

2D and 3D Edwards Aquifer Structural Visualization Using ArcGIS

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Edwards Aquifer Authority

900 E. Quincy, San Antonio, TX 78215

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General Terms and Methodology

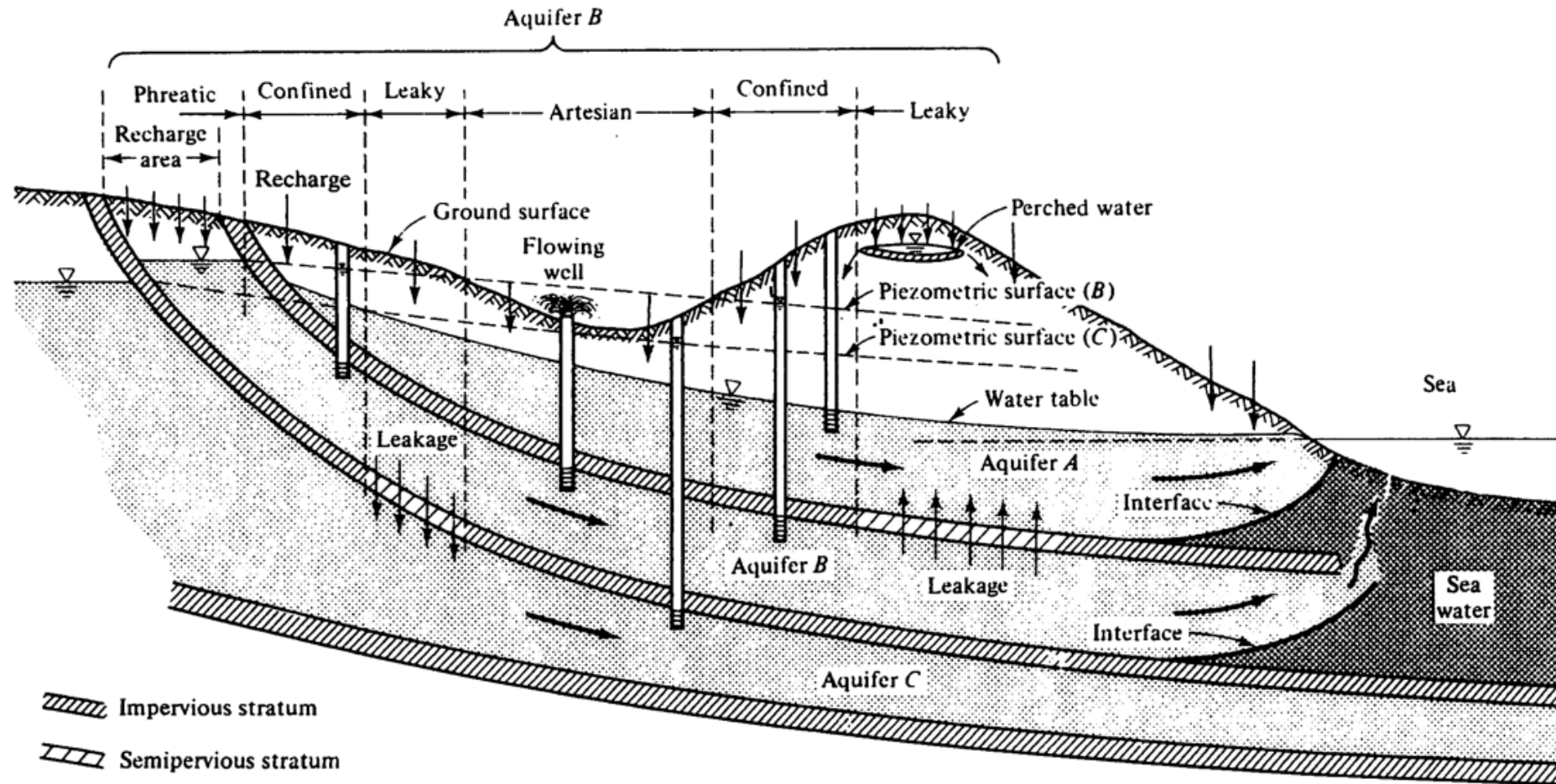
Unconfined / Phreatic



Aquifer Types



Confined /Artesian



Source: J.Bear & A.Verruijt (1987)

Aquifers

Porous

Pores in unconsolidated deposits

Fractured

Fractures, Cracks

Karstic

Features of dissolution

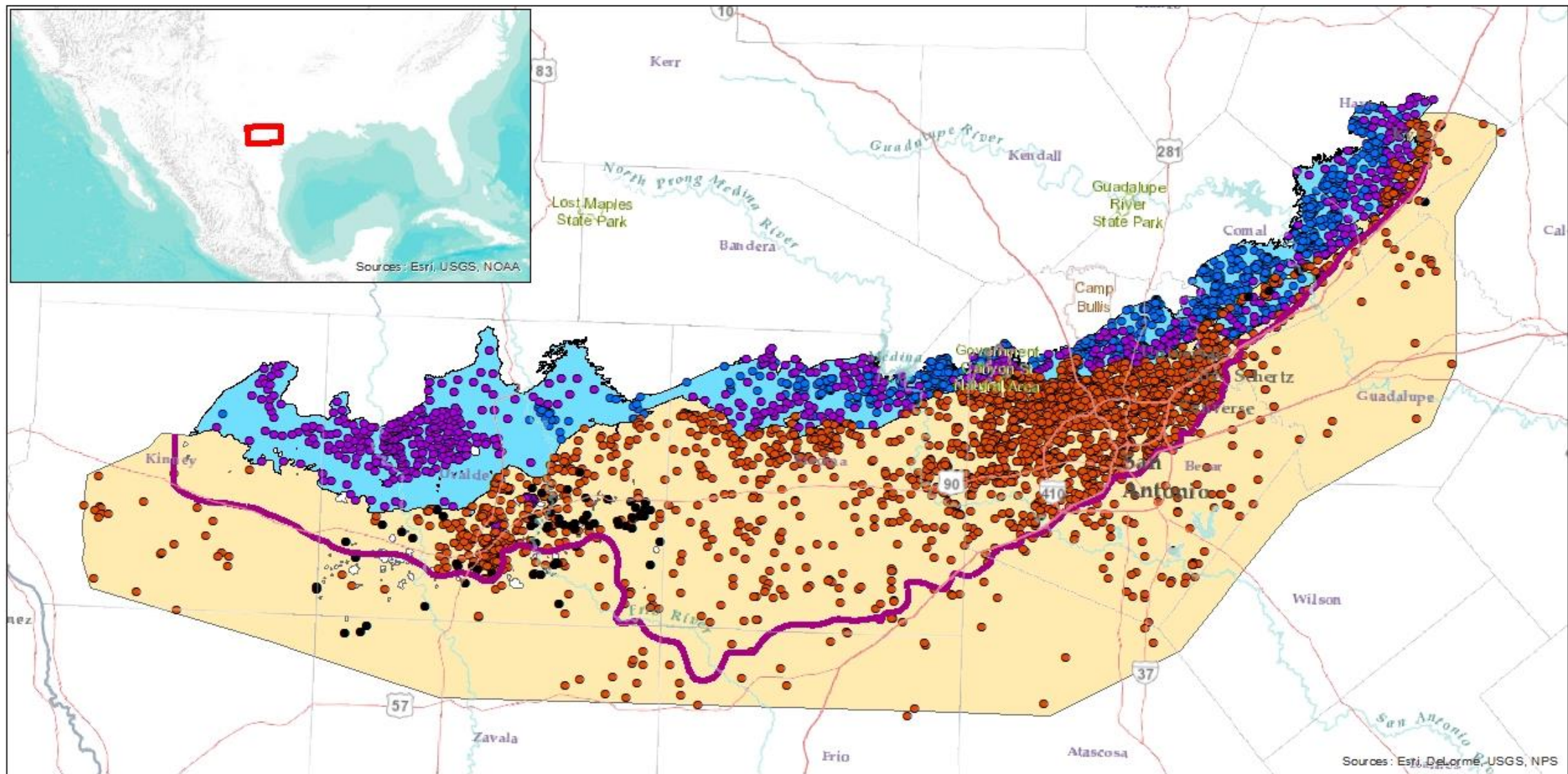
Confining Units

Aquiclude

No leakage

Aquitard

Allows some leakage

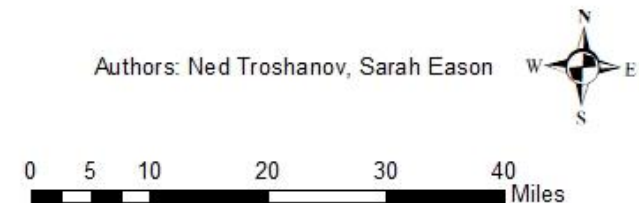


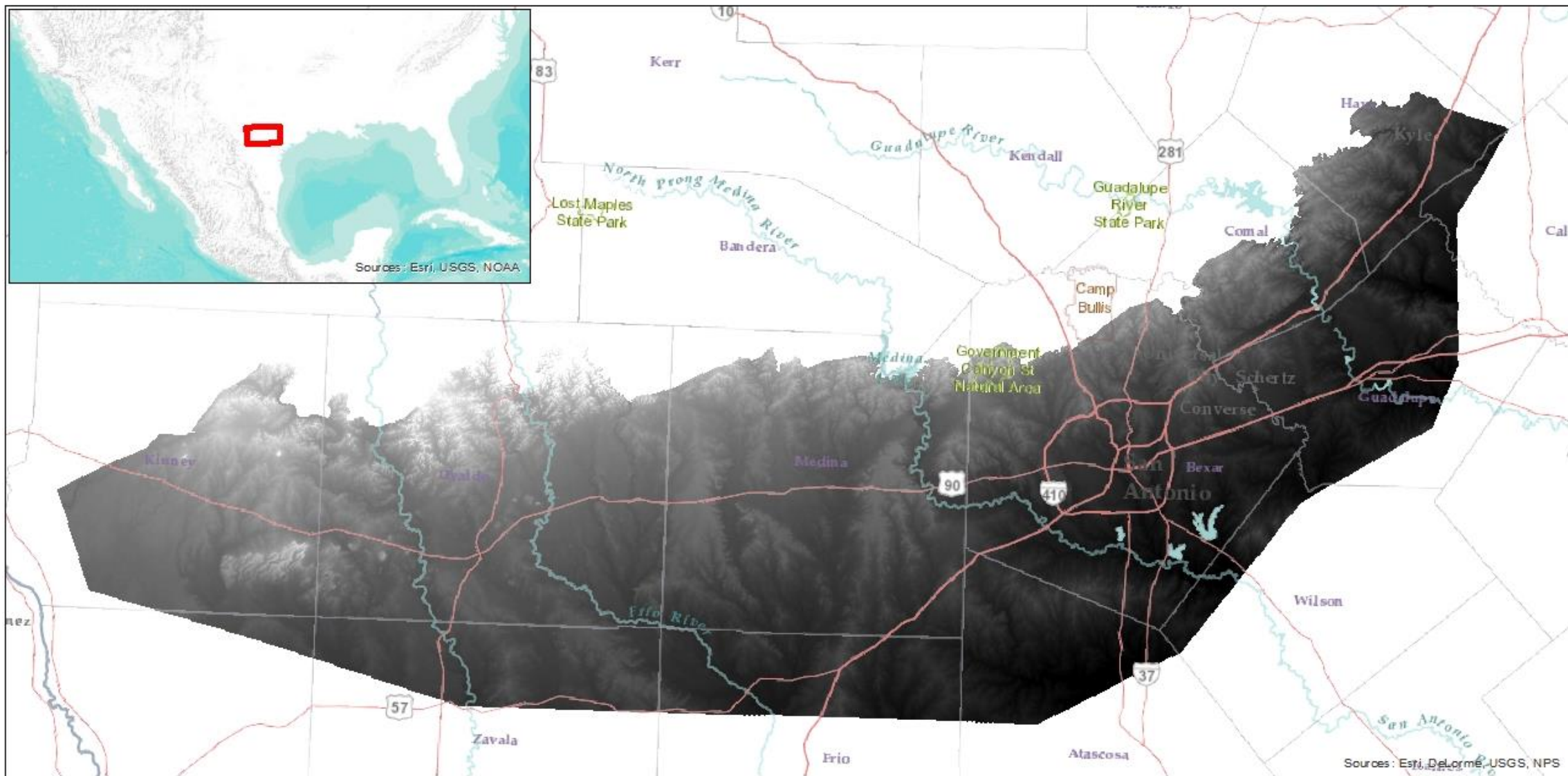
Sources and Types of Structural Input Data

- World Reference Overlay
- "Bad" Water Line (1000 mg/l)
- Seismic Points (65)
- Structural CPs in Confined Zone (3417)
- Geomap Estimates (637)
- Structural CPs in Unconfined Zone (1992)
- Unconfined Zone
- Confined Zone

Sources: EAA, USGS, TWDB, SAWS,
Dr. S. Hovorka, Dr. T. Ewing

Authors: Ned Troshanov, Sarah Eason





USGS Land Surface Digital Elevation Model (DEM)

World Reference Overlay
USGS Land Surface DEM, feet above m.s.l.

