

# *Shallow Woodford Shale Gas Play in NE Oklahoma*



*Oklahoma Gas Shale Conference*

*Presented by*

*John Coates*

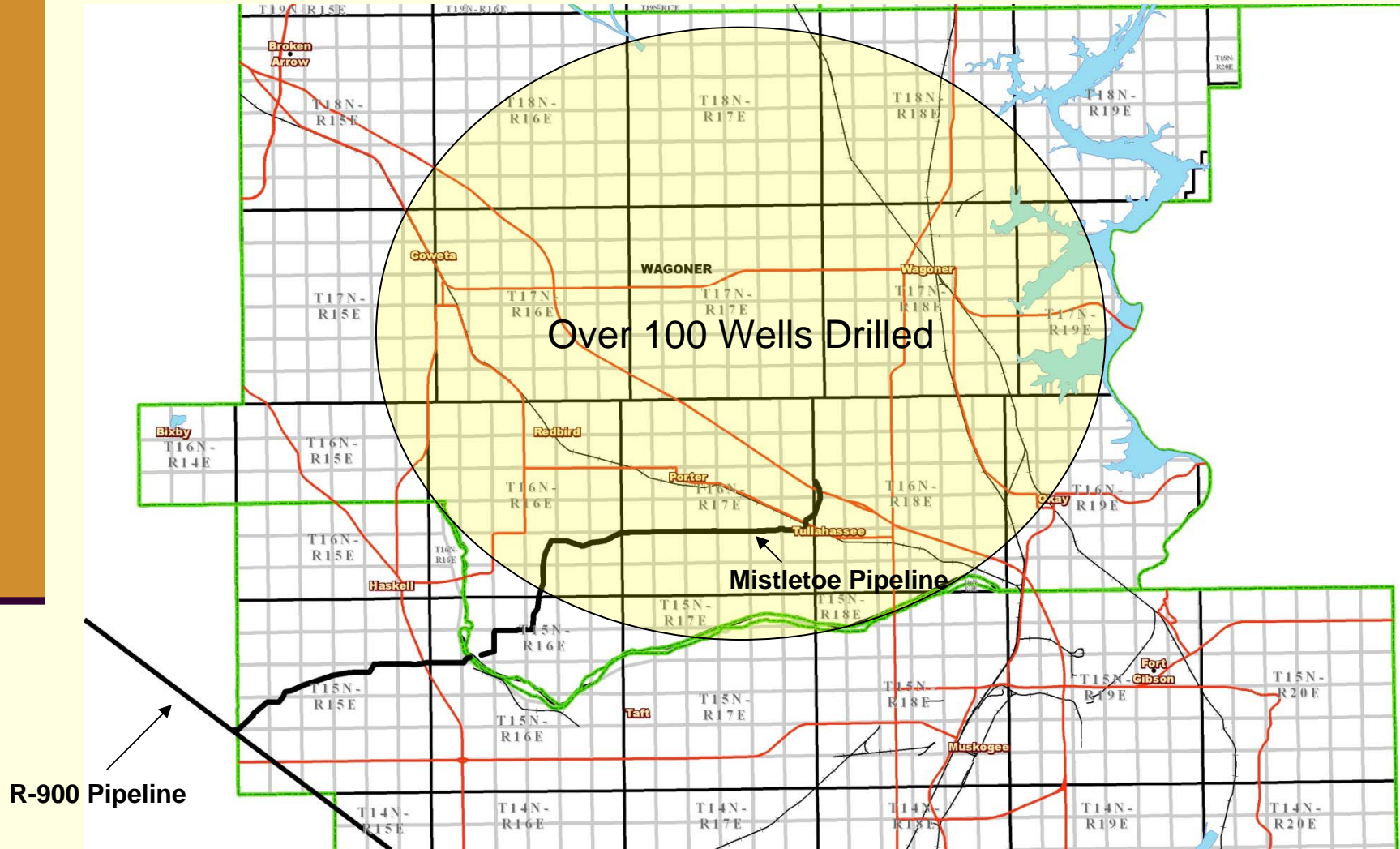
*October 22, 2008*

# Outline

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- *Area of activity*
- *Type log*
- *Geochemistry*
- *Production Data*
- *Drilling and completion*
- *Production practices*
- *Pipeline project*
- *Summary*

# Wagoner County Woodford Activity

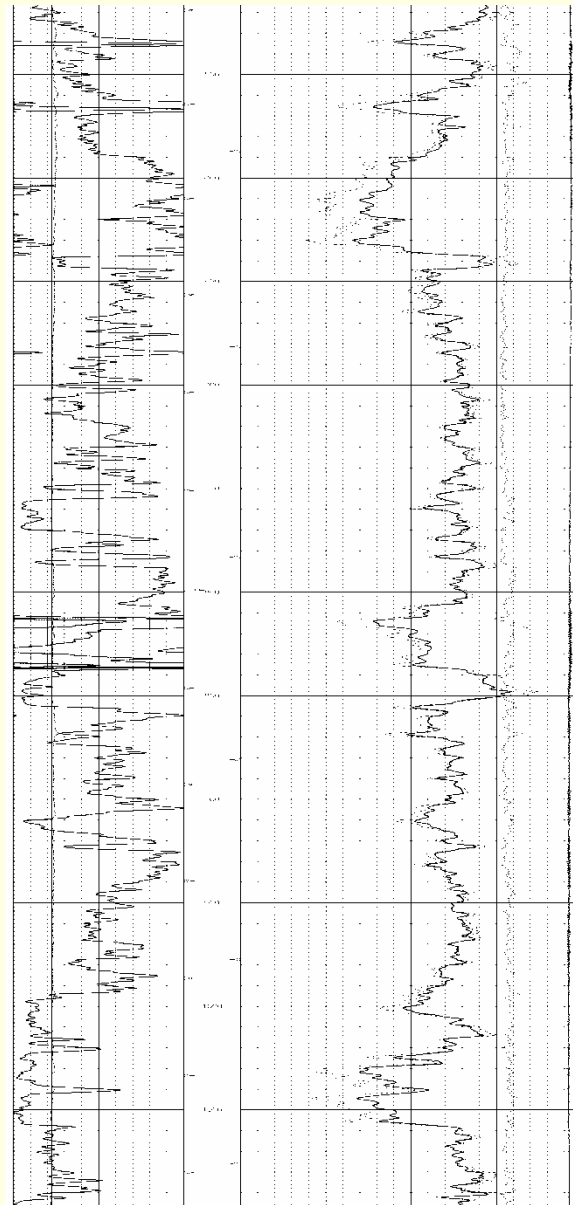


# Woodford Shale - Type GR/Density Log

**Caney/Fayetteville Shale**

**Woodford Shale**

**Arbuckle**



# *Geochemistry*

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- *Gas composition*
- *Isotope geochemistry*
- *Thermal maturity*
- *Total organic content (TOC)*

