Third Stakeholder Advisory Forum for West Texas Igneous and Bolson GAM

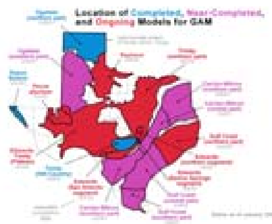
July 29, 2003

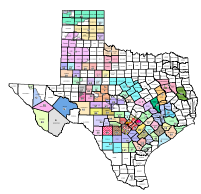
GAM

Groundwater Availability Modeling

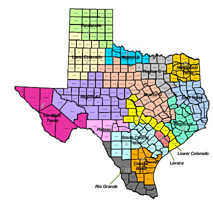
texas water development board

Groundwater Availability Modeling

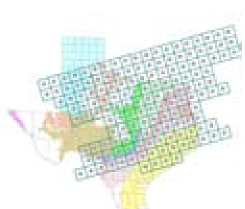




Contract Manager

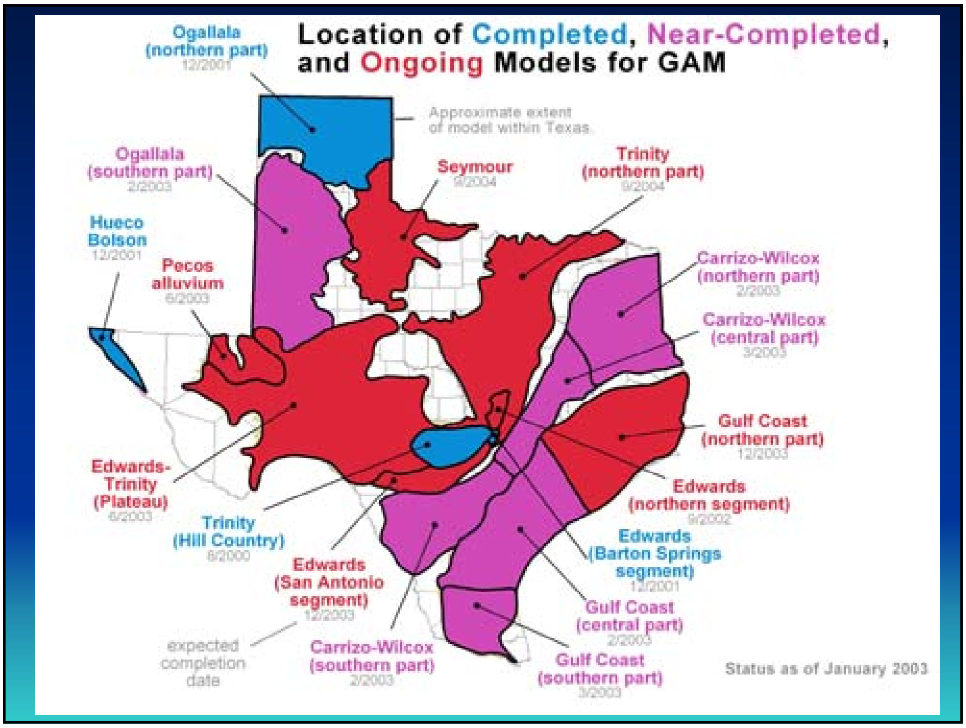


- Texas Water Development Board



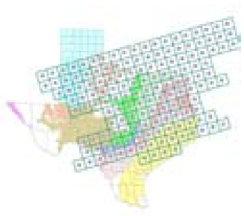
GAM

- <u>Purpose:</u> to develop the best possible groundwater availability model with the available time and money.
- <u>Public process:</u> you get to see how the model is put together.
- <u>Freely available:</u> standardized, thoroughly documented, and available over the internet.
- <u>Living tools:</u> periodically updated.



What is groundwater availability?

- …the amount of groundwater available for use.
- The State does not decide how much groundwater is available for use: GCDs and RWPGs decide
- A GAM is a tool that can be used to assess groundwater availability once GCDs and RWPGs decide how to define groundwater availability.

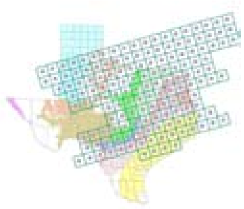


Do we have to use GAM?

- Water Code & TWDB rules require that GCDs use GAM information. Other information can be used in conjunction with GAM information.
- TWDB rules require that RWPGs use GAM information unless there is better site specific information available

How do we use GAM?

- The model itself
  - predict water levels and flows in response to pumping and drought
  - effects of well fields
- Data in the model
  - water in storage
  - recharge estimates
  - hydraulic properties
- GCDs and RWPGs can request runs



Living tools

- GCDs, RWPGs, TWDB, and others collect new information on aquifer
- This information can enhance the current GAMs
- TWDB plans to update GAMs every five years with new info
- Please share information and ideas with TWDB on aquifers and GAMs

Participating in the GAM process

- SAF meetings
  - hear about progress on the model
  - comment on model assumptions
  - offer information (timing is important!)
- Report review
  - at end of project
- Contact TWDB
  - Robert Mace
  - Ted Angle

Comments:

Ted Angle
(512)936-2387
tangle@twdb.state.tx.us
www.twdb.state.tx.us/gam

TEXAS WATER DEVELOPMENT BOARD

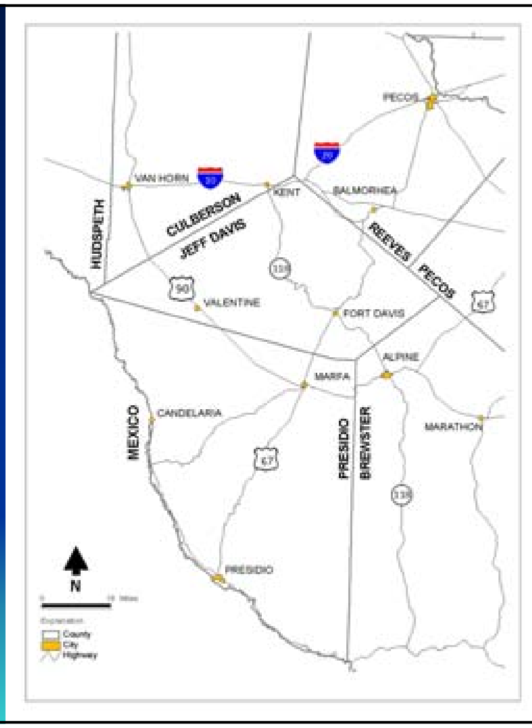
West Texas Igneous and Bolson GAM Team

- LBG-Guyton Associates
  - Water Prospecting and Resource Consulting, LLC
  - John Shomaker & Associates, Inc.
  - Daniel B. Stephens & Associates, Inc.
  - Senior Technical Advisors
    - Kevin Urbanczyk, Ph.D., Sul Ross State University
    - Jack Sharp, Ph.D., University of Texas at Austin

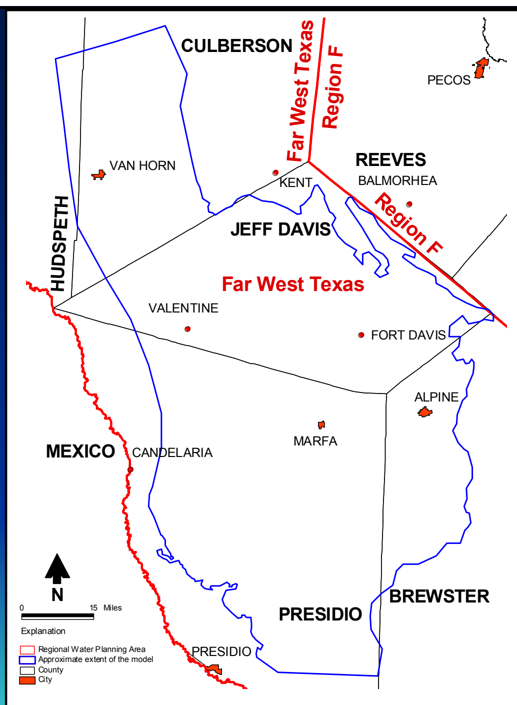
SAF 3 Agenda

- quick review of previous work on GAM
- review of conceptual model
  - physiography
  - geology
  - hydrostratigraphy
  - recharge
  - water levels
  - hydraulic properties
  - discharge (pumping)
  - model boundaries
  - etc.
- questions and answers

General Info

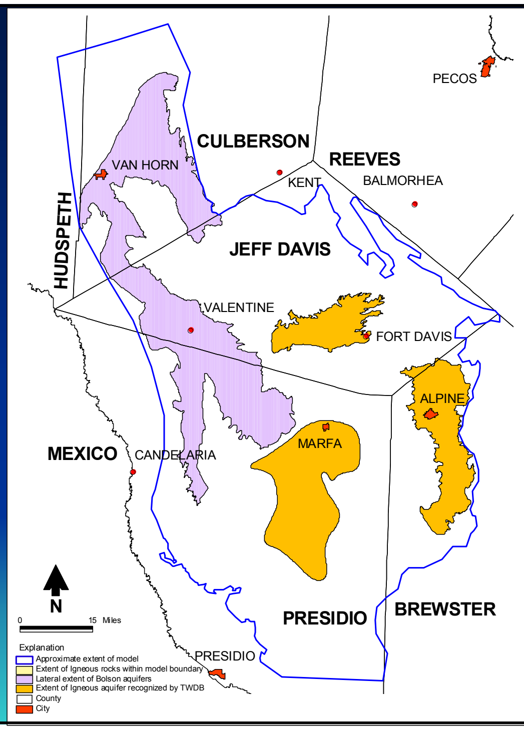


General Location Map

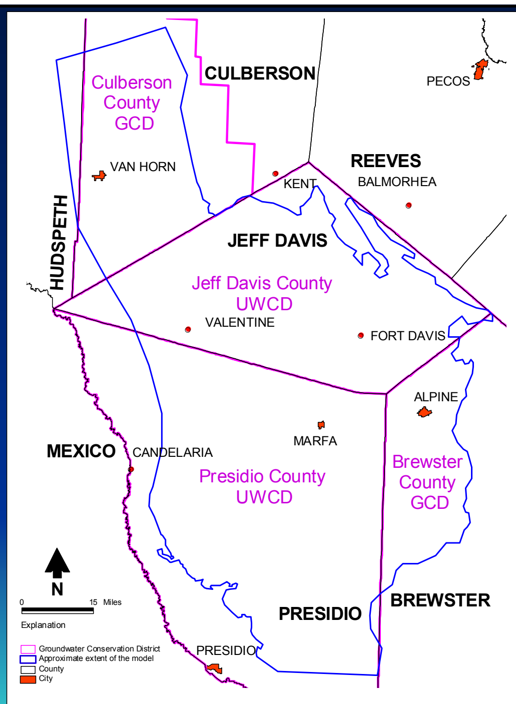


Regional Water Planning Groups

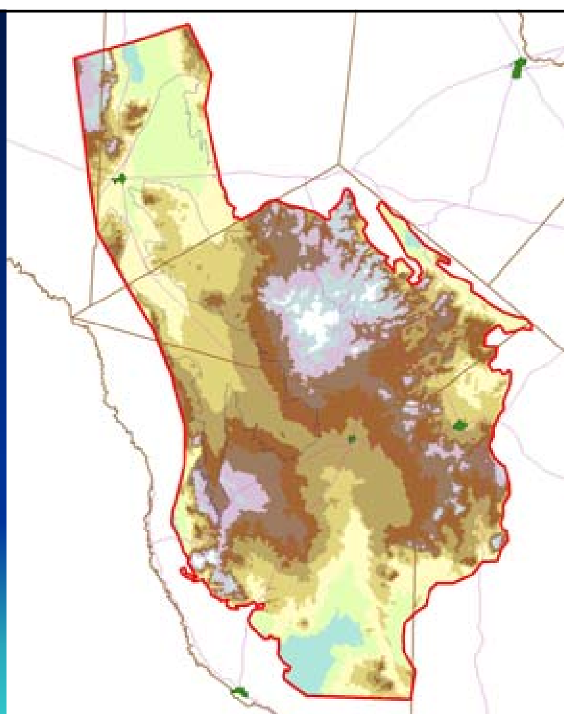
TWDB Aquifers



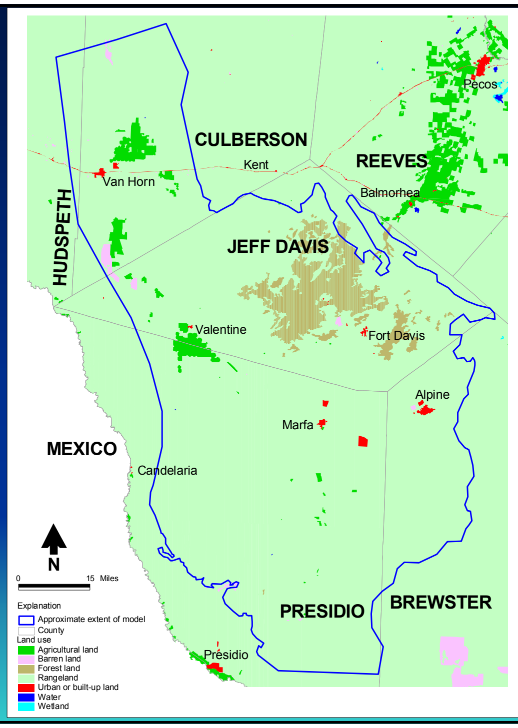
Groundwater Conservation Districts



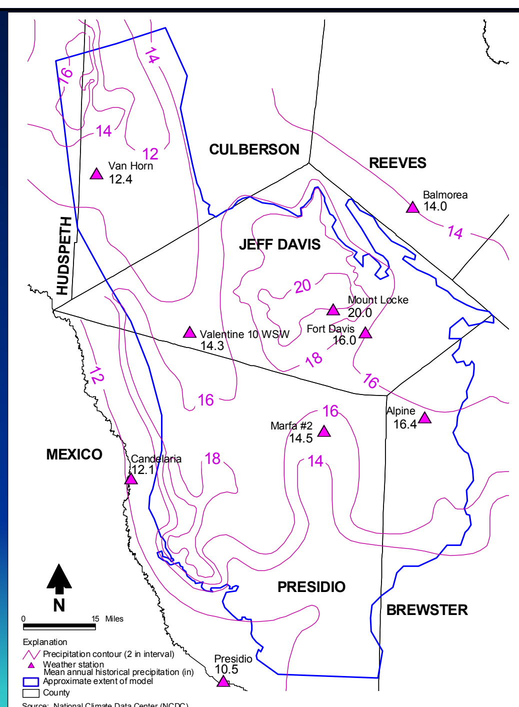
Physiography and Climate



Topography

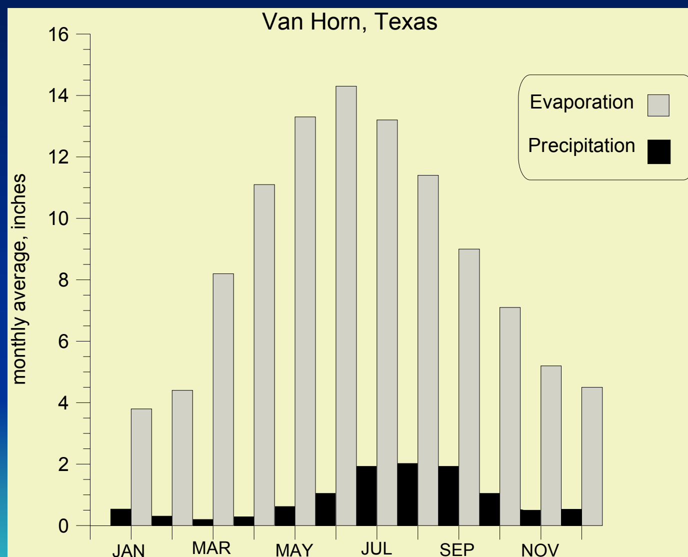


Land Use
Land Cover
(USGS)

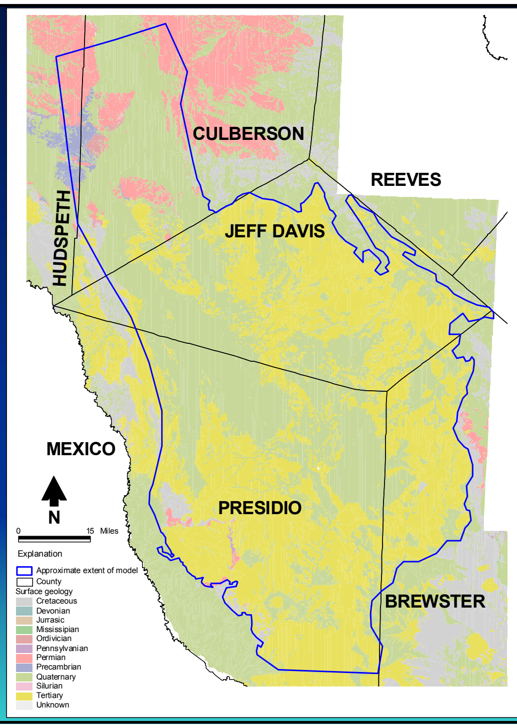


Precipitation
(inches/year)

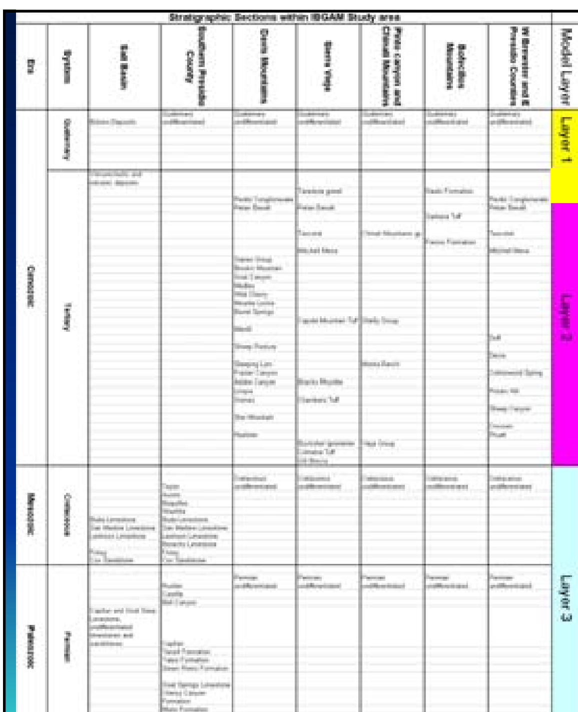
EVAPORATION EXCEEDS PRECIPITATION INDICATING RECHARGE OCCURS FROM INFILTRATION OF STORM RUNOFF



