



# Marathon Aquifer Conceptual Model

Stakeholder Advisory Forum #2

August 4-5, 2022

Marathon, Texas



**DBS&A**  
*Daniel B. Stephens & Associates, Inc.*  
a Geo-Logic Company



*Daniel B. Stephens & Associates, Inc.*

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# Agenda

1. Texas Water Development Board overview
2. Marathon Aquifer Conceptual Model
  - Geology/hydrostratigraphy
  - Water levels and groundwater flow
  - Groundwater recharge
  - Aquifer hydraulic properties
  - Groundwater discharge
  - Water quality
3. Project Closeout Schedule
4. Questions



# Texas Water Development Board (TWDB) Groundwater Availability Modeling (GAM) Program



Grayson Dowlearn  
Groundwater Availability Modeling Program  
Texas Water Development Board

# GAM Program Overview

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**Aim:** Develop Groundwater Availability Models (GAMs) for the major and minor aquifers of Texas.

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**Purpose:** Tools that can be used to aid in groundwater resources management by stakeholders.

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**Public process:** Stakeholder involvement during model development process.

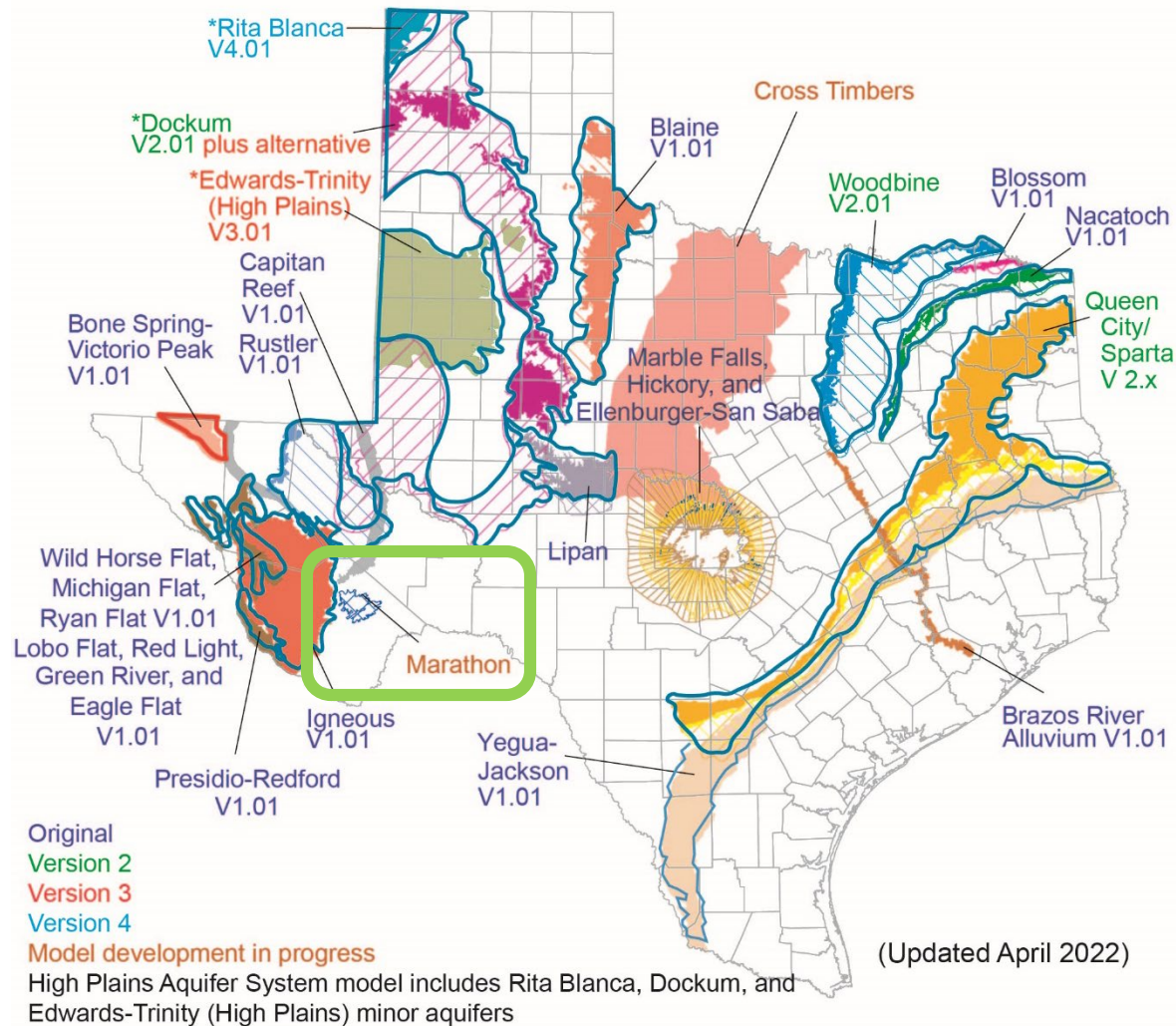
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**Models:** Freely available, standardized, thoroughly documented. Reports, data, and models are available for download from TWDB download page for models.

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**Living tools:** Periodically updated to remain relevant and incorporate improvements.

# GAMs for Minor Aquifers

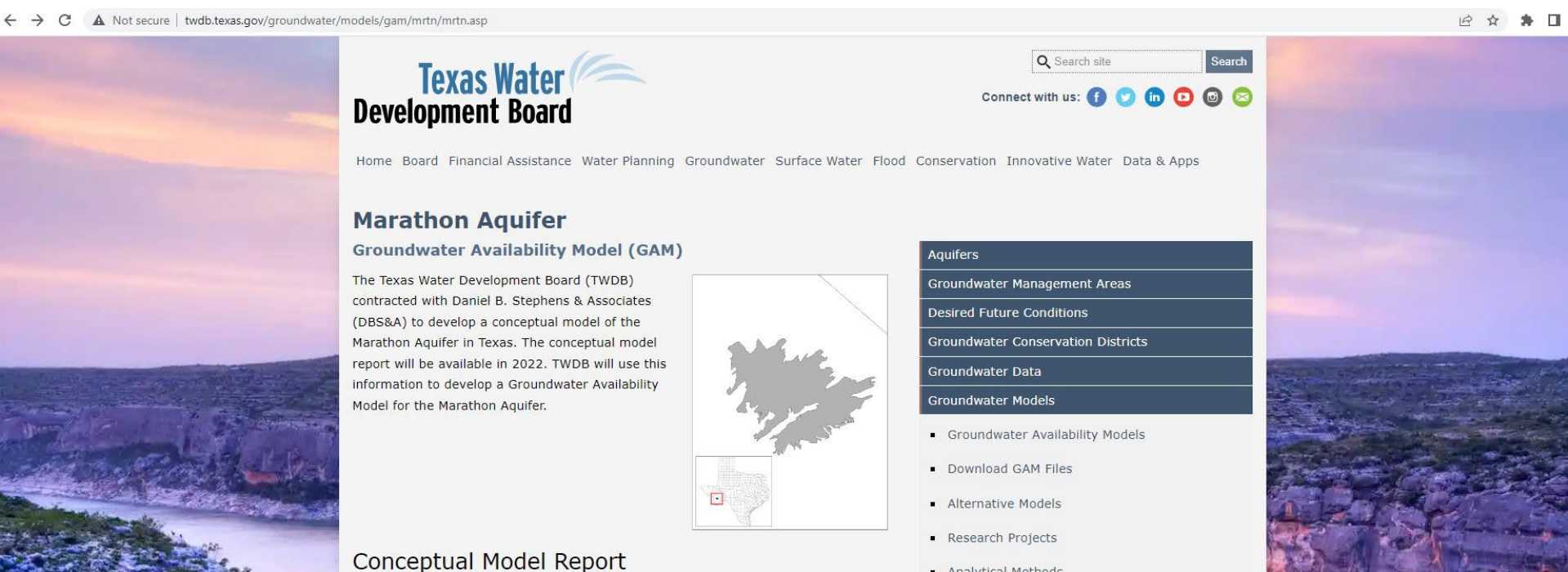


# Why Stakeholder Advisory Forums?

- Keep stakeholders updated about progress of the model
- Inform how the groundwater model can, should, and should not be used
- Provide stakeholders with the opportunity to share input and data to assist with the improvement of the model development

# More Information

- The PowerPoint slides from this Stakeholder Advisory Forum will be made available on the project's TWDB website
- <https://www.twdb.texas.gov/groundwater/models/gam/mrtn/mrtn.asp>



The screenshot shows a web browser window displaying the Texas Water Development Board website. The page title is "Marathon Aquifer Groundwater Availability Model (GAM)". The main content area includes a paragraph stating that the TWDB contracted with Daniel B. Stephens & Associates (DBS&A) to develop a conceptual model of the Marathon Aquifer in Texas, with the report available in 2022. To the right of the text is a map of the Marathon Aquifer area in Texas. Below the text is a link for the "Conceptual Model Report". On the right side of the page, there is a navigation menu with the following items: Aquifers, Groundwater Management Areas, Desired Future Conditions, Groundwater Conservation Districts, Groundwater Data, and Groundwater Models. Under "Groundwater Models", there is a list of sub-items: Groundwater Availability Models, Download GAM Files, Alternative Models, Research Projects, and Analytical Methods. The website header includes the TWDB logo, a search bar, and social media links for Facebook, Twitter, LinkedIn, YouTube, Instagram, and Email. The footer of the page contains the TWDB logo and the text "Texas Water Development Board".

# Contact Information

**Please feel free to contact the us at the Texas Water Development Board**

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phone: (512)475-0470

Jean Broce Perez: Contract Manager

email: [Jean.Perez@twdb.texas.gov](mailto:Jean.Perez@twdb.texas.gov)

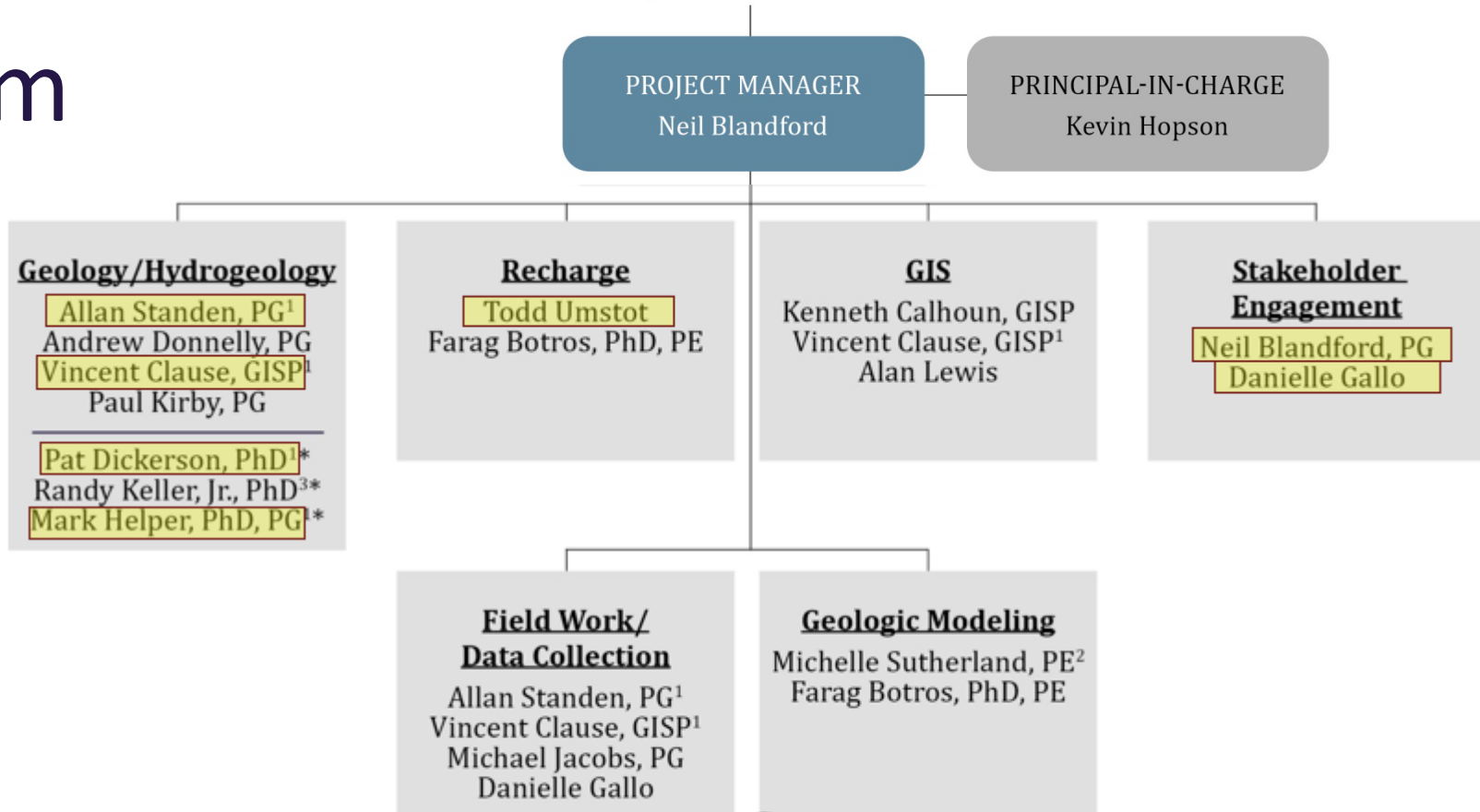
phone: (512)936-4017

Website: [www.twdb.texas.gov/groundwater/index.asp](http://www.twdb.texas.gov/groundwater/index.asp)

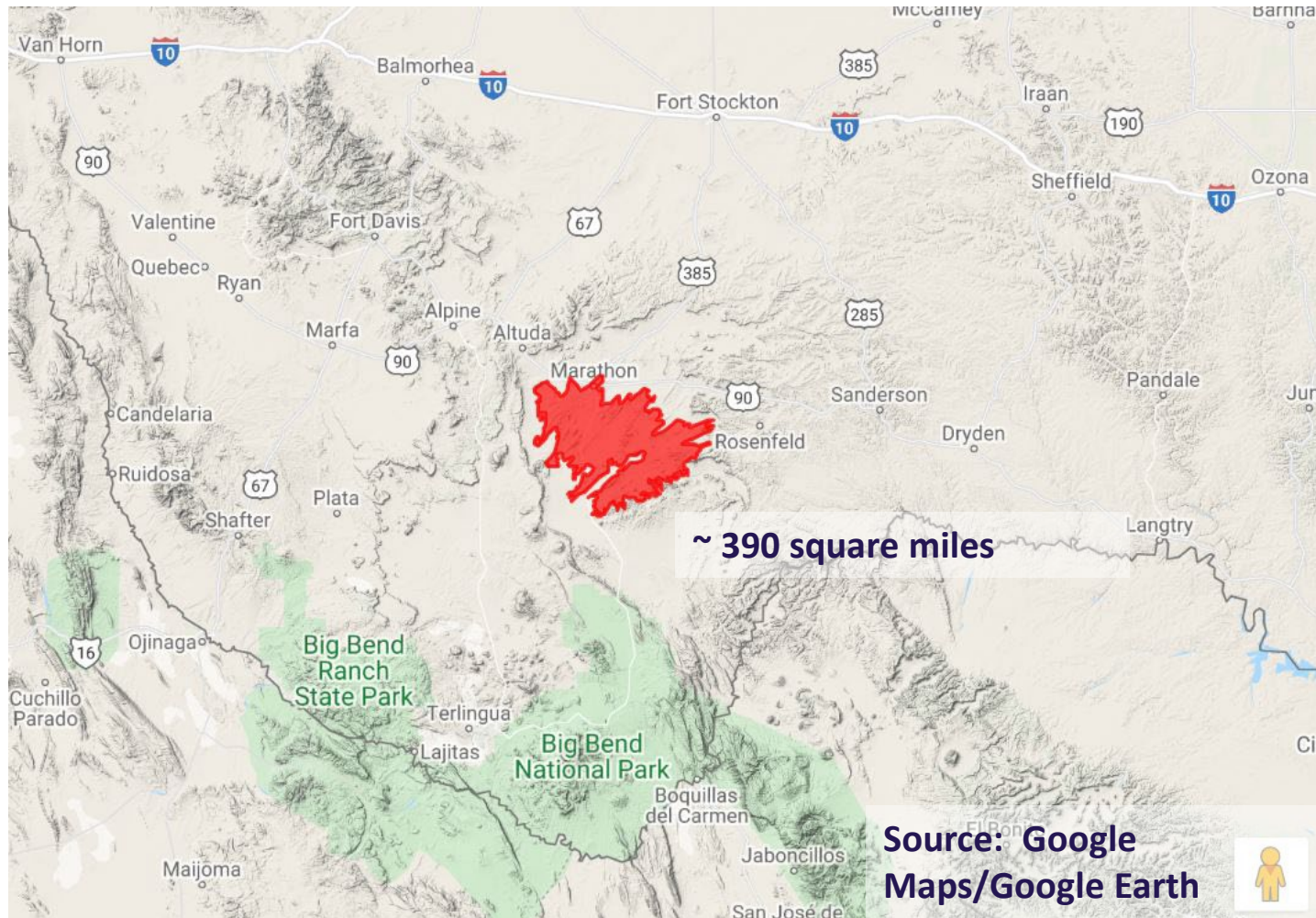


# Project Team

Texas Water Development Board  ← Jean Perez



# Marathon Aquifer



# Project Objectives

- Develop a conceptual model of the Marathon Aquifer
  - Describe the best understanding of the occurrence of groundwater and how groundwater moves through the aquifer system
- Future Goal: Develop numerical groundwater flow model (GAM) of the Marathon Aquifer