# Gas Composition

*High CH<sub>4</sub>, Some CO<sub>2</sub> and BTU~1,000  
Similar to Antrim Gas*

## Coronado Resources, LLC

### Gas Isotopes and Hydrocarbon Composition (in vol%)

HGS No.:	Well Name	Methane (C <sub>1</sub> )	Ethane (C <sub>2</sub> )	Propane (C <sub>3</sub> )	Carbon Dioxide (CO <sub>2</sub> )
07-4726-200637	McCullough 17-1	95.7	0.9	0.0	2.74
07-4726-200639	McCullough 17-2	95.6	0.9	0.0	2.77
07-4726-200640	McCullough 17-2	95.7	0.9	0.0	2.68

### Non-Hydrocarbon Gas Composition (%)

Sample Id.	Gas units	He %	H <sub>2</sub> %	Ar %	O <sub>2</sub> %	N <sub>2</sub> %	CO %	Specific Gravity	BTU
McCullough 17-1	50 PSIG	0.005	0.000	0.000	0.000	0.61	0	0.587	987
McCullough 17-2	50 PSIG	0.006	0.004	0.007	0.008	0.71	0	0.588	986
McCullough 17-2	185 PSIG	0.007	0.000	0.006	0.005	0.69	0	0.588	987

# Only Woodford Shale is "Dry Gas"

Cuttings Headspace Gas Ratios

Median Depth (ft)	SUM of C2, C3, i-C4, n-C4	C2 / C1	i-C4 / n-C4	C1 / C1-C4	GWR C2...C5 / C1...C5 x 100	LHR C1+C2 / C3+C4+C5	OCQ C4+C5 / C3
923	67.0	0.934	0.2	0.279	73.38	1	0.7
953	66.5	0.961	0.2	0.279	73.43	1	0.7
985	65.0	0.917	0.2	0.307	70.36	1	0.6
995	60.1	0.807	0.2	0.377	63.13	2	0.5
1005	57.2	0.725	0.2	0.409	59.98	2	0.5
1025	62.9	1.019	0.3	0.357	64.79	2	0.4
1035	53.8	0.725	0.2	0.452	55.38	3	0.4
1173	34.7	0.209	0.2	0.645	36.35	3	0.4
1185	35.7	0.125	0.3	0.622	39.82	2	0.9
1195	24.9	0.069	0.3	0.734	29.47	3	1.4
1205	0.5	0.005	0.7	0.995	0.51	1623	1.3
1215	0.4	0.003	0.4	0.996	0.39	2413	1.1
1225	0.3	0.003	0.3	0.997	0.35	2346	1.7

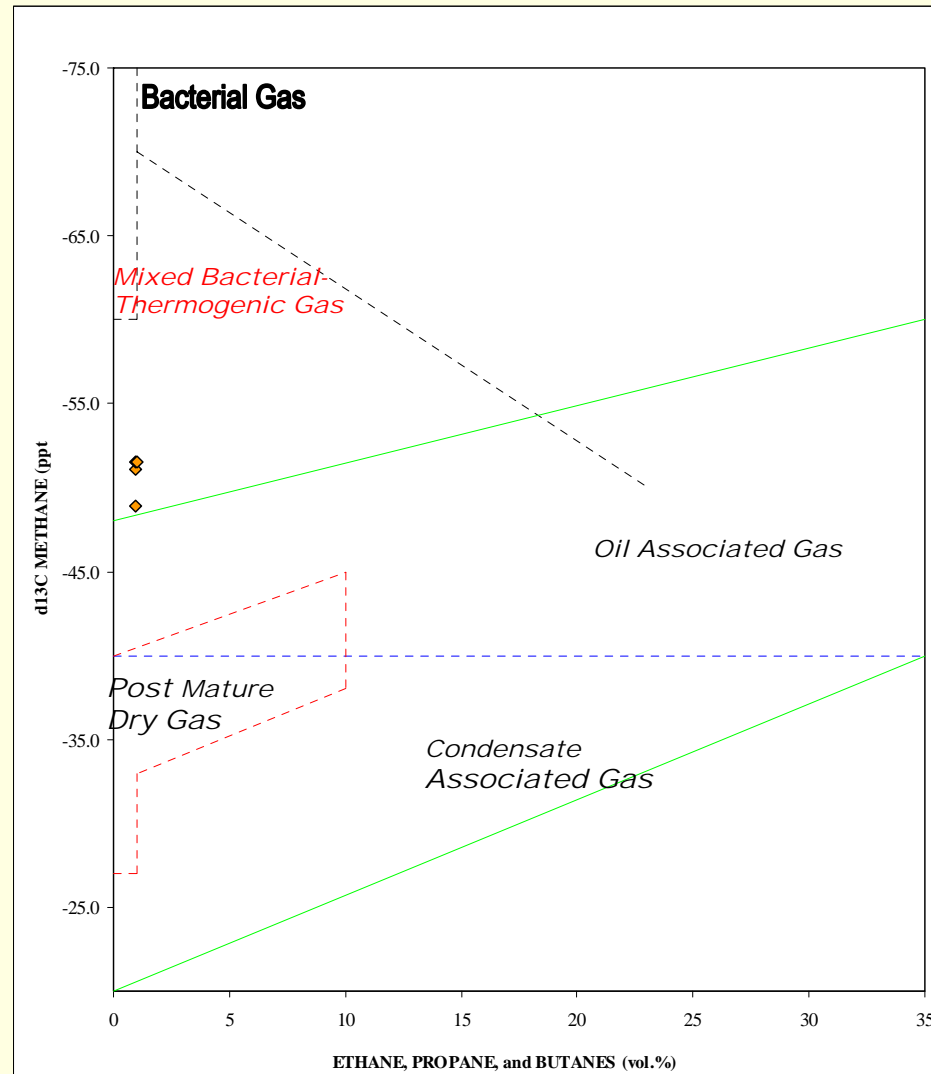
Caney

Woodford

GWR = gas wetness index < 0.5 dry gas; 0.5-17.5 gas; 17.5-40 oil; > 40 residual oil  
 LHR = light-to-heavy ratio LHR > 100 - dry gas; < 100 condensate/oil  
 OCQ = oil character qualifier < 0.5 gas potential; > 0.5 gas/light oil potential