Geology

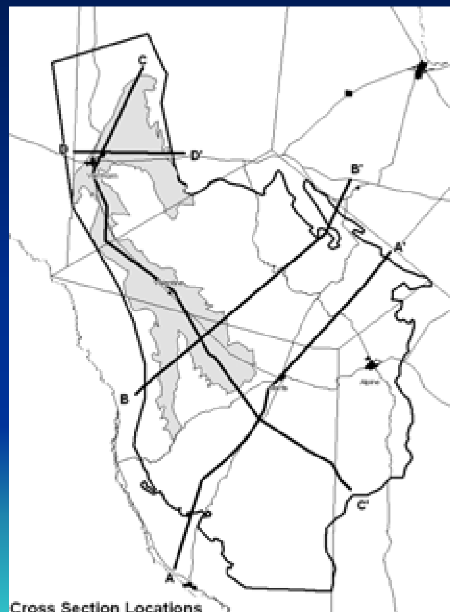


Surface Geology

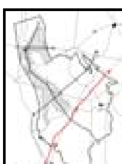


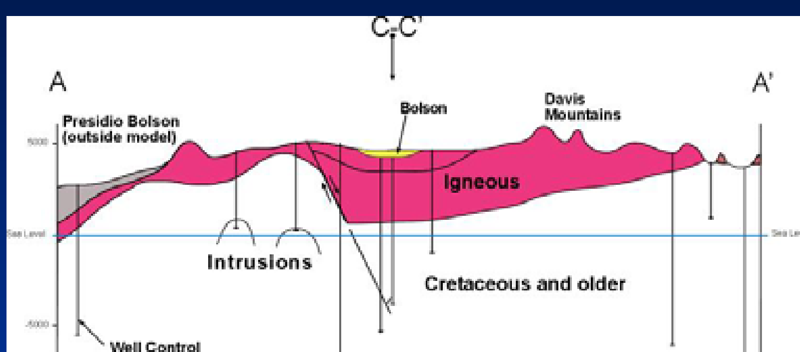
Hydrostratigraphy

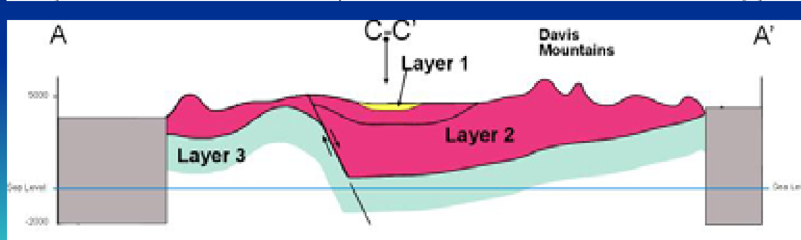
Cross-sections



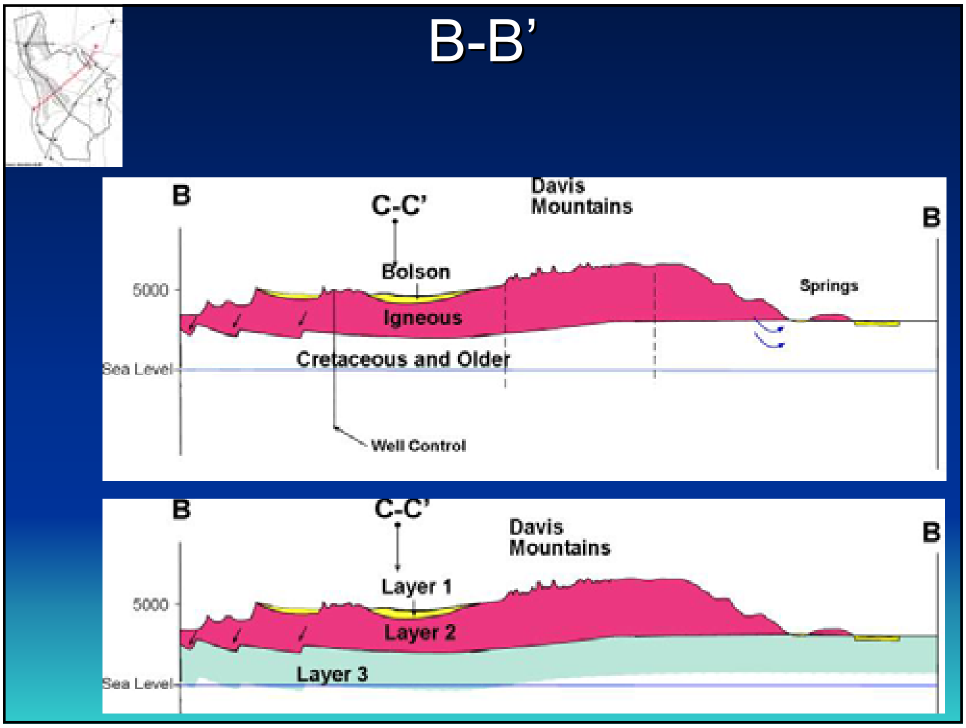
A-A’



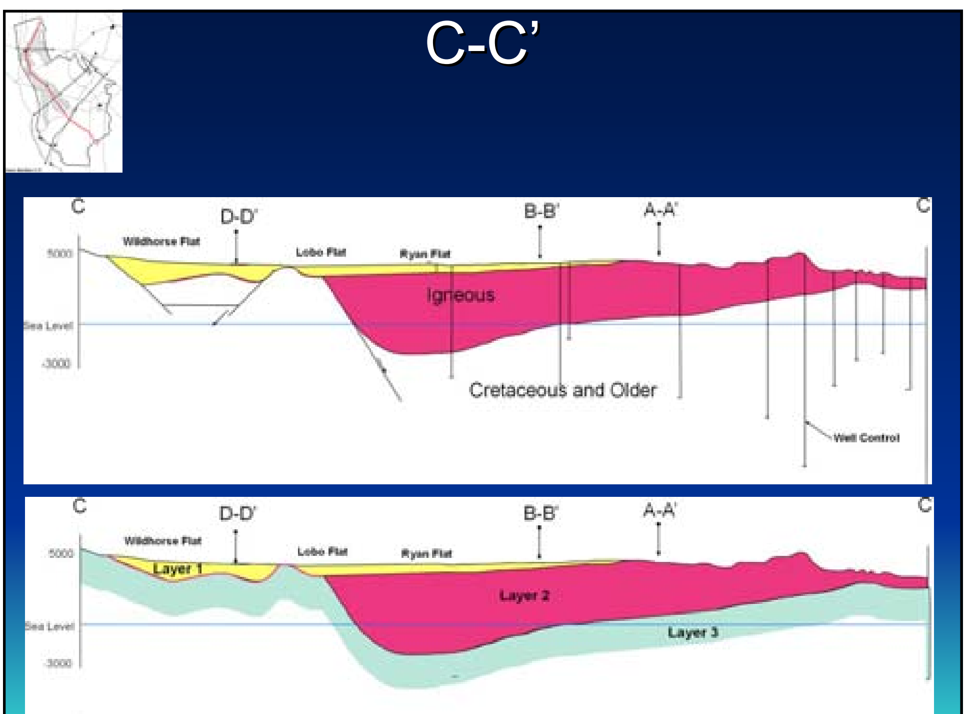




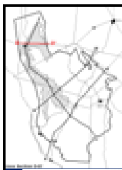
B-B'

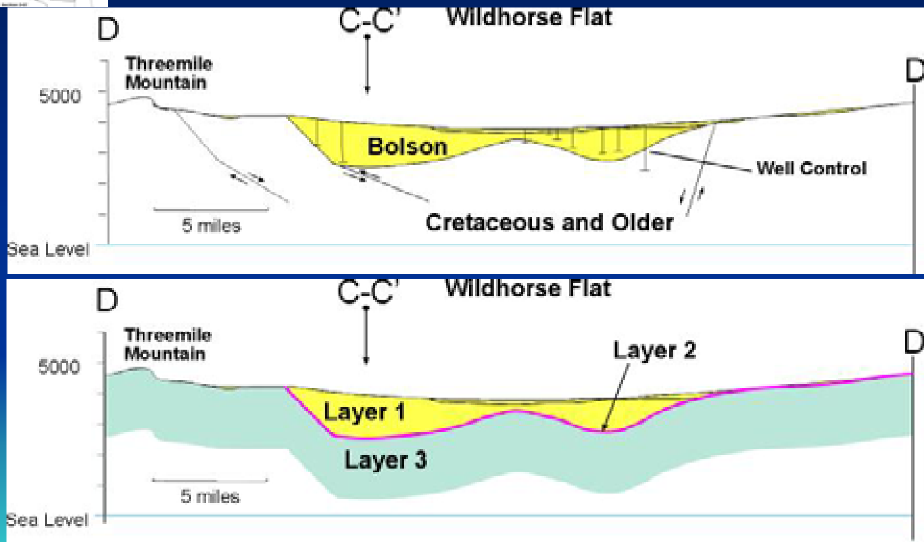

B
C-C'
Davis Mountains
B
5000
Bolson
Igneous
Springs
Sea Level
Cretaceous and Older
Well Control
B
C-C'
Davis Mountains
B
5000
Layer 1
Layer 2
Sea Level
Layer 3

C-C'

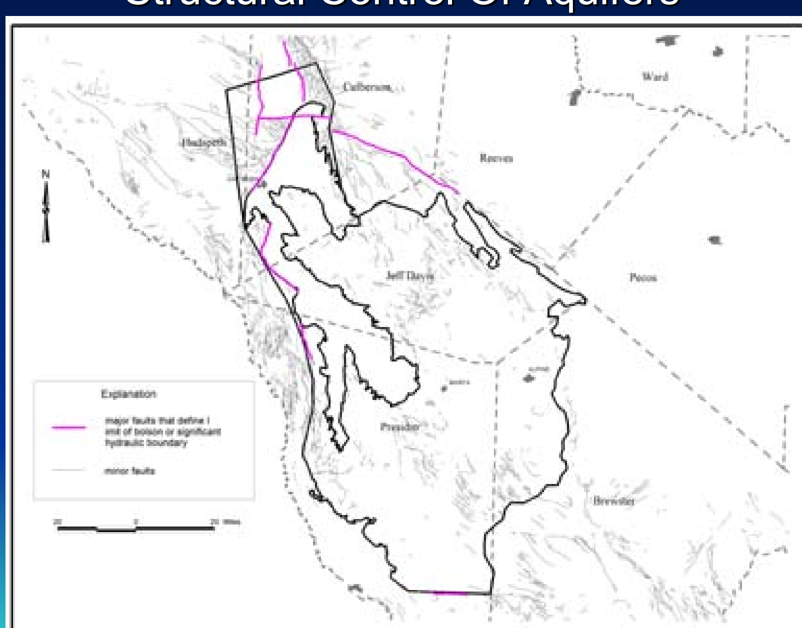

C
D-D'
B-B'
A-A'
C'
Wildhorse Flat
Lobo Flat
Ryan Flat
5000
Igneous
Sea Level
-3000
Cretaceous and Older
Well Control
C
D-D'
B-B'
A-A'
C'
Wildhorse Flat
Lobo Flat
Ryan Flat
5000
Layer 1
Layer 2
Sea Level
Layer 3
-3000

D-D’



