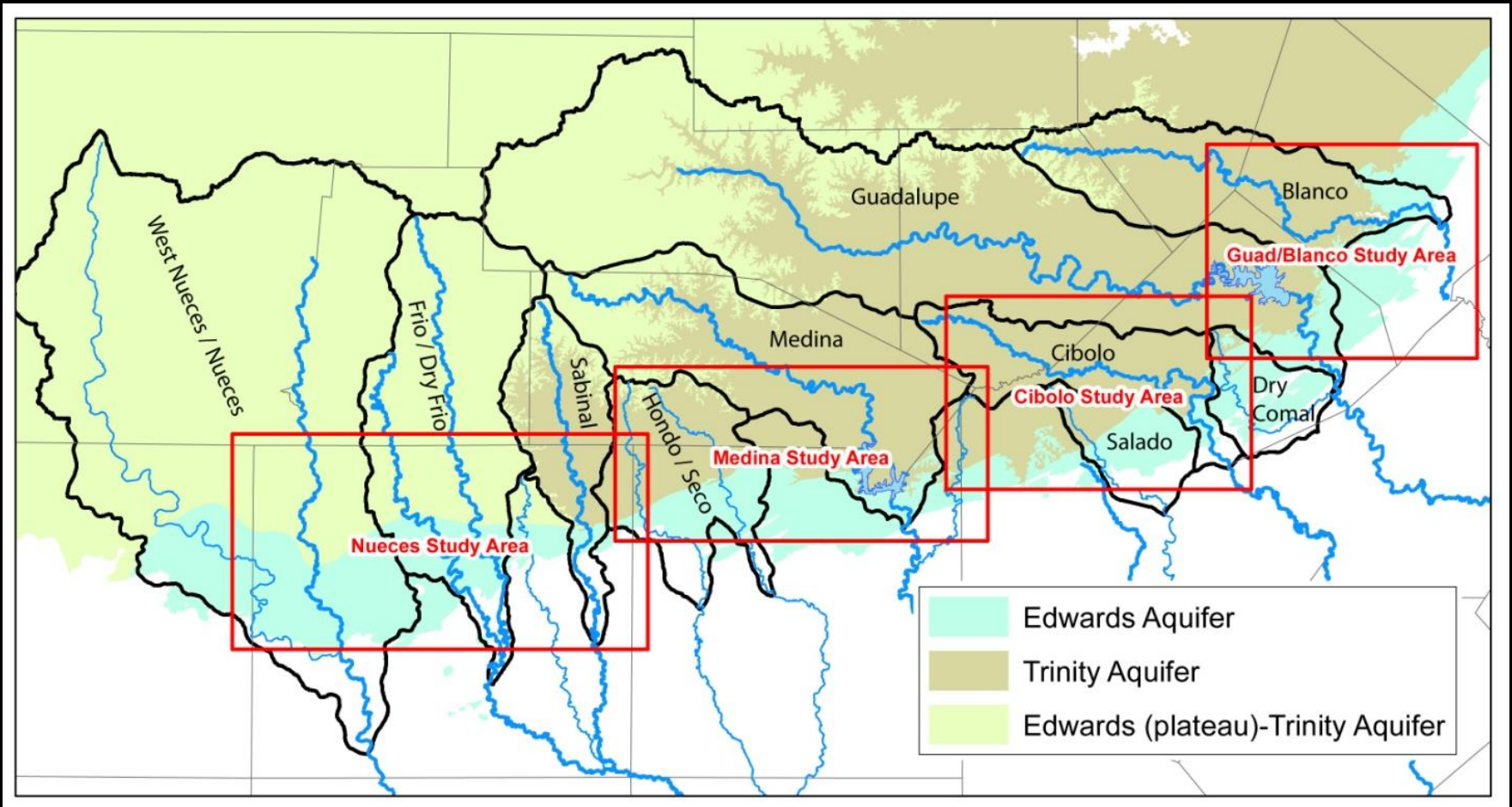
EDWARDS AQUIFER AUTHORITY

Edwards Aquifer – Trinity Aquifer Inter-Formational Flow Study

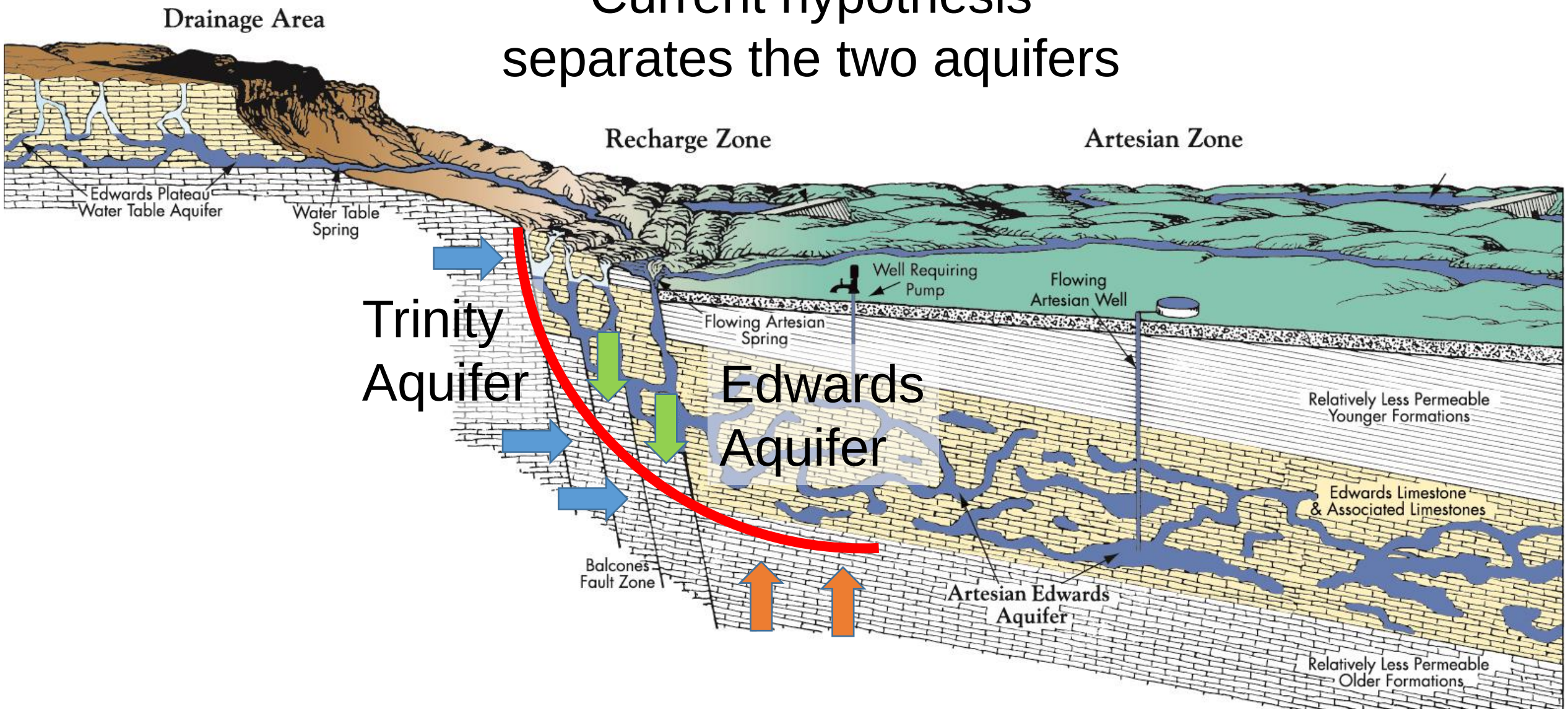


Marcus Gary, Ph.D., P.G.
Steve Johnson, P.G.
Geary Schindel, P.G.

Technical Briefing for
EAA Board of Directors

September 10, 2013

Current hypothesis separates the two aquifers



What is an aquifer?

- **a consolidated or unconsolidated geologic unit (material, stratum, or formation) or set of connected units that yields water of suitable quality to wells or springs in economically usable amounts.**

Slide courtesy of
Jack Sharp, UT Austin

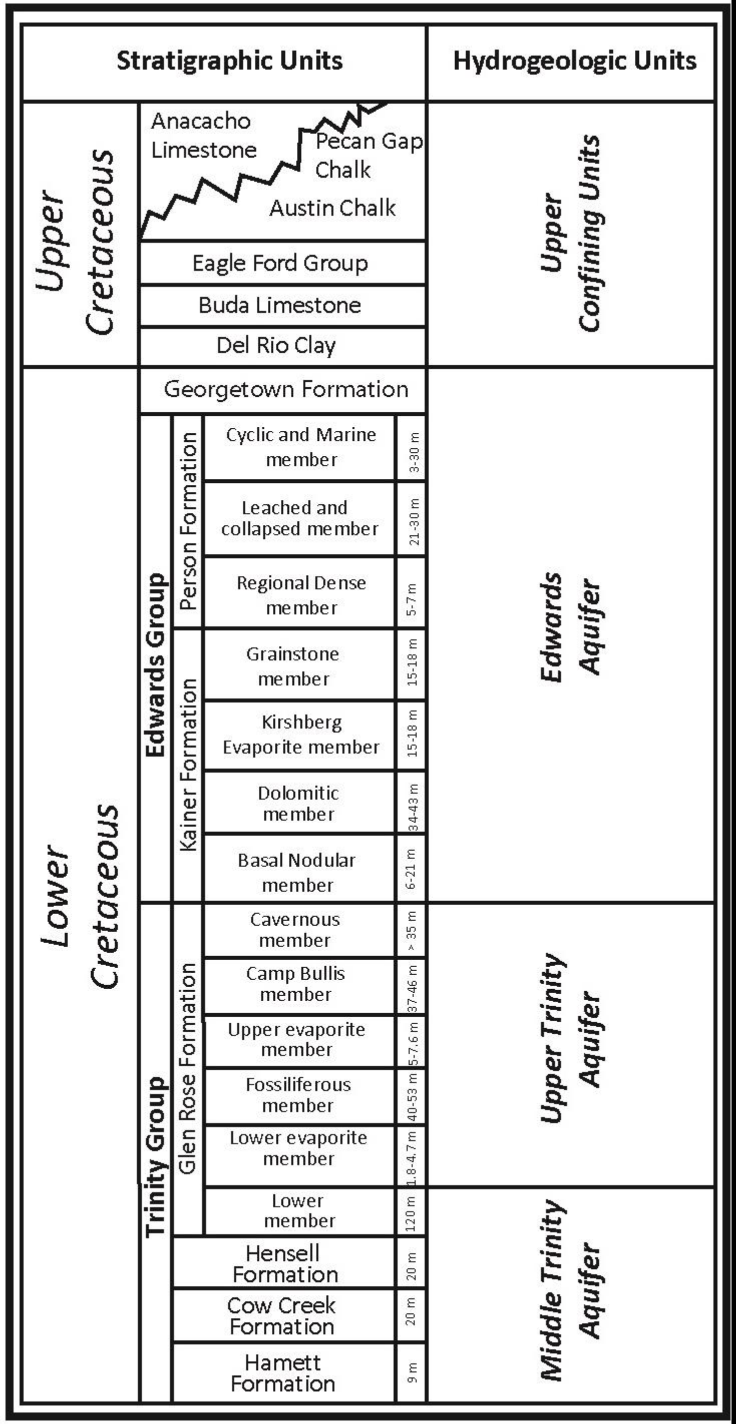
What is a geologic formation?

- **A mappable body of rock identified by lithic characteristics and stratigraphic position; a mappable body of igneous or metamorphic rock.**

Slide courtesy of
Jack Sharp, UT Austin

geologic formation ≠ aquifer

Slide courtesy of
Jack Sharp, UT Austin



Stratigraphic Units
Hydrogeologic Units
Upper Cretaceous
Anacacho Limestone
Pecan Gap Chalk
Austin Chalk
Eagle Ford Group
Buda Limestone
Del Rio Clay
Upper Confining Units
Lower Cretaceous
Georgetown Formation
Edwards Group
Person Formation
Cyclic and Marine member
3-30 m
Leached and collapsed member
21-30 m
Regional Dense member
5-7 m
Kainer Formation
Grainstone member
15-18 m
Kirshberg Evaporite member
15-18 m
Dolomitic member
34-43 m
Basal Nodular member
6-21 m
Edwards Aquifer
Trinity Group
Glen Rose Formation
Cavernous member
> 35 m
Camp Bullis member
37-46 m
Upper evaporite member
5-7.6 m
Fossiliferous member
40-53 m
Lower evaporite member
1.8-4.7 m
Upper Trinity Aquifer
Lower member
120 m
Hensell Formation
20 m
Cow Creek Formation
20 m
Hamett Formation
9 m
Middle Trinity Aquifer

WHY IS IT IMPORTANT TO UNDERSTAND INTER-FORMATIONAL FLOW?

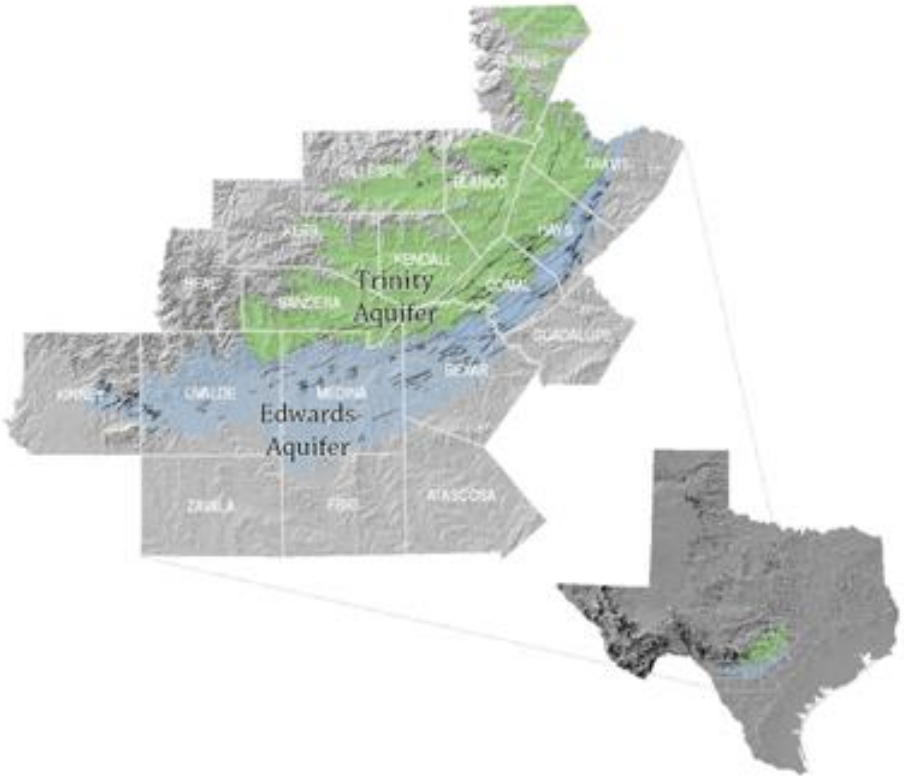
- Improves ability to quantify total recharge to both aquifers.
- Aids in reducing uncertainty of water balance equations.
- Helps define lateral hydrogeologic properties of both aquifers.

Karst Conservation Initiative Symposium - 2011

Interconnection of the Trinity (Glen Rose) and Edwards Aquifers along the Balcones Fault Zone And Related Topics

Karst Conservation Initiative
February 17, 2011 meeting

Proceedings



Editors:
Marcus Gary Brian Hunt Robin Gary

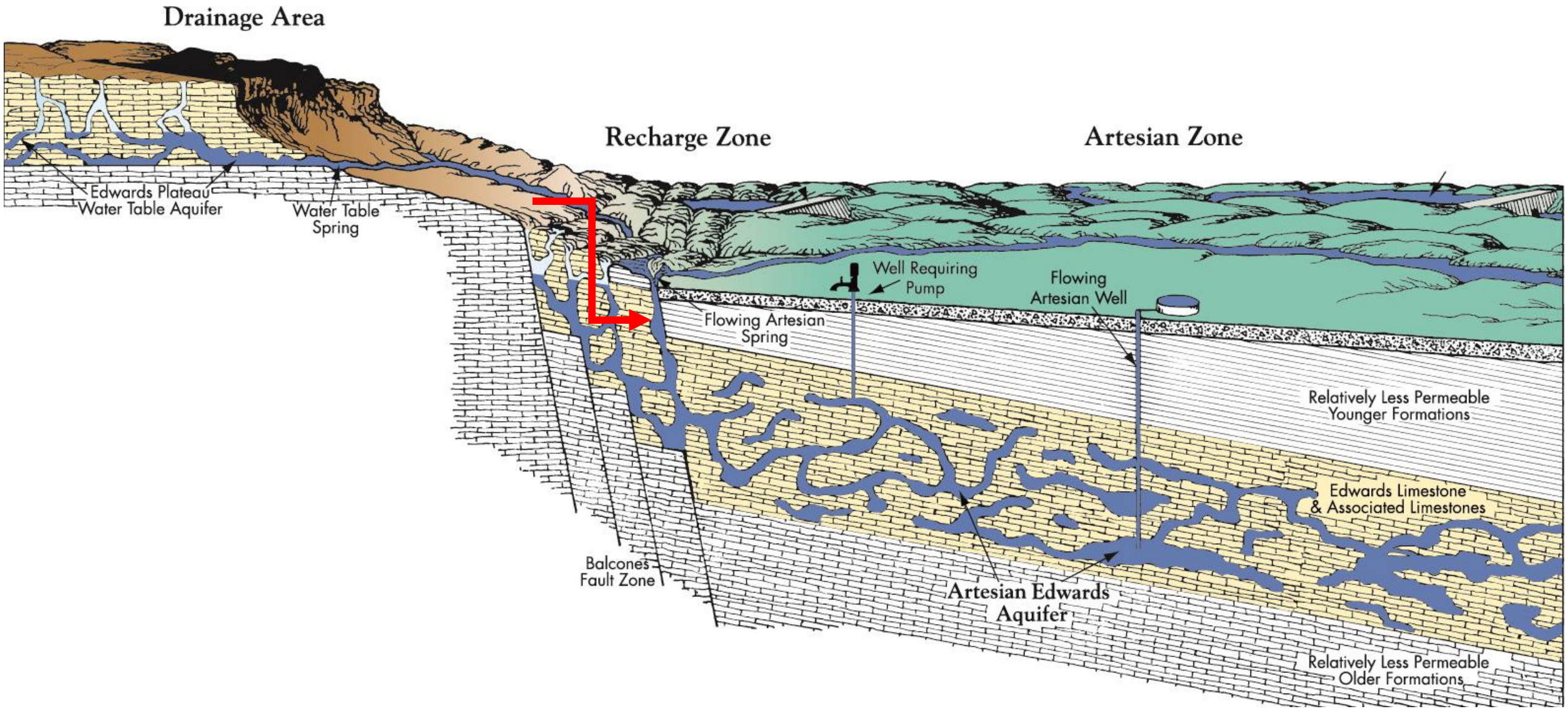
June 2, 2011

ZARA ENVIRONMENTAL LLC

Barton Springs Edwards Aquifer

- **Interconnection of the Edwards and Trinity Aquifers, central Texas, U.S.A.**
  Marcus Gary
- **Spatial and Temporal Recharge Variability Related to Groundwater Interconnection of the Edwards and Trinity Aquifers, Camp Bullis, Bexar and Comal Counties, Texas**
  Marcus Gary, George Veni, Beverly Shade, Robin Gary
- **Potential for Vertical Flow Between the Edwards and Trinity Aquifer, Barton Springs Segment of the Edwards Aquifer**
  Brian A. Smith, Brian B. Hunt
- **Could much of the Edwards Aquifer "Matrix Storage" Actually be Trinity Aquifer Contributions from the Blanco River?**
  Nico Hauwert
- **Geophysical Correlation of Haby Crossing Fault (Medina Co.) and Mt. Bonnell Fault (Travis Co.) and Their Implications on Trinity-Edwards Interconnection**
  Mustafa Saribudak
- **Edwards Aquifer-Upper Glen Rose Aquifer Hydraulic Interaction**
  Ron T. Green, F. Paul Bertetti, M.O. Candelario
- **Interaction between the Hill Country Portion of the Trinity and Edwards Aquifers: Model Results**
  Ian C. Jones
- **Using Tracer Testing Data for Resource Management Planning**
  Geary Schindel, Steve Johnson