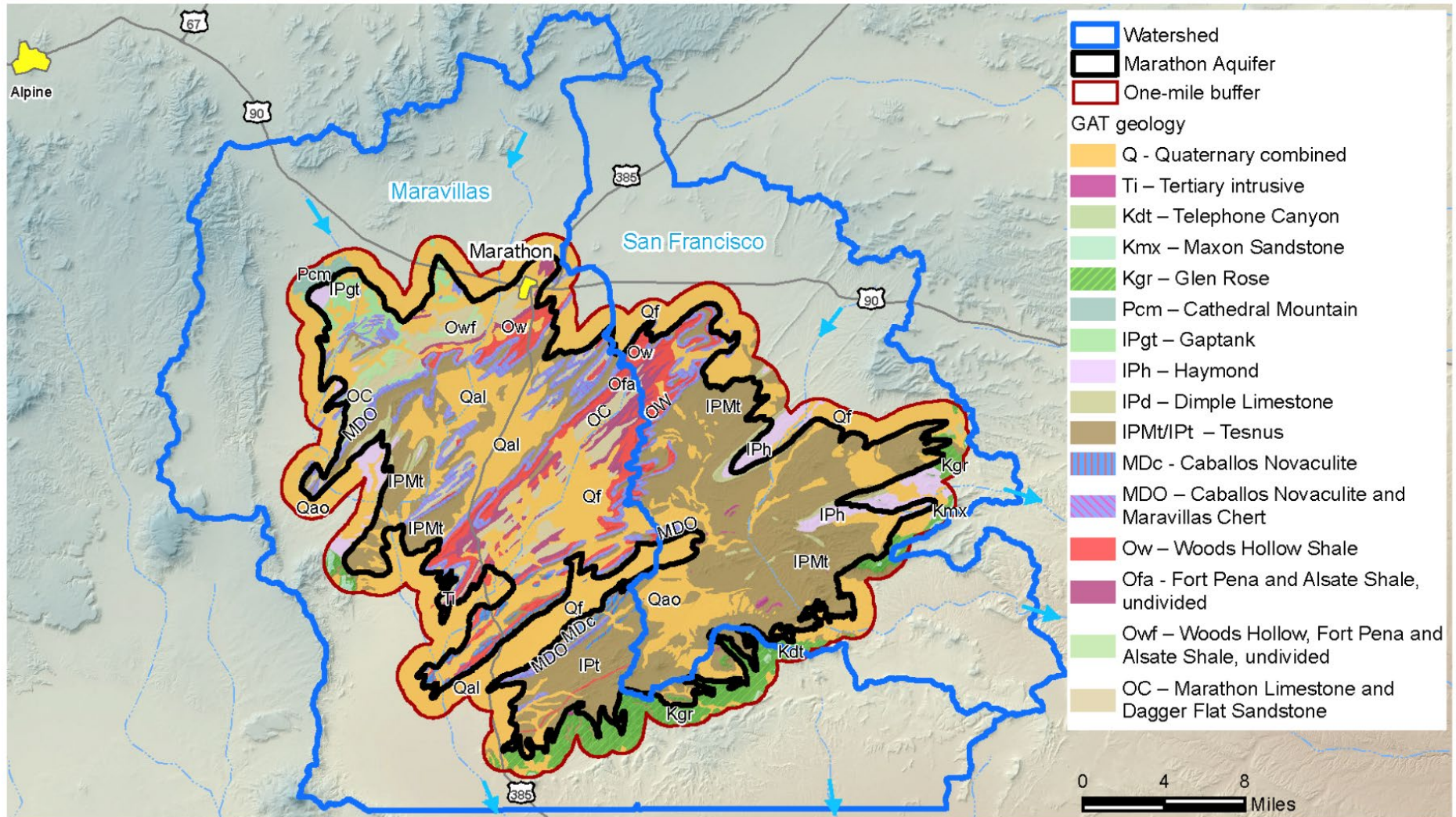


# Previous Studies

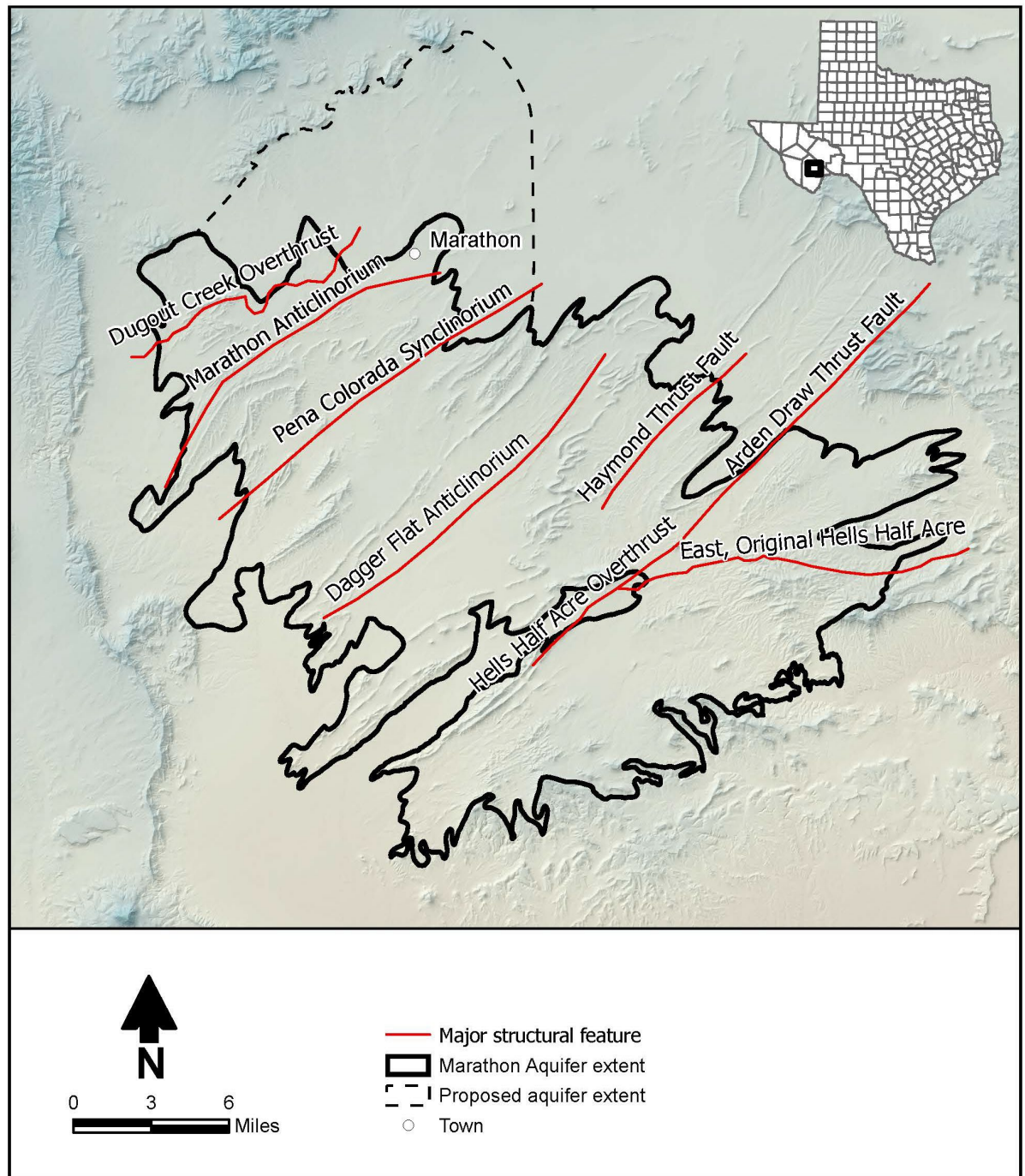
- Geology - Over 30 publications used in our proposal
- Hydrogeology
  - Brune (2002) - Springs of Texas
  - DeCook (1961) - Reconnaissance of Groundwater Resources in the Marathon Area
  - Muse (1966) - Water level data for Brewster and adjoining counties
  - Smith (2001) - Hydrogeology of the Marathon Basin



# Study Area and Surface Geology



# Main Structural Features in the Marathon Area



# Anticline



photo by Neil Blandford

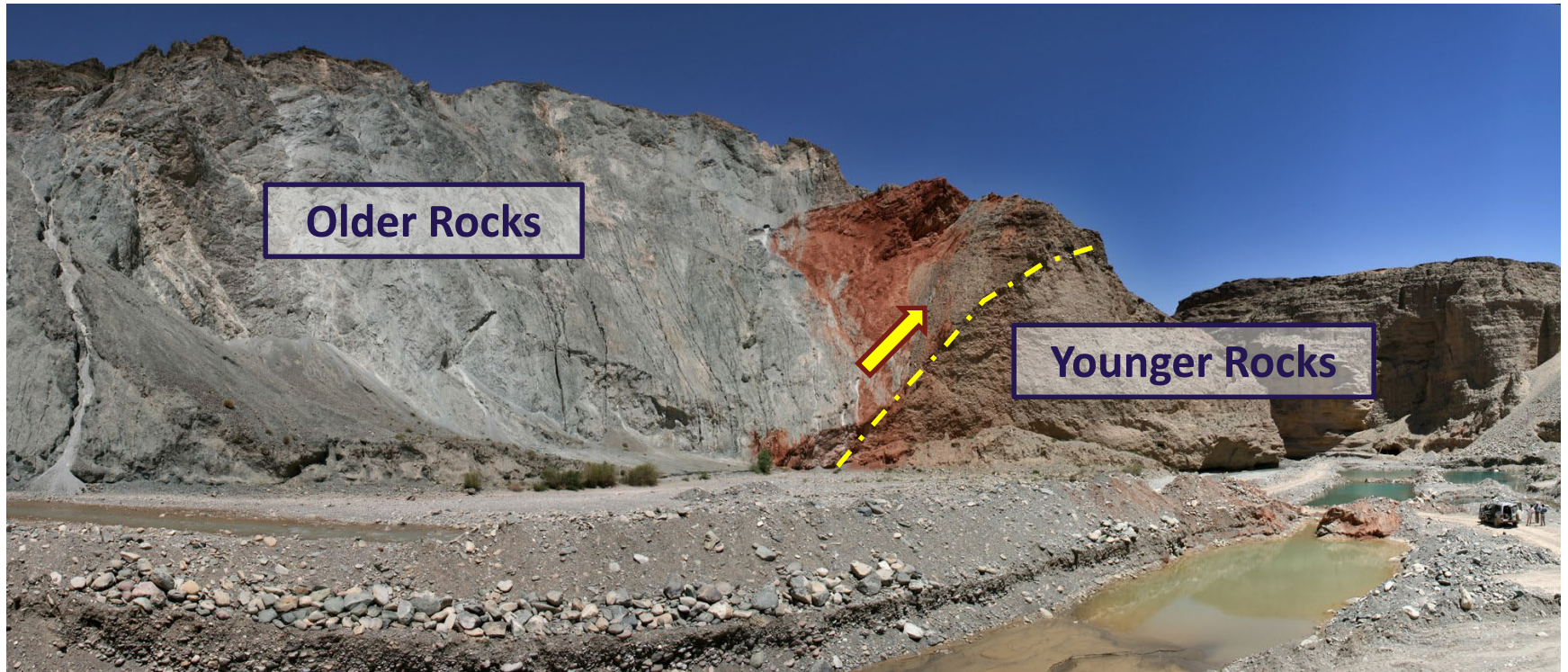
# Syncline



photo by Neil Blandford



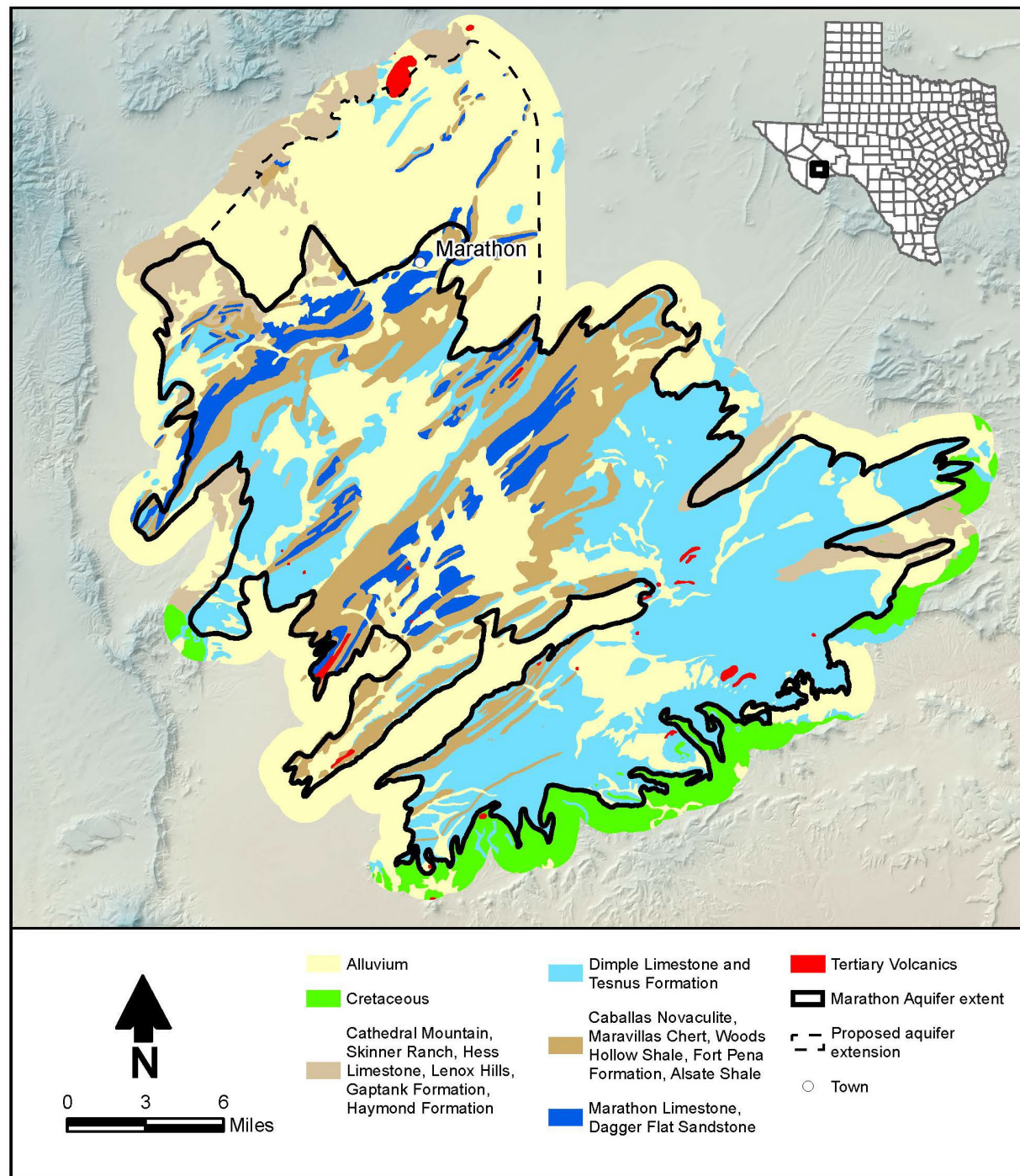
# Overthrust Fault



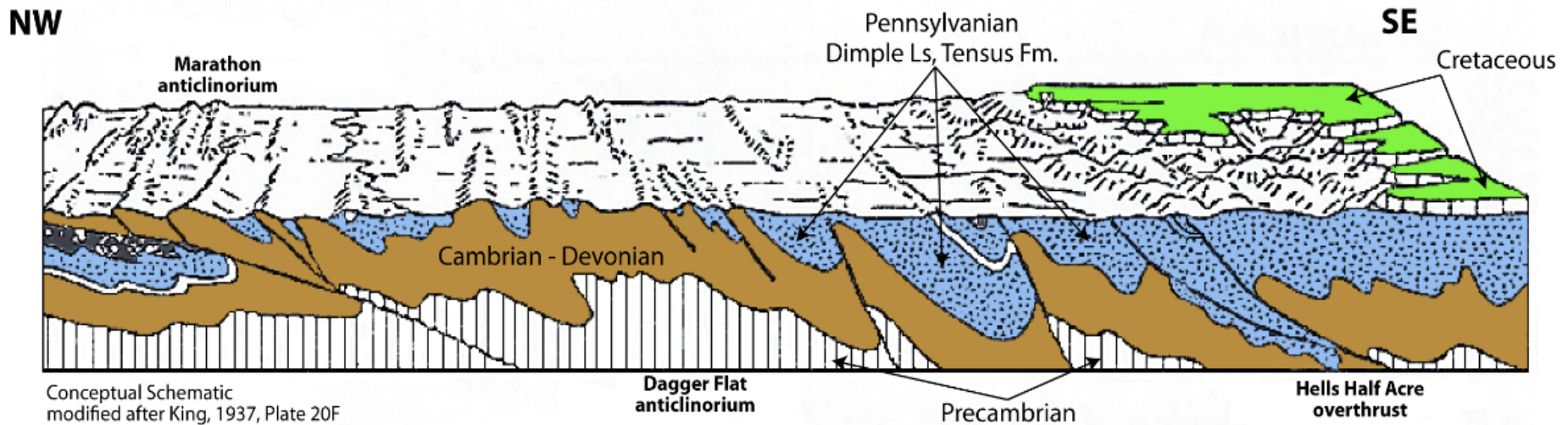
Source: [https://en.wikipedia.org/wiki/Thrust\\_fault](https://en.wikipedia.org/wiki/Thrust_fault)