Value
High : 2172
Low : 357

Source: <https://earthexplorer.usgs.gov/>

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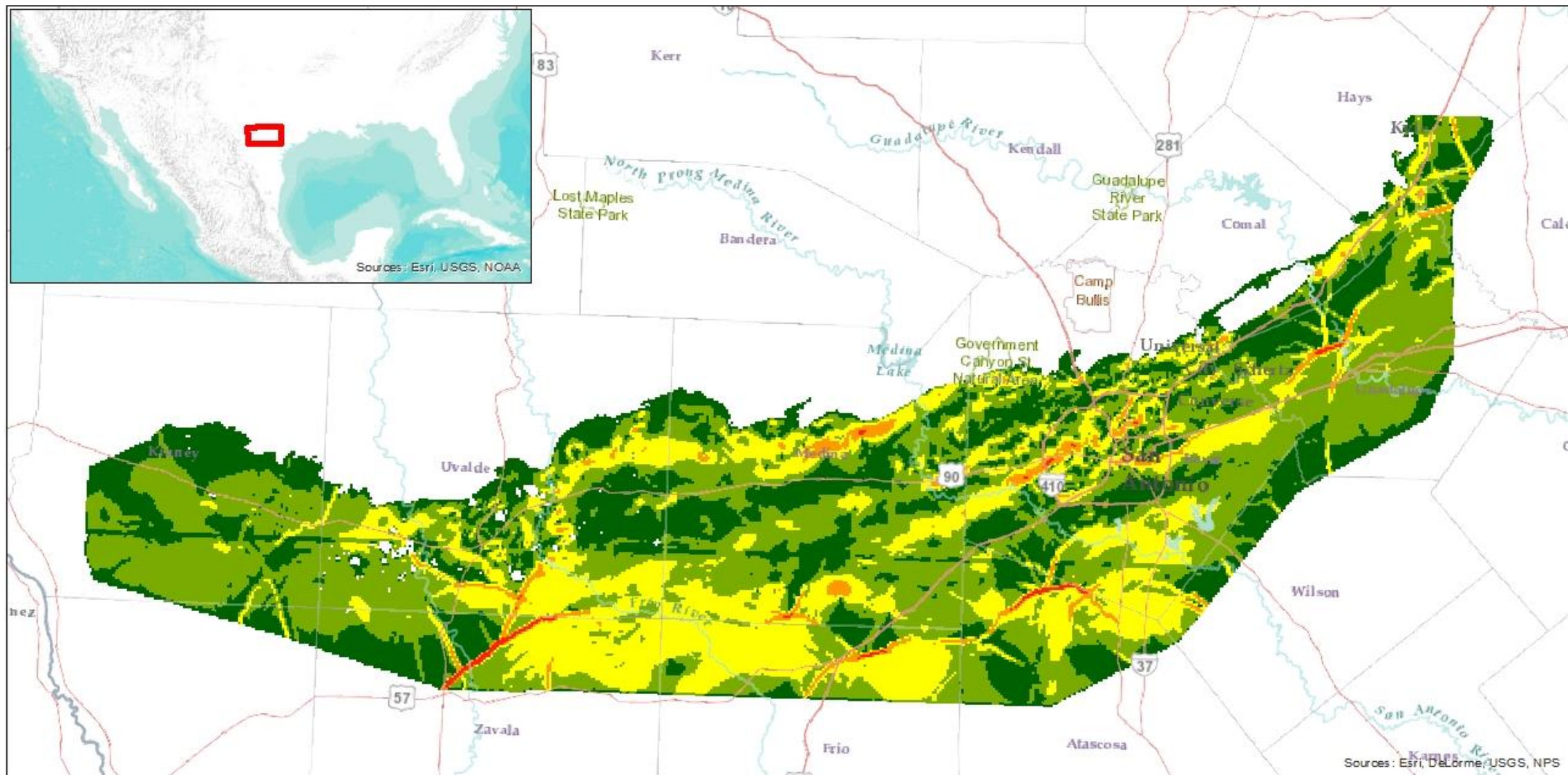


0 5 10 20 30 40
Miles

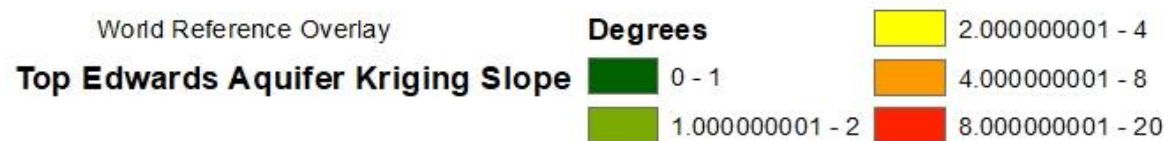
Note: This model is a property of the Edwards Aquifer Author

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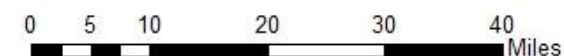
2D Model Visualization

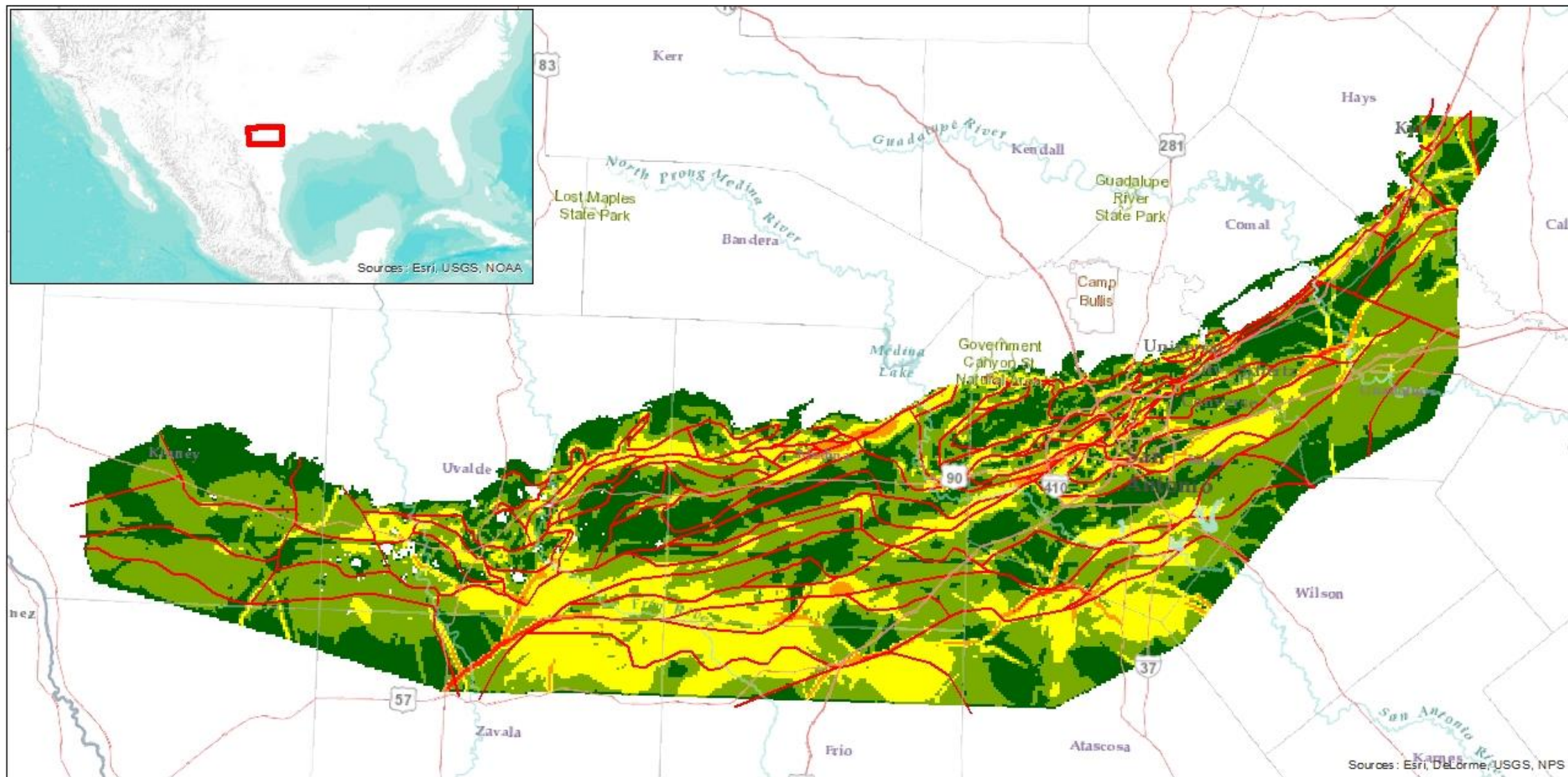


Top Edwards Aquifer Kriging Slope Without Barriers



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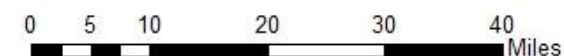


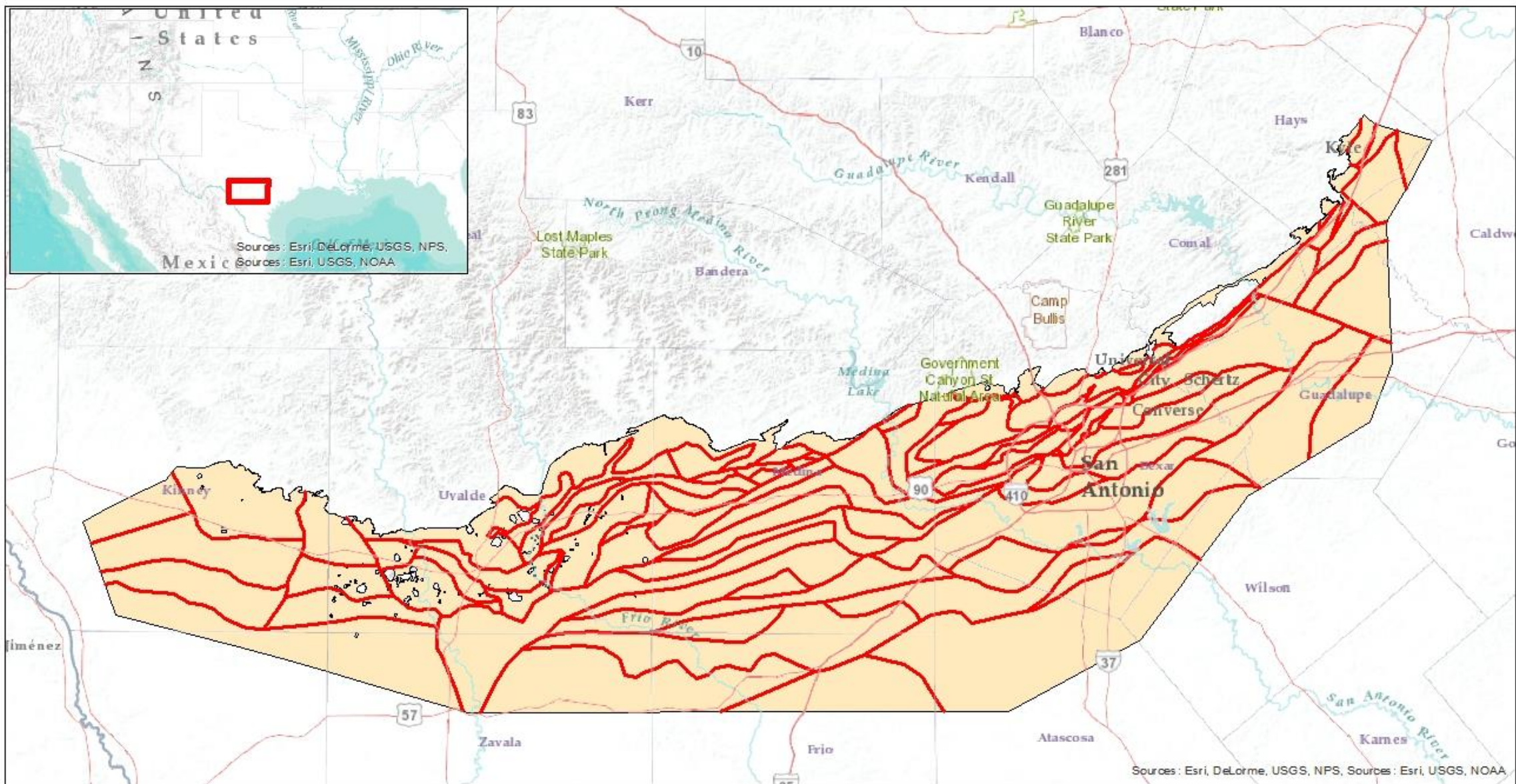


Delineated Inferred Faults in Confined Zone



Authors: Ned Troshanov, Sarah Eason





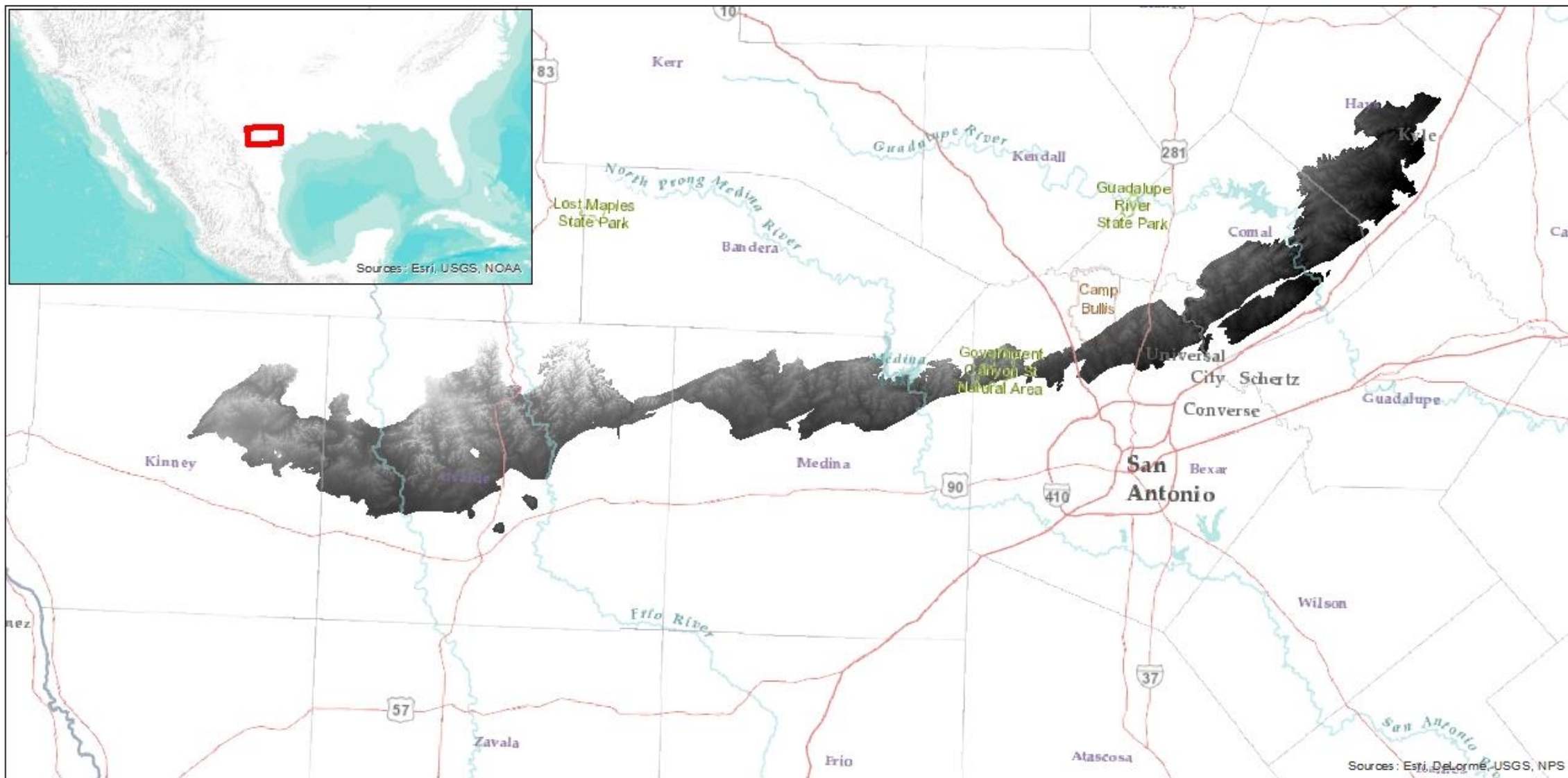
Structural Framework in Confined Zone

- World Reference Overlay
- Inferred Faults in Confined Zone
- Confined Zone
- World Terrain Base