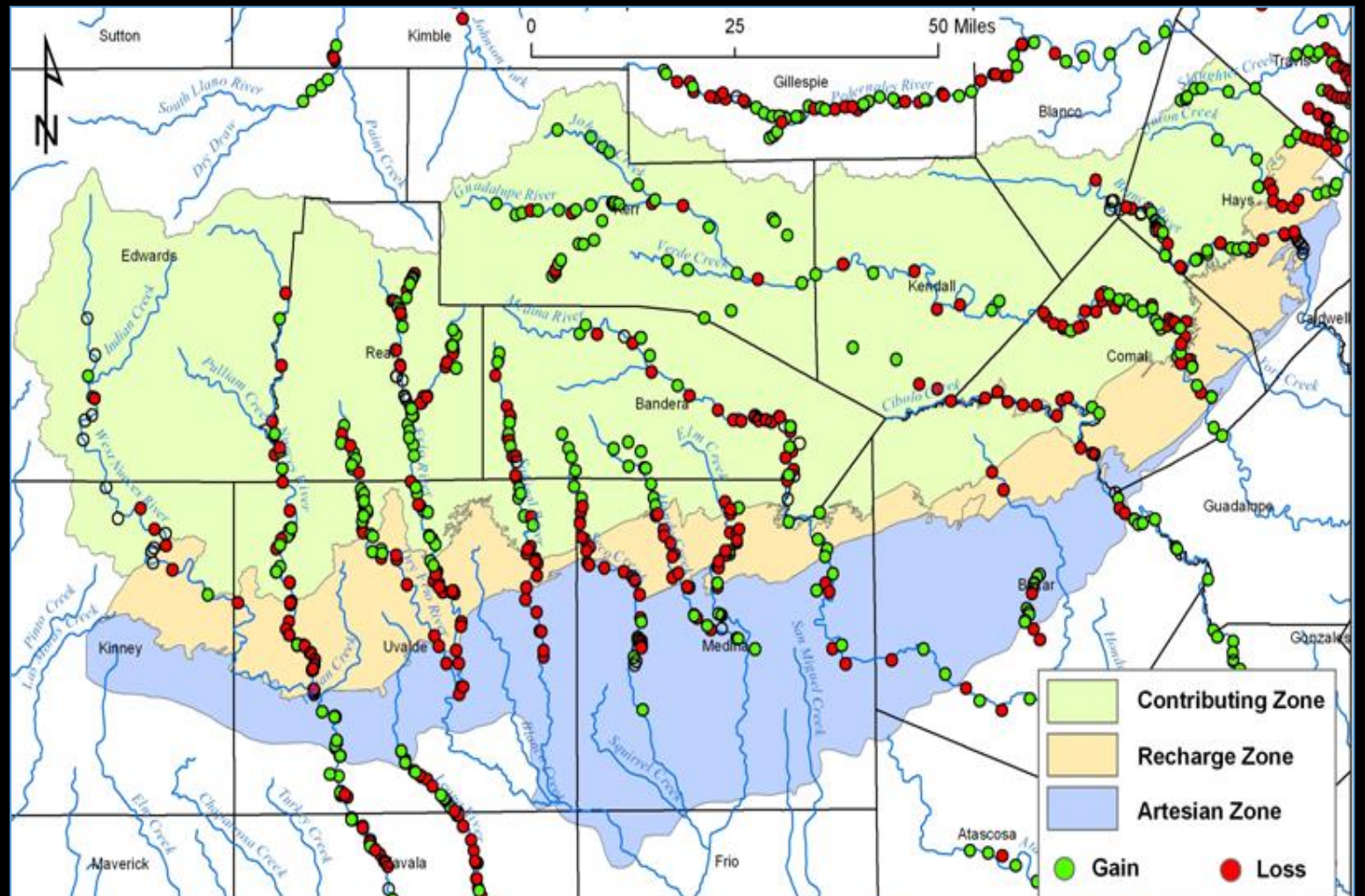
DISCRETE RECHARGE THROUGH STREAMS



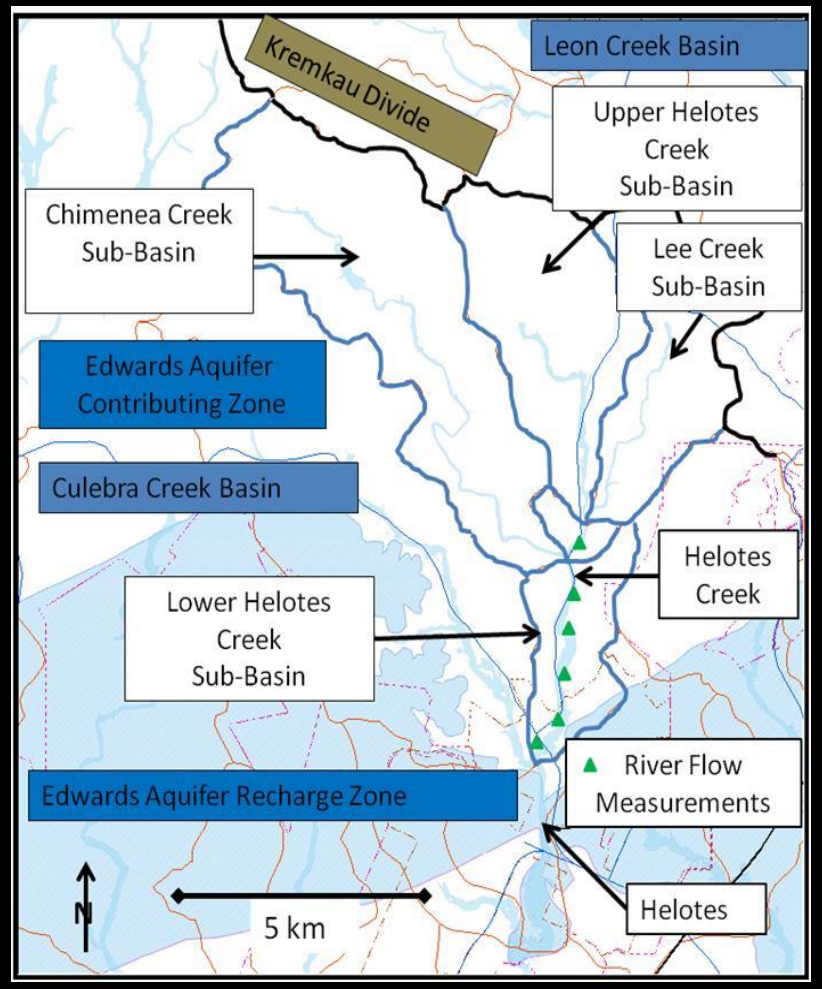
Edwards Aquifer – Upper Glen Rose Aquifer Hydraulic Interaction

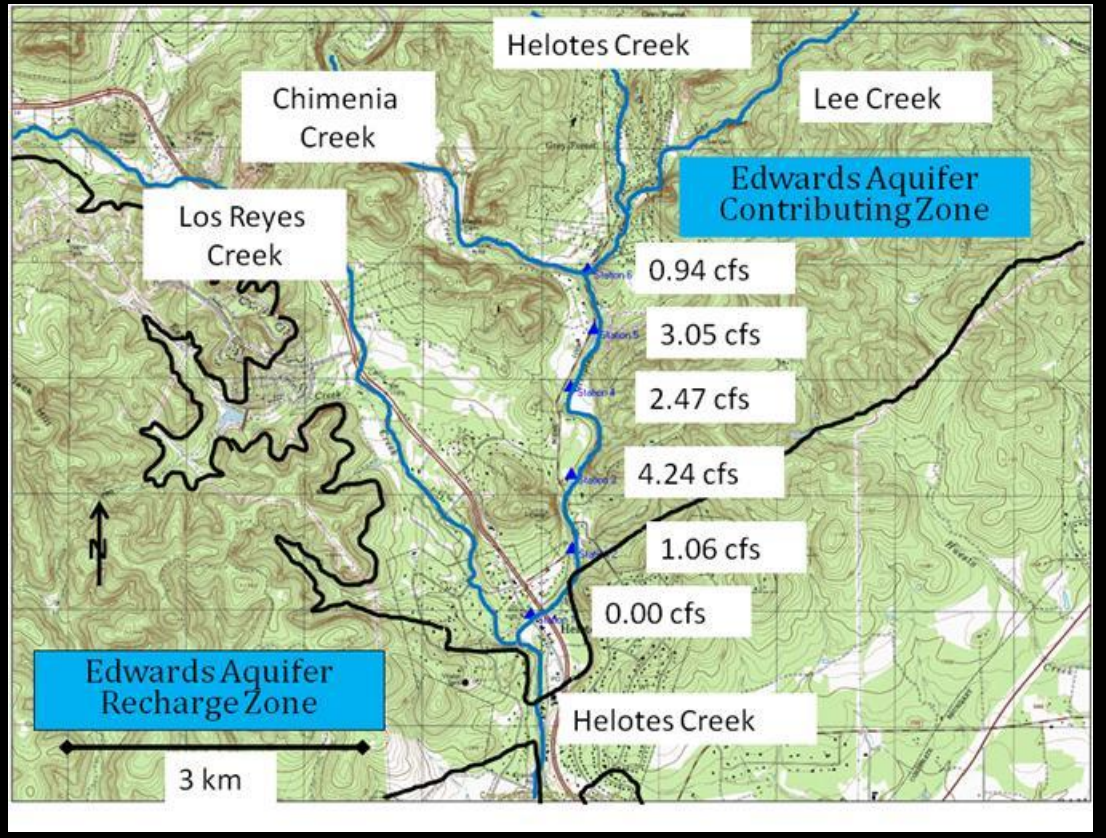
R.T. Green[1], F.P. Bertetti[1], and M.O. Candelario[2]

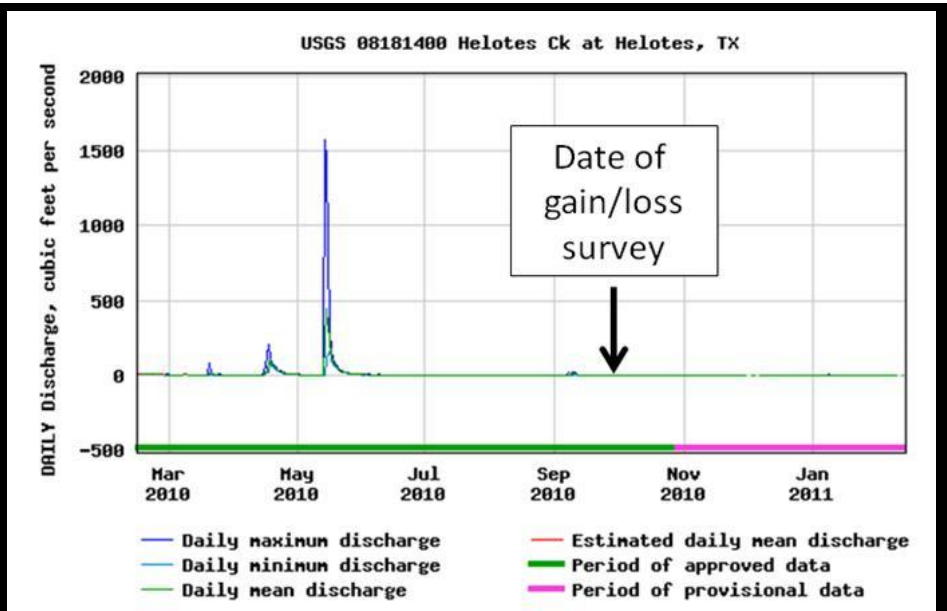
[1]Geosciences and Engineering Division, Southwest Research Institute, San Antonio, Texas; [2]Stimson Middle School, San Antonio Texas



