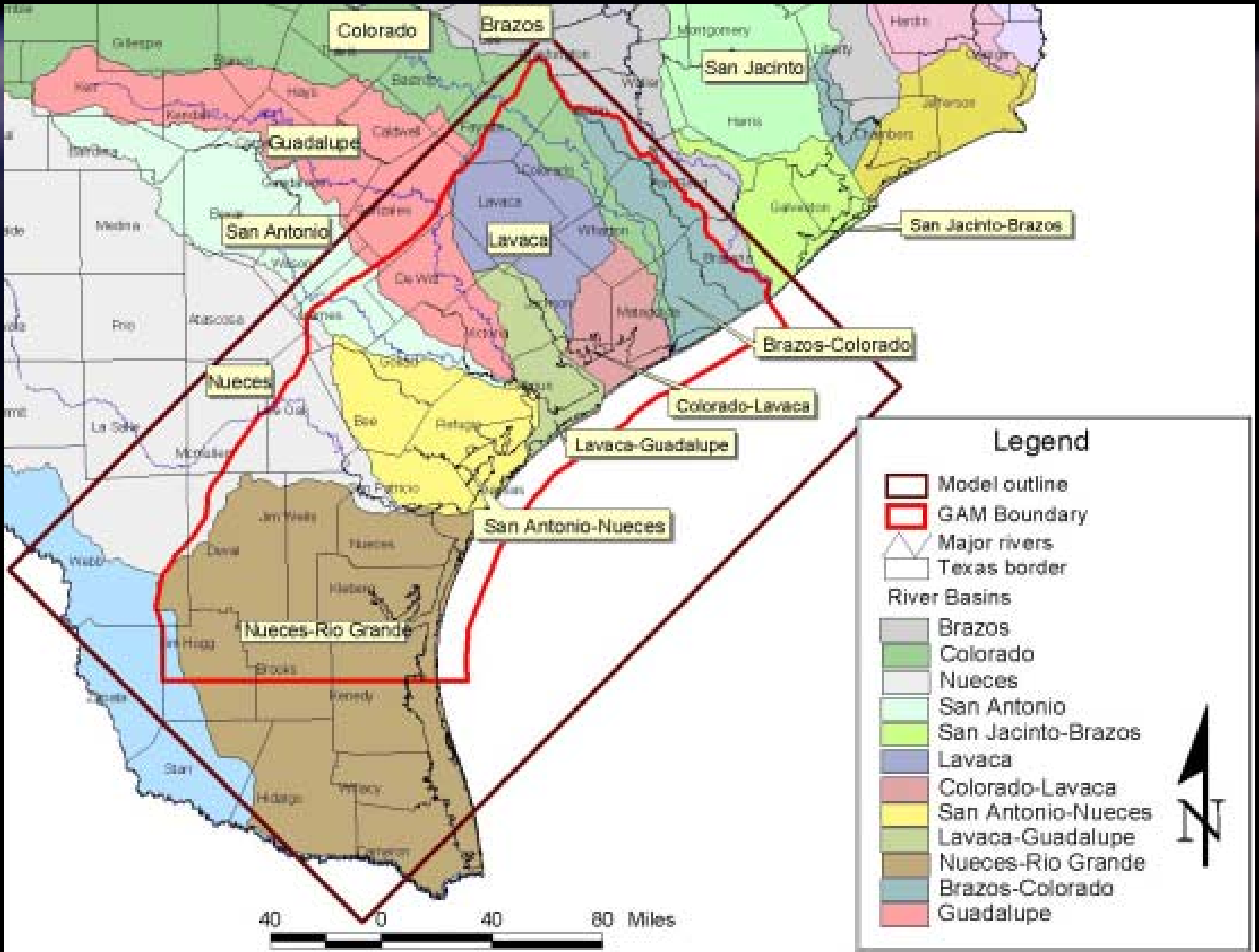
The Central Gulf Coast GAM: Draft Report Overview and Predictive Run Results

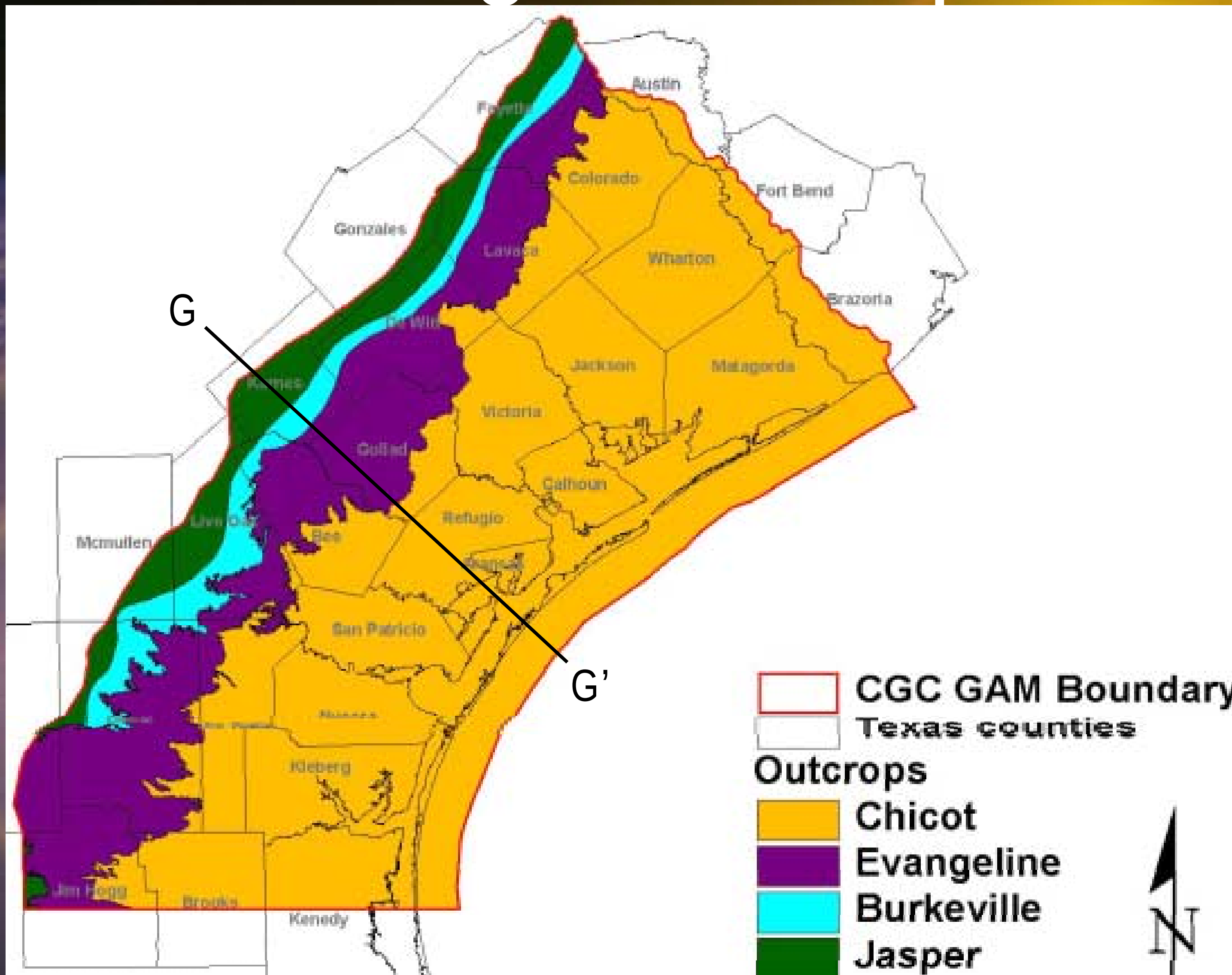
Seventh Stakeholder's Advisory Forum
San Patricio Municipal Water District
Ingleside, Texas
October 22nd, 2002

Waterstone Environmental Hydrology and Engineering, Inc.

Model Grid, GAM Region, and River Basins



Hydrostratigraphic Unit (HSU) Geologic Outcrops



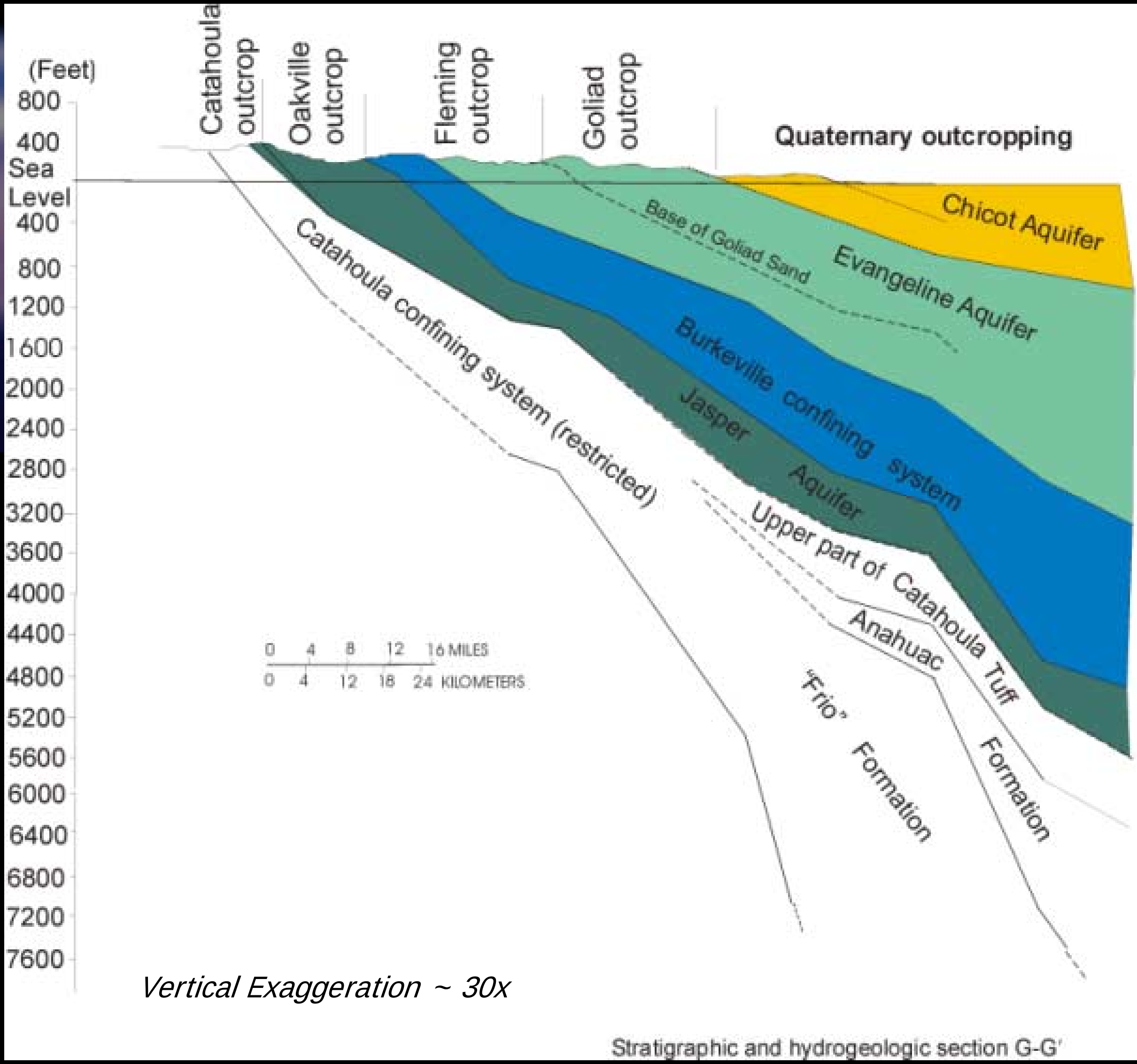
Vertical Cross Section Showing The Major Aquifer Composition

