Water Usage in the Permian Basin: Drilling and Fracturing without Fresh Water

AAPG Global Super Basin Conference – The Permian

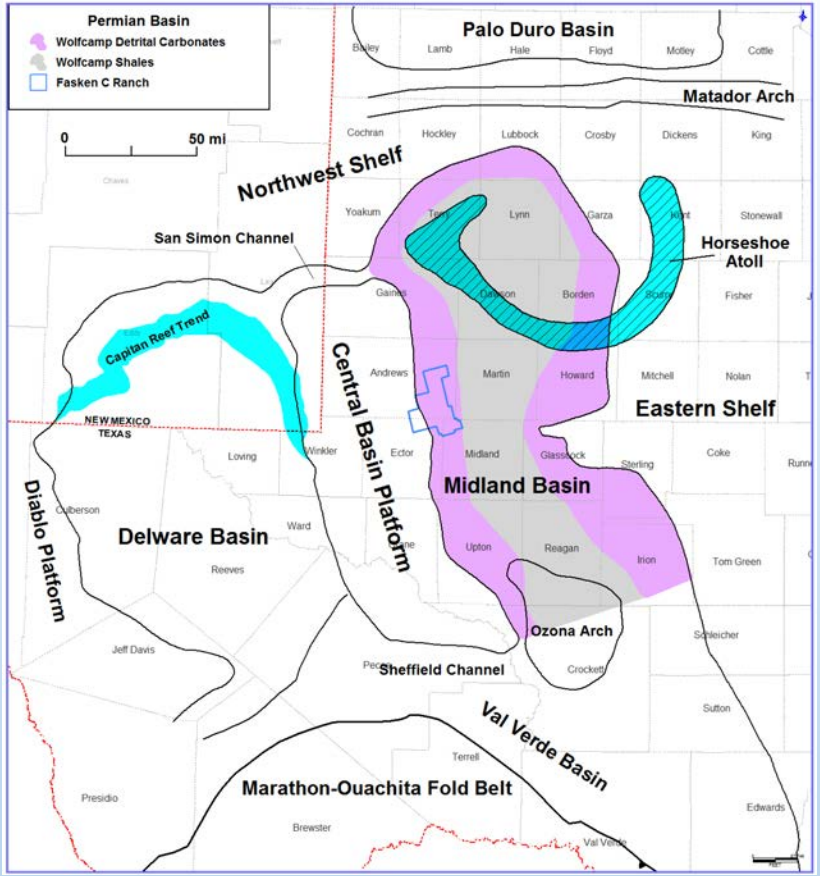
January 23rd - 24th, 2019

Stonnie L. Pollock, Senior Geologist, Fasken Oil and Ranch

FASKEN OIL AND RANCH

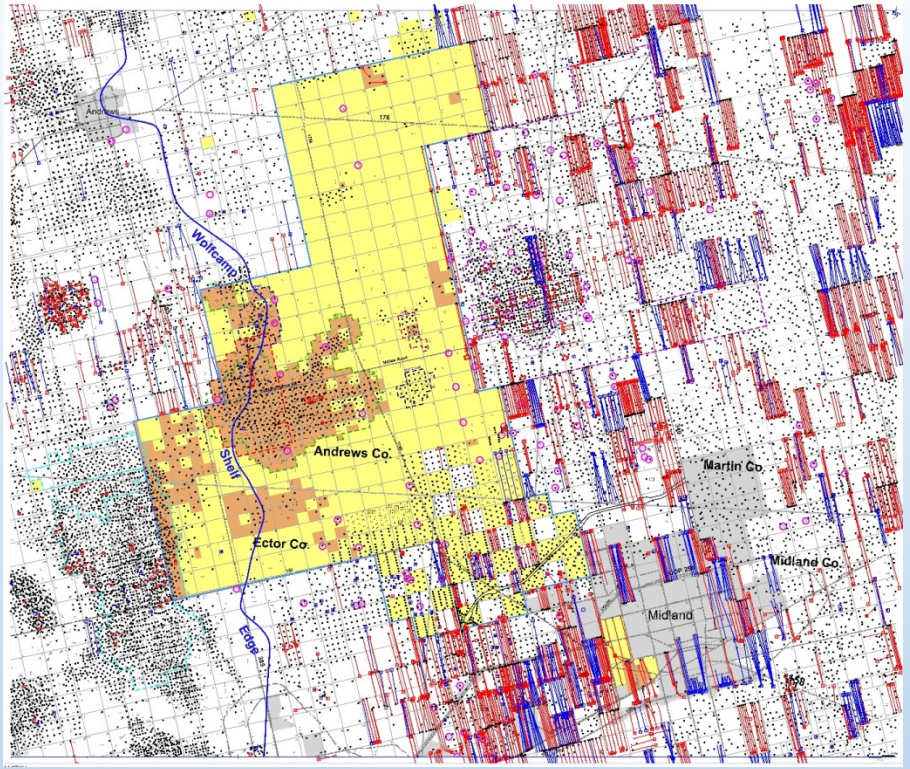
Outline

- Location: Midland Basin – CB Platform
- Fasken Operations
- Aquifers of West Texas
- Dockum Geology
- Santa Rosa Water Production & Treatment
- Produced Water Treatment/Recycling
- Permian Basin Water Usage

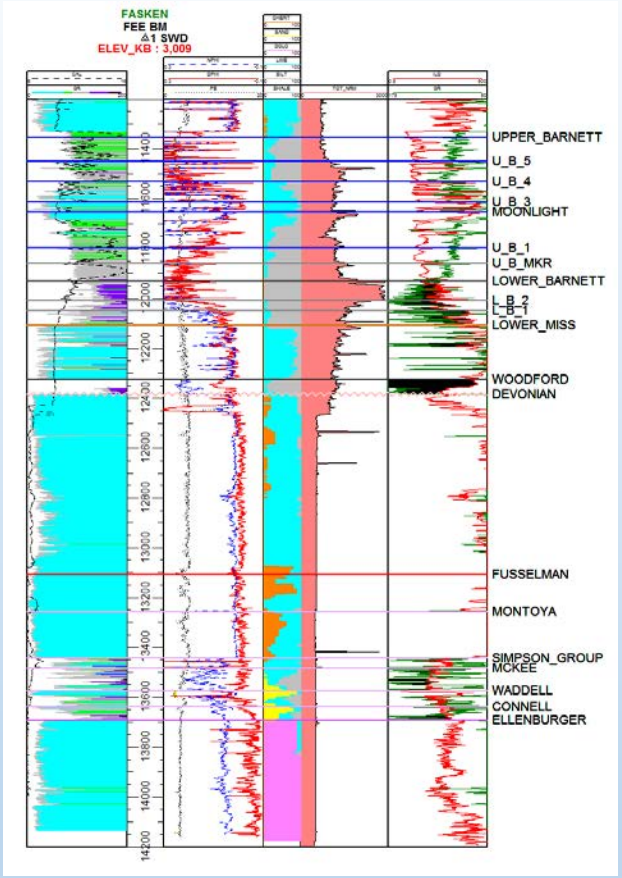


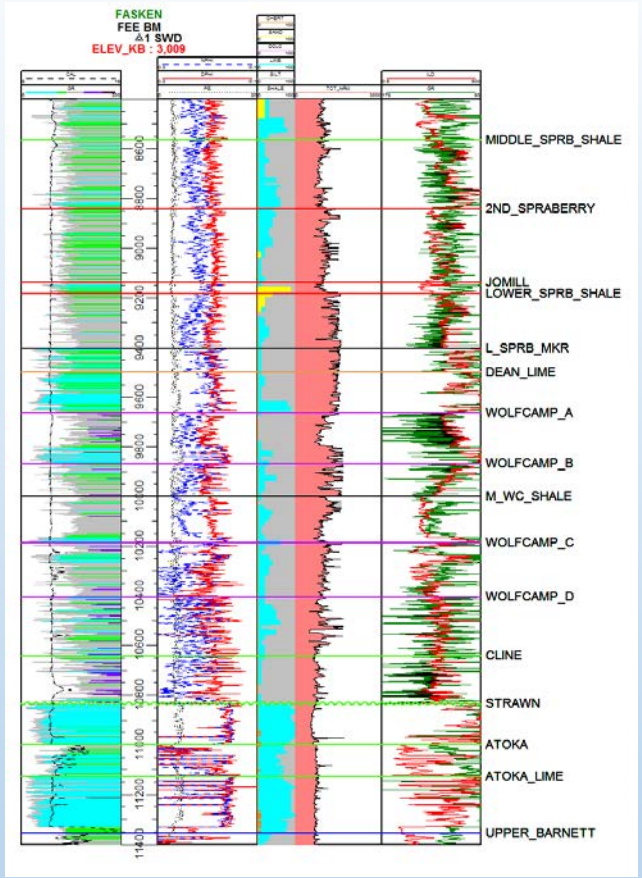
Fasken Operations

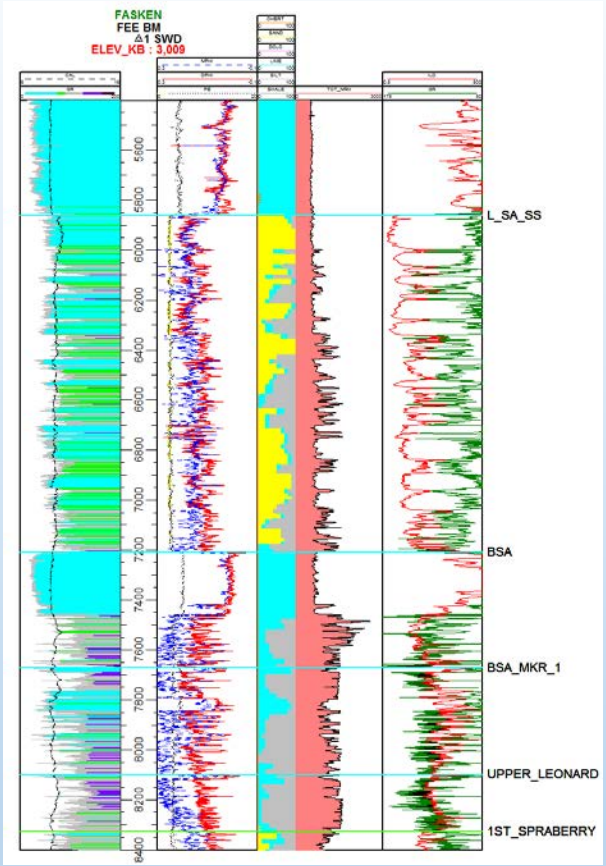
- C Ranch Acreage Position
  - 250 mi2 – 166,000 acres
- Wolfberry Drilling Program
  - 2008 to Present
  - 700 Wolfberry Wells
  - 17 Wolfberry Horizontals
  - 2019 Manor Park Project
- Drilling & Fracing Water Usage
  - Began with Fresh Groundwater (Ogallala)
  - 2013 Begin Producing and Treating Santa Rosa Water from the Dockum Aquifer
  - 2013 Begin Transitioning from SWD to Treated/Recycled Produced Water
  - Vertical vs. Horizontal
    - Volume: 50,000 bbls to 500,000 bbls
  - Larger Frac Pits