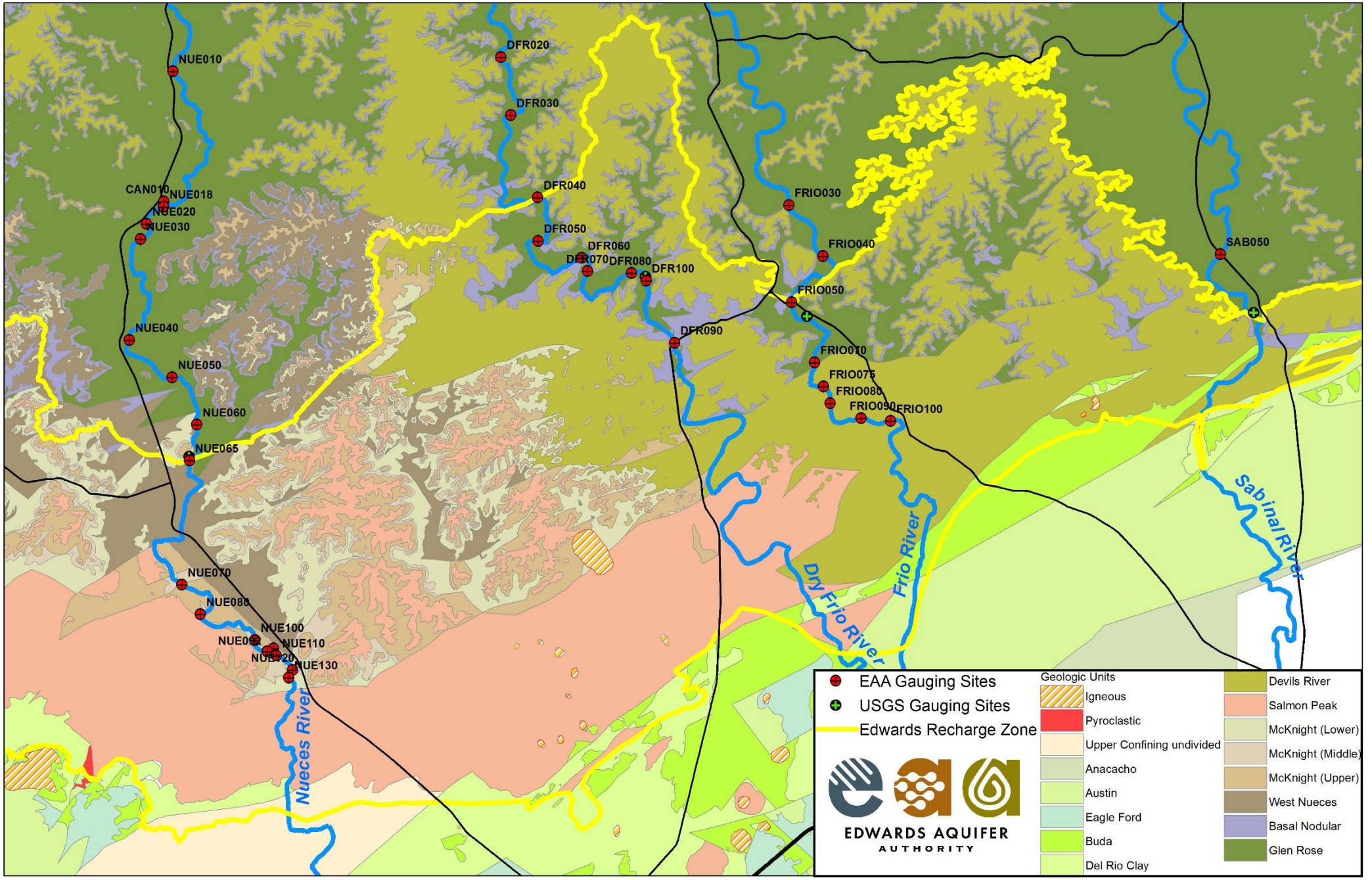
Slide courtesy of Ron Green, SwRI





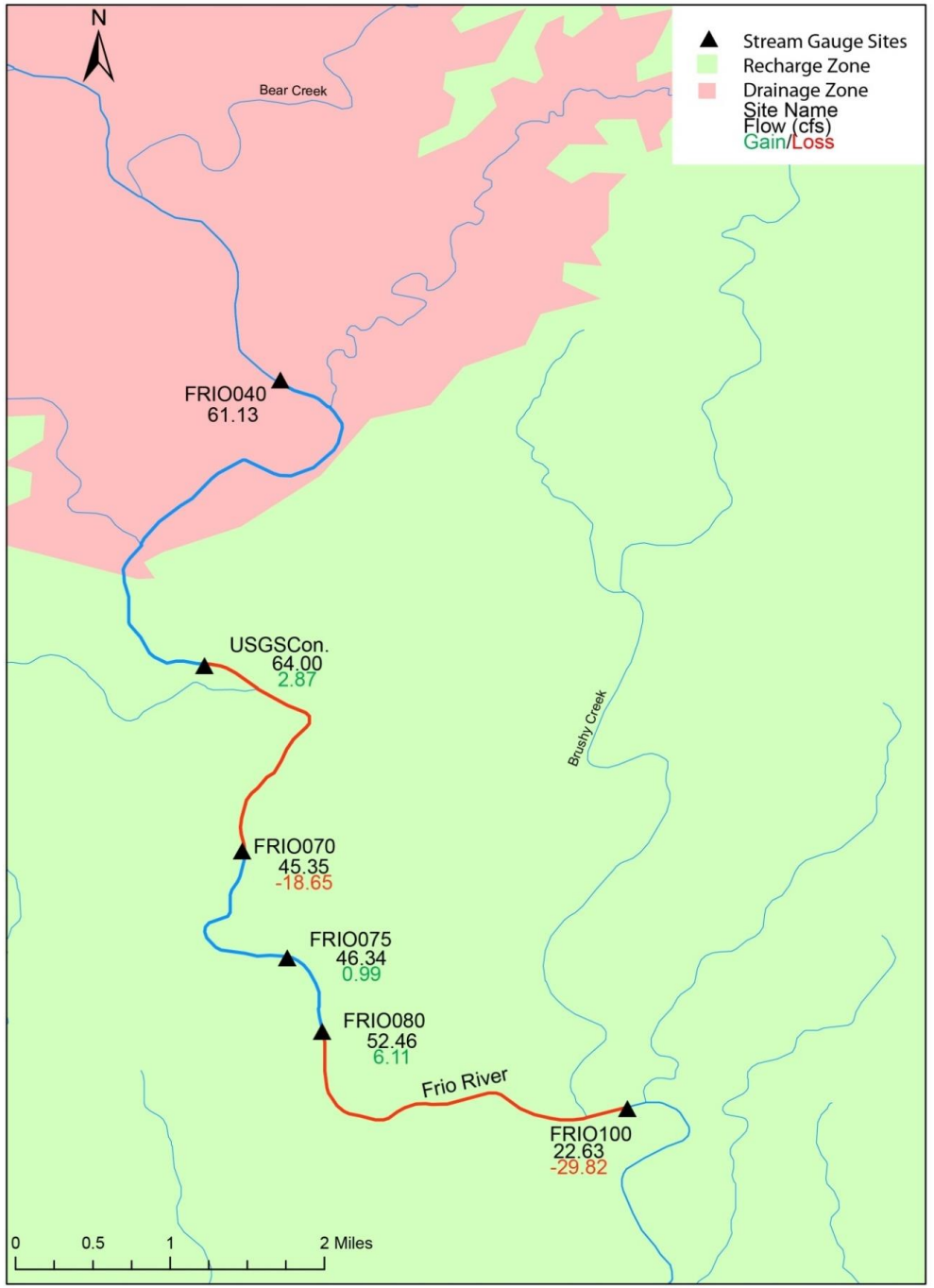


Slide courtesy of Ron Green, SwRI

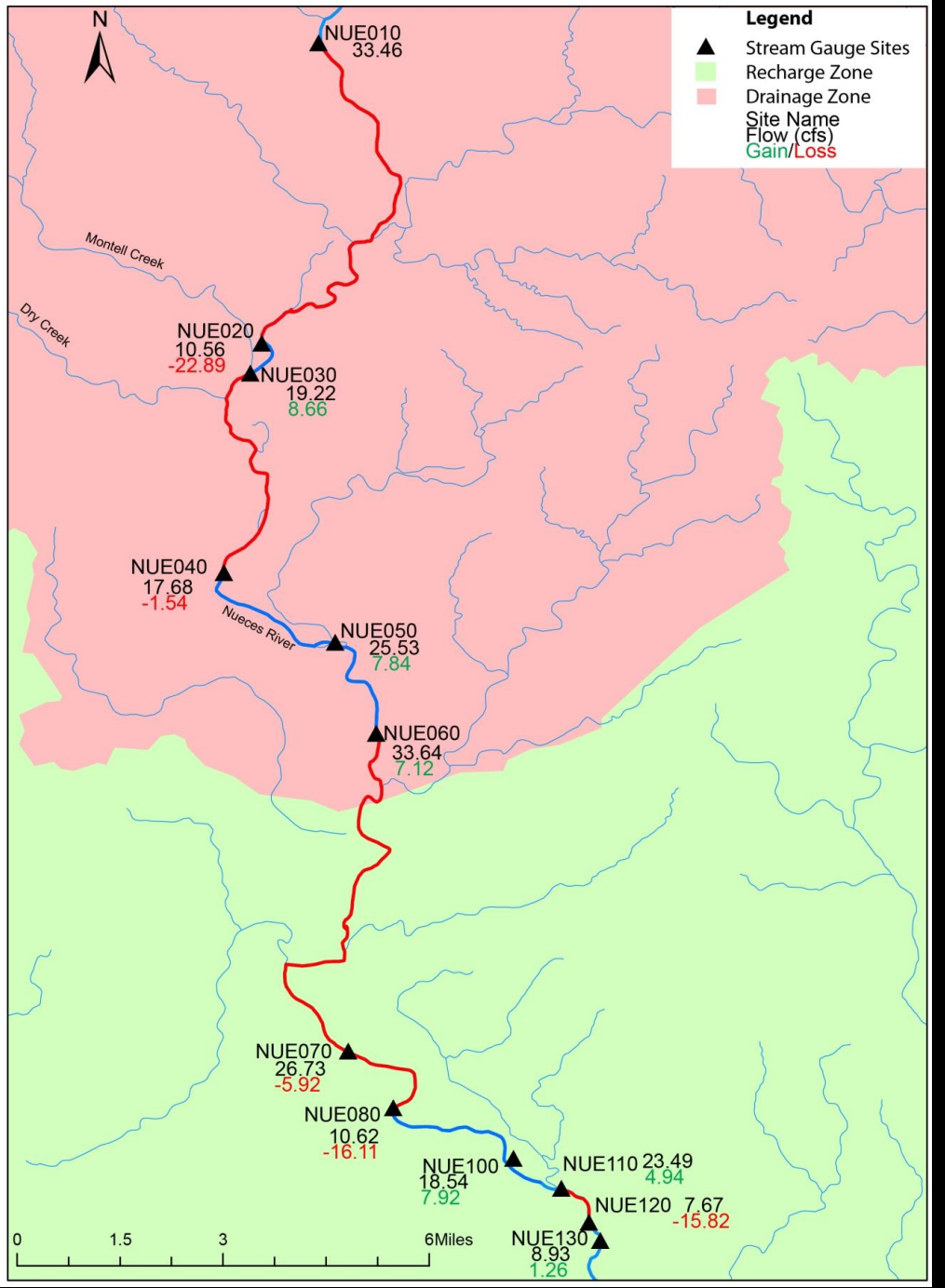

NUE010
DFR020
DFR030
CAN010
NUE018
NUE020
NUE030
DFR040
DFR050
DFR060
DFR070
DFR080
DFR100
FRIO030
FRIO040
SAB050
FRIO050
NUE040
DFR090
FRIO070
NUE050
FRIO075
FRIO080
FRIO090
FRIO100
NUE060
NUE065
NUE070
NUE080
NUE100
NUE110
NUE120
NUE130
Nueces River
Dry Frio River
Frio River
Sabinal River
EAA Gauging Sites
USGS Gauging Sites
Edwards Recharge Zone
EDWARDS AQUIFER
AUTHORITY
Geologic Units
Igneous
Pyroclastic
Upper Confining undivided
Anacacho
Austin
Eagle Ford
Buda
Del Rio Clay
Devils River
Salmon Peak
McKnight (Lower)
McKnight (Middle)
McKnight (Upper)
West Nueces
Basal Nodular
Glen Rose

EDWARDS AQUIFER AUTHORITY

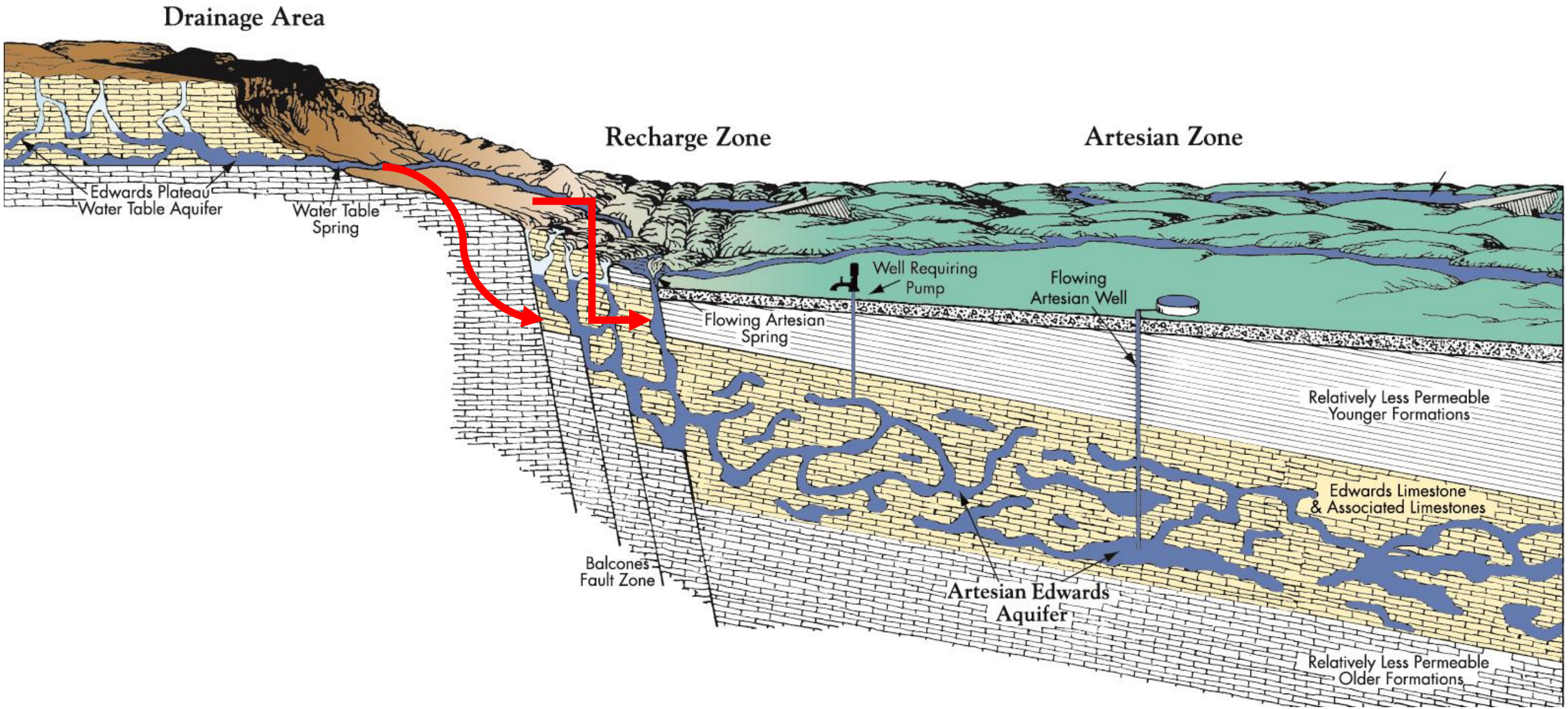
Gain Loss June 2012 on the Frio River



Gain Loss 2012 on the Nueces River



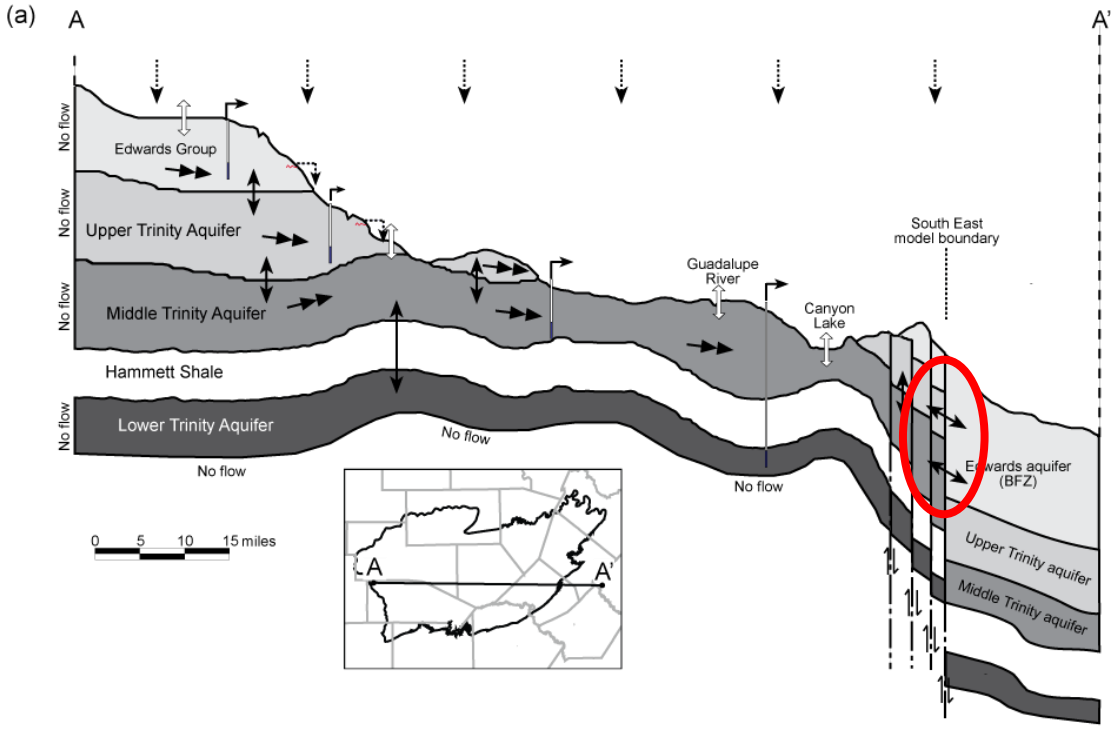
DISCRETE RECHARGE THROUGH STREAMS

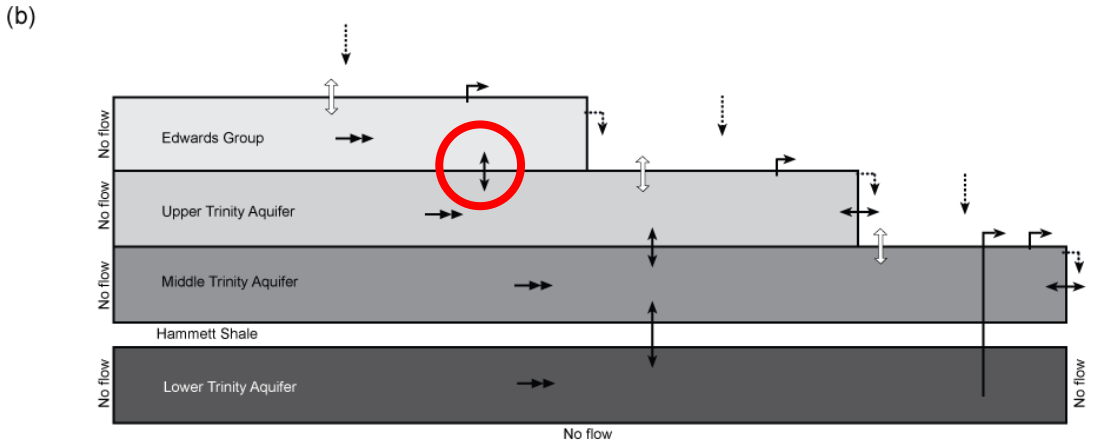


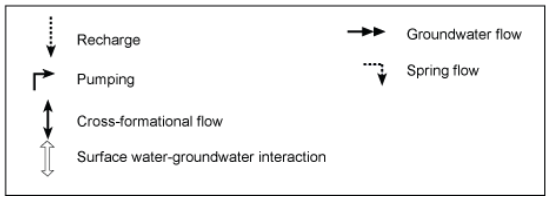
Interaction Between the Hill Country Portion of the Trinity and Edwards Aquifers: Model Results