# Main Structural Features of Marathon Aquifer after King (1937)



# Example King (1937) Cross Section



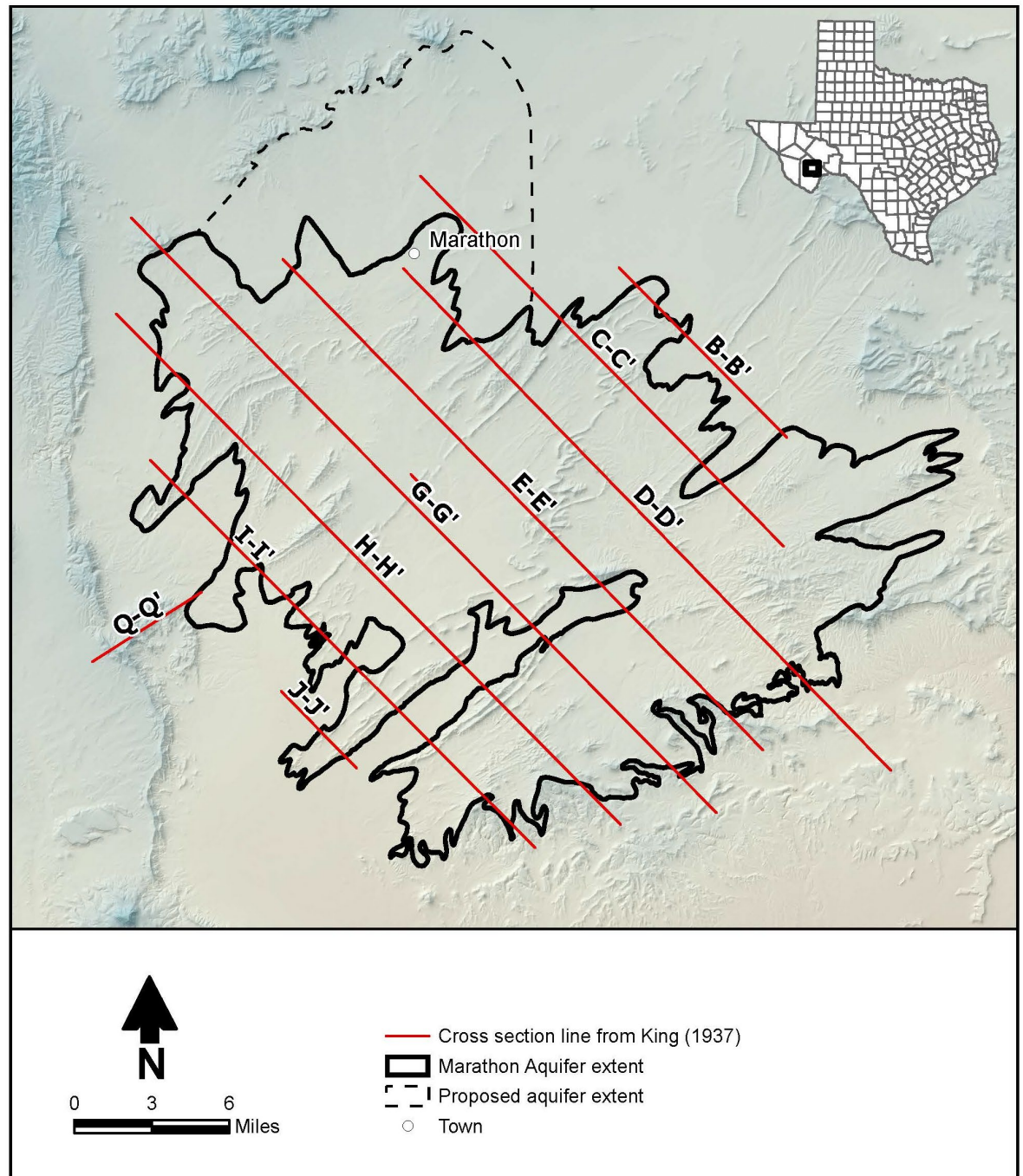
Blue – tends to be aquifer

Brown – tends to be aquitard

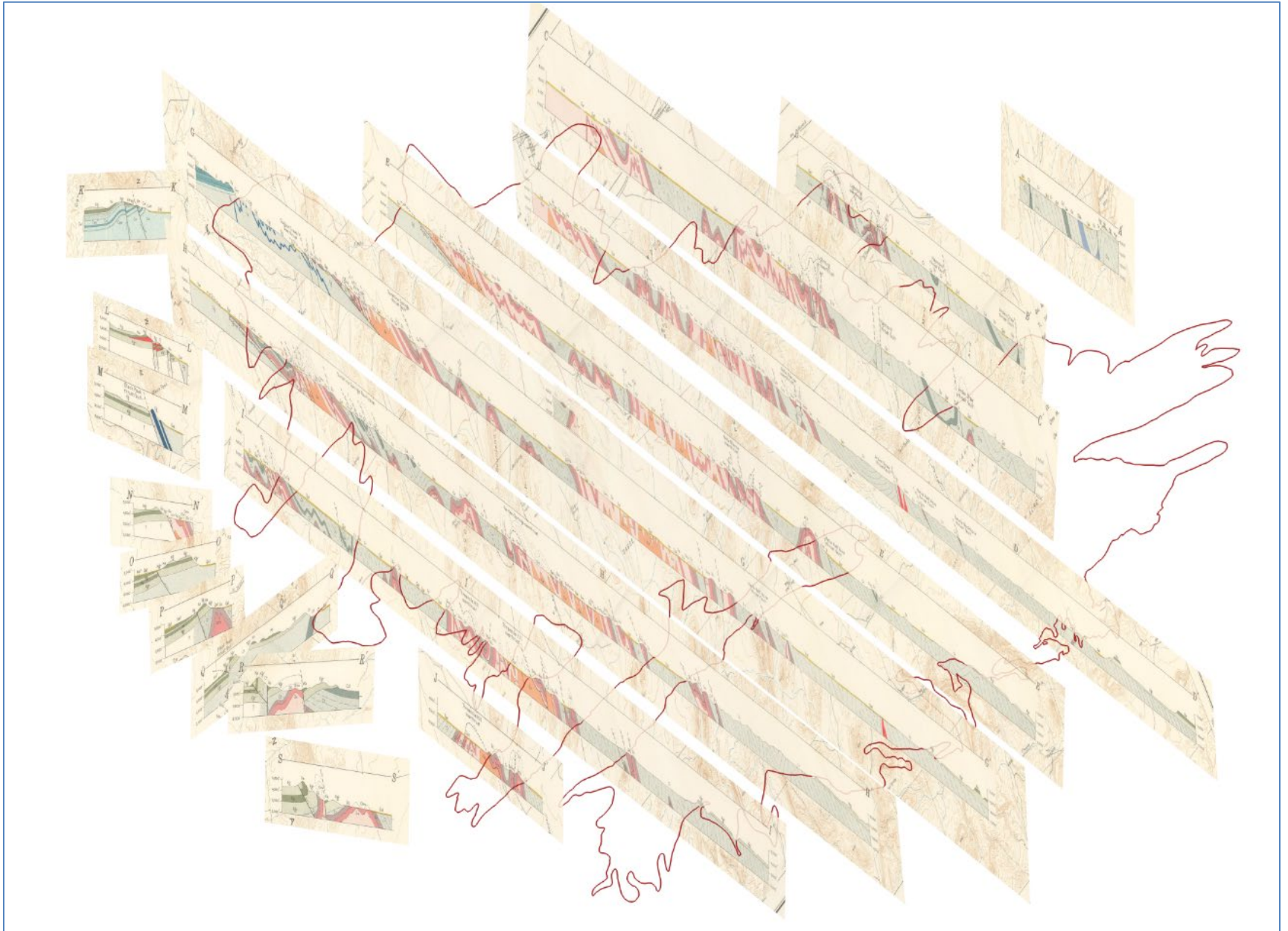
# Geologic Column and Hydrostratigraphic Designations

| Period and Series                          | Model Layer | Predominant Hydrogeologic Character    | Formation/ Geologic Unit          | Primary Lithology                         |
|--|-------------|--|-----------------------------------|---|
| Quaternary                                 | 1           | Aquifer                                | Alluvial types                    | Gravel, sand, silt, clay                  |
| Tertiary                                   | 2           | Aquitard                               | Volcanic intrusives               | Volcanic, intrusive rocks                 |
| Cretaceous, Lower Trinity                  | 3a          | Aquitard – not saturated in study area | Del Carmen and Telephone Canyon   | Limestones, chert, and shales             |
| Permian, Leonard                           |             |  | Maxon Sandstone                   | Sandstone and marl                        |
|  |             |  | Glen Rose                         | Limestone, marl, chert, conglomerate      |
|  |             |  | Cathedral Mountain                | Shale, limestone, and pebble conglomerate |
| Permian, Wolfcamp                          |             | Skinner Ranch and Hess Limestone       | Limestone and pebble conglomerate |   |
|  |             |  | Lenox Hills                       | Conglomerate, shale, and limestone        |
| Upper to Lower, Pennsylvanian              | 3b          | Aquitard                               | Gaptank                           | Limestone, sandstone conglomerate         |
|  |             |  | Haymond                           | Sandstone, shale, boulder beds            |
| Lower Pennsylvanian to Upper Mississippian | 4           | Aquifer                                | Dimple Limestone                  | Limestone and shale                       |
|  |             |  | Tesnus                            | Sandstone and shale                       |
| Devonian to Upper Ordovician               | 5           | Aquitard                               | Caballos Novaculite               | Novaculite and chert                      |
|  |             |  | Maravillas Chert                  | Chert conglomerate                        |
|  |             |  | Woods Hollow Shale                | Shale                                     |
|  |             |  | Fort Pena                         | Limestone, chert, and shale               |
|  |             |  | Alsate Shale                      | Shale, limestone, and sandstone           |
| Lower Ordovician to Upper Cambrian         | 6           | Aquifer                                | Marathon Limestone                | Limestone, sandstone, and conglomerate    |
|  |             |  | Dagger Flat Sandstone             | Sandstone                                 |

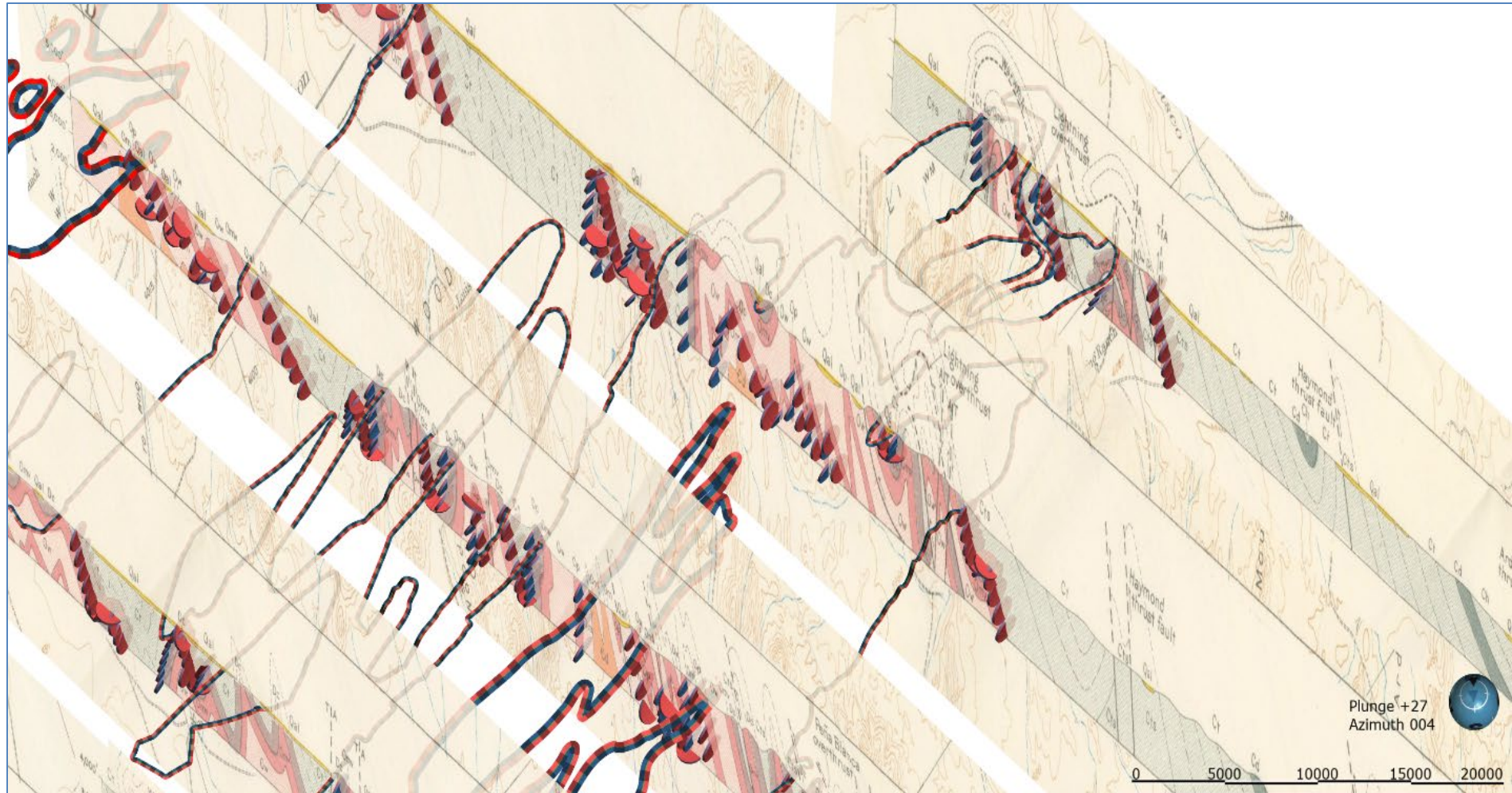
# Locations of King (1937) Cross Sections










# King (1937) Scanned/Georeferenced Cross Sections



# King (1937) Cross Sections – Close Up

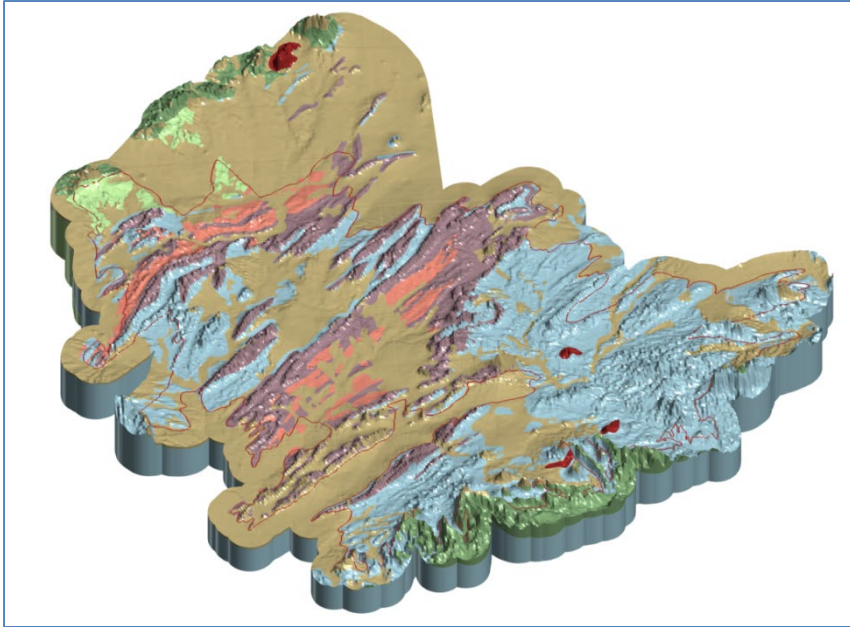


# Seven Hydrostratigraphic Units

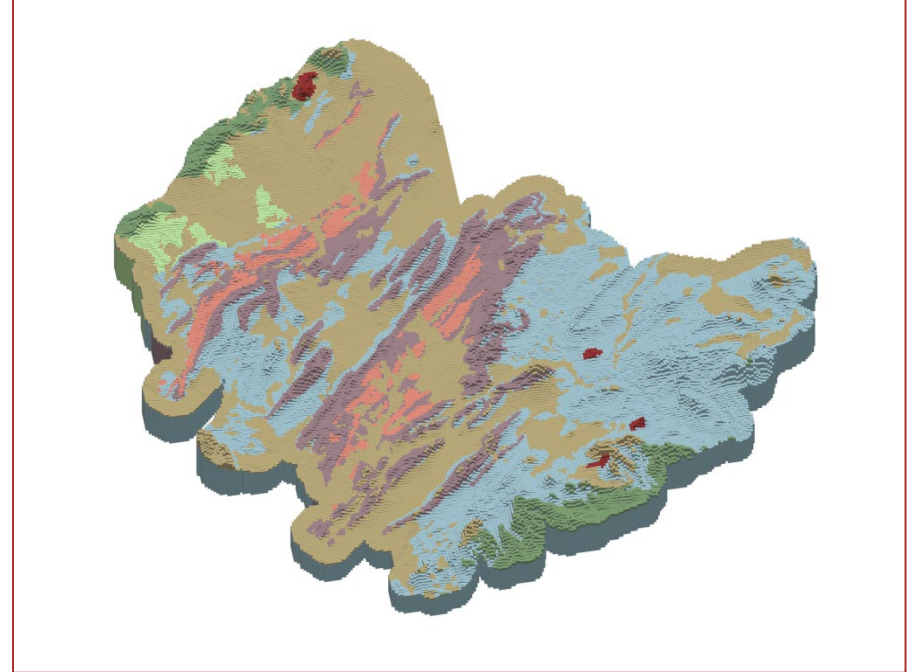
| Code   | Colour  |
|--|---|
| <i>1_Alluvium (Qal)</i>  |    |
| <i>2_Igneous (Ti)</i>  |    |
| <i>3a_Telephone Canyon, Glen Rose, Skinner Ranch, Hess, Lenox Hills (Ke, Kgr, Cw)</i>      |    |
| <i>3b_Gaptank, Haymond (Cg, Ch)</i>  |    |
| <i>4_Dimple, Tensus (Cd, Ct)</i>   |    |
| <i>5_Caballos, Maravillas, Fort Pena, Woods Hollow, Alsate Shale (Dc, Omv, Op, Ow, Oa)</i> |  |
| <i>6_Marathon and Dagger Flat (Om, -Cd)</i>  |  |



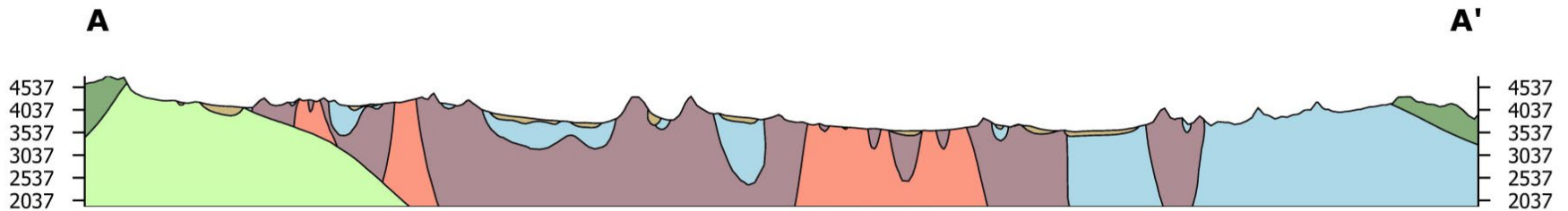
# Completed 3-D Geology



# Interpolation to Groundwater Model Grid



# Leapfrog Section A-A'



Scale: 1:200,000

Vertical exaggeration: 5x



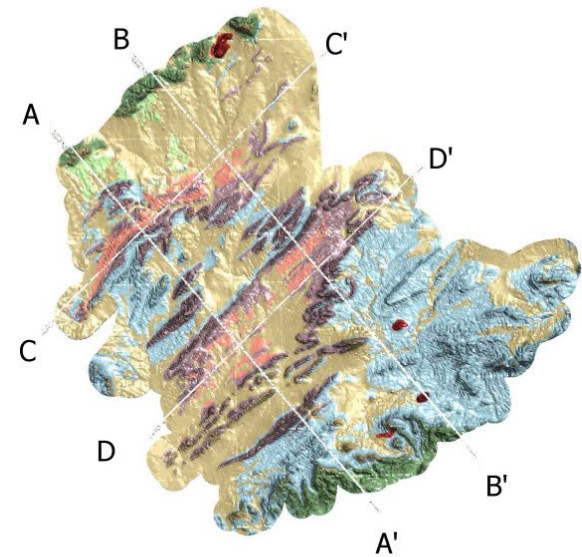
## Location

A: 3841920, 19324103

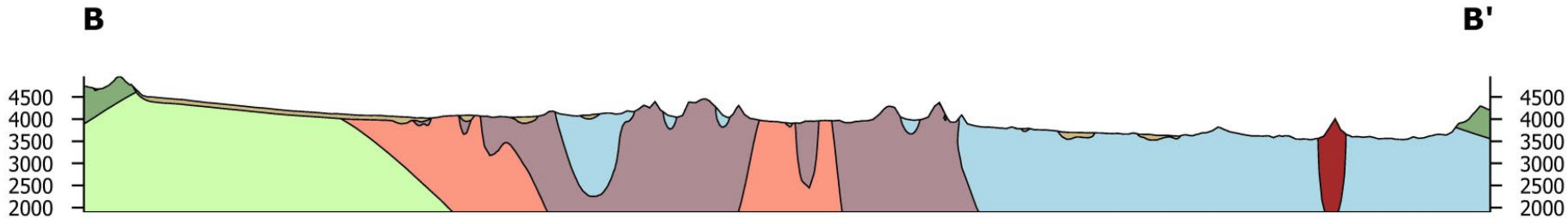
A': 3939418, 19204830

## Legend

- 1\_Alluvium (Qal)
- 3a\_Telephone Canyon, Glen Rose, Skinner Ranch, Hess, Lenox Hills (Ke, Kgr, Cw)
- 3b\_Gaptank, Haymond (Cg, Ch)
- 4\_Dimple, Tensus (Cd, Ct)
- 5\_Caballos, Maravillas, Fort Pena, Woods Hollow, Alsate Shale (Dc, Omv, Op, Ow, Oa)
- 6\_Marathon and Dagger Flat (Om, -Cd)



