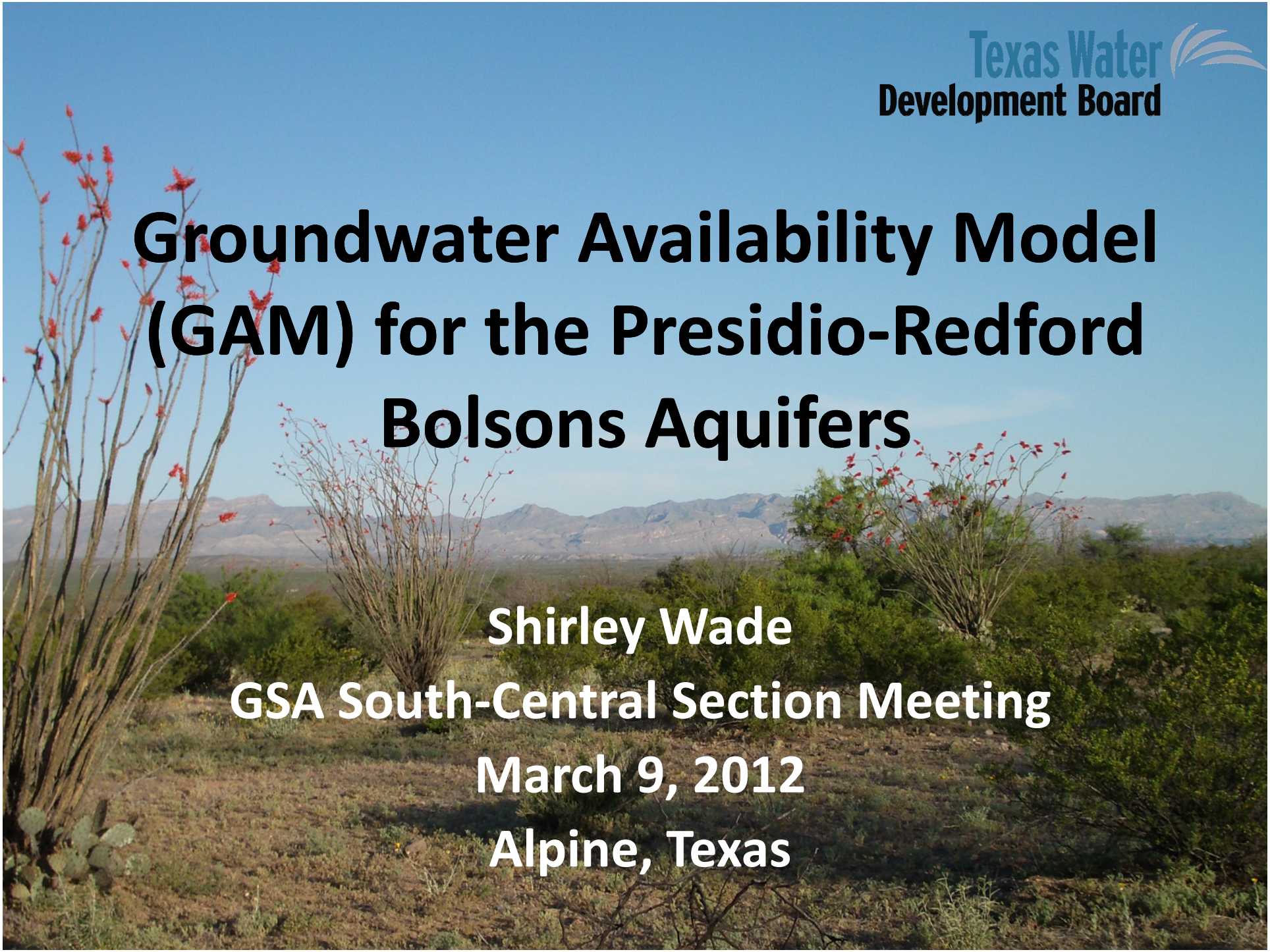


Groundwater Availability Model (GAM) for the Presidio-Redford Bolsons Aquifers

Shirley Wade

GSA South-Central Section Meeting

March 9, 2012

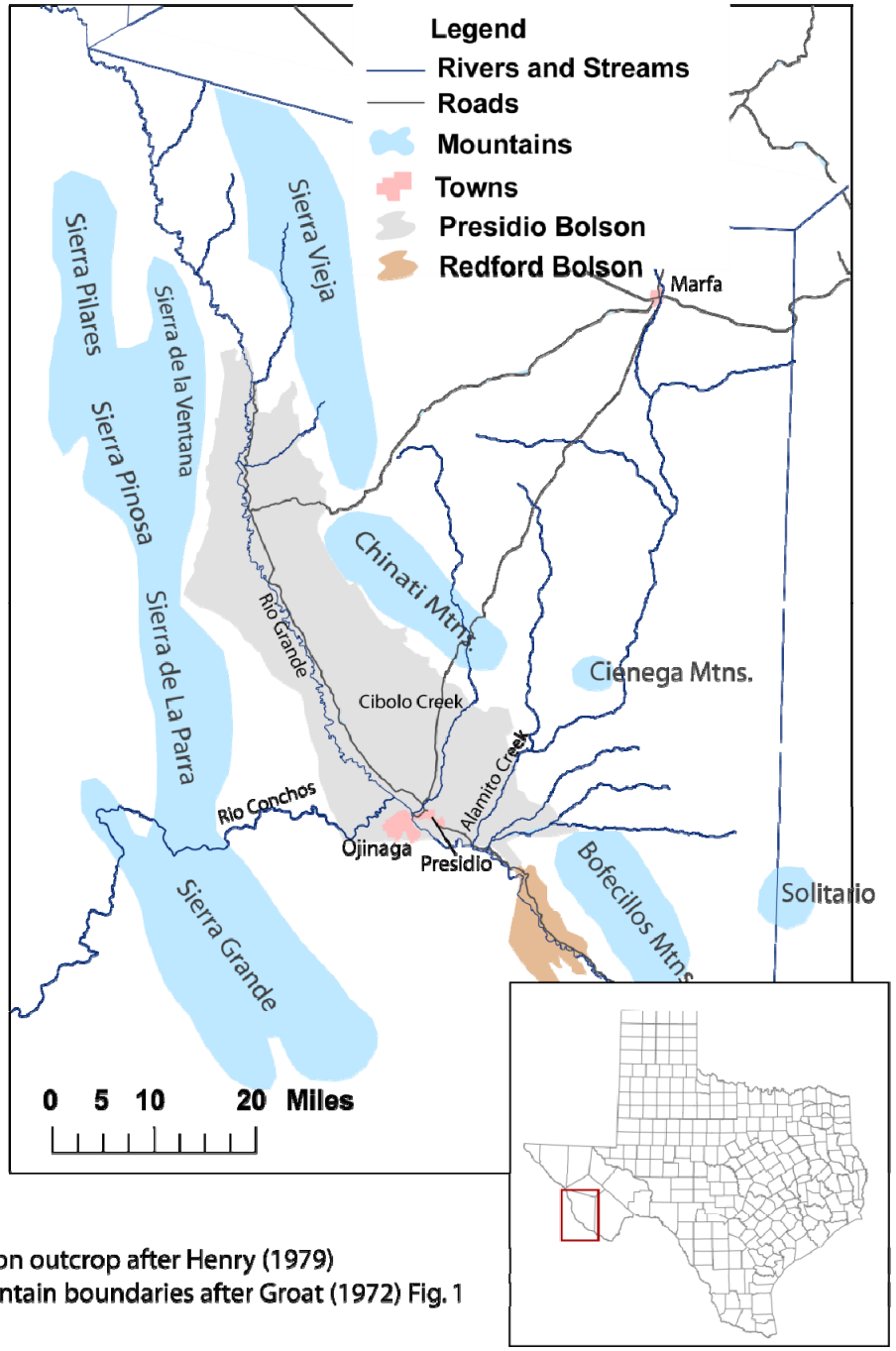
Alpine, Texas

Acknowledgements

- This project would not have been possible without contributions and support of the following individuals and organizations: Ali Chowdhury, Doug Coker, Melissa Hill, Bill Hutchison, Marius Jigmond, Robert Mace, Cindy Ridgeway, Miguel Pavon, Presidio County Groundwater Conservation District, International Boundary and Water Commission, Texas Parks and Wildlife Department, City of Presidio, local landowners

