



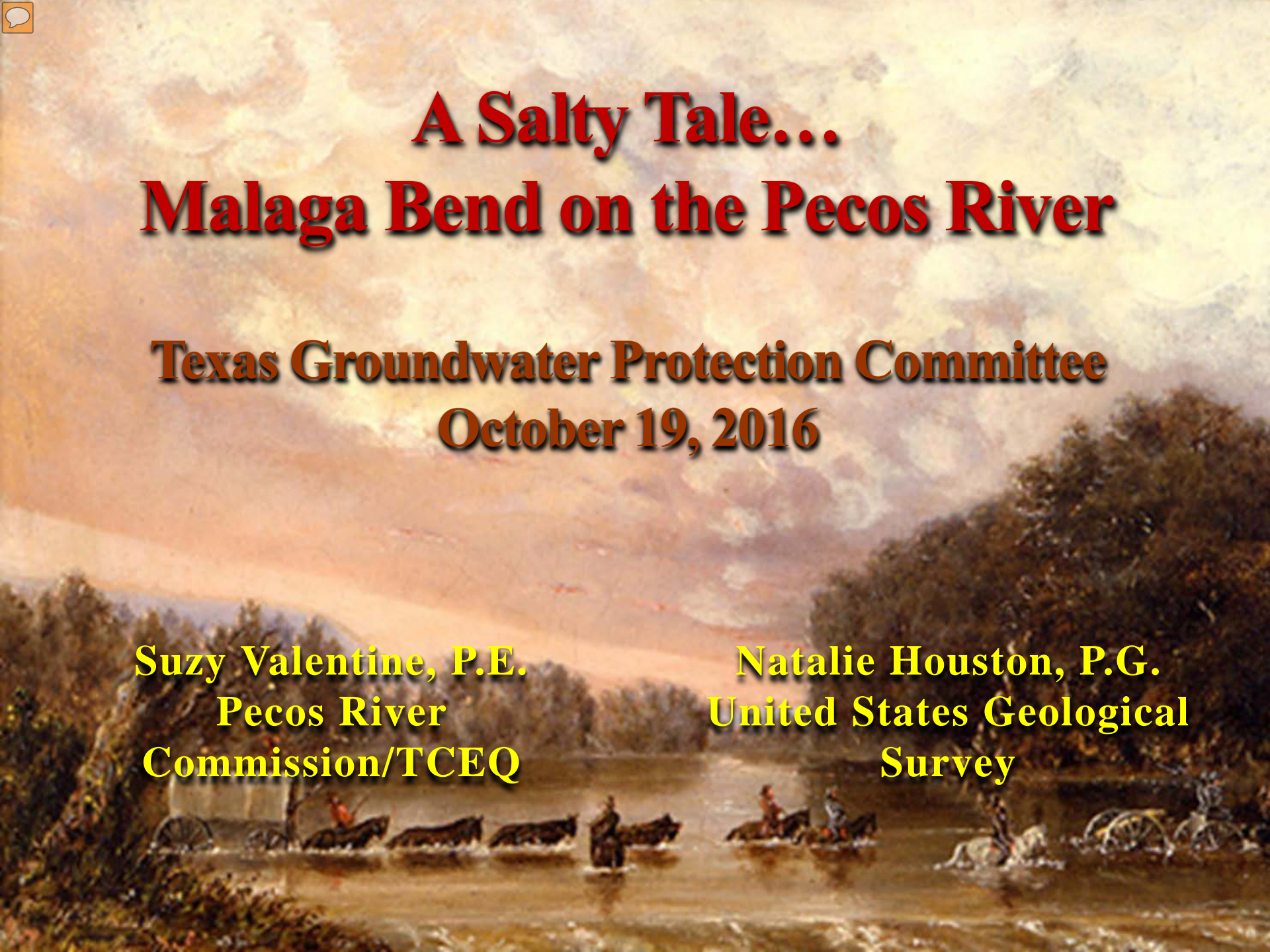
A Salty Tale...

Malaga Bend on the Pecos River

Texas Groundwater Protection Committee
October 19, 2016

Suzy Valentine, P.E.
Pecos River
Commission/TCEQ

Natalie Houston, P.G.
United States Geological
Survey



A Salty Tale...

- Background
- Historical context
- Causes
- Sources
- Impacts
- Malaga Bend Project



Rio de las Vacas...Rio Salado...Rio Puerco ...Rio Pecos...Pecos River

- 929 miles long
- > 44,000 square miles watershed
- Sangre de Cristo Mountains to Rio Grande
- Average daily flows
 - ~90 cfs at Malaga Bend
 - ~33 cfs at Girvin
 - ~265 cfs at Langtry
- Contributes ~222,000 acre feet into Lake Amistad or ~10% of inflows



Barrier to Westward Expansion

"The Graveyard of a Cowman's Hopes..." ~ C. Goodnight

- **Treacherous crossings**

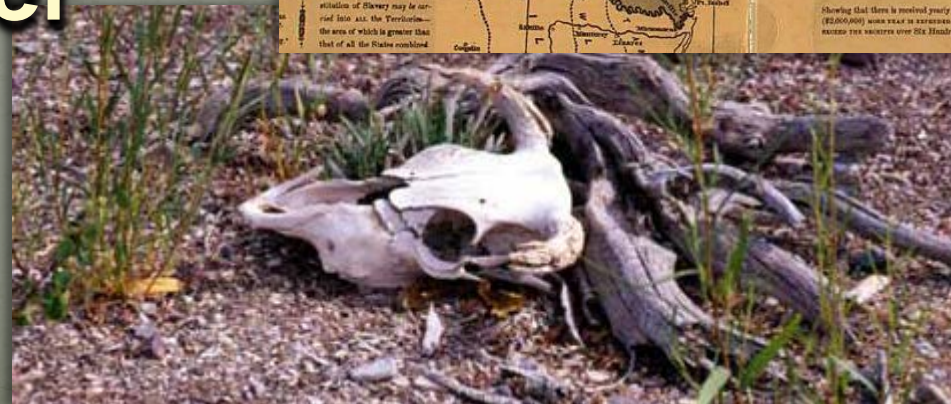
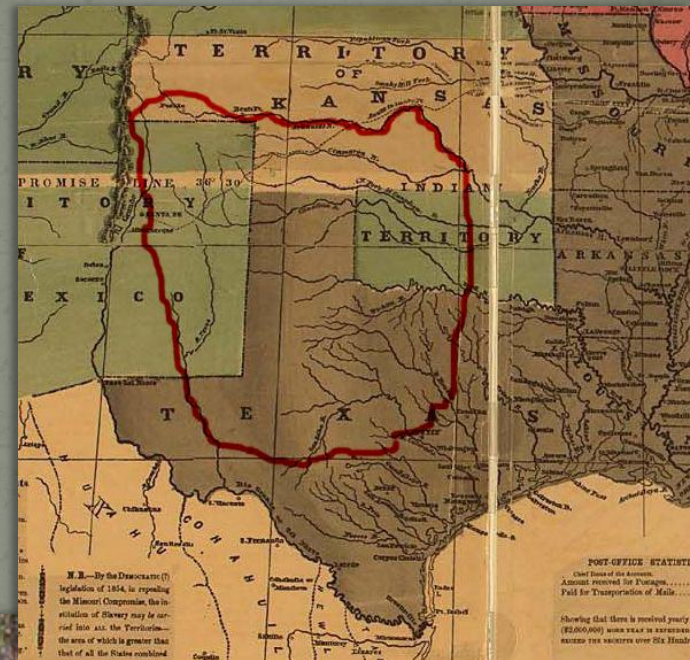
- **Steep, unstable banks upstream**
- **Deep gorges downstream**
- **Flash floods**



Barrier to Westward Expansion

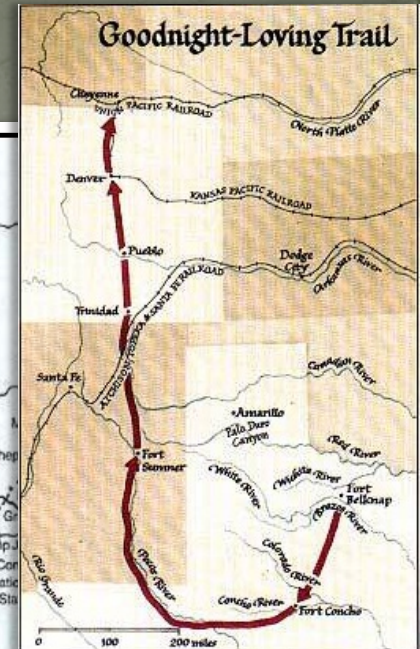
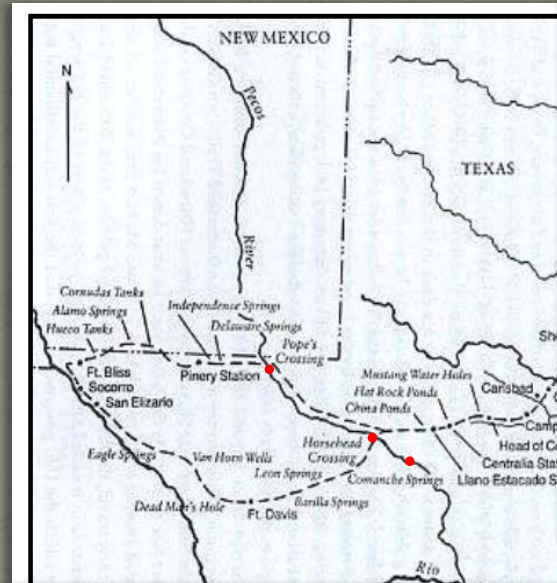
"The Graveyard of a Cowman's Hopes..." ~ C. Goodnight

- **Treacherous crossings**
 - Flash floods
 - Steep, unstable banks upstream
 - Deep gorges downstream
- **Comanche territory**
- **Lack of fresh water**
 - High salinity water
 - Alkaline pools
 - Artesian springs

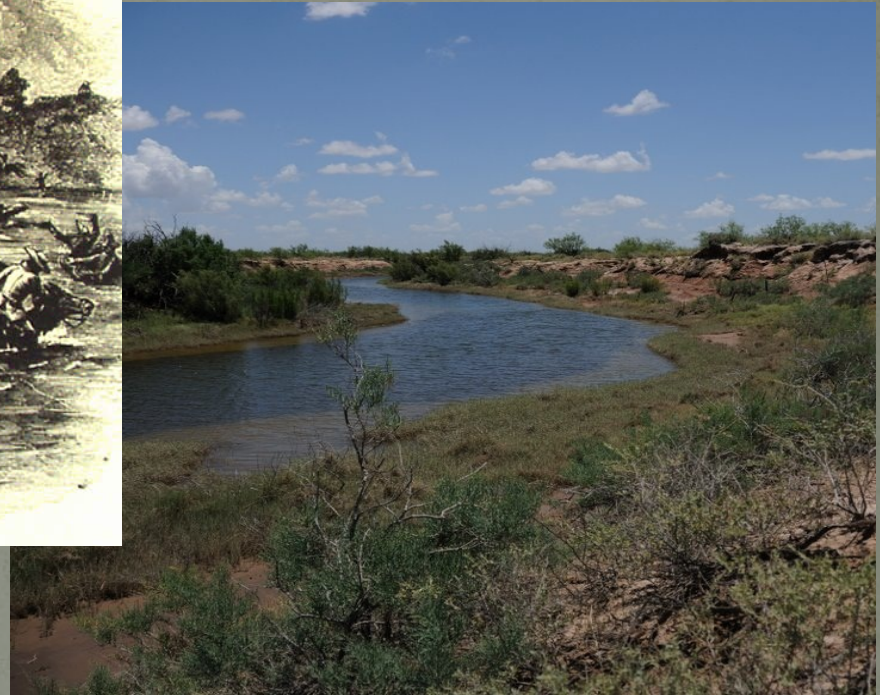


Crossing the Pecos River

- Early Spanish exploration
- Westward settler migration routes
- Goodnight-Loving Cattle Trail
- Butterfield Overland Stage Route
- Military crossings



Horsehead Crossing on the Pecos

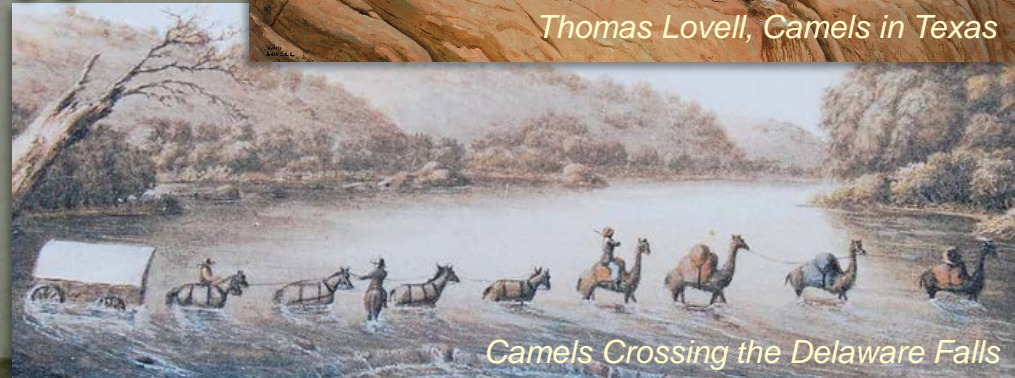
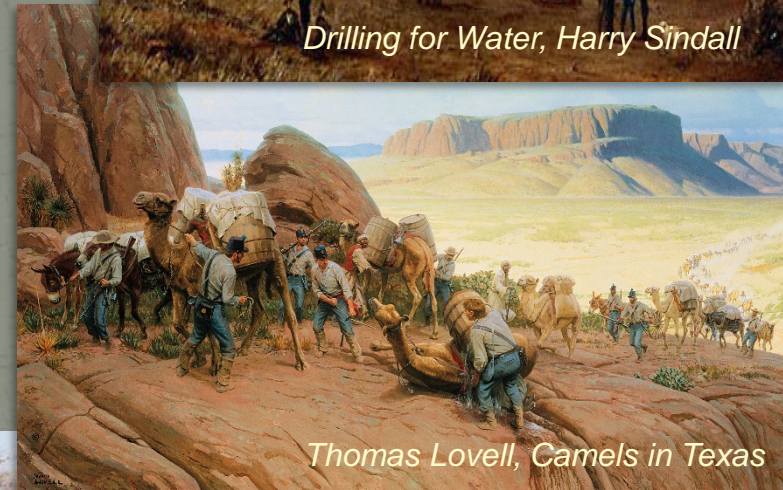
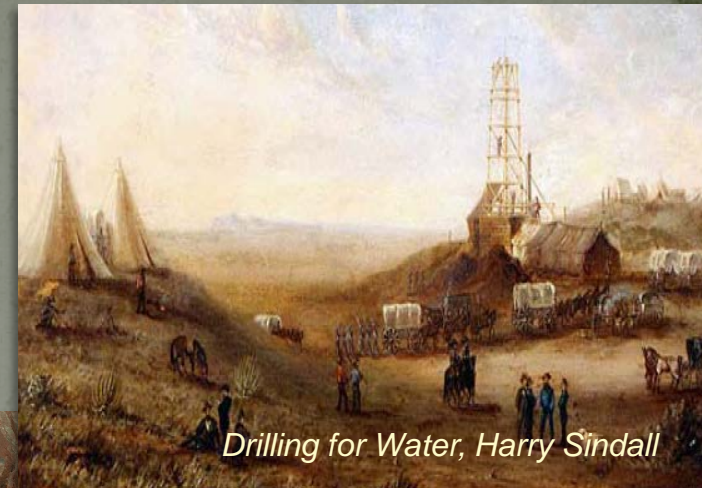


- Emigrants bound for California crossing at Horsehead Crossing, circa 1850

(Texasbeyondhistory.net)

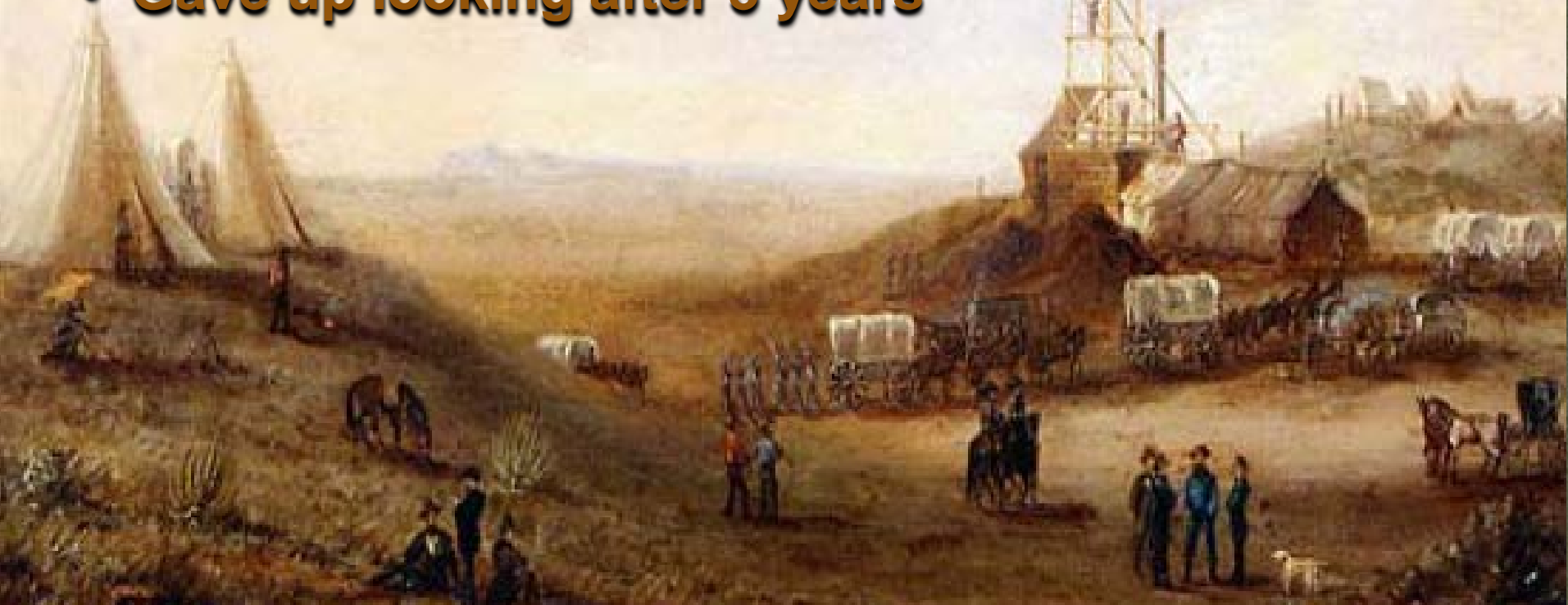
Searching for Fresh Water

- Looking for convenient routes west, river crossings and water sources
- Pope's expedition - 1854
- Echols' "Topographical engineers" expedition - 1859
- Surveyed and documented hydrographical features
- Camel Corps

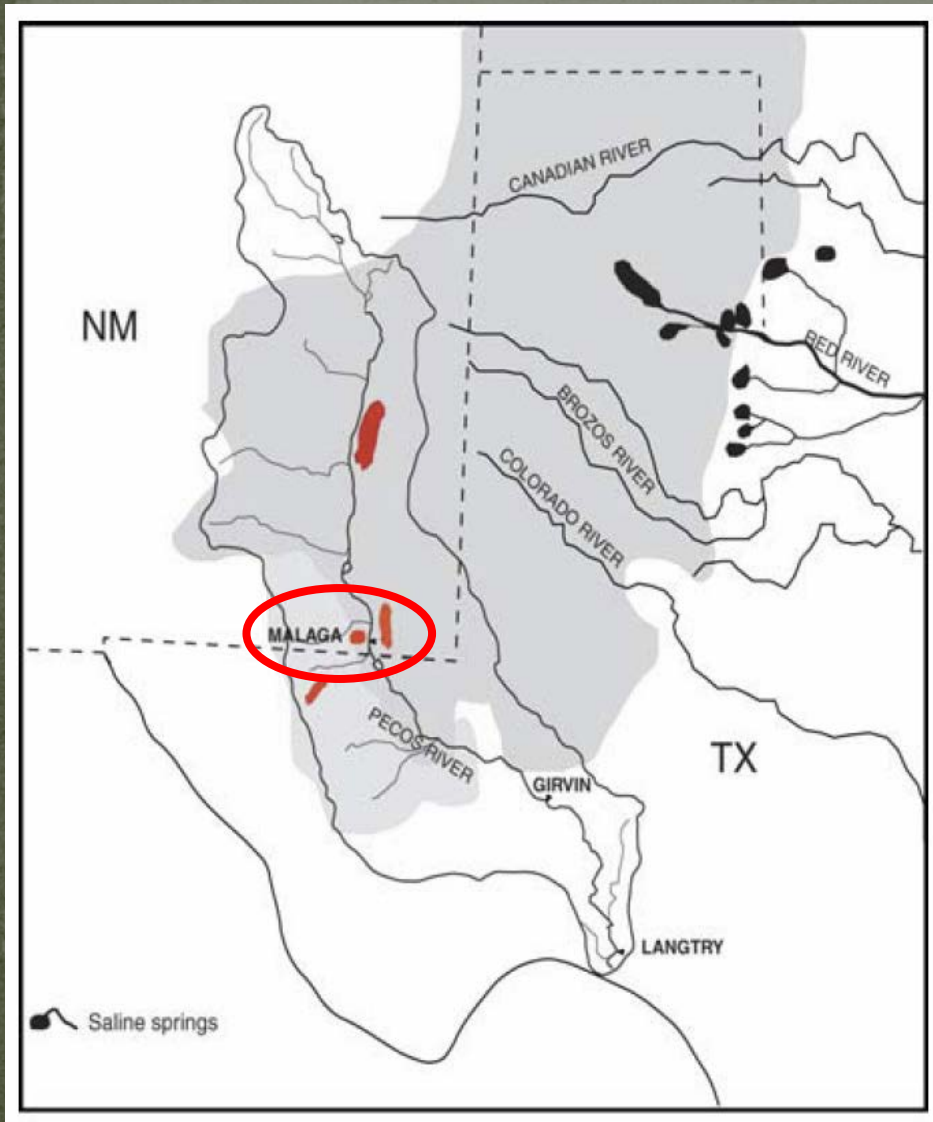


Captain John Pope's Expedition

- Captain John Pope's Expedition – 1854-1857
- Pope's Crossing on the Pecos River
- Artesian well drilling site
- Gave up looking after 3 years



