HARRIS-GALVESTON SUBSIDENCE DISTRICT

FORT BEND SUBSIDENCE DISTRICT

2023 Joint Regulatory Plan Review

Stakeholder Meeting 1

20 May 2020

Project Sponsors and Collaborators

HARRIS-GALVESTON SUBSIDENCE DISTRICT

FORT BEND SUBSIDENCE DISTRICT

Texas Water Development Board

USGS science for a changing world

Stakeholder Participants

- Regulated community
- Decision-makers
- Elected officials
- GMA 14 and GCDs
- River authorities
- Region H Water Planning Group
- Texas Water Development Board

Purpose and Objectives

- Refresh population and per-capita water demand projections within and surrounding the Regulatory Areas
- Improve the understanding of future alternative source waters
- Update and improve predictive tools
- Evaluate regulatory and climatic scenarios versus the occurrence of subsidence through 2100

Keys Stakeholder Engagement Opportunities

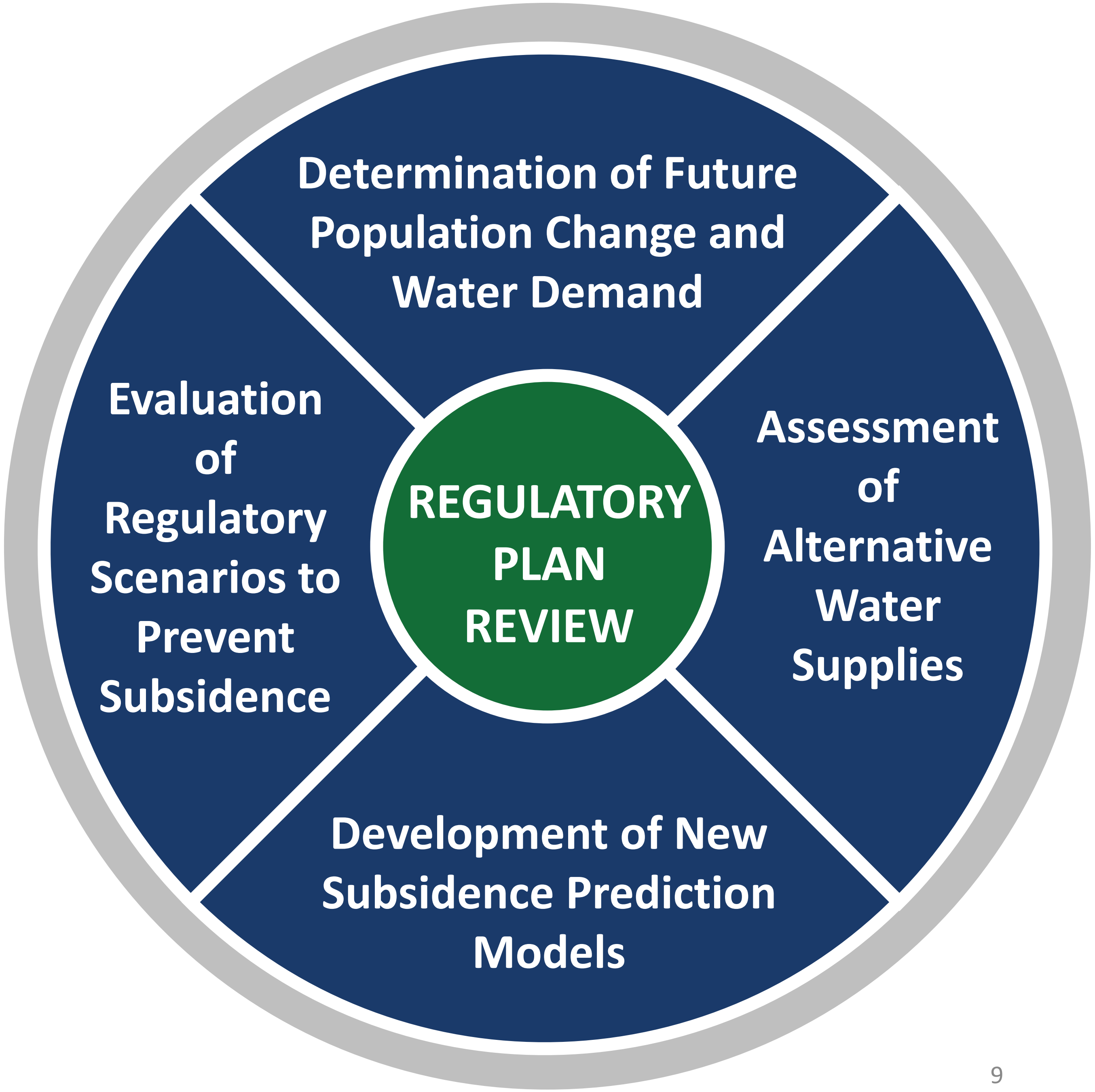
Meeting attendance and project awareness

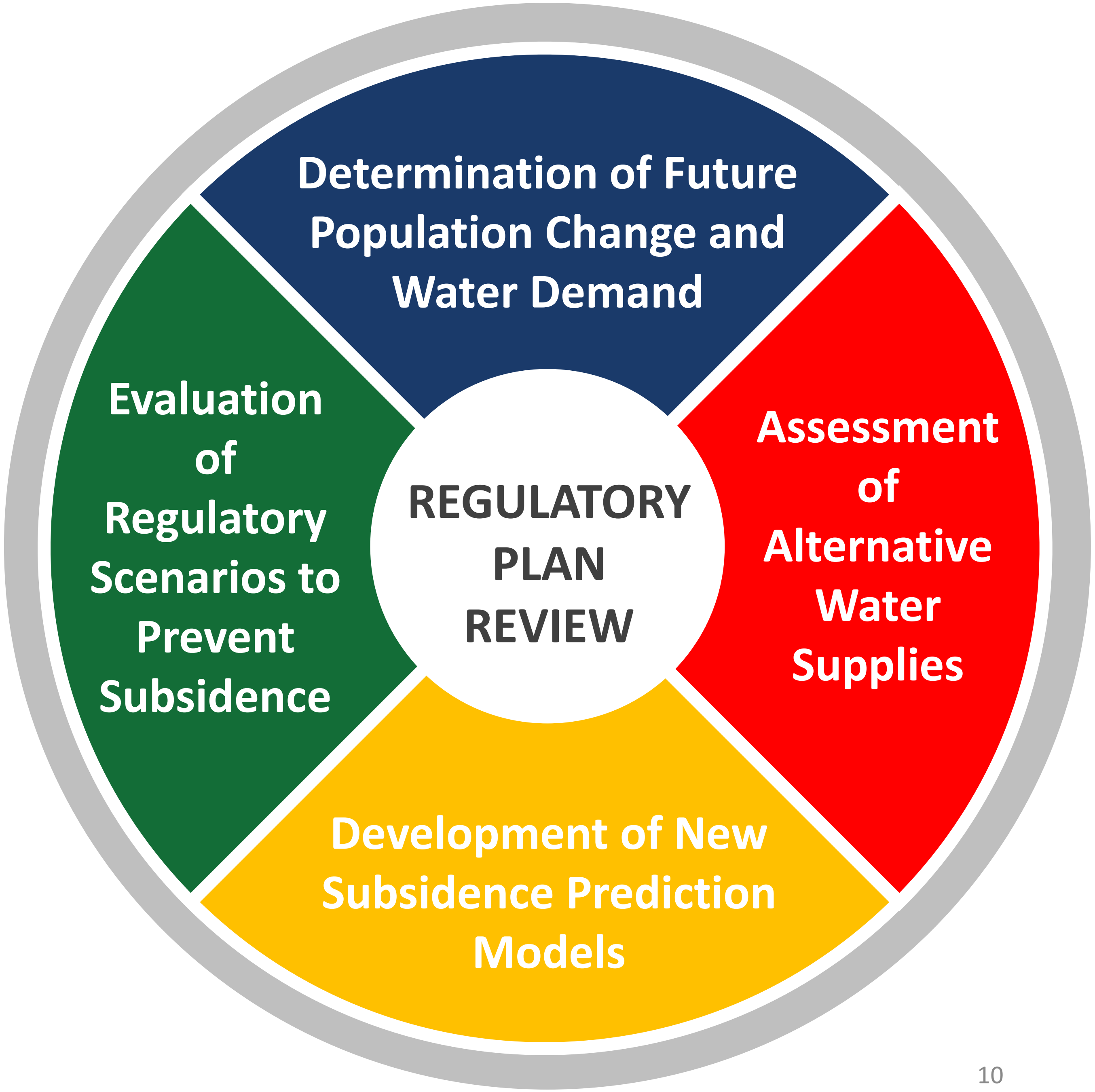
Providing data for technical analyses

Providing feedback on draft material

Participate in targeted outreach efforts

Project Elements




Determination of Future Population Change and Water Demand
Assessment of Alternative Water Supplies
Development of New Subsidence Prediction Models
Evaluation of Regulatory Scenarios to Prevent Subsidence
REGULATORY PLAN REVIEW

Jason Afinowicz

- Freese and Nichols

Wade Oliver

- INTERA

Sunil Kommineni

- KIT

Cindy Ridgeway

- TWDB

John Ellis

- USGS

Linzy Foster

- USGS

Project Elements and Updates

PROJECT ELEMENTS

2013 Regulatory Plan Post Audit

Alternative Water Supply Availability

Projected Water Needs

Modeling

- Groundwater Availability Modeling
- Development of GULF 2023 Model
- PRESS Assessment

Water Use Scenario Development

2013 Regulatory Plan Post Audit

Background: Models are tools that help us understand cause and effect – primarily the relationship between groundwater pumping and subsidence

Evaluate process and data used to develop 2013 Regulatory Plan

Compare to observed water use and aquifer data

Identify lessons learned to apply and inform current round of planning

Evaluate Collected Data

- Pumping
- Water Levels
- Compaction
- Subsidence

2013 Regulatory Plan Post Audit

Where do model observations match and diverge from collected data?

Does modeling actual pumping reproduce observations?

How does actual pumping compare to forecast pumping?

What can we do differently to improve modeling and forecast use?

Lessons Learned

Project Elements

2013 Regulatory Plan Post Audit

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Projected Water Needs

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Water Use Scenario Development

Alternative Water Supply Availability

- Focus of evaluation is to compile and characterize alternative water supplies and their availability for use by systems in the regulatory areas
- Assessment will include supplies originating both within (i.e., reclaimed water) and outside the regulatory areas (i.e., seawater, new reservoirs)

Alternative Water Supply Availability

Identified 18 Options

Surface Water Development
- New Reservoirs
- Off Channel Reservoirs
- Inter-Basin Transfers
- Appropriated but Undeveloped Water

Water Demand Management
- Basic Conservation
- Advanced Conservation
- Water Loss Control w/ Advanced Metering Infrastructure
- Industry-Driven Innovative Strategies

Brackish Groundwater Desalination
- Brackish Groundwater Wells and Desalination

Seawater Desalination
- Onshore Facility Desalination
- Offshore Facility Desalination

Reclaimed Water
- Indirect Potable Reuse
- Direct Potable Reuse
- Purple Pipe Network
- Scalping Plants / Onsite Reuse

Aquifer Storage and Recovery
- ASR w/ Surface Water
- ASR w/ Stormwater
- Inter-Basin Transfers

Alternative Water Supply Availability

Shortlisted Seven Options through Consistent Methodology

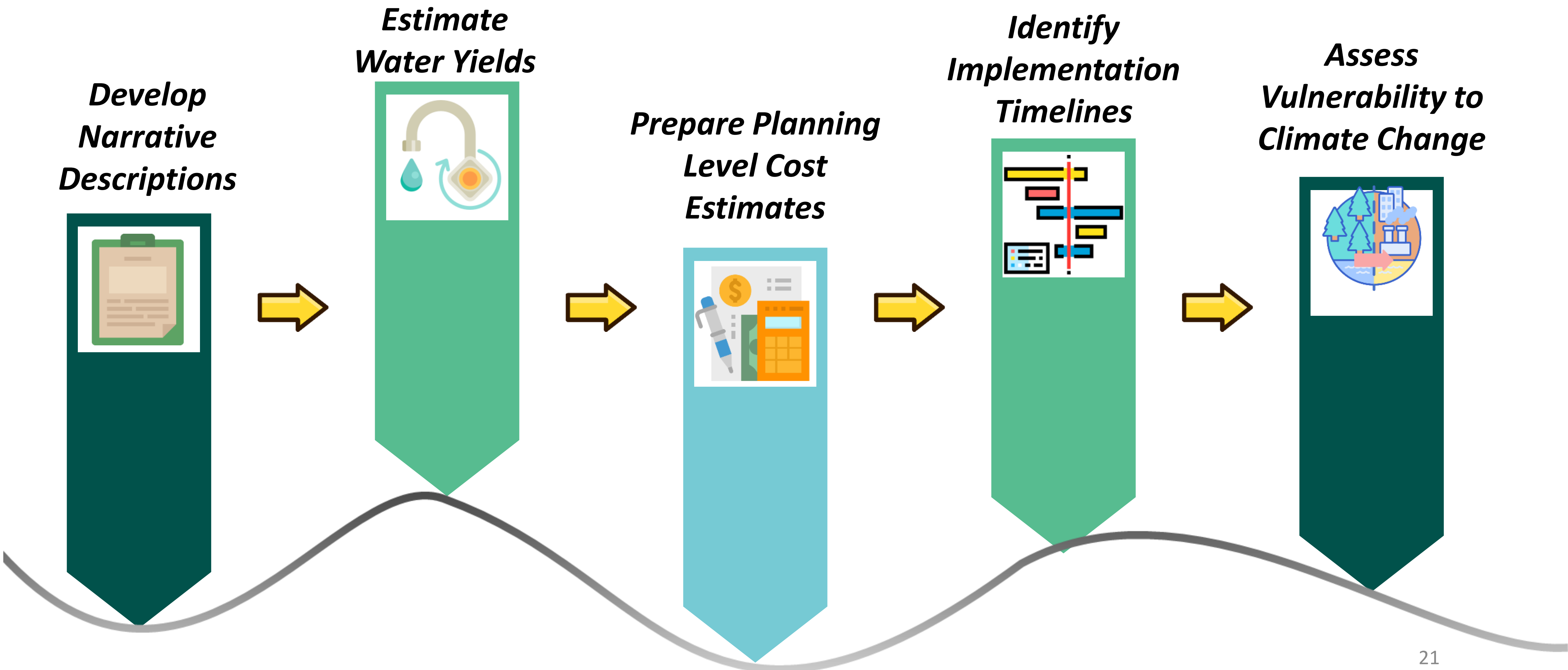
- **Review Regional Water Plans, Prior Studies, Available Literature and Data**
- **Assess Scalability, Efficacy and Implementability**
- **Discussions with HGSD and FBSD**

Alternative Water Supply Availability

Shortlisted Options

ALTERNATIVE WATER SUPPLY AVAILABILITY

Characterization of Shortlisted Options



Project Elements

2013 Regulatory Plan Post Audit

Alternative Water Supply Availability

Projected Water Needs

Modeling

- Groundwater Availability Modeling
- Development of GULF 2023 Model
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Water Use Scenario Development

