UIC PRESSURE CONSIDERATIONS & PRODUCED WATER MANAGEMENT

July 15, 2025

Ted Wooten









OUTLINE

UIC PRESSURE CONSIDERATIONS (30 MINUTE SLIDE DISCUSSION)

- AREA OF REVIEW
  - CHECKING ALL WELL RECORDS IN THE AOR
    - PROTECTION OF BUQW
    - CONFINEMENT OF PERMITTED INJECTION INTERVAL
- CONFINEMENT
  - DETERMINING CONFINING STRESSES

PRODUCED WATER MANAGEMENT (60 MINUTES Q&A - PANELISTS)

- CURRENT METHODS AND STRATEGIES FOR MANAGING PRODUCED WATER
- TECHNOLOGIES FOR TREATING PRODUCED WATER AND REGULATORY STATUS ON PERMITS FOR BENEFICIAL REUSE OF THE TREATED WATER.

AREA OF REVIEW

- **CHECKING ALL WELL RECORDS IN THE AOR**
  - **PROTECTION OF BUQW**
  - **CONFINEMENT OF PERMITTED INJECTION INTERVAL**

<u>What are we all trying to determine when we check these offset well records?</u>

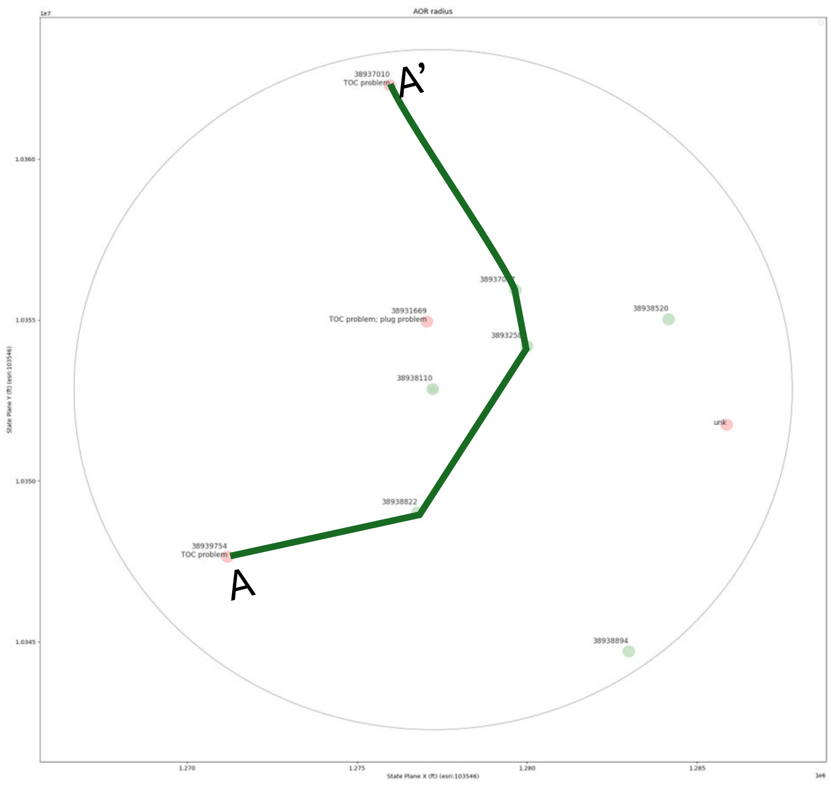
1. **It's not a contrived exercise to test whether the rules were adequately explicit and prescriptive.**
2. **It's a level of diligence that is intended to answer the primary question: Will these injected fluids remain confined to the permitted interval?**

AREA OF REVIEW (AOR well list/map)

Subject Well Latitude:	31.028871
Subject Well Longitude:	-103.588407

MAP INDEX NO.	DISTANCE FROM SUBJECT WELL (MILES)	LATITUDE83	LONGITUDE 83	ORPHAN WELL / UNKNOWN STATUS (Y/N)	ANNULAR CEMENT ACROSS PERMITTED INJECTION INTERVAL (Y/N)	ANNULAR OR PLUG CEMENT ADEQUATE TO PROTECT USDW/BUQW (Y/N)	API NO.
EXAMPLE:	**0.00**	**31.02887100**	**-103.58840700**	**Y**	**N**	**Y**	**30100000**
1	0.00	31.02889467	-103.58842470	N	Y	Y	38938110
2	0.40	31.03463622	-103.58916663	Y	Y	N	38931669
3	0.58	31.03278879	-103.57971028	N	Y	Y	38932588
4	0.73	31.01832433	-103.58949288	N	Y	Y	38938822
5	0.75	31.03754598	-103.58094956	N	Y	Y	38937067
6	1.38	31.03540749	-103.56649401	N	Y	Y	38938520
7	1.51	31.01409486	-103.60720172	N	Y	Y	38939754
8	1.65	31.02654393	-103.56073507	Y	N	N	389
9	1.81	31.05472387	-103.59333814	N	N	N	38937010
10	1.89	31.00696878	-103.56927128	N	Y	Y	38938894