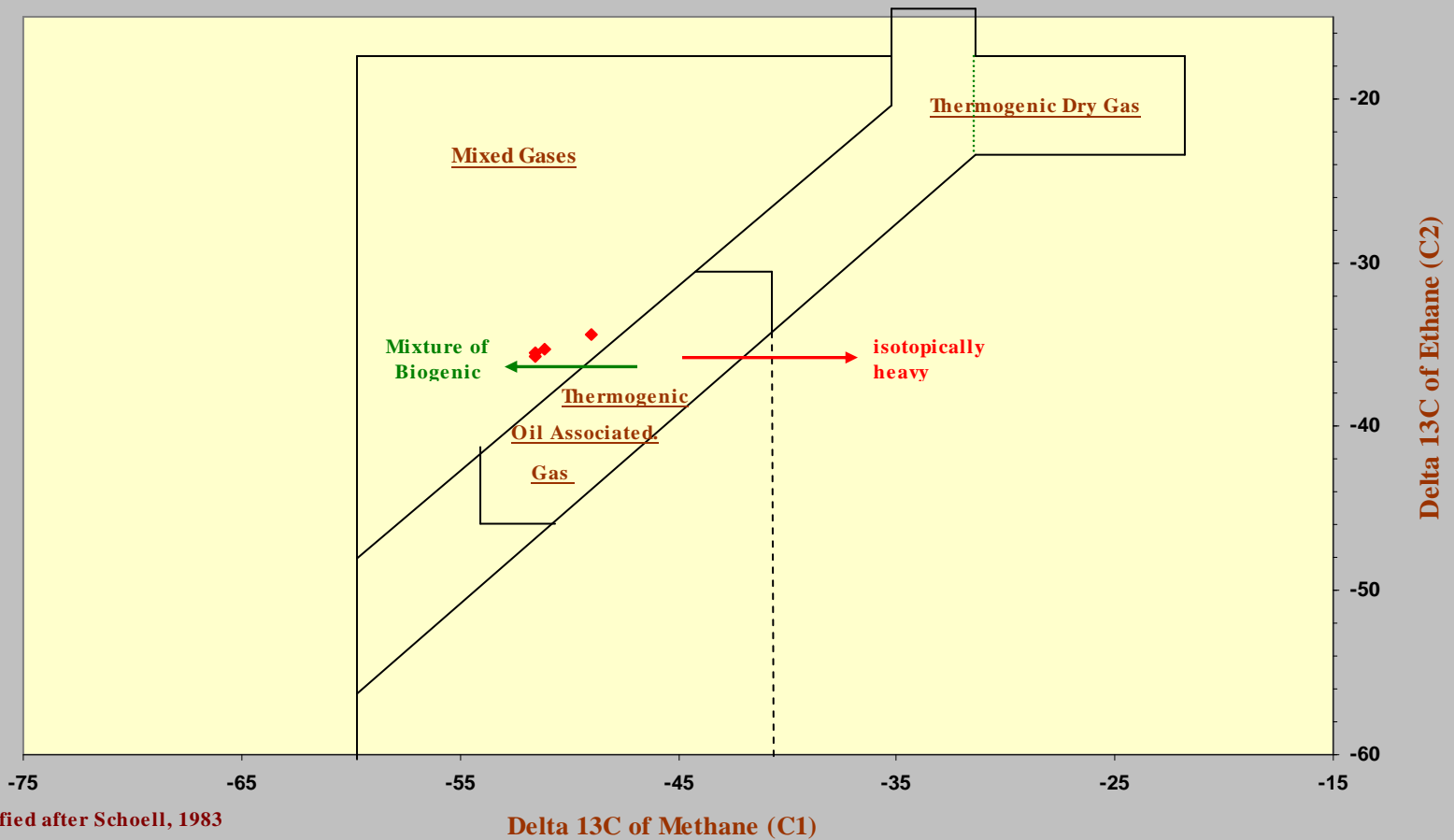
# Isotope Geochemistry

## Biogenic Component to Woodford Gas





## Characterization of Gases by Carbon Isotopic Ratios

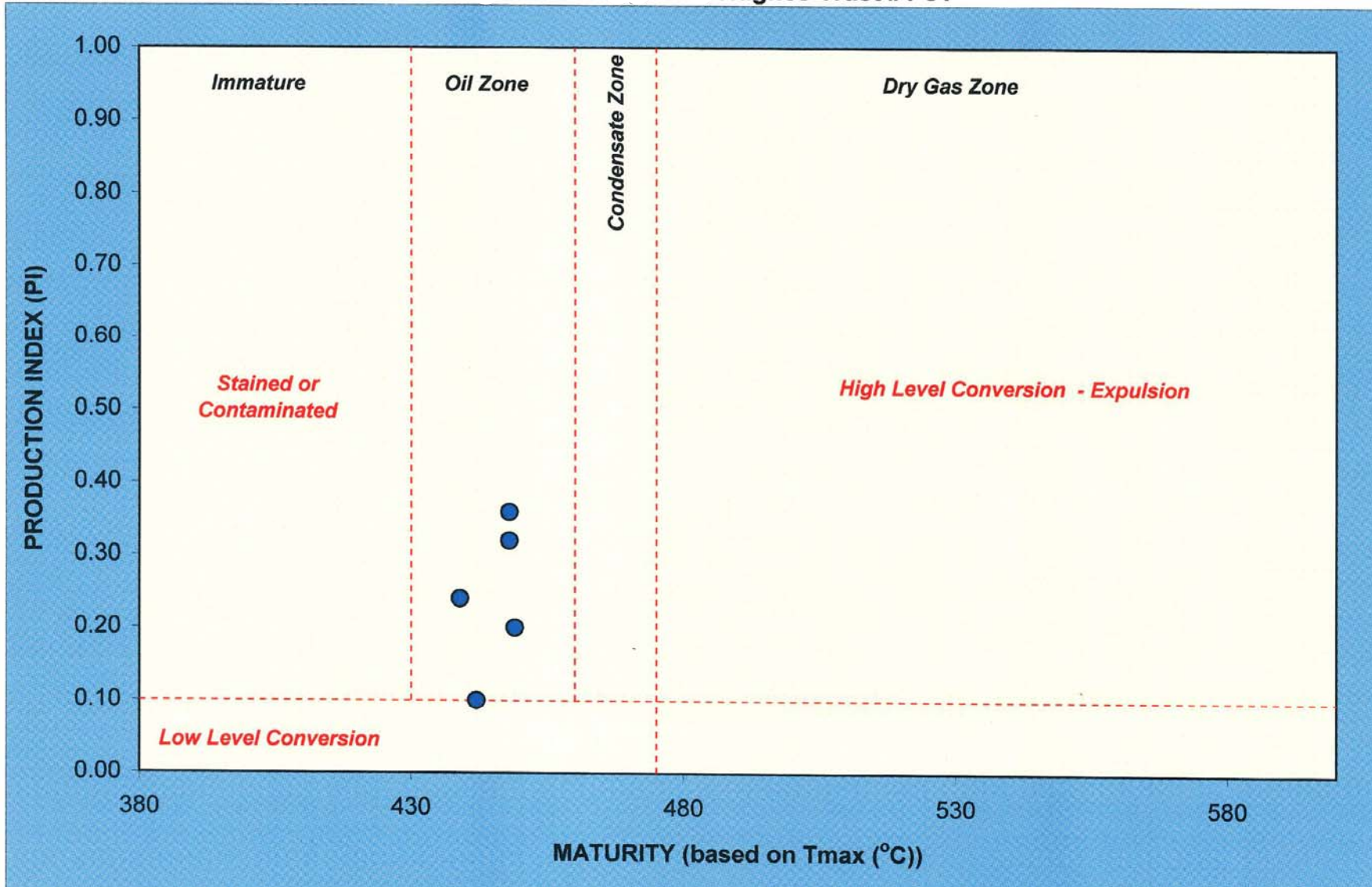


Modified after Schoell, 1983

Delta 13C of Methane (C1)