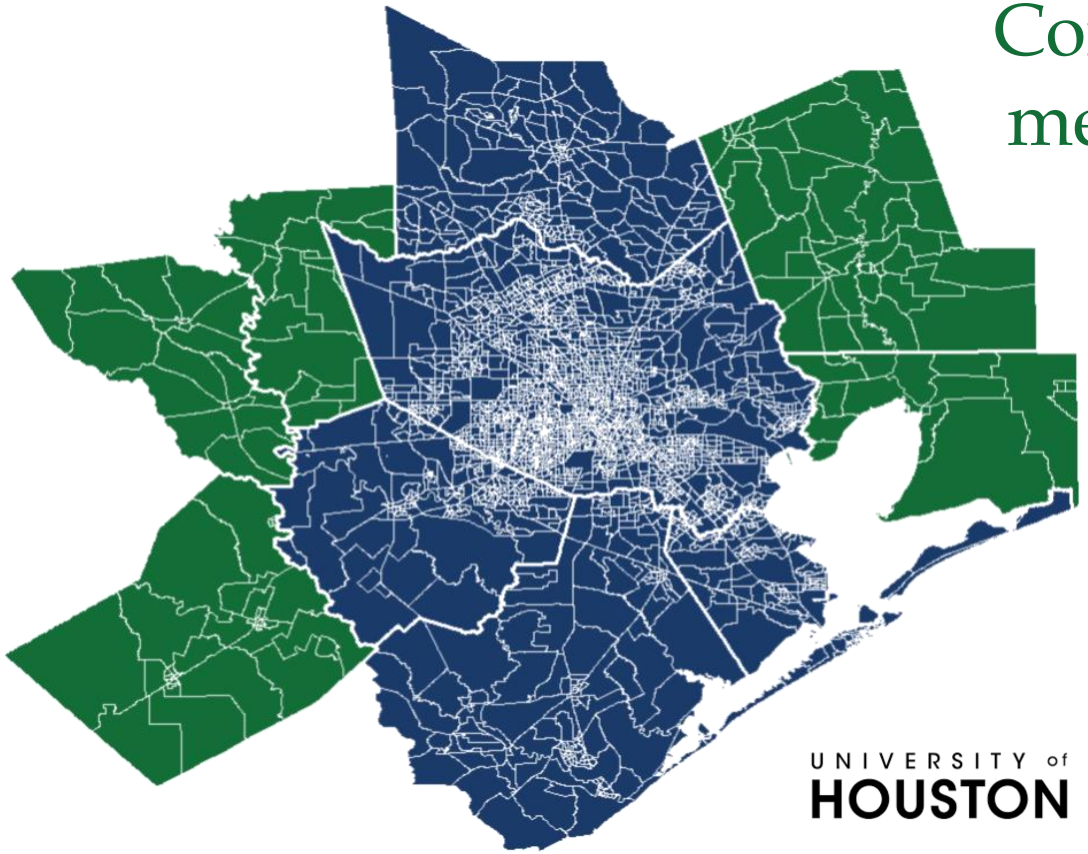
Projected Water Needs

Enhancements to 2013 Regulatory Plan Update methodology

- Ten counties
- Evaluate single- and multi-family growth
- Refine industrial projections
- Water use data from stakeholders
- Various demand futures
- Projections to 2100

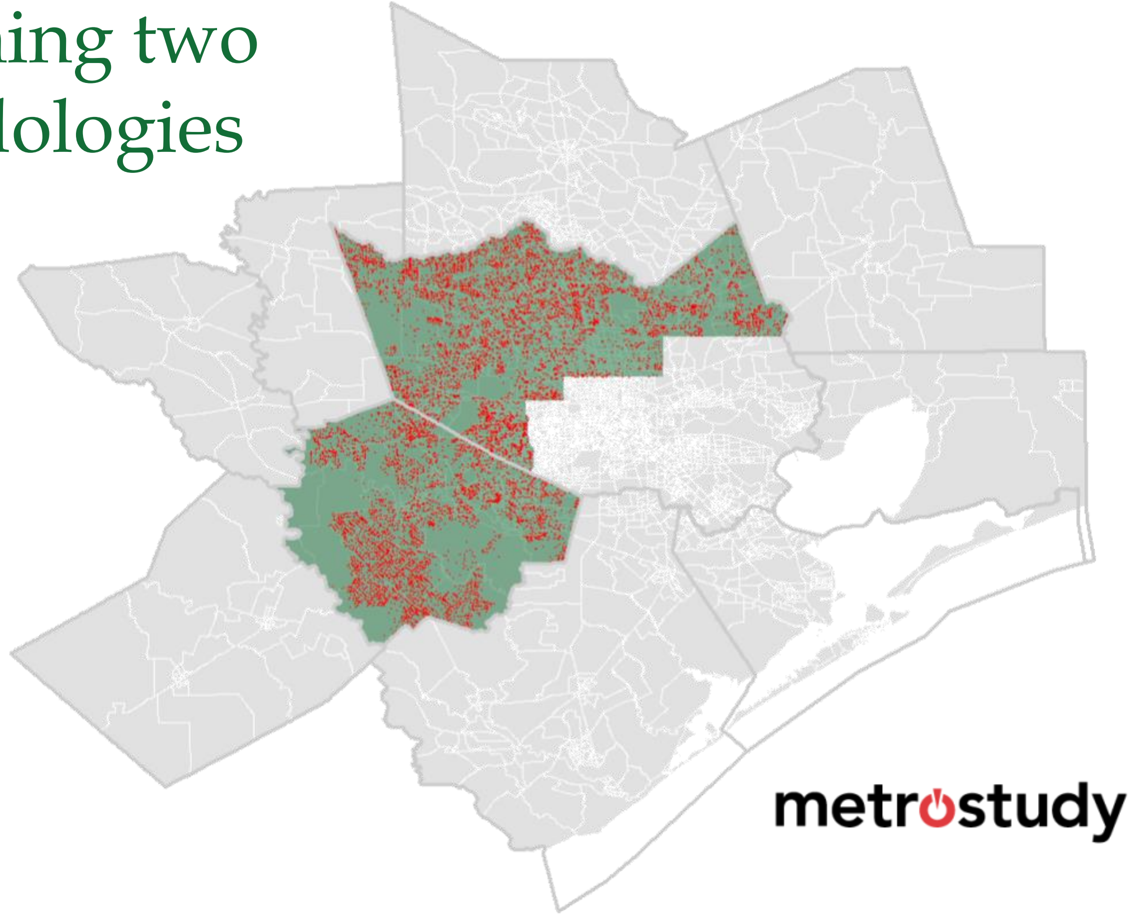
PROJECTED WATER NEEDS

Combining two methodologies



Small Area Model Houston (SAM-Houston)

Long-range, wide-area projections



Projected Development Methodology

Short-range, detailed projections

Project Elements

2013 Regulatory Plan Post Audit

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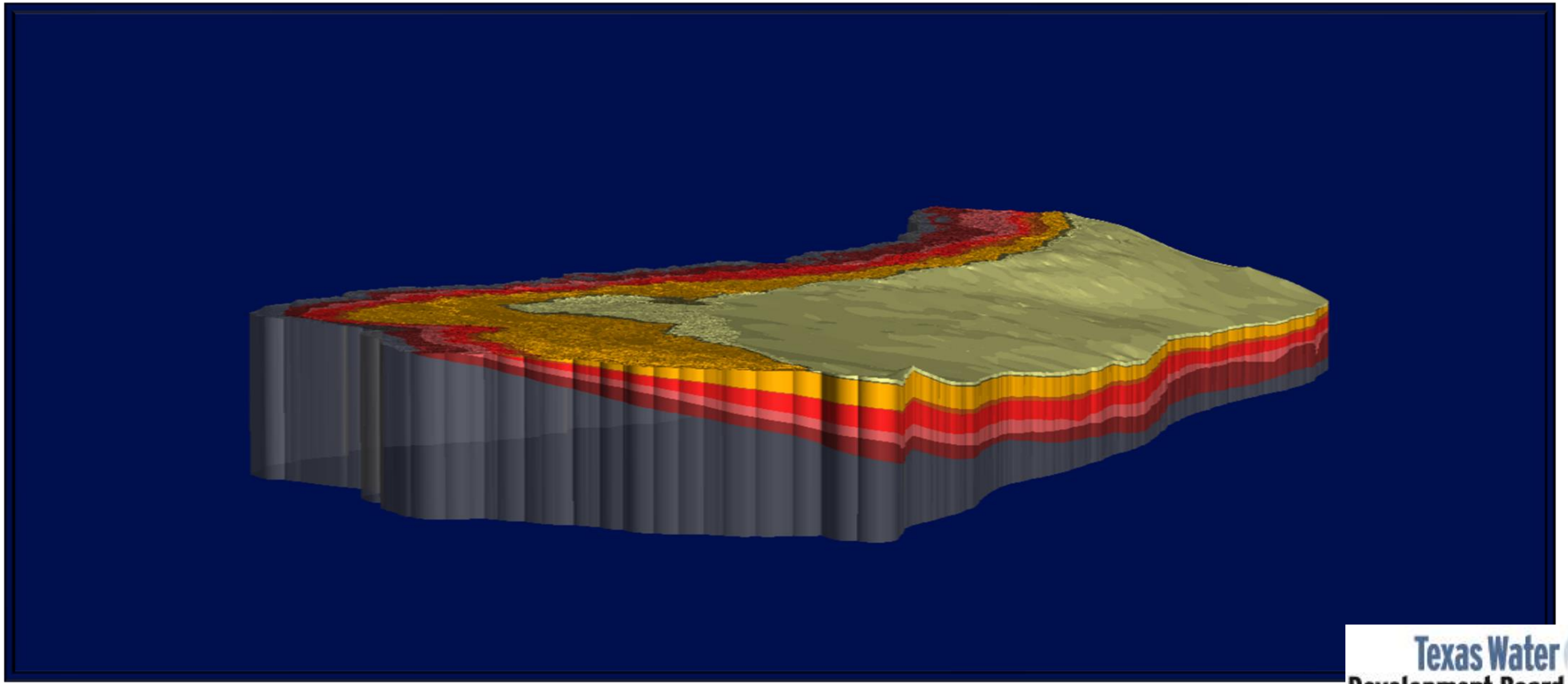
Water Use Scenario Development

Groundwater Availability Modeling



Texas Water Development Board

Groundwater Availability Modeling

In Statute: Develop groundwater flow models for the major and minor aquifers of Texas.

Purpose: Tools that can be used to aid in groundwater resources management by stakeholders.

Public process: Stakeholder involvement during model development process.

Models: Freely available, standardized, thoroughly documented. Reports available over the internet.

Living tools: Periodically updated.

Texas Water Development Board

PURPOSE OF STAKEHOLDER MEETINGS

Opportunity for input and data to help with model development

Updates on model progress

Providing feedback on draft material

Learn how to best use model & model limitations

Groundwater Availability Modeling

Cindy Ridgeway, P.G.

Manager of Groundwater Availability Modeling Section

512-936-2386

Cindy.ridgeway@twdb.texas.gov

Texas Water Development Board

P.O. Box 13231

Austin, Texas 78711-3231

Web information:

www.twdb.texas.gov/groundwater/models/gam/

USGS
science for a changing world

HARRIS-GALVESTON SUBSIDENCE DISTRICT

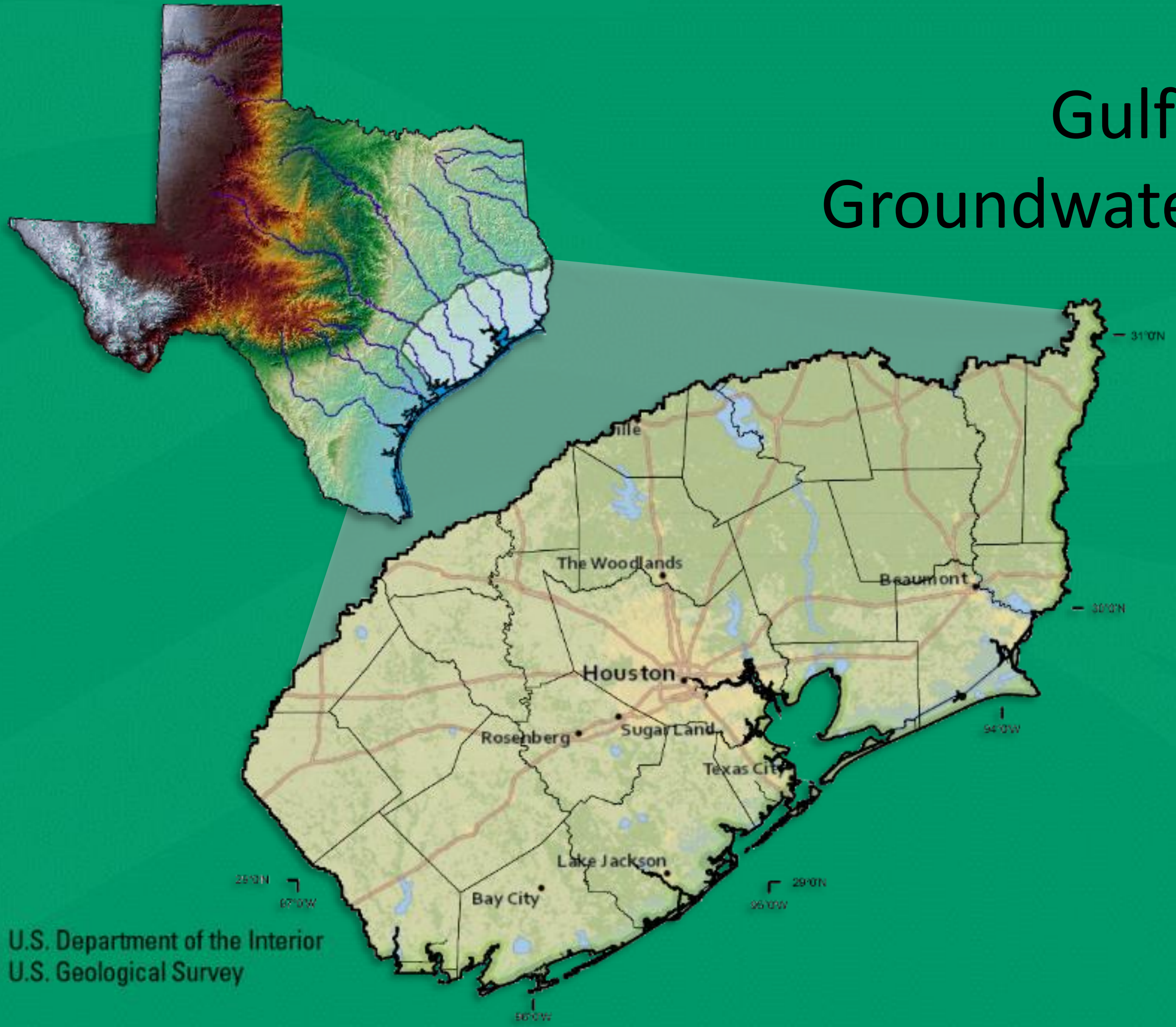
FORT BEND SUBSIDENCE DISTRICT

Gulf Coast Land Subsidence and Groundwater-Flow Model (GULF 2023):

Stakeholder meeting

John H. Ellis | jellis@usgs.gov
USGS Oklahoma–Texas Water Science Center
Gulf Coast Branch

Linzy Foster | lfoster@usgs.gov
USGS Oklahoma–Texas Water Science Center
Central Texas Branch



In cooperation with the Harris-Galveston and Fort Bend Subsidence Districts

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

1 Overview

- This project is in cooperation with the Harris-Galveston and Fort Bend Subsidence Districts (collectively “subsidence districts”)
- This project was developed to update the Houston-Area Groundwater Model (HAGM) due to: 1) the length of time since publication of the HAGM (15 years), 2) advances in modeling technology, and 3) availability of new hydrogeologic data.
- This model (GULF 2023) is a refinement of the larger Costal Lowlands (CLAS) model that includes the U.S. Gulf Coast from Texas to the Florida panhandle.
- The GULF model will be used by a subsidence district consultant (Intera Geosciences) to develop and simulate predictive water-use and water planning scenarios.

