



Waterstone

Environmental Hydrology Inc.



Groundwater Availability Model (GAM):

Gulf Coast Aquifer

Stakeholders Advisory Forum

1st Quarterly Meeting

RWPG Regions K,L,N & P

April 27, 2001

Texas A&M University

Corpus Christi, TX



Presentation Topics



- **Groundwater Availability and the GAM Program**
 - What is groundwater availability?
 - What is the GAM Program?
 - Why is GAM important?
 - Previous Studies

- **Who is the Gulf Coast GAM Team?**
 - Overview and Qualifications



Presentation Topics (cont)



- **Overview of the Gulf Coast Aquifer GAM**
 - **Basics of groundwater flow in the GC aquifer**
 - **Why use a numerical model?**
 - **Where are we heading and how fast are we going?**



What is Groundwater Availability?



- **Groundwater availability... is simply the amount of groundwater that is available for use from an aquifer.**
- **It requires both the guidance of policy and the procedures of science (hydrology).**



What is the TWDB Groundwater Availability Model (GAM) Program

Approved during the 76th legislative session to:

- **Provide reliable and timely information on groundwater availability to the citizens of Texas,**
- **A tool to ensure adequate supplies (or recognize inadequate supplies) over a 50-year planning period.**

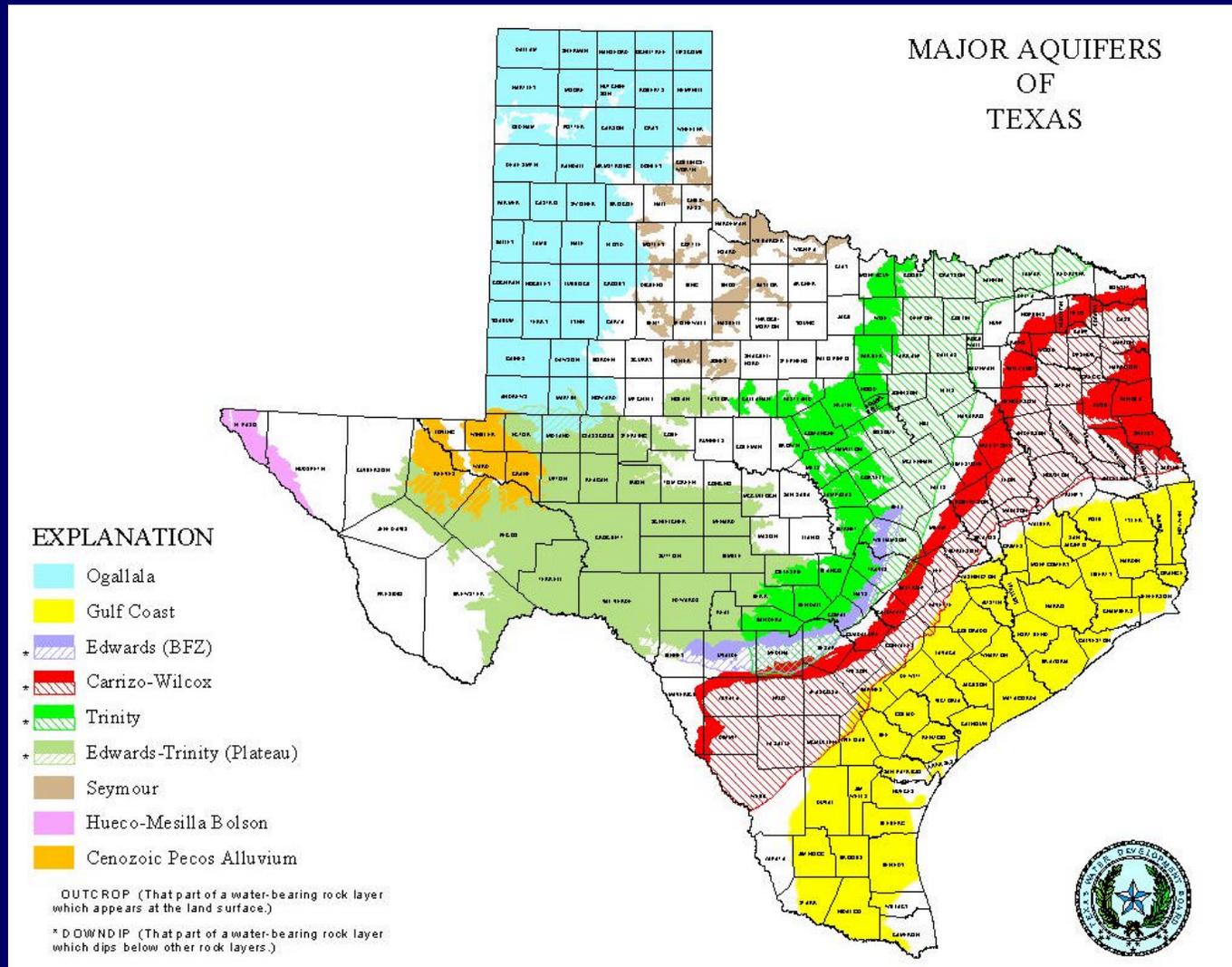


What is the TWDB Groundwater Availability Model (GAM) Program

GW Availability is accessed by the Regional Water Planning Groups. The RWPGs will pose the policy question (What if?) and GAM models of the major aquifers will provide an estimate of the GW Availability.



Major Aquifers in Texas





GAM Models

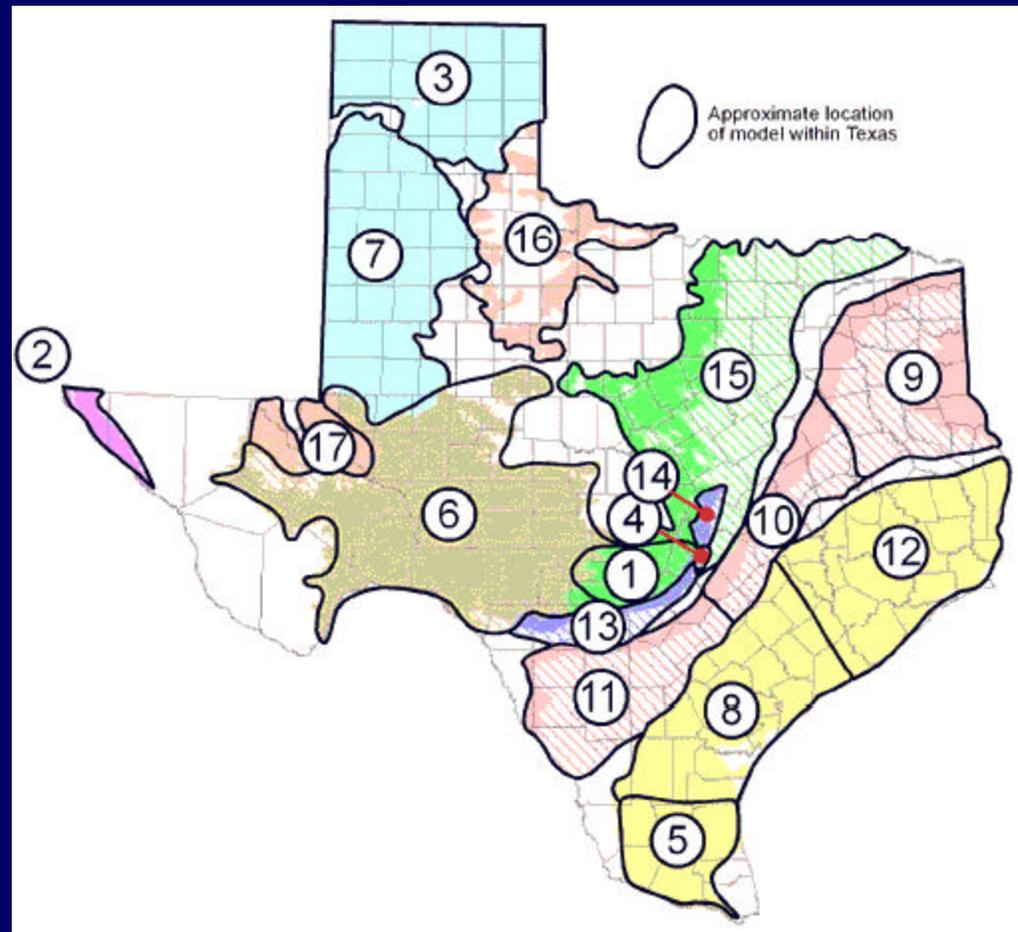


■ Ongoing:

- 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)





Expectations of GAM



GAM is expected to:

- **Include substantial Stakeholder input,**
- **Result in standardized, publicly available numerical groundwater flow models and supporting data,**
- **Provide predictions of groundwater availability through 2050 during normal and drought-of-record conditions,**
- **Provide strategic water-management tools for regional water planning**



Why Is GAM Important ?



- **Groundwater availability directly impacts socio-economic and environmental goals of the communities.**
- **GAM will facilitate standardized long-term planning across each RWPG with the best available scientific technology.**



Previous Gulf Coast Modeling Studies



- **From 1965 – 2000: Fifteen relevant studies**
 - **Eight focused on Houston Area**
 - **Two focused on Lower Rio Grande Valley Area**

- **Most relevant modeling studies are:**
 - **Region N Model (TAMU 2000)**
 - **USGS Model (2000)**
 - **Dodson (1998)**
 - **Baker (1986)**
 - **Meyer and Carr (1979)**
 - **Ryder (1988)**



TWDB GAM Enhancements



- **Standard Modeling Objectives**
- **Standardized Models**
- **Public access to raw data, model input files**
- **Integration with TNRCC WAM Studies**
- **Standardized Groundwater Availability Scenarios (long term planning)**



... Questions or
Comments Concerning
Groundwater Availability
or the GAM Program ...



... Who is the Gulf Coast GAM Team ?



Who is the Gulf Coast GAM Team ?



■ **Waterstone Environmental Hydrology Inc.**

Data Acquisition, Data Analysis, Database, GIS,
Groundwater Modeling, Reporting, Project Mgmt.

■ **Parsons Engineering Science Inc.**

Stakeholder Communication, Planning, Pumpage,
Water Quality, Database Design, WAM Contractor

■ **Duke Engineering and Services Inc.**

Groundwater Modeling Support



Who is the Gulf Coast GAM Team ?



Technical Advisors:

- **Dr. Graham Fogg**

Recognized Expert in Modeling and Geostatistical Analysis of Gulf Coast Sedimentary Systems

- **Dr. John Wilson**

Recognized International Expert in Hydrology & Sensitivity/Uncertainty Analysis of Model Results

- **Dr. John Pickens**

Recognized Expert in Regional GW Modeling, Transport, and Aquifer Testing and Data Analysis



Waterstone Team Qualifications



Extensive experience in:

- **The development and design of regional groundwater models**
- **The development and design of sensitivity and uncertainty analyses for hydrologic model results**
- **Modeling Gulf Coast Aquifers and Texas Surface Water Systems**
- **Application of geostatistics to improve model input parameter estimates**



Waterstone Team Qualifications



Unique expertise in:

- **Water Demand Forecasting**
- **Optimal groundwater management
(Decision Support Systems)**
- **The application of Landsat imagery and NEXRAD
radar to quantify key hydrologic parameters on a
regional scale (GW Recharge)**



**Texas Water
Development
Board**

Ms. Cindy Ridgeway



Technical Advisors

**John Wilson, Ph.D.
Graham Fogg, Ph.D.
John Pickens, Ph.D.**

Project Manager

Marsh Lavenue, Ph.D.