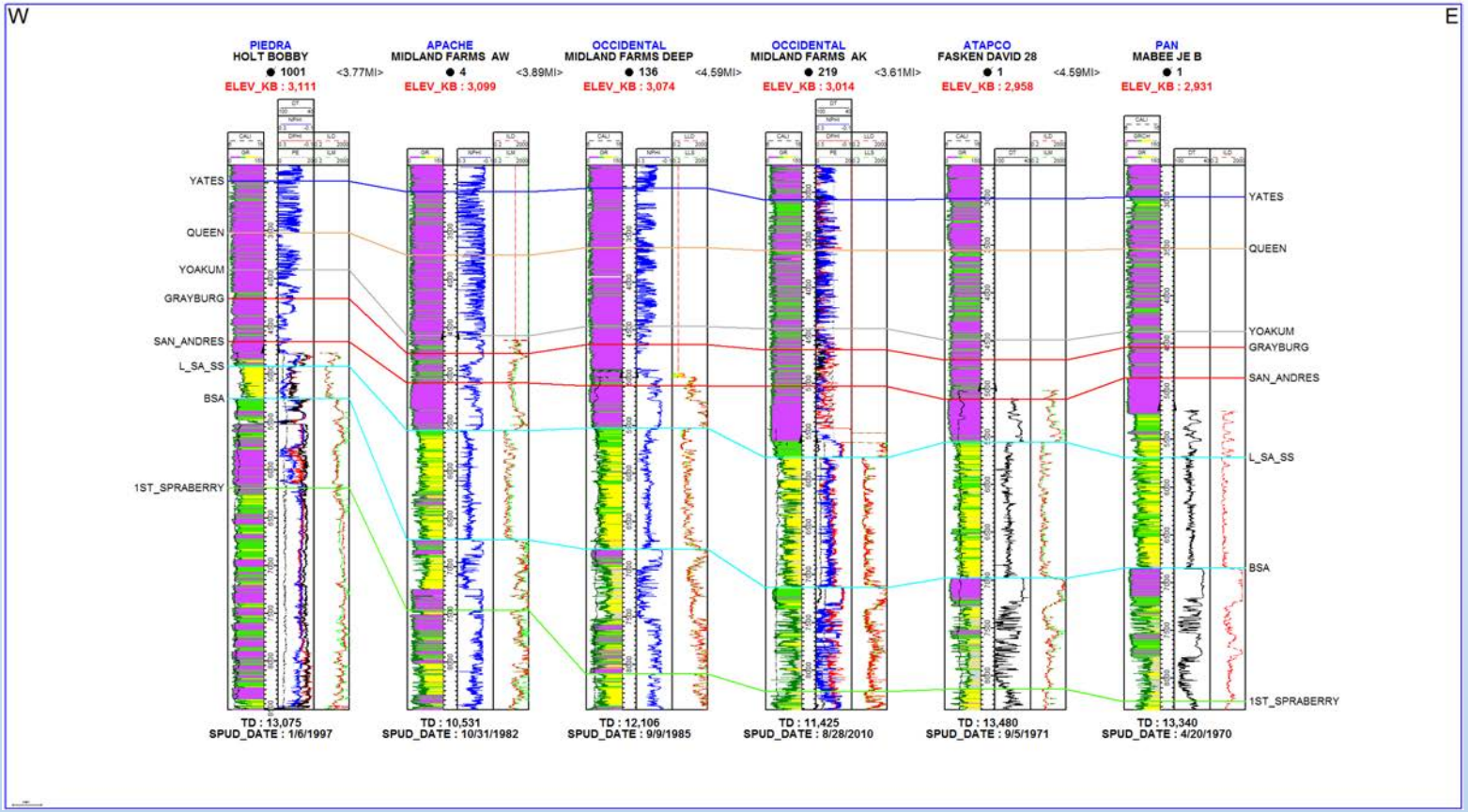
C Ranch Type Log – Ordovician to Permian







