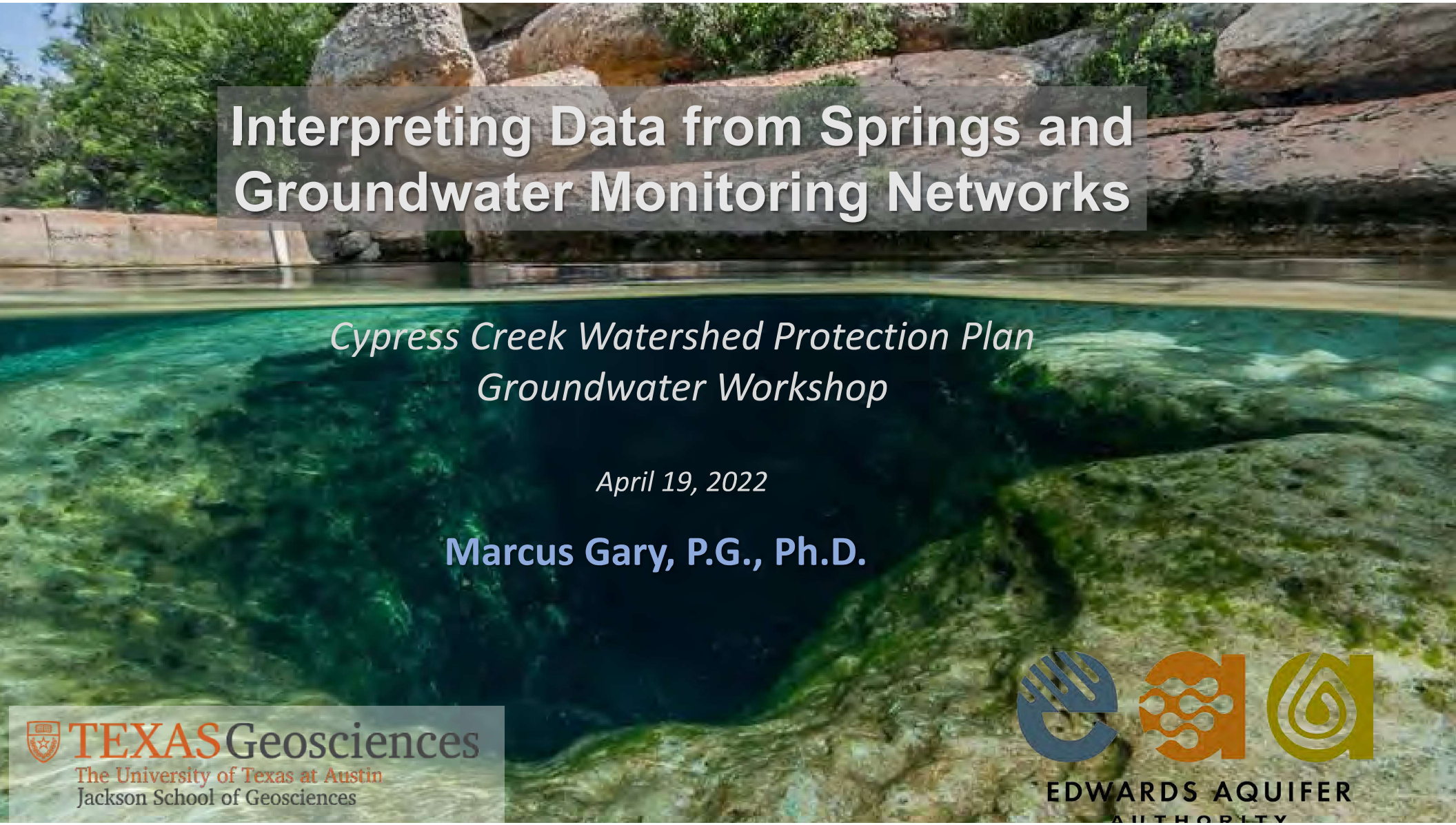


Interpreting Data from Springs and Groundwater Monitoring Networks

Cypress Creek Watershed Protection Plan
Groundwater Workshop

April 19, 2022

Marcus Gary, P.G., Ph.D.

TEXAS Geosciences
The University of Texas at Austin
Jackson School of Geosciences

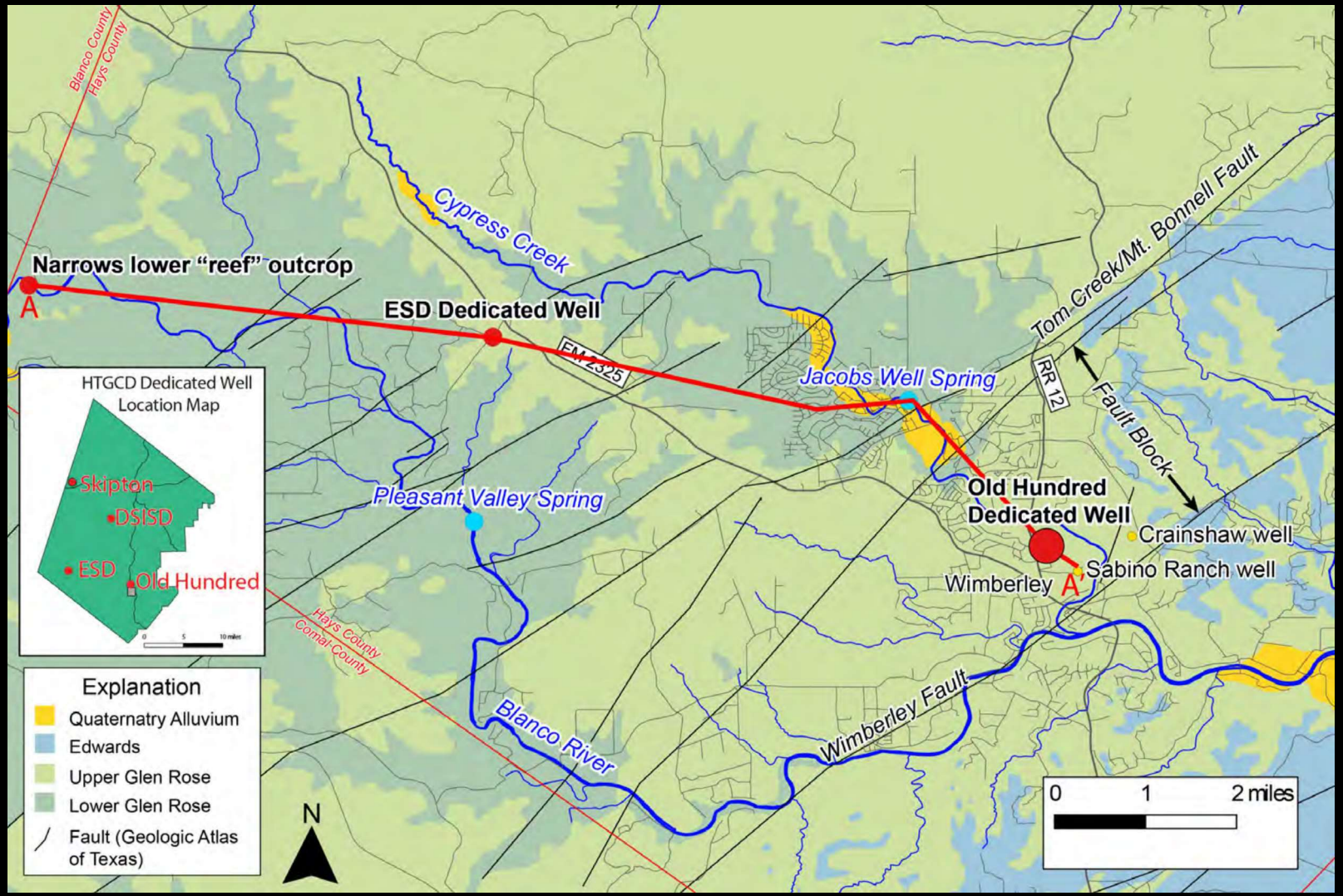
EDWARDS AQUIFER
AUTHORITY

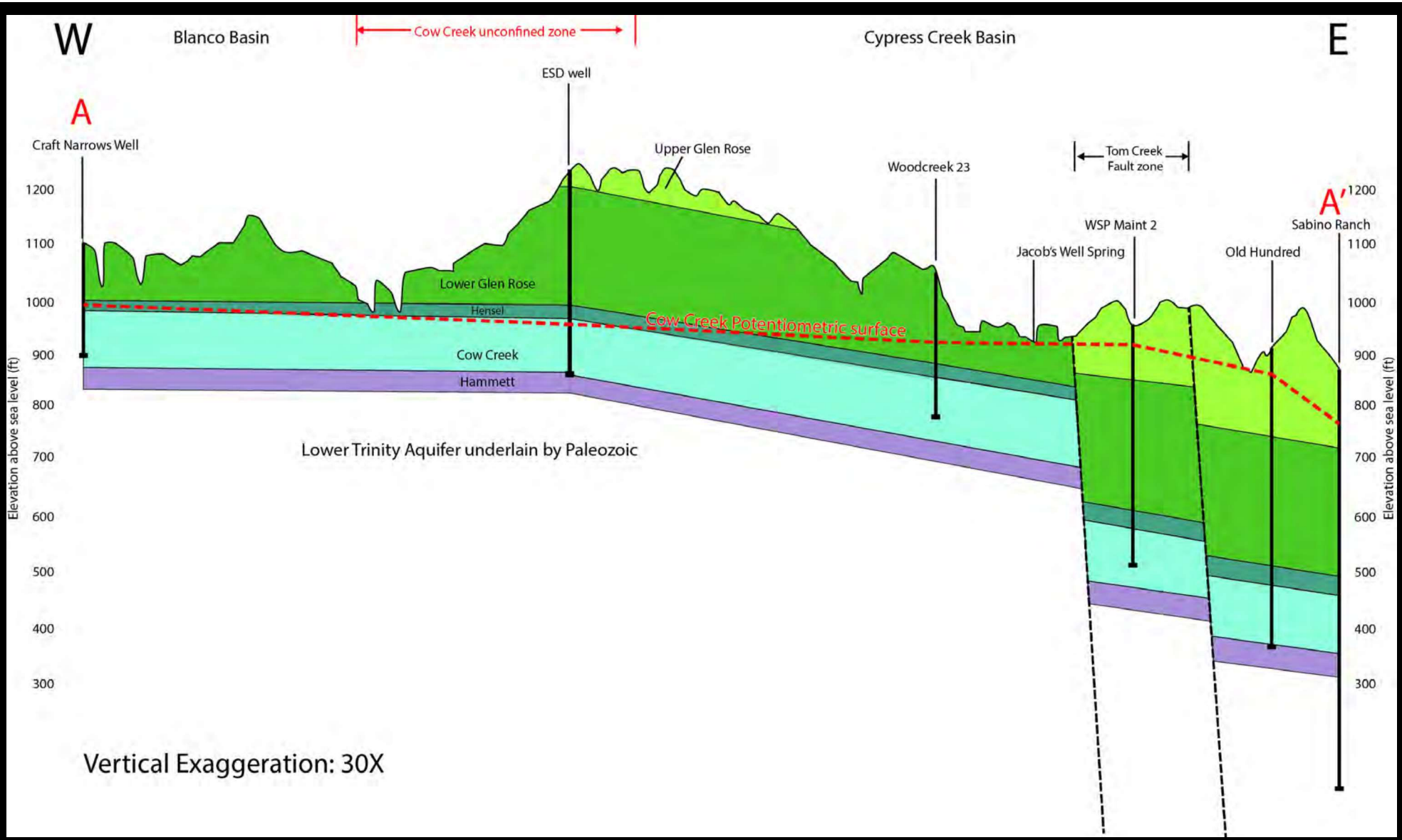
Topics for today's discussion

- Overview of groundwater dynamics – Basic hydrogeologic framework.
- Monitoring the major springs in western Hays County.
- How does spring flow relate to the groundwater level in my well? Well…….. It depends…..
- Assessing drought impacts on groundwater in western Hays County and implications downstream (and downdip—in groundwater systems). Using the Jacob's Well Groundwater Management Zone as an example.

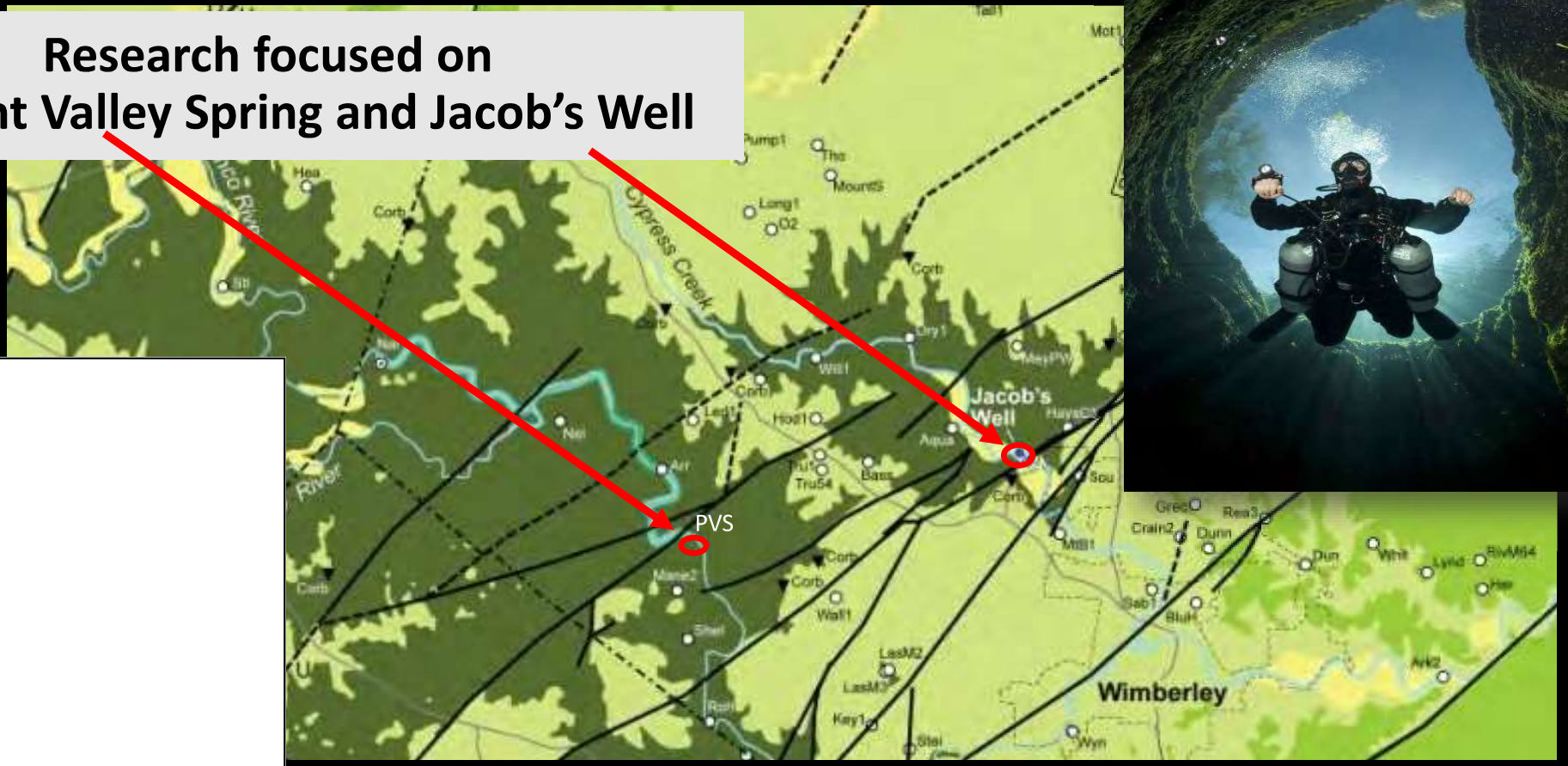
Regional cross-section

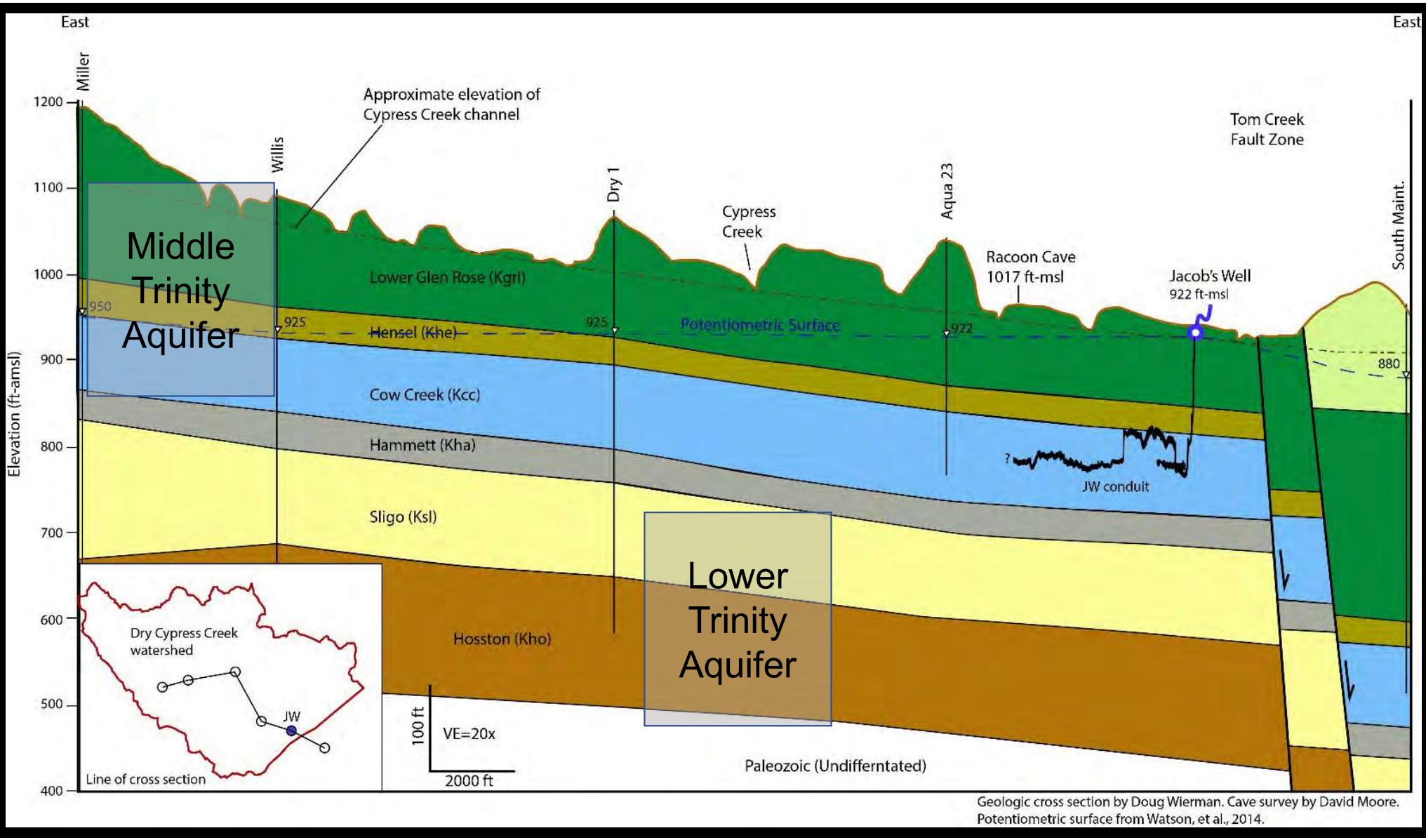
- The HTGCD produced a regional cross-section through JWS running from west to east from the Hays Co. line through the Wimberley area.

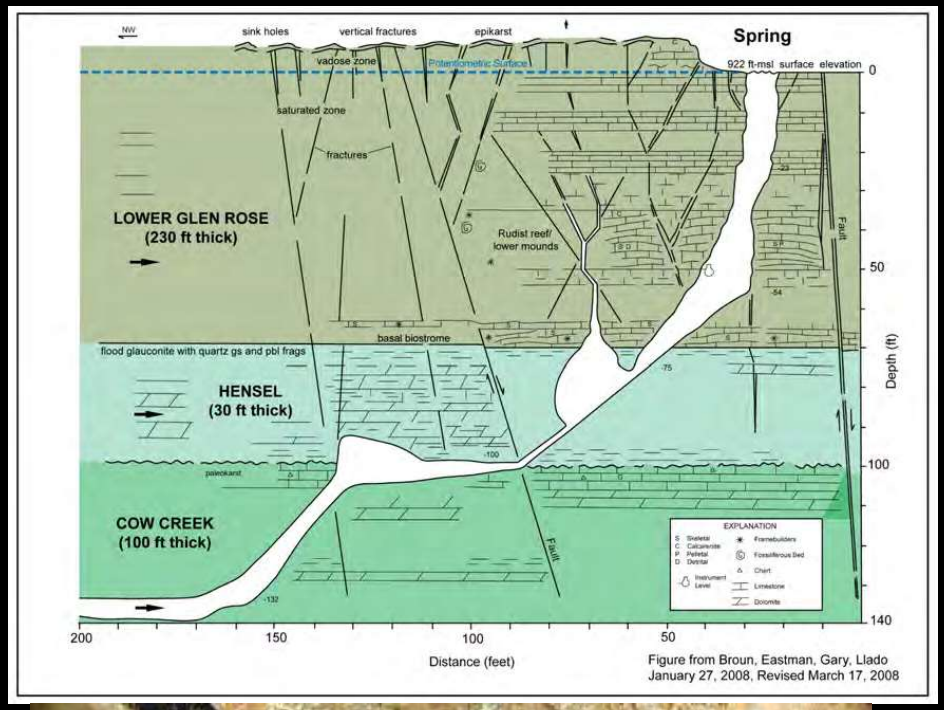



W
Blanco Basin
Cow Creek unconfined zone
Cypress Creek Basin
E
A
A′
Craft Narrows Well
ESD well
Upper Glen Rose
Woodcreek 23
Tom Creek
Fault zone
WSP Maint 2
Jacob's Well Spring
Old Hundred
Sabino Ranch
Lower Glen Rose
Hensel
Cow Creek Potentiometric surface
Cow Creek
Hammett
Lower Trinity Aquifer underlain by Paleozoic
Elevation above sea level (ft)
1200
1100
1000
900
800
700
600
500
400
300
Vertical Exaggeration: 30X

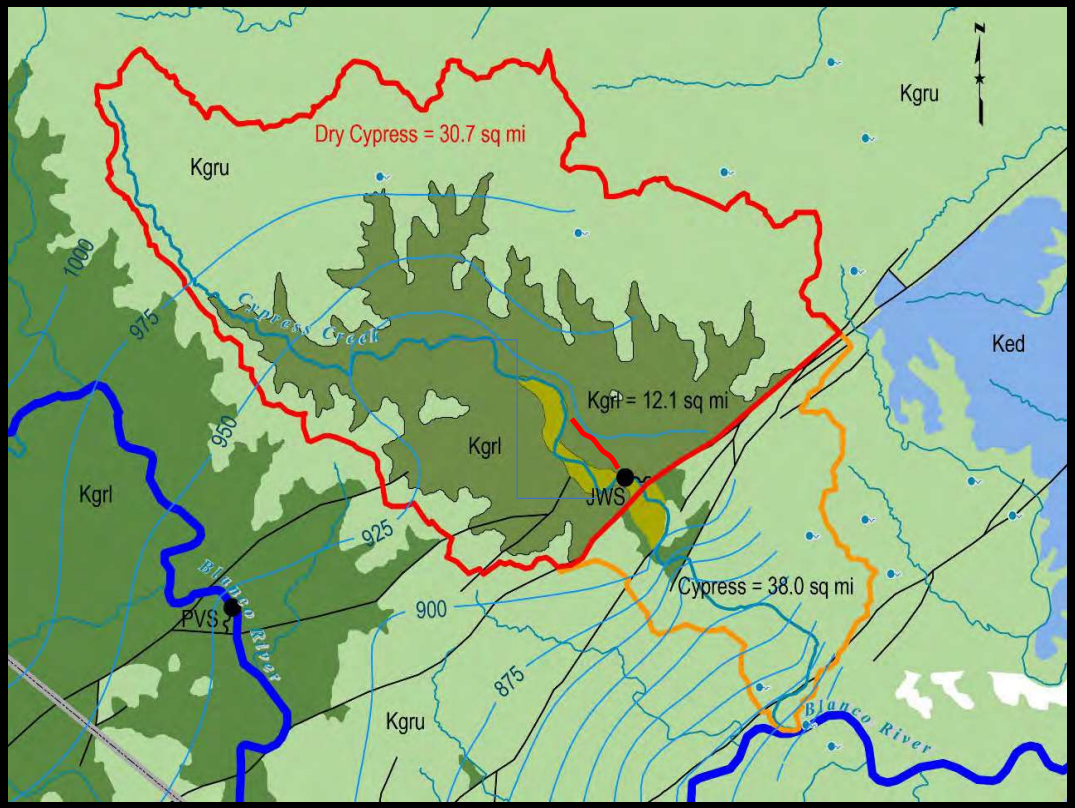
Research focused on Pleasant Valley Spring and Jacob's Well




East
East
Miller
Willis
Dry 1
Aqua 23
Approximate elevation of
Cypress Creek channel
Tom Creek
Fault Zone
South Maint.
Cypress
Creek
Racoon Cave
1017 ft-msl
Jacob's Well
922 ft-msl
Middle
Trinity
Aquifer
Lower Glen Rose (Kgrl)
Hensel (Khe)
Potentiometric Surface
950
925
925
922
880
Cow Creek (Kcc)
Hammett (Kha)
Sligo (Ksl)
JW conduit
?
Lower
Trinity
Aquifer
Hosston (Kho)
Paleozoic (Undifferntated)
Elevation (ft-amsl)
1200
1100
1000
900
800
700
600
500
400
Dry Cypress Creek
watershed
JW
Line of cross section
100 ft
VE=20x
2000 ft
Geologic cross section by Doug Wierman. Cave survey by David Moore.
Potentiometric surface from Watson, et al., 2014.