**Stakeholders Advisory
Forum (SAF)**

**Statistics/Data Analysis
&
Recharge/ET**

Alaa Aly, Ph.D.

GIS/IT

Tom Liebert

Modeling

Greg Ruskauff, M.S.

**Stakeholder
Communication
& Planning**

Randy Palacheck

Modeling Team

**T. Dale, M.S.
D. Peterson Ph.D.
R. Senger Ph.D.
A. Whallon M.S.**



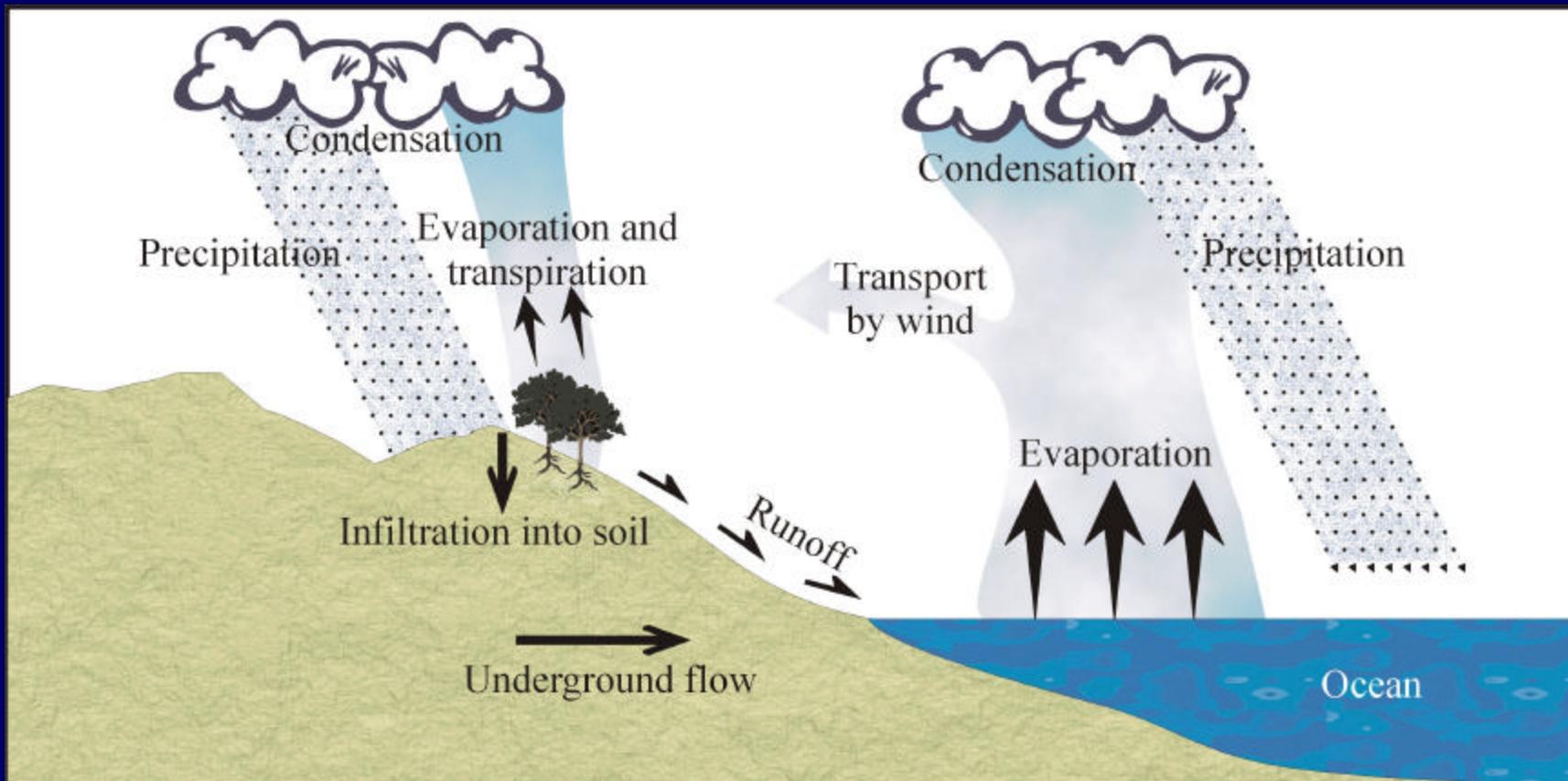
... Questions or
Comments Concerning
Gulf Coast GAM Team
Qualifications or Capabilities