# Thermal Maturity is in the Oil Zone

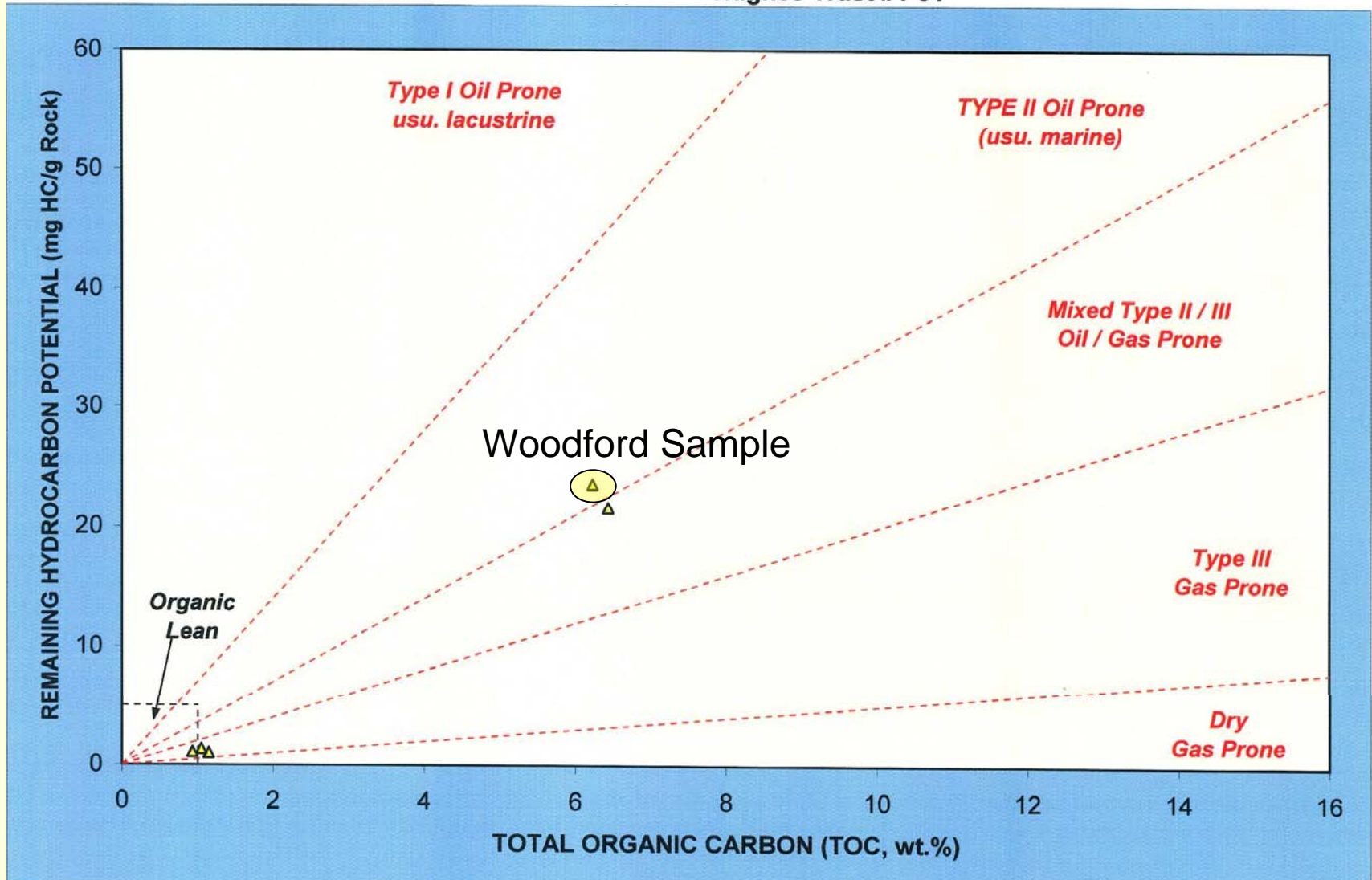
Hughes Trust #1-31



# Woodford TOC >6%, Marine Type II

## KEROGEN QUALITY

Hughes Trust #1-31



# Production History

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- *2 years of production is now available for some wells*
  
- *Observed well production is consistent with a desorption driven reservoir (e.g. Antrim Shale)*
  - *Good initial gas and water rates*
  - *Gas inclines as dewatering progresses*
  - *Flattening followed by gradual decline in gas rate*

# 3<sup>rd</sup> Party Well – Over 1 Year Production History

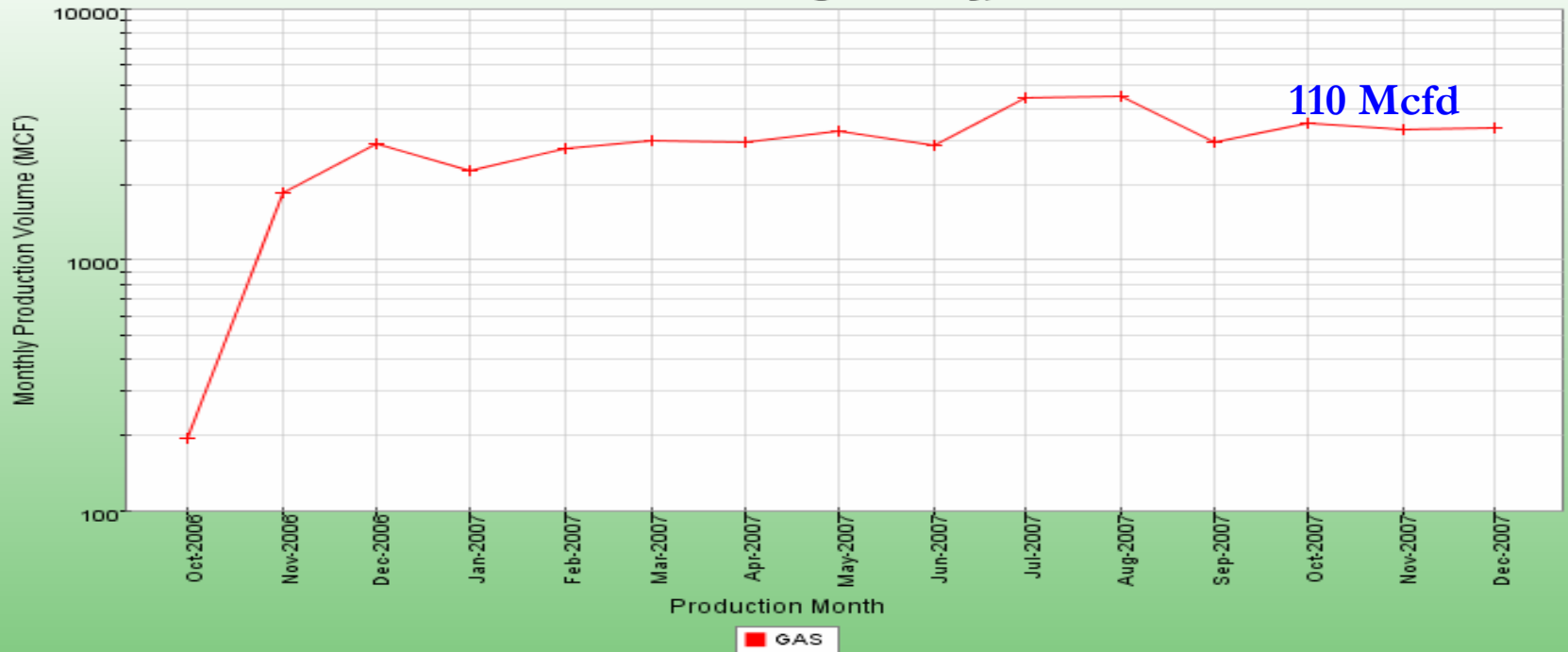
<b>Field</b>	<b>Operator</b>	<b>Location</b> Wagoner County, Oklahoma	
<b>Lease Name</b>	<b>PUN</b> 14511971300000	<b>Reporting Entity</b> OTC	<b>Cumulative (since 1979)</b> 44 MMCF
<b>Wells</b> 35-145-22966(19-4C)			