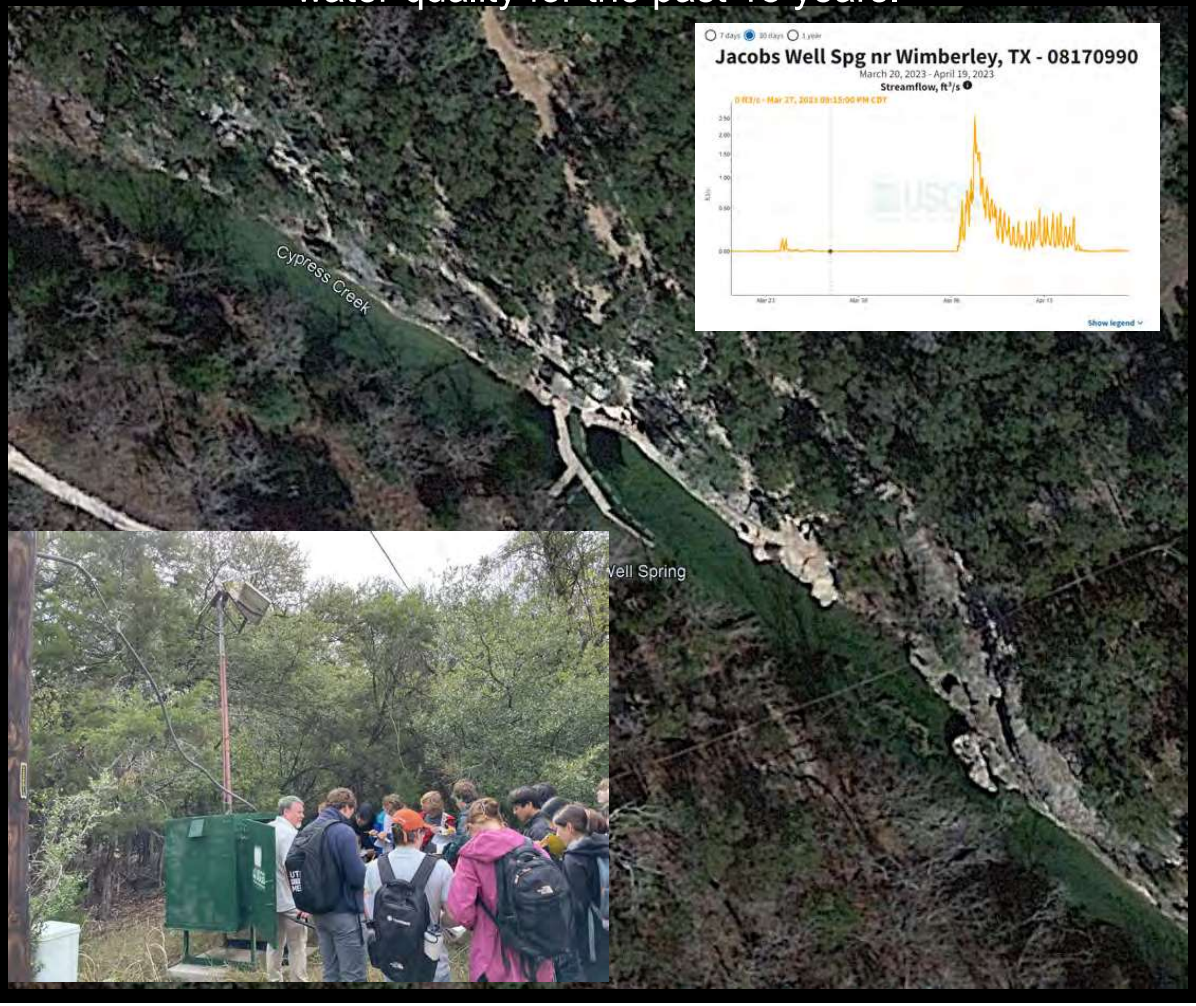


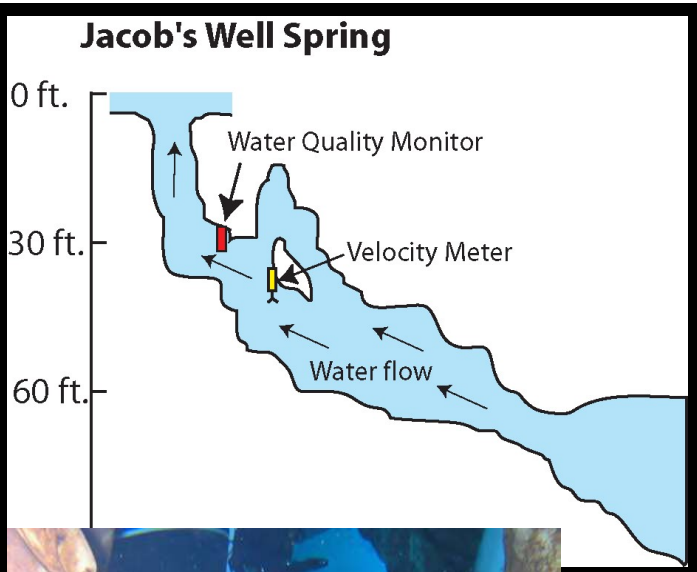
Jacob's Well Spring emerges from the underwater cave system that has developed along fractures in the limestone running from the spring to the northwest.



USGS gage at Jacobs Well

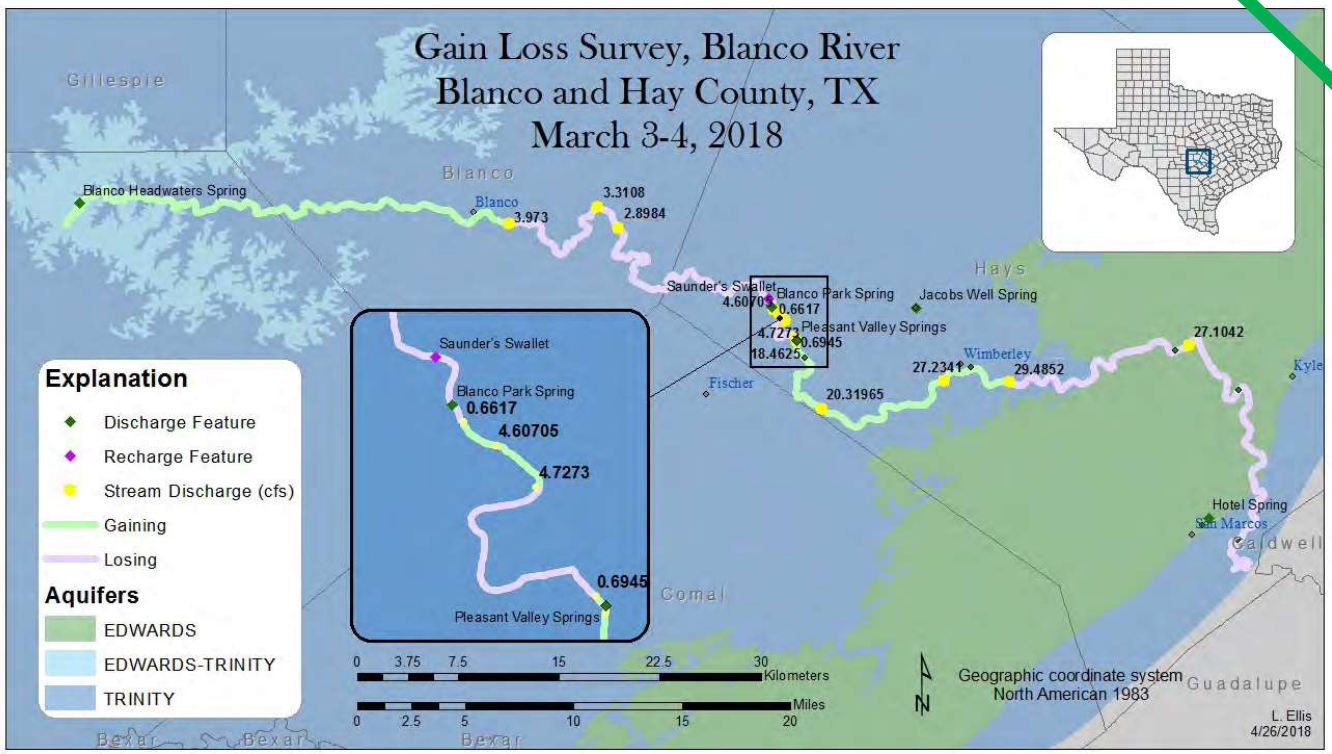
Generating a record of spring flow and basic water quality for the past 18 years.

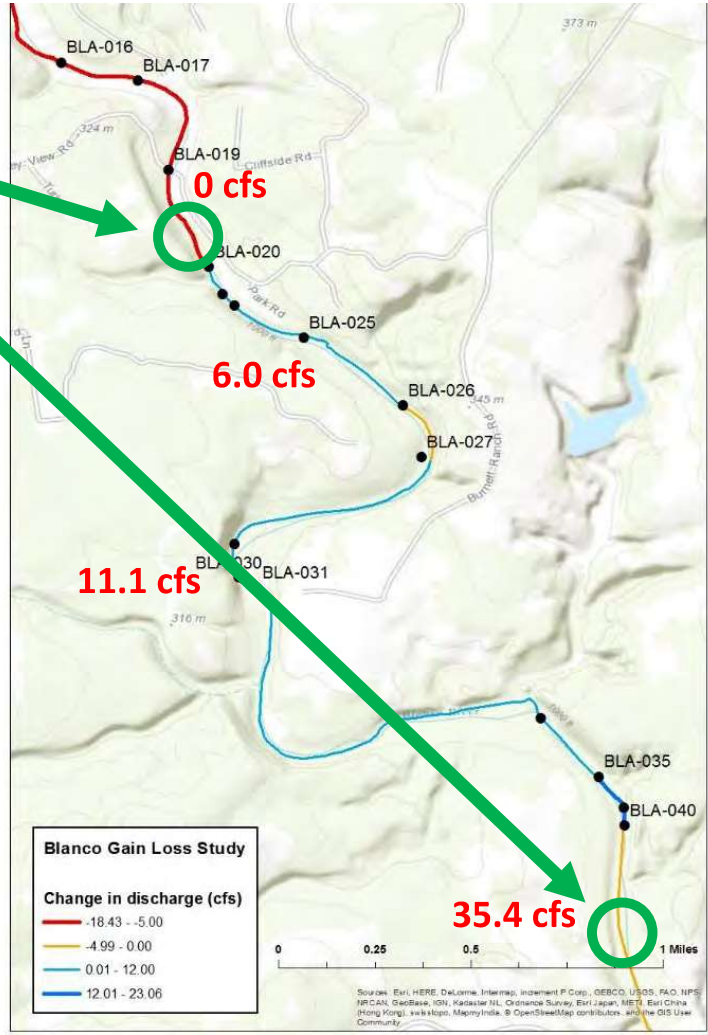




Using gain/loss surveys to identify springs and recharge features along the Blanco River and Cypress Creek.

EAA funded USGS stream gauges now quantify Middle Trinity Spring flow from the Spring Reach of the Blanco River



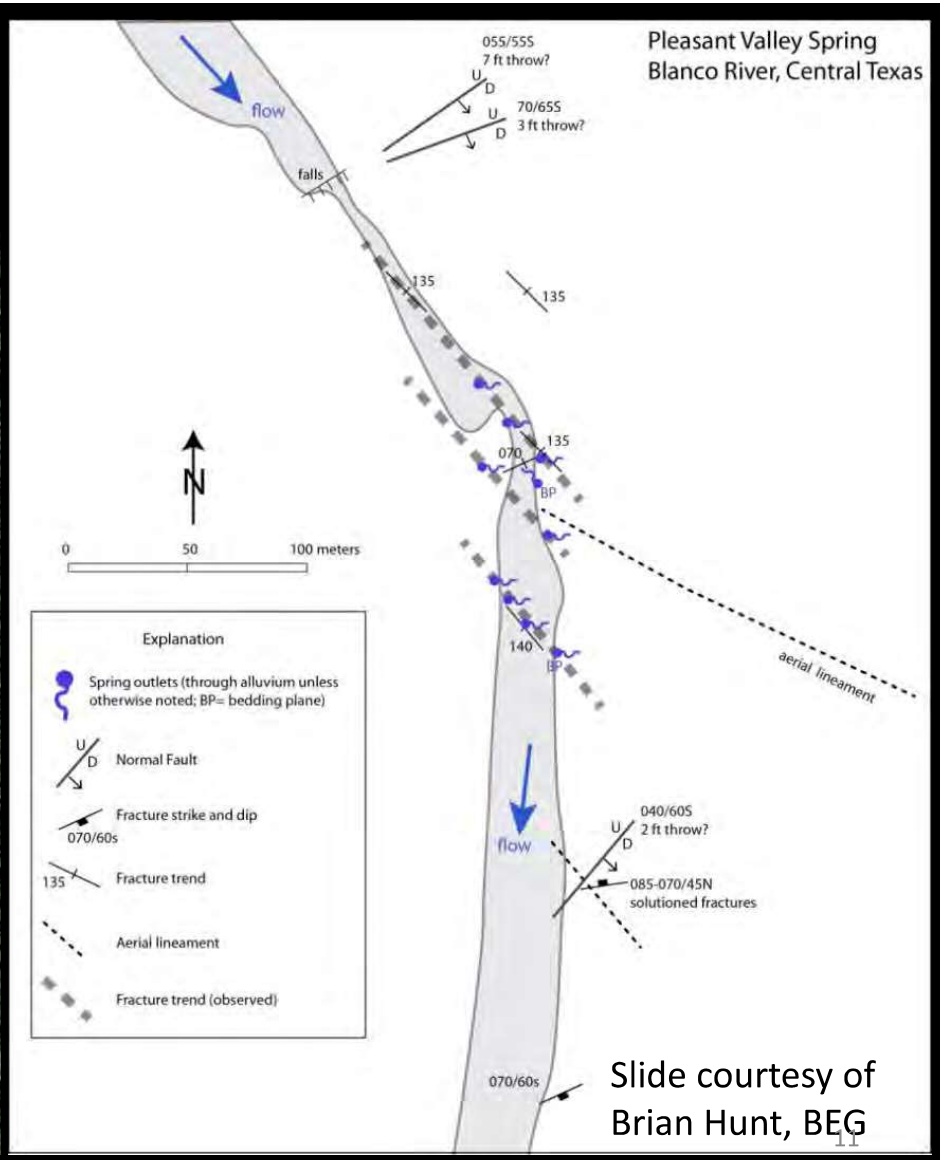


https://waterdata.usgs.gov/monitoring-location/08170905/#parameterCode=00060&period=P365D

https://waterdata.usgs.gov/monitoring-location/08170950/#parameterCode=00060&period=P365D

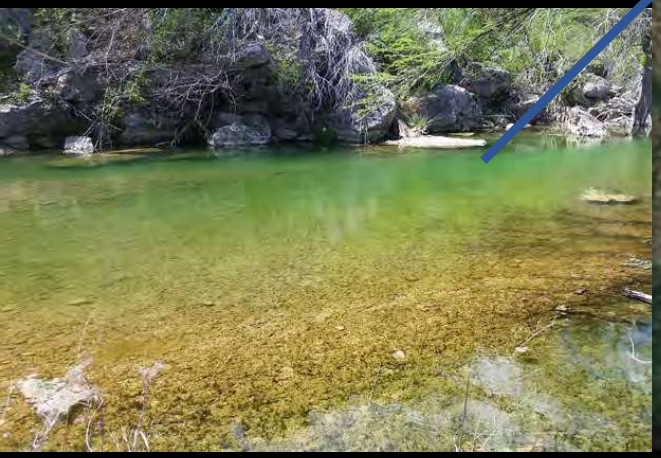
EDWARDS AQUIFER AUTHORITY

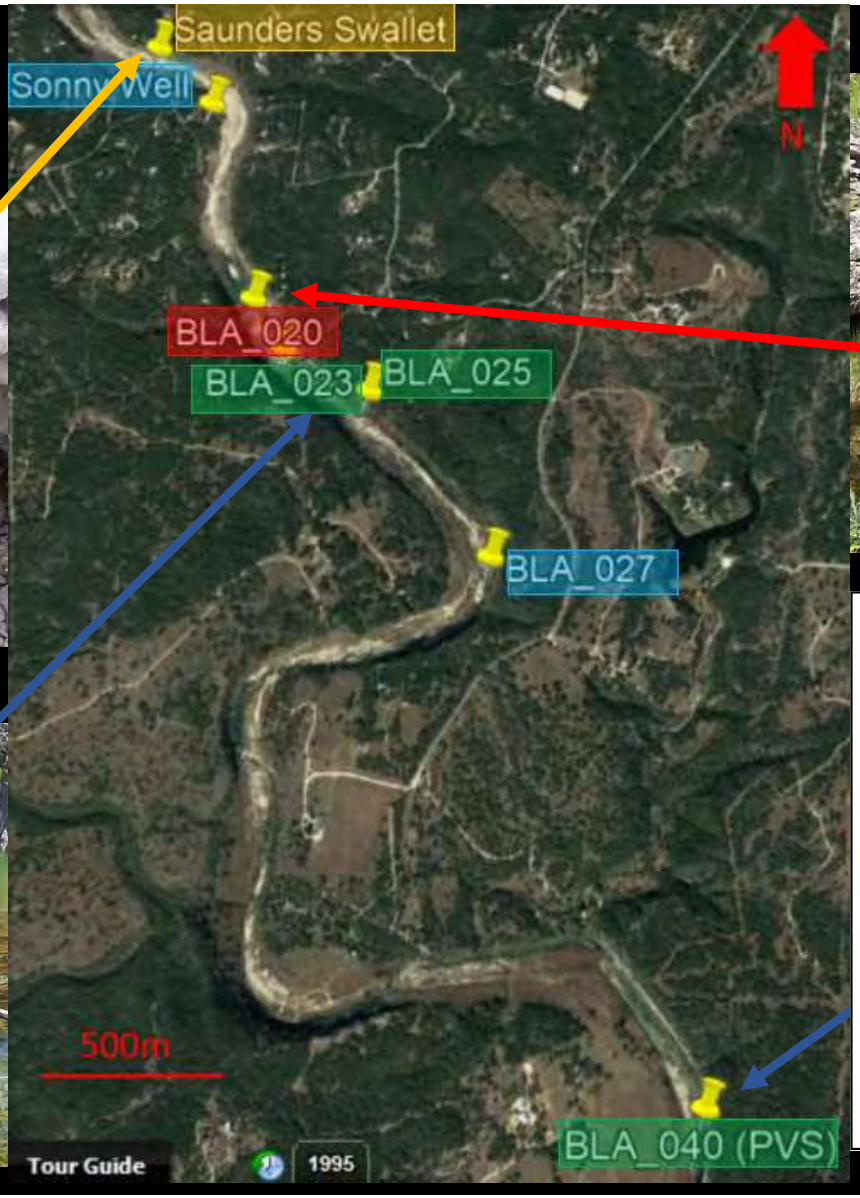
Pleasant Valley Spring



Slide courtesy of Brian Hunt, BEG

EDWARDS AQUIFER
AUTHORITY





Environ Earth Sci
DOI 10.1007/s12665-015-4630-1

CrossMark

THEMATIC ISSUE

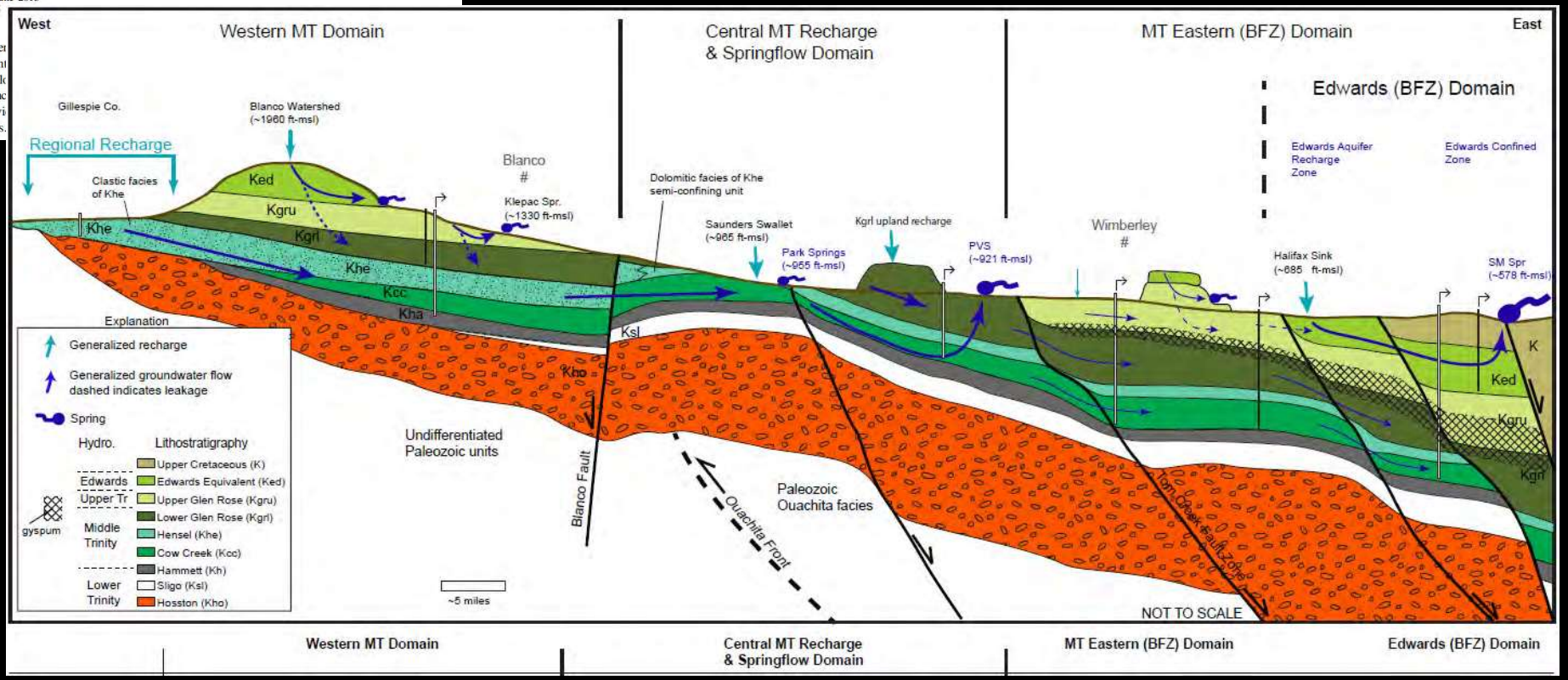
Surface water–groundwater interactions along the Blanco River of central Texas, USA

B. A. Smith[1] · B. B. Hunt[1] · A. G. Andrews[1] · J. A. Watson[1] · M. O. Gary[2] · D. A. Wierman[3] · A. S. Broun[3]

Received: 2 February 2015 / Accepted: 7 June 2015

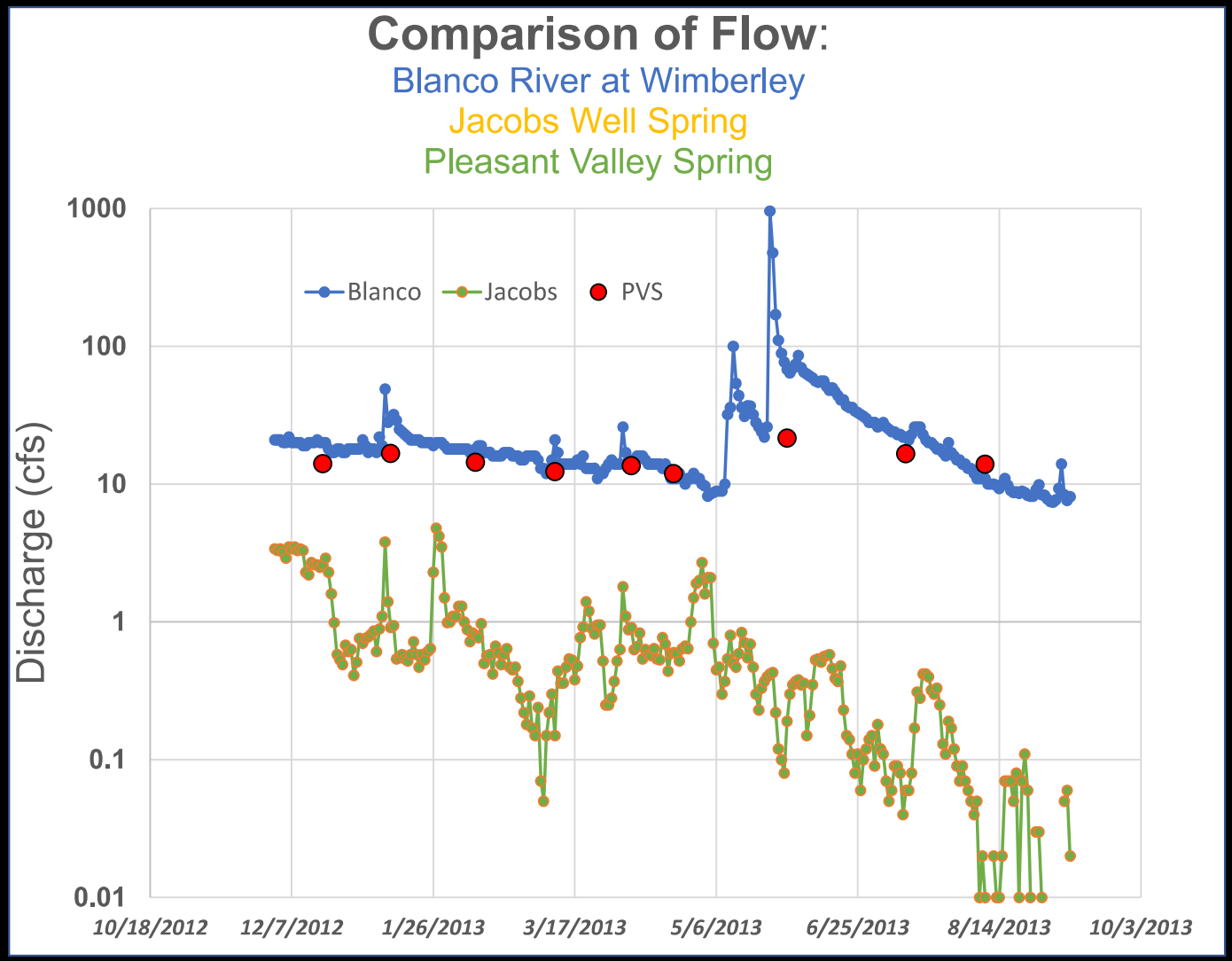
Abstract The Blanco River is a ver
for water supplies in the Hill Count
Some communities and properties alc
surface water directly. But, the Blanc
nificant in the role it plays in provi
karstic Trinity and Edwards Aquifers.