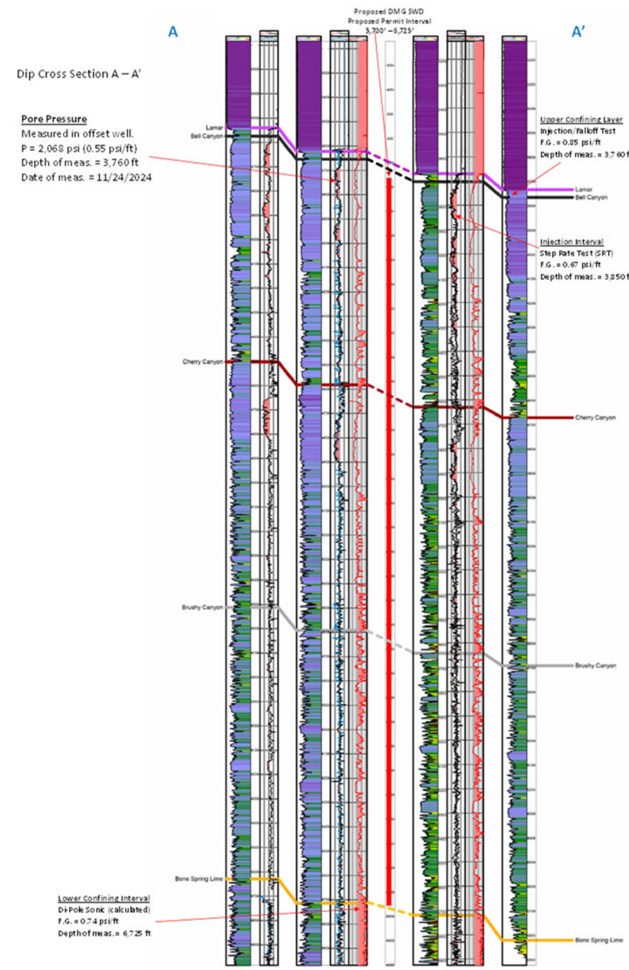
LEASE	WELL NO.	WELL TYPE	UIC PERMIT NUMBER (IF APPLICABLE)	OPERATOR
THE NEXT SWD	**1**	**INJECTION**	**1234567**	**LOTS OF WATER, LLC**
BAPTIST 13-176 SWD	2	INJECTION		WATERBRIDGE TEXAS OPERATING LLC
IKINS W.C.		NO PRODUCTION		AMOCO PRODUCTION COMPANY
BAPTIST 13-223	1	INJECTION		WATERBRIDGE TEXAS OPERATING LLC
DYLAN UNIT 176-175E	10H	PRODUCING		APACHE CORPORATION
BLANCO UNIT 224-223W	1H	PRODUCING		APACHE CORPORATION
BLANCO A 224-223E	10H	PRODUCING		APACHE CORPORATION
STRANGELOVE 160-161E A1		NO PRODUCTION		CALLON PETROLEUM OPERATING CO
		UNKNOWN		
CASH UNIT 176-177W	1H	PRODUCING		APACHE CORPORATION
ZELDA-LINK UNIT 237-238W	1H	PRODUCING		APACHE CORPORATION



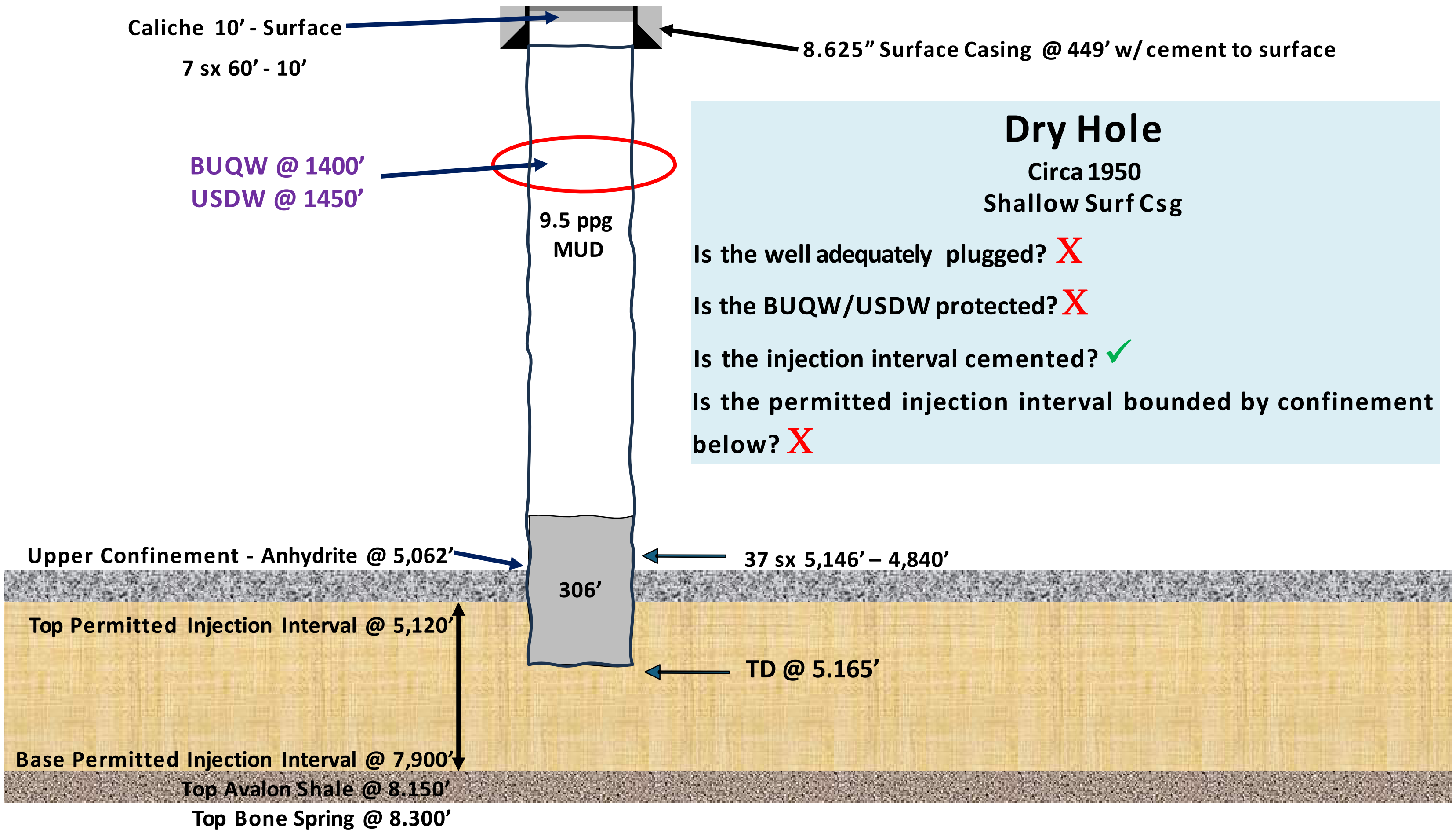
AREA OF REVIEW (x-section)