[Monthly Production in a Table](#) or download [DRI Version 2 Format \(PHDWin users\)](#) or, for compatibility with older programs, you can download [Older DRI Version 1 Format](#) or give me [help on downloading files](#)

## Gas Production

Monthly Production Volume (Logarithmic) vs. Time

PUN : 14511971300000 - Wagoner County, Oklahoma



# 3<sup>rd</sup> Party Wells

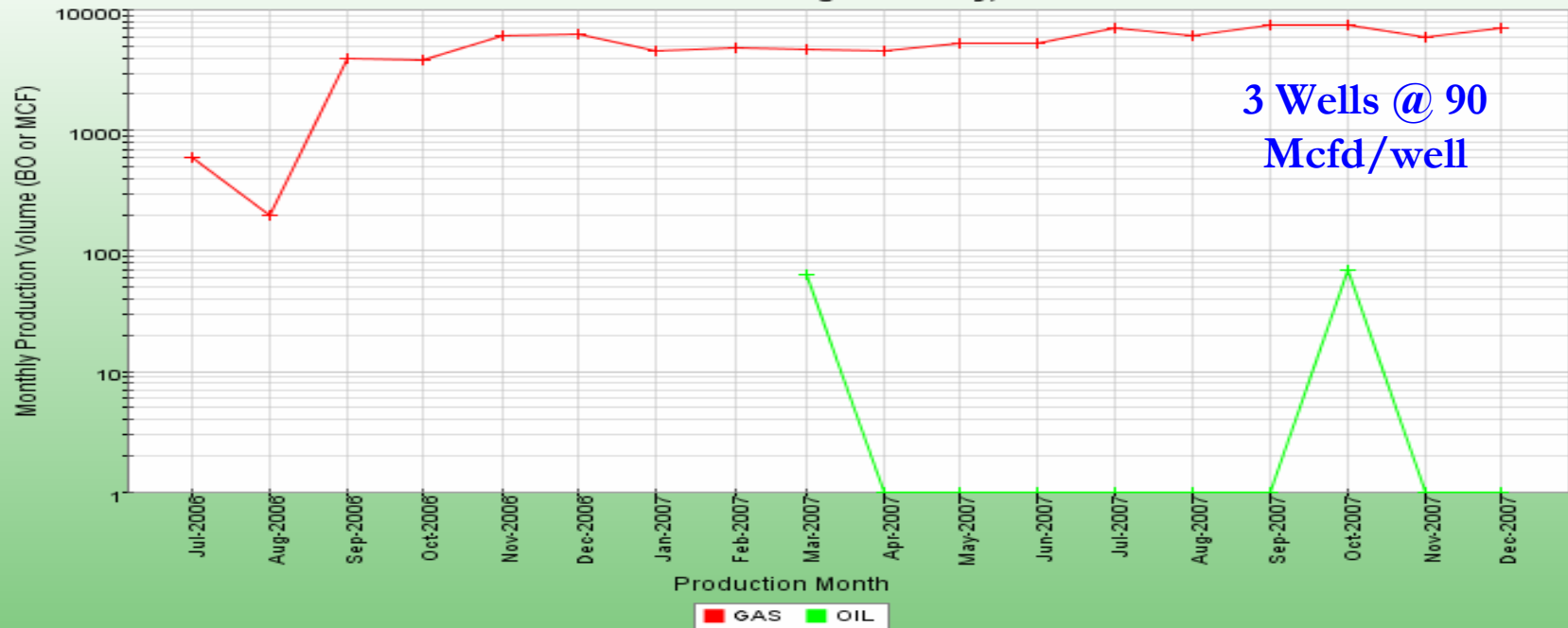
<b>Field</b> UNKNOWN (UNION VALLEY-CROMWELL, WOODFORD)	<b>Operator</b>	<b>Location</b> Wagoner County, Oklahoma	
<b>Lease Name</b>	<b>PUN</b> 14511865500000	<b>Reporting Entity</b> OTC	<b>Cumulative (since 1979)</b> 91 MMCF; 133 BO
<b>Wells</b> 35-145-22949(18-1R) 35-145-22957(18-2R) 35-145-22962(18-4Q) 35-145-22965(18-3J)			

[Monthly Production in a Table](#) or download [DRI Version 2 Format \(PHDWin users\)](#) or, for compatibility with older programs, you can download [Older DRI Version 1 Format](#) or give me [help on downloading files](#)

## Gas and Condensate Production

Monthly Production Volume (Logarithmic) vs. Time

PUN : 14511865500000 - Wagoner County, Oklahoma



# Coronado's Production Test Summary

Well Name	Well Cost (\$)	Peak Rate (M cfd)	Water (BWPD)
McCullough 17-2	173,170	422	188
McCullough 17-1	184,921	400	332
Coronado 18-3	158,050	353	391
Showman 17-2	125,206	347	308
Essary 7-1	136,394	342	319
Gaither 7-1	160,557	313	237
Johnson 8-2	137,722	308	203
Chase 8-2	243,276	280	245
George 17-1	199,243	275	217
Coronado 18-5	210,703	260	272
Coronado 18-4	154,218	224	257
Showman 17-1	160,889	222	179
Chase 8-1	140,367	214	264
Tibbs 7-1	178,807	186	225
Miller 17-3	161,600	178	227