Overview of the Gulf Coast Aquifer GAM

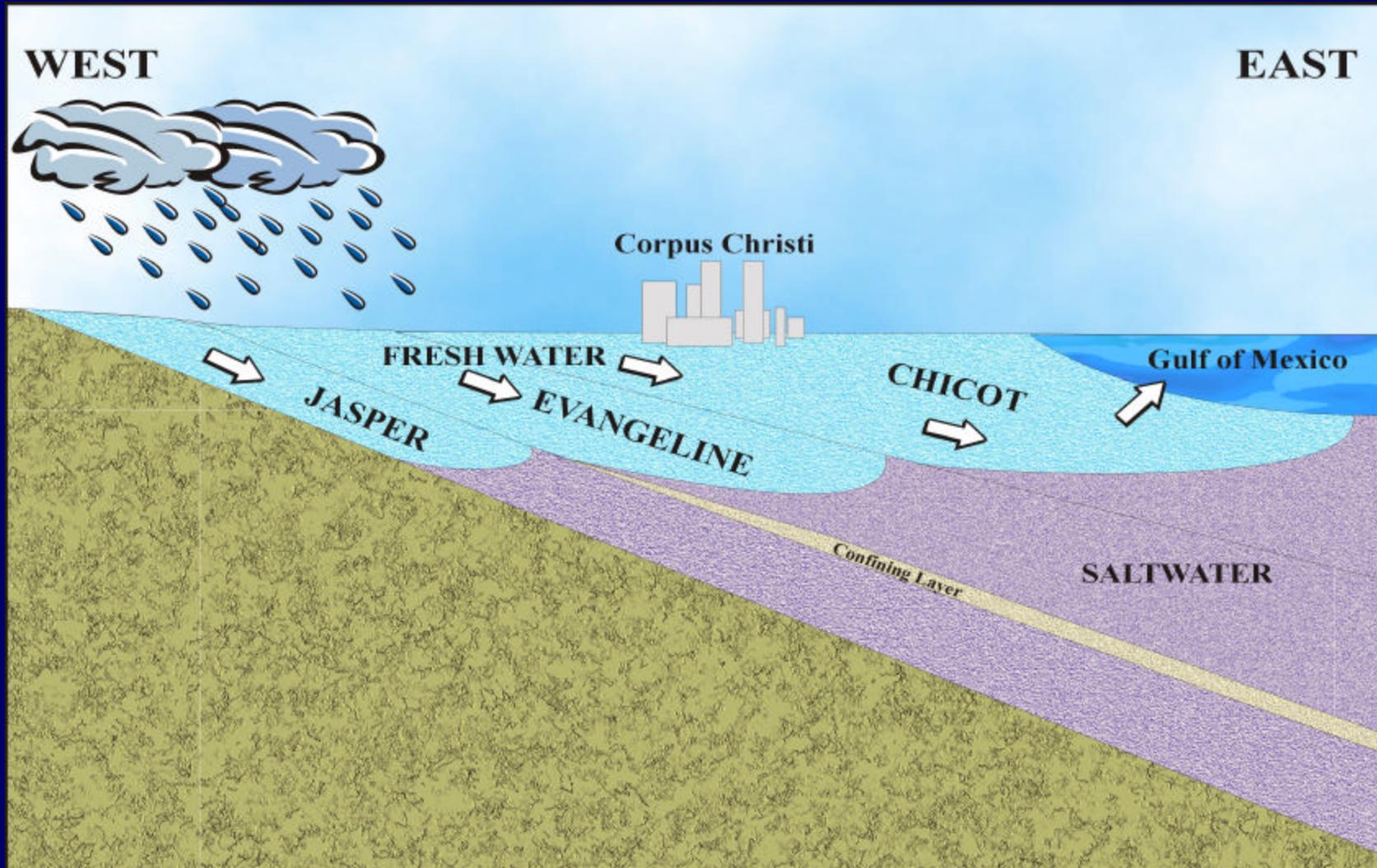


Hydrologic Cycle



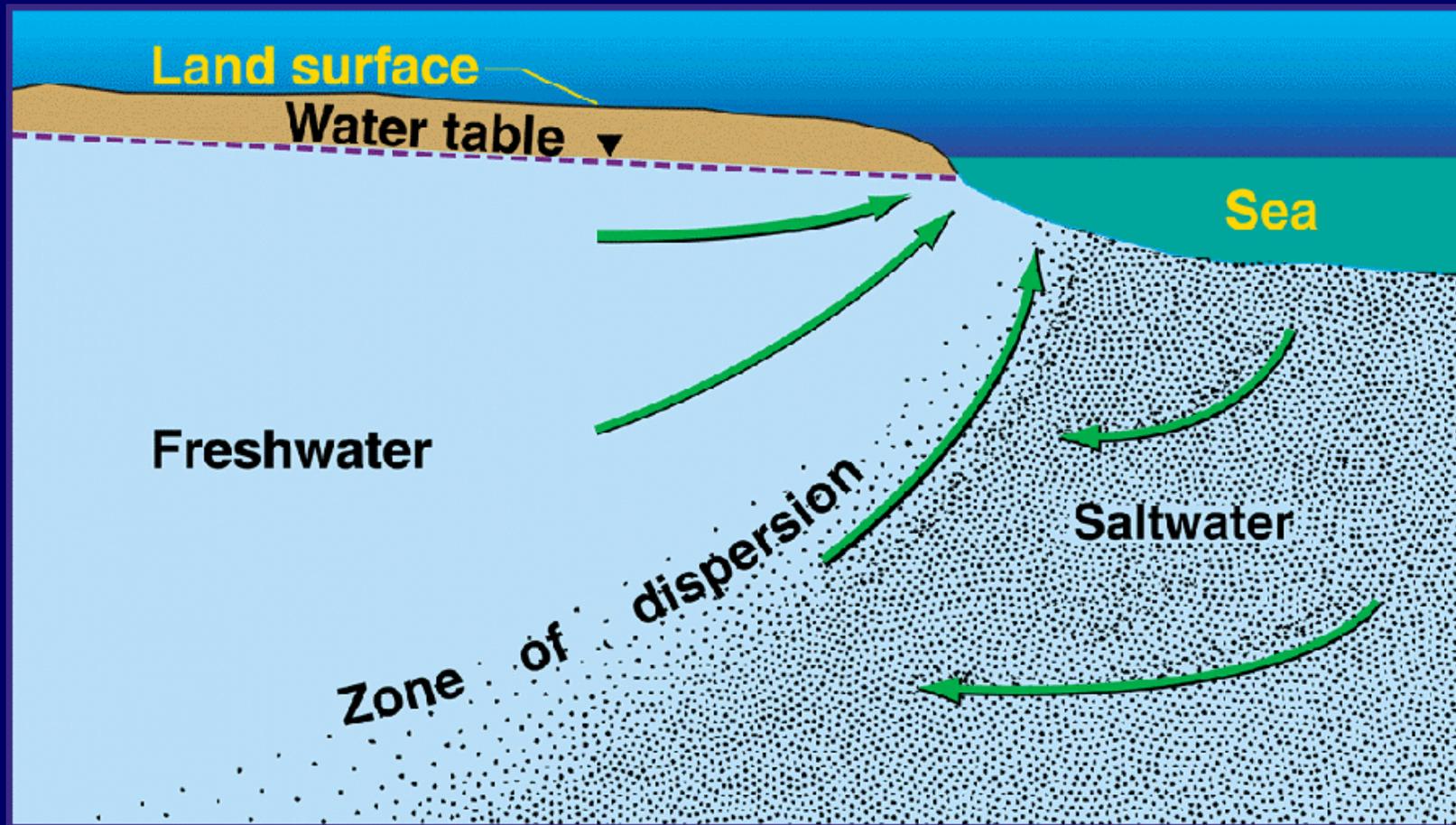


General Flow in Gulf Coast Aquifer





A Coastal Aquifer Example – Salt Water Intrusion



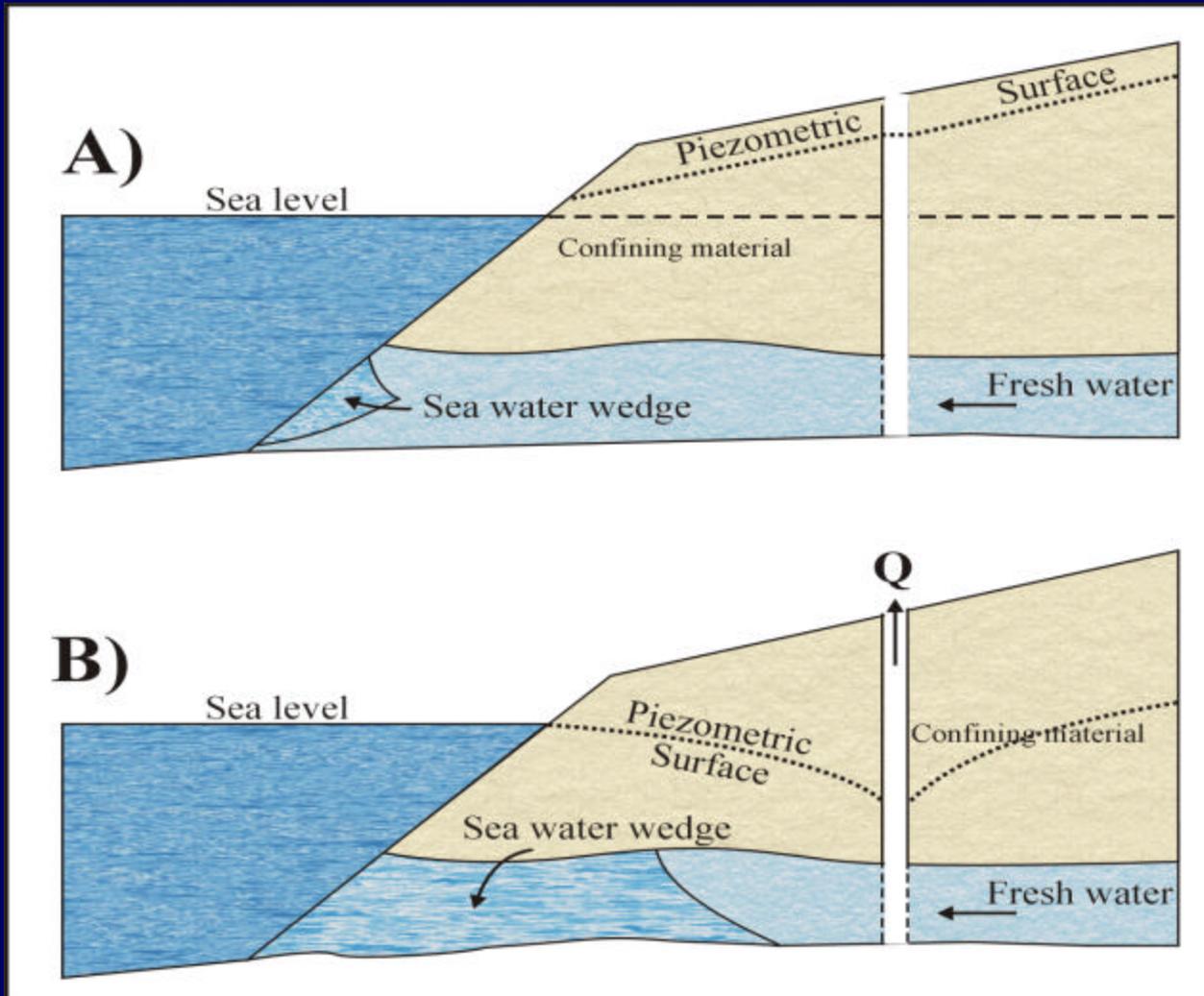


Impact of Pumping on Salt Water Intrusion



A = No Pumping

B = Pumping





What is a Groundwater Model ?



- **A Groundwater model is simply a mathematical representation of reality**
- **Model parameters represent spatial averages of aquifer properties assigned to blocks used in the model construction**
- **Model calculations have uncertainty associated with them due to the error in data, amount of data, and our simplification of reality**

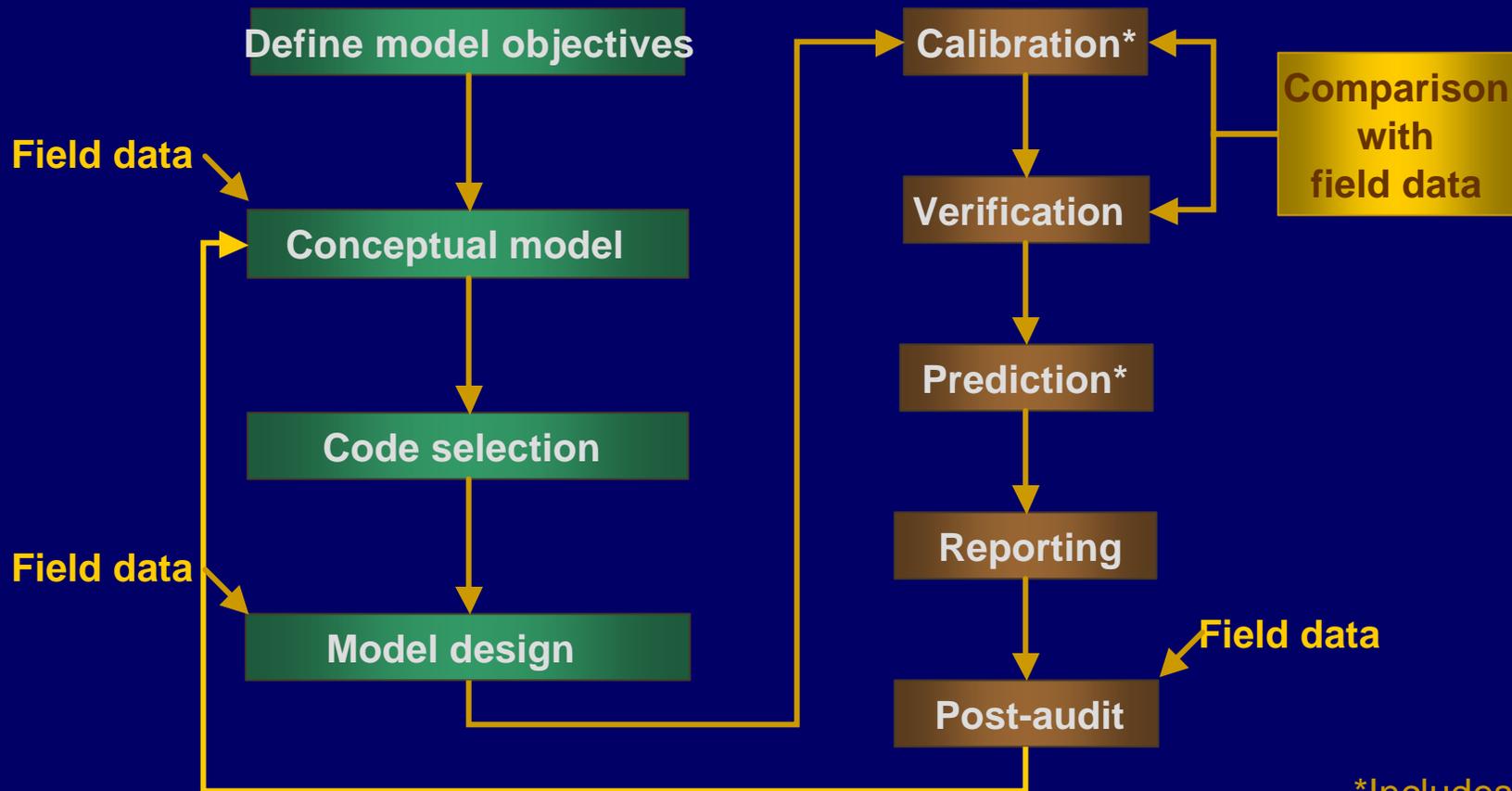


Limitations of a Groundwater Model

- **Spatial Scale Limitations**
(1 mile grid = 1 mile average water levels)
- **Temporal Scale Limitations**
- **Input Data Uncertainty (pumpage)**

