Salinity in the Northern Segment of the Brazos River Alluvium Aquifer: A Hydro-Forensic Approach

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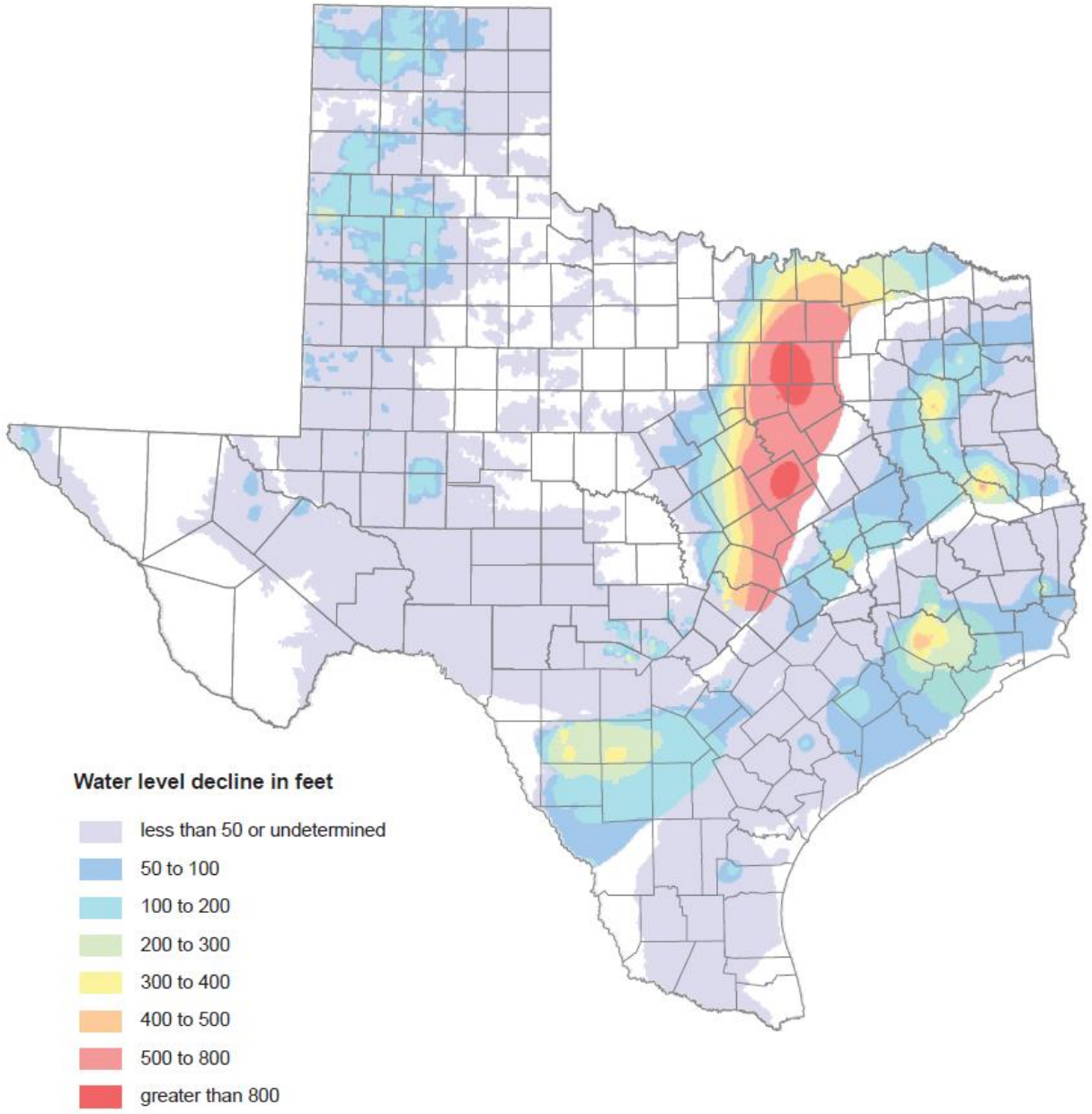
BAYLOR UNIVERSITY

Introduction

- Growth along I-35 corridor has strained regions water resources
- Brazos River Alluvium aquifer (BRAA) is an underutilized minor aquifer
- Elevated salinity levels documented as early as 1967 by Cronin and Wilson
- Effective aquifer management requires a better understanding of variability and sources of elevated salinity



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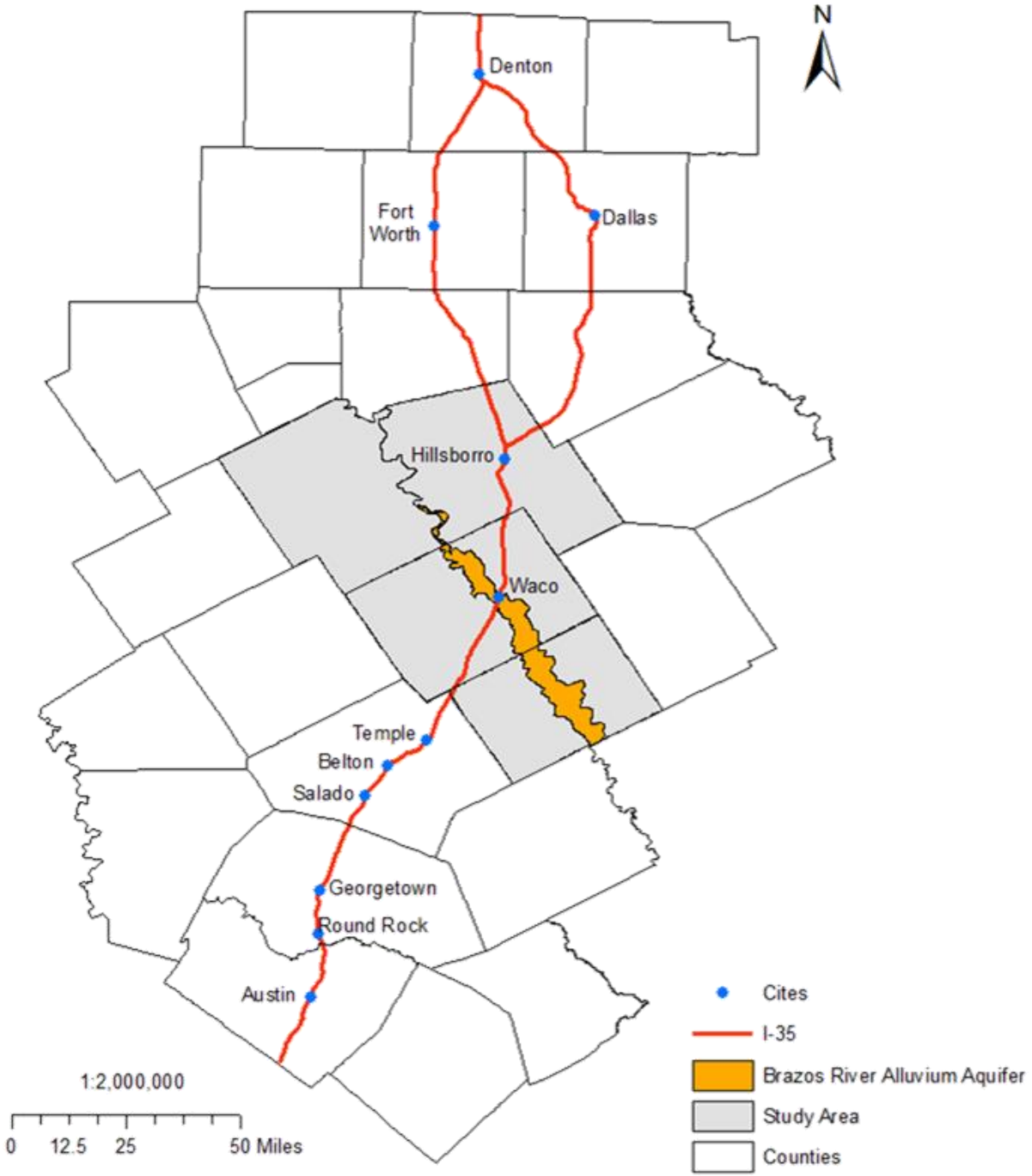
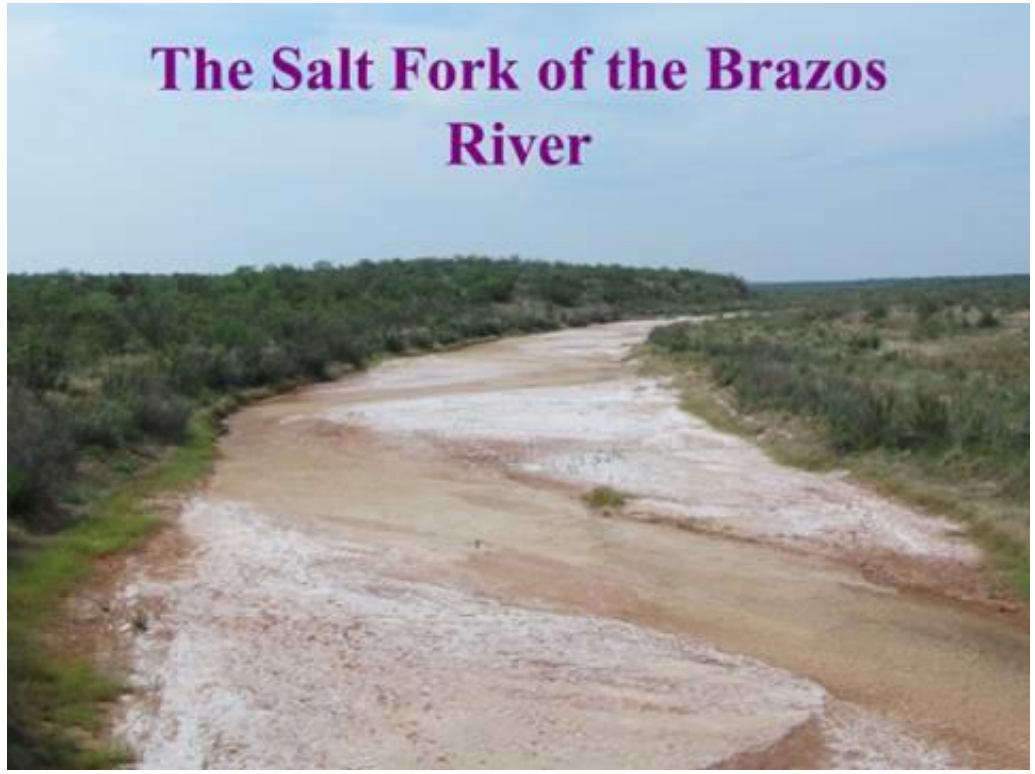


Objective

- Characterize the variability of salinity in the northern segment of the BRAA and evaluate potential sources of elevated salinity

Hypotheses

1. Groundwater – surface water interactions between aquifer and Brazos River
2. Irrigation and evapotranspiration
3. Brine contamination from historic oil and gas fields