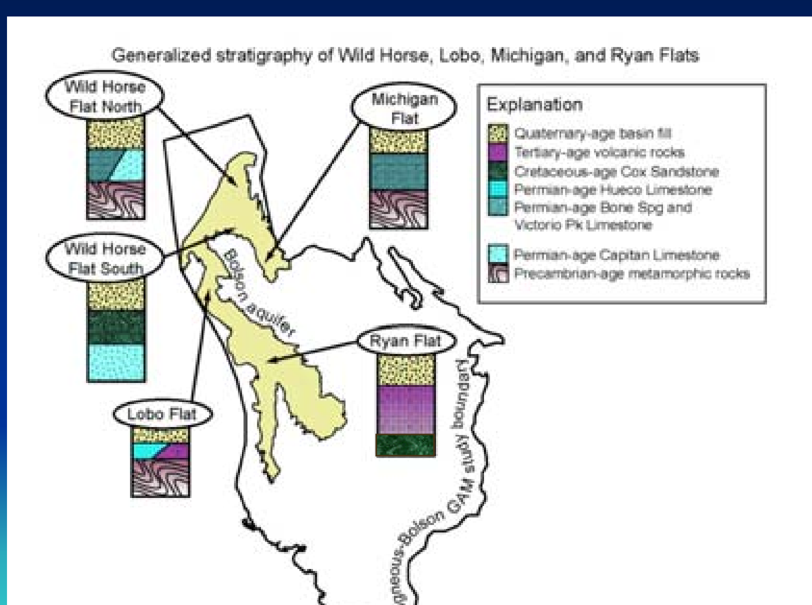


Structural Control Of Aquifers

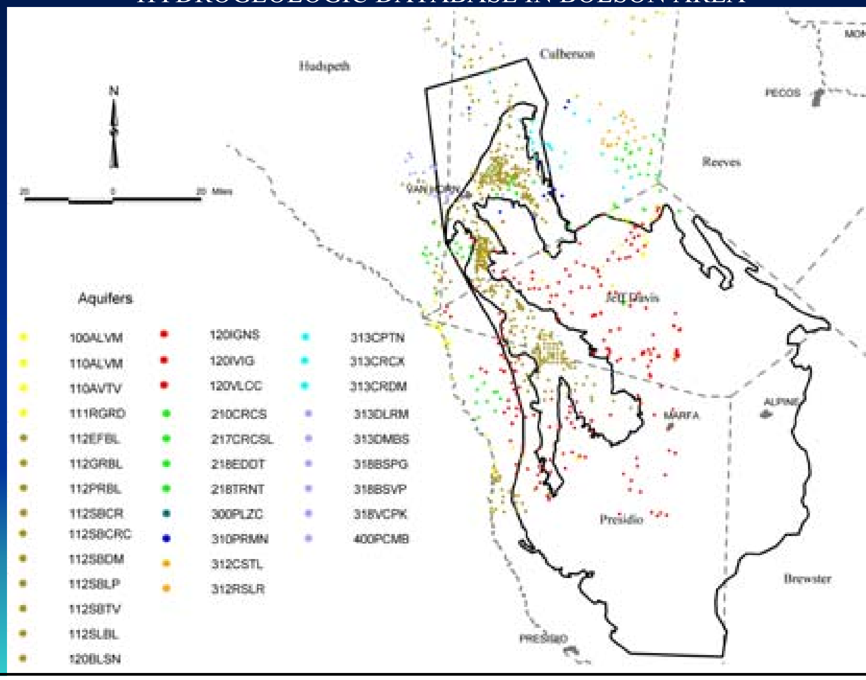


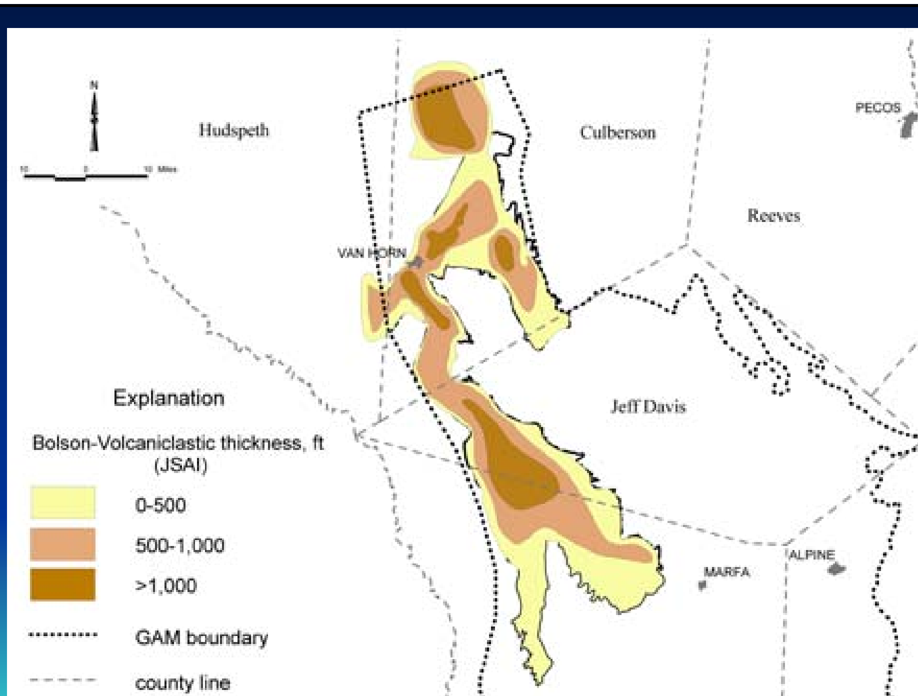
Structure

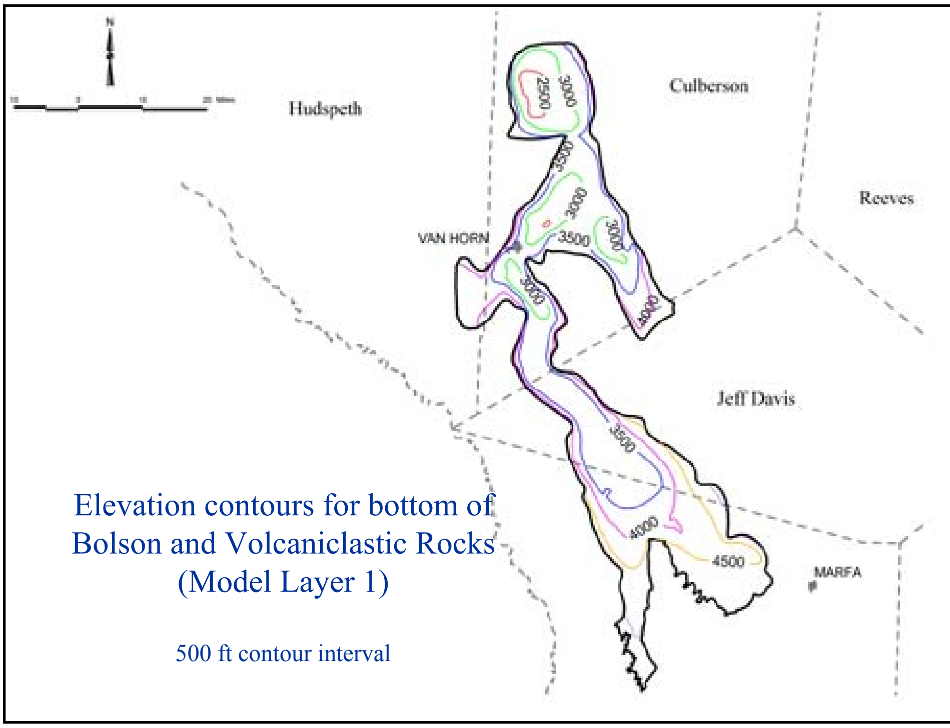
Generalized Stratigraphy



HYDROGEOLOGIC DATABASE IN BOLSON AREA

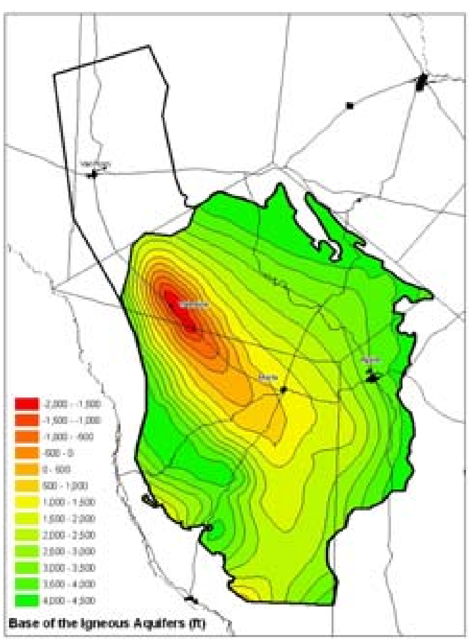






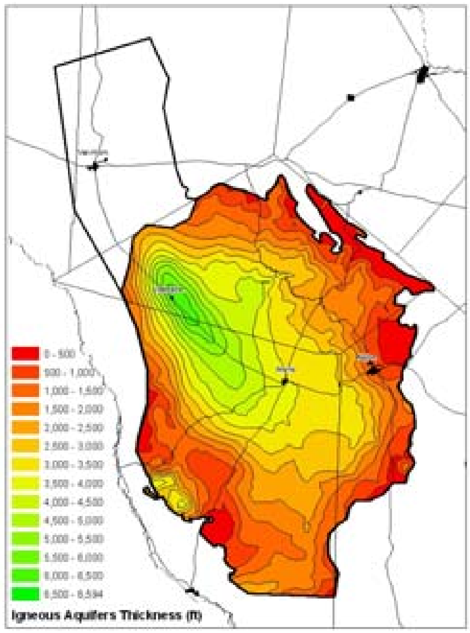
Elevation contours for bottom of Bolson and Volcaniclastic Rocks (Model Layer 1)

500 ft contour interval



Base of Volcanics

Bottom of Layer 2



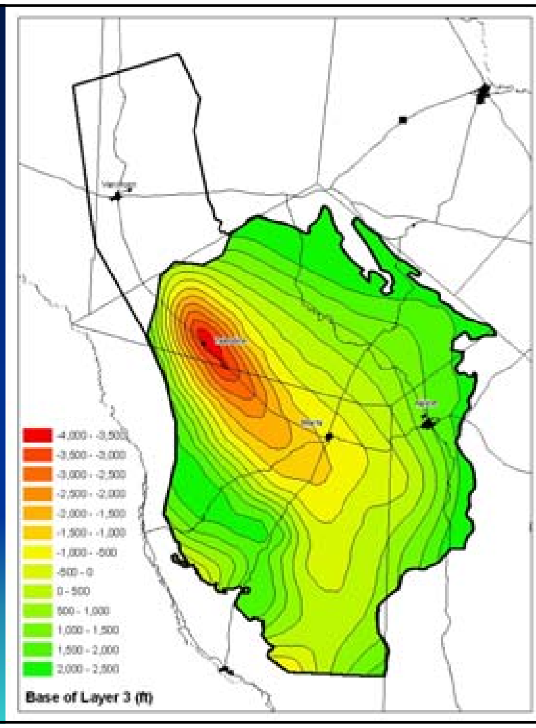
Thickness of Igneous Volcanics

Thickness of Layer 2

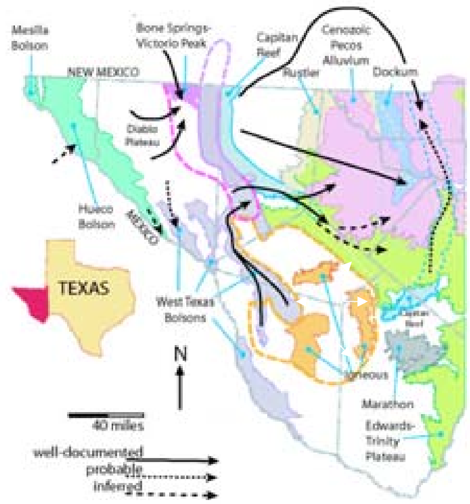
Cretaceous and Permian

- Assume Cretaceous and Permian (Layer 3) is 2000 feet thick
  - water supply projections for the 50-year prediction period will not be impacted by deeper zones

Bottom of Layer 3



Water Levels and Regional Groundwater Flow



Modified from Sharp (2001) and Mace (2001)

Regional Groundwater Flow Paths

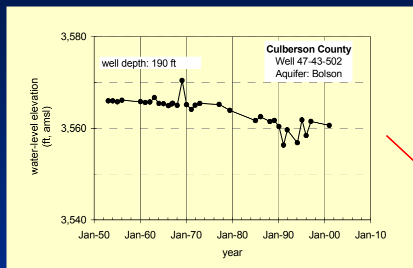
Radial flow from the Igneous aquifer in the Davis Mountains

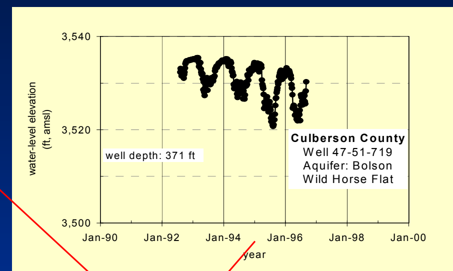
Groundwater from Ryan, Lobo and Michigan Flats (Bolsons) flow toward Wild Horse Flat and discharges as groundwater outflow to structures in Apache Mountains

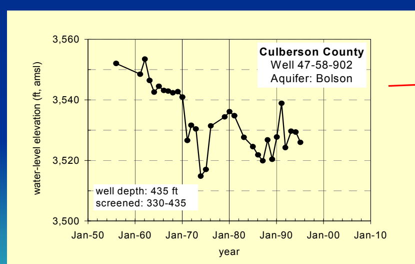
Well Information

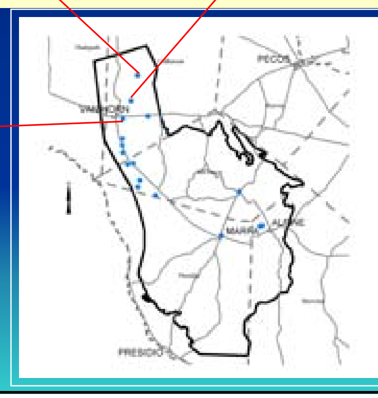
• TWDB Record of Wells	291
• Igneous Aquifers Report	121
• TCEQ central records	712
• New wells/measurements during GAM	93