Jasper:
- Oakville sandstone
- Catahoula sandstone and tuff

Burkeville:
- typically lower Fleming

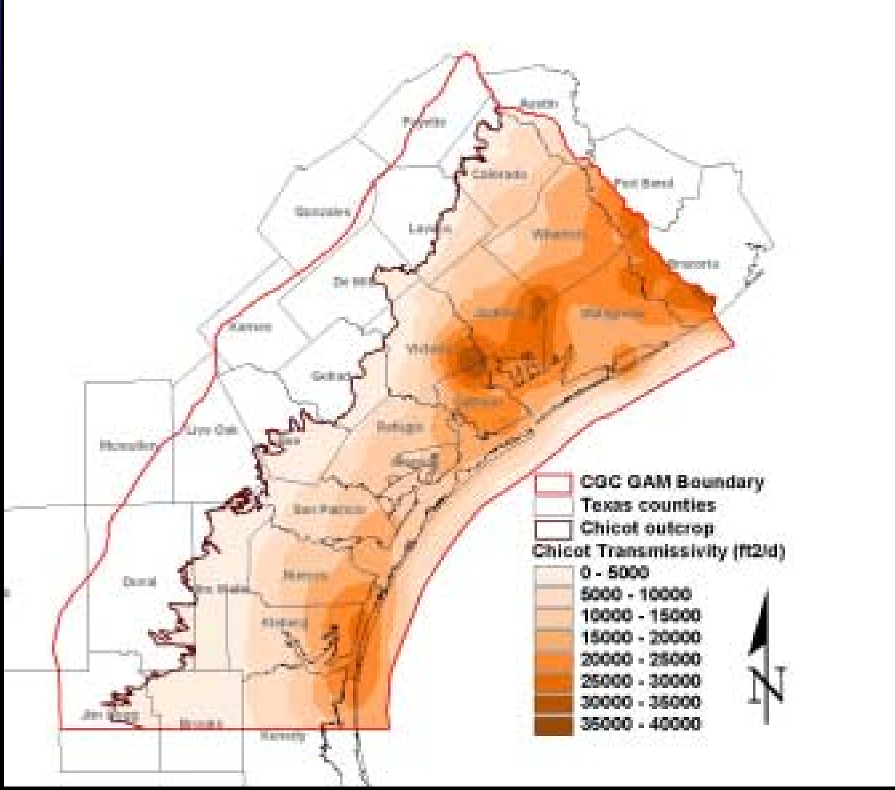
Evangeline:
- Goliad sand
- upper Fleming

Chicot
- surface alluvium
- shallow units overlying Evangeline



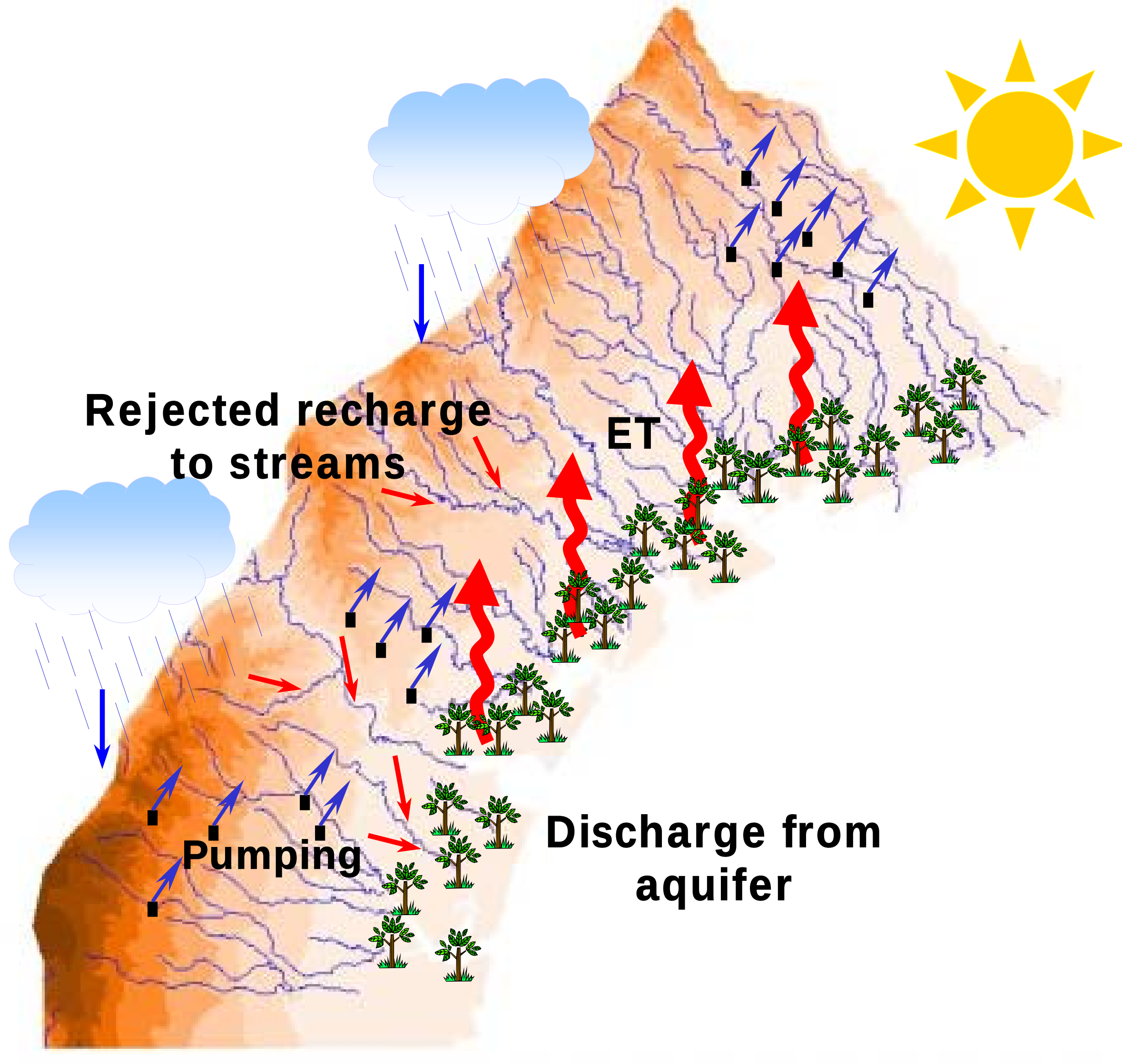
Transmissivity

- Water comes primarily from the sand lenses
- Quantify flow potential by characterizing sand hydraulic conductivity and distribution
- Transmissivity calculations
  - pump-test transmissivity
  - screened interval ⇨ hydraulic conductivity of sands
  - hydraulic conductivity geometric mean
  - sand percentage and aquifer thickness ⇨ sand thickness
  - aquifer transmissivity values



Characterizing the Hydrologic System

- Long-term water balance from the steady-state model
- Characterize time varying deviations from steady-state conditions
  - Recharge
  - Evapotranspiration
  - Discharge/recharge to streams
  - Pumping

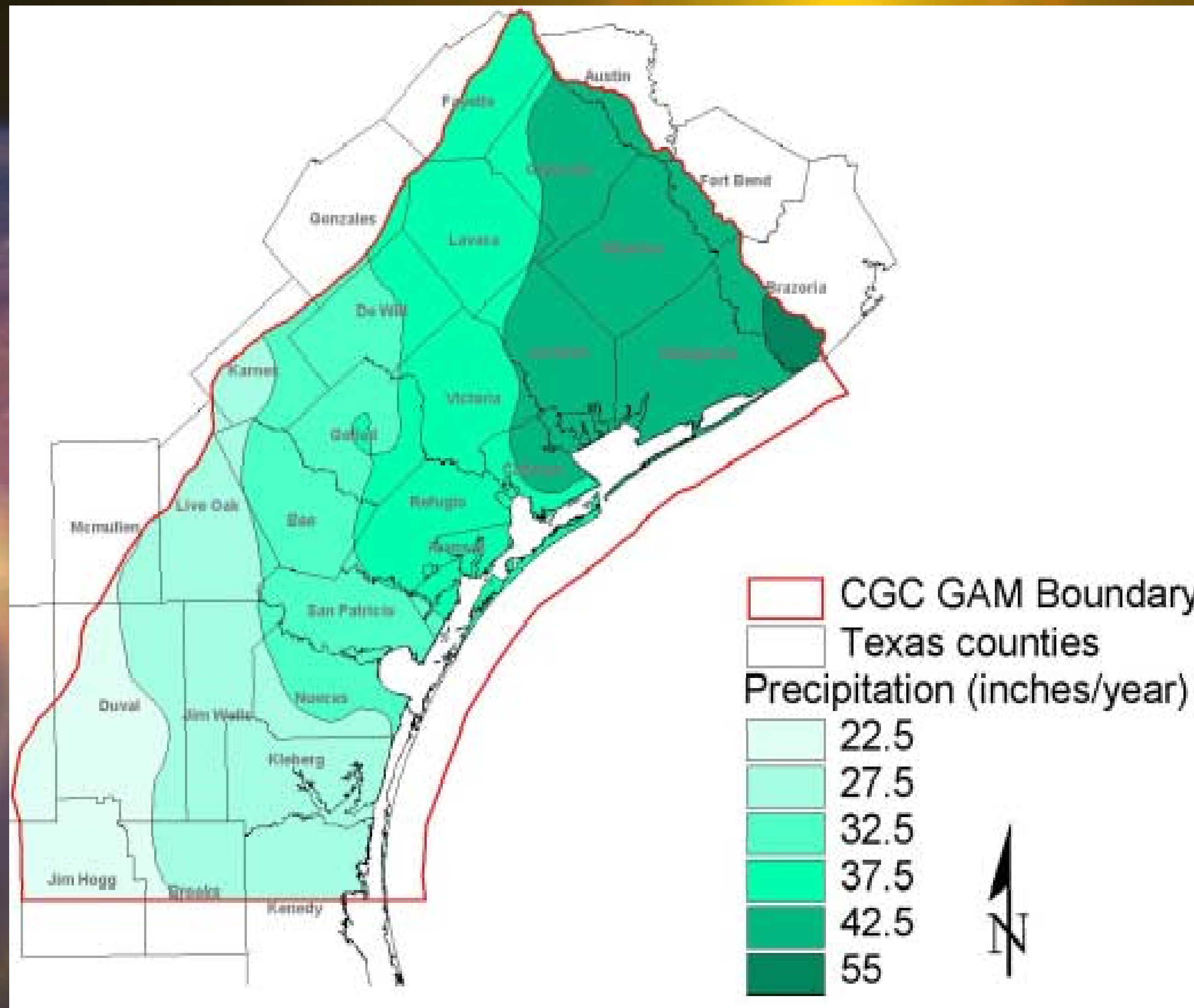


Precipitation: Potential Recharge

Precipitation is a primary source of water to the aquifer

Data are mean annual averages from 1961-1990

- PRISM (Parameter-elevation Regressions on Independent Slopes Model)



Recharge

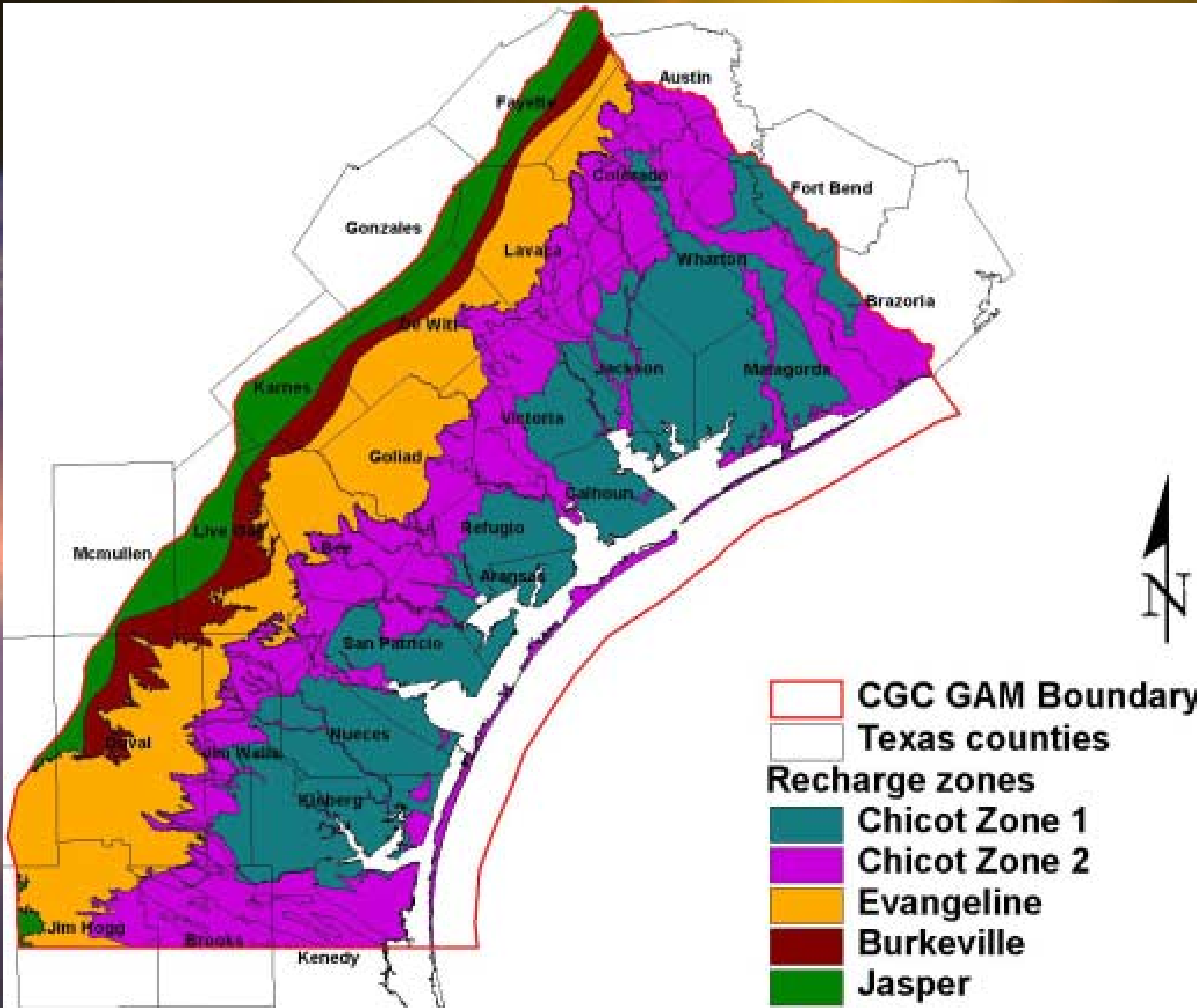
Surface material affects potential for recharge.