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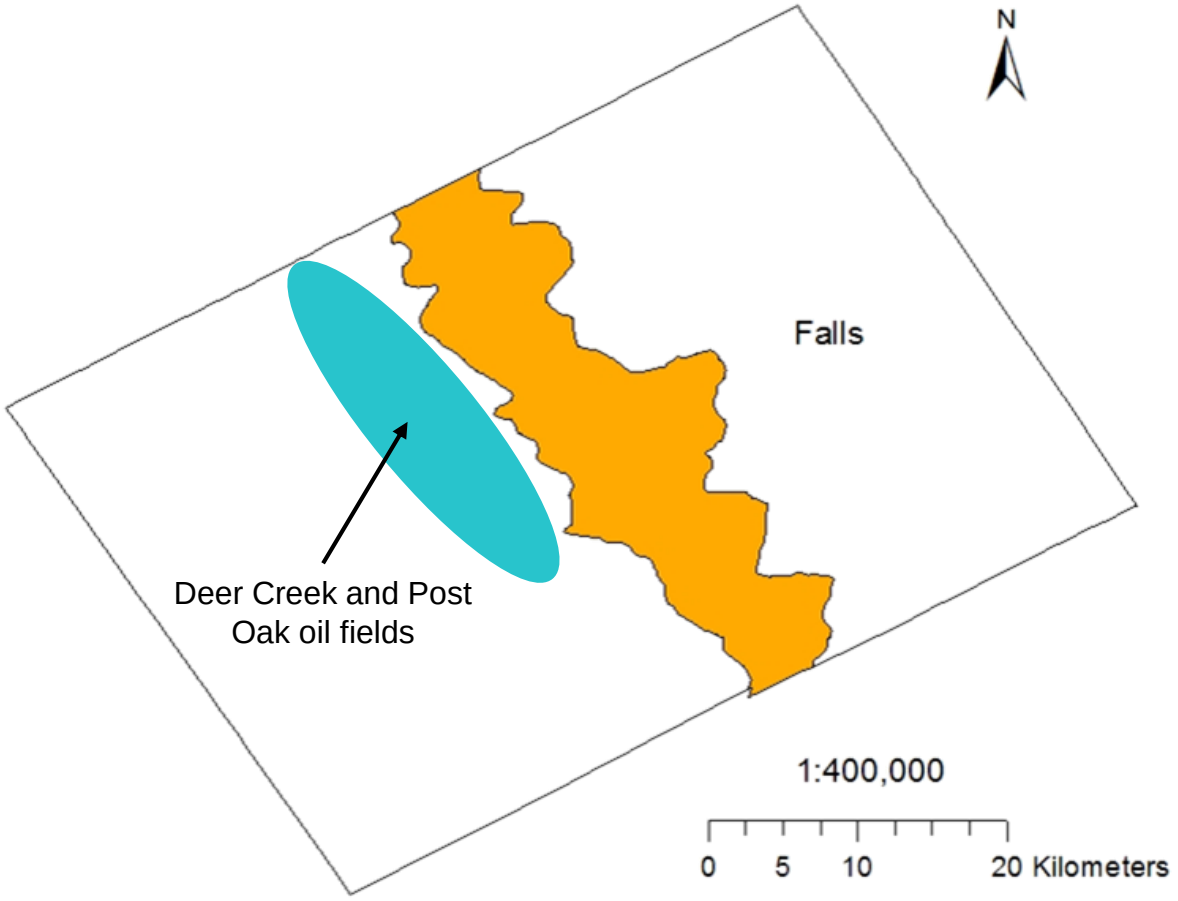
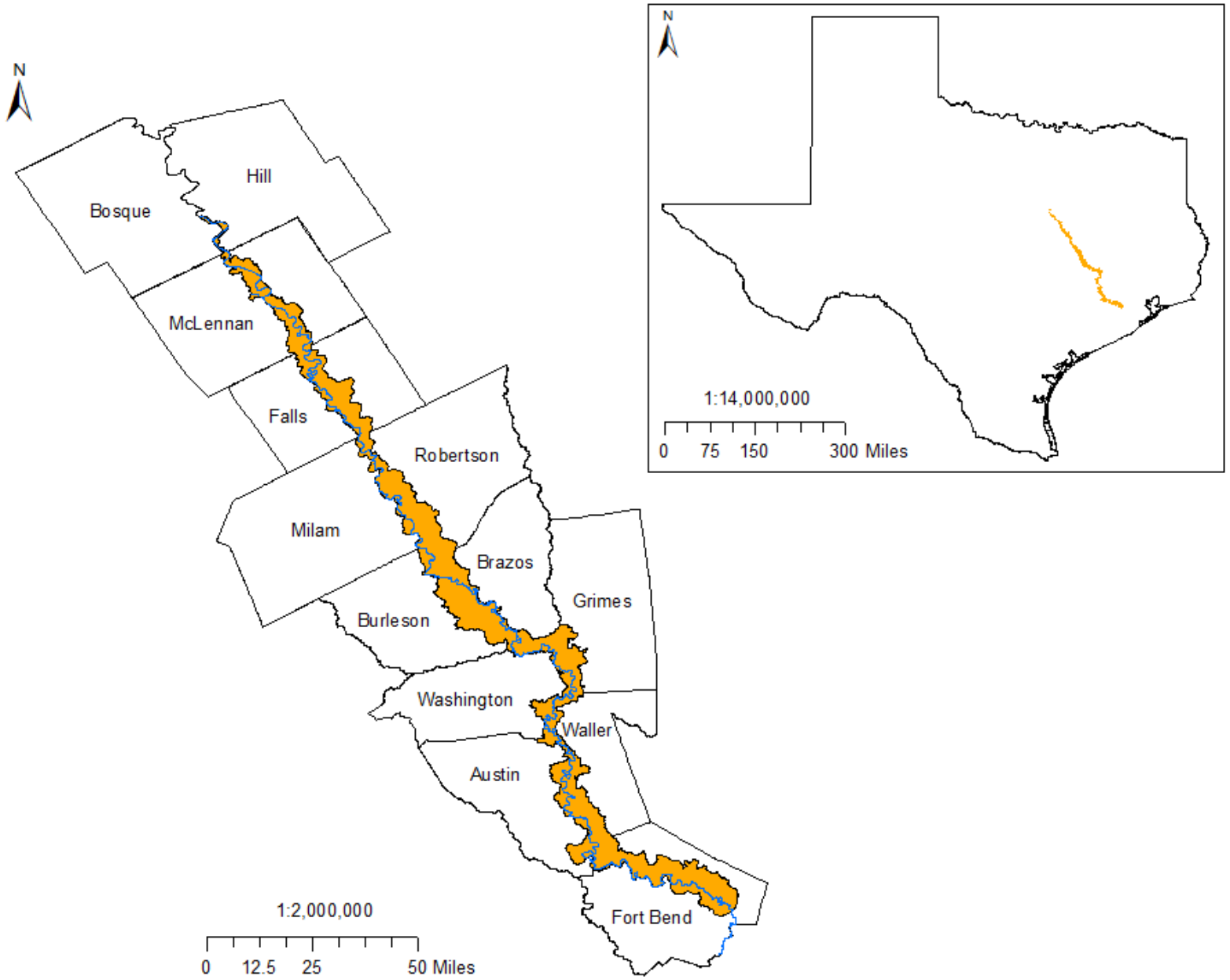