Wild Horse Flat Hydrographs

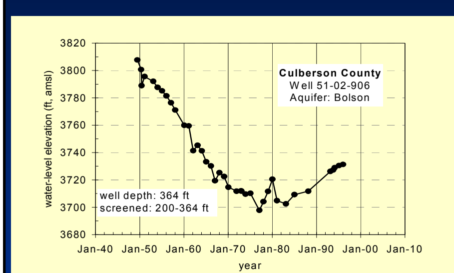


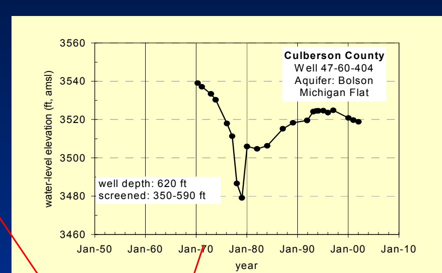


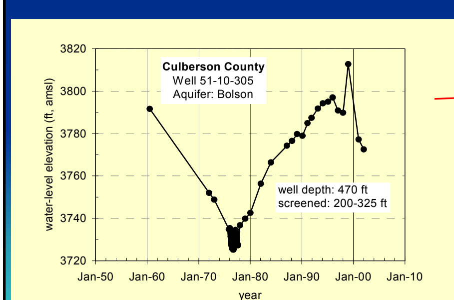


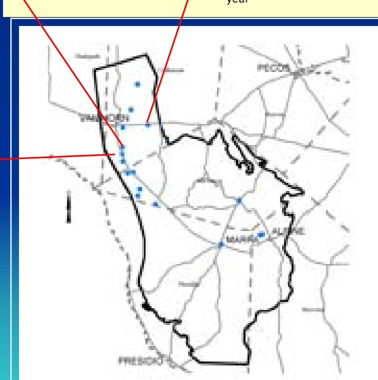


Michigan And Lobo Flat Hydrographs

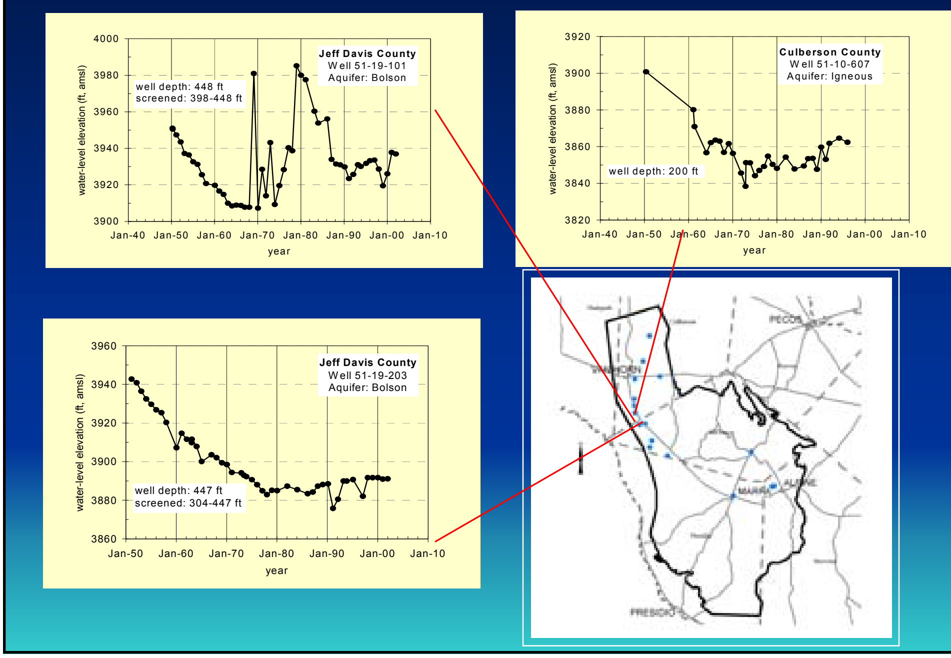




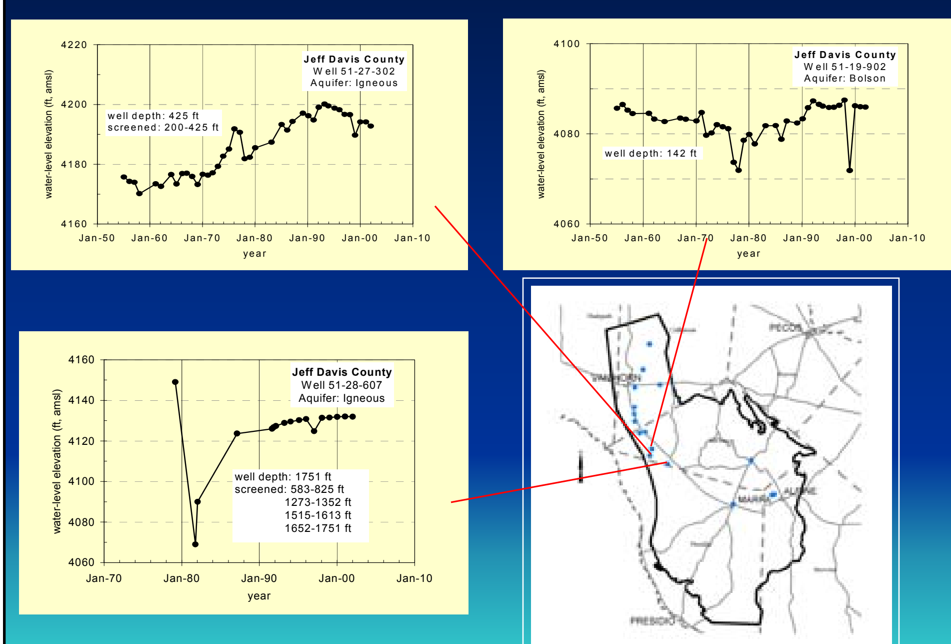




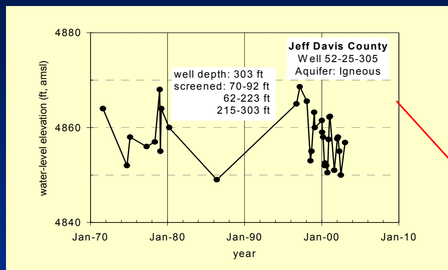
Lobo Flat Hydrographs

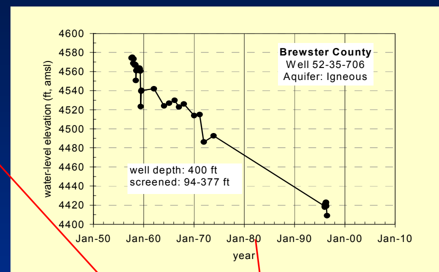


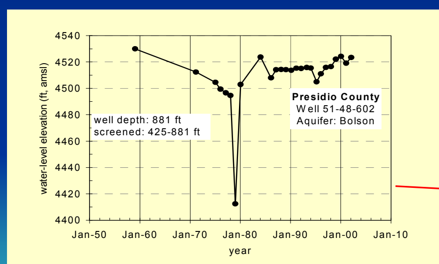
Lobo And Ryan Flat Hydrographs

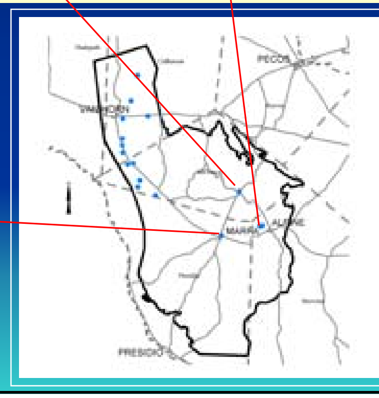


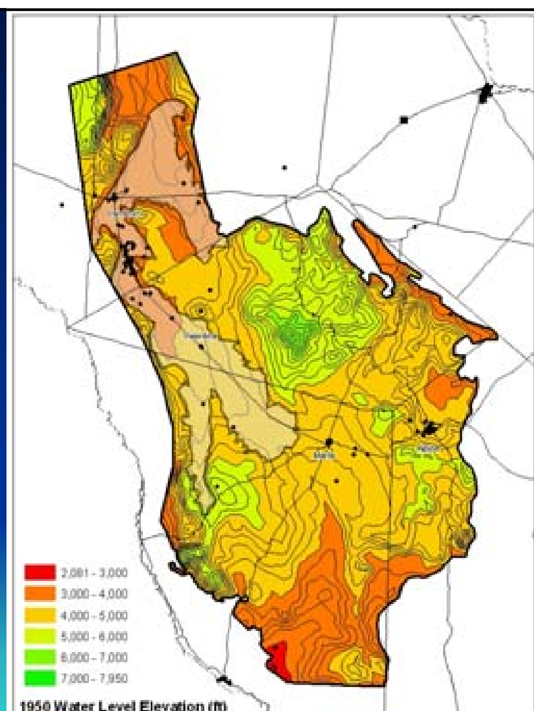
Igneous Aquifer Hydrographs





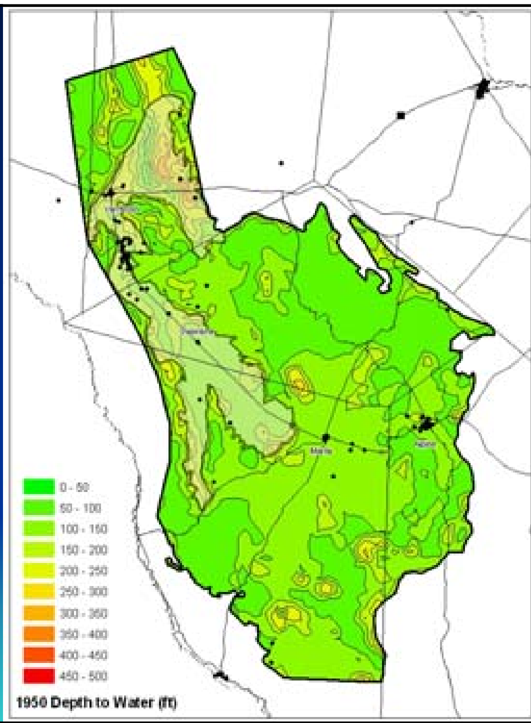




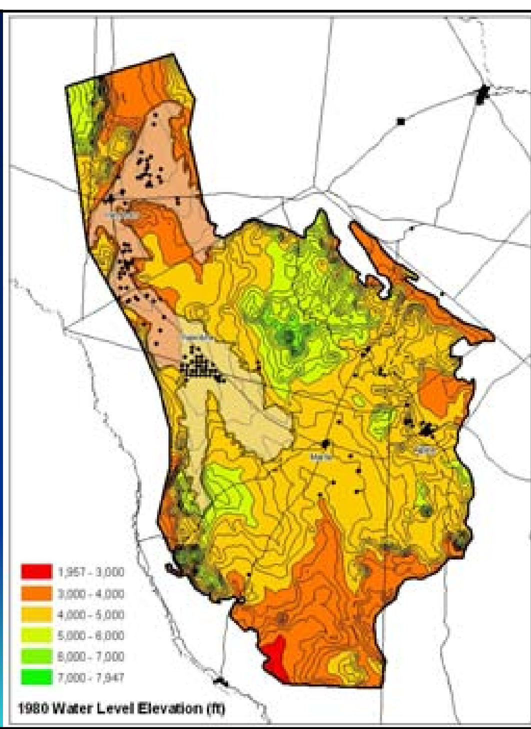


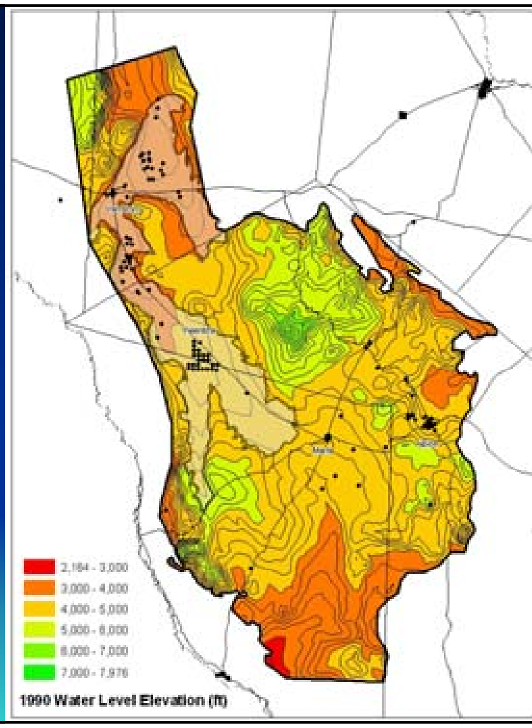
Predevelopment (1950) Water Level Contours

Predevelopment (1950) Depth to Water Contours

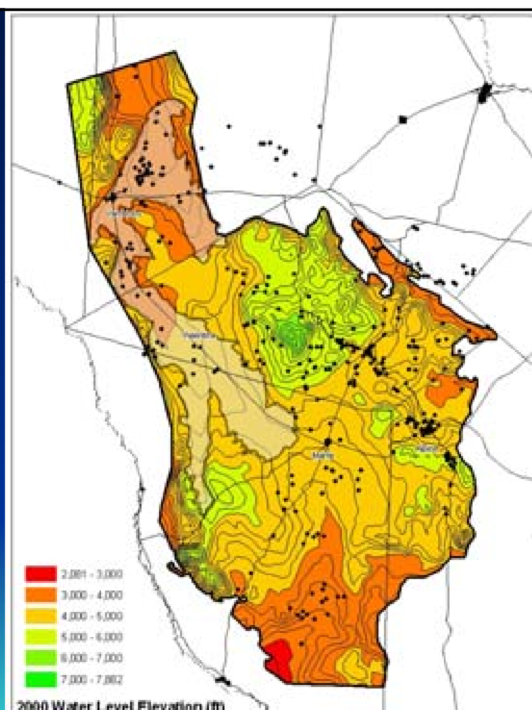


1980 Water Level Contours





1990 Water Level Contours



2000 Water Level Contours

Recharge

Data

Precipitation
- Annual
- Daily

Watershed characteristics
- Elevation
- Soil type
- Geology
- Land cover

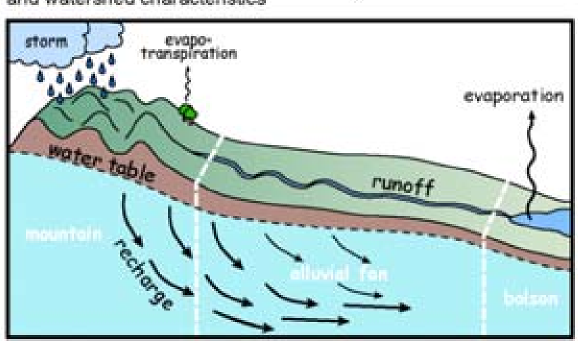
Estimate recharge for each watershed

Total precipitation based on precipitation-elevation relationship

Potential recharge
precipitation
- evapotranspiration

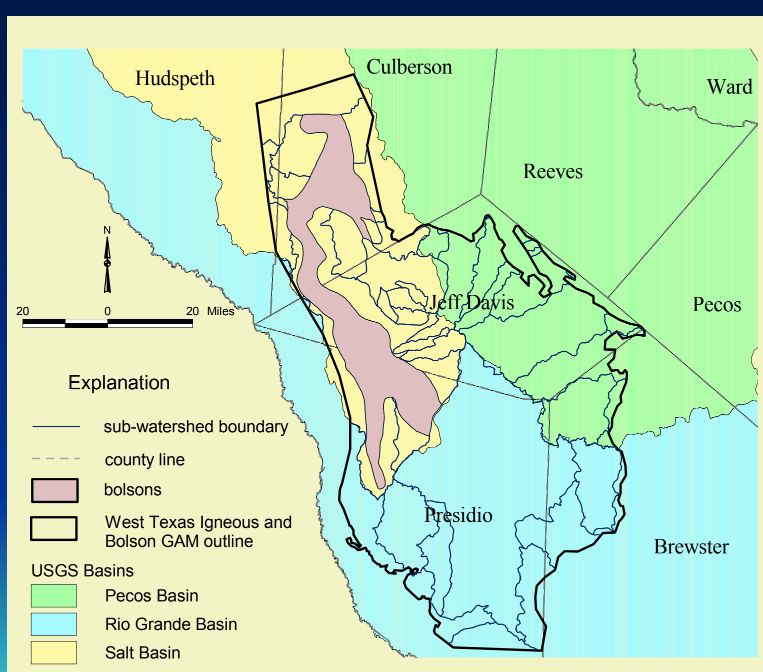
Runoff based on daily precipitation and watershed characteristics

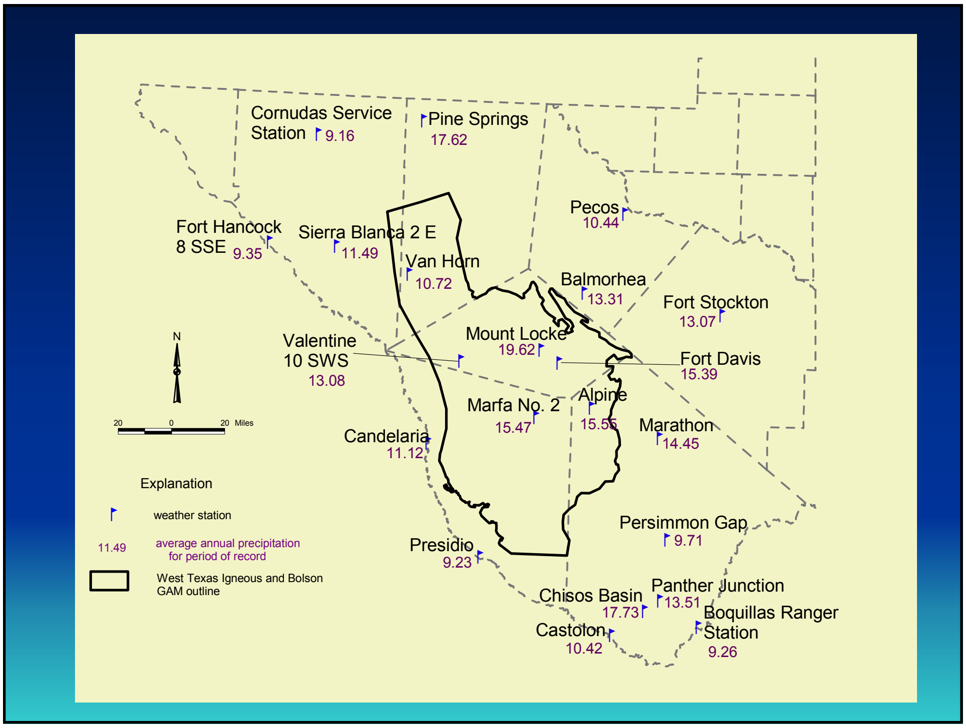
Recharge
potential recharge
- runoff
+ redistributed runoff



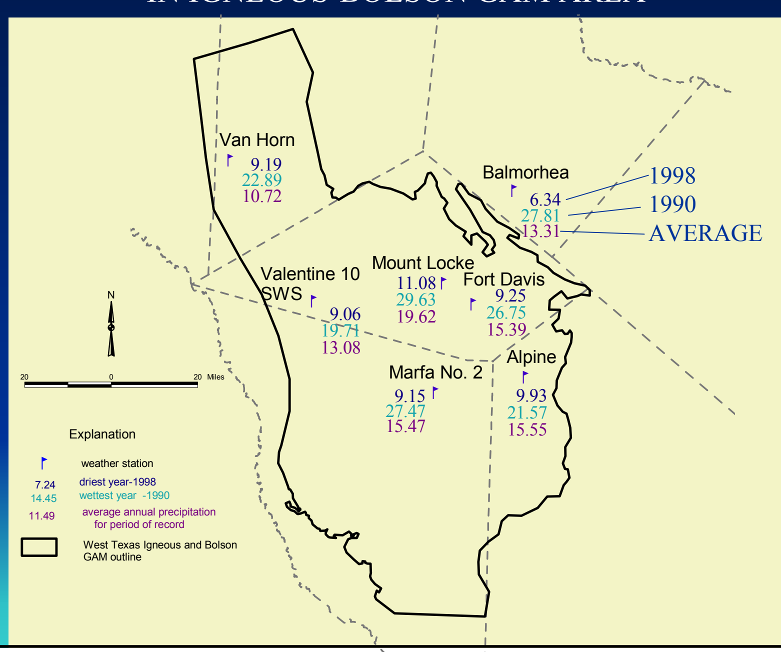
RUNOFF RE-DISTRIBUTION METHOD

1. Delineate watershed area and subbasins
2. Determine potential recharge from empirical relationships
3. Calculate runoff for each subbasin
4. Potential recharge - runoff = subbasin recharge
5. Runoff = potential recharge to bolson

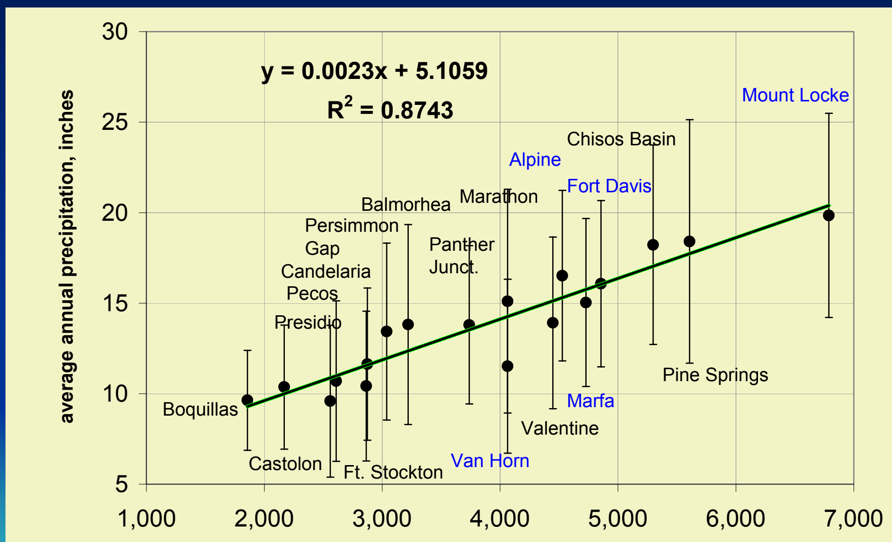




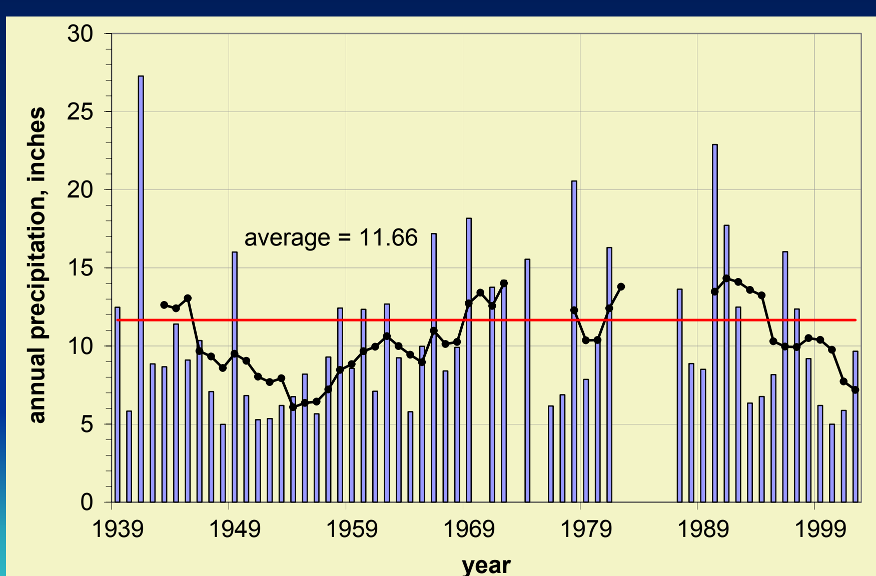
PRECIPITATION DATA FOR WEATHER STATIONS IN IGNEOUS-BOLSON GAM AREA



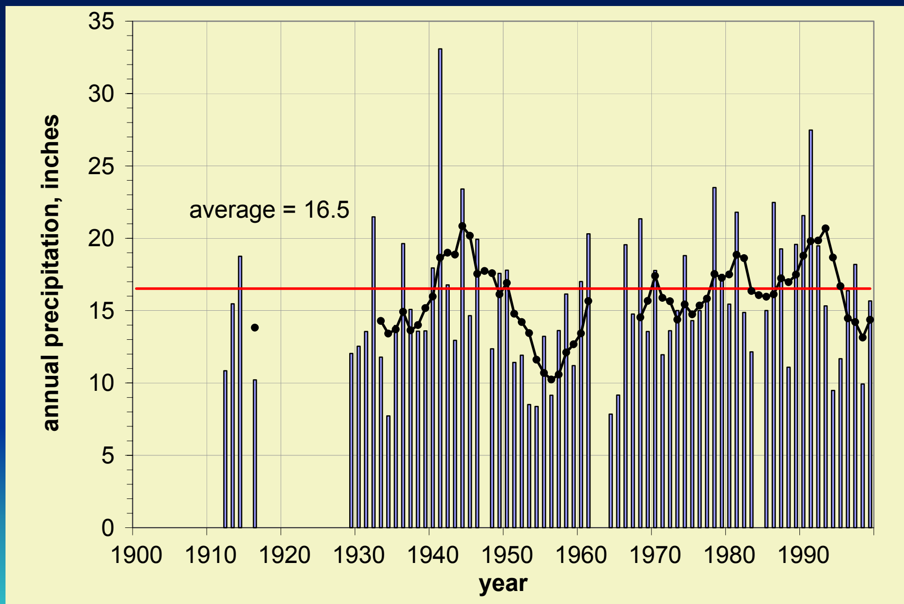
PRECIPITATION VERSUS ELEVATION



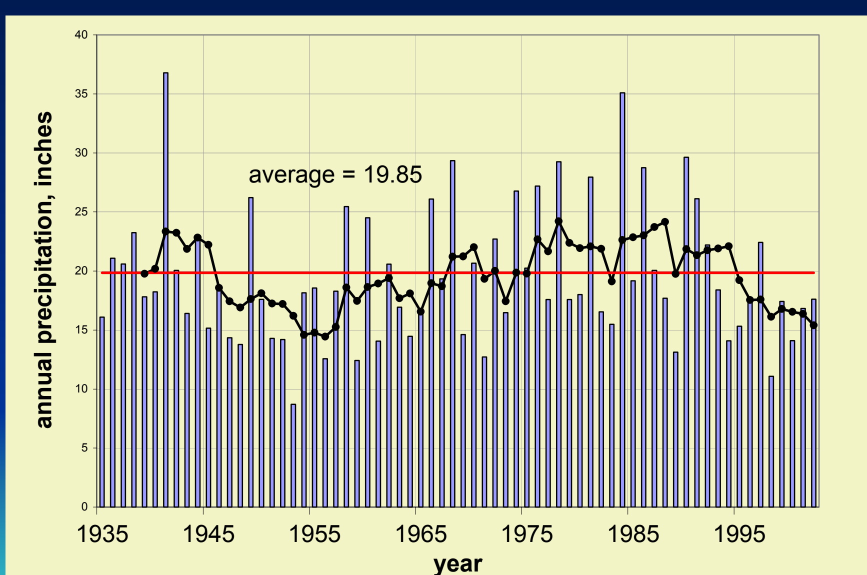
ANNUAL PRECIPITATION FOR PERIOD OF RECORD (1935 – 2002) FOR VAN HORN WEATHER STATION