# Leapfrog Section B-B'



Scale: 1:210,000

Vertical exaggeration: 5x



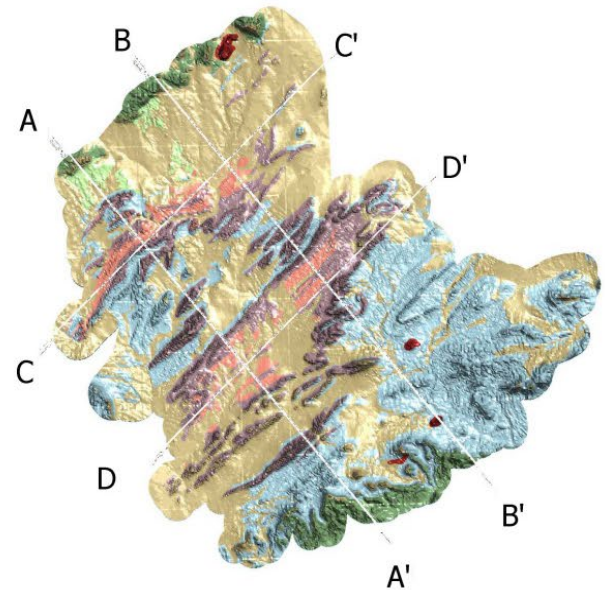
## Location

B: 3869802, 19348994

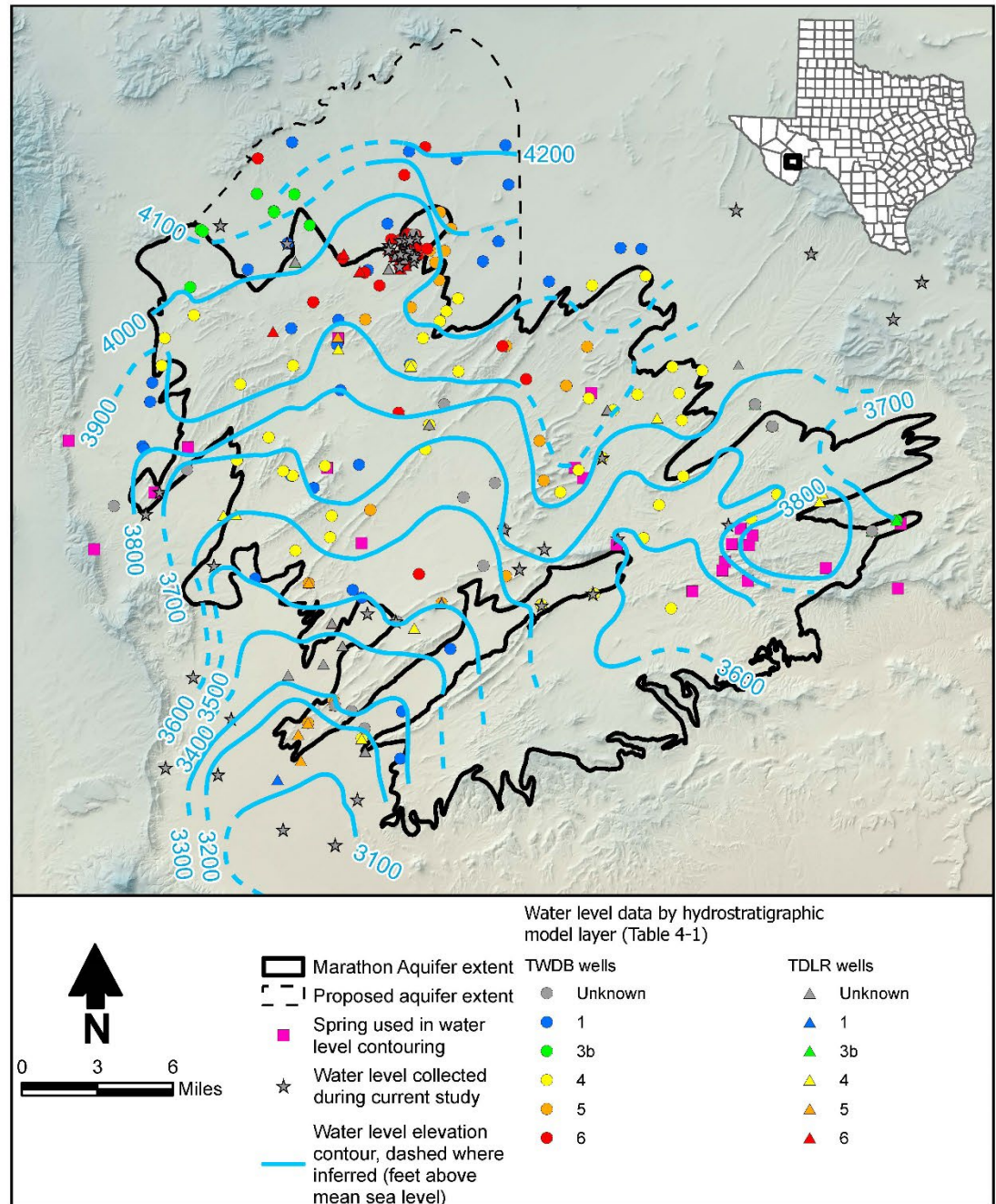
B': 3972983, 19222769

## Legend

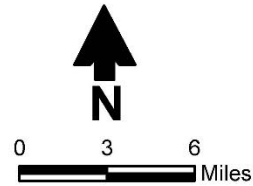
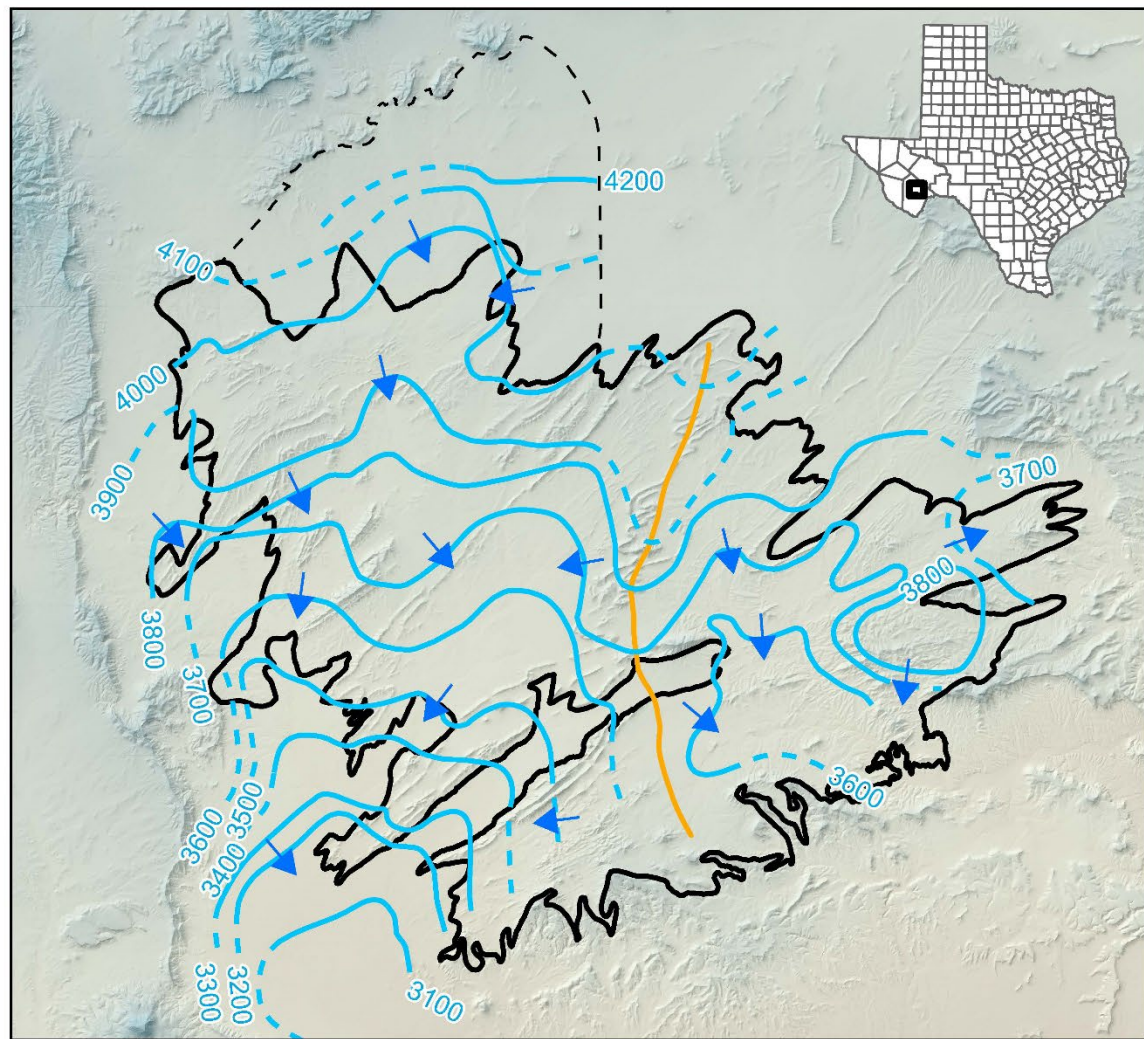
- 1\_Alluvium (Qal)
- 2\_Igneous (Ti)
- 3a\_Telephone Canyon, Glen Rose, Skinner Ranch, Hess, Lenox Hills (Ke, Kgr, Cw)
- 3b\_Gaptank, Haymond (Cg, Ch)
- 4\_Dimple, Tensus (Cd, Ct)
- 5\_Caballos, Maravillas, Fort Pena, Woods Hollow, Alsate Shale (Dc, Omv, Op, Ow, Oa)
- 6\_Marathon and Dagger Flat (Om, -Cd)



# Regional Marathon Aquifer Water Levels

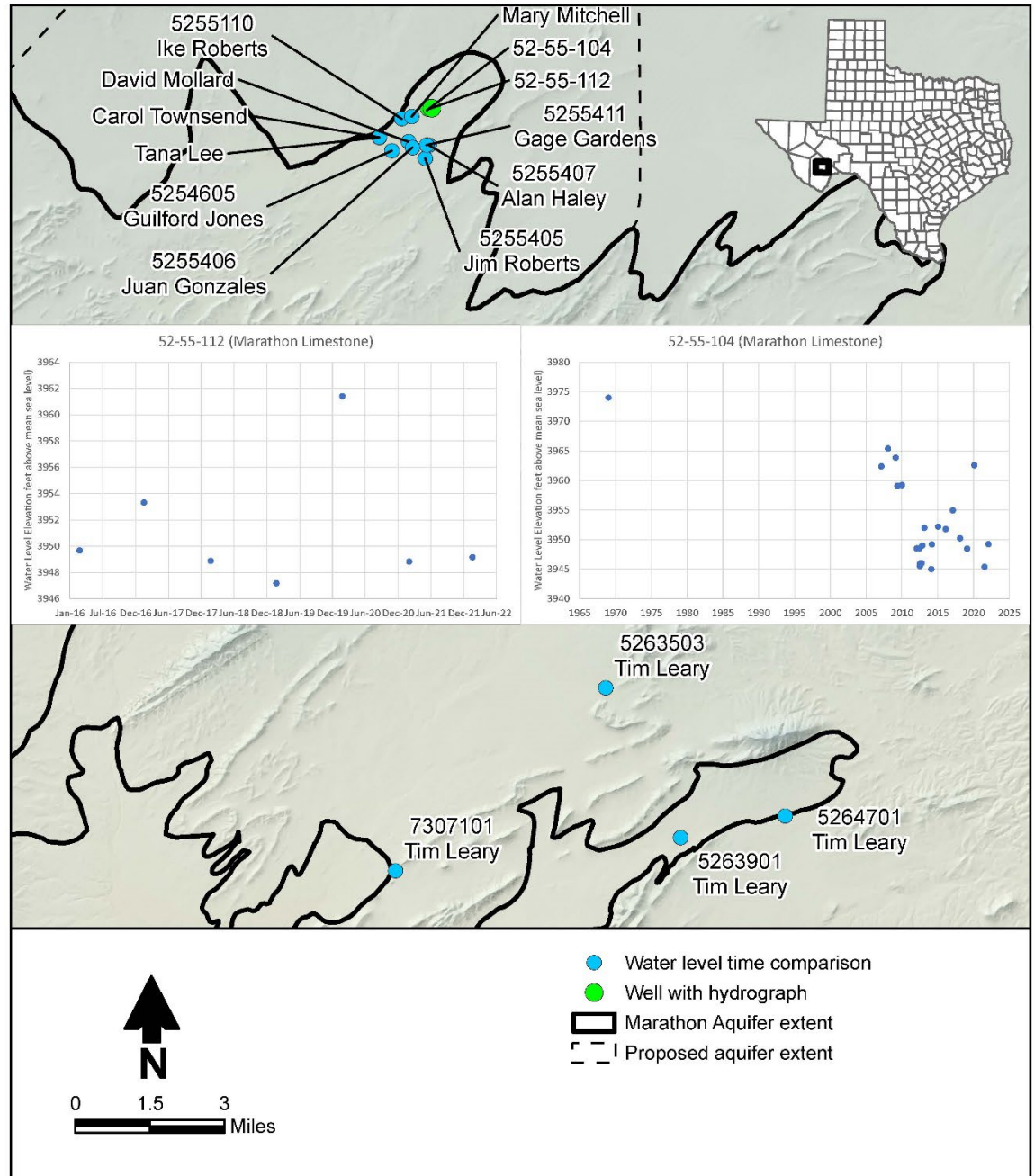


# Regional Groundwater Flow Direction



- Marathon Aquifer extent
- Proposed aquifer extent
- Groundwater divide
- Water level elevation contour, dashed where inferred (feet above mean sea level)
- Direction of groundwater flow

# Water Levels Through Time

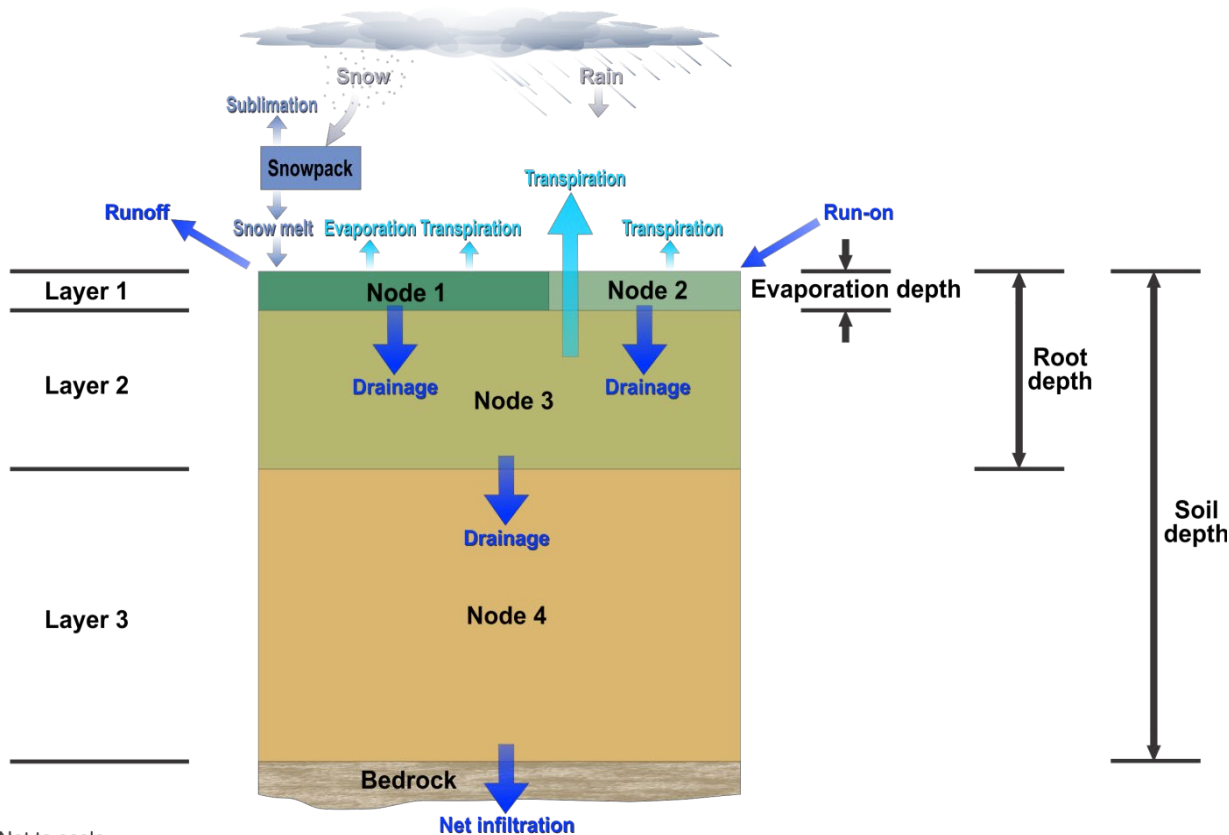


# Water Levels Through Time

| State Well Number | Current Owner  | Well Depth (feet) | First Measurement |                       | Second Measurement |                       | Change (feet) | Percent Change in Water Column |
|-------------------|----------------|-------------------|-------------------|-----------------------|--------------------|-----------------------|---------------|--------------------------------|
|                   |                |                   | Date              | Depth to Water (feet) | Date               | Depth to Water (feet) |               |                                |
|                   | David Mollard  | 343               | 5/9/2019          | 146                   | 5/4/2021           | 142                   | 4             | 2.0%                           |
| 5255407           | Alan Haley     | 185               | 3/21/2006         | 110                   | 5/5/2021           | 121                   | -11           | -14.7%                         |
| 5255405           | Jim Roberts    | 205               | 12/13/2006        | 123.17                | 5/4/2021           | 134                   | -11           | -13.2%                         |
| 5254605           | Guilford Jones | 515               | 10/27/2004        | 75                    | 7/19/2021          | 105                   | -30           | -6.8%                          |
| 5255411           | Gage Gardens   | 425               | 4/28/2009         | 108.1                 | 6/16/2021          | 120                   | -12           | -3.8%                          |
| 7307101           | Tim Leary      | Unknown           | 7/28/2021         | 27                    | 8/3/2021           | 12                    | 15            | —                              |
| 5264701           | Tim Leary      | Unknown           | 9/16/1957         | 95.9                  | 8/4/2021           | 87                    | 9             | —                              |
| 5263503           | Tim Leary      | Unknown           | 9/16/1957         | 67.9                  | 8/7/2021           | 70                    | -2            | —                              |
| 5263901           | Tim Leary      | Unknown           | 4/7/1973          | 30                    | 8/8/2021           | 76                    | -46           | —                              |
|                   | Tana Lee       | 250               | 4/18/2017         | 84                    | 3/19/2022          | 89                    | -5            | -3.0%                          |
| 5255110           | Ike Roberts    | Unknown           | 6/21/2011         | 120.55                | 2/25/2022          | 109                   | 12            | —                              |
| 5255406           | Juan Gonzales  | 225               | 11/15/2006        | 100                   | 4/3/2022           | 117                   | -17           | -13.6%                         |
|                   | Mary Mitchell  | 278               | 4/4/2008          | 139                   | 3/25/2022          | 151                   | -12           | -8.6%                          |
|                   | Carol Townsend | 230               | 4/18/2017         | 84                    | 3/19/2022          | 83                    | 1             | 0.7%                           |