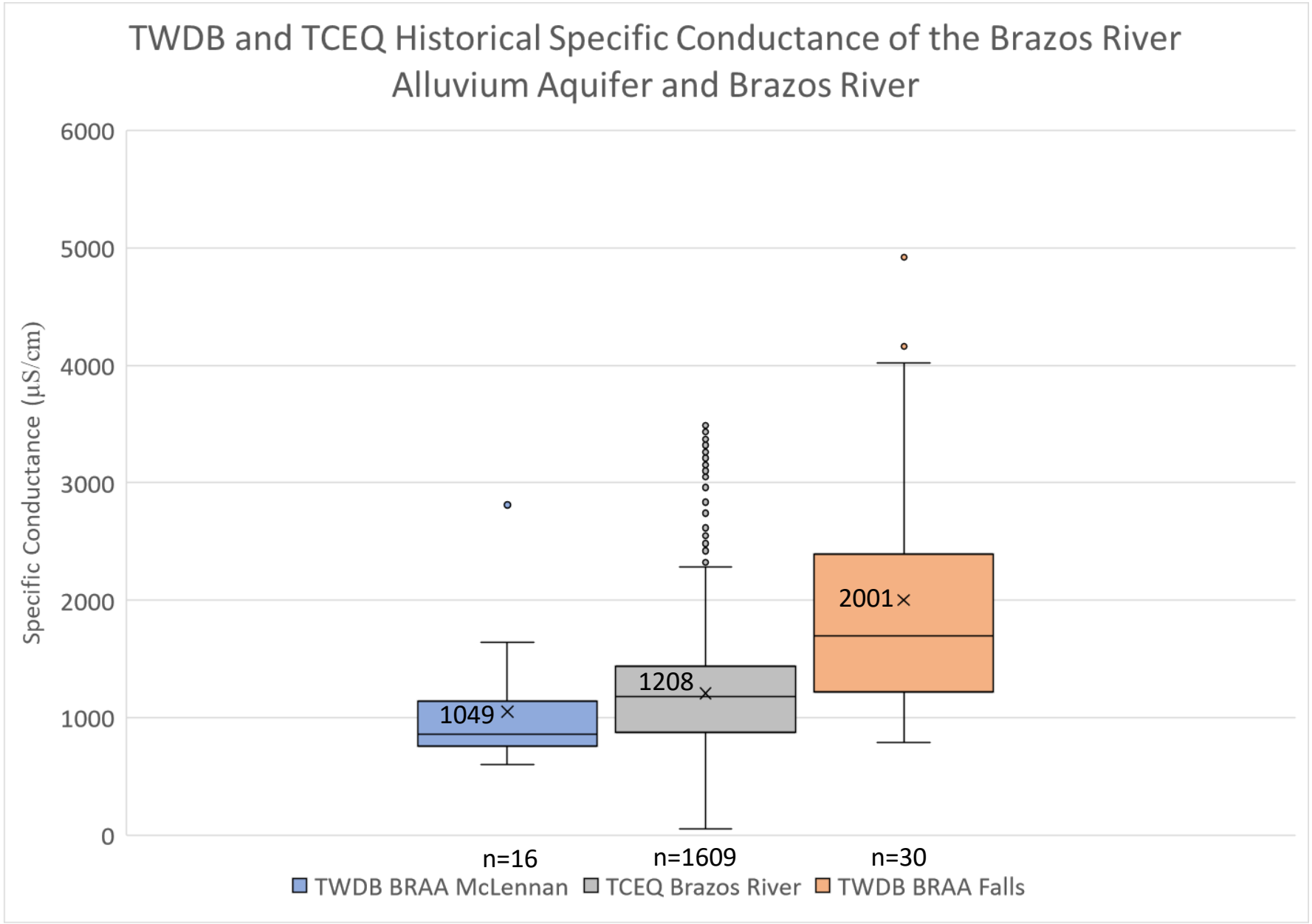
Hydrogeologic Setting

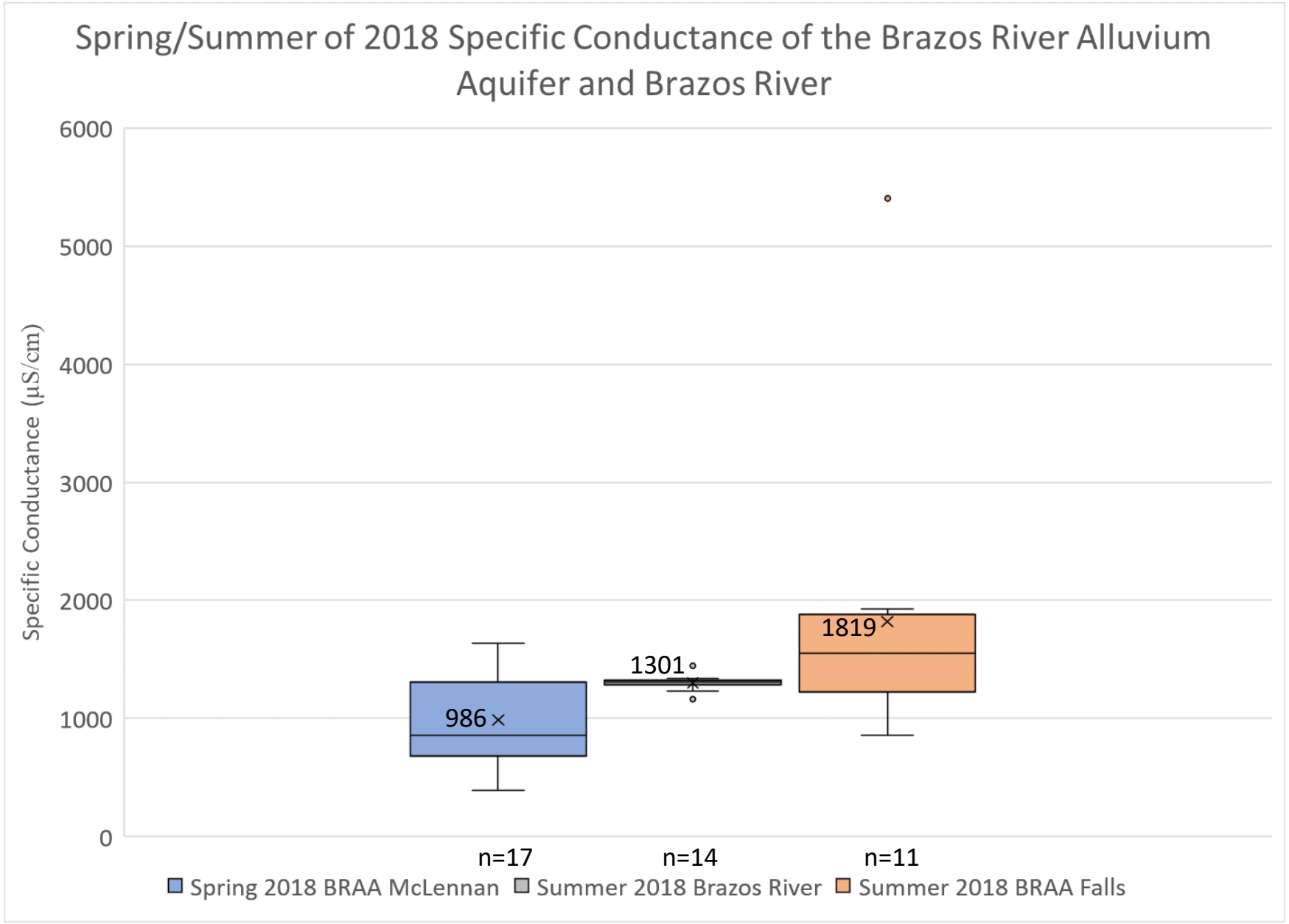
- Primarily used for irrigation
- Heterogeneous but typically exhibits fining upward sequence
- Recharged by precipitation and discharges at Brazos River
- Northern segment underlain by Cretaceous and Tertiary age bedrock



Methods

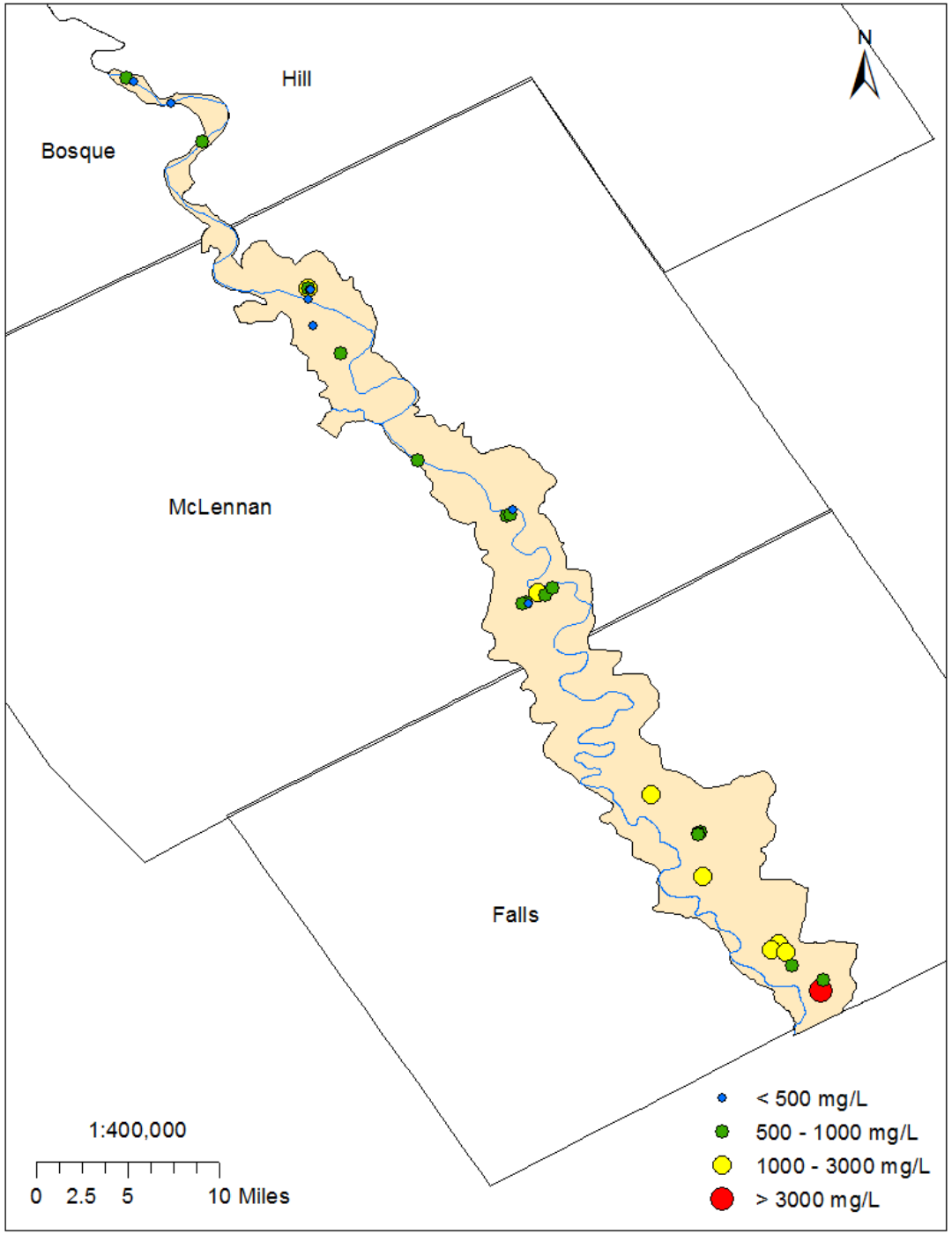
1. Analysis of historical BRAA and Brazos River chemistry data
2. BRAA and Brazos River water sampling: Specific conductance, temperature, major cations and anions, and ratios of hydrogen and oxygen isotopes
3. Coring and in-situ water sampling at three sites
4. Installation of data loggers to monitor changes in water level over time


TWDB and TCEQ Historical Specific Conductance of the Brazos River Alluvium Aquifer and Brazos River
Specific Conductance (µS/cm)
6000
5000
4000
3000
2000
1000
0
1049
1208
2001
n=16
n=1609
n=30
TWDB BRAA McLennan
TCEQ Brazos River
TWDB BRAA Falls


Spring/Summer of 2018 Specific Conductance of the Brazos River Alluvium Aquifer and Brazos River
Specific Conductance (µS/cm)
6000
5000
4000
3000
2000
1000
0
986
1301
1819
n=17
n=14
n=11
Spring 2018 BRAA McLennan
Summer 2018 Brazos River
Summer 2018 BRAA Falls

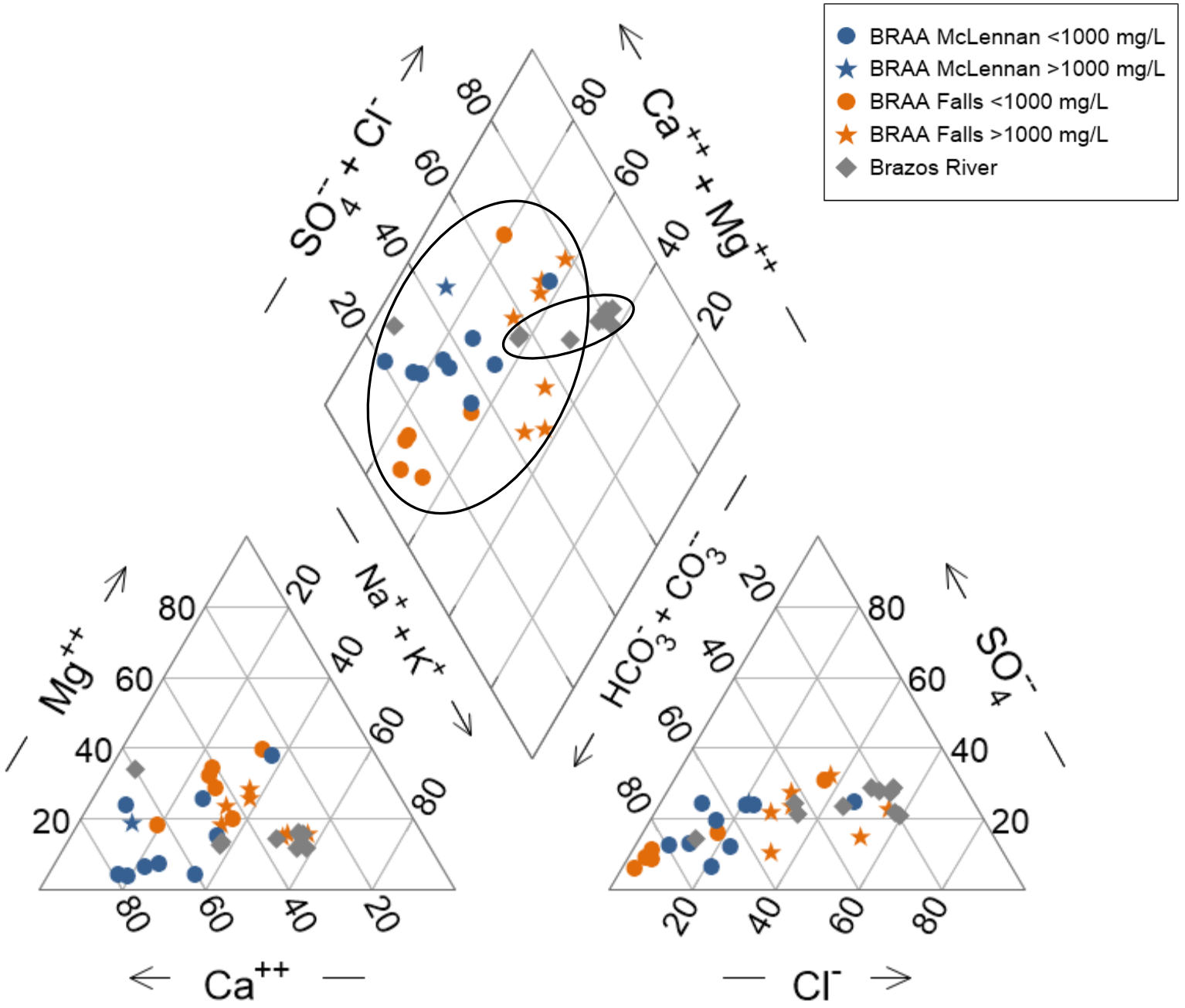
TDS of the Brazos River Alluvium Aquifer