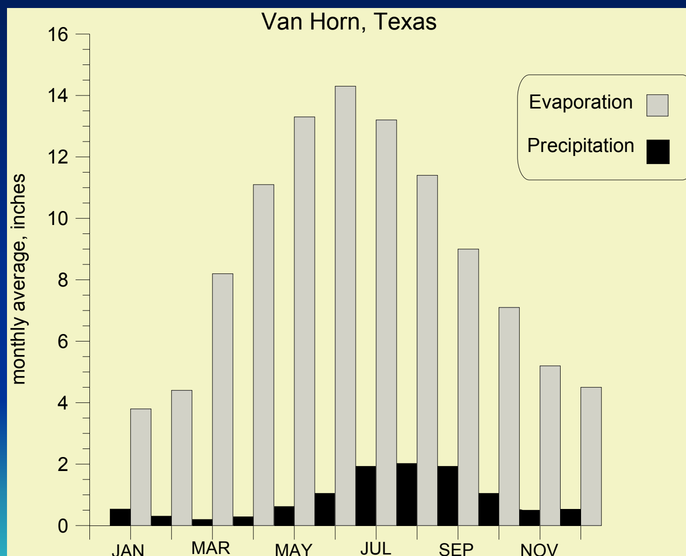
ANNUAL PRECIPITATION FOR PERIOD OF RECORD (1902 – 2000) FOR ALPINE WEATHER STATION



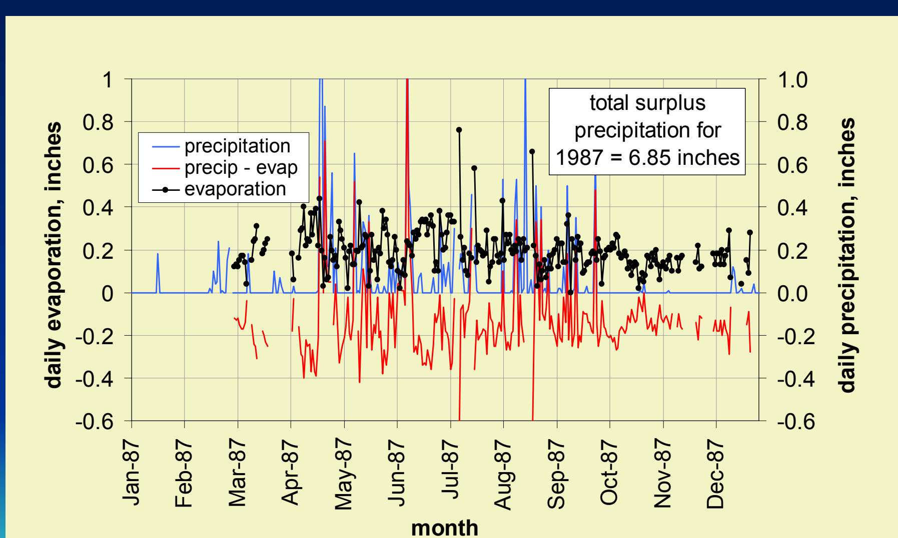
ANNUAL PRECIPITATION FOR PERIOD OF RECORD (1935 – 2002) FOR MOUNT LOCKE WEATHER STATION



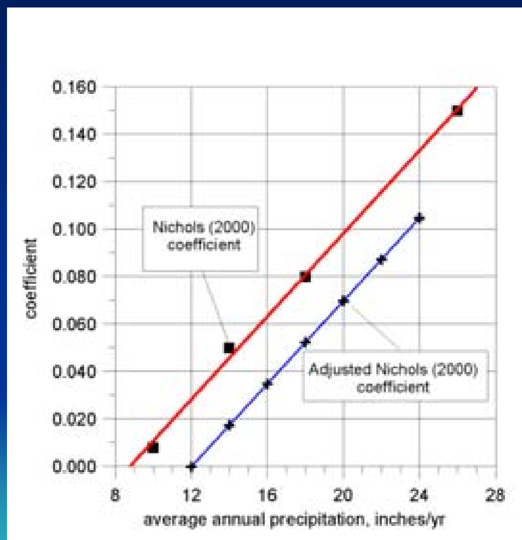
EVAPORATION EXCEEDS PRECIPITATION INDICATING RECHARGE OCCURS FROM INFILTRATION OF STORM RUNOFF



1987 DAILY PRECIPITATION, EVAPORATION, AND SURPLUS FOR MOUNT LOCKE WEATHER STATION



POTENTIAL RECHARGE



- Coefficient based on multiple linear regression model
- Accounts for evapotranspiration

pptn	potential recharge
in/yr	in/yr
12	0.00
16	0.56
20	1.40

Calculation of Runoff

$$Q = \frac{(P-I_a)^2}{(P-I_a)+S}$$

Q = runoff

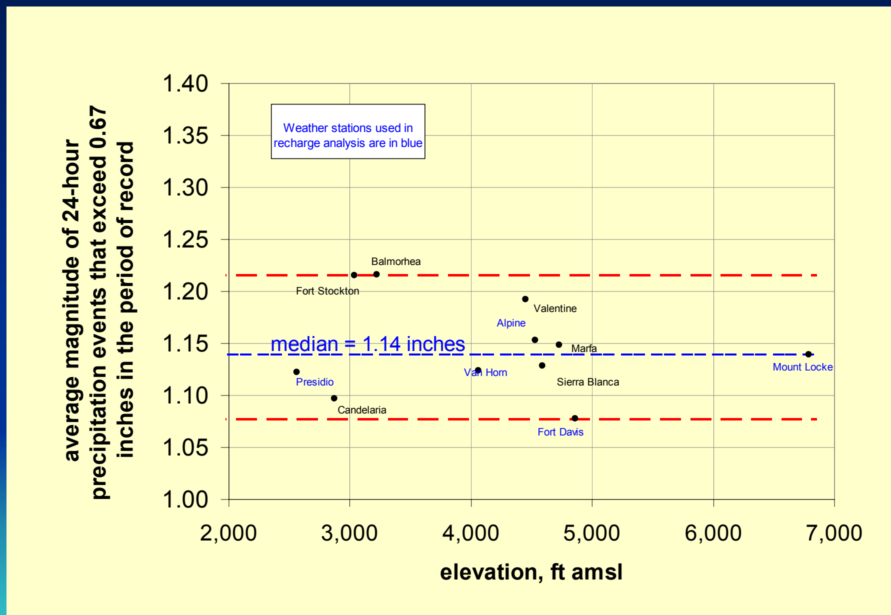
P = precipitation event
(freq. scaled to elevation)

S = potential max. retention after runoff begins

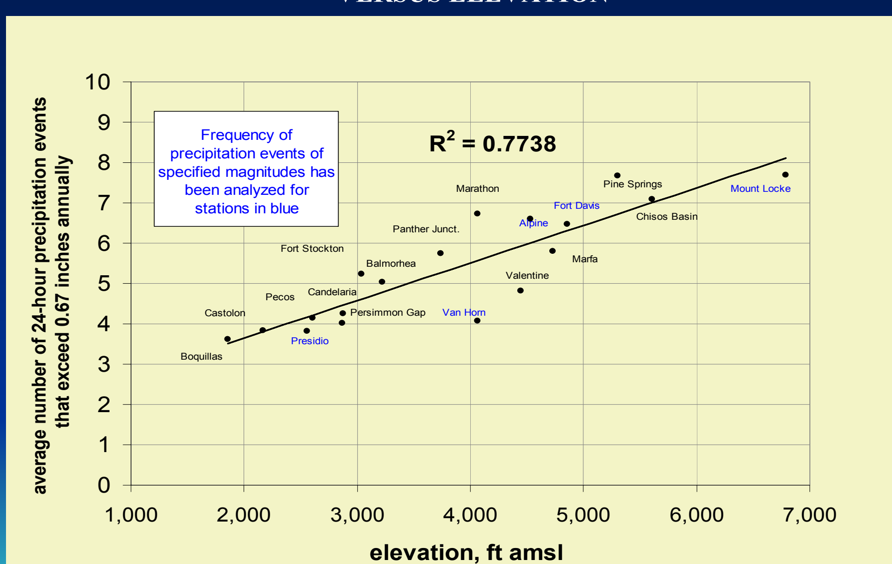
I_a = water retained

- SCS Method
- Based on precipitation events rather than total annual precipitation
- Accounts for vegetation type and density, and hydrologic characteristics of soil or rock

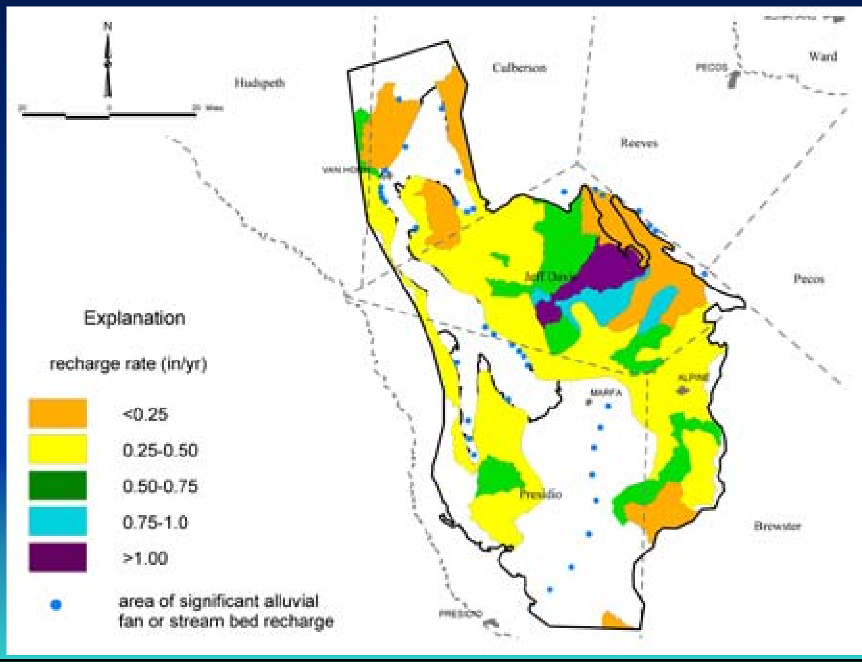
MAGNITUDE OF 24-HR PRECIPITATION EVENTS VERSUS ELEVATION

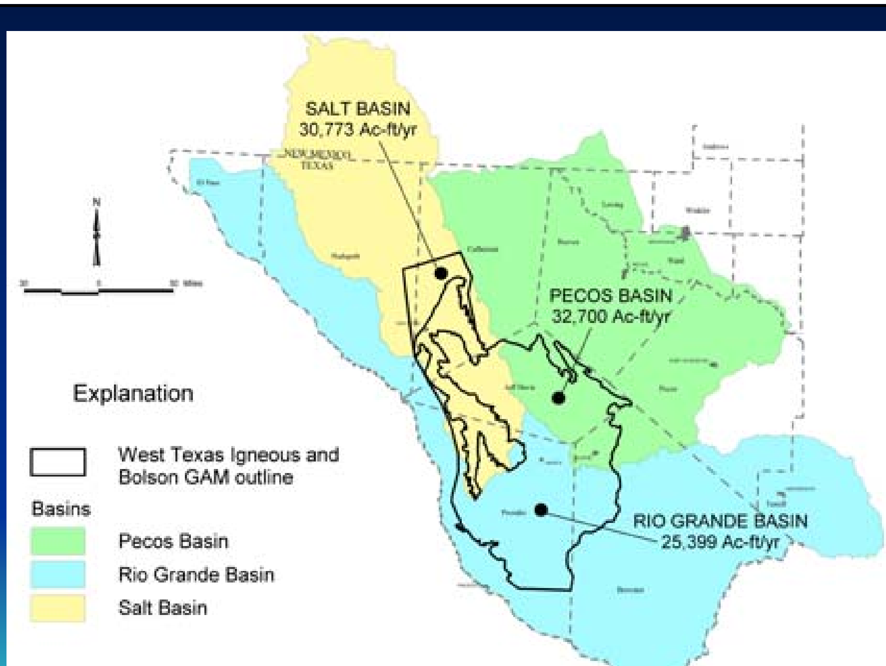


FREQUENCY OF 24-HR PRECIPITATION EVENTS VERSUS ELEVATION



DISTRIBUTION OF RECHARGE





Estimated recharge for West Texas Igneous and Bolson GAM study area.

RESULTS OF RECHARGE ANALYSIS USING RUNOFF REDISTRIBUTION METHOD

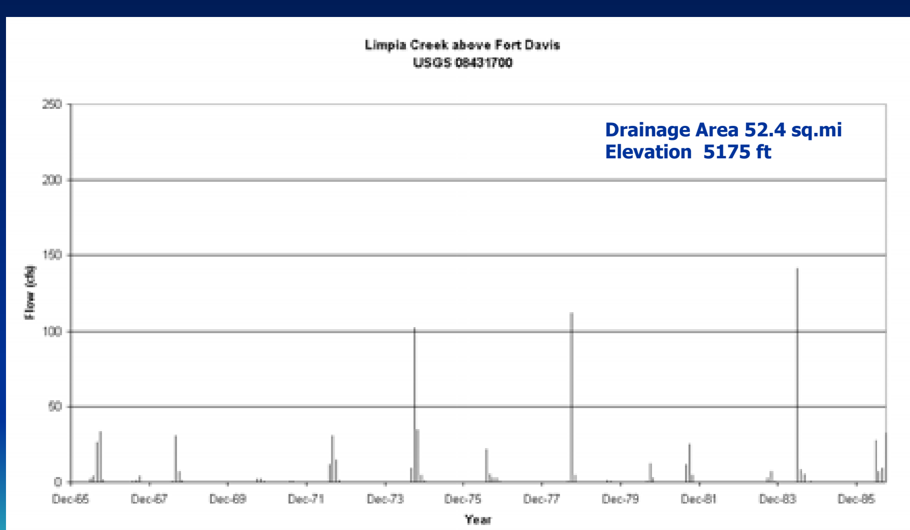
parameter	unit	Salt	Pecos	Rio Grande	total
area	acres	1,625,355	1,135,324	1,370,137	4,130,816
total precipitation	ac-ft/yr	2,111,077	1,512,759	1,798,709	5,422,545
potential recharge	ac-ft/yr	51,665	55,964	60,787	168,416
runoff	ac-ft/yr	35,548	32,700	49,787	118,035
estimated recharge	ac-ft/yr	30,773	32,708	25,399	88,880
	in/yr	0.42	0.35	0.22	0.26
total precipitation that becomes recharge	percent	1.5	2.2	1.4	1.6
runoff that becomes recharge	percent	26	29	25	26

COMPARISON OF RECHARGE METHODS

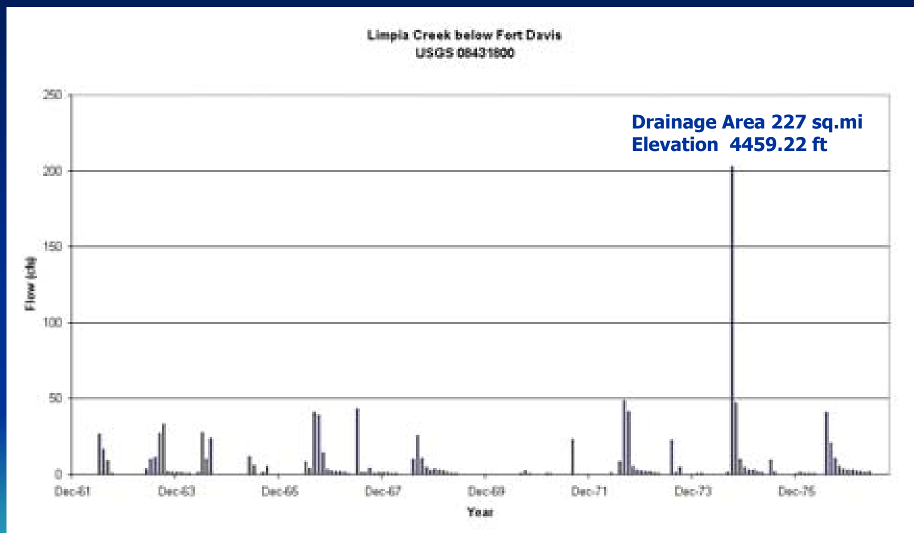
Method	unit	Salt	Pecos	Rio Grande	total	comments
total precipitation	ac-ft/yr	2,111,077	1,512,759	1,798,709	5,422,545	
one-percent rule	ac-ft/yr	21,111	15,128	17,987	54,225	does not consider watershed or geologic variability
Modified Maxey Eakin	ac-ft/yr	135,543	172,641	205,256	513,440	over estimates recharge at lower elevations
	in/yr	1.0	1.8	1.8		
Storm-runoff infiltration	ac-ft/yr	10,664	9,810	10,263	30,737	does not consider aerial recharge at higher elevations or geology
runoff redistribution	ac-ft/yr	30,773	32,708	25,399	88,880	
	in/yr	0.42	0.35	0.22		