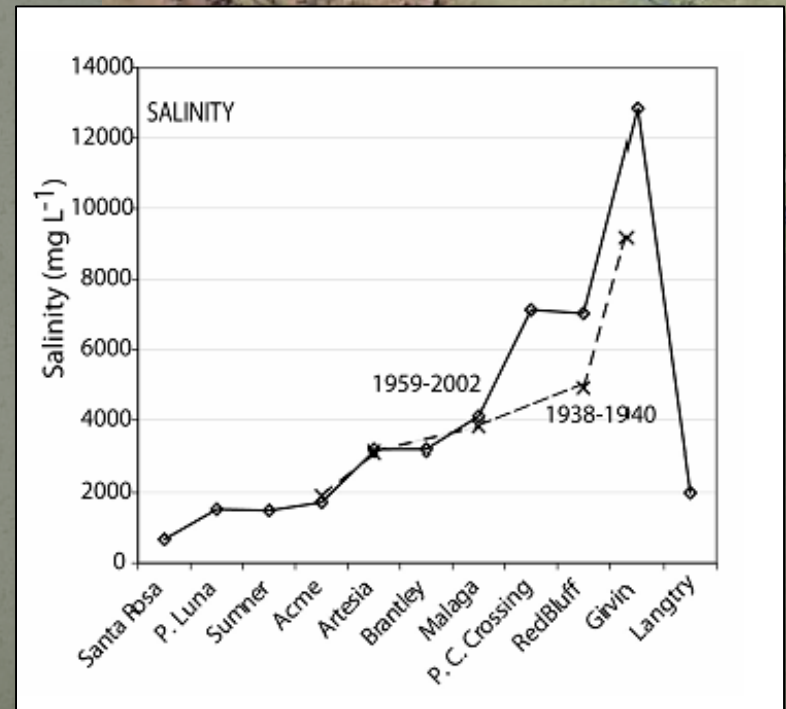
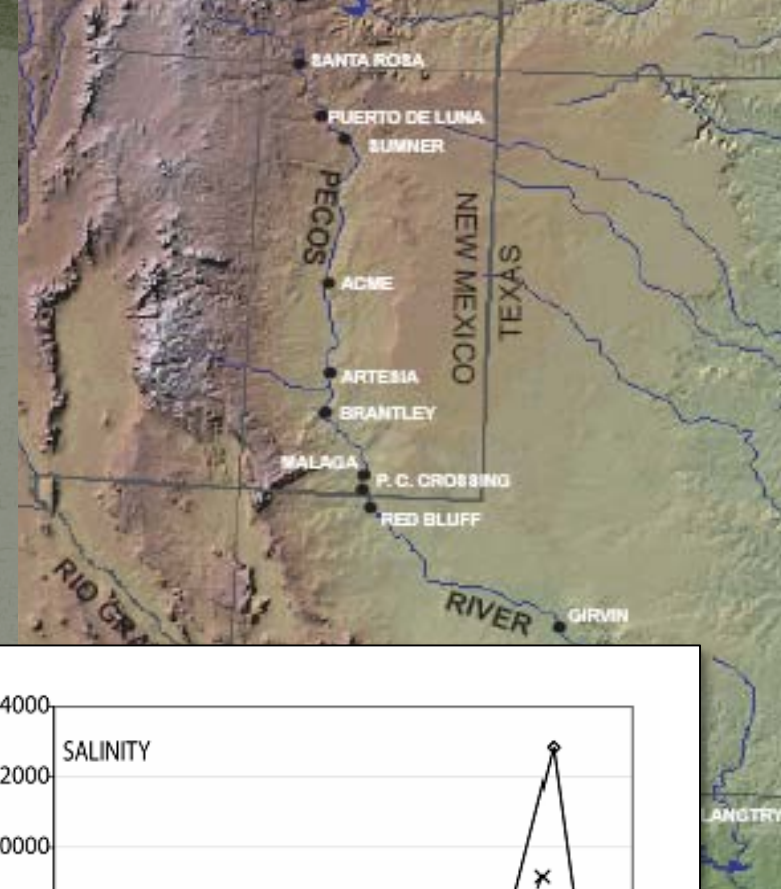
Salinity Causes



- Permian period shallow sea - 245 million years ago
- Sea advanced/ retreated forming evaporite deposits
- Groundwater dissolution => collapsed sinkholes
- Created salt springs and seeps

Salinity Sources

- Groundwater discharge/seeps
- Bottomless Lakes
 - ~300,000 tons per year
- Malaga Bend springs
 - ~150,000 tons per year
 - Salinity = ~4,100 ppm
- Old flowing wells
- Lower flows in river
- Flows at Malaga Bend
 - 210,000 acre-feet in 1959
 - 66,000 acre-feet in 2001



from Miyamoto & others (2008)

Locating the sources of salinity

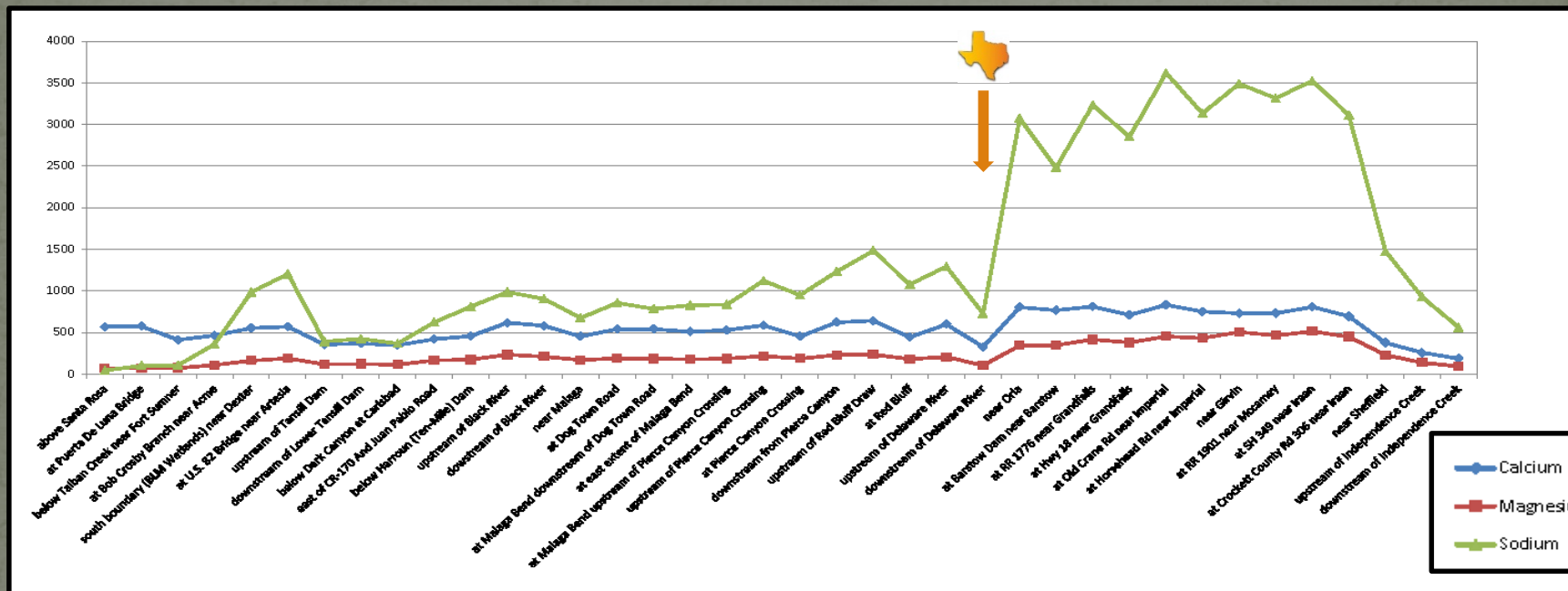
- Review the literature
- Look at the historical geochemistry data
- Sampling



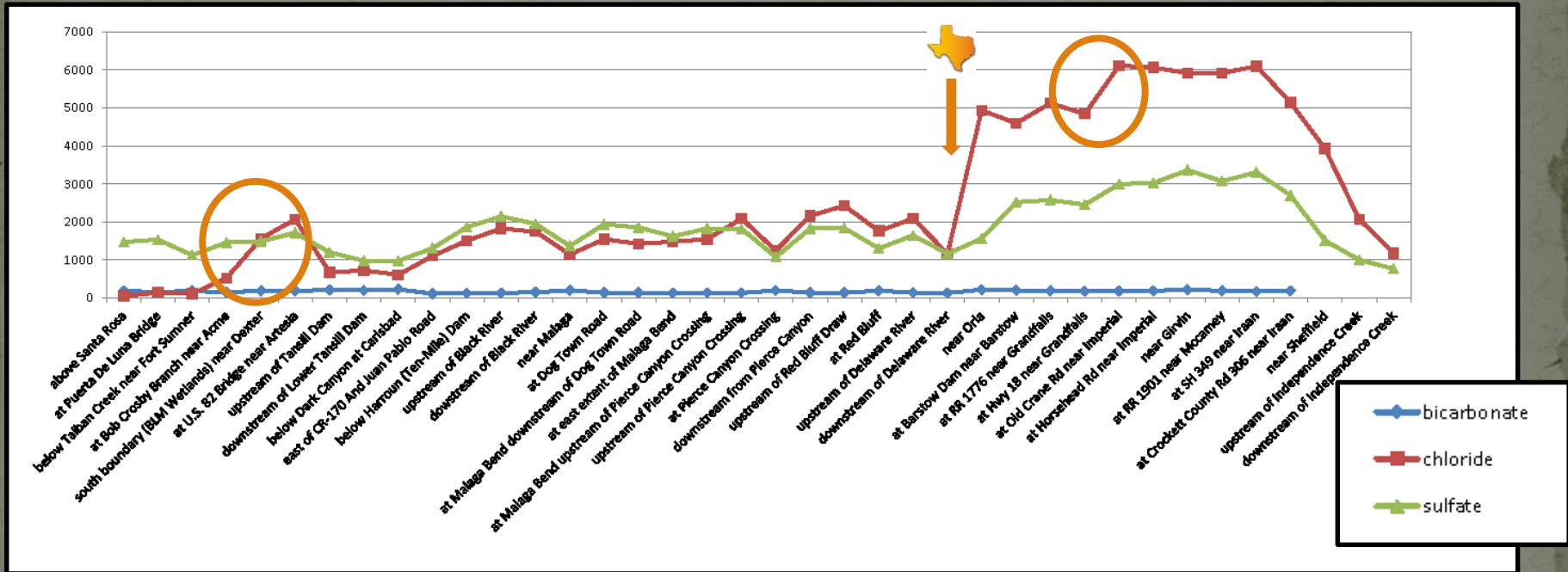
Pecos River Basin



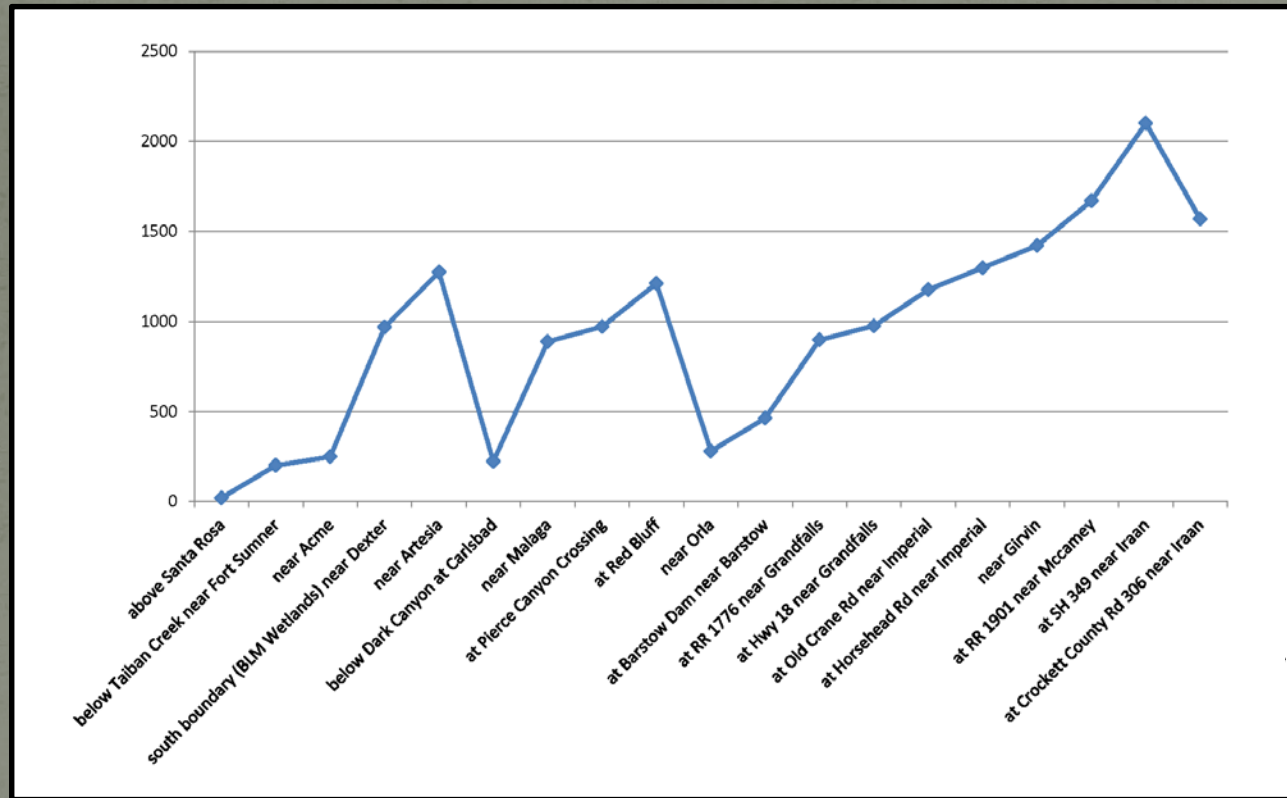
Pecos River Basin – Major Ions – Cations