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0 5 10 20 30 40 Miles



Unconfined Zone DEM Elevation

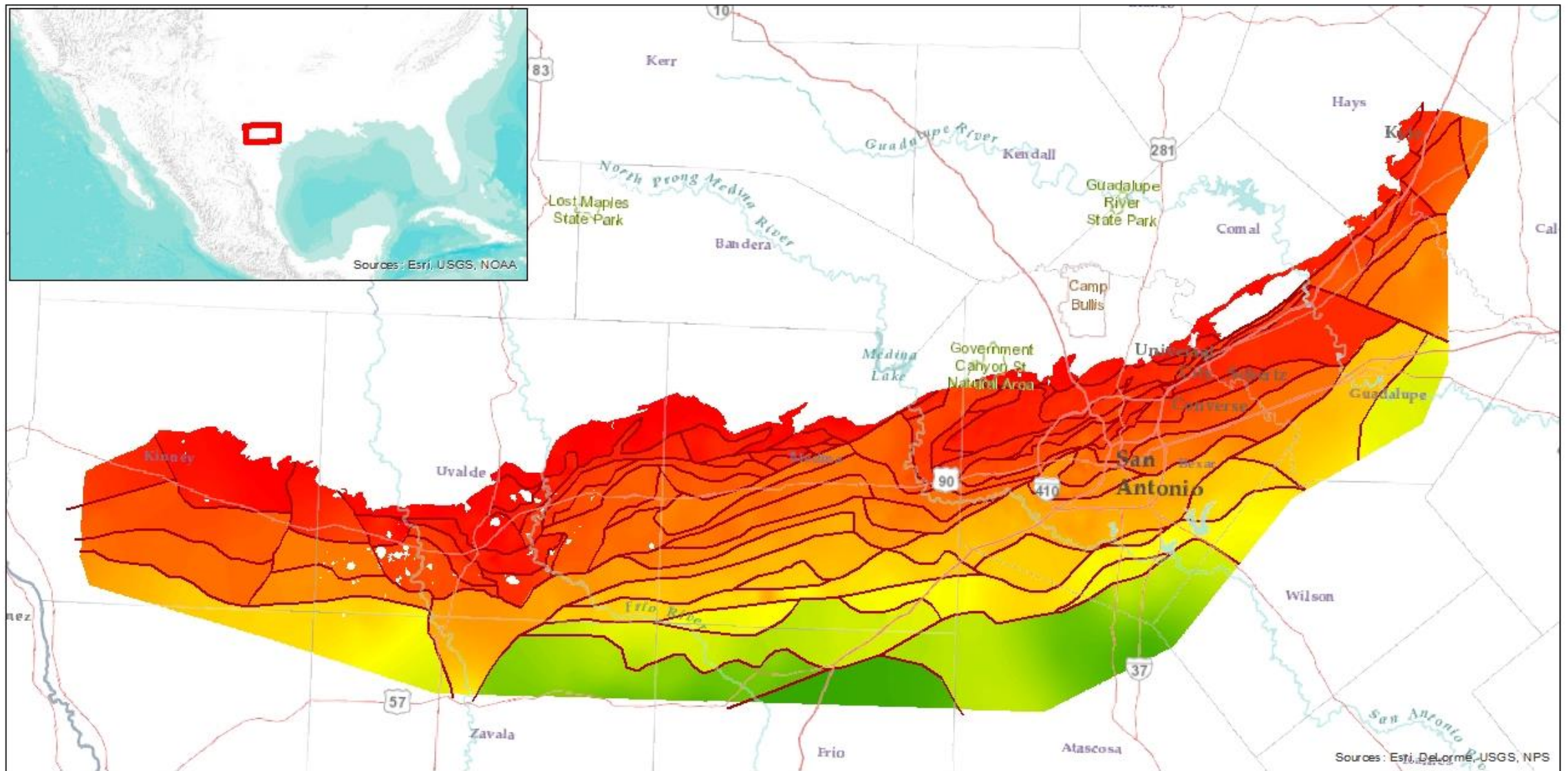
World Reference Overlay
Unconfined Zone DEM Elevation

Feet above m.s.l.
High : 2172
Low : 577

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0 5 10 20 30 40
Miles



Top Edwards Aquifer Elevation in Confined Zone

World Reference Overlay

Inferred Faults in Confined Zone

Top Edwards Aquifer Elevation in Confined Zone

Feet above m.s.l.

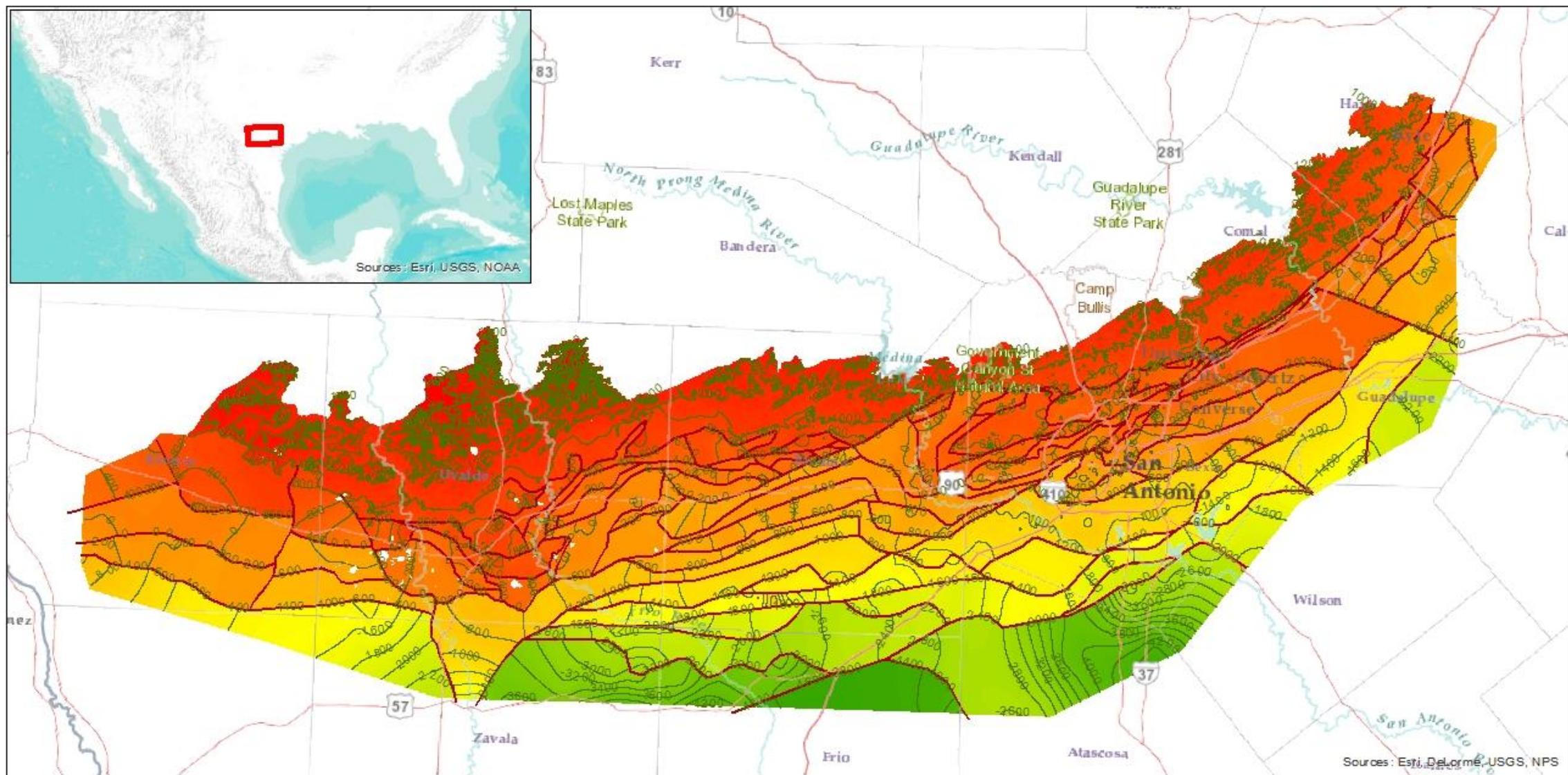
High : 2172

Low : -6192

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0 5 10 20 30 40 Miles



Structural Map of Top Edwards Aquifer Elevation

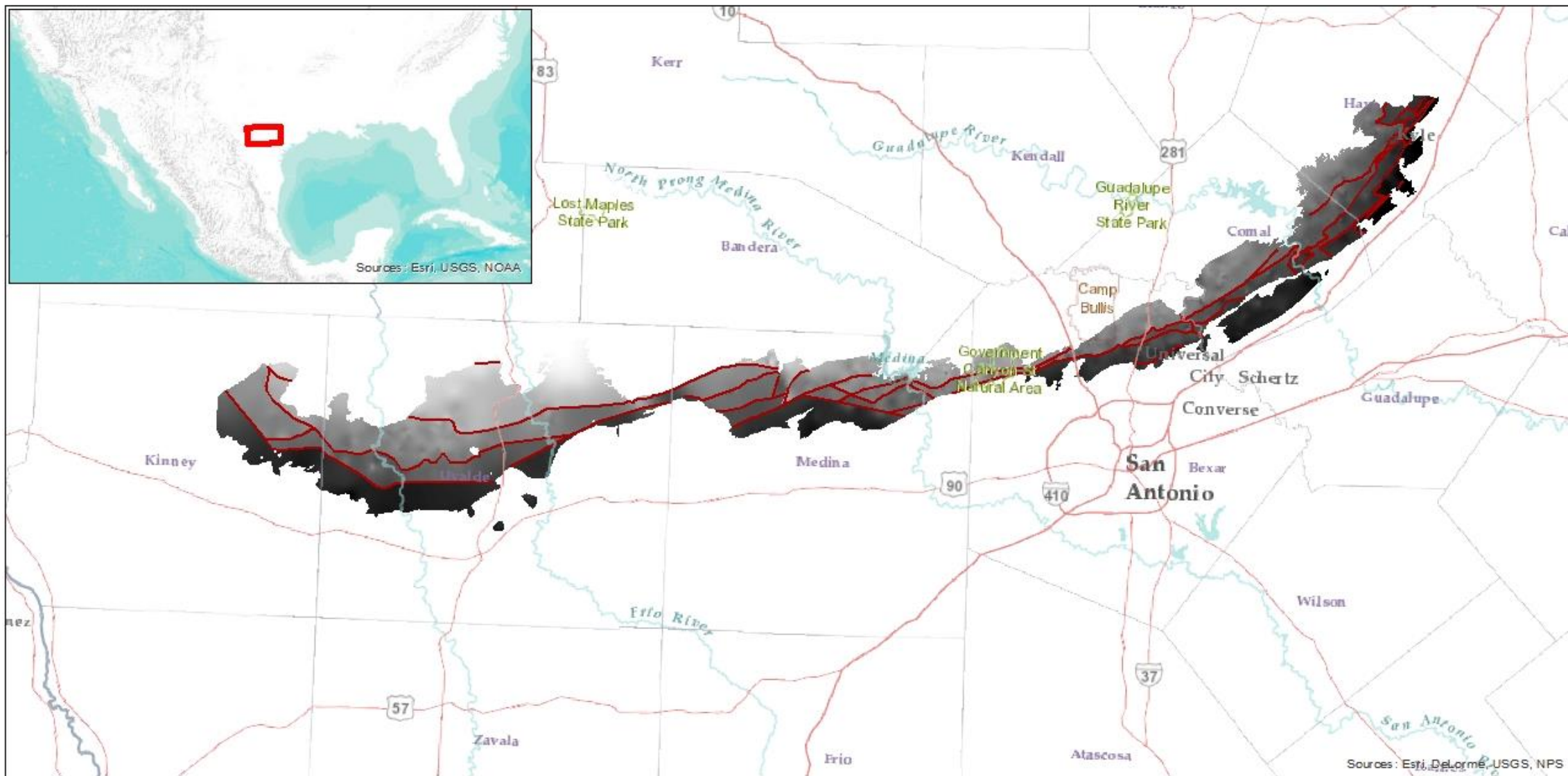
- World Reference Overlay
 - Inferred Faults in Confined Zone
 - Top Edwards Aquifer Elevation Contours, feet above msl
- Feet above m.s.l.**
- High : 2172
- Low : -6192

Top Edwards Aquifer Elevation

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0 5 10 20 30 40 Miles



Base Edwards Aquifer Elevation in Unconfined Zone

World Reference Overlay

Inferred Faults in Unconfined Zone

Feet above m.s.l.