Uppermost Leonardian and Guadalupian Section – From NCU to MFU to Mabee



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Aquifers of Texas

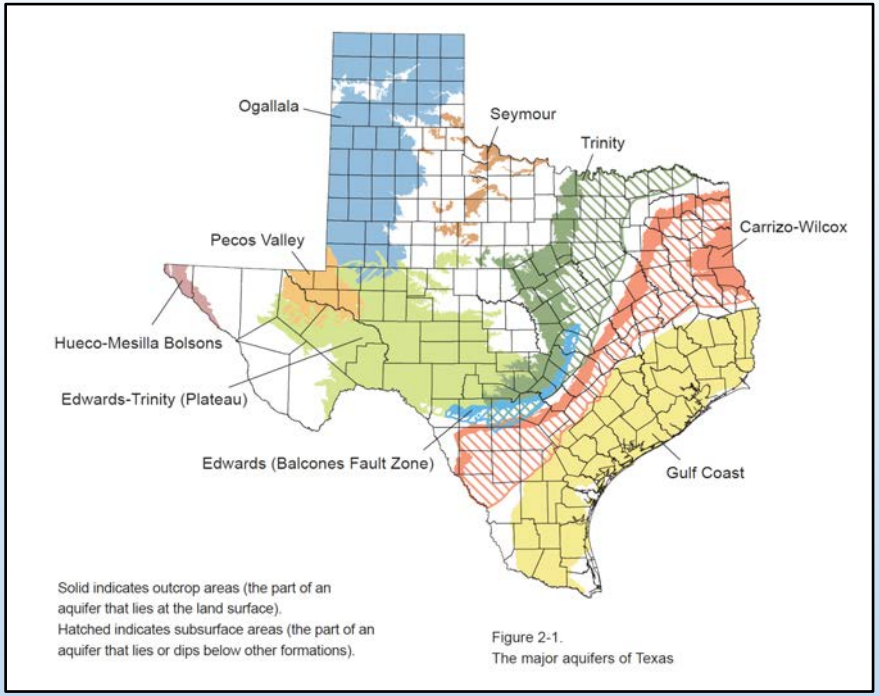


Figure 2-1.
The major aquifers of Texas

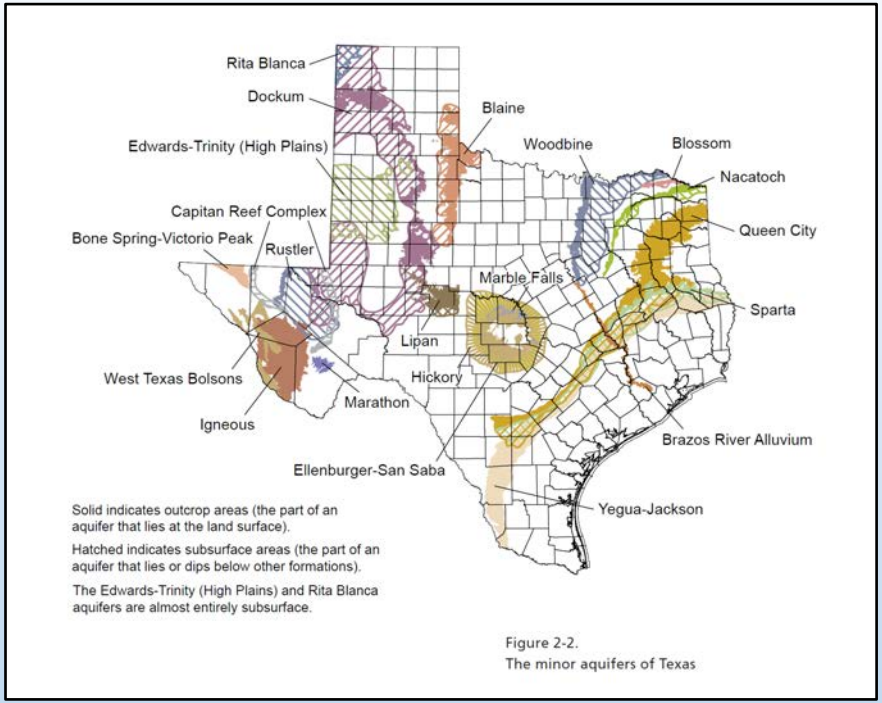
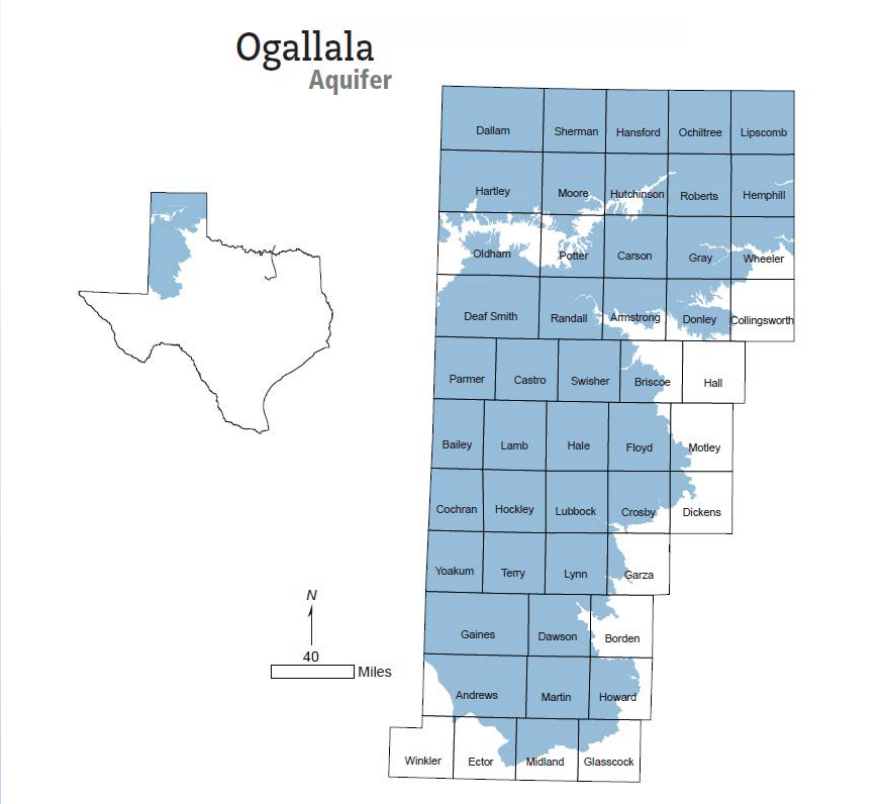
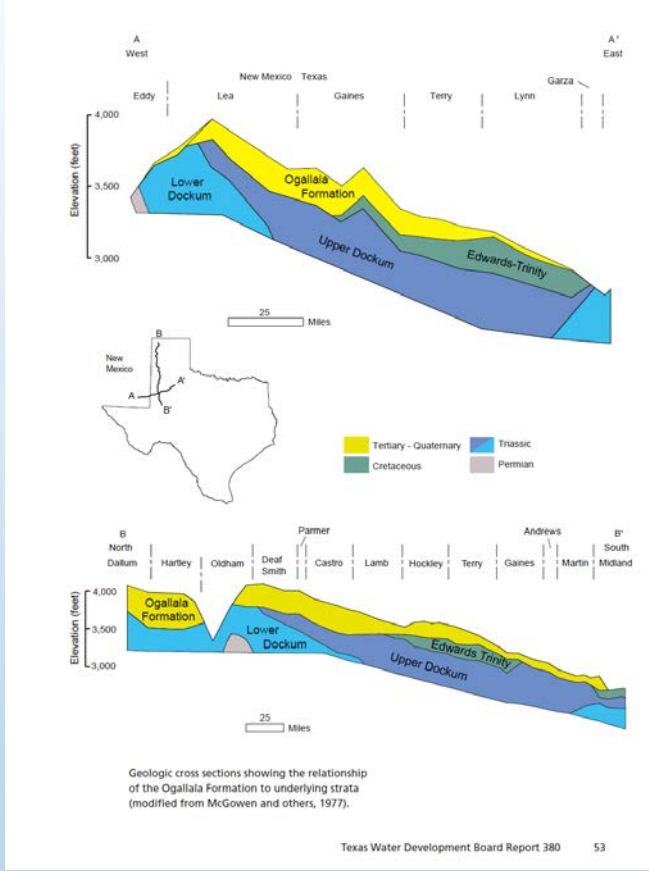


Figure 2-2.
The minor aquifers of Texas

George, P.G., Mace, R.E., Petrossian, R., 2011, Aquifers of Texas: Texas Water Development Board Report 380, 172p.

Ogallala Aquifer

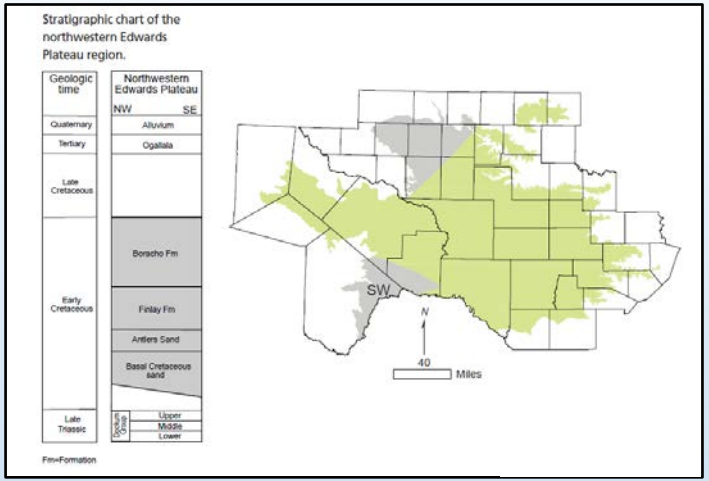


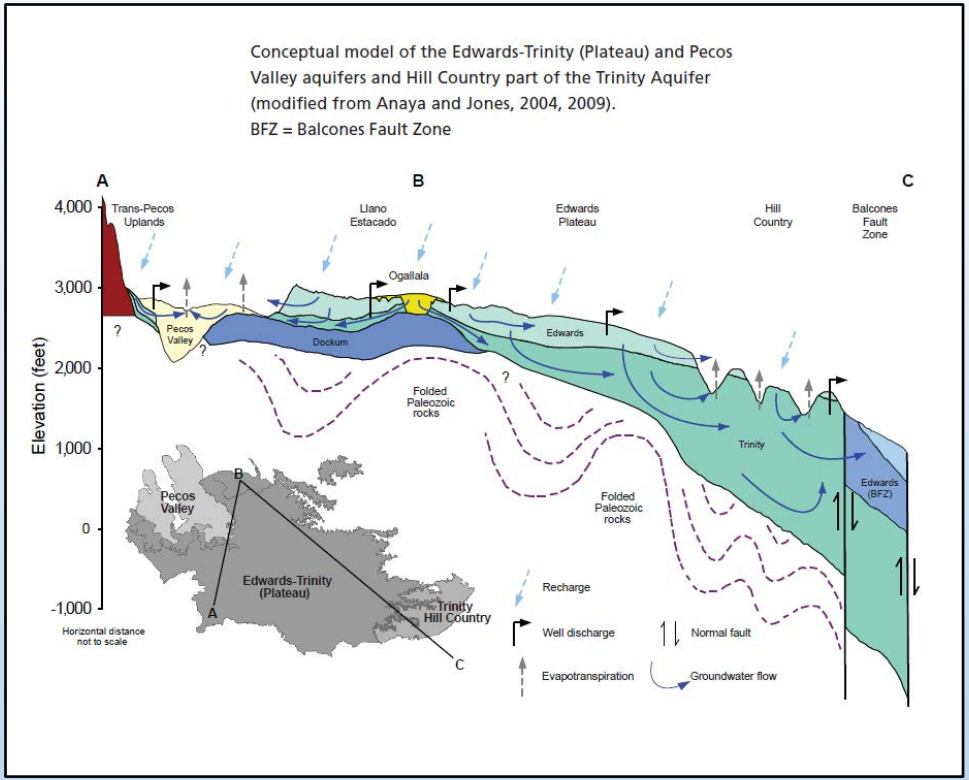


Geologic cross sections showing the relationship of the Ogallala Formation to underlying strata (modified from McGowen and others, 1977).

George, P.G., Mace, R.E., Petrossian, R., 2011, Aquifers of Texas: Texas Water Development Board Report 380, 172p.

Edwards Trinity Aquifer





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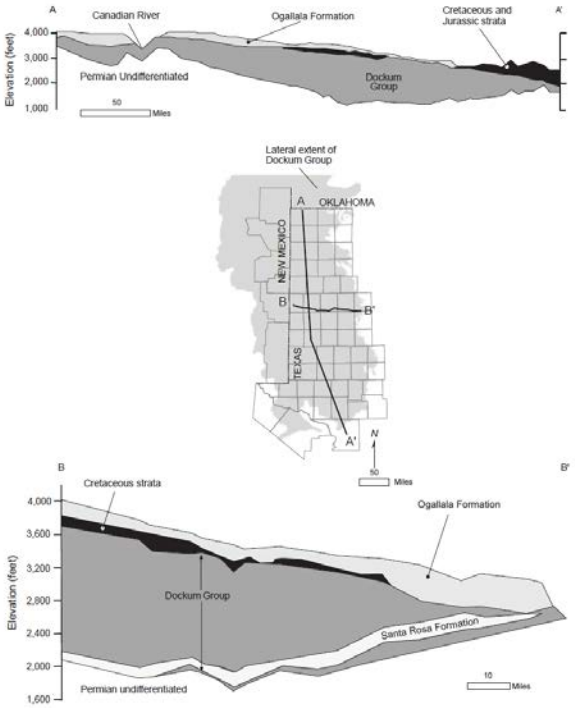
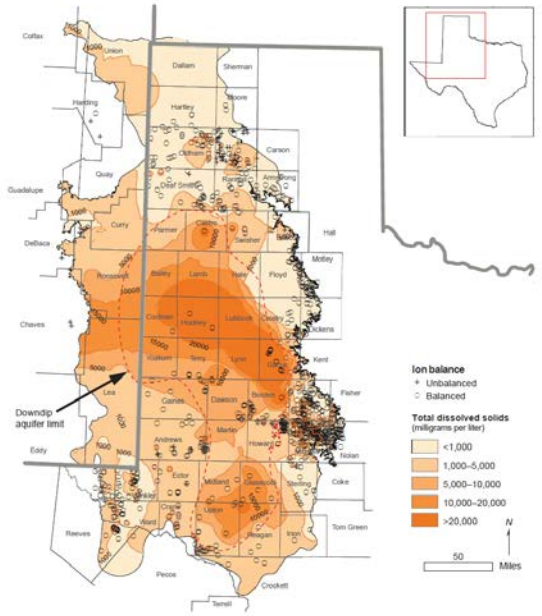
Dockum Aquifer



Geologic cross sections along (A-A') and across (B-B') the Dockum Aquifer (modified from Bradley and Kalaswad, 2003).