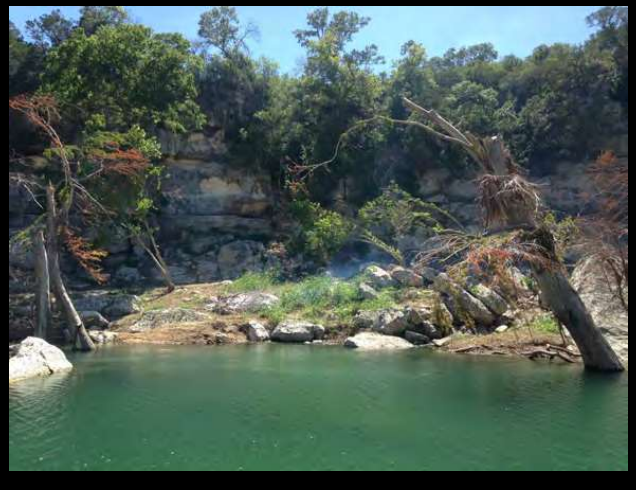
These studies are key in understanding how the rivers and creeks are linked to groundwater through springs and recharge features.



EDWARDS AQUIFER AUTHORITY

Pleasant Valley Spring was completely undocumented until 2013.





The Spring Reach of the Blanco River

USGS stream gage 08170905

Little Park Spring

Park Spring

Miller Spring

Pleasant Valley Spring

USGS stream gage 08170950

2325

244

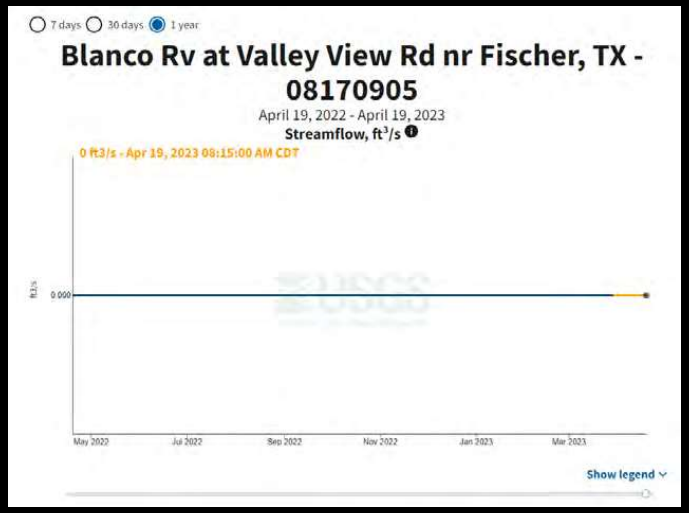
318

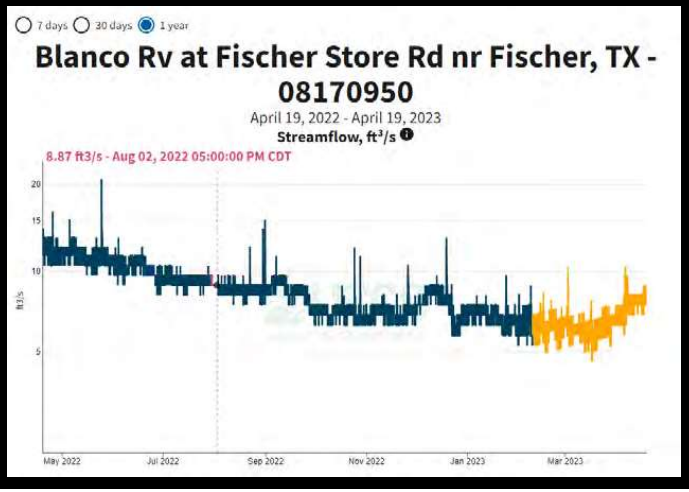
181

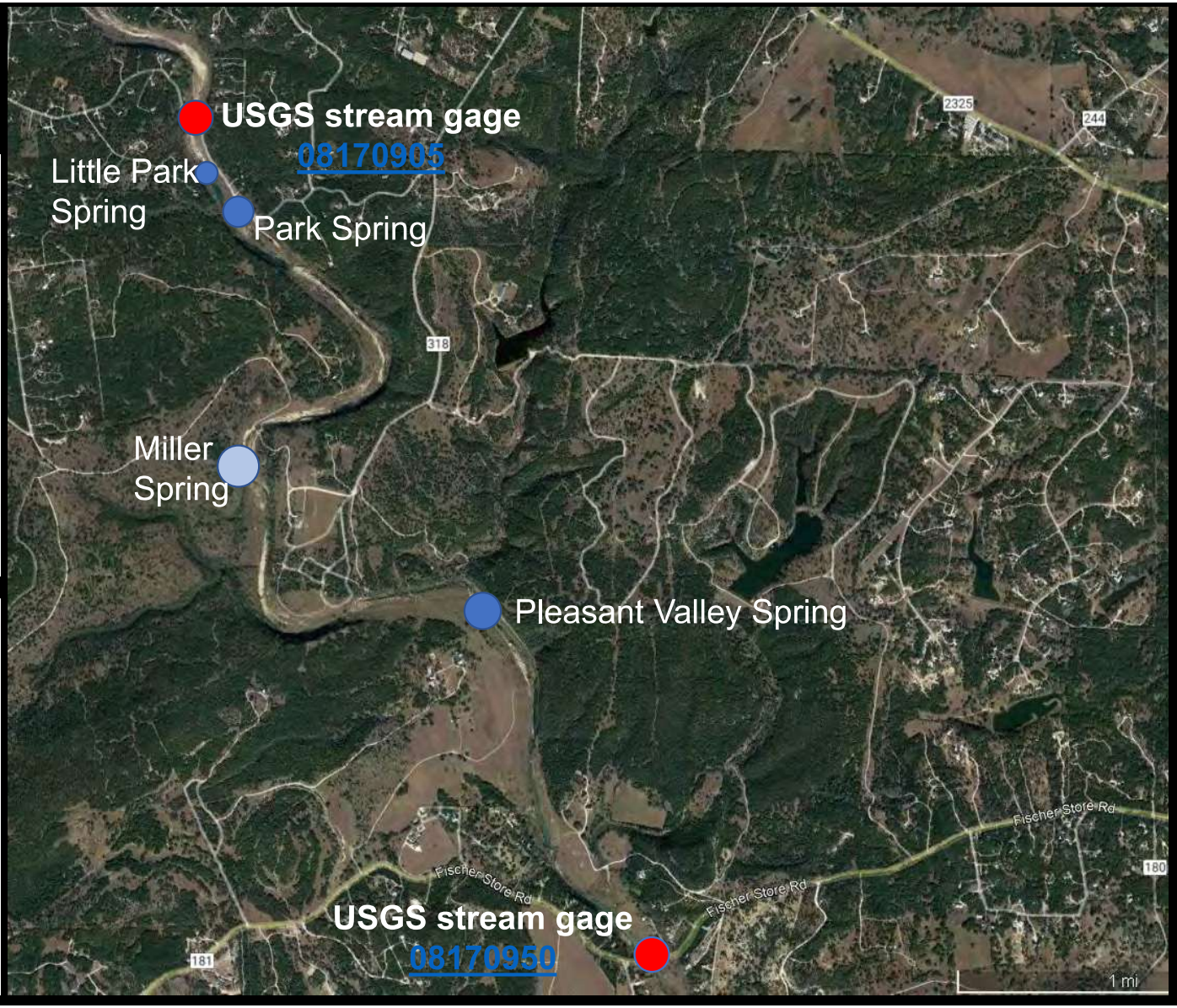
180

Fischer Store Rd

1 mi

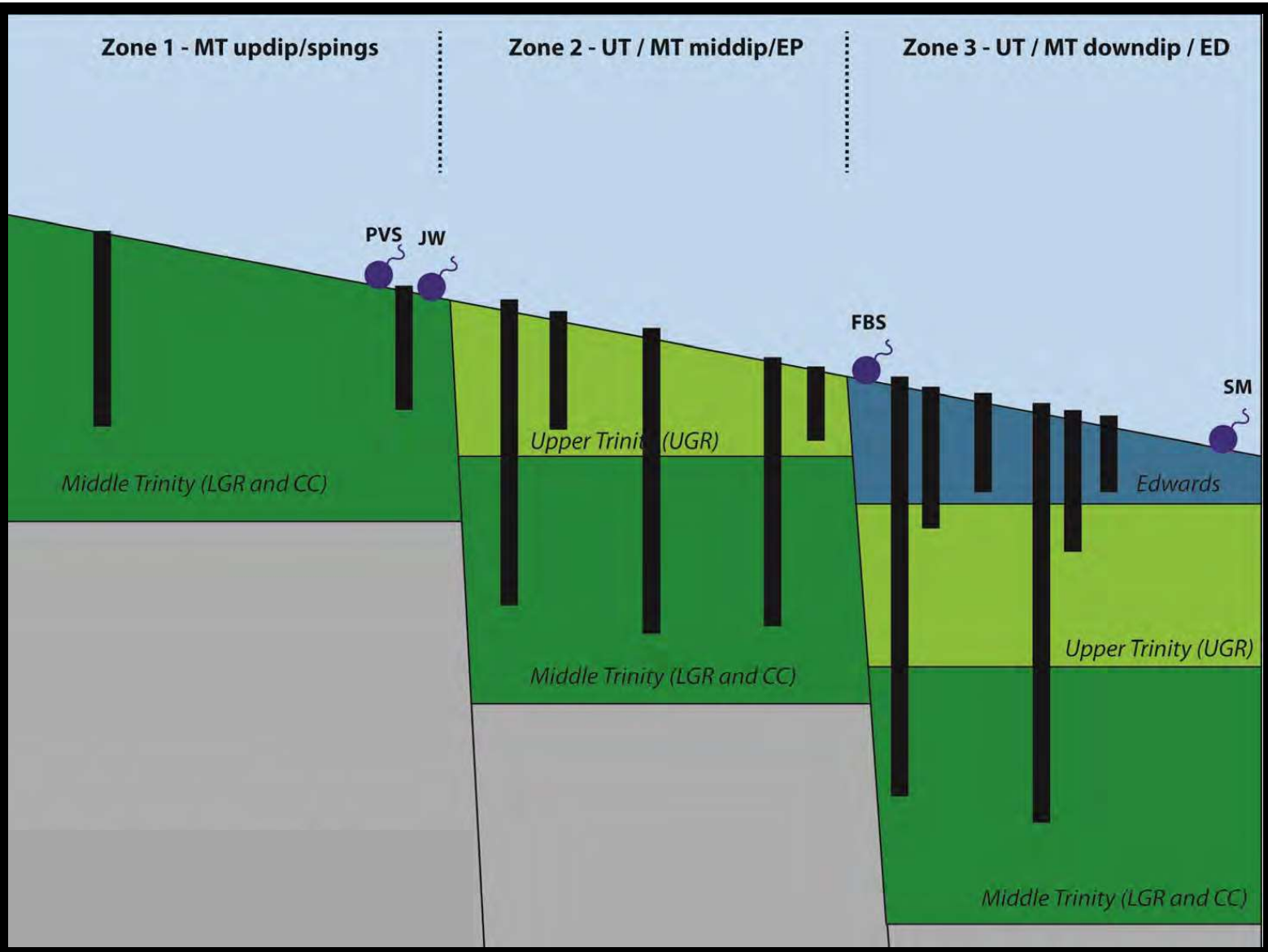

7 days
30 days
1 year
Blanco Rv at Valley View Rd nr Fischer, TX - 08170905
April 19, 2022 - April 19, 2023
Streamflow, ft³/s
0 ft3/s - Apr 19, 2023 08:15:00 AM CDT
0.000
May 2022
Jul 2022
Sep 2022
Nov 2022
Jan 2023
Mar 2023
Show legend


7 days
30 days
1 year
Blanco Rv at Fischer Store Rd nr Fischer, TX - 08170950
April 19, 2022 - April 19, 2023
Streamflow, ft³/s
8.87 ft3/s - Aug 02, 2022 05:00:00 PM CDT
20
15
10
5
May 2022
Jul 2022
Sep 2022
Nov 2022
Jan 2023
Mar 2023


USGS stream gage
08170905
Little Park Spring
Park Spring
Miller Spring
Pleasant Valley Spring
USGS stream gage
08170950
2325
244
318
181
180
Fischer Store Rd
Fischer Store Rd
Fischer Store Rd
1 mi

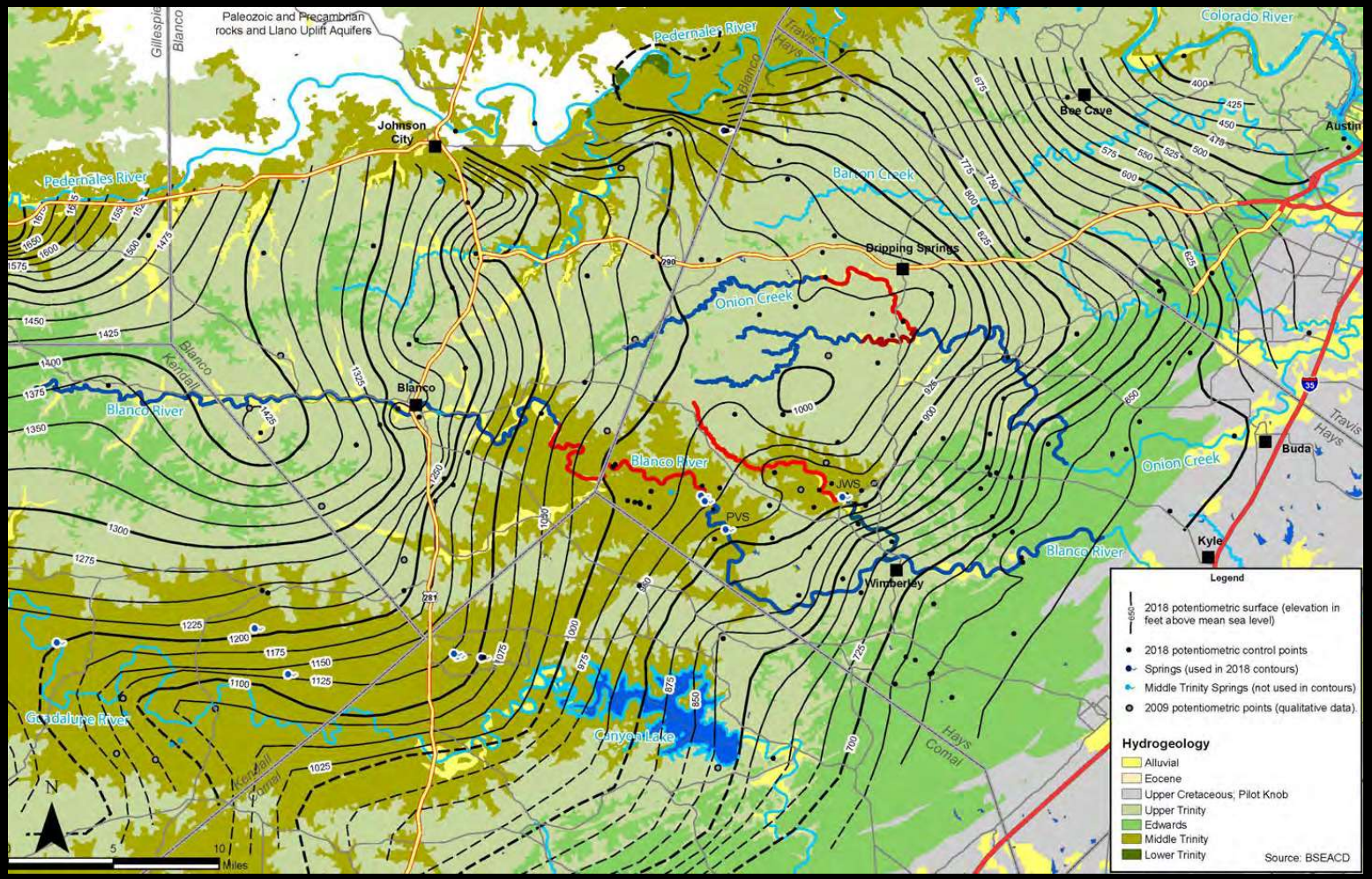
Monitor wells in different aquifer units aid in understanding how the entire groundwater system works

HTGCD Monitor Wells



Regional Groundwater Surface

- Water levels in the Middle Trinity aquifer in this portion of the Hill Country are generally from the west to east.
- The water level surface tends to "flatten out" in areas where extensive karst exists, such as JWS



July 2021 Potentiometric Surfaces of the Lower and Middle Trinity Aquifers in Southwestern Hays County, Texas

Hays Trinity Groundwater Conservation District **January 2022**

HTGCD Technical Report 2022-0107

Barton Springs Edwards Aquifer Conservation District

Preliminary Report on the Installation of Two Multilevel Monitor Wells Near Jacob's Well

Technical Memo 2022-0831
August 2022

Brian A. Smith, Ph.D., P.G., Jeffery A. Watson, P.G., and Justin Camp

Introduction

Between March and April 2022, the Barton Springs/Edwards Aquifer Conservation District (BSEACD) installed two monitor wells upgradient of Jacob's Well in Hays County. These wells were installed with the cooperation of Hays County, Hays Trinity Groundwater Conservation District (HTGCD), and Wimberley Valley Watershed Association (WVWA). The purpose of these wells is to better characterize the Trinity Aquifers in central Hays County and to understand the flow relationships between the distinct hydrogeologic units of the Trinity. A better understanding of these units will allow for better management of the Trinity Aquifers. The main target of these wells is the Middle Trinity Aquifer which is the main source of the groundwater that flows from Jacob's Well and to many water-supply wells in the area. Additional tasks that are a part of these Interlocal Agreements (ILAs) are installation of transducers in these and other monitor wells, water-level measurements, dye tracing, and water-quality analyses.

ILAs between Hays County and the BSEACD and between the HTGCD and the BSEACD were signed on October 10, 2019, and May 12, 2020, respectively. The principal goal of the studies associated with these ILAs was the installation of two monitor wells, one is a dual completion well and the other is a multiport well. Construction of these wells was postponed until the outcome of a grant application that included the monitor well funding as a matching component. Amendments to the ILAs were agreed on by all parties with a new completion date of August 31, 2022.

Background

Hydrogeology

The geologic units that make up the Trinity Aquifers in the study area (Figure 1) are largely limestones and dolomites of Early Cretaceous age (Hunt et al. 2020; Wierman et al., 2010). These sediments were deposited on a broad shelf that separated the deeper water of the Gulf of Mexico to the southeast and land of the Llano Uplift to the northwest. Major faulting occurred during the early Miocene along the Balcones Fault Zone which consists of a series of en-echelon normal faults, with down-to-the southeast displacement. These faults and associated fractures provide pathways for groundwater movement and the development of solution conduits which are a key feature of karst aquifers such as the Middle Trinity Aquifer.