ANNOTATING CROSS-SECTIONS

- Include all data reference wells, even if wells are outside 2-mile AOR
- Data for application doesn't have to come from one well
- Important to annotate on map and x-section to illustrate relevance (geologic continuity)



AREA OF REVIEW (cement example 1)



Dry Hole

Circa 1950

Shallow Surf Csg

Is the well adequately plugged? X

Is the BUQW/USDW protected? X

Is the injection interval cemented? ✓

Is the permitted injection interval bounded by confinement below? X

*Fail Permian Basin review

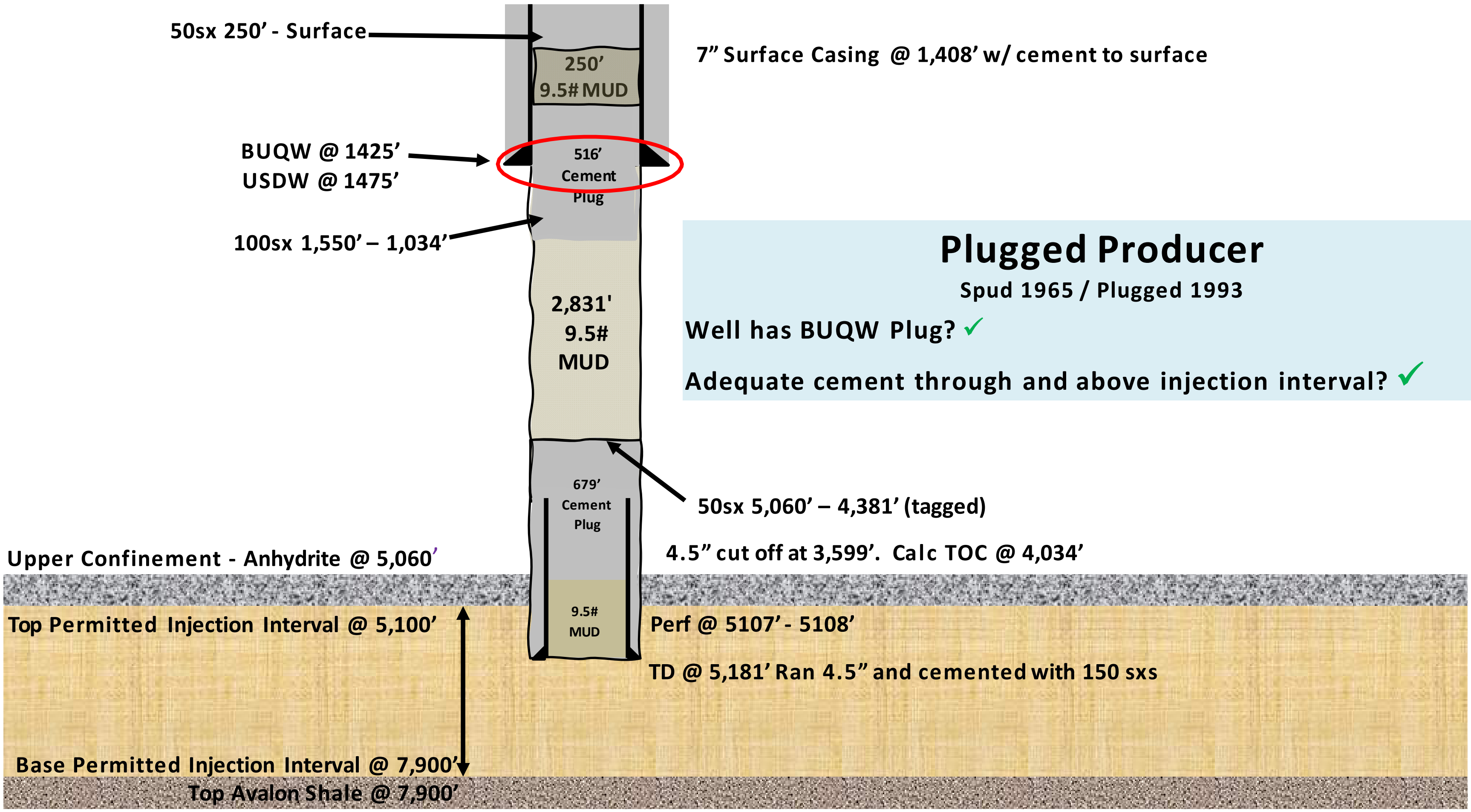
AREA OF REVIEW (cement example 2)

