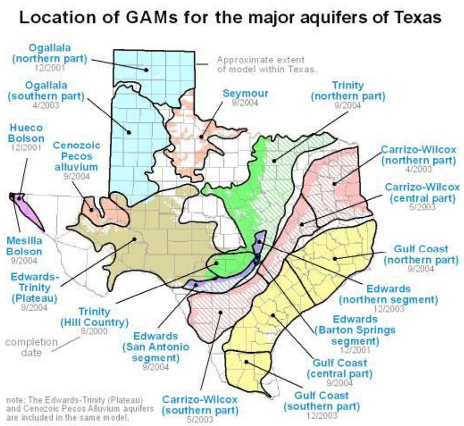
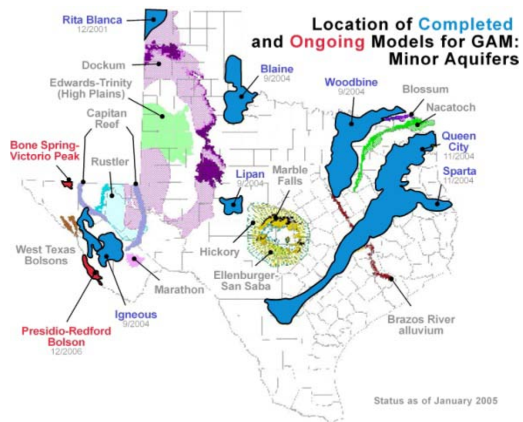
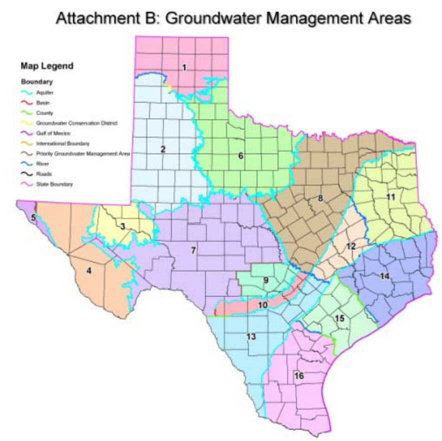
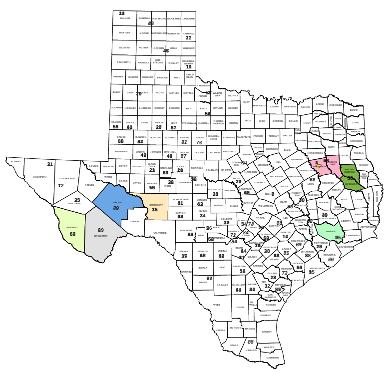
Groundwater Availability Modeling

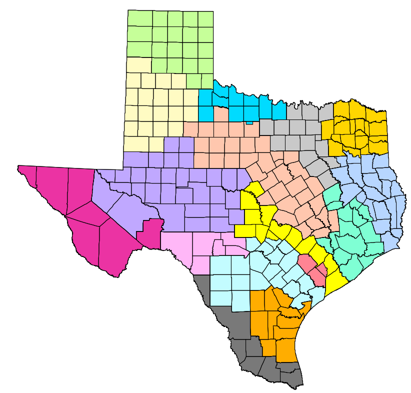








Texas Water Development Board



Texas Water Development Board

Groundwater Availability Model (GAM) for the Presidio-Redford Bolsons

Stakeholder Advisory Forum No. 2

March 15, 2011

Shirley Wade

Texas Water Development Board

Contributors to the project at TWDB

- Doug Coker
- Ali Chowdhury
- Bill Hutchison
- Cindy Ridgeway
- Marius Jigmond
- Melissa Hill
- Miguel Pavon

Texas Water Development Board

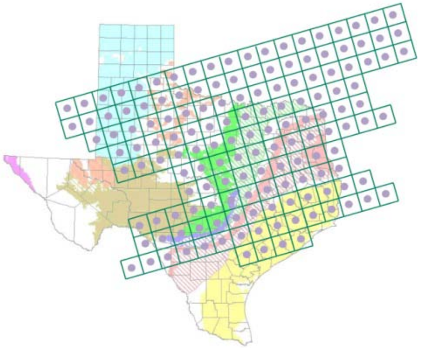
Acknowledgements

- Janet Adams and the Presidio County UWCD Board Members
- The City of Presidio
- Many individual landowners who allowed access to their wells
- TPWD
- IBWC

Agenda for Stakeholder Advisory Forum (SAF) Meeting No. 2
March 15, 2011

- Overview of TWDB's Groundwater Availability Modeling (GAM)
- Purpose of project
- Study Area and Geography
- Conceptual Model
- Climate, and Geology
- Hydrology data
- Pumping data
- Project schedule

Texas Water
Development Board



Groundwater Availability Modeling (GAM)

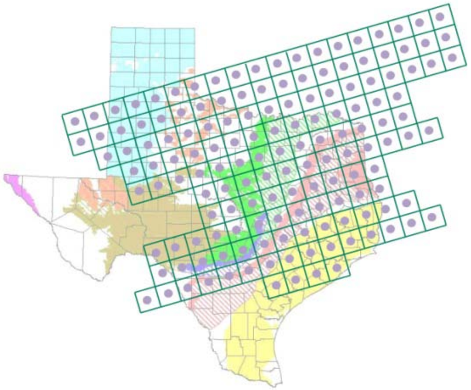
- **Purpose:** to develop tools that can be used to help evaluate groundwater
- **Public process:** you get to see how the model is put together.
- **Freely available:** standardized, thoroughly documented, with reports available over the internet.
- **Living tools:** periodically updated.

GAM Groundwater Availability Modeling

texas water development board

House Bill 1763

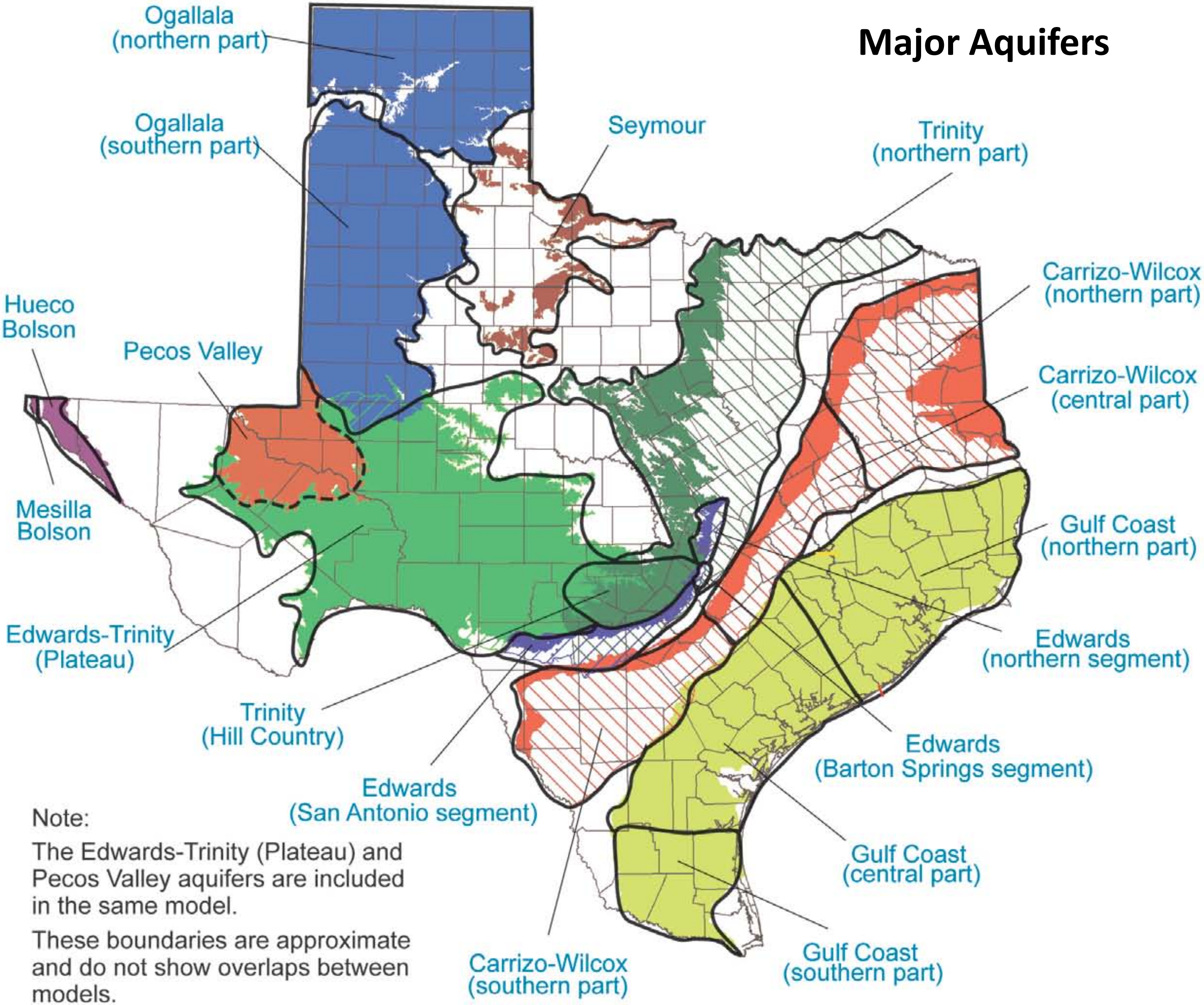
- **Passed in 2005**
- **Introduced concept of desired future condition of aquifers though joint planning of groundwater conservation districts in groundwater management areas**
- **Refocused attention to groundwater management area tools instead of aquifer wide models**



What is managed available groundwater?

- …**the amount of groundwater that may be permitted by a district for beneficial use in accordance with the desired future condition of the aquifer (HB 1763)**
- **A GAM is a <u>tool</u> that can be used to assess groundwater availability once the GMAs decide the desired future condition of their aquifer(s).**

Major Aquifers

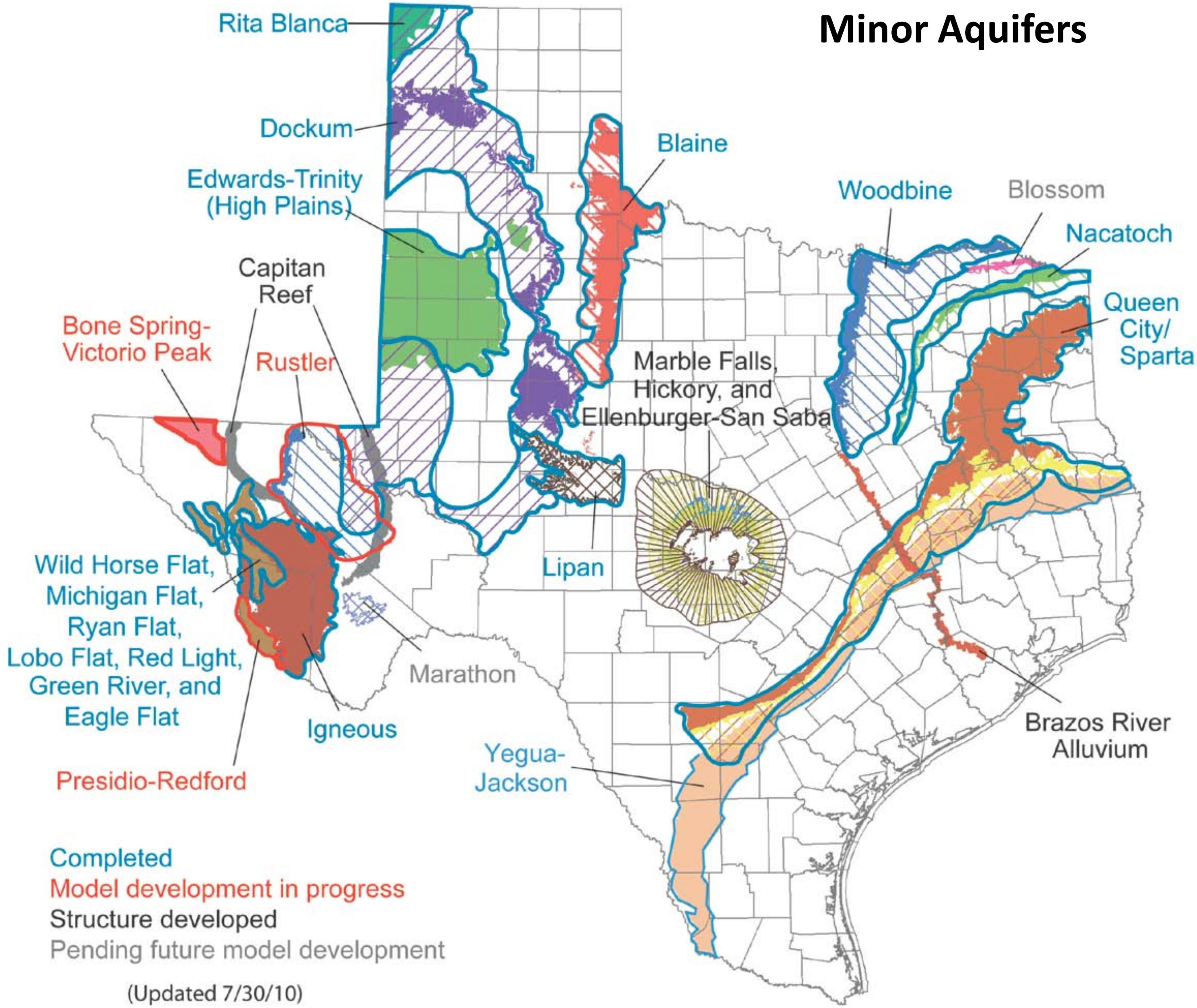


Note:

The Edwards-Trinity (Plateau) and Pecos Valley aquifers are included in the same model.

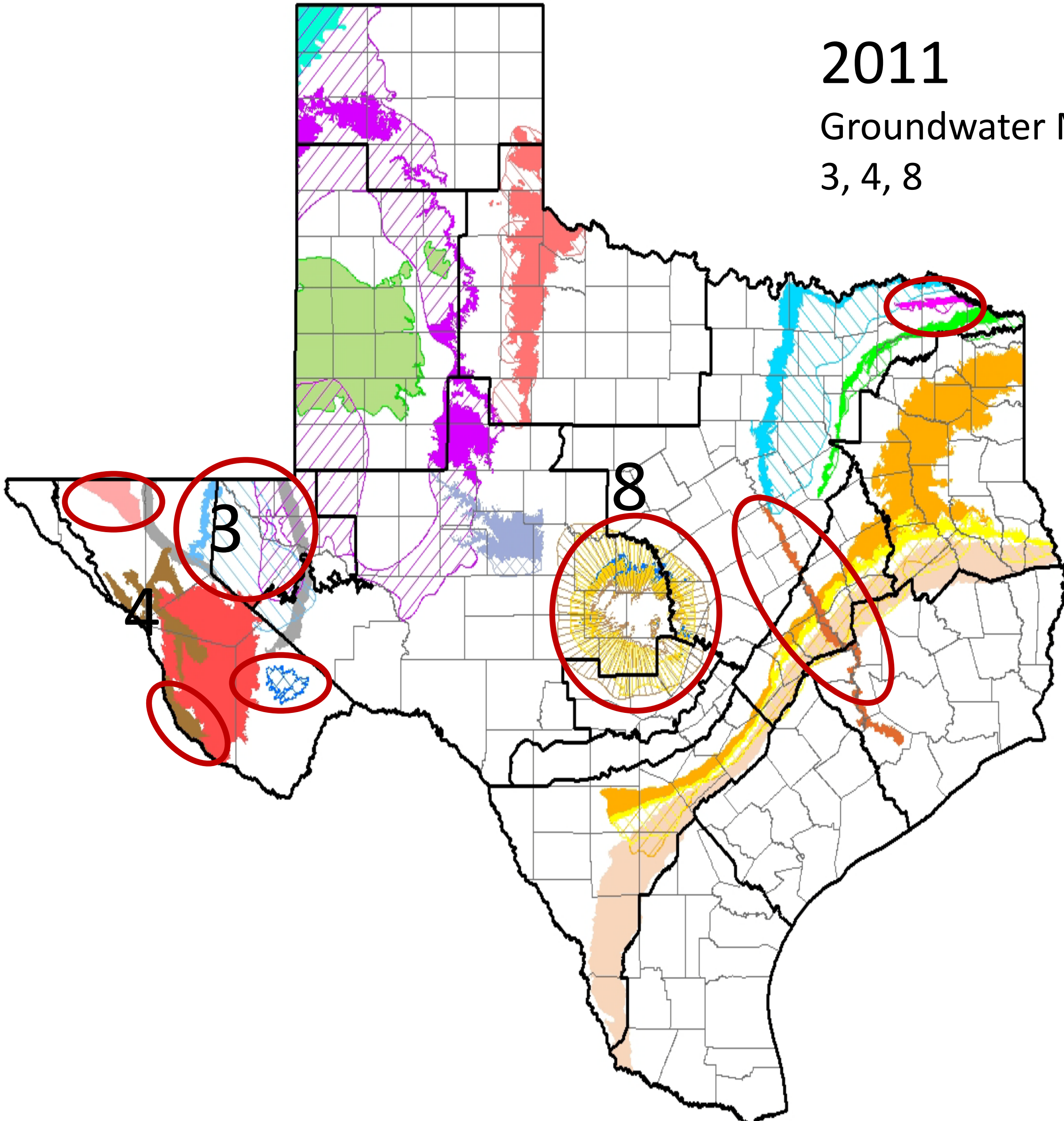
These boundaries are approximate and do not show overlaps between models.