- Land-type map (Bureau of Economic Geology)

Recharge zones based on

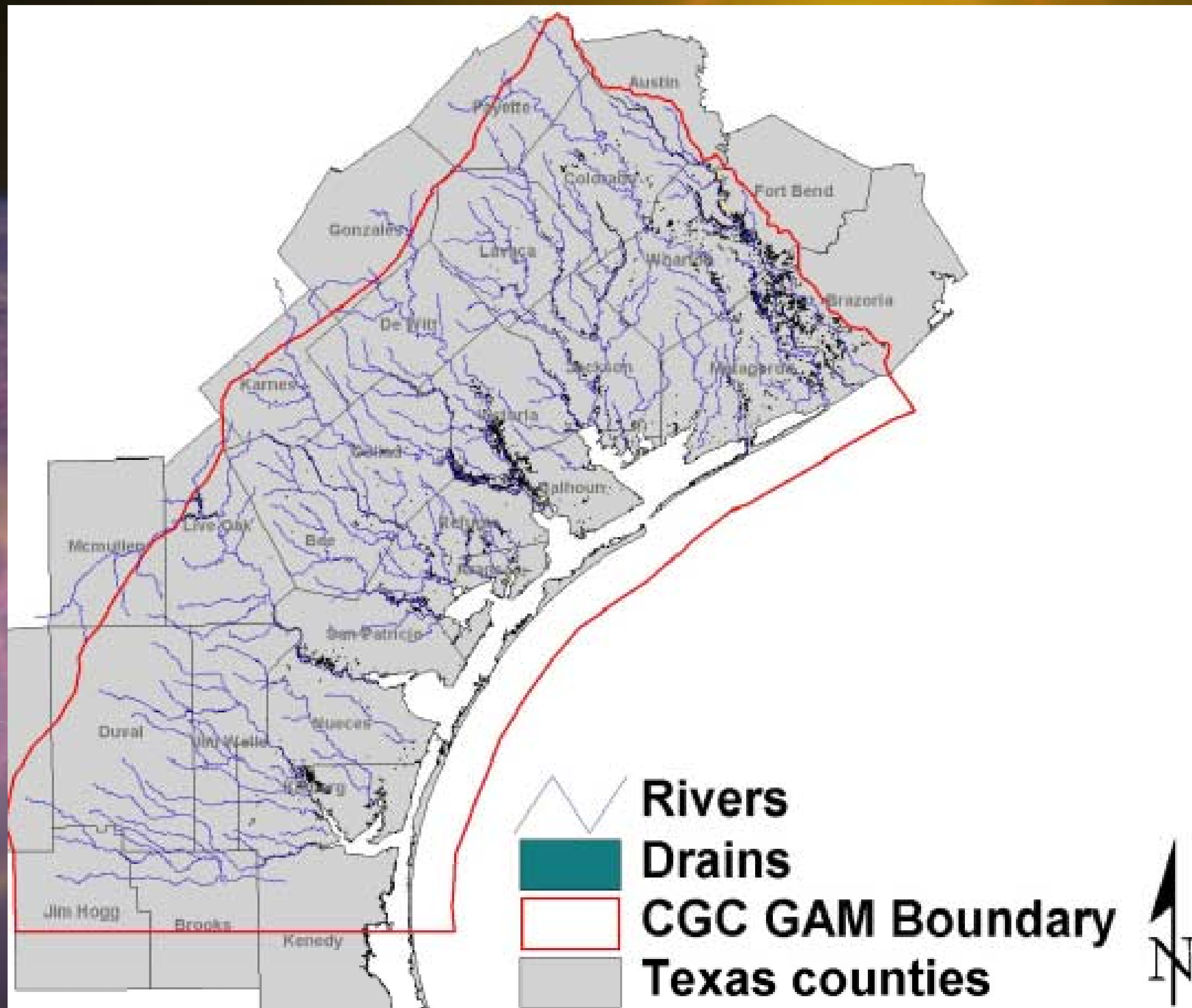
- land type
- HSU outcrops

Estimate the deviations from steady-state and apply to model



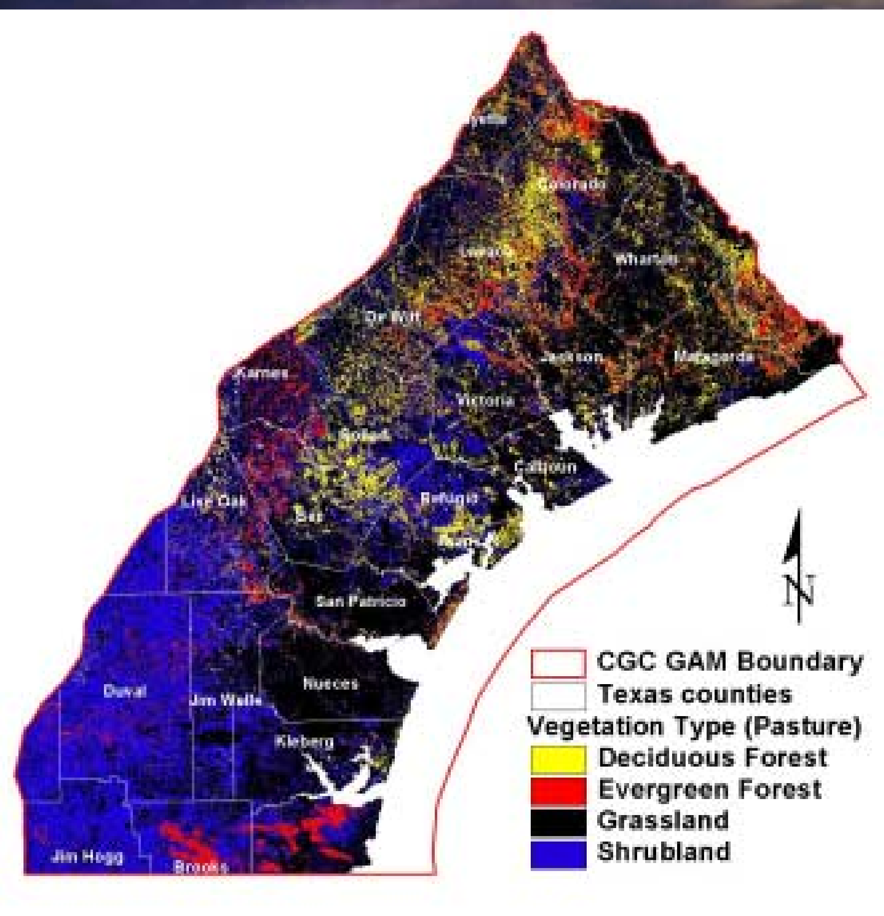
Seepage from the Aquifer

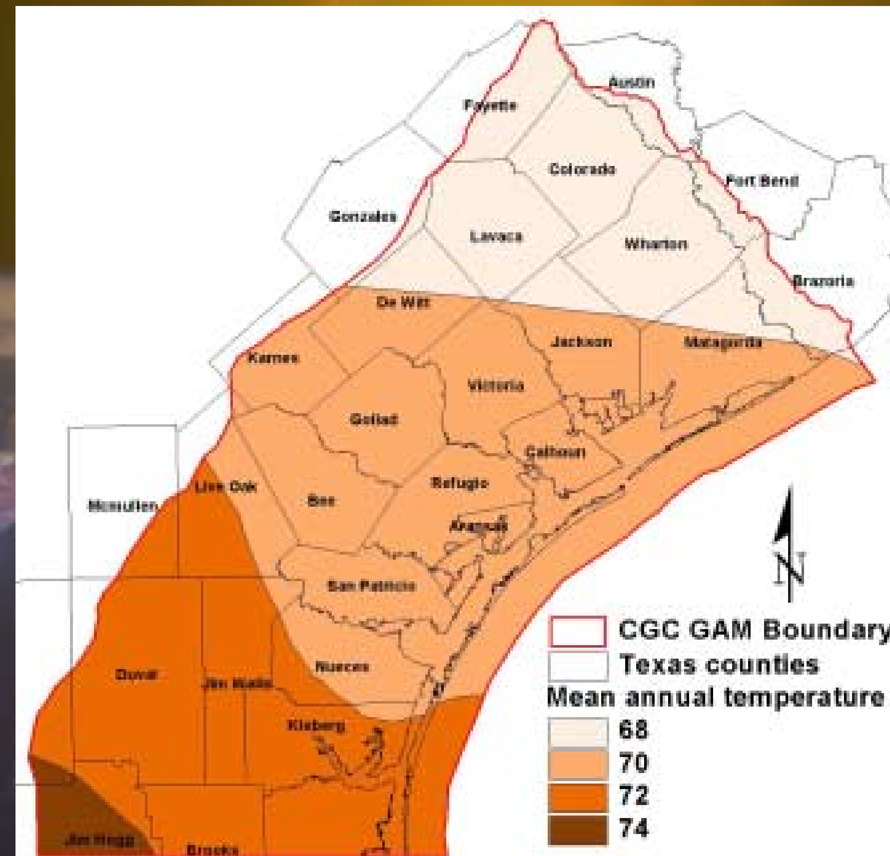
- Water leaves the aquifer through springs, seeps and wetlands represented as **drains**
- Wetlands indicate high potential for discharge from the aquifer



Evapotranspiration (ET)

- Hargraeves method based on temperature, and vegetation type and density





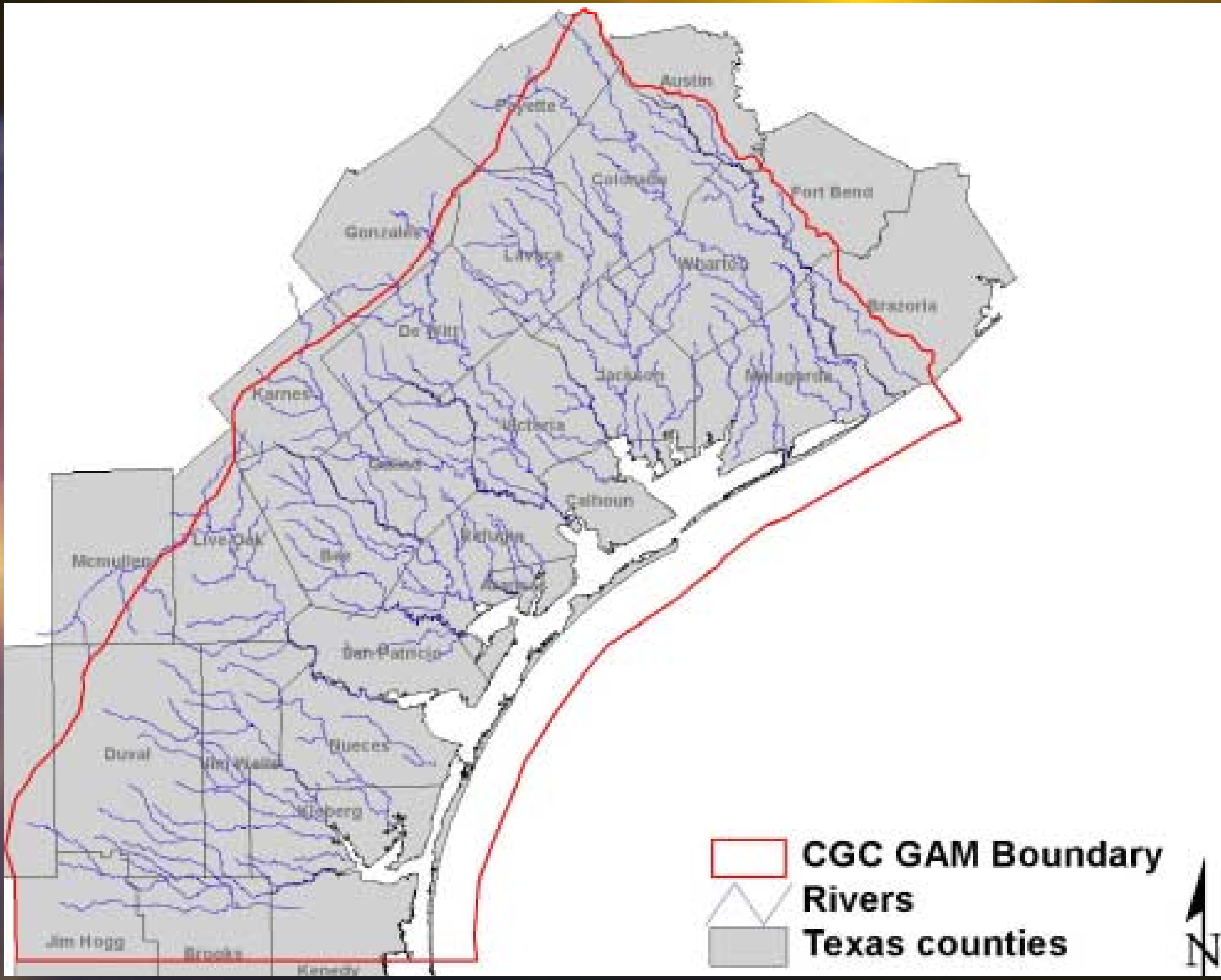
- Simulation of ET in MODFLOW also uses root depth (vegetation type)