# Distributed Parameter Watershed Model (DPWM) Operation



- Soil water-balance
- Site-specific climate, topography, geology, soils and vegetation
- Daily time step

Not to scale

## Notes:

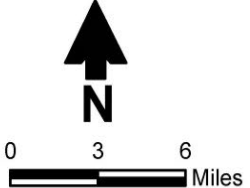
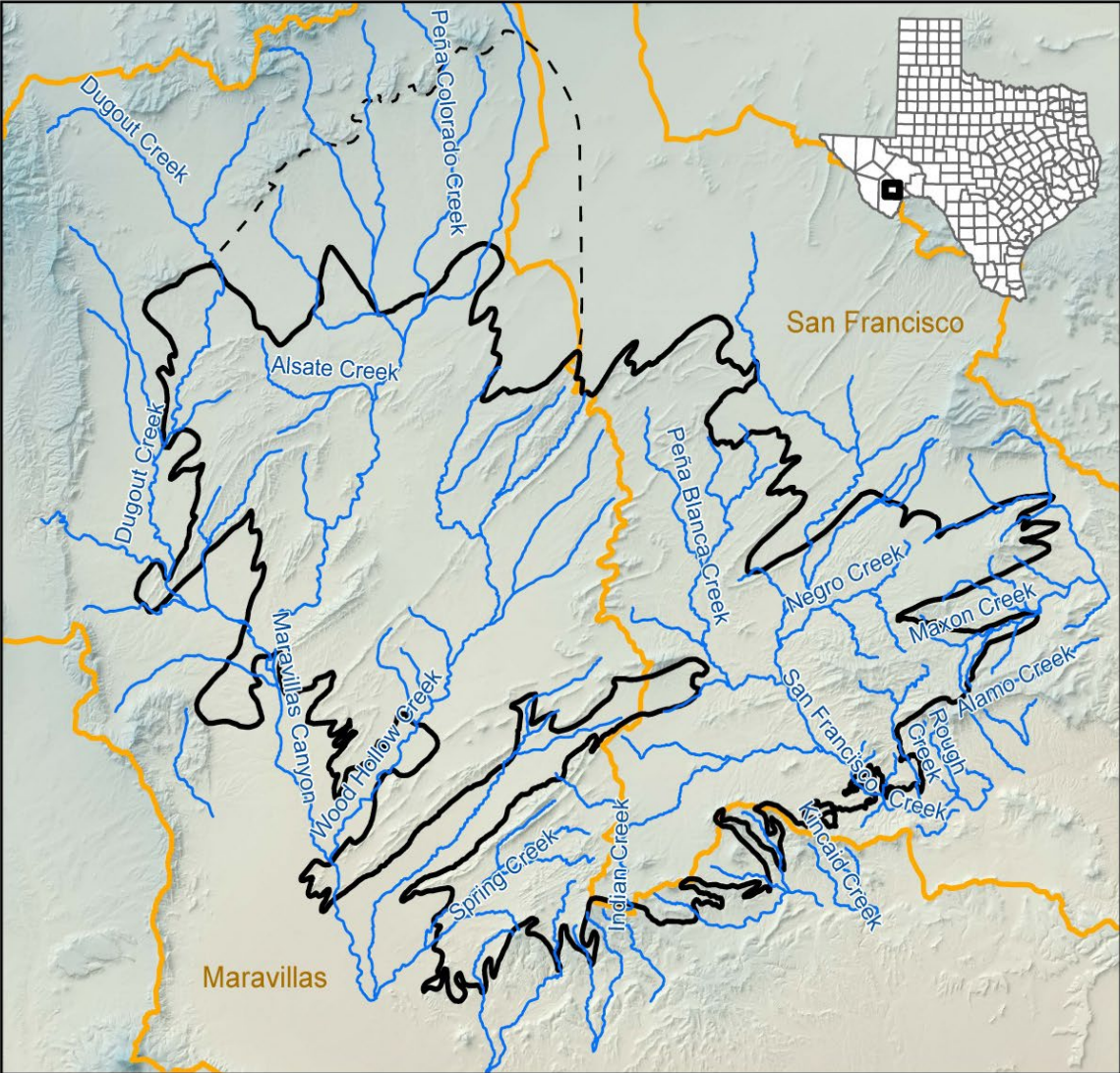
**Node 1** = fraction exposed and wetted ( $f_{ew}$ )

**Node 2** = fraction covered by vegetation canopy ( $f_v$ )



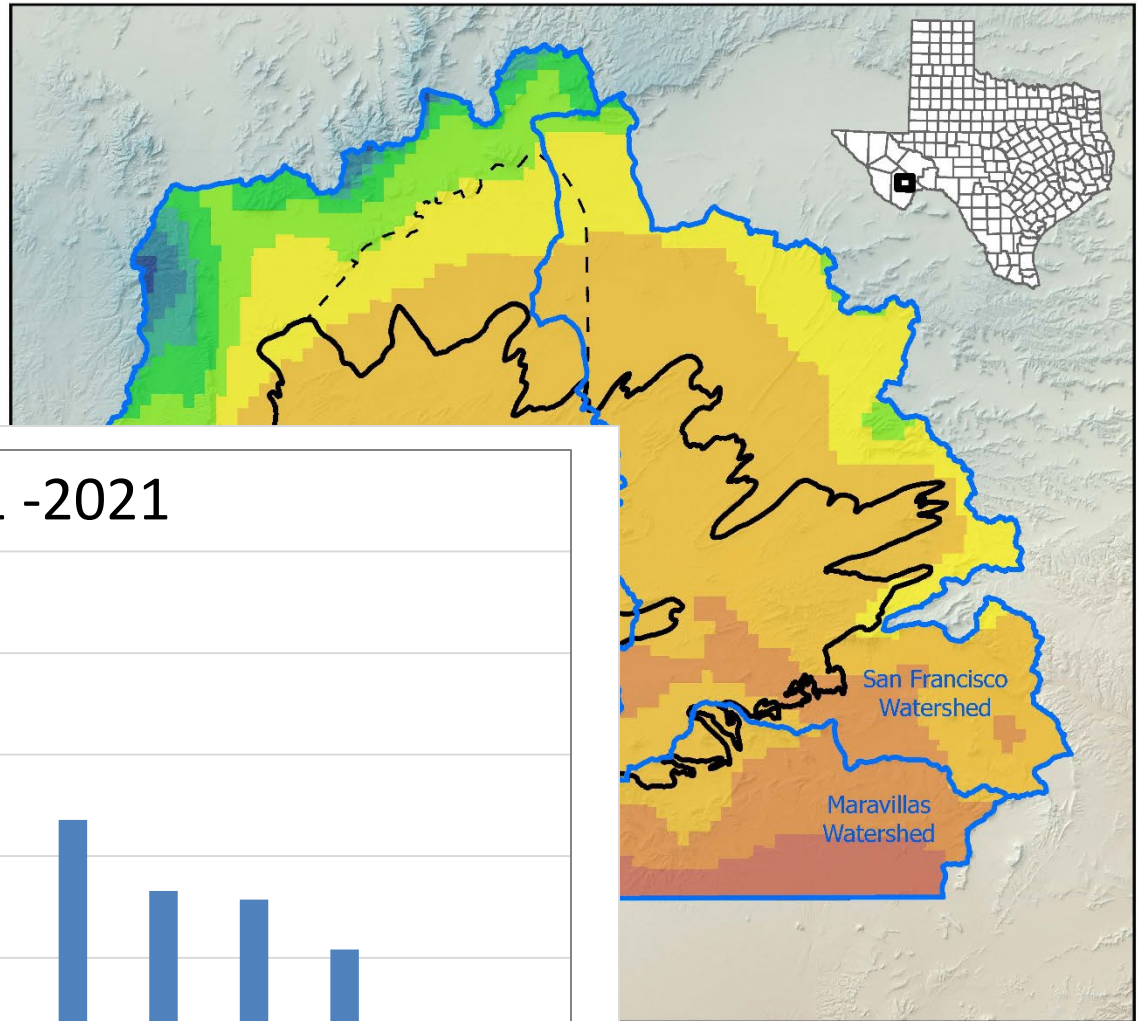


# Major Drainages

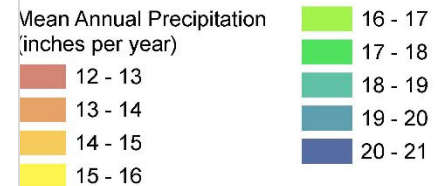
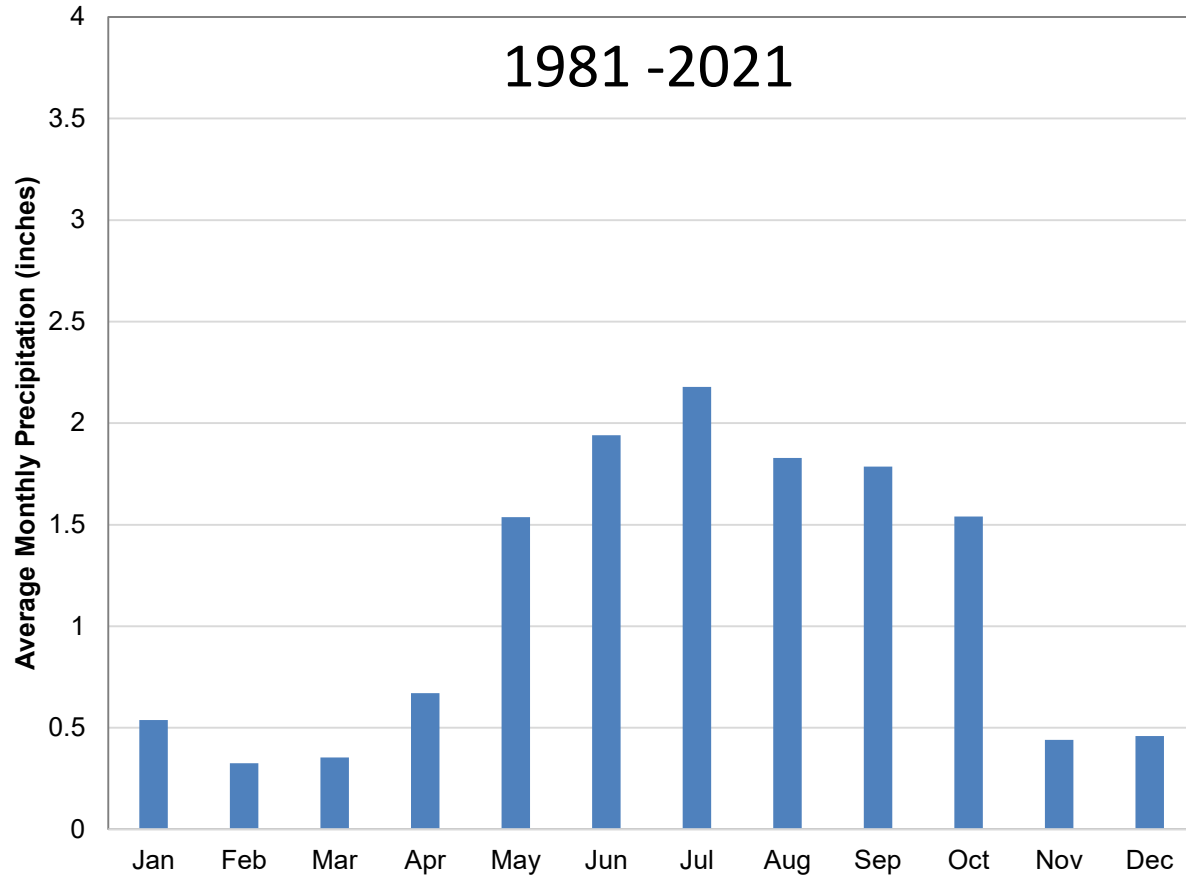


- Drainage
- Watershed
- Marathon Aquifer extent
- - - Proposed aquifer extent

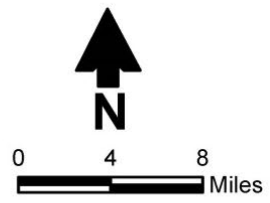
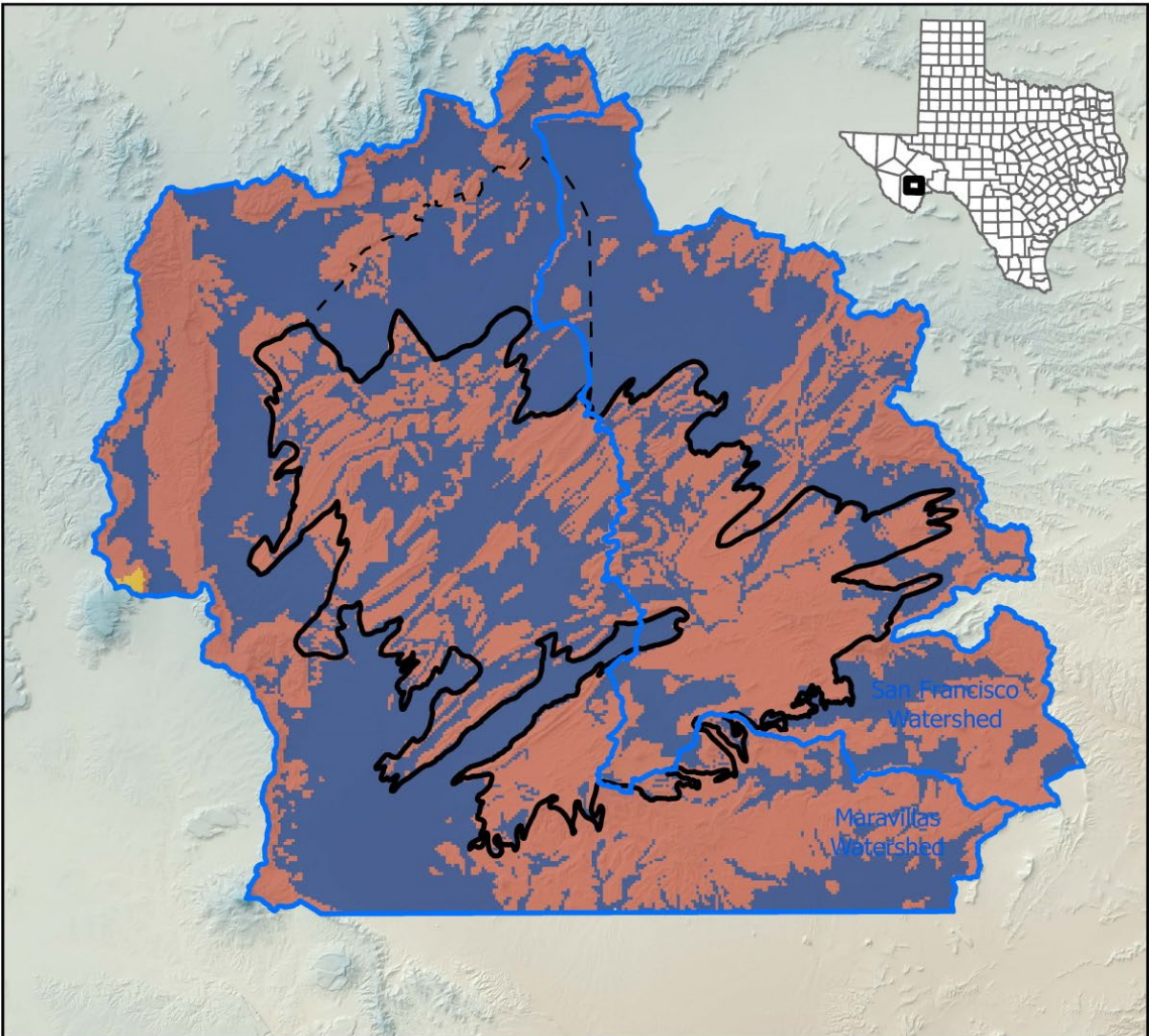
# Mean Annual Precipitation