- Spring/summer of 2018: 32 samples
- 75% of samples exceeded EPA's secondary drinking water standard for TDS
- High degree of variability in TDS
- TDS can double over the course of a few hundred yards
- Brine contamination from oil fields not likely cause of elevated TDS in Falls County



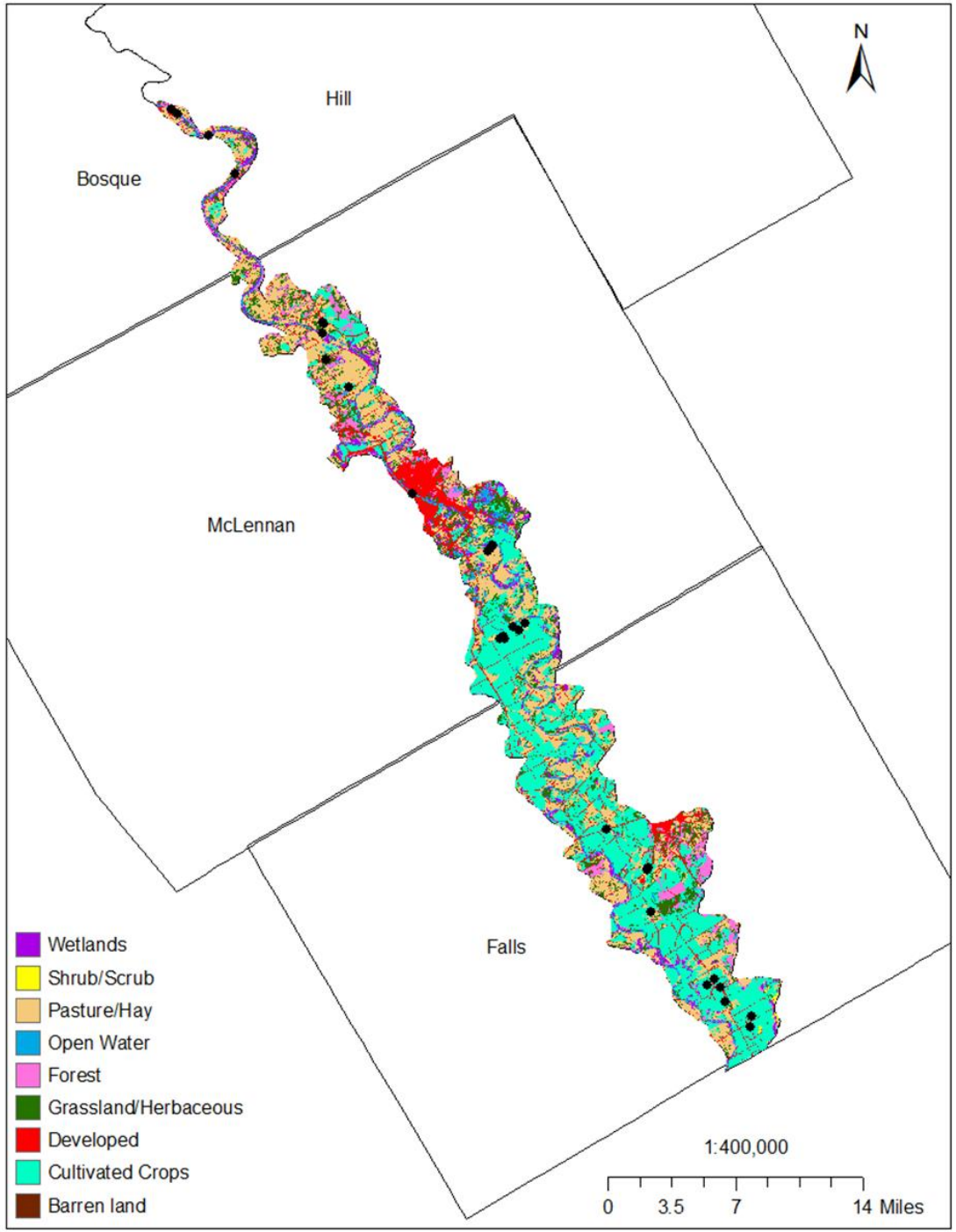
Piper Diagram

- Brazos River: Sodium chloride type water
- BRAA McLennan County: Calcium bicarbonate type water
- BRAA Falls County: Mixed bicarbonate to mixed cation and anion type water
- Aquifer and river tend to have distinct chemistries



Land Cover

- 2011 USGS land cover map
- Falls County has a higher proportion of land used for cultivated crops than McLennan County
- McLennan County has a much higher population than Falls County
- Cultivated crops can be either irrigated or non-irrigated
- Historically, Falls County has significantly more irrigation than McLennan County