Units that make up the Trinity Aquifers in the vicinity of Jacob's Well are from top to bottom: lower member of the Glen Rose limestone, Hensel formation, Cow Creek limestone, Hammett shale, Sligo limestone, and Hosston sandstone (Figures

Evaluation for the Development of a Jacob's Well Groundwater Management Zone Hays County, Texas

Technical Report prepared for the Hays Trinity Groundwater Conservation District, Hays County, Texas

Report: 2019-05

July 2019

The Meadows Center for Water and the Environment
Texas State University

Authors:

Marcus O. Gary, Ph.D., P.G.
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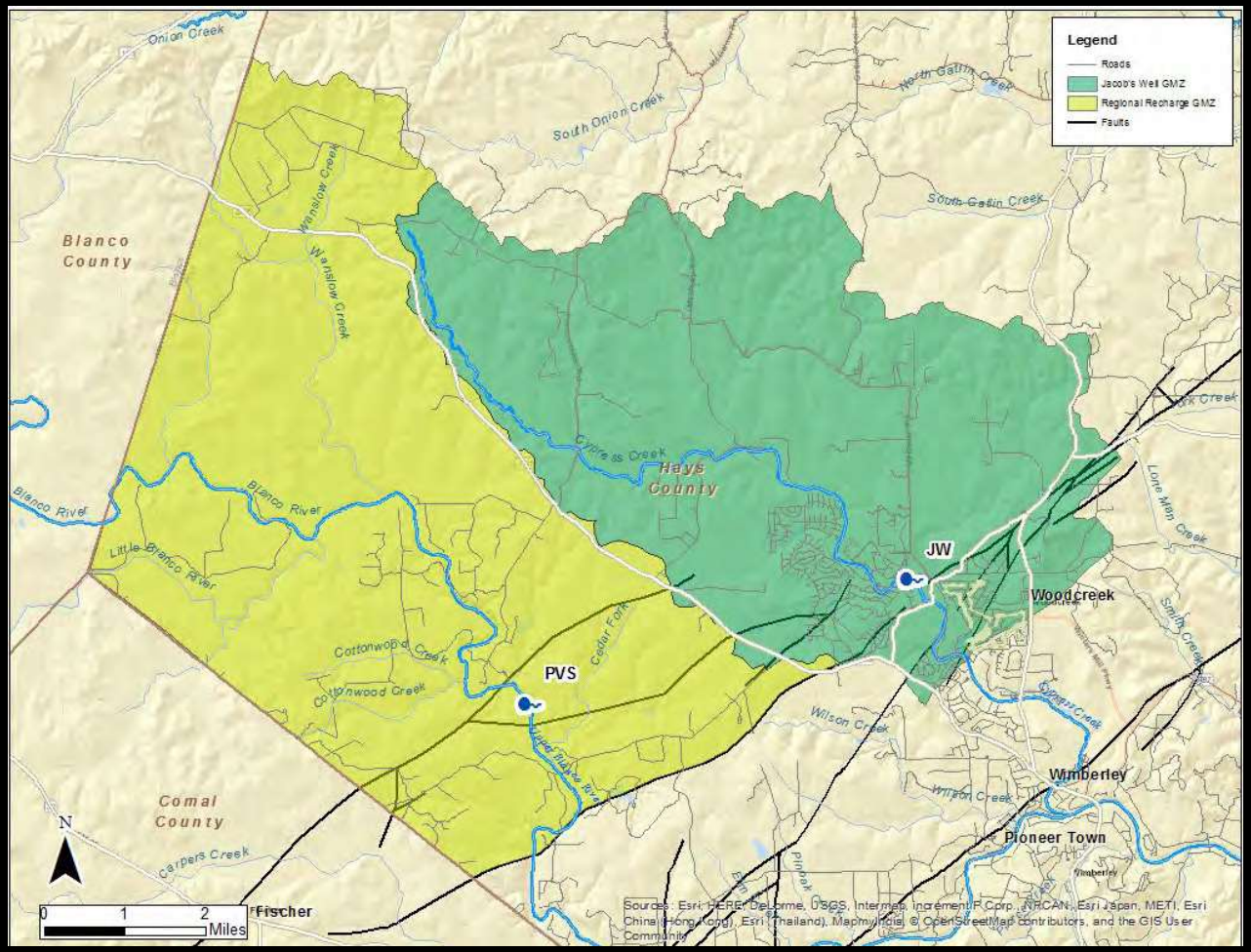
Barton Springs/Edwards Aquifer Conservation District

Brian A. Smith, Ph.D., P.G.
Barton Springs/Edwards Aquifer Conservation District

Jeffery A. Watson, P.G.
Hays Trinity Groundwater Conservation District

Douglas A. Wierman, P.G.
Fellow , The Meadows Center for Water and the Environment, Texas State University

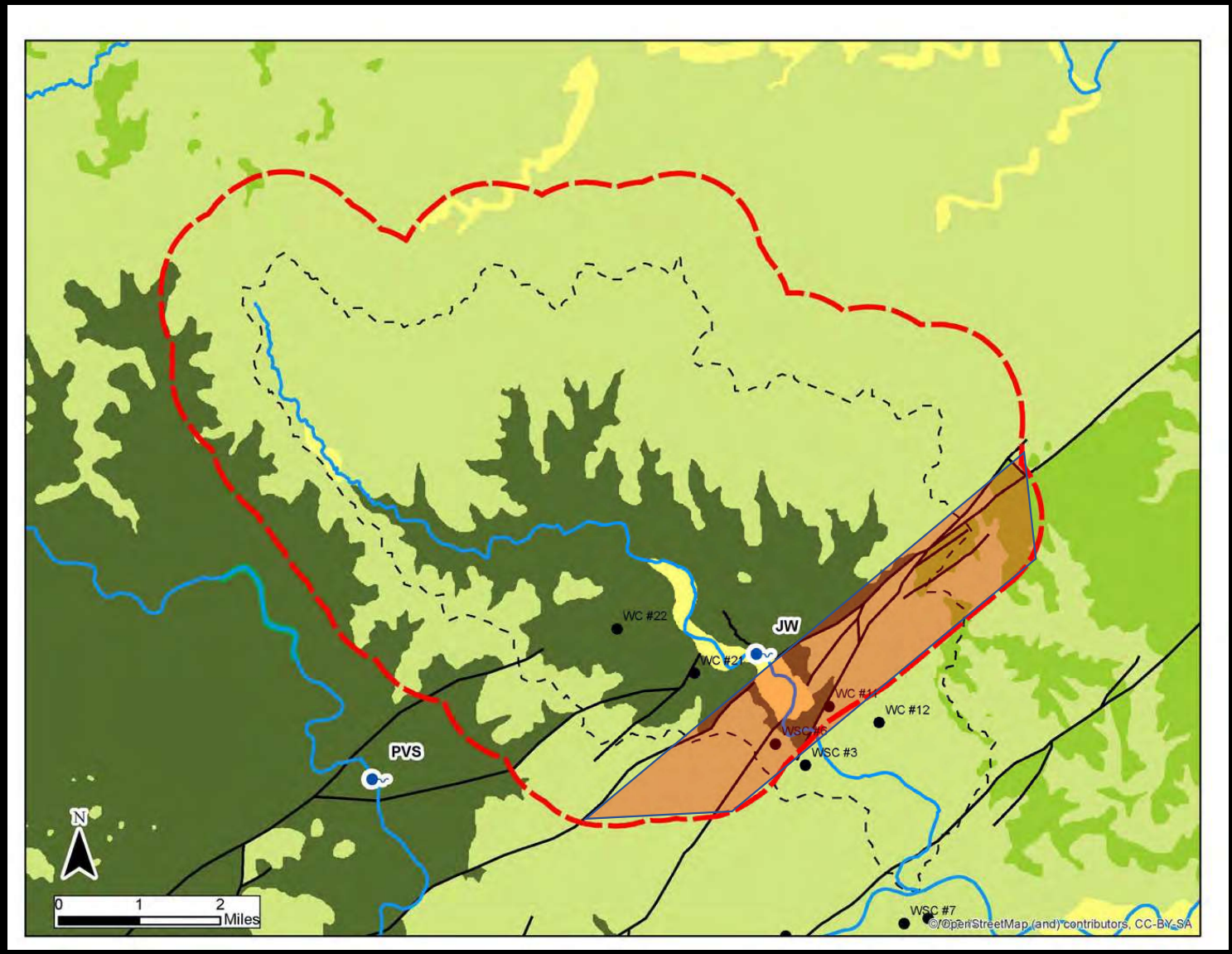
MEMBER **THE TEXAS STATE UNIVERSITY SYSTEM**



Suggested JWGMZ Area v 1.0

(presented December 6, 2018)

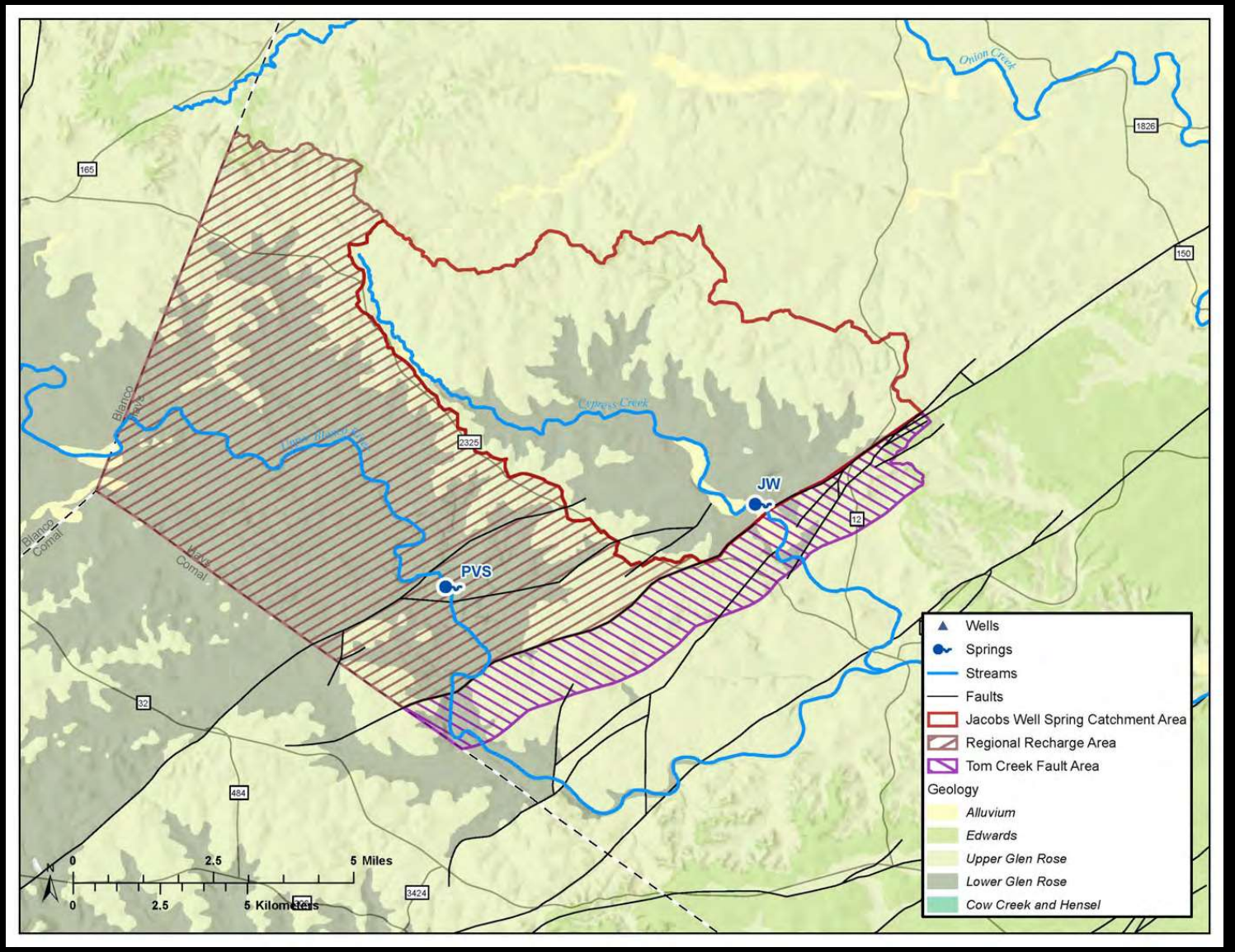
- 1-mile buffer around Dry Cypress Creek watershed upstream of Tom Creek Fault Zone.
- Includes Fault Zone – wells in this area respond similarly to wells in upstream watershed.



JWS Areas of Hydrogeologic Influence

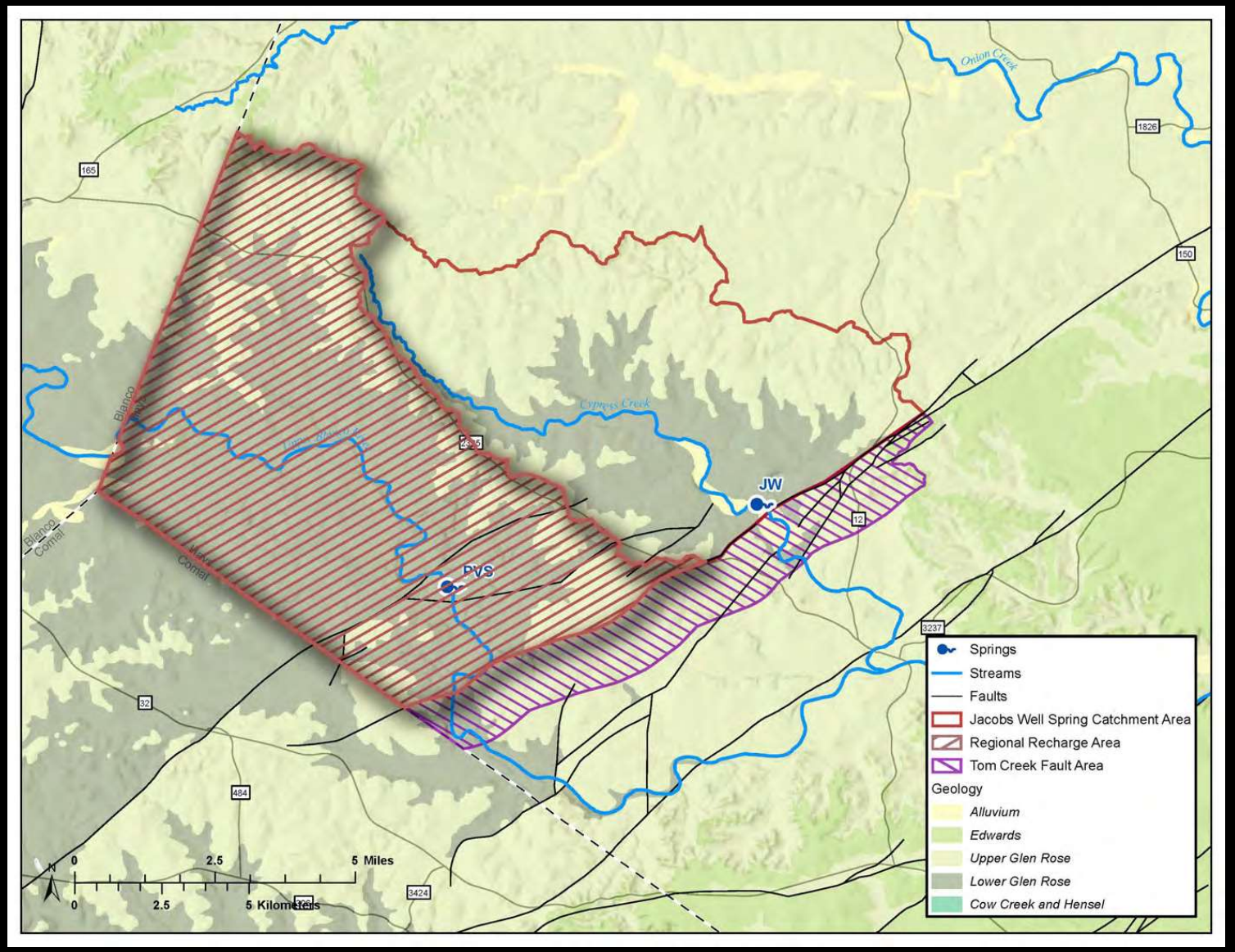
- Three separate areas that each influence flow at Jacob's Well are identified.

1. Jacob's Well catchment area (springshed)
2. Tom Creek Fault area.
3. Regional recharge area.



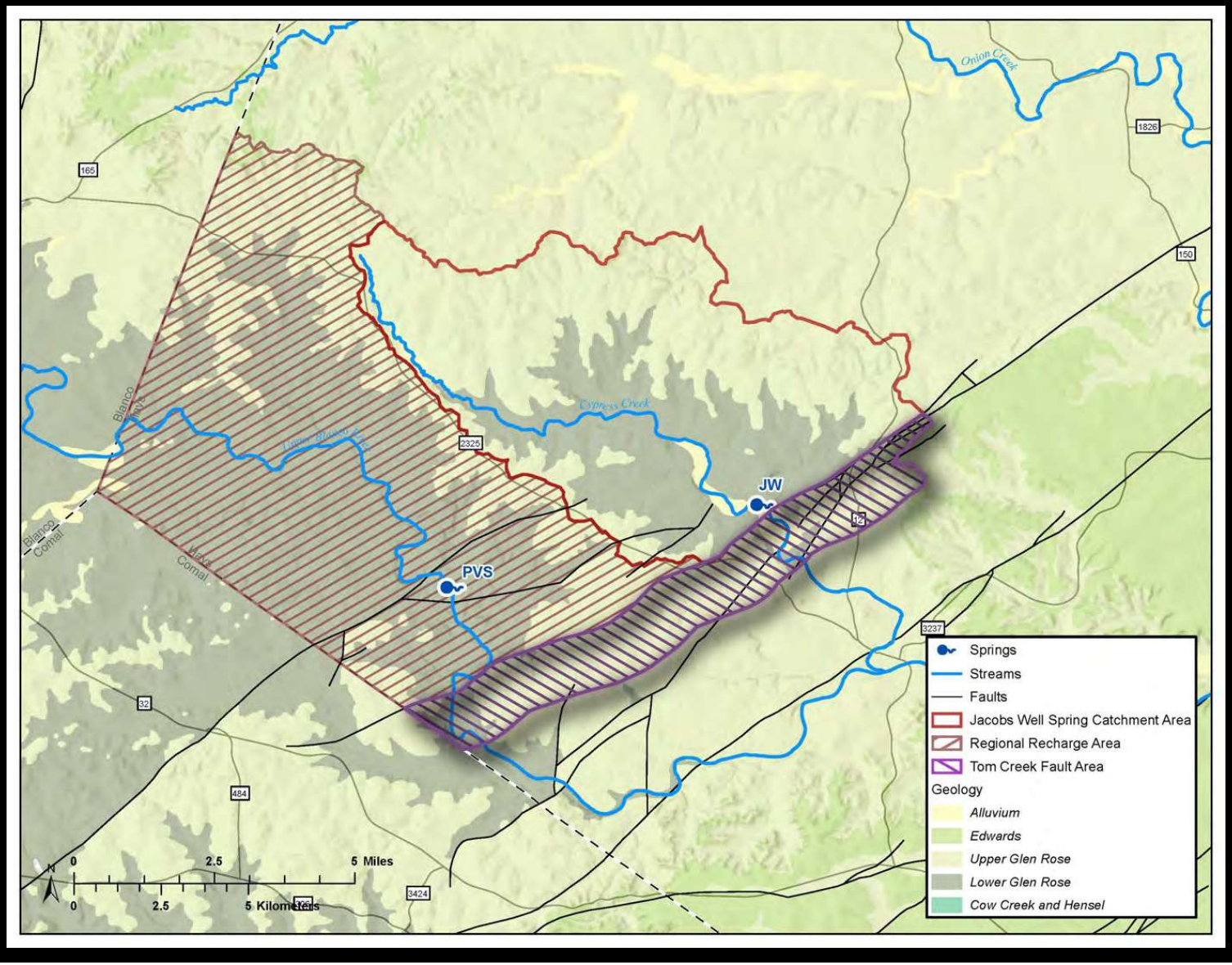
JW Regional Recharge Area

- Bounded by Hays County line to the west, Region K-L boundary to the north, Dry Cypress Creek to the east, and Tom Creek Fault to the south.
- Regional GW flow into the JWS springshed area.
- Includes PVS and Blanco Rv springs.
- Five-year study period created to determine future management strategies to support sustainable spring flows to the Blanco.

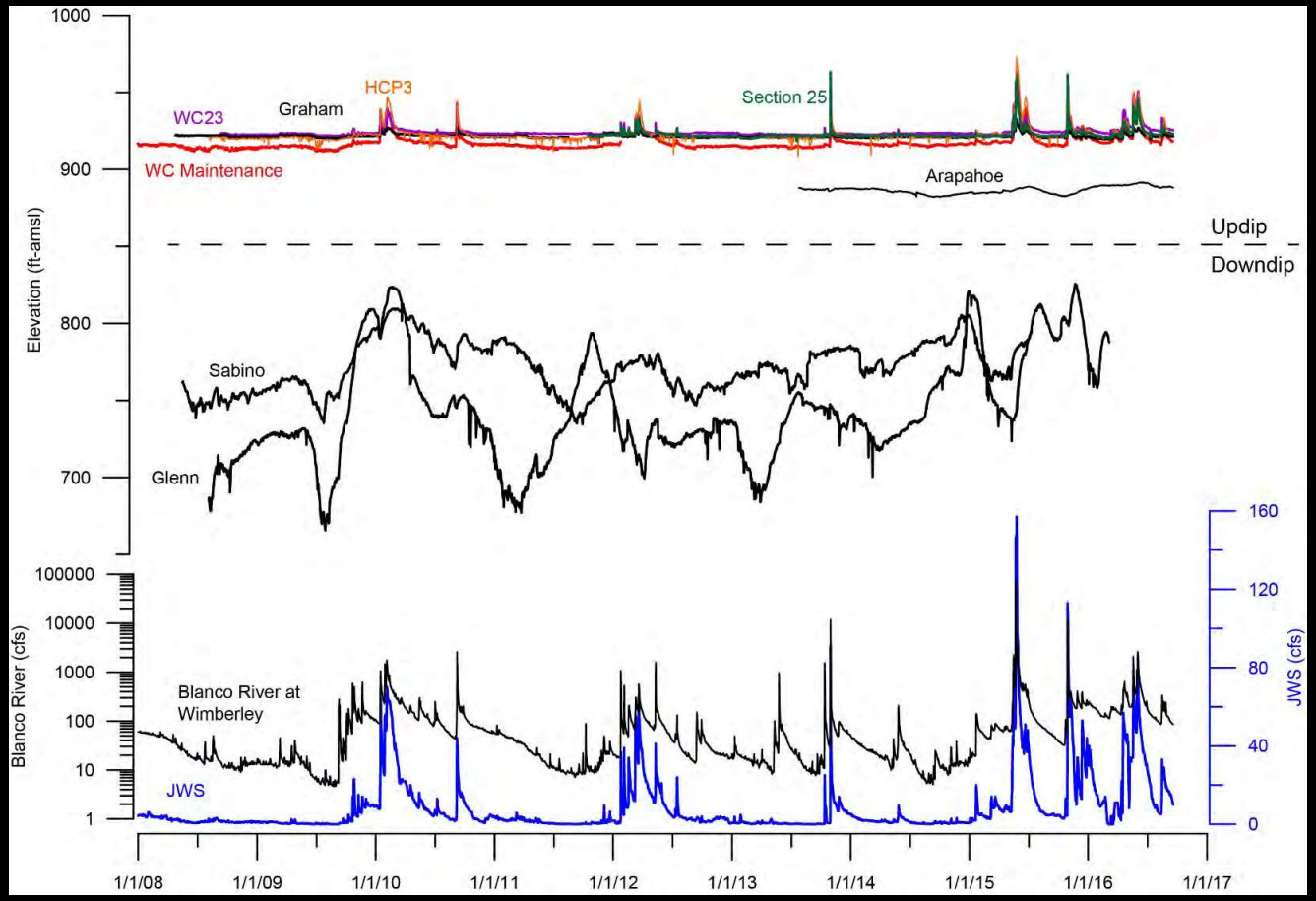


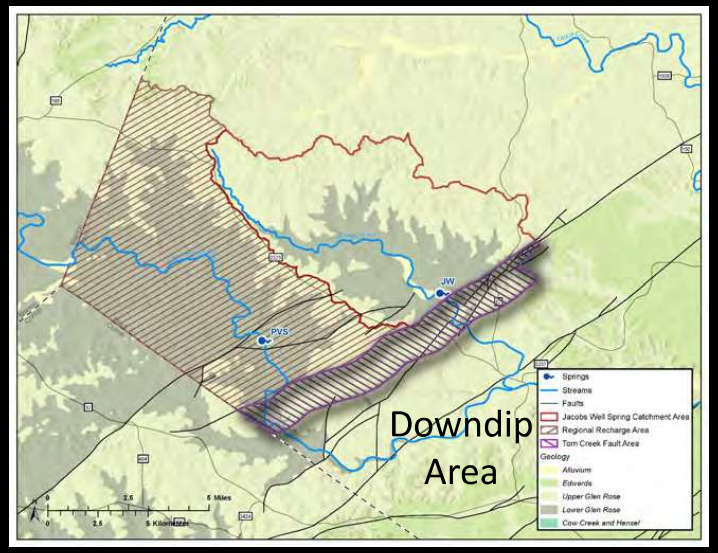
Tom Creek Fault Zone Area

- Bounded by Regional Recharge Area and JW Catchment to the west.
- Reflects a 1-mile wide fault zone southeast from the Tom Creek Fault as mapped by the BEG.