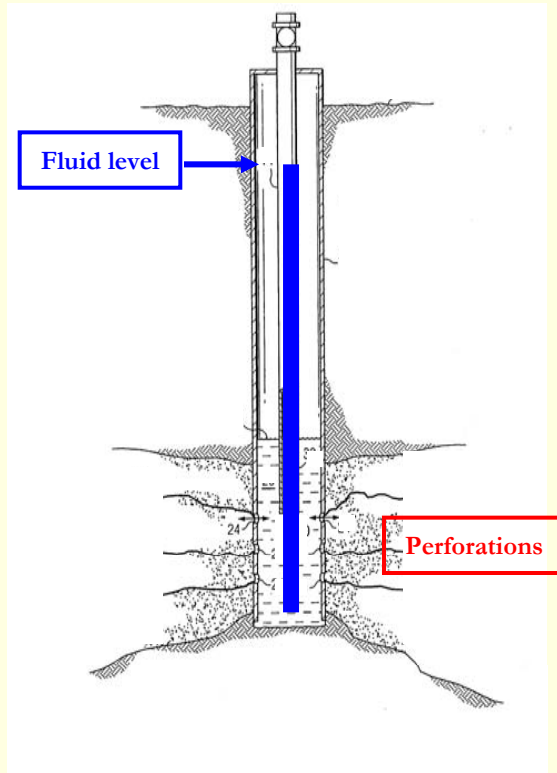
# Coronado's Production Test Summary

Well Name	Well Cost (\$)	Peak Rate (Mcf/d)	Water (BWPD)
Edwards 8-1	141,116	150	97
McCullough 17-3	537,110	146	156
Tracy 20-1	187,271	142	255
Coronado 18-2	170,747	112	263
Methvin 7-1	143,941	82	89
Johnson 7-1	195,822	70	142
Chrisman 21-1	177,860	61	640
Coronado 18-7	139,641	39	230
Ternes 8-2	168,413	32	58
Coronado 18-6	174,069	32	256
Thompson 12-1	154,729	29	11
Edwards 8-2	162,622	29	199
Berry 13-1	186,699	26	246
Gillin 20-2	489,494	21	250
Johnson 8-1	191,263	11	146
Staner 29-1	198,972	11	35
<b>Average w/ all Wells</b>	<b>191,771</b>	<b>172</b>	<b>224</b>