Minor Aquifers



2011

Groundwater Management Areas 3, 4, 8



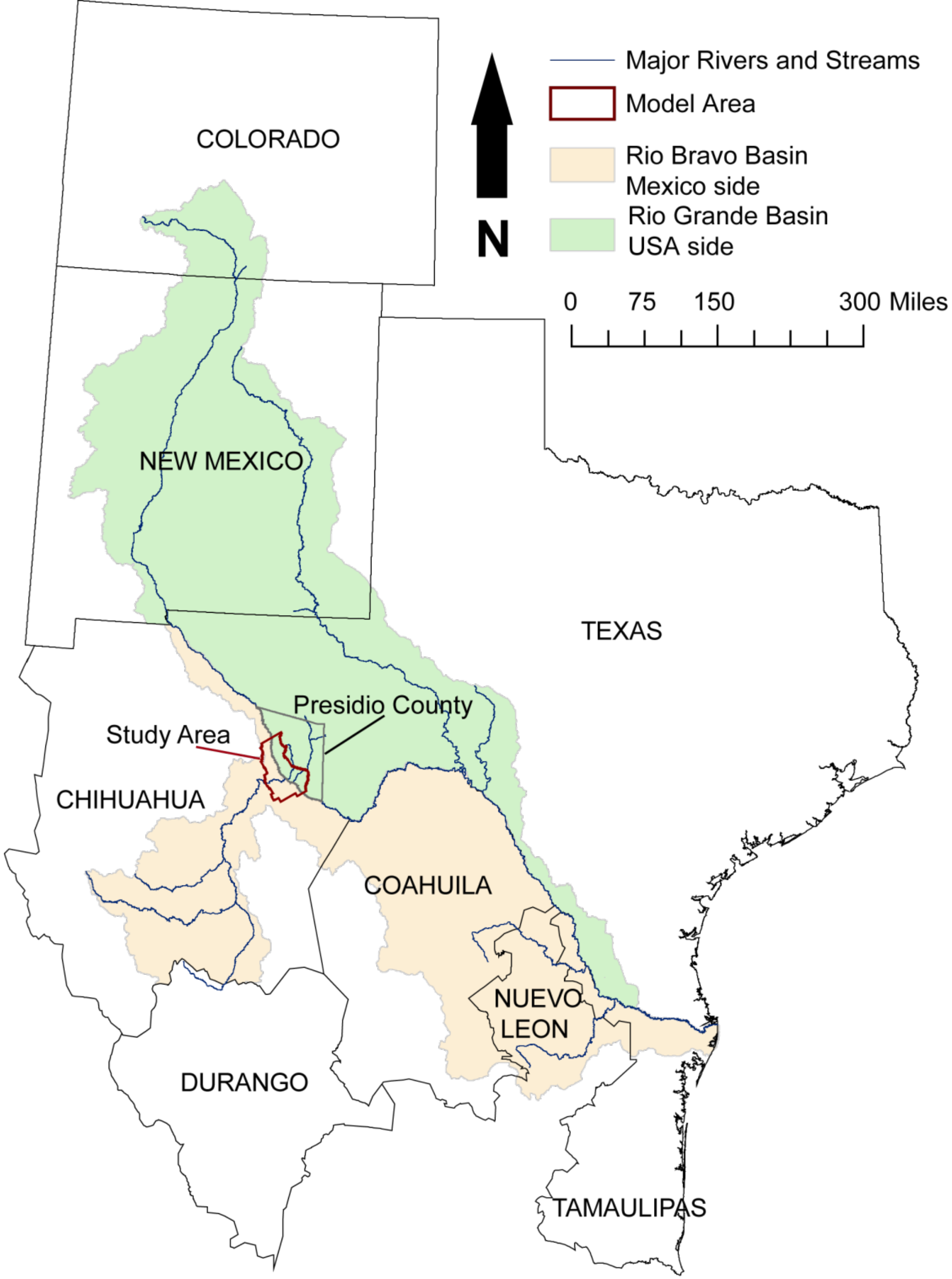
1. Rustler
2. Capitan Reef
3. Bone Springs-Victorio Peak
4. Marathon
5. Presidio-Redford Bolsons of West Texas Bolsons

6. Blossom
7. Brazos River Alluvium
8. Llano Uplift (Ellenburger-San Saba, Hickory, & Marble Falls

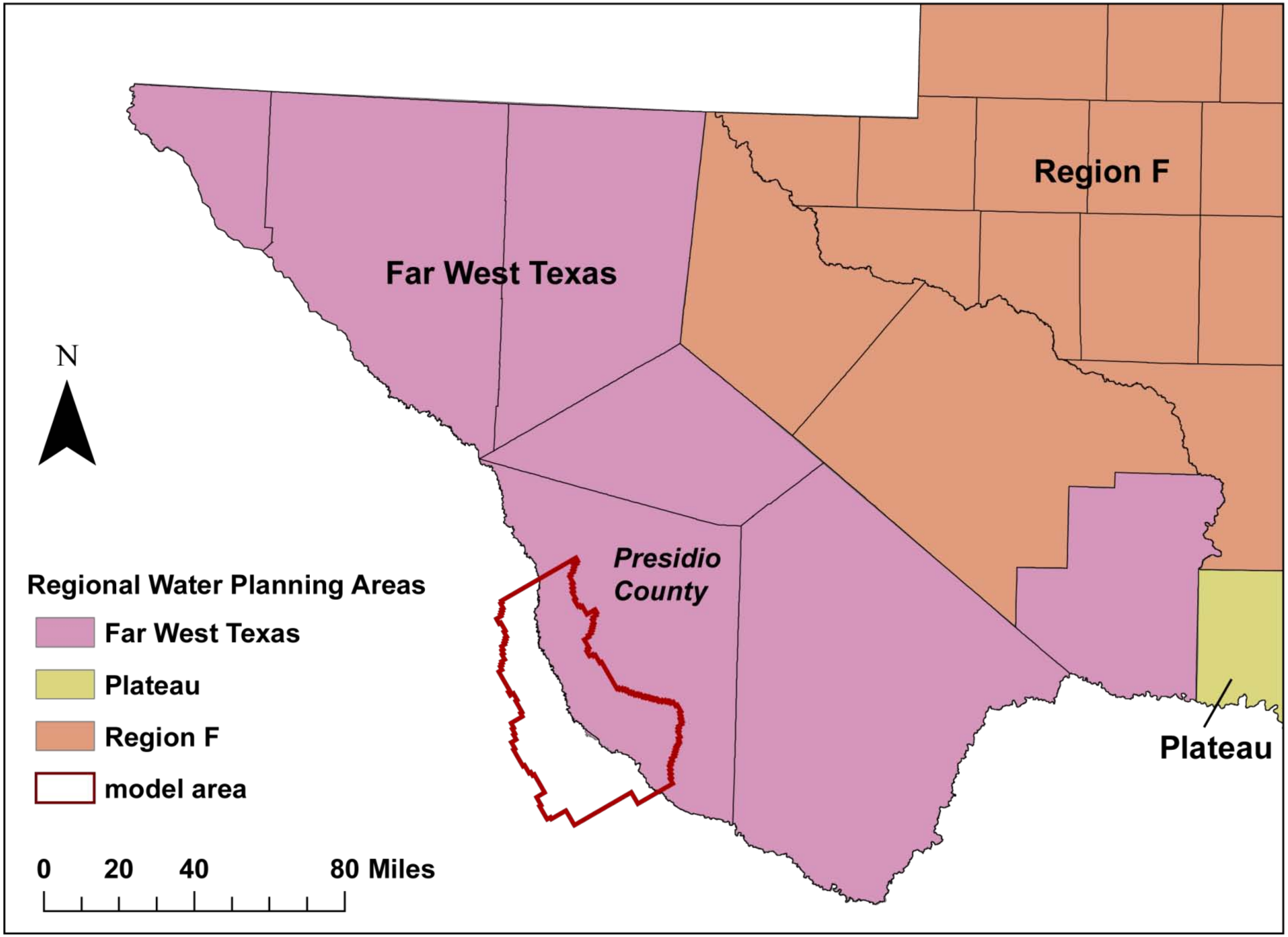
Purpose of project

- **To develop a groundwater model that can be used as a tool by Presidio County Underground Water Conservation District, Groundwater Management Area 4, and the Far West Texas Regional Water Planning group for groundwater resource planning**

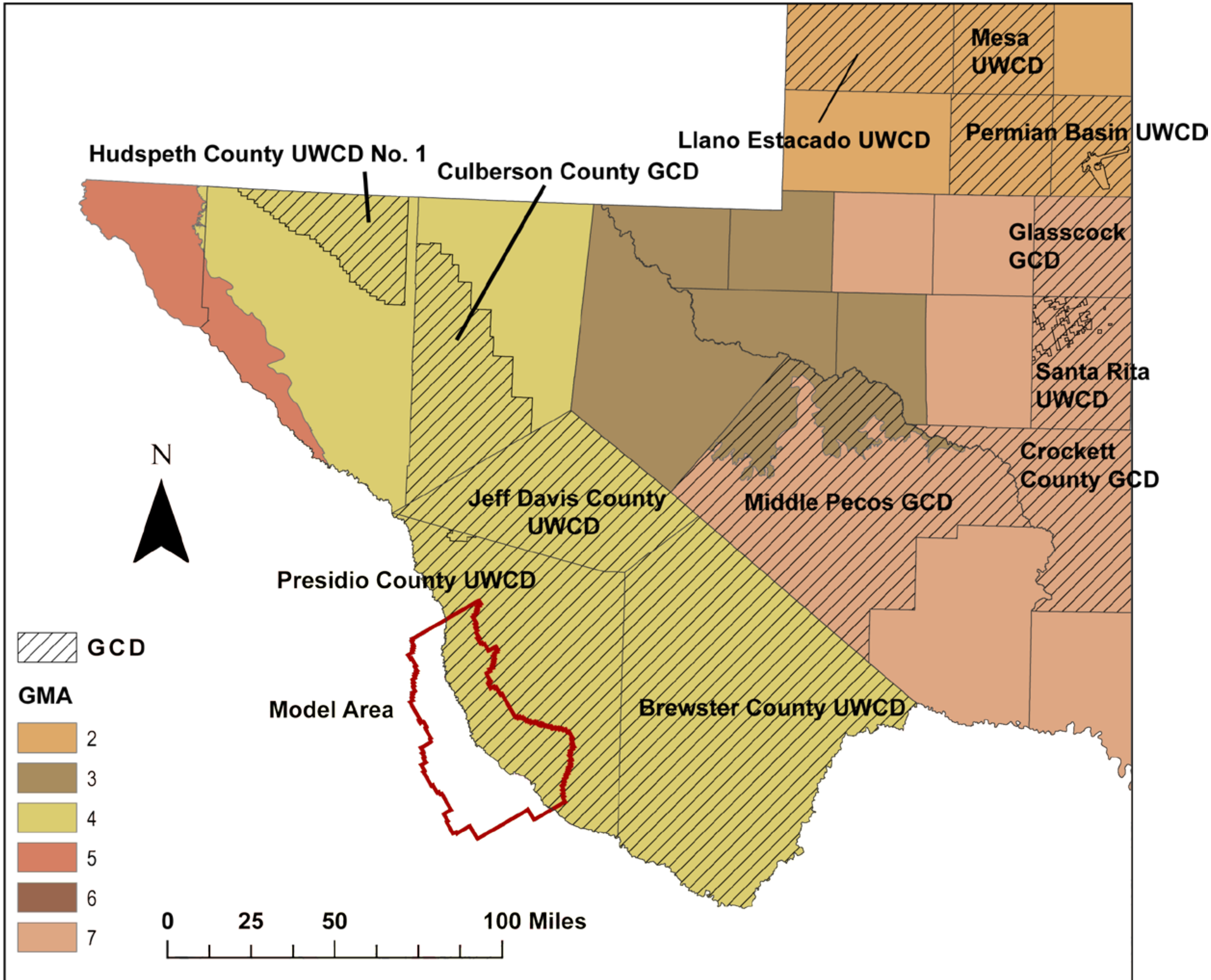
Study Area



sources: ArcHydro Binational Geodatabase, Center for Water Resources Research, University of Texas at Austin, and National Hydrography Dataset, US Geological Survey

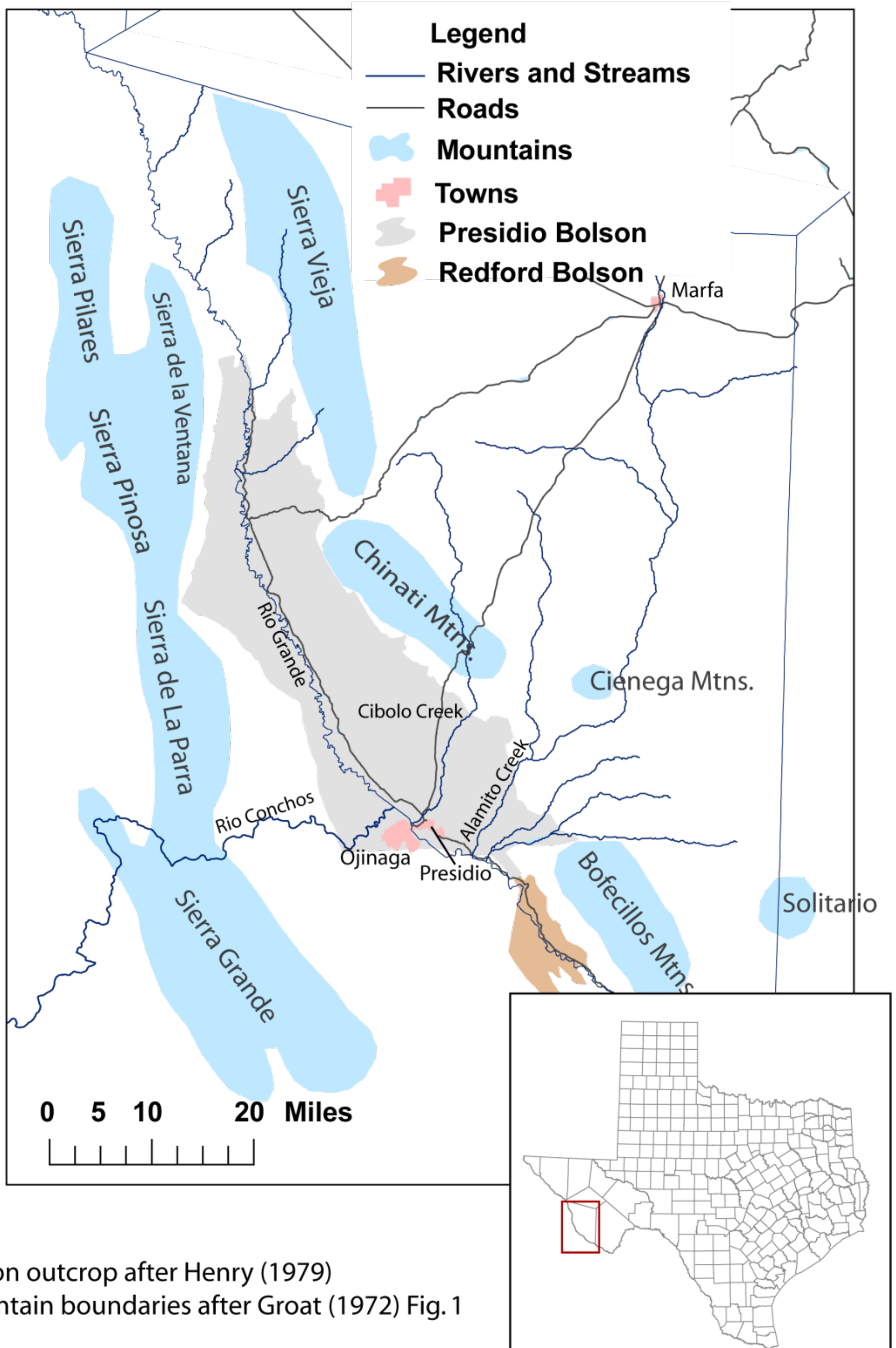


Far West Texas
Region F
Presidio County
Plateau
N
Regional Water Planning Areas
Far West Texas
Plateau
Region F
model area
0 20 40 80 Miles

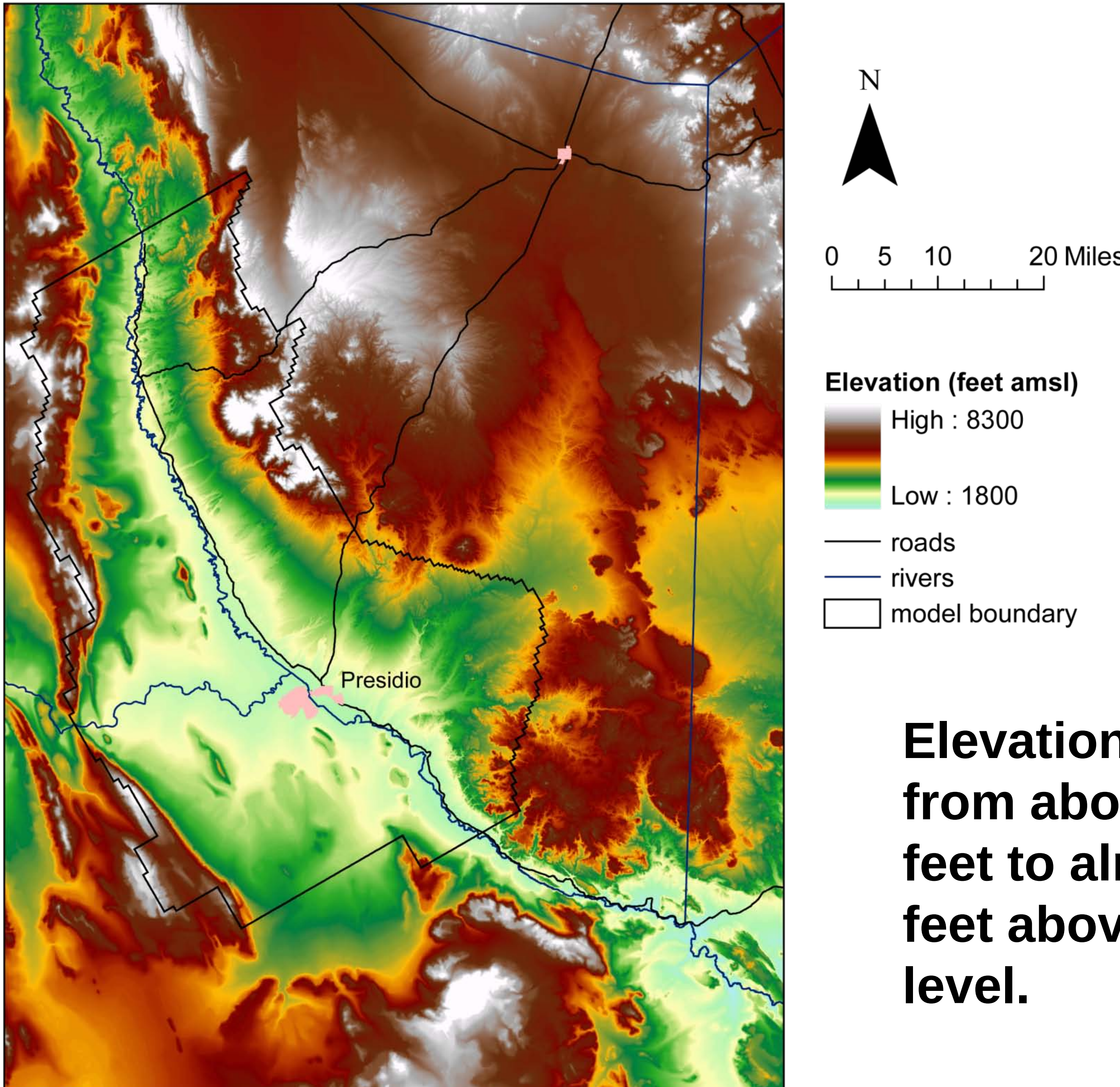


Mesa UWCD
Llano Estacado UWCD
Permian Basin UWCD
Hudspeth County UWCD No. 1
Culberson County GCD
Glasscock GCD
Santa Rita UWCD
Crockett County GCD
Middle Pecos GCD
Jeff Davis County UWCD
Presidio County UWCD
N
GCD
GMA
2
3
4
5
6
7
Model Area
Brewster County UWCD
0
25
50
100 Miles

Study area bounded on east and west by mountain ranges and drained by tributaries of the Rio Grande