1 Overview

Project Objectives:

- Construction and calibration of a refined groundwater model for the northern Texas Gulf Coast that can be used as a decision-support tool to assess groundwater availability and subsidence
- The model will be provided to support groundwater management decisions at a regional to sub-regional scale
- Development and simulation of predictive climate scenarios
- Provide technical and quality-assurance assistance to the subsidence districts regarding modification of the model

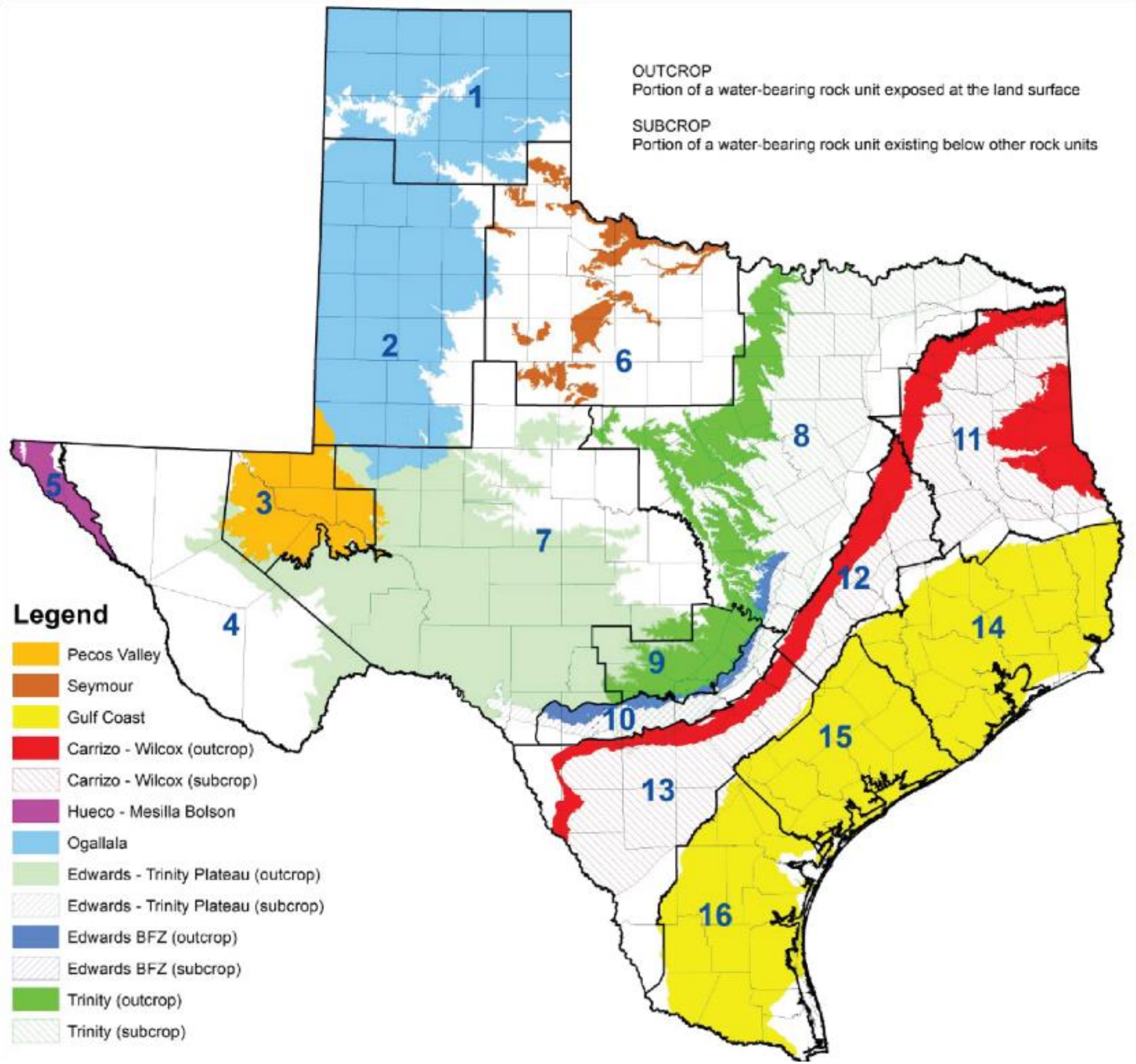
Approach:

- **Phase I:** Construction and calibration of the model, generate and run climate scenarios, model publication and archiving
- **Phase II:** Predictive water-use and water-planning scenarios to be run by Intera Geosciences

Groundwater-flow definitions

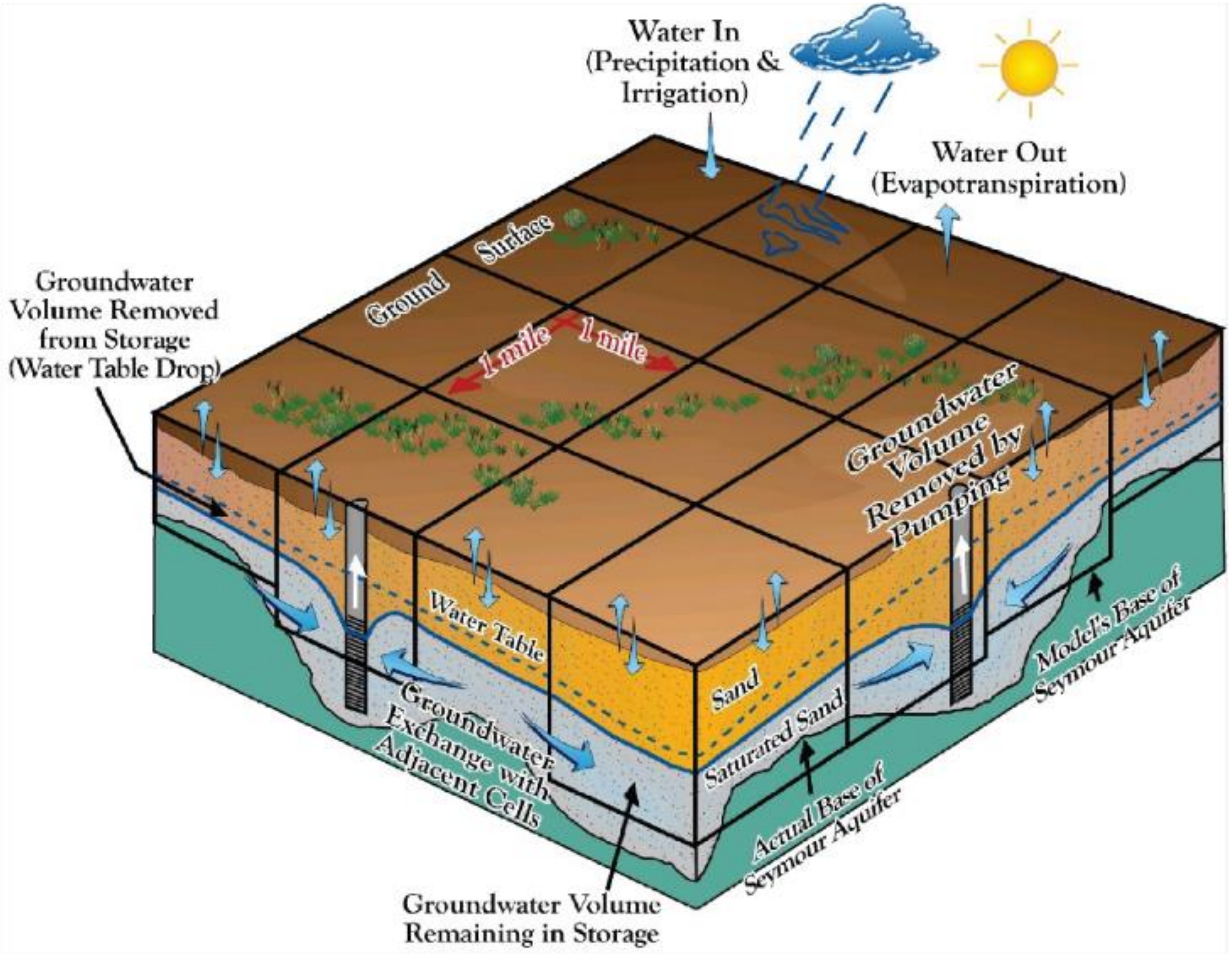
- Aquifer: Water saturated permeable geologic unit that can transmit significant quantities of water
- Water table: The level at which water stands in a shallow screened well in an unconfined aquifer
- Recharge: The entry of water to the saturated zone at the water table
- The primary observable quantity describing groundwater flow is the water level as measured in a well

1 Major aquifers



Texas Water Development Board

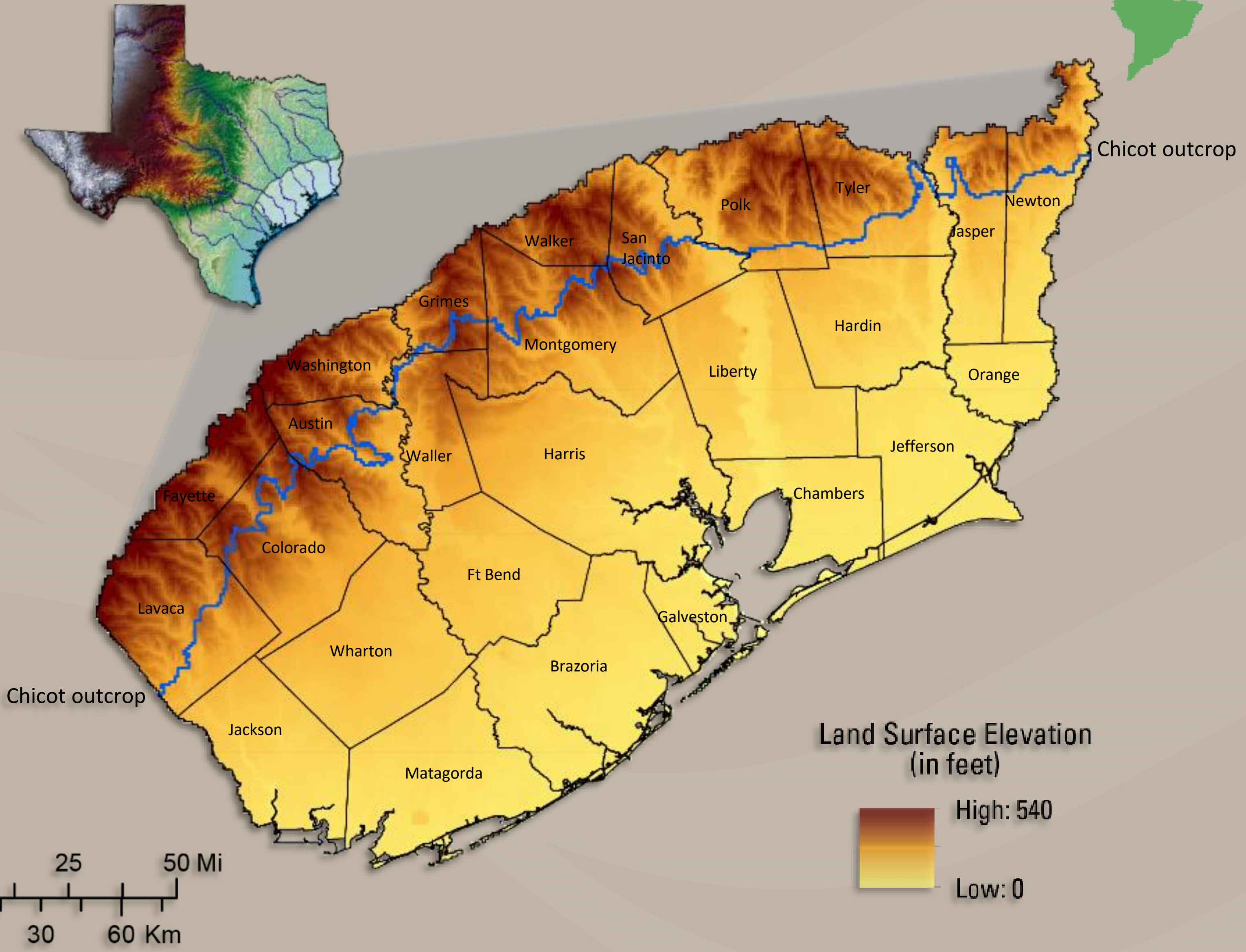
Numerical Groundwater Model: Model Cells and their interactions



2 Study area

Physical setting

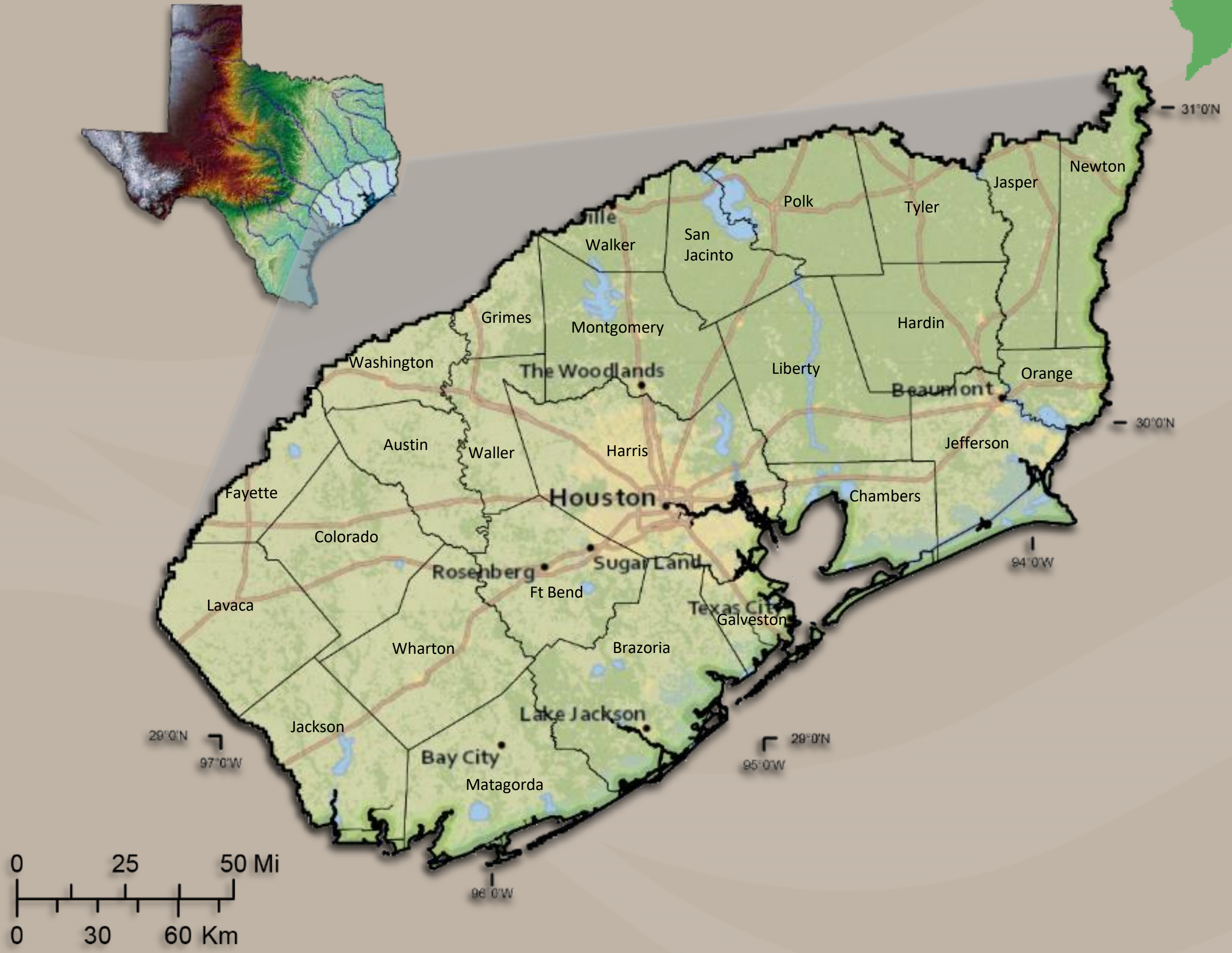
- Approximately 20,900 mi^2 of sand, silt, and clay across 26 counties
- Fluvial deltaic environment with river alluvium dissecting the Chicot aquifer
- About 540 feet of surface relief based on a 10m digital elevation map
- Land surface has substantial variation updip of the Chicot aquifer outcrop