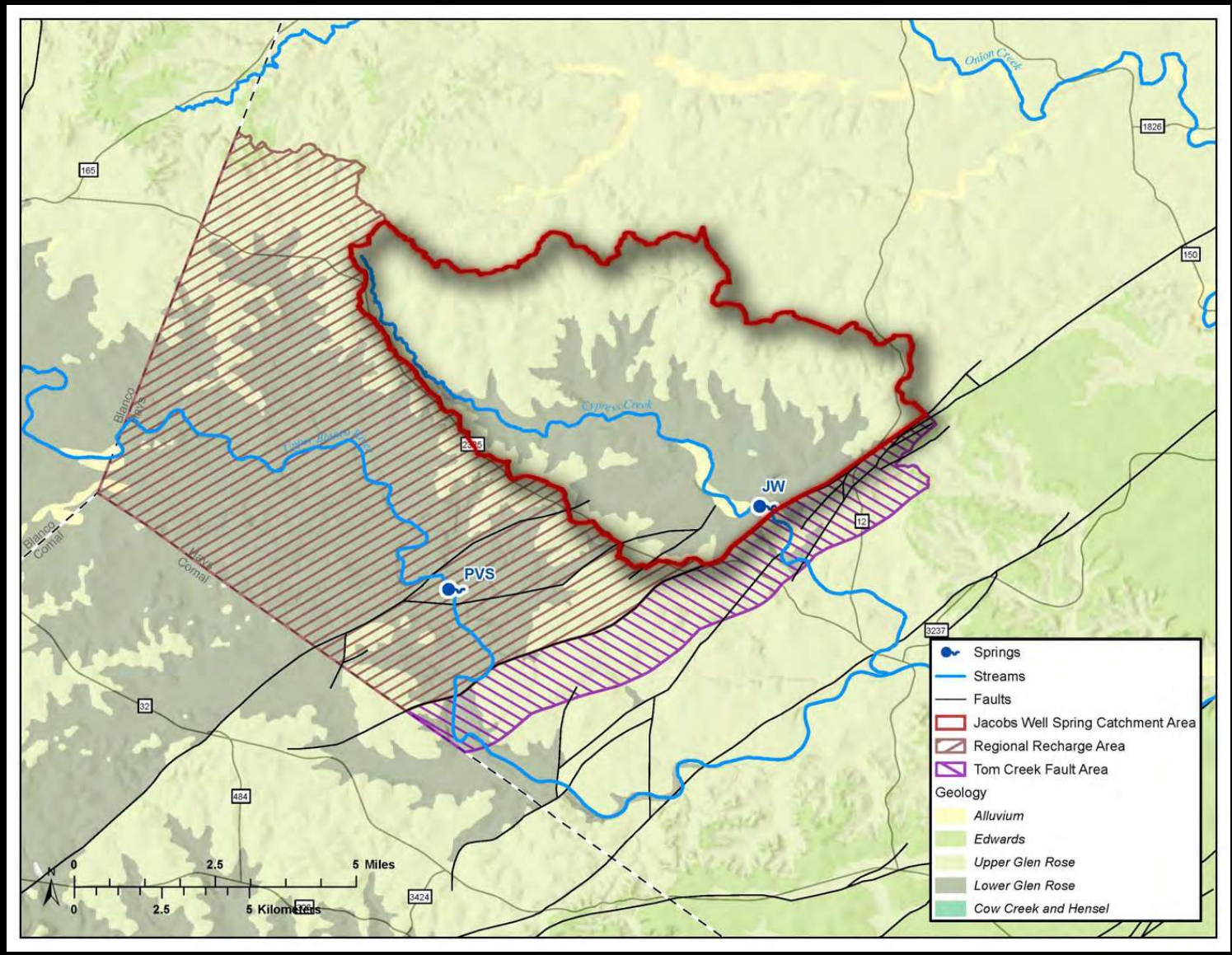
Wells located in the Tom Creek Fault Area and the Jacob's Well Spring Catchment Area (updip) respond differently than wells to the southeast (downdip) where the Middle Trinity aquifer is deeper in the subsurface



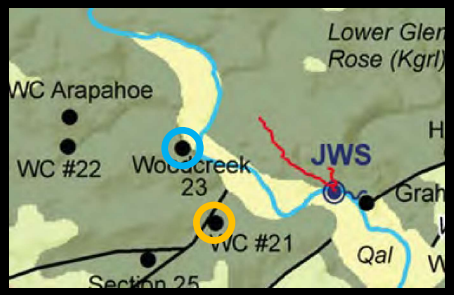


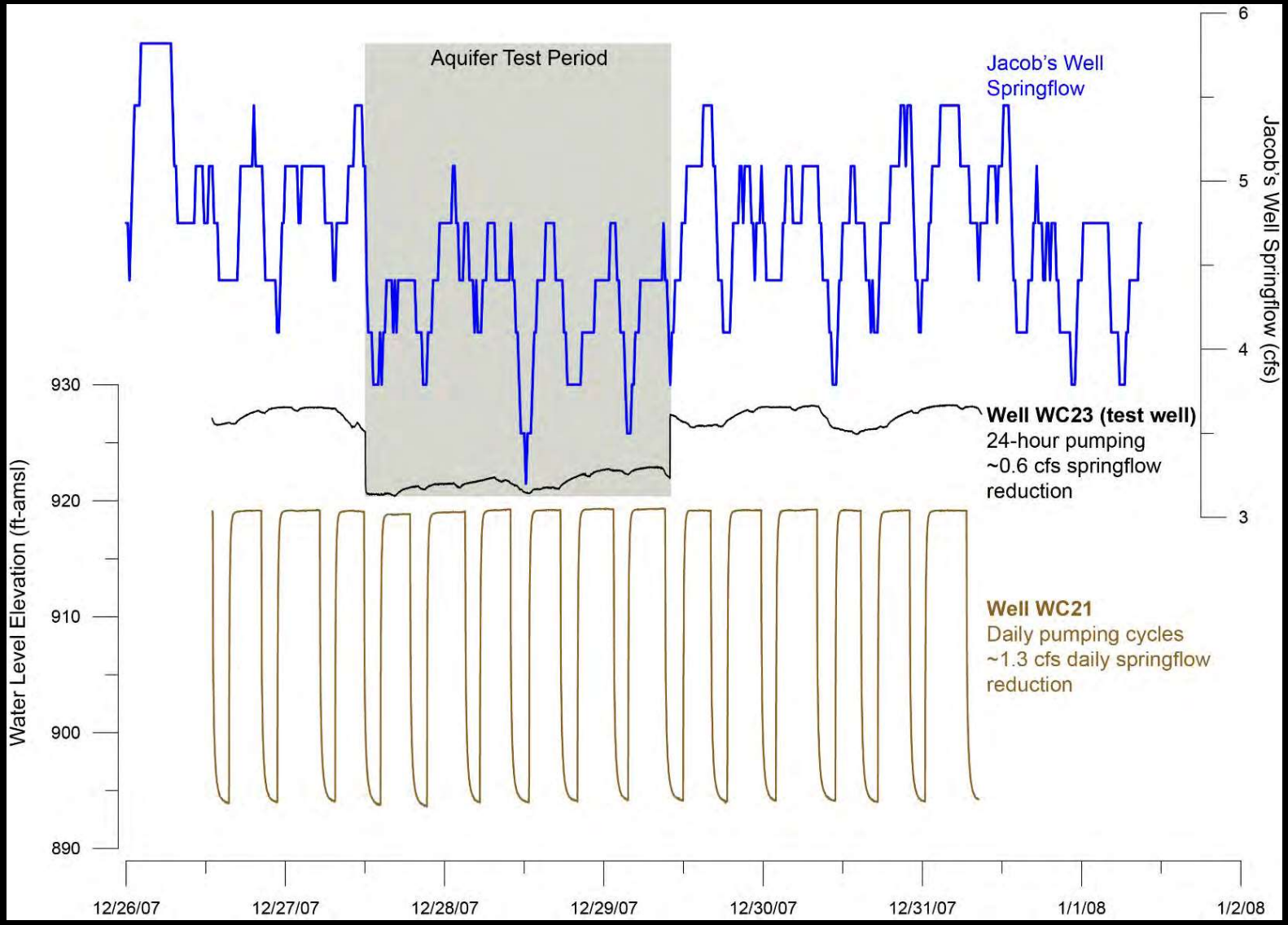
Jacob's Well Spring Catchment Area

- Represents the primary recharge area for JW.
- Water levels in the Middle Trinity aquifer are directly tied to spring flow.
- Cave passages feeding JW developed in this area.



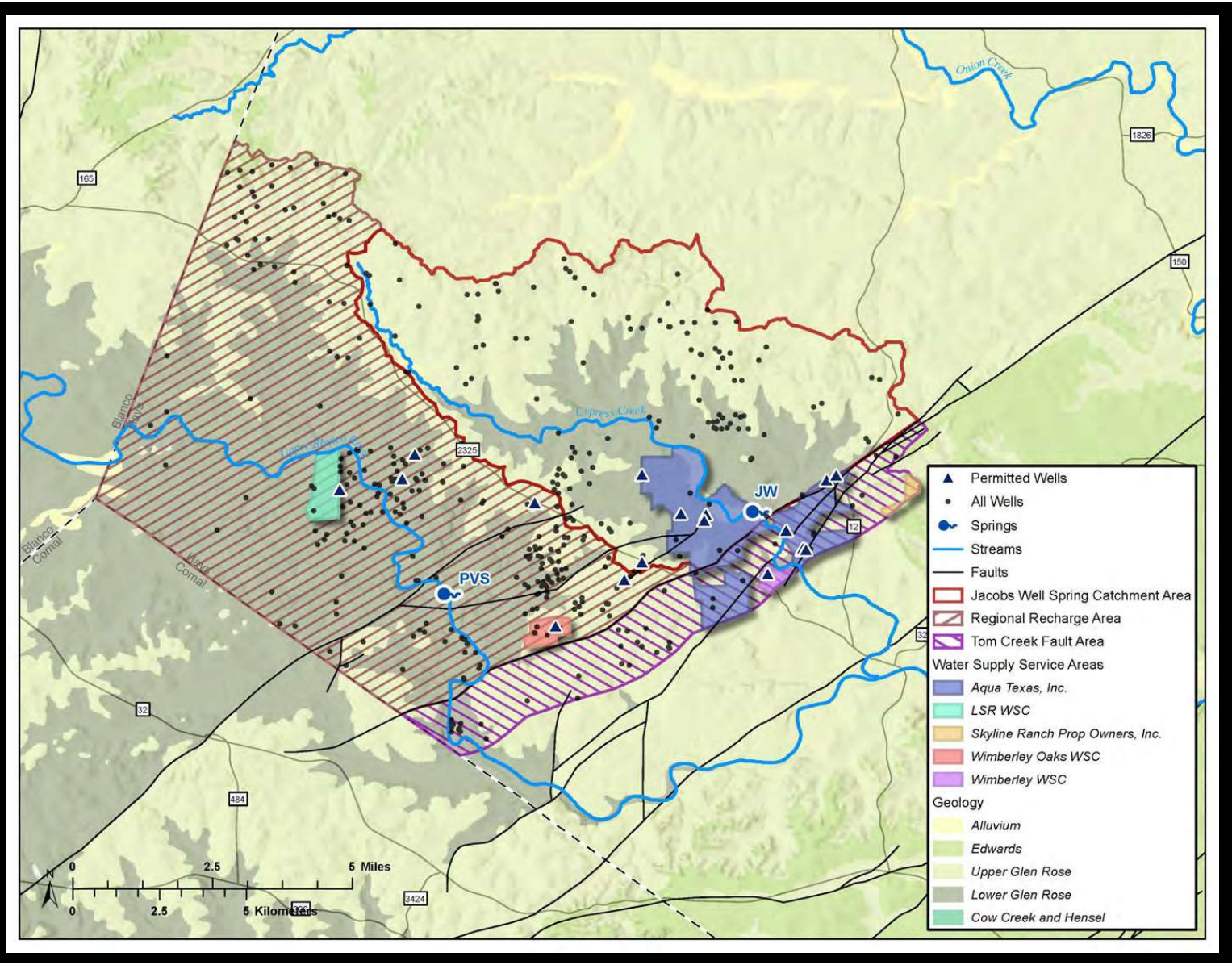
Observed effects of pumping on spring flow

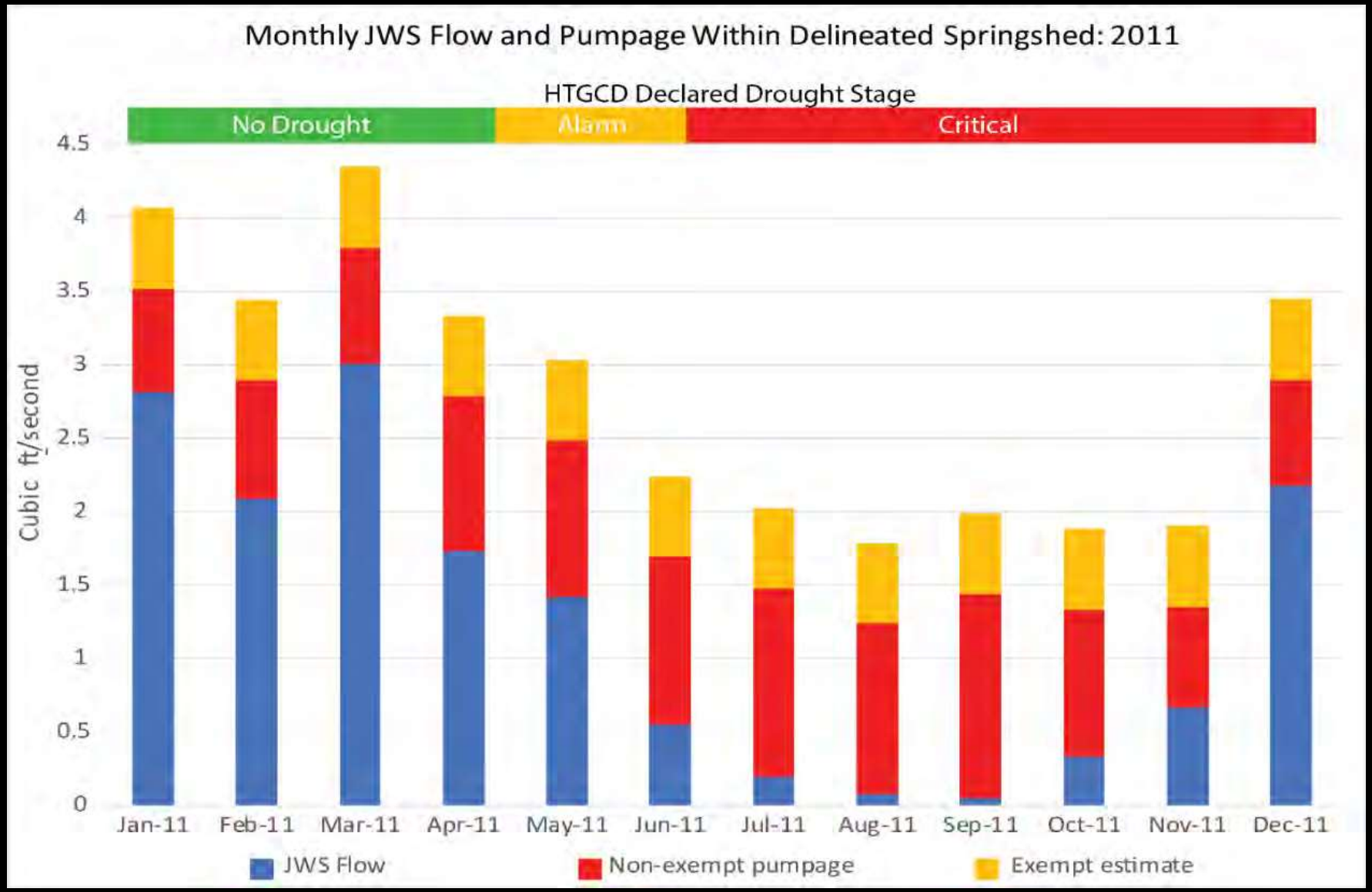


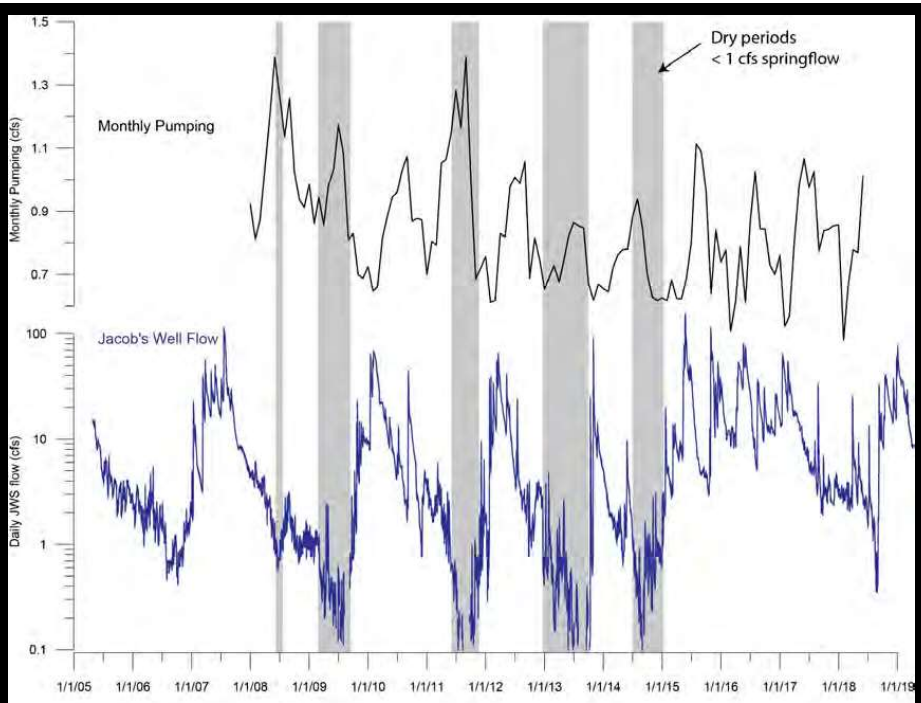


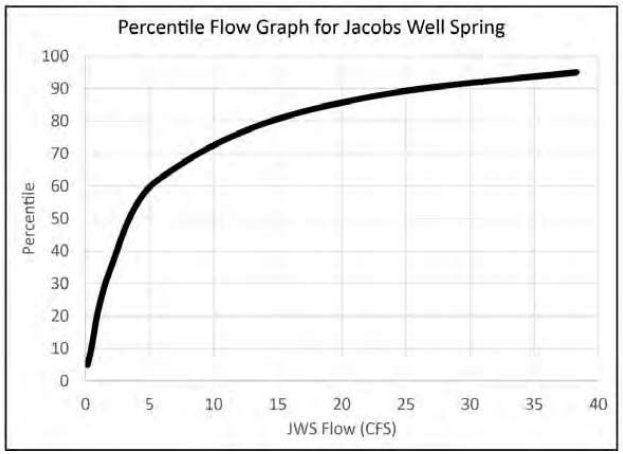
JWS Areas of Hydrogeologic Influence

- Permitted wells shown as large triangles
- Exempt wells registered in HTGCD database shown as small dots.
- CCN areas shown as colored polygons.

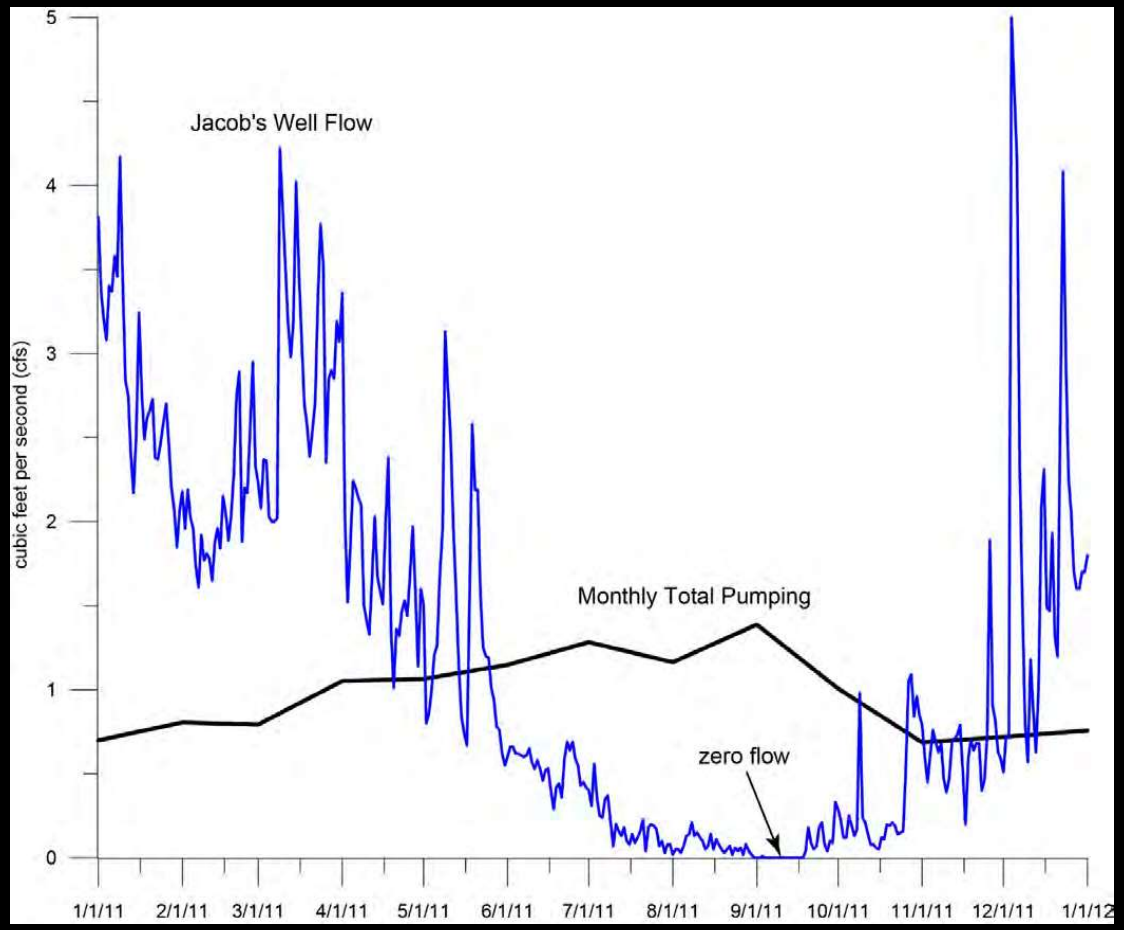



Monthly JWS Flow and Pumpage Within Delineated Springshed: 2011
HTGCD Declared Drought Stage
No Drought
Alarm
Critical
Cubic ft/second
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-11
Feb-11
Mar-11
Apr-11
May-11
Jun-11
Jul-11
Aug-11
Sep-11
Oct-11
Nov-11
Dec-11
JWS Flow
Non-exempt pumpage
Exempt estimate



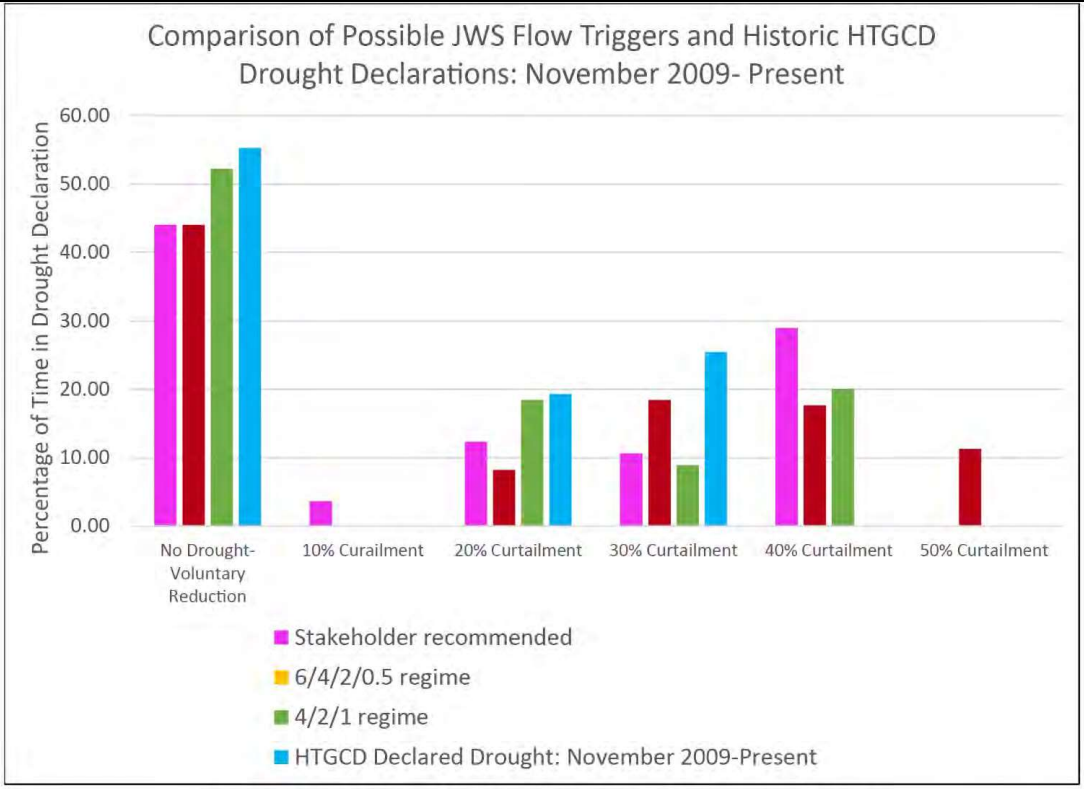


Percentile Analysis	
Percent	Flow (CFS)
95	38.3
90	26.3
85	19.2
80	14.5
75	11.3
70	8.8
65	6.78
60	5.1
55	4.1
50	3.4
45	2.9
40	2.5
35	2.0
30	1.6
25	1.2
20	0.9
15	0.7
10	0.5
5	0.2



The Stakeholder Task Force recommended the following drought trigger levels for permitted pumping reductions based on a flow index directly from Jacob's Well.