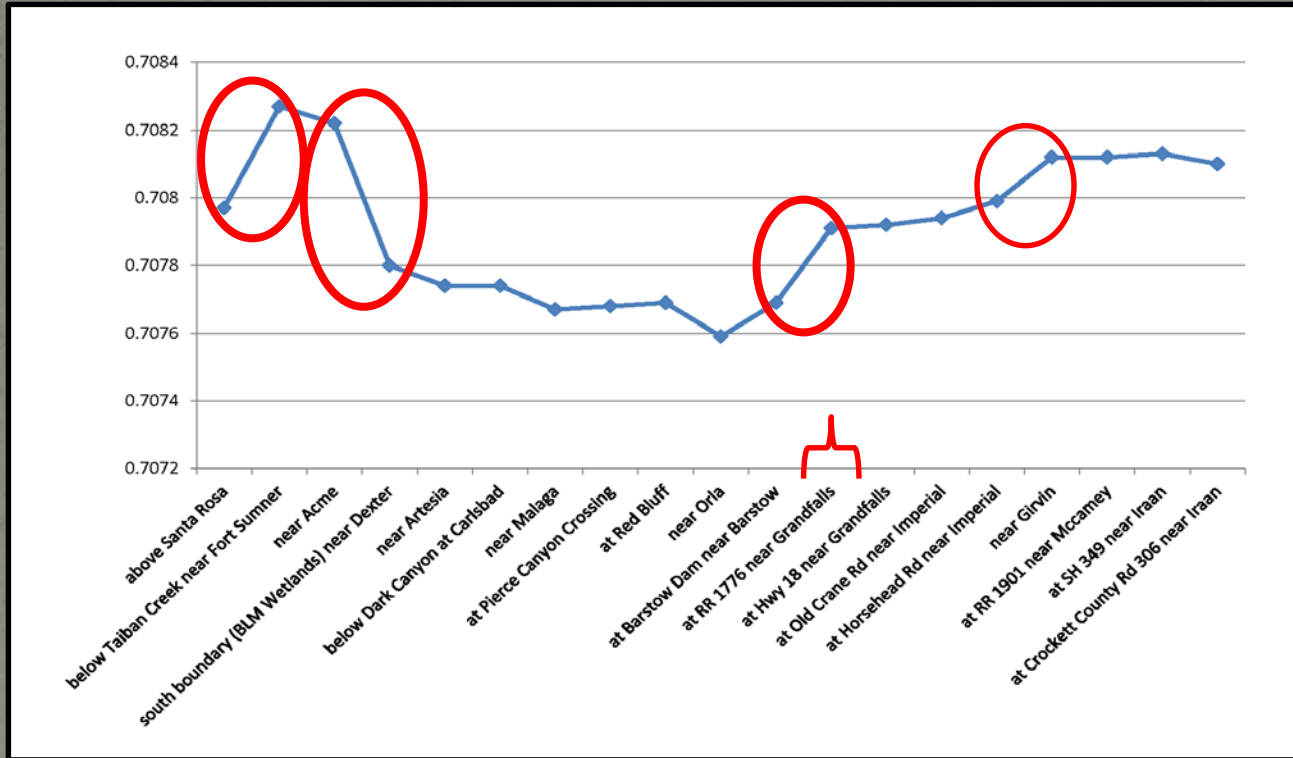
Pecos River Basin – Major Ions – Anions



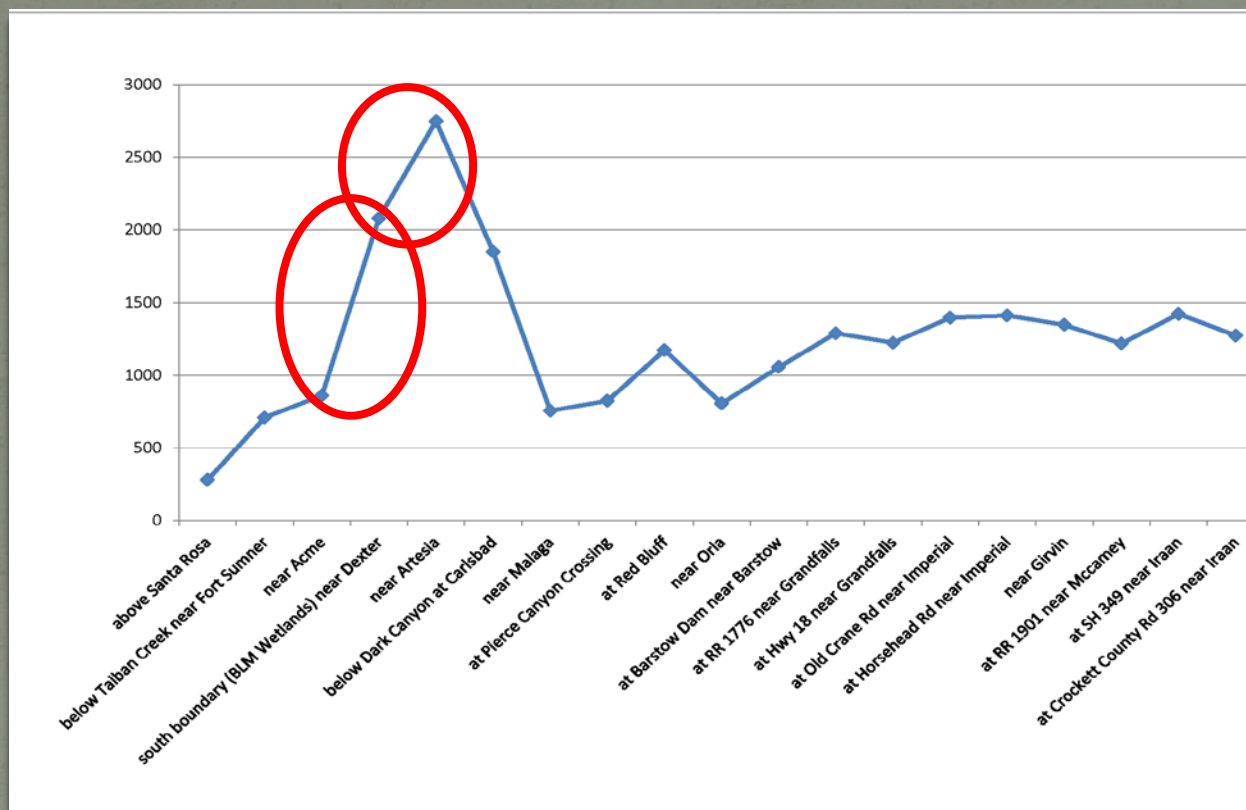
Instantaneous Load – in tons/day



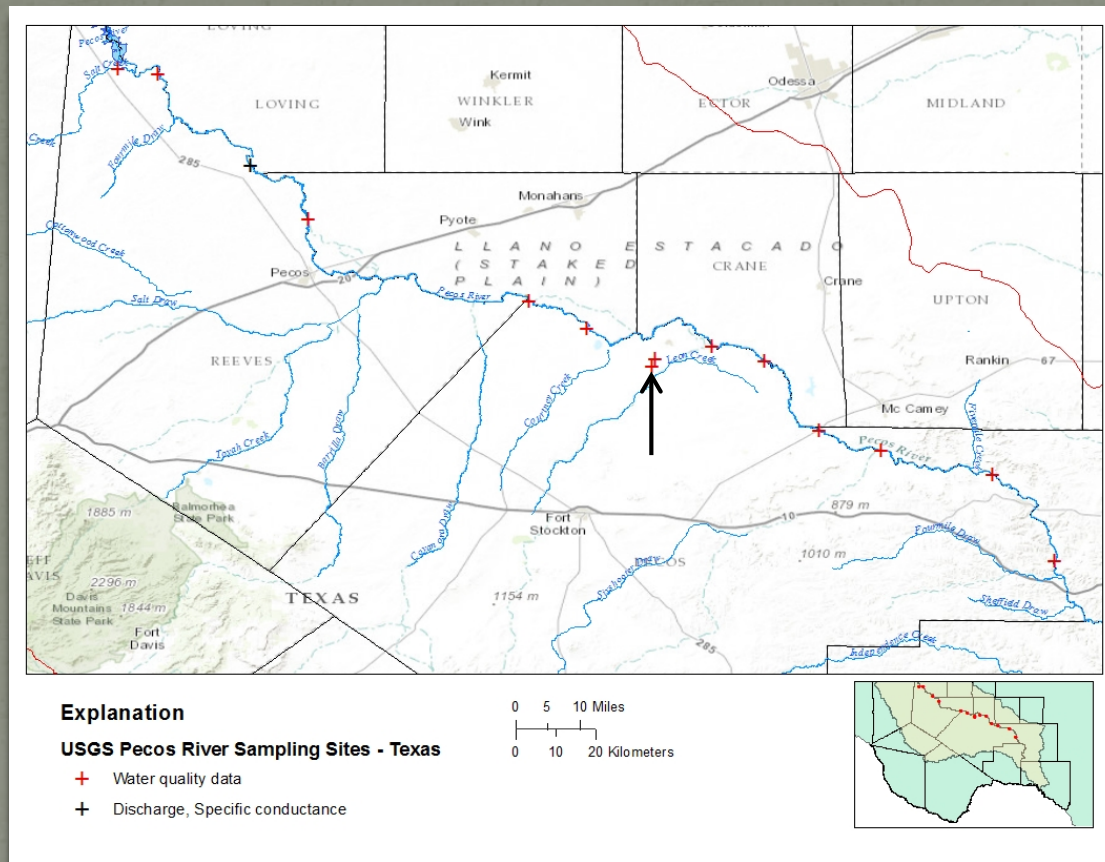
Sr 87/86 along the Pecos River



Cl/Br ratios along the Pecos River



Location of Sites sampled in Texas in February 2015



One of the Texas sampling sites



Well SE of RR 1053 near Imperial, TX



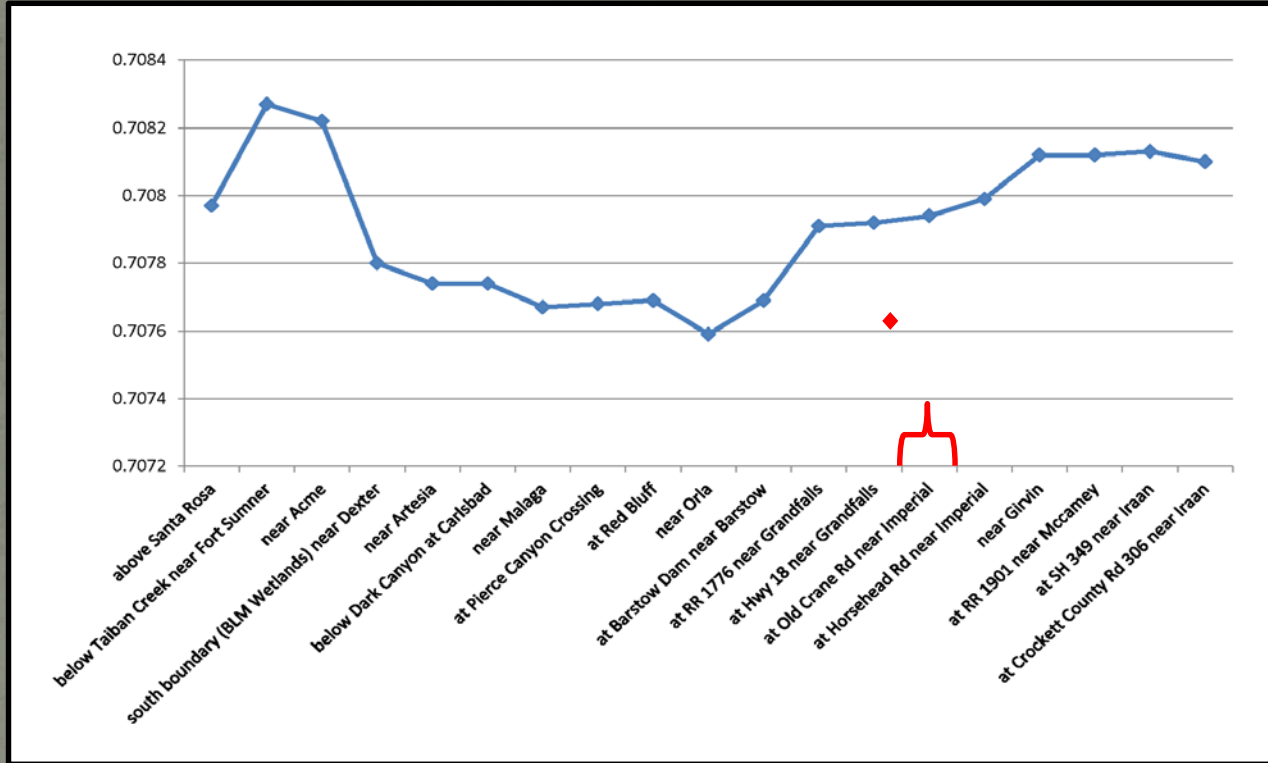
Flowing since 1950's – Very Saline



At well head – ready to sample

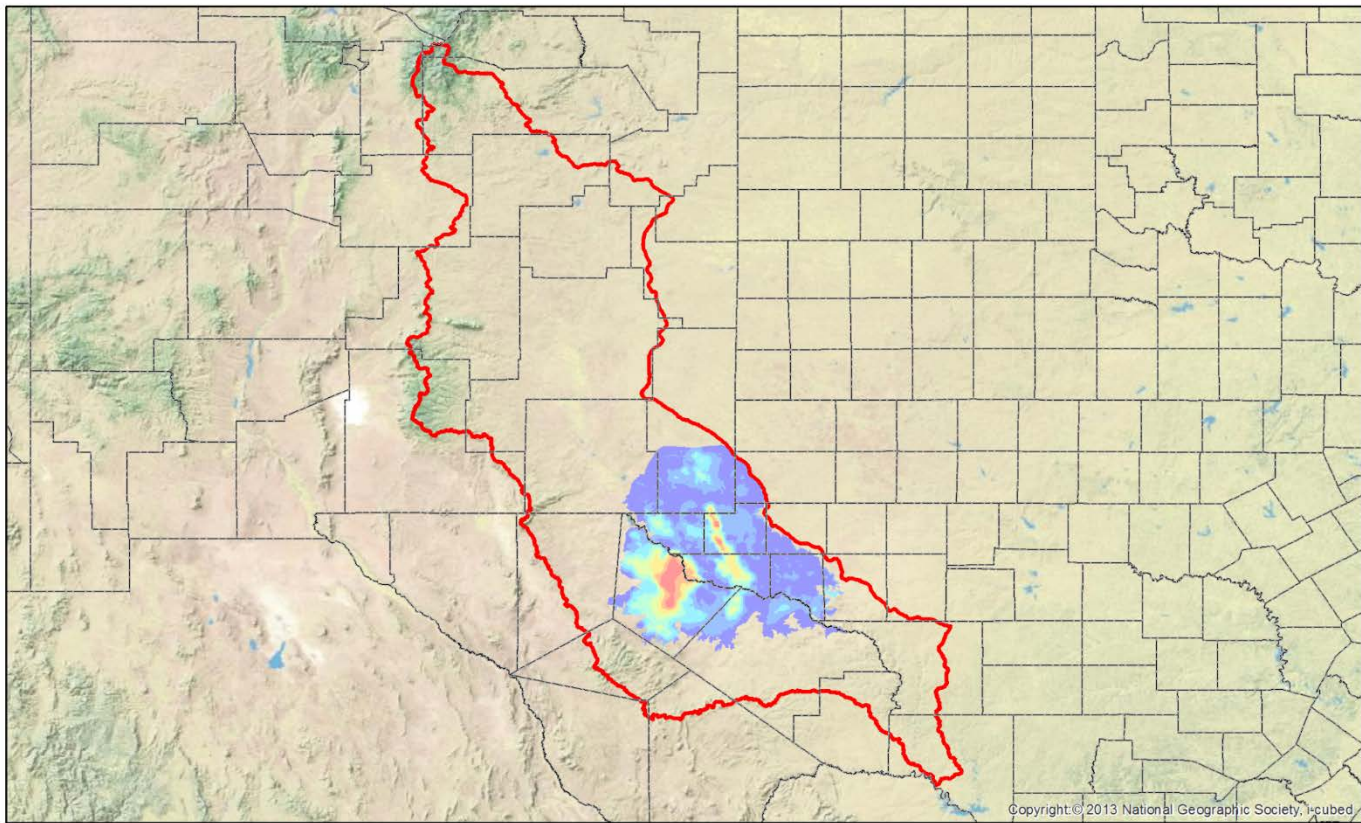


Sr 87/86 along the Pecos River





Other Tools

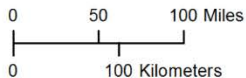
- Developed structure of the basin (regional scale)
- Compiled geospatial locations of areas of Interest and attribute information (for example interval of injection, depth of well) including but not limited to
 - Salt water disposal wells
 - springs, seeps, and sinkholes
- Developed a Web Map Viewer for display of compiled data



EXPLANATION

Depth to the Pecos Valley Alluvium, in feet below land surface

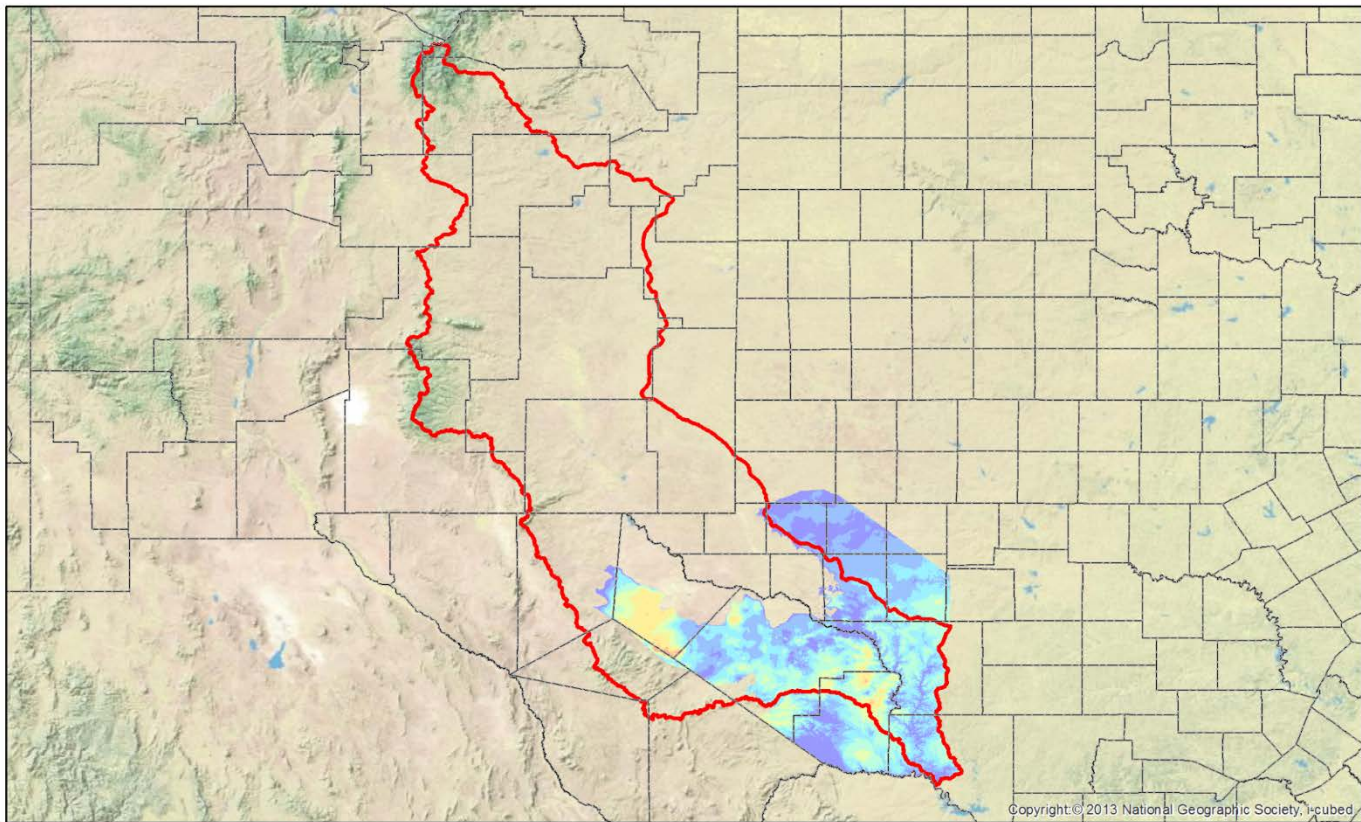
- | | | | |
|-------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------|--------------------------|
|  | 66 to less than 132 |  | 605 to less than 809 |
|  | 132 to less than 257 |  | 809 to less than 1,032 |
|  | 257 to less than 421 |  | 1,032 to less than 1,282 |
|  | 421 to less than 605 |  | 1,282 to 1,740 |
|  | Pecos River Basin boundary | | |



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





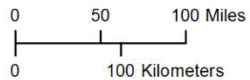
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EXPLANATION

Depth to the base of the Cretaceous units, in feet below land surface

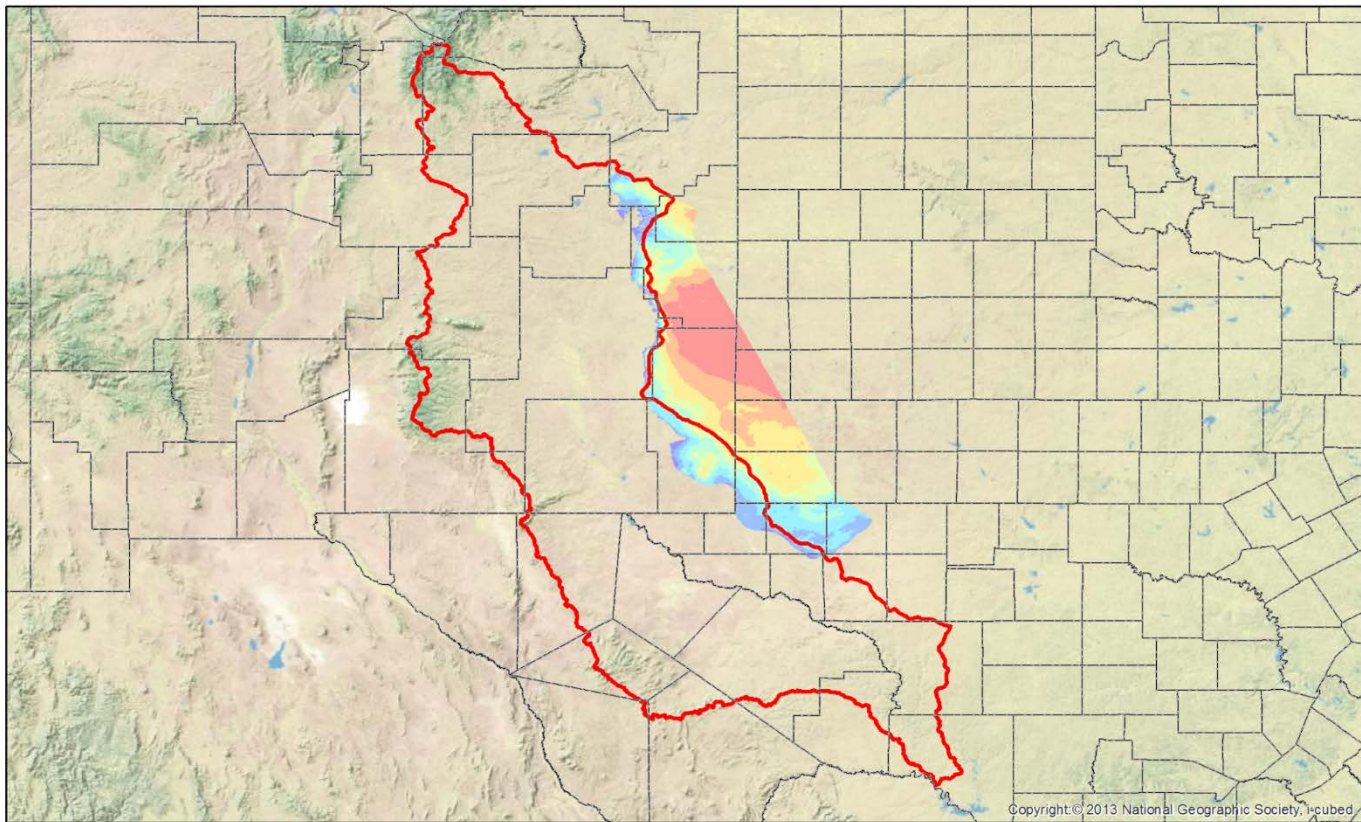
- | | |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
|  3 to less than 203 |  757 to less than 1,050 |
|  203 to less than 360 |  1,050 to less than 1,426 |
|  360 to less than 527 |  1,426 to less than 1,928 |
|  527 to less than 757 |  1,928 to 2,669 |
|  Pecos River Basin boundary | |



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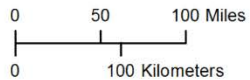
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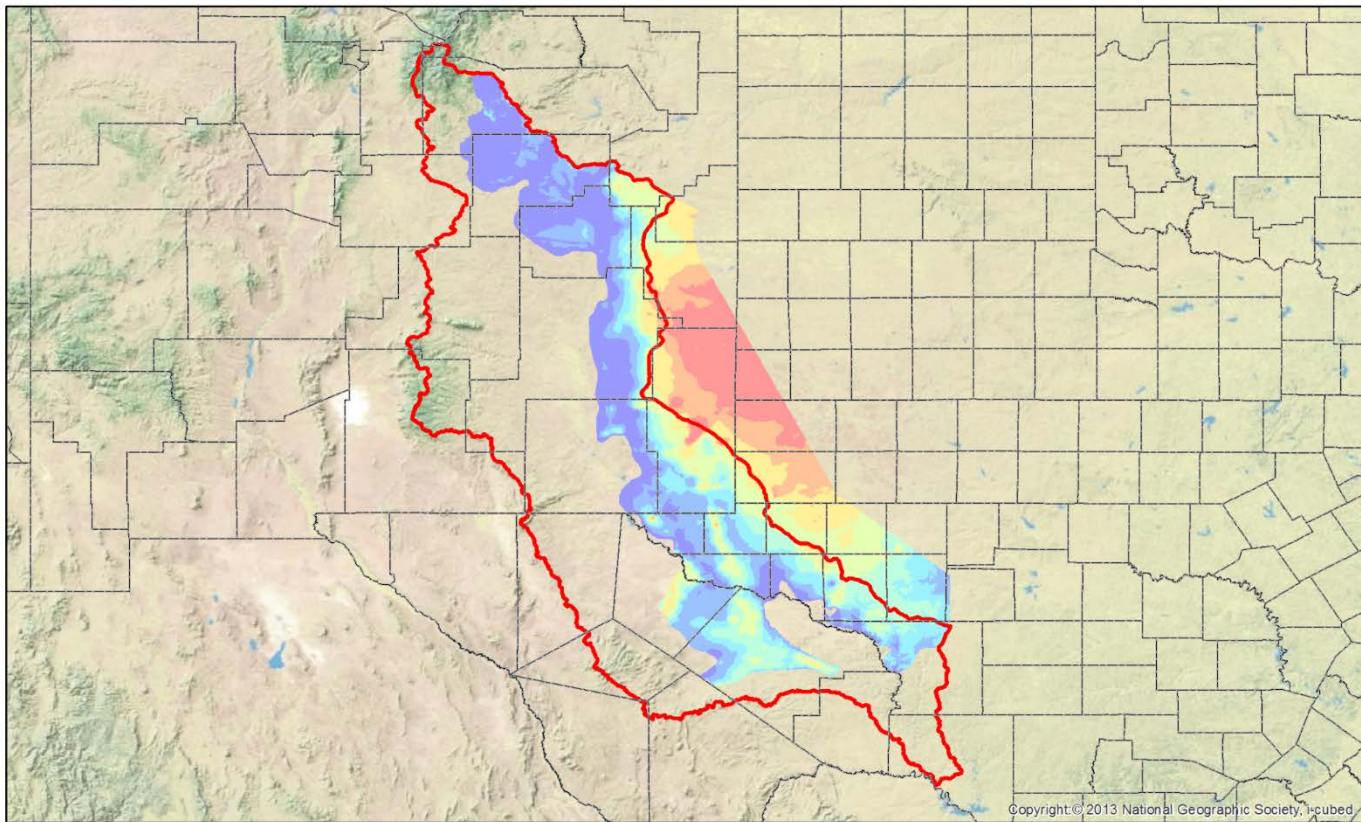
EXPLANATION

Depth to the base of the Upper Dockum Group, in feet below land surface

- | | |
|----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
|  27 to less than 116 |  520 to less than 634 |
|  116 to less than 257 |  634 to less than 776 |
|  257 to less than 392 |  776 to less than 998 |
|  392 to less than 520 |  998 to 1,738 |
|  Pecos River Basin boundary | |



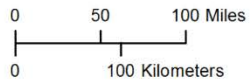
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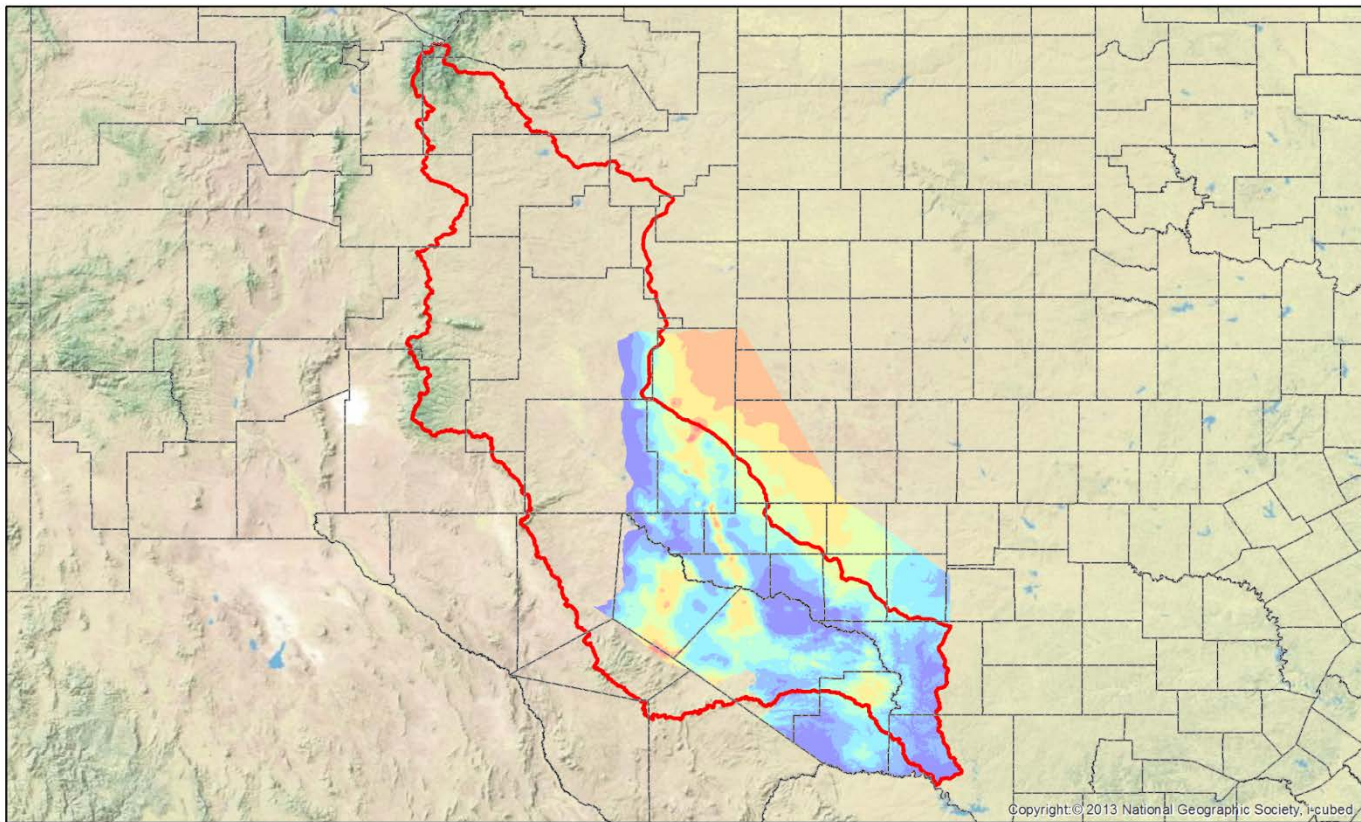
Depth to the base of the Lower Dockum Group, in feet below land surface