3 Model Properties

Spatial extent

- Northern boundary corresponds with the upgradient extent of the Jasper outcrop
- Eastern extent is the TX—LA border (Sabine River)
- Western extent is Lavaca and Jackson Counties
- Southern boundary is nearshore area
- Barrier islands removed in model (shown here)



3 Model Properties

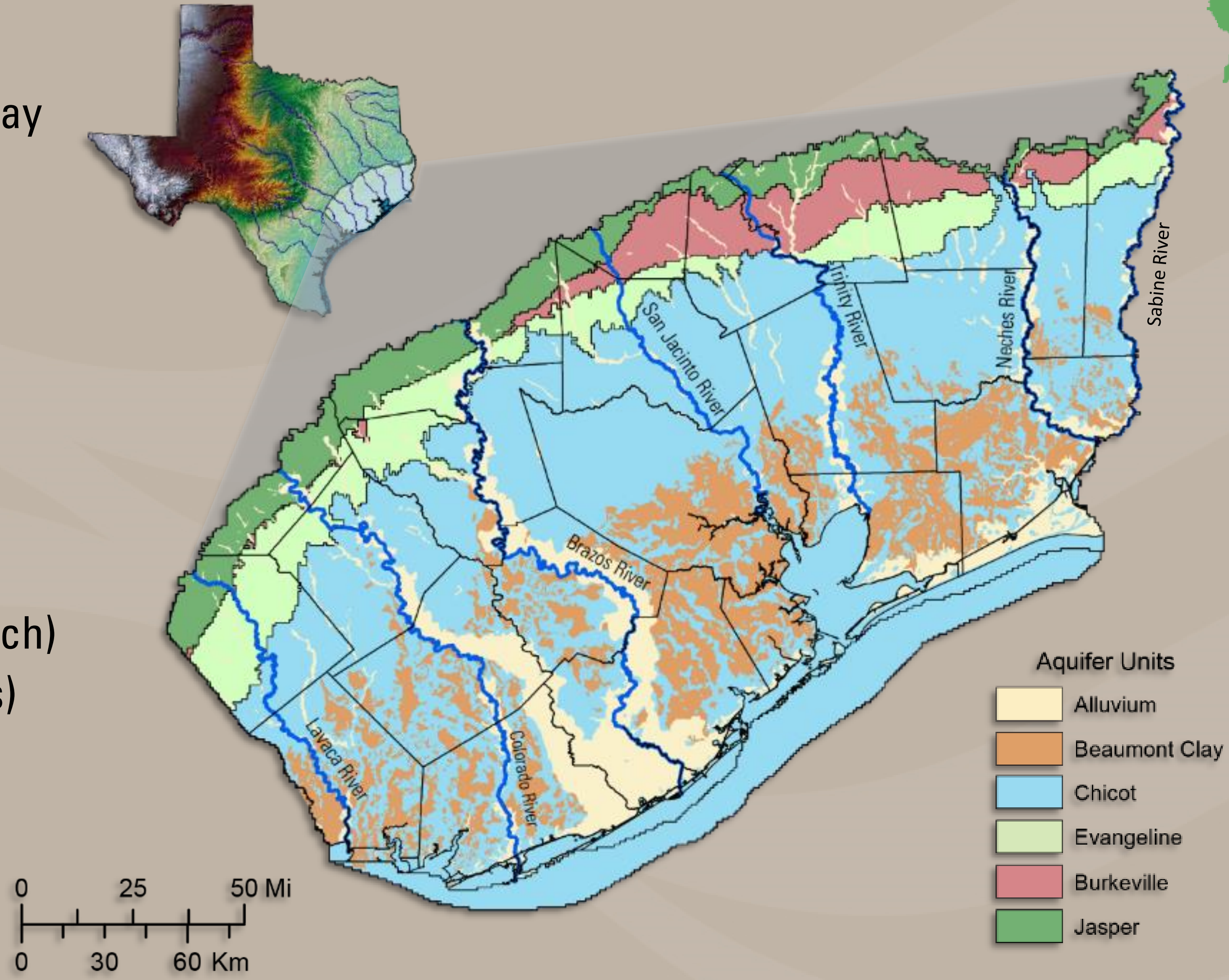
Model Layering

- Layer 1: Alluvium and Beaumont Clay
- Layer 2: Chicot Aquifer
- Layer 3: Evangeline Aquifer
- Layer 4: Burkeville Confining Unit
- Layer 5: Jasper Aquifer

Time Discretization

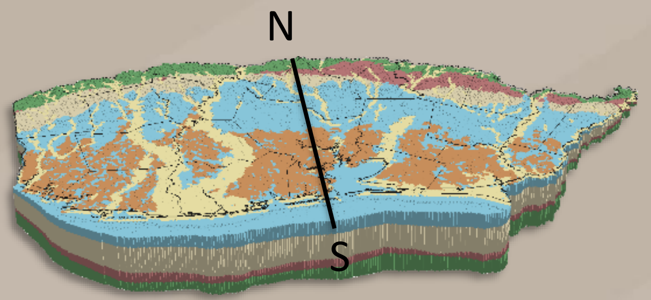
- 1896: 1 (Predevelopment)
- 1897–1939: 3 (about 14 years each)
- 1940–1969: 6 (5 year increments)
- 1970–1999: 30 (annual)
- 2000–2018: 228 (monthly)

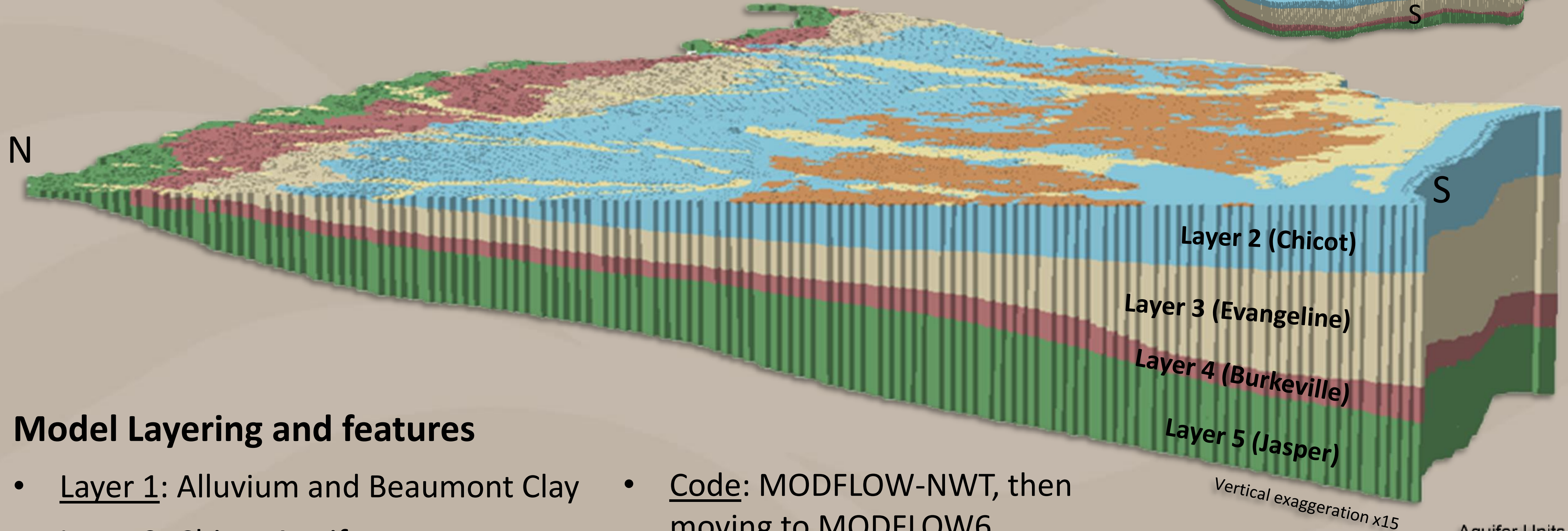
268 Total



3 Model Properties

North-South cross-section in Houston area





Model Layering and features

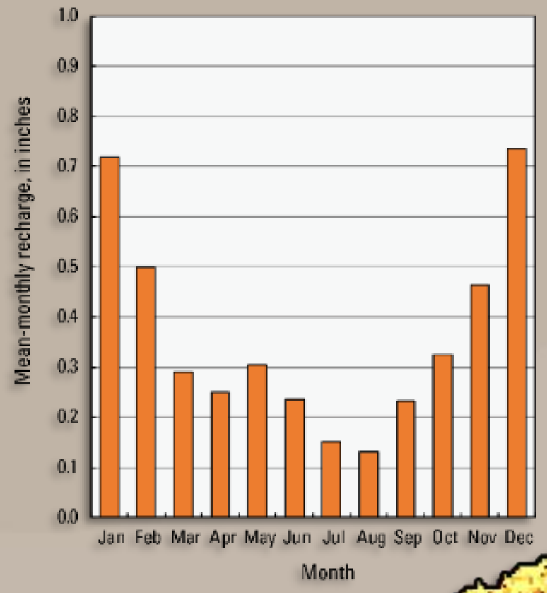
- Layer 1: Alluvium and Beaumont Clay
- Layer 2: Chicot Aquifer
- Layer 3: Evangeline Aquifer
- Layer 4: Burkeville Confining Unit
- Layer 5: Jasper Aquifer

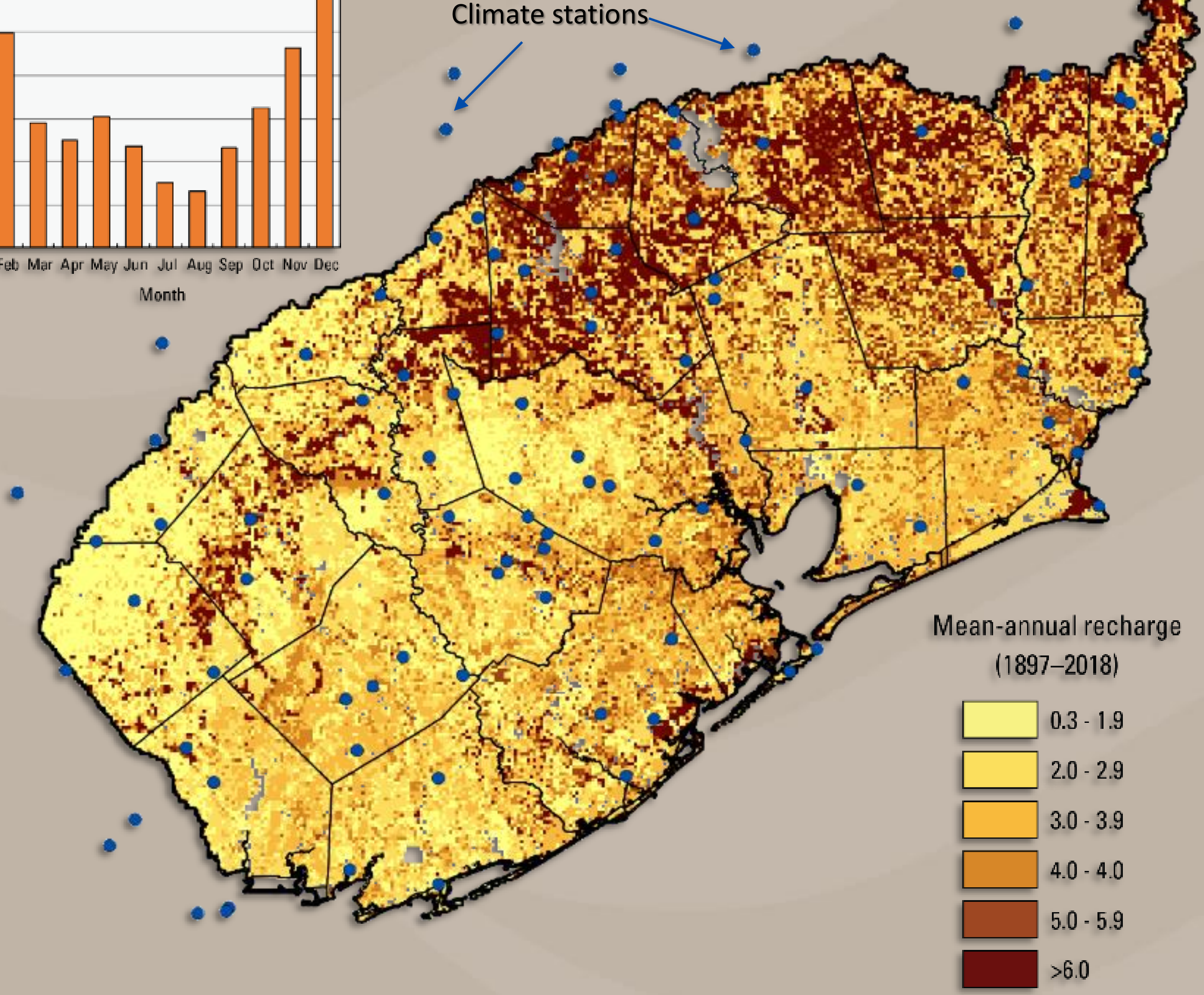
- Code: MODFLOW-NWT, then moving to MODFLOW6
- Subsidence: SUB package, then moving to CSUB
- Streams: River and Drain packages
- Lateral flow: General head boundary

4 Model Features

Recharge

- Groundwater recharge here is defined as water that infiltrates from land surface to the top of the water table
- Can use many different methods to estimate. This project used the Soil-Water-Balance code.
- SWB-derived recharge occurs primarily in outcrop area (dark brown colors on map)
- Majority of the estimated recharge is discharged to streams
- Vertical movement of water in the model is adjusted to limit downward recharge movement