Bolson outcrop after Henry (1979)
Mountain boundaries after Groat (1972) Fig. 1

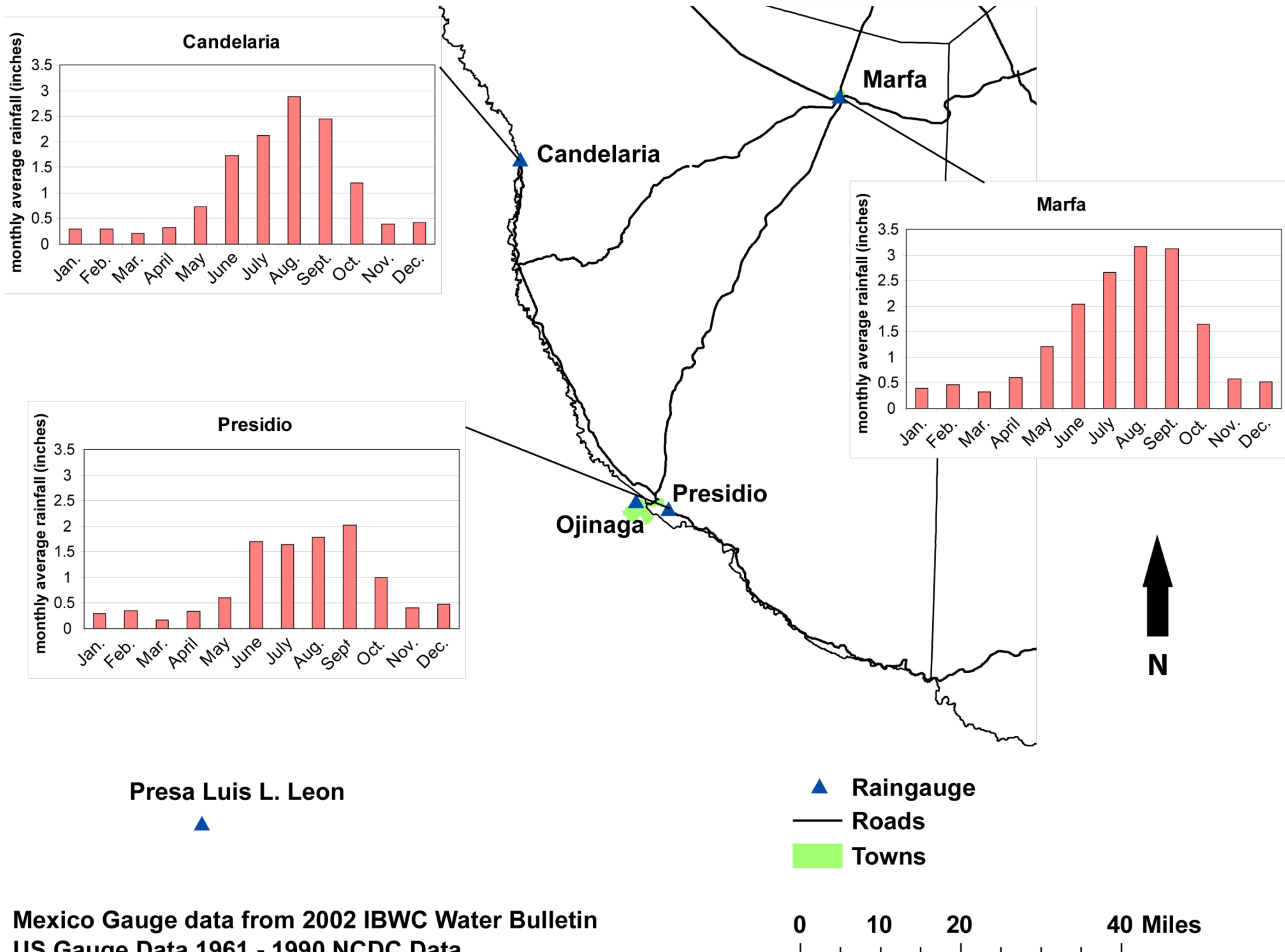


Elevations range from about 2,000 feet to almost 8,000 feet above sea level.

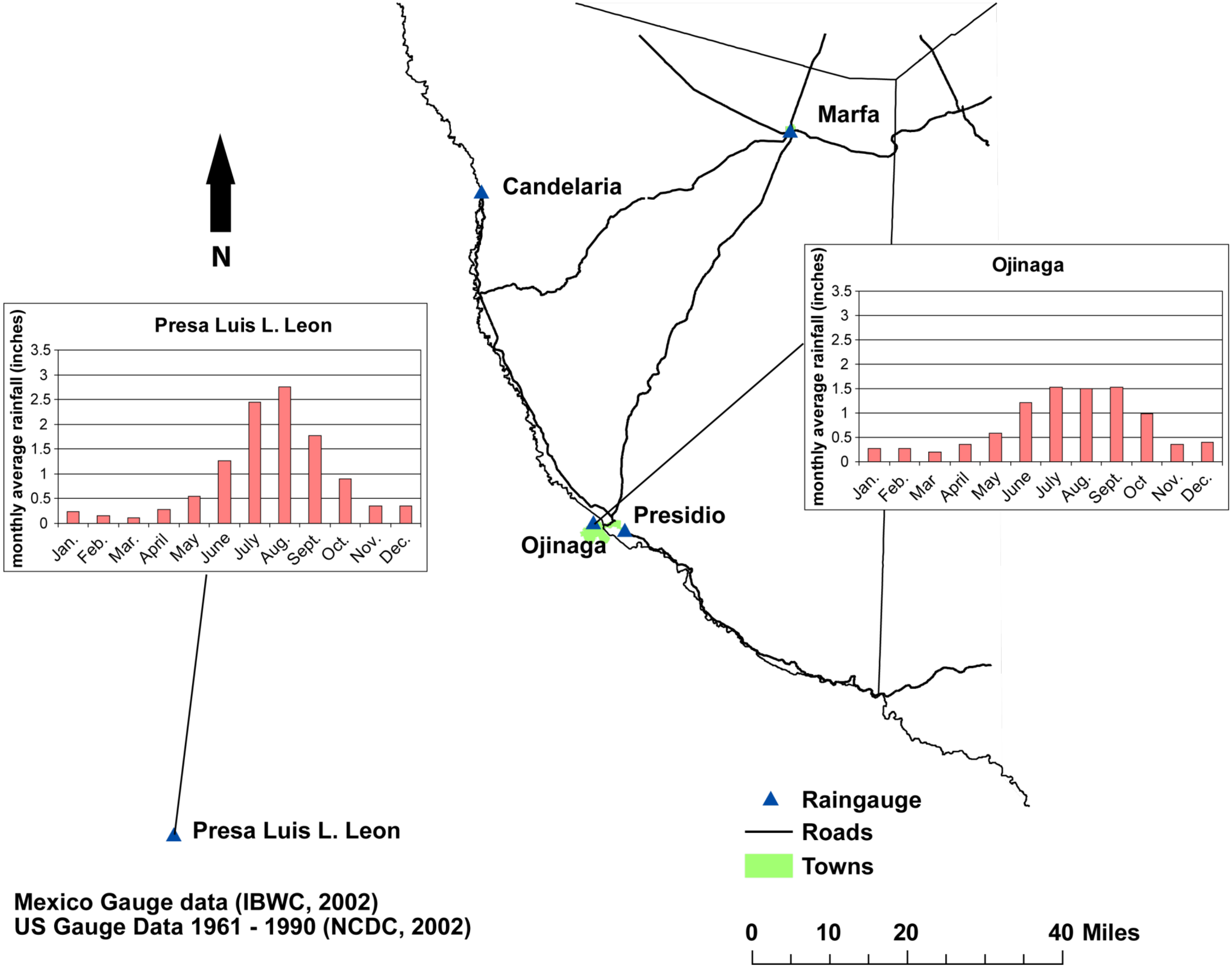
Information required for model

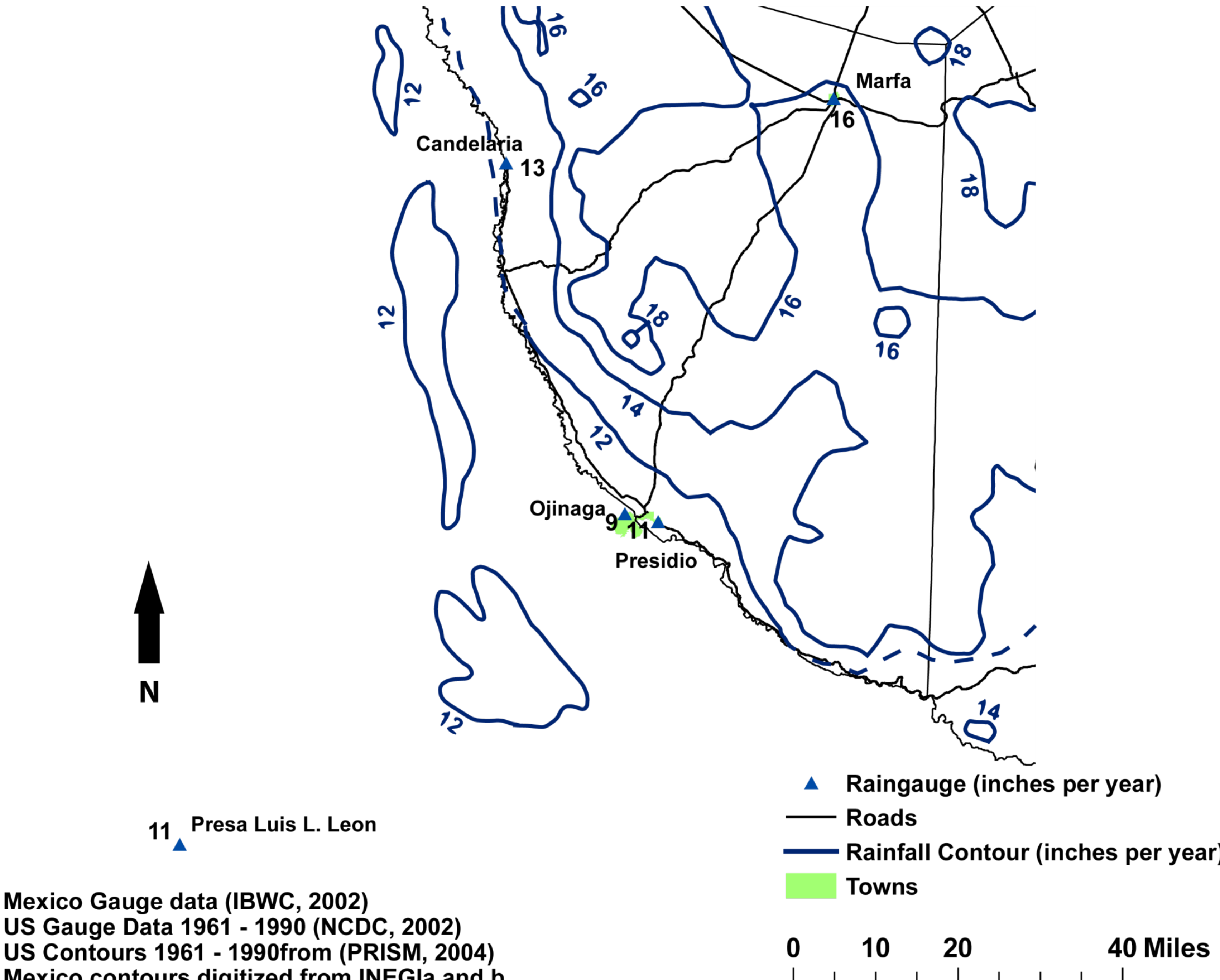
- Climate and recharge estimates
- Geology and framework
- Water levels
- Surface water flows
- Hydraulic properties
- Springs
- Pumping amounts and locations

Climate



Mexico Gauge data from 2002 IBWC Water Bulletin
US Gauge Data 1961 - 1990 NCDC Data


Marfa
Candelaria
N
Presidio
Ojinaga
Presa Luis L. Leon
monthly average rainfall (inches)
0
0.5
1
1.5
2
2.5
3
3.5
Jan.
Feb.
Mar.
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Ojinaga
monthly average rainfall (inches)
0
0.5
1
1.5
2
2.5
3
3.5
Jan.
Feb.
Mar
April
May
June
July
Aug.
Sept.
Oct
Nov.
Dec.
Presa Luis L. Leon
Raingauge
Roads
Towns
0
10
20
40 Miles
Mexico Gauge data (IBWC, 2002)
US Gauge Data 1961 - 1990 (NCDC, 2002)


Marfa
16
Candelaria
13
Ojinaga
9
11
Presidio
11
Presa Luis L. Leon
12
12
12
12
14
14
16
16
16
16
16
18
18
18
N
Raingauge (inches per year)
Roads
Rainfall Contour (inches per year)
Towns
0
10
20
40 Miles
Mexico Gauge data (IBWC, 2002)
US Gauge Data 1961 - 1990 (NCDC, 2002)
US Contours 1961 - 1990from (PRISM, 2004)
Mexico contours digitized from INEGIa and b

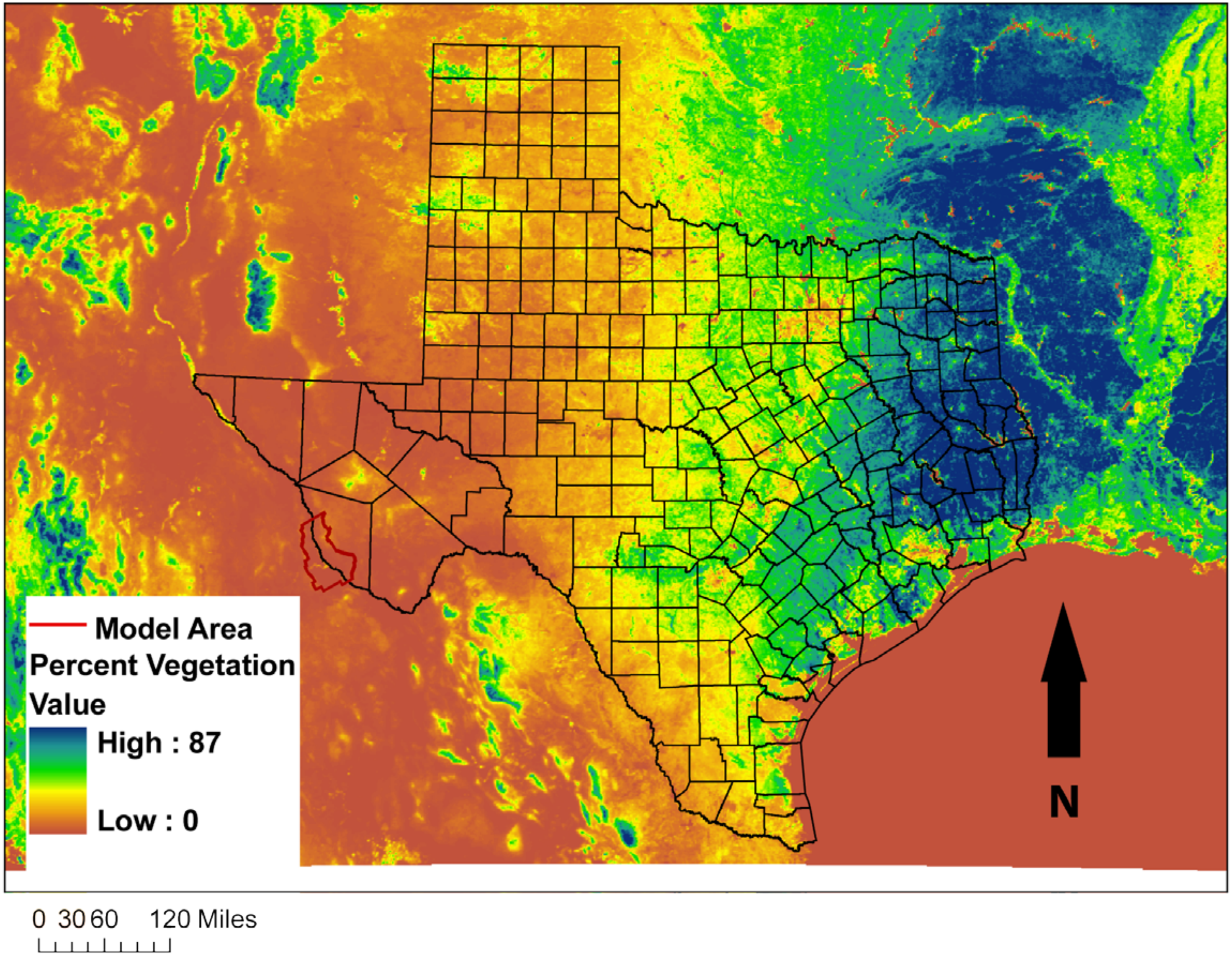
Recharge Estimates

Source	Recharge (inches/year)	Recharge amount (acre-feet/year)	Percent of rainfall
Gates and others, 1980	0.12	7,000 (1,100 square miles)	One percent
LBG-Guyton and Associates, 2001	0.11	3,630 (620 square miles)	One percent
Gabaldon, 1991	0.186	520 [1] (52 square miles)	Two percent
Chowdhury and Wade, report in prep (this study)	0.0 to 0.45 inches per year	~3,200 (600 square miles)	0.05 to 3.4 percent

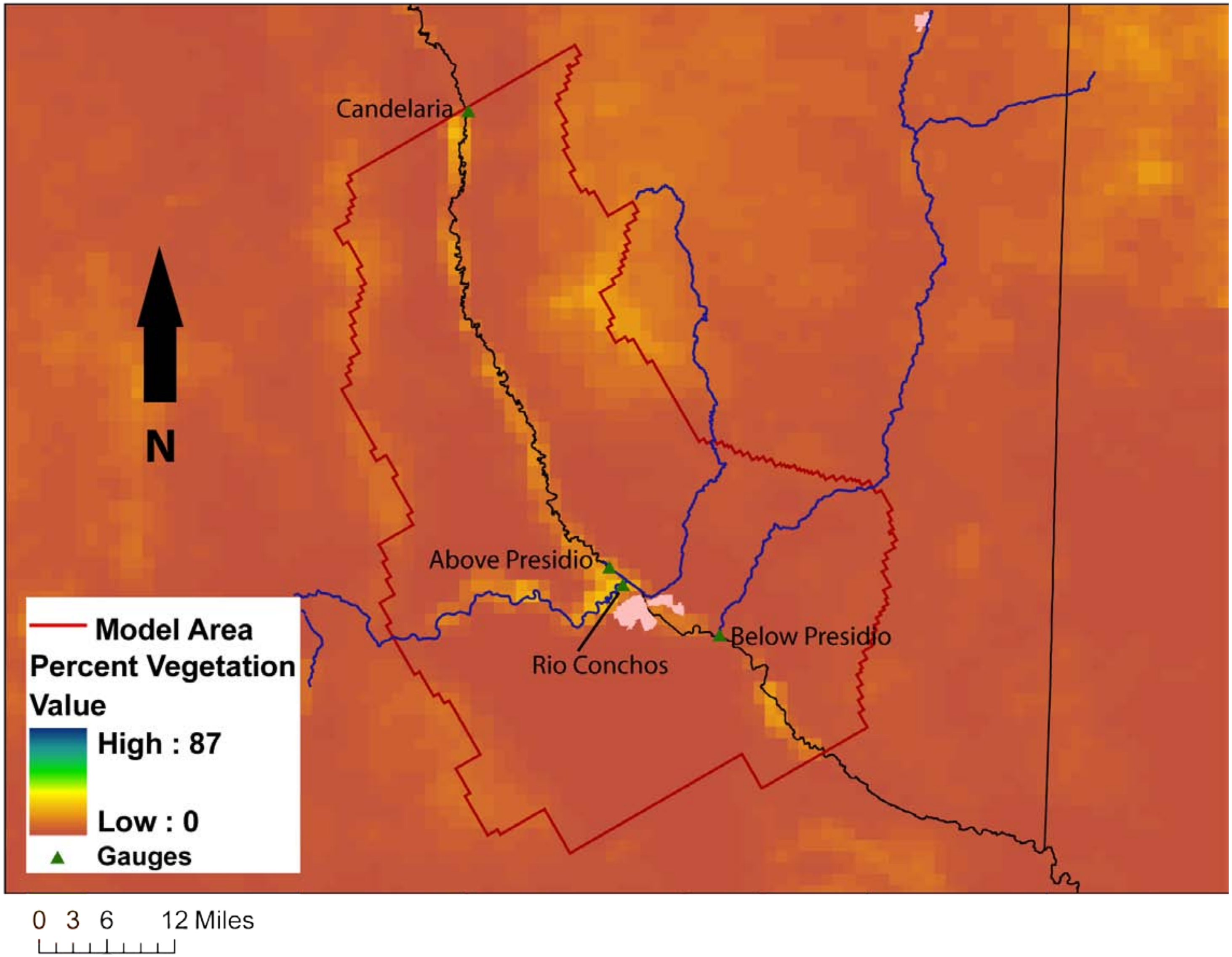
[1] Mountain front – does not include inflow from the Chinati Mountains boundary

Approach for recharge:

- We propose to use a modified Maxey Eakin approach. The Maxey Eakin approach was originally developed for closed basins in eastern Nevada with a Mediterranean climate.
- The percentage of precipitation that becomes recharge increases step-wise as precipitation increases.
- A modification of the method also assumes recharge is a function of elevation zones.
- Elevation zones and percentages of precipitation are determined in the calibration process.
- A further modification is to incorporate a lag time in the recharge to account for travel time in the unsaturated zone. The lag time is accounted for by applying a dampening factor which reduces annual variation from the long-term average.