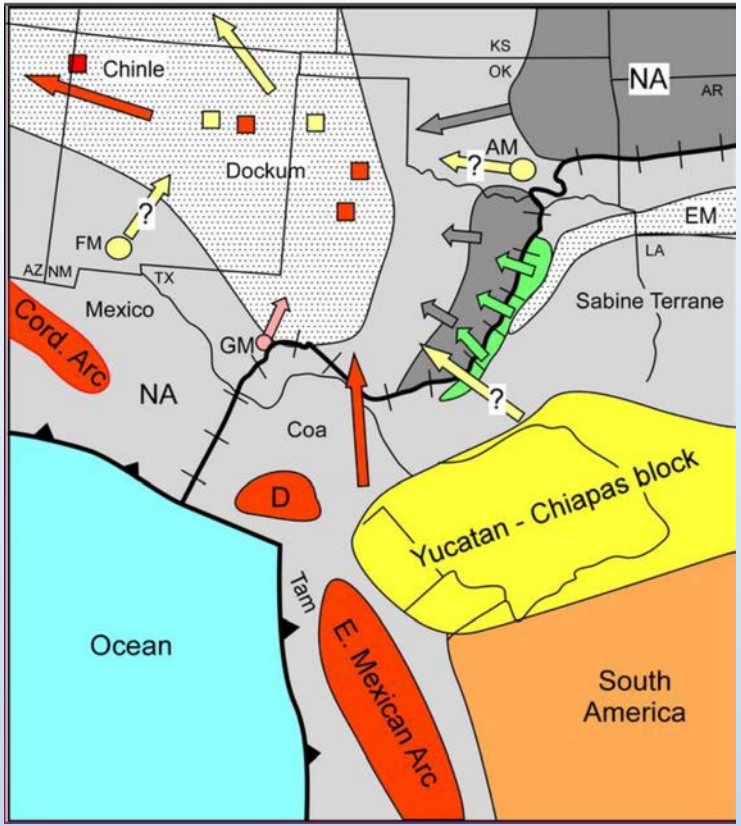


Total dissolved solids in groundwater from the Dockum Aquifer (from Ewing and others, 2008). mg/l=milligrams per liter

George, P.G., Mace, R.E., Petrossian, R., 2011, Aquifers of Texas: Texas Water Development Board Report 380, 172p.

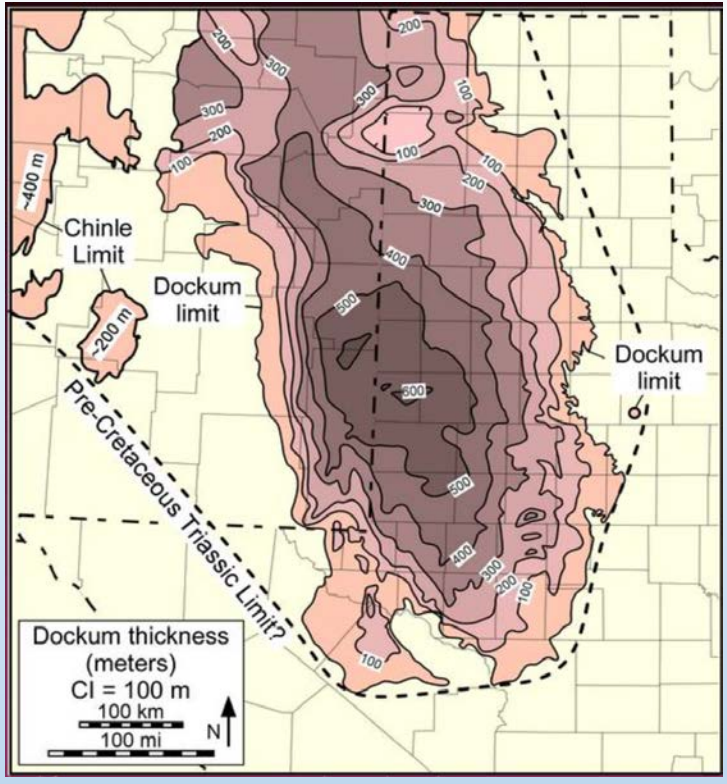
Dockum Geology

Late Triassic Paleographic Map

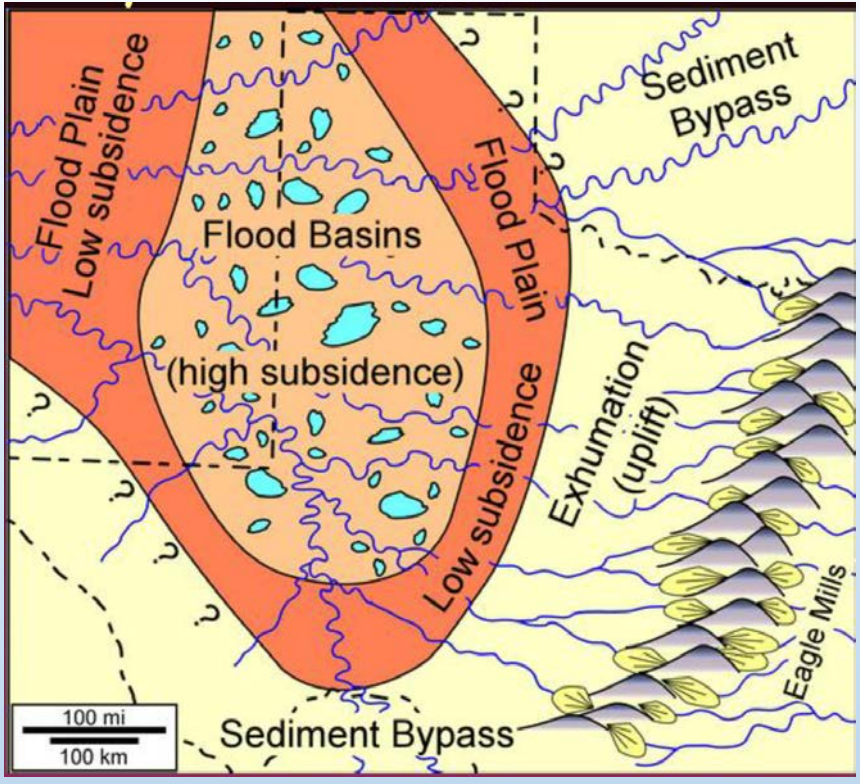


Brown (2016), Modified from Dickinson and Lawton (2001)

Tectonics and Sedimentation of the Dockum

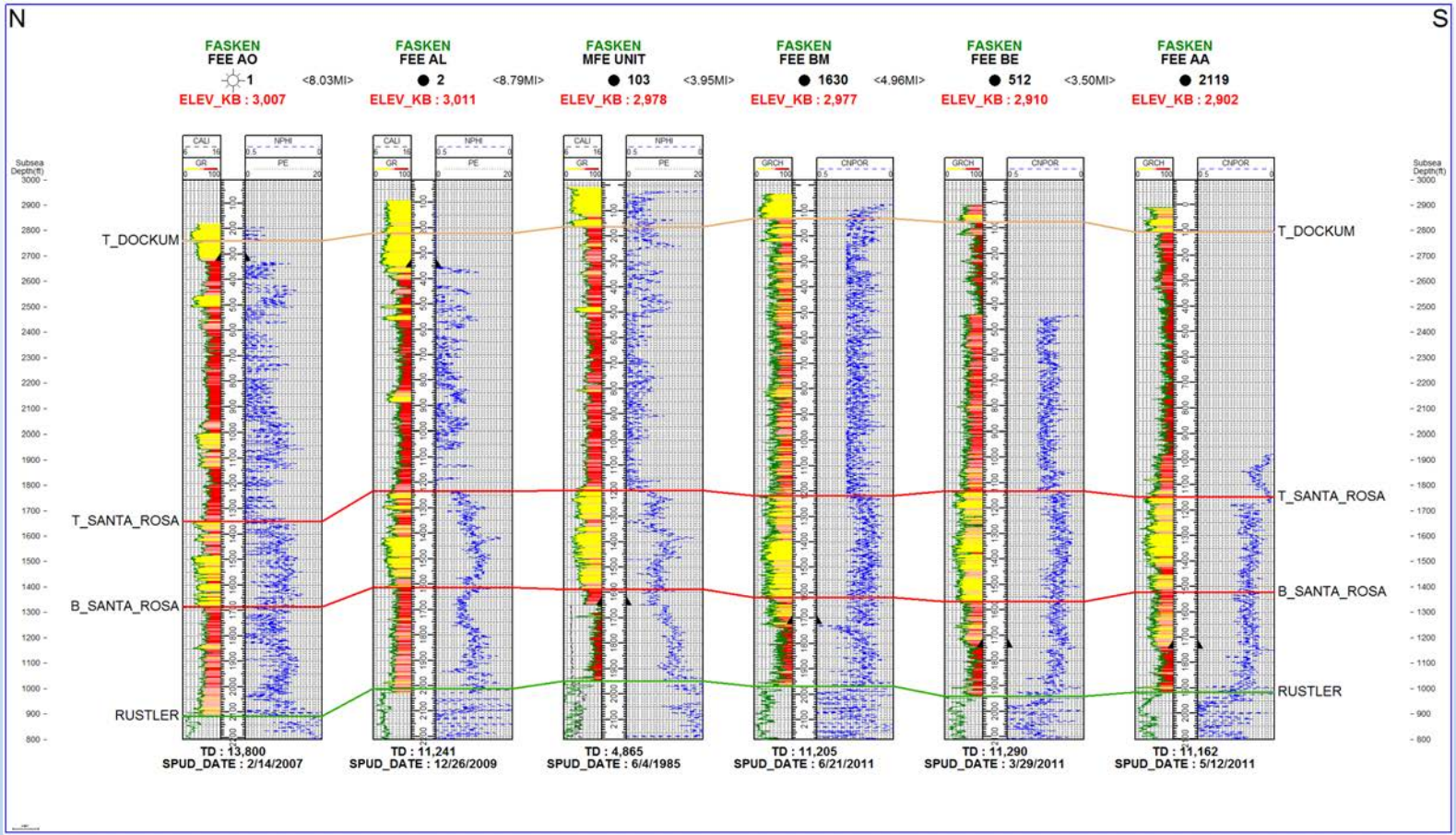


Brown (2016), Modified from McGowen, Granata, and Seni (1977)