Plugged Producer

Spud 1965 / Plugged 1993

Well has BUQW Plug? ✓

Adequate cement through and above injection interval? ✓



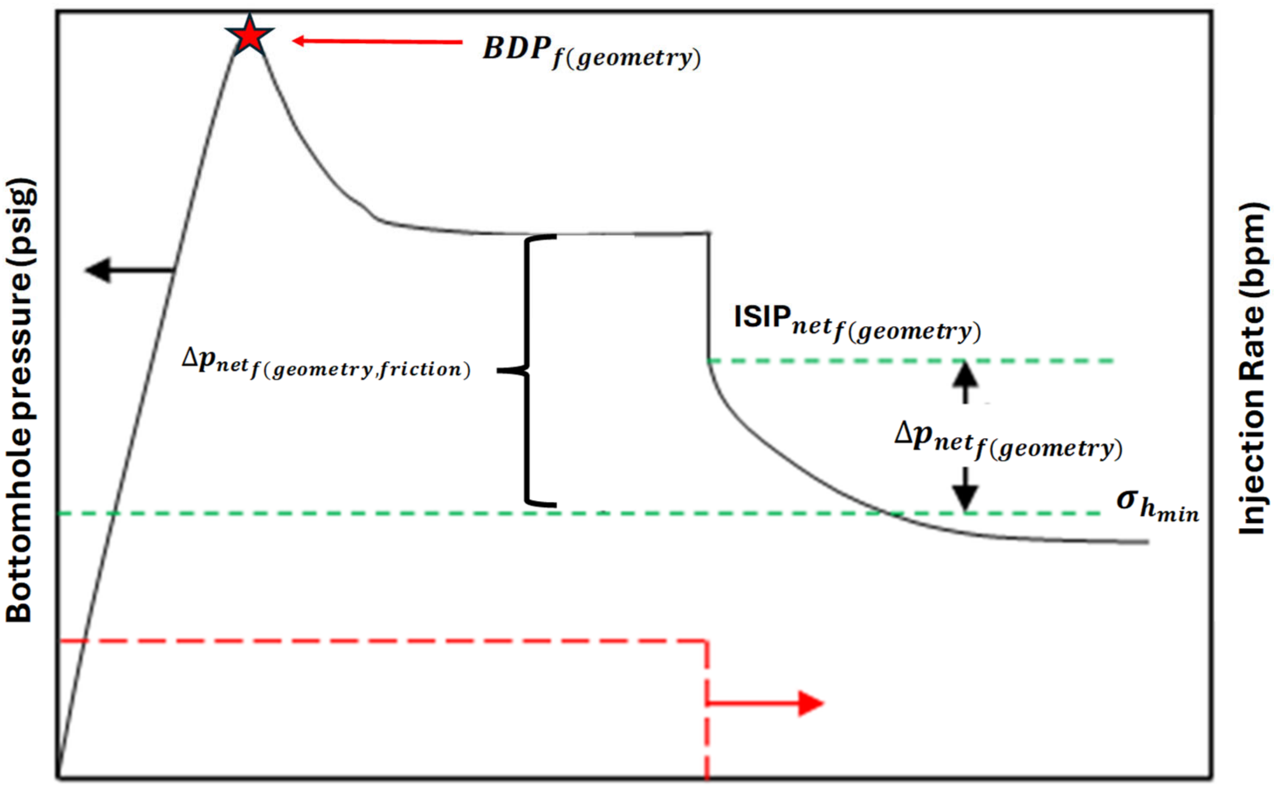
AREA OF REVIEW

CONFINEMENT OF PERMITTED INTERVAL

- Why should we focus on frac gradient = frac closure pressure = least principal stress? It's an independent variable in most models.
- Do you know that break down pressures, propagation pressures, even the ISIP all have a strong dependency on fracture geometry and rate? These are dependent variables and are much less correlative across the subsurface.
- Why injection – falloff versus step rate test?
  - Injection falloff can give you the frac gradient for an injection interval
  - Step rate tests are mostly useful to assess injectivity (volume versus rate relationship). They are also often laden with misinterpretations.

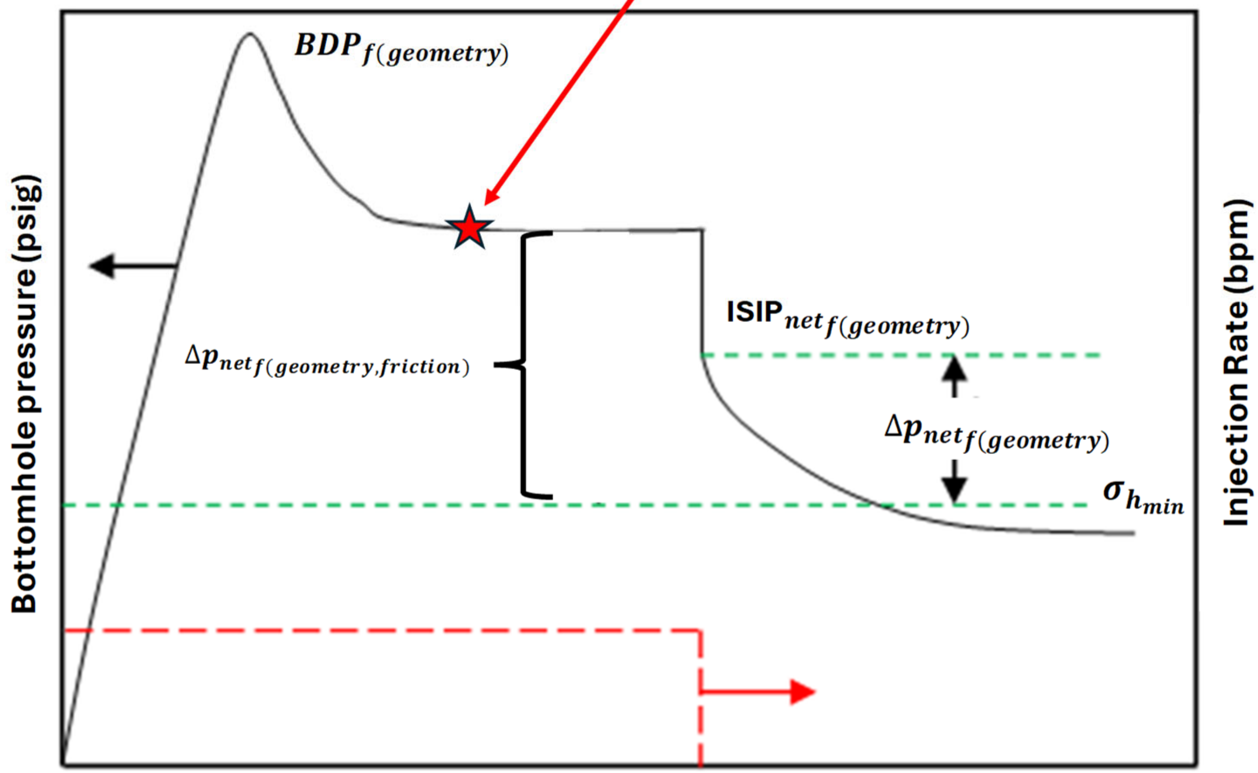
AREA OF REVIEW

"**Breakdown pressure**". ($BDP_{f(geometry)}$) *Often discussed and seldom observed.* A fleeting one-time event that involves several aspects of mechanical failure and fracture initiation. Very seldom visible in actual pressure/rate records. EXTREMELY sensitive to initial geometry effects.