6 cfs – 10% reduction
5 cfs – 20% reduction
3 cfs – 30% reduction
2 cfs – 40% reduction

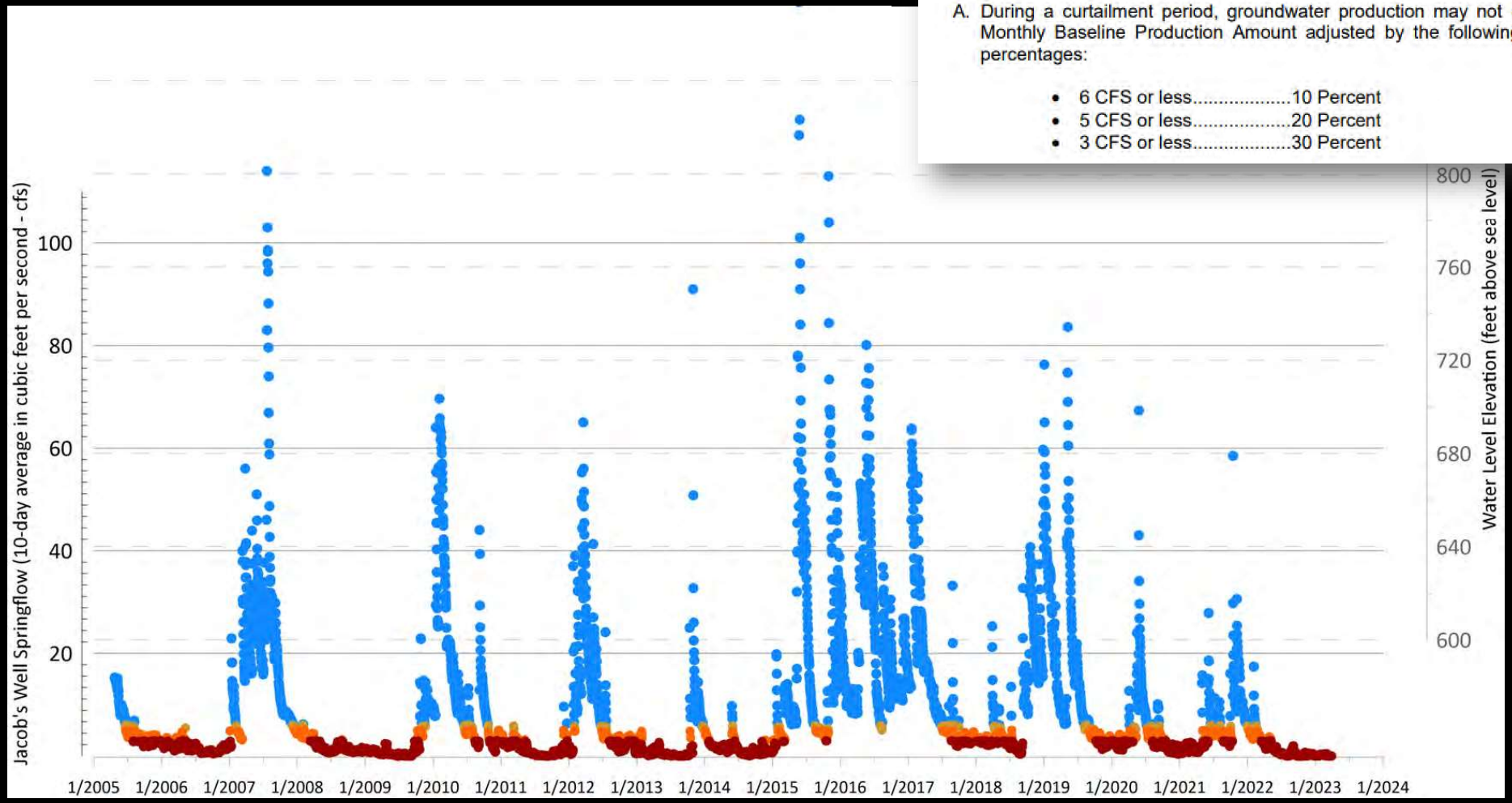


Curtailment Regimes (JWS Flow Values in Cubic-Feet/second)			
Recommended	6/4/2/0.5 Regime	4/2/1 Regime	Curtailment Percentage
-	-	-	0%
6	-	-	10%
5	6	4	20%
3	4	2	30%
2	2	1	40%
-	0.5	-	50%

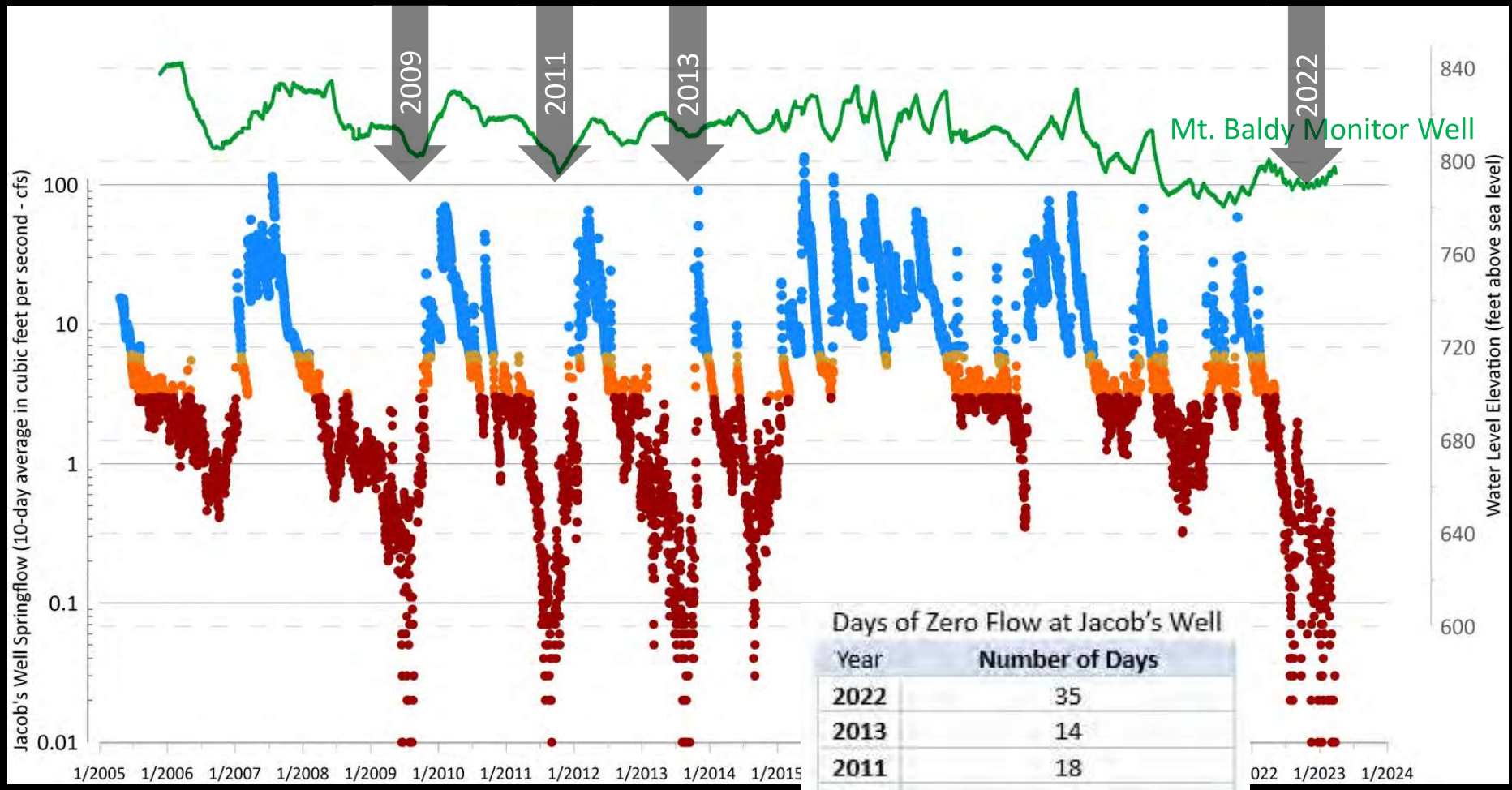
(15.2.4) Drought curtailment shall be based on a 10-Day running average of the USGS flow meter at Jacob's Well.

A. During a curtailment period, groundwater production may not exceed the Monthly Baseline Production Amount adjusted by the following reduction percentages:

- 6 CFS or less.....10 Percent
- 5 CFS or less.....20 Percent
- 3 CFS or less.....30 Percent



Slide courtesy of Robin Gary, The Watershed Association

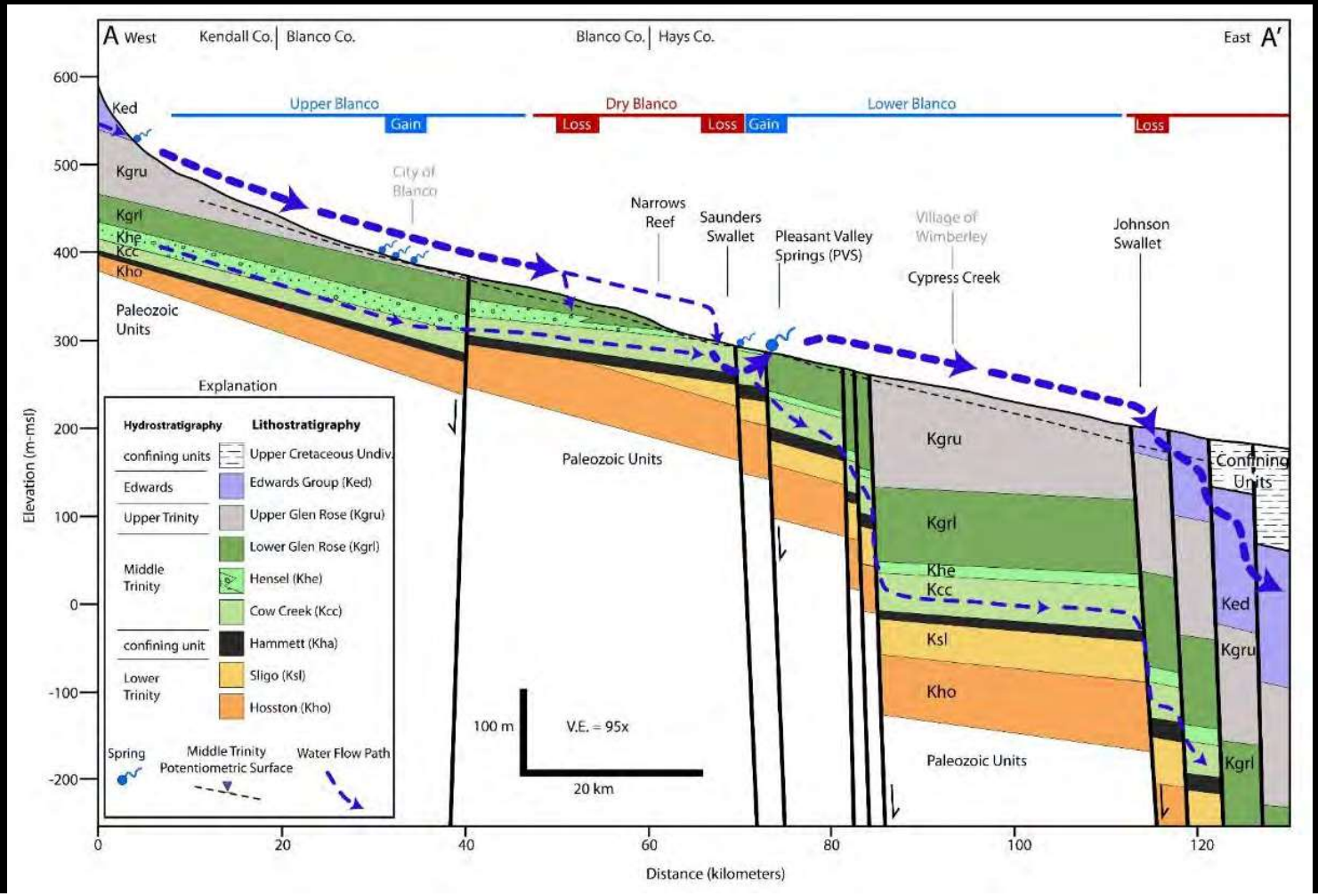


Days of Zero Flow at Jacob's Well

Year	Number of Days
2022	35
2013	14
2011	18
2009	33
2000	manual measurements only

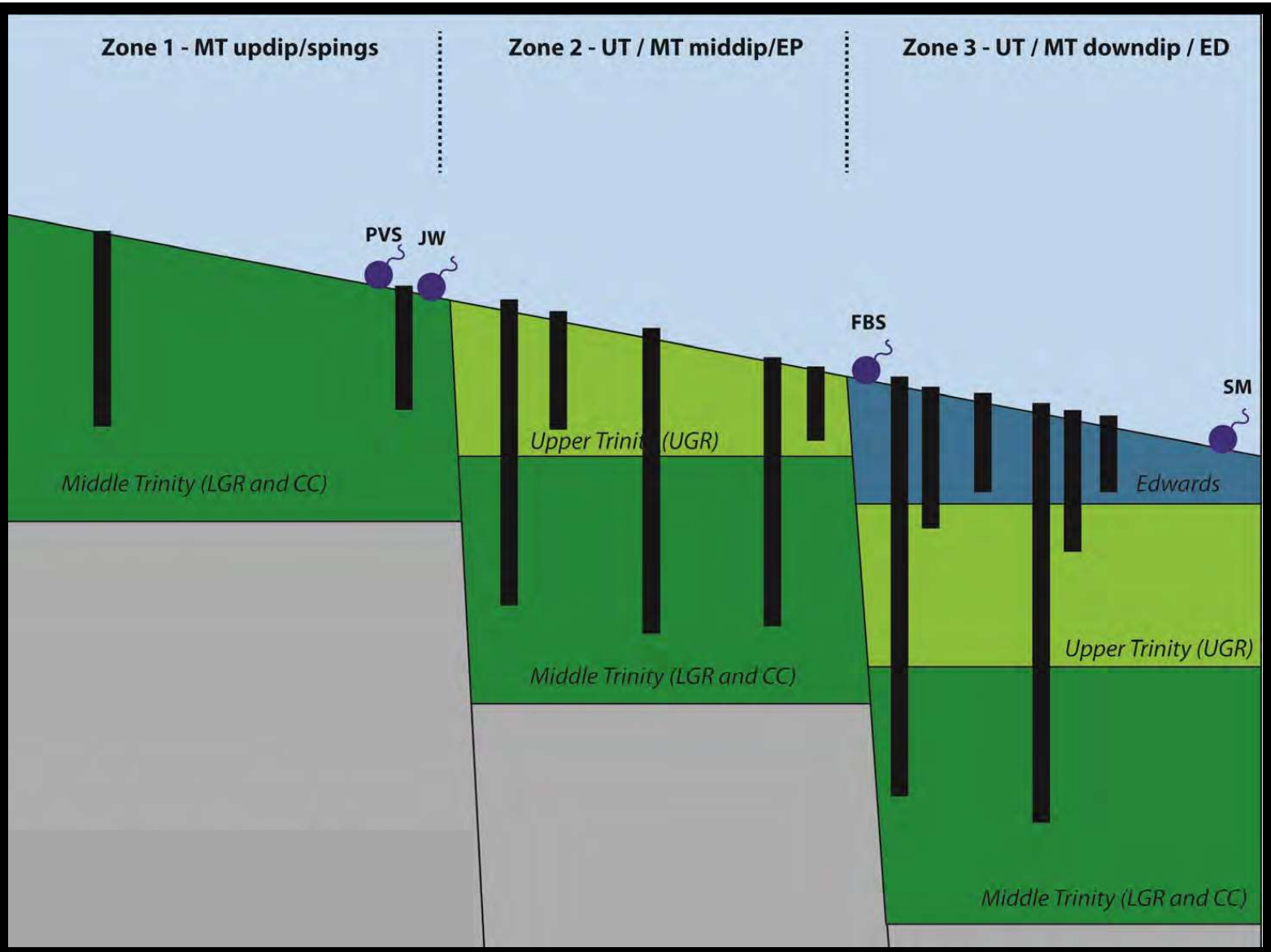
Slide courtesy of Robin Gary, The Watershed Association

Effects of groundwater pumping and Trinity springflow directly impacts recharge to the Edwards Aquifer.

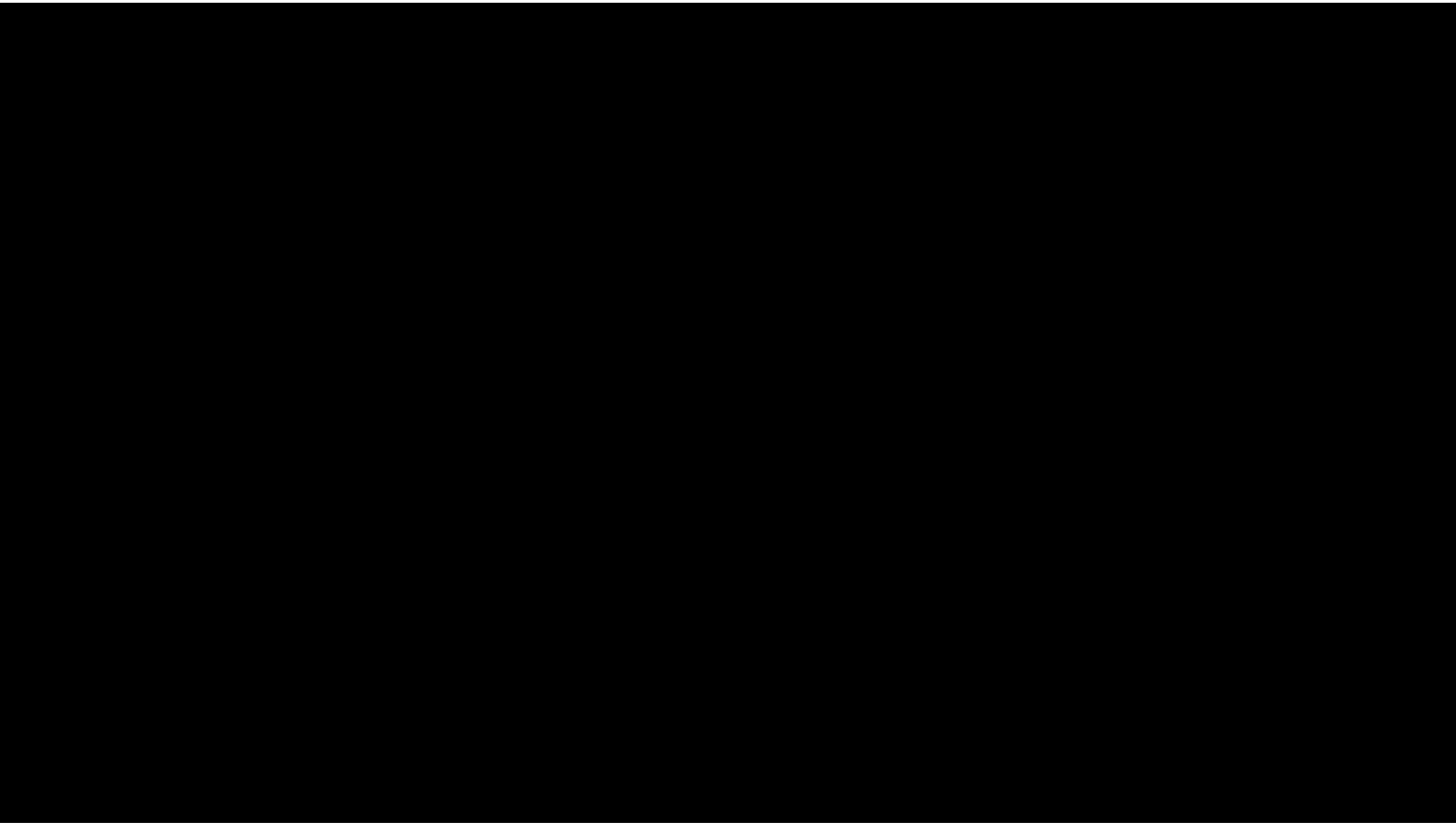


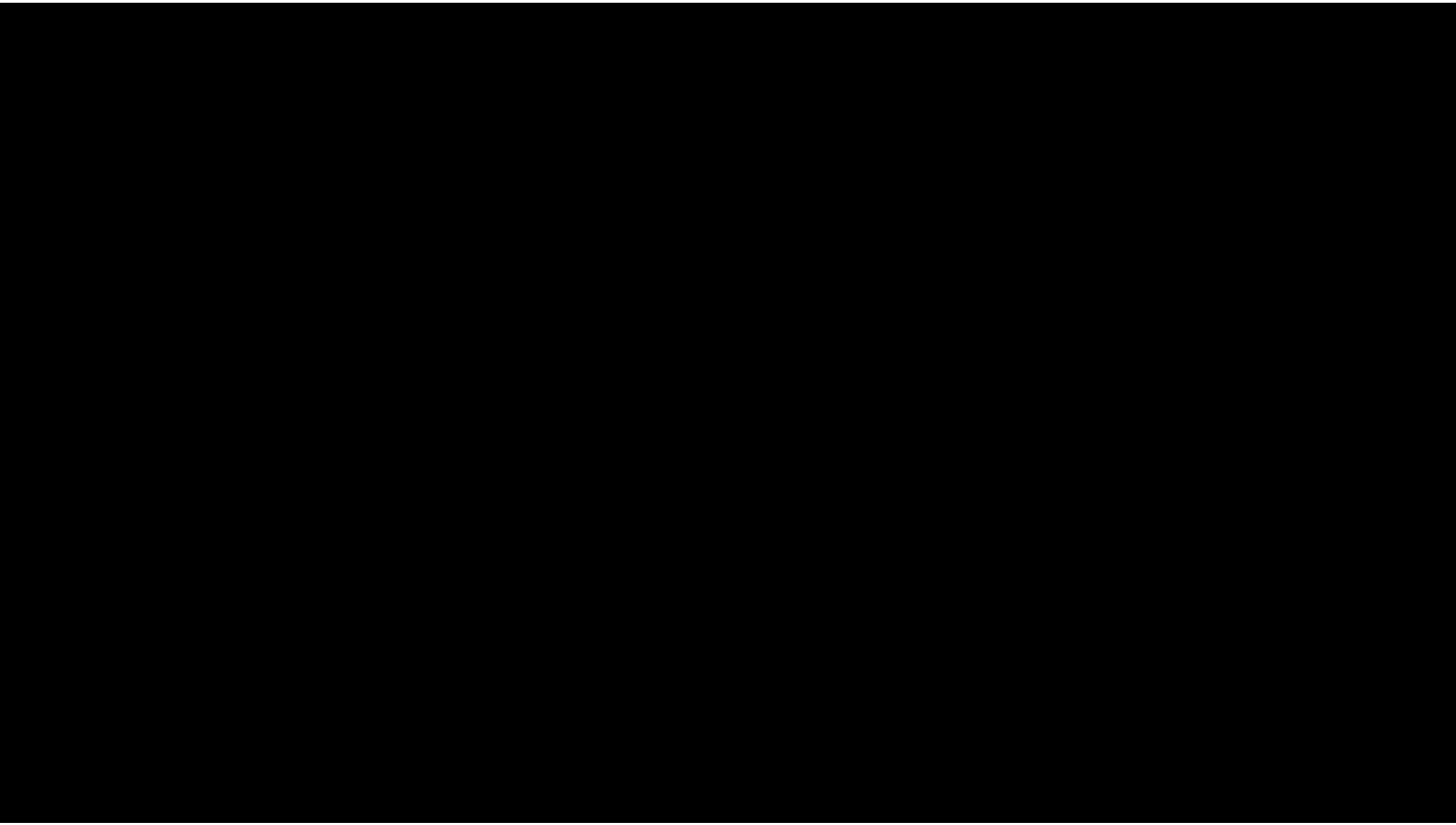
It's important to know where your well is in this complex aquifer system.

Impacts from pumping in different areas and depths affect wells differently.




Thank you!





Demand Reduction Tools for Maintaining Sustainable Base Flow at Jacob's Well Spring

Strategy	Description
Drought curtailments	Implementation of a simple, representative drought declaration methodology using Jacob's Well as one of the triggers.
Education	Effective communication to the public related to water resources, drought, and conservation efforts the public can take.
Conservation	Measures and actions taken to reduce the use of water. These could include watering schedules.
Permit reductions and restrictions	Right-sizing and placing ceilings on permitted pumping during non-drought periods.
Infrastructure and efficiency	Reduce line loss and fix other water infrastructure problems that may waste groundwater.

Alternative Water Supply Tools for Maintaining Sustainable Base Flow at Jacob's Well Spring

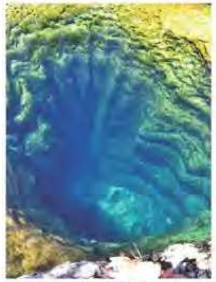
Strategy	Description
Conjunctive use	Use of surface water and groundwater sources
Aquifer storage and recovery (ASR)	Injection of surface or other water supplies into the Lower Trinity Aquifer for withdrawal during drought periods.
Lower Trinity	Development of the Lower Trinity Aquifer to (1) temporarily or permanently replace pumping from the Middle Trinity and (2) use as a sole-source for future permitted pumping.
Rainwater	Promotion of the use of rainwater for commercial and domestic uses.
Alternative Water Supplies	Importing water from more distant sources.
Temporary interconnections and pipelines	These could alleviate pumping in certain areas.

collective strength
RESEARCH
PLANNING
SUSTAINABILITY

MEMORANDUM

To: HTGCD Board Members, JWGMZ Stakeholders, JWGMZ Technical Team
From: Robin Rather
Date: July 15, 2019
Re: Facilitator's Report: Jacob's Well Spring Flow Stakeholder Task Force--Final Recommendations

Executive Summary



Thirty-five volunteer members of the Hays Trinity Groundwater Conservation District (HTGCD) "Spring Flow" Task Force were asked to review technical and scientific data and to identify best practices to ensure perennial spring flow at Jacob's Well and Cypress Creek. The Task Force came to 100% consensus on all but one of seven recommendations, and that one recommendation had all but two members in consensus. This memo contains a summary of the Task Force's work.