Purpose of project

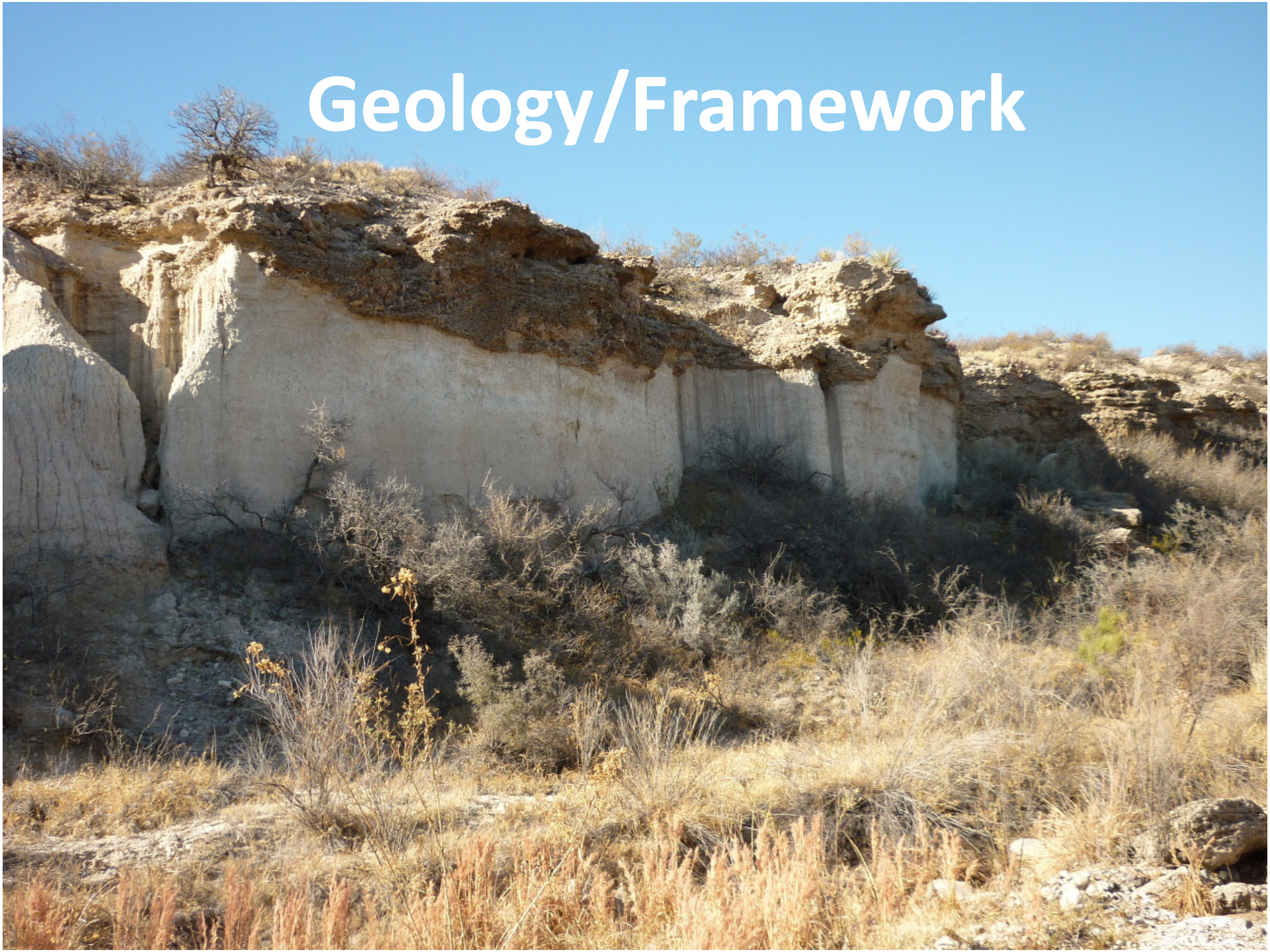
- **To develop a model that can be used as a tool for groundwater resource planning**