Source: Earth System Science Center (ESSC) Pennsylvania State University 1990 - 1999 average from AVHRR data



Source: Earth System Science Center (ESSC) Pennsylvania State University
1990 - 1999 average from AVHRR data

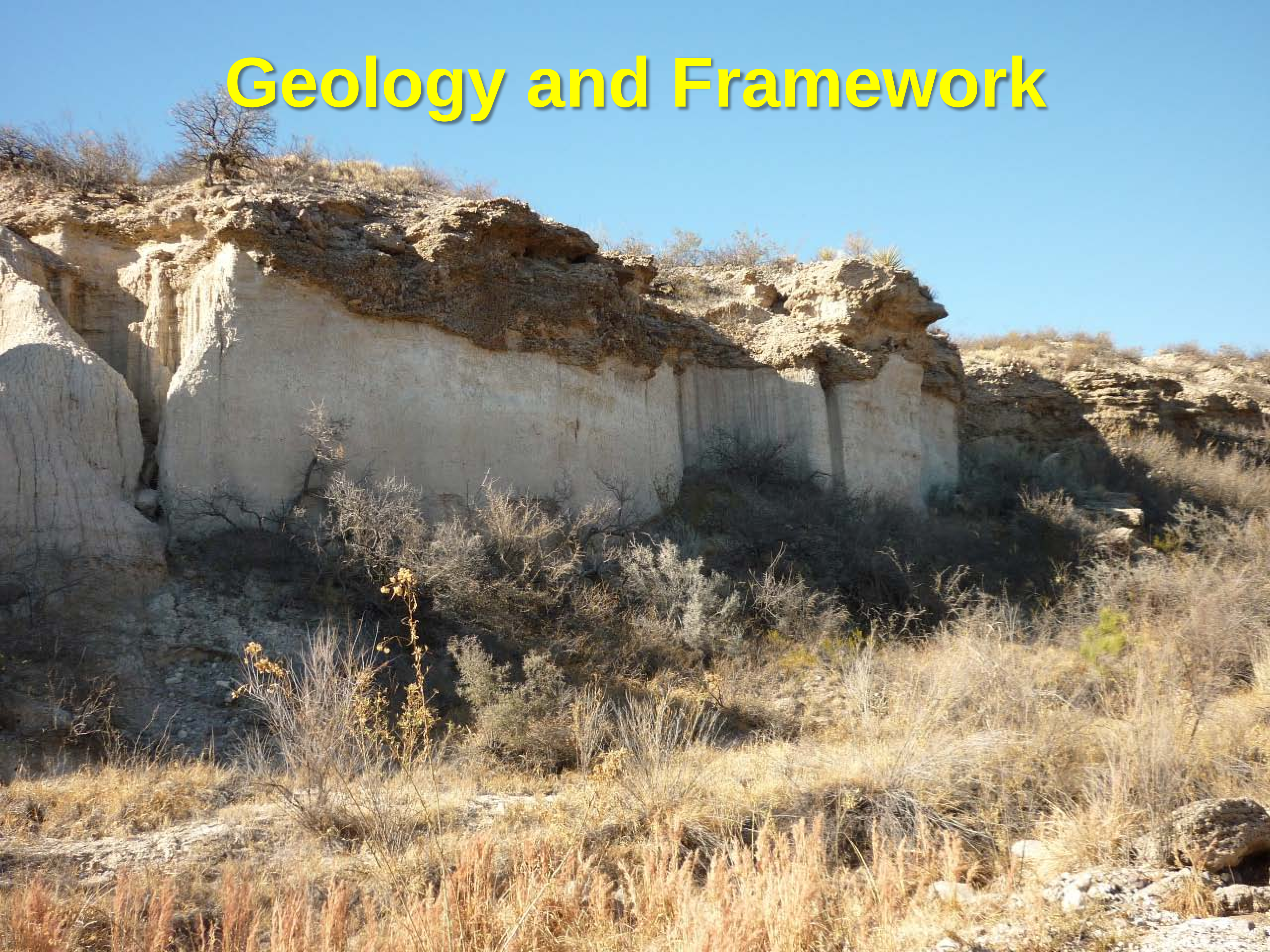
Evapotranspiration

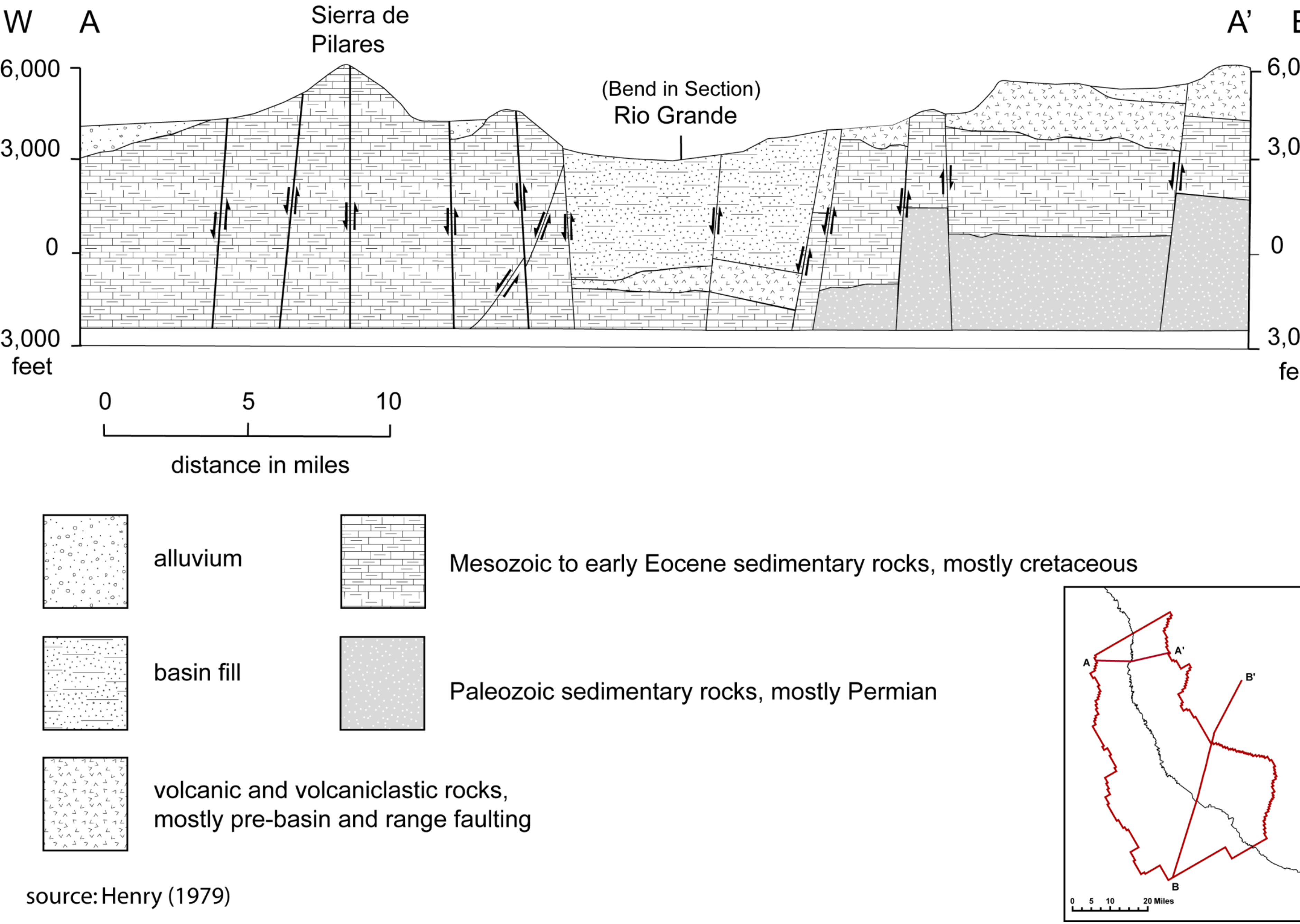
- **Evaporation from bare soil and open water bodies plus transpiration of soil water and groundwater by plants.**
- **Controlled by energy supply and water supply.**
- **Phreatophytes have their roots in the capillary fringe and feed on groundwater all or most of the growing season.**
- **Groundwater evapotranspiration can be a significant component of groundwater discharge for many aquifers where the water table is shallow.**

Estimates of Total Possible Evapotranspiration (acre-feet per year)

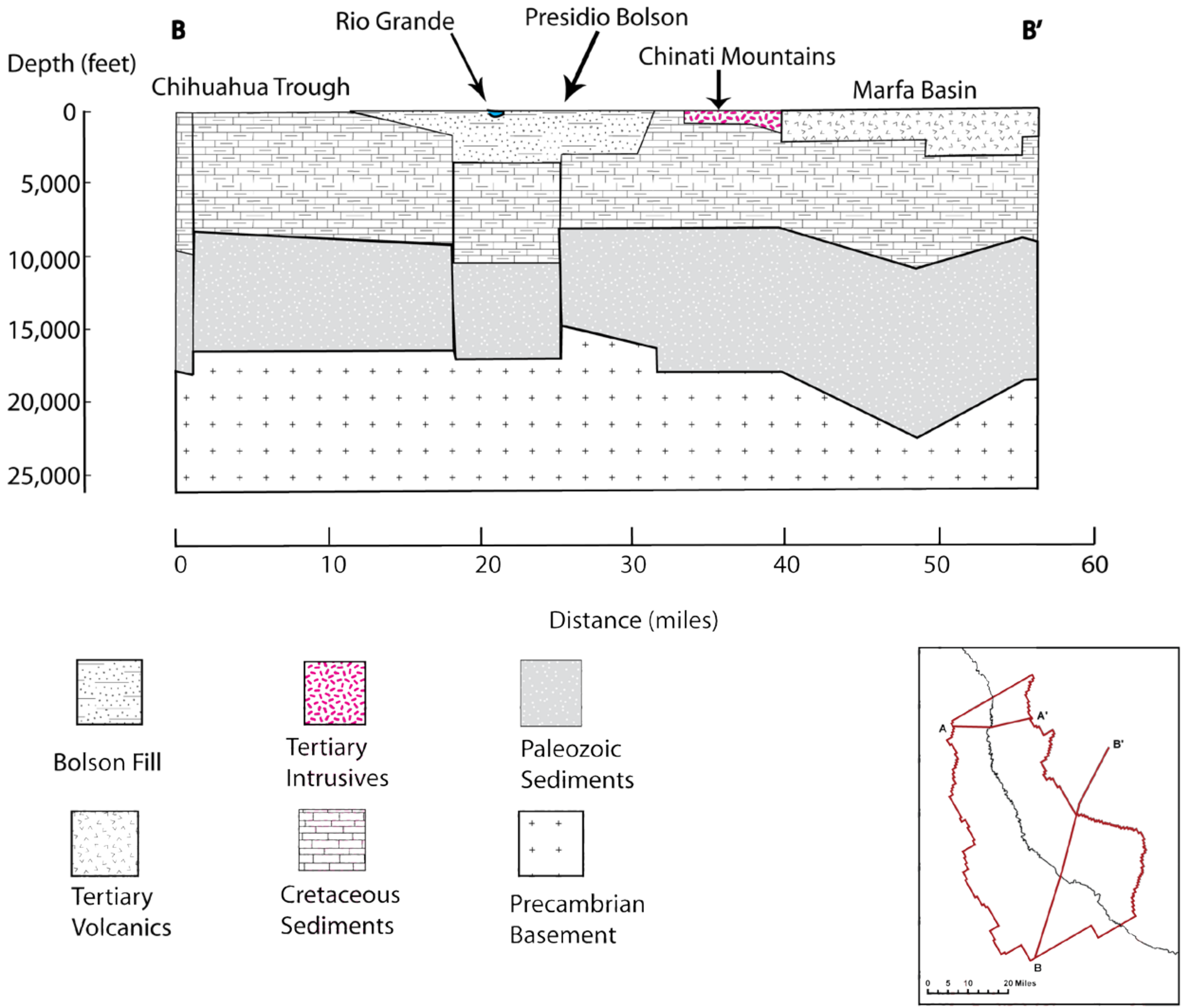
Segment	Area (square miles)	Owens and Moore (2007 Pecos River) 4 in/yr	Owens and Moore (2007 Rio Grande) 82 in/yr	Scanlon and others (2005) 50 in/yr	Scanlon and others (2005) 60 in/yr	Blaney (1958 Pecos River) 72 in/ yr
Rio Grande Candelaria to above Presidio	12.9	2,752	56,416	34,400	41,280	49,536
Rio Conchos Just above confluence with Rio Grande	8.0	1,707	34,987	21,333	25,600	30,720
Rio Grande Above Presidio to below Presidio	3.2	683	13,995	8,533	10,240	12,288
Rio Grande Below Presidio to end of model	4.1	875	17,931	10,933	13,120	15,744
Total	28.2	6,016	123,328	75,200	90,240	108,288

Geology and Framework





source: Henry (1979)



source: Mraz and Keller (1980)

Rock Units

Era	System	Period	Stratigraphy	Hydrostratigraphy
Cenozoic	Quaternary		channel gravel and sand flood plain sand and mud	alluvium aquifers
			bolson fill: conglomerate, sandstone, claystone, and mudstone	bolson aquifers
	Tertiary		undifferentiated volcanic rocks, lava, welded tuffs, tuff, and, tuffaceous sedimentary rocks, intrusive igneous rocks	igneous aquifer
Paleozoic and Mesozoic		Permian and Cretaceous	limestone, sandstone, quartzite, marl, and mudstone	Permian and Cretaceous Rocks

Framework

- Elevations of the tops and bottoms of the model layers
- Land surface elevation from DEM (top)
- Extent of Bolsons based on Henry (1979)
- Bolson thickness map

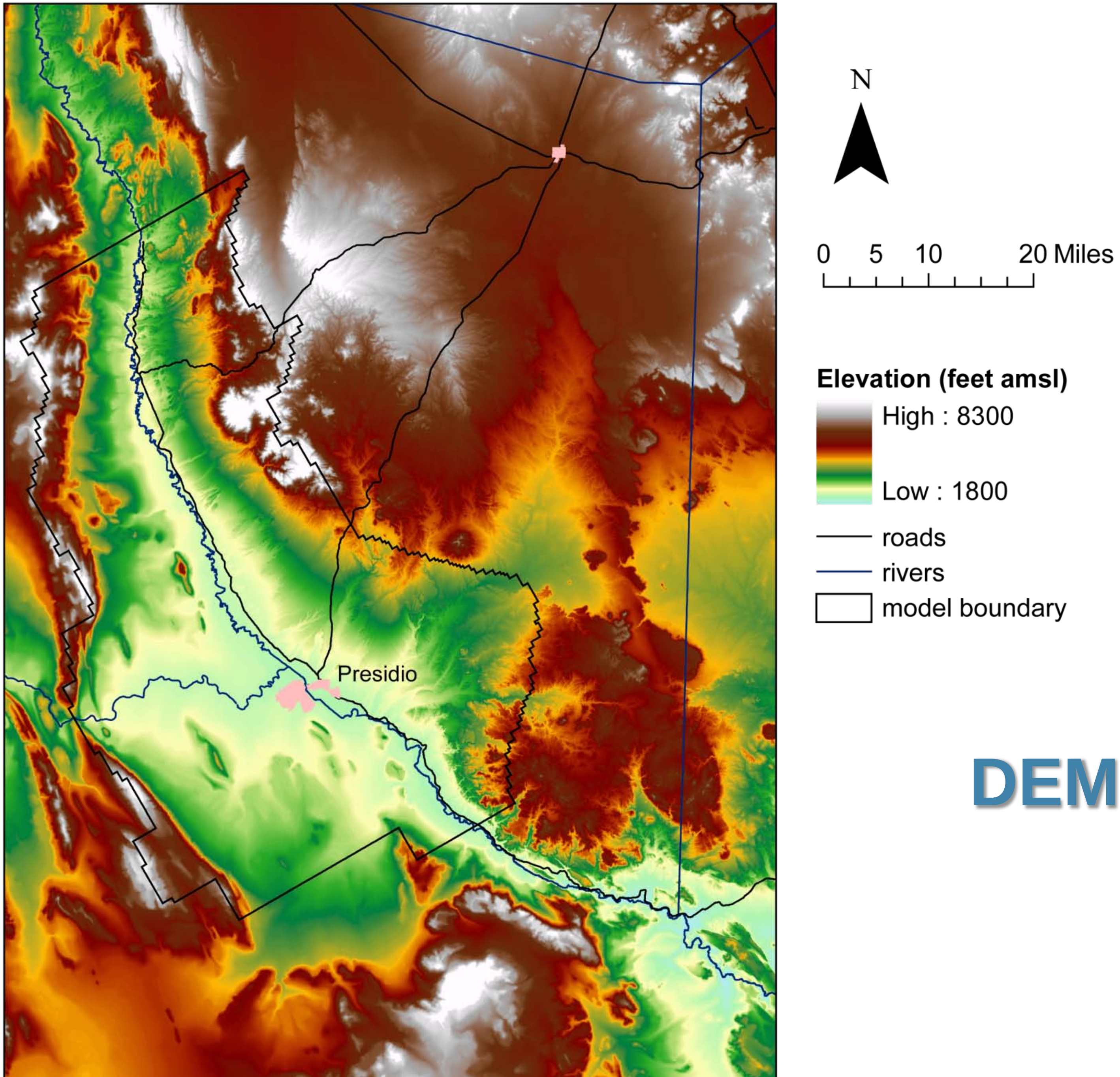
Aquifer Layers

Era	System	Period	Stratigraphy	Hydrostratigraphy
Cenozoic	Quaternary		channel gravel and sand flood plain sand and mud	alluvium aquifers
			bolson fill: conglomerate, sandstone, claystone, and mudstone	bolson aquifers
	Tertiary		undifferentiated volcanic rocks, lava, welded tuffs, tuff, and, tuffaceous sedimentary rocks, intrusive igneous rocks	igneous aquifer
Paleozoic and Mesozoic		Permian and Cretaceous	limestone, sandstone, quartzite, marl, and mudstone	Permian and Cretaceous Rocks