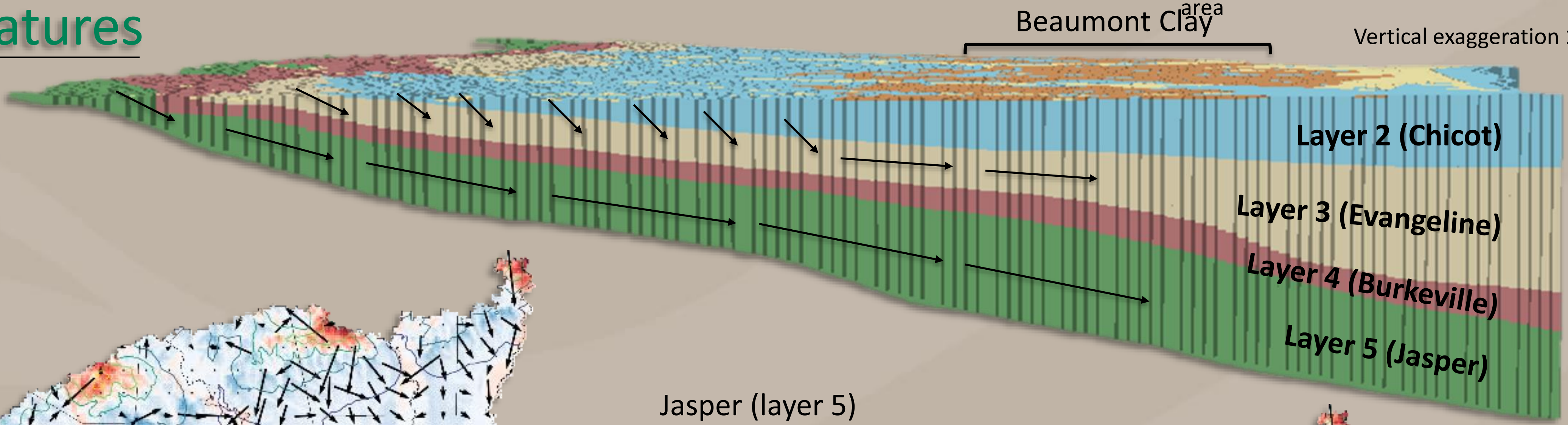




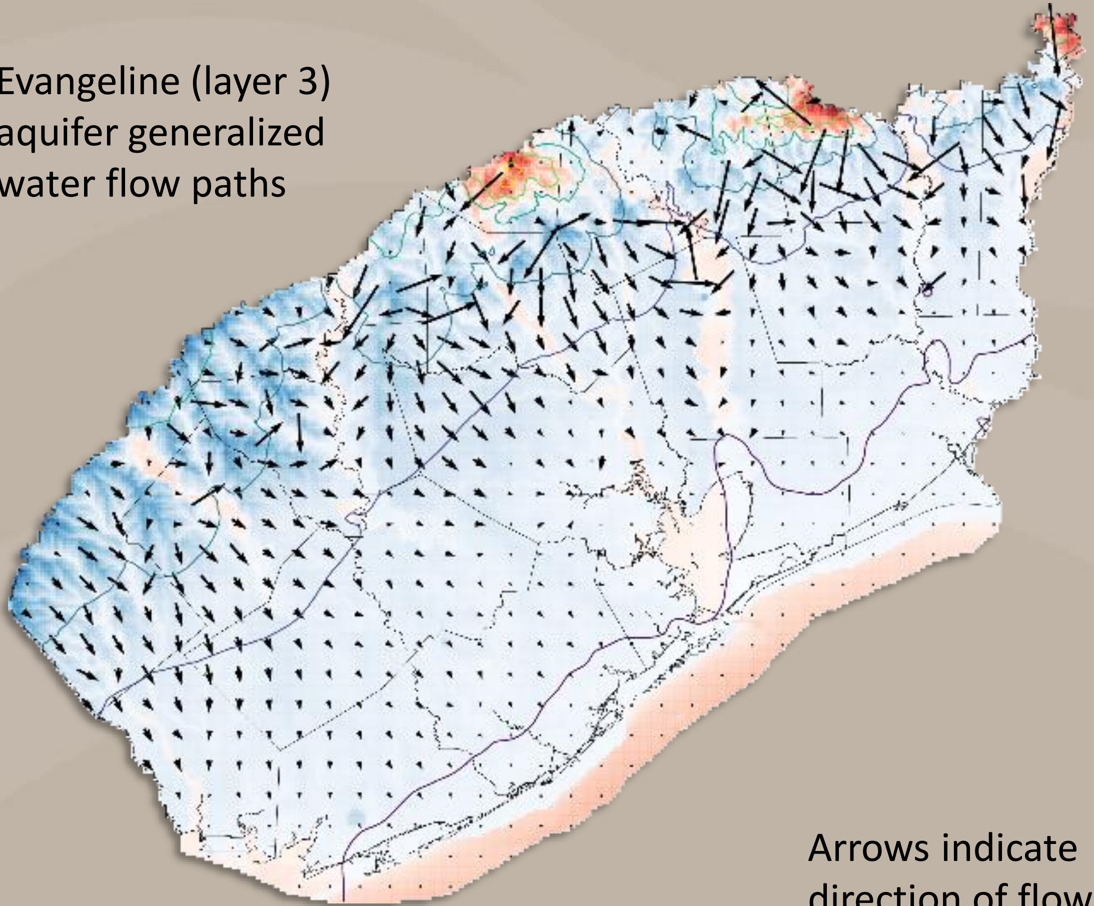
4 Model Features

North-South cross-section along Houston area

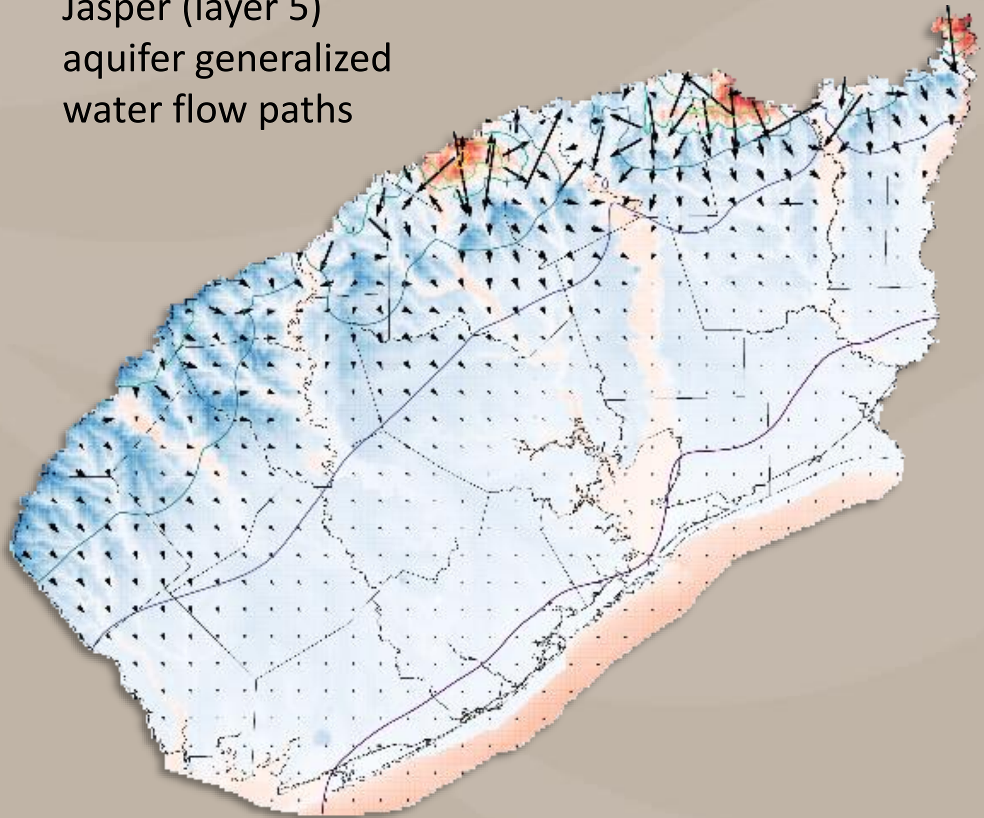
Vertical exaggeration 15x



Evangeline (layer 3) aquifer generalized water flow paths



Jasper (layer 5) aquifer generalized water flow paths

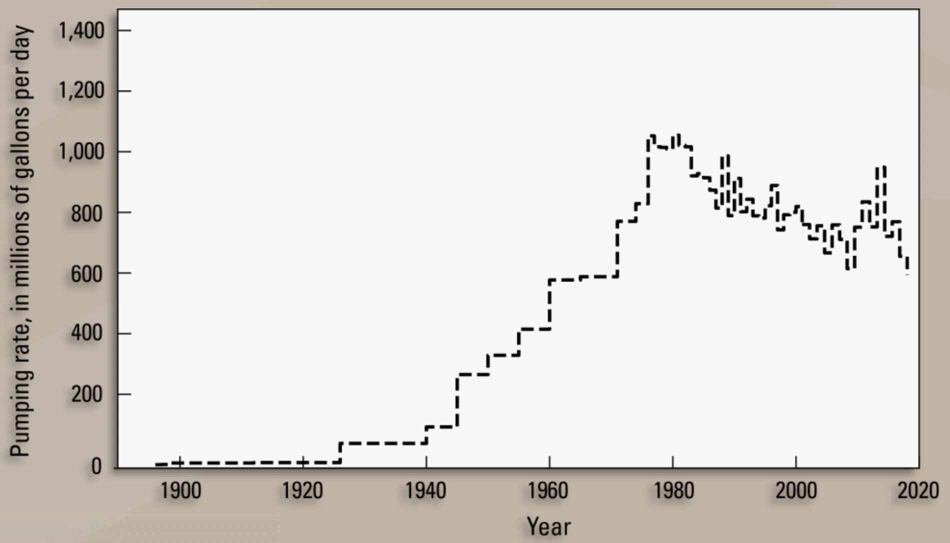


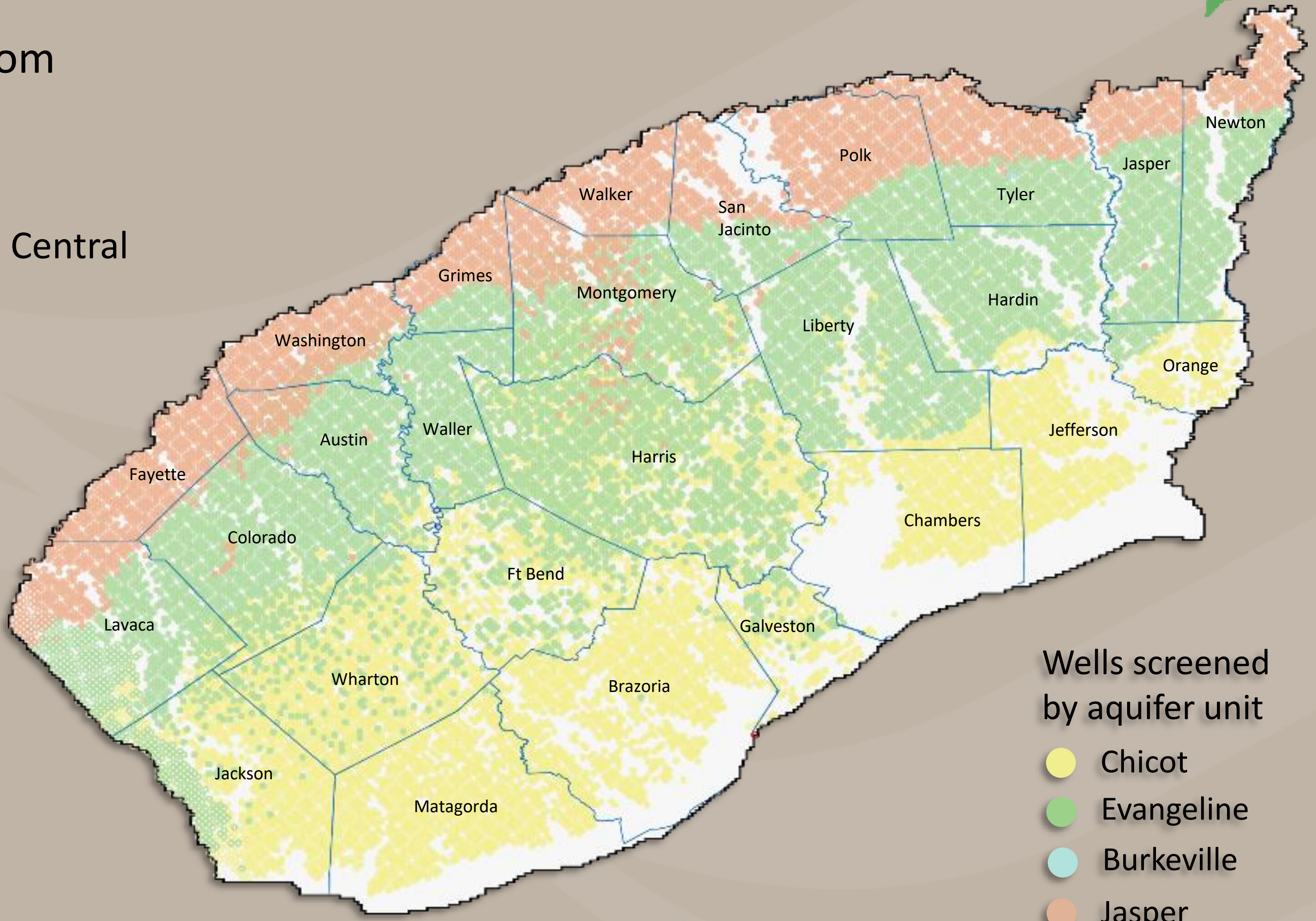
Arrows indicate direction of flow

Model features

Groundwater use

- The GULF model uses water-use data from multiple sources:
  - 1897–1999: HAGM[1], Central GAM[2]
  - 2000–2018: TWDB water-use database, Central GAM[2]





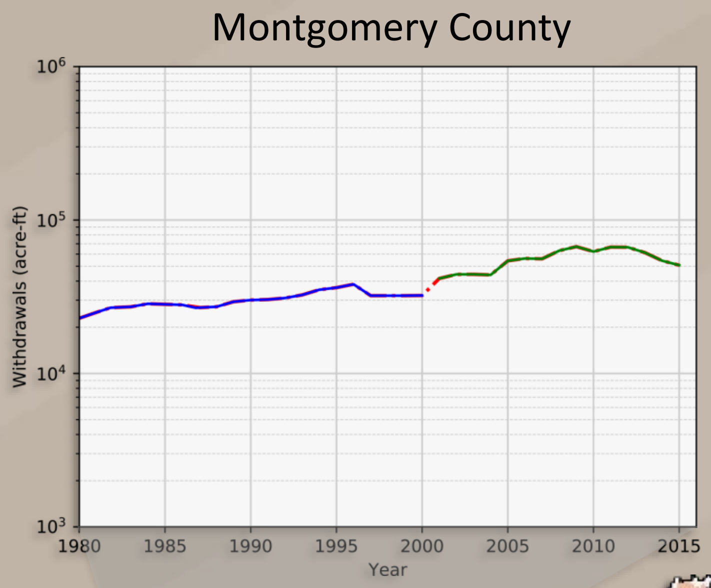
[1]Kasmarek (2012)
[2]Chowdhury and others (2004)