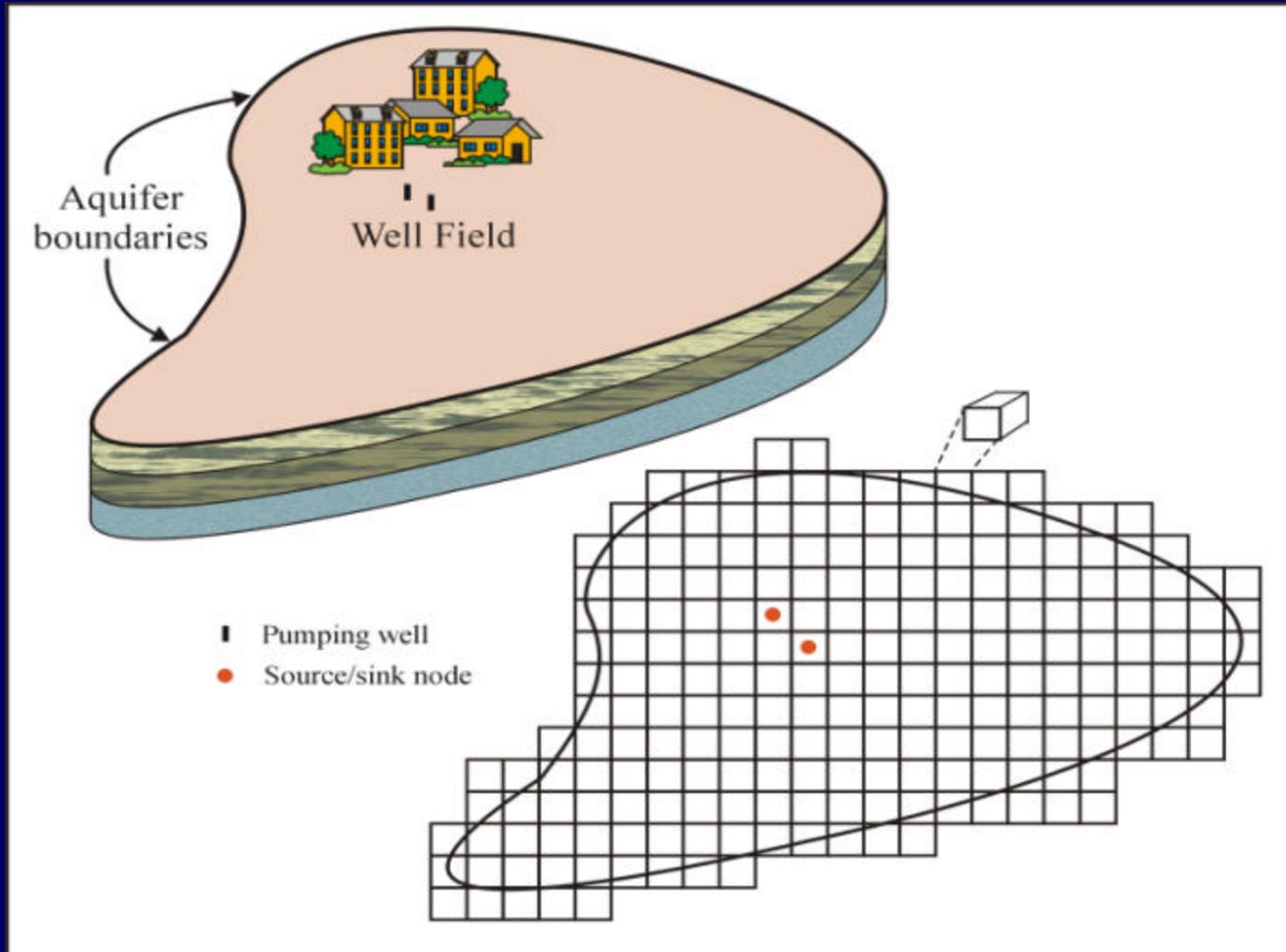


Groundwater Modeling Steps



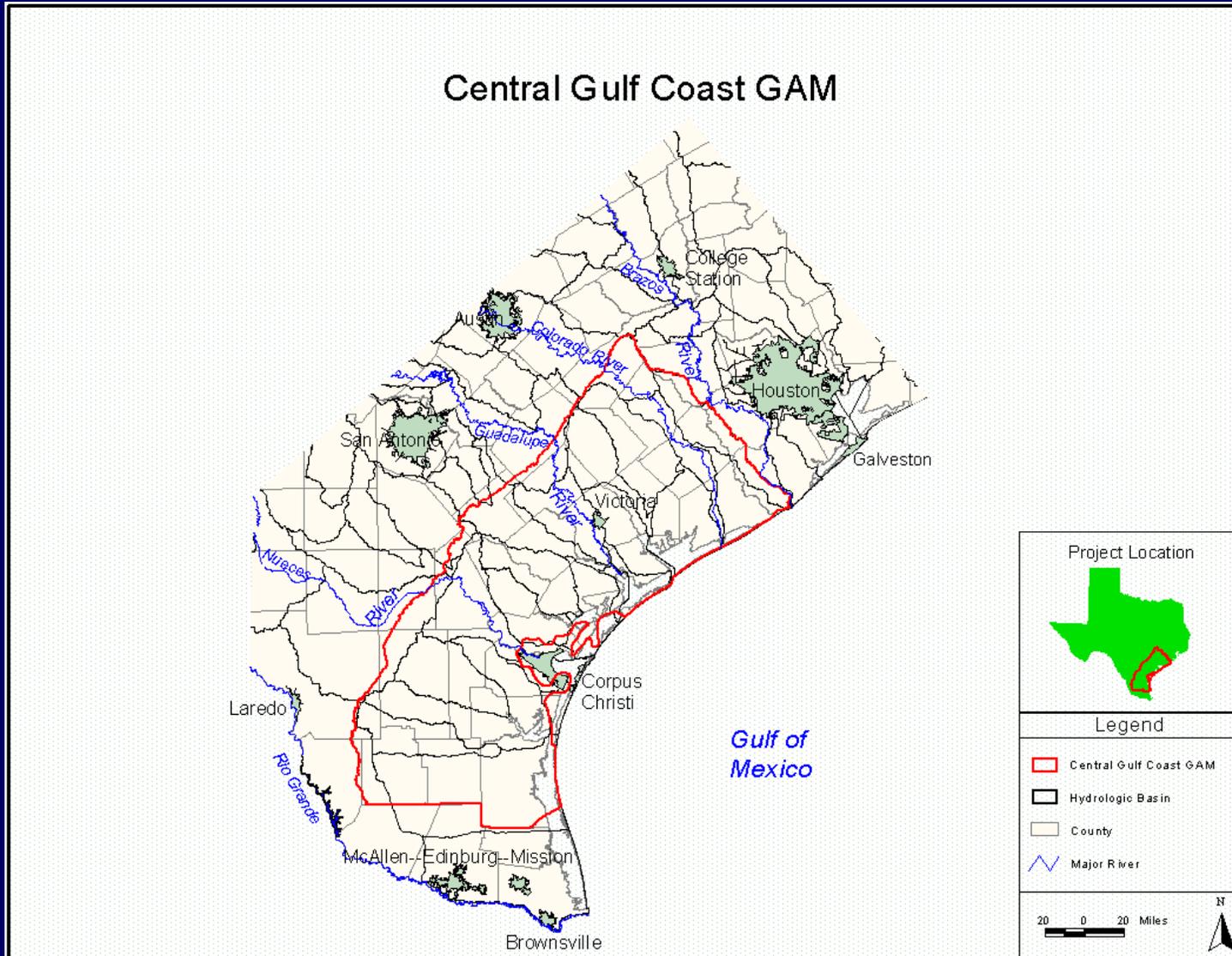


Example Groundwater Model Area & Grid



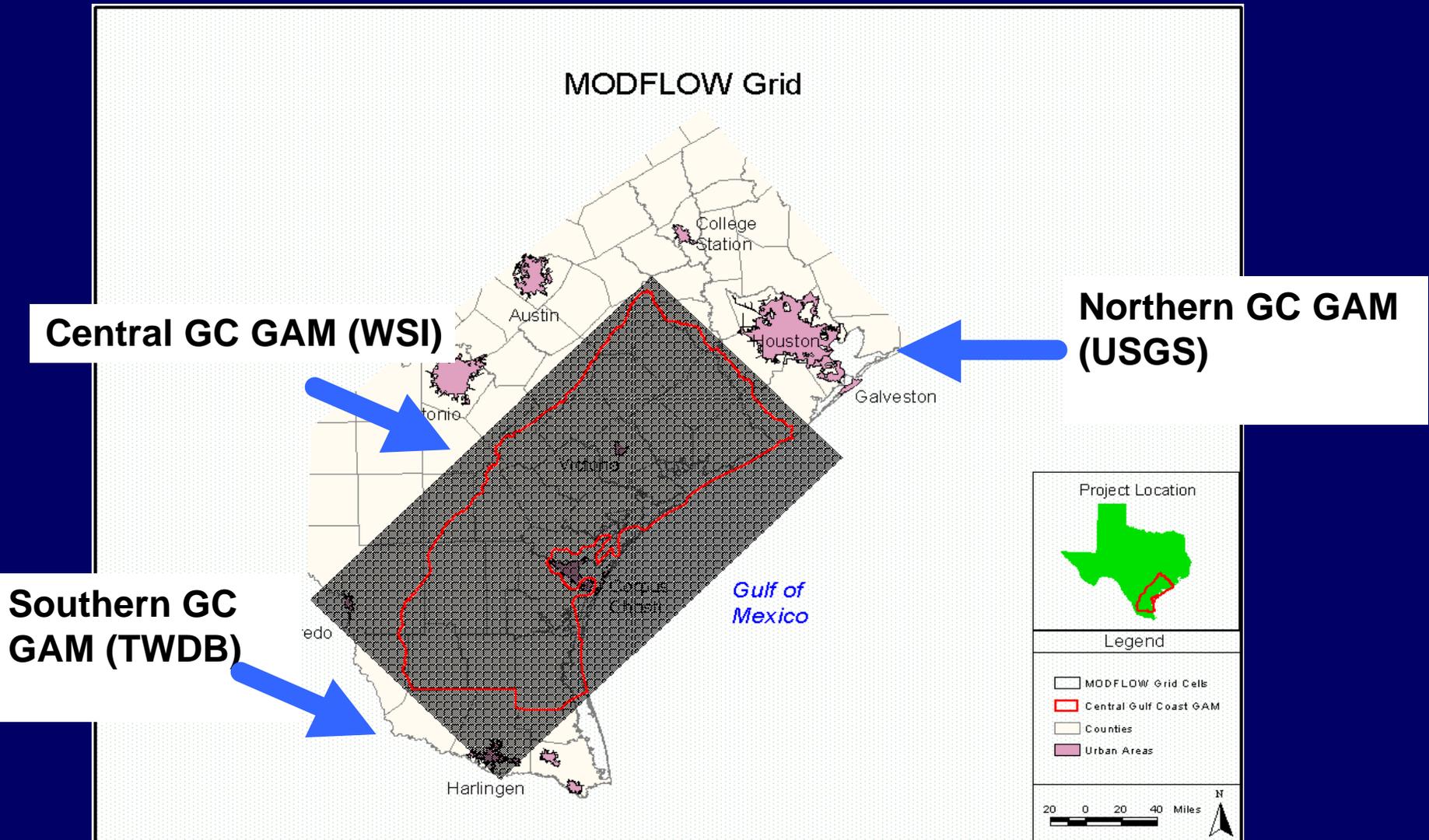


Gulf Coast Aquifer – GAM Model Boundaries



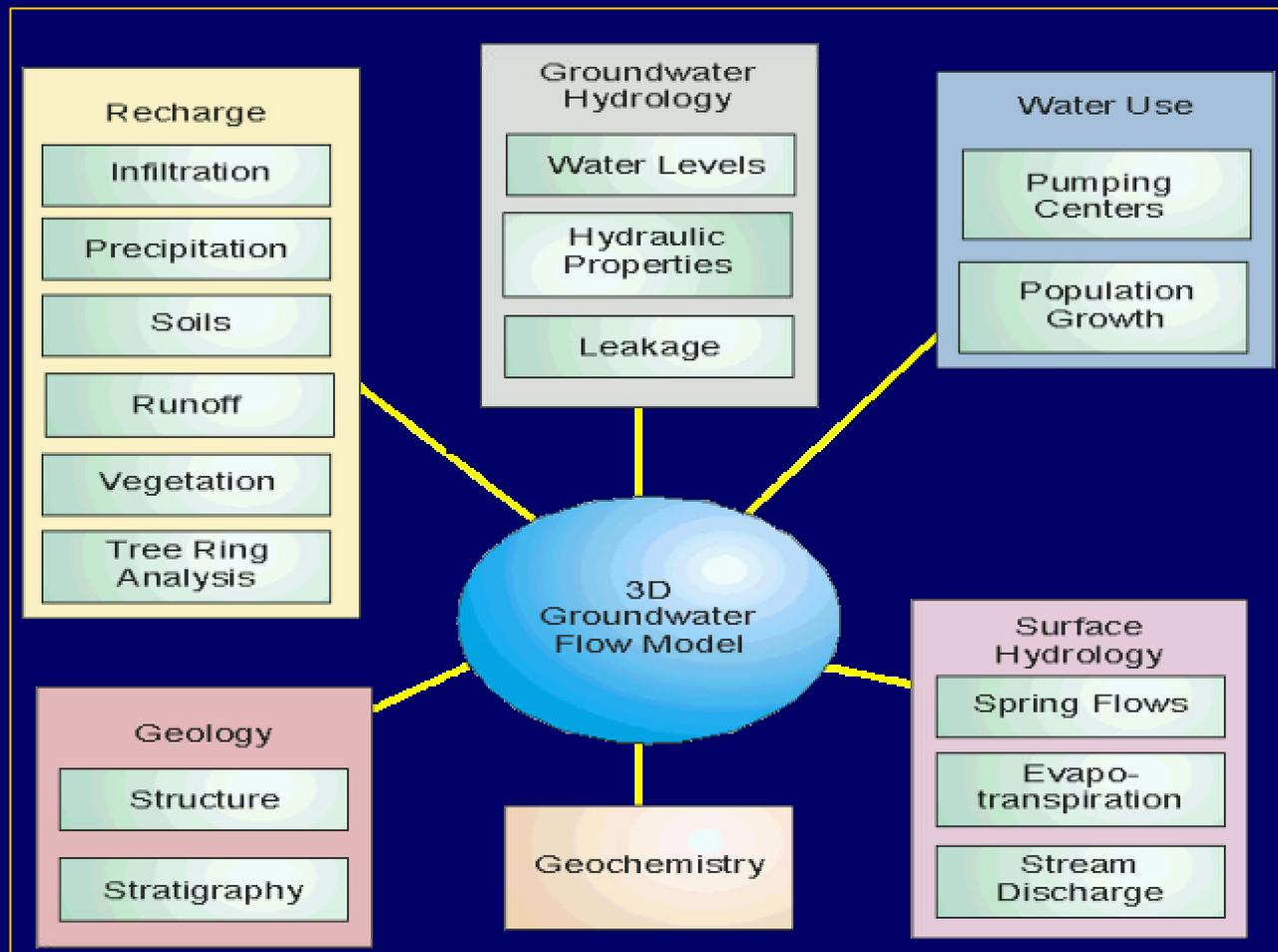