High : 1751

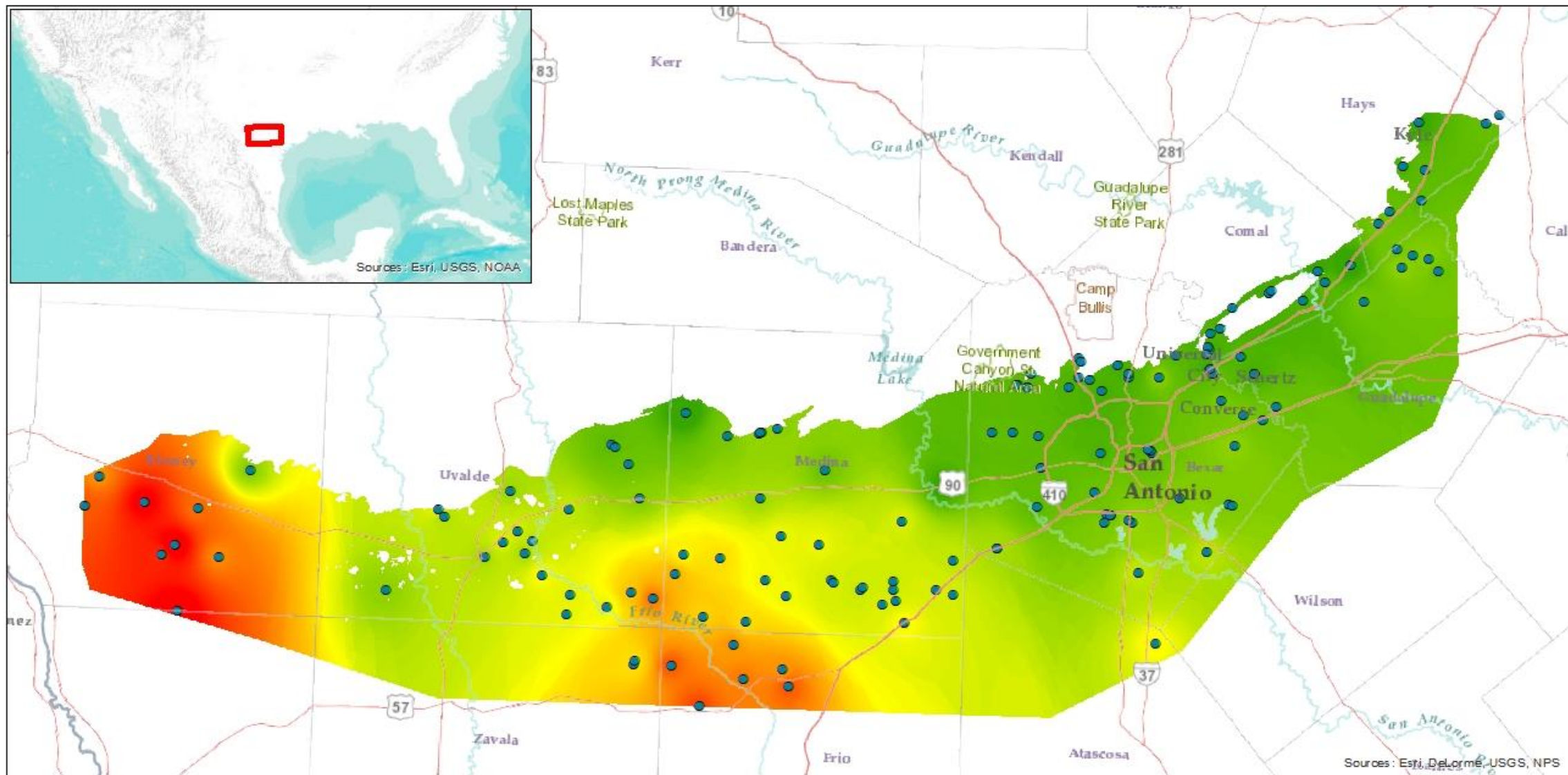
Low : 134

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0 5 10 20 30 40 Miles

Base Edwards Aquifer Elevation in Unconfined Zone



Edwards Aquifer Thickness in Confined Zone

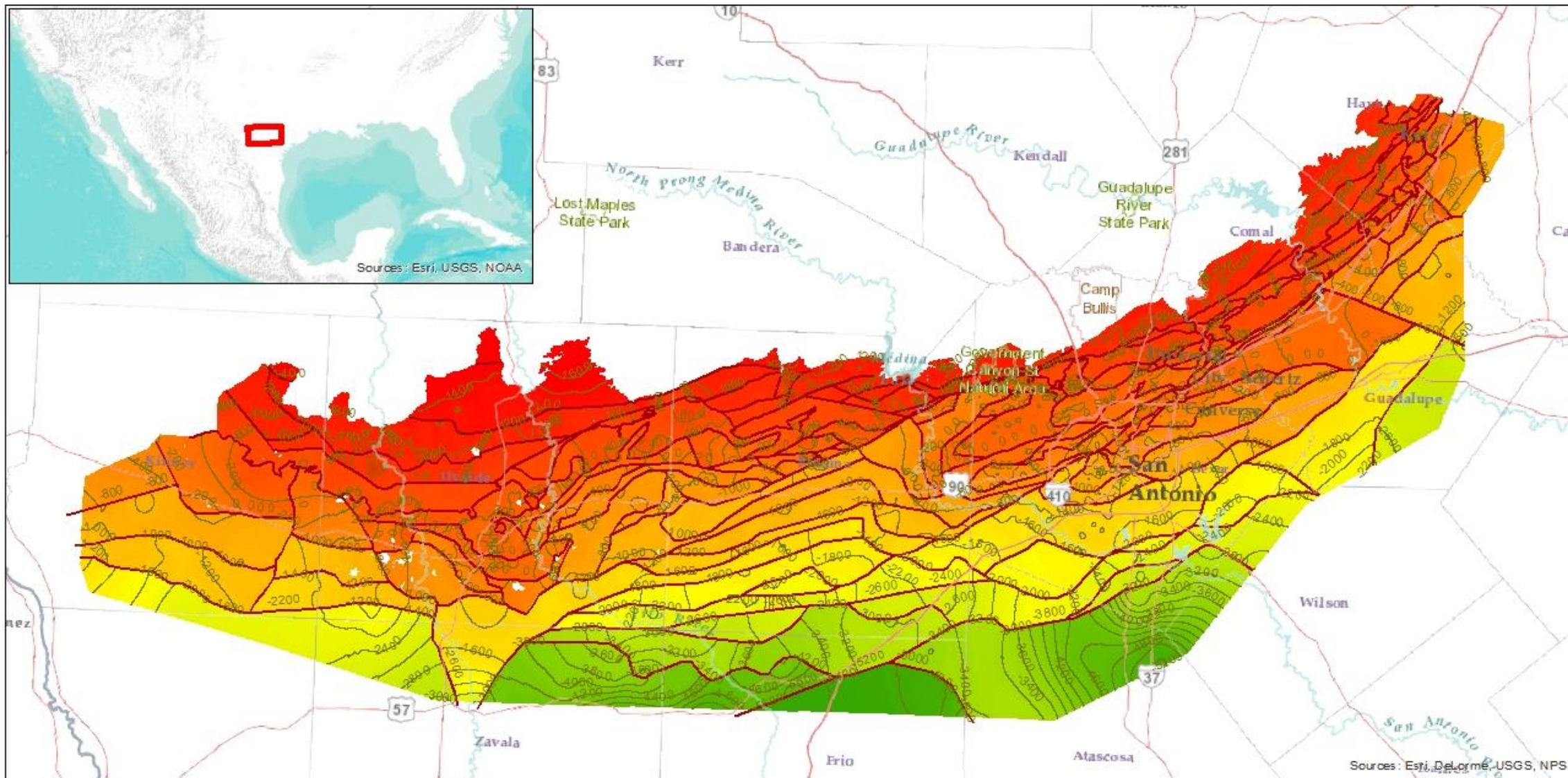
World Reference Overlay
 ● Edwards Aquifer Thickness CPs in Confined Zone
Edwards Aquifer Thickness in Confined Zone

Feet
 High : 1093
 Low : 365

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0 5 10 20 30 40 Miles



Structural Map of Base Edwards Aquifer Elevation

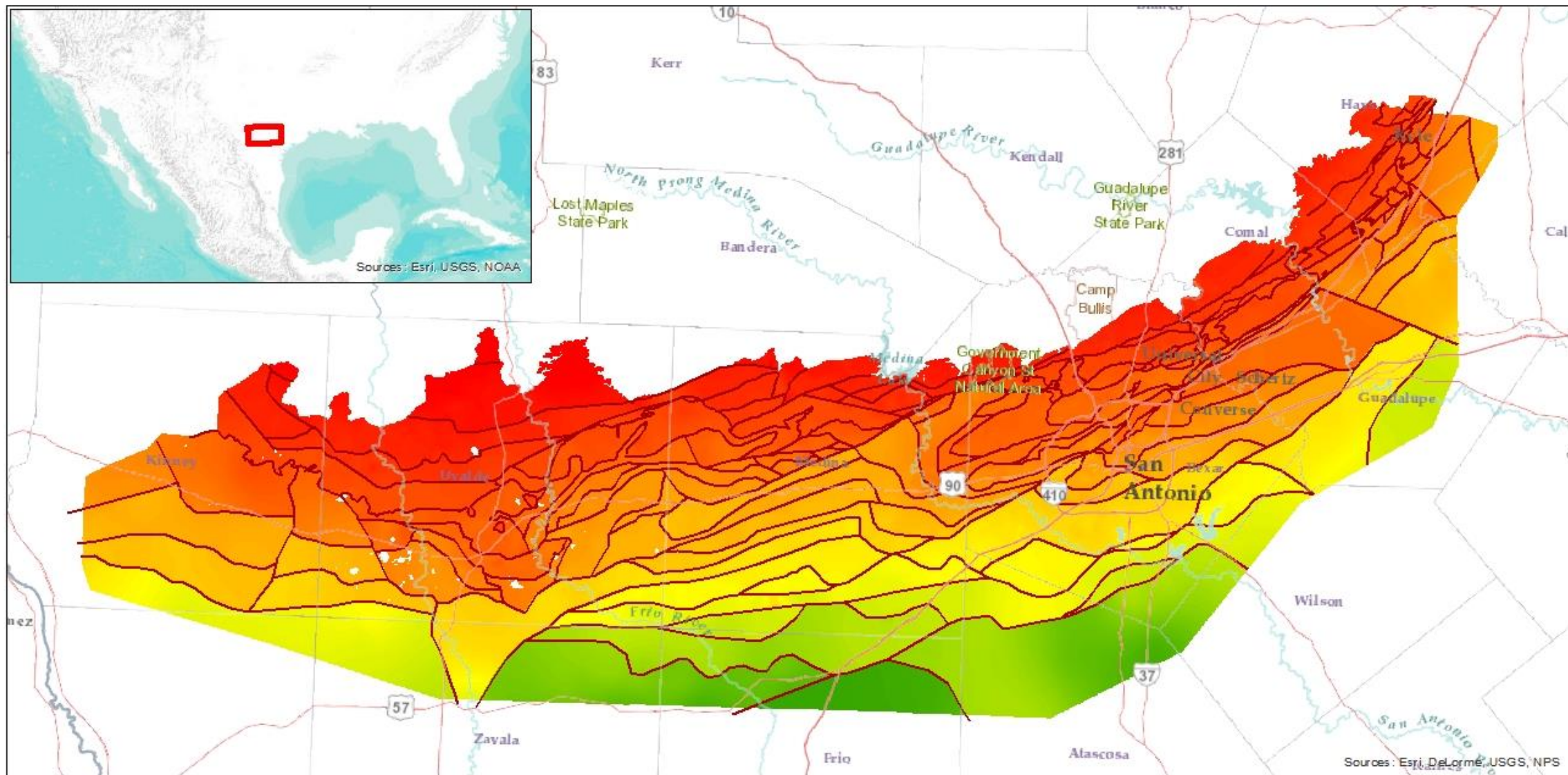
- World Reference Overlay
 - Inferred Faults
 - Base Edwards Aquifer Elevation Contours, feet above msl
- Feet above m.s.l.**
- High : 2172
- Low : -6192

Base Edwards Aquifer Elevation

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0 5 10 20 30 40 Miles



Base Upper Glen Rose Formation Elevation

World Reference Overlay
 — Inferred Faults

Base Upper Glen Rose Fm Elevation, feet above m.s.l.

Feet above m.s.l.