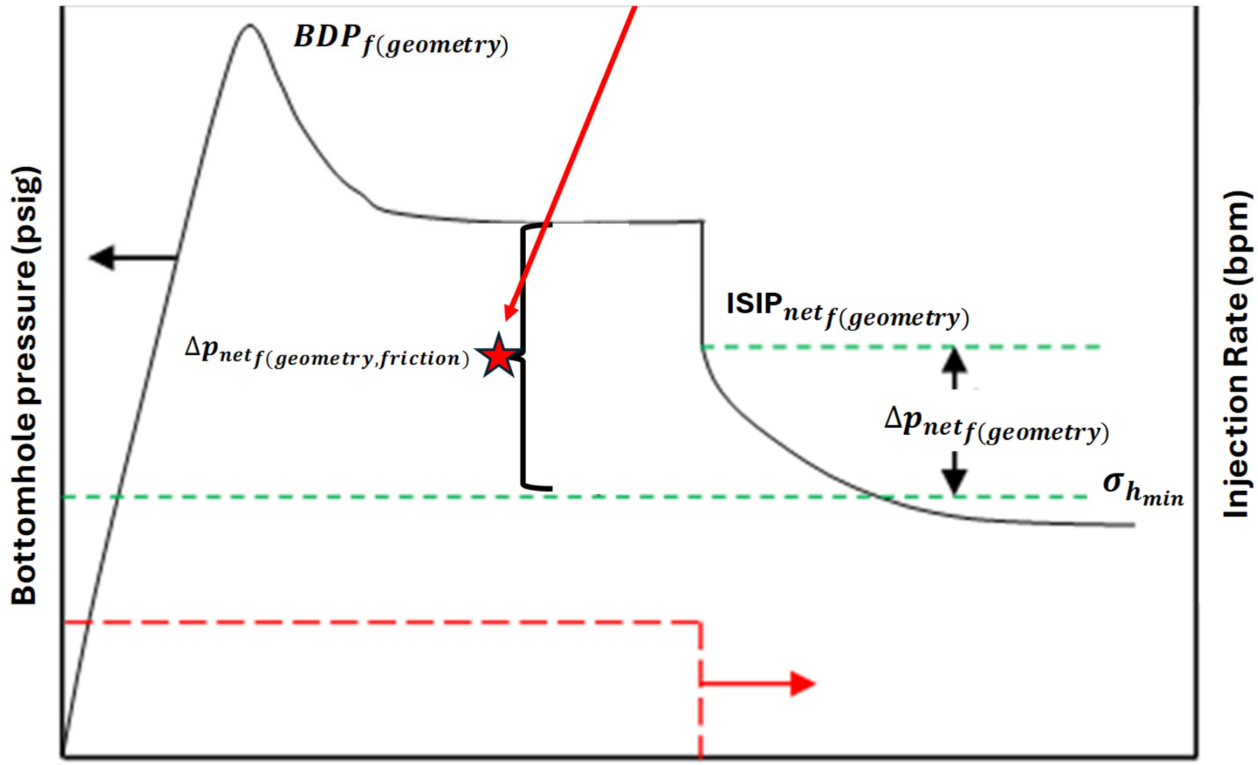
AREA OF REVIEW

"**<u>Fracture Extension Pressure</u>**" while injecting". This pressure **<u>in excess</u>** of the $\sigma_{h_{min}}$ (i.e., least principal stress, frac gradient). A portion of the total injection pressure required to open the fracture, propagate the fracture, and move fluids from the wellbore into and down the hydraulic fracture. Can include significant amounts of friction or geometry effects.