The first three recommendations are the most immediate and the most impactful in the short term:

1. We recommend the immediate establishment of one groundwater management zone shown in dark green in the map at right (the Jacob's Well Groundwater Management Zone, or JWGMZ). We also ask that the establishment of second zone be considered shown in yellow below (Regional Recharge Zone).

   For more detailed maps and technical specifics please refer to the Technical Report written by the JWGMZ Technical team (forthcoming.)

2. Using Jacob's Well Spring as a trigger for permitted

Evaluation for the Development of a Jacob's Well Groundwater Management Zone Hays County, Texas

Technical Report prepared for the Hays Trinity Groundwater Conservation District, Hays County, Texas

Report: 2019-05
July 2019

THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY

Authors:

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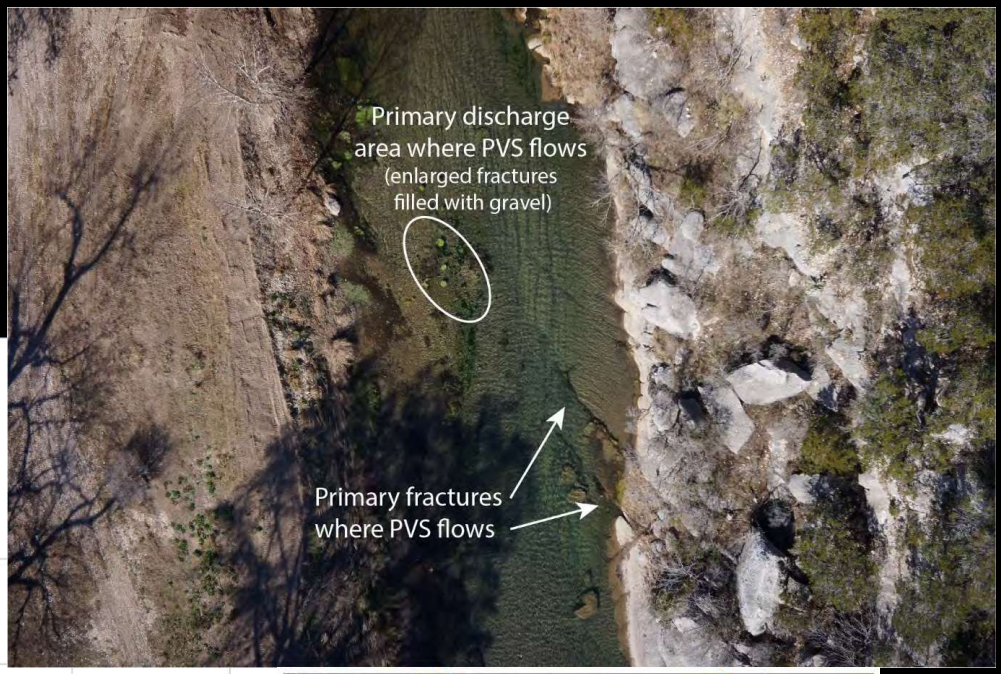
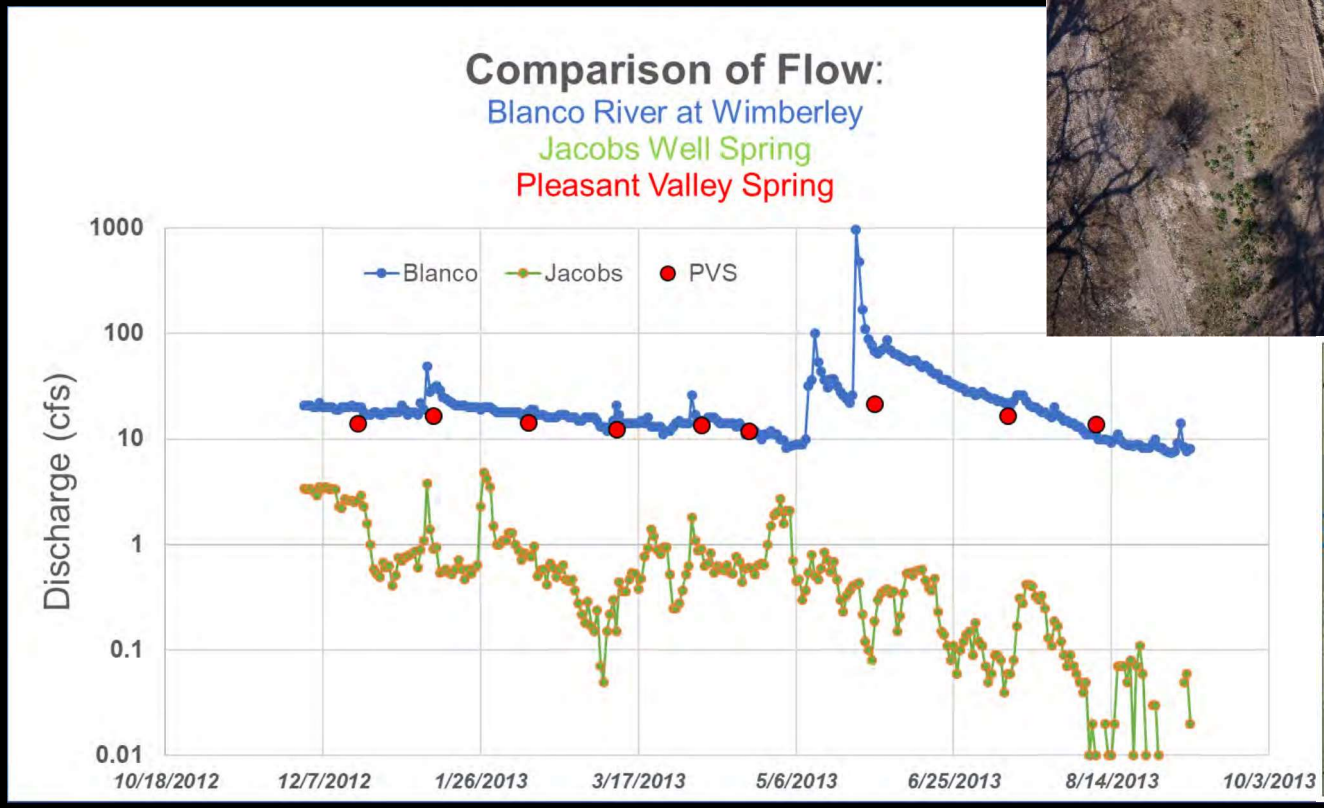
Hays Trinity Groundwater Conservation District

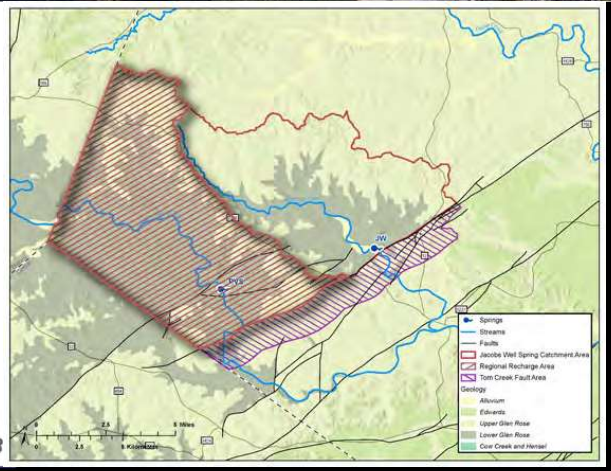
Douglas A. Wierman, P.G.
Fellow , The Meadows Center for Water and the Environment, Texas State University

MEMBER **THE TEXAS STATE UNIVERSITY SYSTEM**

Pleasant Valley Spring (PVS) is a single spring that provides all the flow to the Blanco River in Wimberley under drought conditions.

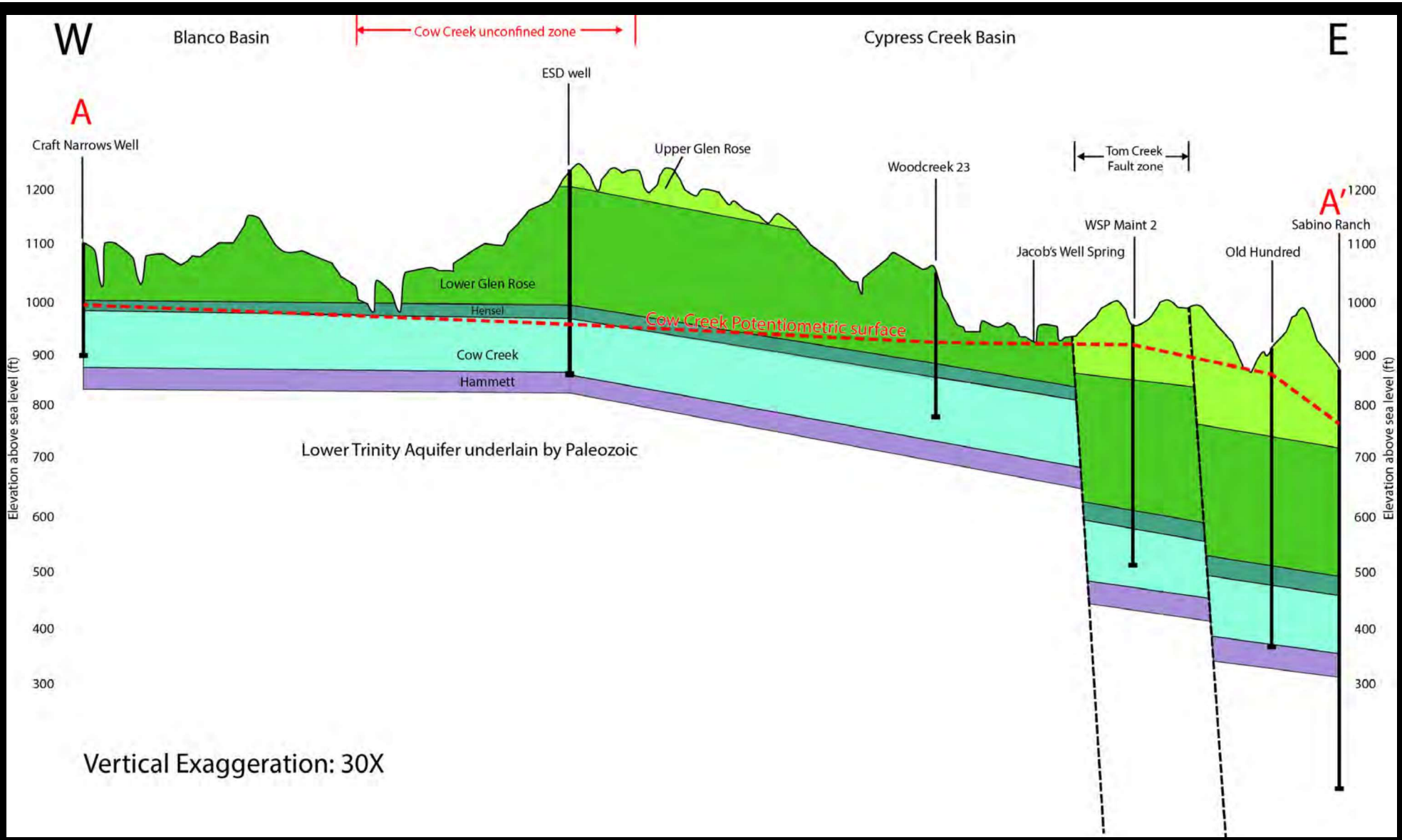




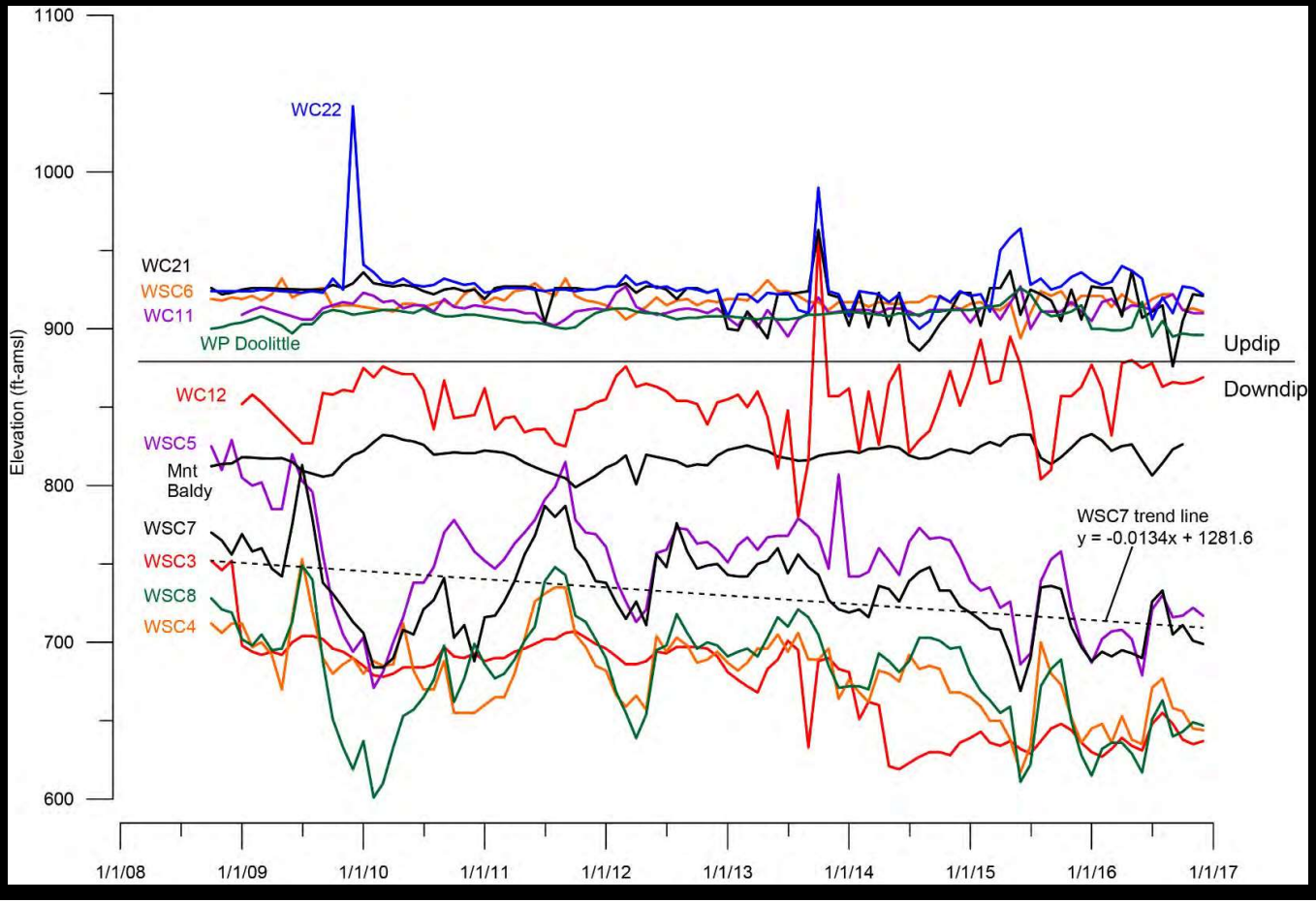


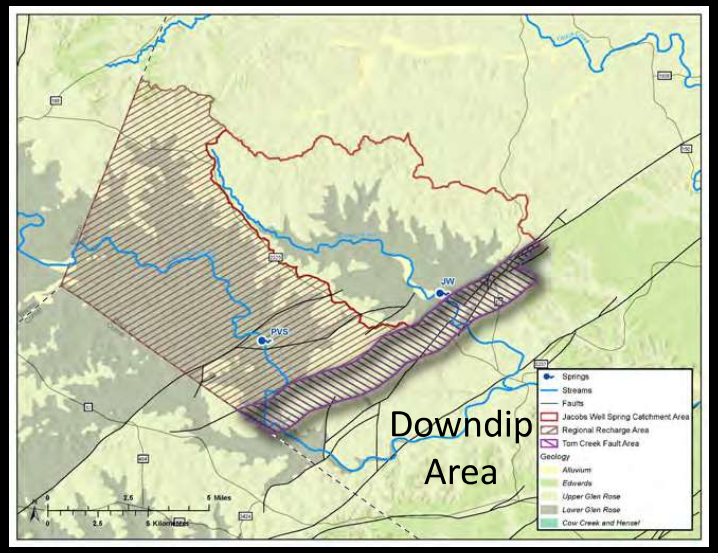
Datasets used in evaluation for this process.

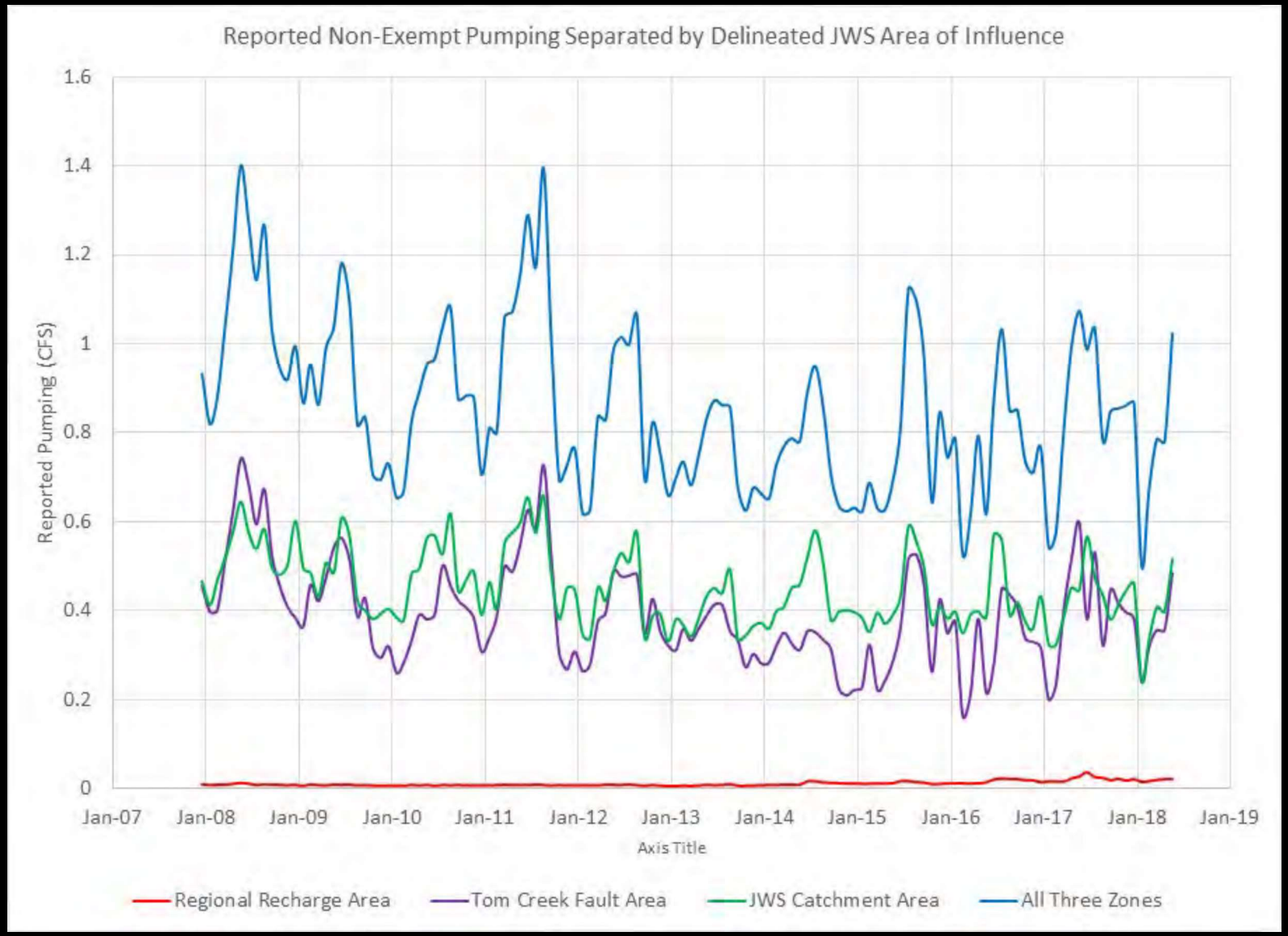
1. Hydrogeologic setting
2. Geologic structure
3. Recharge area for JW
4. Well pumping data
5. Spring flow data
6. Groundwater level data


W
Blanco Basin
Cow Creek unconfined zone
Cypress Creek Basin
E
A
A′
Craft Narrows Well
ESD well
Upper Glen Rose
Woodcreek 23
Tom Creek
Fault zone
WSP Maint 2
Jacob's Well Spring
Old Hundred
Sabino Ranch
Lower Glen Rose
Hensel
Cow Creek Potentiometric surface
Cow Creek
Hammett
Lower Trinity Aquifer underlain by Paleozoic
Elevation above sea level (ft)
1200
1100
1000
900
800
700
600
500
400
300
Vertical Exaggeration: 30X

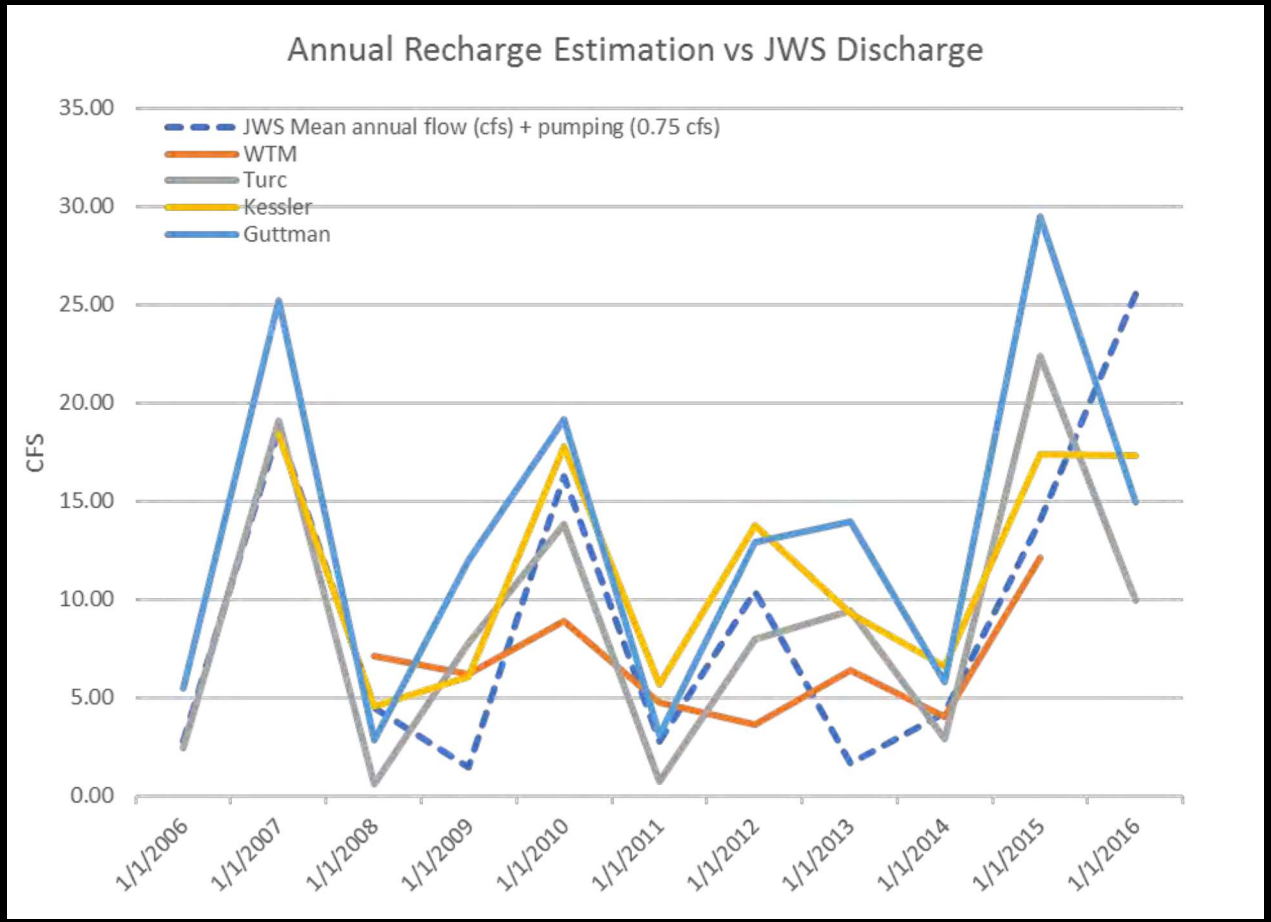
Wells located in the Tom Creek Fault Area and the Jacob's Well Spring Catchment Area (updip) respond differently than wells to the southeast (downdip) where the Middle Trinity aquifer is deeper in the subsurface