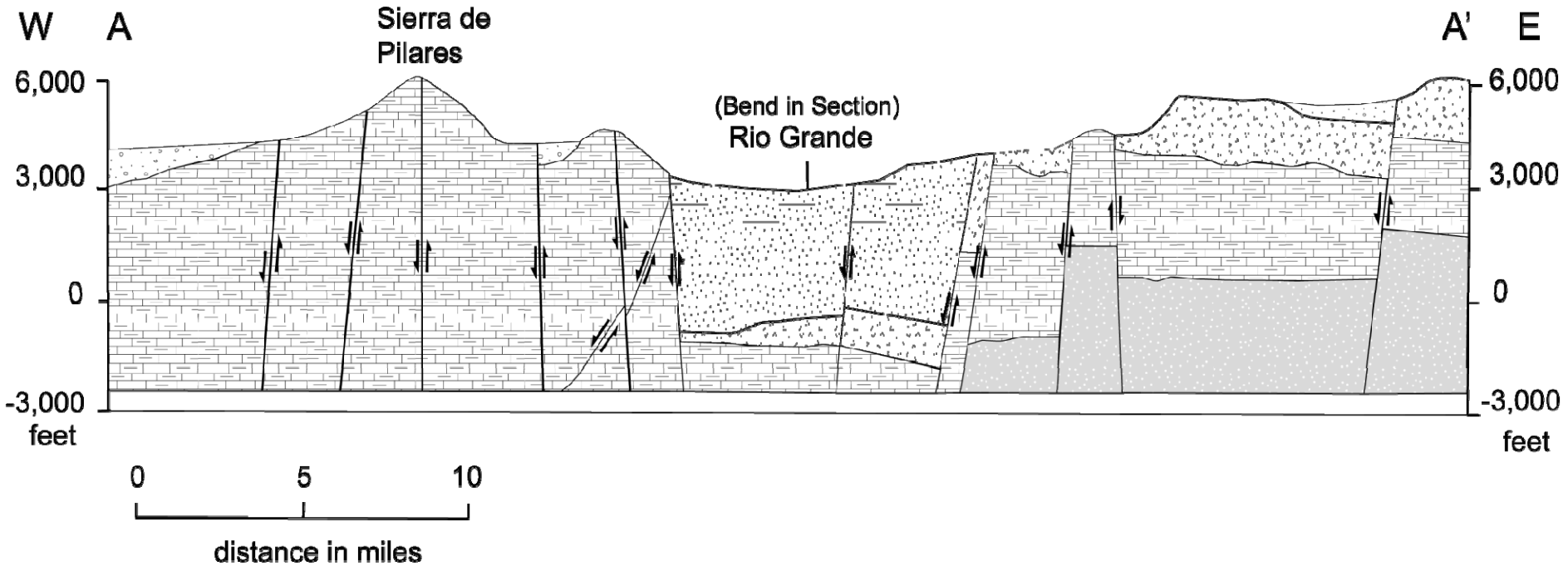


Bolson outcrop after Henry (1979)
Mountain boundaries after Groat (1972) Fig. 1

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

Geology/Framework





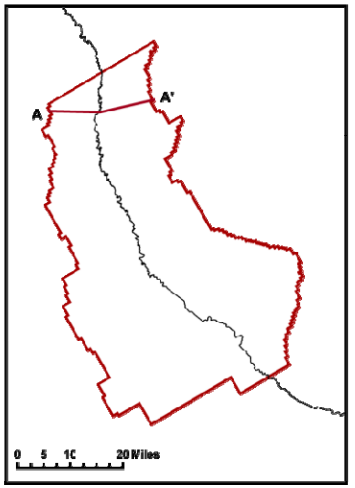
alluvium

basin fill

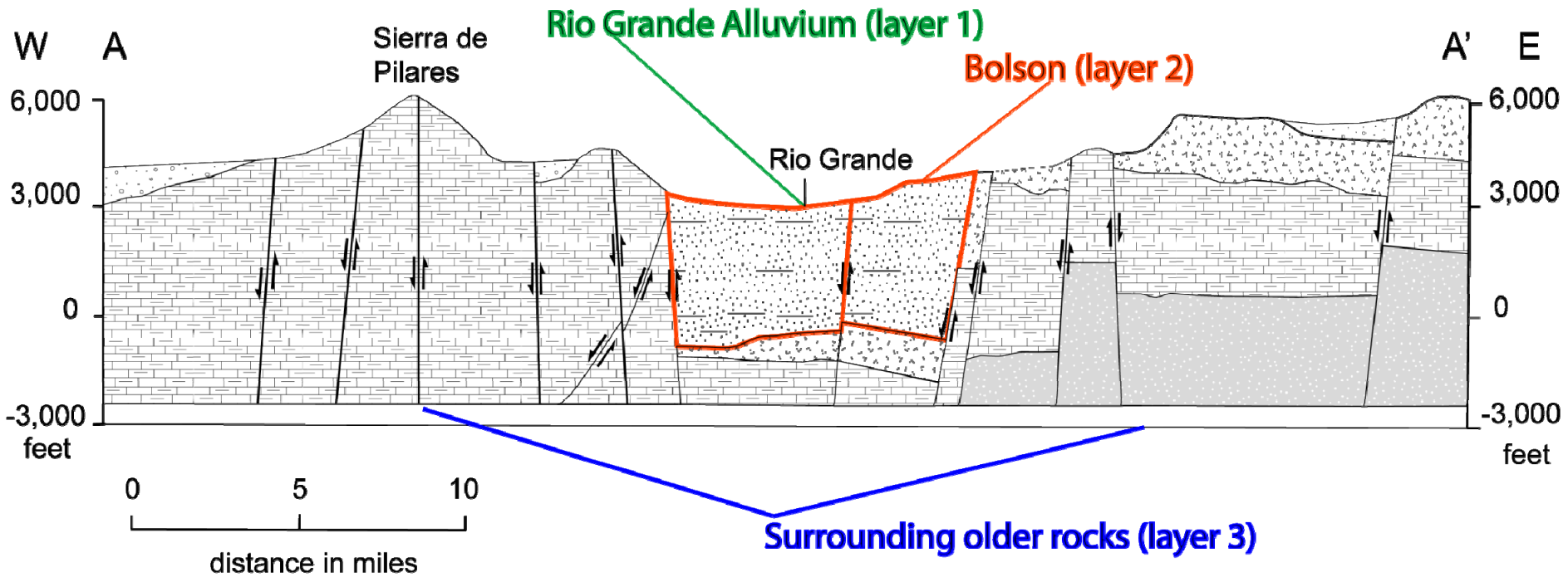
volcanic and volcaniclastic rocks, mostly pre-basin and range faulting

Mesozoic to early Eocene sedimentary rocks, mostly Cretaceous

Paleozoic sedimentary rocks, mostly Permian



source: Henry (1979)