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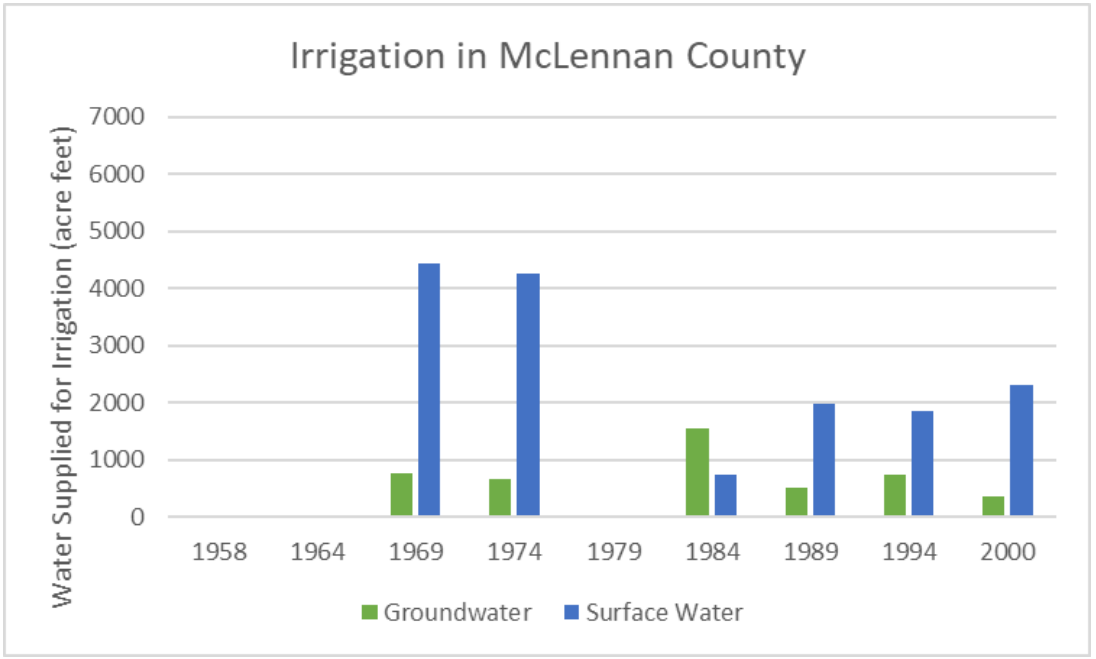
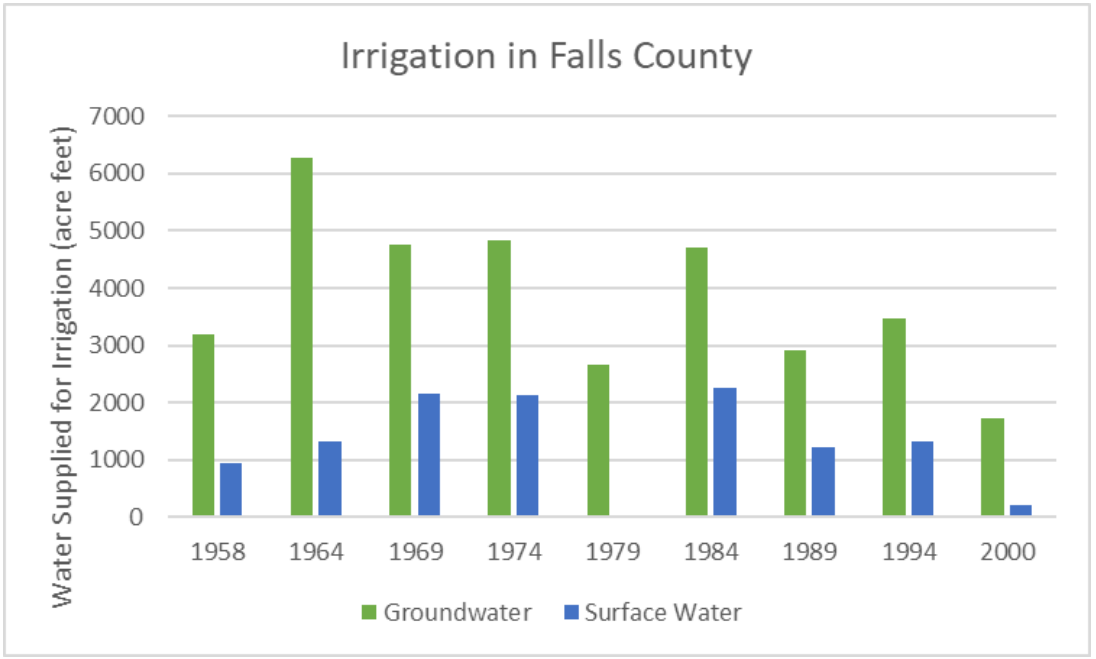
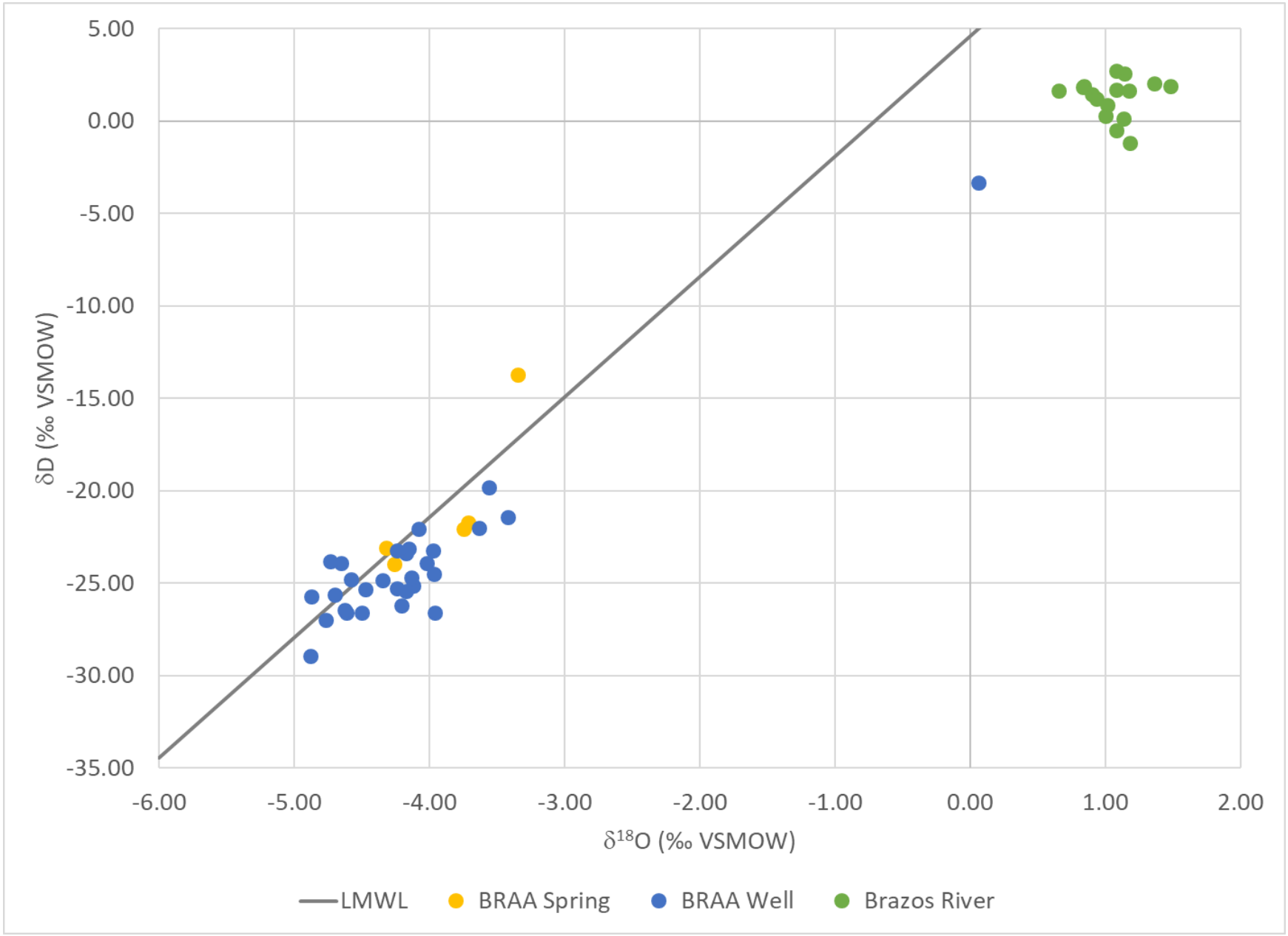
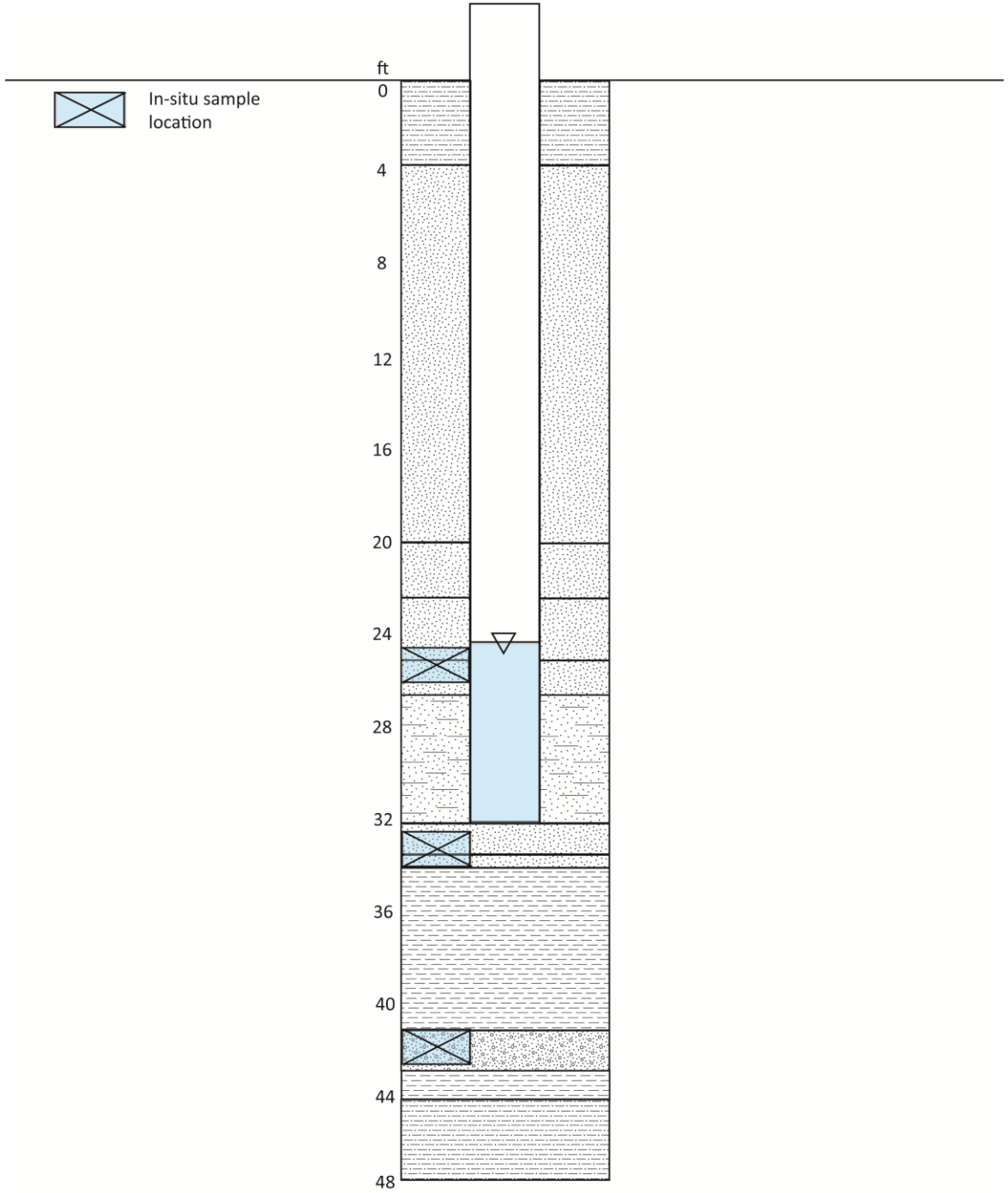





5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
δD (‰ VSMOW)
-6.00
-5.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
δ18O (‰ VSMOW)
LMWL
BRAA Spring
BRAA Well
Brazos River