Streamflow

Stream network from EPA and USGS data

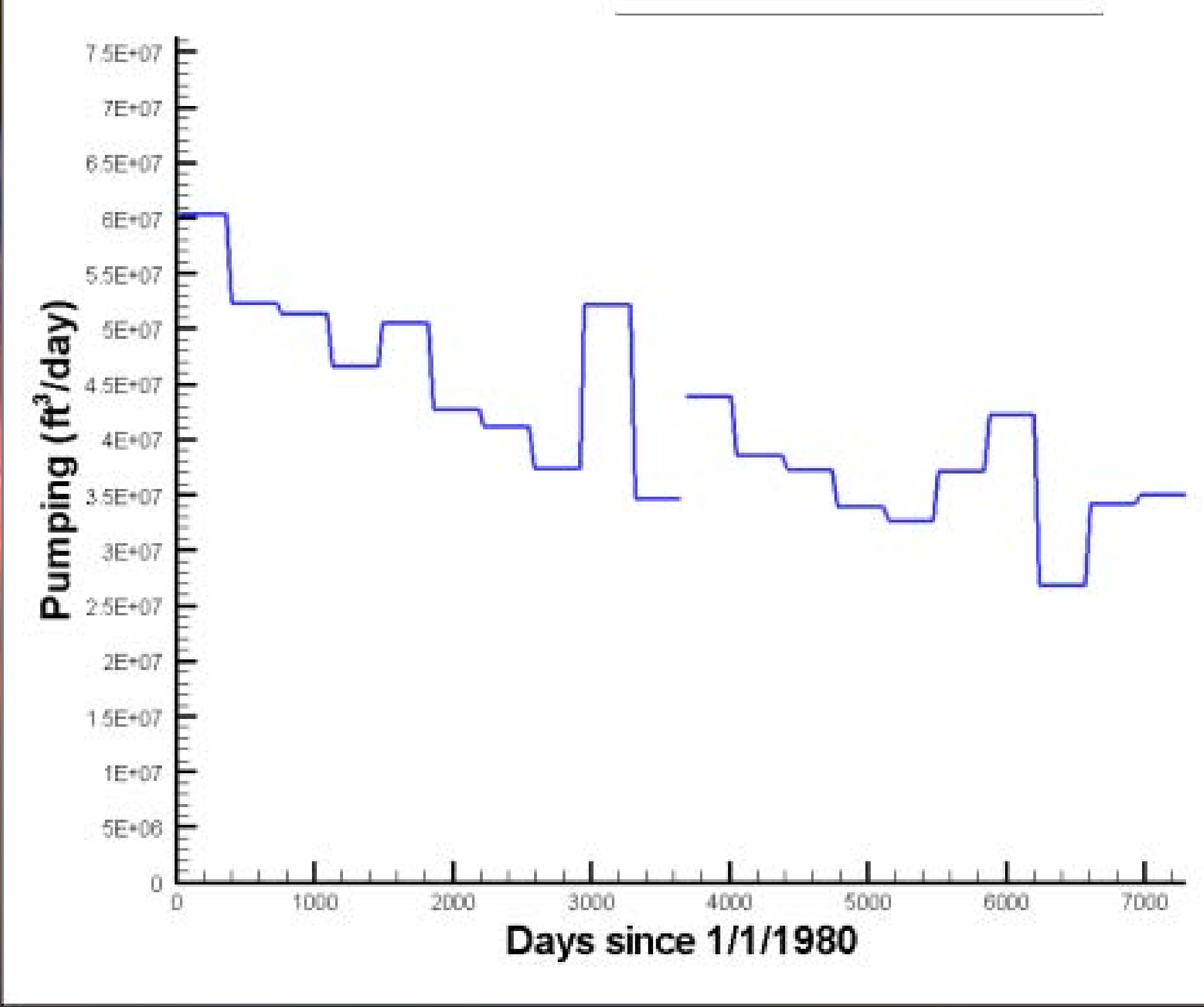
Characterize the temporal variations in flows

- associate each segment with stream gage
- mean flow for each segment: $RF1_s$
- segment with a gage: $RF1_g$
- segment multiplier: $RF1_s / RF1_g$
- gage average by stress period: g_i
- Time varying flow: $g_i * RF1_s / RF1_g$



Pumping

- Parsons SOP for pumping different uses
- Vertical discretization according to well screens
- 30,000 model cells have pumping



CGC Draft Report

Available on the GAM website

http://www.twdb.state.tx.us/gam/glfc_c/glfc_c.htm

- Figures can be downloaded seperately
- Summarizes all information and results
- Stakeholder comments by November 8th
- Adobe Acrobat File

Predictive Runs

Evaluating future water levels by combining

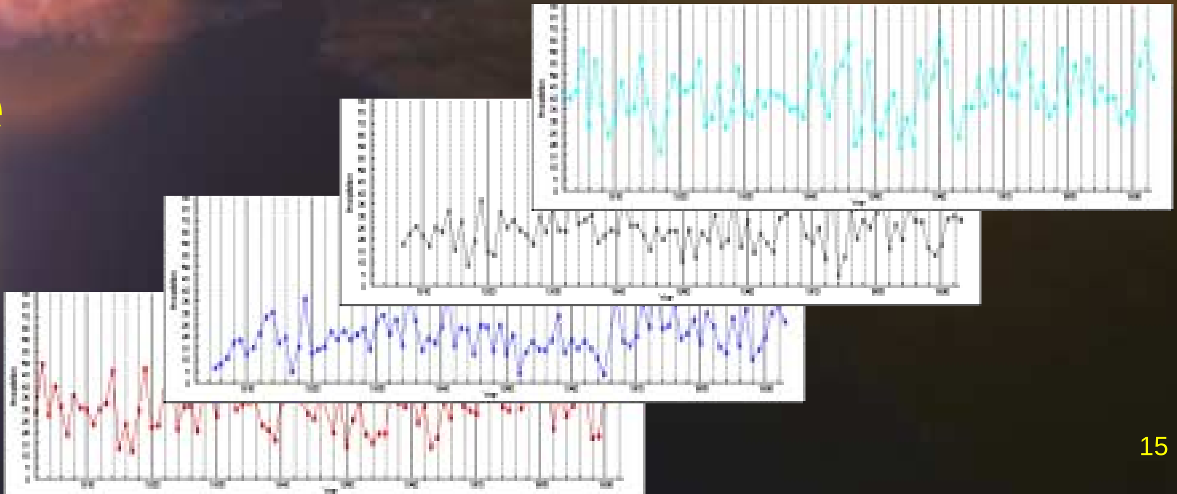
- RWPG forecasted pumping demands
- drought of record

Six Scenarios

- A: 50 year run w/constant recharge (CR)
- B: 10 yr. run (48 CR months, 67 month drought of record)
- C: 20 yr. run (10 CR years, 48 CR months, 67 month drought of record)
- D: 30 yr. run (20 CR years, 48 CR months, 67 month drought of record)
- E: 40 yr. run (30 CR years, 48 CR months, 67 month drought of record)
- F: 50 yr. run (40 CR years, 48 CR months, 67 month drought of record)

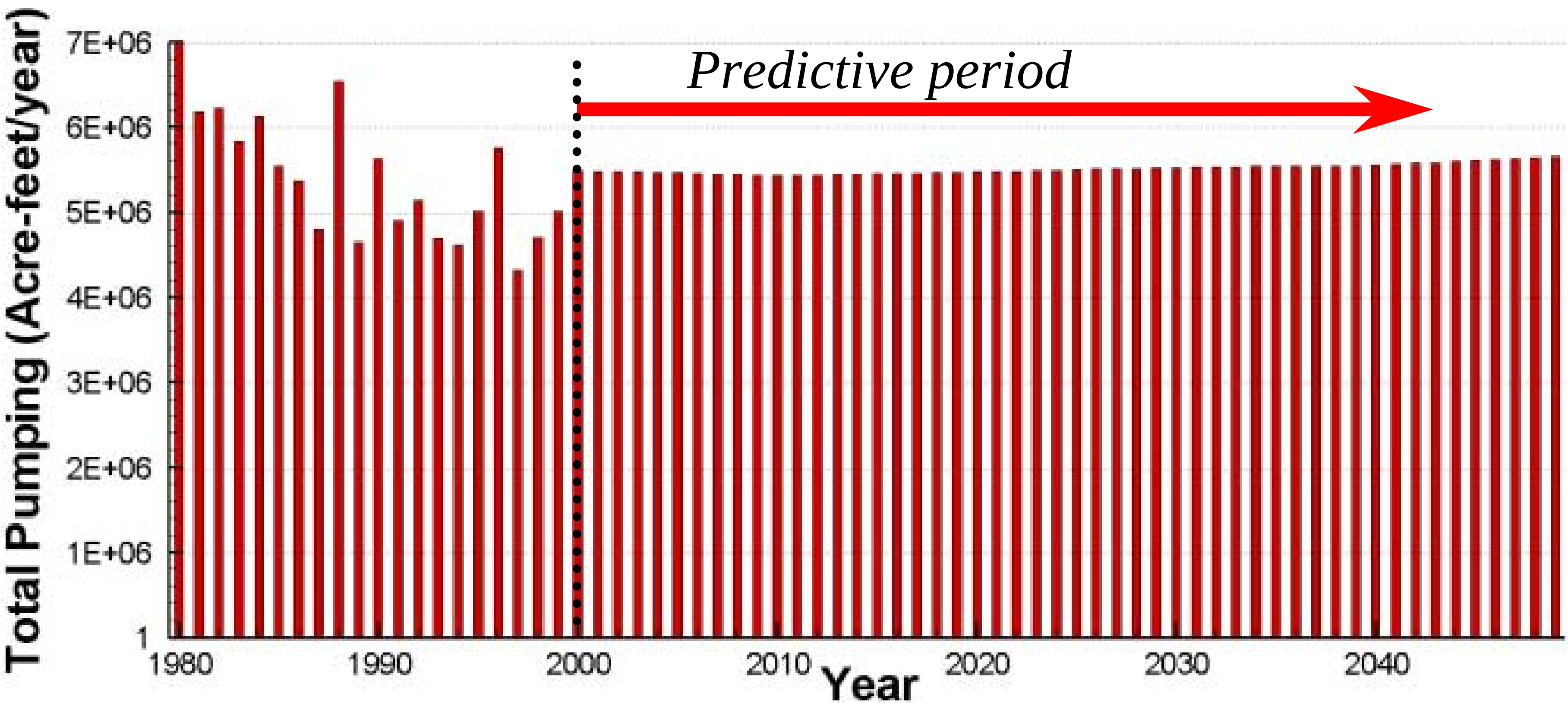
Central Gulf Coast Drought of Record

- Determined regional drought of record using the Palmer Index
  - Obtained Palmer index for entire century for the CGC region
  - Data indicates the period from 1951 through 1956 as the regional drought of record
- Created six-year drought-of-record stresses using
  - Temperature
  - Streamflow
  - Precipitation



Historic and Predictive Pumping

- Predictive demands of the RWPG from TWDB
- Minor variability in annual rate
- Expect major changes in water level to be caused by changes in other stresses