Ian C. Jones

Texas Water Development Board

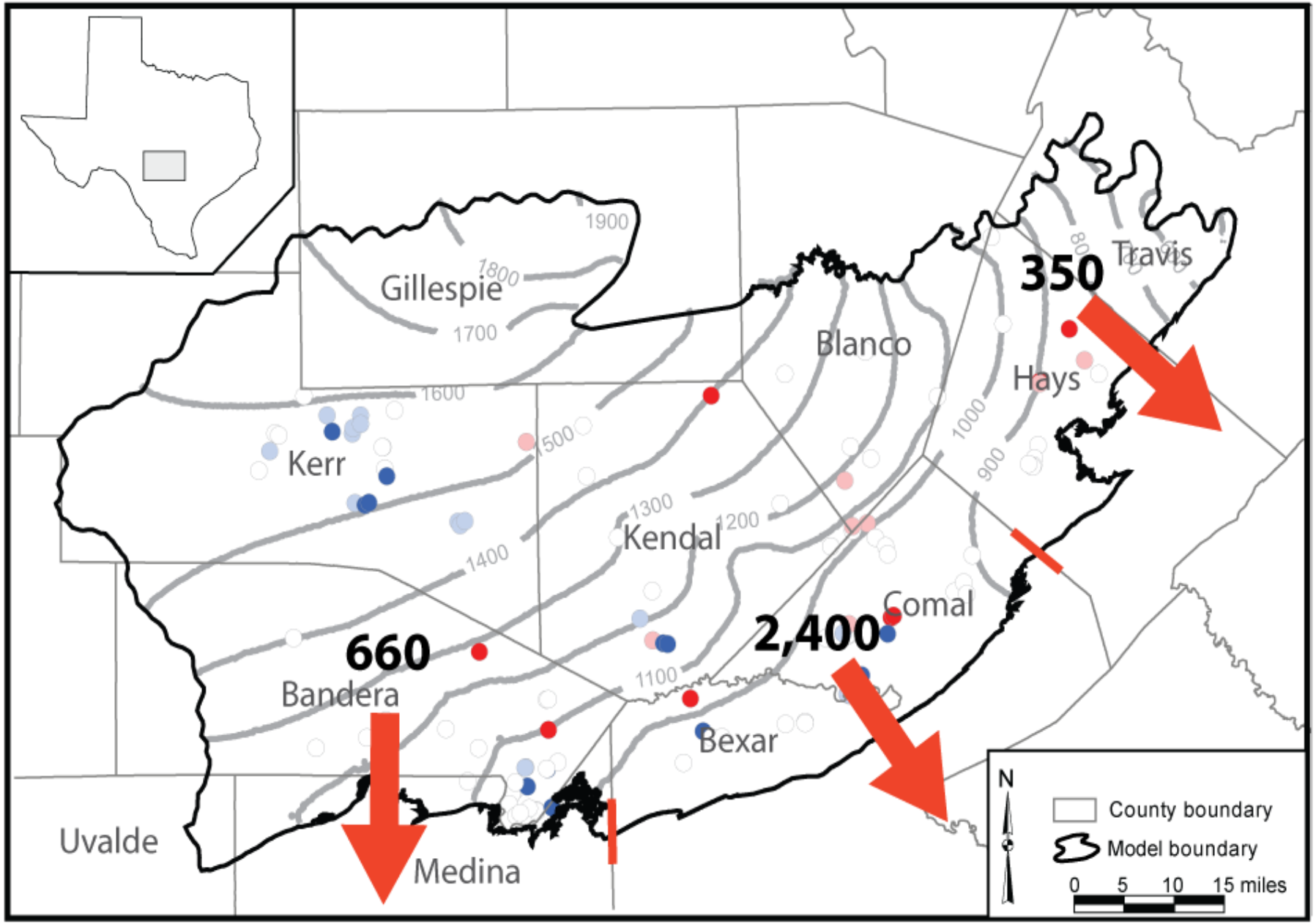






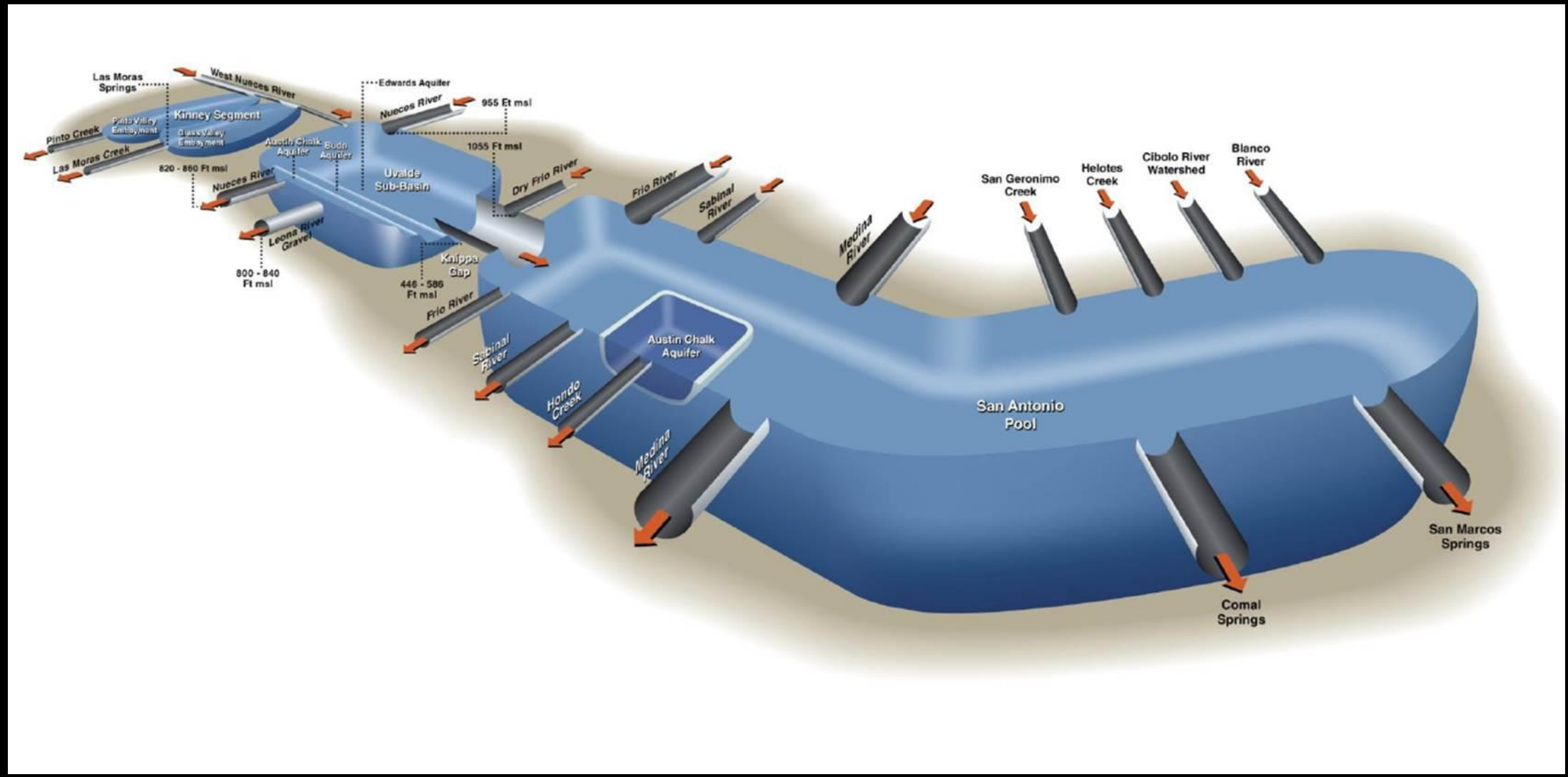
Slide courtesy of Ian Jones, TWDB

Acre-feet/year per linear mile of contact between the Trinity-Edwards = **110,000 ac.ft./year from Trinity**



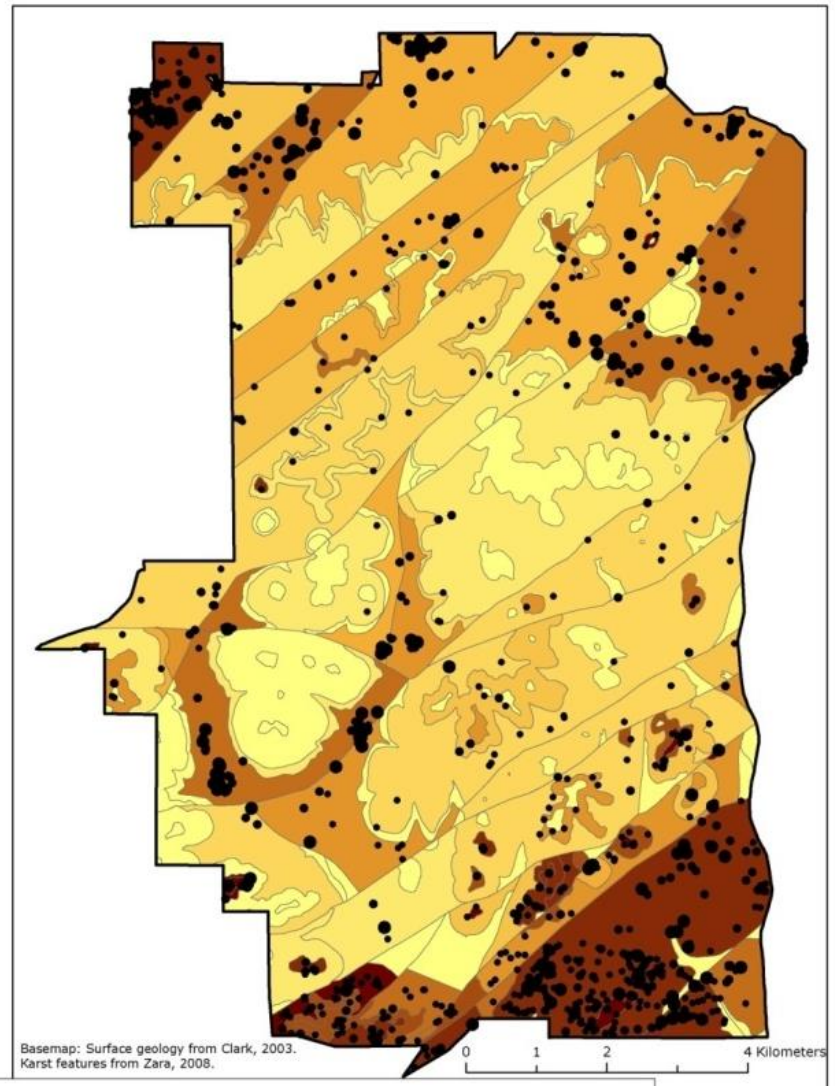
Slide courtesy of Ian Jones, TWDB

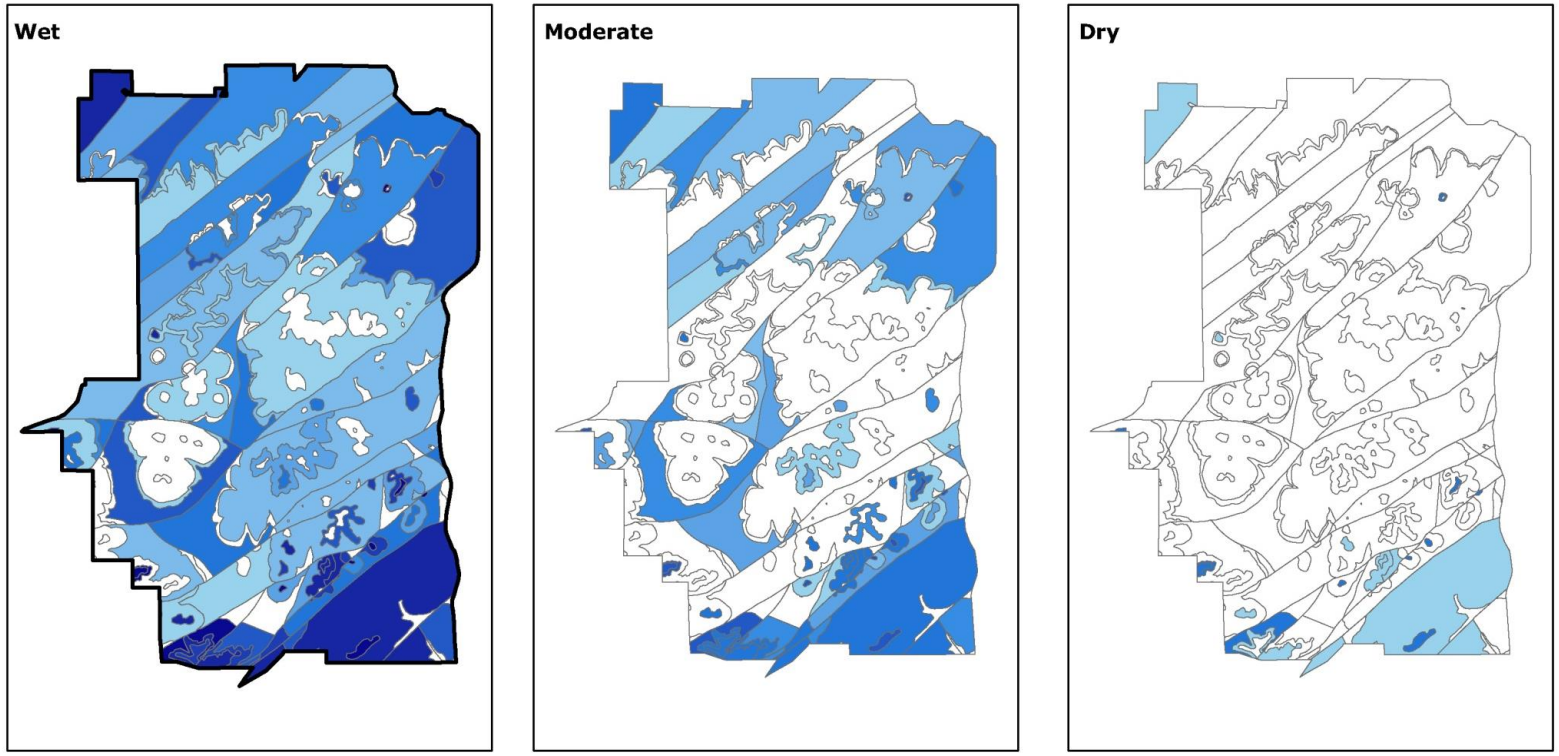
Conceptual Model of inputs and outputs of the Edwards Aquifer