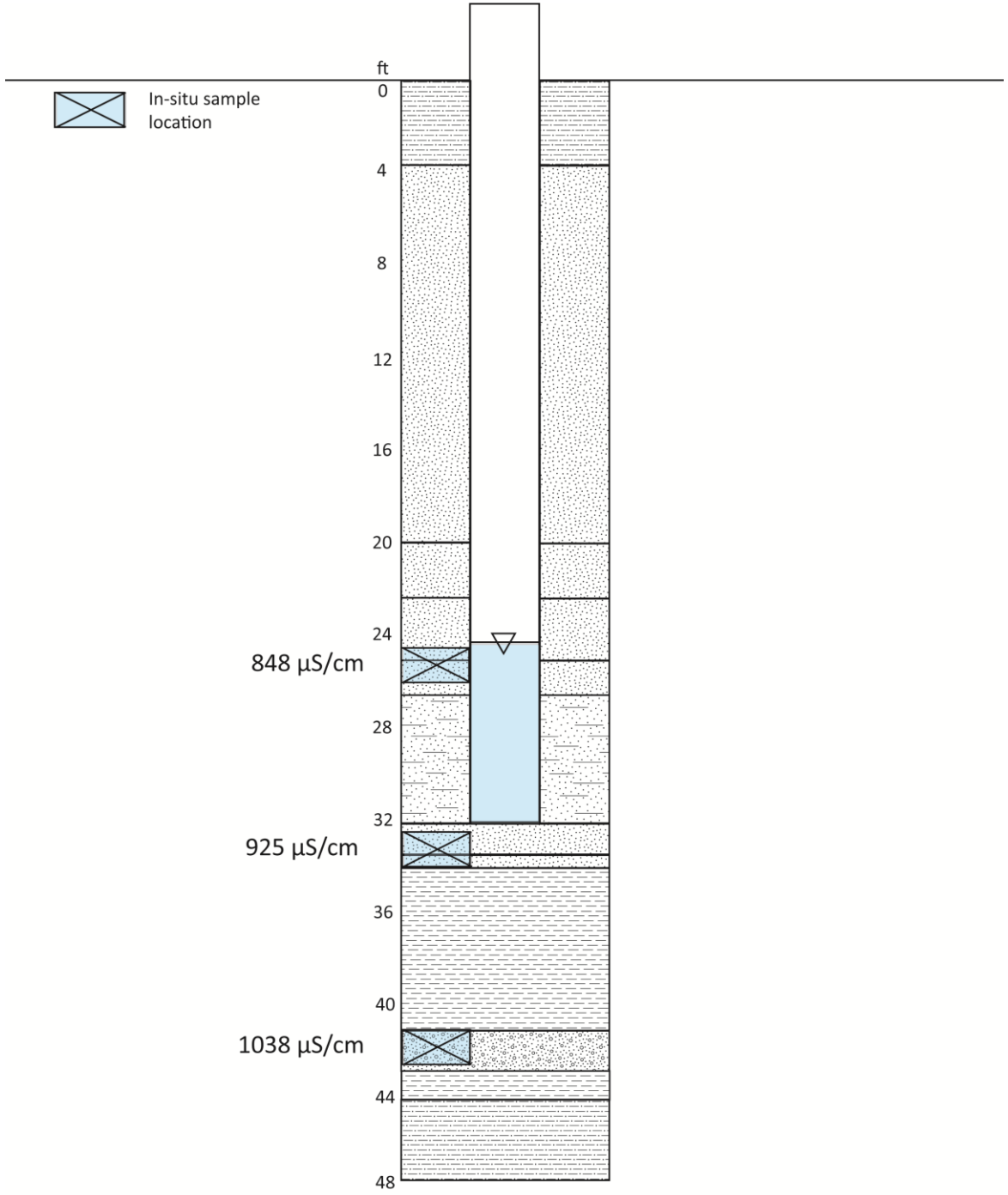
Coring and In-situ Water Sampling

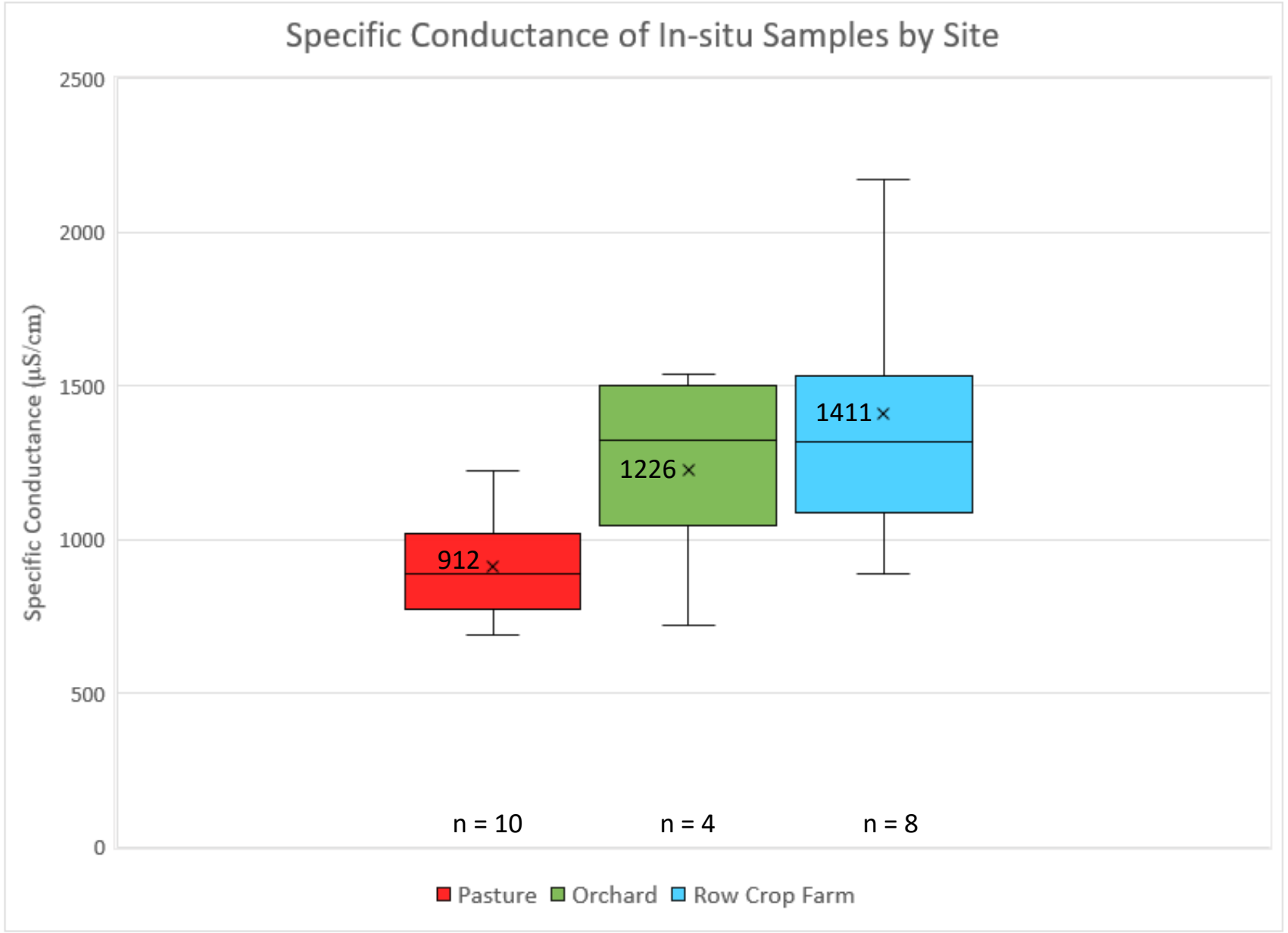
- Three sites: Non-irrigated pasture, irrigated orchard, and irrigated row-crop farm
- Core and in-situ water samples collected next to 3-4 wells at each site
- In-situ water samples collected using 1.5 ft screened interval
- Composite well sample also collected



Coring and In-situ Water Sampling

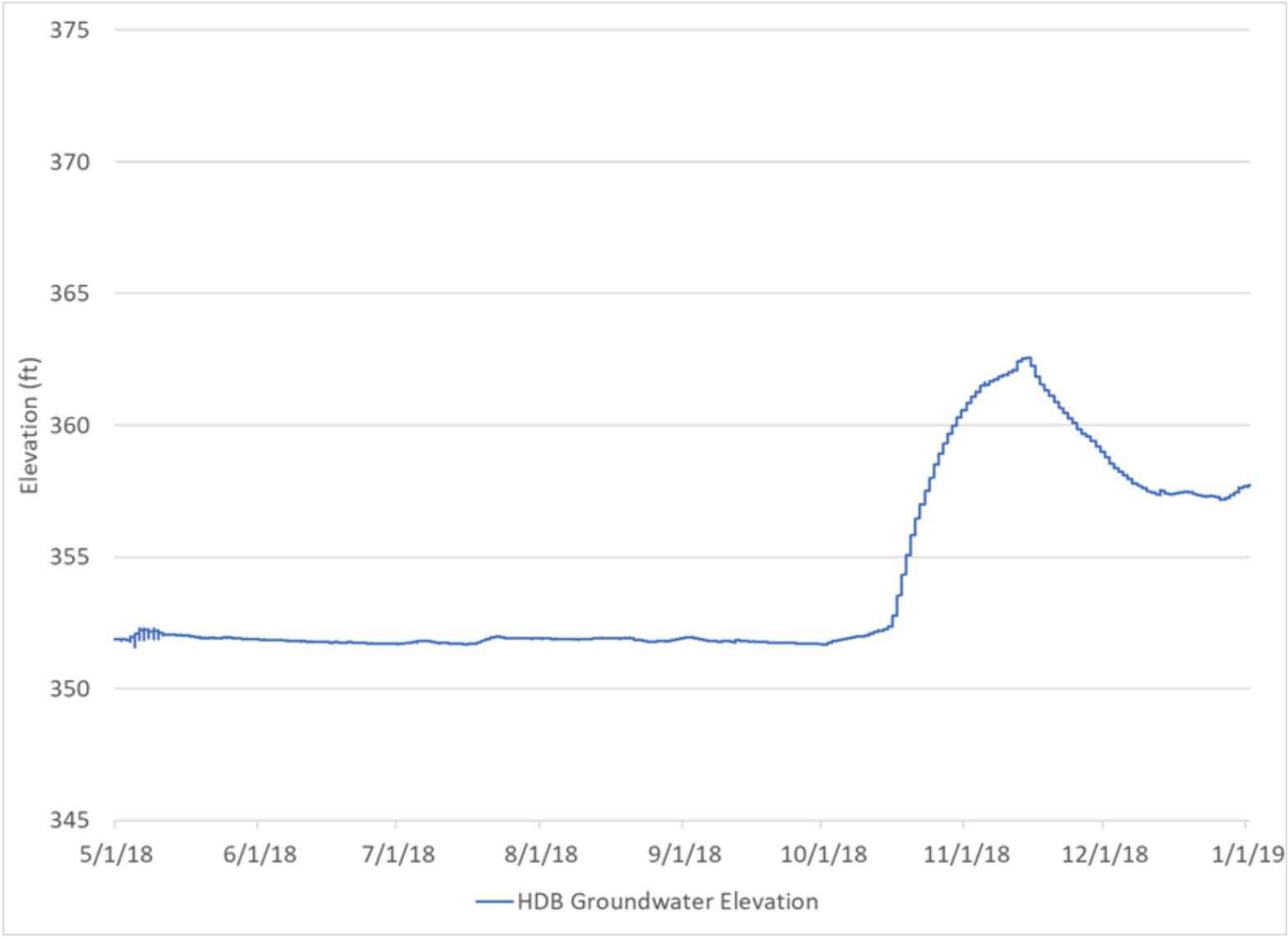
- In-situ water sampling showed some stratification present in aquifer
- However, specific conductance was found to both increase and decrease with depth, and is some cases was constant depending on the location




Specific Conductance of In-situ Samples by Site
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
912
1226
1411
n = 10
n = 4
n = 8
Pasture
Orchard
Row Crop Farm

Groundwater / Surface Water Interactions between BRAA and Brazos River

- To create 10.78 foot rise in water level (assuming a porosity of 25%) would need 32.34 inches of recharge
- Area only received 15.24 inches of precipitation
- River stage rose 20.75 feet



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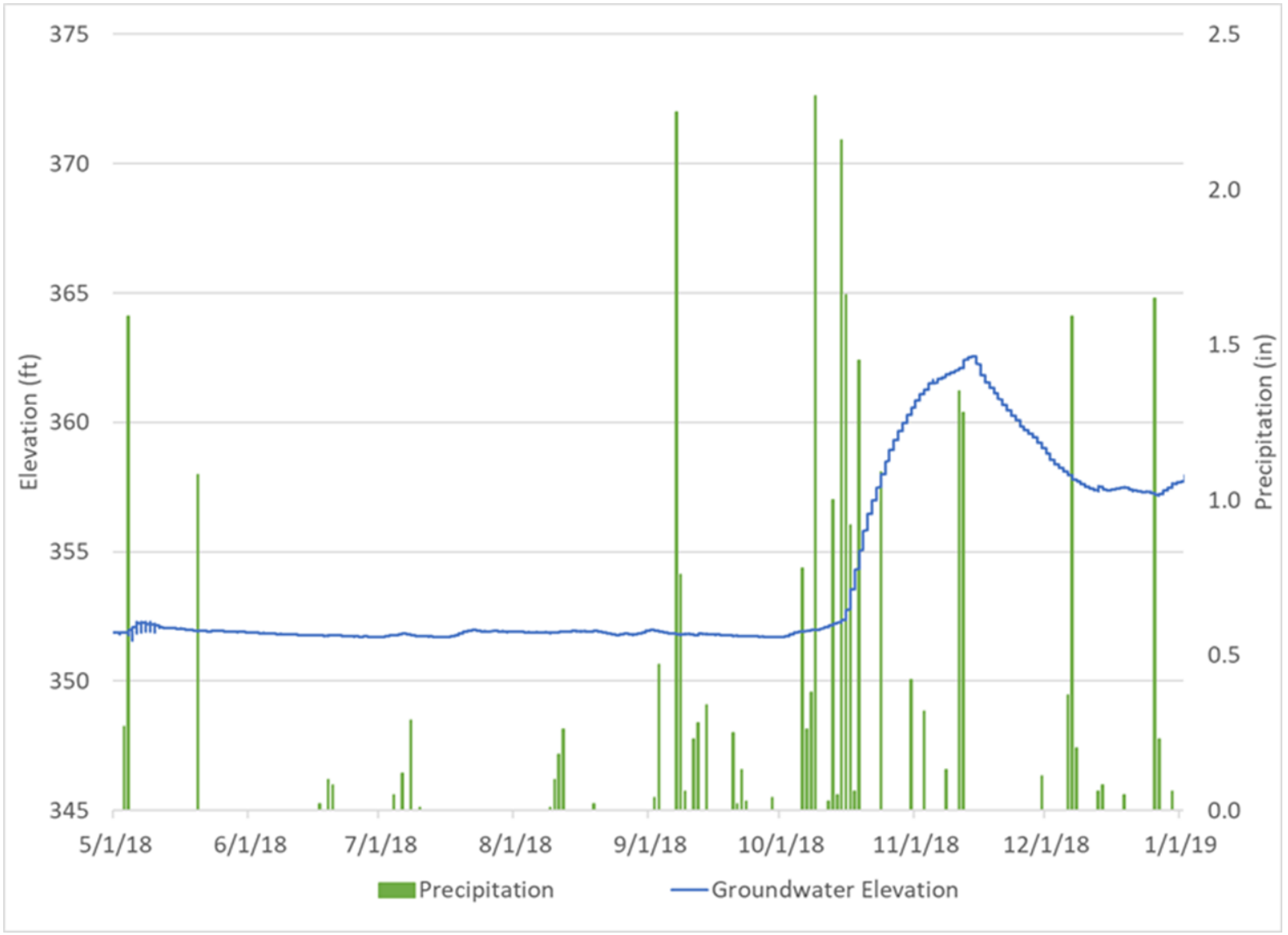