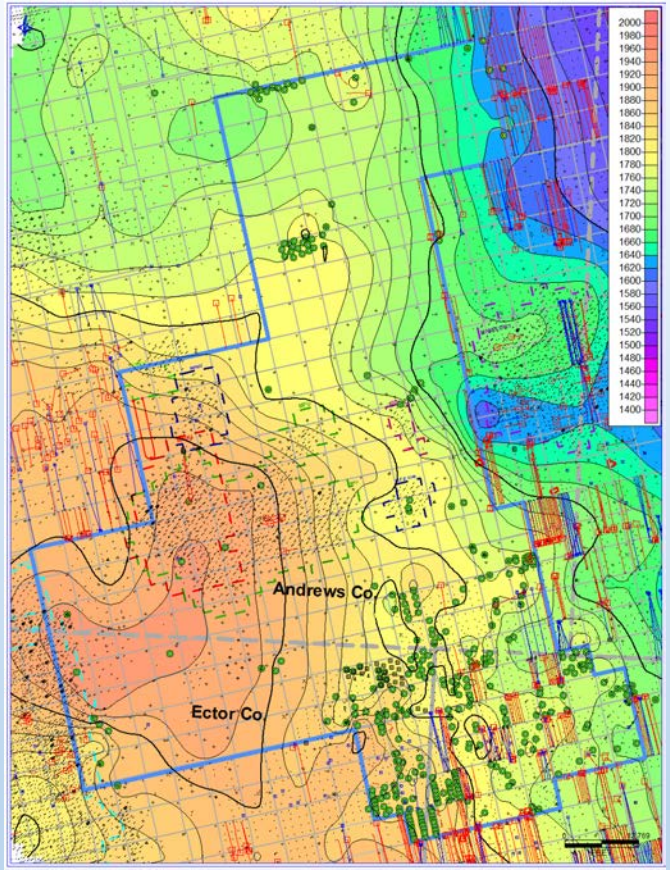
Brown (2016)