Gulf Coast Aquifer – GAM Model Grid



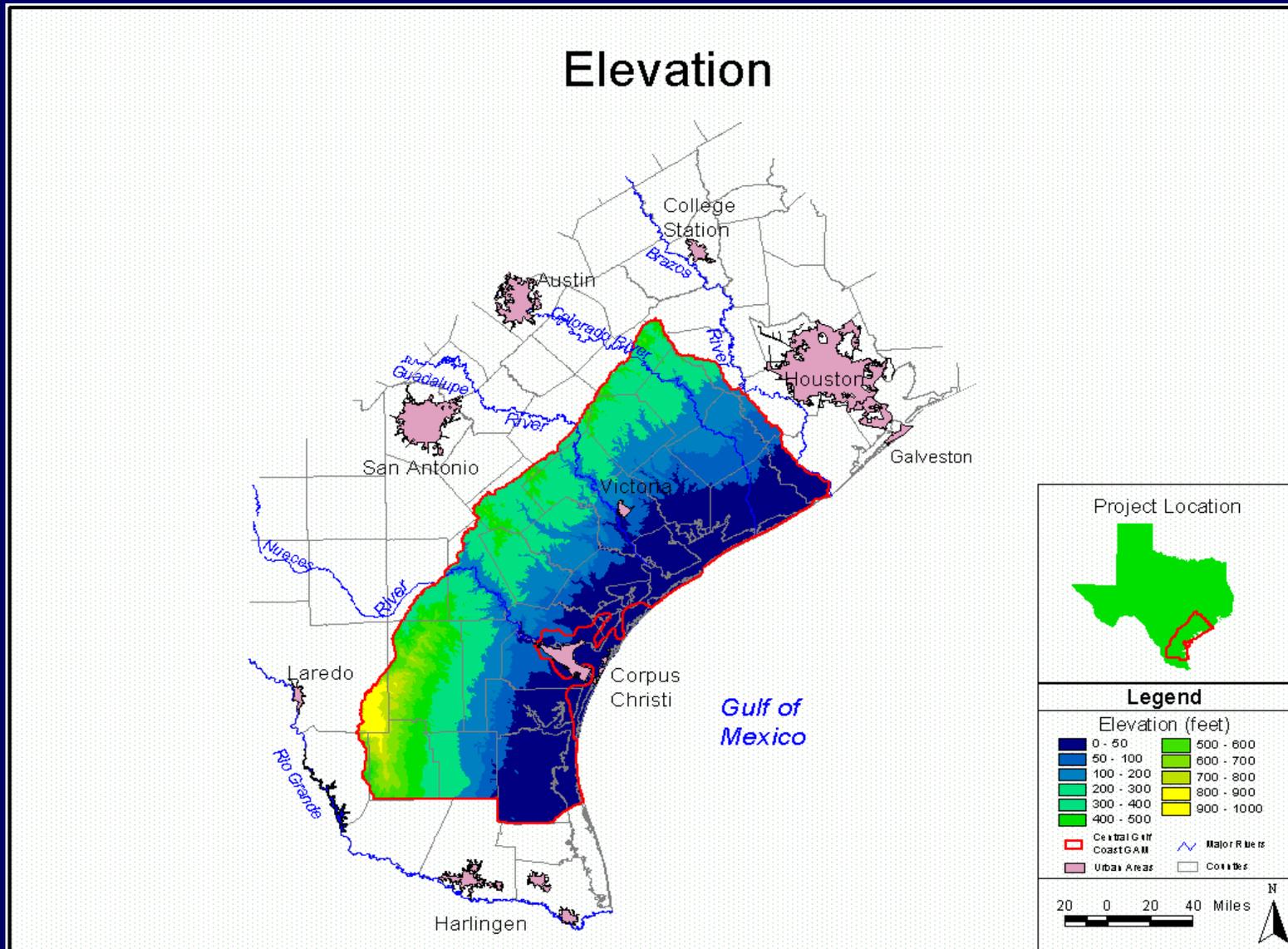


Groundwater Model Input



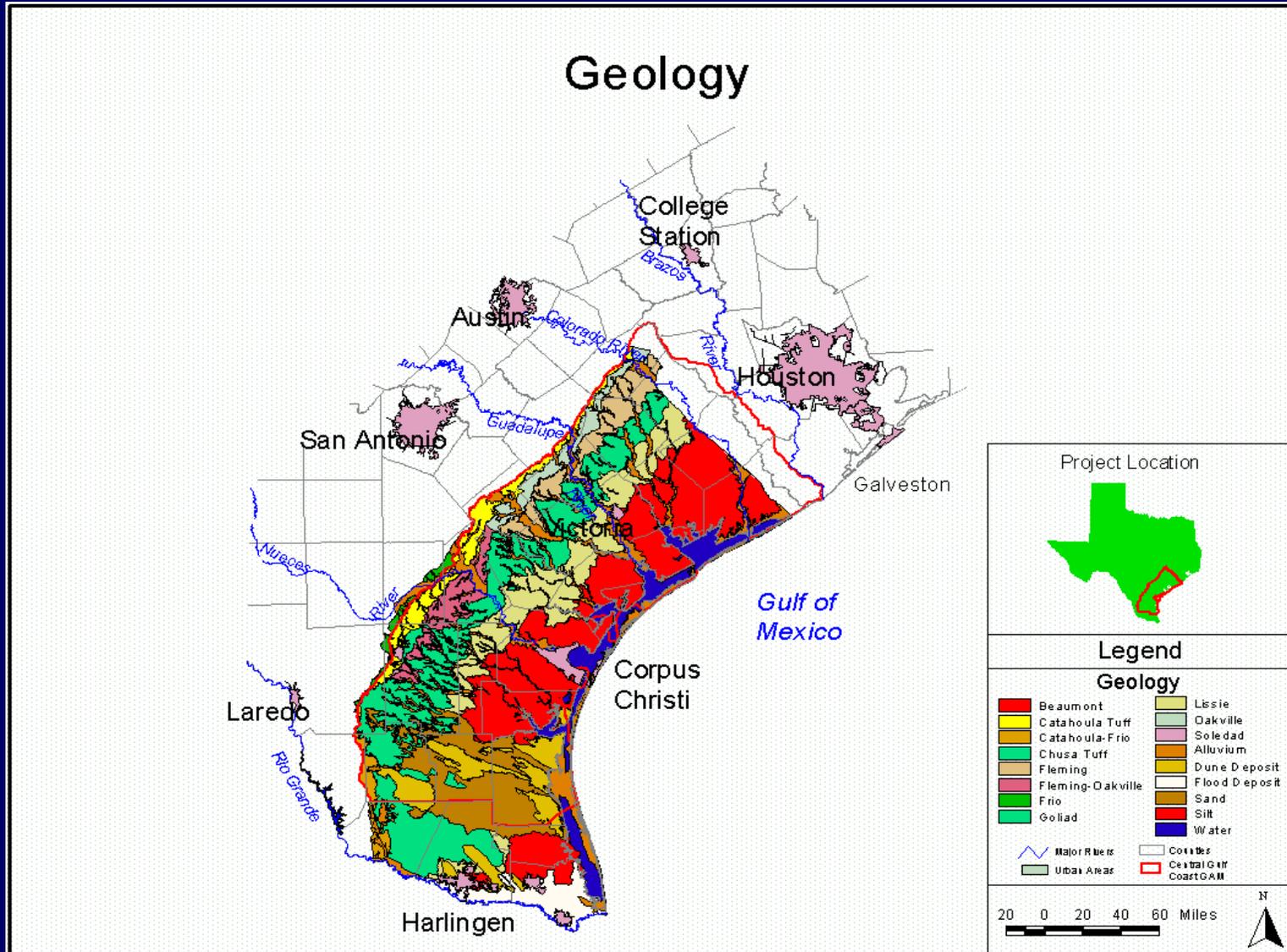


Gulf Coast Aquifer – GAM Model Surface Elevations





Gulf Coast Aquifer – GAM Model Geology (from Texas A&M Model)