Results

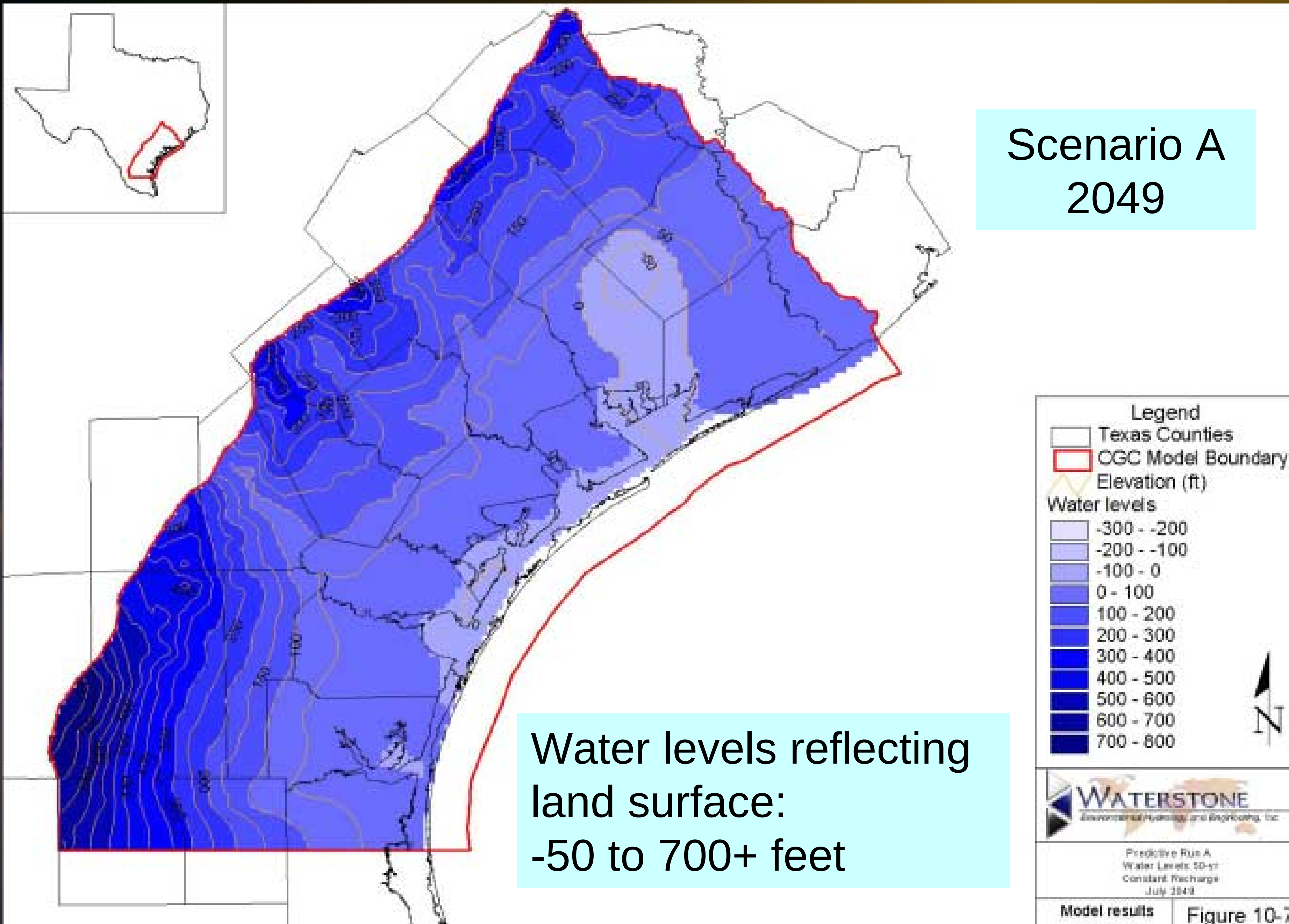
Water Levels

Saturated Thickness

Drawdown

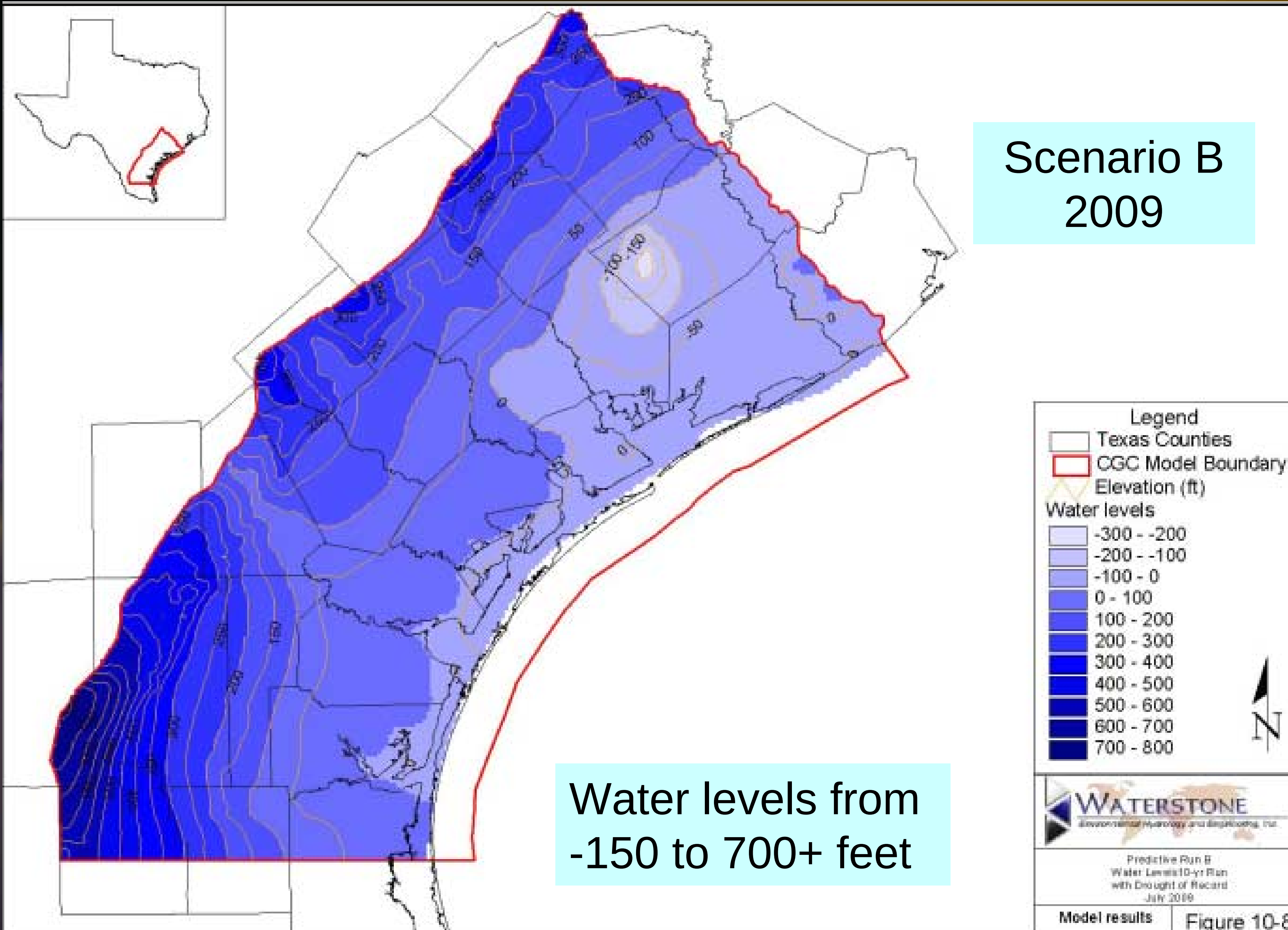
- Scenario A: at the end of each decade
- Scenarios B - F: at the end of the drought of record

Scenario A
2049



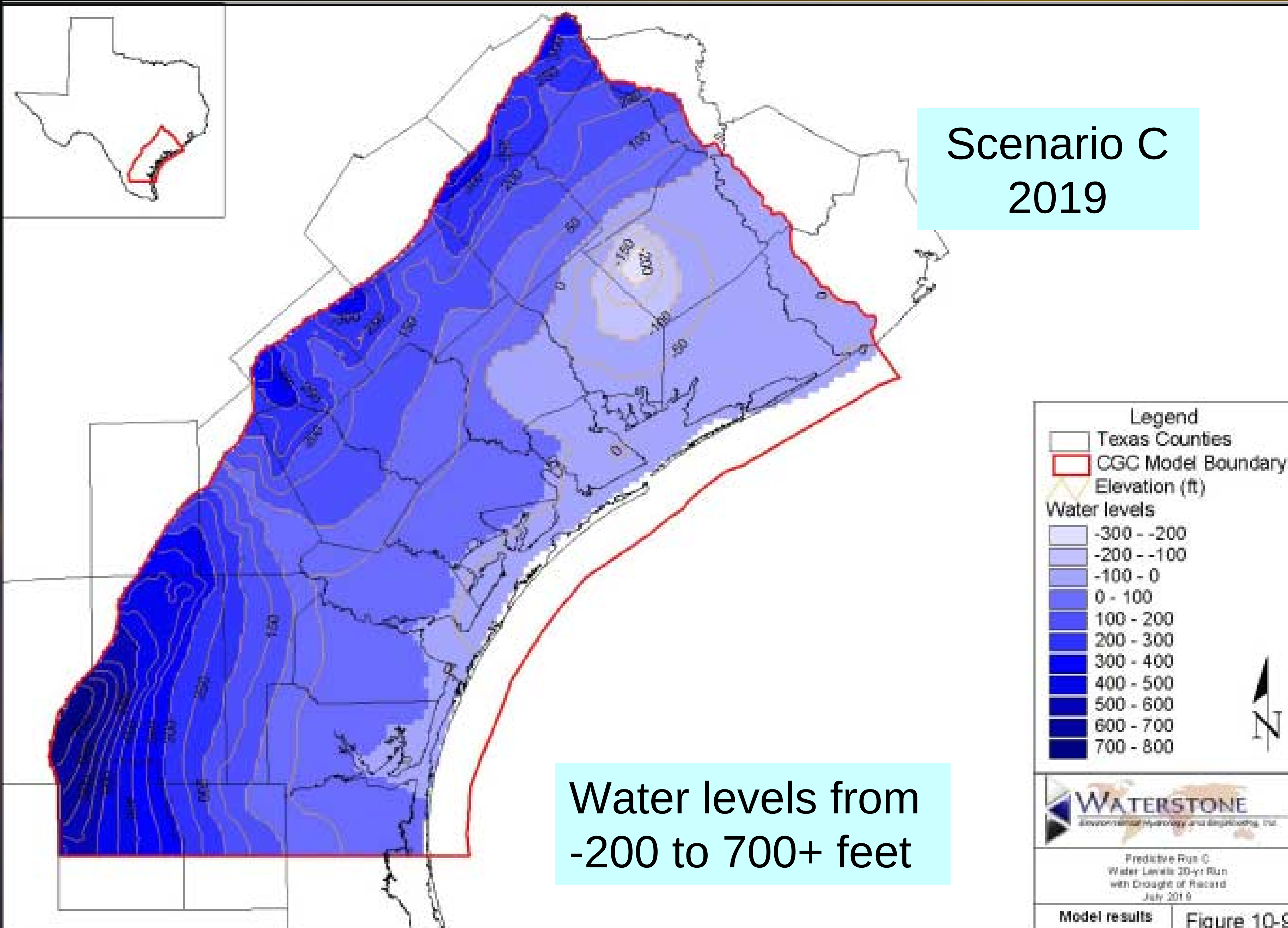
Water levels reflecting land surface:
-50 to 700+ feet

