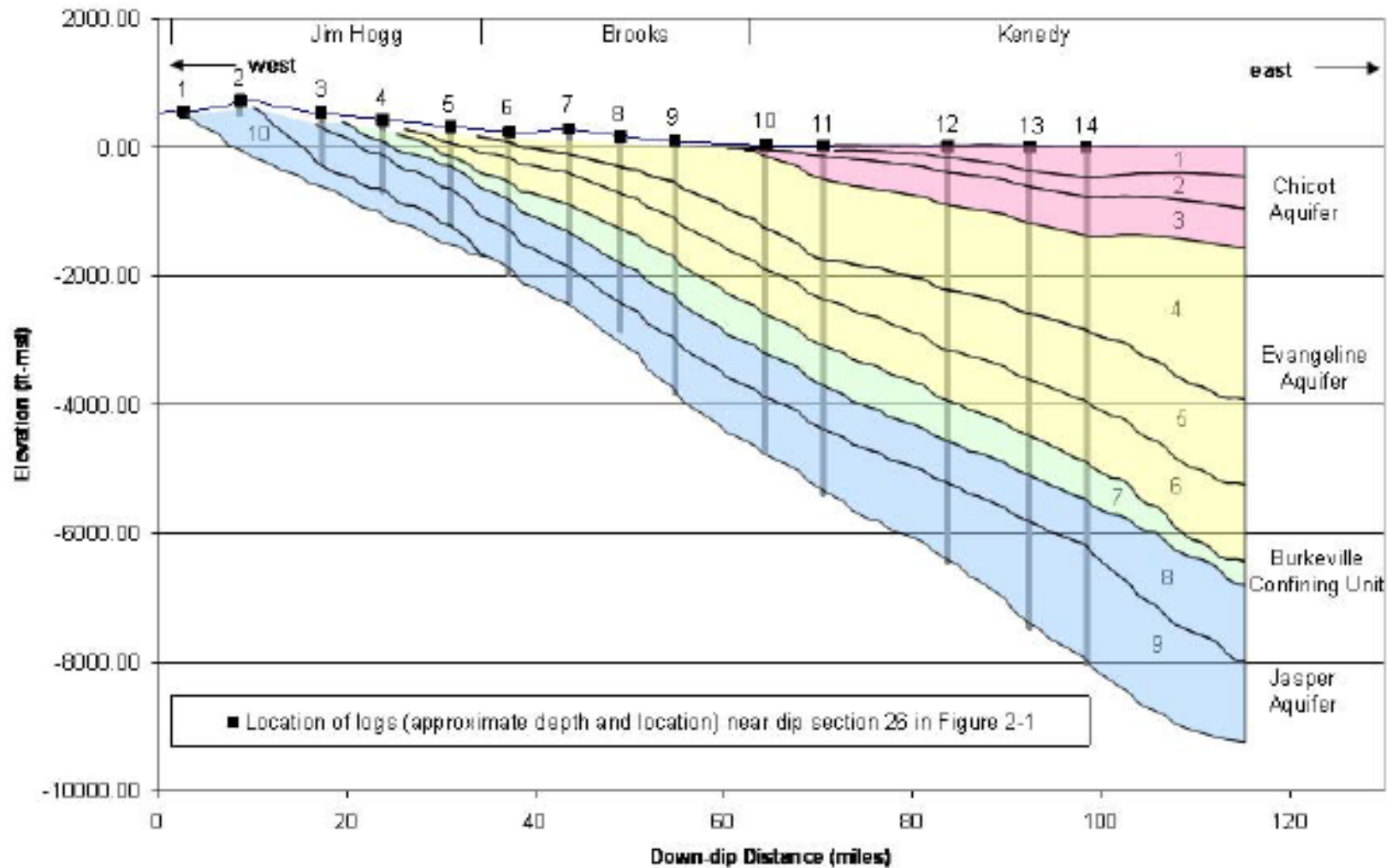
Vertical cross-section near dip section 9. Taken from Young and others (2010)