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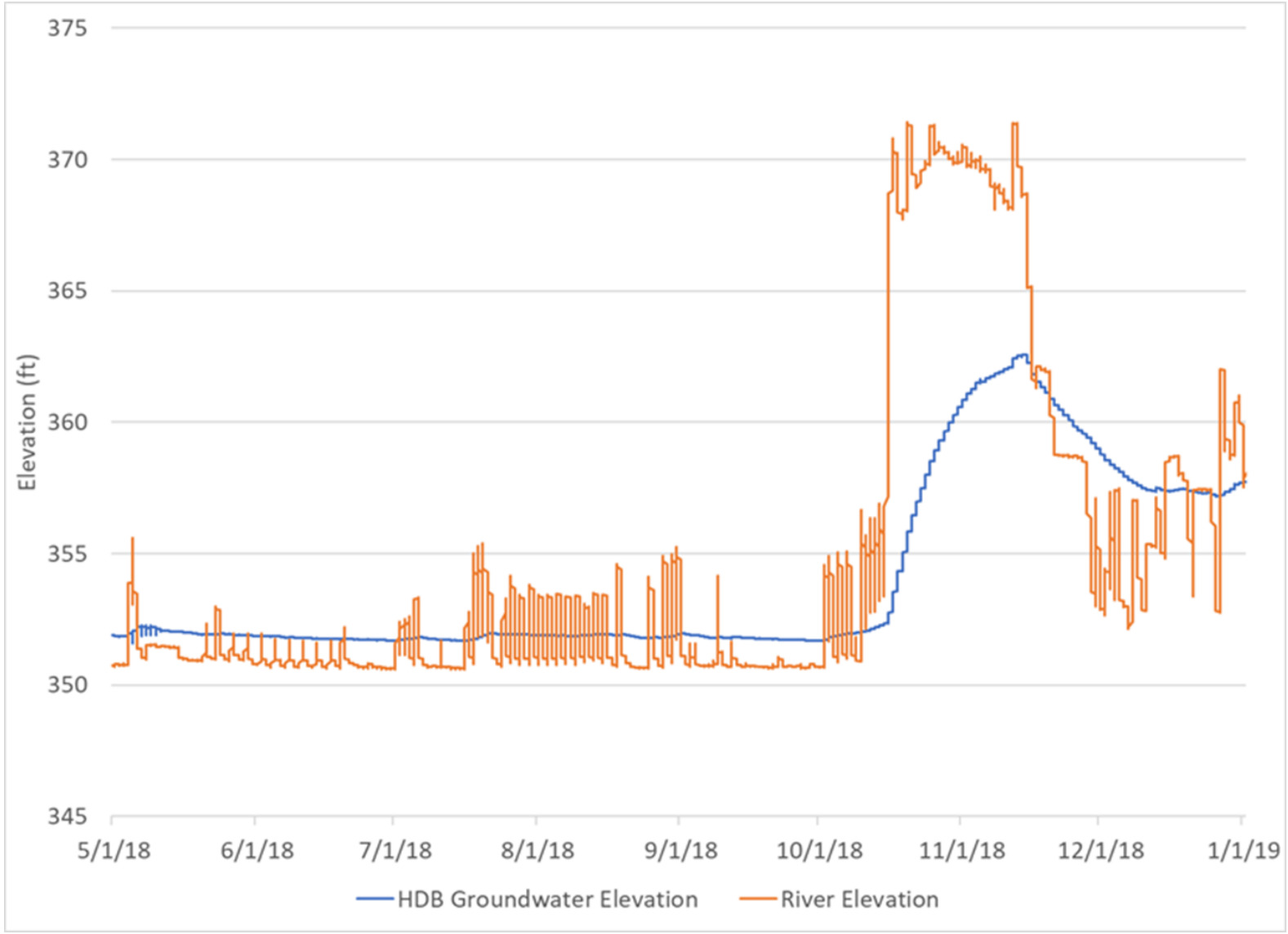
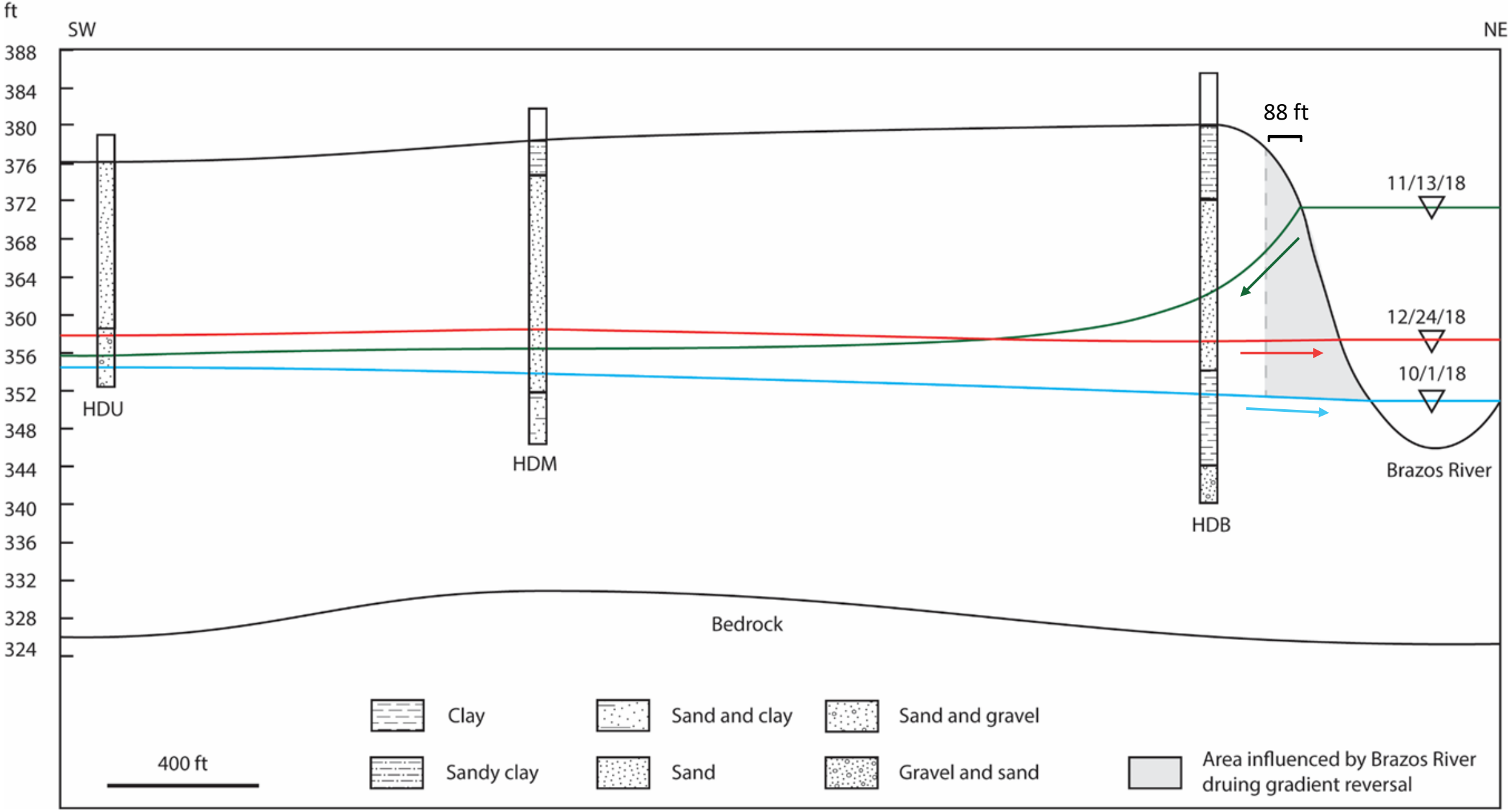
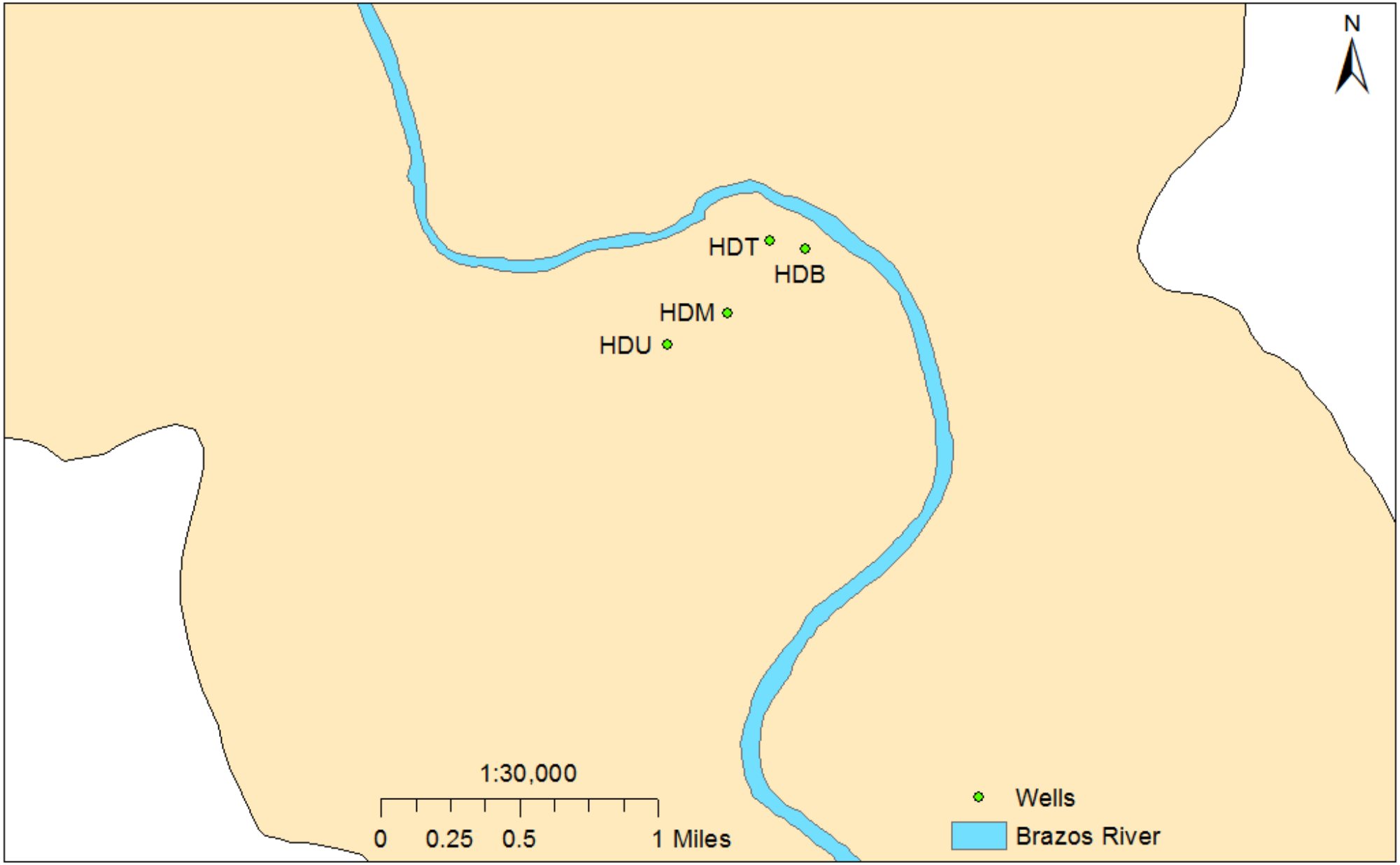
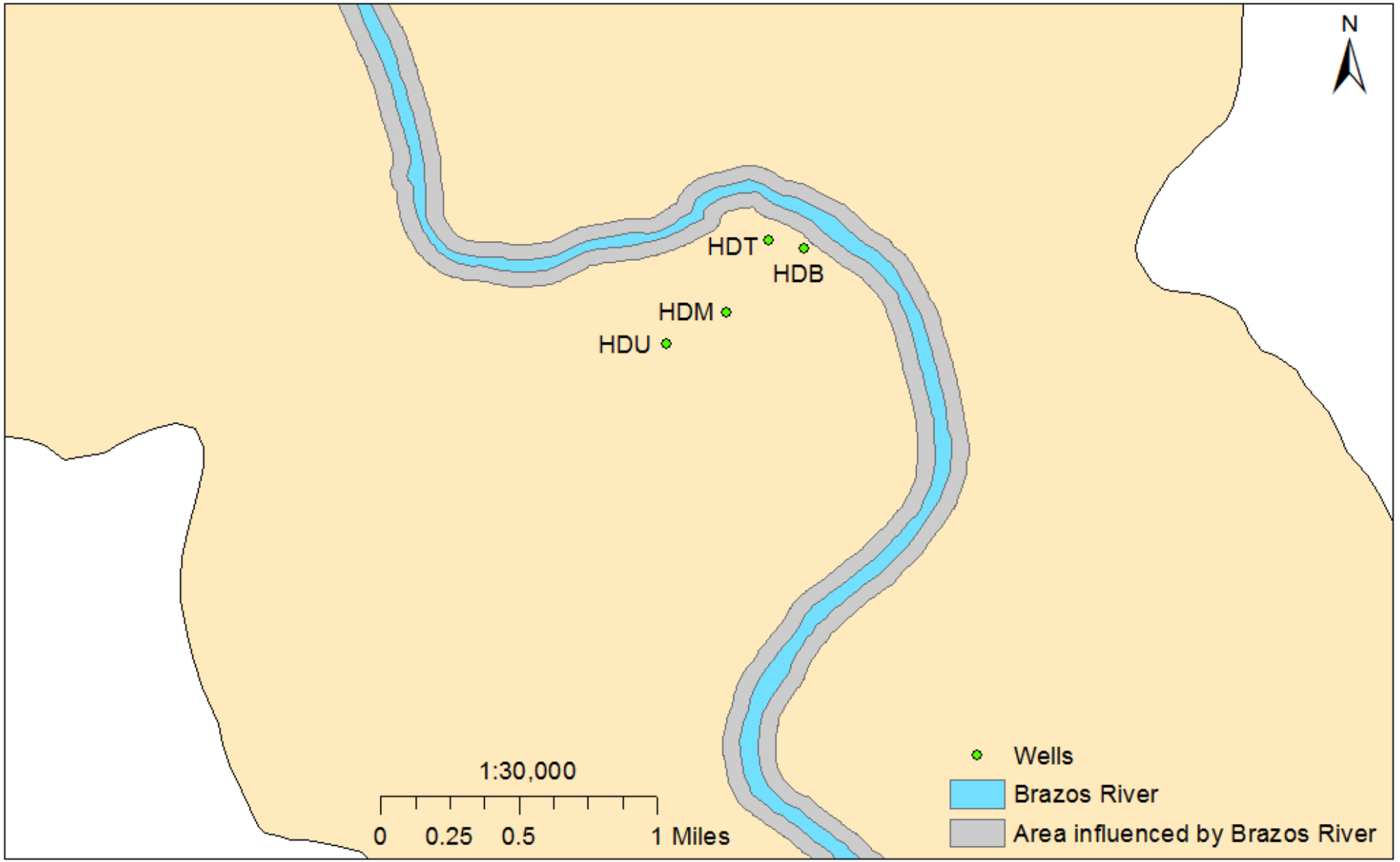