Rivers, Streams, Springs and Lakes

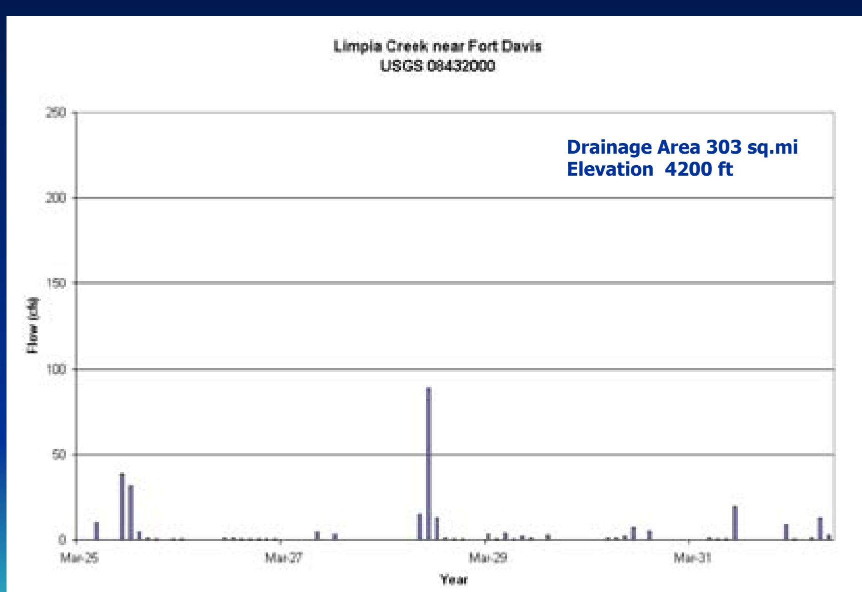
USGS 08431700



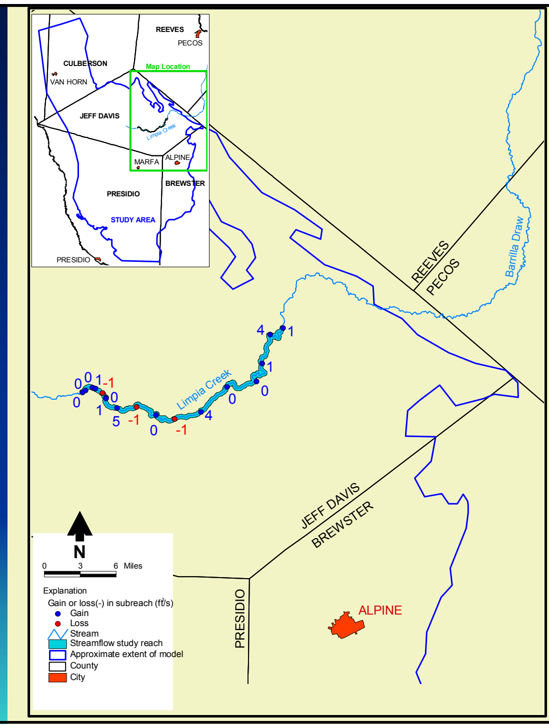
USGS 08431800



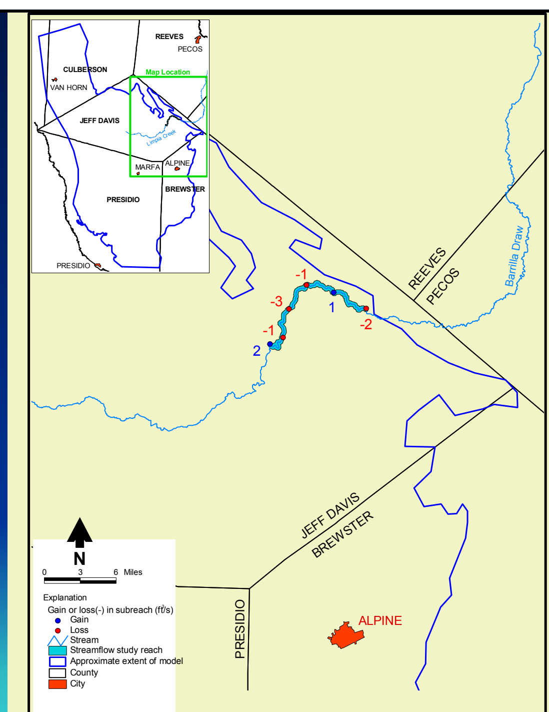
USGS 08432000

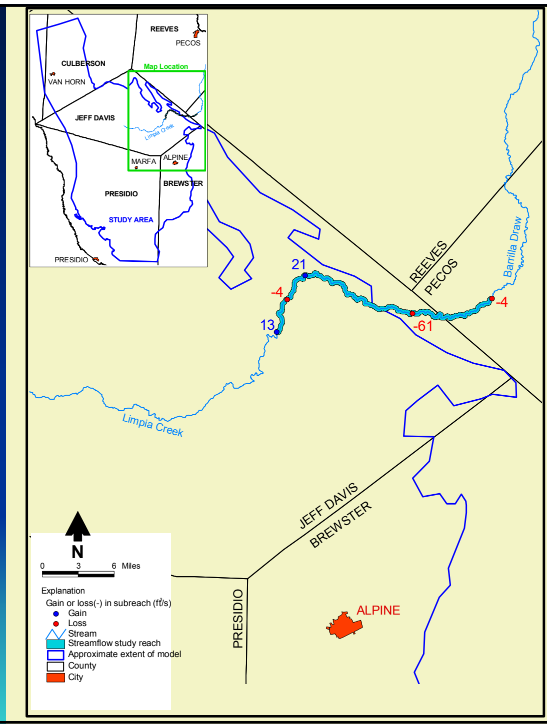


Gain-Loss Data for Limpia Creek

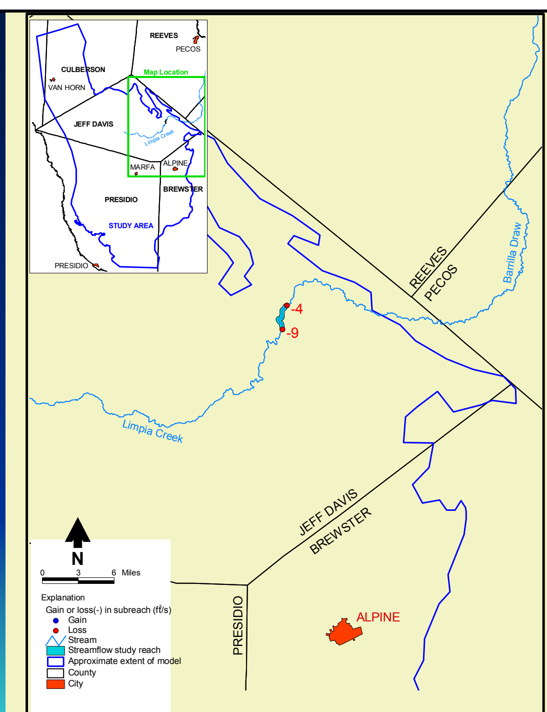


Gain-Loss Data for Limpia Creek

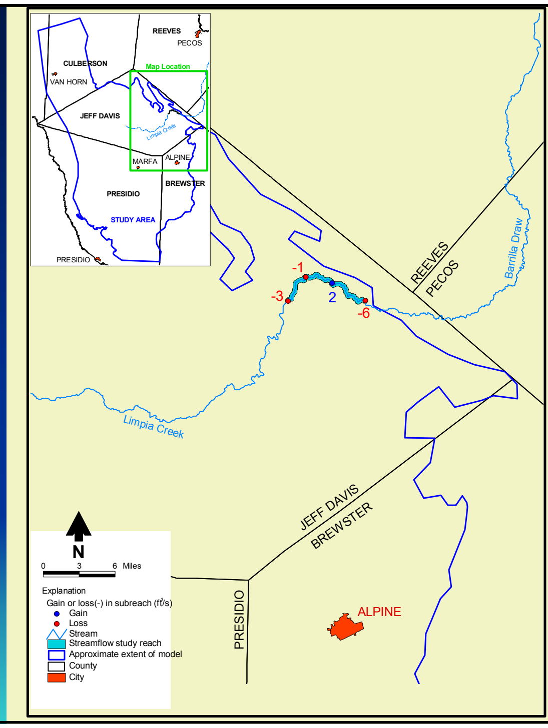




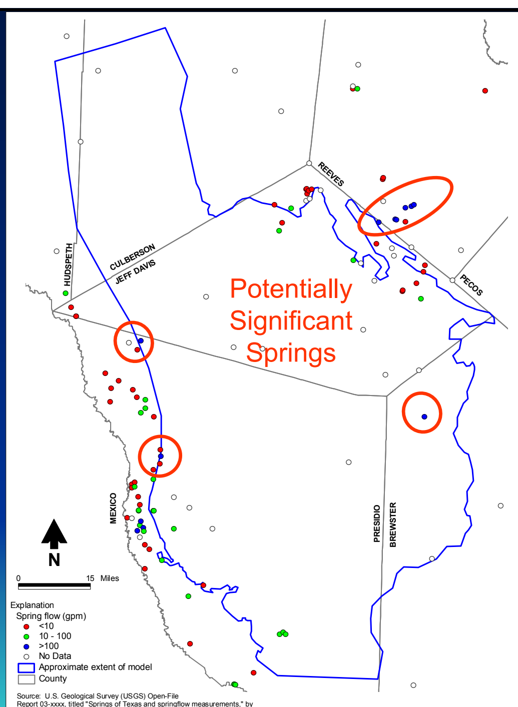
Gain-Loss Data for Limpia Creek



Gain-Loss Data for Limpia Creek

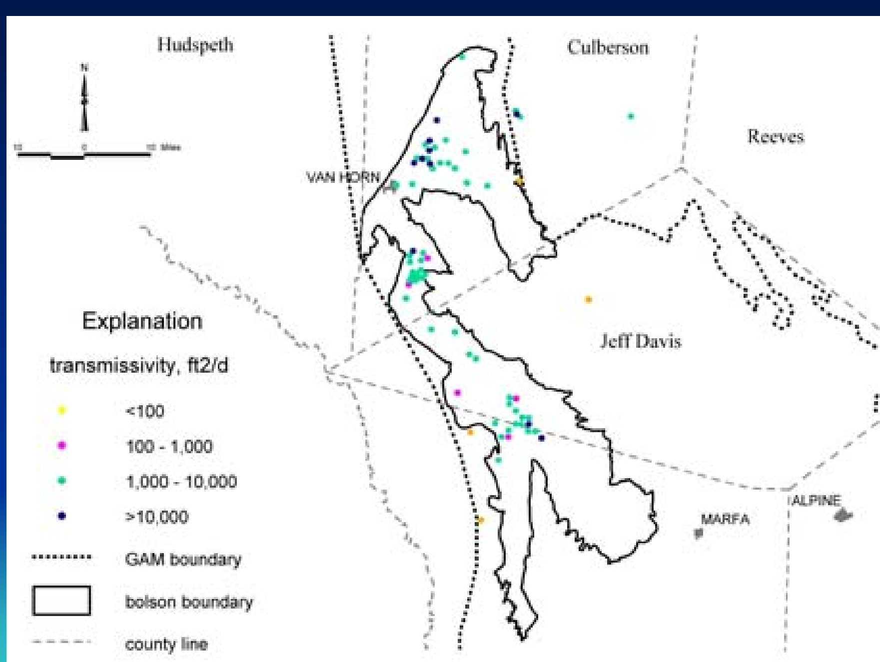


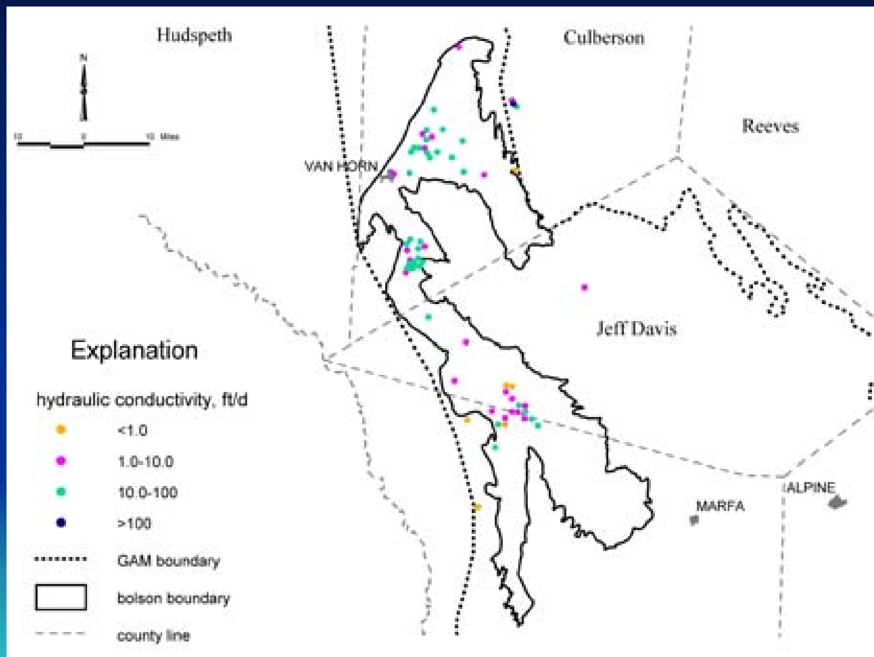
Gain-Loss Data for Limpia Creek



Springs

Hydraulic Properties



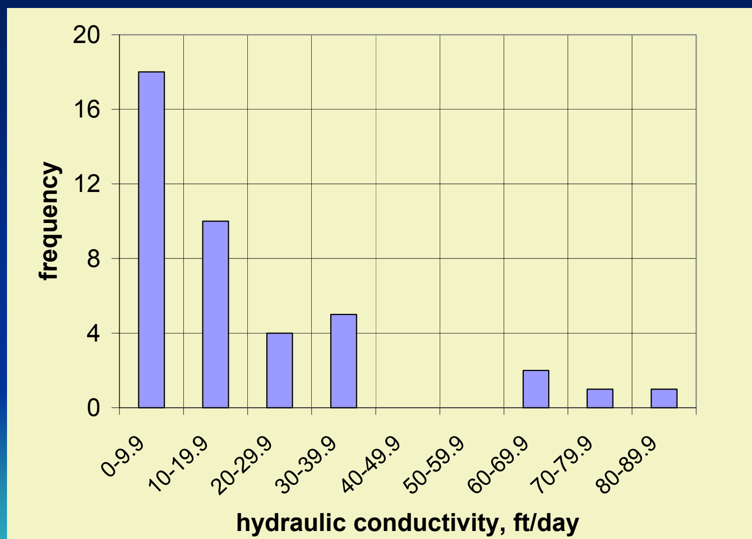


HYDRAULIC PROPERTIES OF BOLSON AND UNDERLYING ROCKS

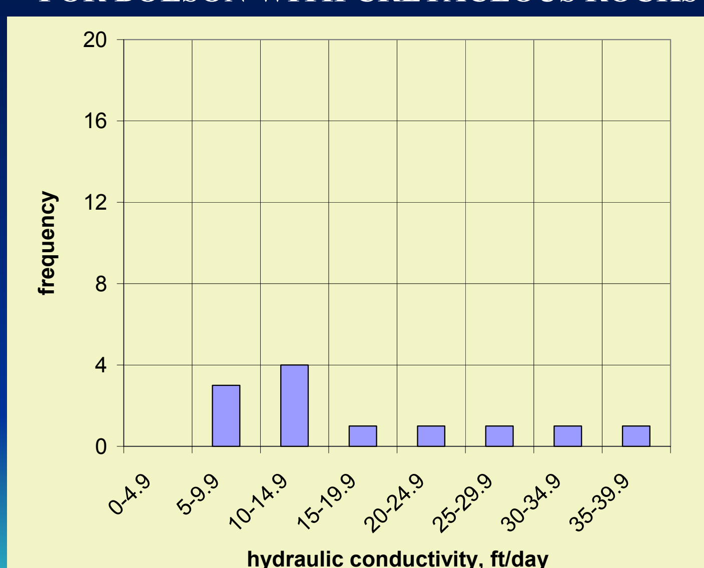
- Collected data from 98 wells in Bolson area
- Most hydraulic properties were interpreted from specific capacity

aquifer	average transmissivity (ft2/d)	average hydraulic conductivity (ft/day)
Salt Basin	5,987	24
Salt Basin and Cretaceous	1,544	4
Salt Basin and Permian	2,197	10
Cretaceous	20,948	68
Permian	62,370	263
Volcanic	14,220	96