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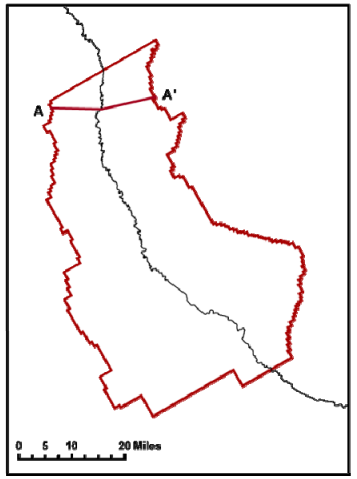
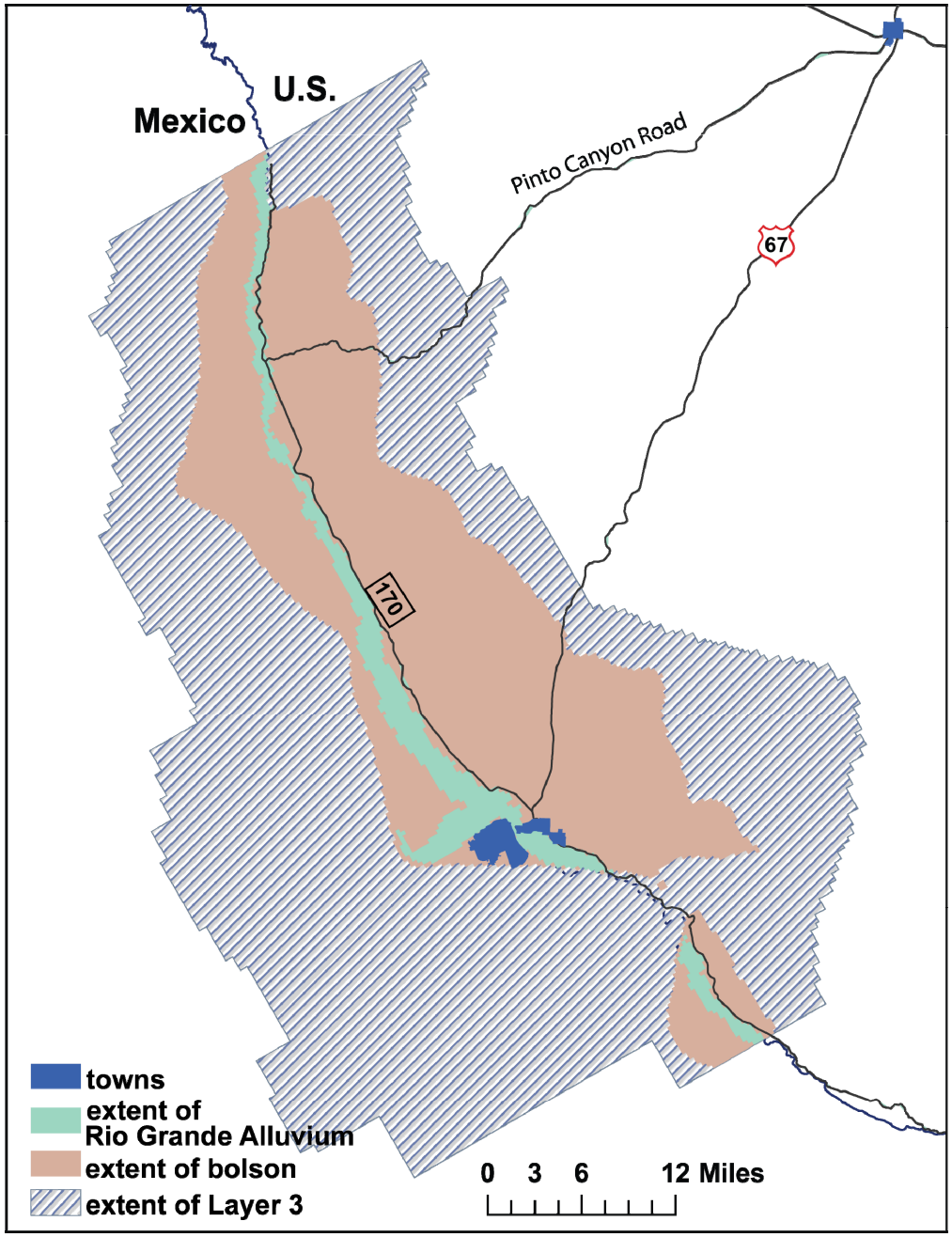
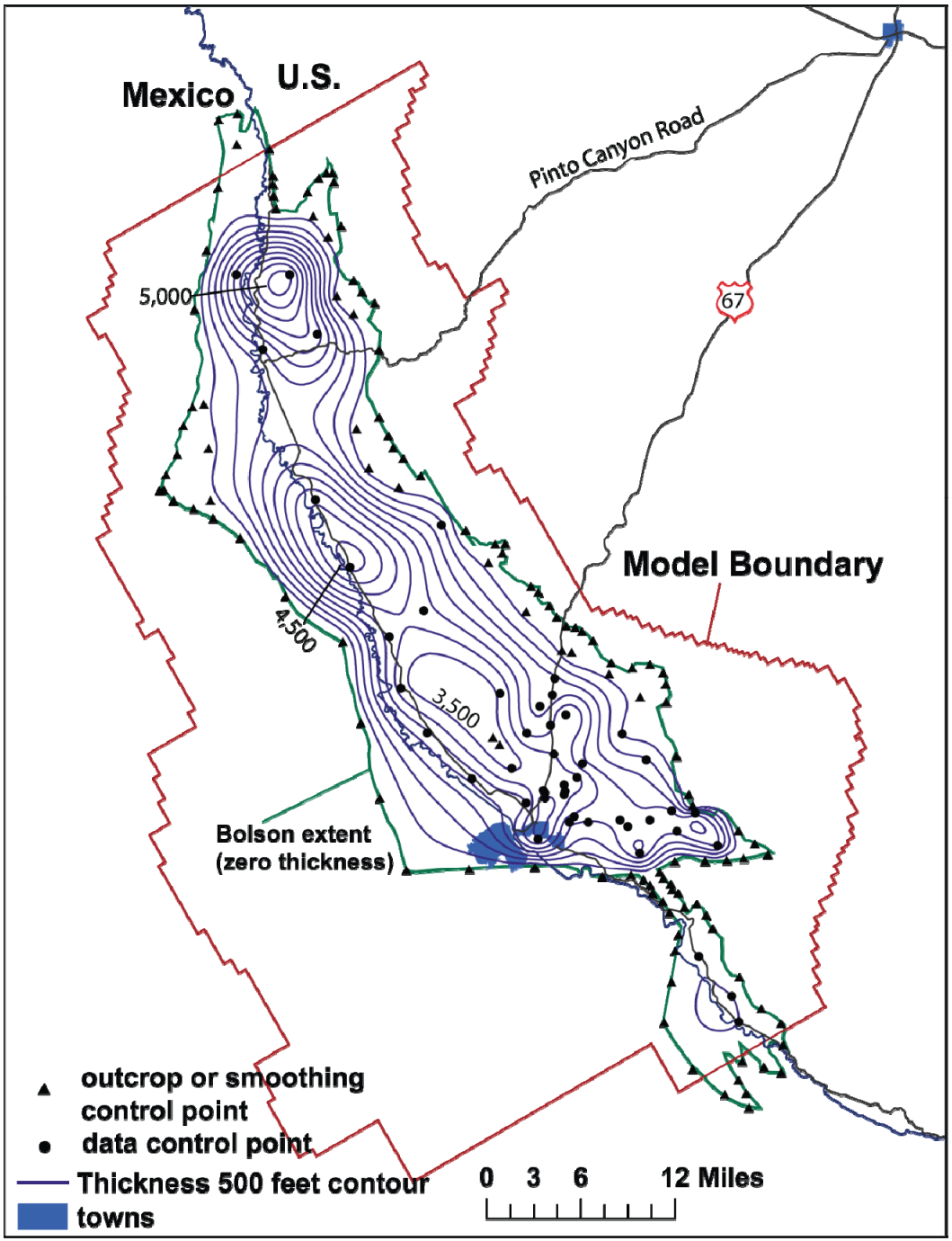


source: Henry (1979)