- | | |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
|  82 to less than 310 |  1,090 to less than 1,353 |
|  310 to less than 582 |  1,353 to less than 1,625 |
|  582 to less than 836 |  1,625 to less than 1,933 |
|  836 to less than 1,090 |  1,933 to 2,394 |
|  Pecos River Basin boundary | |







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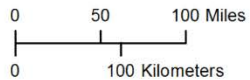




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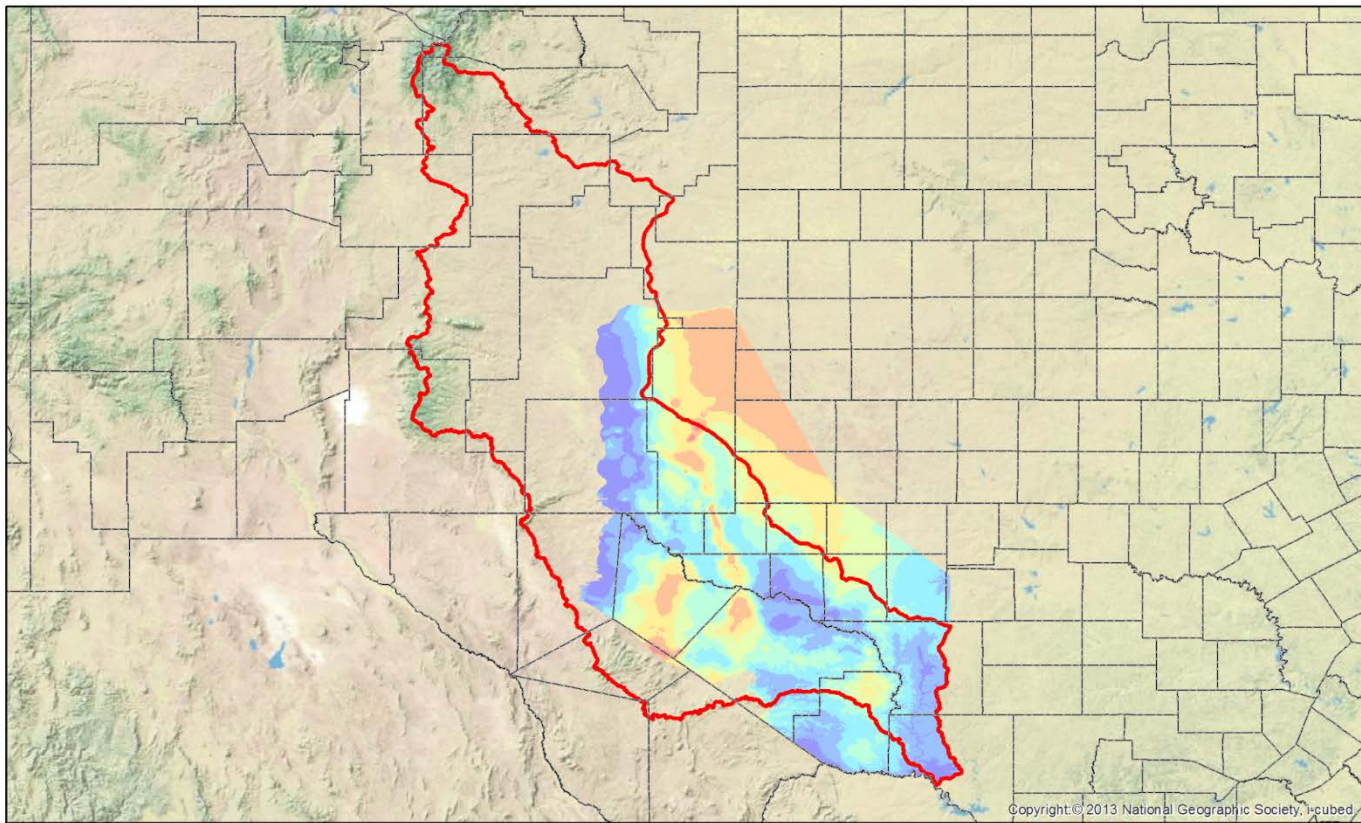
Depth to the base of the Dewey Lake Formation, in feet below land surface

- | | | | |
|-------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------|--------------------------|
|  | 103 to less than 566 |  | 1,450 to less than 1,740 |
|  | 566 to less than 882 |  | 1,740 to less than 2,043 |
|  | 882 to less than 1,159 |  | 2,043 to less than 2,544 |
|  | 1,159 to less than 1,450 |  | 2,545 to 3,467 |
|  | Pecos River Basin boundary | | |












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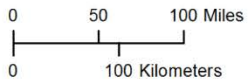




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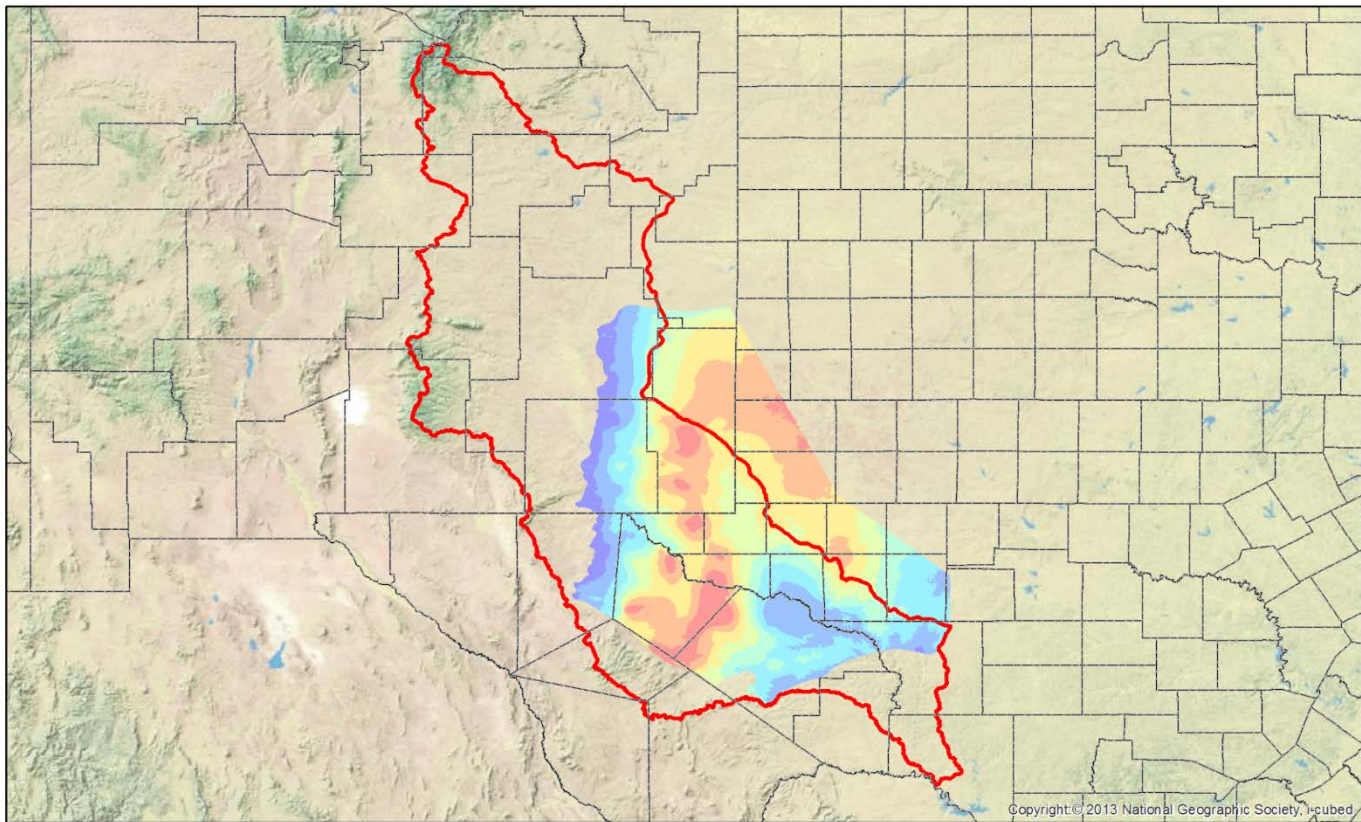
Depth to the base of the Rustler, in feet below land surface

- | | | | |
|-------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------|--------------------------|
|  | 33 to less than 544 |  | 1,549 to less than 1,849 |
|  | 544 to less than 919 |  | 1,849 to less than 2,164 |
|  | 919 to less than 1,249 |  | 2,164 to less than 2,705 |
|  | 1,249 to less than 1,549 |  | 2,705 to 3,844 |
|  | Pecos River Basin boundary | | |



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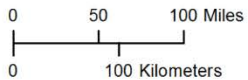




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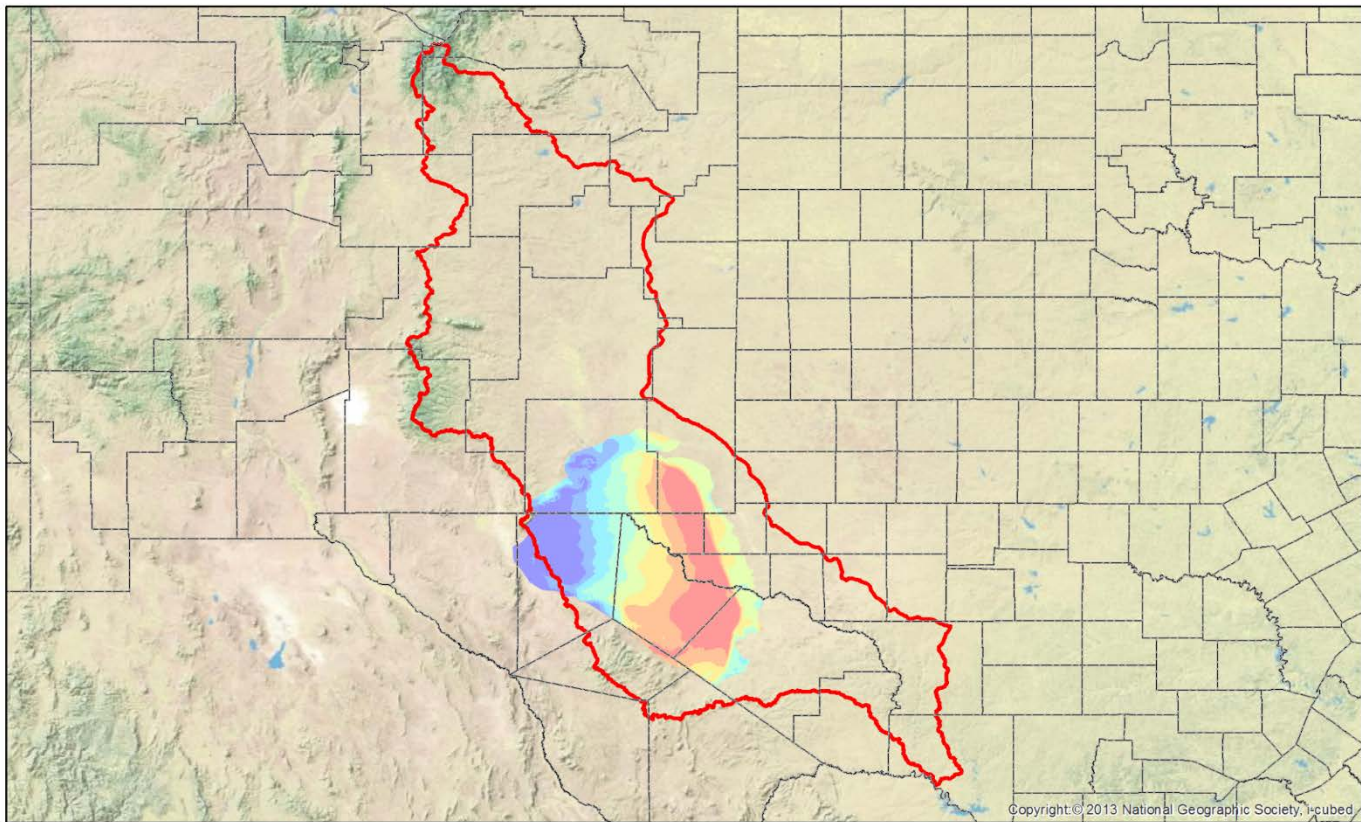
Depth to the base of the Salado Formation, in feet below land surface

- | | |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
|  66 to less than 705 |  2,225 to less than 2,620 |
|  705 to less than 1,287 |  2,620 to less than 2,939 |
|  1,287 to less than 1,775 |  2,939 to less than 3,295 |
|  1,775 to less than 2,225 |  3,295 to 4,852 |
|  Pecos River Basin boundary | |




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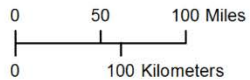




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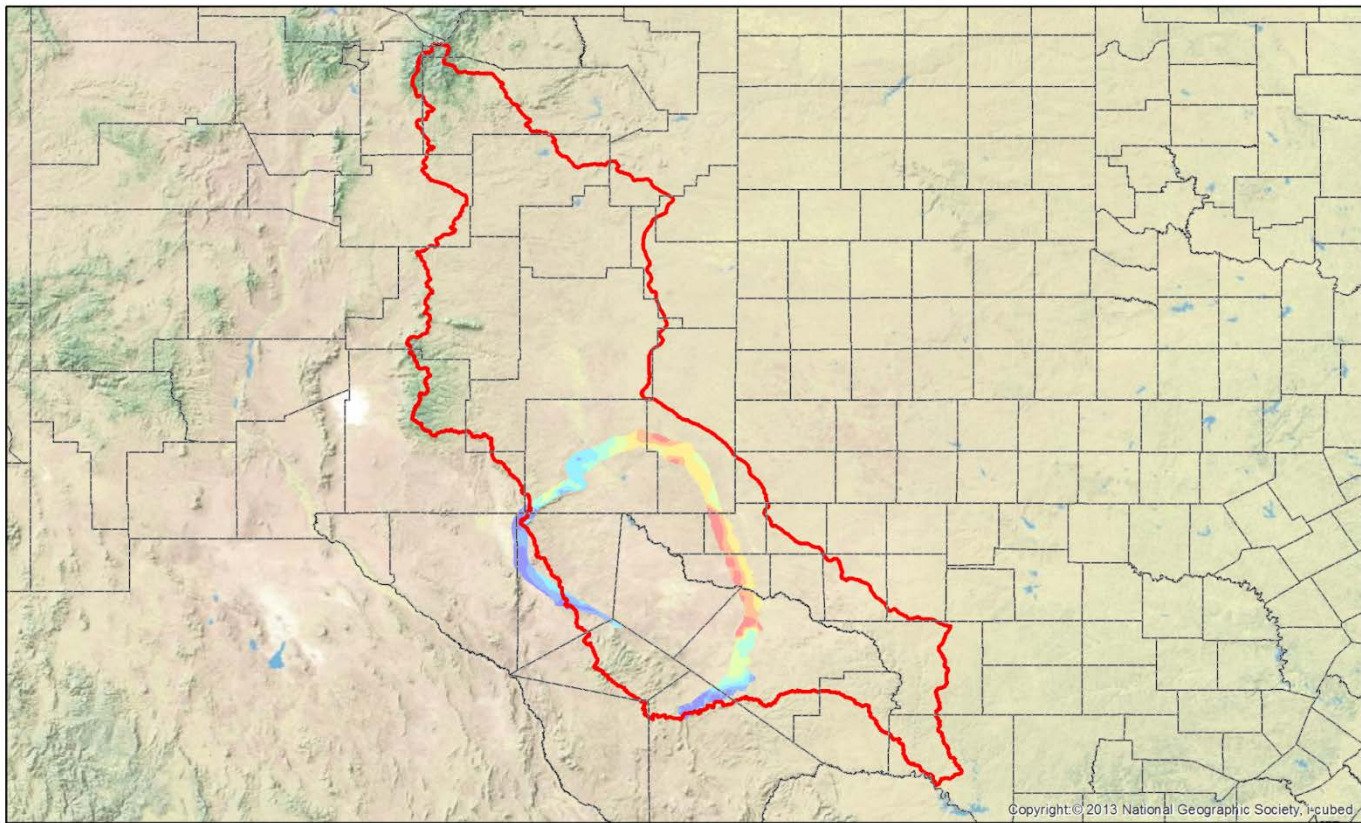
Depth to the base of the Castile Formation, in feet below land surface

- | | |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
|  70 to less than 840 |  2,989 to less than 3,644 |
|  840 to less than 1,586 |  3,644 to less than 4,232 |
|  1,586 to less than 2,310 |  4,232 to less than 4,775 |
|  2,310 to less than 2,989 |  4,775 to 5,837 |
|  Pecos River Basin boundary | |











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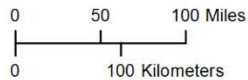




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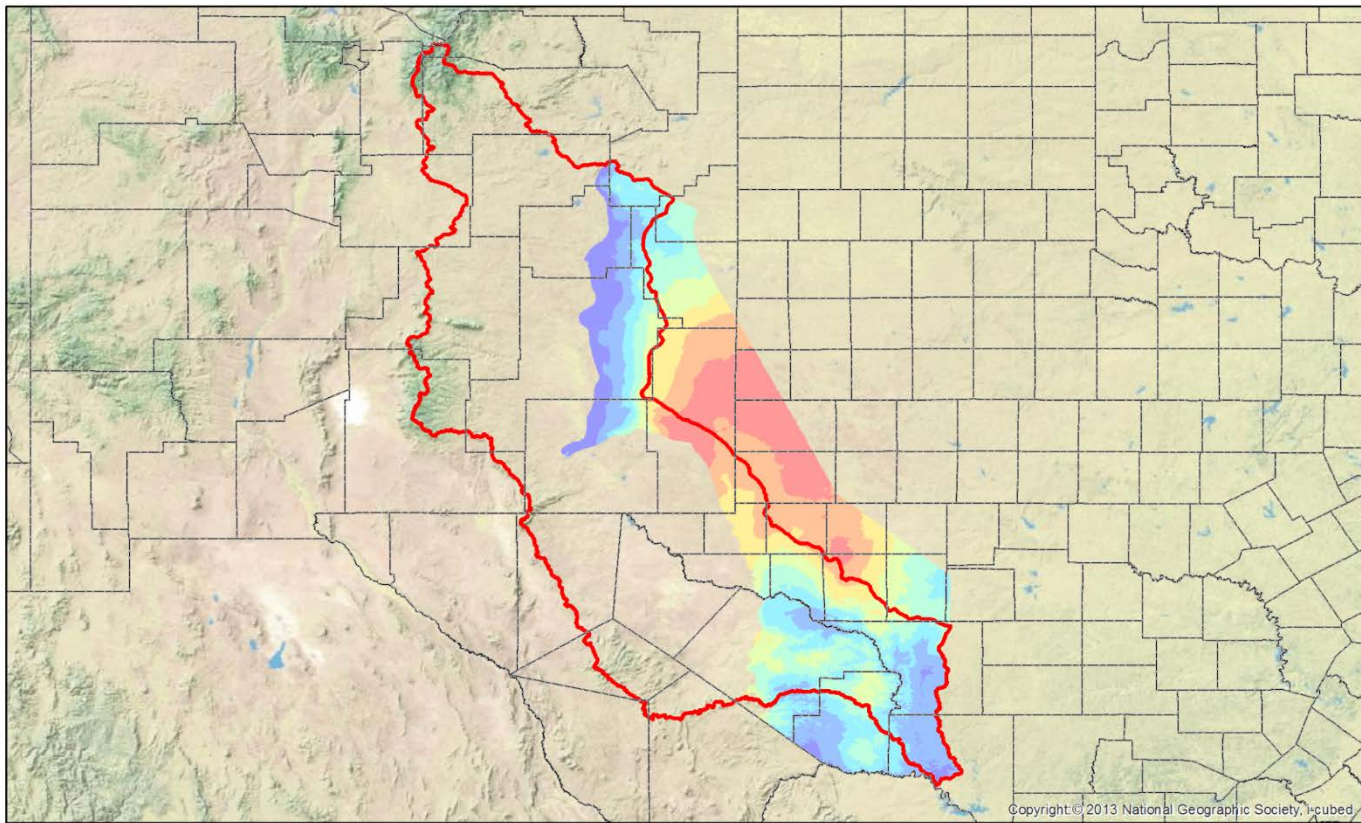
Depth to the base of the Capitan Reef, in feet below land surface

- | | | | |
|-------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------|--------------------------|
|  | 35 to less than 833 |  | 2,794 to less than 3,483 |
|  | 833 to less than 1,372 |  | 3,483 to less than 4,086 |
|  | 1,372 to less than 2,061 |  | 4,086 to less than 4,647 |
|  | 2,061 to less than 2,794 |  | 4,647 to 5,529 |
|  | Pecos River Basin boundary | | |





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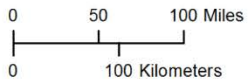