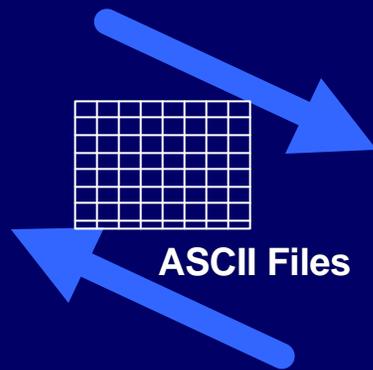




GAM Database/Modeling Interface



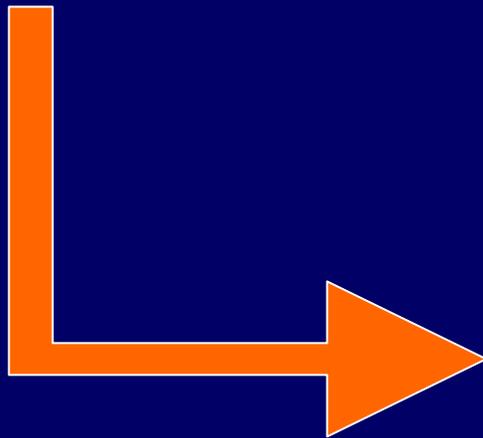
MODFLOW



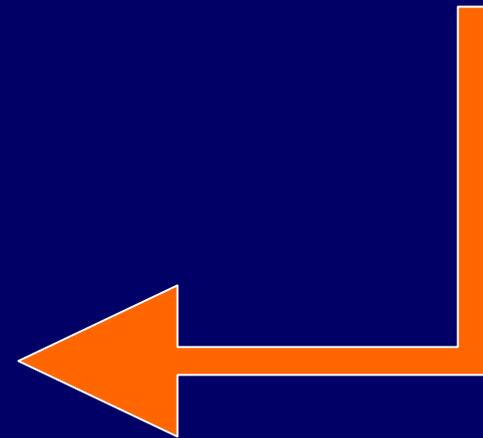
**GAM
Access
Database**



Arc View GIS



Report	
A	GW Avail. Time
B	GW Avail. Time



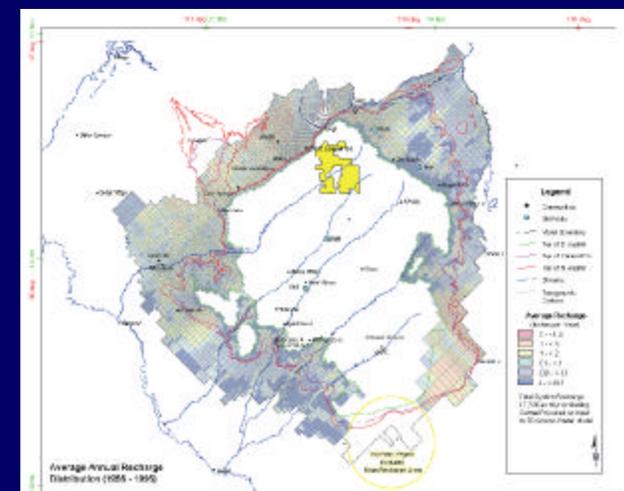
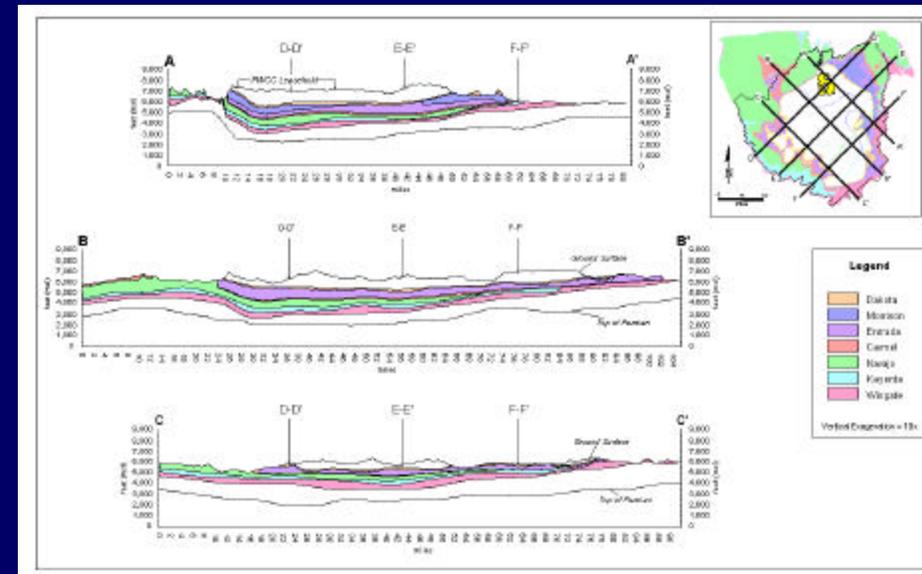


Groundwater Model Database (an example)



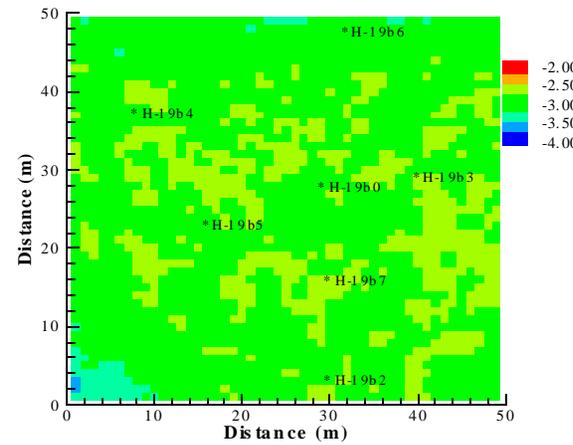
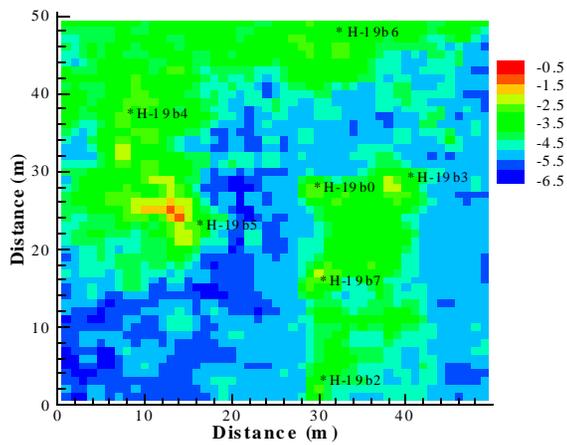
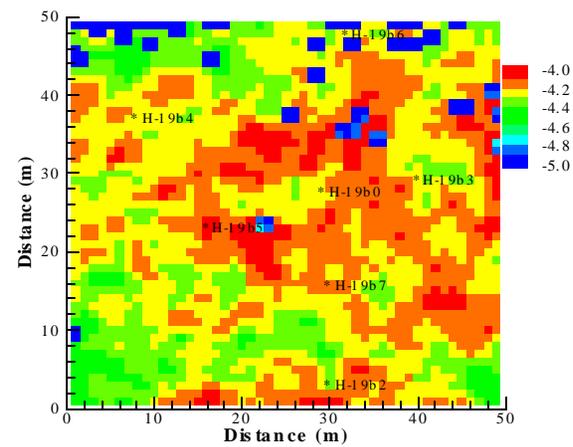
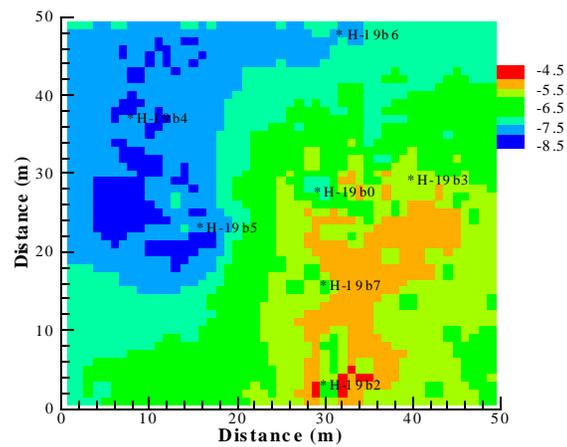
Database and GIS-Based Development of Geologic and Recharge Models

- Data Evaluation
 - Database design
- Pre-Processing
 - Geologic model
 - Recharge model
 - MODFLOW input datasets





Model Transmissivity .. (an example)





Model Calibration Quality



Evaluation Methods

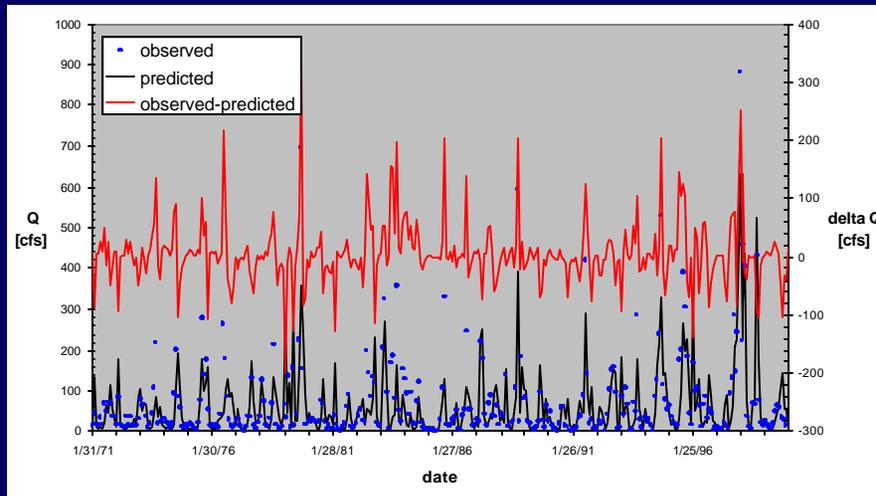
- **Qualitative**
Comparison of Contours

- **Quantitative**
Statistical Measures

- **Semi-Quantitative**
Residual Scatter Plots
Post Residuals on Contours

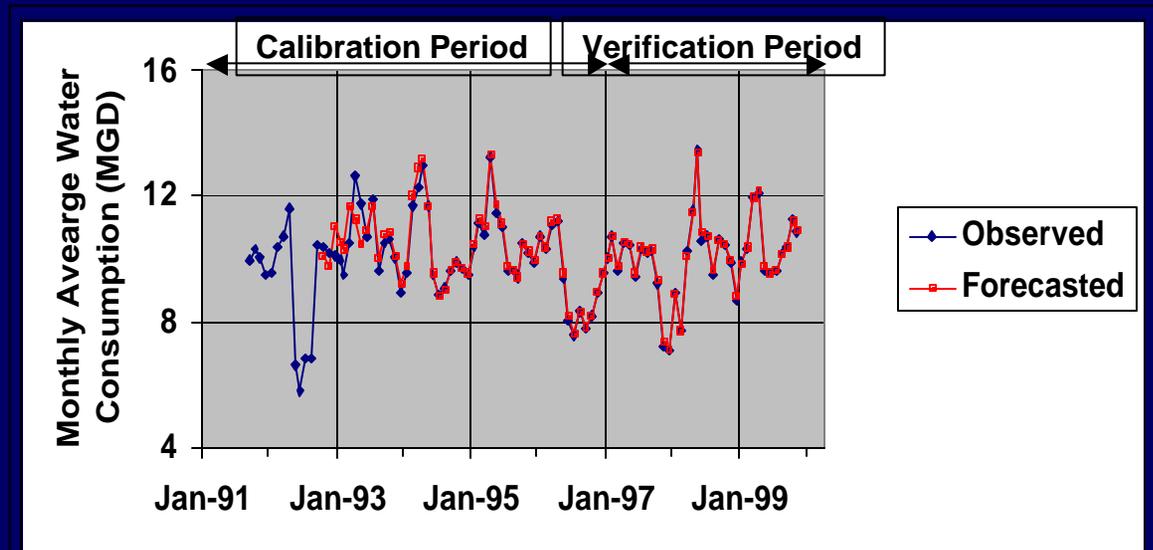


Model Quality .. (an example)