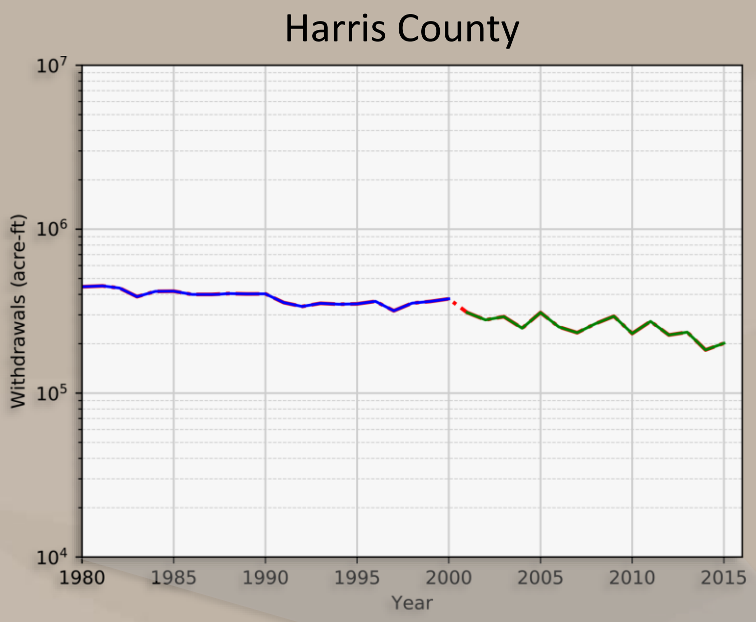
4 Model Features

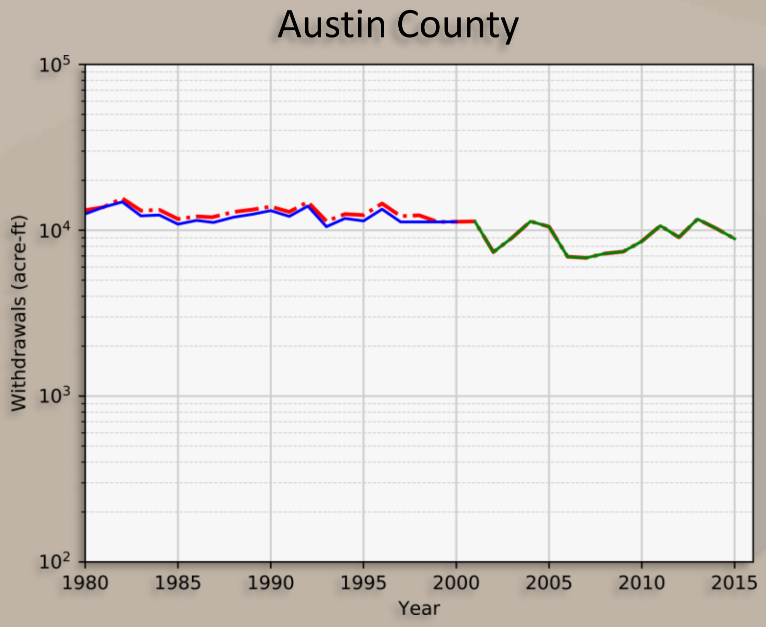
Groundwater use

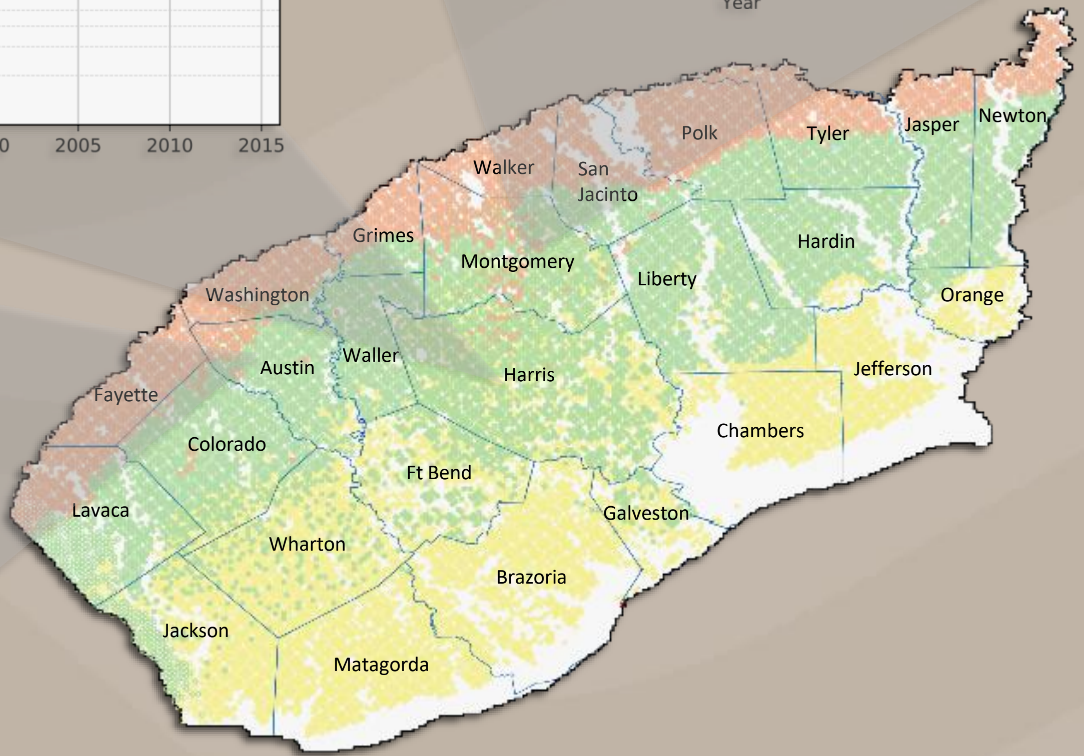
Groundwater data:

- 1897–1999: HAGM[1], Central GAM[2]
- 2000–2018: TWDB water-use database, Central GAM[2]
- TWDB water-use sources include:
  - Submitted Drillers Reports
  - Groundwater Database
  - Historical Groundwater Pumpage Estimates









Data source

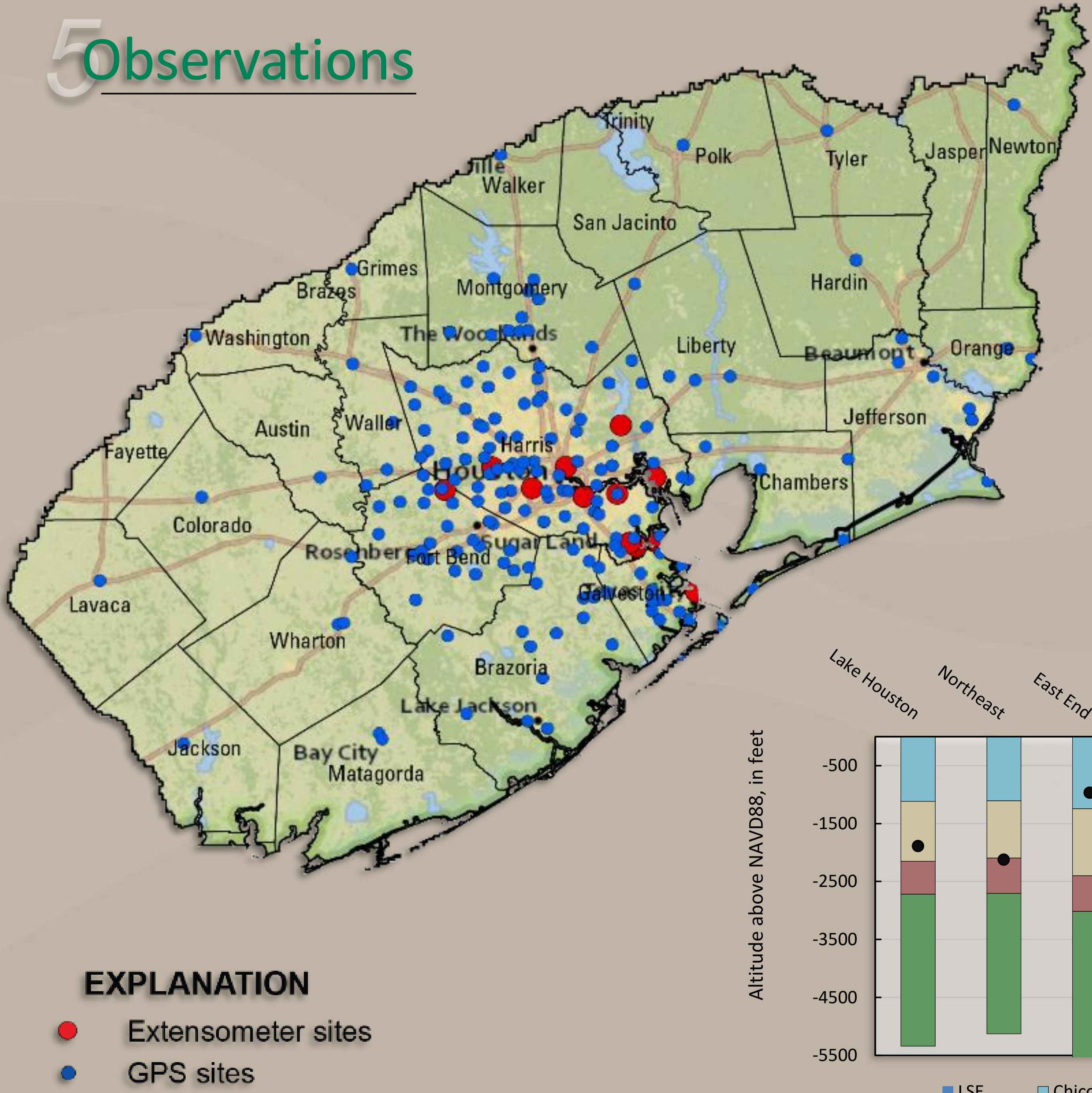
- Model sum
- HAGM
- TWDB

4 Model features

Subsidence Package

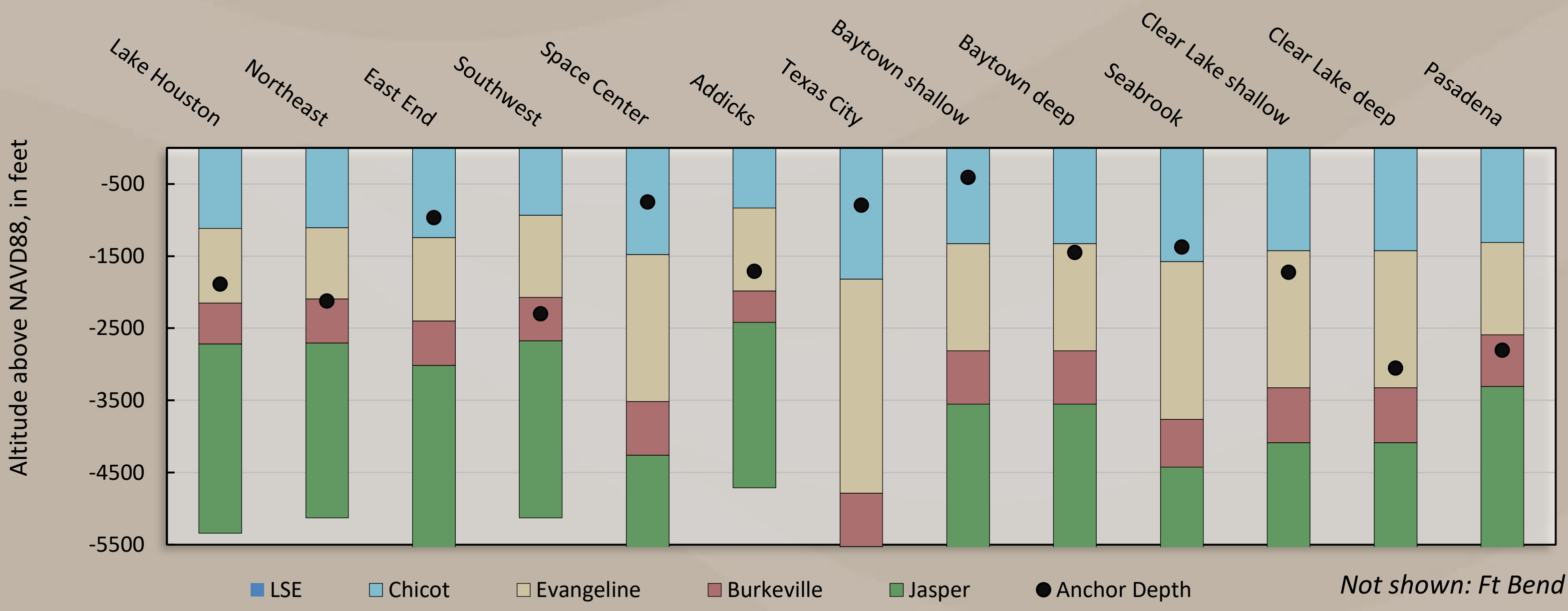
- Newly formulated for the MODFLOW6 model code
- Can simulate groundwater-storage changes and compaction
  - Can simulate elastic compaction in coarse-grained sediment
  - Can simulate elastic and inelastic compaction in discontinuous, fine-grained interbeds or confining units
- Outputs simulated compaction separately for each model layer
- Using delay bed functionality for all subsidence in the GULF model
  - Allows the amount of delay to be driven by the clay thicknesses versus a pre-determined value

5 Observations



Subsidence estimation methods

- Extensometers–measure compaction in the aquifer system
  - Fourteen extensometers at 12 sites
- GPS sites, leveling–measure total vertical displacement
  - GPS: 173 sites
  - Leveling data: 60-70 measurements, about half prior to 1960



Not shown: Ft Bend extensometer

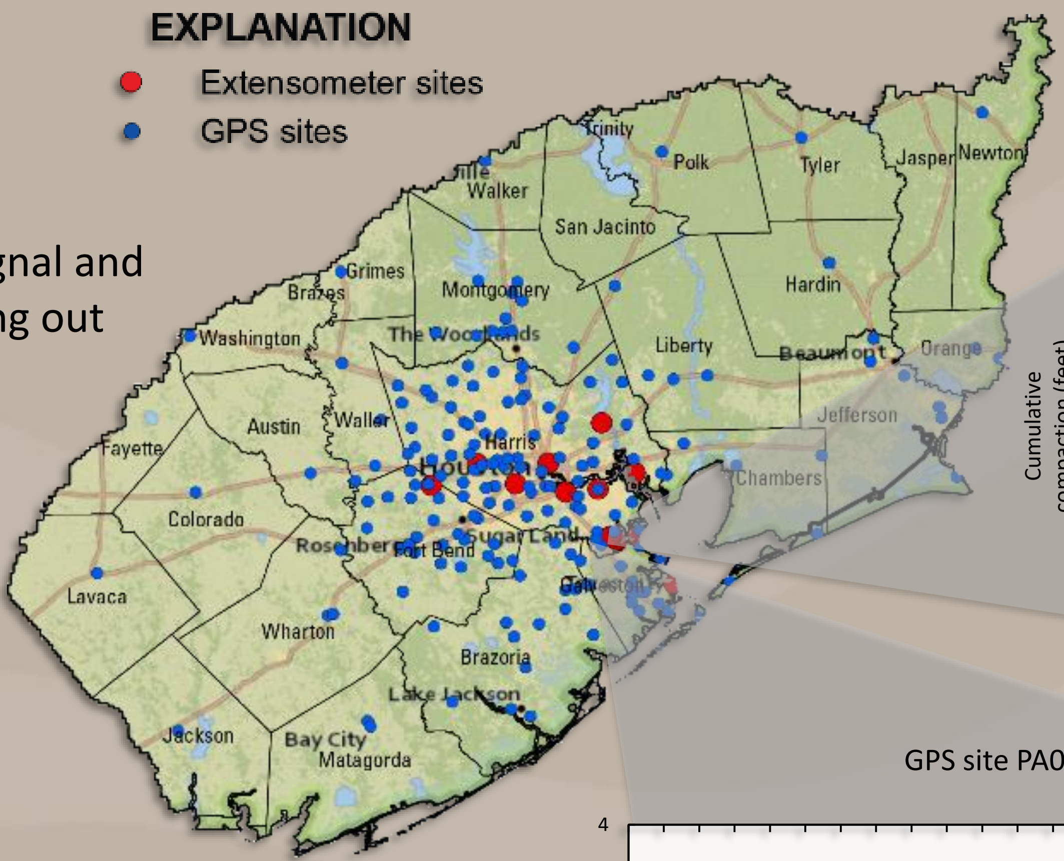
5 Observations

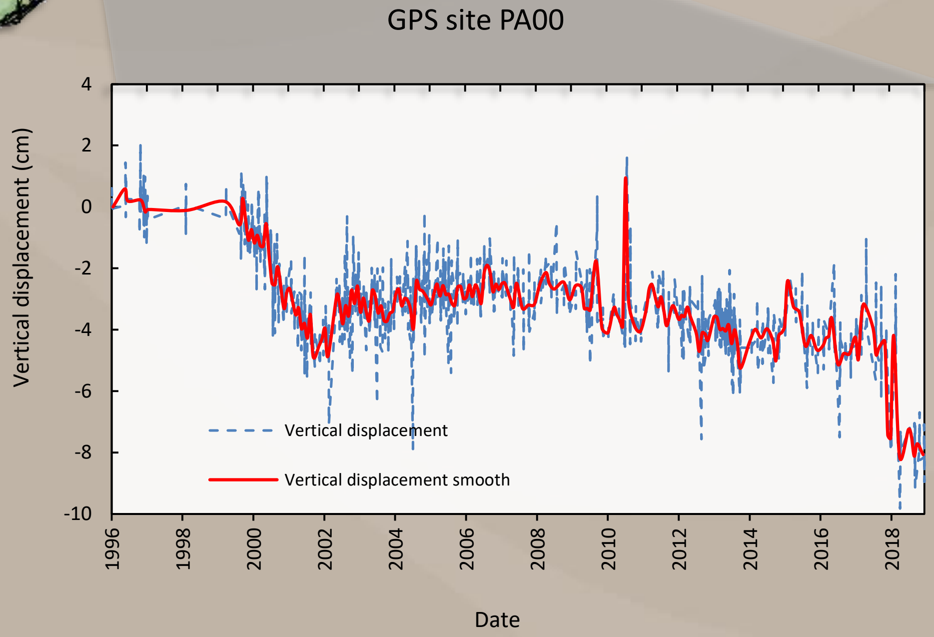
GPS sites

- Smooth applied: preserves signal and long-term trends while filtering out high-frequency noise
- Duplicate sites in same model cell removed
- Shorter period of record (1995 – present)