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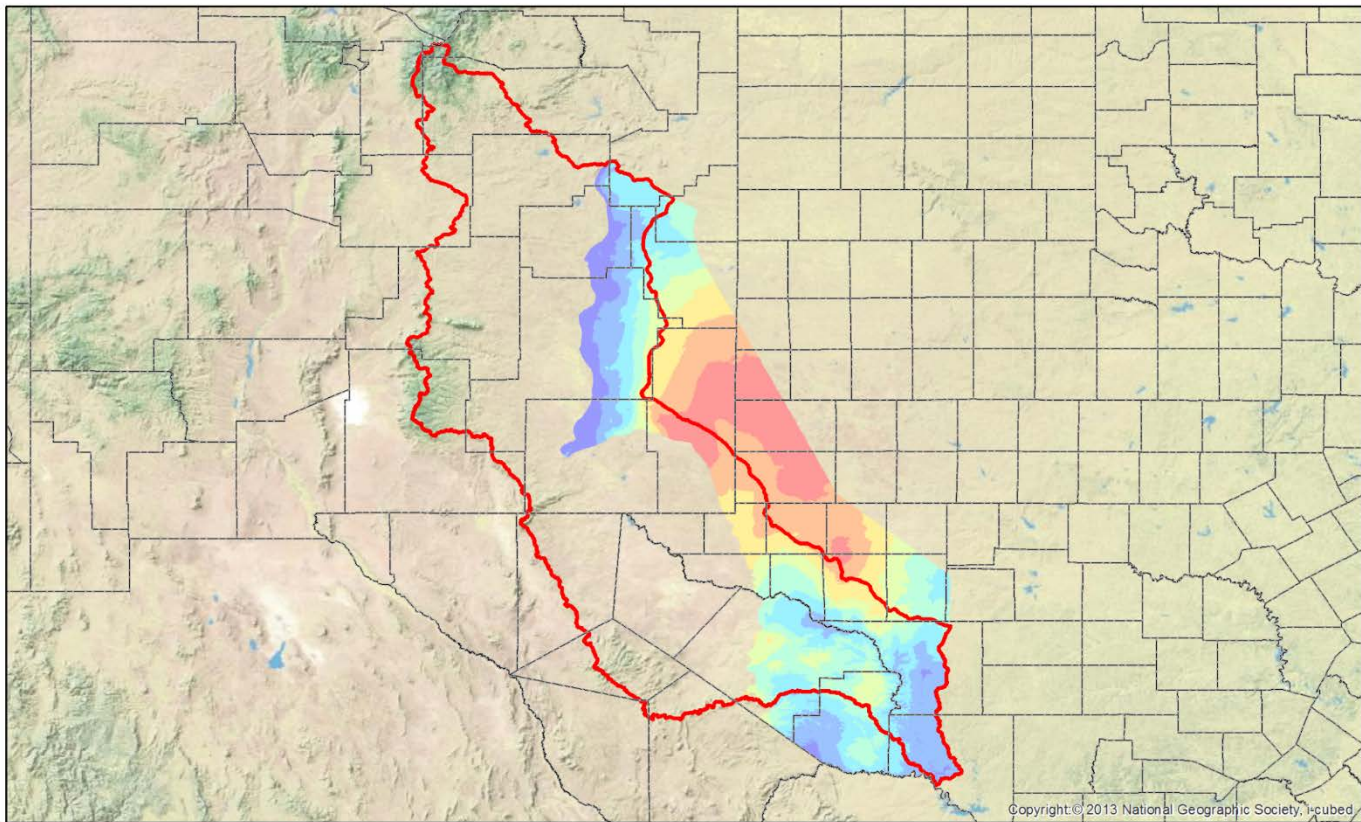
Depth to the base of the Tansill Formation, in feet below land surface

- | | | | |
|-------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------|--------------------------|
|  | 33 to less than 539 |  | 1,788 to less than 2,234 |
|  | 539 to less than 1,030 |  | 2,234 to less than 2,664 |
|  | 1,030 to less than 1,401 |  | 2,664 to less than 3,036 |
|  | 1,401 to less than 1,788 |  | 3,036 to 3,808 |
|  | Pecos River Basin boundary | | |












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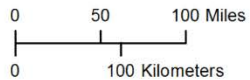




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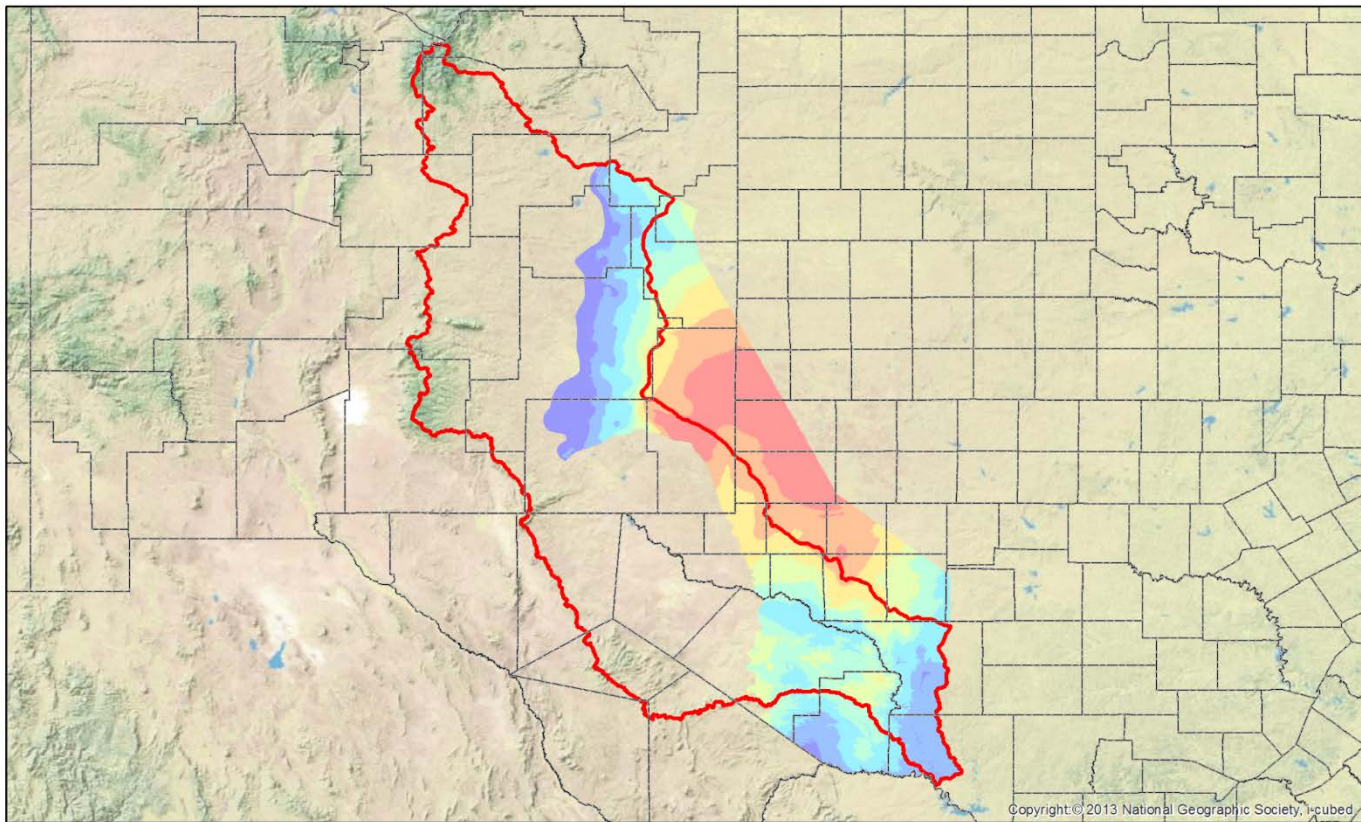
Depth to the base of the Yates Formation, in feet below land surface

- | | | | |
|-------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------|--------------------------|
|  | 35 to less than 571 |  | 1,914 to less than 2,372 |
|  | 571 to less than 1,093 |  | 2,372 to less than 2,831 |
|  | 1,093 to less than 1,503 |  | 2,831 to less than 3,226 |
|  | 1,503 to less than 1,914 |  | 3,226 to 4,062 |
|  | Pecos River Basin boundary | | |









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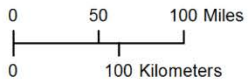




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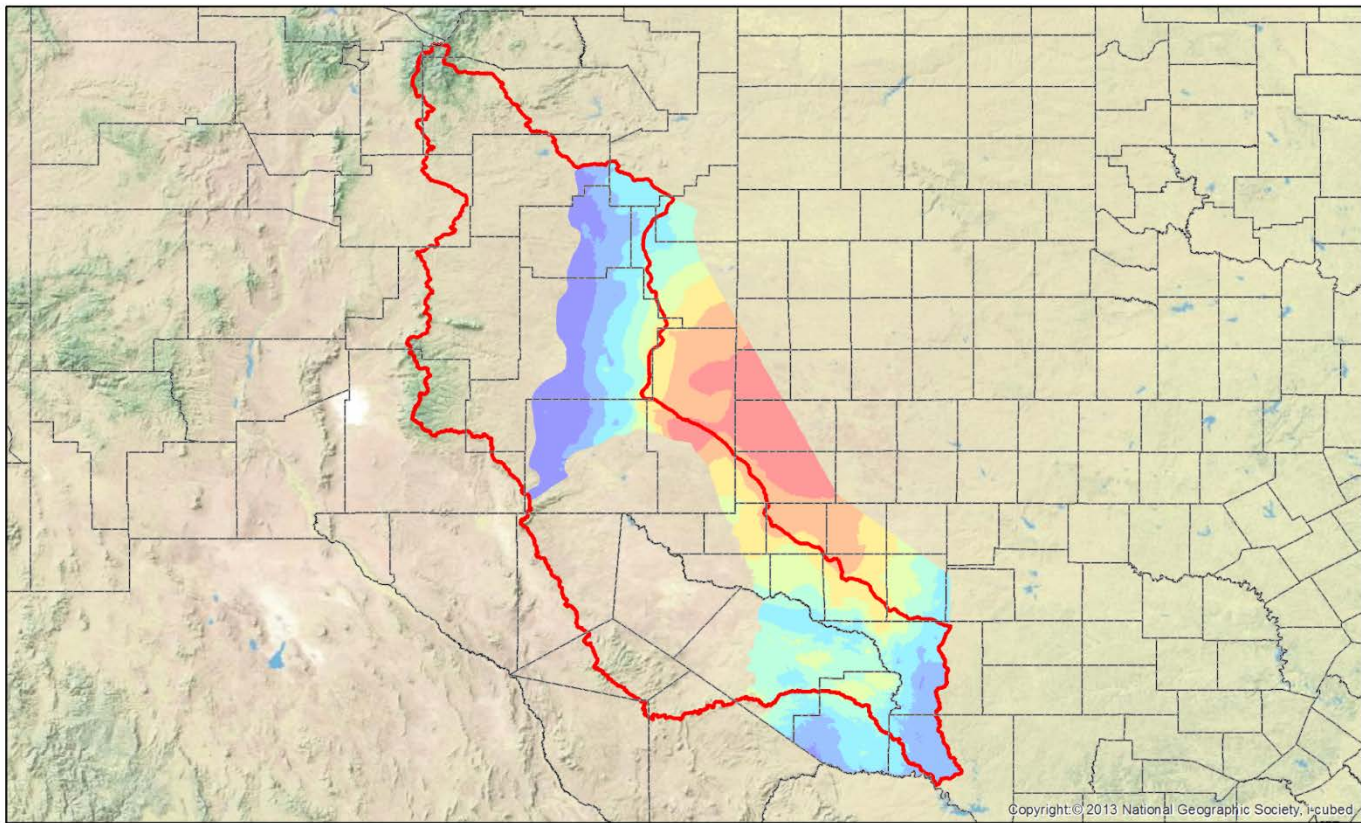
Depth to the base of the Seven Rivers Formation, in feet below land surface

- | | |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
|  33 to less than 637 |  2,228 to less than 2,722 |
|  637 to less than 1,241 |  2,722 to less than 3,216 |
|  1,241 to less than 1,771 |  3,216 to less than 3,673 |
|  1,771 to less than 2,228 |  3,673 to 4,697 |
|  Pecos River Basin boundary | |








DRAFT DOCUMENT

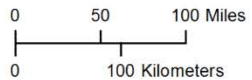




EXPLANATION

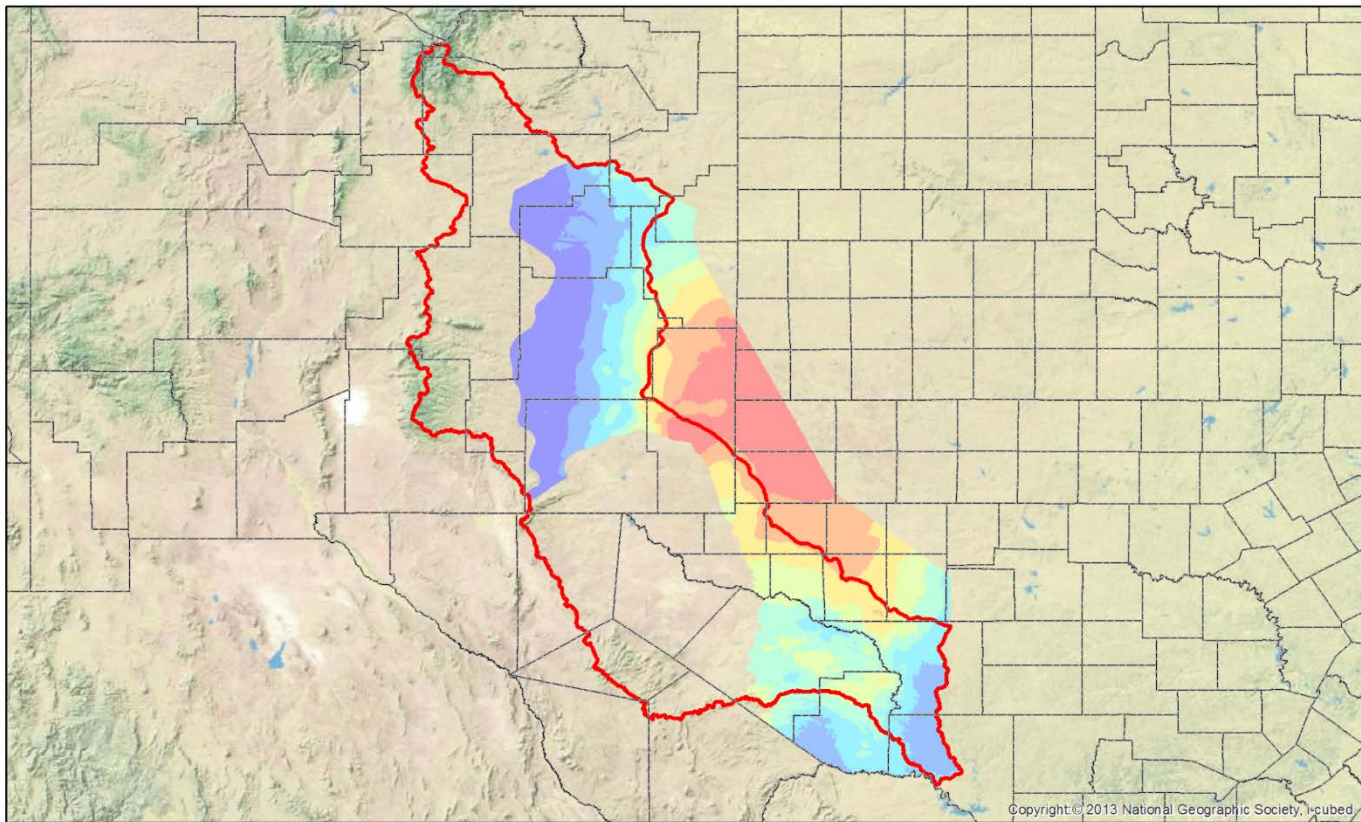
Depth to the base of the Queen Formation, in feet below land surface

- | | | | |
|-------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------|--------------------------|
|  | 33 to less than 708 |  | 2,613 to less than 3,169 |
|  | 708 to less than 1,423 |  | 3,169 to less than 3,725 |
|  | 1,423 to less than 2,058 |  | 3,725 to less than 4,241 |
|  | 2,058 to less than 2,613 |  | 4,241 to 5,093 |
|  | Pecos River Basin boundary | | |



DRAFT DOCUMENT












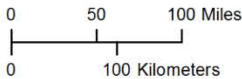


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EXPLANATION

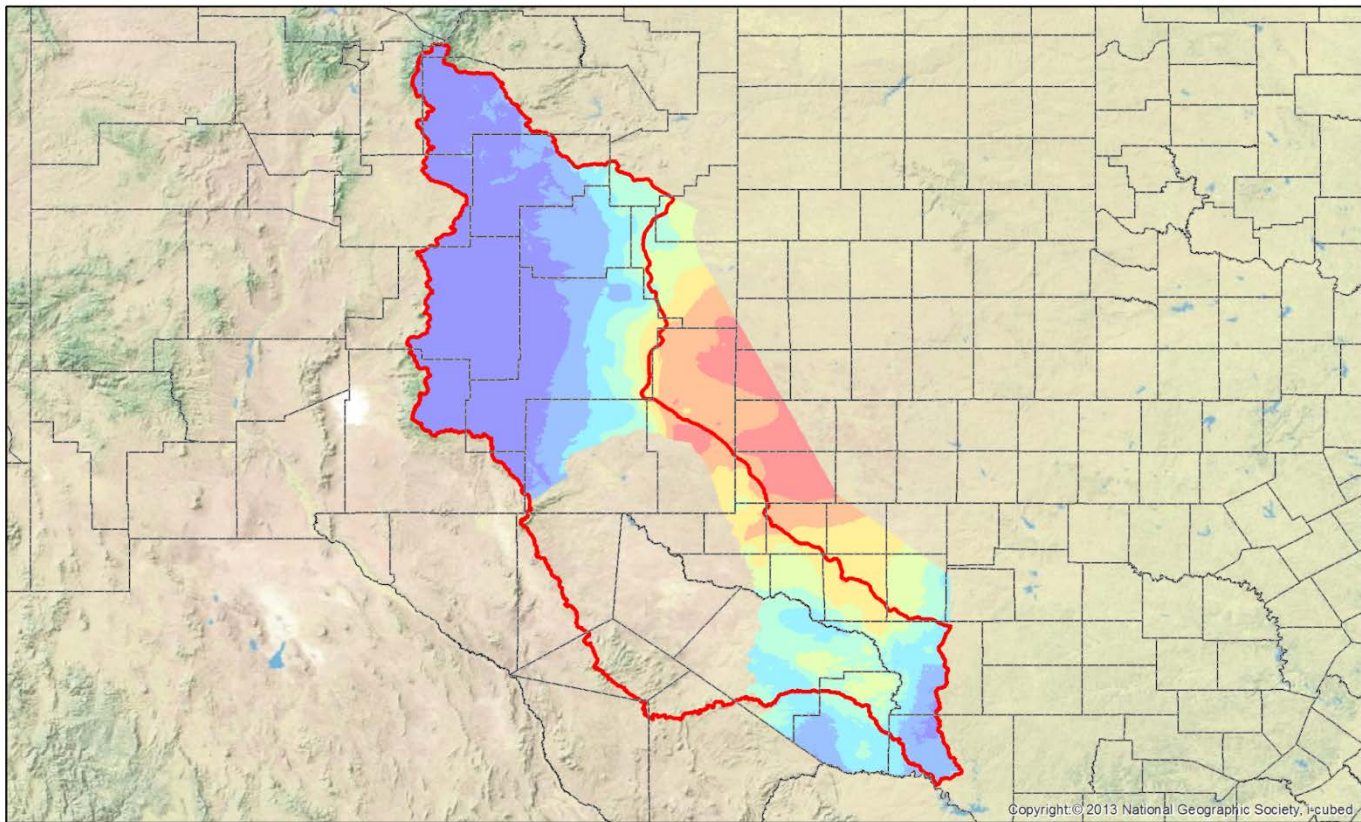
Depth to the base of the Grayburg Formation, in feet below land surface

- | | |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
|  33 to less than 722 |  2,681 to less than 3,264 |
|  722 to less than 1,451 |  3,264 to less than 3,848 |
|  1,451 to less than 2,118 |  3,248 to less than 4,389 |
|  2,118 to less than 2,681 |  4,389 to 5,347 |
|  Pecos River Basin boundary | |



DRAFT DOCUMENT






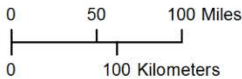


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EXPLANATION

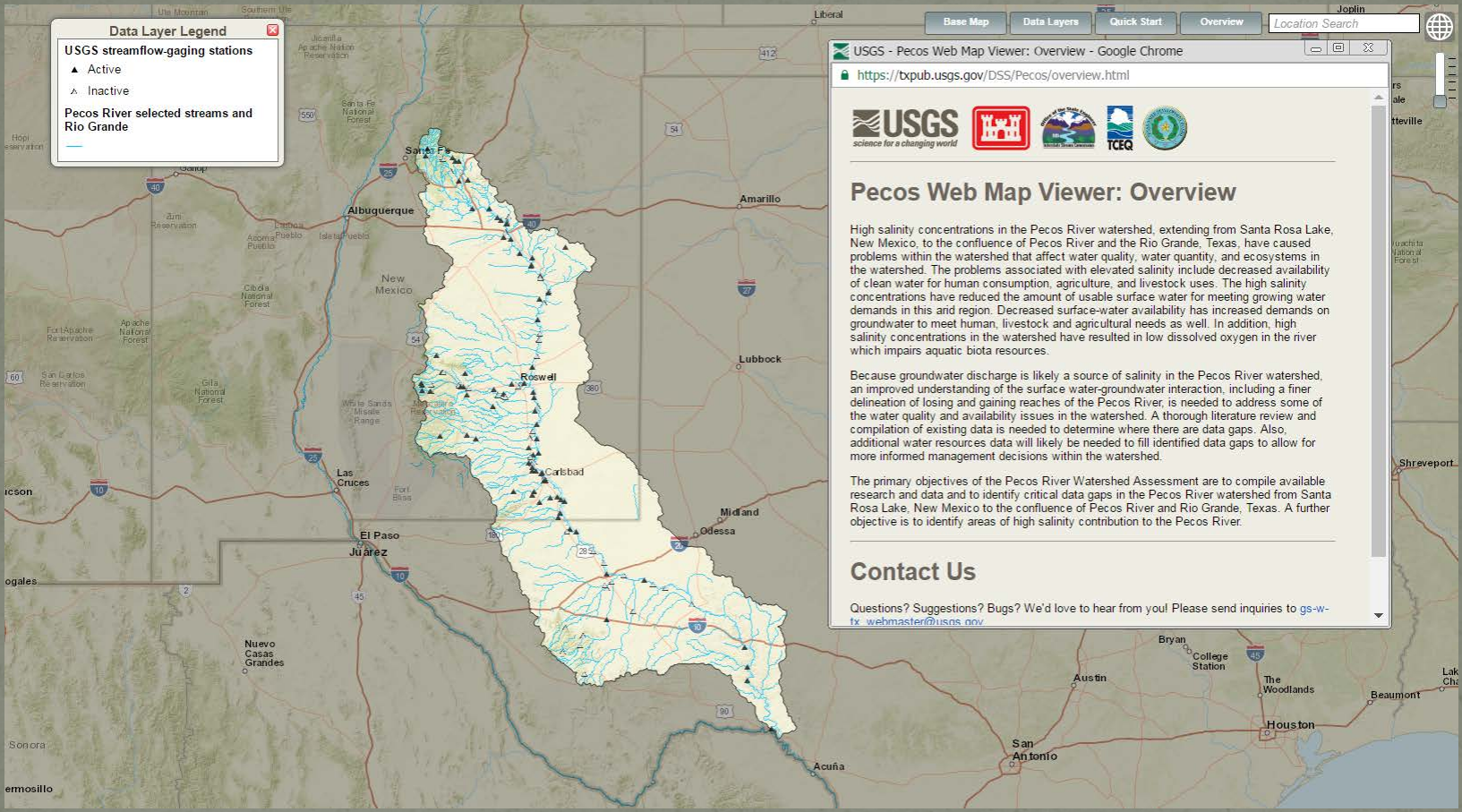
Depth to the base of the San Andres Formation, in feet below land surface

- | | |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
|  81 to less than 1,265 |  3,394 to less than 4,078 |
|  1,265 to less than 1,975 |  4,078 to less than 4,814 |
|  1,975 to less than 2,711 |  4,814 to less than 5,523 |
|  2,711 to less than 3,394 |  5,523 to 6,784 |
|  Pecos River Basin boundary | |



DRAFT DOCUMENT





Data Layer Legend

USGS streamflow-gaging stations

- ▲ Active
- △ Inactive

Pecos River selected streams and Rio Grande

USGS - Pecos Web Map Viewer: Overview - Google Chrome

<https://bpub.usgs.gov/DSS/Pecos/overview.html>

Pecos Web Map Viewer: Overview

High salinity concentrations in the Pecos River watershed, extending from Santa Rosa Lake, New Mexico, to the confluence of Pecos River and the Rio Grande, Texas, have caused problems within the watershed that affect water quality, water quantity, and ecosystems in the watershed. The problems associated with elevated salinity include decreased availability of clean water for human consumption, agriculture, and livestock uses. The high salinity concentrations have reduced the amount of usable surface water for meeting growing water demands in this and region. Decreased surface-water availability has increased demands on groundwater to meet human, livestock and agricultural needs as well. In addition, high salinity concentrations in the watershed have resulted in low dissolved oxygen in the river which impairs aquatic biota resources.