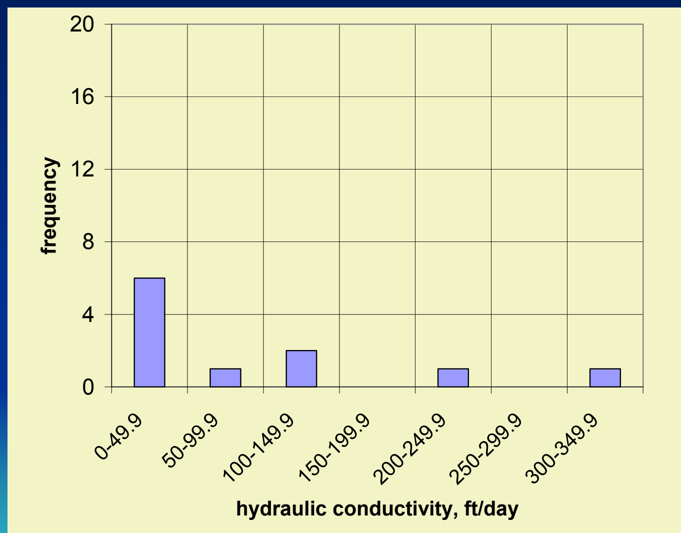
HISTOGRAM OF HYDRAULIC CONDUCTIVITY FOR BOLSON



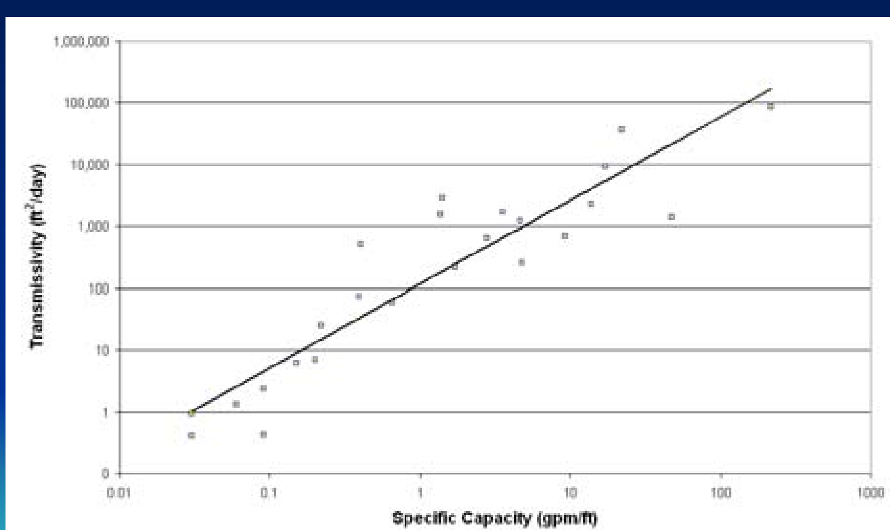
HISTOGRAM OF HYDRAULIC CONDUCTIVITY FOR BOLSON WITH CRETACEOUS ROCKS



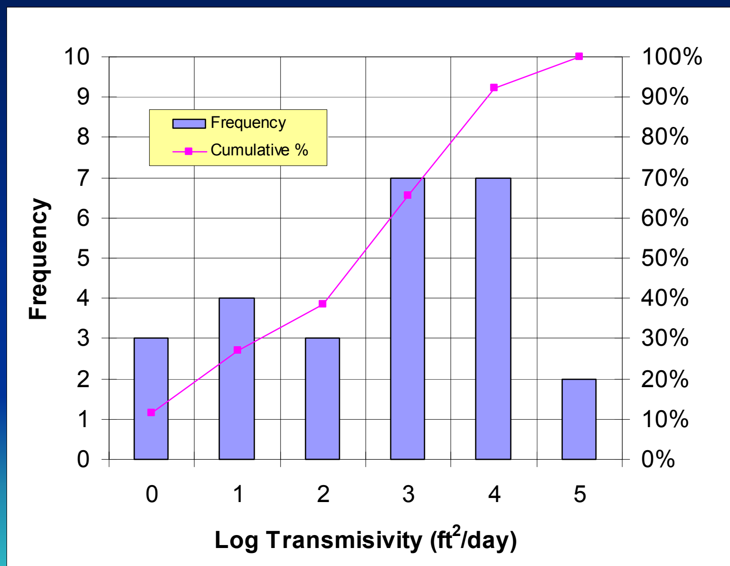
HISTOGRAM OF HYDRAULIC CONDUCTIVITY FOR PERMIAN ROCKS

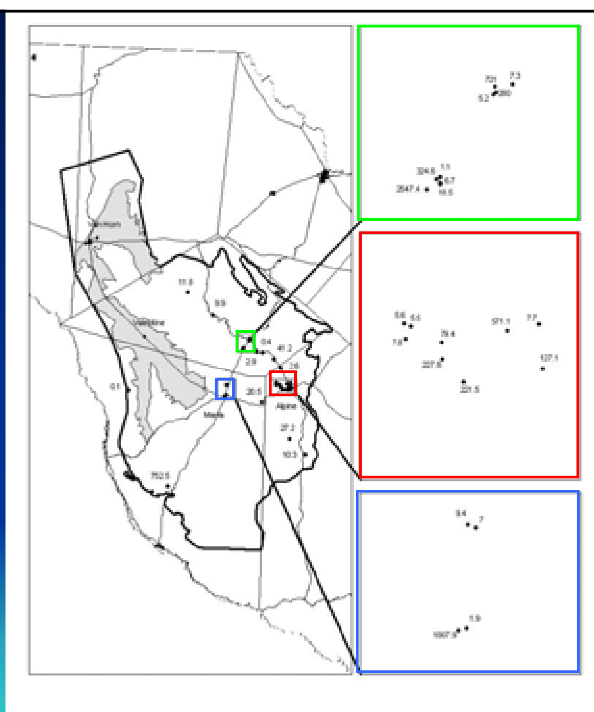


Sc versus T – Igneous Aquifers

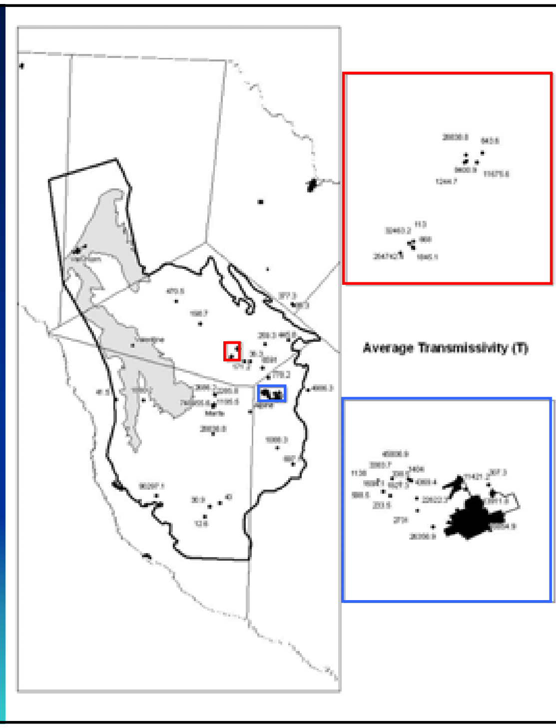


HISTOGRAM OF TRANSMISSIVITY IN IGNEOUS WELLS

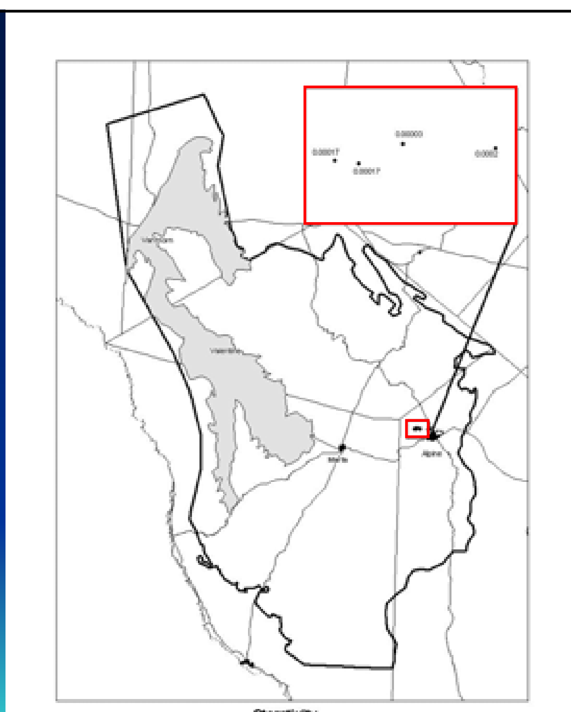




Hydraulic Conductivity Data (feet/day)



Transmissivity
Data
(ft^2/day)



Storativity
Data
(ft/ft)

Discharge

Pumping Data

- Agricultural
- Livestock
- Municipal
- Rural domestic
- Manufacturing point
- Manufacturing non-point

Pumping Data

- TWDB database is primary source of data
- Supplemental data from other source documents
- Data is assembled in Microsoft Access and spatially related to the model grid with ArcView GIS.

Point Data

- Distributed to a model grid cell at the point of withdrawal.
- Dates are used, when available, to determine when a well begins and ends pumping.

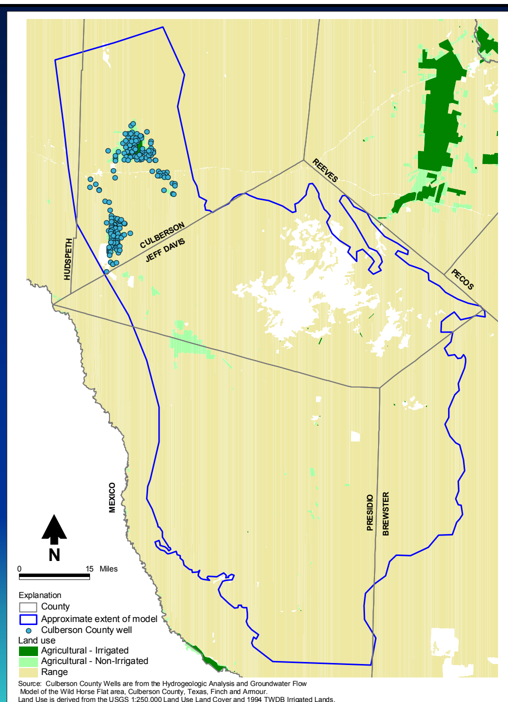
Non-Point Data

- Distributed throughout the model based on land use.
- USGS 1:250,000 Land Use Land Cover.
- 1994 TWDB irrigated acreage coverage is used to distinguish between irrigated and non-irrigated agricultural lands within the USGS Land Use file.

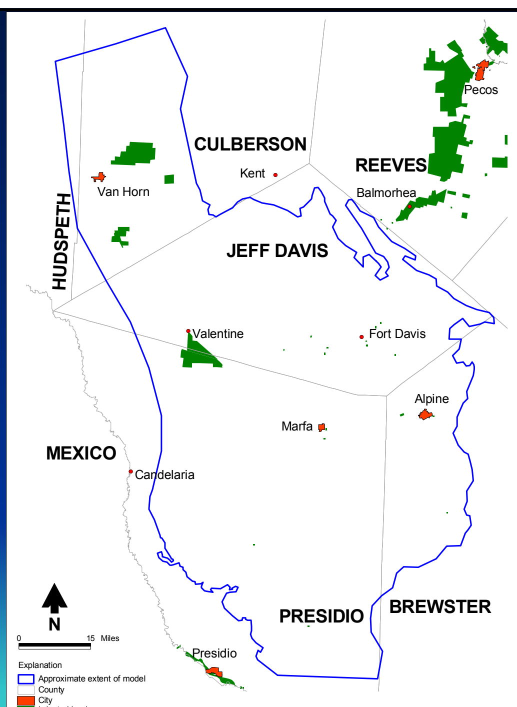
Irrigated Agriculture

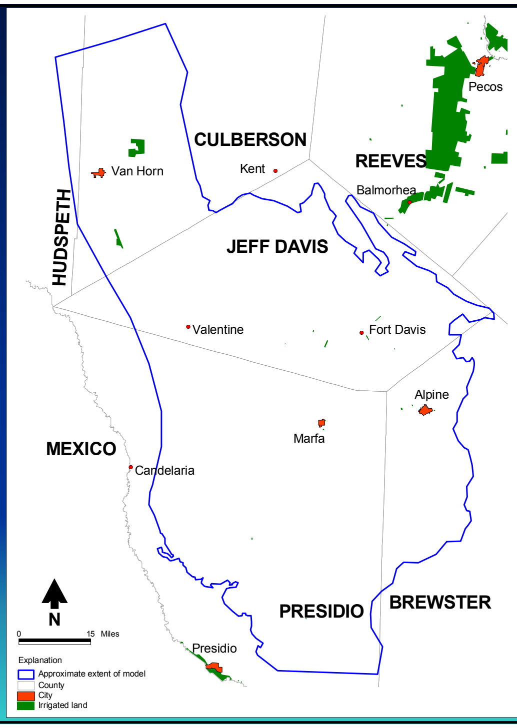
- The majority of agricultural pumping is in Culberson County
- Point data is available for Culberson County from an existing modeling report (Finch and Armour)
- TWDB irrigation surveys will be used for the remaining counties; pumping will be distributed to model grid cells within the agricultural-irrigated lands portion of the land use layer.

Irrigated Agriculture



Irrigation (1989)

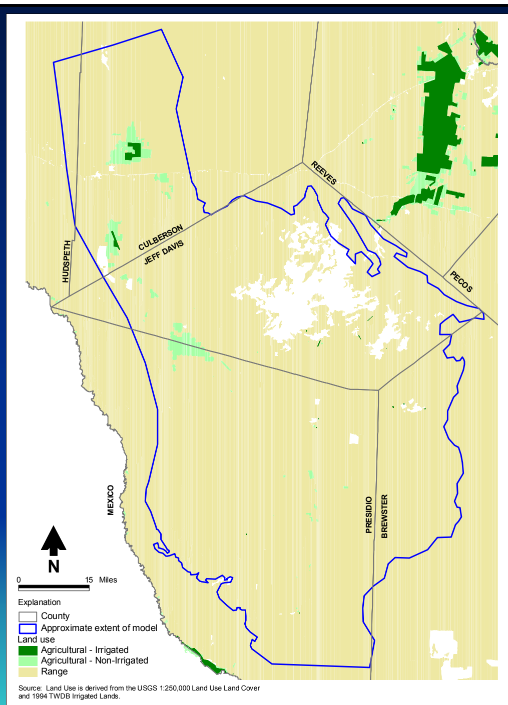




Irrigation (1994)

Livestock

- Livestock pumping is provided at the county level in the TWDB database
- Will be distributed to model grid cells within the *agricultural non-irrigated* and *rangeland* land use portions of the land use layer



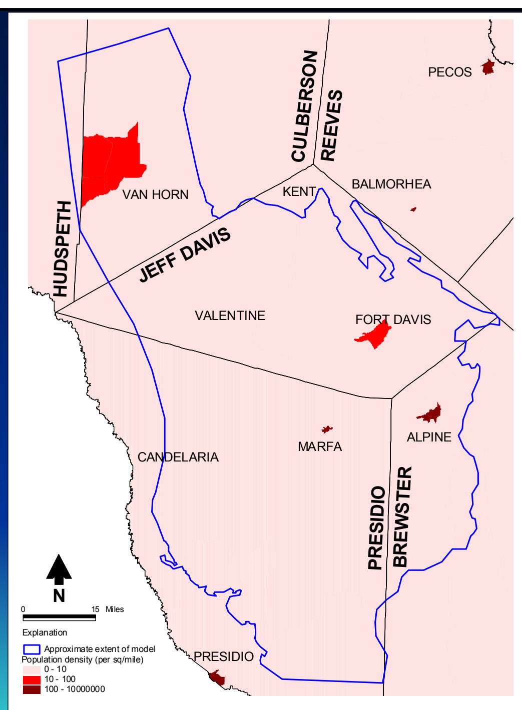
Agricultural Land Use

Municipal

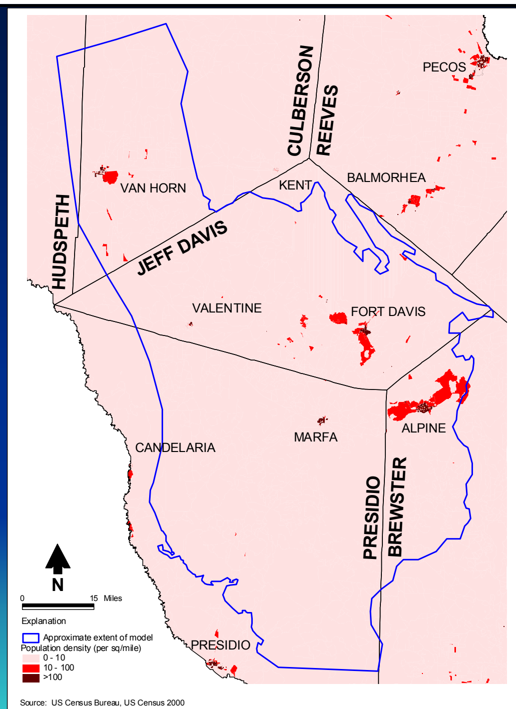
- Municipal pumping reported at the city level
- Most or all will be distributed evenly among model grid cells that lie within the city limits
- If data on point locations is obtained, it will be used to distribute pumping to the corresponding model cell(s)

Rural Domestic

- 1990 and 2000 Census block data used to distribute rural domestic pumping.
- Rural areas are the census blocks outside of the TNRIS city coverage boundaries.
- Census blocks are intersected with the model grid from which a population factor is calculated and used to distribute county rural domestic pumping throughout the rural areas.