Model layer 1

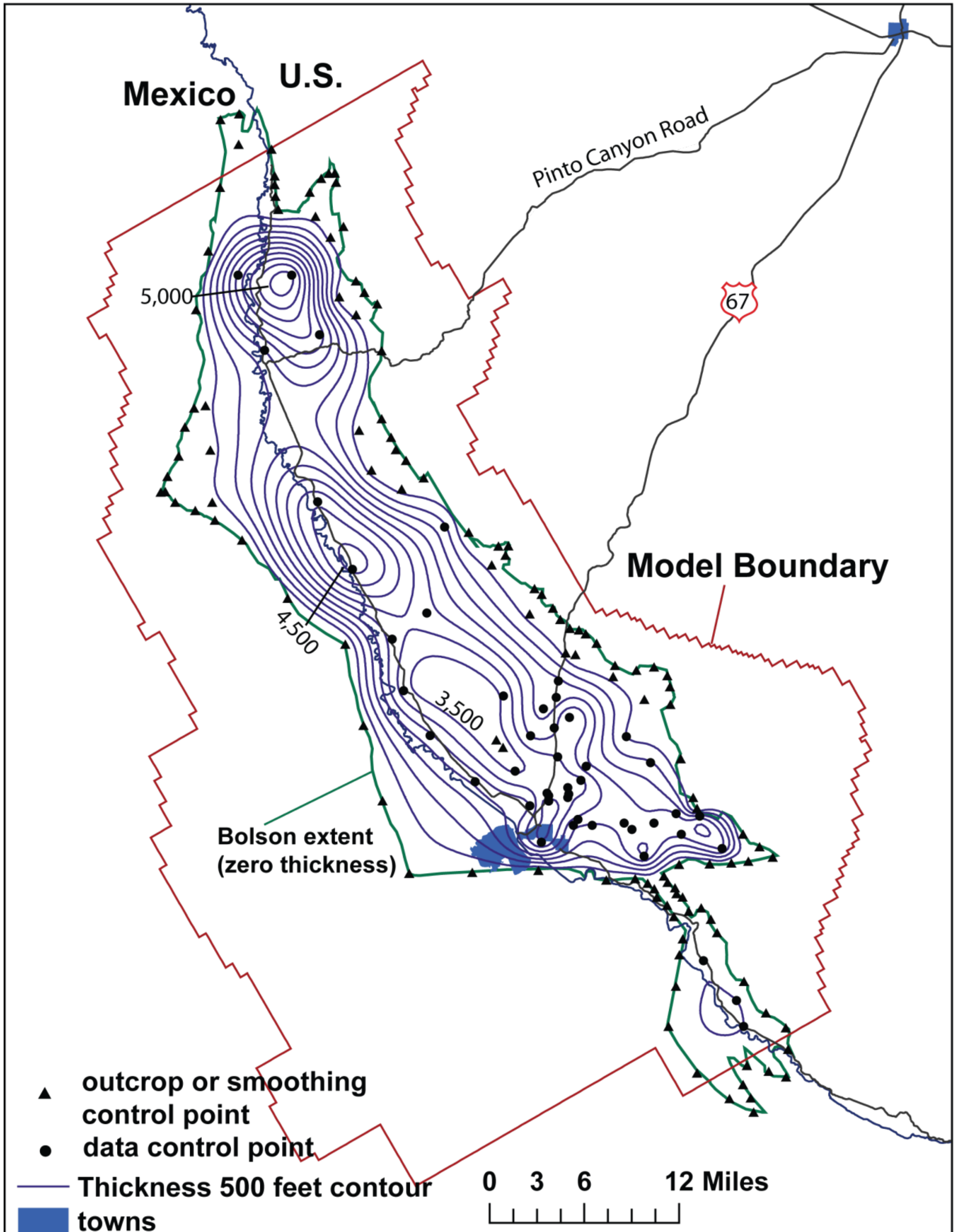
Model layer 2

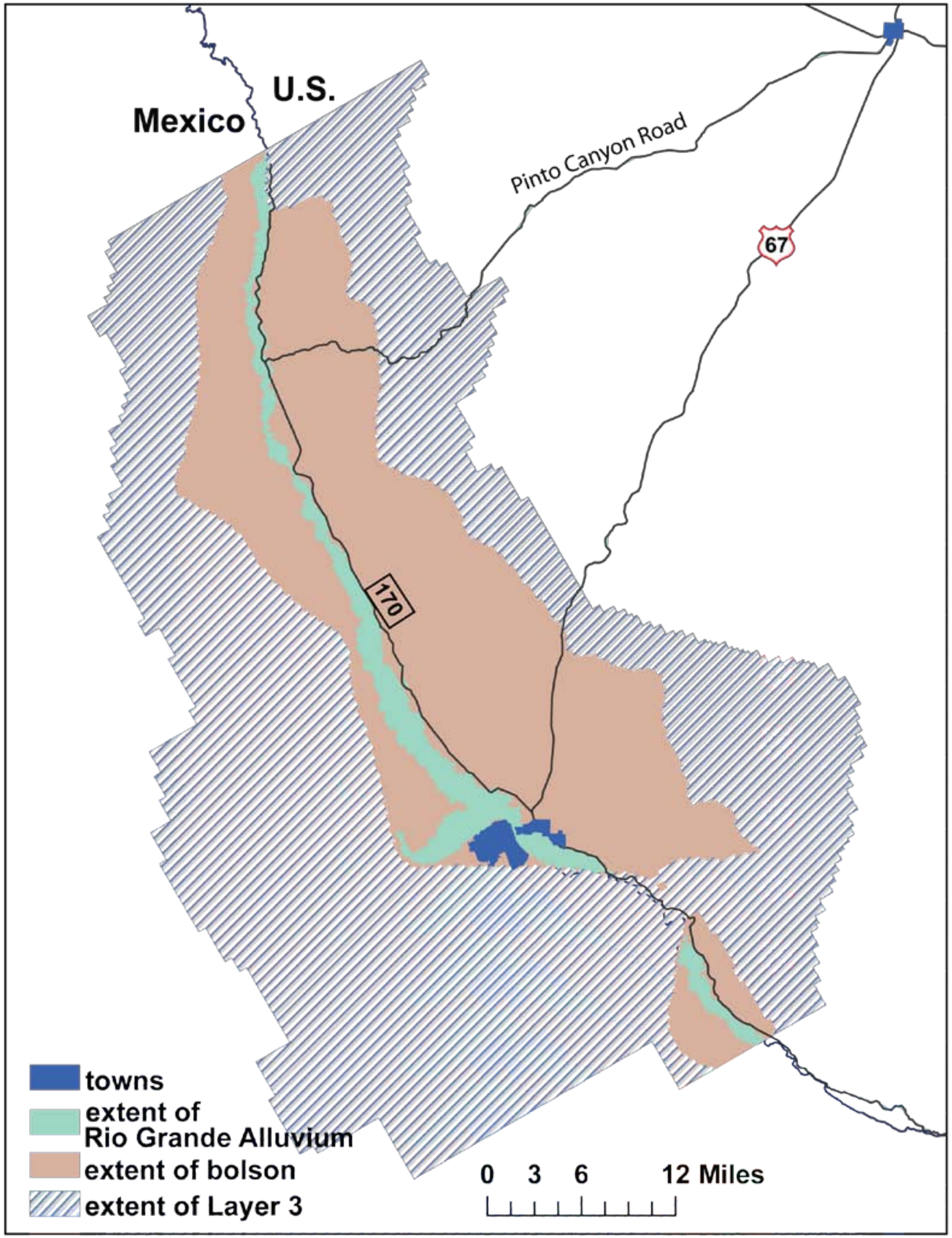
Model layer 3


Presidio
N
0 5 10 20 Miles
Elevation (feet amsl)
High : 8300
Low : 1800
roads
rivers
model boundary