Because groundwater discharge is likely a source of salinity in the Pecos River watershed, an improved understanding of the surface water-groundwater interaction, including a finer delineation of losing and gaining reaches of the Pecos River, is needed to address some of the water quality and availability issues in the watershed. A thorough literature review and compilation of existing data is needed to determine where there are data gaps. Also, additional water resources data will likely be needed to fill identified data gaps to allow for more informed management decisions within the watershed.

The primary objectives of the Pecos River Watershed Assessment are to compile available research and data and to identify critical data gaps in the Pecos River watershed from Santa Rosa Lake, New Mexico to the confluence of Pecos River and Rio Grande, Texas. A further objective is to identify areas of high salinity contribution to the Pecos River.

Contact Us

Questions? Suggestions? Bugs? We'd love to hear from you! Please send inquiries to gs-w-tx_webmaster@usgs.gov

Data Layer Legend

USGS streamflow gaging stations

- ▲ Active
- △ Inactive

Pecos River selected streams and Rio Grande

Geology

- Water
- Cretaceous, Kc
- Cretaceous, Kdg
- Cretaceous, Kgg
- Cretaceous, Kgh
- Cretaceous, Kgr
- Cretaceous, Kl
- Cretaceous, Km
- Cretaceous, Kmv
- Cretaceous, Ku

Identify Results

Geology Map Click

Rock unit age	Permian; Ochoa Series
Rock type 1	evaporite
Rock unit code	Prc
Rock unit name	gypsum of Rustler, Salado, and Castile Formations, undivided

Drag Zoom To Close

Basic Map

Gray

Topographic

Imagery

Streets

Transparency: [Slider]

Show Overview Map

Drag Dock Close

Sites

- USGS streamflow-gaging stations
- Wastewater treatment plants
- 2015 USGS sampling events
- Latest water quality data
- Sites with water quality
- Reconnaissance sites

Wells and Pipelines

- Augmentation well field wells
- Augmentation well field pipelines
- Salt water disposal and injection wells
- Wells with water quality
- Wells with logs

Hydrologic Features

- Springs, seeps, sinkholes
- Watersheds - 8 digit HUCs
- Areas of interest - salinity
- Pecos River selected streams and Rio Grande
- Minor Texas aquifers
- Major Texas aquifers
- New Mexico groundwater basins

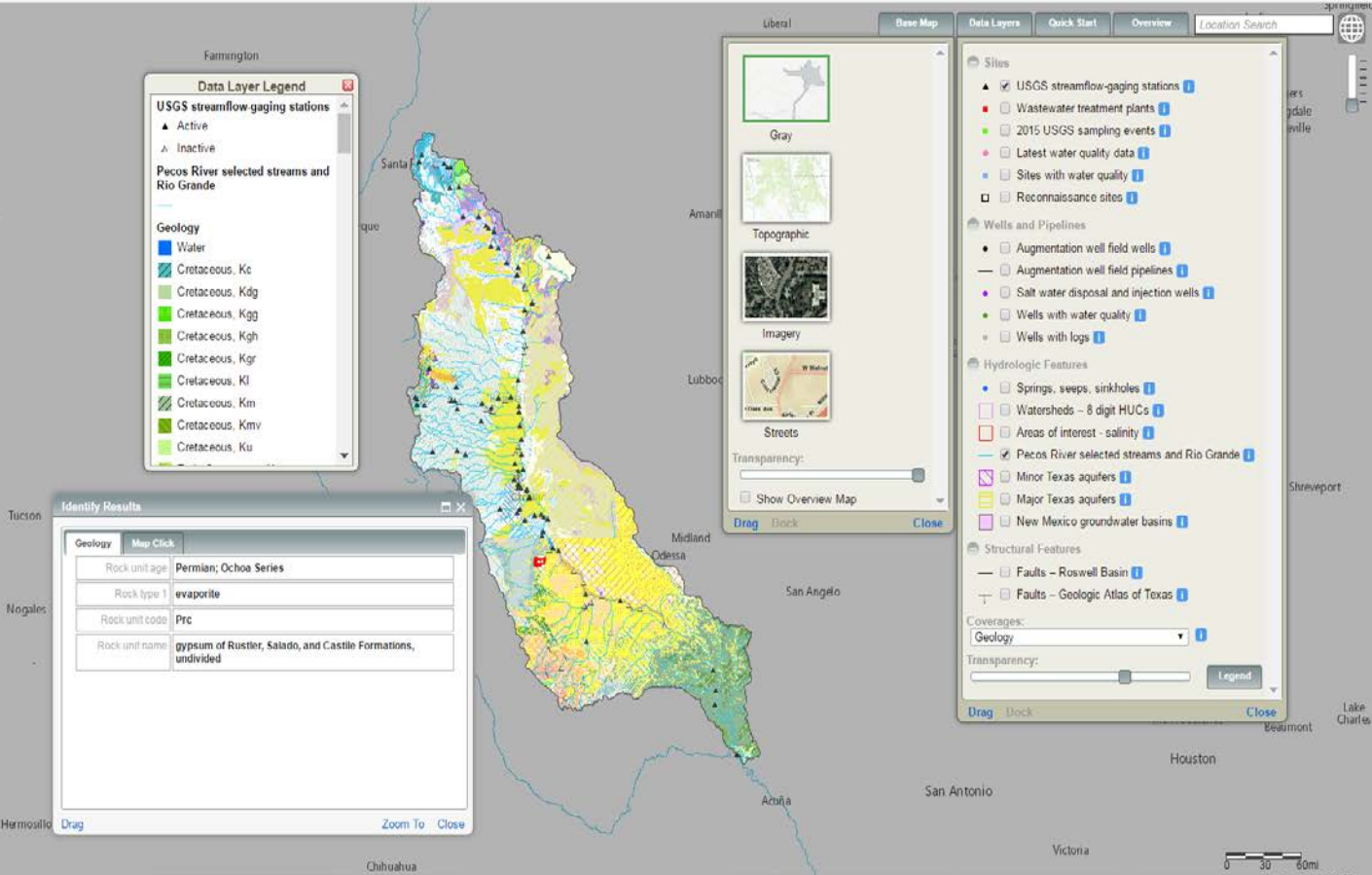
Structural Features

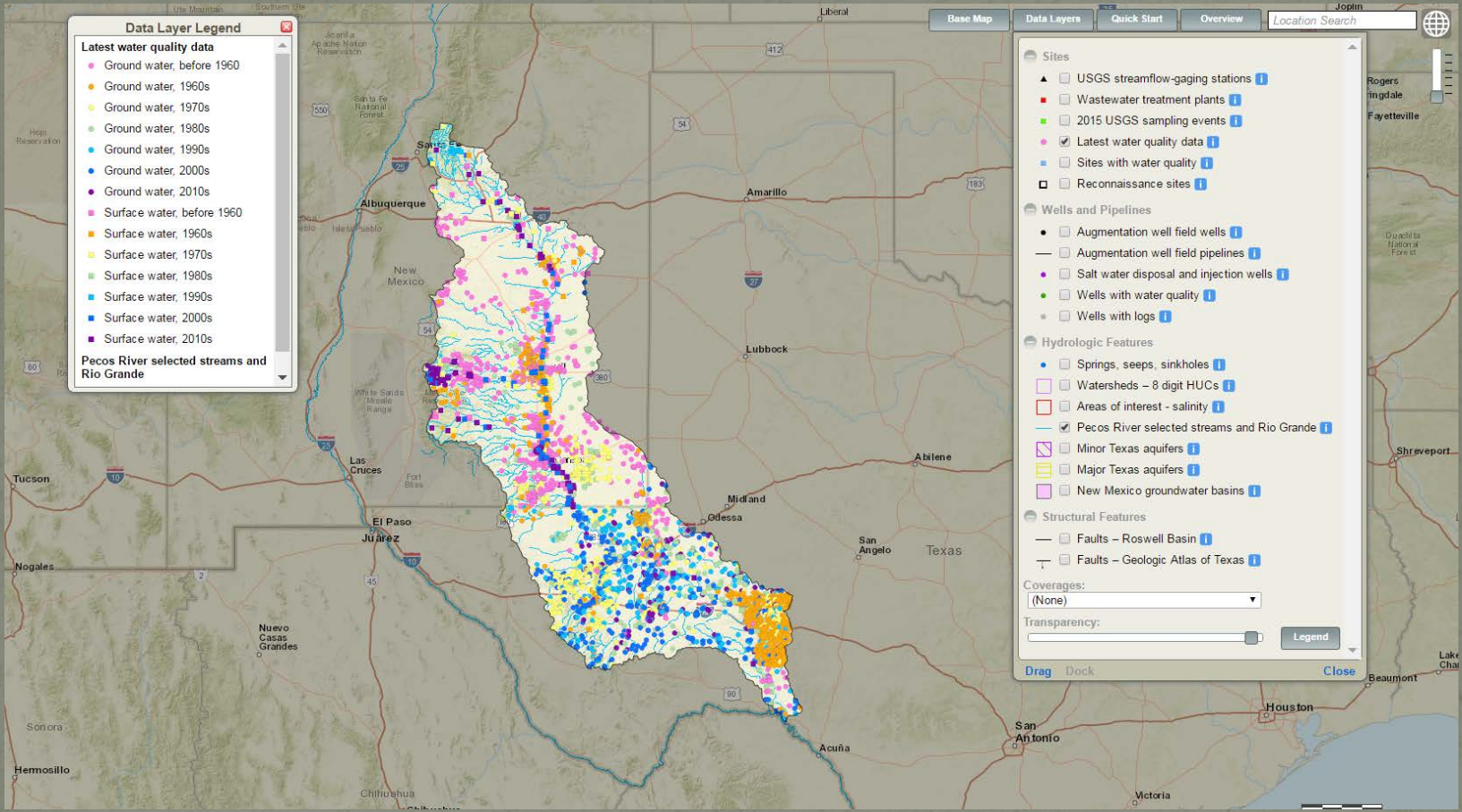
- Faults - Roswell Basin
- Faults - Geologic Atlas of Texas

Coverages: Geology

Transparency: [Slider] Legend

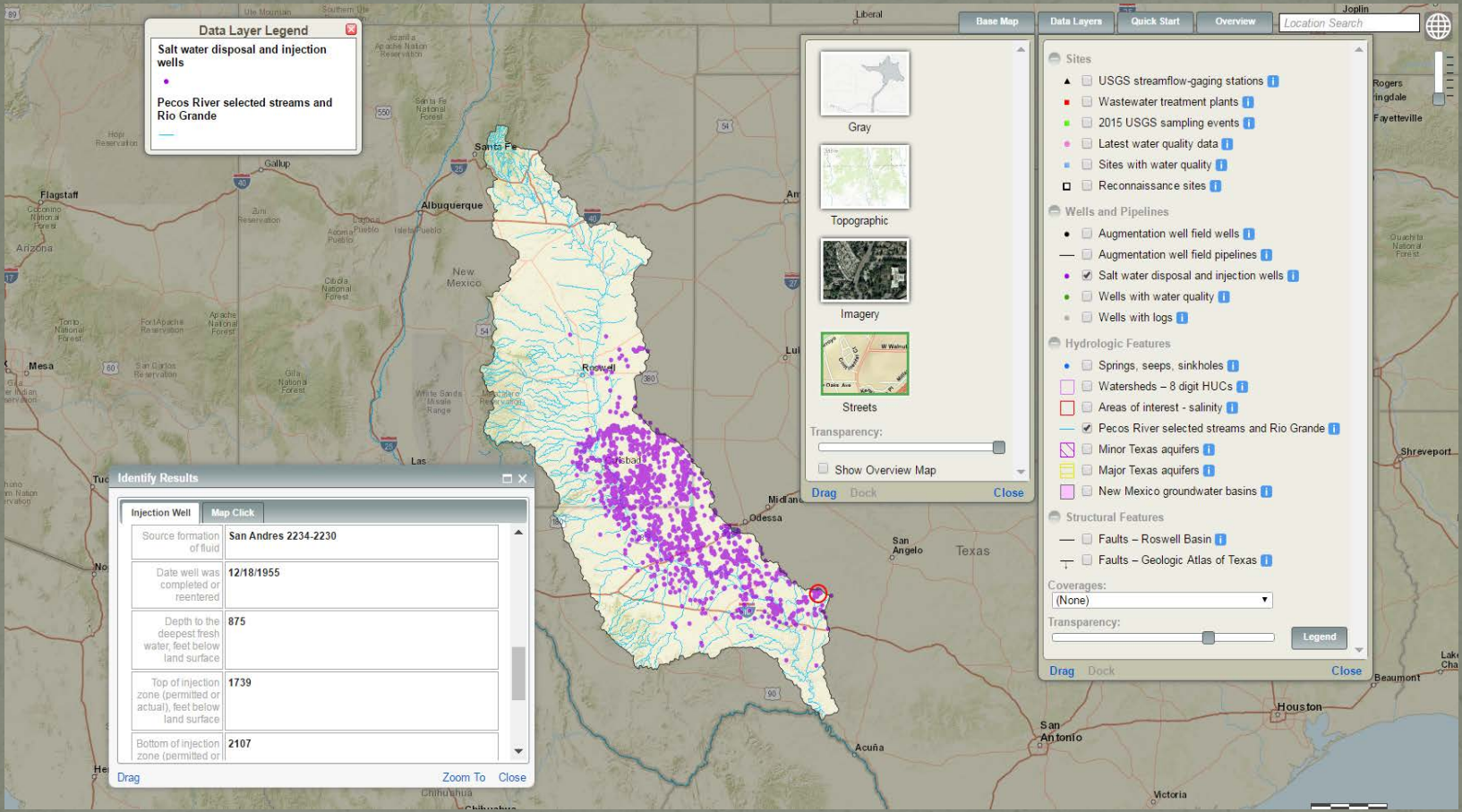
Drag Dock Close

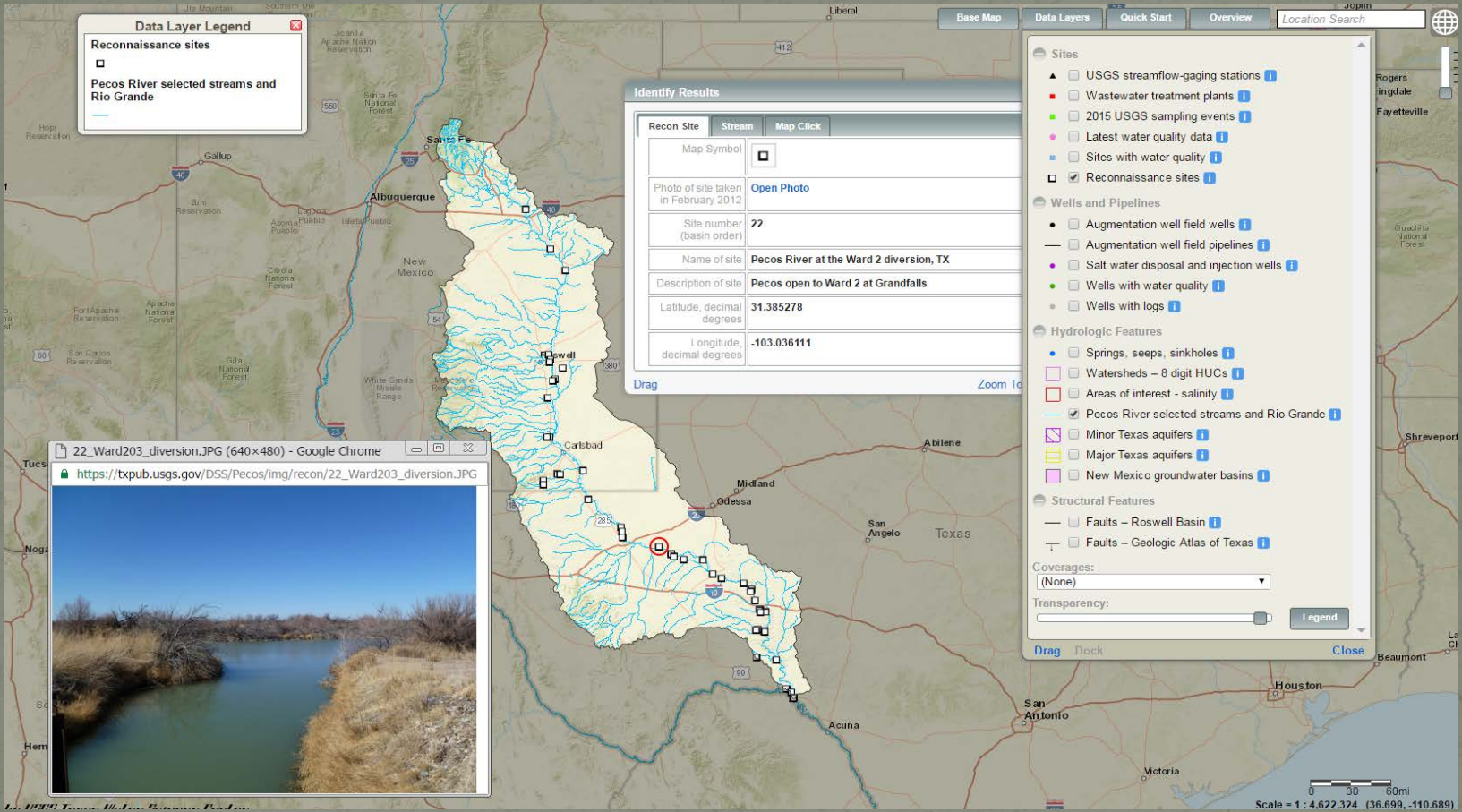




- Data Layer Legend**
- Latest water quality data**
- Ground water, before 1960
 - Ground water, 1960s
 - Ground water, 1970s
 - Ground water, 1980s
 - Ground water, 1990s
 - Ground water, 2000s
 - Ground water, 2010s
 - Surface water, before 1960
 - Surface water, 1960s
 - Surface water, 1970s
 - Surface water, 1980s
 - Surface water, 1990s
 - Surface water, 2000s
 - Surface water, 2010s
- Pecos River selected streams and Rio Grande**

- Sites**
- USGS streamflow-gaging stations
 - Wastewater treatment plants
 - 2015 USGS sampling events
 - Latest water quality data
 - Sites with water quality
 - Reconnaissance sites
- Wells and Pipelines**
- Augmentation well field wells
 - Augmentation well field pipelines
 - Salt water disposal and injection wells
 - Wells with water quality
 - Wells with logs
- Hydrologic Features**
- Springs, seeps, sinkholes
 - Watersheds - 8 digit HUCs
 - Areas of interest - salinity
 - Pecos River selected streams and Rio Grande
 - Minor Texas aquifers
 - Major Texas aquifers
 - New Mexico groundwater basins
- Structural Features**
- Faults - Roswell Basin
 - Faults - Geologic Atlas of Texas
- Coverages:
(None)
- Transparency: [Slider]
- Legend
- Drag Dock Close





Data Layer Legend

- Reconnaissance sites
- Pecos River selected streams and Rio Grande

Identify Results

Recon Site	Stream	Map Click
Map Symbol		<input type="checkbox"/>
Photo of site taken in February 2012		Open Photo
Site number (basin order)		22
Name of site		Pecos River at the Ward 2 diversion, TX
Description of site		Pecos open to Ward 2 at Grandfalls
Latitude, decimal degrees		31.385278
Longitude, decimal degrees		-103.036111

Sites

- USGS streamflow-gaging stations
- Wastewater treatment plants
- 2015 USGS sampling events
- Latest water quality data
- Sites with water quality
- Reconnaissance sites

Wells and Pipelines

- Augmentation well field wells
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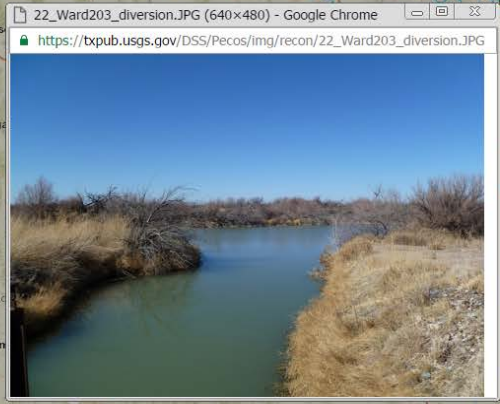
Structural Features