Scenario B 2009

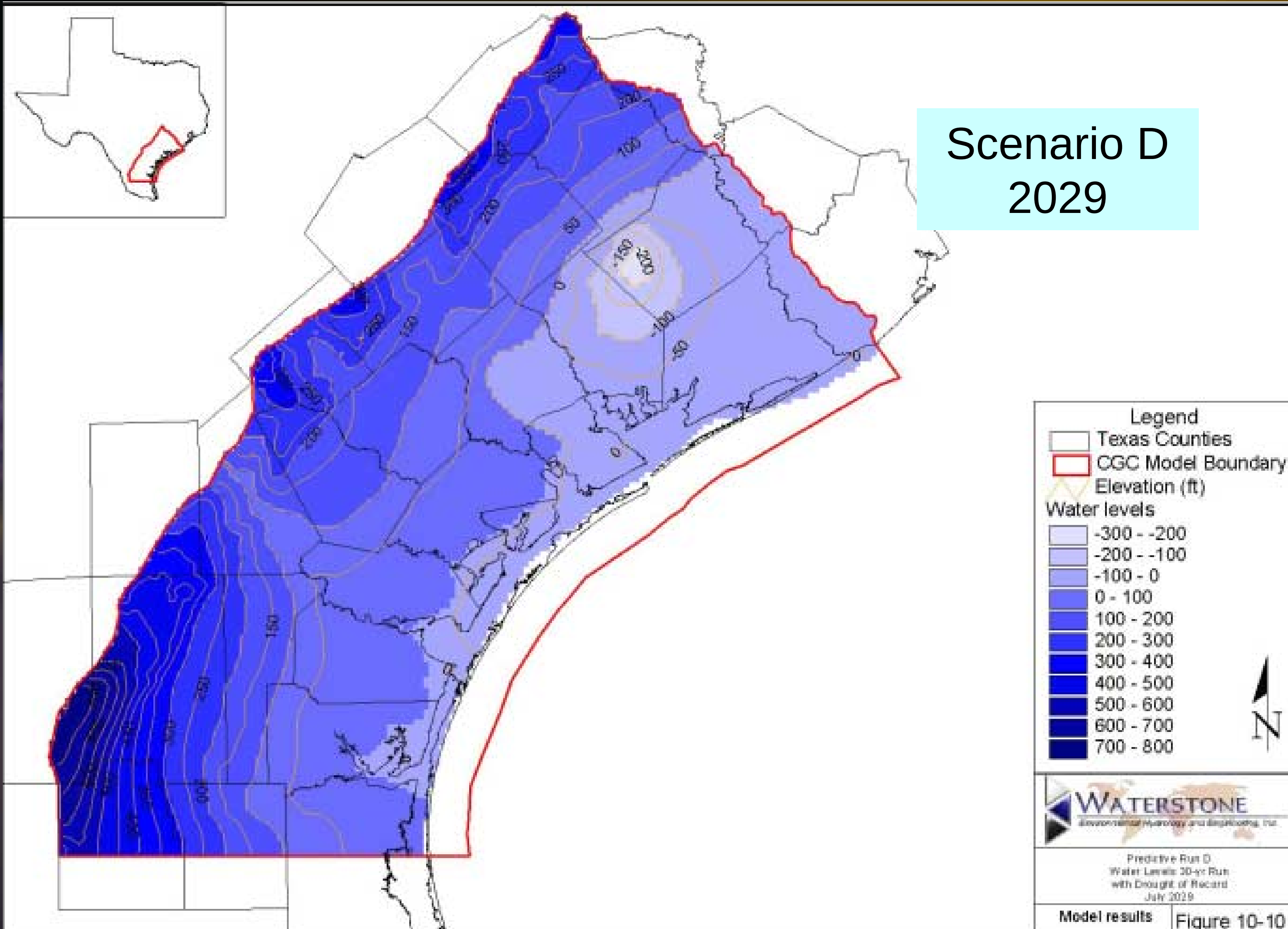


Water levels from -150 to 700+ feet

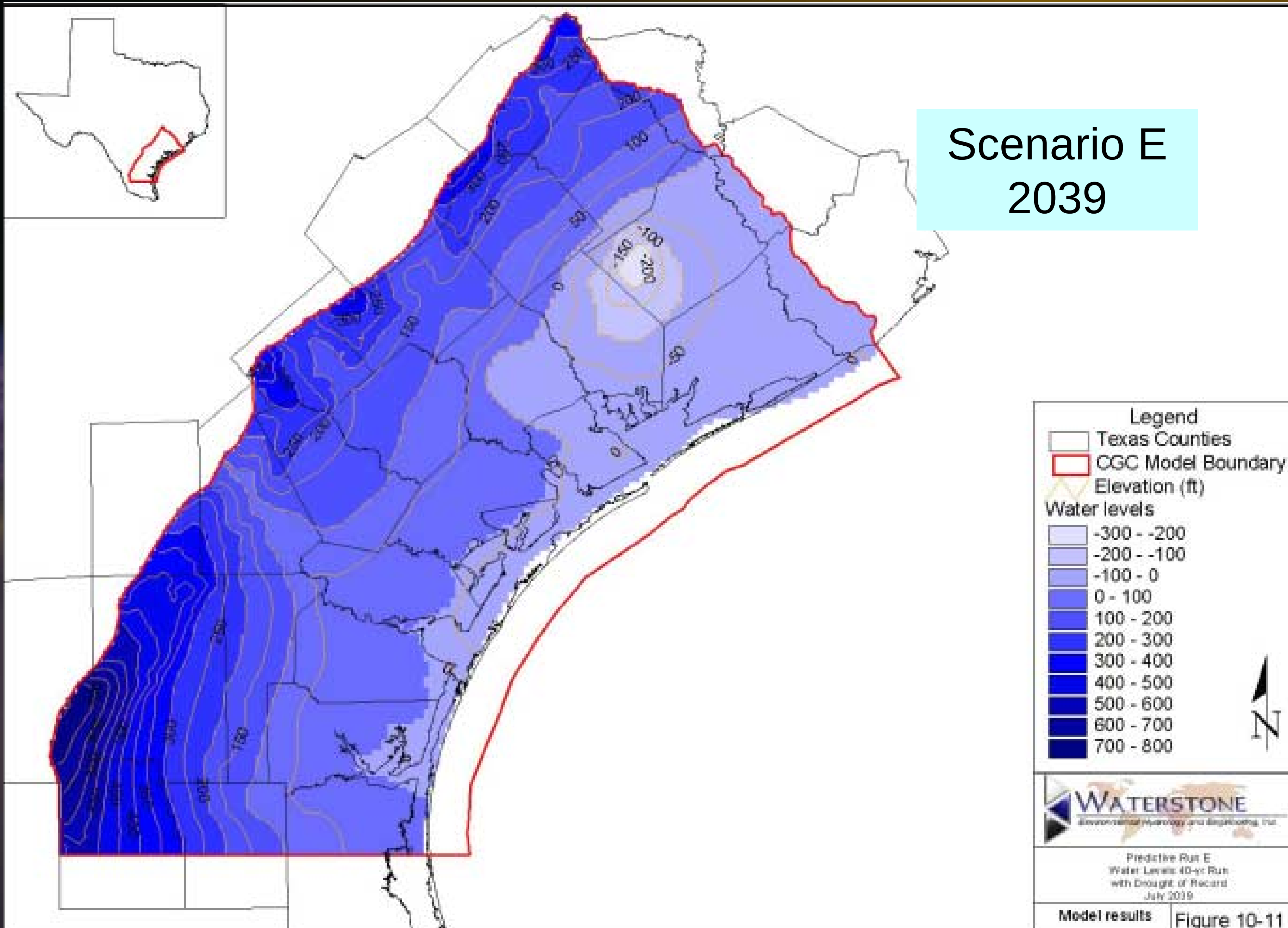
Scenario C 2019



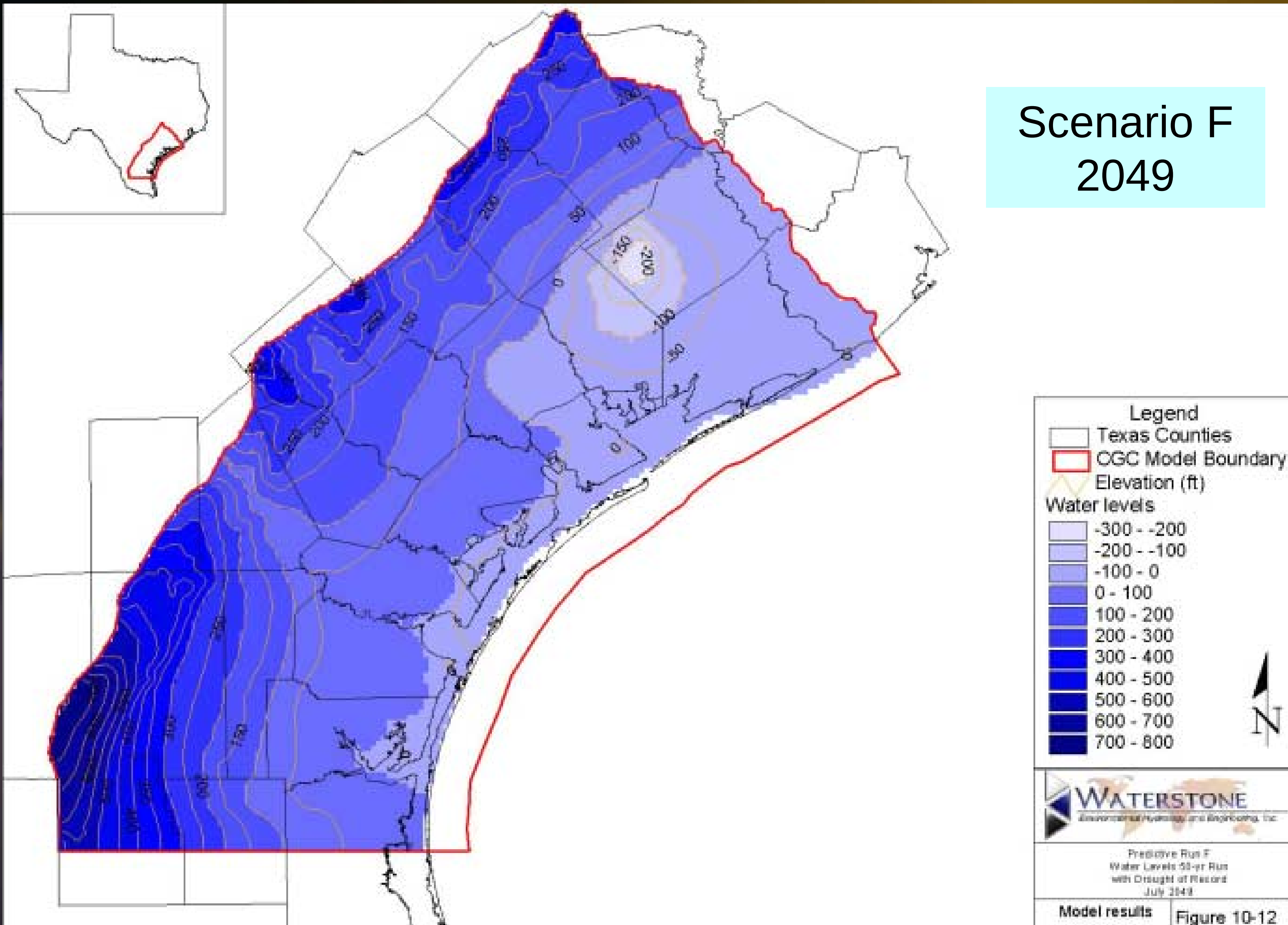
Water levels from -200 to 700+ feet


Scenario D
2029
Legend
Texas Counties
CGC Model Boundary
Elevation (ft)
Water levels
-300 - -200
-200 - -100
-100 - 0
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
N
WATERSTONE
Predictive Run D
Water Levels: 30-yr Run
with Drought of Record
July 2029
Model results
Figure 10-10