Reported Non-Exempt Pumping Separated by Delineated JWS Area of Influence
Reported Pumping (CFS)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Axis Title
Regional Recharge Area
Tom Creek Fault Area
JWS Catchment Area
All Three Zones

Multiple recharge analyses were conducted to evaluate area of greatest influence to spring flow

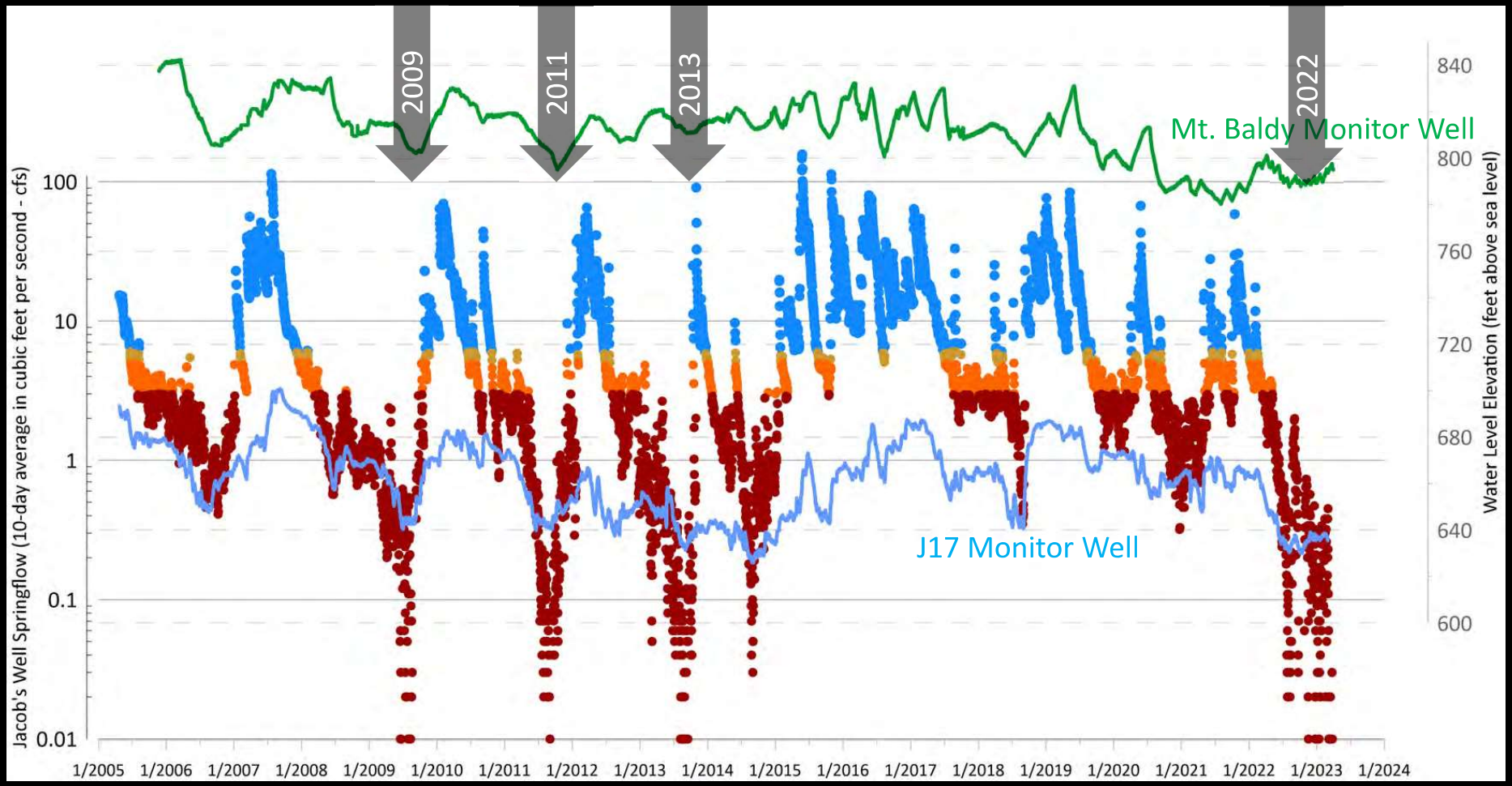


Springshed is estimated by integrating hydrologic data with methods published by Lanini et al., 2016 and Bonacci and Andric, 2015.

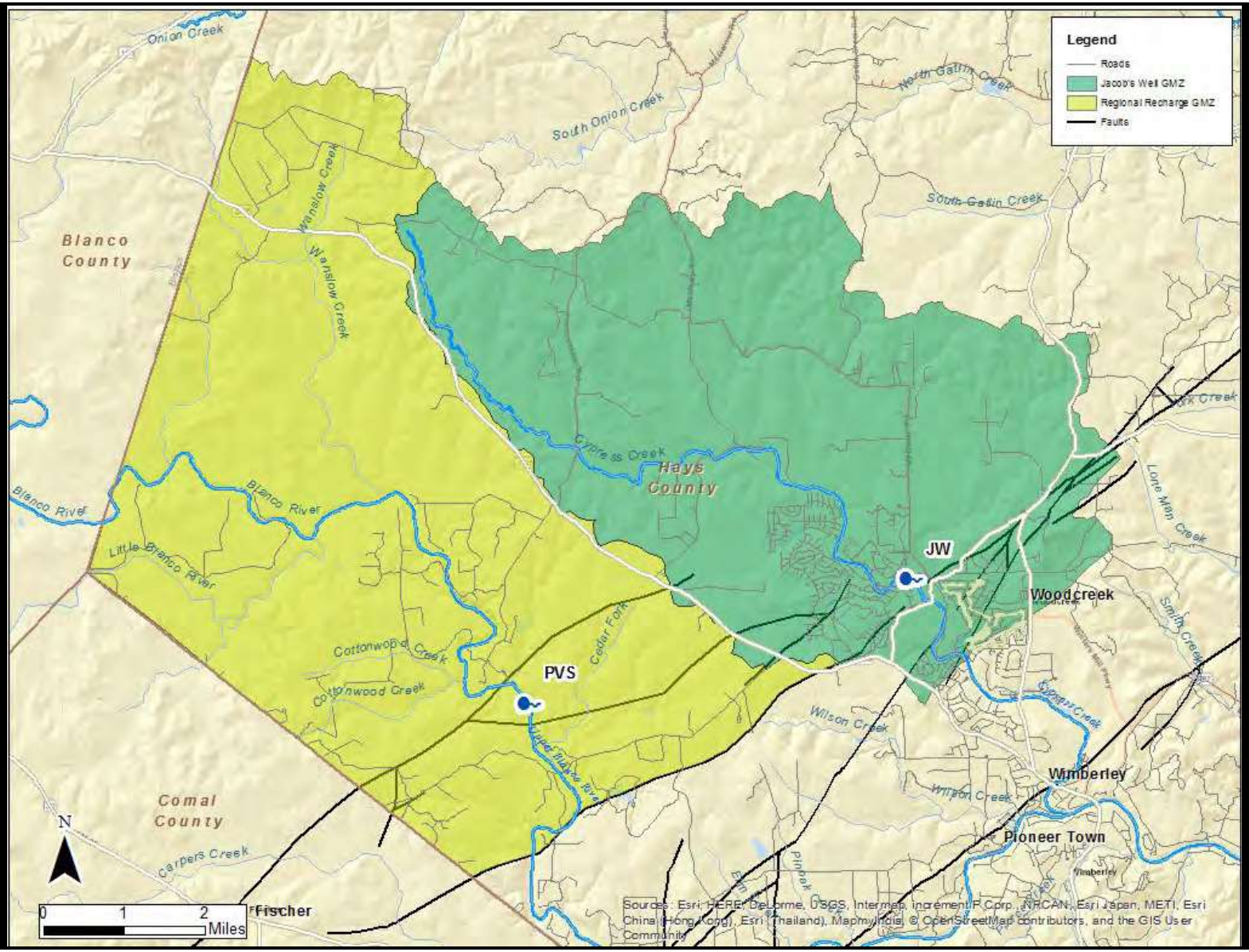
Springshed of Dry Cypress Creek (~31 mi2, or less) is sufficient for all recharge estimates.

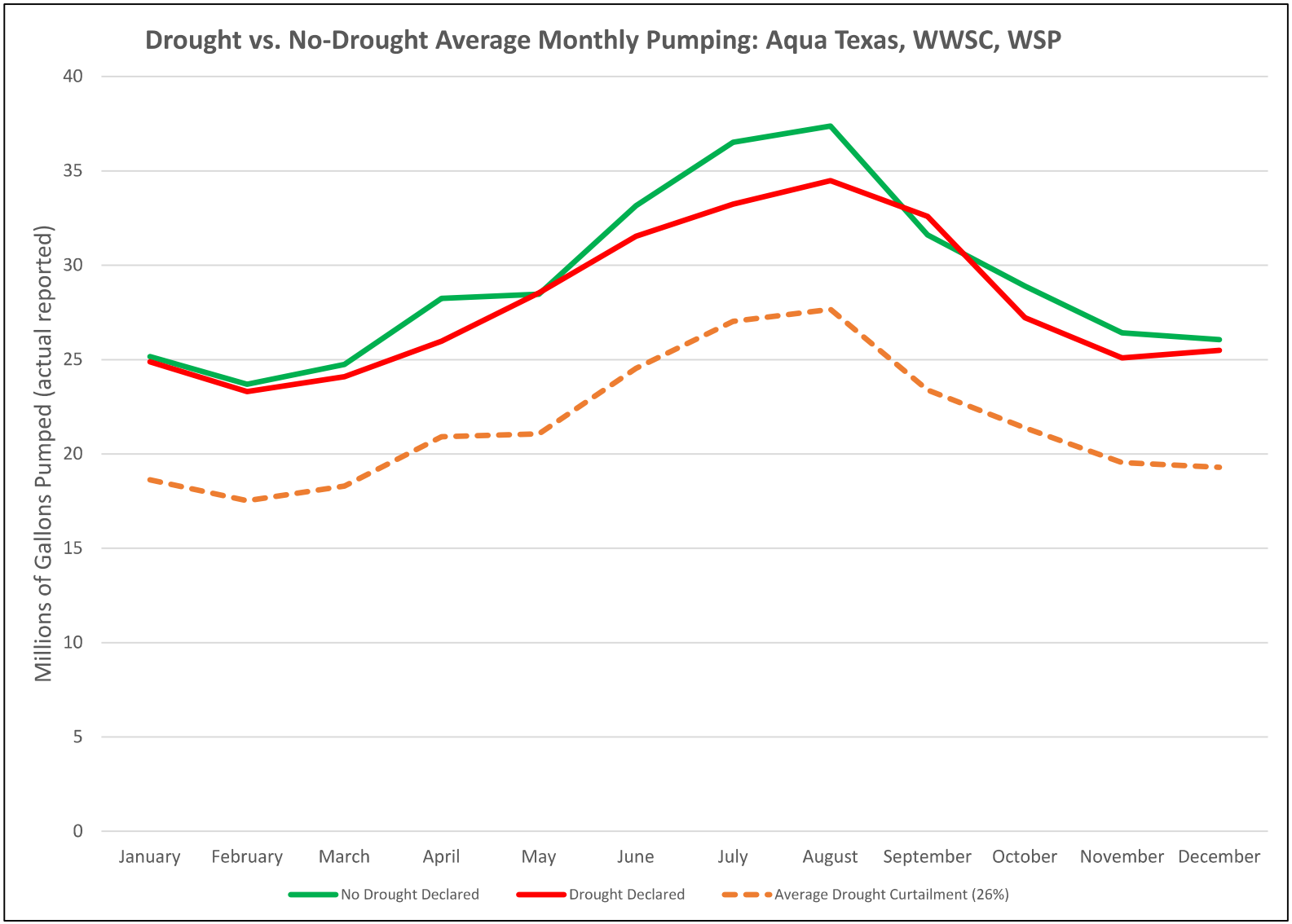
Estimated average annual effective recharge is about 30% of rainfall.

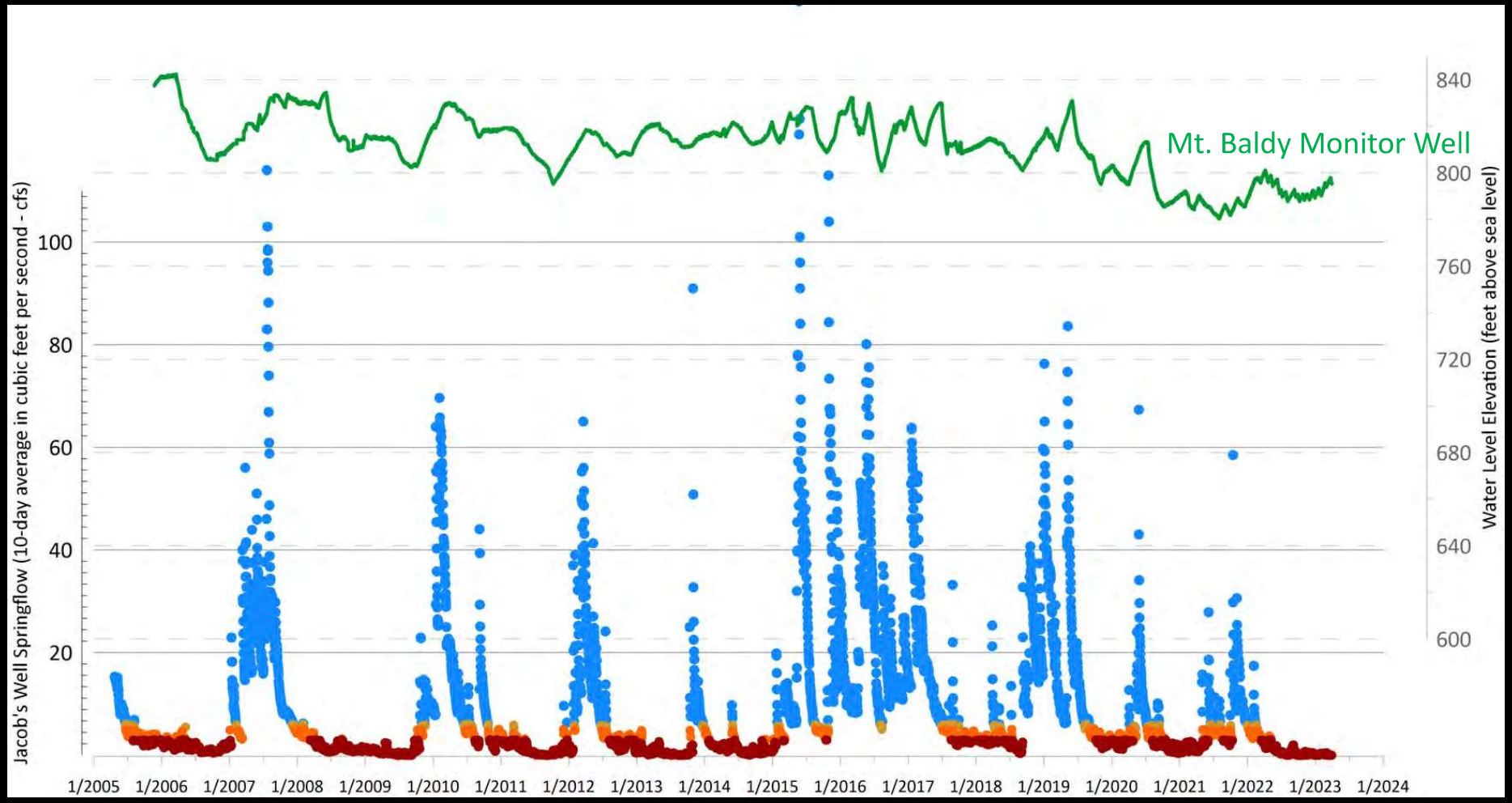
Hunt et. al, in prep

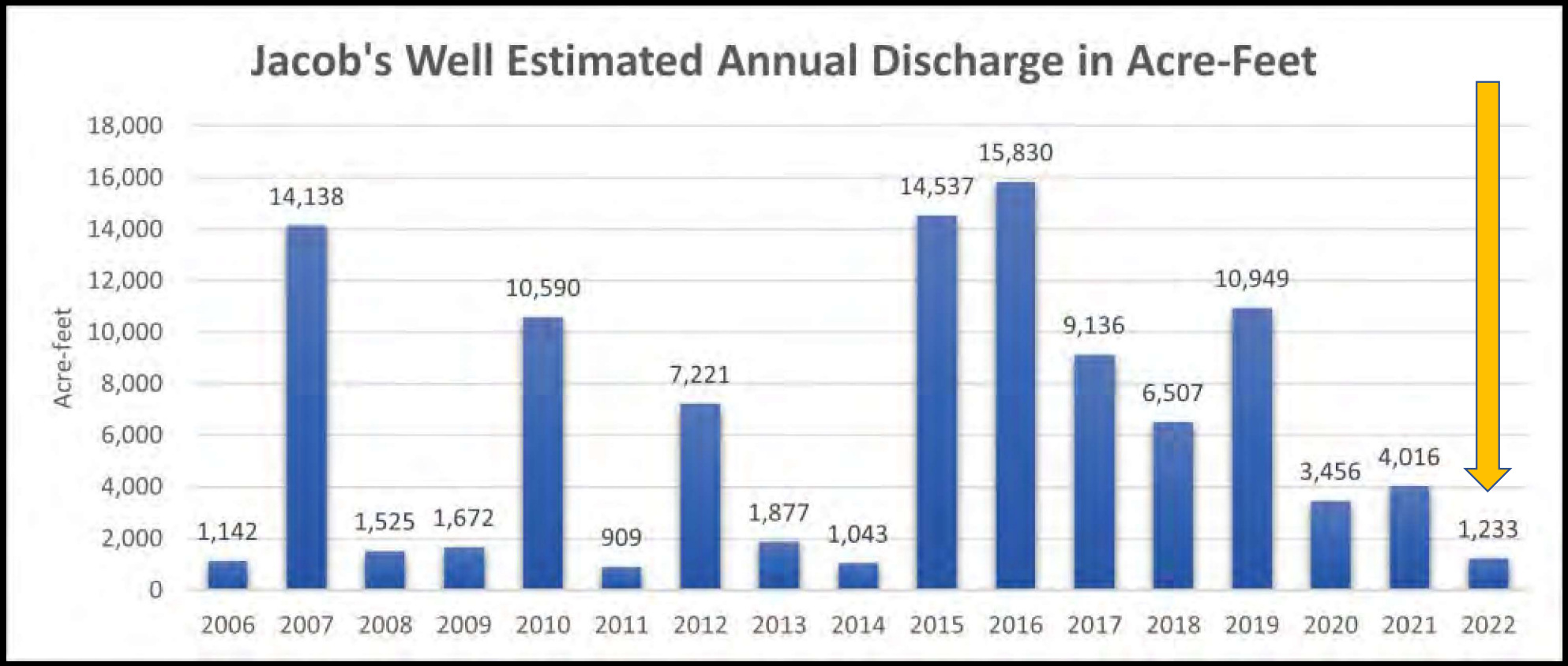

2009
2011
2013
2022
Mt. Baldy Monitor Well
J17 Monitor Well
Jacob's Well Springflow (10-day average in cubic feet per second - cfs)
Water Level Elevation (feet above sea level)
100
10
1
0.1
0.01
840
800
760
720
680
640
600
1/2005
1/2006
1/2007
1/2008
1/2009
1/2010
1/2011
1/2012
1/2013
1/2014
1/2015
1/2016
1/2017
1/2018
1/2019
1/2020
1/2021
1/2022
1/2023
1/2024

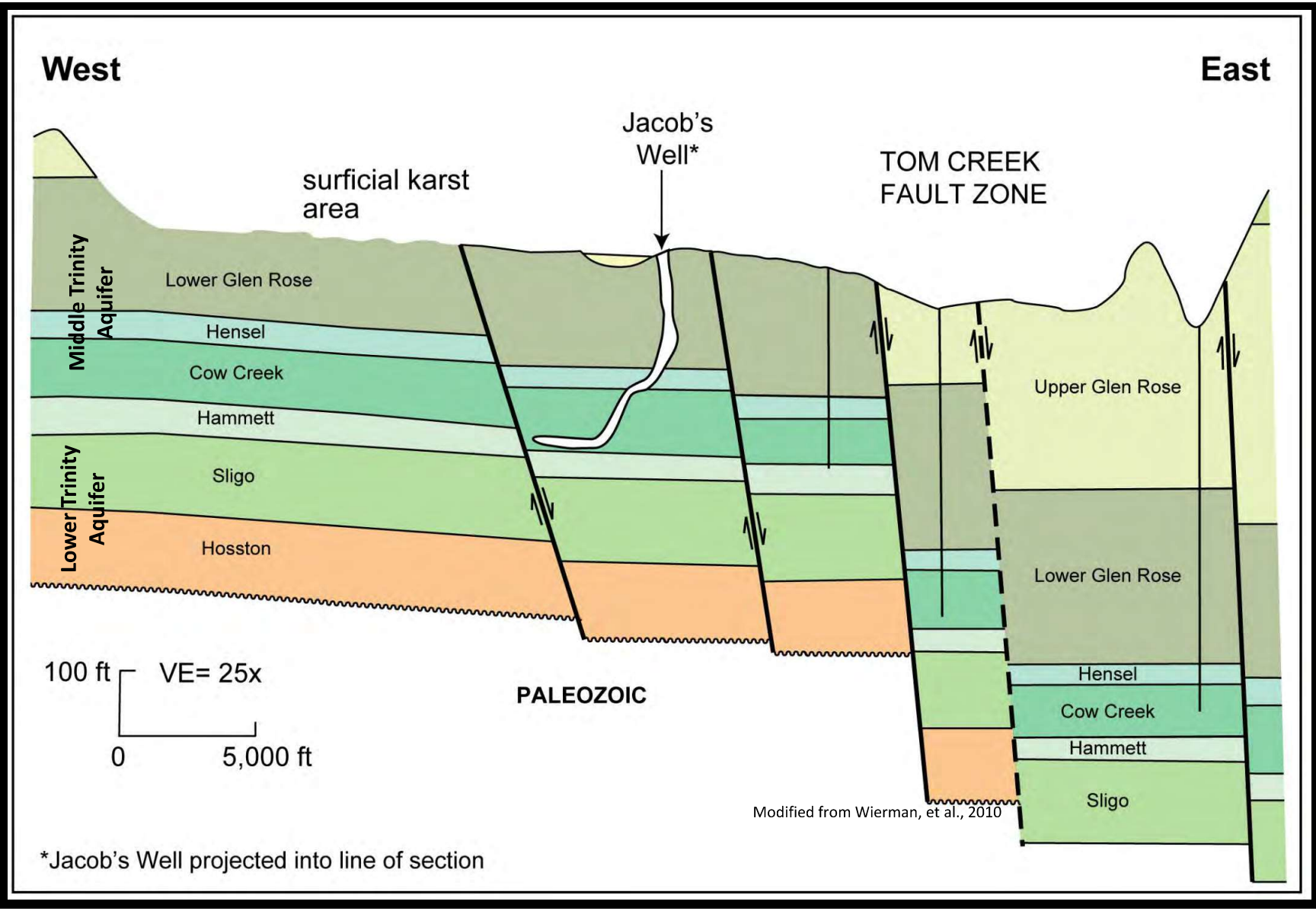
Two suggested areas for potential GMZs




Drought vs. No-Drought Average Monthly Pumping: Aqua Texas, WWSC, WSP
Millions of Gallons Pumped (actual reported)
40
35
30
25
20
15
10
5
0
January
February
March
April
May
June
July
August
September
October
November
December
No Drought Declared
Drought Declared
Average Drought Curtailment (26%)


Mt. Baldy Monitor Well
Jacob's Well Springflow (10-day average in cubic feet per second - cfs)
Water Level Elevation (feet above sea level)
100
80
60
40
20
840
800
760
720
680
640
600
1/2005
1/2006
1/2007
1/2008
1/2009
1/2010
1/2011
1/2012
1/2013
1/2014
1/2015
1/2016
1/2017
1/2018
1/2019
1/2020
1/2021
1/2022
1/2023
1/2024


Jacob's Well Estimated Annual Discharge in Acre-Feet
Acre-feet
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1,142
14,138
1,525
1,672
10,590
909
7,221
1,877
1,043
14,537
15,830
9,136
6,507
10,949
3,456
4,016
1,233
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022


West
East
Jacob's Well*
surficial karst area
TOM CREEK FAULT ZONE
Middle Trinity Aquifer
Lower Trinity Aquifer
Lower Glen Rose
Hensel
Cow Creek
Hammett
Sligo
Hosston
Upper Glen Rose
Lower Glen Rose
Hensel
Cow Creek
Hammett
Sligo
PALEOZOIC
100 ft
VE= 25x
0
5,000 ft
Modified from Wierman, et al., 2010
*Jacob's Well projected into line of section