1981 - 2021



# Distribution of Soil Depth

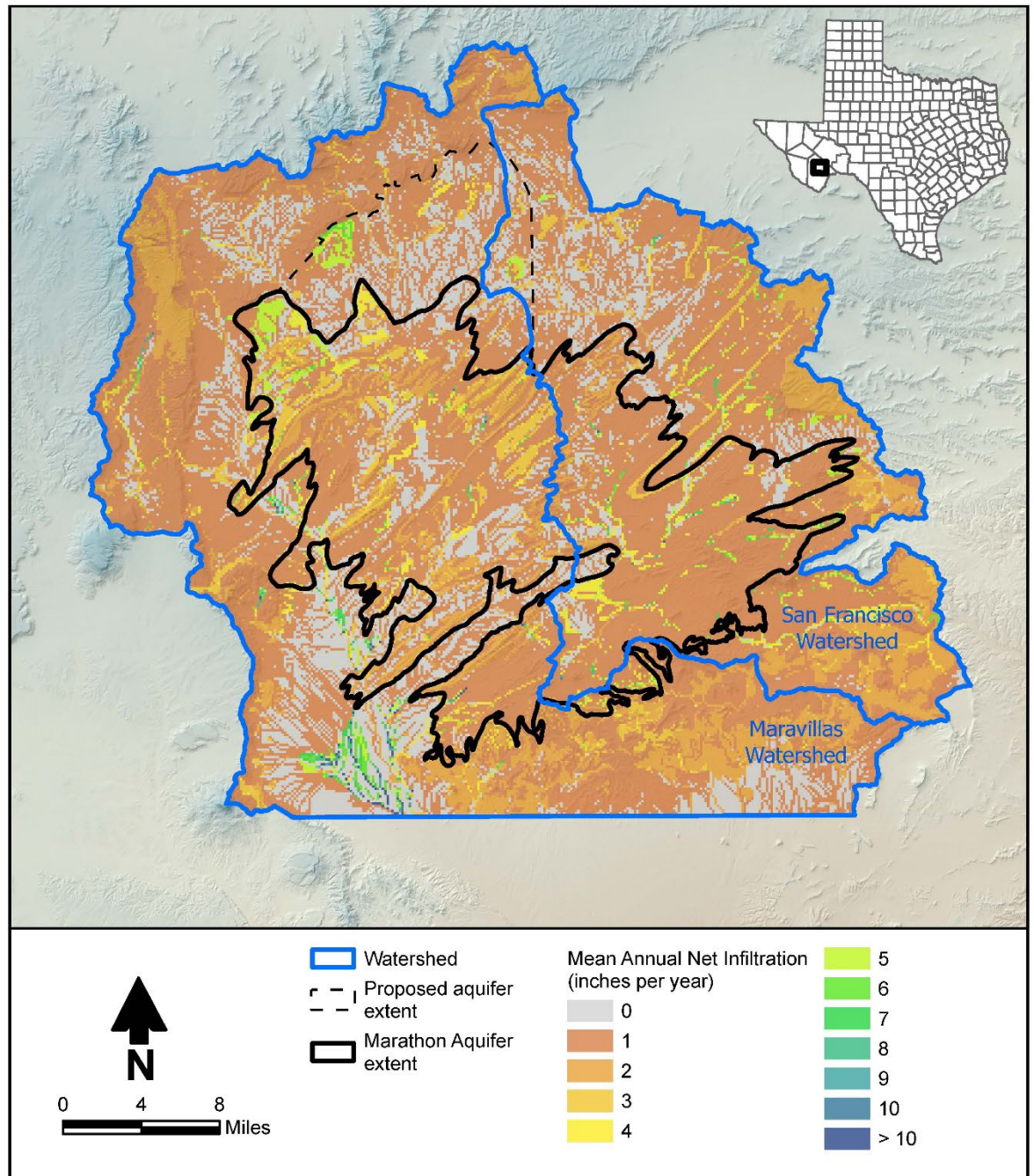


- Watershed
- Proposed aquifer extent
- Marathon Aquifer extent

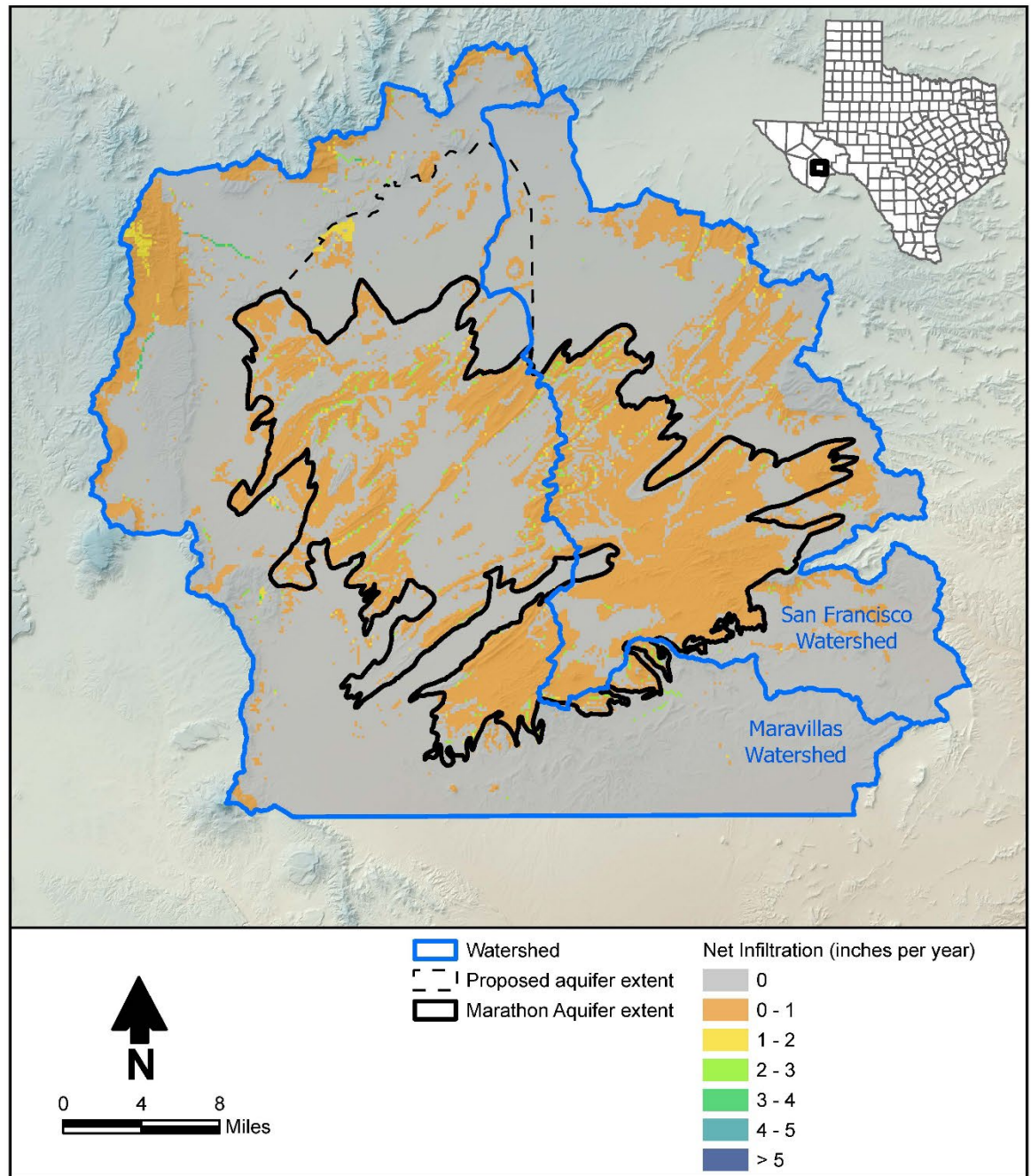
- Soil depth (meters)
- < 0.5
  - 0.5 - 1.0
  - 1 - 2
  - 2 - 3
  - > 3

# Mean Annual Groundwater Recharge

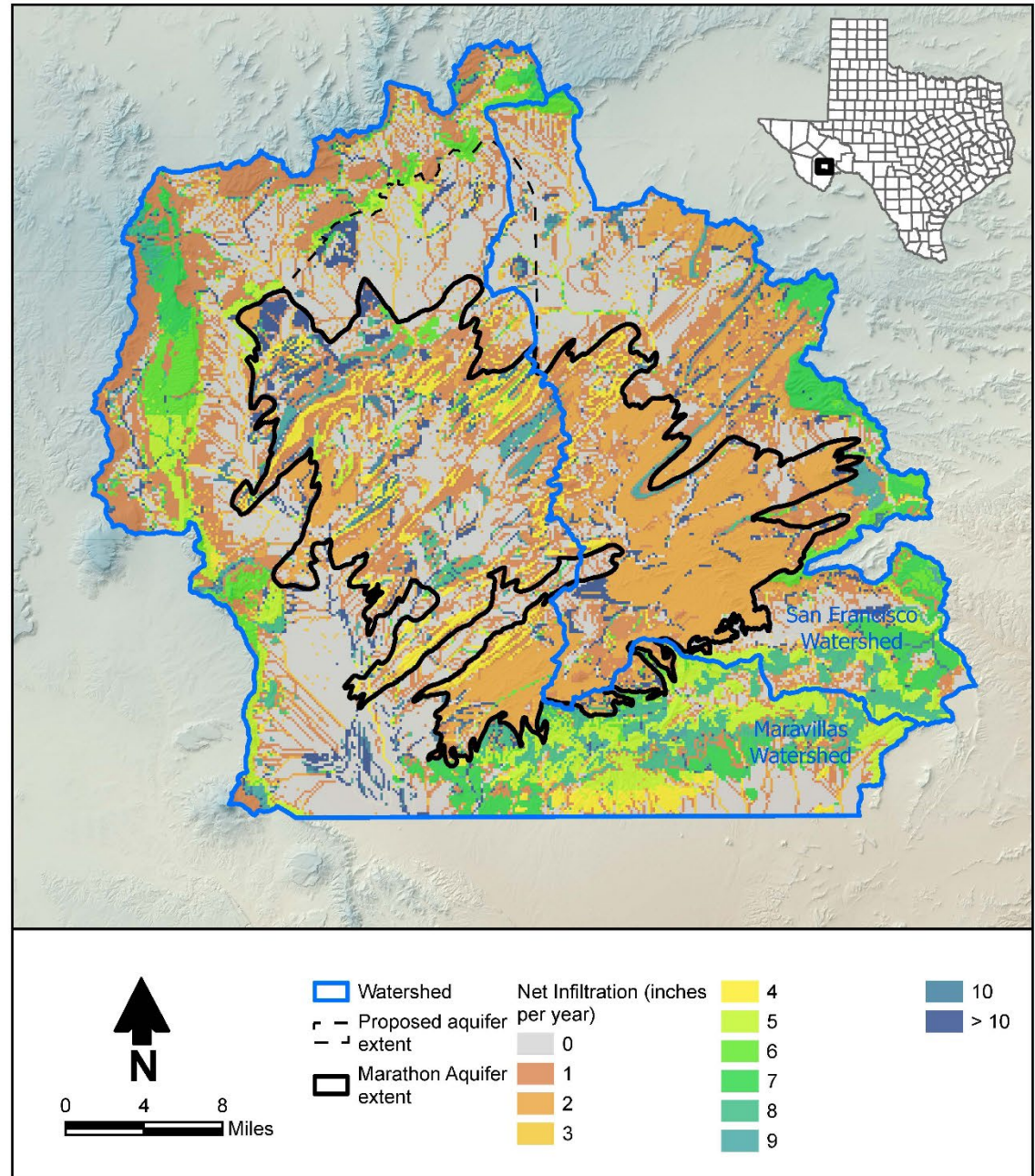
21,284 ac-ft/yr



# Dry Year Groundwater Recharge - 2011

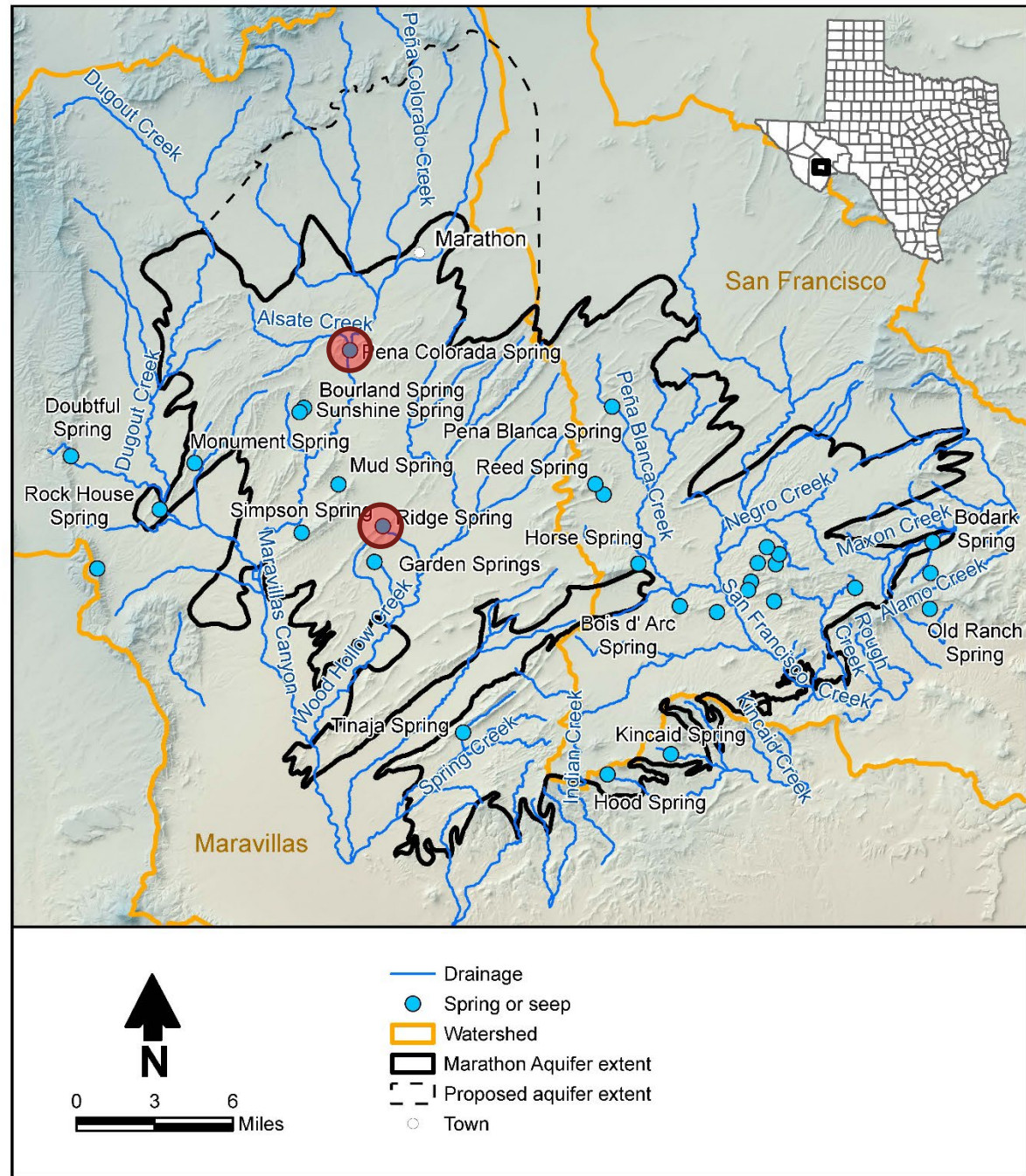


# Wet Year Groundwater Recharge - 2004

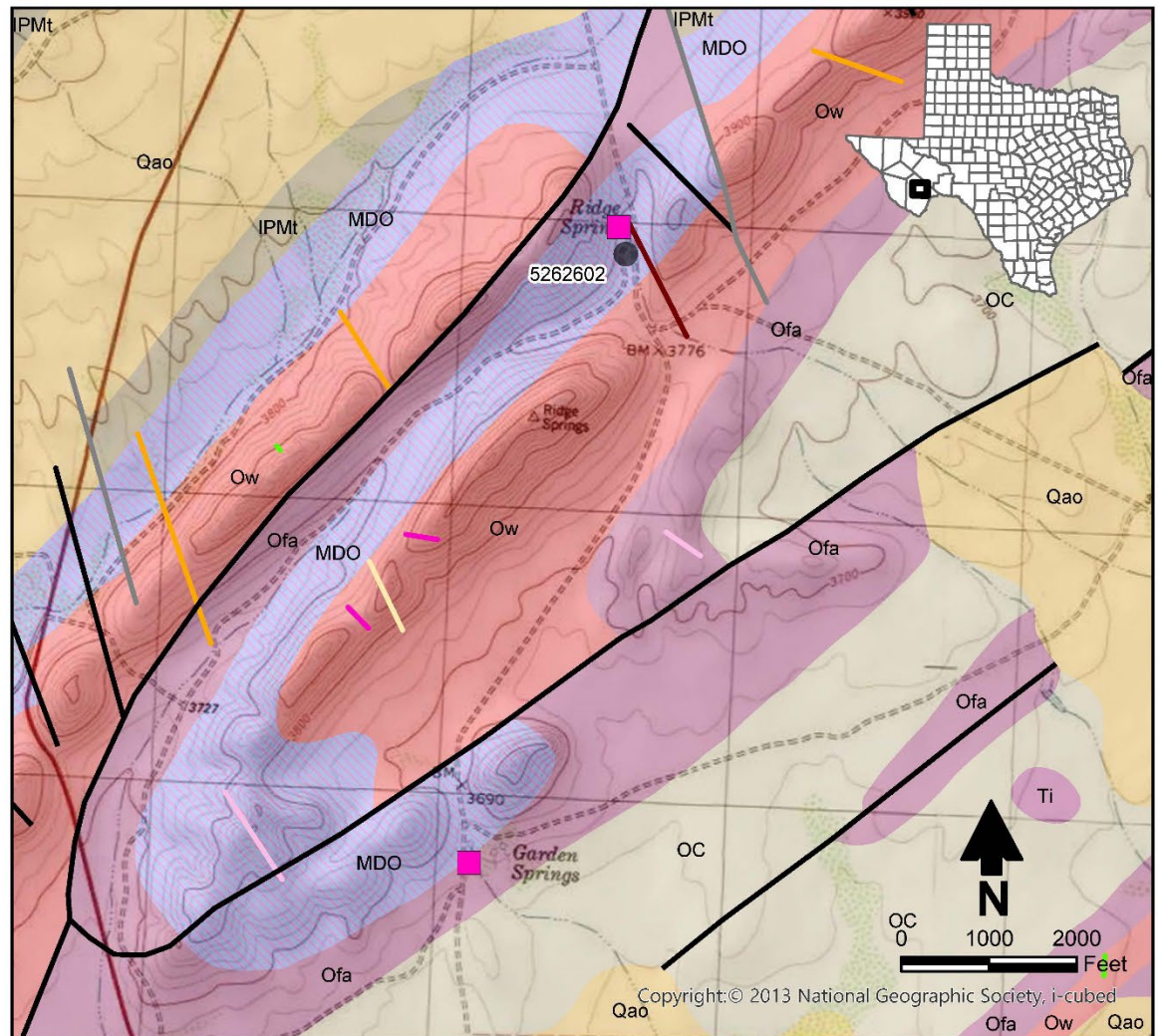


# Drainages and Springs

| Spring        | Flow range (gpm) |
|---------------|------------------|
| Pena Colorada | 151-444          |
| Ridge         | 95-320           |