DEM

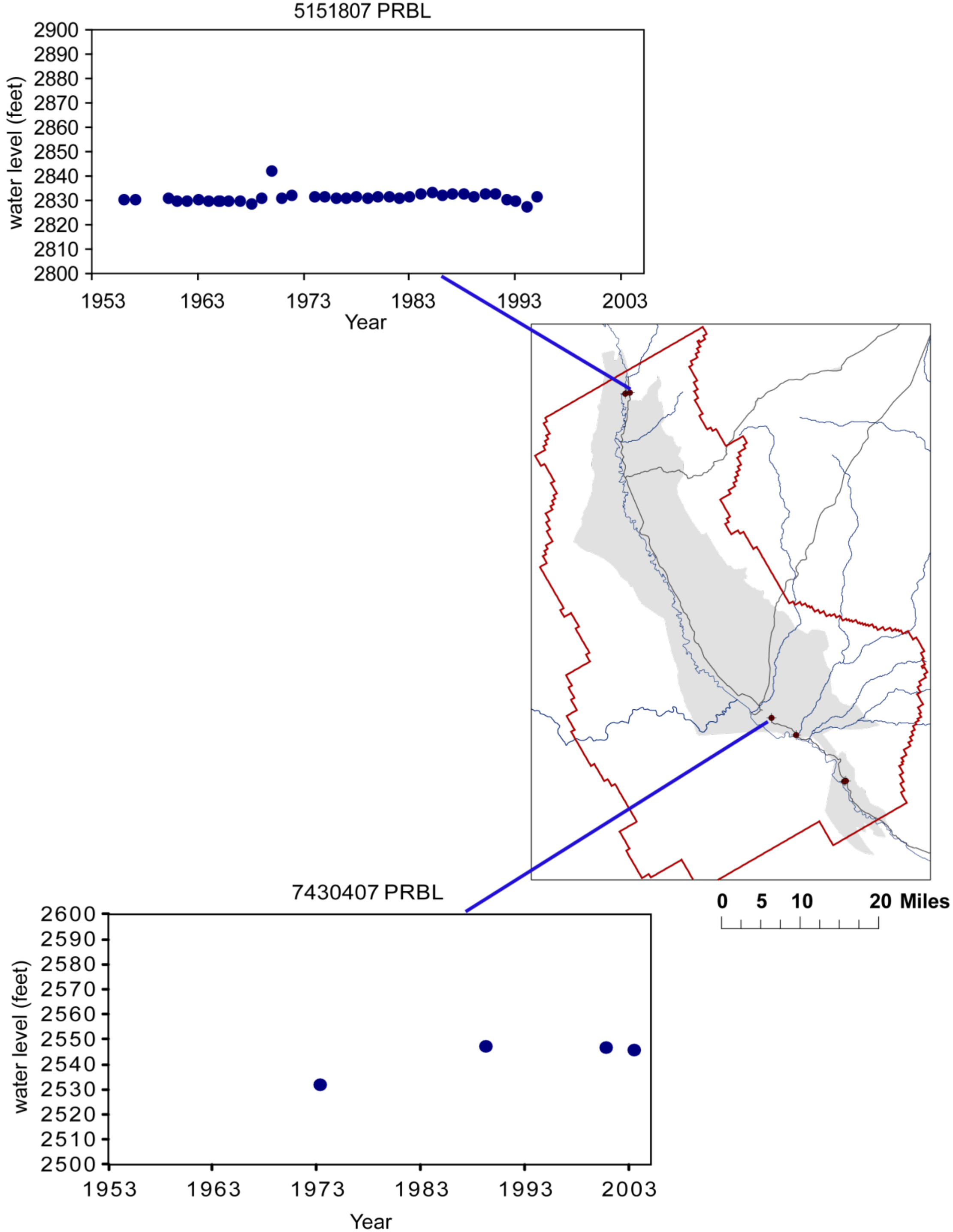
Estimated Bolson Thickness



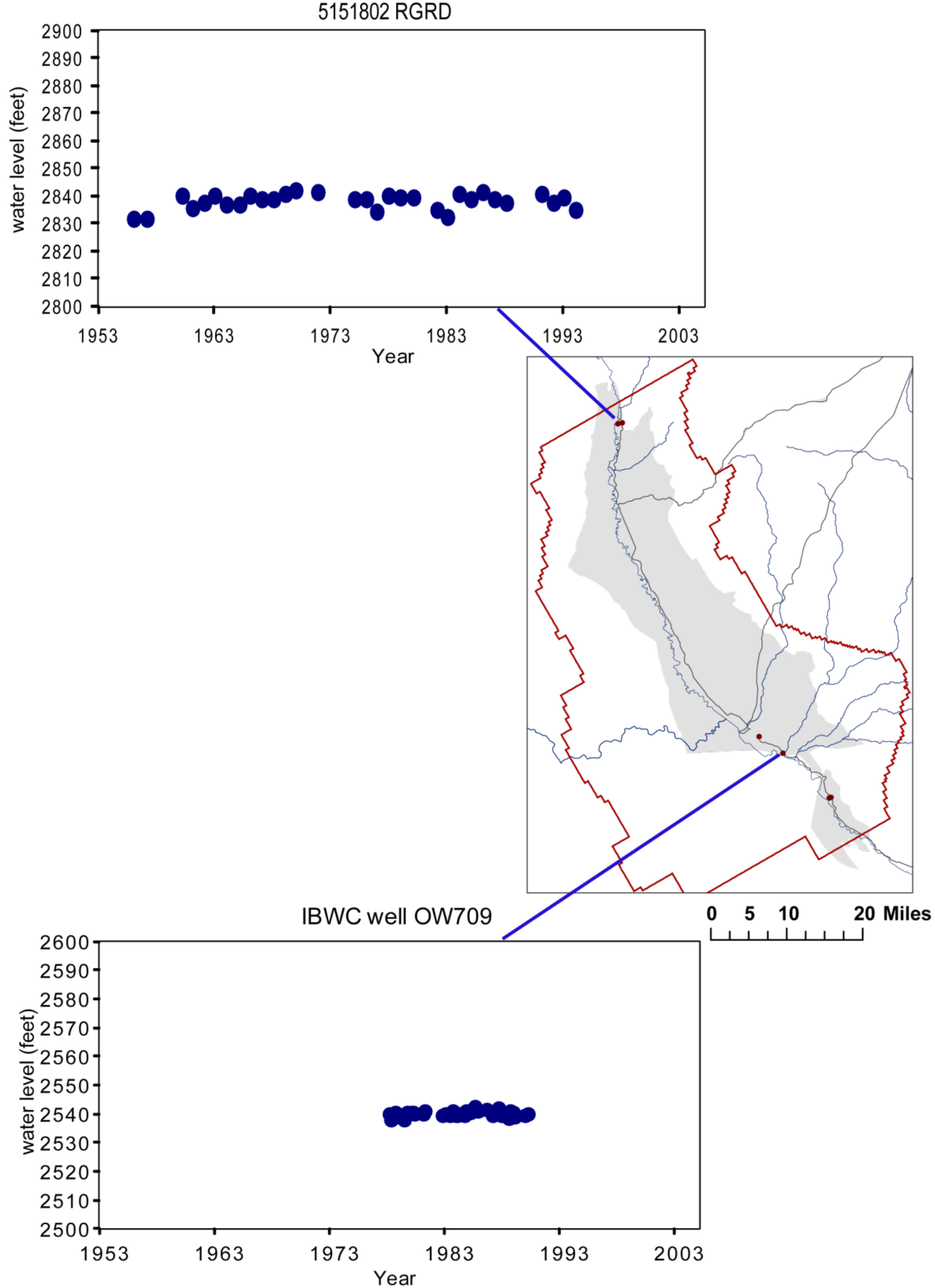


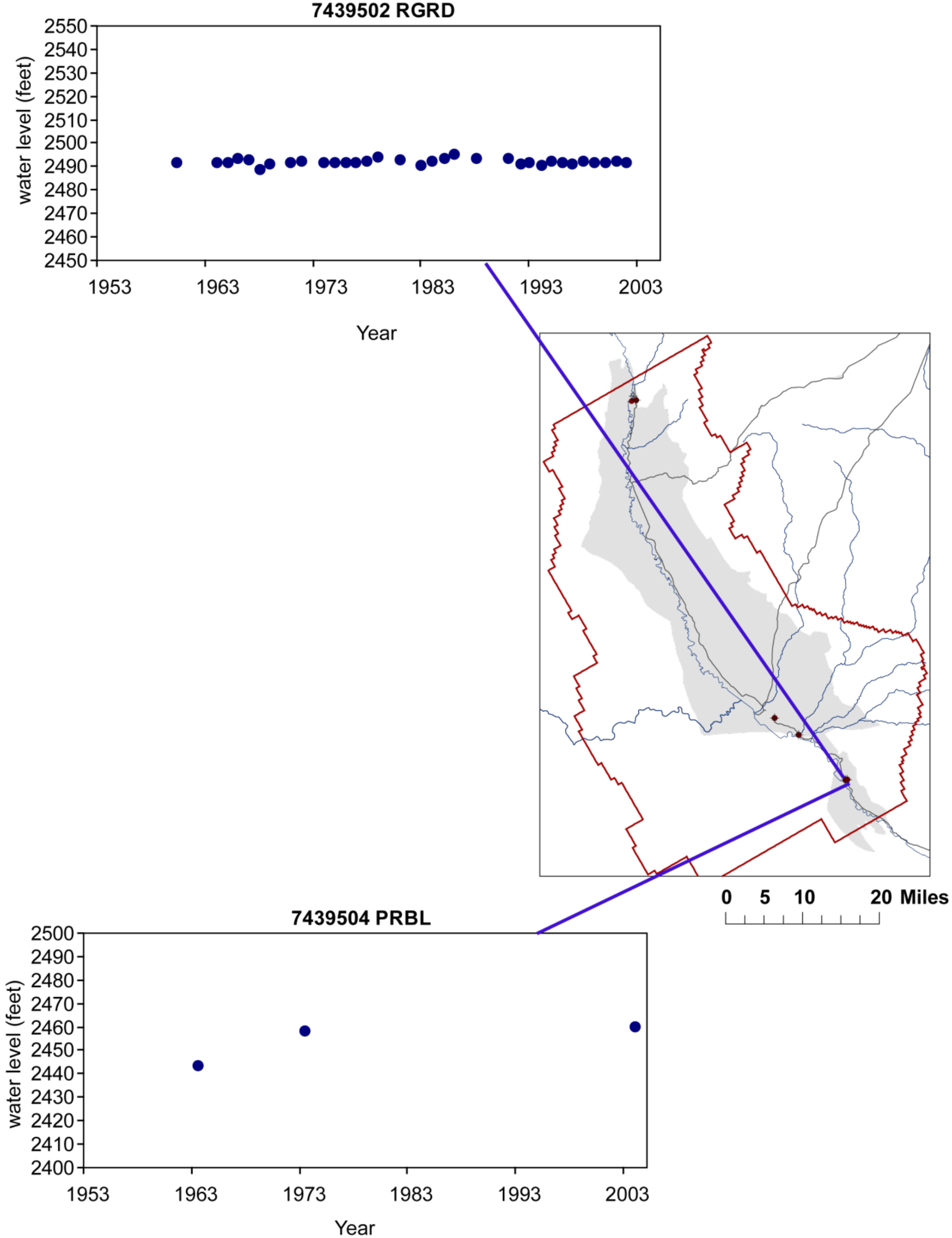
Extent of model layers

Hydrology

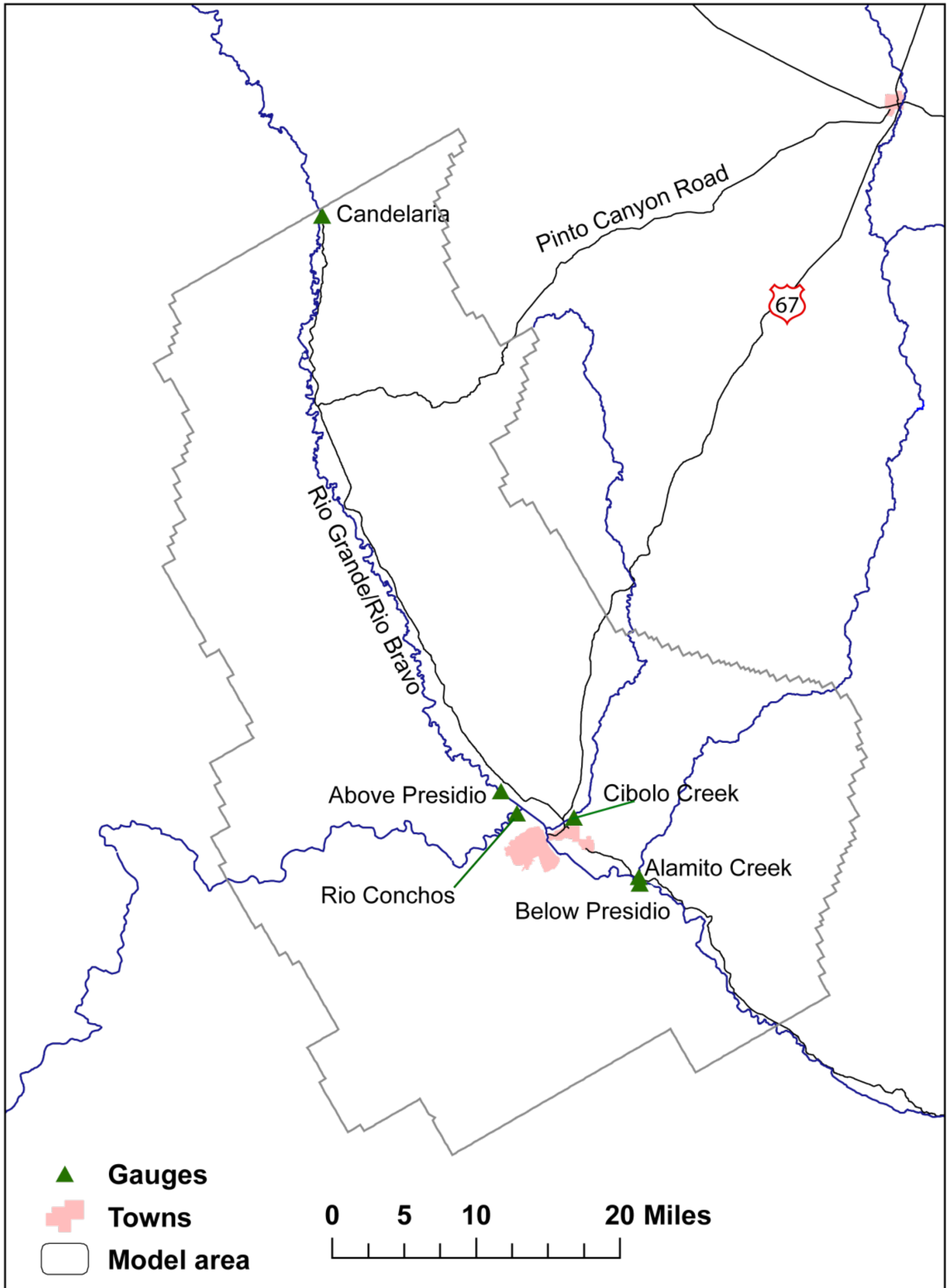


5151807 PRBL
water level (feet)
2900
2890
2880
2870
2860
2850
2840
2830
2820
2810
2800
1953
1963
1973
1983
1993
2003
Year
7430407 PRBL
2600
2590
2580
2570
2560
2550
2540
2530
2520
2510
2500
0 5 10 20 Miles

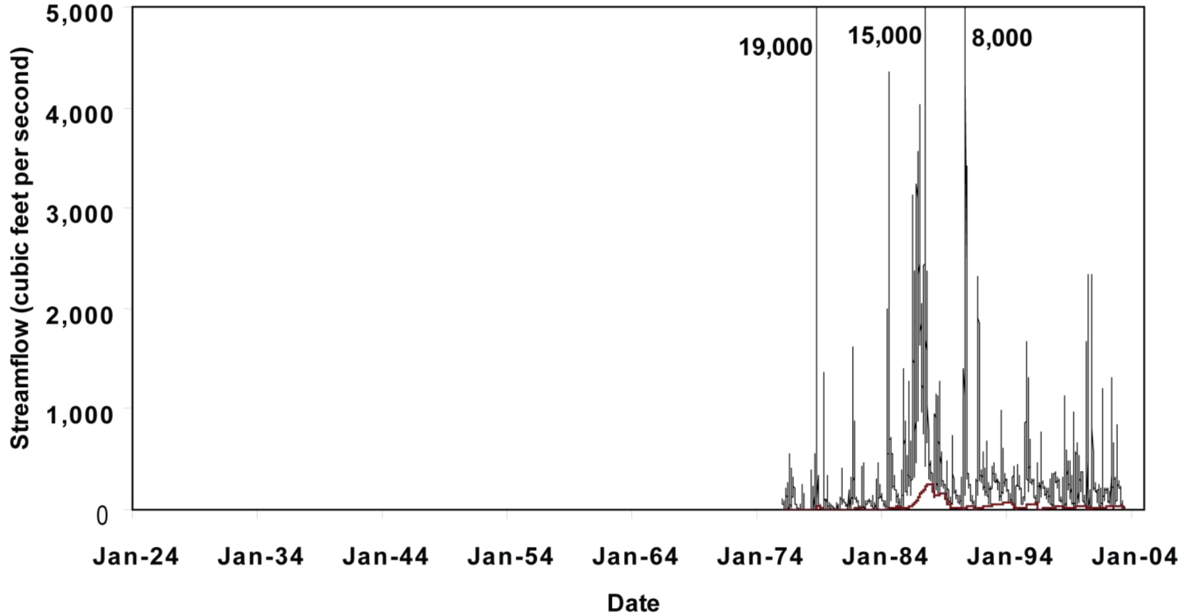

5151802 RGRD
water level (feet)
2900
2890
2880
2870
2860
2850
2840
2830
2820
2810
2800
1953
1963
1973
1983
1993
2003
Year
0 5 10 20 Miles
IBWC well OW709
water level (feet)
2600
2590
2580
2570
2560
2550
2540
2530
2520
2510
2500
1953
1963
1973
1983
1993
2003
Year


7439502 RGRD
water level (feet)
2550
2540
2530
2520
2510
2500
2490
2480
2470
2460
2450
1953
1963
1973
1983
1993
2003
Year
0 5 10 20 Miles
7439504 PRBL
water level (feet)
2500
2490
2480
2470
2460
2450
2440
2430
2420
2410
2400
1953
1963
1973
1983
1993
2003
Year

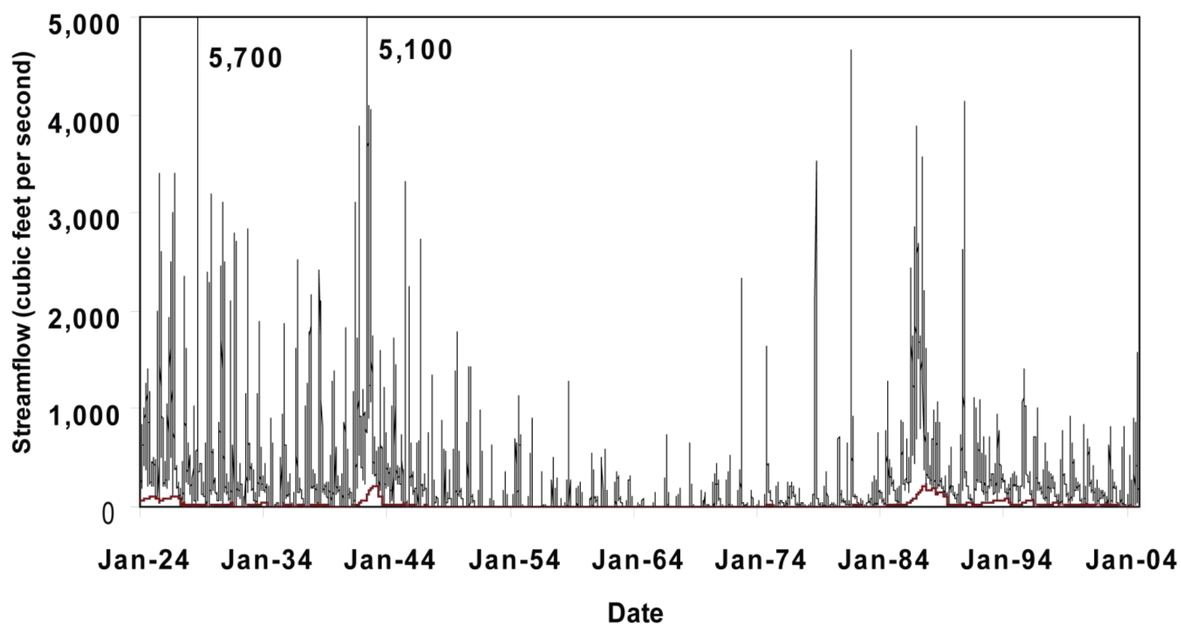
Stream gauge locations

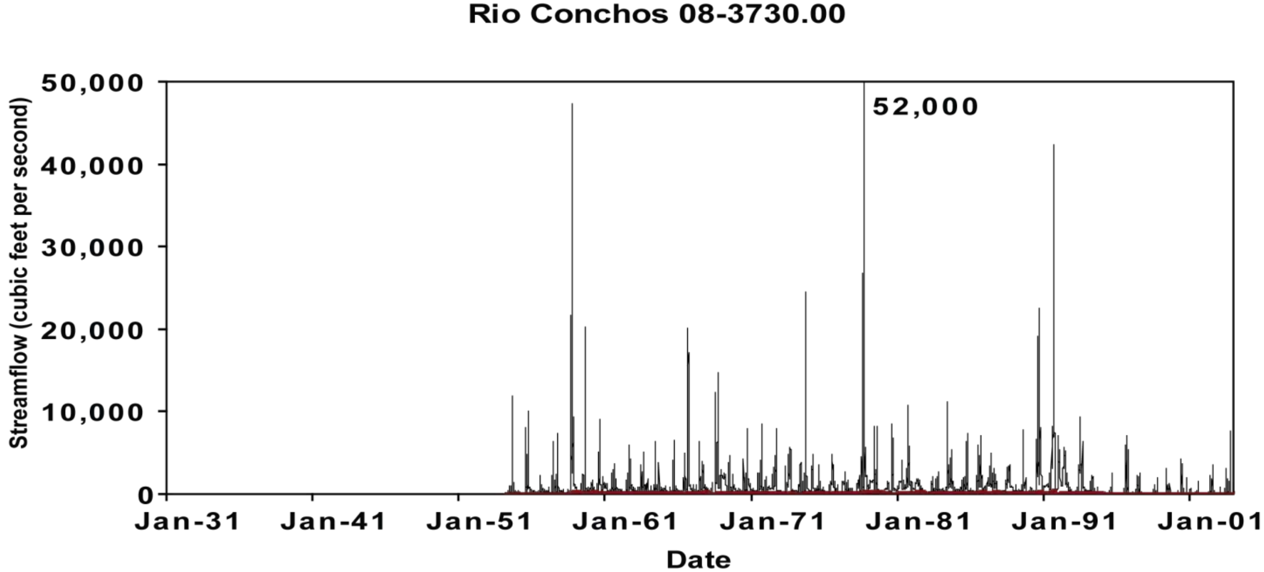


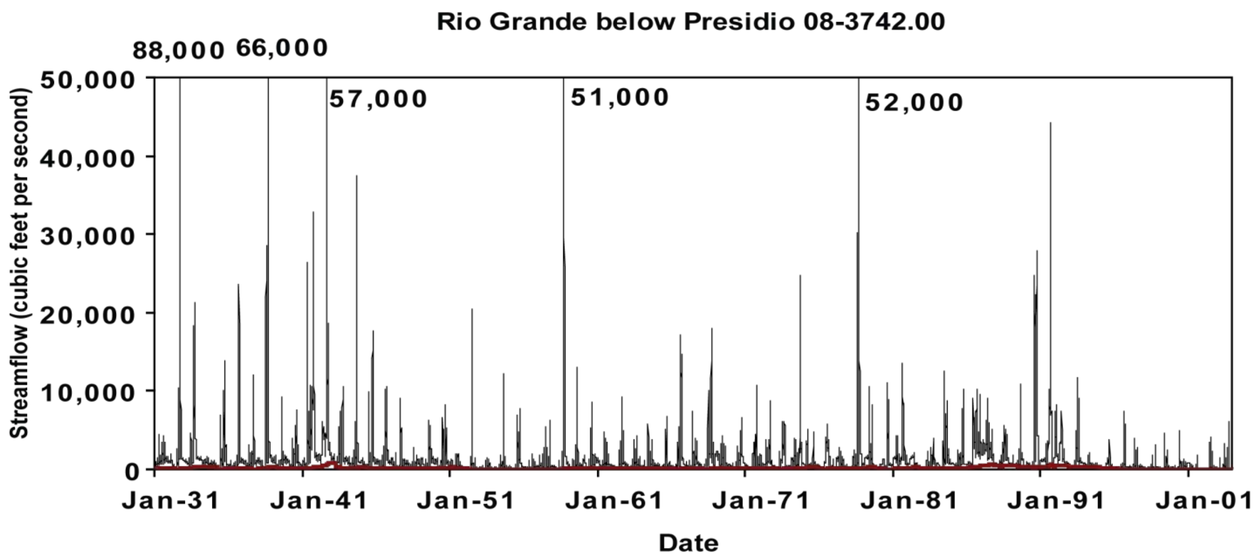
Rio Grande near Candelaria 08-3712.00



Rio Grande above Presidio 08-3715.00

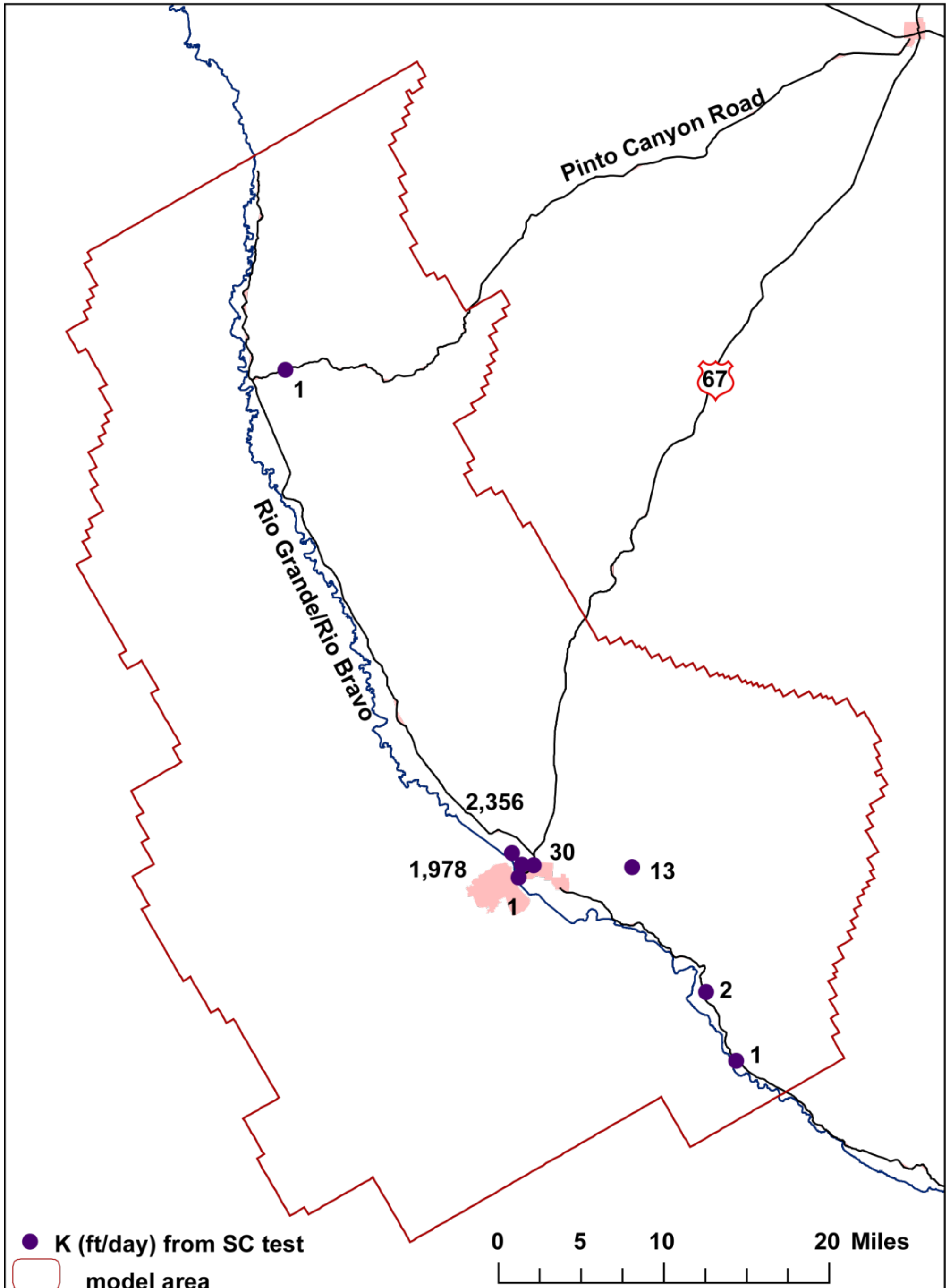



Rio Conchos 08-3730.00
52,000
50,000
40,000
30,000
20,000
10,000
0
Streamflow (cubic feet per second)
Jan-31
Jan-41
Jan-51
Jan-61
Jan-71
Jan-81
Jan-91
Jan-01
Date