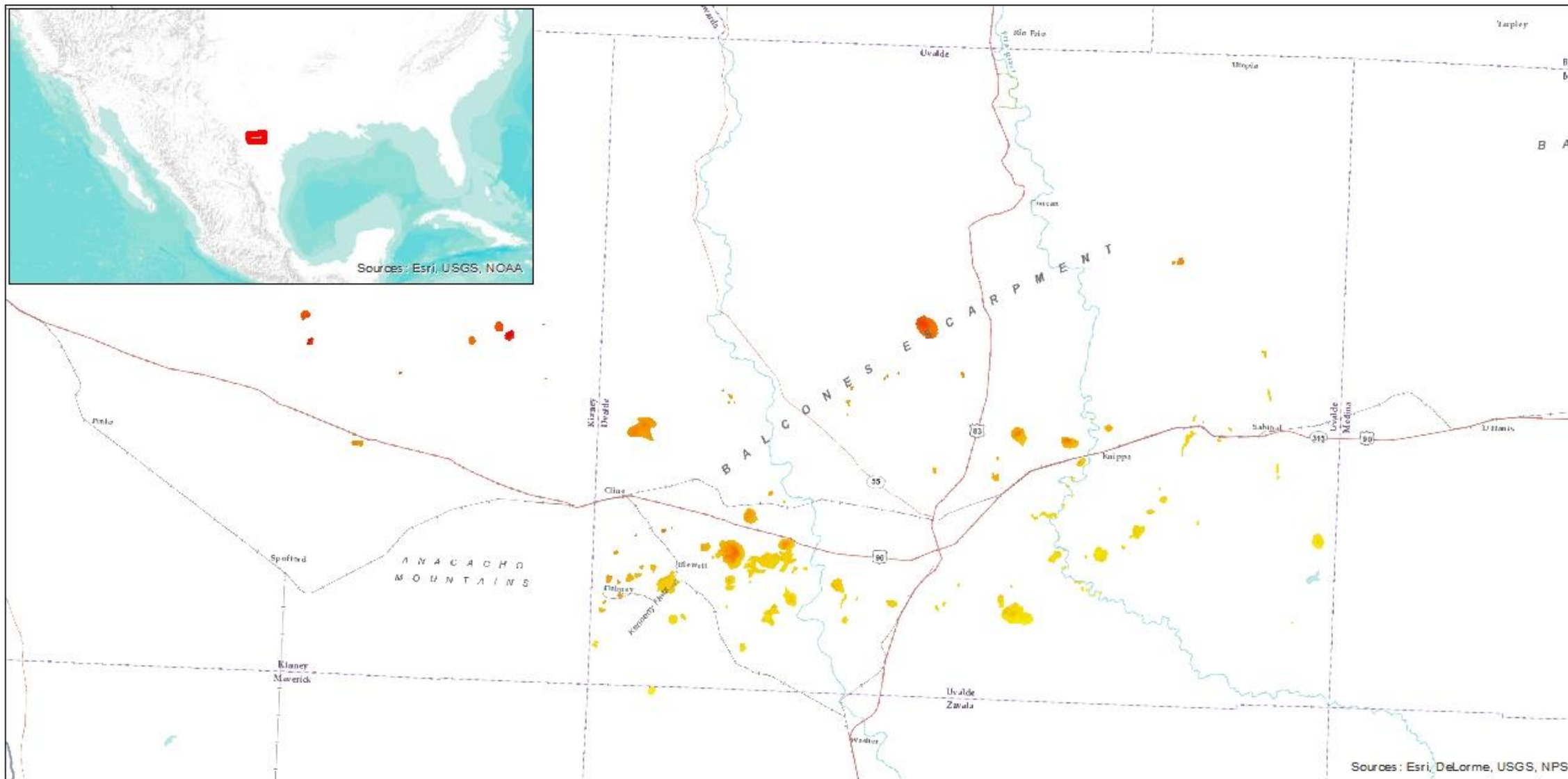
High : 2172

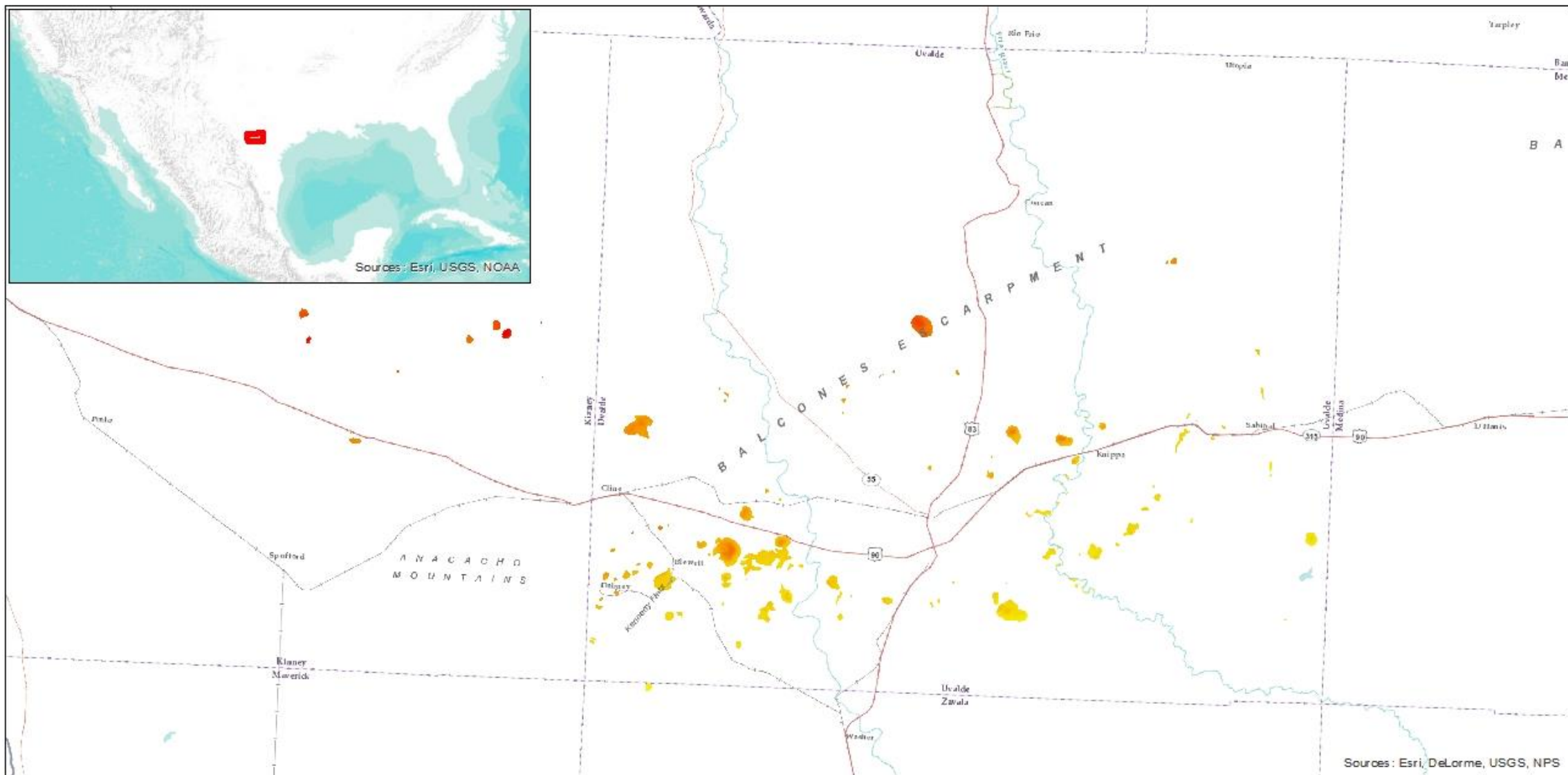
Low : -6192

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0 5 10 20 30 40 Miles





Basalt Base Truncated Elevation in Uvalde and Kinney Counties

World Reference Overlay
Basalt Base Truncated Elevation

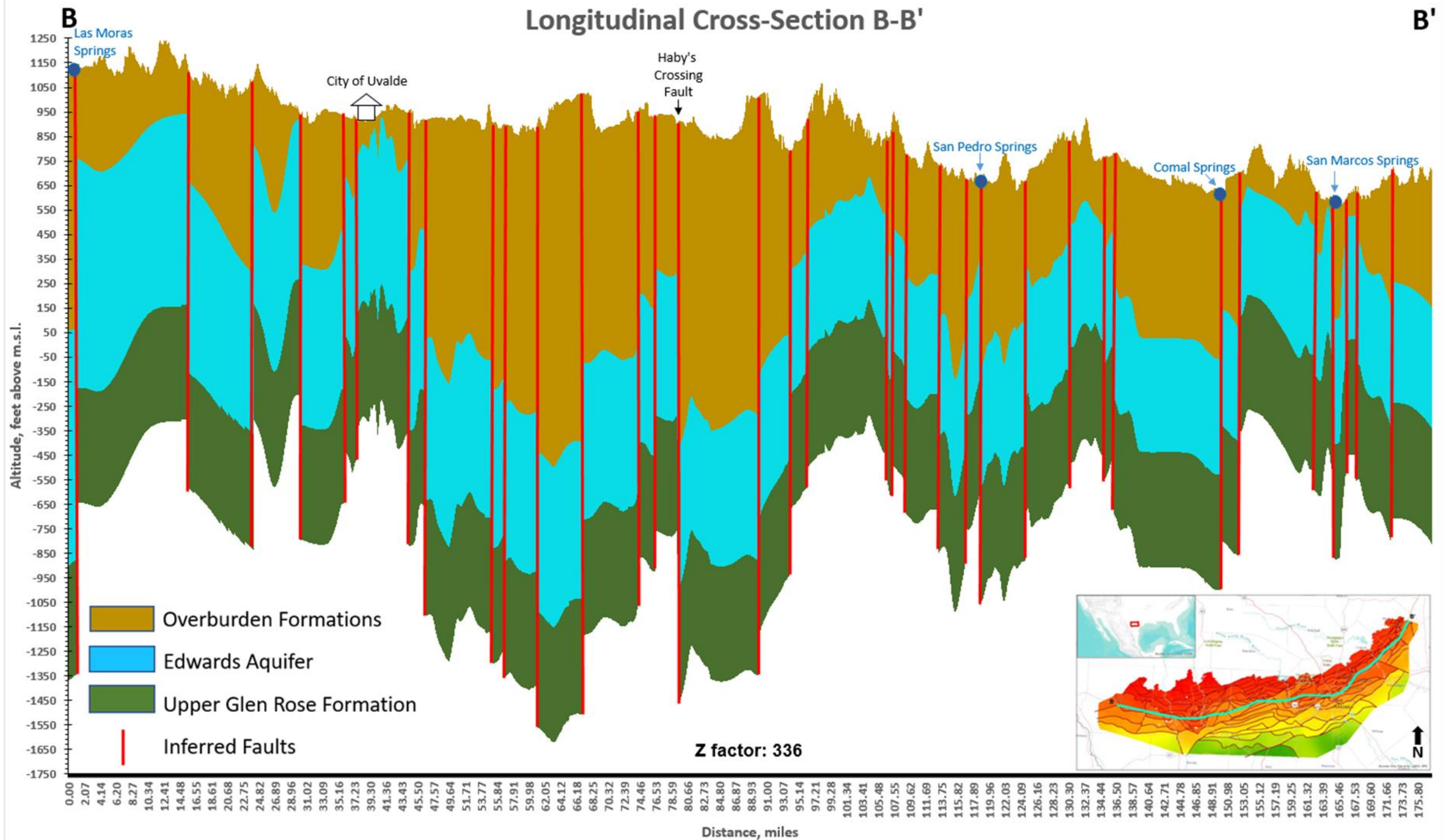


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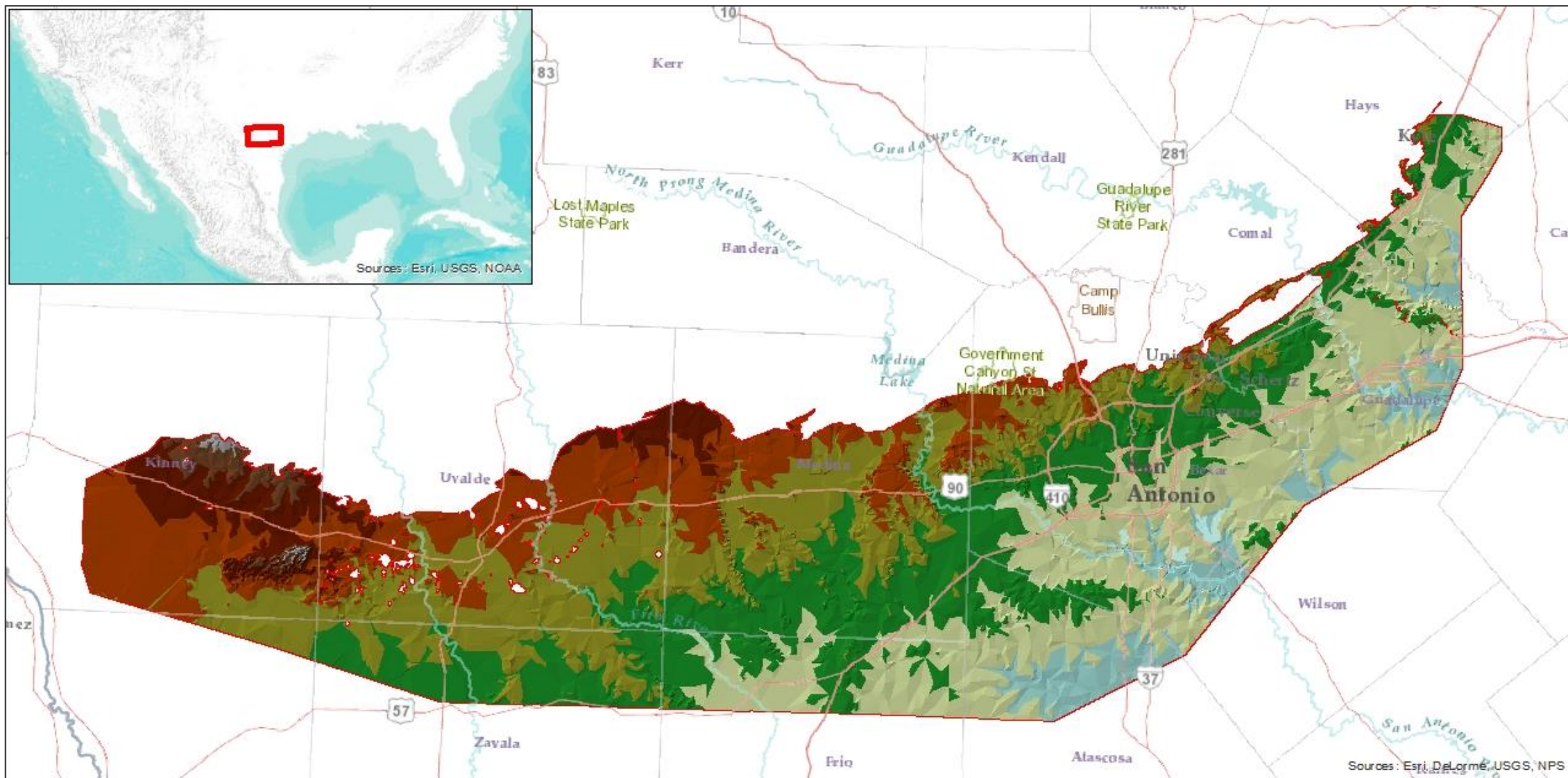


0 2.5 5 10 15 20 Miles

Longitudinal Cross-Section B-B'



Raster TIN Datasets



Land Surface TIN Elevation in Confined Zone

World Reference Overlay

Land Surface TIN Elevation in Confined Zone

Edge type

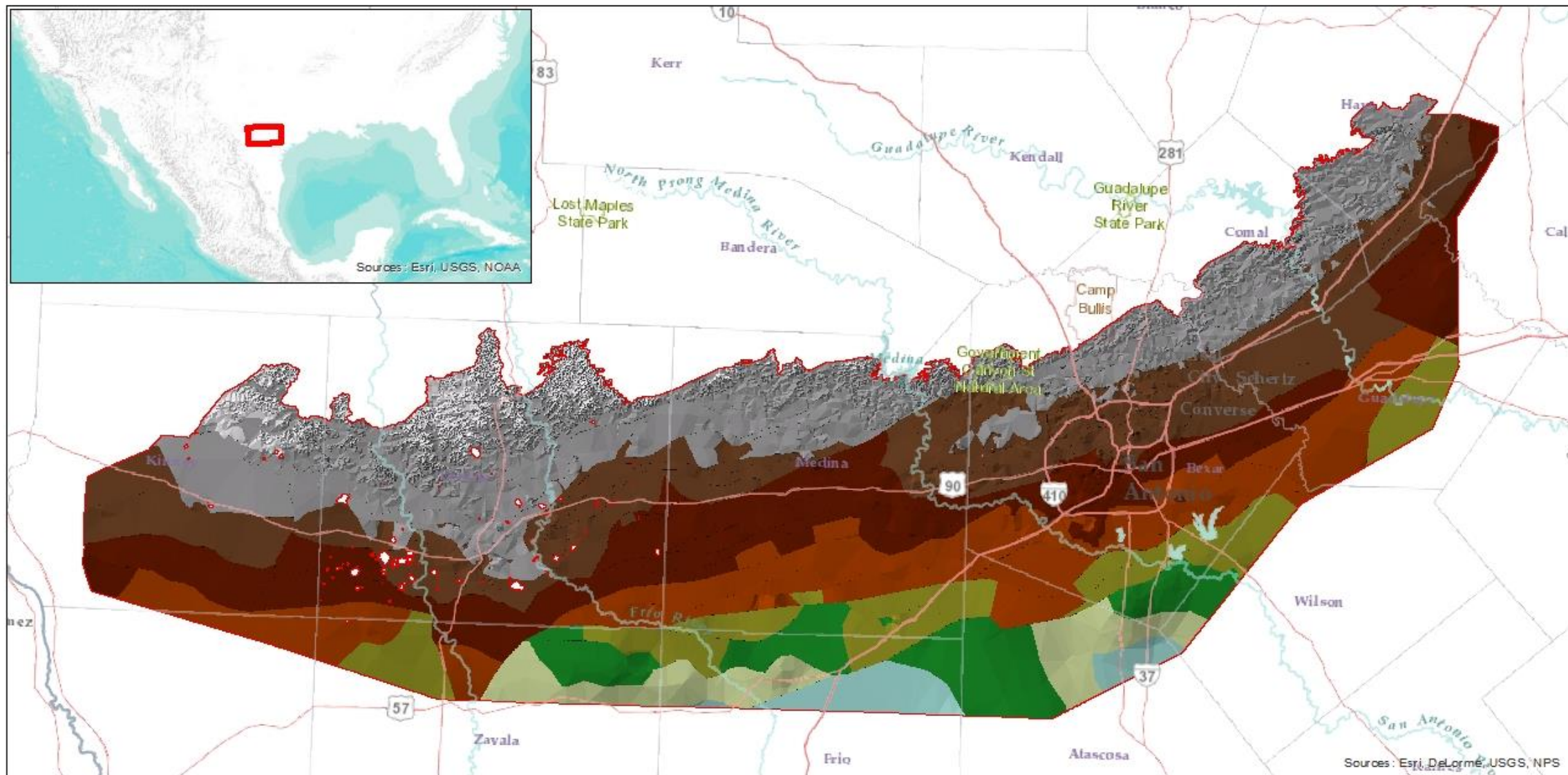
Soft Edge

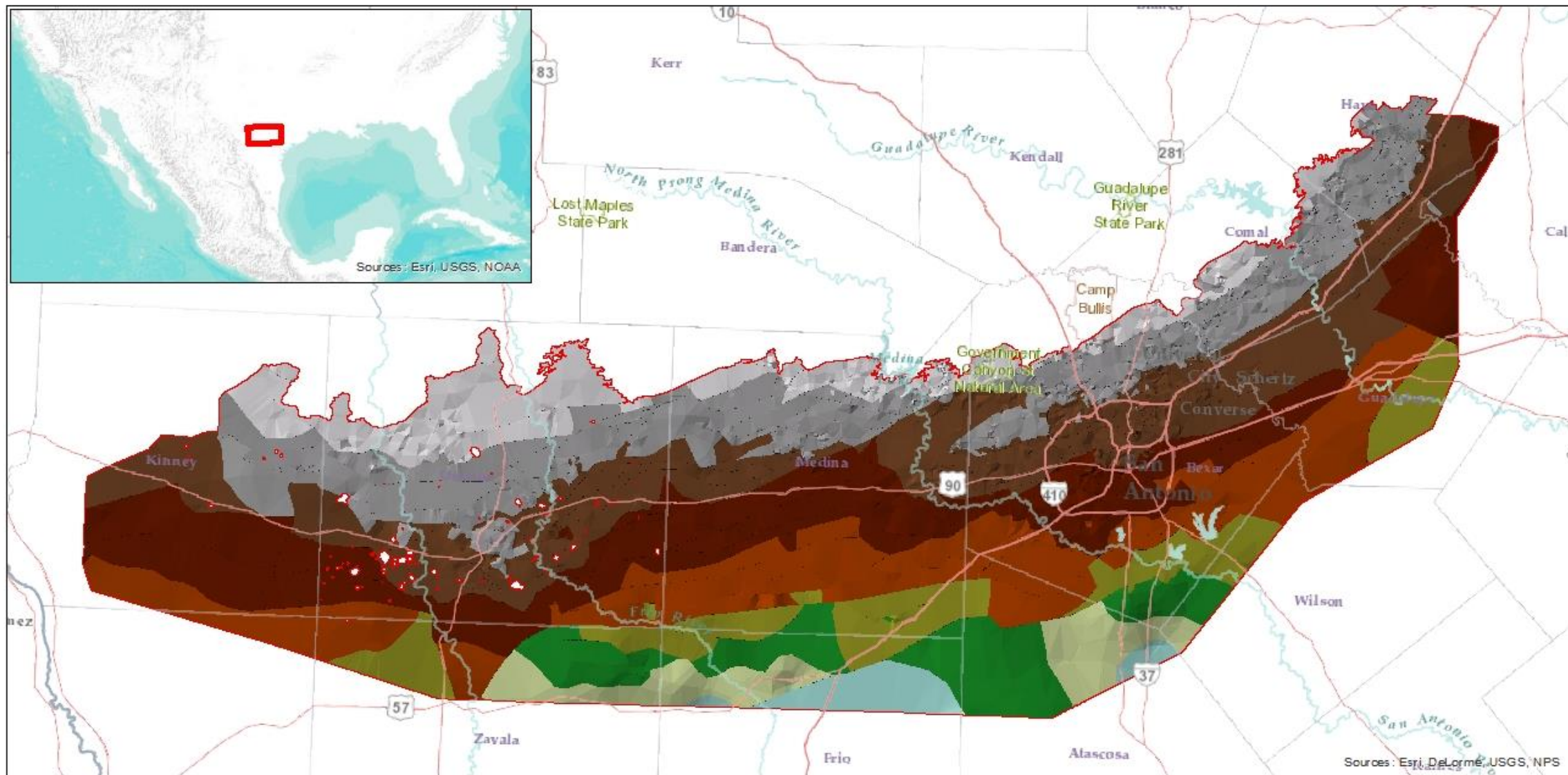
Feet above m.s.l.	1085 - 1230	503 - 649
1521 - 1667	939 - 1085	358 - 503
1376 - 1521	794 - 939	
1230 - 1376	649 - 794	

Authors: Ned Troshanov, Sarah Eason



0 5 10 20 30 40 Miles





Base Edwards Aquifer TIN Elevation

World Reference Overlay

Base Edwards Aquifer TIN Elevation

Edge type

Soft Edge

Feet above m.s.l.