Cross-sections for Stratigraphic Surfaces



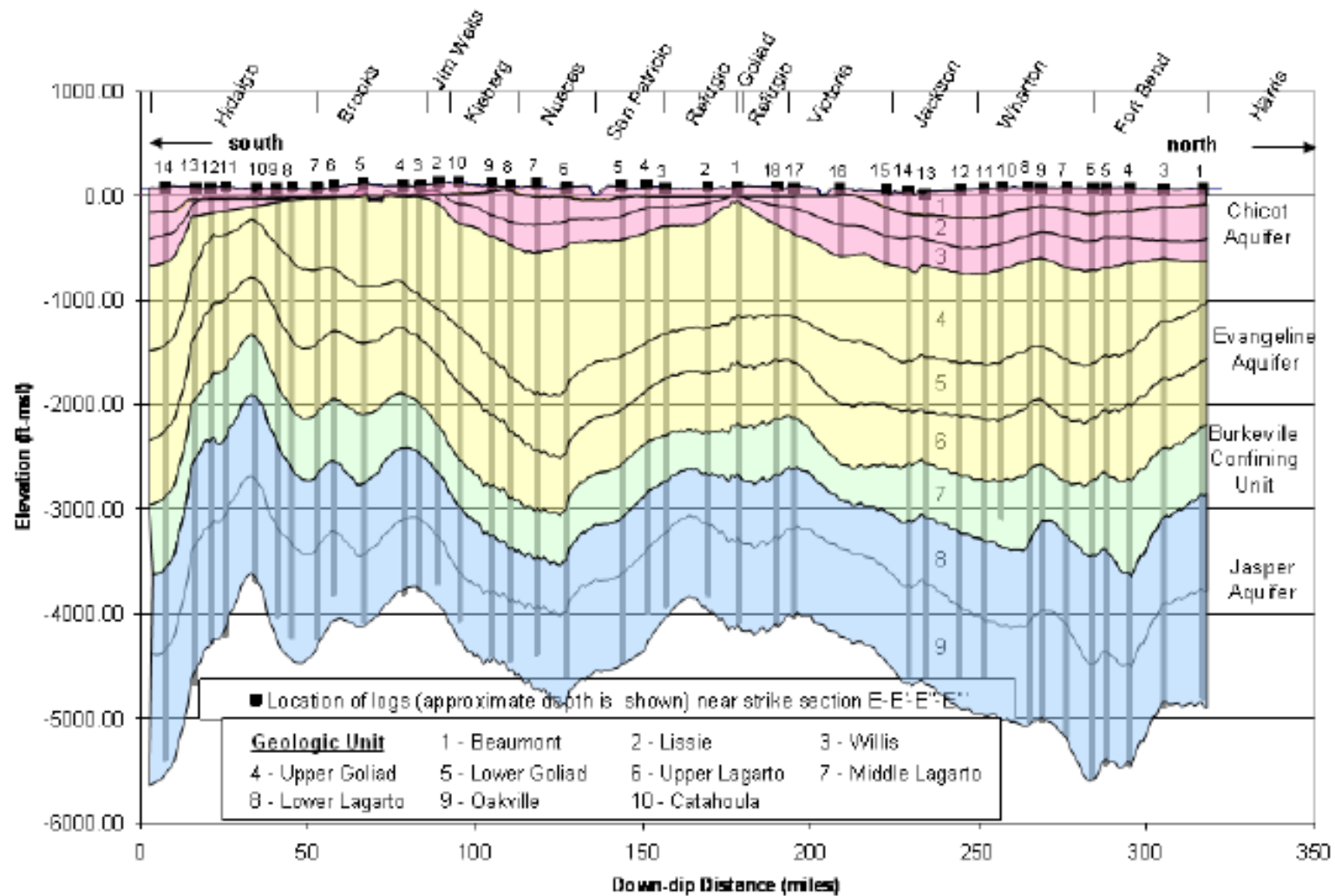
Vertical cross-section near dip section 16. Taken from Young and others (2010)