Rio Grande below Presidio 08-3742.00
88,000
66,000
57,000
51,000
52,000
50,000
40,000
30,000
20,000
10,000
0
Streamflow (cubic feet per second)
Jan-31
Jan-41
Jan-51
Jan-61
Jan-71
Jan-81
Jan-91
Jan-01
Date

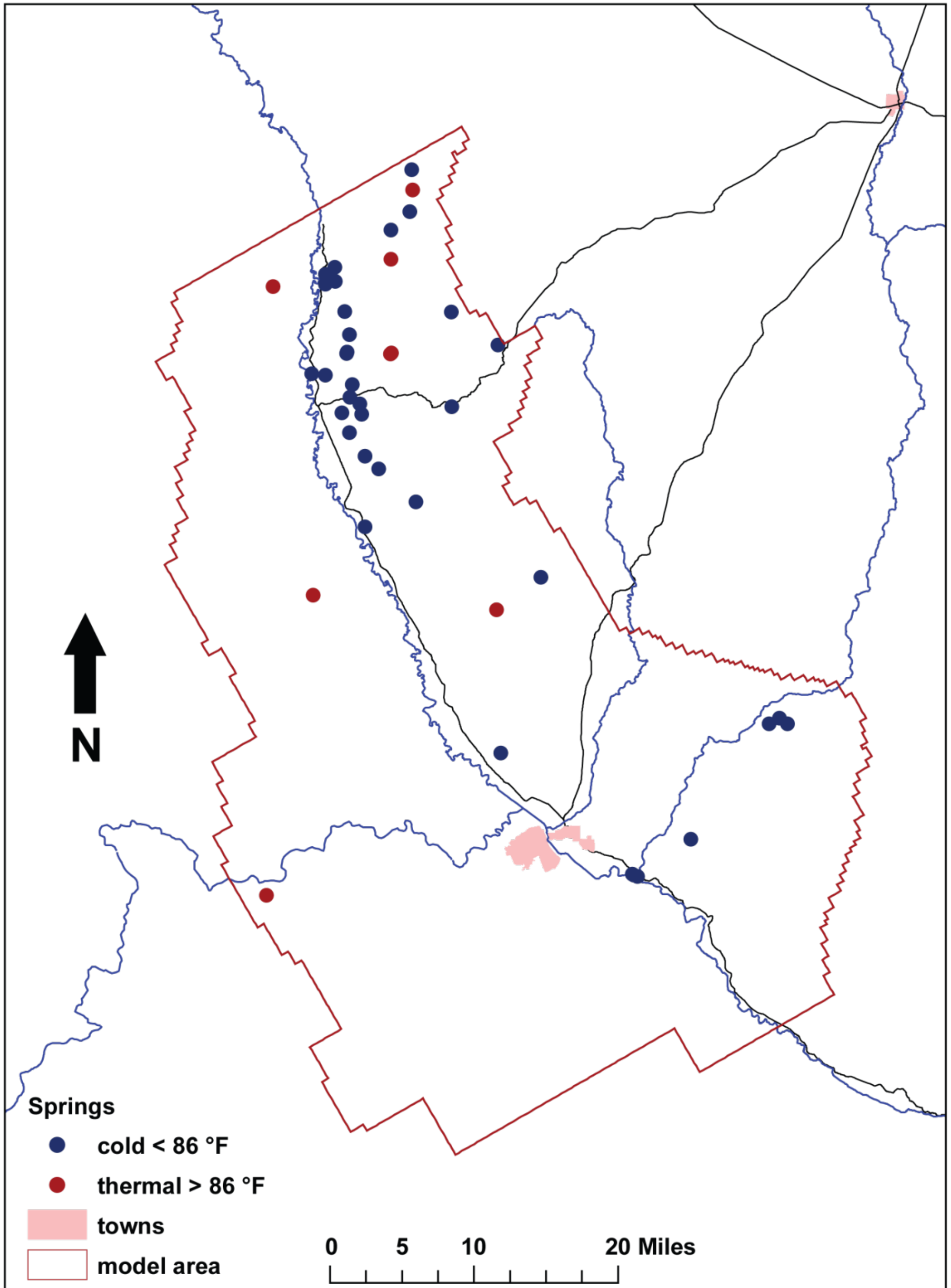
Baseflow Estimates

Gauge	Cubic feet per second	Acre-feet per year
Rio Grande at Candelaria (1976 – 2003)	35	25,135
Rio Grande above Presidio (1976 – 2003)	32	23,054
Rio Grande above Presidio (1924 – 2004)	21	14,883
Rio Conchos just above confluence with Rio Grande (1954 – 2005)	107	77,250
Rio Grande below Presidio (1931 – 2005)	170	123,180



Hydraulic Conductivity Data in feet per day

- **Hydraulic Conductivity measures how easily water moves through the aquifer.**

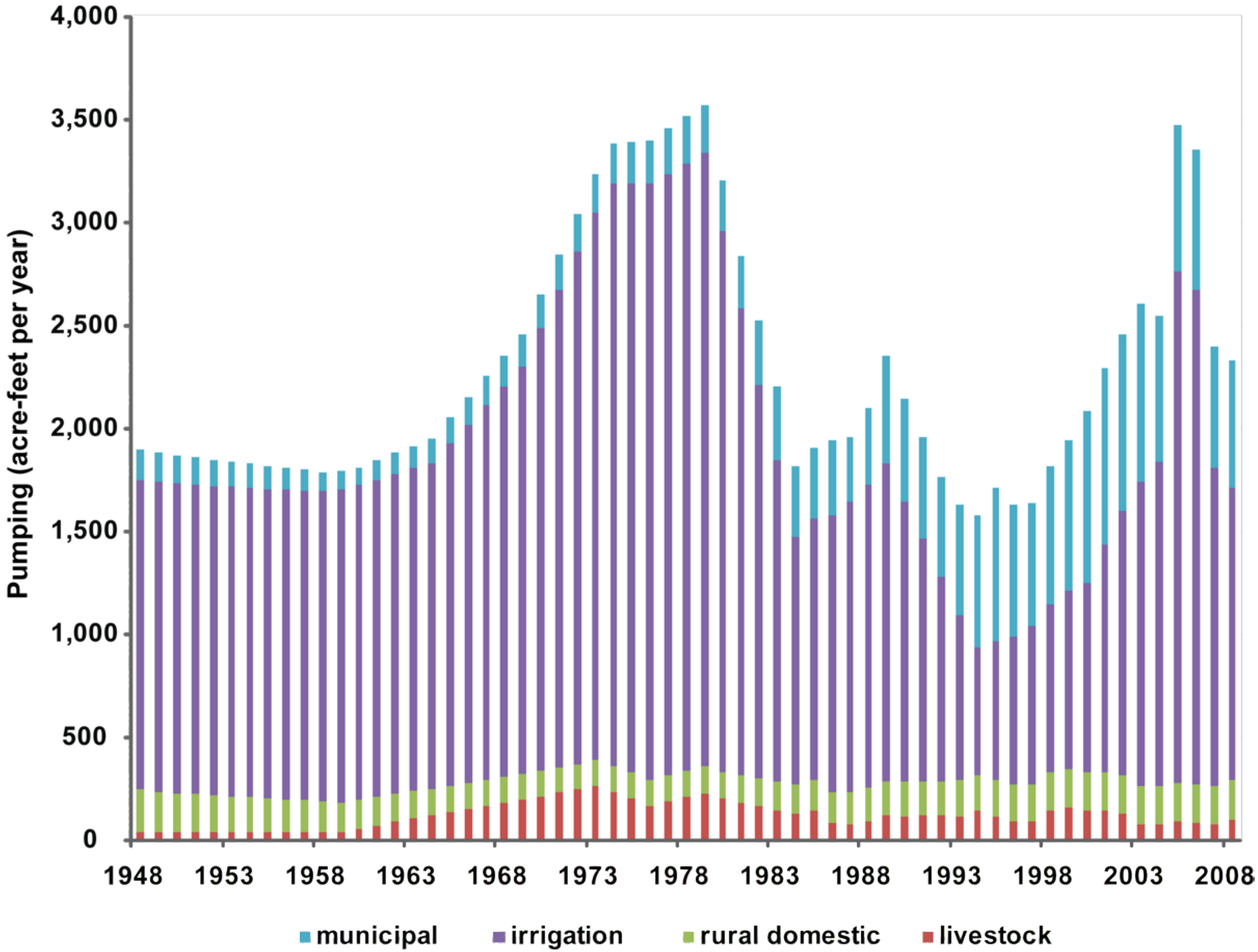


Springs

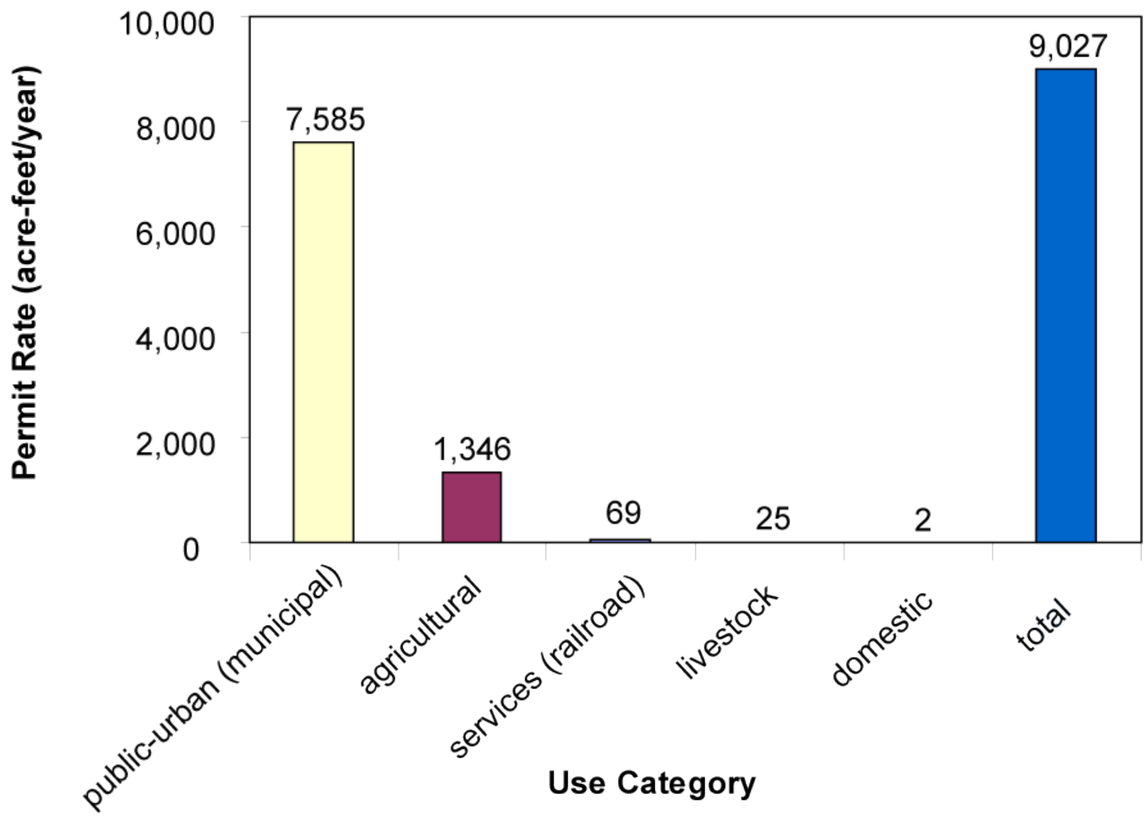
- Total reported flow from the hot springs is about 140,000 to 186,000 cubic feet per day (1,170 to 1,560 acre-feet per year).
- Total reported flow from the cold springs is about 180,000 cubic feet per day (1,510 acre-feet per year).

Pumping

Estimated groundwater pumping in U.S. portion of study area

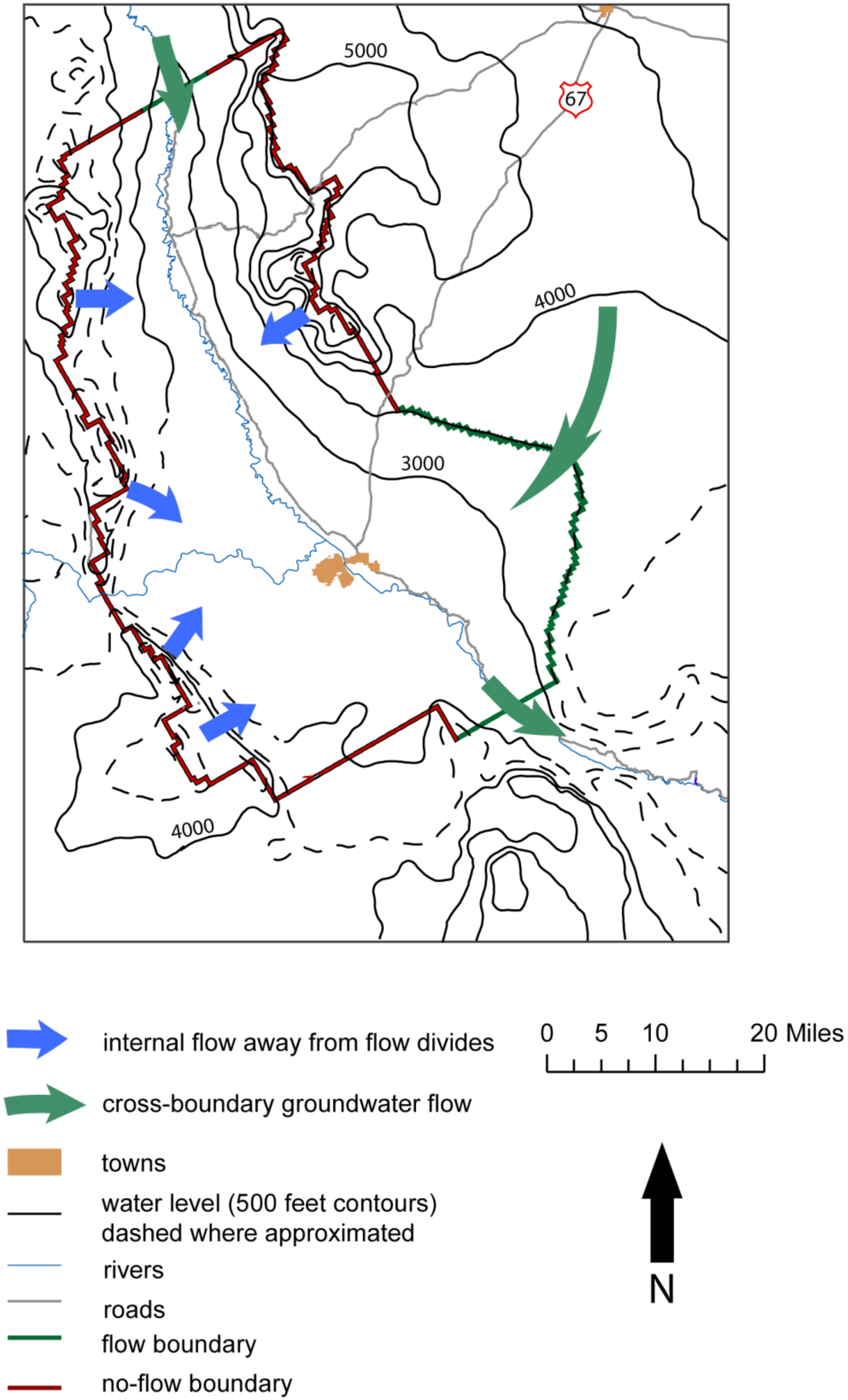


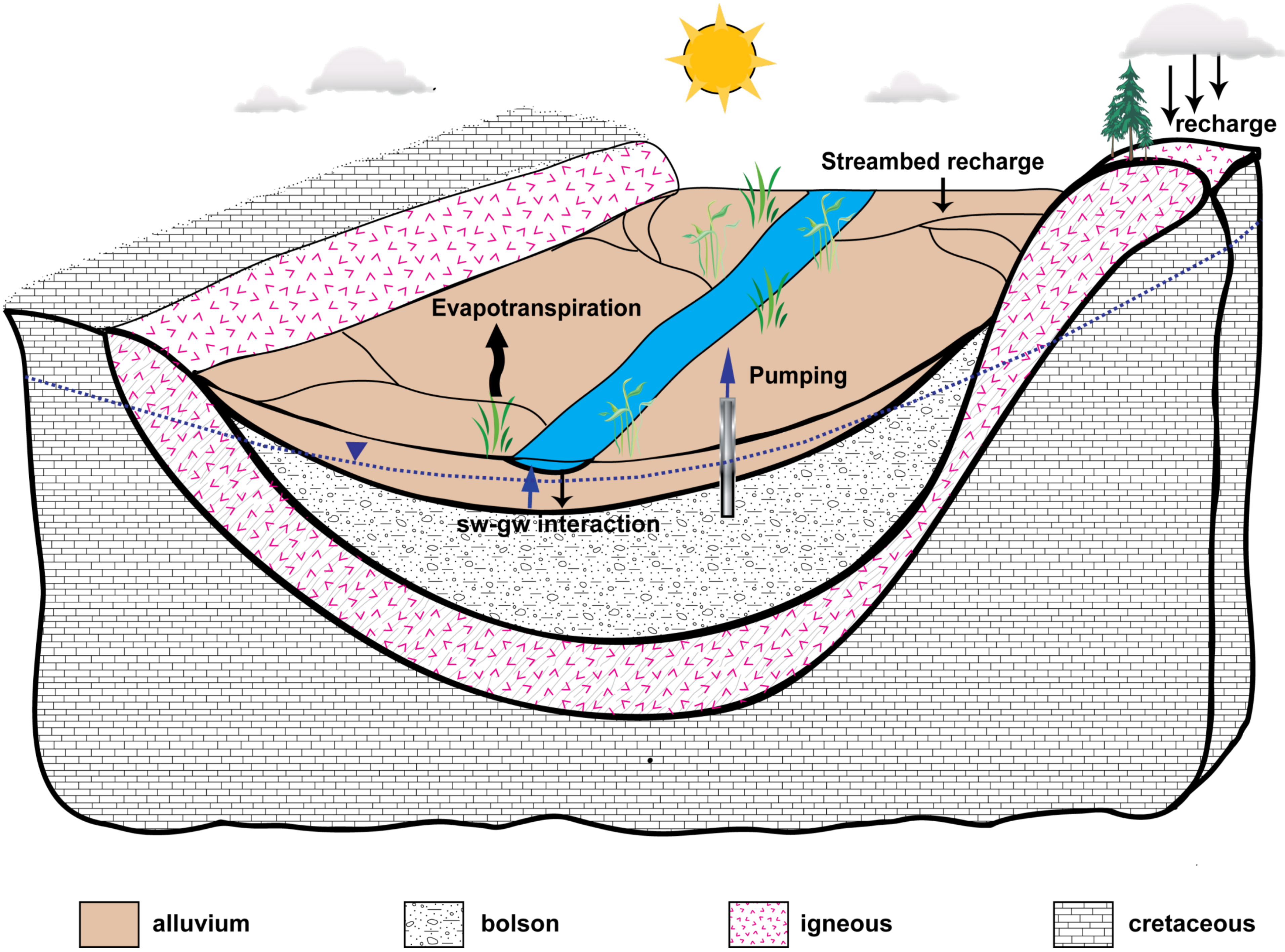
Permitted groundwater use for Ojinaga area of Mexico from CNA online database