Slide courtesy of
Ron Green, SwRI

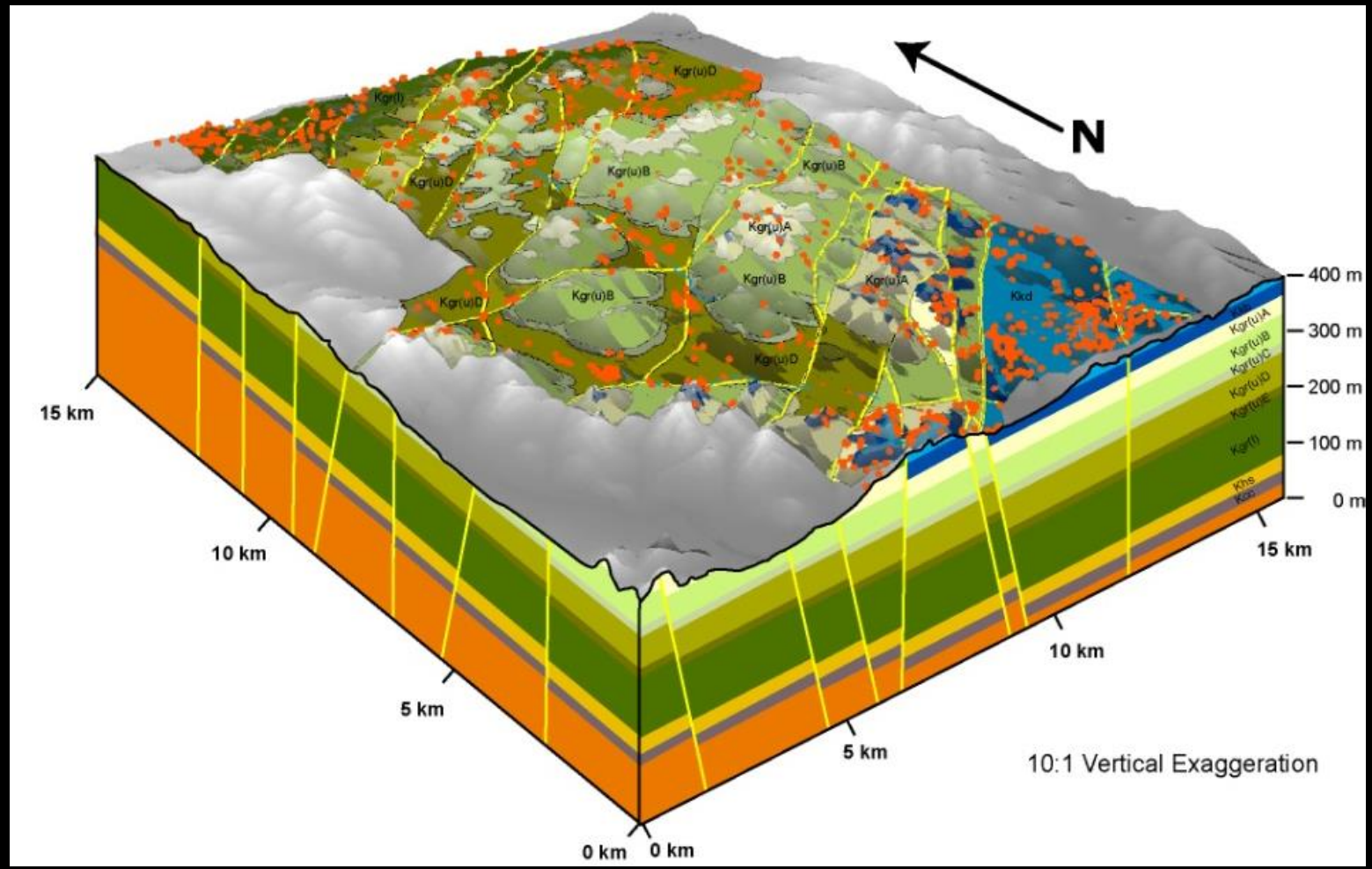
KARST RESEARCH AT CAMP BULLIS EVALUATES SPATIAL AND TEMPORAL DIFFUSE RECHARGE

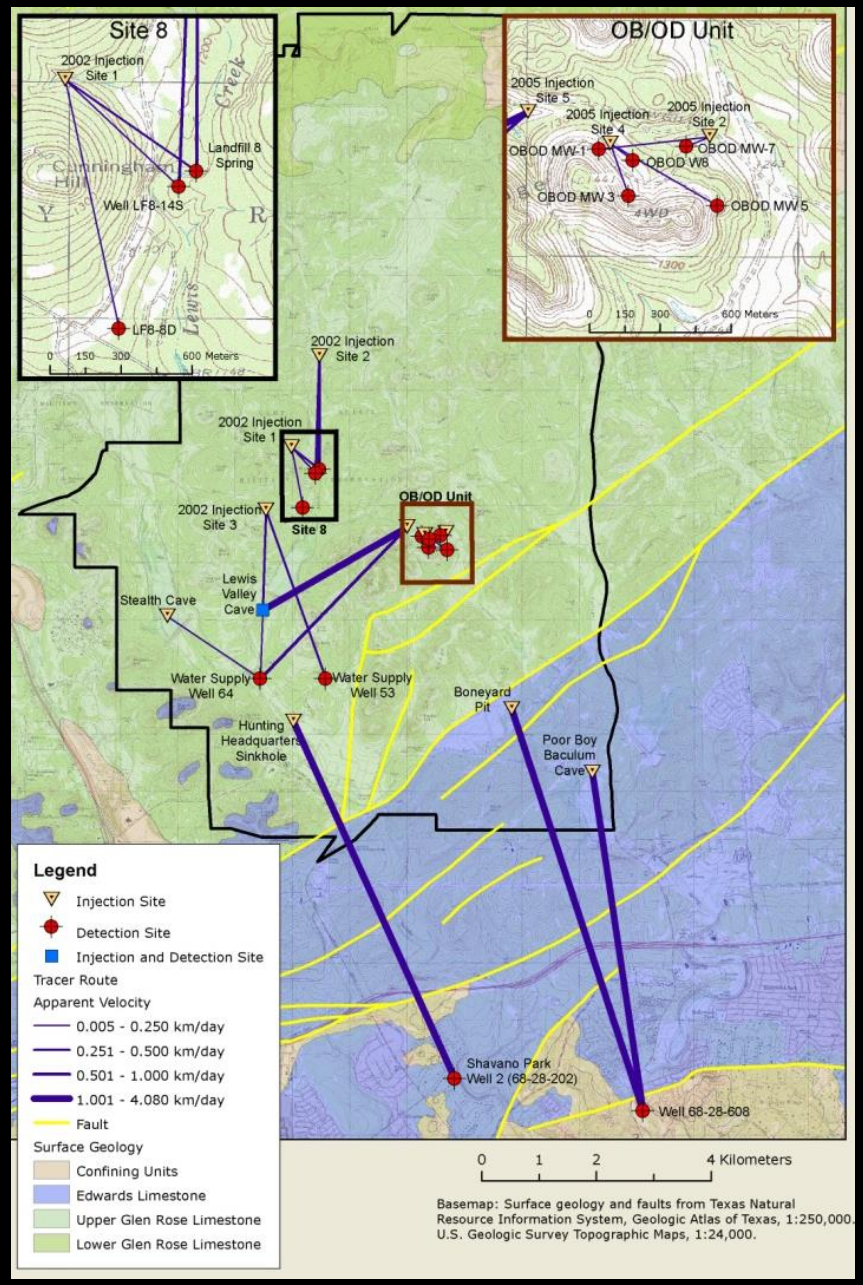




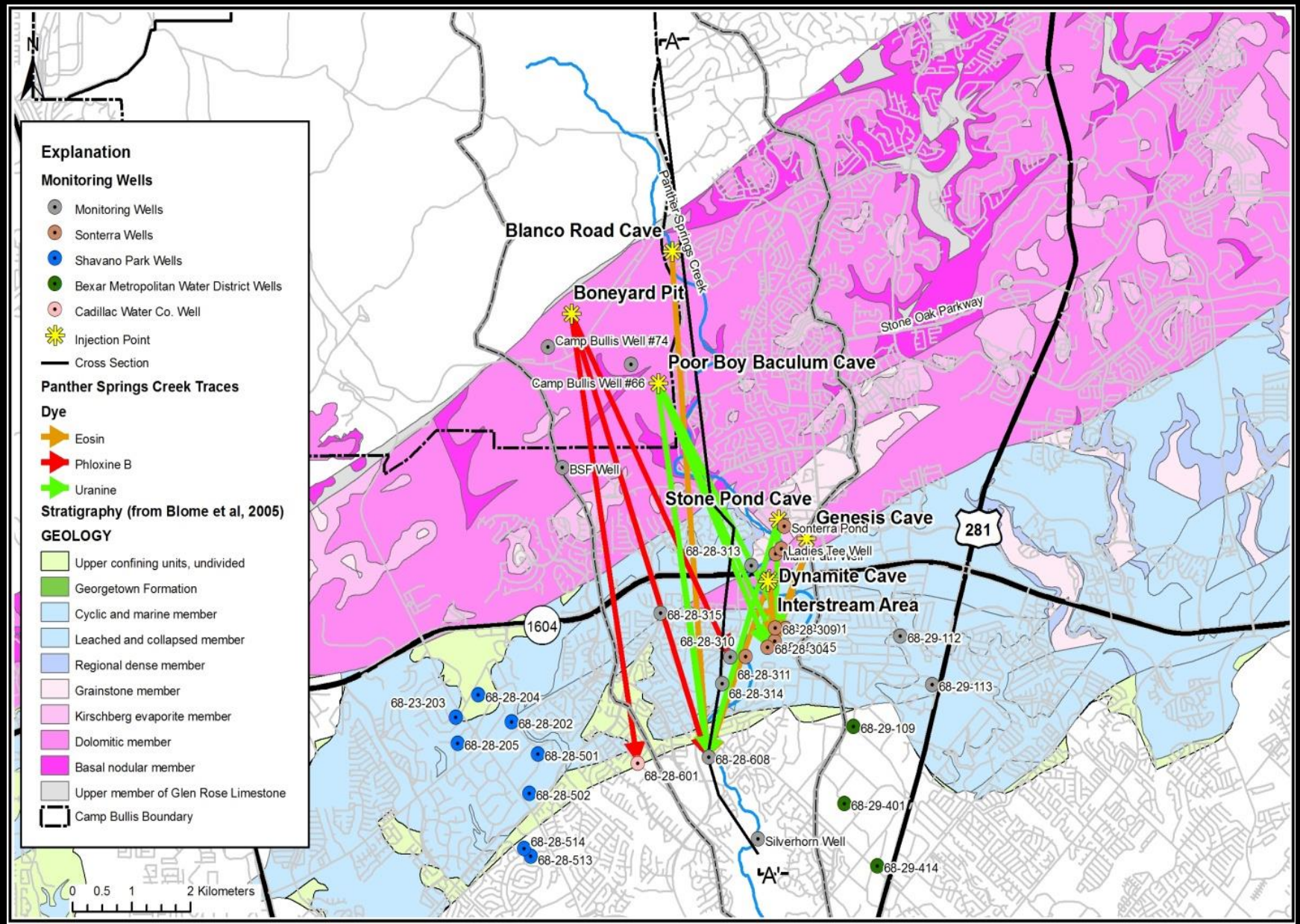
TRINITY → EDWARDS INTER-FORMATIONAL FLOW

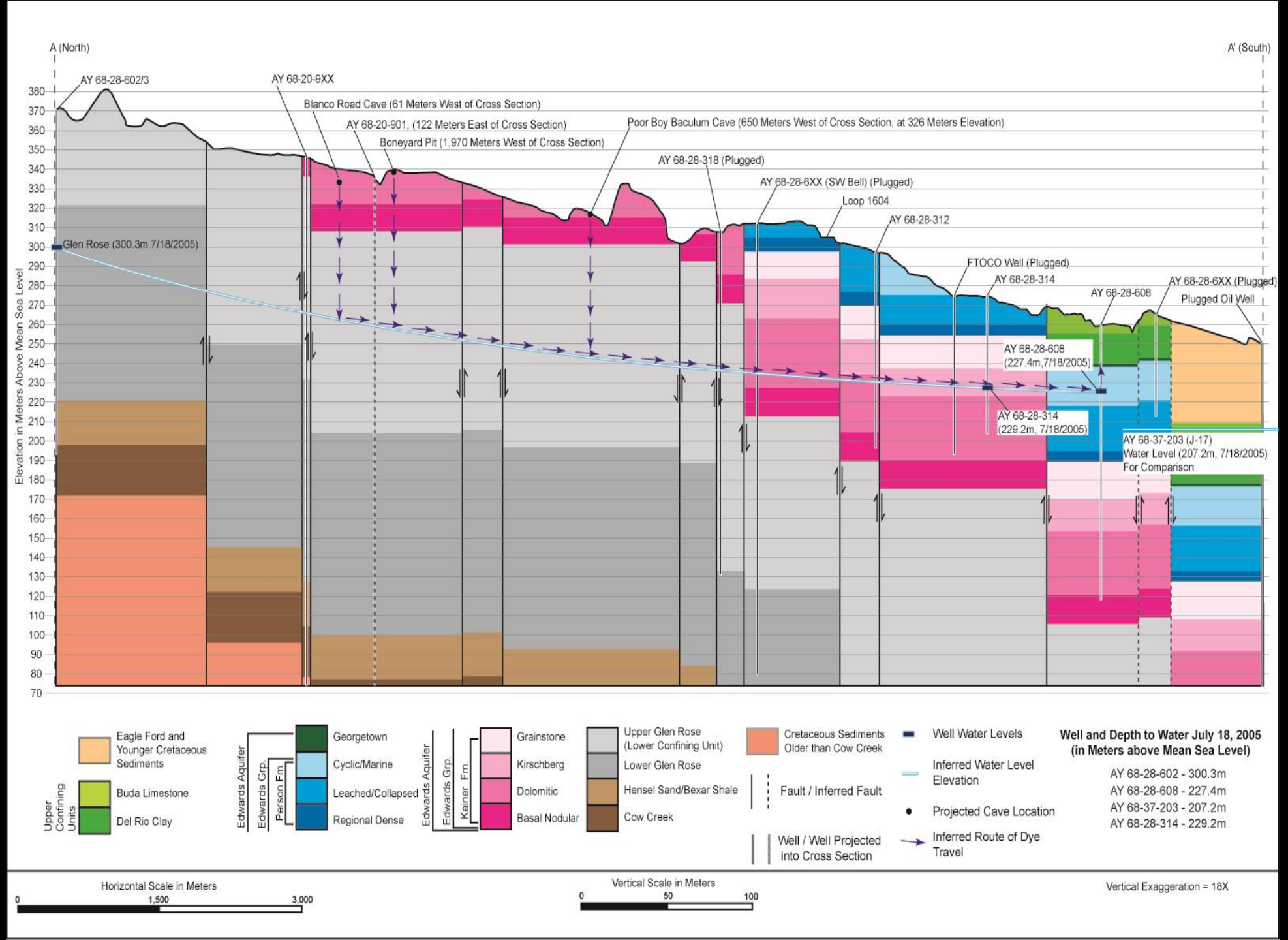
Dye tracer tests at Camp Bullis (Johnson et al., 2010; Zara, 2010) show rapid discrete flowpaths from Glen Rose limestone to Edwards wells.

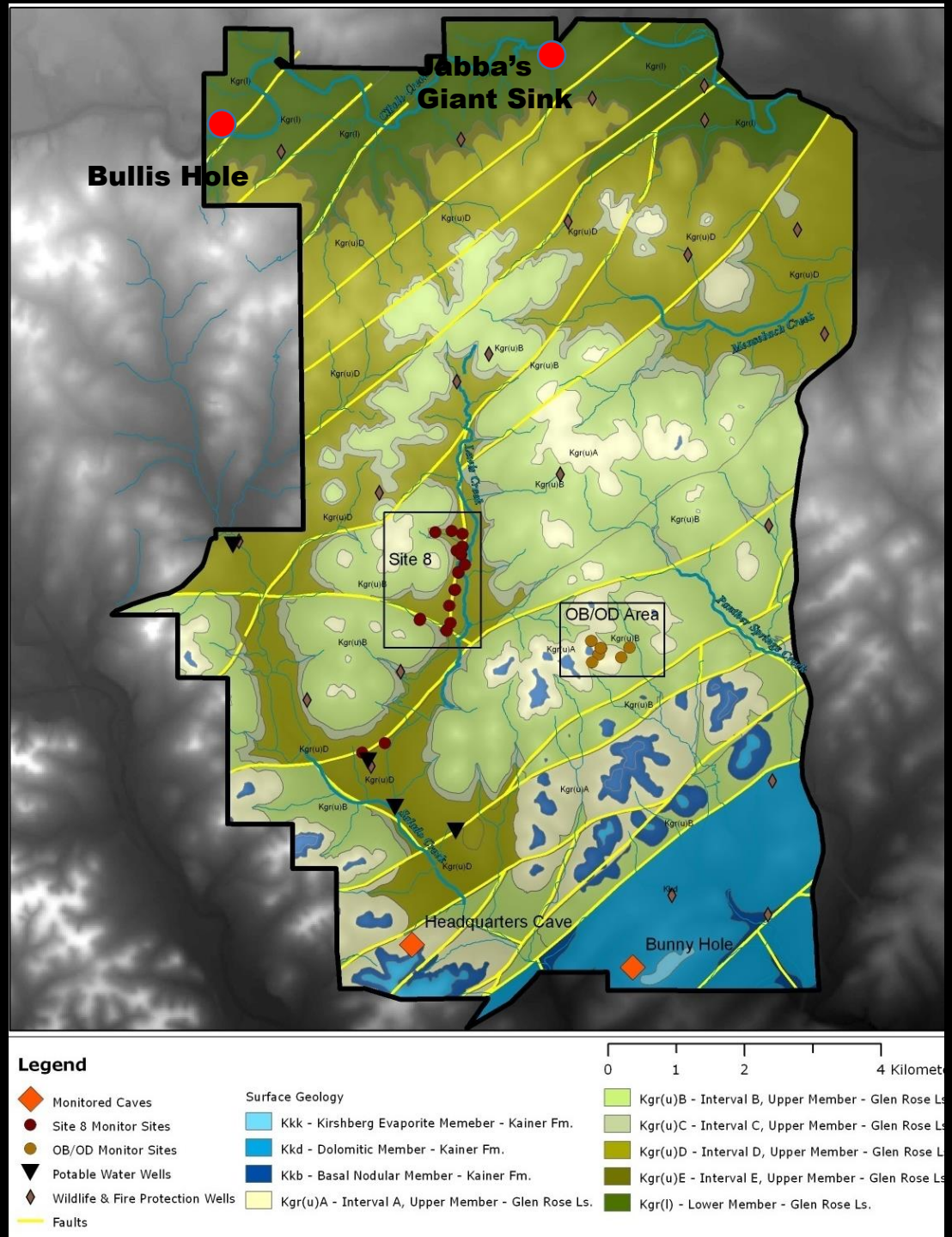




More detailed tracer testing in the area show rapid flow rates across major faults..

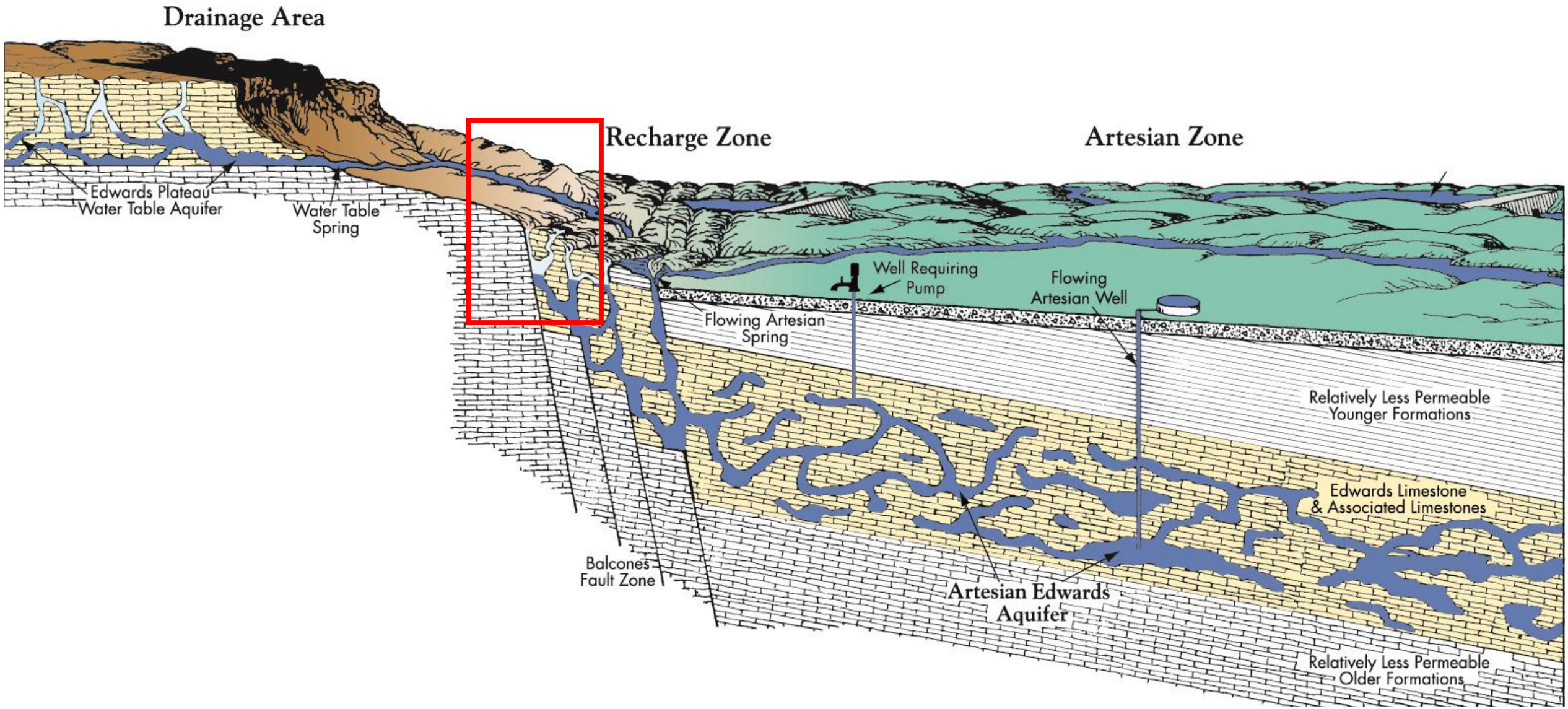



A (North)
A' (South)
AY 68-28-602/3
AY 68-20-9XX
Blanco Road Cave (61 Meters West of Cross Section)
AY 68-20-901, (122 Meters East of Cross Section)
Boneyard Pit (1,970 Meters West of Cross Section)
Poor Boy Baculum Cave (650 Meters West of Cross Section, at 326 Meters Elevation)
AY 68-28-318 (Plugged)
AY 68-28-6XX (SW Bell) (Plugged)
Loop 1604
AY 68-28-312
FTOCO Well (Plugged)
AY 68-28-314
AY 68-28-608
AY 68-28-6XX (Plugged)
Plugged Oil Well
Glen Rose (300.3m 7/18/2005)
AY 68-28-608 (227.4m,7/18/2005)
AY 68-28-314 (229.2m, 7/18/2005)
AY 68-37-203 (J-17) Water Level (207.2m, 7/18/2005) For Comparison
Elevation in Meters Above Mean Sea Level
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
Upper Confining Units
Eagle Ford and Younger Cretaceous Sediments
Buda Limestone
Del Rio Clay
Edwards Aquifer
Edwards Grp.
Person Fm.
Georgetown
Cyclic/Marine
Leached/Collapsed
Regional Dense
Edwards Aquifer
Edwards Grp.
Kainer Fm.
Grainstone
Kirschberg
Dolomitic
Basal Nodular
Upper Glen Rose (Lower Confining Unit)
Lower Glen Rose
Hensel Sand/Bexar Shale
Cow Creek
Cretaceous Sediments Older than Cow Creek
Fault / Inferred Fault
Well / Well Projected into Cross Section
Well Water Levels
Inferred Water Level Elevation
Projected Cave Location
Inferred Route of Dye Travel
Well and Depth to Water July 18, 2005 (in Meters above Mean Sea Level)
AY 68-28-602 - 300.3m
AY 68-28-608 - 227.4m
AY 68-37-203 - 207.2m
AY 68-28-314 - 229.2m
Horizontal Scale in Meters
0
1,500
3,000
Vertical Scale in Meters
0
50
100
Vertical Exaggeration = 18X

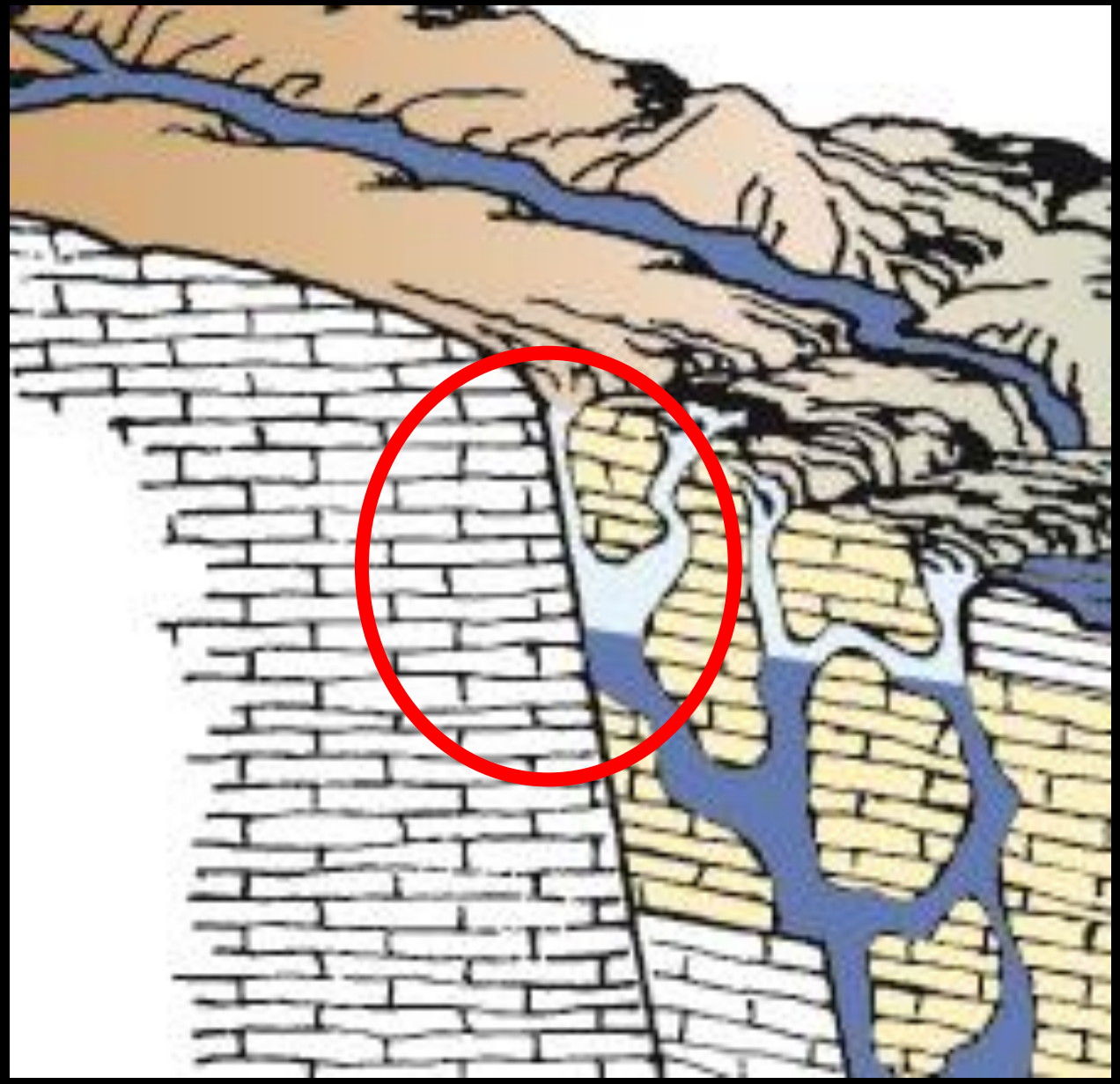


On-going tracer tests along Cibolo Creek on Camp Bullis.