- Faults - Roswell Basin
- Faults - Geologic Atlas of Texas

Coverages: (None)

Transparency:

[Legend](#)



Scale = 1 : 4,622,324 (36.699, -110.689)



Variables Model Input

Model input
 Model output

Variable 1:
 BaseRustler [XY]

Fill Style:
 Color Fill:
 Color Palette: Symmetric
 Legend

Transparency:
 Global min-max

Variable 2:
 [NONE]

Drag Dock Close

Variables Model Output

Model input
 Model output

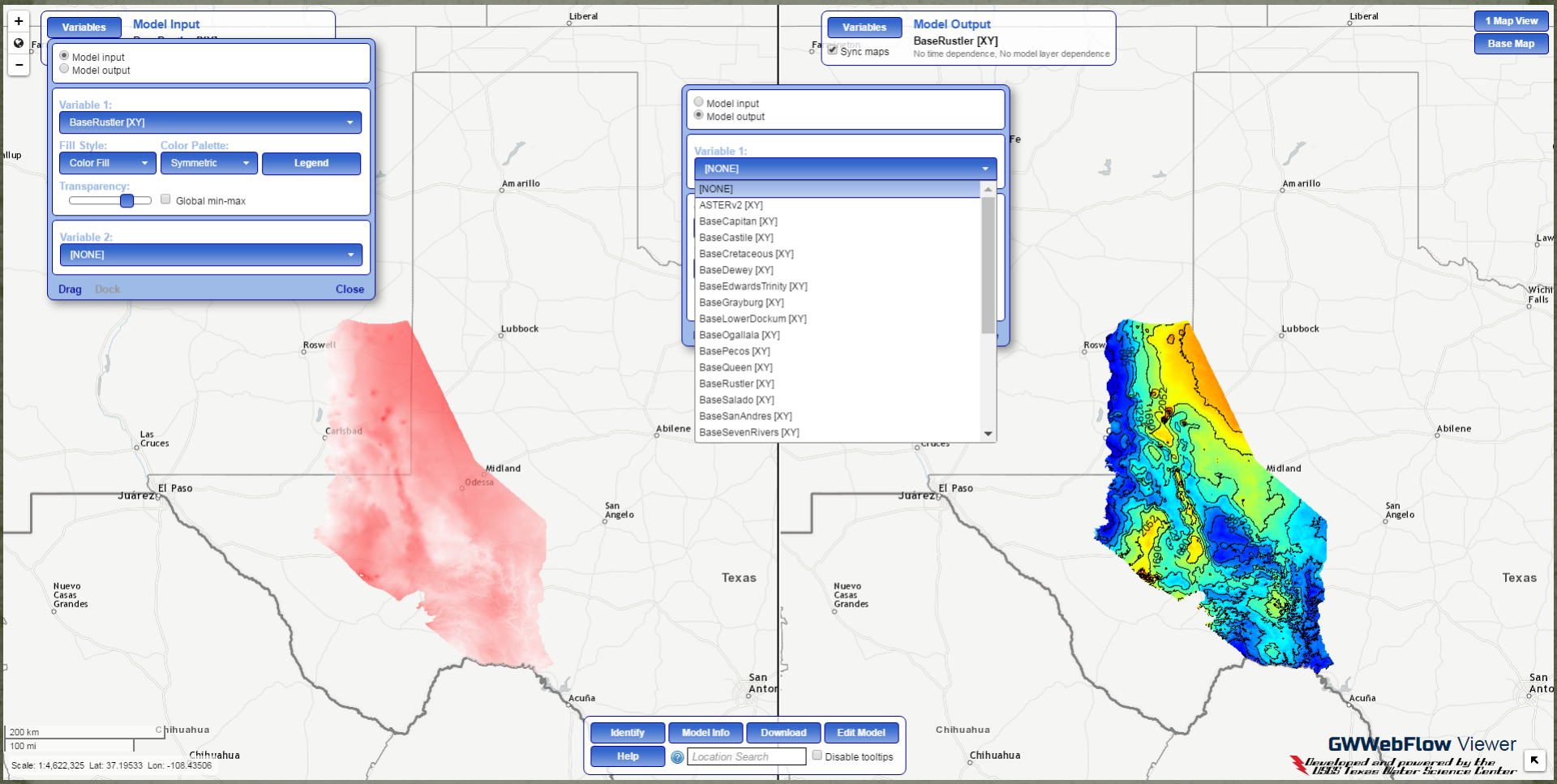
Sync maps
 No time dependence, No model layer dependence

1 Map View
 Base Map

Model input
 Model output

Variable 1:
 [NONE]

- ASTERV2 [XY]
- BaseCapitan [XY]
- BaseCastle [XY]
- BaseCretaceous [XY]
- BaseDewey [XY]
- BaseEdwardsTrinity [XY]
- BaseGrayburg [XY]
- BaseLowerDockum [XY]
- BaseOgallala [XY]
- BasePecos [XY]
- BaseQueen [XY]
- BaseRustler [XY]
- BaseSalado [XY]
- BaseSanAndres [XY]
- BaseSevenRivers [XY]



Identify Model Info Download Edit Model
 Help Location Search Disable tooltips

Salinity Impacts in Texas

• Red Bluff Reservoir

- Salt loading: ~560,000+ tons/year
- Outflow: ~410,000 tons per year
- TDS of water = 6,000 ppm
 - Too high for most crops
 - Marginal for livestock
 - Limits biodiversity of species

• Girvin: ~12,000 ppm

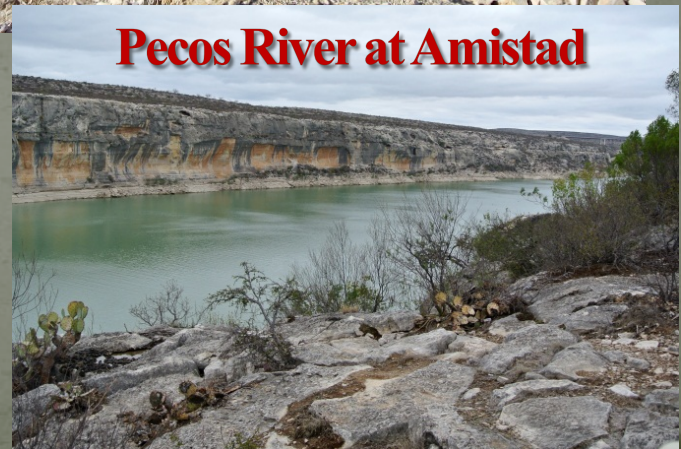
• Lake Amistad

- 26% from Pecos River (~10% flow)
- Upper limit of drinking water standards

from Miyamoto & others (2006)



Red Bluff Reservoir



Pecos River at Amistad

Pecos River Commission



- Pecos River Compact (signed in 1948) – Texas and New Mexico
- Lawsuit: Texas v. New Mexico (1974-1988)
 - River Master appointed
 - Accounting process
- Pecos River Settlement Agreement (2003)
 - Efforts to insure compliance in New Mexico
- Water Quality becomes focus in Texas
- Sponsored studies and projects with USGS and Bureau of Reclamation



Malaga Bend Springs and Seeps

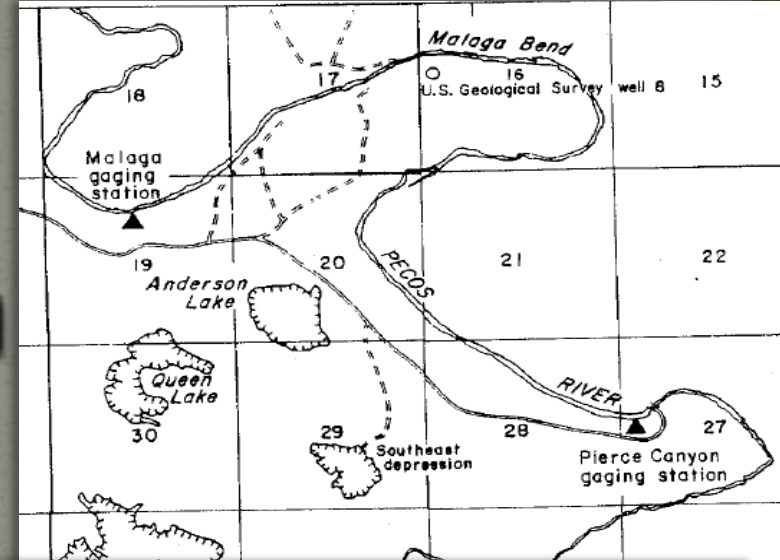
1938-1970 – USGS reports identified
brine discharge



Water Salvage Alleviation Project

1958: First salt control project of its kind in U.S.

- Cooperation from state and federal agencies
- Construction - Bureau of Reclamation
- Data collection - USGS
- Right of way - NM
- Operation and maintenance - TX

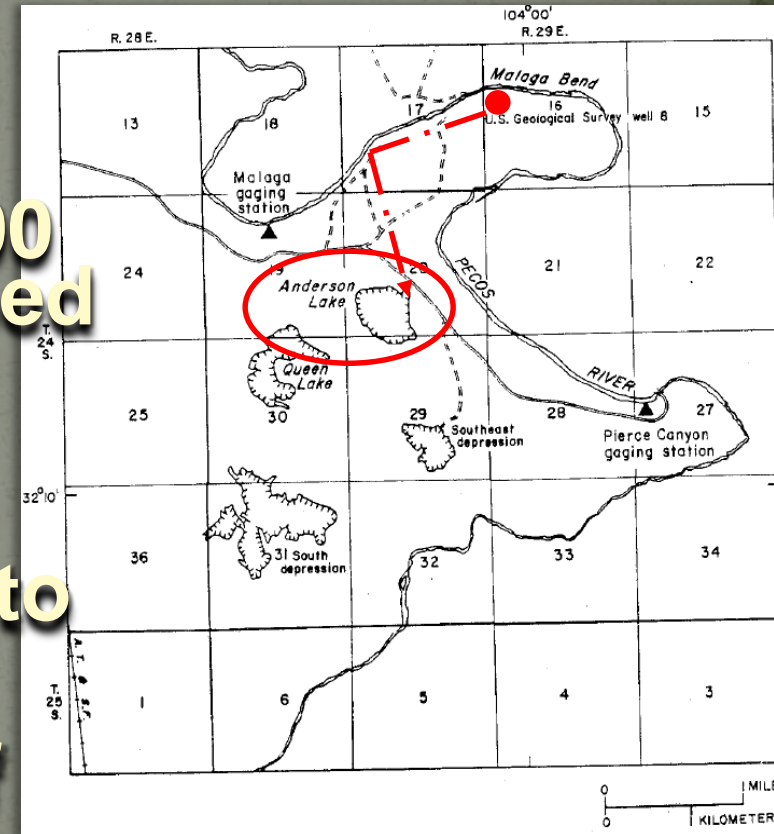


Malaga Bend Salinity Alleviation Project

1963: Pumping starts

1963 to 1976:

- By December 1964, 1,000 acre-feet of water pumped
- 300,000 tons of salt removed
- Decreased brine inflow to river by 70%
- About 3,878 acre-feet of brine is pumped



From Havens, 1970.

Malaga Bend Salinity Alleviation Project

1970, 1976, 1979, 1980:

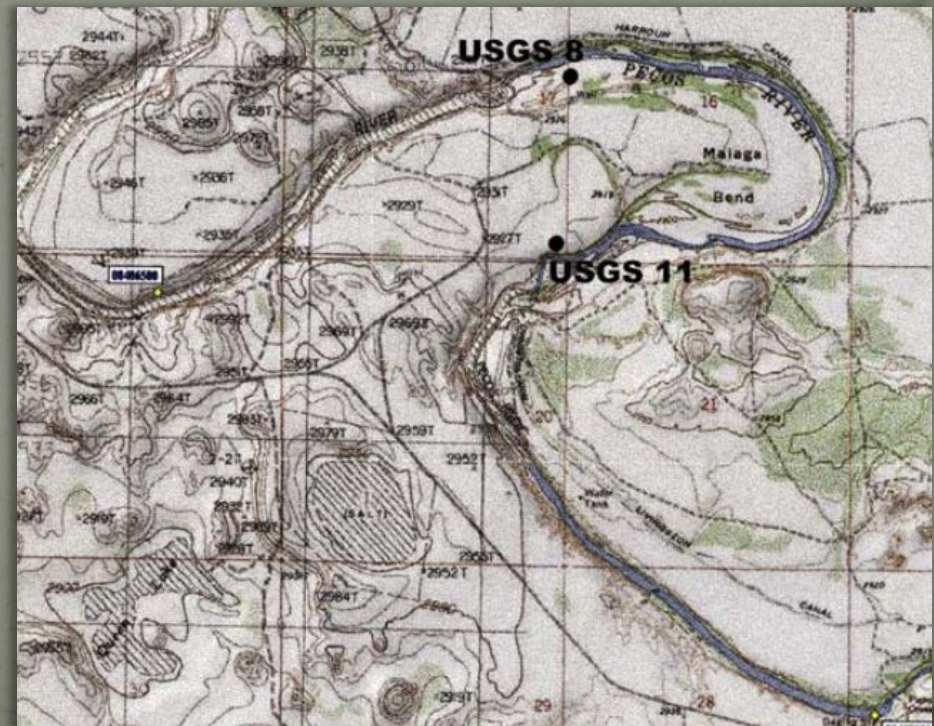
- USGS reports show leakage from disposal lake

1972: Brine pumped to Culberson County (TX)

- Enhanced oil recovery (EOR)

1977: EOR Pumping stops

- Pump and casing problems



Salinity Control Efforts Continue

1992: Private companies propose to pump and “harvest” salt for sale

1993: Pumping stops:

- To re-engineer the pond
- Due to water fowl concerns
- Due to lack of interest by salt company



2005: Private companies were once again offering proposals to mine salt

Pecos River Water Quality Coalition

2010: PRC, state and local officials, stakeholders and federal and state agencies

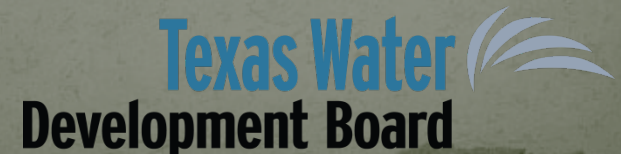
2012: Pecos Initial Assessment by USACE and conducted by USGS

2013: USACE Pecos Watershed Assessment Project

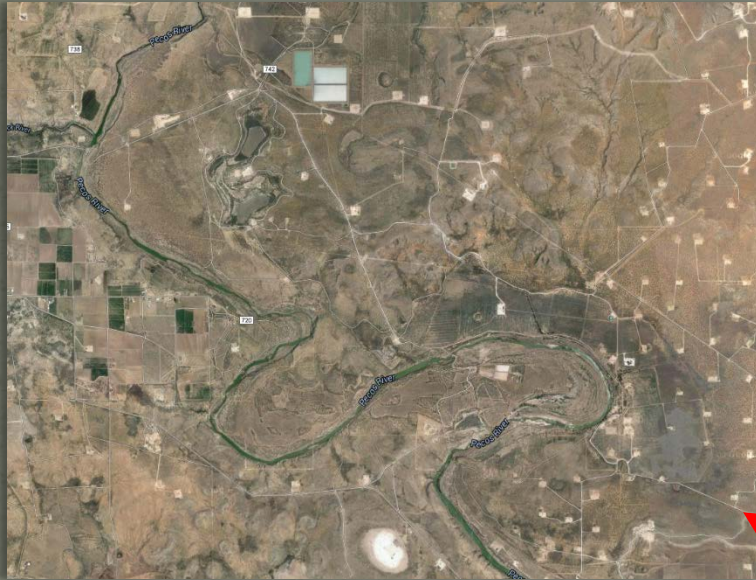
- Non-Federal sponsors: Texas TCEQ and New Mexico ISC
- Funds provided by Texas Water Development Board



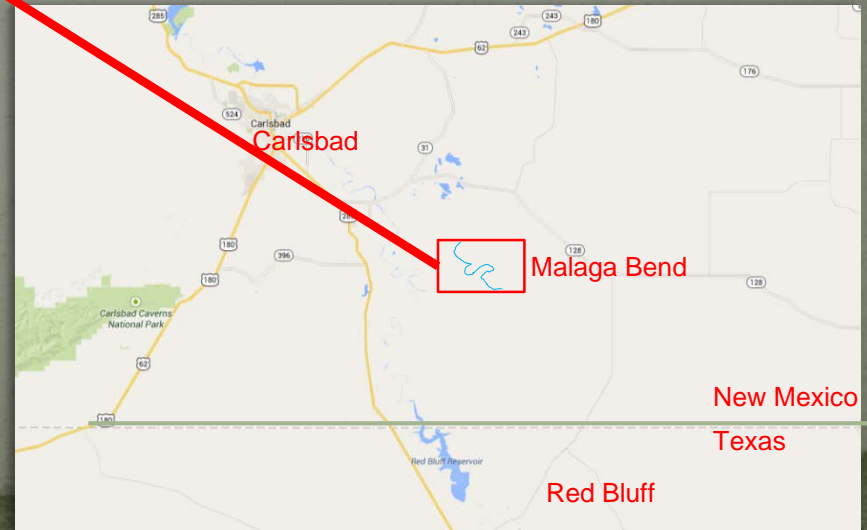
**US Army Corps
of Engineers**



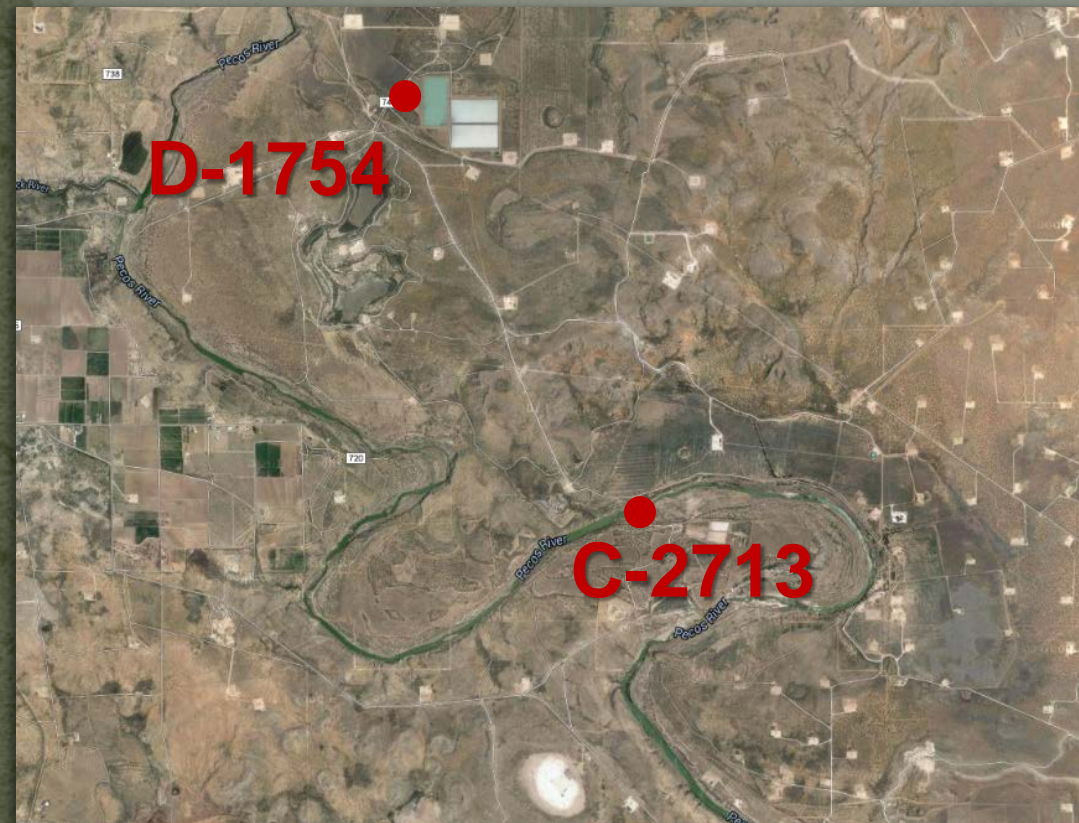
Current Malaga Bend Project



2010-2012: Pecos Commissioners and Pecos Coalition work with Southwest Salt to pump well again to produce salt



Malaga Bend Project Legal Requirements



- Red Bluff Diversion Permit SP-3254 for well C-2713
 - Max of 645 acre-feet
- Southwest Salt Discharge Permit – D-1754

Pecos River Master Manual Requirements

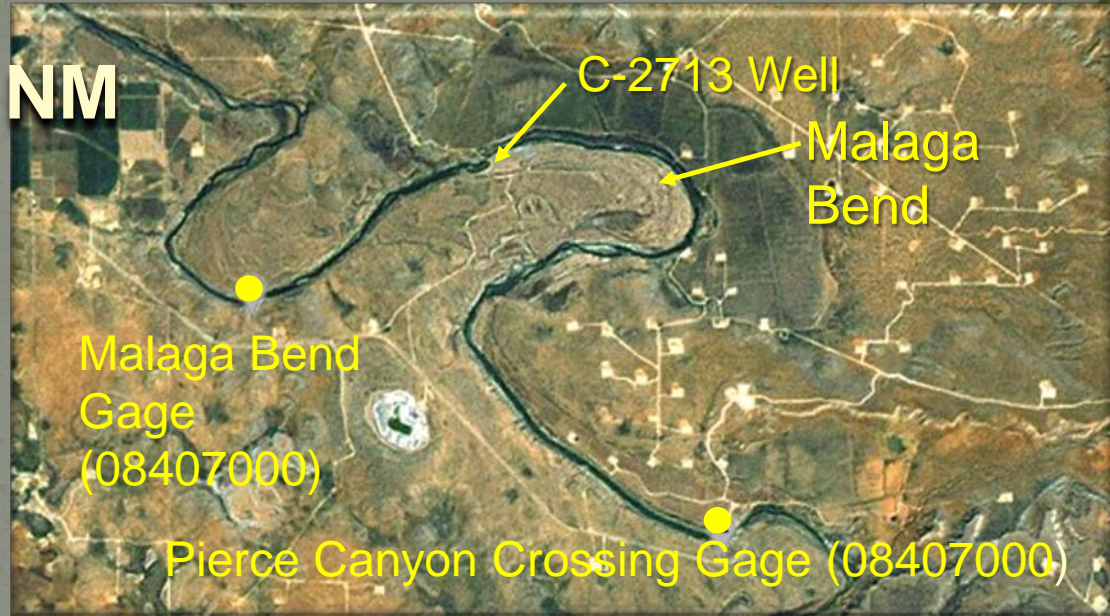
- Pumping Limit and NM credit of 645 acre feet/year