Cross Section of Dockum Group

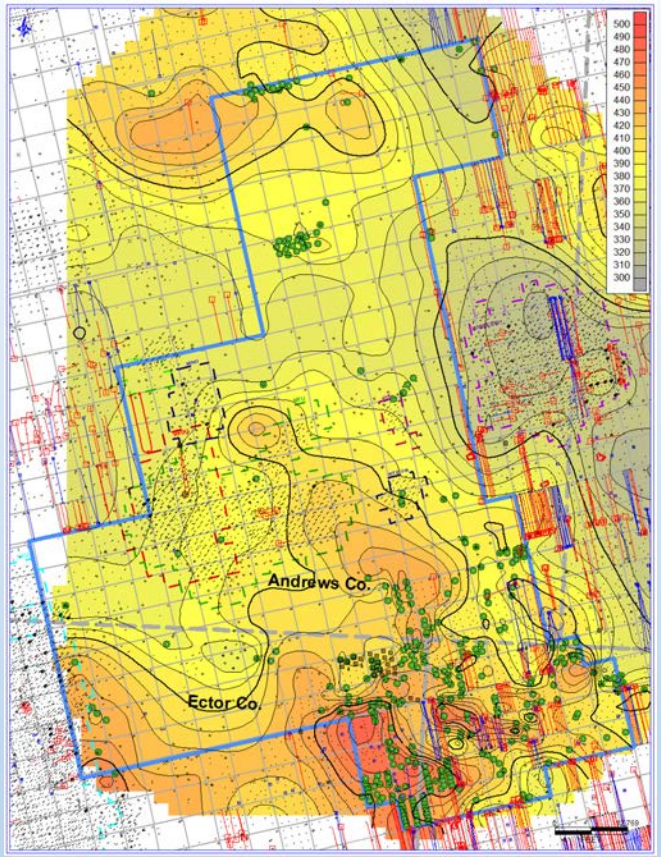


Santa Rosa Sandstone

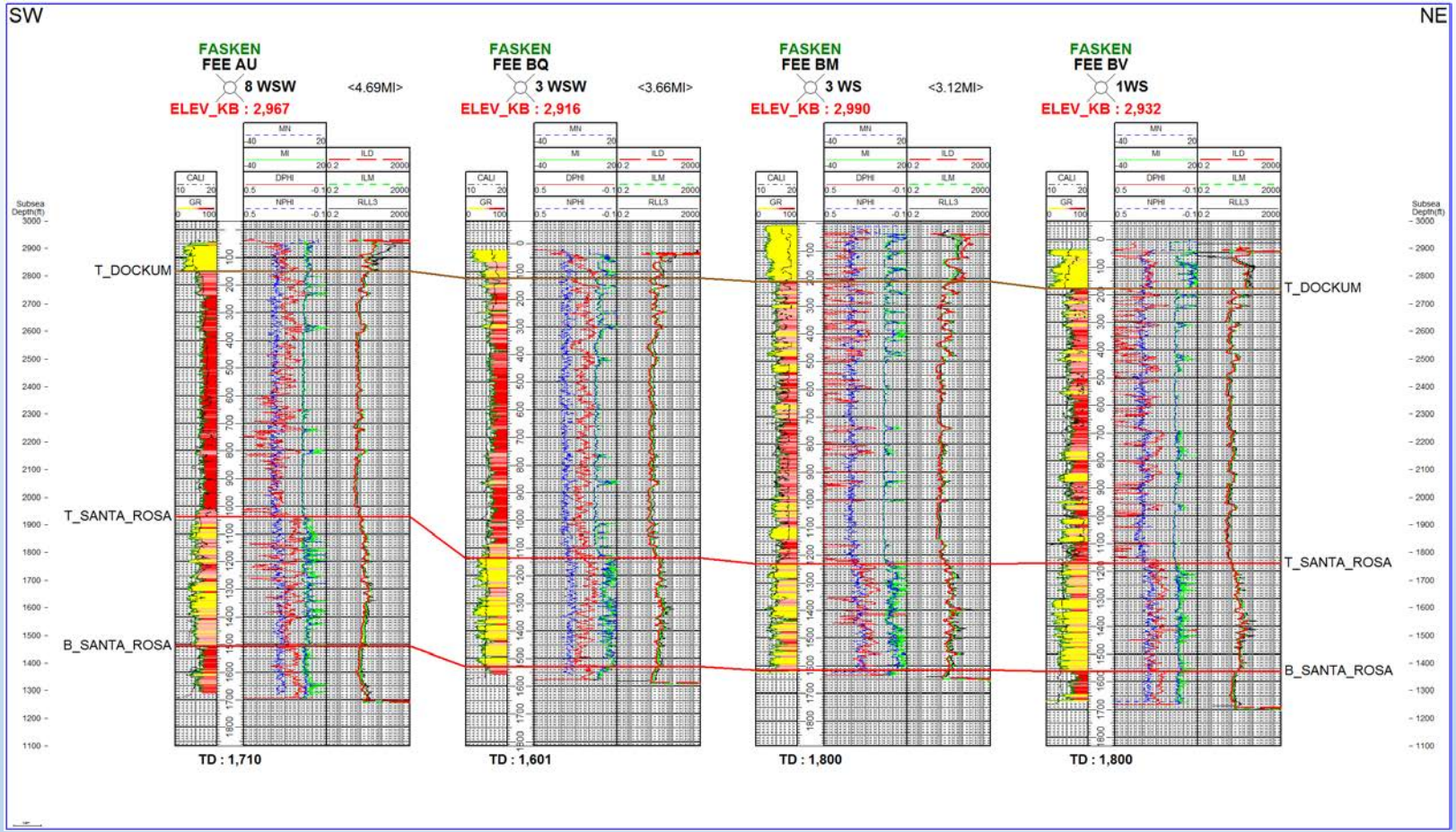
Top Santa Rosa



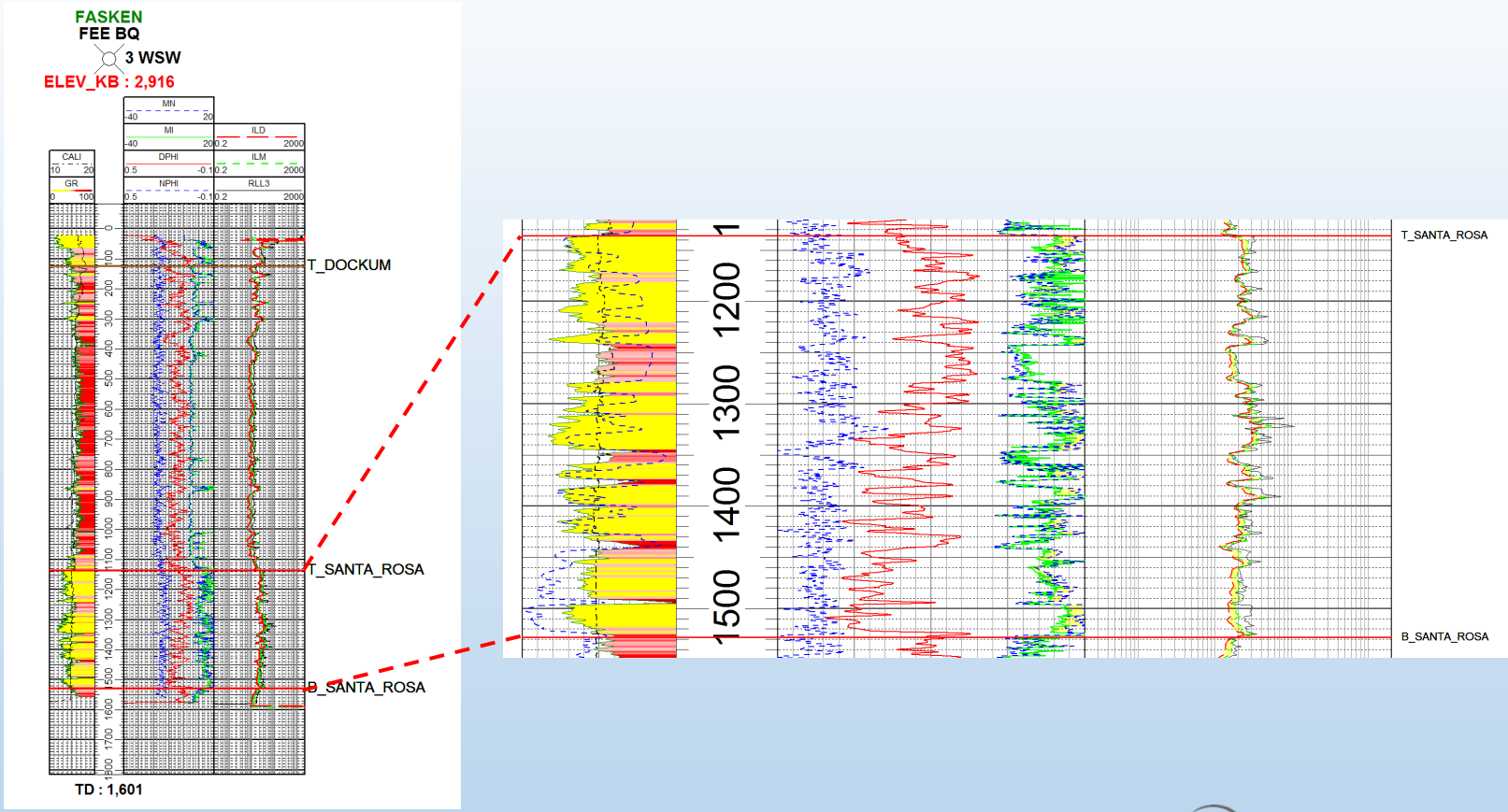
Isopach Santa Rosa



Open-Hole Logging of the Santa Rosa



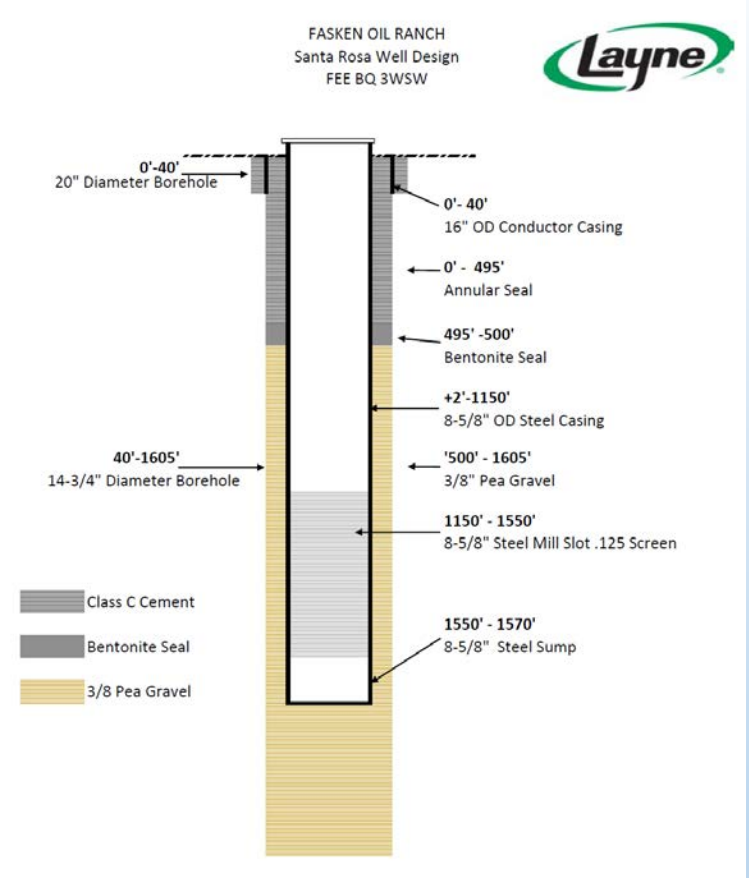
Santa Rosa Water Sand



Santa Rosa Water Production

- Fasken Operates 14 Wells
  - 4 Plugback/Re-Entries
  - 10 Drilled
  - 3 Inactive
  - 5 New Wells
    - Currently Testing
    - See Wellbore Diagram
- Depth = 1,600’
- Average Interval = 1,100’-1,500’
- Current Production = 24,160 BWPD
- Drilled and Equipped Cost = $225,000
- Average Rate = 2,500 BWPD

- Production Cost = $0.09 per raw bbl



Santa Rosa Water Treatment – RO Facility

Santa Rosa Reverse Osmosis Water Treatment

- Average RO Feed = 3,964 BWPD
- Average Rejection = 1,467 BWPD
- Average Production = 2,498 BWPD
- 2018 Production = 911,624 BW
- Treatment Cost = $0.29 per bbl
- Usage = Drilling, Cementing, and Camp Water
- Brine Water for Drilling Salt Section
  - Purchase about 1,500 BW, then reuse

- Water Per Well
  - 11,500’ Vertical Wolfberry Well = 4,000 BW
  - 20,000’ Horizontal = 10,000 BW
  - Cementing = 500 – 1000 BW
  - Camp Water = 500 BW

Santa Rosa - Reverse Osmosis Water Treatment

Raw Water

WaterBusters, Fasken Oil, Fasken ,Pre MMF

Field Data	
Initial Temperature (°F):	190
Final Temperature (°F):	80
Initial Pressure (psi):	1250
Final Pressure (psi):	15
Sample Specifics	
pH:	7.8

Alkalinity by Titration:	mg/L	meq/L
Bicarbonate (HCO_3^-):	431	7.1
Carbonate (CO_3^{2-}):	0.0	0.0
Hydroxide (OH^-):	ND	
aqueous CO_2 (ppm):	ND	
aqueous H_2S (ppm):	0.7	
Calculated TDS (mg/L):		4702
Calculated Density (g/cm³):		1.0006
Resistivity (Ωcm):		N/A
Conductivity (mS/cm):		N/A
Turbidity (NTU):		N/A

N/A - Not Applicable

Analysis of Sample

Anions:	mg/L	meq/L
Chloride (Cl^-):	1530	43.2
Sulfate (SO_4^{2-}):	920	19.2
Borate (H_3BO_3):	6.0	0.1
Silica (SiO_2):	10.5	0.2
Phosphate (PO_4^{3-}):	0.6	0.0
Anion EPM Total:		69
% RPD of Cations/Anions:		13.6%

Cations:	mg/L	meq/L
Sodium (Na^+):	1699	73.9
Potassium (K^+):	14.3	0.4
Magnesium (Mg^{2+}):	23.8	2.0
Calcium (Ca^{2+}):	66.6	3.3
Strontium (Sr^{2+}):	ND	
Barium (Ba^{2+}):	ND	
Iron (Fe^{2+}):	1.1	0.0
Manganese (Mn^{2+}):	ND	
Lead (Pb^{2+}):	0.1	0.0
Zinc (Zn^{2+}):	0.1	0.0
Lithium (Li^+):	0.3	0.0
Aluminum (Al^{3+}):	ND	
Total Hardness ($CaCO_3$):	264	
Cation EPM Total:		80

ND = Not Detected

Treated Water

WaterBusters, Fasken Oil, Fasken ,Plant 5 Perm

Field Data	
Initial Temperature (°F):	190
Final Temperature (°F):	80
Initial Pressure (psi):	1250
Final Pressure (psi):	15
Sample Specifics	
pH:	6.2

Alkalinity by Titration:	mg/L	meq/L
Bicarbonate (HCO_3^-):	12.4	0.2
Carbonate (CO_3^{2-}):	0.0	0.0
Hydroxide (OH^-):	ND	
aqueous CO_2 (ppm):	10.0	
aqueous H_2S (ppm):	1.2	
Calculated TDS (mg/L):		724
Calculated Density (g/cm³):		0.9975
Resistivity (Ωcm):		N/A
Conductivity (mS/cm):		N/A
Turbidity (NTU):		N/A