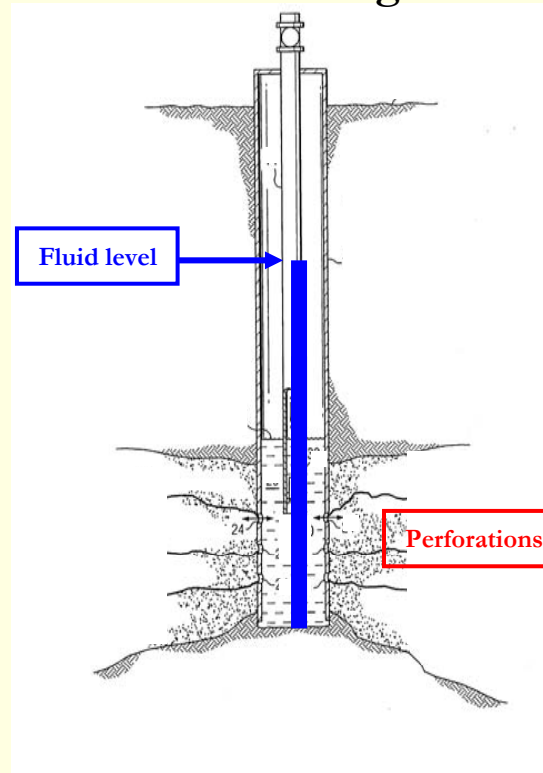


# Woodford Shale Dewatering

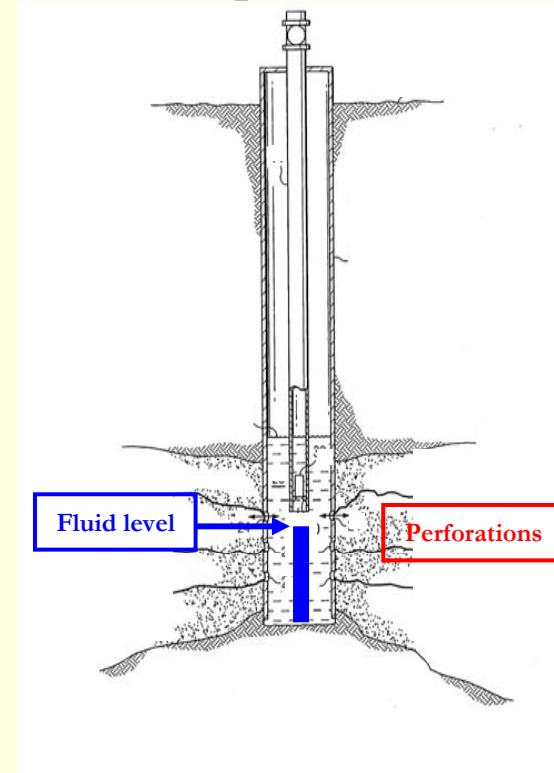
**Initial**



**Dewatering**



**Pumped Down**

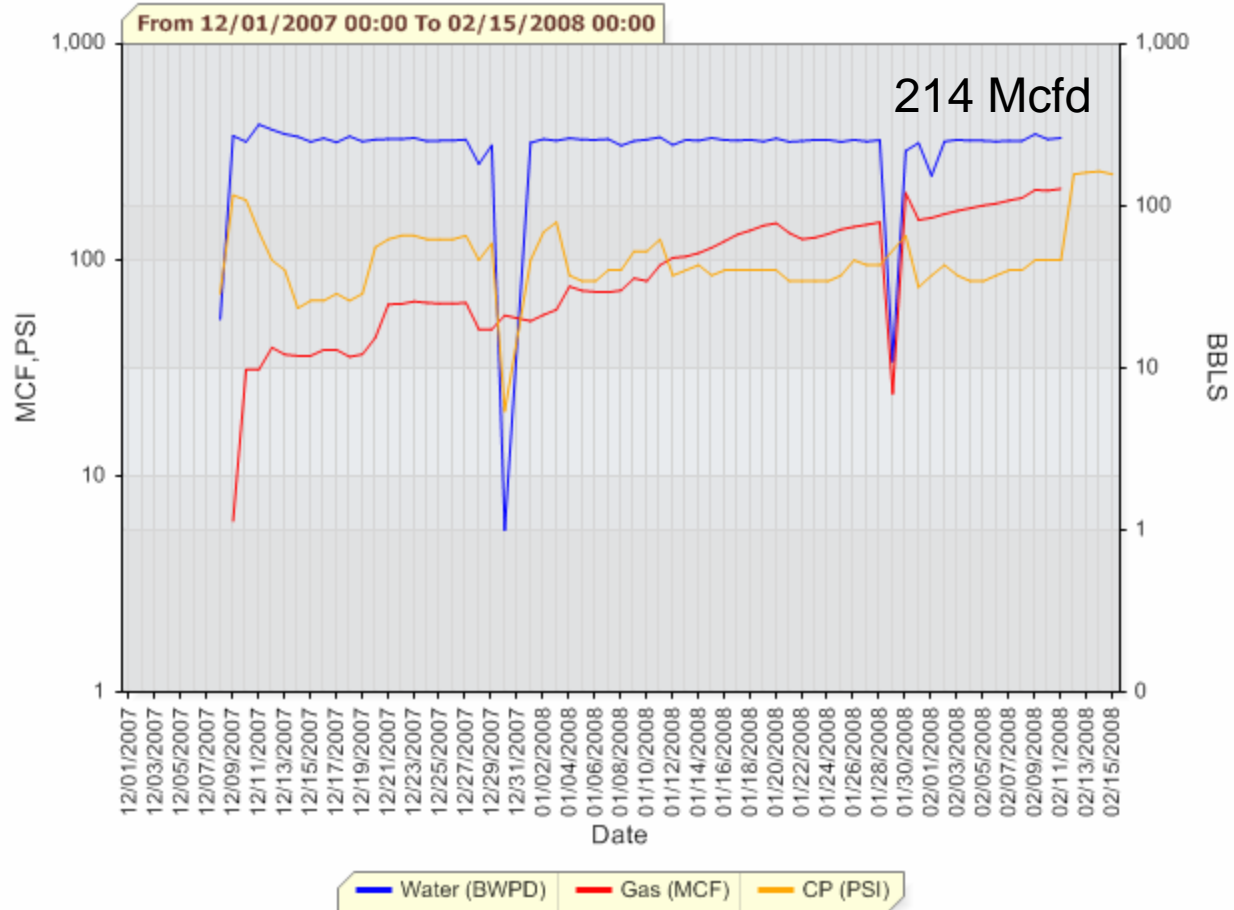


- Fluid level - high
- Water rate - high
- Gas rate - zero/minimal
- Casing psi - low pressure

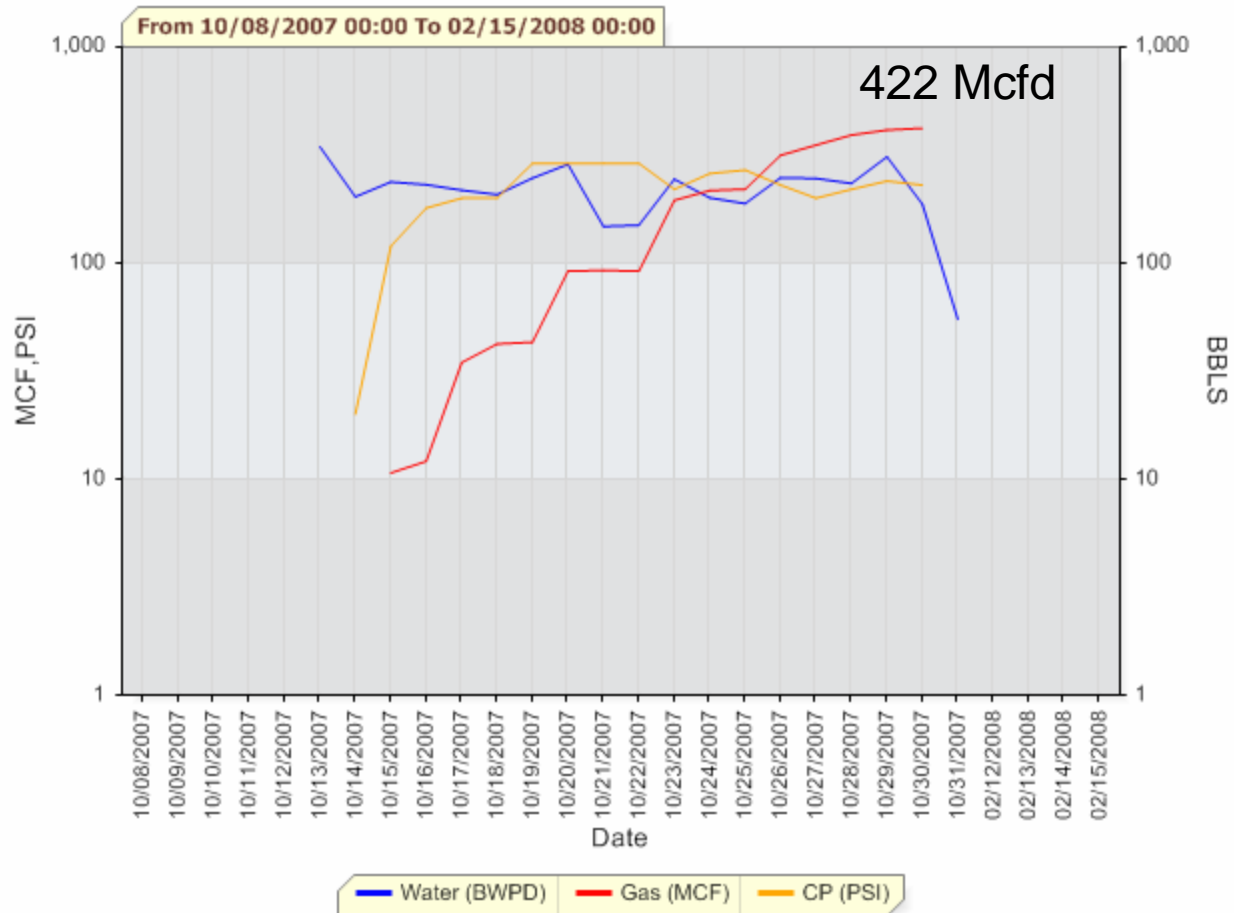
- Fluid level - dropping
- Water rate - steady
- Gas rate - increasing
- Casing psi - increasing

- Fluid level - at perms
- Water rate - dropping
- Gas rate - maximum
- Casing psi - maximum