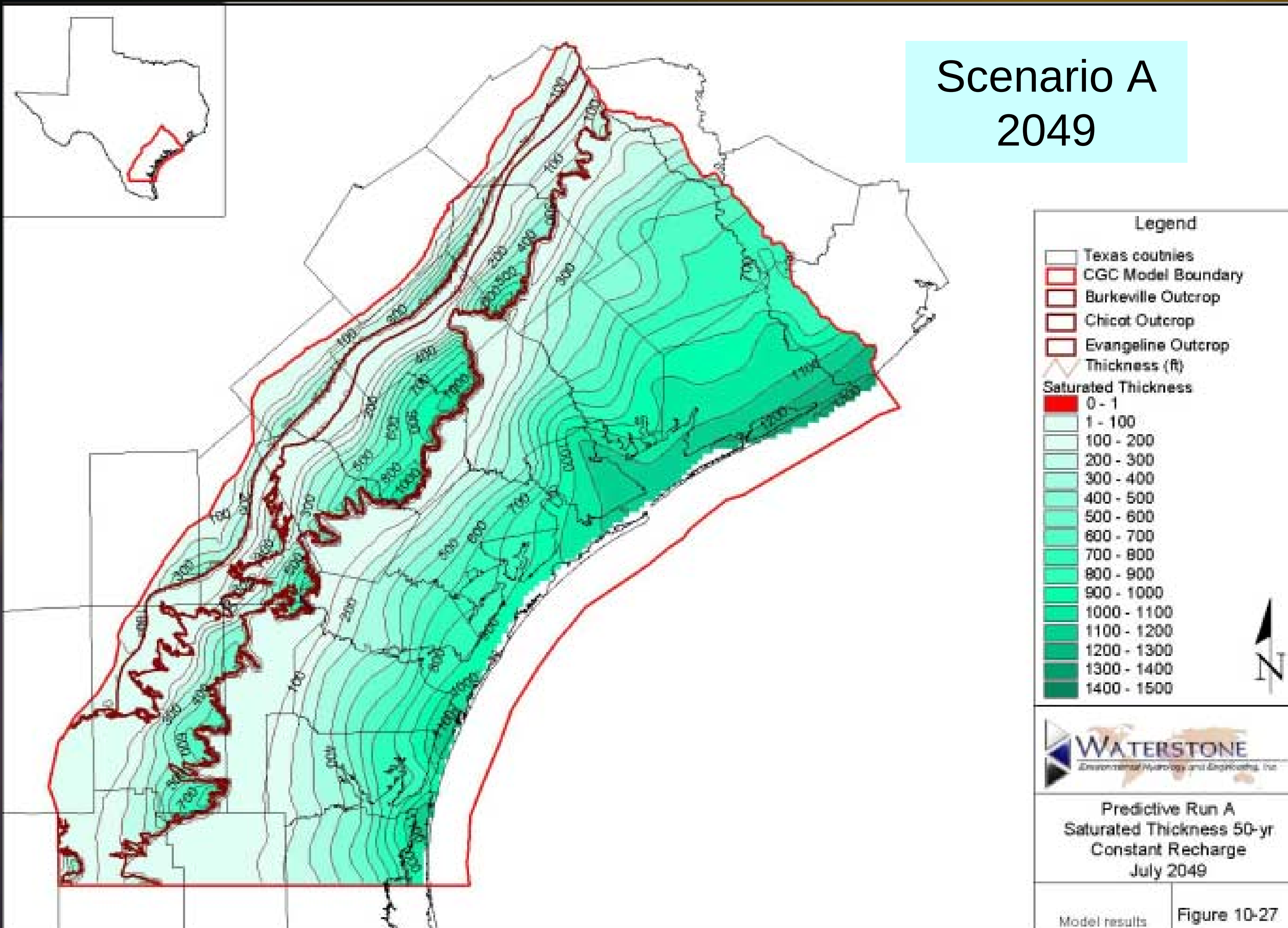
Scenario E 2039



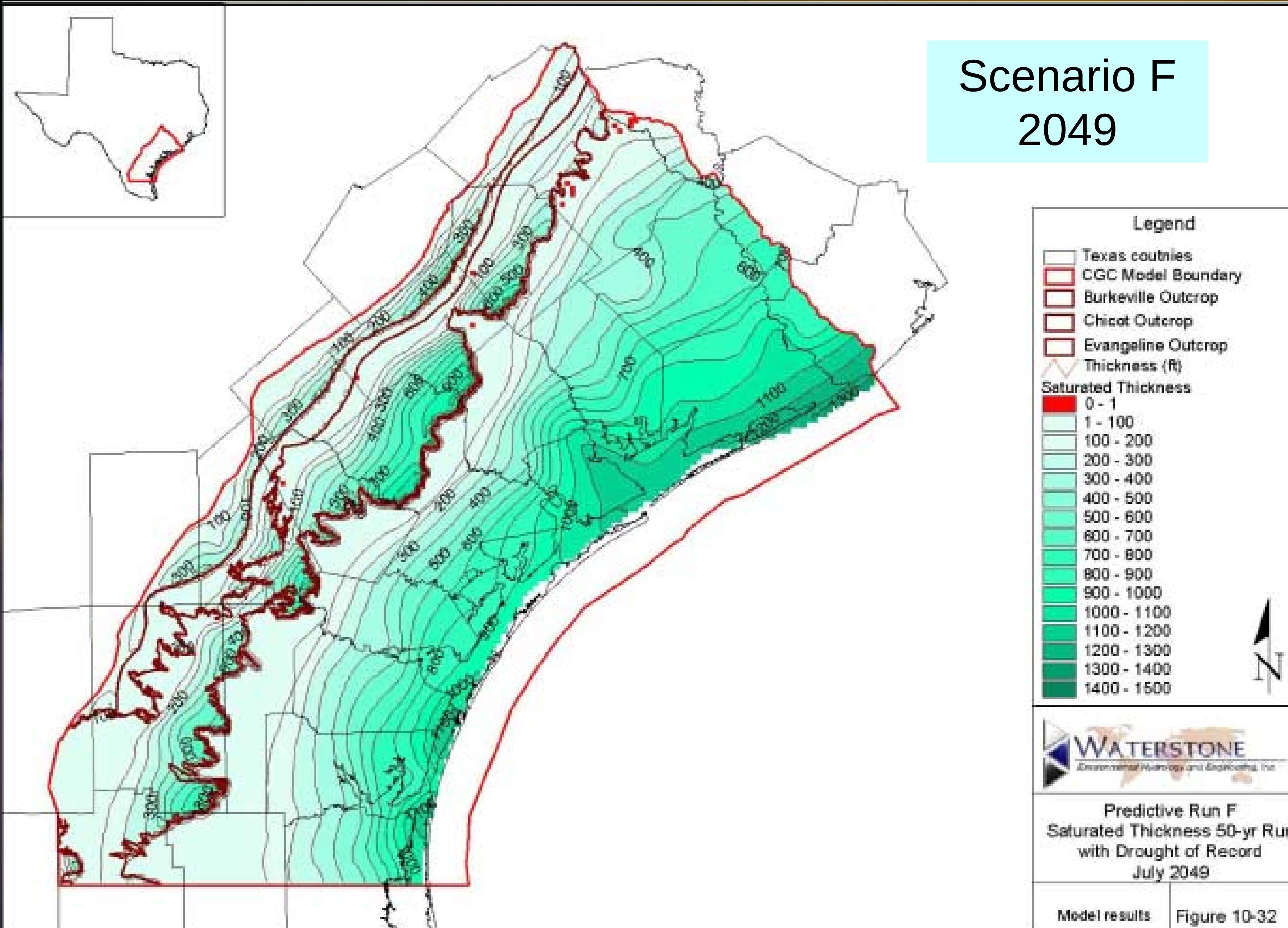
Scenario F 2049



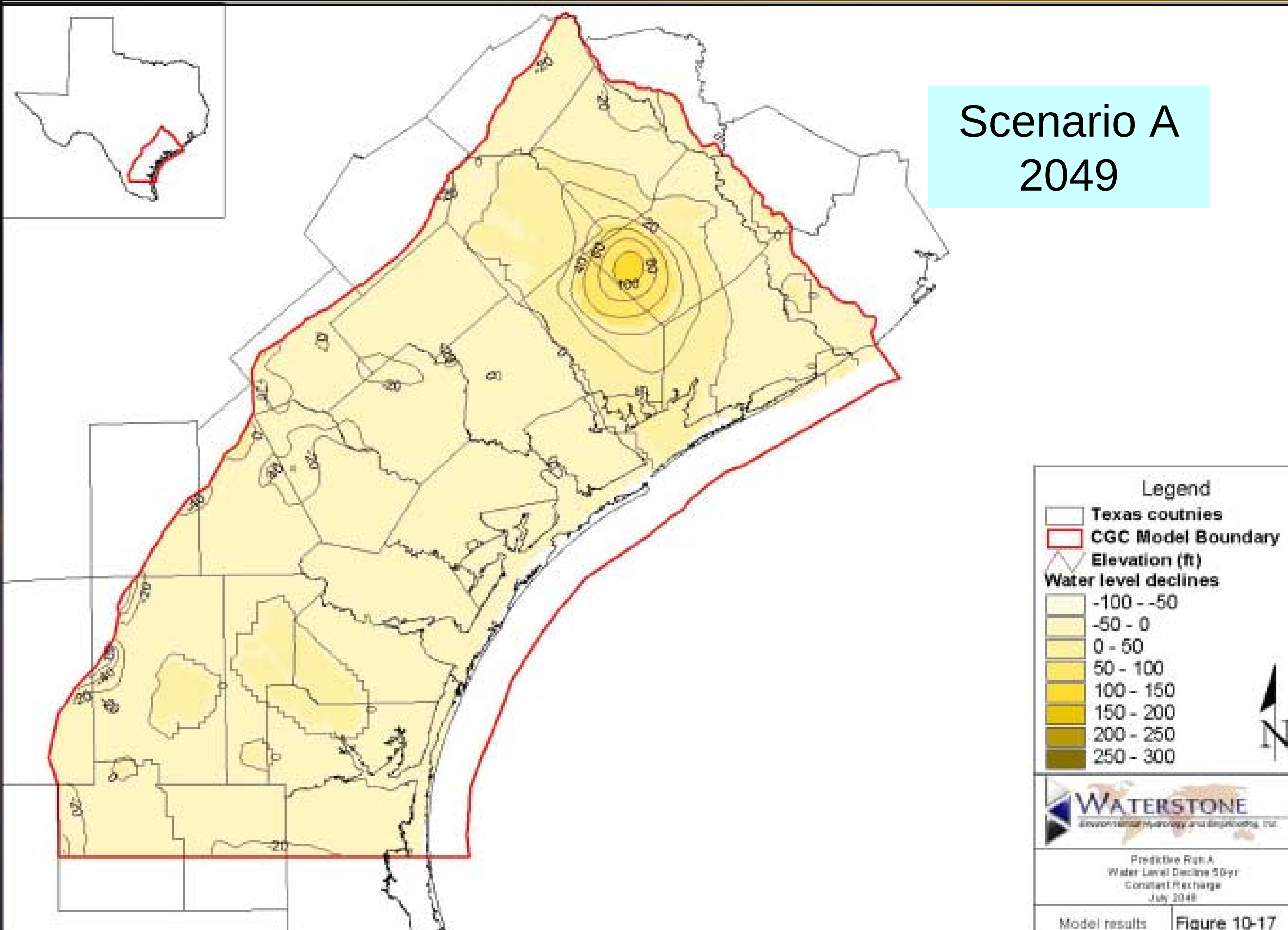
Scenario A
2049



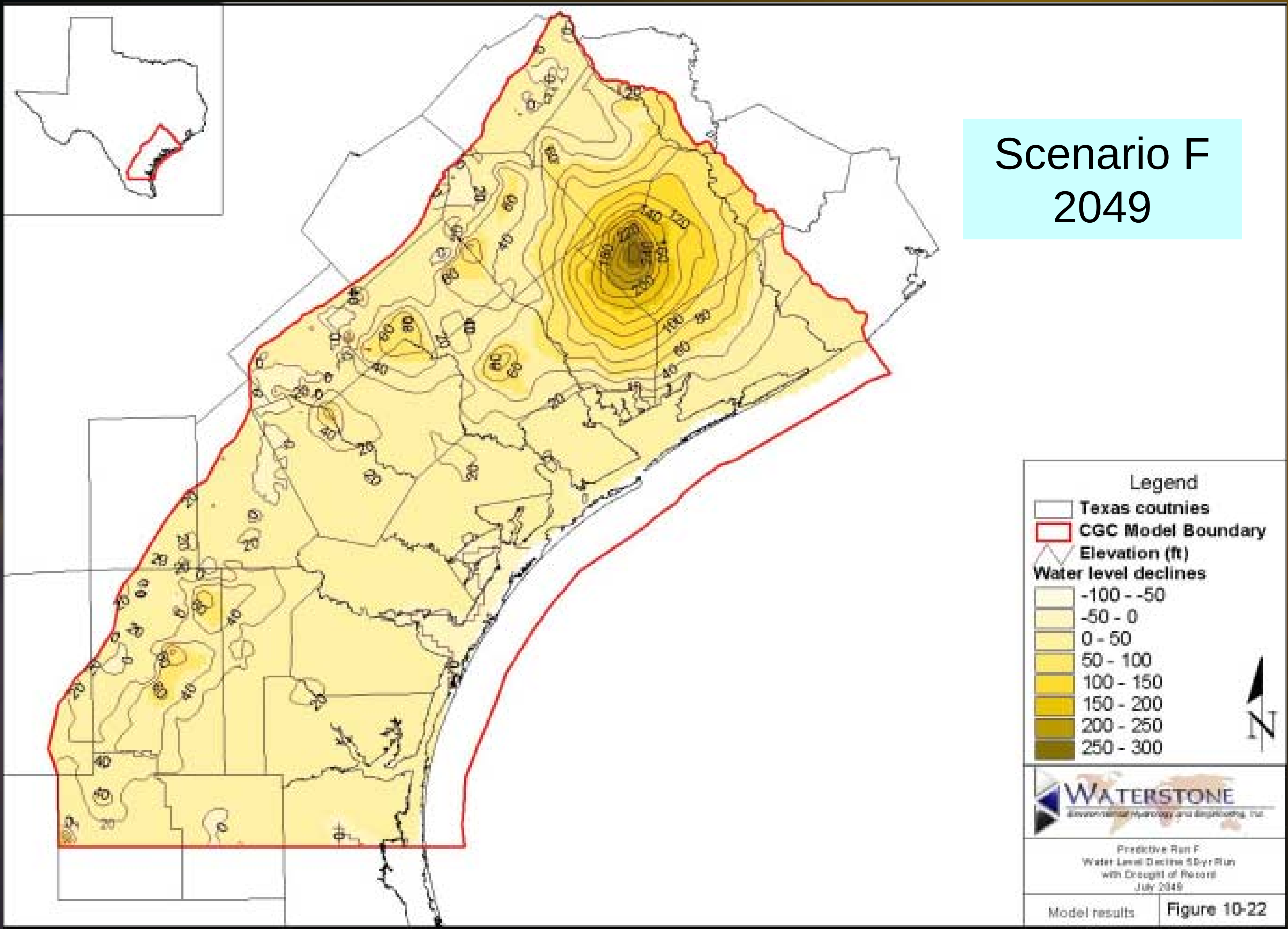
Scenario F 2049



Scenario A
2049



Scenario F
2049



Water Budget

Scenario A

- Water Budget for July 2049 after 50 years of constant recharge.