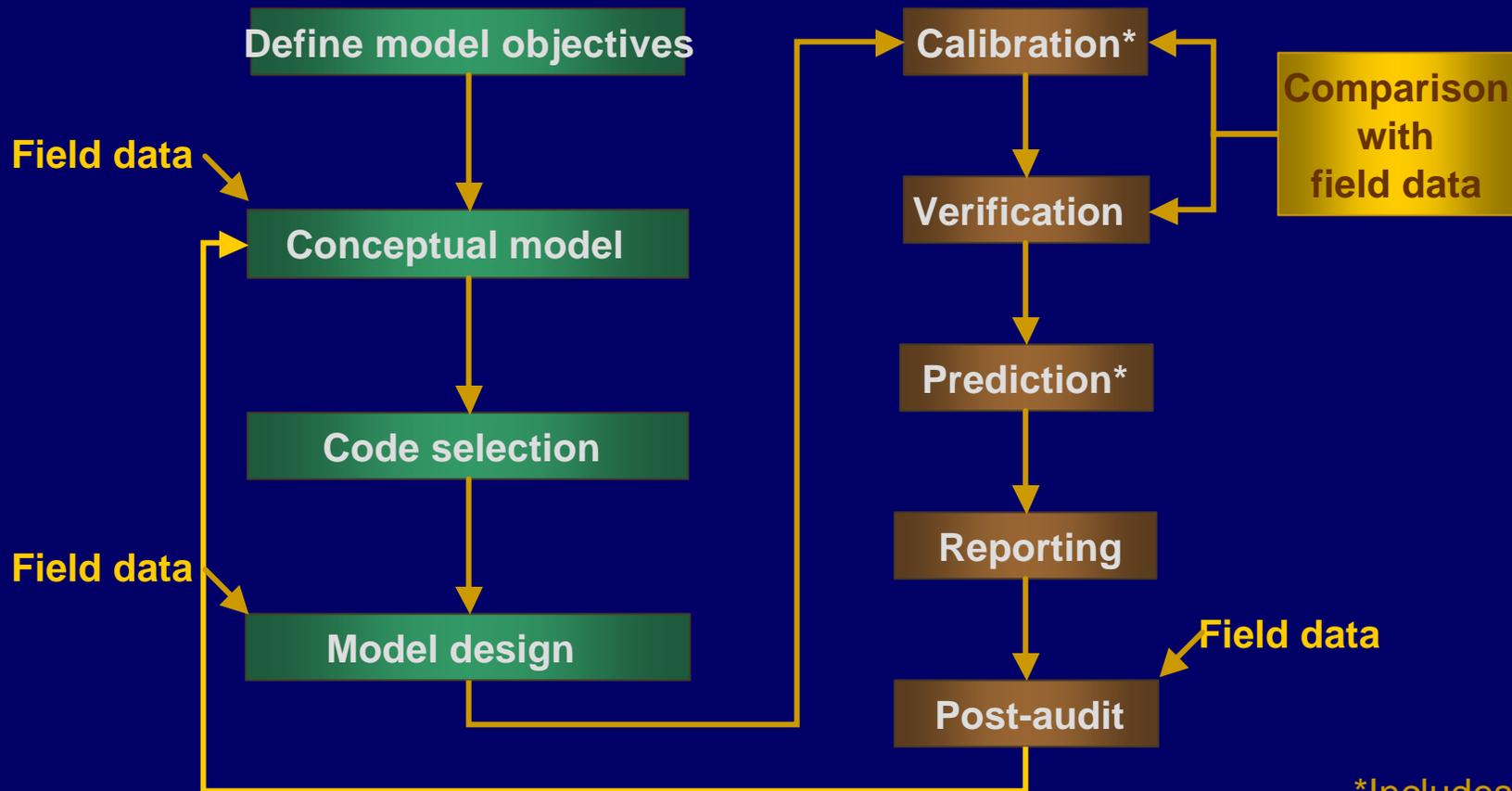
Surface Water Model

Groundwater Model





Groundwater Modeling Steps

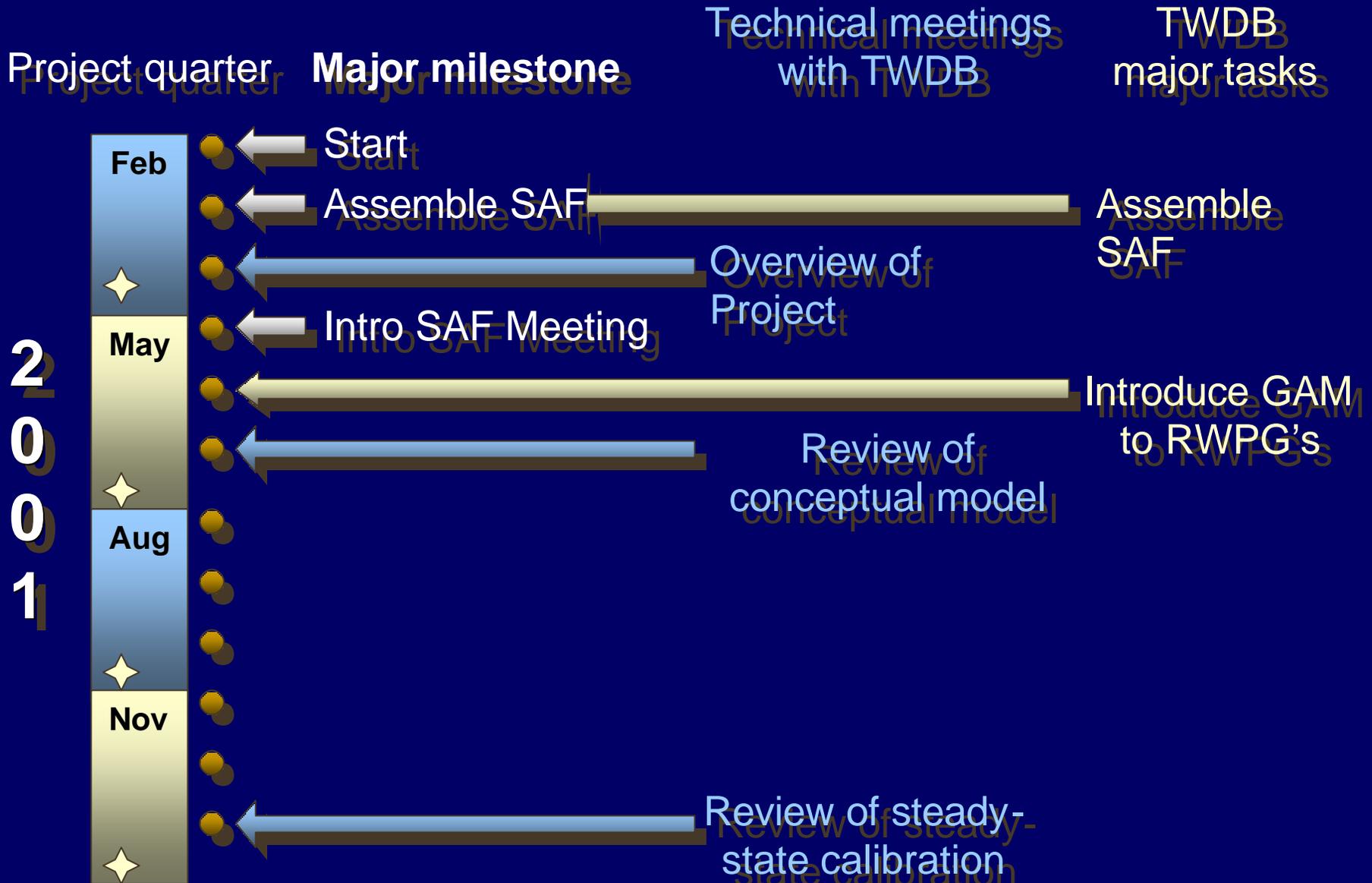


*Includes sensitivity analysis

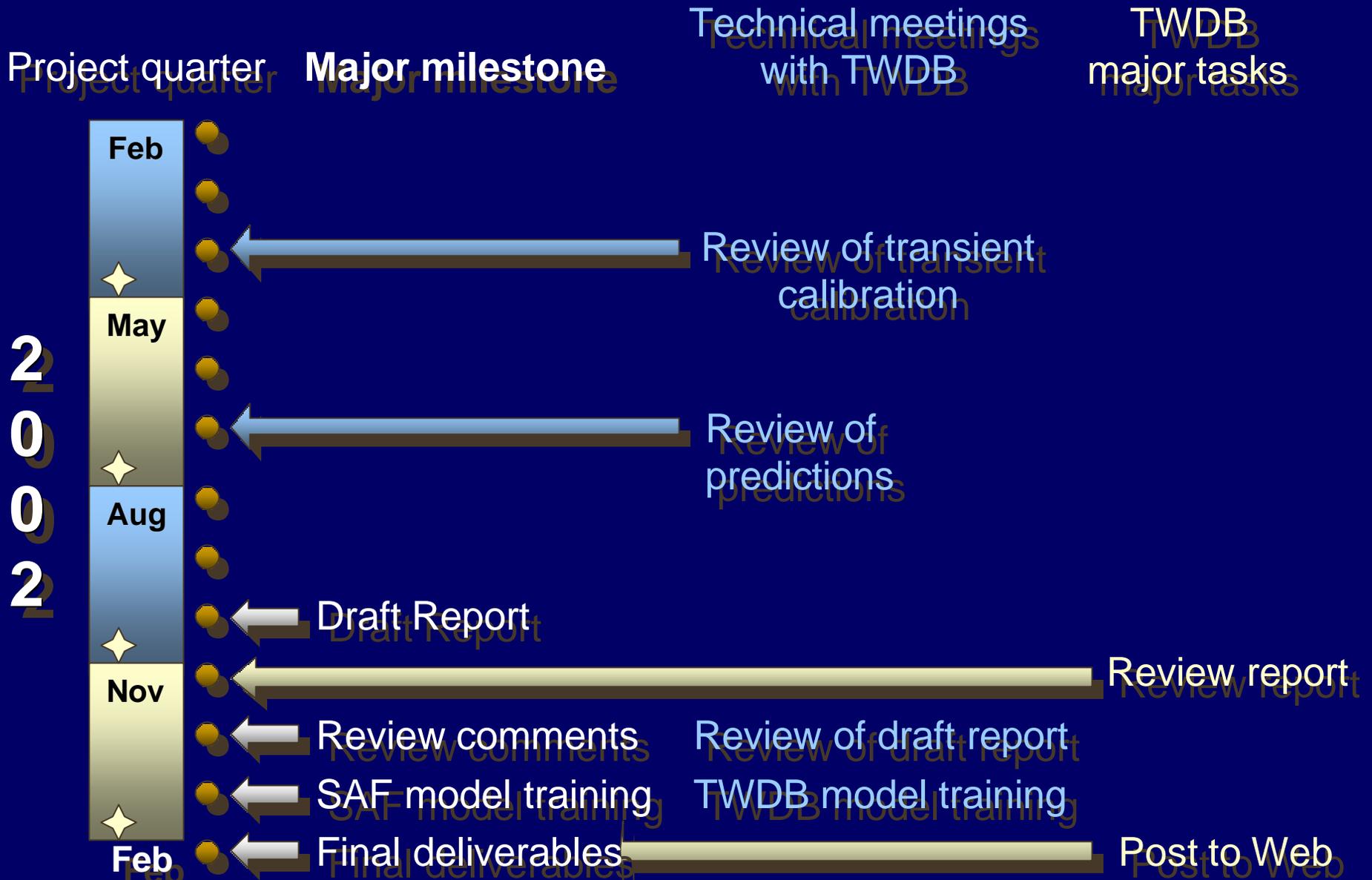


Scope and Schedule for Gulf Coast Aquifer GAM

- Monthly Reports
- ★ Quarterly Stakeholder Advisory Forum (SAF) meeting



- Monthly Reports
- ★ Quarterly Stakeholder Advisory Forum (SAF) meeting





... Questions or
Comments Concerning
Gulf Coast GAM
Schedule or Tasks



Waterstone

Environmental Hydrology Inc.

Stakeholder Advisory Forum (SAF)

Central Gulf Coast Aquifer Groundwater Availability Model

Forum Meeting No. 1

Friday, April 27, 2001, at 1:00 P.M.

Texas A&M University – Corpus Christi

Natural Resources Center, Room 1003

6300 Ocean Drive

Corpus Christi, Texas 78412

List of Attendees

<u>Name</u>	<u>Affiliation</u>
Marsh Lavenue	Waterstone Environmental Hydrology and Engineering Inc.
Randy M. Palachek	Parsons
Cindy Ridgeway	Texas Water Development Board
Robert Mace	Texas Water Development Board
Robert Flores	Texas Water Development Board
David Meesey	Texas Water Development Board
James R. Elium	Olmito Water Supply
Vicente Guerra	Freer WCID
Kevin J. Spencer	R.W. Hardin and Associates
Larry H. Akers	Evergreen UWCD
Tom Michel	Harris-Galveston Subsidence District
Robert K. Grabrysch	Harris-Galveston Subsidence District
Ray N. Finch	STWA
James A. Dodson	Nueces River Authority

Bob Pickens	Post Oak GCD Colorado County
Scott Bledsoe	Live Oak UGCD
Lonnie C. Stewart	Live Oak UWCD
Don A. Roach	San Patricio MWD
F. Steve Petersen	Malcolm Pirnie - consultant
Jim Naismith	San Patricio MWD
Karen K. Dodson	Consultant
Carola G. Serrato	South Texas Water Authority
Haskell L. Simon	Region K RWPG
Greg Carter	AEP-CPL
James M. Tolan	Texas Parks and Wildlife
Pat L. Hubert	Regional Water Planning Group
Rick Hay	Texas A&M University – Corpus Christi
Mike F. Thuss	Parsons

Central Gulf Coast Groundwater Availability Model

Stakeholder Advisory Forum No.1 April 27, 2001

Meeting Minutes/ Questions & Answers

Dr. Robert Mace (TWDB):

- Introduction of Team members (included introduction of Robert Grabrysch – retired from USGS and developed first model of the Gulf Coast aquifer in the 1960's)
- Introduction and Purpose of Groundwater Availability Model (GAM):
 - Create scientific/realistic tool – using best information available to assess water levels and groundwater availability
 - Tool to estimate availability of groundwater but defining availability is not within the scope of this project.
 - Initial remarks about a recent paper on “Estimating Groundwater Availability in Texas” by Robert E. Mace (TWDB), William F. Mullican, II (TWDB), and Ted (Shao-Chih) Way (TWDB). This is only one way to approach availability.
 - Scientists will develop the GAM tool but policy addresses availability. Policy within regional areas is most important part of assessing availability.
- Goal of SAF – State will be developing models. Stakeholders can and should provide input, be part of the process, get familiar with the tool.

Dr. Marsh Lavenue (Waterstone – President)

- Gave overview of project Central Gulf Coast GAM Presentation. (See related presentation on web-site for details).

• Questions:

1. Please discuss and explain scenarios to be modeled.
 - Mace - The TWDB will set up one or two main scenarios for all GAMS. In addition, scenarios will be included based on regional water planning group. This means that results will vary from area to area based on regional plans and stakeholders' input. Example: Trinity model used RWPG data. When the model was run with this input, there was a decline of water levels observed in a portion of the model area vs. previous runs by TWDB
2. What will the grid size be?
 - 1 square mile – datasets/pumpage will be developed and combined. Additional information will be presented in presentation.
3. What is the role of GAM in establishing pumping limits? Will limits be based on recent paper “Estimating Groundwater Availability in Texas?”
 - Mace - The paper suggested just one way. The paper was written to show one way to address this issue. Availability is up to the RWPG working with GW districts. This stakeholders group won't determine availability but will help refine the model in providing input. Example:

Alcoa sales to SAWS. Region K based their availability on recharge and Region L based the same supply with a higher availability value.

4. What is process and what will be provided to regional plans, will this trickle down to default groundwater limits and does regional planning groups have to run model? Previous model had its own group to define water levels, but what about RWPGs who define availability differently?
 - Mace- Good question. The Trinity model did this with three different RWPGs. Need to compare and contrast the results. Different regional planning groups may run the same model with different inputs and get different answers. For example, one region may run model with existing pumpage levels for the future, while another may run model with substantially higher pumping in their region and get drawdown which affects an adjacent region.

5. How "salty" does the water need to be to be excluded from model?