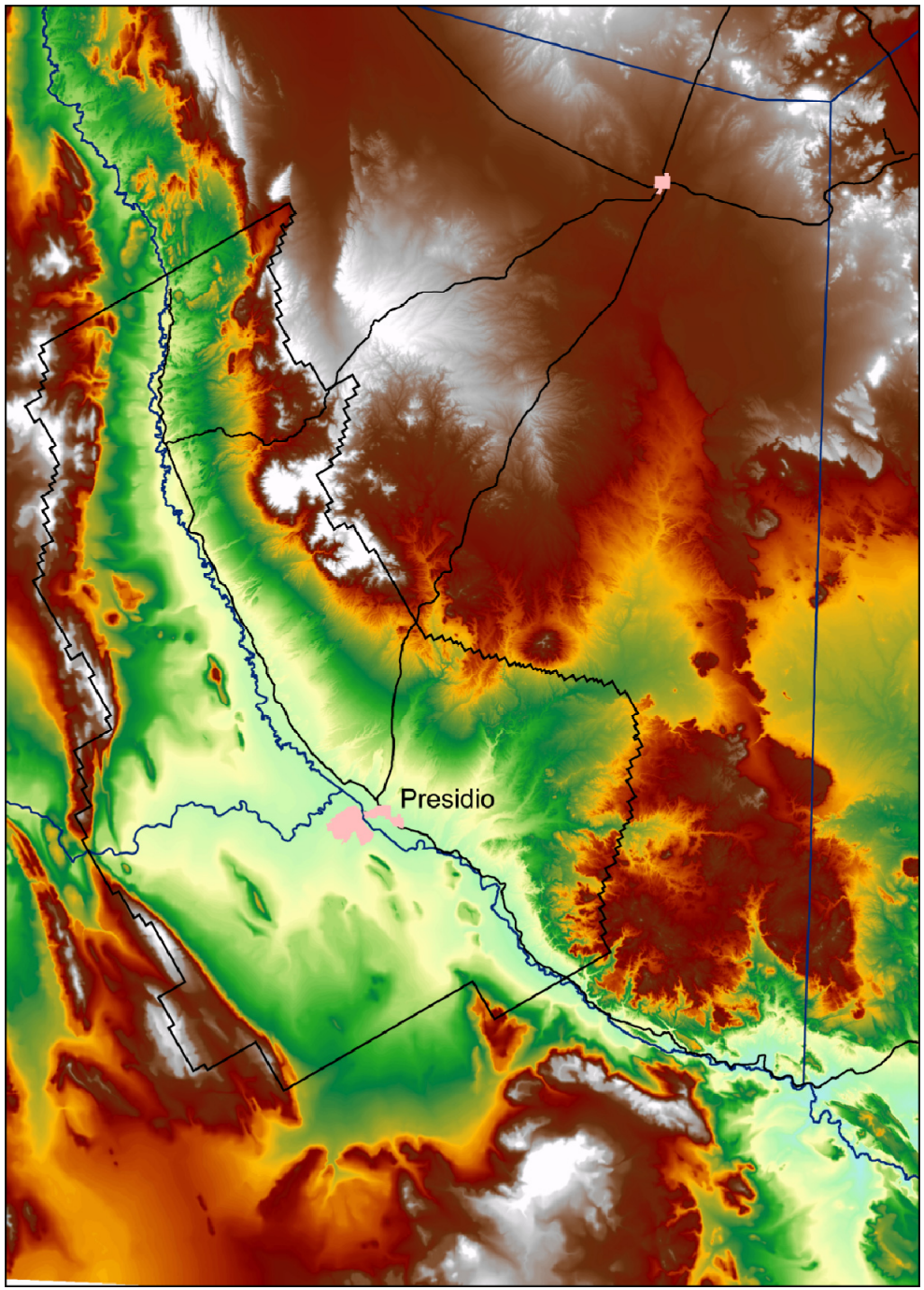
Model includes 3 layers

- **Rio Grande Alluvium (layer 1)**
- **Bolson (layer 2)**
- **Underlying/surrounding volcanic and Cretaceous sedimentary rocks (layer 3)**



Estimated Bolson Thickness


Topography and Regional
Groundwater Flow



N

0 5 10 20 Miles

Elevation (feet amsl)

High : 8300

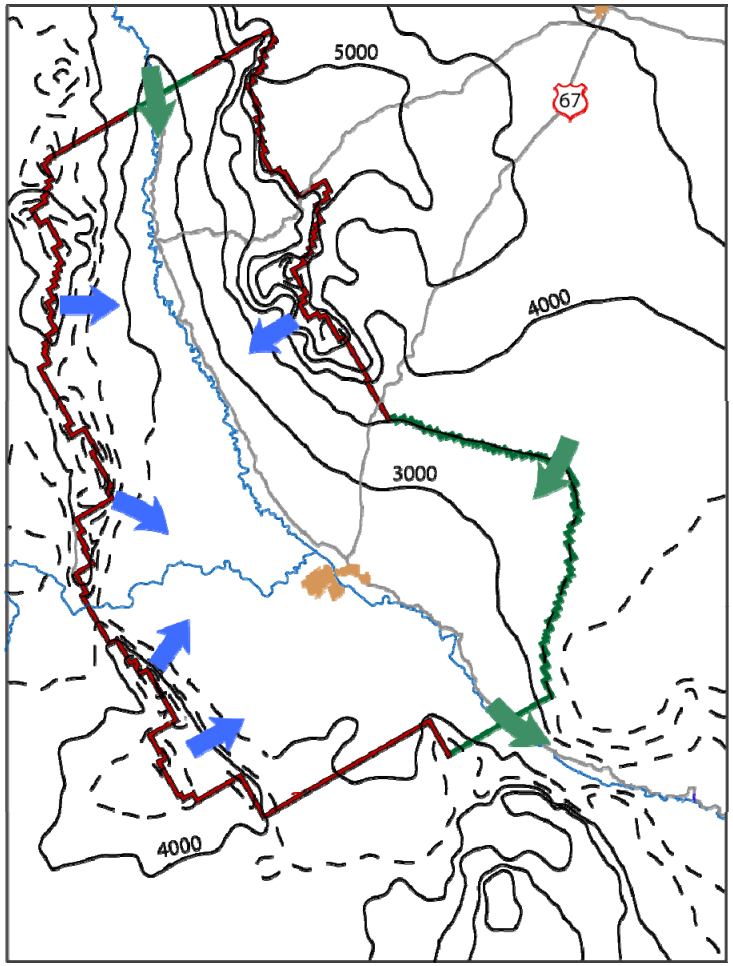
Low : 1800

roads

rivers

model boundary

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



Groundwater Flow Directions and model boundaries

Elevation contours based on well Data supplemented with correlation between land surface elevation and depth to water

internal flow away from flow divides

cross-boundary groundwater flow

towns

water level (500 feet contours) dashed where approximated

rivers

roads

flow boundary

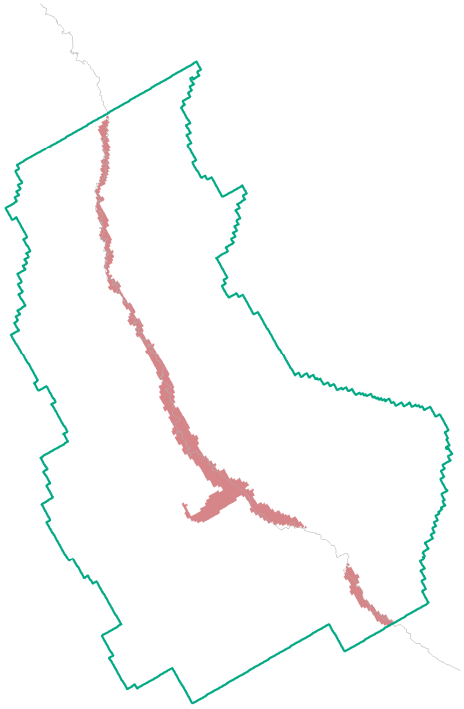
no-flow boundary

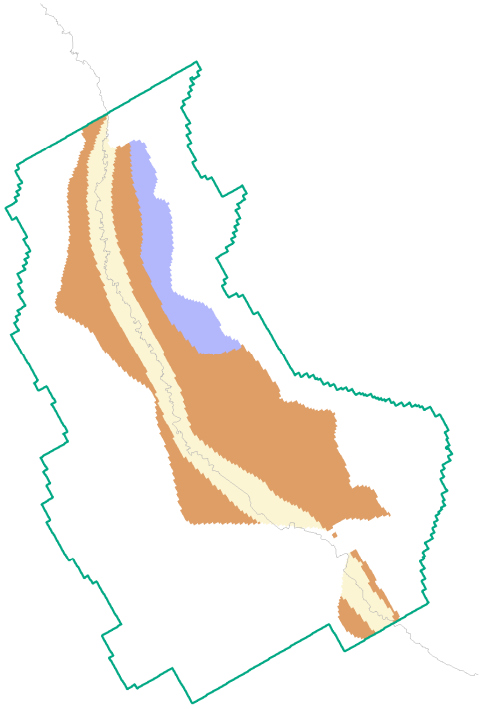
0 5 10 20 Miles

N

Modeling Approach

- We are using MODFLOW 2000 calibrated with PEST, an automated model calibration program
- The model calibration period runs from 1948 to 2008
- Historical pumping estimates used in the calibration include distributed livestock, domestic, and irrigation pumping and point municipal and Mexico pumping