Extensometers

- Use end-of-month recorded compaction at 12 sites across the period of record
- Measure compaction in Chicot and/or Evangeline units
- Longer period of record (early 1970's – present)

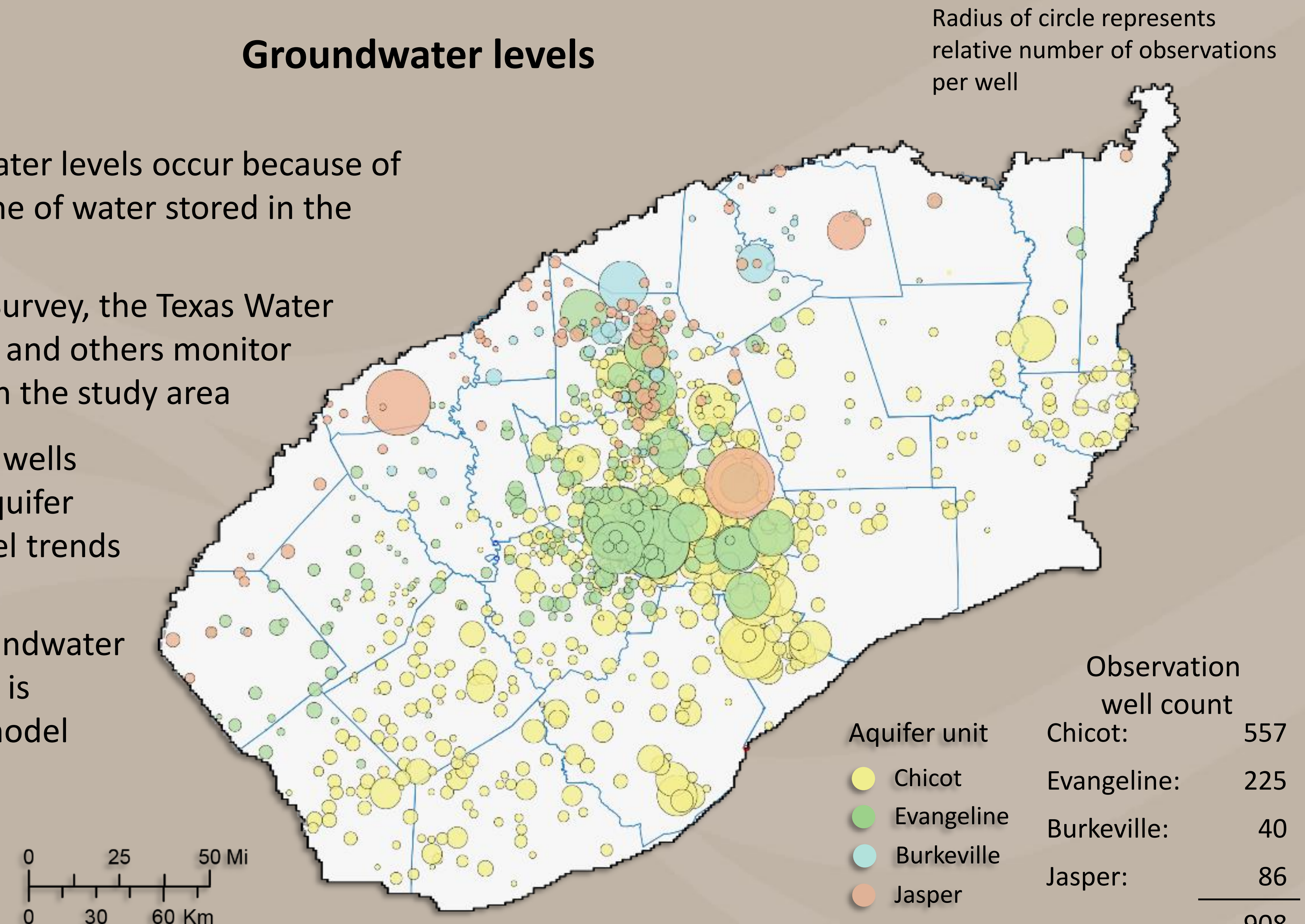




5 Observations

Groundwater levels

- Changes in groundwater levels occur because of changes in the volume of water stored in the aquifer
- The U.S. Geological Survey, the Texas Water Development Board, and others monitor groundwater levels in the study area
- The model includes wells representative of aquifer units and water-level trends through time
- A match to the groundwater levels in these wells is attempted during model calibration

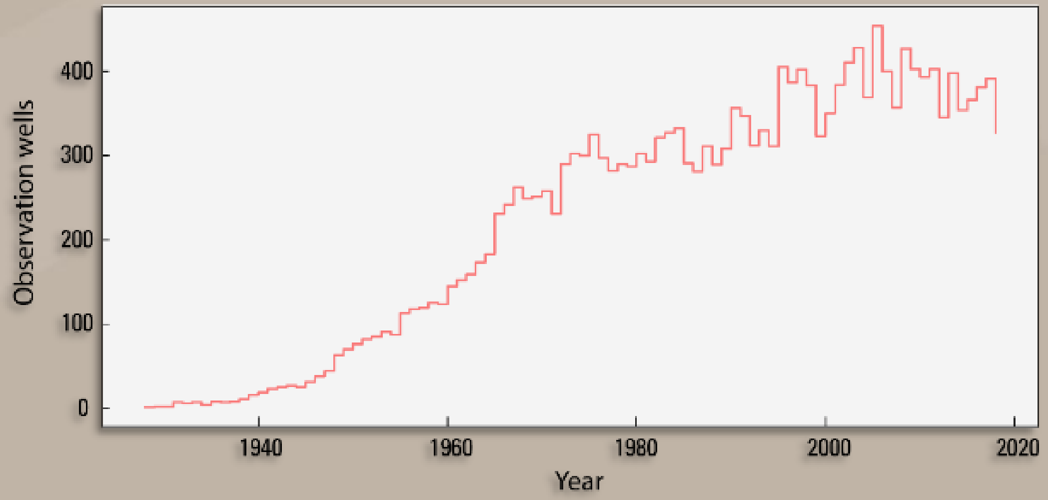


Observation well count

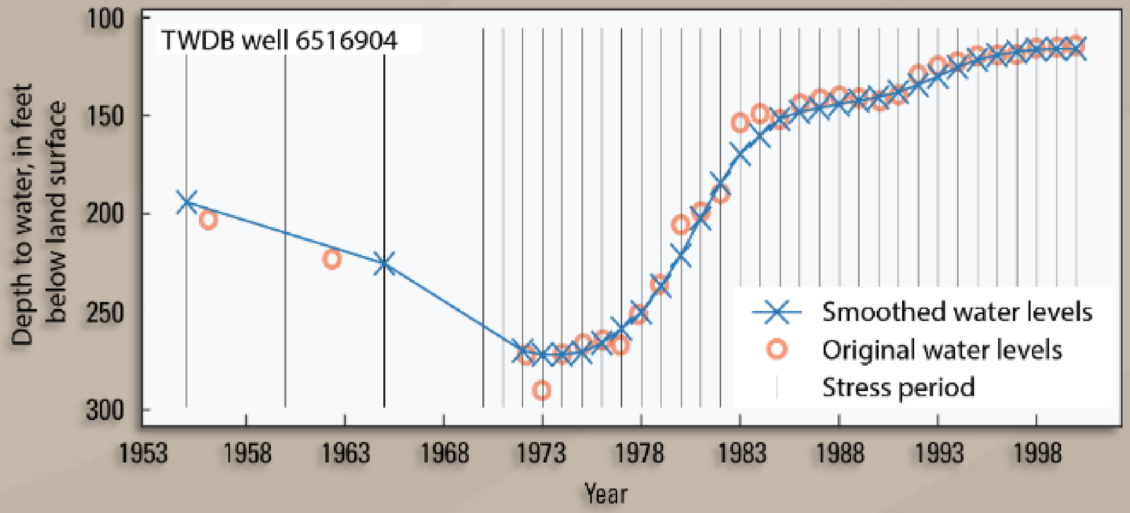
Chicot:	557
Evangeline:	225
Burkeville:	40
Jasper:	86
	908

5 Observations

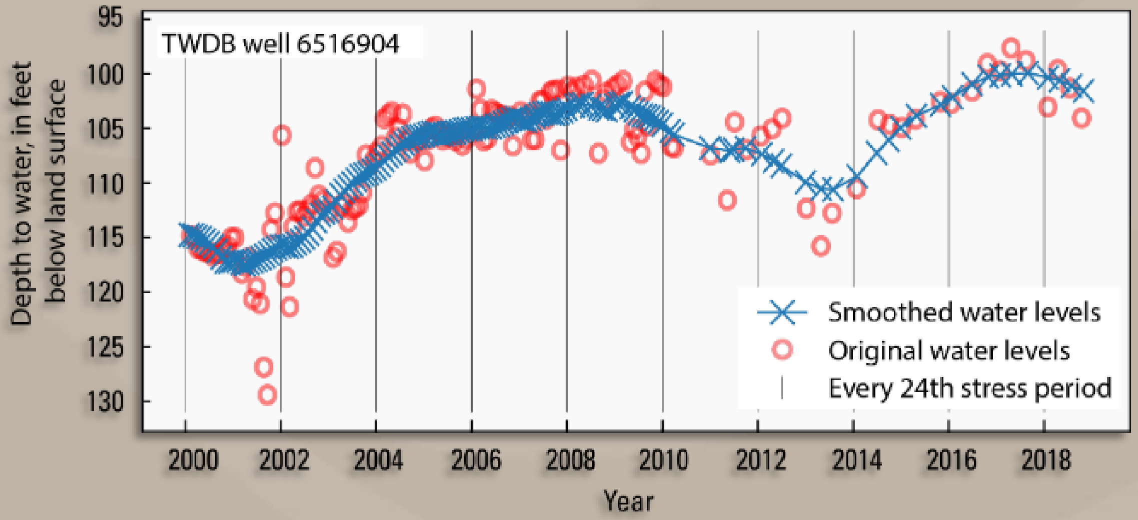
- Model groundwater levels: Include dataset of wells representative of aquifer units and water-level trends through time
- Goal is to ensure 1) disparate water levels don't occur in a spatially dense area, and 2) all model areas are represented during calibration
- Final dataset: 908 wells with a total of 67,451 observations during the model period to use for model calibration



Pre-2000 observations (5-year rolling average)

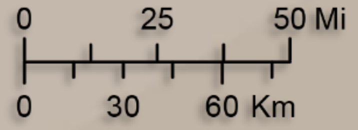


Post-2000 observations (2-year rolling average)

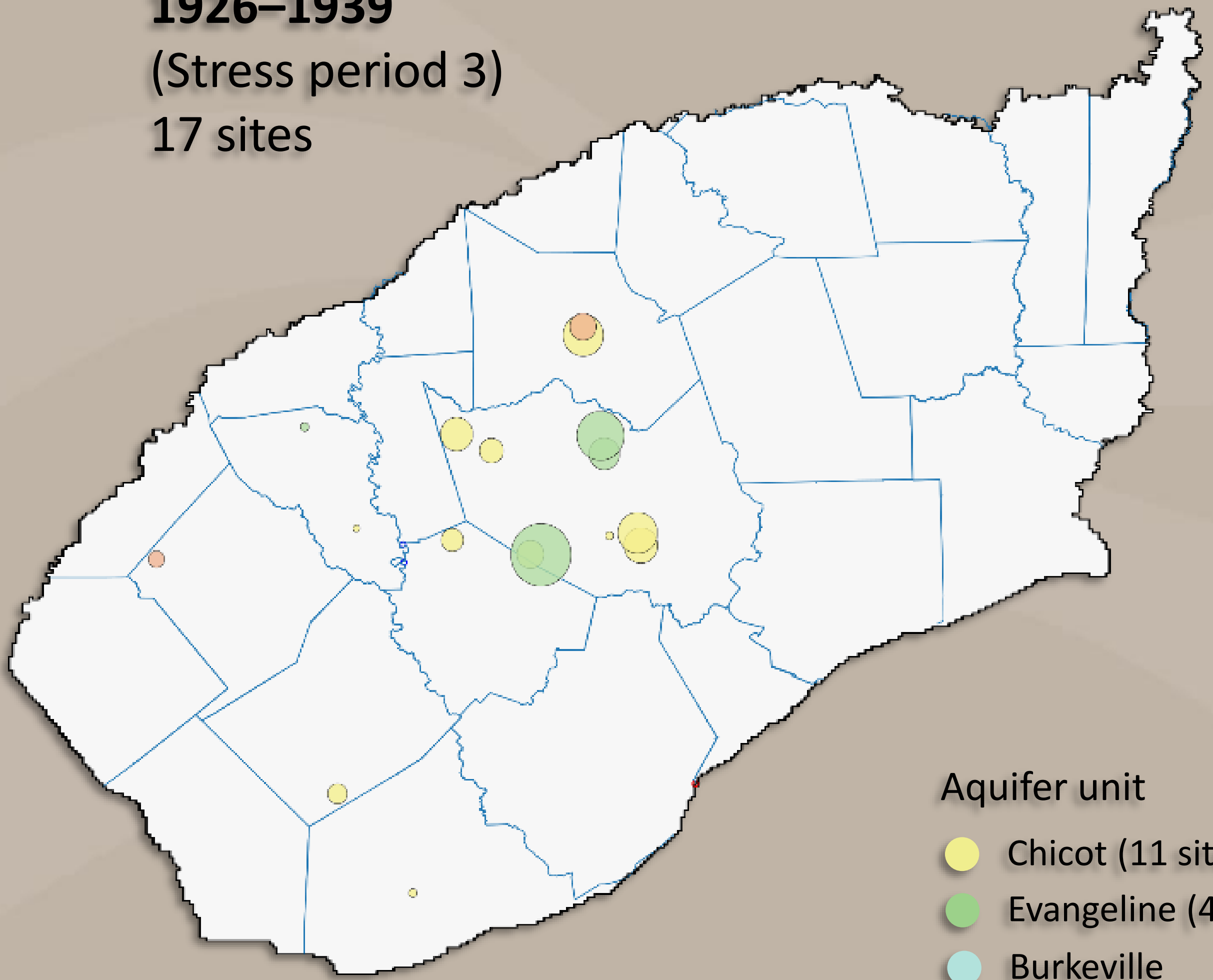


5 Observations

- Includes observation wells submitted by districts to USGS
- Radius of circle represents relative number of observations per well