 - Mace- Drinking water is typically less than 1000 ppm total dissolved solids, but TWDB uses up to 3000 ppm for other uses (livestock). Potential uses of water from desalination facilities may need to look at water up to 10,000 ppm. Waterstone will be looking at water quality (TDS).

6. How will the model be verified? Drawdown? Look at several wells?
 - Lavenue - Yes, this will be covered later in the presentation but will use wells for calibration.

7. Define Gulf Coast aquifer, it consists of many aquifers.
 - Lavenue - Gulf Cost units shown on slide including Chicot, Evageline, Jasper, Catahoula.

8. Are we mining the aquifer?
 - Mace - This depends on your definition of mining, example Ogalalla and Hueco Bolson. This definition goes back to regional planning groups for modeling scenarios and inputs.

9. Are you using subsidence package in the model?
 - Mace - No, at this time only the northern Gulf Coast GAM has this in their scope of work.
 - USGS is still working on the subsidence package. The model is a living tool and this feature may be added in the future. Other areas of the state do not have as much data on subsidence as northern Gulf Coast.
 - Lavenue- We may be able to look at this (clay storage/subsidence) in sensitivity analysis.

10. Is there subsidence around here? Around Robstown?
 - Mace: No; however, measurements and documentation is not readily available – if at all.
11. Question concerning well spacing, pumping restrictions i.e. rule of capture.
 - Groundwater districts have the ability to regulate and have the right to establish spacing and production and additional language in SB-2 may strengthen groundwater districts.
12. Is GAM integrated with WAM, isn't this done in the process?
 - Lavenue – No they are not coupled at this time. However, information from WAM can be utilized in GAM.
13. Please discuss predictive runs, different RWPGs used different concepts and strategies.
 - TWDB will test drive the model with information from the various RWPGs plans for input. This will allow us to see results from different scenarios, how the model reacts, and where there may be problems.
14. Question: what will you do in areas of little data? Take an average?
 - Lavenue- We haven't seen all the data yet; however, an average per grid cell may be used with some input parameters. (Robert Grabeyesch – responded that they [Waterstone] need the GW districts to gather/provide data for the model) Open discussion: Mace stated TWDB/USGS have collected water levels. For properties may need pump tests.
15. Question: Do the grids in the northern and central model areas overlay?
 - Mace- No, they are oriented to generally match water flow direction. The models will share layer information but not necessarily model cell properties.
16. Question: Will the model cover well fields in the Gulf of Mexico?
 - Lavenue - Currently had planned to shut model cells off in the Gulf. May use 10,000 ppm as limit.
17. Question: Discuss fact that Chicot disappears around Corpus Christi and cell width.
 - Vertical cell width is based on layers. Vertical layer may have more importance in some situations. This was discussed with USGS at an earlier meeting.
18. Question: Evageline has pockets of salt within freshwater – how is this portrayed?
 - The model will not cover water quality transports. USGS suggested being careful of salt pockets/fingers that occur around salt domes.
19. Question: Stakeholder lives 3 miles from Baffin Bay. How much intrusion occurs in his area?
 - Lavenue - Not much recharge but has good fresh water. Open discussion: 3,000 ppm is used by TWDB and USGS to draw water line.

This model will use available water quality data to depict these concentrations.

20. Question: If you pump too much what happens?

- Lavenue - Subsidence, salt water intrusion, or lowering of water table.

21. Question: Is the model considering subsidence? Salt water intrusion?

- No, not at this time.

22. Question: Define sustainable yield.

- David Meesey (TWDB) stated: Model can be used to make decisions but need to know your question before we can use the model to answer. Sustainable yield, and available supply are a policy issue to be analyzed in a different forum and individual runs can be conducted by RWPG.
- Mace - The GAM can't tell you an exact amount for sustainable pumping, due to all the regional and policy inputs and assumptions. It is a tool to evaluate various scenarios.

23. Question: Can you use logs for the Gulf?

- SAF answer - Many may have been shot too deep for our interests, since most information collected for oil and gas exploration.

24. Question: Is each block a layer? Is it thicker than the grid?

- Lavenue discussed example shown: Dolomitic regime with pumping well and 7 monitor wells. Only 8 meters thick but modeled in 2 layers since bottom layer was a fracture zone. This will be discussed in the conceptual plan after looking at all the data.

25. Question: What will the uncertainty based on your results become?

- Mace - you know the measured well point and the farther away you are, the more uncertain your results become. Lavenue also discusses how certain or uncertain you are about the model and conducting sensitivity analysis.

26. When is data and model available to everyone?

- Mace- January/February 2003

27. Will the SAF have training, and will it be available to everyone?

- Mace - yes, training will be targeted for those who model but anyone can attend.