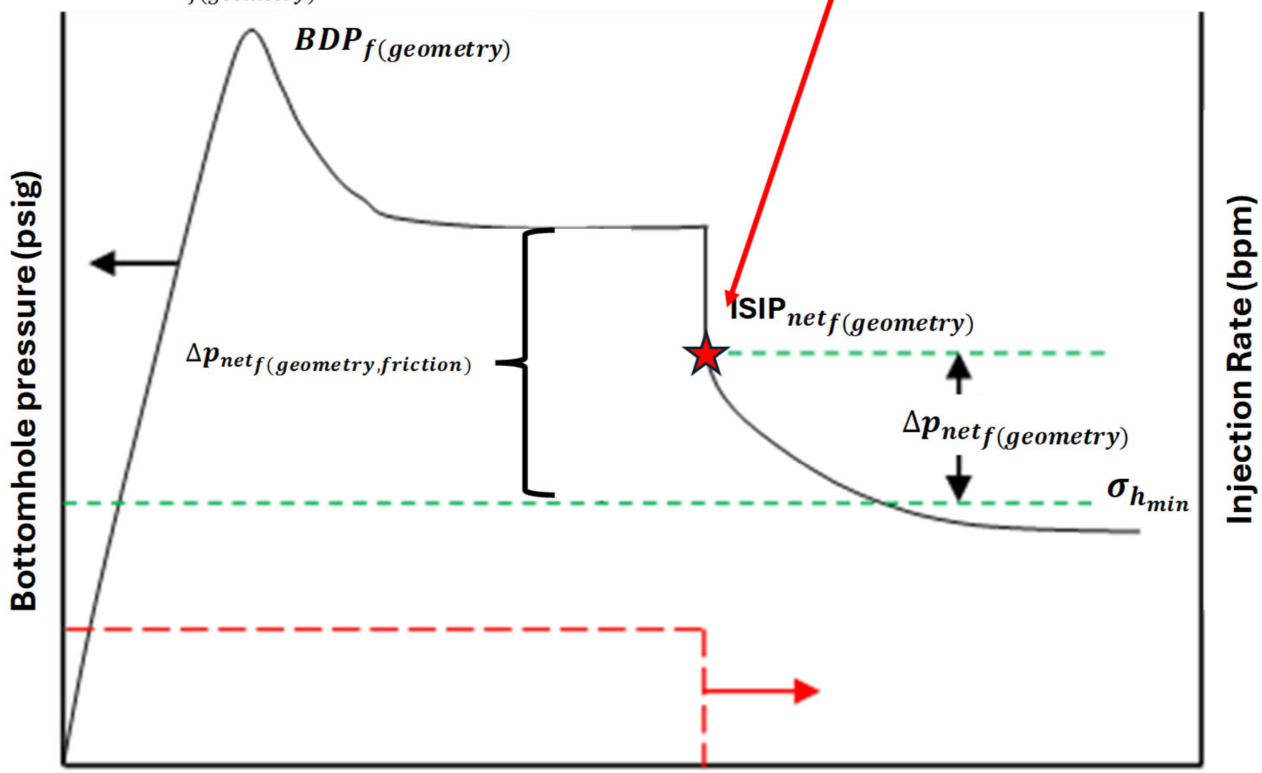
AREA OF REVIEW

$\Delta p_{net_{f(geometry,friction)}}$ The NET pressure **<u>in excess</u>** of the $\sigma_{h_{min}}$(i.e., least principal stress, frac gradient). A portion of the total injection pressure required to open the fracture, propagate the fracture, and move fluids from the wellbore into and down the hydraulic fracture. Can include significant amounts of friction or geometry effects.



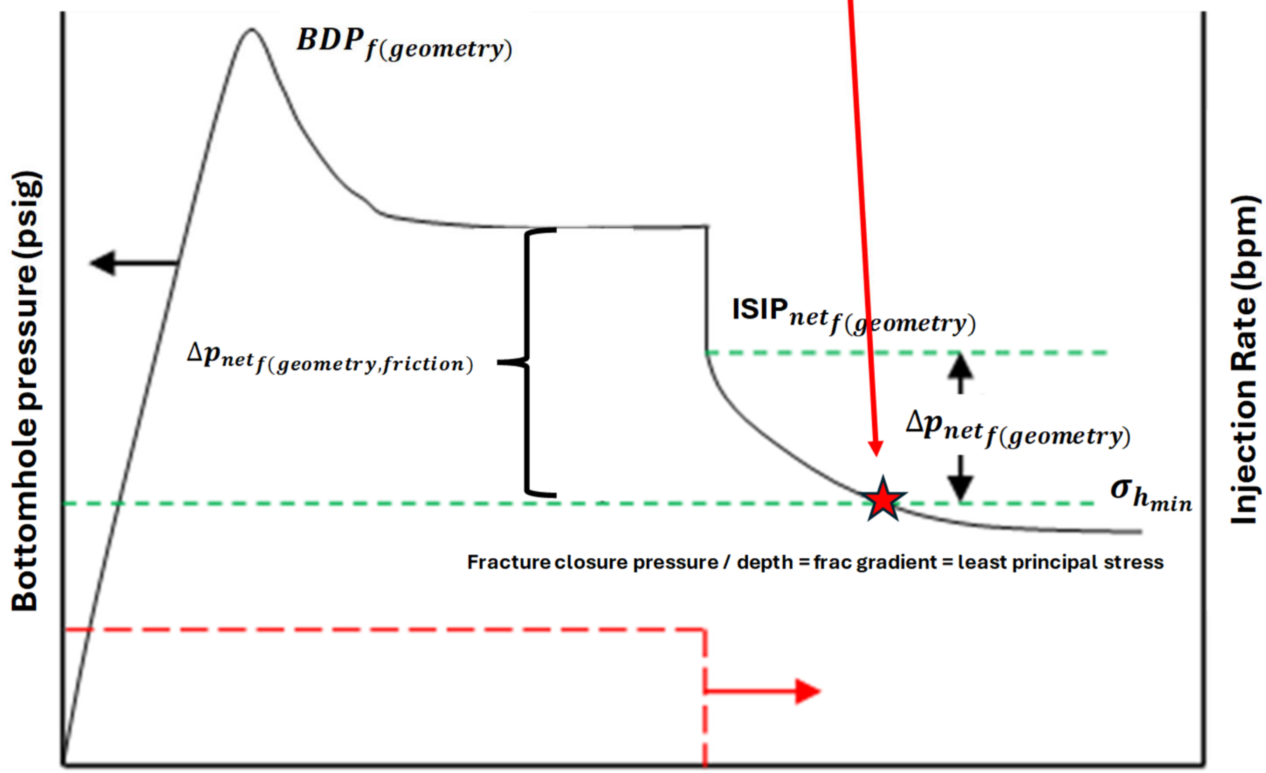
AREA OF REVIEW

"**<u>Instantaneous Shut-In Pressure (ISIP)</u>**". The first measurable pressure after injection rate drops to zero. The difference between that last injection pressure and the ISIP, is perceived as being primarily friction pressure drops. The ISIP, being instantaneous, still includes the final "net pressure" minus the frictional components only. ISIP generally includes a measurable amount of $\Delta p_{net_{f(geometry)}}$



AREA OF REVIEW

"**Delta P Net Final ($\Delta p_{net_{geometry}}$)**". In almost all instances, the hydraulic fracture still has width, length, and height at the moment the ISIP is observed. All fracture geometry is dependent upon the "net pressure" inside the fracture. Various decline pressure analysis techniques have been developed to identify the closure time and closure pressure when the fracture closes.