Cross-sections for Stratigraphic Surfaces



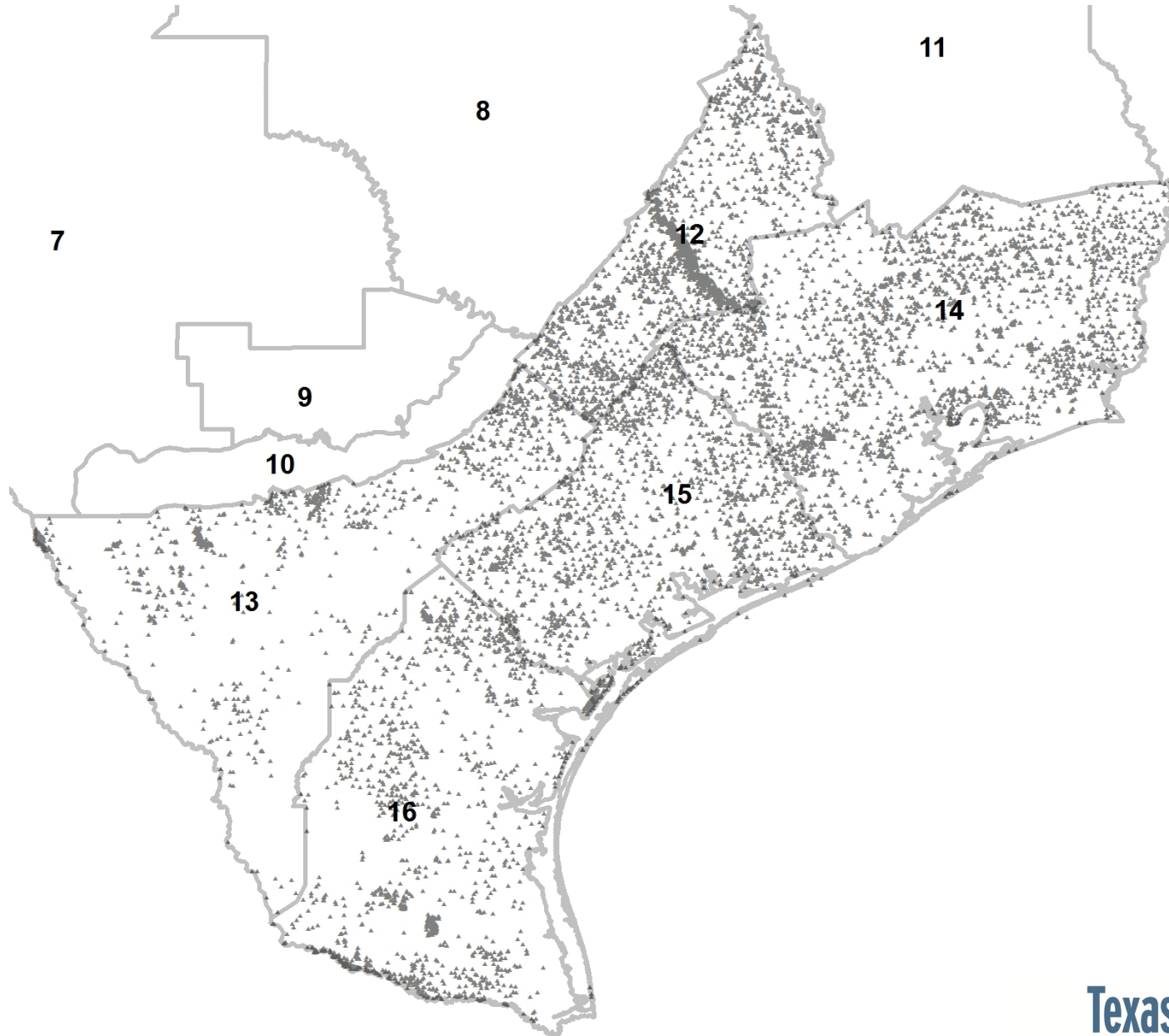
Vertical cross-section near dip section 26. Taken from Young and others (2010)

Cross-sections for Stratigraphic Surfaces



Vertical cross-section near strike section E-E'-E''-E'''. Taken from Young and others (2010)

Water Levels



Key Data Sources

- ❖ TWDB data at the website:

<http://www.twdb.state.tx.us/groundwater/data/index.asp>

- ❖ TWDB reports
- ❖ Contract reports submitted to TWDB
- ❖ U.S. Geological Survey reports
- ❖ Bureau of Economic Geology reports
- ❖ Texas Commission on Environmental Quality drillers logs

Key Data Sources (cont'd)

- ❖ Websites:

- ❖ U.S. Geological Survey

- ❖ topography

- ❖ stream flows

- ❖ stream gain/loss studies

- ❖ U.S. EPA

- ❖ stream characteristics

- ❖ land use / land cover

- ❖ soil type

- ❖ National Climatic Data Center – precipitation

Data Request

- ❖ Gulf Coast
 - ❖ geologic logs
 - ❖ water levels (elevations)
 - ❖ aquifer properties
 - ❖ Burkeville confining unit, Jasper Aquifer
- ❖ Possibly, also for underlying units such as and Carrizo–Wilcox, Queen City and Sparta Aquifers, and Yegua–Jackson Aquifer
- ❖ Data provided must be documented and publicly available.
- ❖ Data to be submitted to the GAM section by December 18, 2014