Package	Flow (acre-ft/yr) In	Flow (acre-ft/yr) Out	Percentage In	Percentage Out
Storage	269,951	2,737	26.1%	0.3%
Wells	0	886,828	0.0%	85.8%
Recharge	358,892	--	34.7%	--
Streams	738,370	422,263	71.5%	40.9%
GHB	0	81,642	0.0%	7.9%
ET	--	--	--	--
Reservoirs	9,761	0	0.9%	0.0%
Drains	--	3,094	--	0.3%
Total:	1,376,974	1,396,563	100%	100%

Layer Interface	Net	Downward	Upward
Chicot - Evangeline	-29,947	173,048	-202,996
Evangeline - Burkeville	-3,405	5,174	-8,580
Burkeville - Jasper	-960	5,504	-6,465

Note: negative net cross-formational flow is in the upward direction

Water Budget

Scenario B

- Water Budget for July 2009 after 4 years of constant recharge, then a 6-year drought of record

	Flow (acre-ft/yr)		Percentage	
Package	**In**	**Out**	**In**	**Out**
Storage	839,424	4,657	84.9%	0.4%
Wells	0	864,002	0.0%	82.4%
Recharge	120,132	--	12.1%	--
Streams	17,560	86,395	1.8%	8.2%
GHB	0	27,970	0.0%	2.7%
ET	--	64,929	--	6.2%
Reservoirs	11,823	0	1.2%	0.0%
Drains	--	421	--	0.0%
Total:	988,938	1,048,373	100%	100%

Layer Interface	Net	Downward	Upward
Chicot - Evangeline	-384,976	63,129	-448,105
Evangeline - Burkeville	-44,657	547	-45,204
Burkeville - Jasper	-16,951	1,018	-17,968

Note: negative net cross-formational flow is in the upward direction

Water Budget

Scenario C

- Water Budget for July 2019 after 14 years of constant recharge, then a 6-year drought of record

Package	Flow (acre-ft/yr)		Percentage	
	In	Out	In	Out
Storage	835,653	4,166	84.8%	0.4%
Wells	0	863,227	0.0%	82.2%
Recharge	120,132	--	12.2%	--
Streams	17,850	88,523	1.8%	8.4%
GHB	0	28,361	0.0%	2.7%
ET	--	65,441	--	6.2%
Reservoirs	11,833	0	1.2%	0.0%
Drains	--	424	--	0.0%
Total:	985,467	1,050,142	100%	100%

Layer Interface	Net	Downward	Upward
Chicot - Evangeline	-380,411	66,521	-446,932
Evangeline - Burkeville	-46,101	494	-46,595
Burkeville - Jasper	-17,374	972	-18,346

Note: negative net cross-formational flow is in the upward direction

Water Budget

Scenario D

- Water Budget for July 2029 after 24 years of constant recharge, then a 6-year drought of record

	Flow (acre-ft/yr)		Percentage	
Package	**In**	**Out**	**In**	**Out**
Storage	839,990	3,815	84.9%	0.4%
Wells	0	869,908	0.0%	82.3%
Recharge	120,132	--	12.1%	--
Streams	18,021	89,373	1.8%	8.5%
GHB	0	28,481	0.0%	2.7%
ET	--	65,480	--	6.2%
Reservoirs	11,821	0	1.2%	0.0%
Drains	--	425	--	0.0%
Total:	989,964	1,057,482	100%	100%

Layer Interface	Net	Downward	Upward
Chicot - Evangeline	-382,760	67,717	-450,477
Evangeline - Burkeville	-46,440	469	-46,909
Burkeville - Jasper	-17,732	941	-18,672

Note: negative net cross-formational flow is in the upward direction

Water Budget

Scenario E

- Water Budget for July 2039 after 34 years of constant recharge, then a 6-year drought of record

	Flow (acre-ft/yr)		Percentage	
Package	In	Out	In	Out
Storage	842,037	3,805	84.9%	0.4%
Wells	0	872,635	0.0%	82.2%
Recharge	120,132	--	12.1%	--
Streams	18,026	89,918	1.8%	8.5%
GHB	0	28,548	0.0%	2.7%
ET	--	65,807	--	6.2%
Reservoirs	11,816	0	1.2%	0.0%
Drains	--	425	--	0.0%
Total:	992,346	1,061,138	100%	100%

Layer Interface	Net	Downward	Upward
Chicot - Evangeline	-384,132	68,900	-453,032
Evangeline - Burkeville	-46,555	454	-47,008
Burkeville - Jasper	-18,007	915	-18,922

Note: negative net cross-formational flow is in the upward direction

Water Budget

Scenario F

- Water Budget for July 2049 after 44 years of constant recharge, then a 6-year drought of record

Package	Flow (acre-ft/yr) In	Flow (acre-ft/yr) Out	Percentage In	Percentage Out
Storage	853,688	3,981	85.1%	0.4%
Wells	0	889,764	0.0%	82.6%
Recharge	120,132	--	12.0%	--
Streams	17,761	88,046	1.8%	8.2%
GHB	0	27,903	0.0%	2.6%
ET	--	65,869	--	6.1%
Reservoirs	11,821	0	1.2%	0.0%
Drains	--	421	--	0.0%
Total:	1,003,401	1,072,985	100%	100%

Layer Interface	Net	Downward	Upward
Chicot - Evangeline	-382,839	73,579	-456,418
Evangeline - Burkeville	-46,922	393	-47,315
Burkeville - Jasper	-18,198	901	-19,099

Note: negative net cross-formational flow is in the upward direction

Comment Period and Training

- Stakeholder comments to the TWDB by November 8th
- TWDB submits comments to Waterstone by November 29th
- December/January:
  - incorporate comments
  - TWDB and stakeholder training

Central Gulf Coast GAM
Seventh Stakeholder Forum,
October 22nd, 2002,
Ingleside, TX
List of attendees that signed the attendance list.

Name	Affiliation
Bob Keith	DOW-Seadrift
Carola Serrato	South Texas Water Authority
Cindy Ridgeway	TWDB
Cliff Lowe	EUWCD
Don Roach	SPMWD
Gilbert Barth	Waterstone
James Dodson	J.F. Welder Heirs, Ltd.
Jim Naismith	San Patricio MWD
Jim Tolan	TPWD
Larry Akers	EUWCD
Richard Hay	CWSS-TAMU-CC
Ralph Boeker Jr.	TWDB
Ronnie Hernandez	San Antonio River Authority
V. K. Malone	Goliad County GWCD

Summary of Questions/Responses/Discussion from
Seventh Stakeholder Advisory Forum
Central Gulf Coast GAM
Held
October 22nd, 2001
San Patricio Municipal Water District, Ingleside, Texas

As with postings for previous SAF meetings, this document summarizes the technical questions, answers and discussions.

1. Regarding the water-table elevation figures from the predictive model runs: which aquifer are the values from?

Response: The water-table elevations represent data from all the aquifers. For any particular location the figure indicates the water-table elevation of the top aquifer at that location.

2. The predictive run results seem to be highly dependent on the pumping projections. How confident are you in the projections?

Response: You would probably need to examine the level of effort expended by the individual planning groups.

3. So the pumping projections should reflect the implementation of the projects that are included in the regional plans?

Response: Yes. It is worth noting that a lot of the strategies that were added into the regional water planning groups were vague, and did not have very much detail for many different reasons. However, a model run requires very specific information so the challenge was to interpret the relatively vague information and produce a set of model input files for the predictive runs. It may turn out creation of a reasonable pumping predictions requires an iterative process to refine the amount, and spatial and temporal distribution of pumping.

4. There are a few areas where I would expect a fair amount of pumping, but the model prediction indicates only a small amount of water level decline. Is there an explanation for this?

Response: It could be due to a number of reasons. It may be that the hydrogeology and recharge in that area are able to sustain a high rate of pumping. It could also be that the pumping rates simulated are different from your expectations, which may be the result of the reporting of the manner in which the projections were evaluated.

5. Can you briefly cover some of the sections in the draft report on limitations and future improvements?

Response: Limitations focus on the quality and spatial refinement of data incorporated into the model. The scale of the model and the grid cell size impose practical limits on the level of detail that can be incorporated into the representation of any of the hydraulic parameters or boundary conditions.

6. Does the report contain information on how the approach may have been modified in the process of developing the model?

Response: Yes. The report provides details of any modifications in methodology. Where there were modifications, the modifications and justification are included in the descriptions of individual parameters.

7. Was there analysis of the how confidence in the model simulations is affected by the lack or scarcity of data in certain areas?

Response: No. Uncertainty analysis would have required a considerable amount of additional effort beyond the scope of the GAM projects.

8. Is water quality included in the model?

Response: No. The GAM models only simulate groundwater quantity. It would be possible to apply particle tracking to perform a basic assessment of transport directions but a full assessment of water quality requires a great deal more model inputs and a model capable of representing the geochemical interactions. The only information on water quality is supplied as an appendix which summarizes water quality at a point in time.

9. In terms of water supply though, it is not just a matter of water quantity, but the quality that matters as well?

Response: Correct. That is why we included the section on water quality, to make people aware of the quality issues. Simulation of water quality will need to be addressed in the future. The CGC GAM provides an excellent foundation; it provides the flow system that would be the precursor for any water quality model. In a general sense the model can provide some indication of the potential for saltwater intrusion. Model runs that indicate a net inflow through the general head boundary, which is the coastline, will indicate water moving from the ocean into the aquifer. This did not occur for any of the model runs performed

10. What about cross-formational flow, can it provide water quality information?

Response: No. Cross formational flow is only with regard to water within the system.

11. How are you defining fresh water?

Response: The 10,000 ppm salinity line from maps by Pettijohn *et al.* were used to delineate freshwater and its extent downdip.

12. So the GAM program only applies to water quantity, water quality is a separate issue. That means that the predicted water levels you are presenting just reflect a quantity of water pumped.

Response: Yes. The pumping may have produced good quality water or not, the model only provides an indication of the quantity pumped and the impact on the aquifer.

13. This model provides a great indication of quantity, but now we need to keep thinking about quality as well. The economics of treating water requires that we have a good idea of the quality.

Response: Yes, the challenge will be trying to figure out what are the constituents of concern, characterizing their distribution and the subsurface parameters that control their transport, and putting it all together using the flow model as a foundation.

14. I have a question regarding some of your figures in the draft report. There are a number of figures that include reservoirs that were never built.

Response: Yes. While preparing the draft report there was a last minute mix up with one of the map coverages and unfortunately we ended up with the wrong reservoirs in that figure. The mix up did not affect the model data sets or any of the runs. The figures have been corrected.

15. There seems to be very little difference between the results from the 6 predictive scenarios that you performed. Would it not have been more useful to come up with scenarios that produced different results?

Response: The predictive runs scenarios are consistent across all GAMS, they may not provide an idealized set of stresses for any single GAM but they allow a comparison across the GAMs. It would have been informative, but at the same time the similarity between the runs performed provides information about the system as it was simulated in 2000 and how it would respond to changes after that time. Based on the predictive results one could tailor a specific set of scenarios to gain more insight to the CGC GAM. Testing different scenarios is one of the primary objectives of any GAM model.

16. Does the model incorporate any variability of hydraulic properties?

Response: Yes, transmissivity varies as a function of both the aquifer thickness and sand percentages.

17. I thought the drought of record had been re-evaluated. Is the drought of record really the 1950s for this area?

Response: For the CGC area as a whole, yes the period from 1951 through 1956 is the drought of record. For regions within the CGC there may well be other periods that were more stressful but for the GAM we wanted as much of the region to be impacted as possible. The transient simulations included droughts in the 1980s and 1990s, but the 1950s period had a more severe impact on the system as a whole.

18. Did the transient runs end in a period of drought?

Response: No, the drought during the 90s occurred primarily in 1995 through 1997, so there were two years of recovery prior to the end of the simulations. The conditions from the end of these simulations provided the starting point for the predictive runs.

19. Can we supplement or refine existing model input to improve the accuracy of predictions in specific areas?

Response: Yes, that would be possible. The important thing would be to insure that the methods of evaluating parameters was similar to that used for the rest of the model, and that a sufficient QA/QC process performed.

20. How difficult would it be to split out the model on a county by county basis?

Response: It would be difficult, impractical and misleading. The extents of the CGC GAM were selected so that the boundary assumptions would have minimal impact on the model. A county model would be driven almost entirely by the boundary conditions derived from the CGC GAM. Any changes to the county model that interacted with the boundaries would require using CGC GAM to revaluate the boundaries.

21. How can we use the CGC GAM to determine well spacing?

Response: GAMs should not be used for well spacing. There are analytical equations that will provide a much better evaluation of well spacing on the scale that would typically be relevant to well spacing. The discretization of the GAM models precludes their use as effective methods of determining well spacing.