- USGS gage flow measurements

- Malaga Bend
- Pierce Canyon Crossing

- Water Quality Testing

- 2x/month by Center of Excellence for Hazardous Materials Management (CEHMM)



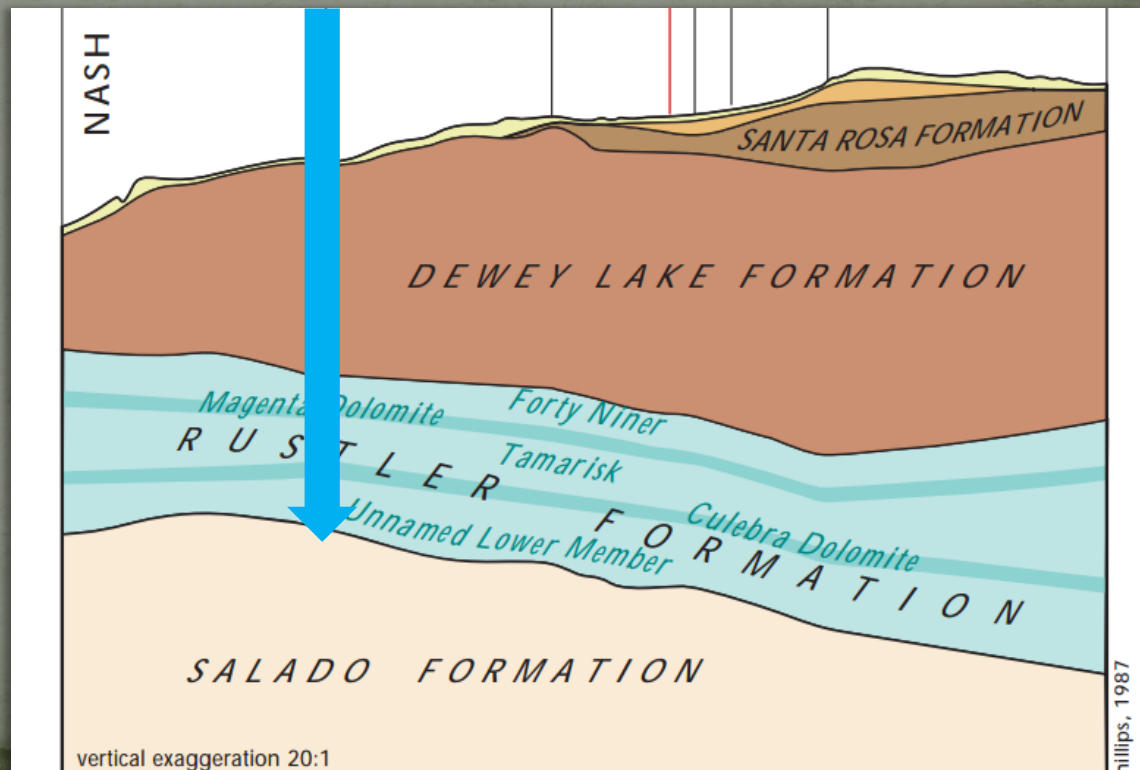
- Gain in Total Daily Salt Load limit < 367.7 Tons/day

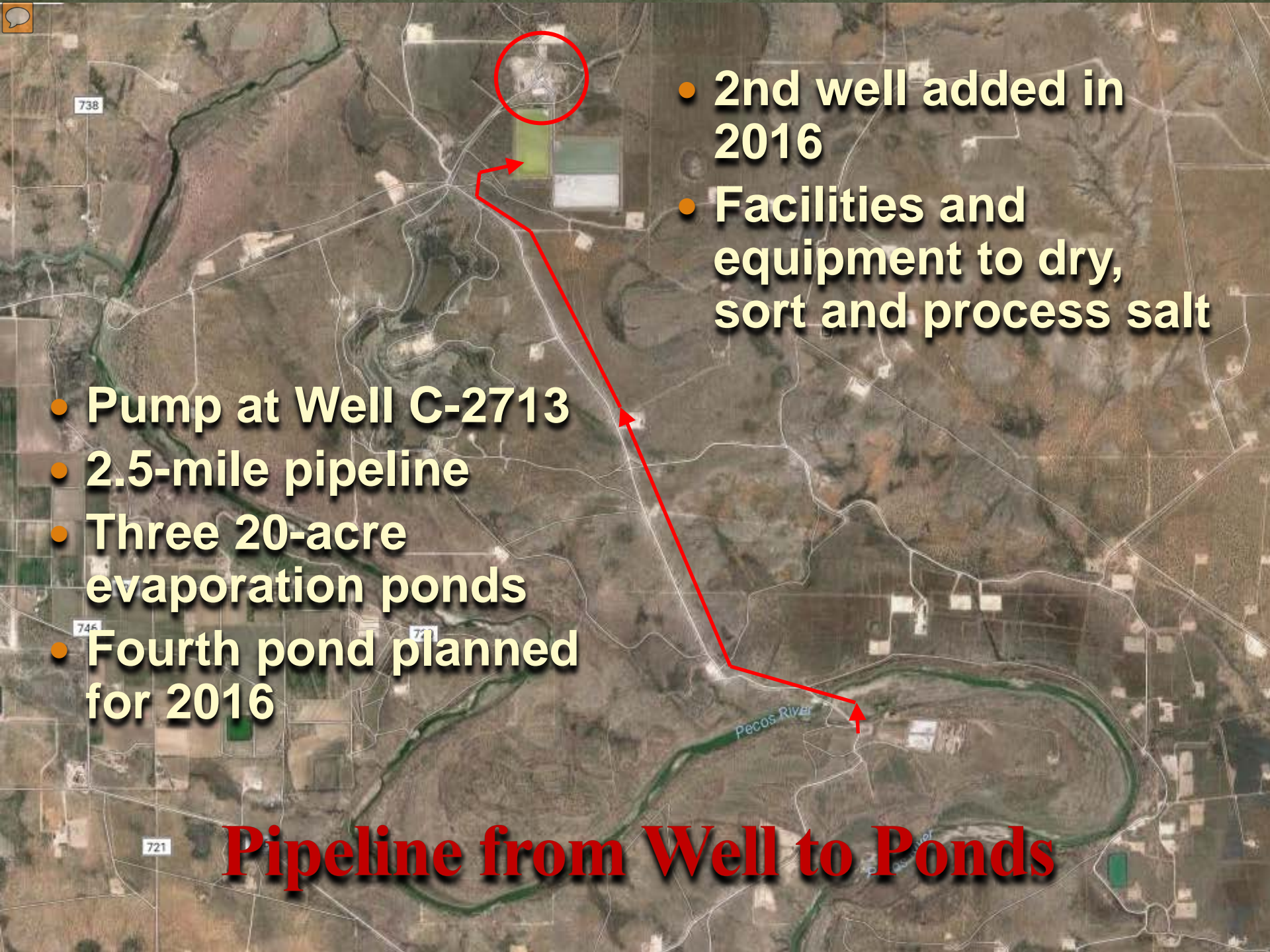
Well C-2713 at Malaga Bend



- Well drilled into brine aquifer in Salado Formation
- Can produce ~250,000 tons of salt per year (with 8 ponds)

- Permit from NM allows 4 ponds
- **2013:** Pumping begins
- **2014:** Began selling salt





- 2nd well added in 2016
- Facilities and equipment to dry, sort and process salt

- Pump at Well C-2713
- 2.5-mile pipeline
- Three 20-acre evaporation ponds
- Fourth pond planned for 2016

Pipeline from Well to Ponds

Evaporation Ponds

- In 2015, 197 acre feet pumped
- 250 gallons per minute
- 90,000 tons of salt
- 1 foot of base salt required
- 1 foot of salt expected per year
- Salt can be harvested after 18 months
- 2014-2015 increased pumping to >200 acre feet, 158 acre feet in 2016 so far



SWS Salt Operations

- Pump from river into evaporation ponds
- Evaporation process
- Harvest salt with trucks
- Processing facility – dry, sort and bag
 - Observe daily
 - Easy to capture birds
 - Veterinarian on call for cleaning



SWS Onsite Processing Plant

- Processing facility and equipment
- Salt for water softening
- Delivery by truck



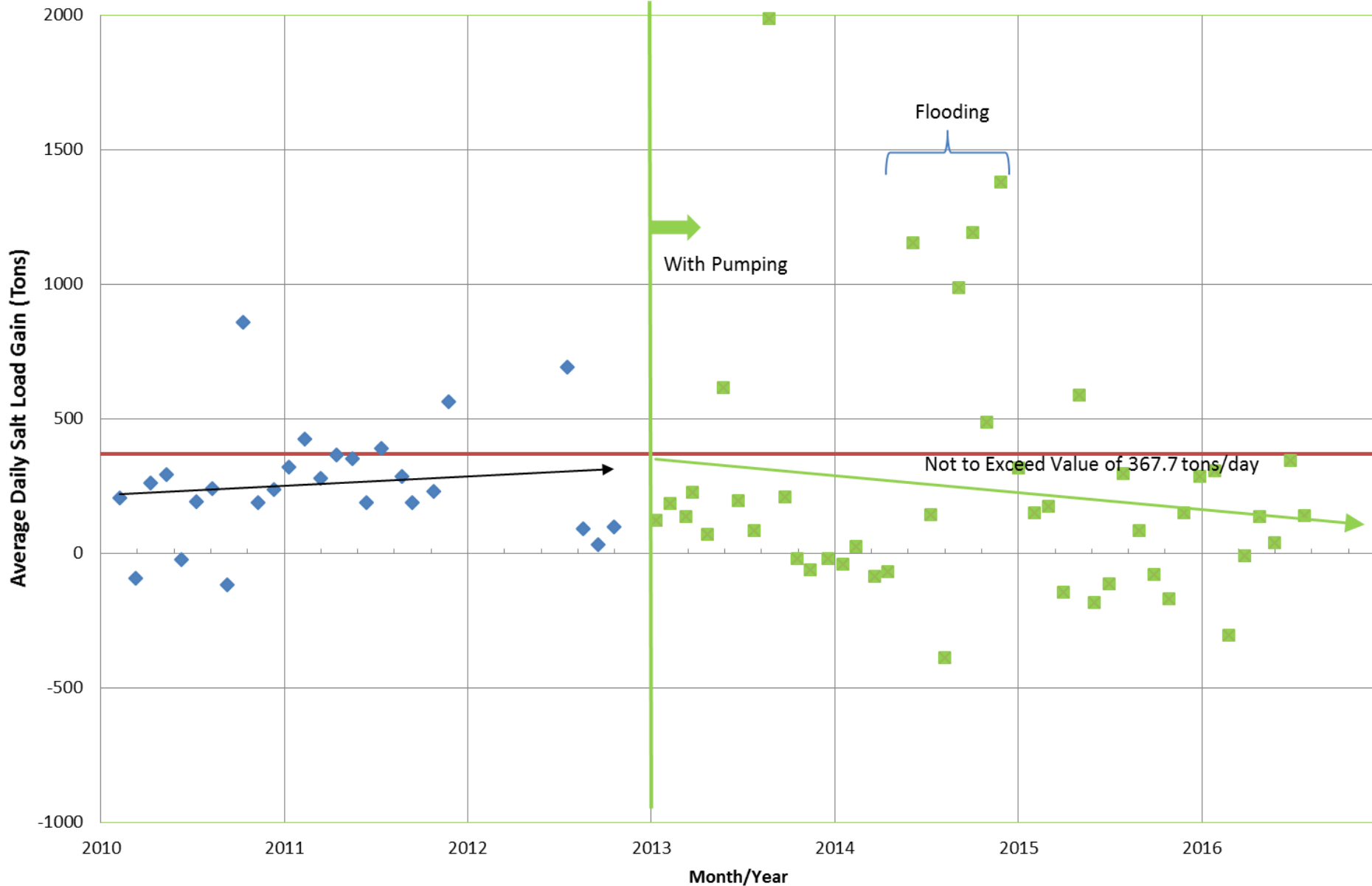
“Pure Salt Harvested from an Underground Sea Below the Pecos River” at HEB



Southwest Salt Company Malaga Bend Project

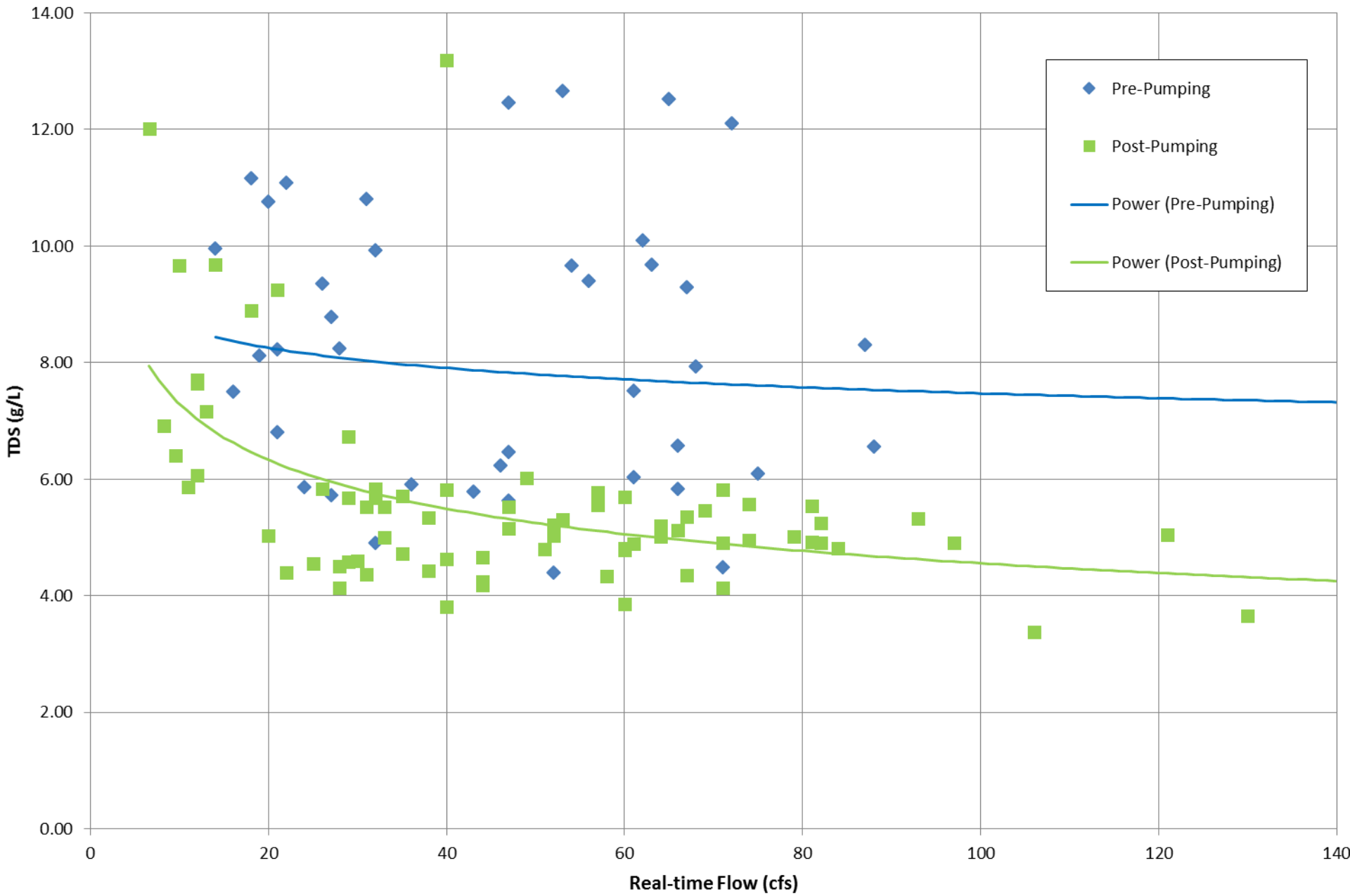
Average Daily Salt Gain

Between Upstream and Downstream Stations



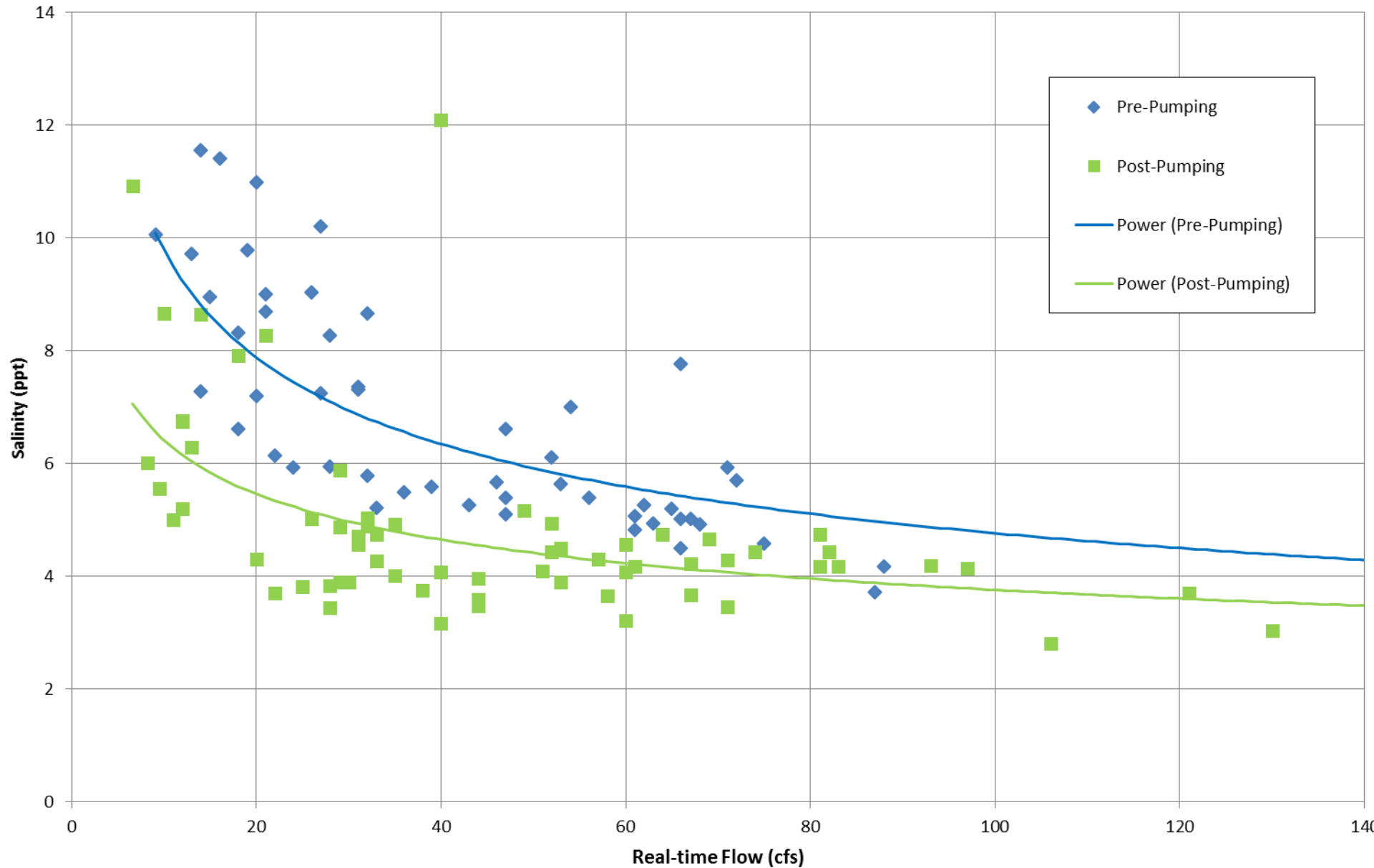


TDS vs. Flow at Malaga Bend Pre- and Post-pumping





Salinity vs. Flow at Malaga Bend Pre- and Post-Pumping



QUESTIONS?

Suzy Valentine, P.E. - TCEQ
Natalie Houston, P.G. - USGS



References

- Pecos River Commission, 1955. *Initial Development, Water Salvage and Salinity Alleviation Action Programs, Pecos River Basin.*
- Cox, E.H. and J.L. Kunkler, 1962. *Feasibility of Injecting Brine from Malaga Bend into the Delaware Mountain, Eddy County, NM.* USGS in cooperation with the Pecos River Commission.
- Havens, J.S., 1970. *Malaga Bend Experimental Salinity Alleviation Project – A Comprehensive Interim Report – Eddy County, NM.* USGS in cooperation with the Pecos River Commission.
- Kunkler, J.L. and Havens, J.S., 1976. *Preliminary Draft - Evaporation and Leakage of Brine from Anderson Lake at Malaga Bend, Eddy County, NM.* USGS in cooperation with the Pecos River Commission.
- Kunkler, J.L., 1980. *Evaluation of the Malaga Bend Salinity Alleviation Project, Eddy County, NM.* USGS Open-File Report 80-1111. Prepared in cooperation with the Pecos River Commission.
- Miyamoto, S., Yuan, f, and Anand, S. 2005. *Reconnaissance Survey of Salt Sources and Loadings into the Pecos River, TR-291.* Texas A&M University Agricultural Research Center at El Paso, Texas Cooperative Extension at Fort Stockton (TCE), Texas Water Resources Institute (TWRI), Texas Clean Rivers Program and International Boundary and Water Commission (IBWC).
- Miyamoto, S., Yuan, f, and Anand, S. 2006. *Water Balance, Salt Loading, and Salinity Control Options of Red Bluff Reservoir, Texas, TR-298.* Texas A&M University Agricultural Research Center at El Paso, Texas Agricultural Experiment Station and TWRI.
- Miyamoto, S., Anand, S. and Hatler, W. 2008. *Hydrology, Salinity, and Salinity Control Possibilities of the Middle Pecos River: A Reconnaissance Report, TR-2008-315.* Texas A&M University AgriLife Research Center at El Paso, and TWRI.
- Gregory, L. and Hatler, W. 2008. *A Watershed Protection Plan for the Pecos River in Texas.* Texas A&M University, Texas State Soil and Water Conservation Board, Environmental Protection Agency, Texas AgriLife Research and Extension, TWRI and IBWC.
- Shepherd, C. 2014. Personal communication; M. Dixon. Personal communication, 2016.