# Ridge Spring



## Lineament analysis

- Fracture in outcrop
- Lineament with no observed separation
- Lineament with possible separation
- Lineament with < 100 feet of separation
- Lineament with 100 - 250 feet of separation

- Lineament with > 500 feet of separation
- GAT Fault
- GAT Replacement
- GAT Fault - Off

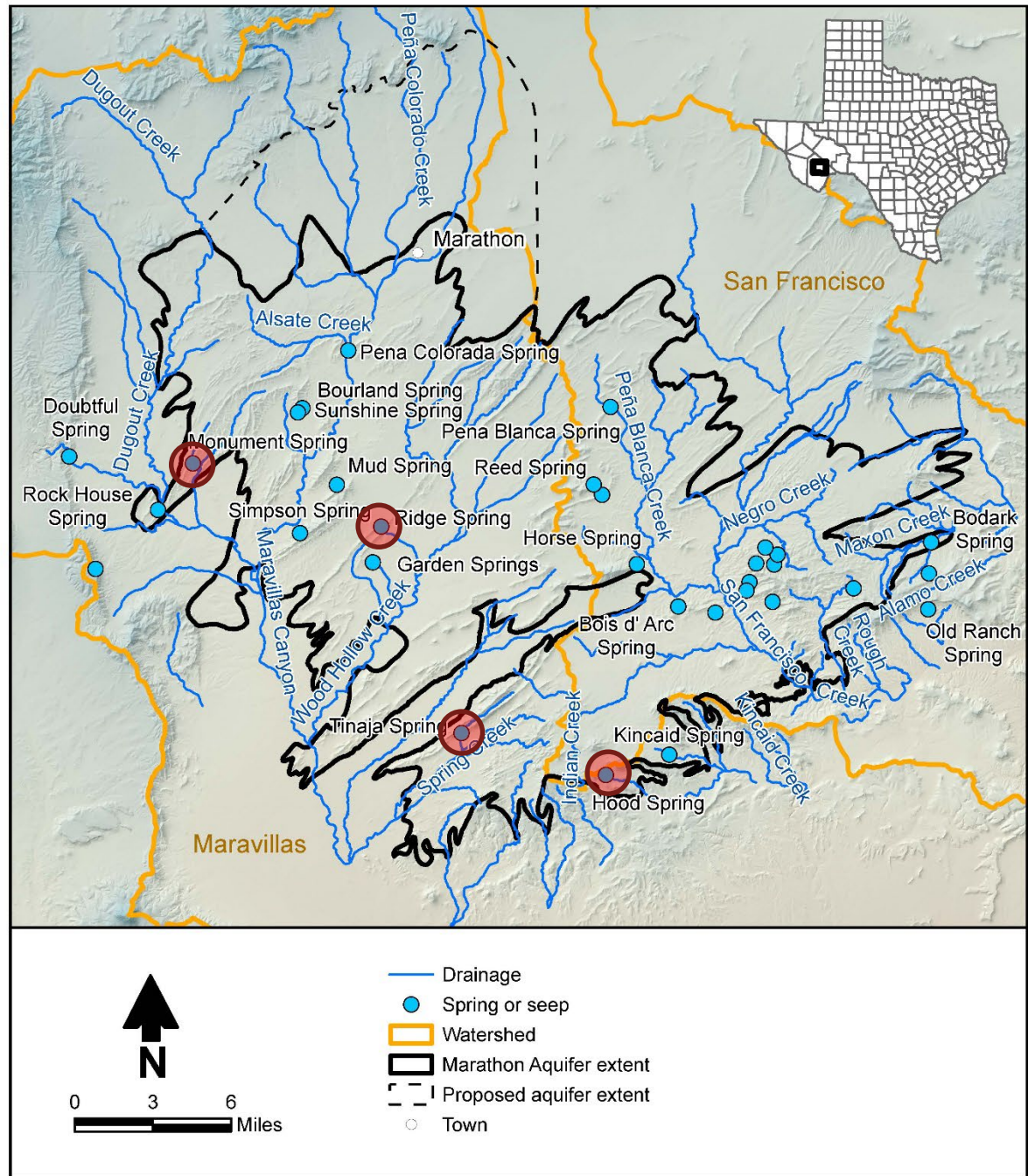
## Geology

- Q\_ - Quaternary combined
- Ti - Tertiary intrusive
- IPMt/IPt - Tesnus

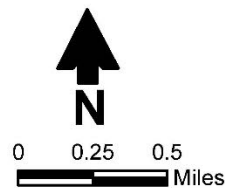
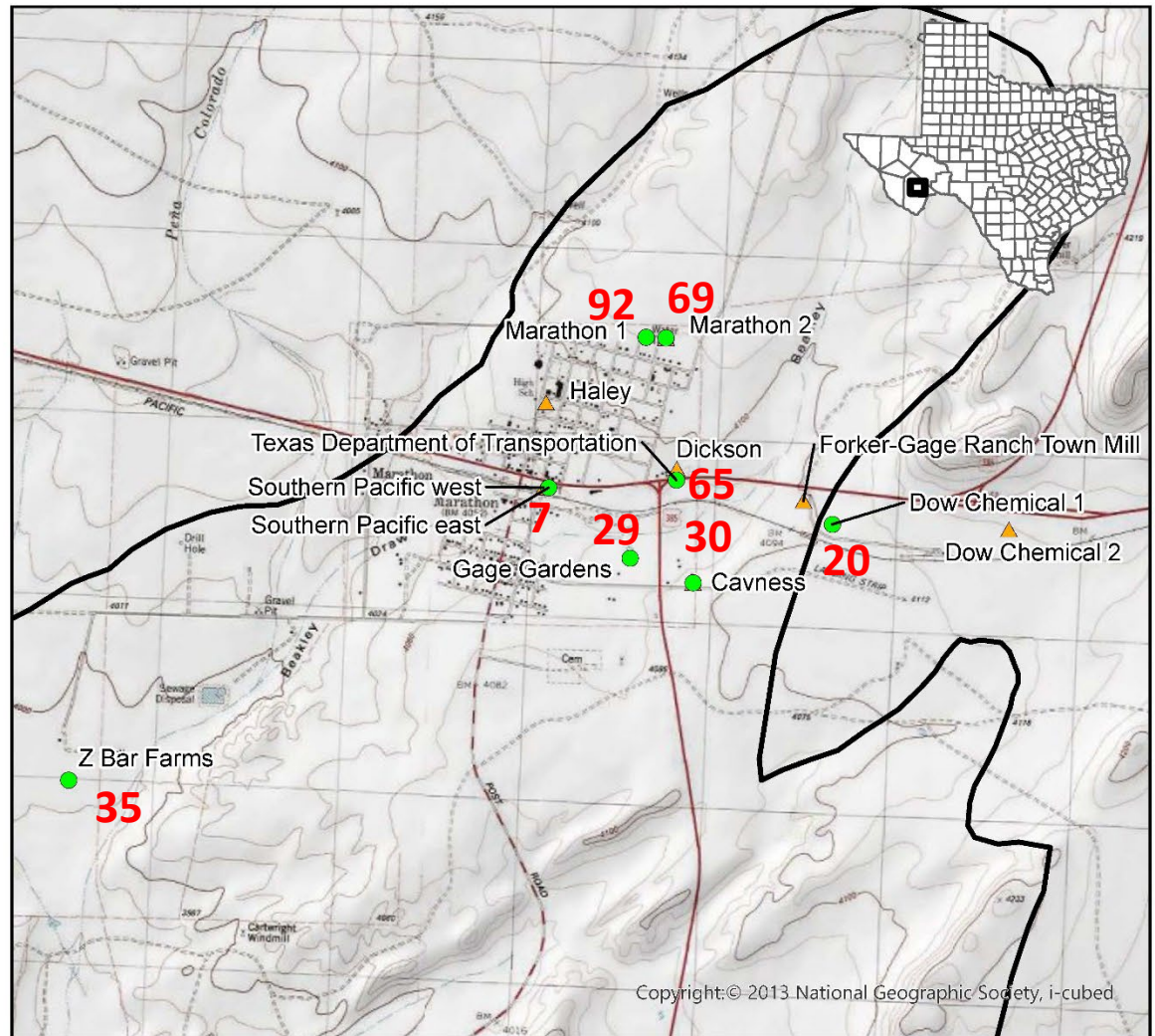
- MDO - Caballos Novaculite and Maravillas Chert
- Ow - Woods Hollow Shale
- Ofa - Fort Pena and Alsate Shale, undivided
- OC - Marathon Limestone and Dagger Flat Sandstone
- Spring
- Well



# Perched Springs

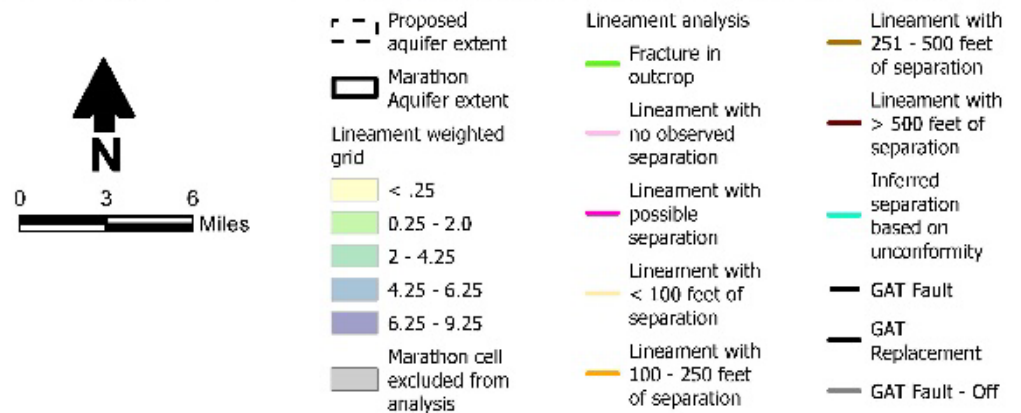
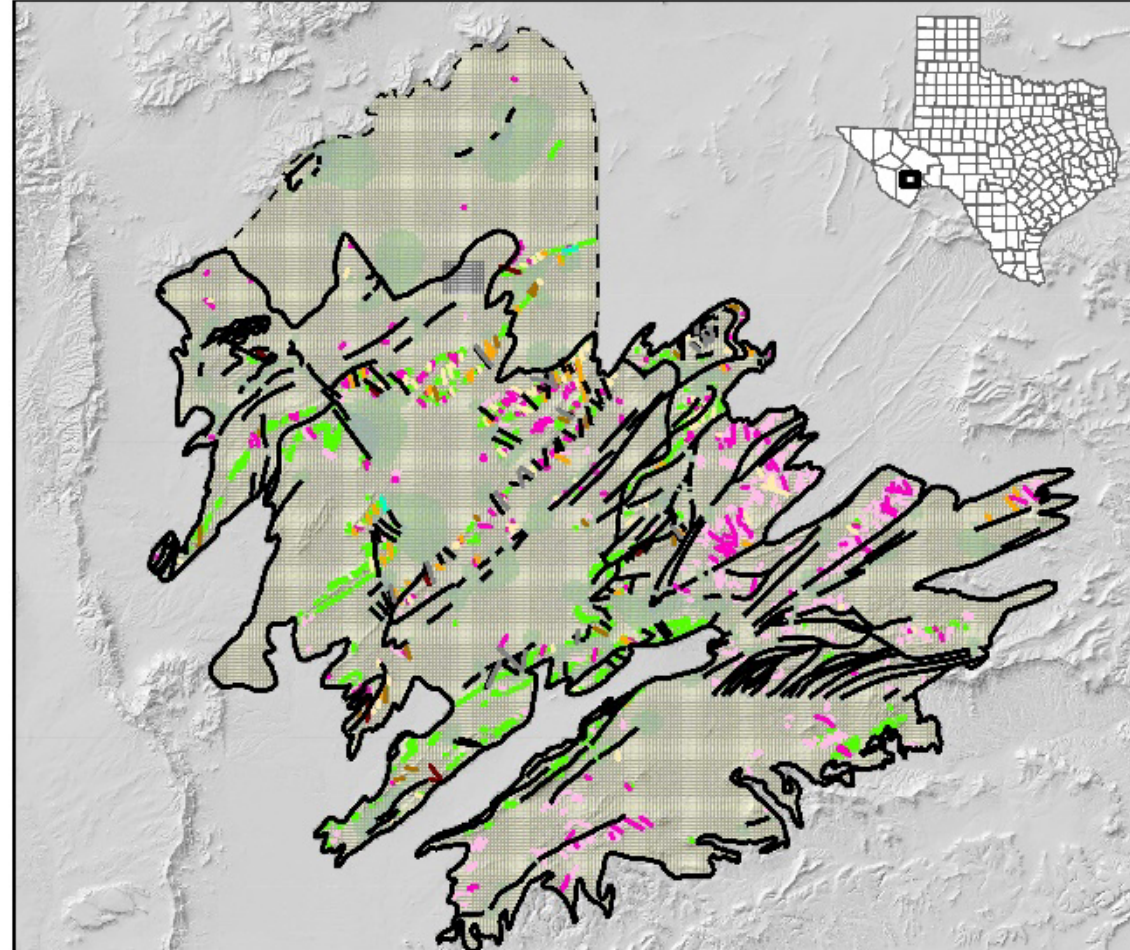


# Wells Used for Aquifer Tests in the Vicinity of Marathon

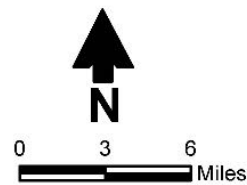
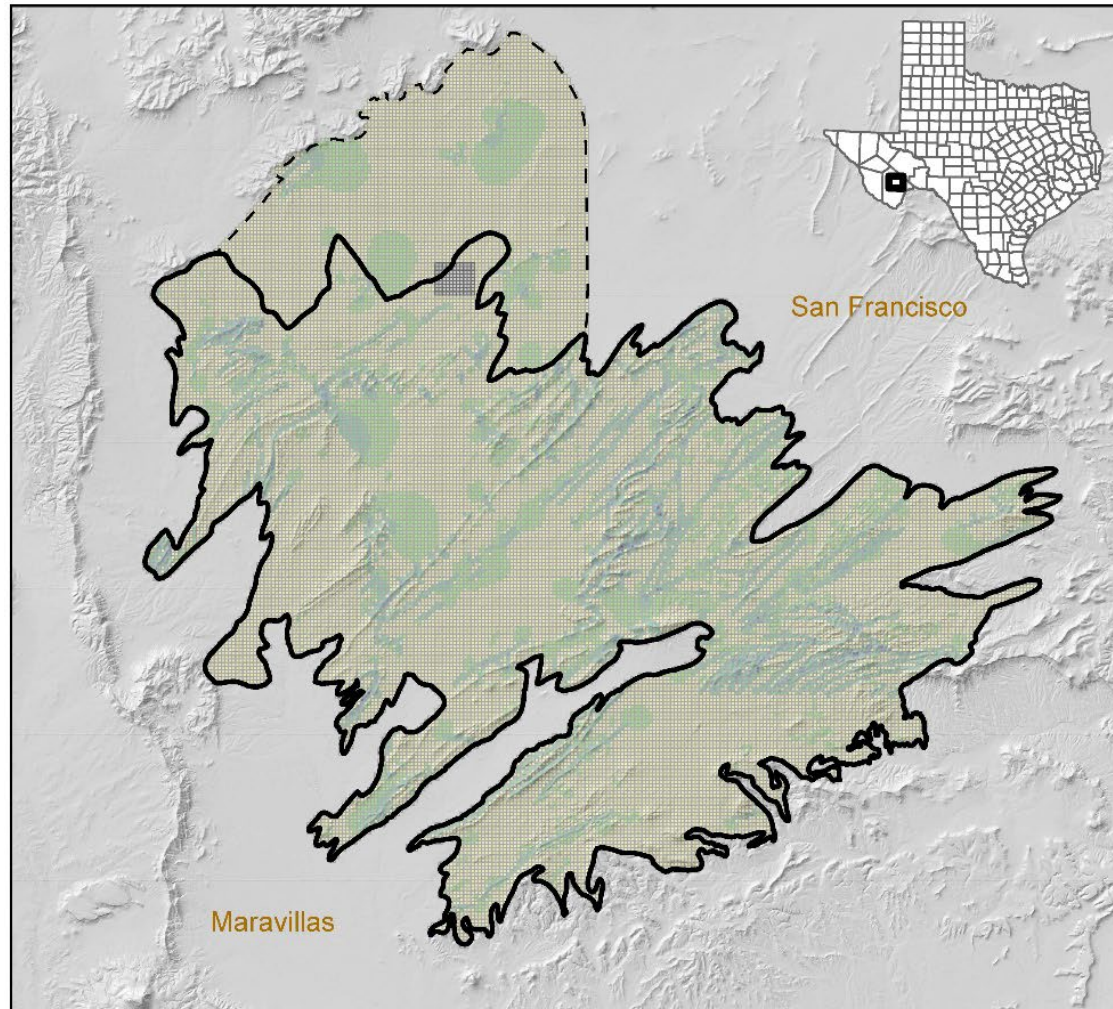


- Marathon Aquifer extent
- Aquifer well test
  - Observation well
  - Pumping well