ft
SW
NE
388
384
380
376
372
368
364
360
356
352
348
344
340
336
332
328
324
88 ft
11/13/18
12/24/18
10/1/18
HDU
HDM
HDB
Brazos River
Bedrock
Clay
Sand and clay
Sand and gravel
Sandy clay
Sand
Gravel and sand
400 ft
Area influenced by Brazos River druing gradient reversal


N
HDT
HDB
HDM
HDU
1:30,000
0 0.25 0.5 1 Miles
Wells
Brazos River


N
HDT
HDB
HDM
HDU
1:30,000
0 0.25 0.5 1 Miles
Wells
Brazos River
Area influenced by Brazos River

Summary and Conclusions

- Aquifer shows significant variability in salinity
- Aquifer specific conductance in Falls County is almost double that of McLennan County
- Little change in aquifer specific conductance due to seasonality or since 1960's
- In-situ sampling showed some salinity stratification, but stratification is not consistent
- River is not likely source of elevated aquifer salinity
  - Aquifer and river tend to have different ionic chemistries
  - Aquifer and river are isotopically distinct
  - During 37-day gradient reversal, river water only traveled ~88 feet into aquifer
- Historic oil and gas fields do not appear to be source of elevated salinity
- Irrigation could potentially be source of elevated salinity

Acknowledgements

- Dr. Joe C. Yelderman Jr., Dr. Steve Dworkin, and Dr. Jack D. Tubbs
- Wayne Hamilton, Jacob Jarvis, Wynne Casteel, William Brewer, and Stephanie Wong
- Scooter Radcliffe at Southern Trinity Groundwater Conservation District
- The Brazos River Authority, Texas Water Resource Institute, United States Geological Survey, and Southern Trinity Groundwater Conservation District
- Katie Frank from the Statistics Department
- All land owners who participated in this study

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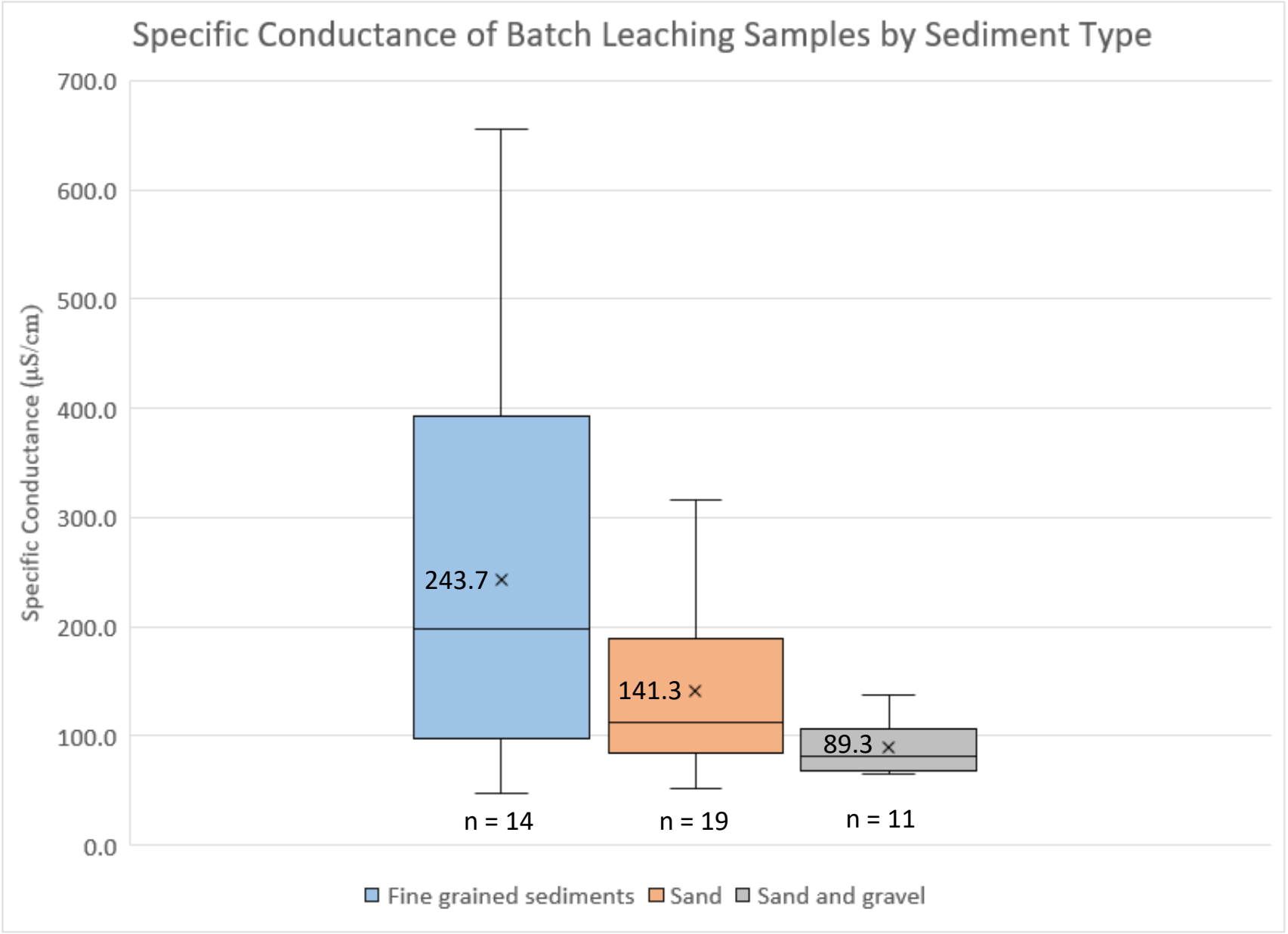
This material is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G16AP00085. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the options or policies of the U.S. Geological Survey. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Geological Survey.


Specific Conductance of Batch Leaching Samples by Sediment Type
Specific Conductance (µS/cm)
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
243.7
141.3
89.3
n = 14
n = 19
n = 11
Fine grained sediments
Sand
Sand and gravel