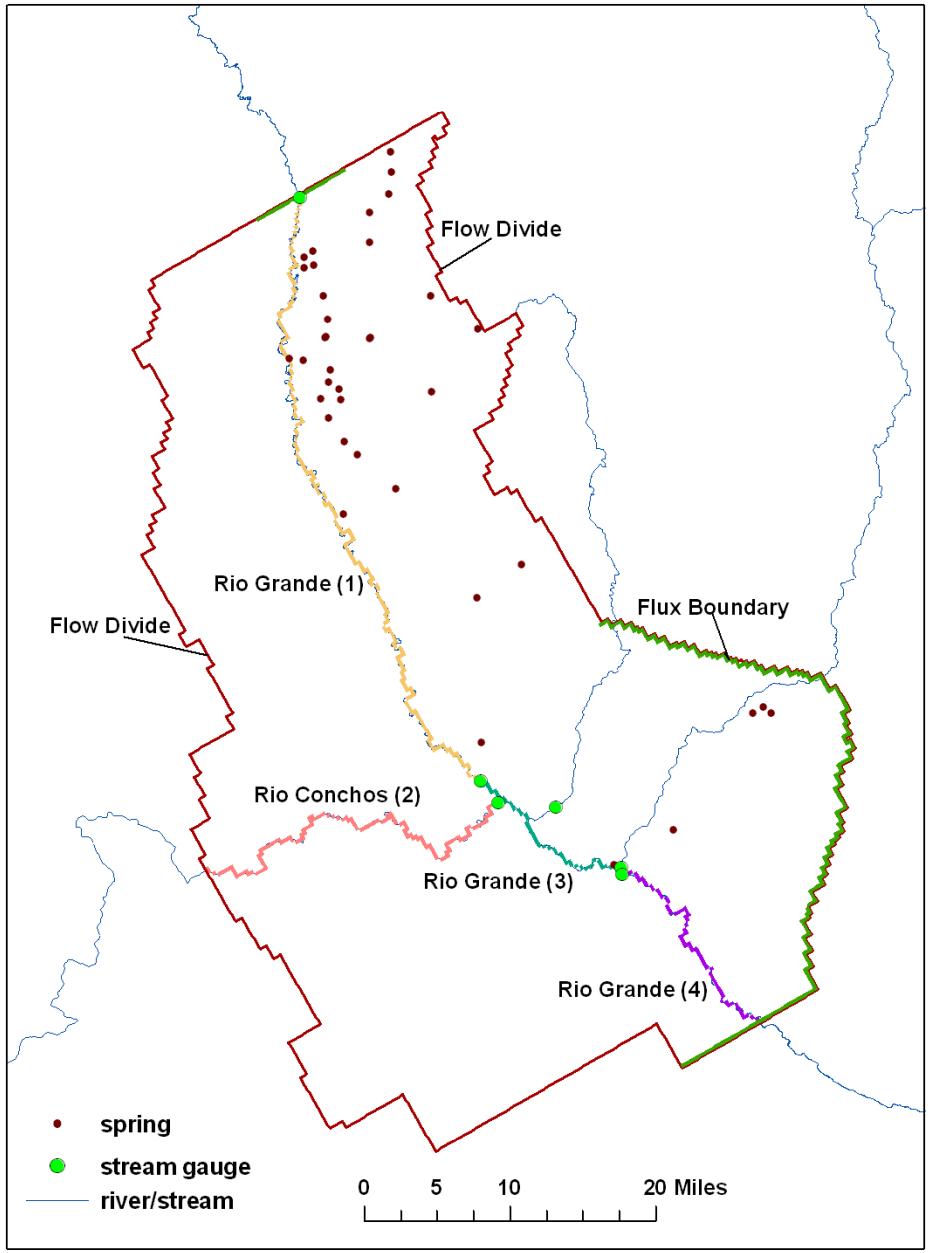
area where Bolson deposits missing zone to provide connection between layers 1 and 3

Layer 1
S = 0.1
Kh = 100 ft/day

Layer 2
S = 0.005
Kh = (0.06 to 4.1 ft/day)

Layer 3
S = 0.0001
Kh = 0.15 ft/day

Hydraulic Properties are zoned



MODFLOW Packages

- River Package used for net riparian evapotranspiration and baseflow discharge for Rio Conchos and Rio Grande

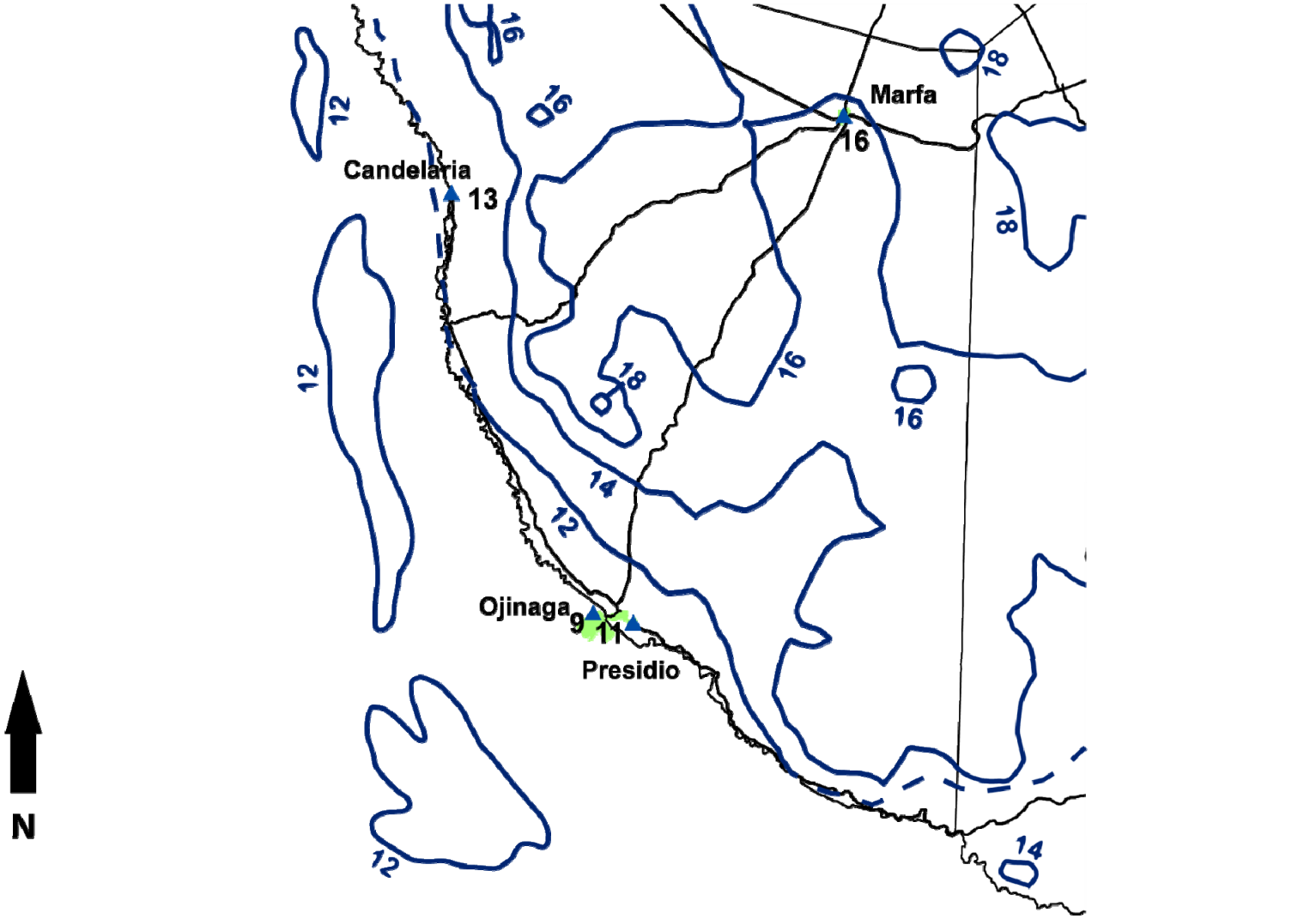
- Drain Package used for spring discharge