1990 Census Data



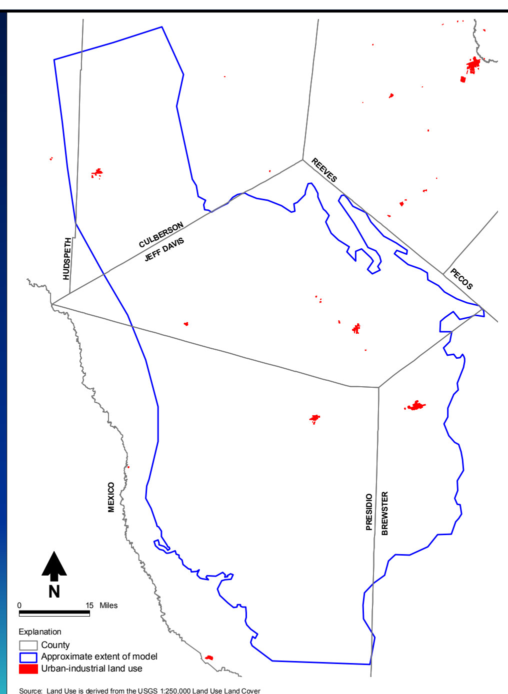
2000 Census Data

Manufacturing Point

- Locations of manufacturing data will be researched based on supplier information field in the TWDB database
- Manufacturing pumping data that has an identifiable location is assigned to the appropriate model grid cell

Manufacturing Non-Point

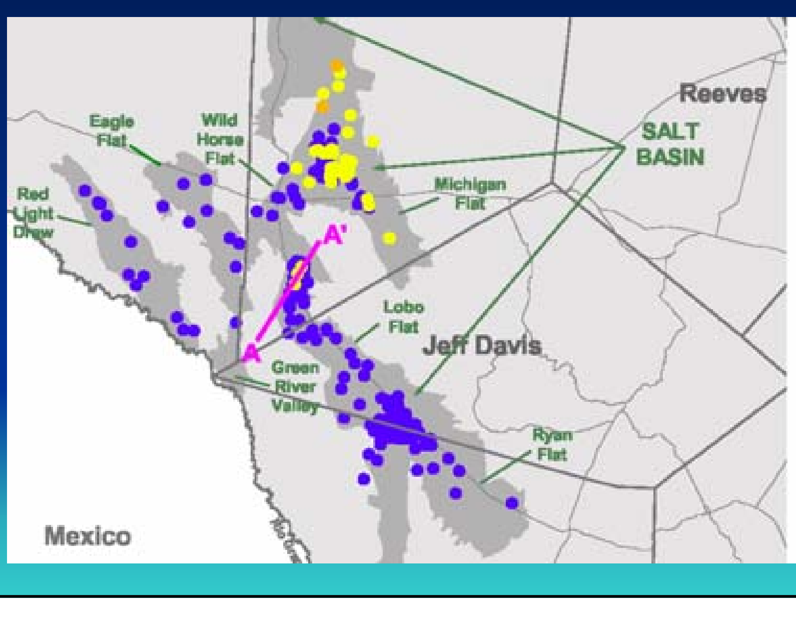
- Manufacturing pumping that does not have an identified location will be distributed over the *urban*, *industrial*, and *mining* land use codes from the land use GIS layer



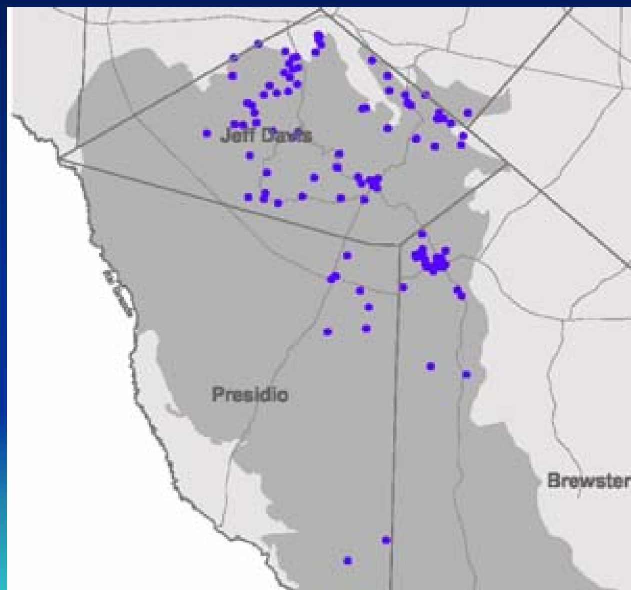
Urban-Industrial Land Use

Water Quality

Bolson Water Quality

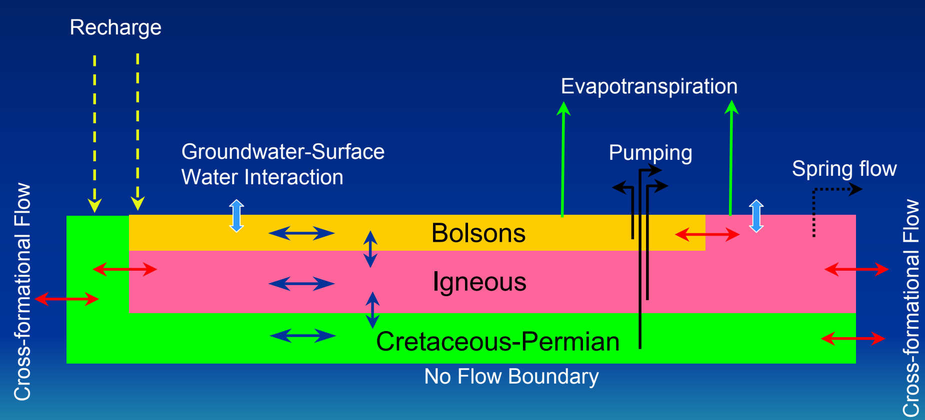


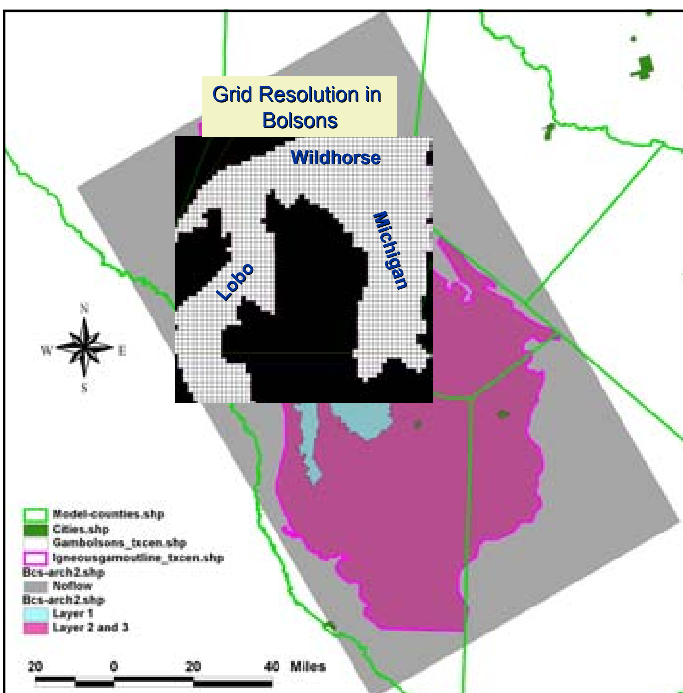
Igneous Water Quality



Model Architecture

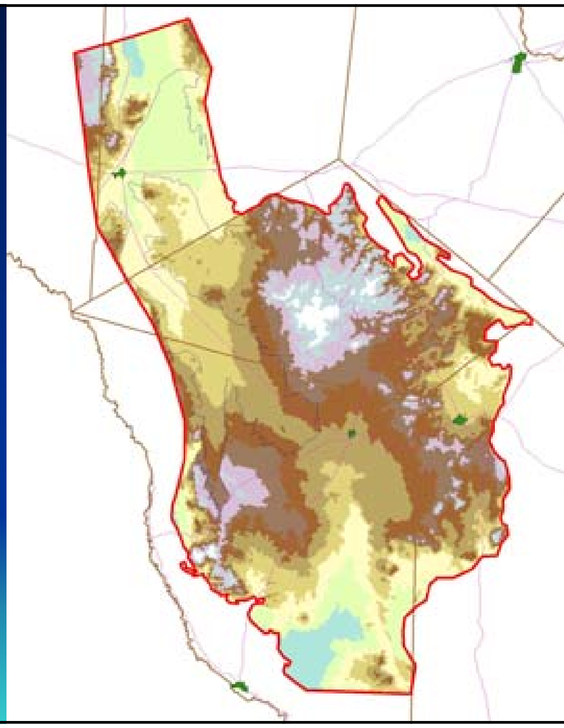
Conceptual Block Diagram



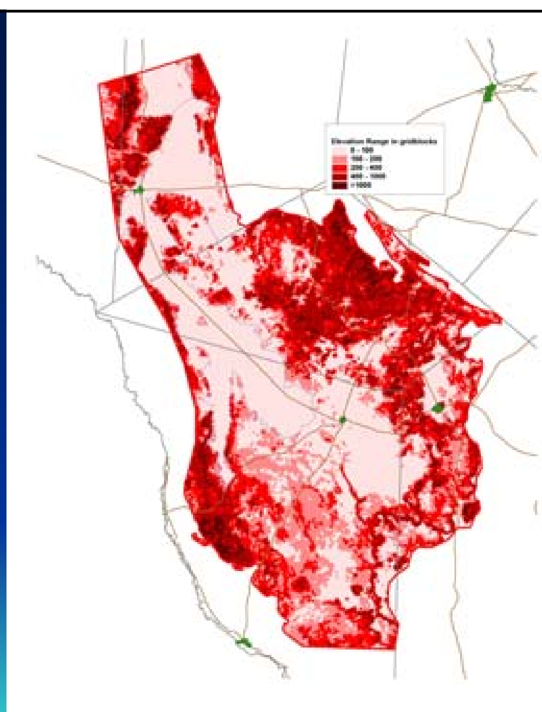


Model Grid

300 x 180 x 3 = 162,000
Active ~ 55,000

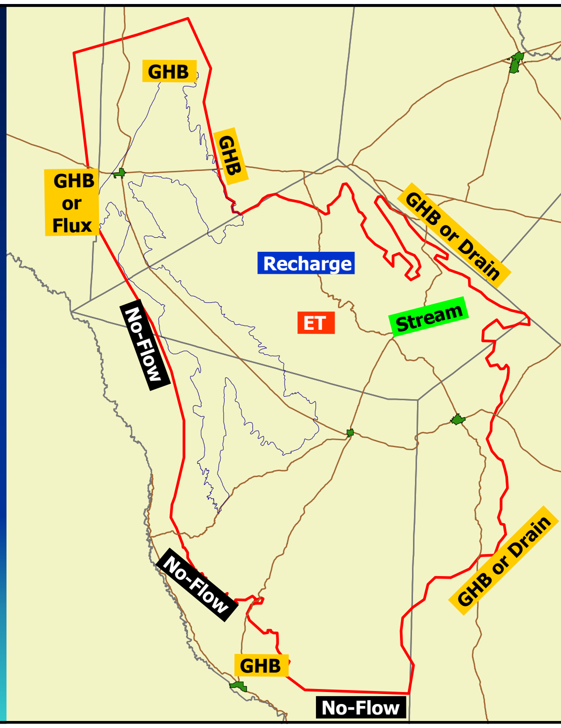


Topography on ½-mile Grid

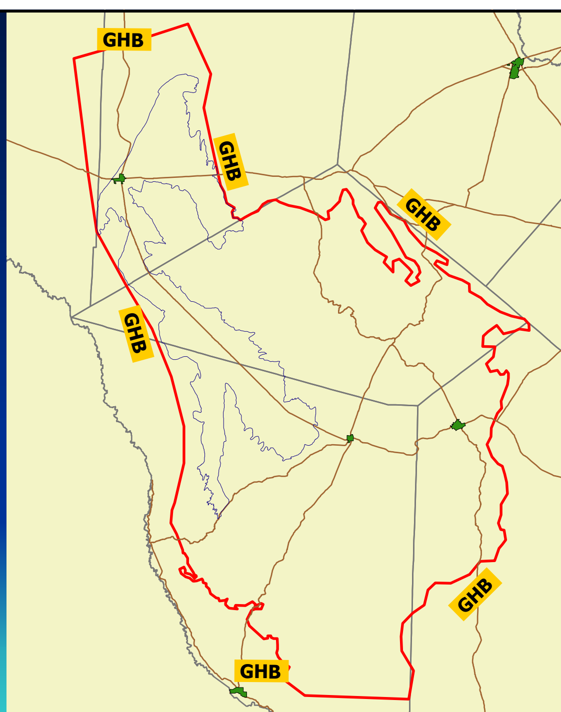


Elevation Range of 30-meter DEM data in Gridblocks

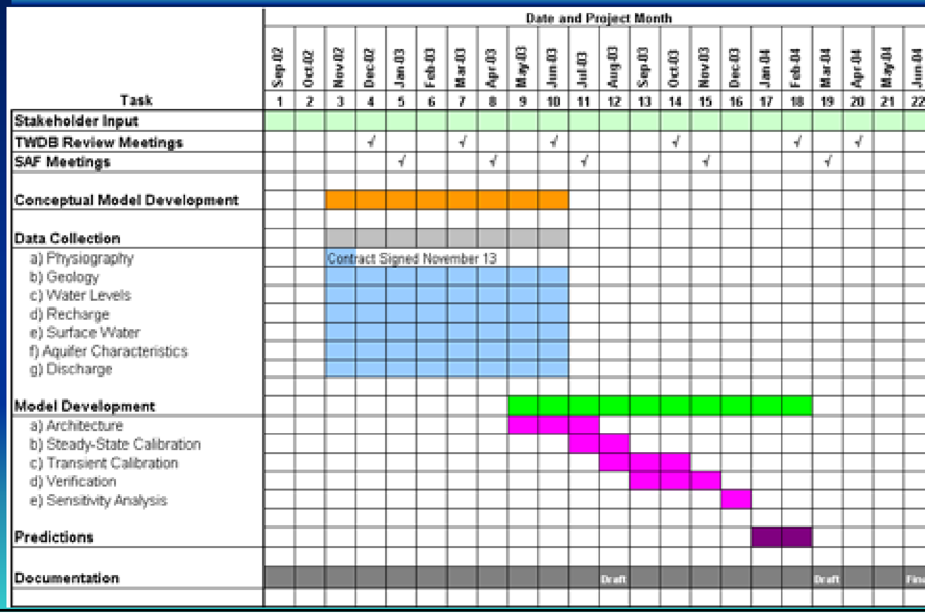
Layer 1 and 2 Boundary Conditions



Layer 3 Boundary Conditions



Project Schedule



Questions

3rd Stakeholder Advisory Forum
West Texas Igneous and Bolson GAM
List of Attendees

Name	Affiliation
James Beach	LBG-Guyton Associates
John Ashworth	LBG-Guyton Associates
Curtis Schrader	City of Marfa
Andrew Chastain-Howley	WPRC
Zhuping Sheng	TAMU
Terry Bishop	Presidio County Water Board
Becky Thorp	Presidio County Water Board
Van Robinson	
Bill Hutchison	El Paso Water Utilities
E.S. Angle	TWDB
Annie McCoy	John Shomaker & Associates
Steve Finch	John Shomaker & Associates
Laurie Trevizo	SRSU
Dave Hall	Public of El Paso
Kevin Urbanczyk	SRSU
Janet Adams	
Allan Standen	D.B. Stephens
Ralph Merriwether	
Bill Jenkins	ZO Resources

QUESTIONS AND ANSWERS
West Texas Igneous and Bolson GAM
SAF Meeting 3 - July 29, 2003
Alpine, Texas

Q: What is boundary between layers 1 and 2?
A: Layer 1 will contain the total thickness of the basin fill and the volcaniclastics within the boundaries of the TWDB designated Bolson aquifers.

Q: If the group is modeling the West Texas bolsons, why are they not on the TWDB map of modeled minor aquifers?
A: This will be corrected for the next meeting.

Q: Please explain the nature of dry cells and the issues associated with (layer 2 in the northern area).
A: Dry cells occur in MODFLOW when the simulated water level drops below the base of the aquifer. The Igneous aquifer (designated by model layer 2) does not exist in the northern part of the study area. In that area, the bolson aquifer (model layer 1) is in direct contact with the underlying Cretaceous aquifers (model layer 3). To simulate this hydraulic connection, layer 2 will be implemented as a thin layer (1-foot thick) in that area.

Bill Hutchison (EPWU) commented that Layer 2 is 6000 feet thick, and suggested that the use of the variable transmissivity layer conceptualization (LAYCON=3) would not be user-friendly for this model. He suggested that the constant transmissivity conceptualization (LAYCON = 0) be used for Layer 2 and 3 so the model would be more robust. He also suggested that using three layers is still the most efficient way of modeling this system and suggested that having a 1-foot thickness for layer 2 in areas where it is hydrogeologically absent will be most effective.

Q: Will the faults be incorporated into the model?
A: The major faults will be incorporated indirectly through the water levels and structure, which is integrated into the model.

Several stakeholders suggested that the hydrographs on the same page have consistent scales on the X and Y-axes.

Q: Is there any chance that subsidence will cause lower water levels with the same amount of recharge?
A: No, in fact, there would most likely be a slight reversal, in that subsidence would reduce slightly the pore space available for the water and the same amount of recharge would cause water levels to be higher.

Q: Is there any significant difference between the mean and median (related to the recharge values)?
A: There is no significant difference.

Q: There is an area around Alamito Creek where no recharge is assigned – is this correct?
A: Yes, we do not have enough data in this area to suggest otherwise.

Q: Will you be using yearly stress periods?
A: Yes, except for the period of 3 years (as stipulated in the contract) during the 1980s and 1990s when monthly stress periods will be applied. Because there is very little data (water level, pumping, recharge, etc.) for calibration and verification at the monthly level, we will discuss the requirement with the TWDB to see if the monthly stress periods will still be required.

Q: Will the model show the impact of pumping on the springs?
A: Even with a refined grid spacing of ½-mile, the model will probably not be an appropriate tool for simulating the impact of pumping on springs. This is partly due to the large variation in topography over a single model gridblock. In the Davis Mountains there is up to 1,000 feet of topographic variation within a ½-mile gridblock. In addition, some of the springs exist because of local hydrogeologic structural controls and are mainly a function of relatively local flow systems that cannot be simulated well at the regional level.

Q: What are the team's thoughts about the distribution pattern and magnitude of the recharge? How will you be using the recharge numbers in the calibration process?
A: The distribution of recharge from the initial analysis looks reasonable and intuitive from a hydrologic perspective. It is probable that the distribution pattern will stay the same but the magnitude may change during the modeling.

Q: What percent of runoff becomes recharge? Will you be using the 2.5 to 5 percent recharge in the Igneous as used in the 2001 regional plan?
A: Initial recharge estimates will be based on the percentages identified for the various areas within the study model area as specified in the recharge evaluation of this project.

Q: Is there any problem using a drought period for predevelopment calibration?
A: The predevelopment (steady-state) simulation will be based on "average" conditions for the area and in general will represent conditions prior to 1950, which is when production from the aquifer began to increase.

Q: Are you recognizing a relationship between depth and T in the Igneous aquifer?
A: Depth and T are only partially relational due to the multiple discontinuous layering within the Igneous strata. Although we recognize that there is significant vertical variation in the permeability in the Igneous units, we do not have sufficient data to describe this variation and feel that incorporating one layer for the Igneous aquifer is consistent with the level of data that exists as well as the objectives of the model.

Q: How will porosity be distributed in the model?
A: Initially, the porosity and storage properties of the aquifers will be assumed to be homogeneous (does not vary geographically) in each layer but will vary from layer to layer based on existing data. During calibration, the specific yield and storativity of the aquifers may be modified.

Q: Will the conceptual model report be released before the next SAF meeting?
A: The draft report is for internal TWDB use and is intended as a means of insuring that the model development remains on schedule. The report is generally not for public release; however, it is likely that the report can be made available to specified reviewers.