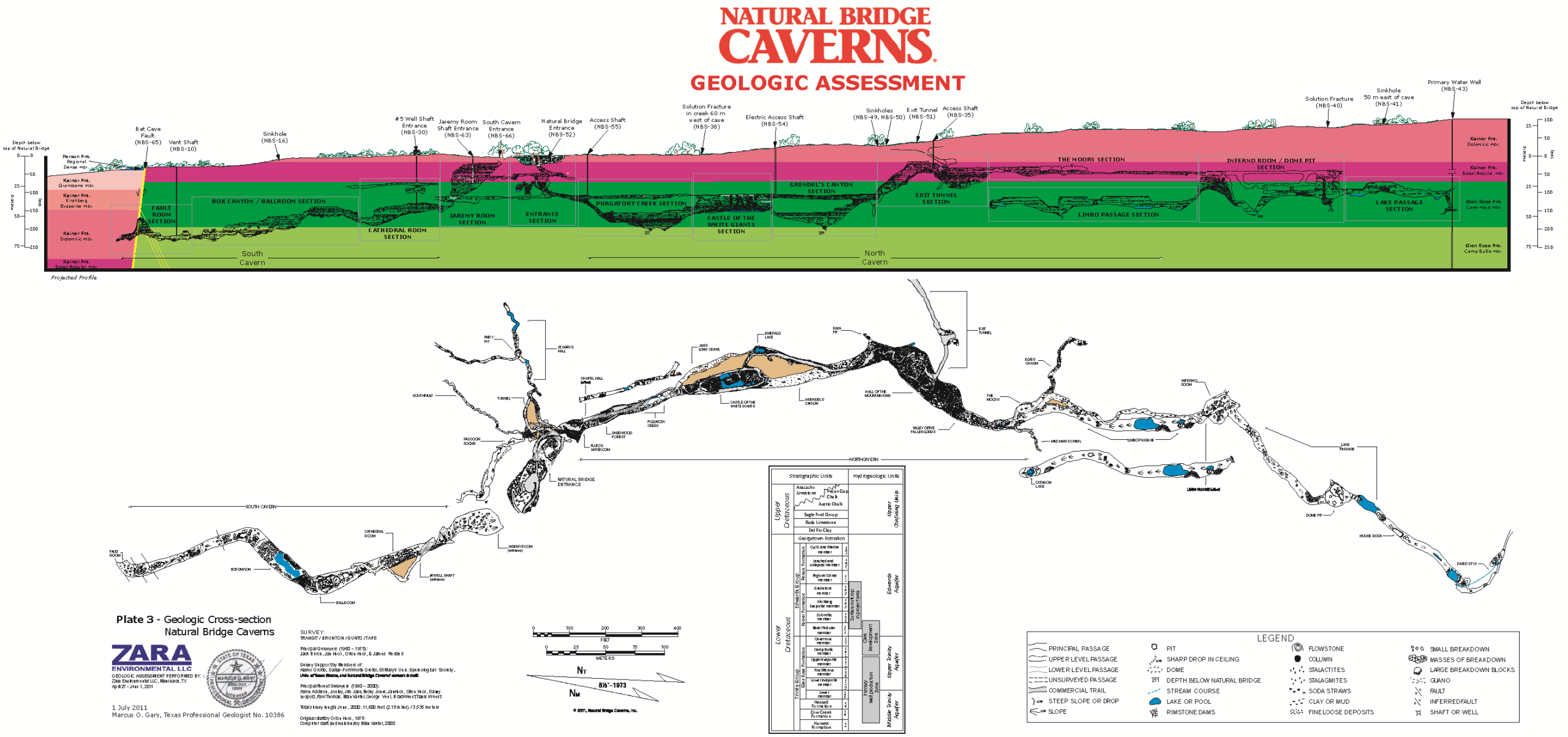
EDWARDS AQUIFER AUTHORITY



Does karst stop at the Trinity?



Not Always!


NATURAL BRIDGE CAVERNS
GEOLOGIC ASSESSMENT
Bat Cave Fault (NBS-65)
Vent Shaft (NBS-10)
Sinkhole (NBS-16)
#5 Well Shaft Entrance (NBS-30)
Jaremy Room Shaft Entrance (NBS-63)
South Cavern Entrance (NBS-66)
Natural Bridge Entrance (NBS-52)
Access Shaft (NBS-55)
Solution Fracture in creek 60 m west of cave (NBS-38)
Electric Access Shaft (NBS-54)
Sinkholes (NBS-49, NBS-50)
Exit Tunnel (NBS-51)
Access Shaft (NBS-35)
Solution Fracture (NBS-40)
Sinkhole 50 m east of cave (NBS-41)
Primary Water Well (NBS-43)
Person Fm. Regional Dense mbr.
Kainer Fm. Gleinstone mbr.
Kainer Fm. Kirtsberg Evaporite mbr.
Kainer Fm. Dolomitic mbr.
Kainer Fm. Basal Nodular mbr.
FAULT ROOM SECTION
BOX CANYON / BALLROOM SECTION
CATHEDRAL ROOM SECTION
JAREMY ROOM SECTION
ENTRANCE SECTION
PURGATORY CREEK SECTION
CASTLE OF THE WHITE GIANTS SECTION
GRENDEL'S CANYON SECTION
EXIT TUNNEL SECTION
THE MOORS SECTION
LIMBO PASSAGE SECTION
INFERNO ROOM / DOME PIT SECTION
LAKE PASSAGE SECTION
Glen Rose Fm. Cavernous mbr.
Glen Rose Fm. Camp Bullis mbr.
South Cavern
North Cavern
Projected Profile
Plate 3 - Geologic Cross-section
Natural Bridge Caverns
ZARA ENVIRONMENTAL LLC
GEOLOGIC ASSESSMENT PERFORMED BY:
Zara Environmental LLC, Manchaca, TX
April 27 - June 1, 2011
1 July 2011
Marcus O. Gary, Texas Professional Geologist No. 10386
SURVEY:
TRANSIT / BRUNTON / SUNTO / TAPE
Principal Surveyors (1963 – 1978):
Jack Brock, Jim Hoor, Otto Hoor, & James Reddell
Survey Support by Members of:
Alamo Grotto, Dallas-Fort Worth Grotto, St. Mary's Univ. Speleological Society,
Univ. of Texas Grotto, and Natural Bridge Caverns' owners & staff.
Principal Recent Surveyors (1990 – 2000):
Aaron Addison, Joe Ivy, Jim Jans, Becky Jones, Jim Hoor, Otto Hoor, Danny Leopold, Rich Thomas, Rita Vantz, George Veni, Brad Wiest, Elaine Wiest
Total survey length June, 2000: 11,600 feet (2.18 mi) / 3,535 meters
Original drafting: Otto Hoor, 1978
Computer draft and final drawing: Rita Vantz, 2000
© 2001, Natural Bridge Caverns, Inc.
FEET
METERS
NT
NM
8½°–1973
NORTH CAVERN
SOUTH CAVERN
NATURAL BRIDGE ENTRANCE
BALLROOM
CATHEDRAL ROOM
BOX CANYON
FAULT ROOM
JAREMY ROOM
ANVIL WELL SHAFT
CHAPEL HALL
EMERALD LAKE
CASTLE OF THE WHITE GIANTS
GRENDEL'S CANYON
EXIT TUNNEL
THE MOORS
LIMBO PASSAGE
INFERNO ROOM
LAKE PASSAGE
DOME PIT
HOUSE ROCK
RIVER STYX
Stratigraphic Units
Hydrogeologic Units
Upper Cretaceous
Lower Cretaceous
Anacacho Limestone
Austin Chalk
Eagle Ford Group
Buda Limestone
Del Rio Clay
Georgetown Formation
Edwards Group
Person Formation
Kainer Formation
Trinity Group
Glen Rose Formation
Hensell Formation
Cow Creek Formation
Hammett Formation
Upper Confining Units
Edwards Aquifer
Upper Trinity Aquifer
Middle Trinity Aquifer
Cave development zone
Major well production zone
LEGEND
PRINCIPAL PASSAGE
UPPER LEVEL PASSAGE
LOWER LEVEL PASSAGE
UNSURVEYED PASSAGE
COMMERCIAL TRAIL
STEEP SLOPE OR DROP
SLOPE
PIT
SHARP DROP IN CEILING
DOME
DEPTH BELOW NATURAL BRIDGE
STREAM COURSE
LAKE OR POOL
RIMSTONE DAMS
FLOWSTONE
COLUMN
STALACTITES
STALAGMITES
SODA STRAWS
CLAY OR MUD
FINE LOOSE DEPOSITS
SMALL BREAKDOWN
MASSES OF BREAKDOWN
LARGE BREAKDOWN BLOCKS
GUANO
FAULT
INFERRED FAULT
SHAFT OR WELL

Geological Society of America Special Session- 2013

REVISING THE CONCEPTUAL MODEL FOR THE EDWARDS AQUIFER/TRINITY AQUIFER INTERFACE

GREEN, Ronald[1], BERTETTI, F. Paul[1], and MCGINNIS, Ronald N. Jr[2], (1) Geosciences and Engineering Division, Southwest Research Institute, 6220 Culebra, San Antonio, TX 78238, rgreen@swri.edu, (2) Geosciences and Engineering Division, Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78238

REDEFINING THE HYDROSTRATIGRAPHY OF THE EDWARDS AND TRINITY AQUIFERS IN THE BALCONES FAULT ZONE, HAYS AND TRAVIS COUNTIES, CENTRAL TEXAS

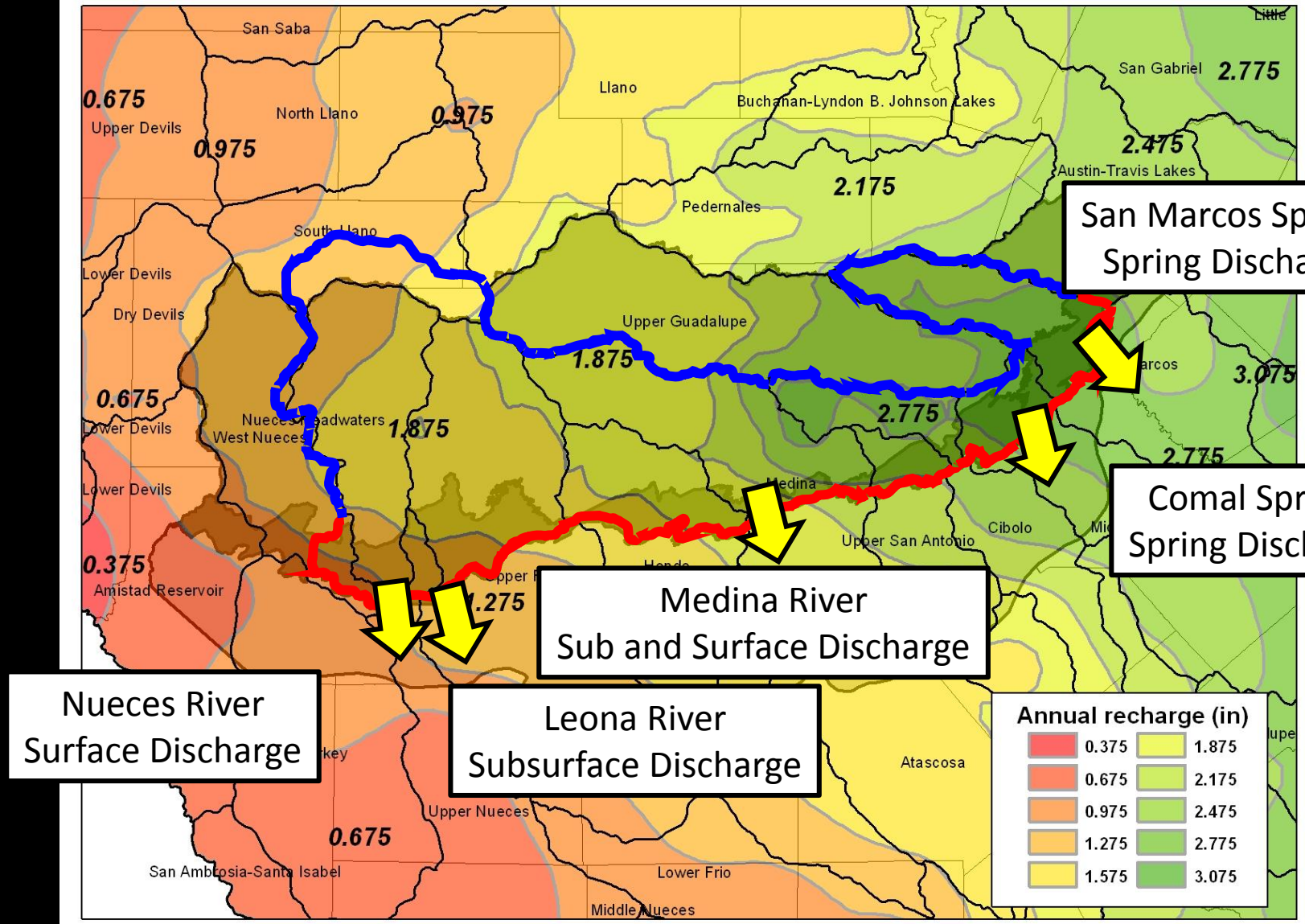
SMITH, Brian A.[1], HUNT, Brian B.[1], and ANDREWS, Alan G.[2], (1) Barton Springs/Edwards Aquifer Conservation District, 1124 Regal Row, Austin, TX 78748, brians@bseacd.org, (2) Barton Springs/Edwards Aquifer Conservation District, 1124 Regal Row, Austin, TX 78748

PLEASANT VALLEY SPRING: A NEWLY DOCUMENTED KARST SPRING OF THE TEXAS HILL COUNTRY TRINITY AQUIFER

HUNT, Brian B.[1], NORRIS, Chad[2], GARY, Marcus[3], WIERMAN, Douglas A.[4], BROUN, Alex S.[5], and SMITH, Brian A.[1], (1) Barton Springs/Edwards Aquifer Conservation District, 1124 Regal Row, Austin, TX 78748, brianh@bseacd.org, (2) Texas Parks and Wildlife, 4200 Smith School Road, Austin, TX 78744, (3) Edwards Aquifer Authority, 1615 N. St. Mary's Street, San Antonio, TX 78215, (4) 400 Blue Creek Drive, Dripping Springs, TX 78620, (5) Hays-Trinity Groundwater Conservation District, PO Box 1648, Dripping Springs, TX 78620

WOODBURN, James Russell, Earth and Physical Sciences, Sul Ross State University, Box C-139 SRSU, Alpine, TX 79832