- General Head Boundary Package used for regional groundwater flow into and out of model area

Recharge Approach

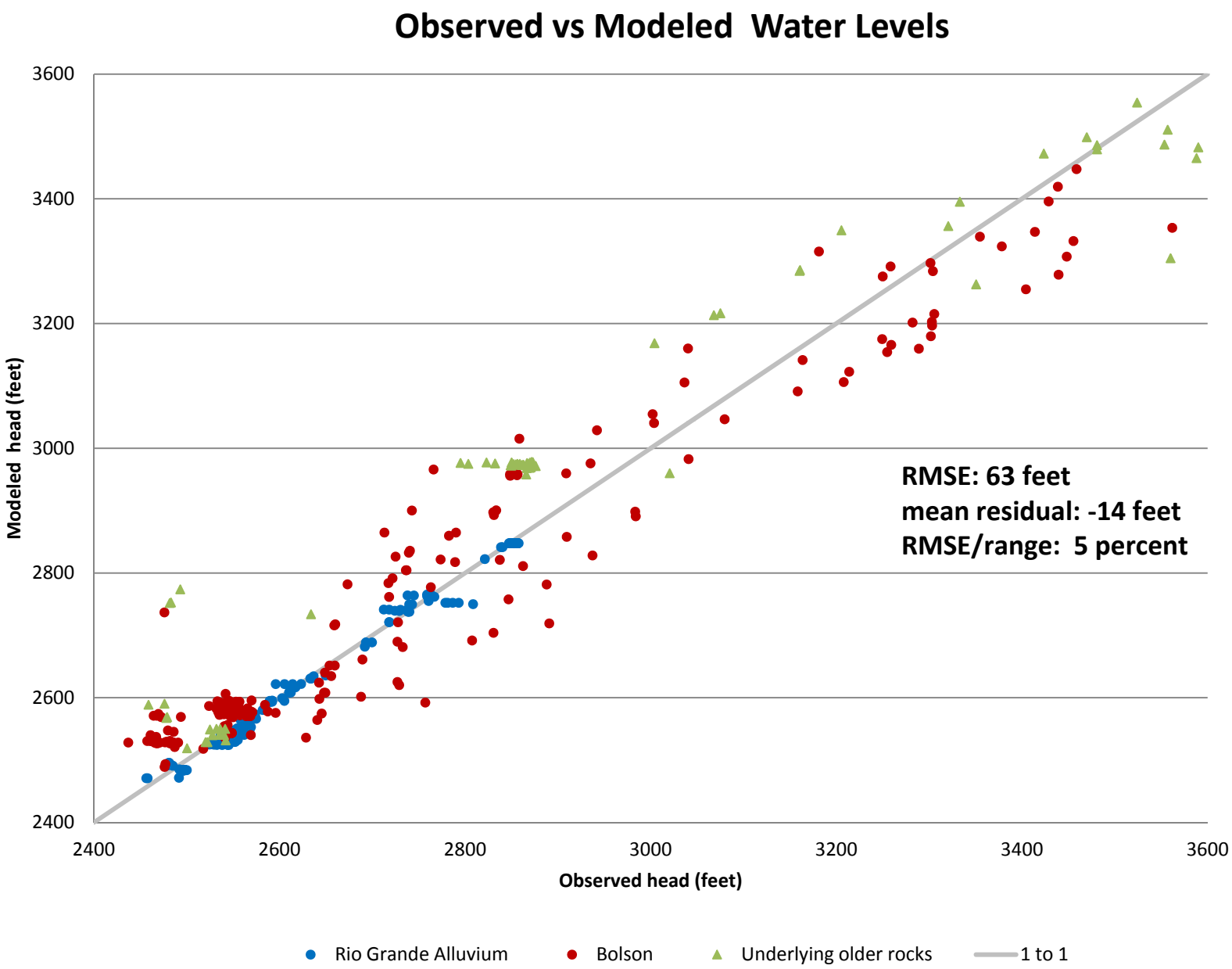
- Recharge is a percentage of precipitation that increases step-wise as precipitation increases.
- 5 parameters for 2 precipitation zones
  - (1) threshold minimum rainfall below which no recharge occurs, (12 inches)
  - (2) percent of rainfall that recharges above the threshold, (10 percent)
  - (3), (4), and (5) dampening factors (DF) to account for unsaturated lag time in each layer:

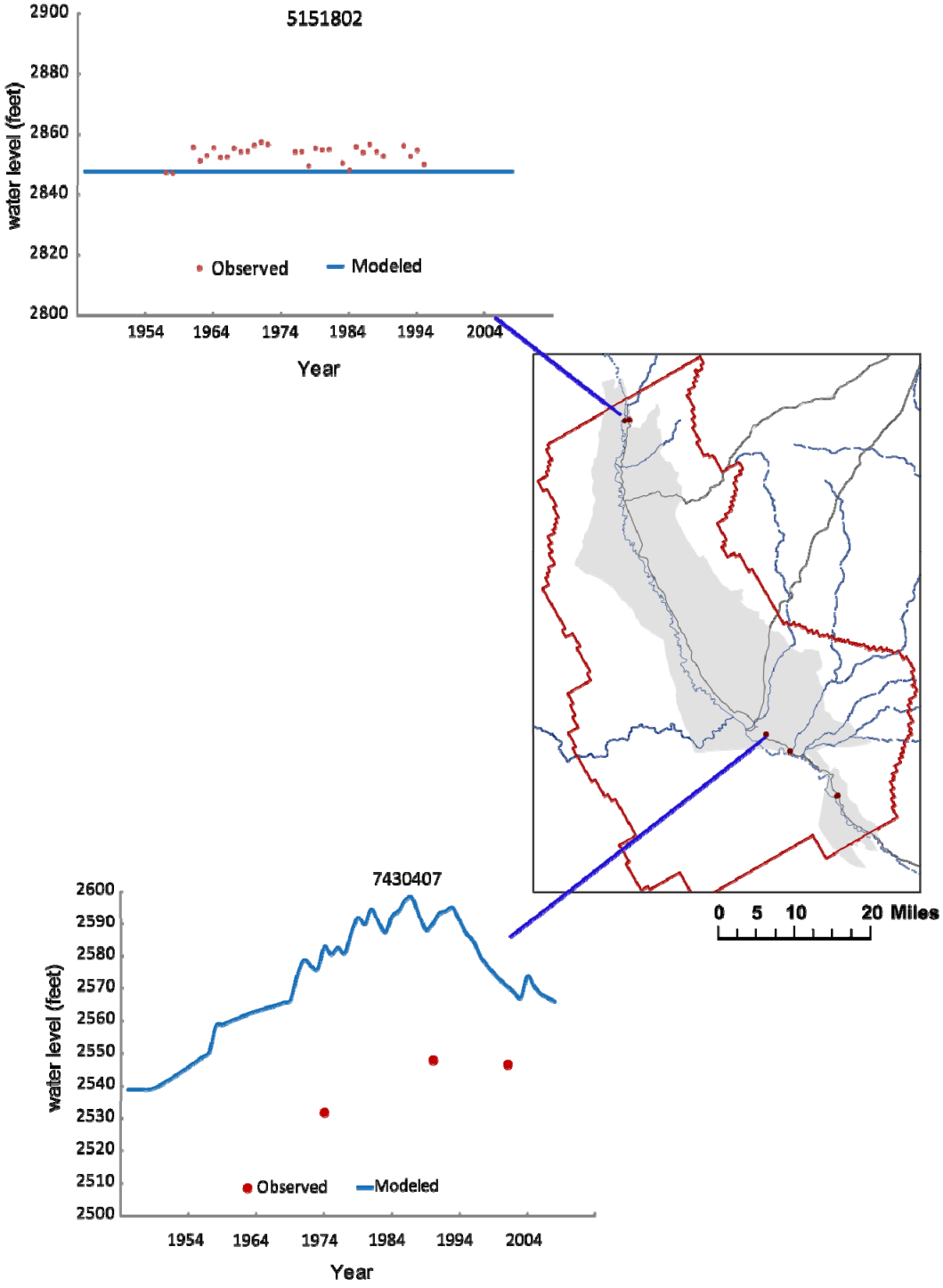
effective rain = (DF*average rain) + (1-DF)*measured rain



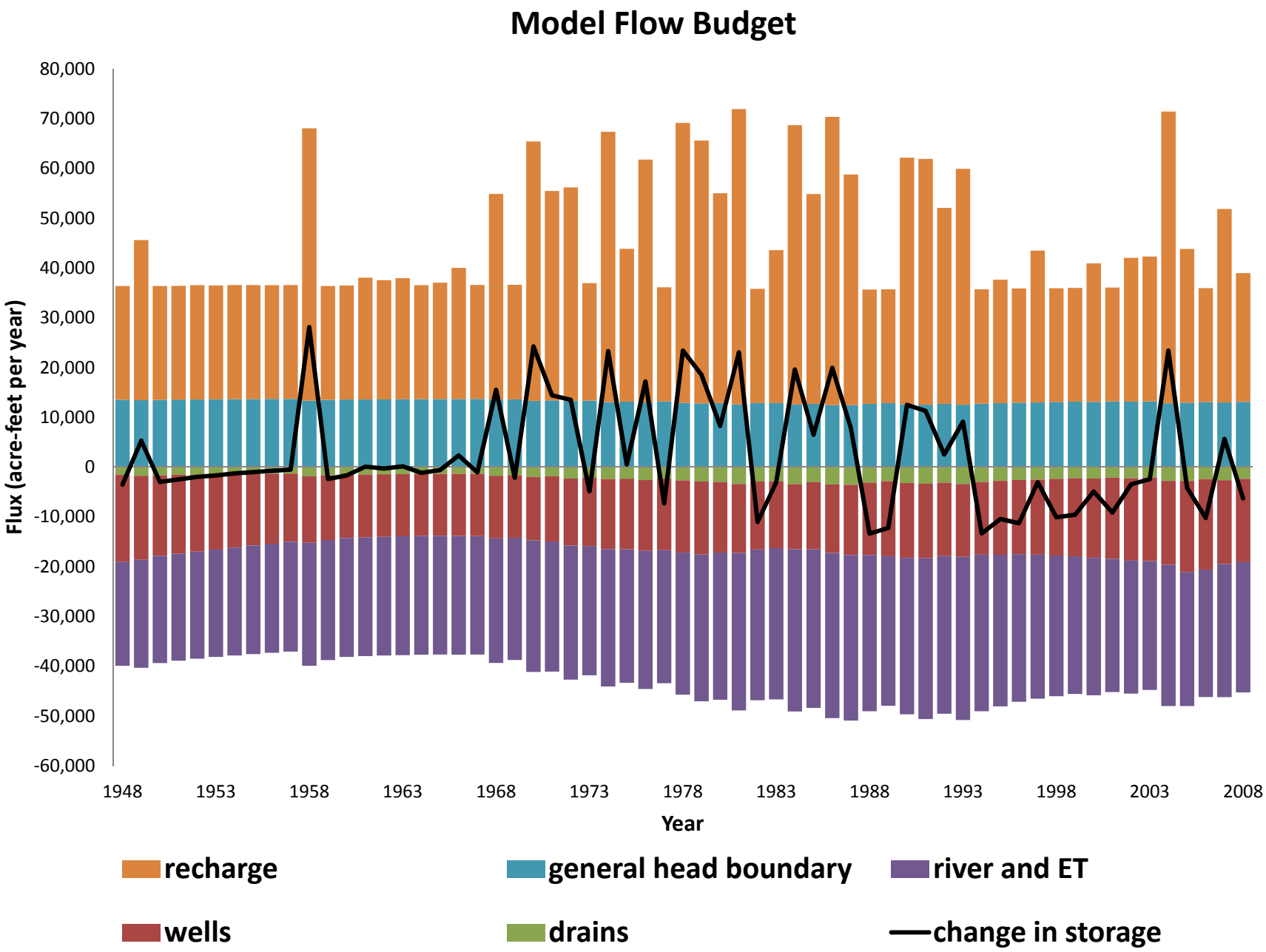
Mexico Gauge data (IBWC, 2002)
US Gauge Data 1961 - 1990 (NCDC, 2002)
US Contours 1961 - 1990from (PRISM, 2004)
Mexico contours digitized from INEGIa and b

Calibration Results


Observed vs Modeled Water Levels
Modeled head (feet)
Observed head (feet)
3600
3400
3200
3000
2800
2600
2400
2400
2600
2800
3000
3200
3400
3600
RMSE: 63 feet
mean residual: -14 feet
RMSE/range: 5 percent
Rio Grande Alluvium
Bolson
Underlying older rocks
1 to 1



Modeled versus observed water levels


Model Flow Budget
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
-50,000
-60,000
Flux (acre-feet per year)
1948
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
Year
recharge
general head boundary
river and ET
wells
drains
change in storage

Summary

- We have developed and calibrated a draft groundwater flow model for the Presidio-Redford Bolsons Aquifer.
- On average the modeled water level is 14 feet greater than the measured water level and the RMSE is 5 percent of the range in heads.
- Recharge when rainfall exceeds 12 inches is estimated as 10 percent of rainfall.


Questions ?