# Weighted Grid for Lineament Analysis



# Ranked Grid for Lineament Analysis



Lineament ranked grid

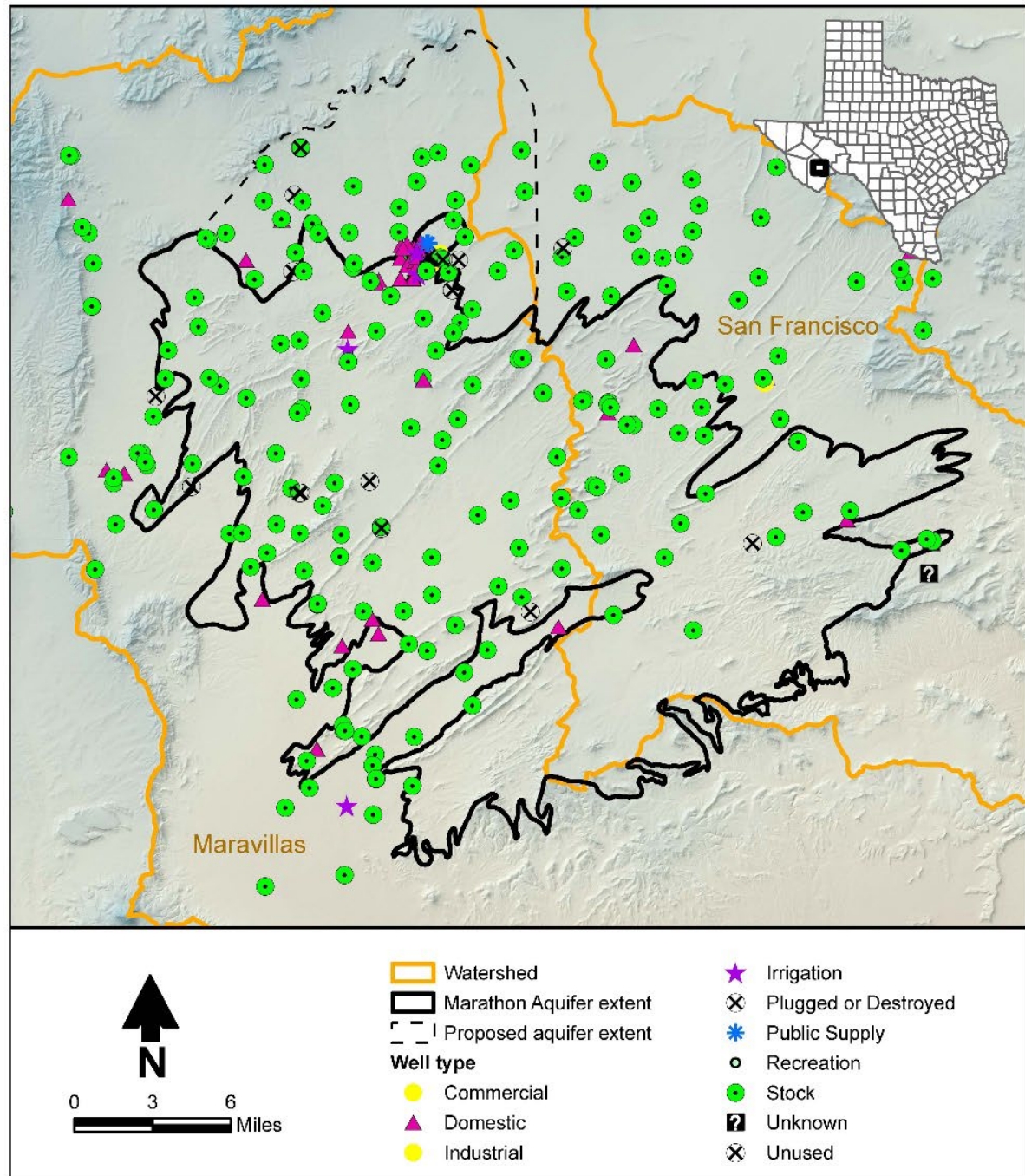


Marathon cell excluded from analysis

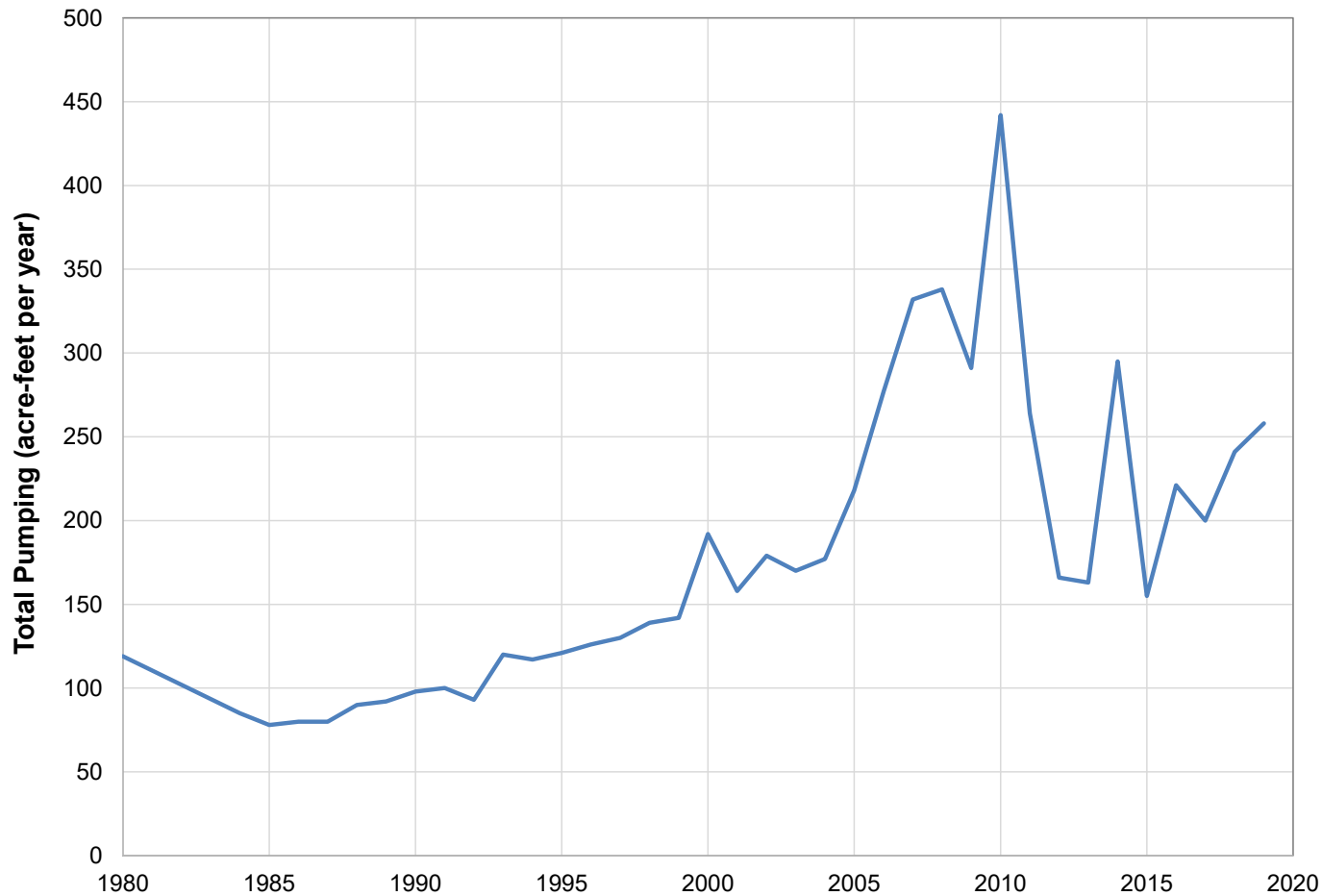
Marathon Aquifer extent

Proposed aquifer extent

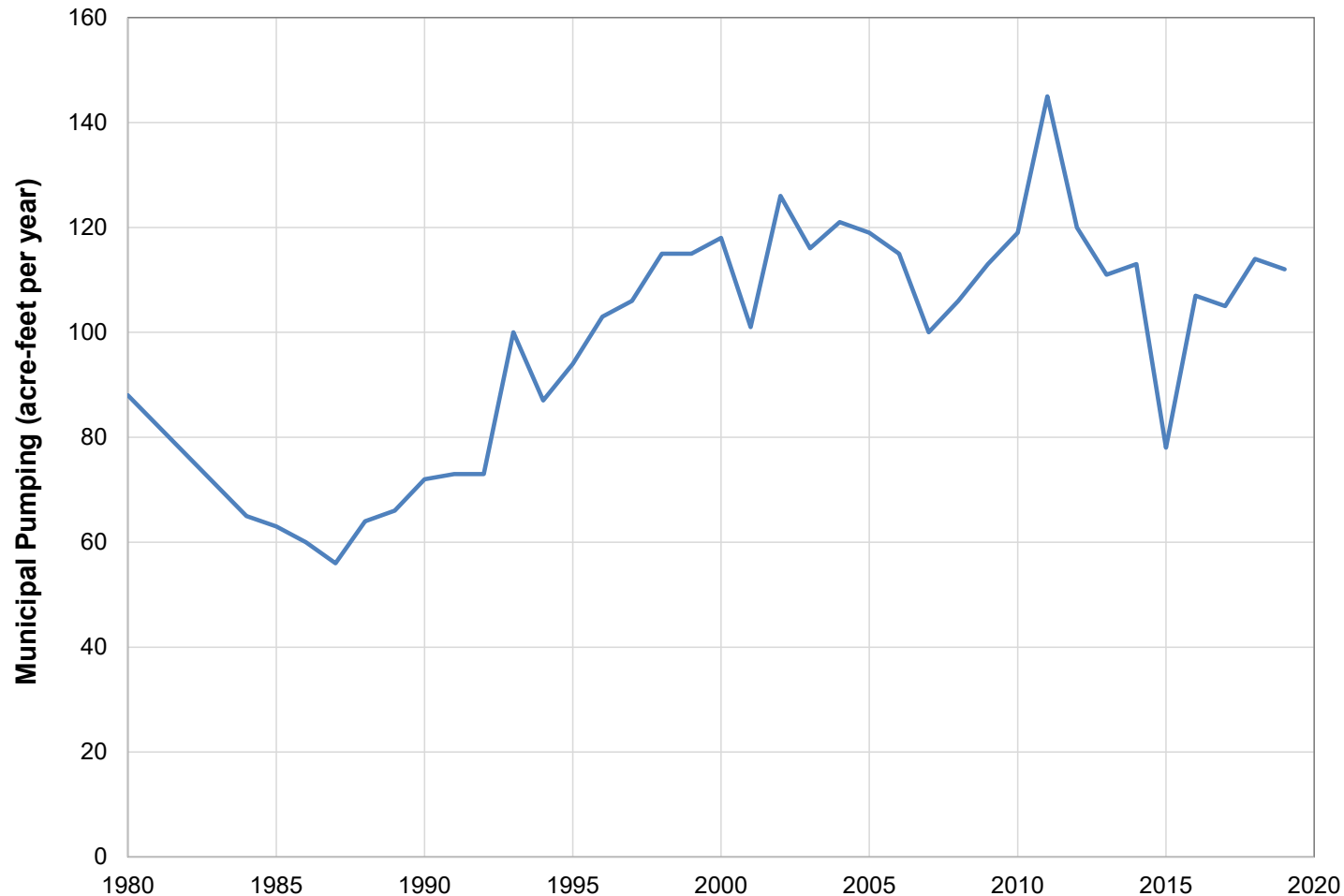
# Well Type



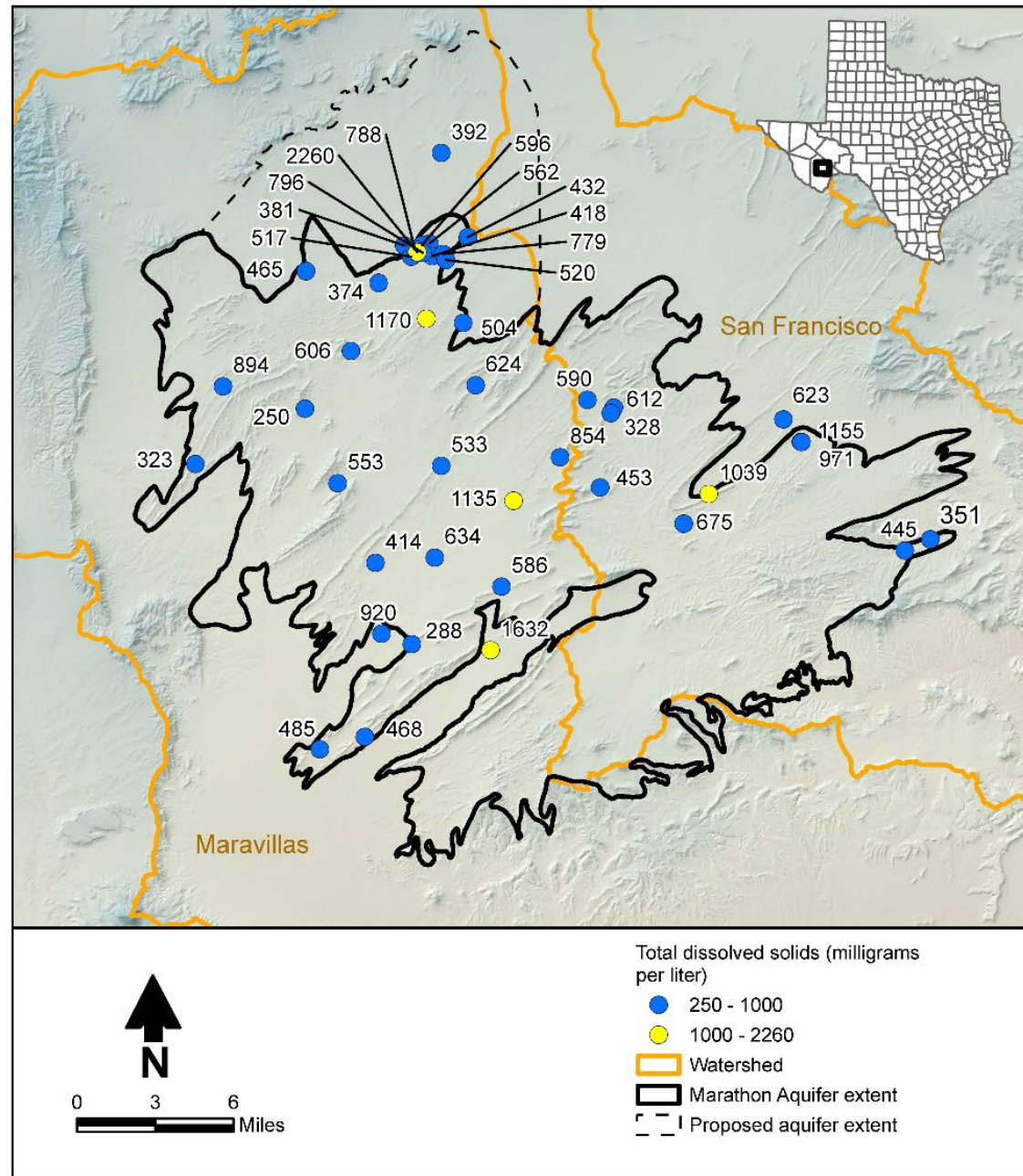
# Total Groundwater Pumping from the Marathon Aquifer - 1980 to 2019



# Estimated Municipal Pumping from the Marathon Aquifer - 1980 to 2019

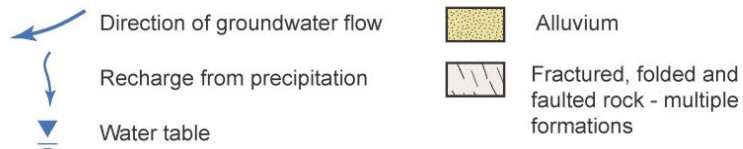
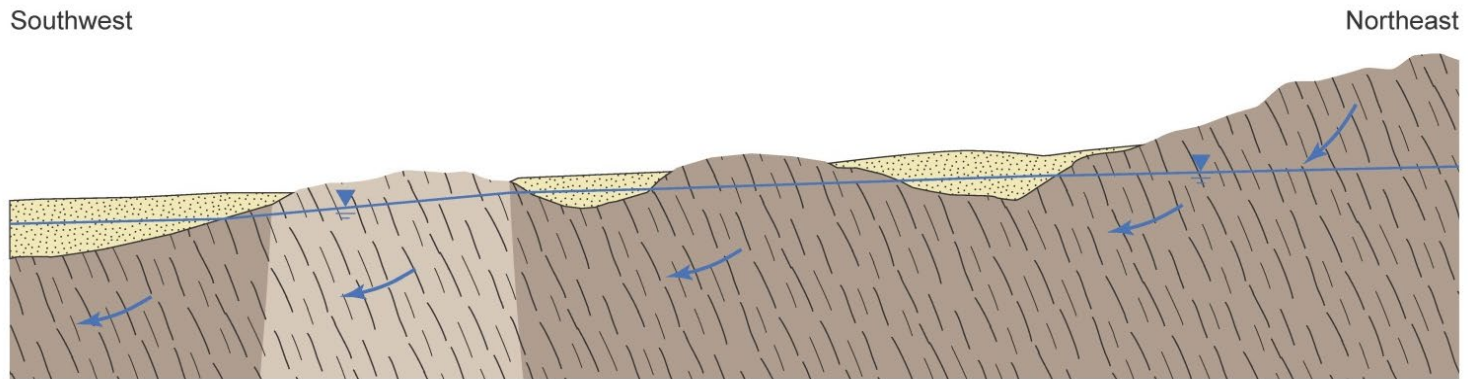
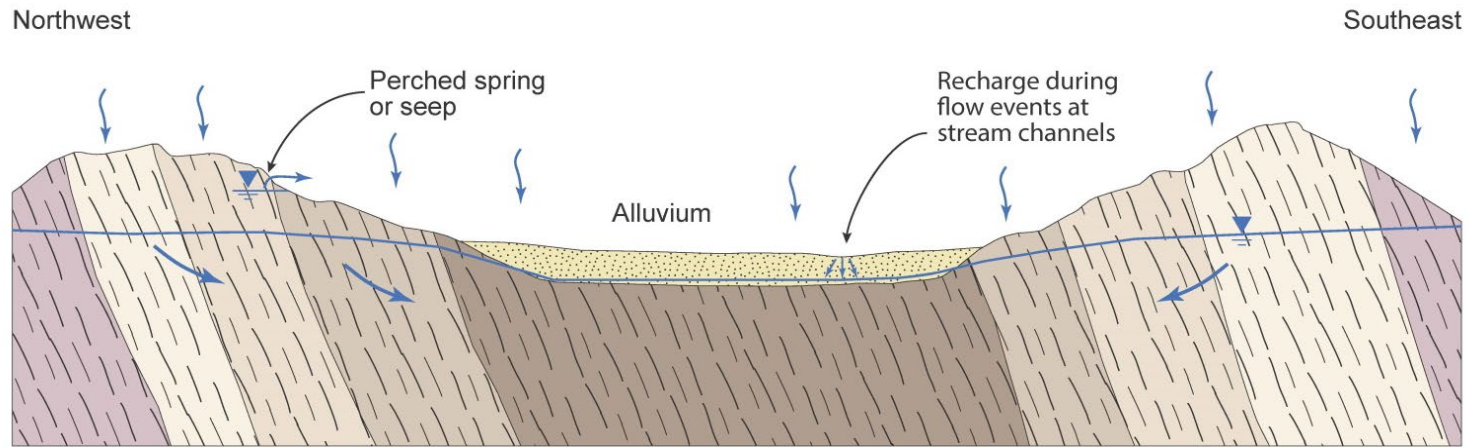


# Water Quality





# Conceptual Model



# Project Schedule

- October 1, 2020 - Start date
- December 3-4, 2020 - SAF 1
- August 4-5, 2022 - SAF 2
- Comments on DRAFT completion report due to TWDB by September 30, 2022
- Study completion – November 30, 2022



# Contact Information – Comments

<https://www.twdb.texas.gov/groundwater/models/gam/mrtn/mrtn.asp>

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# Thank you!

**Marathon Aquifer Conceptual Model  
Stakeholder Advisory Forum #2  
August 4-5, 2022**



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