N/A - Not Applicable

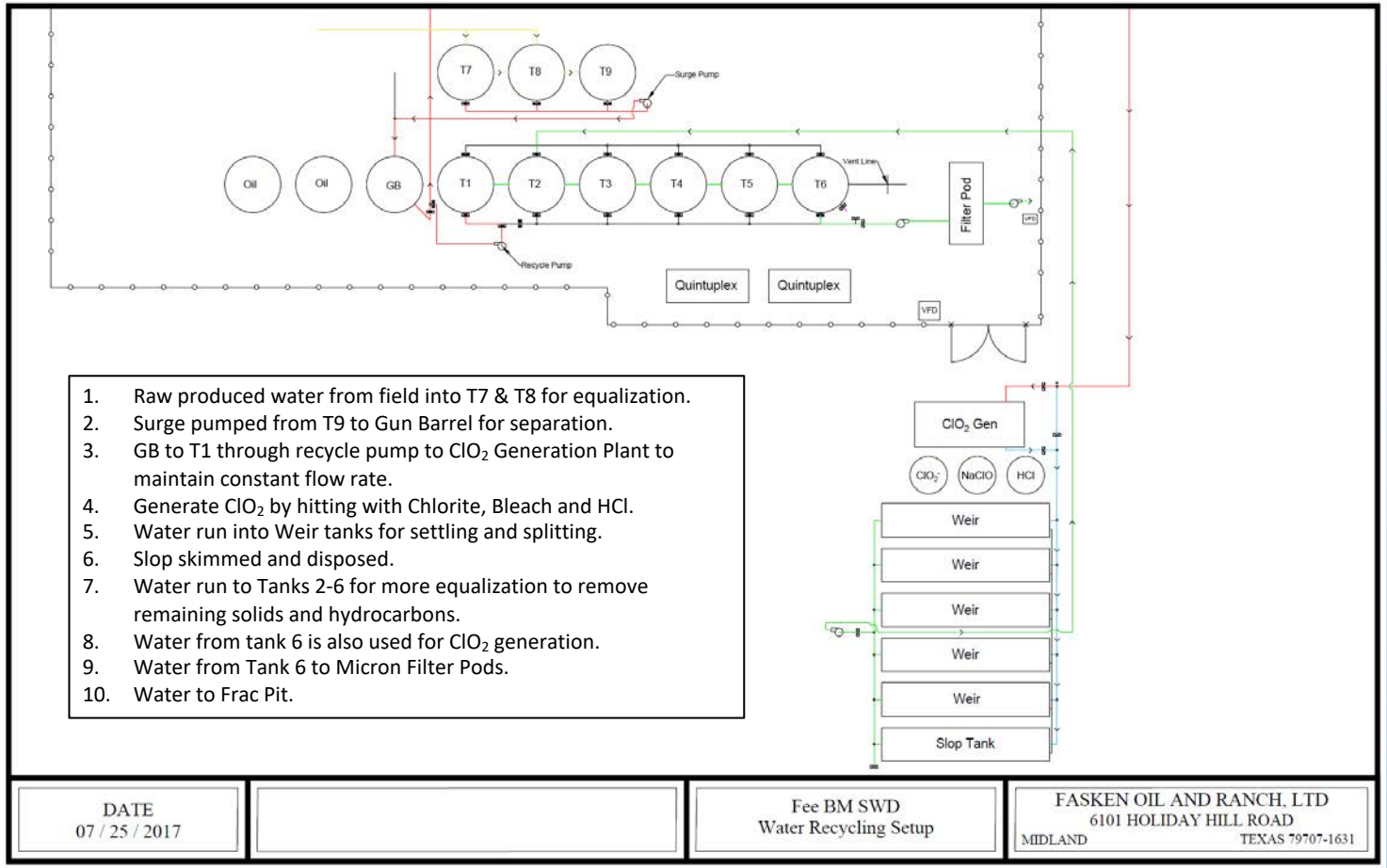
Analysis of Sample

Anions:	mg/L	meq/L
Chloride (Cl^-):	600	16.9
Sulfate (SO_4^{2-}):	10.0	0.2
Borate (H_3BO_3):	3.0	0.0
Silica (SiO_2):	0.5	0.0
Phosphate (PO_4^{3-}):	0.3	0.0
Anion EPM Total:		17
% RPD of Cations/Anions:		119.7%

Cations:	mg/L	meq/L
Sodium (Na^+):	76.2	3.3
Potassium (K^+):	0.6	0.0
Magnesium (Mg^{2+}):	1.0	0.1
Calcium (Ca^{2+}):	18.7	0.9
Strontium (Sr^{2+}):	1.0	0.0
Barium (Ba^{2+}):	ND	
Iron (Fe^{2+}):	ND	
Manganese (Mn^{2+}):	ND	
Lead (Pb^{2+}):	ND	
Zinc (Zn^{2+}):	ND	
Lithium (Li^+):	ND	
Aluminum (Al^{3+}):	ND	
Total Hardness ($CaCO_3$):	52.1	
Cation EPM Total:		4

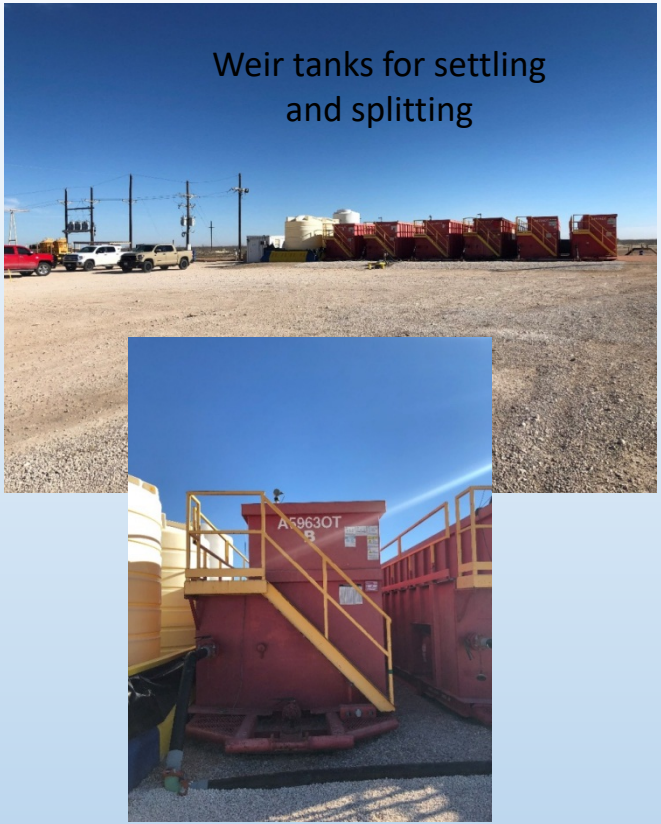
ND = Not Detected

Produced Water Treatment – Fee BM SWD Water Recycling Facility



Fee BM SWD Water Recycling Facility

Battery for separation and equalization



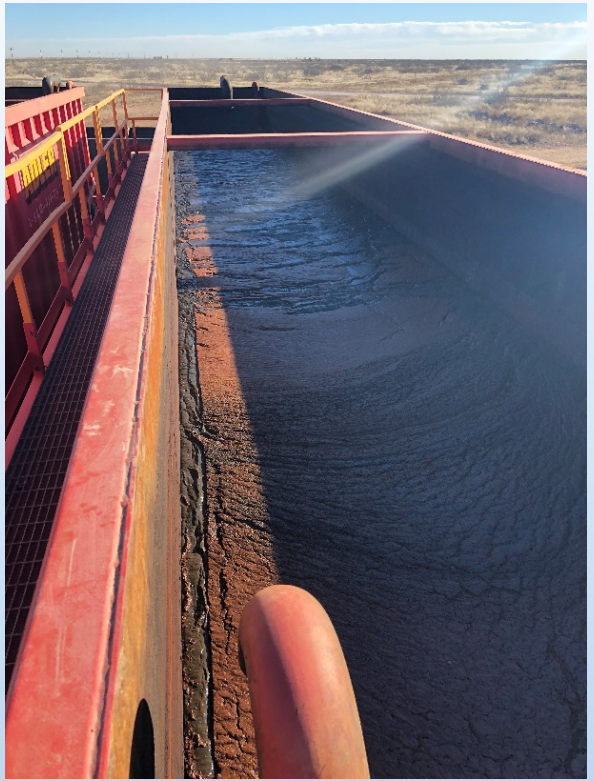
Fee BM SWD Water Recycling Facility

ClO^2 Generation Plant

Fee BM SWD Water Recycling Facility

Skimming Slop

Slop Tank



Splitting Water through Weir Levels

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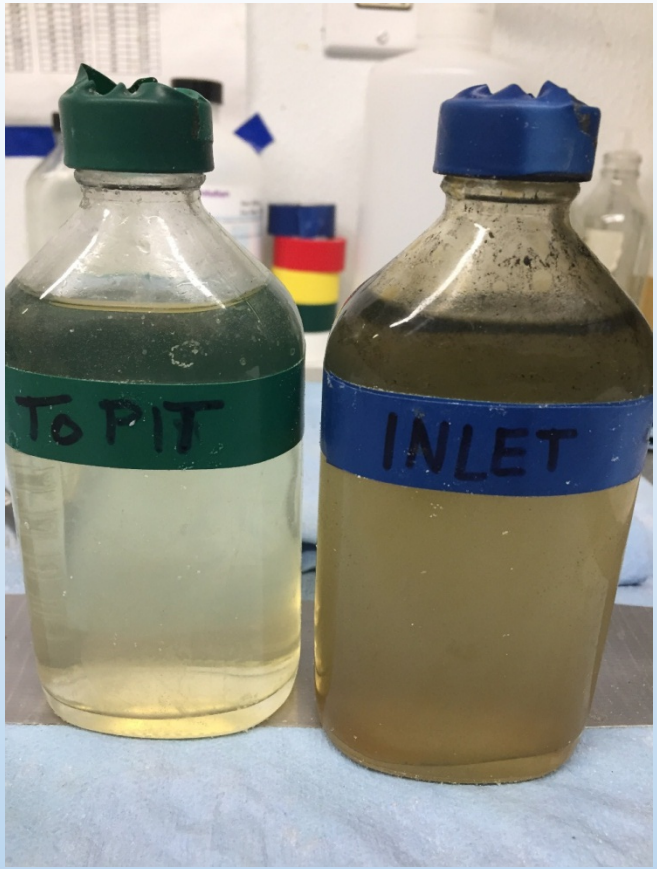
Fee BM SWD Water Recycling Facility

Filter Pods:
16 - 10 micron socks
16 - 5 micron socks

Inlet-to-Pit Chemistry

ClO2 Dosage	Before Weir ClO2 Res	After Weir ClO2 Res	To Pit ClO2 Res	Inlet pH	After Weir pH	To Pit pH	Inlet ORP	After Weir ORP	To Pit ORP	Inlet Iron (mg/L)	After Weir Iron (mg/L)	To Pit Iron (mg/L)	Inlet TDS (mg/L)	After Weir TDS (mg/L)	To Pit TDS (mg/L)
145	2.90	2.43	2.24	4.15	5.82	6.03	48.00	410.00	465.00	45.00	3.00	3.00	236.40	245.10	238.70
145	4.05	2.29	2.28	6.01	5.74	5.93	46.00	409.00	437.00	40.00	4.00	4.00	214.80	240.50	249.00
145	4.48	2.46	2.26	6.25	5.76	6.02	75.00	444.00	410.00	27.00	4.00	3.00	233.30	228.60	215.50
145	4.48	2.84	1.90	6.28	5.74	6.08	65.00	417.00	423.00	33.00	3.00	3.00	221.20	225.80	248.10
145	3.73	1.89	1.69	6.13	5.76	6.04	45.00	438.00	432.00	29.00	3.00	3.00	210.80	246.40	222.60
145	5.37	2.68	2.48	6.05	5.56	5.69	52.00	285.00	233.00	37.00	3.00	5.00	243.80	247.50	215.00
145	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
145	5.80	4.29	2.61	6.04	5.84	5.98	51.00	432.00	401.00	45.00	7.00	6.00	241.00	229.00	219.00
145	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
145	6.90	4.21	2.81	6.21	5.79	6.07	39.00	421.00	393.00	42.00	8.00	6.00	244.00	241.00	239.00
142	6.10	4.43	3.12	6.16	5.83	6.01	42.00	401.00	389.00	51.00	10.00	7.00	243.00	239.00	241.00
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Raw to Treated Produced Water