920 - 1751

90 - 920

-740 - 90

-1571 - -740

-2401 - -1571

-3231 - -2401

-4061 - -3231

-4892 - -4061

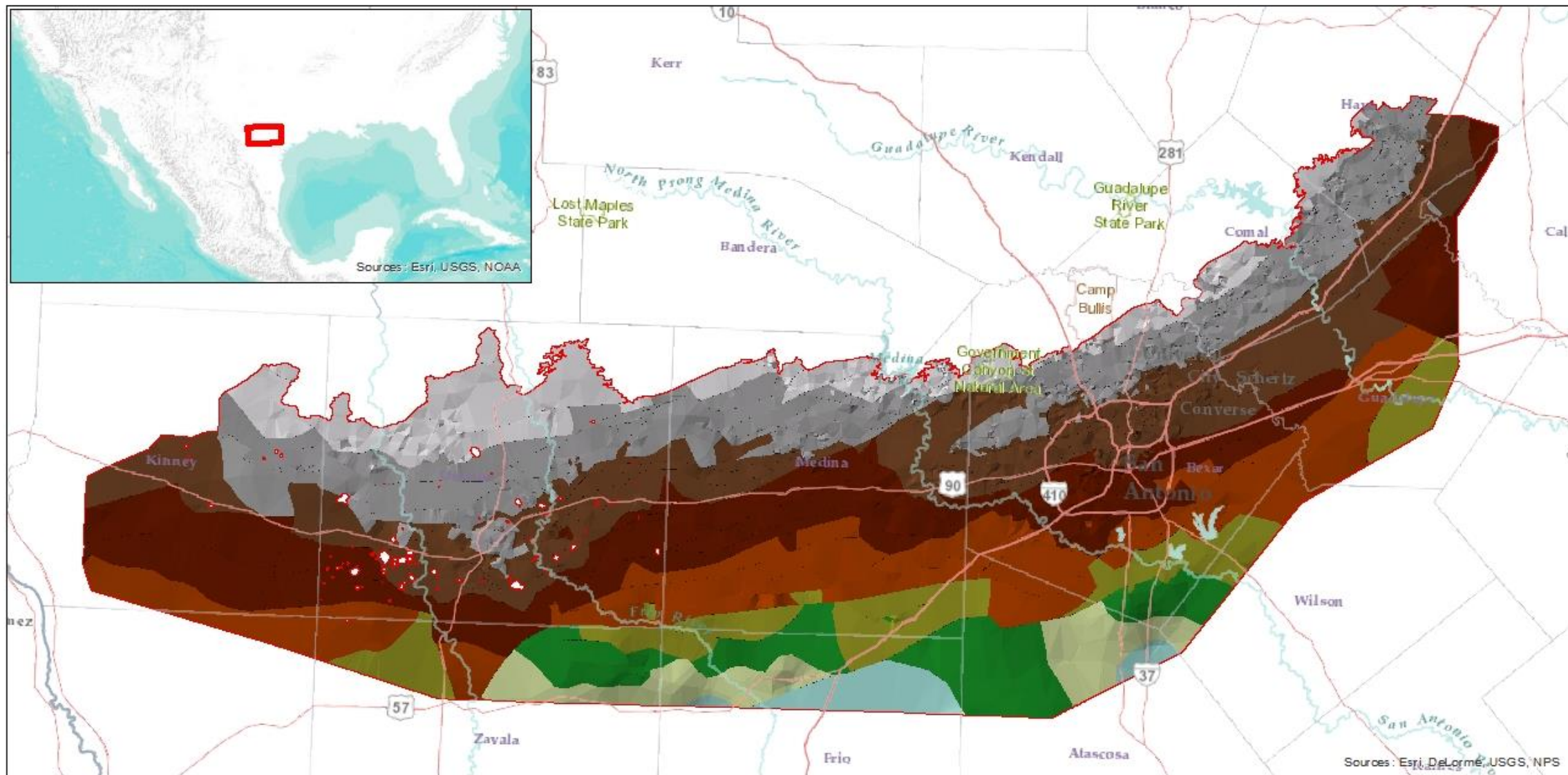
-5722 - -4892

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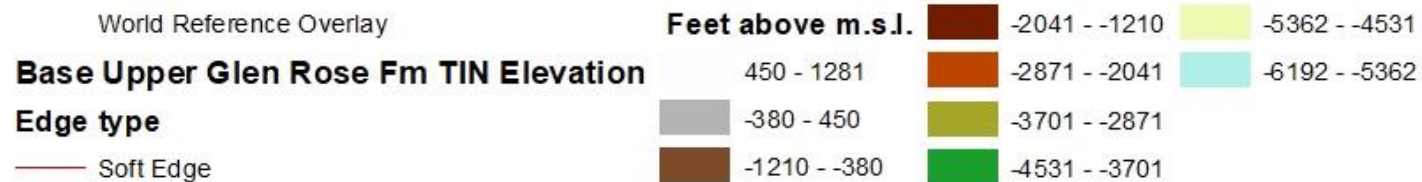


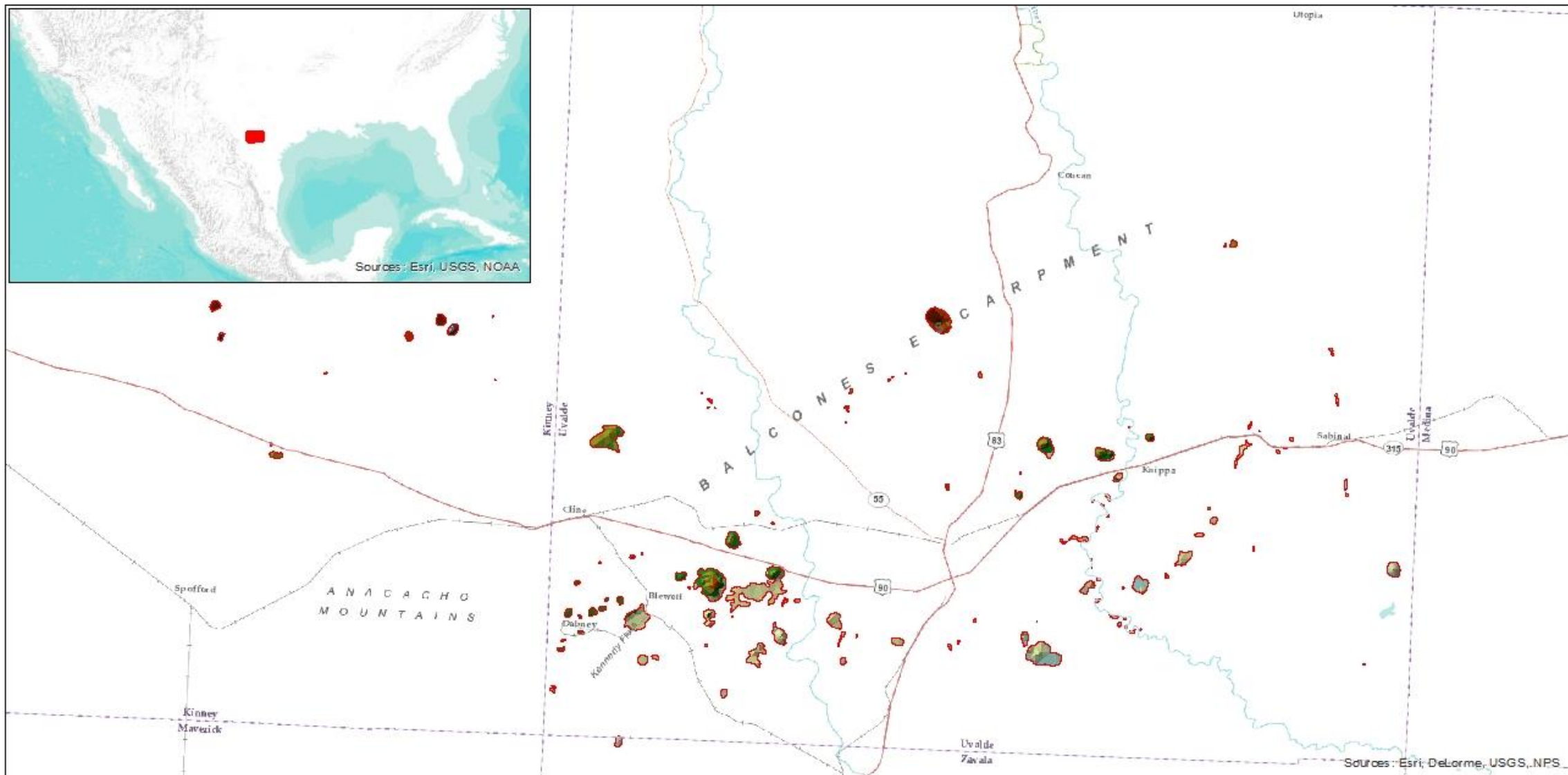
0 5 10 20 30 40 Miles

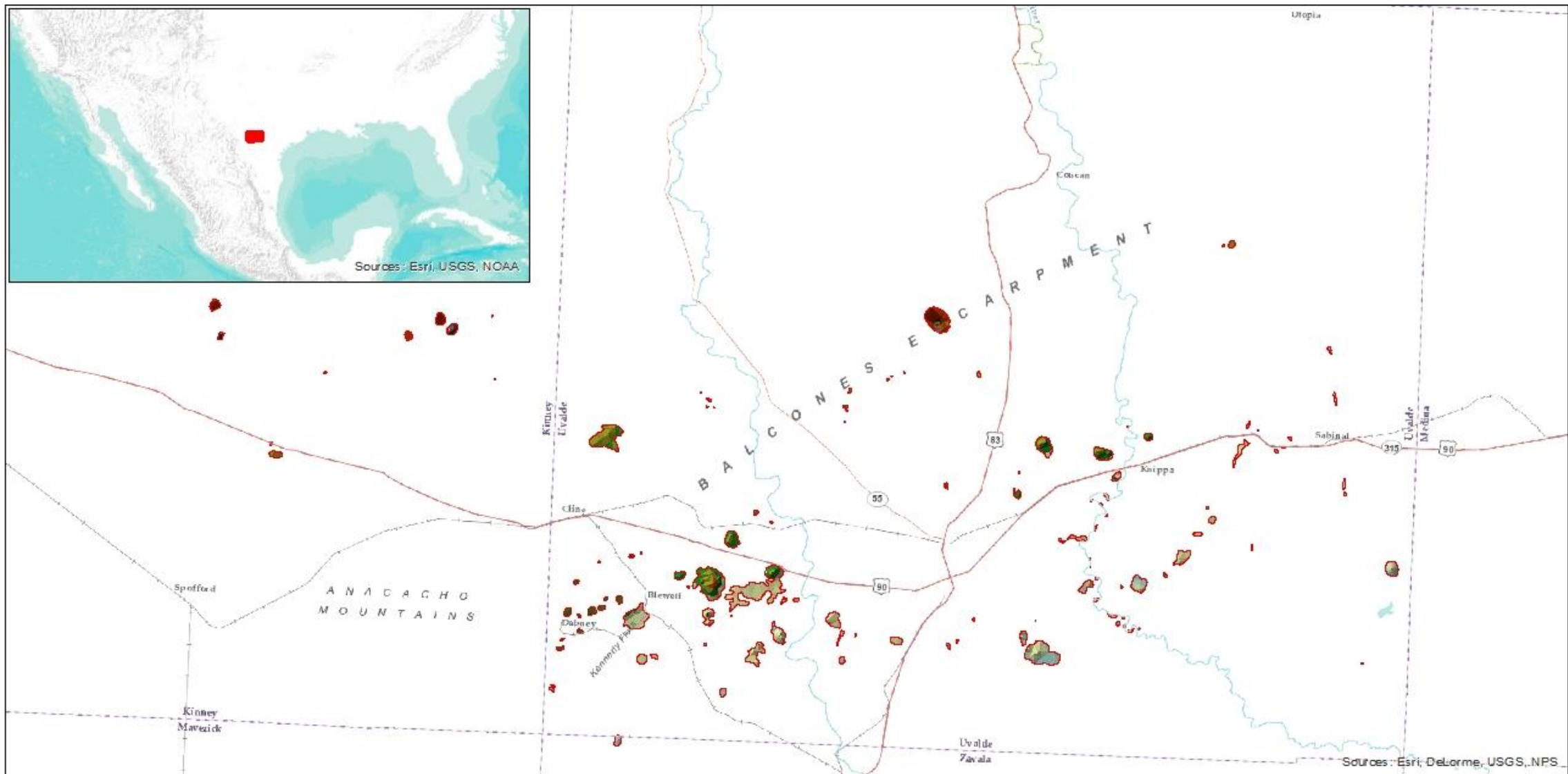
Sources: Esri, USGS, NOAA, NPS



Base Upper Glen Rose Fm TIN Elevation







Basalt Base TIN Elevation

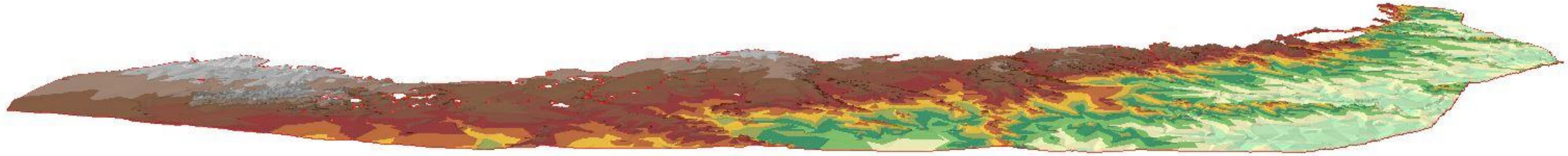
World Reference Overlay	Feet above m.s.l.	-1823 -- -1712	-2157 -- -2045	-2601 -- -2490
Basalt Base TIN Elevation		-1934 -- -1823	-2268 -- -2157	-2713 -- -2601
Edge type		-2045 -- -1934	-2379 -- -2268	-2490 -- -2379
Soft Edge				