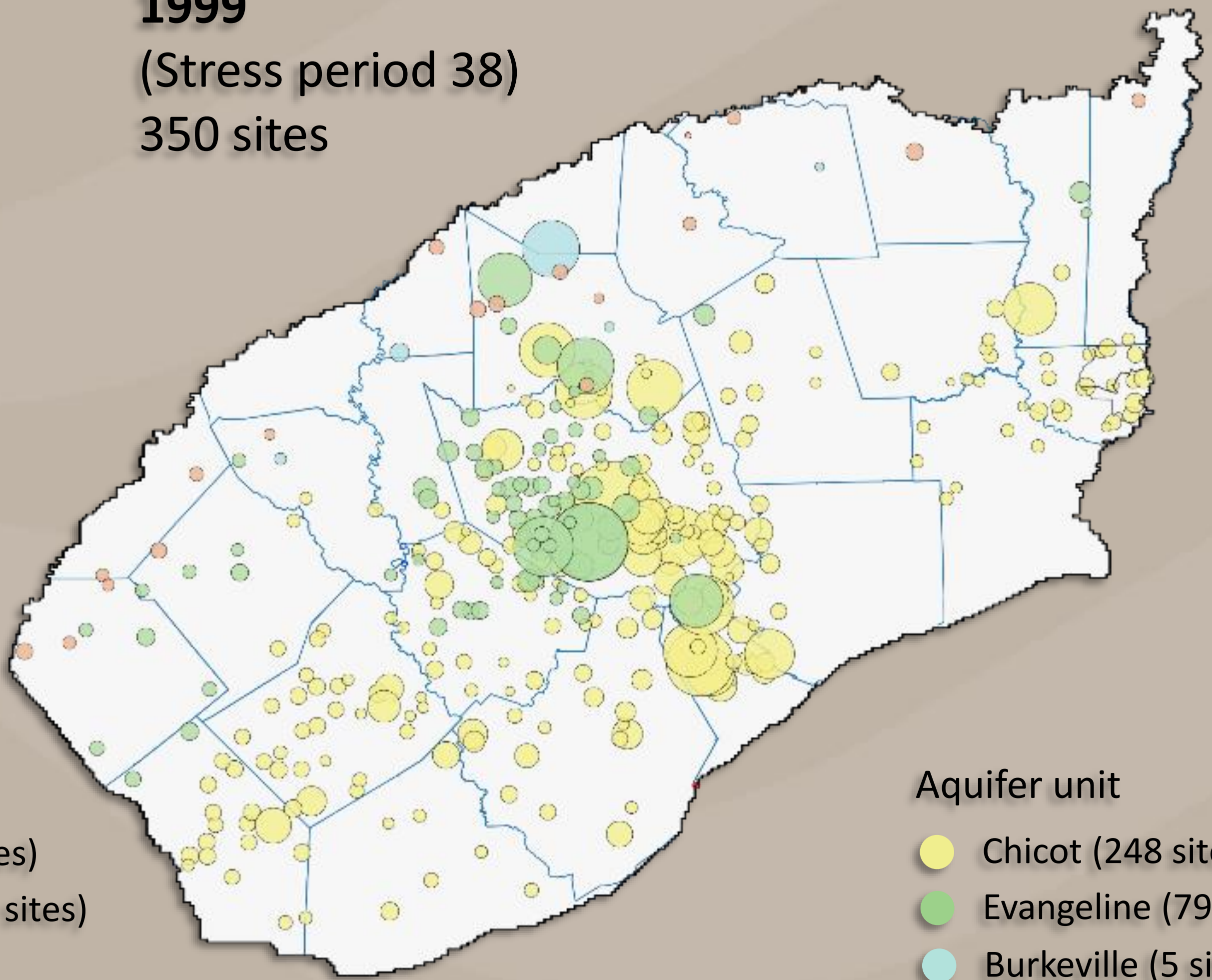


1926–1939
(Stress period 3)
17 sites



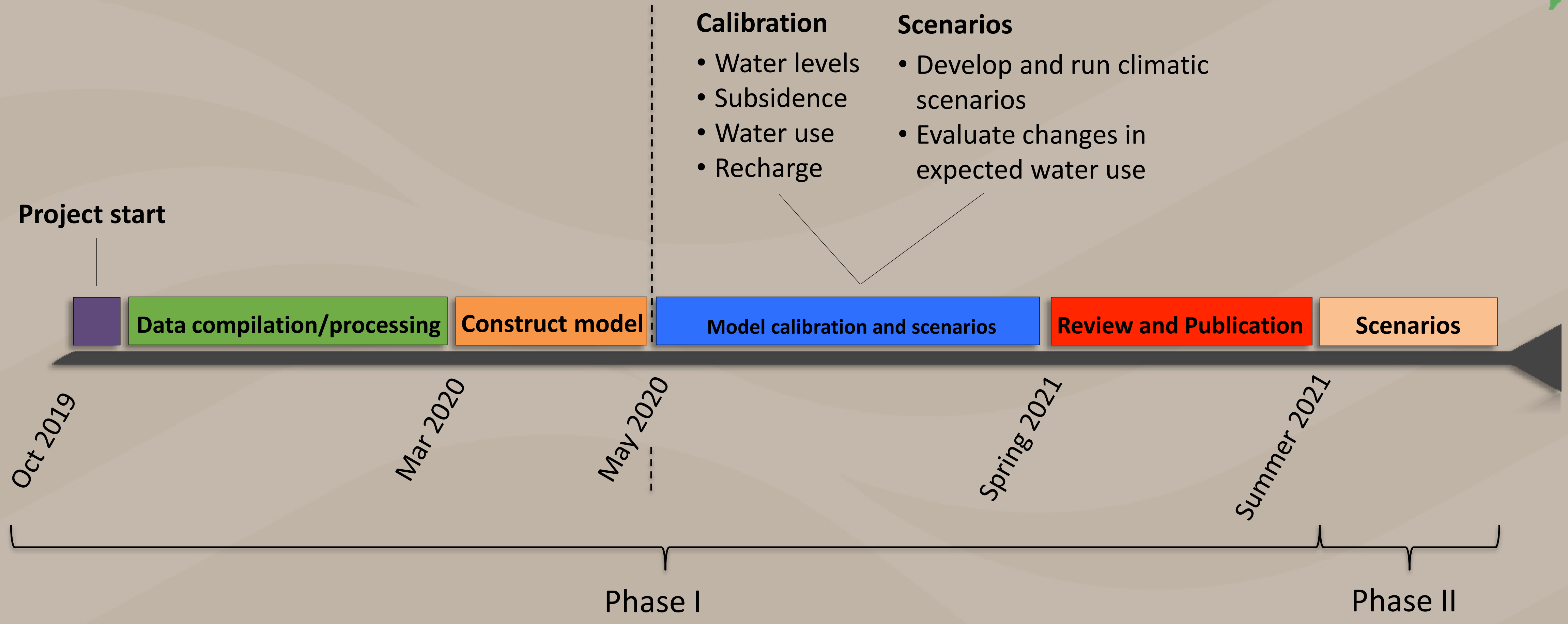
Aquifer unit
- Chicot (11 sites)
- Evangeline (4 sites)
- Burkeville
- Jasper (2 sites)

1999
(Stress period 38)
350 sites



Aquifer unit
- Chicot (248 sites)
- Evangeline (79 sites)
- Burkeville (5 sites)
- Jasper (18 sites)

6 Timeline/next steps



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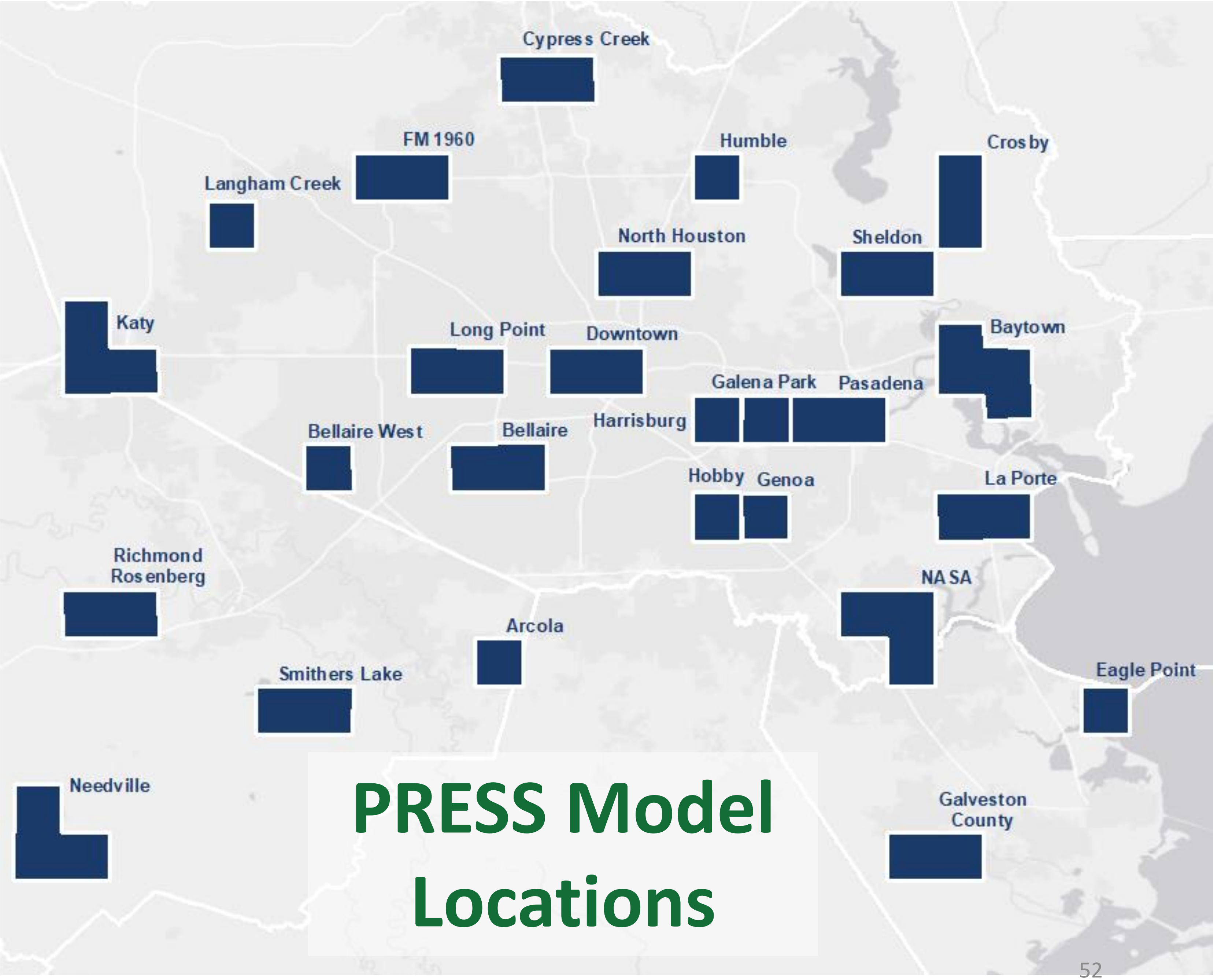
- Water Use Scenario Development

PRESS Assessment

What is PRESS?

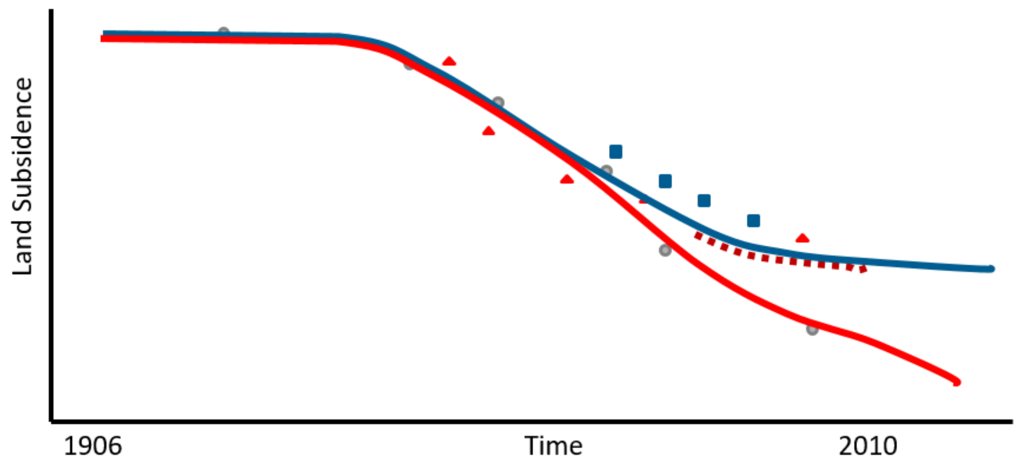
- **P**redictions
- **R**elating
- **E**ffective
- **S**tress to
- **S**ubsidence

Site-specific models used to assess subsidence.



PRESS ASSESSMENT

Verification of existing PRESS models



Comparing results to MODFLOW

Validated PRESS Model Results

Site-Specific MODFLOW 6 CSUB Package Results

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Water Use Scenario Development

WATER USE SCENARIO DEVELOPMENT

Human Variables

Total Water Use

Water Use Distribution

Pumping in Neighboring Area

Natural Variables

Hydrogeologic and Compaction Properties

Drought (short-term)

Climate (long-term)

Regulatory Variables

Regulatory Area Boundaries

Conversion Timeline

Use of Credits

Conversion Percentages

Alternative Water Supply Availability

WATER USE SCENARIO DEVELOPMENT

Define and Evaluate Regulatory Scenarios

↓

Develop Management Recommendations

Considerations:

- Expected subsidence impacts
- Identified risks and uncertainty
- Availability of alternative water supplies
- Feasibility of implementing proposed changes (if any)
- Stakeholder input

Schedule and Next Steps

	GULF 2023 Model	Projected Water Needs	Alternative Water Supplies	PRESS Assessment	Water Use Scenarios
2020	Model Conceptual Report	Methodology, Model Updates	Overview of Alternatives	PRESS Model Validation	
2021	Complete Model Update	Population and Demand Projections	Technical Characterization, Final Report		
2022		Direct Stakeholder Process, Final Projections			Scenario Development
2023				Scenario Testing	Scenario Testing, Recommendations

Upcoming Milestones

Q3 2020

- Post Audit Results
- Overview of Water Supply Alternatives
- PRESS Evaluation Results
- Projected Water Needs Methodology

Q4 2020

- GULF 2023 Conceptual Model Briefing

QUESTIONS AND ANSWERS

Thank you for attending the **Joint Regulatory Plan Review Stakeholder Meeting**

We appreciate your interest and engagement in this meeting.

If you have time, please take a moment to complete the survey at the end of this webinar. We will also include a link to the survey in a follow-up email if you cannot complete the survey now.