Water-Budget Assessment of the Edwards Aquifer
San Antonio Segment



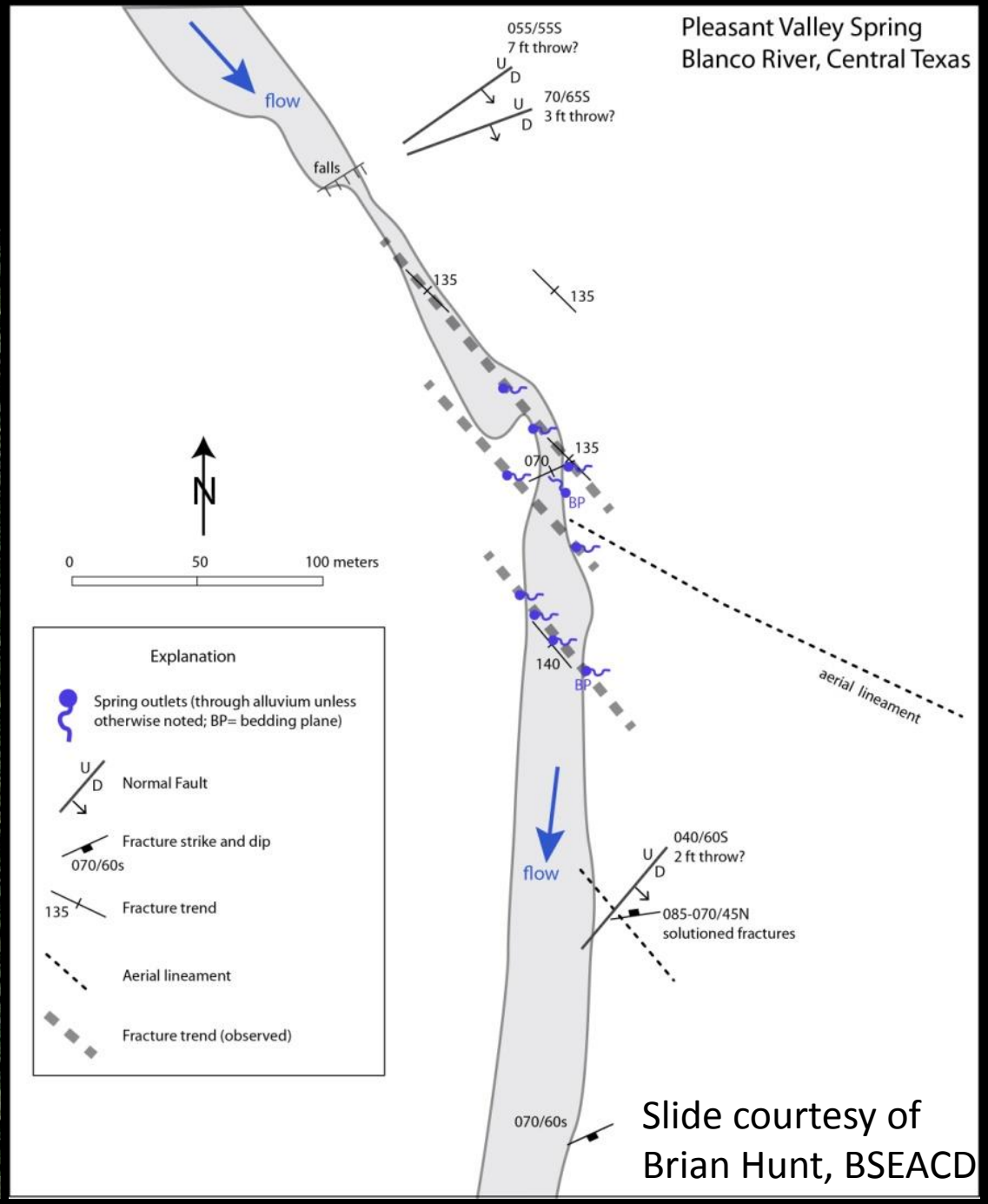
Slide courtesy of
Ron Green, SwRI

Summary *(from Ron Green's presentation at GSA special session)*

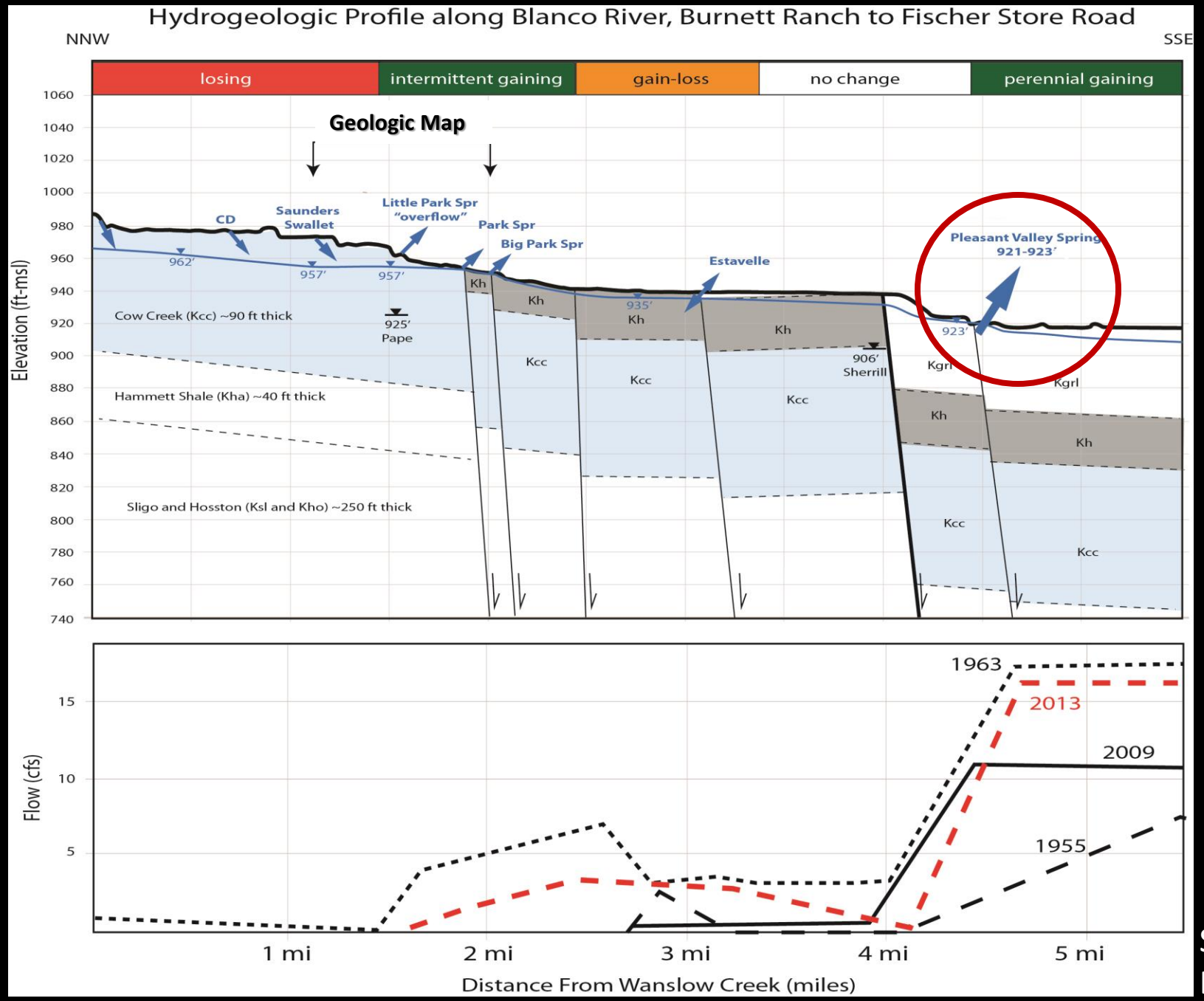
- Conventional conceptualizations of the hydraulic relationship between the Trinity and Edwards aquifers are under review
- This relationship does not appear to be spatially constant
- Water budget analysis is a useful indirect tool to assess subsurface hydraulic relationships
- Confirmatory assessments such as water chemistry or alternative water-budget analysis, needed to reduce uncertainty to an acceptable level

Slide courtesy of
Ron Green, SwRI

Pleasant Valley Spring



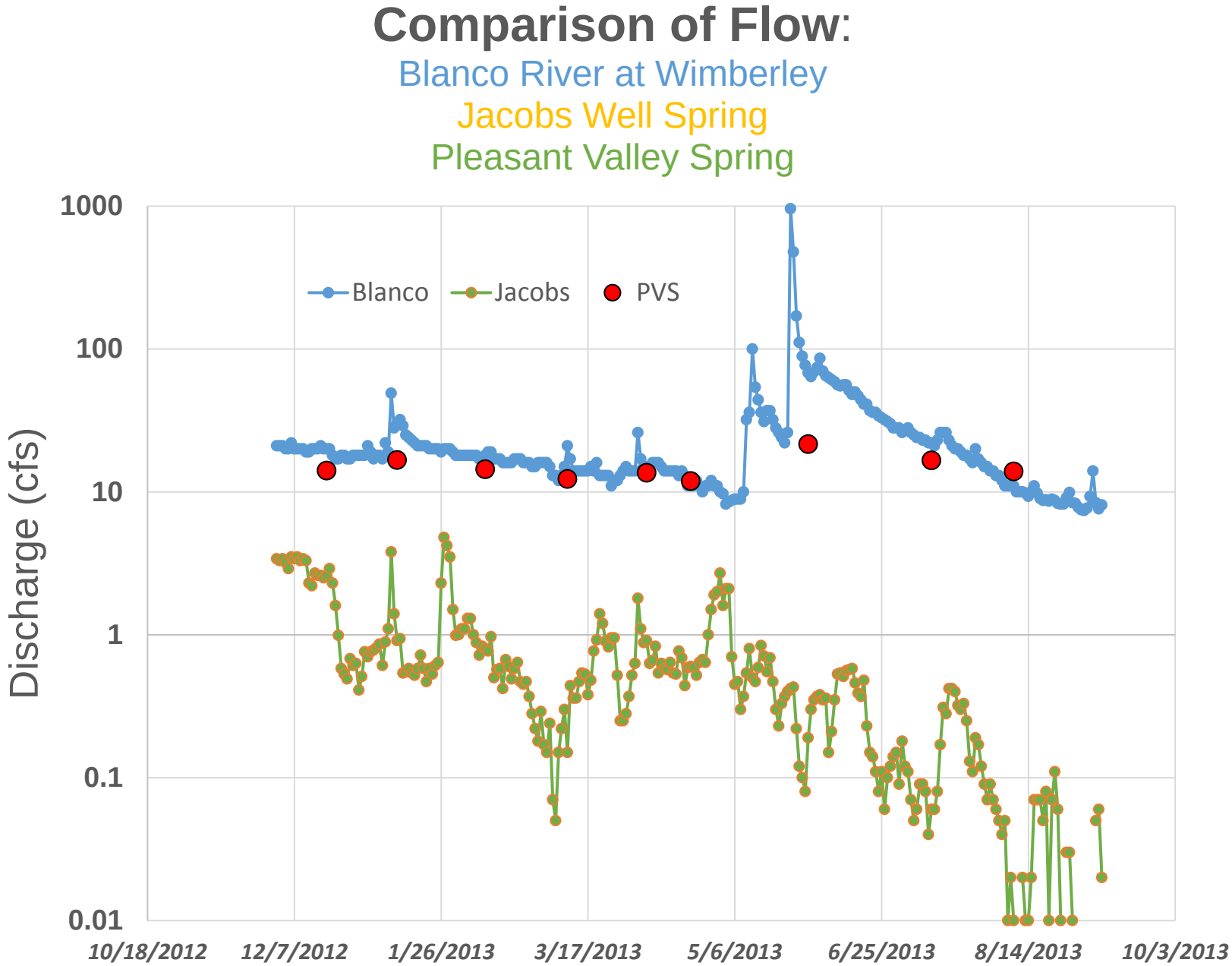
Slide courtesy of Brian Hunt, BSEACD



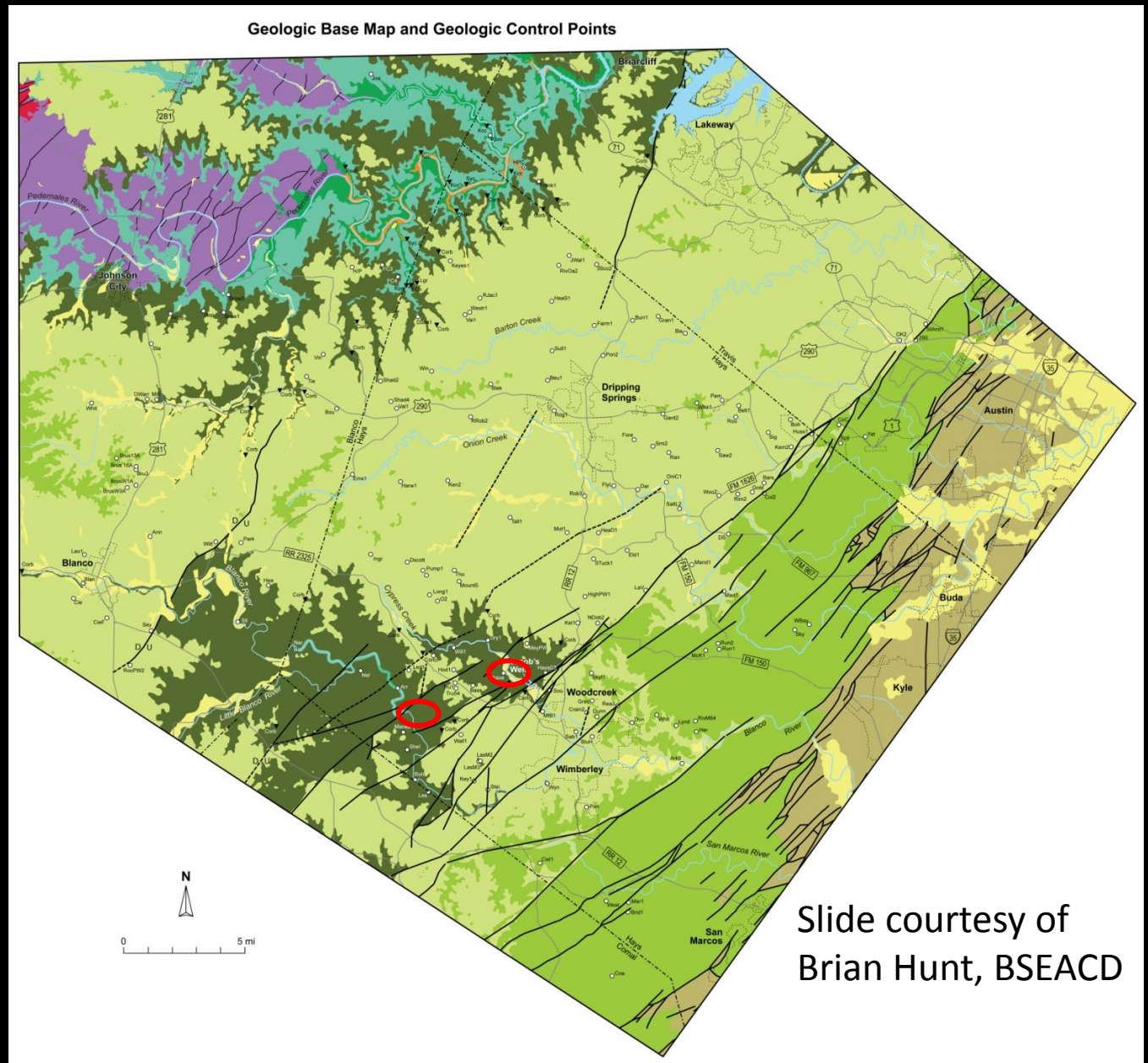
Slide courtesy of Brian Hunt, BSEACD

EDWARDS AQUIFER AUTHORITY

Pleasant Valley Spring was completely undocumented one year ago.