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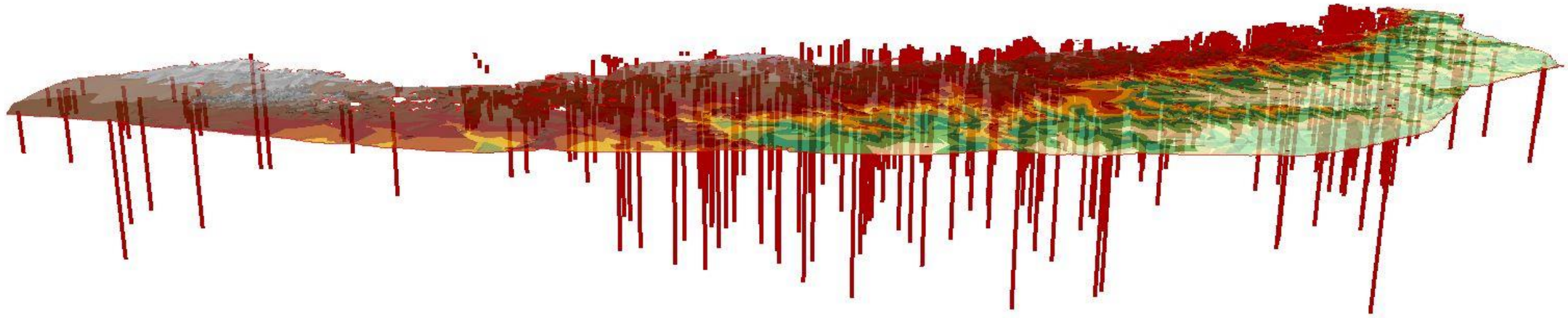


0 2 4 8 12 16 Miles

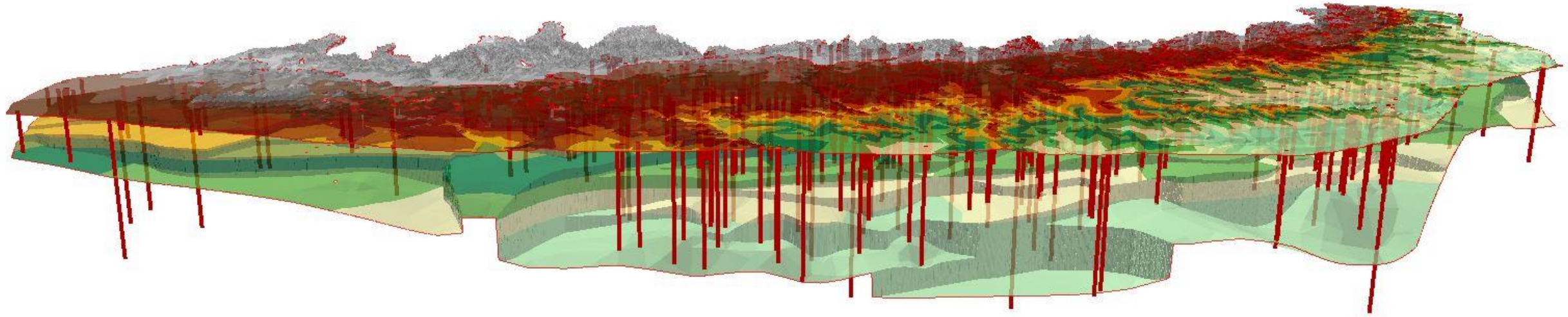
3D Model Visualization



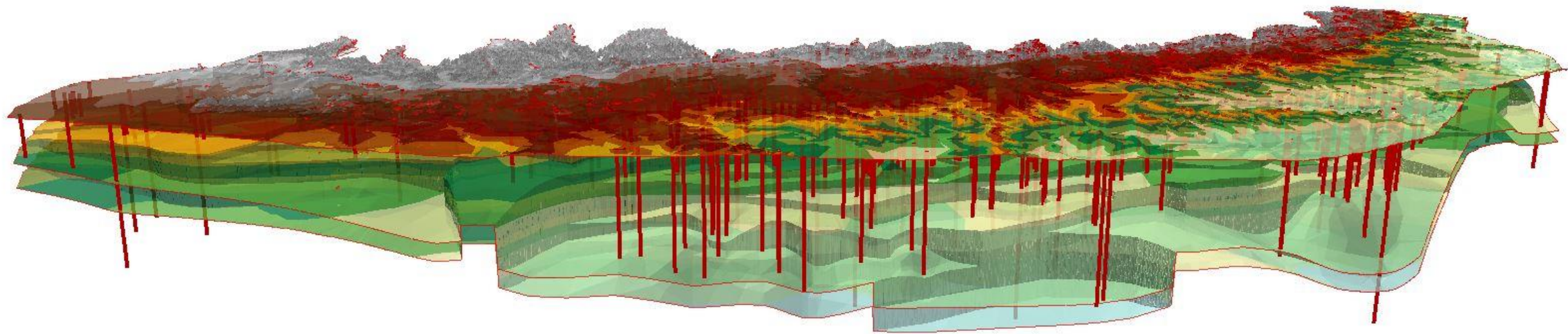
3D TIN Land Surface Raster Dataset in Confined Zone



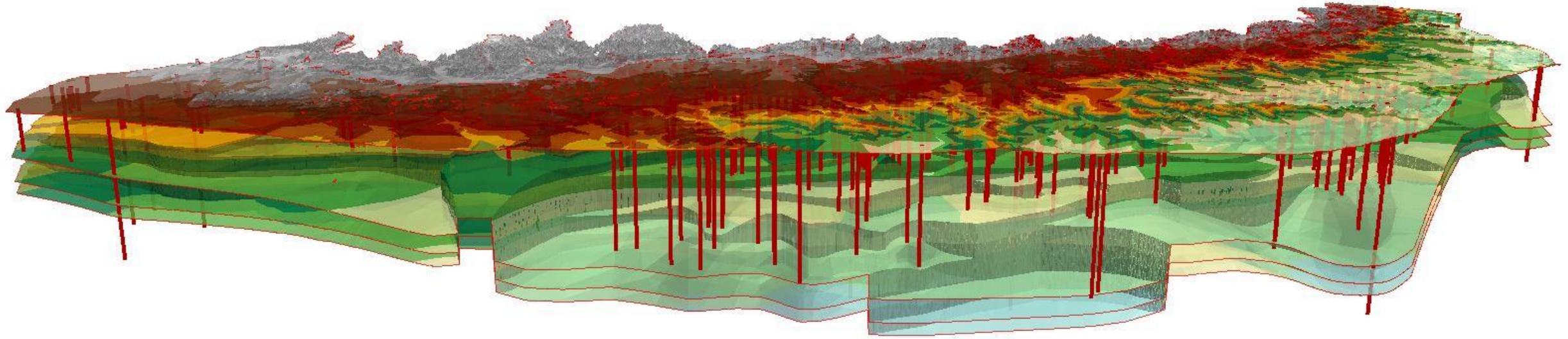
3D TIN Land Surface Raster Dataset in Confined Zone with Control Points



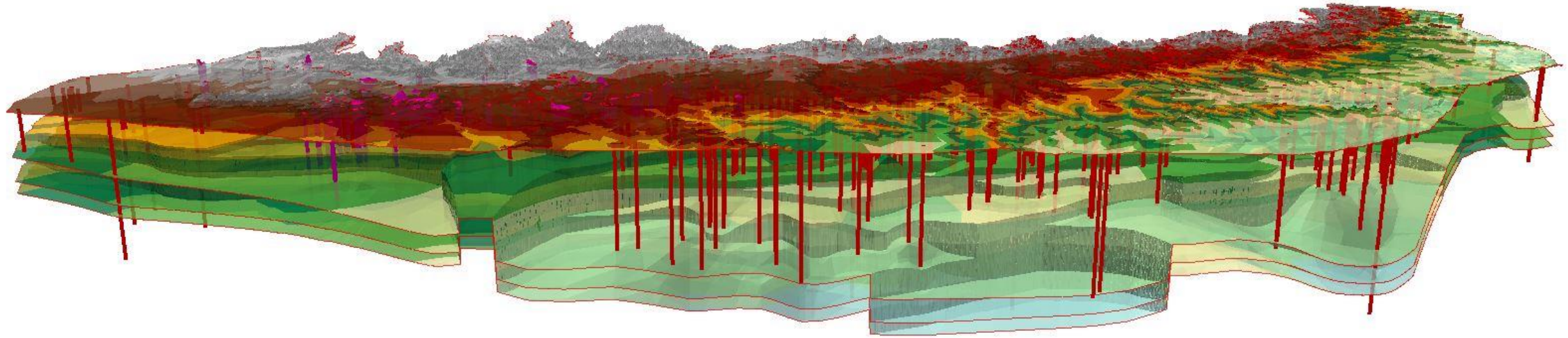
**3D TIN Land Surface and Top Edwards Aquifer Raster Datasets
with Control Points**



**3D TIN Land Surface, Top and Base of Edwards Aquifer Raster Datasets
with Control Points**



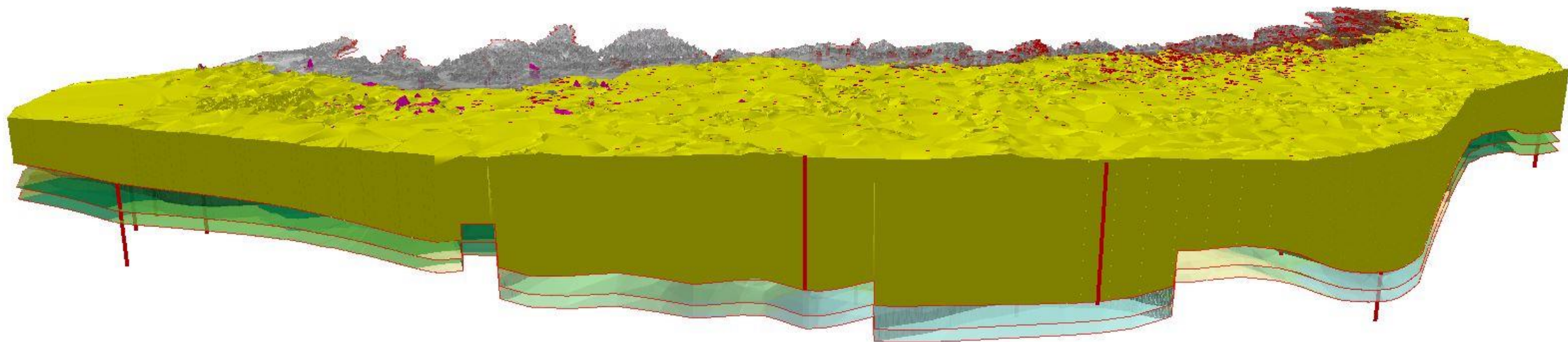
**3D TIN Land Surface, Top, Base of Edwards Aquifer, Base of Upper
Glen Rose Raster Datasets with Control Points**



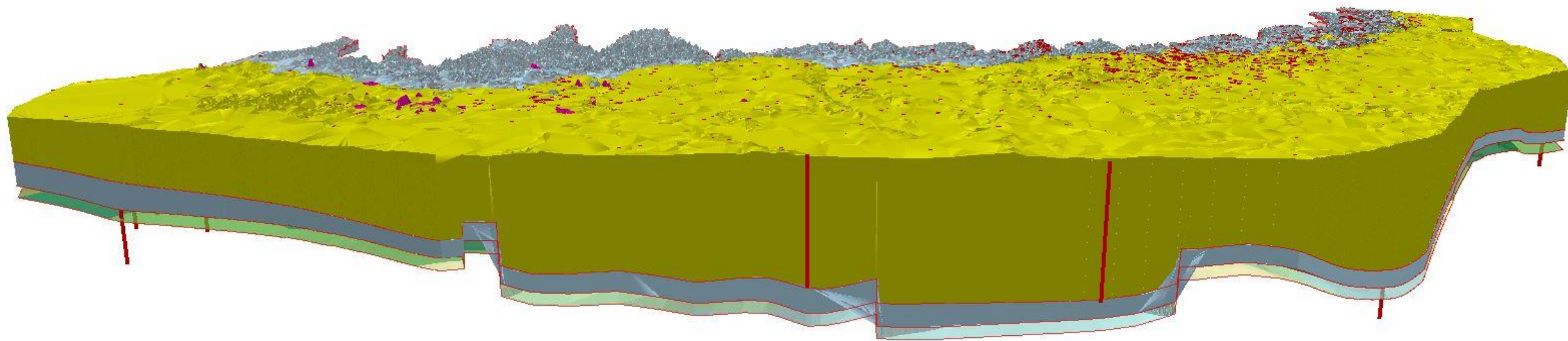
**3D TIN Land Surface, Top, Base of Edwards Aquifer, Base of Upper
Glen Rose Raster Datasets with Control Points and Extruded Basalts**



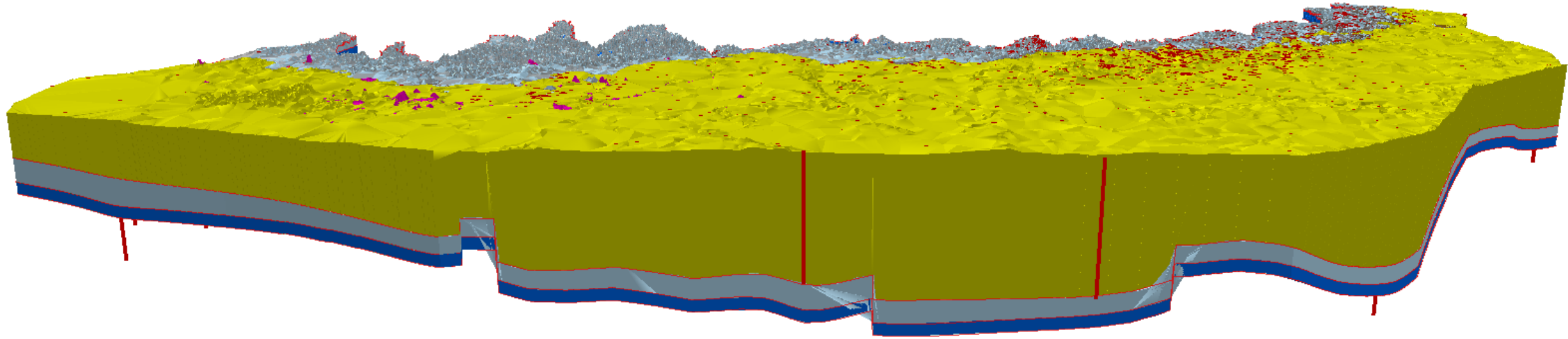
Extruded Inferred Faults (Structural Framework)