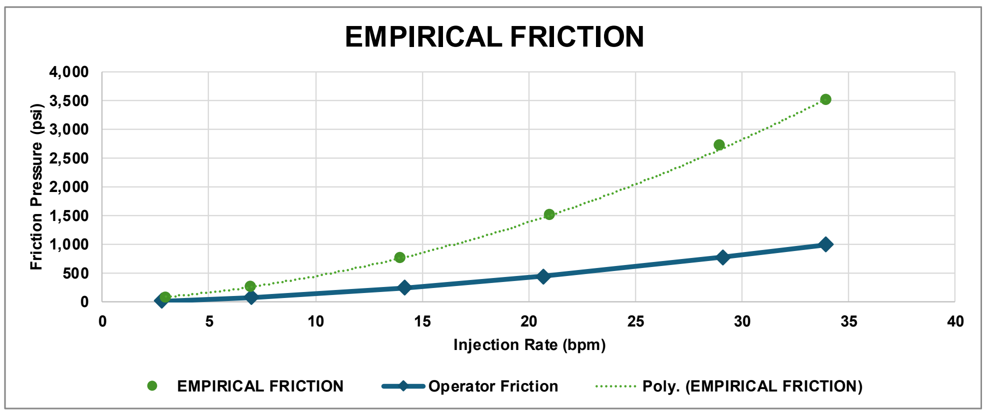


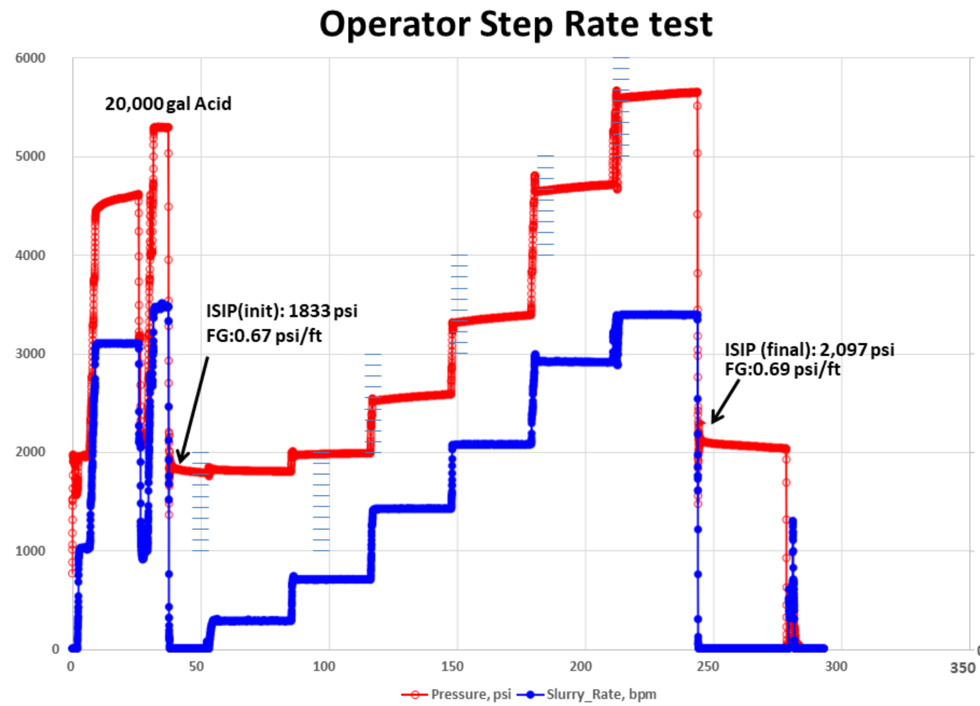
AREA OF REVIEW

Operator Comments:

1. *Based on this test, we should stay below the permitted pressure of 5,623 psi at the allowable injection rate of 40,000 bpd. Also, the frac extension pressure was never reached based on this analysis which shows we were able to stay below frac gradient of this well?????? – Yet the operator annotates the plot with two estimates for the frac gradient.*

2. *Final friction, in main step rate test ~ 995 psi????*



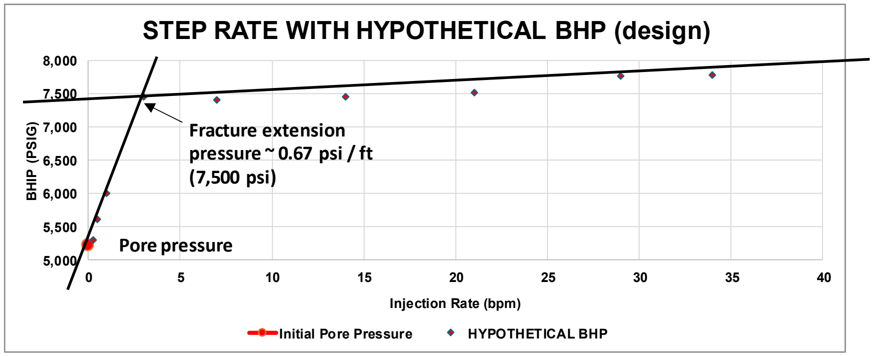


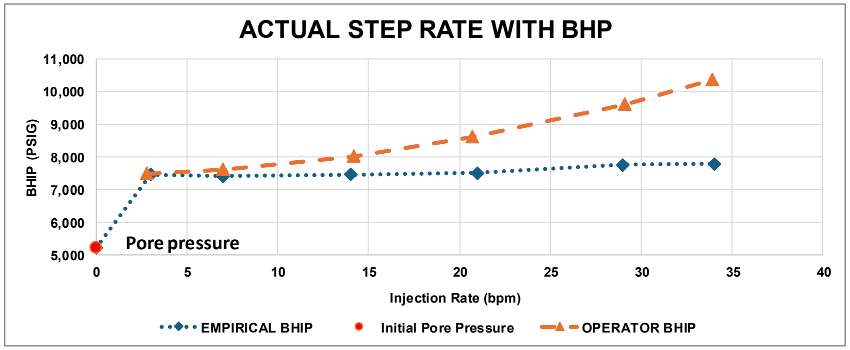
AREA OF REVIEW

Details Matter:

1. *If the test had been conducted with 2-3 relatively low initial injection rates, it could have hypothetically captured the slope of the pressure increase versus rate prior to fracture initiation. That is where the literature gets the notion that the intersection of the two lines are approximately equal to the fracture extension pressure. Very difficult to manage in the field with actual high pressure frac pumps.*

2. *The data in the 2nd plot is the comparison of the estimated bottomhole pressures using empirical data from a plot in a PDF file, and friction pressure provided by the operator. The discrepancies are quite large.*





PRODUCED WATER MANAGEMENT PANEL

CURRENT METHODS AND STRATEGIES FOR MANAGING PRODUCED WATER

- Steve Cole – (Five Point Energy)
- Rick McCurdy – (Select Water)
- Doug White - (NGL)

TECHNOLOGIES FOR TREATING PRODUCED WATER AND REGULATORY STATUS ON PERMITS FOR BENEFICIAL REUSE OF THE TREATED WATER

- Robert Sadlier - (TCEQ)
- Zacariah Hildenbrand, PhD (
- Shane Walker, PhD (Texas Produced Water Consortium, TEXAS TECH Water and the Environment Research Center)

PRODUCED WATER MANAGEMENT PANEL

Steve Cole – (Five Point Infrastructure) Mr. Cole is a Partner and Executive Vice President of Five Point Infrastructure. Five Point holds strategic investments across the oil and gas industry's midstream segment, including WaterBridge, LandBridge, San Mateo, Northwind, Twin Eagle, Northwind, Deep Blue Water, Desert Environmental and PowerBridge. Mr. Cole is a board member of the Texas Alliance of Energy Producers, and a past board member of the National Energy Services Association. Mr. Cole holds a B.S. degree in Petroleum Engineering from the University of Louisiana and an Executive M.B.A. from the University of Houston.

Rick McCurdy – (Select Water Solutions) Mr. McCurdy is Vice President of Innovation and Sustainability for Select Water Solutions. In this role, Rick is focused on minimizing freshwater use and evaluating technologies that may lead to beneficial use of a treated produced water in the future. As such, he is an active participant in the produced water consortiums underway in New Mexico, Texas, and Colorado. Prior to Select, Rick served as a Sr. Engineering Advisor for Chesapeake Energy, where he guided produced water management and chemical usage throughout the company. Rick has presented to the National Academy of Sciences, the Government Accountability Office, the Department of Energy, and the Energy Information Agency regarding water use in the Energy Sector. Rick has an AAS degree in Petroleum Technology.

Doug White - (NGL Water Solutions) Mr. White is Executive Vice President of NGL Water Solutions, LLC a diversified, public midstream energy company. Doug oversees the business and operations of one of the largest produced water transportation and management companies in the US. Since 2009, he has been instrumental in the growth of the Water Solutions business with over $2.5 billion of acquisitions and divestitures. The NGL water disposal system processes more than 3.0 million barrels of produced and flowback water per day and operates in several of the largest oil and gas basins in the US. The entire system includes the largest integrated network of large diameter pipelines, recycling facilities, solids disposal facilities and disposal wells in the highly prolific Delaware Basin. Corporation where he held marketing and trading roles across the power and natural gas markets. Doug received a BA in Economics from Regis University in 2001.

PRODUCED WATER MANAGEMENT PANEL

Robert Sadlier - (TCEQ) Mr. Sadlier serves as the Deputy Director of TCEQ's Water Quality Division. Robert began his career with TCEQ in 2011 and has served in several roles including Environmental Investigator, Emergency Response Coordinator, Team Leader, and Manager of the Edwards Aquifer Protection Program. Robert received a Bachelor of Science in Resource and Environmental Studies from Texas State University.

Zacariah Hildenbrand, Ph.D. Dr. Hildenbrand is a partner of Medusa Analytical and Hilman Kraftwerks, a director of the Curtis Mathes Corporation (OTC:CMCZ), and is an Adjunct Research Professor at the University of Texas at El Paso. Dr. Hildenbrand's research has produced more than 70 peer-reviewed scientific journal articles and textbook chapters. He is also an editor of the textbook 'Advances in Chemical Pollution, Environmental Management and Protection: Environmental Issues Concerning Hydraulic Fracturing', and a co-chairman of the EARTHx - Cynthia and George Mitchell Foundation's 2017 and 2018 'Responsible Shale Energy Extraction' Symposia, and a co-chairman of the 2020 Responsible Energy Acquisition Symposium presented by EARTHx. Dr. Hildenbrand has dedicated his career to unconventional fields of research and he relishes the opportunity to improve operational efficiency and environmental stewardship within the energy sector.

Shane Walker, PhD (Texas Produced Water Consortium, TEXAS TECH Water and the Environment Research Center) Dr. Walker is a professor in the Department of Civil, Environmental, and Construction Engineering at Texas Tech University, and he serves as the Director of the Water and the Environment Research (WATER) Center and the Director of the Texas Produced Water Consortium (TxPWC). Dr. Walker teaches courses on physical/chemical treatment processes and the design of advanced water treatment systems, and researches advanced water treatment, especially high recovery inland desalination, potable reuse, and treatment of produced water for beneficial uses.