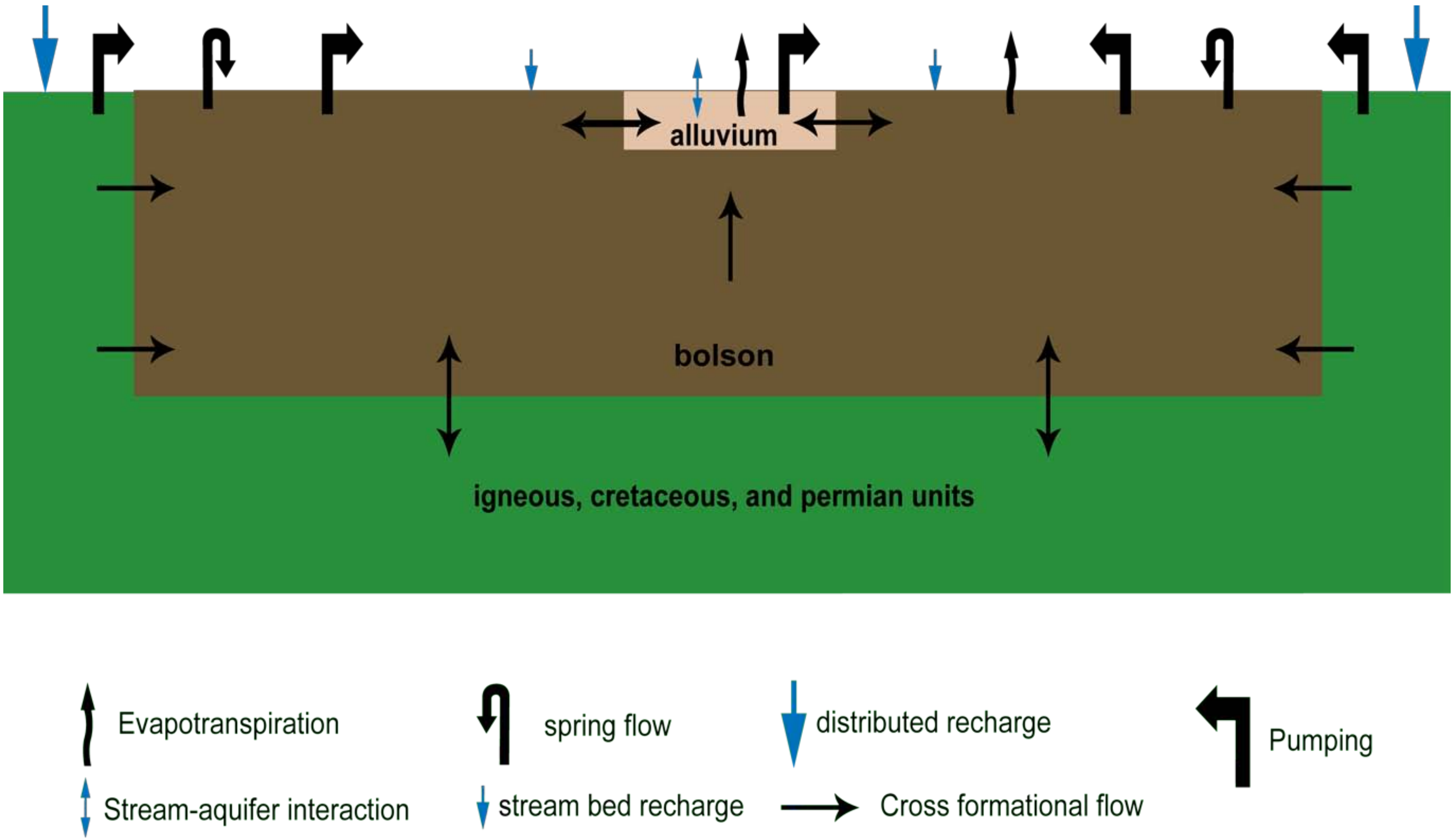


Conceptual Model

Groundwater Flow Directions and proposed model boundaries




recharge
Streambed recharge
Evapotranspiration
Pumping
sw-gw interaction
alluvium
bolson
igneous
cretaceous


alluvium
bolson
igneous, cretaceous, and permian units
Evapotranspiration
spring flow
distributed recharge
Pumping
Stream-aquifer interaction
stream bed recharge
Cross formational flow

Tentative Schedule

2011

- **April 15 – deadline for comments on conceptual report**
- **August 31 – Final conceptual model report posted**
- **October 31 – Draft model report posted**
- **November – SAF3**

2012

- **January 15 – Deadline for comments on draft model report**
- **February 28 – Final model report posted**

Comments:

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Draft report can be found here:
http://www.twdb.state.tx.us/gam/prbl/prbl.asp

Texas Water Development Board

Presidio – Redford Bolson aquifer GAM

Stakeholder Advisory Forum 2

March 15, 2011

Name	Affiliation
Patt Sims	Citizen
Caroline Runge	Regional Water Planning Group F and Menard County Underground Water District
Mike O'Connor	Landowner
Janet Adams	Presidio County Underground Water Conservation District and Jeff Davis Underground Water Conservation District
Guillermo Martinez	US International Boundary and Water Commission
Andres J. Banuelos	Comision Internacional de Limites y Aquas
Doug Coker	Texas Water Development Board
Melissa Hill	Texas Water Development Board
Shirley Wade	Texas Water Development Board

Questions and Answers from the Second Stakeholder Advisory Forum for the Presidio-Redford Bolson Aquifer GAM held at the Presidio Activity Center on March 15, 2011

Question 1: Can you provide a map showing the study area locations for each of the recharge estimate studies [Gates and others (1980), LBG-Guyton and Associates (2001), Gabaldon (1991), and Chowdhury and Wade, (in preparation)] that you reference in your presentation? And can you place them all on one map?

Response 1: Yes, we can provide the requested item.

Question 2: How old are the pumping estimates for the Mexico permits shown in your presentation?

Response 2: Two to three years old.

Question 3: The pumping estimates for Mexico are too low. There has been a recent increase in irrigation use derived from groundwater sources in Ojinaga, Mexico.

Response 3: We will re-examine our estimates for pumping in Mexico and will look at additional sources of information.

Question 4: Are groundwater sources permitted in Mexico? Because 2-300 new irrigation wells have been added in Ojinaga, Mexico to supply water to approximately 40,000 acres of crops.

Response 4: Yes, water use is permitted in Mexico by the Comisión Nacional del Agua (CONAGUA). We will try to locate more recent land use coverages for Mexico within the project study area, and will look for additional sources of information that may be available for estimating permitted quantities for Ojinaga, Mexico.

Question 5: In your presentation, you show that there is no cross-flow with Mexico [slide showing groundwater flow directions and proposed model boundaries]. Is this correct?

Response 5: Yes, we were able to determine clear groundwater divides based on topographic maps. In general, groundwater divides coincide with surface water divides. That is; groundwater flow is from the mountain peaks to the center of the valley.

Question 6: Is layer 3 in the model [igneous aquifer and Permian and Cretaceous rocks] saturated throughout?

Response 6: Yes, layer 3 is saturated throughout, but permeability is low so it is generally not considered a highly productive resource. Because of the low permeability for layer 3, cross-flow with layer 2 will generally only occur if a pumping well is placed in layer 3.

Question 7: How deep is the bottom of layer 3?

Response 7: Most of the action occurs in the shallower portions, but layer 3 is approximately 2,500 feet thick. The thickest portion of the bolson [layer 2] is approximately 5,000 feet.

Question 8: You show pumping estimates for Mexico and the United States, can you include pumping from the Shafter Silver Mine in your model? They resumed mining activities which will include dewatering the mine which is submerged.

Response 8: We will look at pumping information for The Shafter Silver Mine but our previous information indicated the well is right outside the model boundary.

Question 9: You mention using a lag time for recharge of approximately 30 years in the groundwater flow model. I have been monitoring rainfall for the past 5 years at my property, which is located within the mountains. Rainfall has been showing a declining trend over the past 5 years. In fact, rainfall amounts have been relatively lower in the mountains than in the valleys for the past 5 years. Rainfall is also highly variable throughout the study area. How does that fit into the model?

Response 9: A 5-year trend is a relatively shorter time frame, we are aiming for capturing long-term conditions which may be more representative of average conditions. There is data on a relatively tighter scale known as Parameter-elevation Regressions on Independent Slopes Model [PRISM] that captures more of the spatial variability in rainfall than is shown among the 3 rainfall gages in the United States that are used in this presentation. The general conceptualization has been that rainfall amounts are higher in the mountains relative to the valley.

Question 10: Are you using any of the information available from the Texas Natural Resources Information System [TNRIS]?

Response 10: Yes, the Texas Natural Resources Information System [TNRIS] is a division of the Texas Water Development Board.

Question 11: Are you using the State Soil Geographic Database [STATSGO] or the Soil Survey Geographic Database [SSURGO]?

Response 11: No, we are not using the State Soil Geographic Database [STATSGO] or the Soil Survey Geographic Database [SSURGO] at this time. They provide detailed information at a scale that will not be replicated in the groundwater flow model. We are attempting to simulate general conditions and aquifer properties over a broader area, or at a larger scale.

Question 12: Are you using topographic data from the Texas Natural Resources Information System [TNRIS]? And if so, can you cite the reference and year?

Response 12: Yes, we are using topographic data from the Texas Natural Resources Information System [TNRIS] and yes we will add the reference and year.

Question 13: Are you using any of the data available from the Instituto Nacional de Estadistica Geografia e Informatica [INEGI]? They may have more accurate data with respect to digital elevation models, vegetation, and land use for Mexico.

Response 13: Yes, we are using some data from the Instituto Nacional de Estadistica Geografia e Informatica [INEGI], but we will search the website again to see if there is more recent data available.

Question 14: I'm curious why you are using/referencing vegetative cover from Pennsylvania State University in your presentation?

Response 14: We are using the vegetative imagery from Pennsylvania State University for informative purposes, such as this presentation, as it shows vegetative cover for the United States and Mexico. We are not using the vegetative imagery from Pennsylvania State University in the groundwater flow model.

Question 15: Who have you coordinated with in the past that is from the International Boundary and Water Commission [IBWC]?

Response 15: Mr. Rong Kuo.

Question 16: Can you provide us with a copy of your presentation in color?

Response 16: Yes.

Question 17: We found that there were portions of the Edwards-Trinity Plateau Aquifer that did not receive recharge when the percentage of annual recharge dropped below 10%. I would be interested in knowing at what percentage this occurs for this project site.

Response 17: I would expect it is high for this project site, and will provide estimates when they become available.

Question 18: How deep is the bolson well that you show in close proximity to the alluvium well in your presentation, and do we know if it is a bolson well?

Response 18: It is difficult to estimate how deep the bolson well is at this time without looking at the database, but it was originally identified as a bolson well based on its location and depth.

Question 19: How deep are all the wells that you show in the presentation?

Response 19: It is difficult to estimate at this time without looking at the database, but we can provide that information at a later date.

Question 20: I believe you have done some groundwater sampling in this area. Can you identify the layers that the wells are located in based on your water quality analyses?

Response 20: Yes, we have collected samples, but we do not analyze them internally. The collected samples are shipped to a laboratory which analyzes them and provides us with the results. You are correct; there is a difference in the water quality among the layers. Water samples collected from wells penetrating the bolson aquifer are generally fresher than samples collected from wells penetrating the alluvium aquifer.

Question 21: Can you provide us with the well depths for all the wells shown in your presentation, especially for the bolson well and the alluvium well that are located next to each other?

Response 21: Yes, we can provide the requested data.

Follow-up 18, 19 and 21: First pair of Presidio Bolson hydrographs – 5151807 well is 84 feet deep, 7430407 well is 84 feet deep; Second pair of Rio Grande Alluvium hydrographs – 5151802 well is 45 feet deep, IBWC well OW709 (7430820) no data for well depth at this time; third pair of hydrographs – 7439502 (Rio Grande Alluvium) well is 11 feet deep, 7439504 (Presidio Bolson) well is 214 feet deep. A screen shot for two wells from the TWDB WIID is shown on the following page.

Question 22: How deep are the city wells?

Response 22: Several hundred feet, I believe that they are approximately 200 feet deep, but I will check our database and provide this information at a later date.

Follow-up 22: City of Presidio wells range in depth from 34 feet (drilled in 1929) to 537 feet (drilled in 2001).

Question 23: It appears that there is concern over groundwater pumping, has anyone looked at the laws or treaties for pumping groundwater between the United States and Mexico?

Response 23: Our primary area of interest involves pumping in the United States. At this time, we are not aware of any international treaties associated with groundwater pumping for the project area.

Follow-up 23: We have reviewed the IBWC website and verified that there are no treaties regarding groundwater use in the study area. We plan to use the best available information on groundwater use in the model and if better information becomes available we will update the pumping information in the model.

Question 24: Are there any known artesian wells in this area?

Response 24: There are 1 to 2 known artesian wells in the project area, but as I recall they are located in the Chinati Mountains.

TWDB.WIID

Water Well Data

Zoom Move Select

[Layers]

Visible Active

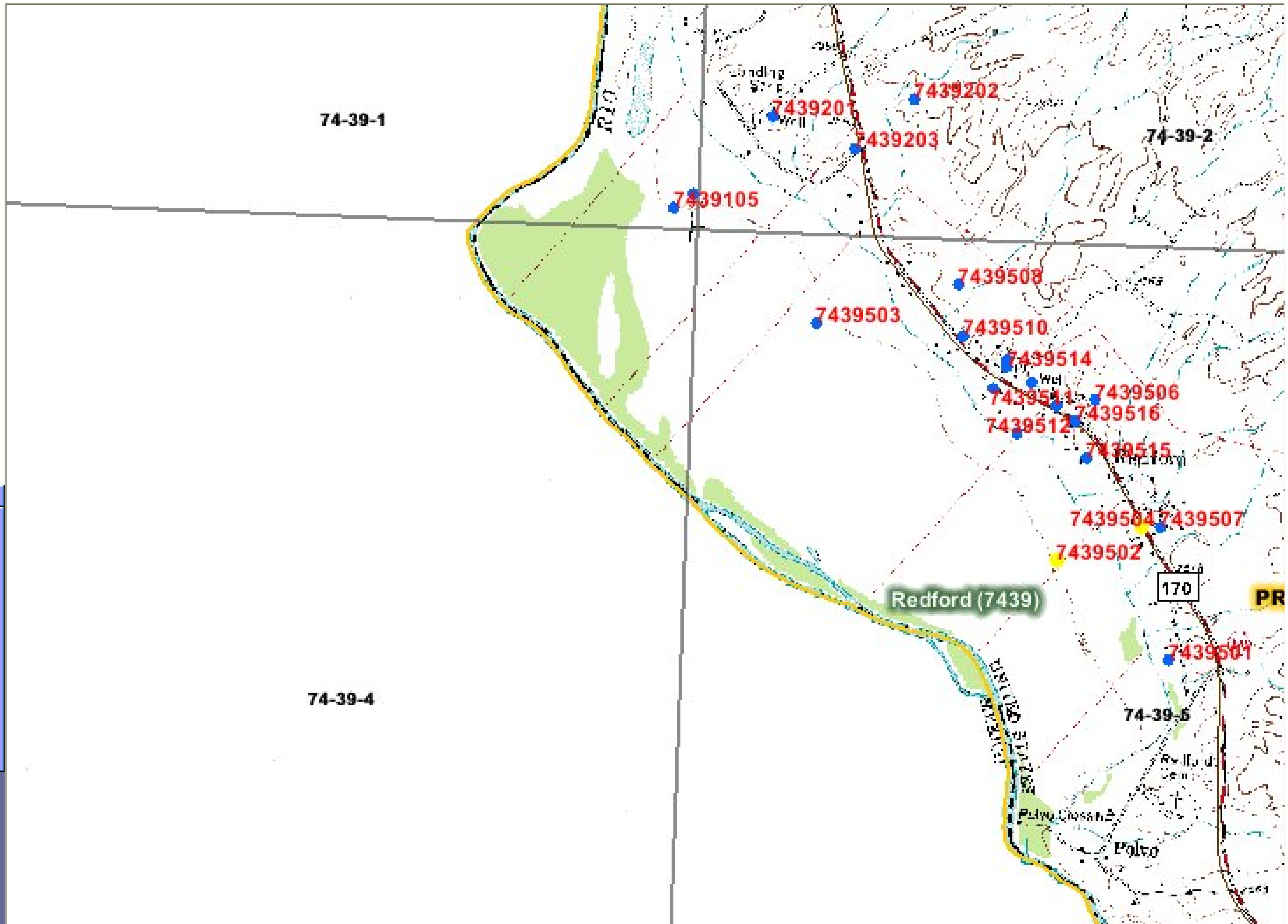
- [x] TWDB Groundwater Data
- [ ] Submitted Driller's Reports
- [ ] Brackish Groundwater Database
- [ ] Submitted Drillers Reports - D.I.M.s
- [ ] Groundwater Districts (updated Aug. 2010)
- [ ] Major Aquifers
- [ ] Minor Aquifers
- [ ] Regional Water Planning Areas
- [ ] Groundwater Management Areas

Wells in TWDB Groundwater Database - Texas

Help

Active Tool

Select Rectangle



TWDB GROUNDWATER DATA (*Explanation*)

Rec	OBJECT	State Well Number	Owner	Water Use	Elevation	Well Depth	Water Level	Water Quality	Aquifer Code	Latitude	Longitude	COUNTY_CODE	WELL_TYPE	area
1	67312108	7439502	Rubin Madrid heirs	U	2502	11	C	N	111RGRD	292647	1041132	377	W	0
2	67312110	7439504	Marfa ISD	U	2503	214	M	Y	112PRBL	292652	1041119	377	W	0

Zoom to these records