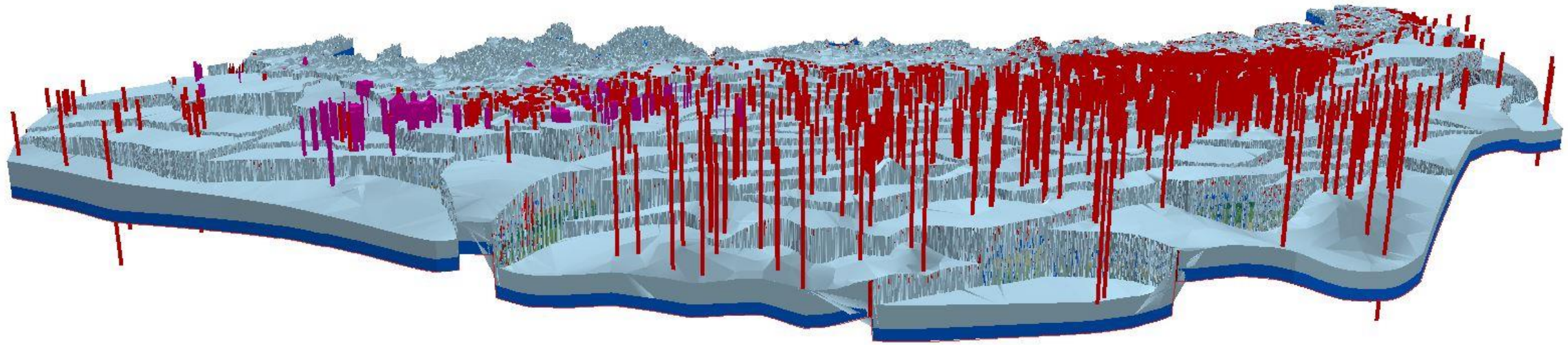
**3D TIN Raster Datasets with Extruded Basalts, Overburden,
Inferred Faults, and Control Points**



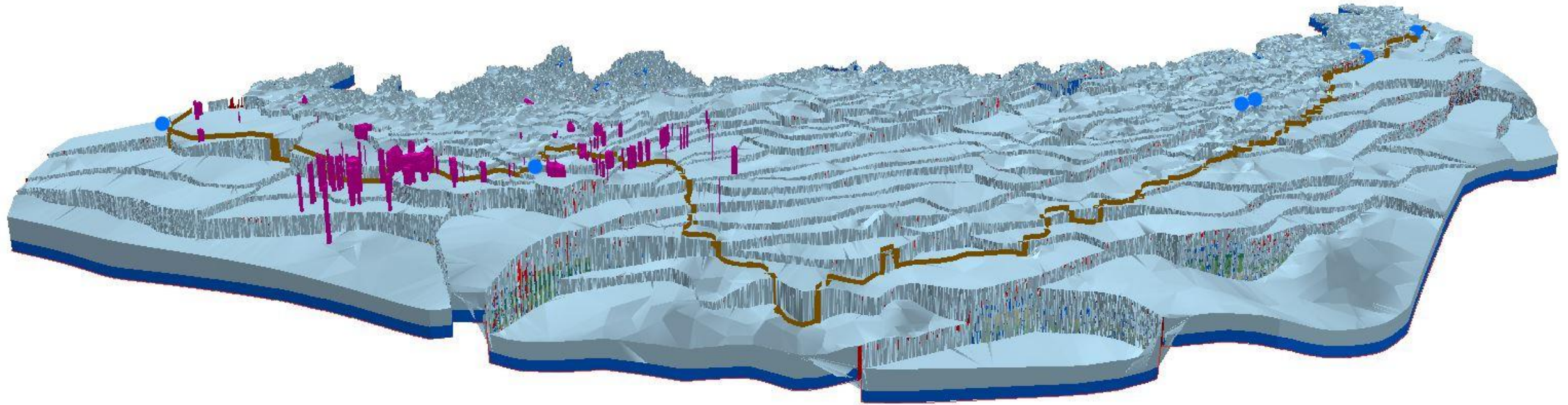
3D TIN Raster Datasets with Extruded Basalts, Overburden, Edwards Aquifer, Inferred Faults, and Control Points



3D TIN Raster Datasets with Extruded Basalts, Overburden, Edwards Aquifer, Inferred Faults, Upper Glen Rose Fm and Control Points



**3D Extruded Edwards Aquifer, Upper Glen Rose Fm,
and Inferred Faults, and Control Points**

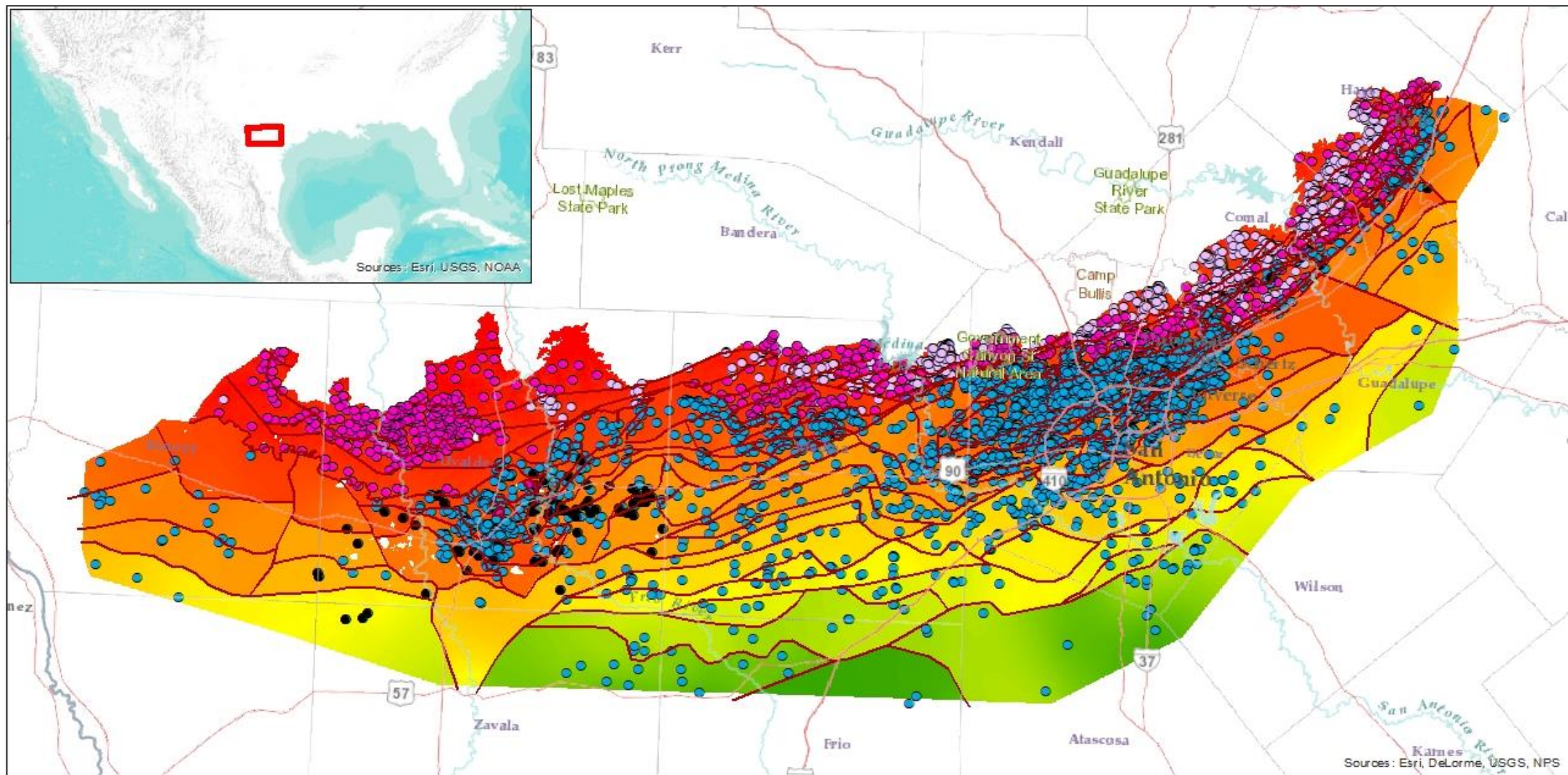


**3D Extruded Edwards Aquifer, Upper Glen Rose Fm,
and Inferred Faults**

Structural Model Limitations

"All models are wrong; some models are useful." – George E. P. Box (1919-2013)

- The Edwards Aquifer Structure Model delineates faults based on the analysis of sudden changes in formation slope. When structural control points (wells) have a higher density, the delineated inferred faults have a higher probability to be at their correct location and vice versa – when the control points are sparse (e.g., in saline subzone and in fresh subzone in Kinney County), the accuracy of inferred fault location estimation is low. Therefore, it is necessary to *check the structural control point density in any particular estimation*.
- Modeled layer elevations close to inferred faults delineated or in *zones with low control point density should be considered with precaution*. Seismic surveys could be a cheaper alternative to drilling boreholes in areas where potential fault locations are most uncertain.
- This *Edwards Aquifer Structure Model will be updated periodically* as new data points become available.



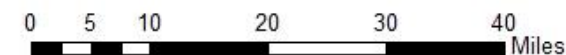
Current Structural Map of Top Edwards Aquifer Elevation and Input Data

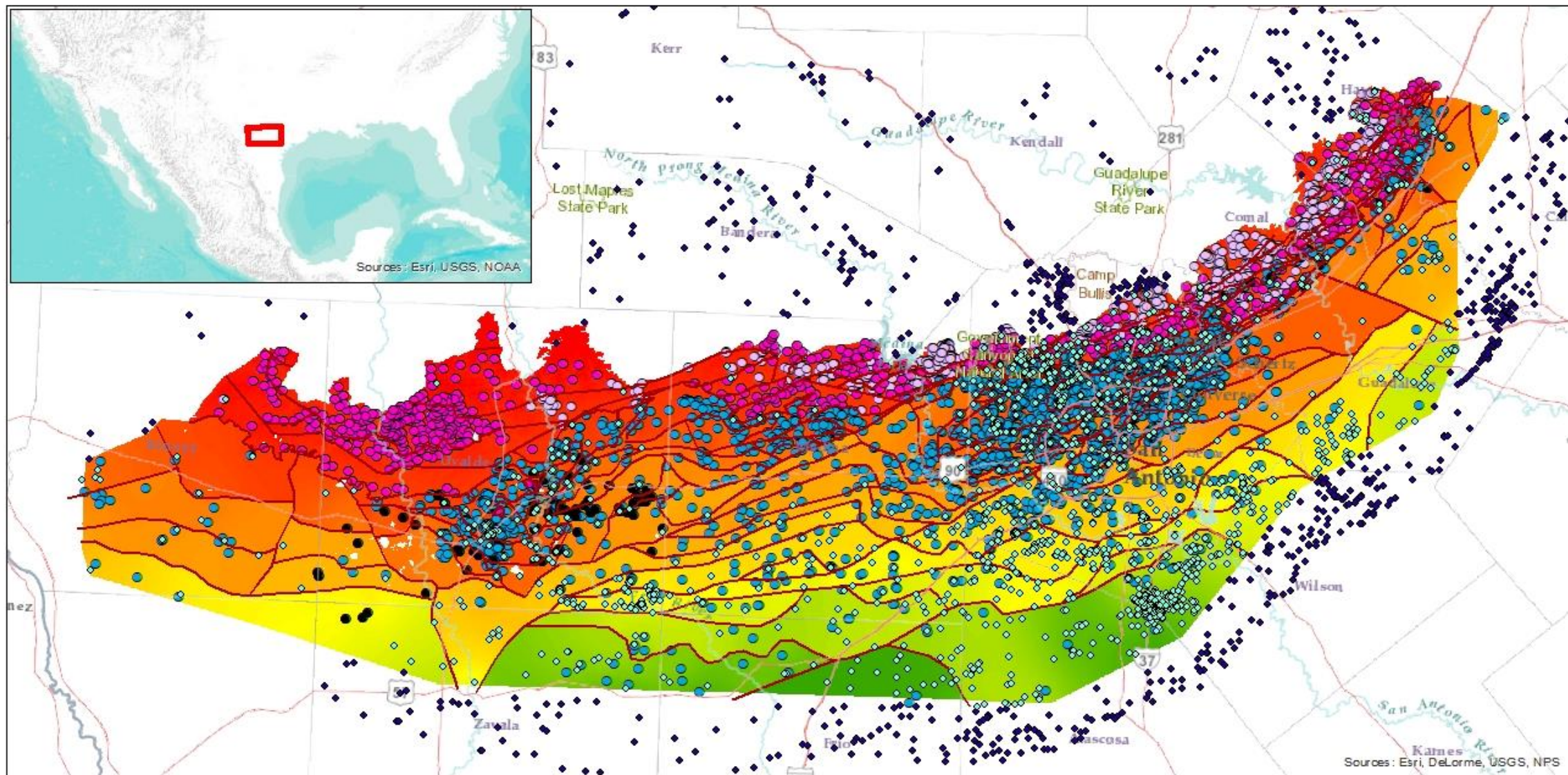
- World Reference Overlay
- Inferred Faults
- Seismic Points (65)
- Structural CPs in Confined Zone (3417)
- Geomap Estimates (637)
- Structural CPs in Unconfined Zone (1992)

Top Edwards Aquifer Elevation, feet above m.s.l. Value



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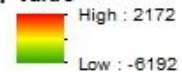




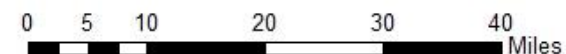
Structural Map of Top Edwards Aquifer Elevation and Future Updates

- ◆ New CPs in Project Area (1972)
- ◆ New TWDB Well Information (2875)
- World Reference Overlay
- Inferred Faults
- Seismic Points (65)
- Structural CPs in Confined Zone (3417)
- Geomap Estimates (637)
- Structural CPs in Unconfined Zone (1992)

Top Edwards Aquifer Elevation, feet above m.s.l. Value



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Project Achievements and Application

1. The Edwards Aquifer 2D ArcGIS structural model has been updated with new data.
2. A project geoprocessing workflow using ModelBuilder visual language has been created, allowing reduction of the time required for future structural model updates.
3. A new method for cross-section drawing has been developed based on the structural model data.
4. The first version of a regional Edwards Aquifer 3D ArcGIS geologic structural model has been developed.

The 2D and 3D ArcGIS structural models can be applied in:

- groundwater-flow conceptual analysis;
- groundwater-flow model construction;
- preliminary information for drilling contractors;
- well exemption status evaluation and
- educational purposes.

Potential Future Steps in Edwards Aquifer ArcGIS Modeling

1. **Increase control point density** in the entire saline subzone and fresh subzone in Kinney County with additional logging information (TxRRC, TWDB).
2. Identify potential zones where faults **juxtapose the Edwards Aquifer and Lower Glen Rose Formation**.
3. Saturated **groundwater flow analysis** on:
 - a. ***Saturated groundwater flow thickness*** in the unconfined (recharge) zone at different hydrologic conditions;
 - b. Evaluation of ***hydraulic restriction zones*** based analysis on hydraulic gradients and water-chemistry, and
 - c. Attempt to ***quantify subsurface flows*** based on formation geometry and hydraulic conductivity estimates.

QUESTIONS?