Contact Information

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Tentative GAM Schedule

- ❖ Project start – April 2014
- ❖ Stakeholder Advisory Forum # 1: June 2014
- ❖ Stakeholder data submission – December 2014
- ❖ Draft conceptual model report – June 2015
- ❖ Stakeholder Advisory Forum # 2: July 2015
- ❖ Numerical model draft report – August 2016
- ❖ Stakeholder Advisory Forum # 3: September 2016
- ❖ Final Model Report – December 2016

Meeting Wrap-Up

❖ Discussion / comments / questions

Questions & Answers
Gulf Coast Aquifer System
Groundwater Availability Modeling (GAM)
Groundwater Management Areas 15 & 16
1st Stakeholder Advisory Forum
June 17, 2014
Harte Research Institute, Corpus Christi, TX

Question 1: How far into Groundwater Management Area (GMA 14) would the model boundaries extend for the proposed model?

Answer 1: Model extent into GMA 14 has not been decided yet and will be ascertained at the numerical modeling stage after conceptual model update is complete. The focus of model extent would be to minimize boundary issues and not to explicitly model GMA 14.

Question 2: How many layers would the proposed model have?

Answer 2: Model layers have not been decided yet and will be ascertained after the conceptual model update depending on hydrogeology and data availability. Number of explicit layers would also depend on the MODFLOW version that is used to develop the model. In case of MODFLOW-USG, number of layers may vary depending on hydrogeology and data availability.

Question 3: Is the entire Nueces Basin being modeled as part of the proposed study?

Answer 3: Focus of the modeling project is Gulf Coast Aquifer System in Groundwater Management Areas 15 and 16. Boundaries of surface water basins such as Nueces are not being considered as primary concerns in setting the model boundaries and extent.

Question 4: How would observed water levels be used during model construction? Would the monthly or annual pumping estimates be modified to match the stress period of the model?

Answer 4: We understand the limitations in temporal discretization of the model. Time stepping and stress period details would be decided after the conceptual model update and during the numerical modeling exercise. Observed water levels would be used as calibration targets during model construction and would be weighted depending on confidence in data collection methods and also other data types available in the local vicinity of the water level measurements.

In general, pumping is a calibration parameter during the modeling process due to uncertainty in pumping estimates and gathered data. More details on inclusion of pumping data in the model would be available after the conceptual model update.

Question 5: How would groundwater surface water interactions be modeled in the proposed study?

Answer 5: It has not been decided on which process would be used to simulate groundwater surface water interactions in the proposed model. More details would be available after conceptual model update and would also depend on the MODFLOW version that is used to develop the model.

Question 6: Will evapotranspiration be modeled explicitly during model construction or would it be lumped with recharge?

Answer 6: More details on process modules included in the model would be available after conceptual model update based on data availability. However, at this time, evapotranspiration is intended to be included as a separate process than recharge in the proposed model.

Question 7: Will the model be calibrated manually or through automated software such as PEST?

Answer 7: Based on model extent and data complexity, PEST would most likely be used during model calibration. However, details would be available during numerical modeling exercise, such as selecting between zonation, pilot points, or hybrid methods for different parameter types for calibration.

Question 8: Would water quality be explicitly delineated within the model or would it be modeled directly in any way perhaps using a variable-density code?

Answer 8: At this time, the proposed model is intended to be a constant-density groundwater model and water quality modeling is not the focus of this study. Variable-density modeling is not being considered at the present time.

Question 9: How will subsidence be considered in the model?

Answer 9: Depending on data availability on subsidence both spatially and temporally, a decision on including subsidence as a process in the model would be taken after the conceptual model update.

Question 10: Would the previous Groundwater Availability Models (GAMs) continue to be used for the next round of [Desired Future Condition] process in 2016 or will the proposed model supersede them before the [Desired Future Condition] process?

Answer 10: At this time, we can state that the proposed model is not intended to replace existing GAMs for the current round of [Desired Future Conditions].

SIGN-IN SHEET

**Gulf Coast Aquifer System
Groundwater Availability Modeling (GAM)
Groundwater Management Areas 15 & 16
1st Stakeholder Advisory Forum
June 17, 2014
Harte Research Institute, Corpus Christi, TX**

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