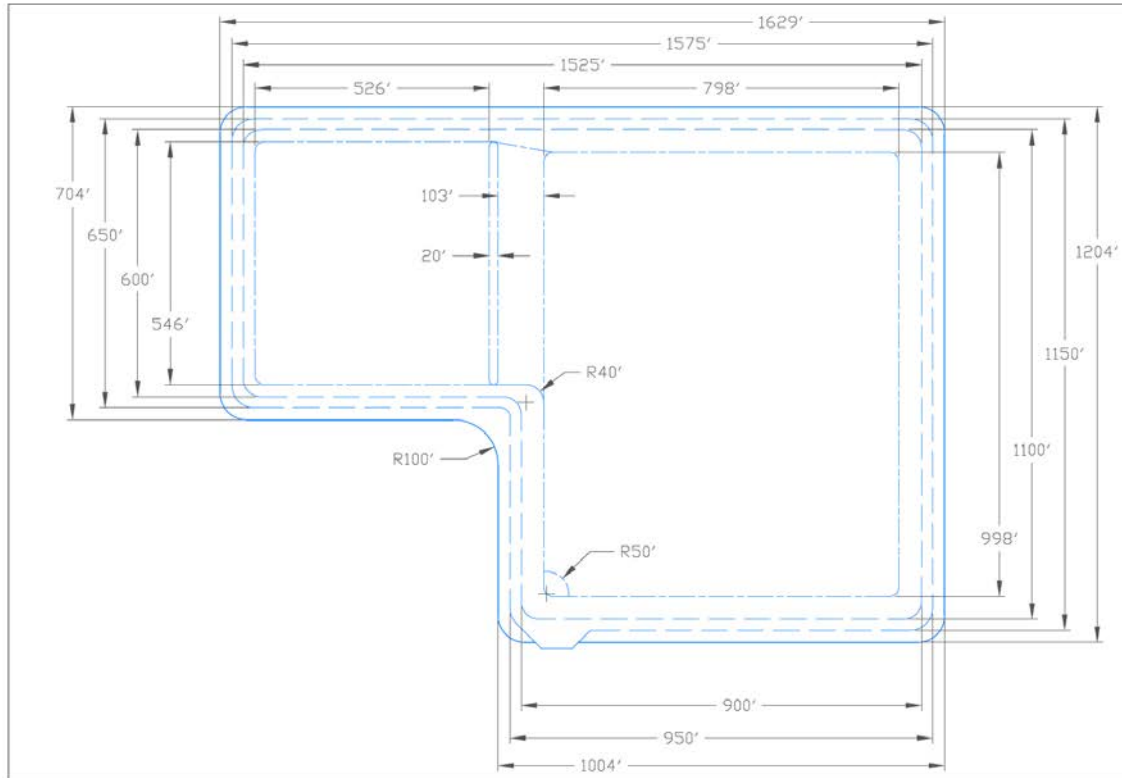
Fee BN Treatment Frac Pits – 800,000 bbls per pit

Produced Water Treatment - Recycling

- Current Procedure: Treated Produced Water mixed with Raw Santa Rosa Water
- Capacity at Fee BN Pit to Treat Produced Water = 15,000 BWPD
- Current Production = 8,092 BWPD
- Current Raw Santa Rosa Mix Volume = 3,782 BWPD
- Total Frac Water = 11,874 BWPD
- 2018 Treated Production = 2,223,603 BW
- Total 2018 Frac Water = 3,603,895 BW
- Treatment Cost = Ave. $0.60 bbl
- SWD Cost (public) = $0.75 bbl
- Beginning in 2013, Fasken eliminated the use of Fresh Groundwater for Drilling & Fracing
  - Exceptions…..?

Fee AA Frac Pit for Manor Park Project – 2,500,000 bbls

Fee AA Frac Pit Dimensions



DIRECTIONS

Enter west-side cattle guard 0.22 miles north of intersection W. County Rd 60 and Hwy 158. Follow lease road (outlined in red) for 0.65 miles and proposed location will be on the north side of road.

SPECIFICATIONS

Pit Dimensions

- West Pit
  - Bottom: 546' x 546' (ground level)
  - Top: 600' x 600'
  - Depth: 9'
- East Pit
  - Bottom: 798' x 998'
  - Top: 900' x 1,100'
  - Depth: 17'

Overall Dimensions

- Footprint: 1,629' x 1,204'
- East pit below grade: 8'
- West pit floor at ground level

PROCEDURE

Step 1: Excavate main pit (east pit) depth to 8'. Removed material will be used for wall construction. One call and all approval permitting must be complete prior to excavation.

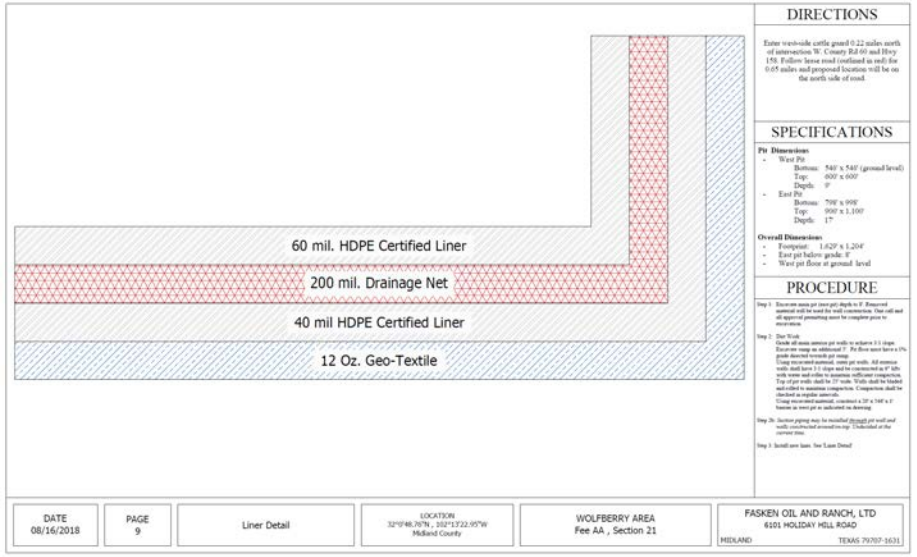
Step 2: Dirt Work
Grade all main interior pit walls to achieve 3:1 slope. Excavate sump an additional 5'. Pit floor must have a 1% grade directed towards pit sump.
Using excavated material, outer pit walls. All exterior walls shall have 3:1 slope and be constructed in 6" lifts with water and roller to maintain sufficient compaction. Top of pit walls shall be 25' wide. Walls shall be bladed and rolled to maintain compaction. Compaction shall be checked in regular intervals.
Using excavated material, construct a 20' x 546' x 1' barrier in west pit as indicated on drawing.

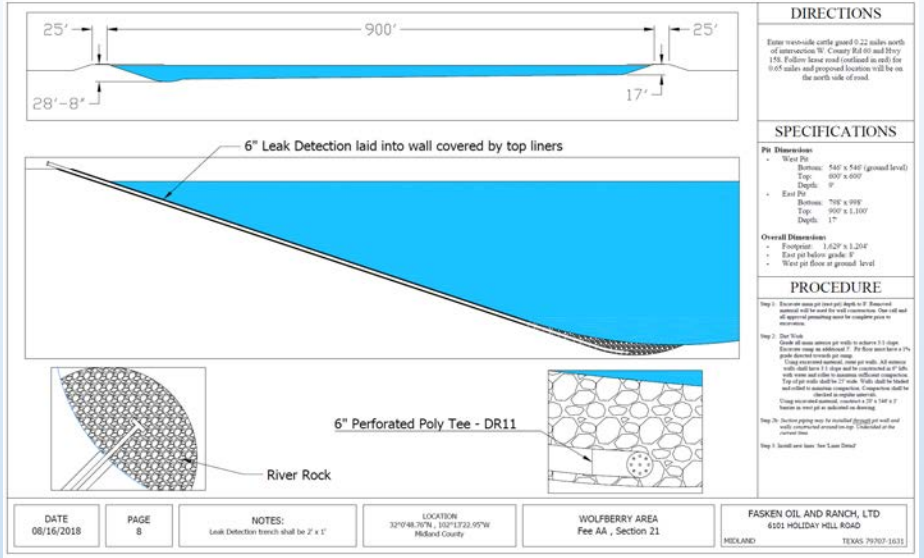
Step 2b: *Suction piping may be installed through pit wall and walls constructed around/on-top. Undecided at the current time.*

Step 3: Install new liner. See 'Liner Detail'

DATE	PAGE		LOCATION		
08/16/2018	3	Fee "AA" Frac Pit Dimensions	32°0'48.76"N , 102°13'22.95"W Midland County	WOLFBERRY AREA Fee AA , Section 21	FASKEN OIL AND RANCH, LTD 6101 HOLIDAY HILL ROAD MIDLAND TEXAS 79707-1631

Fee AA Frac Pit Liner & Leak Detection





FASKEN OIL AND RANCH

Water Management

Basin Comparison

Play	Fracs/month	Bbl/frac	% Slickwater	Produced Water Recycling
Marcellus	90	275,000	95	Most produced water is recycled
Bakken	90	200,000	70	Nearly no recycling
SCOOP & STACK	100	275,000	50	Recycling is being planned and growing
Eagle Ford	160	250,000	55	Very little recycling
Permian	400	500,000	55	About 30% and growing

Slickwater Comparison

Play	% Slickwater 2016	% Slickwater 2018	Produced Water Recycling
Marcellus	75	95	Most produced water is recycled
Bakken	20	70	Nearly no recycling
SCOOP & STACK	20	50	Recycling is being planned and growing
Eagle Ford	20	55	Very little recycling
Permian	35	55	About 30% and growing

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Thanks – Questions?