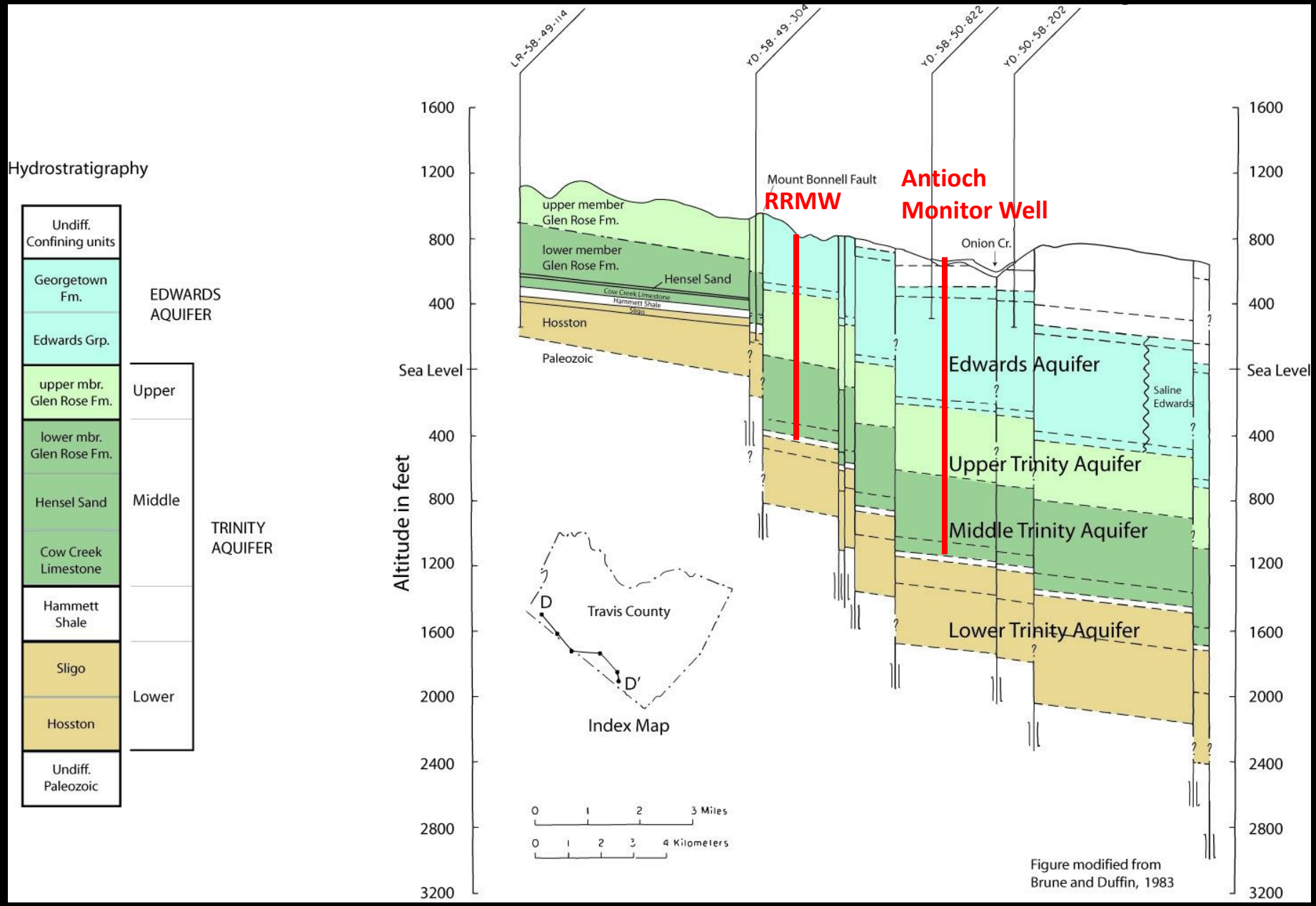


Pleasant Valley Spring and Jacob's Well



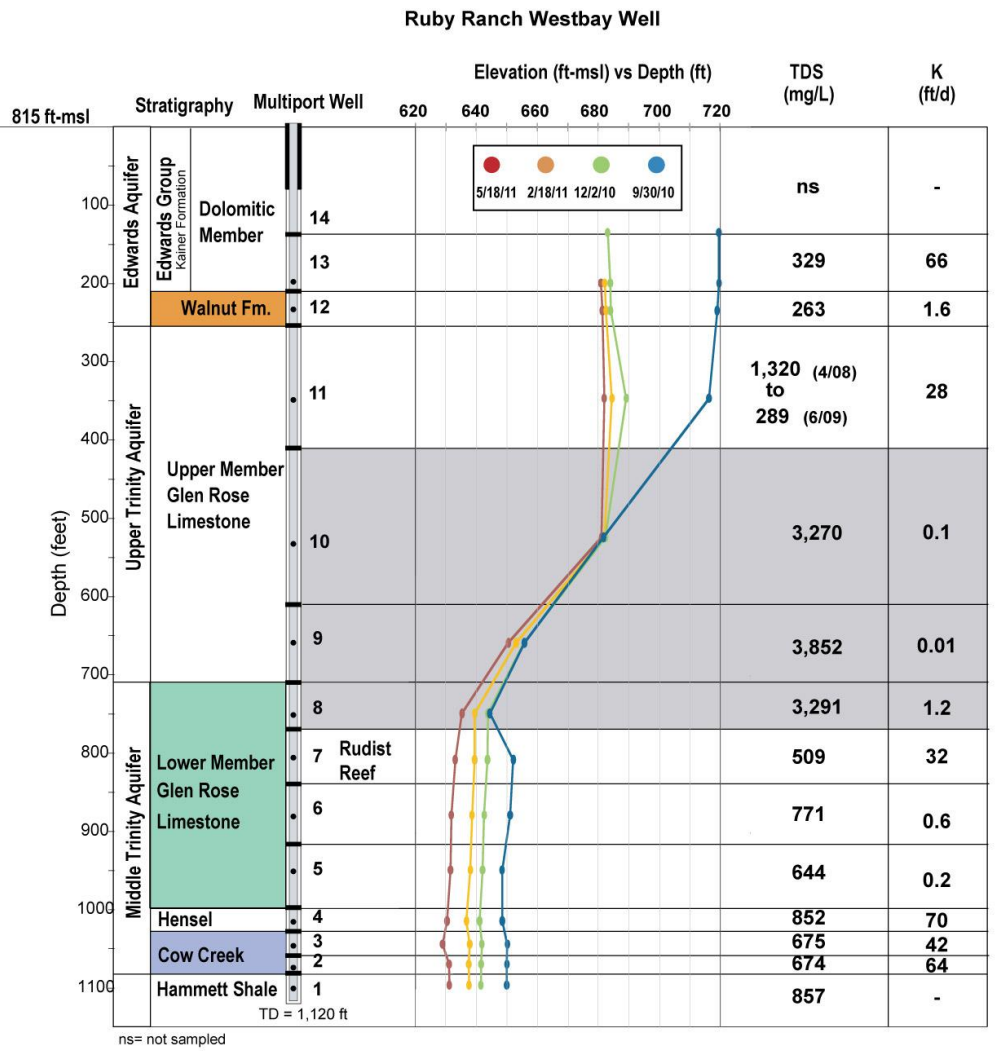
Slide courtesy of Brian Hunt, BSEACD

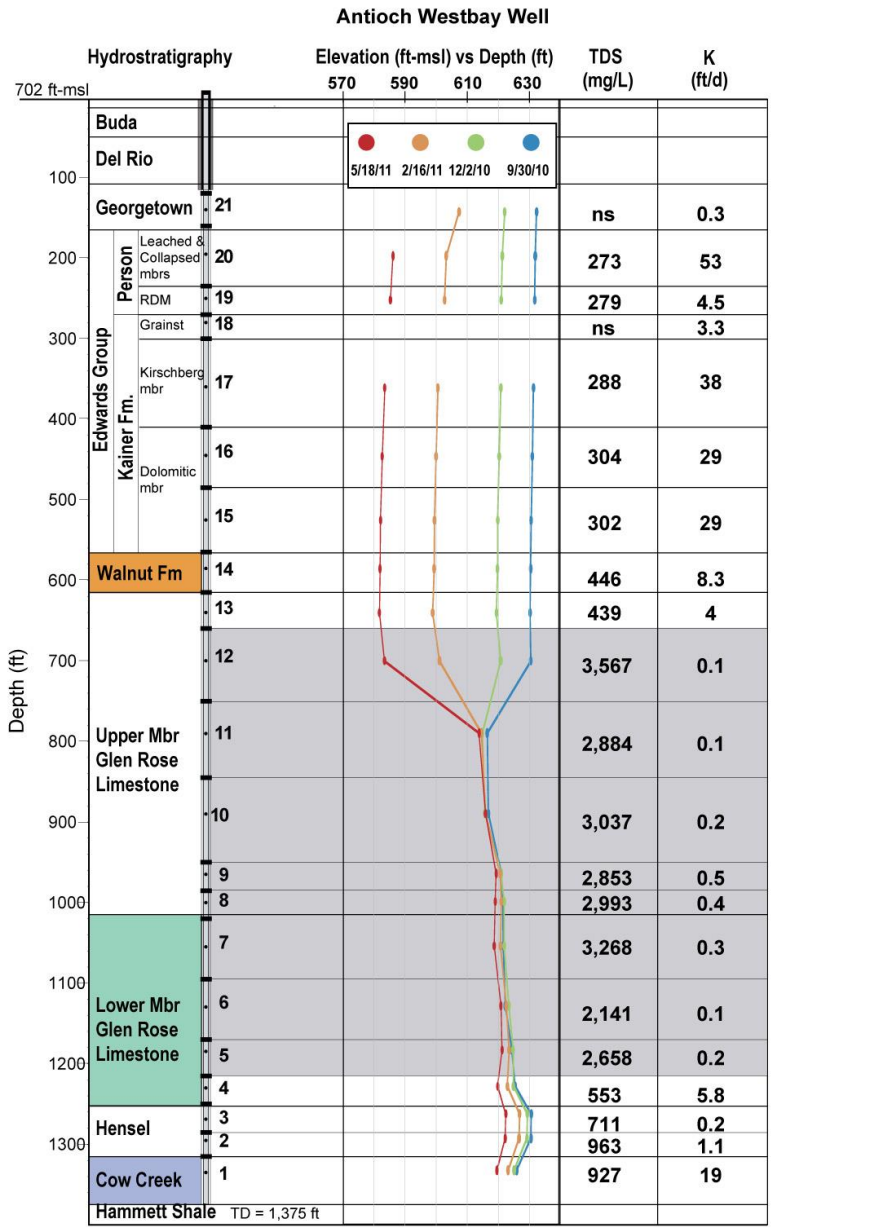
Multi-port monitor wells in Barton Springs Segment



Slide courtesy of Brian Smith, BSEACD

BSEACD Multiport Well Diagram

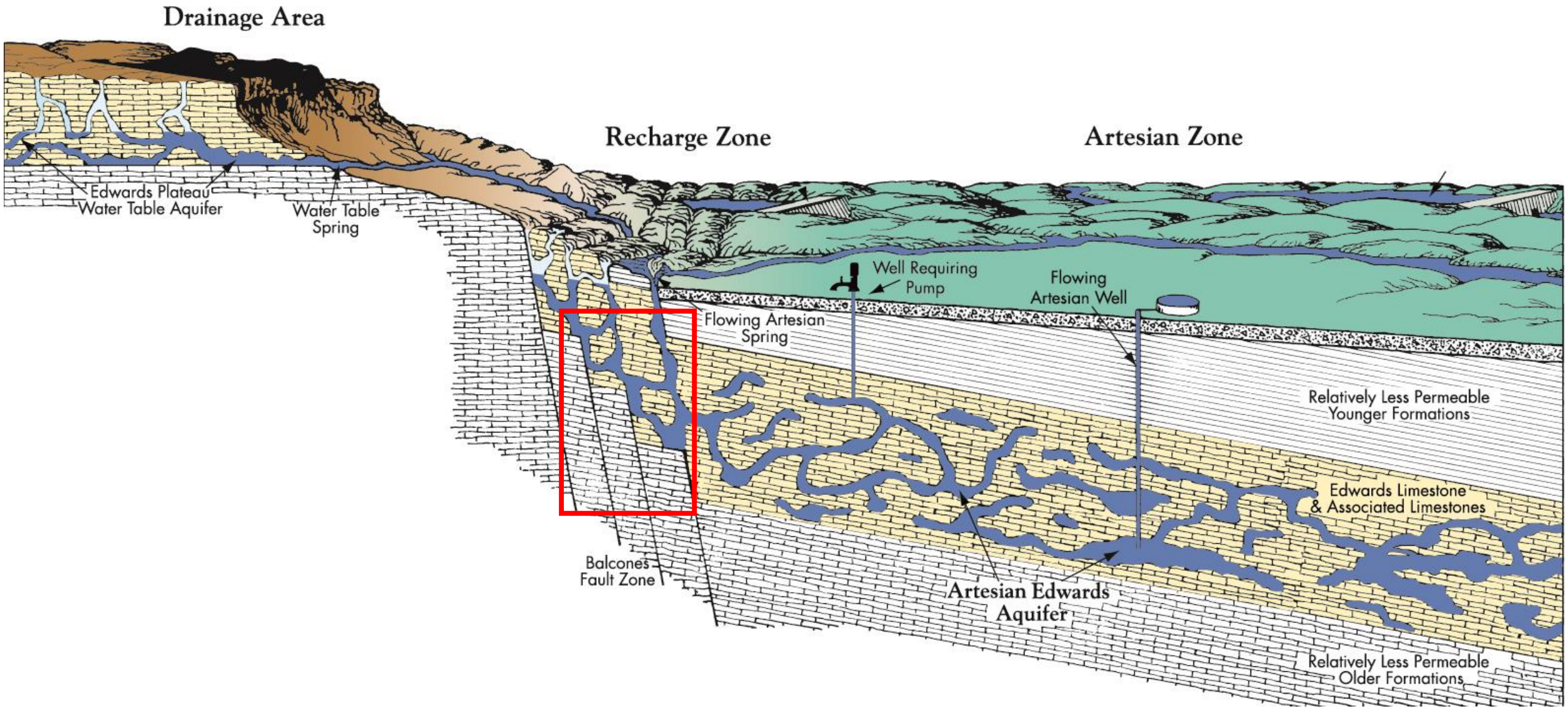




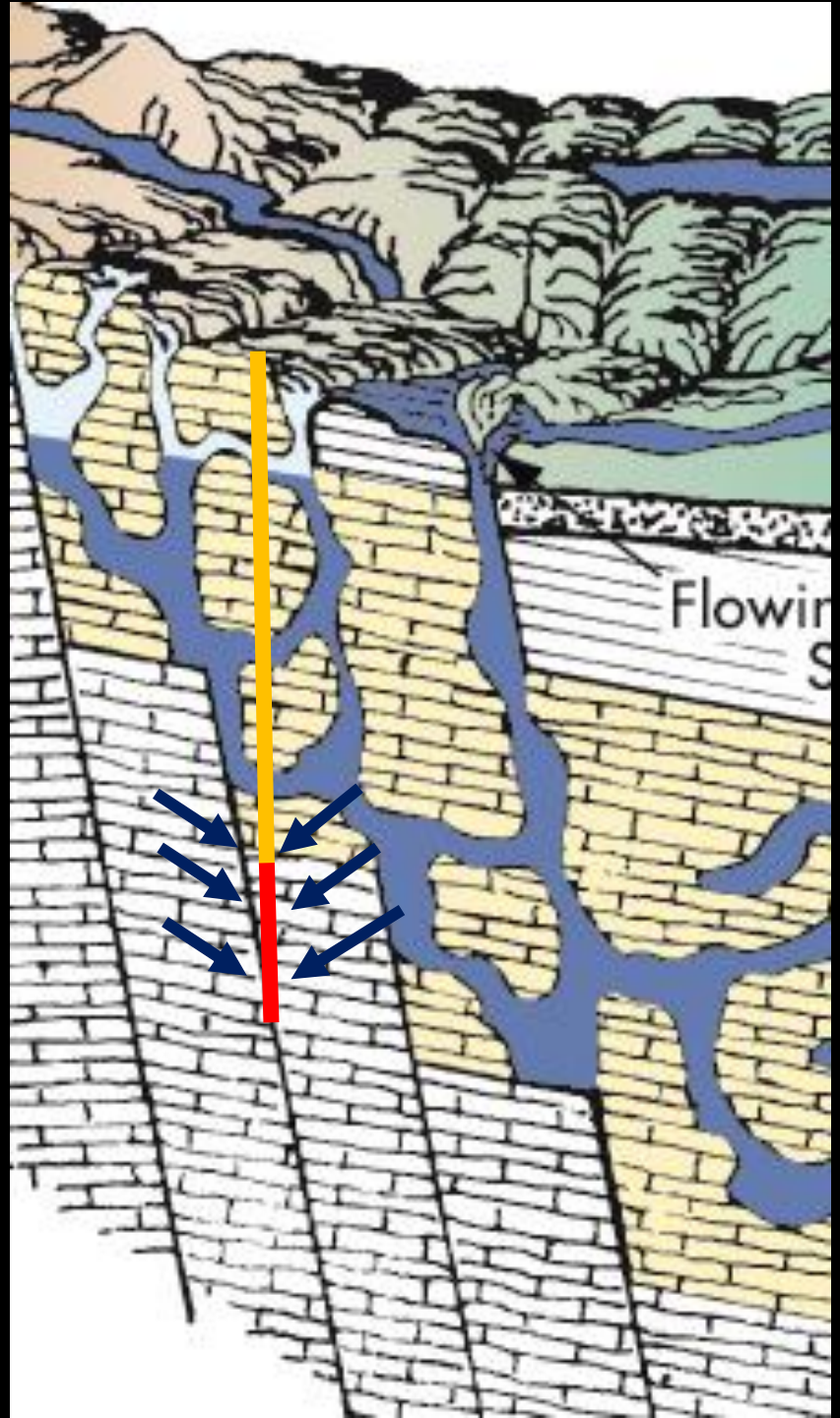
12/2012

Slide courtesy of Brian Smith, BSEACD

EDWARDS AQUIFER AUTHORITY



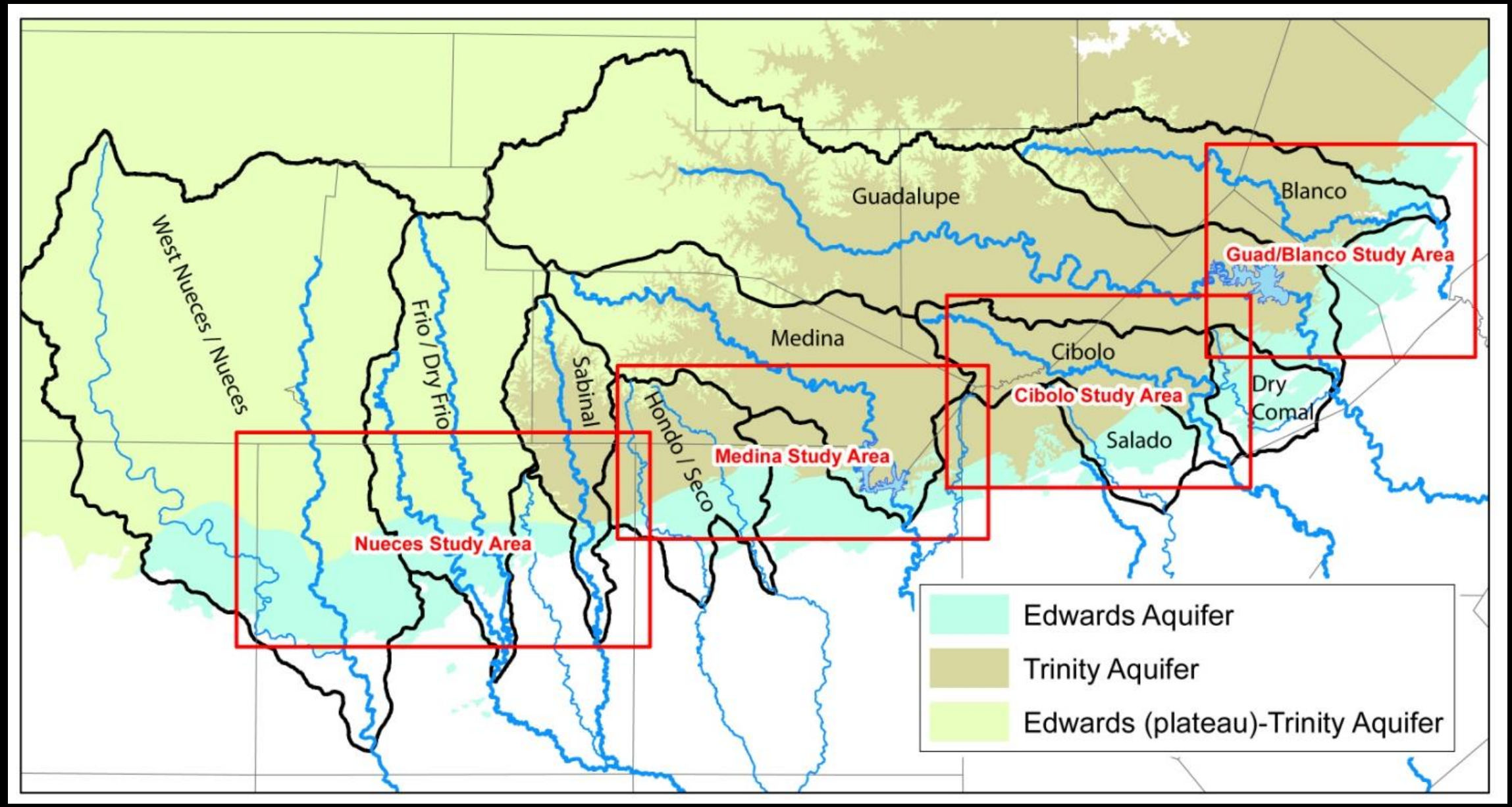
What is effect of pumping out of the top of the Upper Glen Rose on water in the Edwards?



PROPOSED WORK PLAN TO INVESTIGATE EDWARDS-TRINITY INTER-FORMATIONAL FLOW

1. Identify multiple study areas to focus investigations on observed conditions that may vary across the aquifers' boundary.
2. Apply similar investigative techniques in each of the study areas.
3. Conduct long-term (4-5 years) data collection and analysis in each study area; publish detailed report on findings for each area.
4. Complete study by preparing integrated report of entire aquifer system.

Inter-formational Flow Study Areas



INVESTIGATIVE METHODS

1. Perform geologic and hydrostratigraphic mapping of the Glen Rose Formation in focused areas;

2. Perform detailed gain/loss studies of major recharging streams;

3. Develop monitoring and data collection program for well transects along the Edwards - Trinity aquifer interface to evaluate potential lateral flow into the Edwards;

4. Perform analysis of stream flow/recharge data related to groundwater levels in both the Edwards and Trinity aquifers;

INVESTIGATIVE METHODS cont.

5. Install and operate coupled monitoring wells to evaluate vertical flow from the Edwards to the Trinity aquifers;

6. Assess and identify structural geology and geologic controls on karstification of the Edwards and Trinity aquifer. Evaluate the role karstification in interformational flow;

7. Perform tracer testing across the interface;

8. Evaluate geochemical data to determine unique natural markers for groundwater composition of each aquifer; and,

9. Utilize an integrated data management process to evaluate data.

PROJECT TIME TABLE

Year	Study Area Activities
Year 1	Expand monitor network in all study areas. In general, additional data loggers, synoptic measurements, and water quality sampling will be implemented initially to build a foundation of basic data for future investigations. The NSA, GBSA, and CSA will have the initial focus, as several related projects are already underway in these study areas.
Year 2	O/M monitor net; compile data and evaluate the effectiveness of the monitor data.
Year 3	O/M monitor net. Prepare CSA report
Year 4	O/M monitor net. Prepare GBSA and MSA reports
Year 5	Prepare NSA report; Prepare integrated report

COLLABORATIVE EFFORT

working with neighboring agencies and entities

- Trinity Glen Rose Groundwater Conservation District
- Barton Springs Edwards Aquifer Conservation District
- Nueces River Authority
- The University of Texas at Austin
- Hays Trinity Groundwater District
- U.S. Geological Survey
- Camp Bullis – Joint Base San Antonio
- Texas Parks and Wildlife
- Natural Bridge Caverns
- Cibolo Nature Center
- Bandera County River Authority and Groundwater District
- Southwest Research Institute

COLLABORATIVE EFFORT

Formation of Edwards/Trinity Water Research Interest Group

- Organizations from previous slide; and,
- Medina County Groundwater Conservation District
- Uvalde County Underground Water Conservations District
- Kinney County Groundwater Conservation District
- Cow Creek Groundwater Conservation District
- GMA-10
- GMA-9
- Other stakeholder groups

EDWARDS AQUIFER AUTHORITY

Thank You