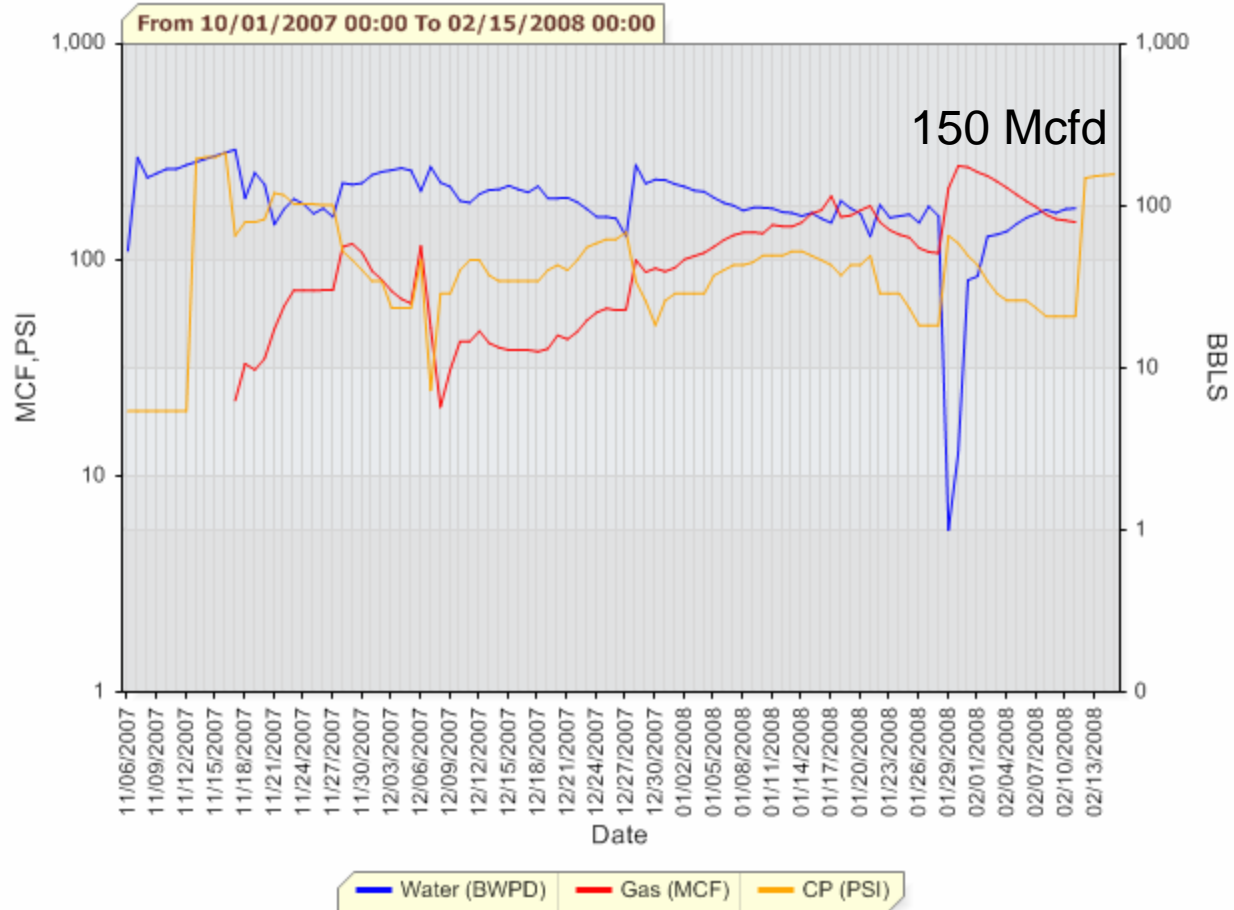
# Chase 8-1



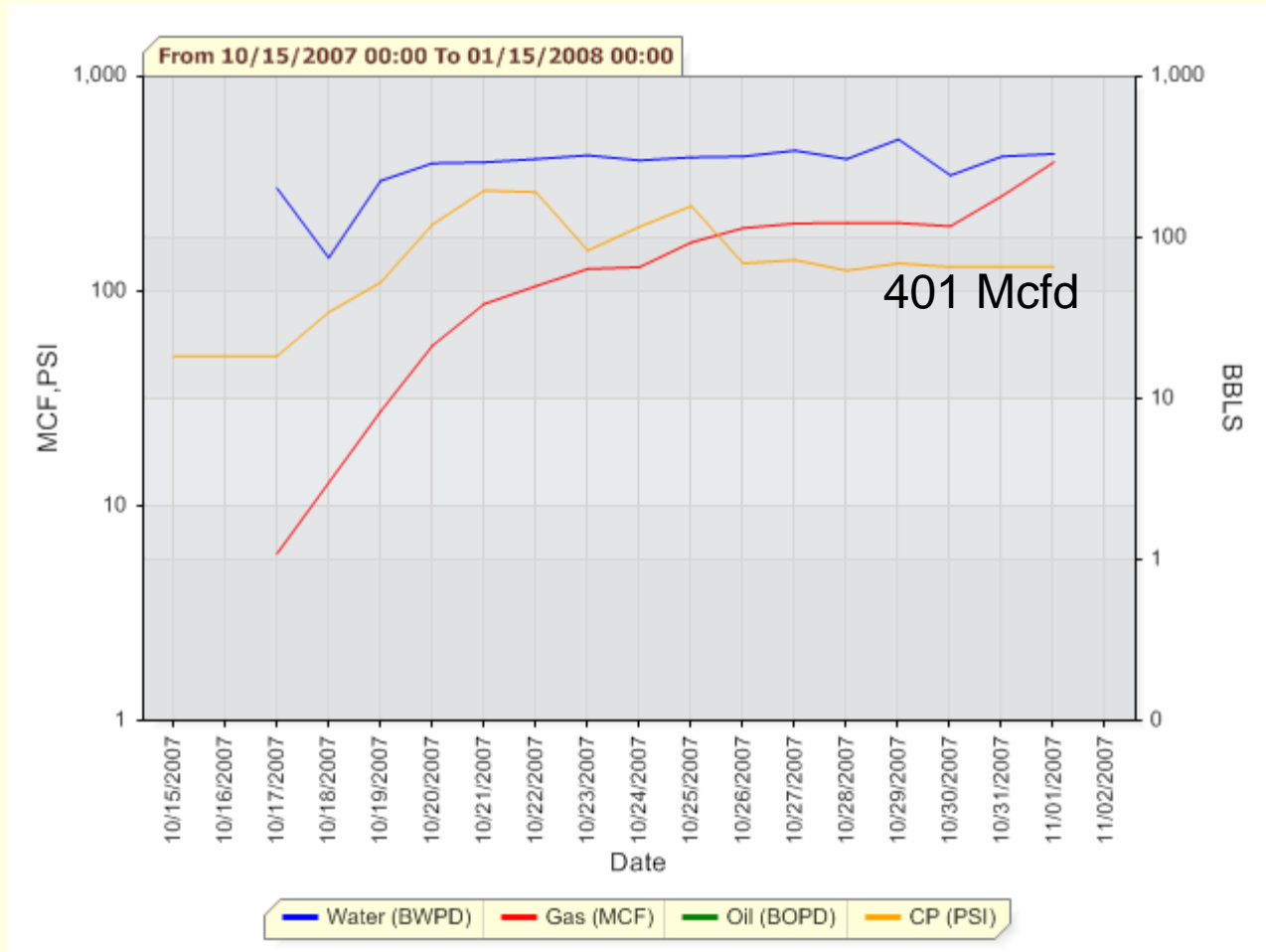
# McCullough 17-2



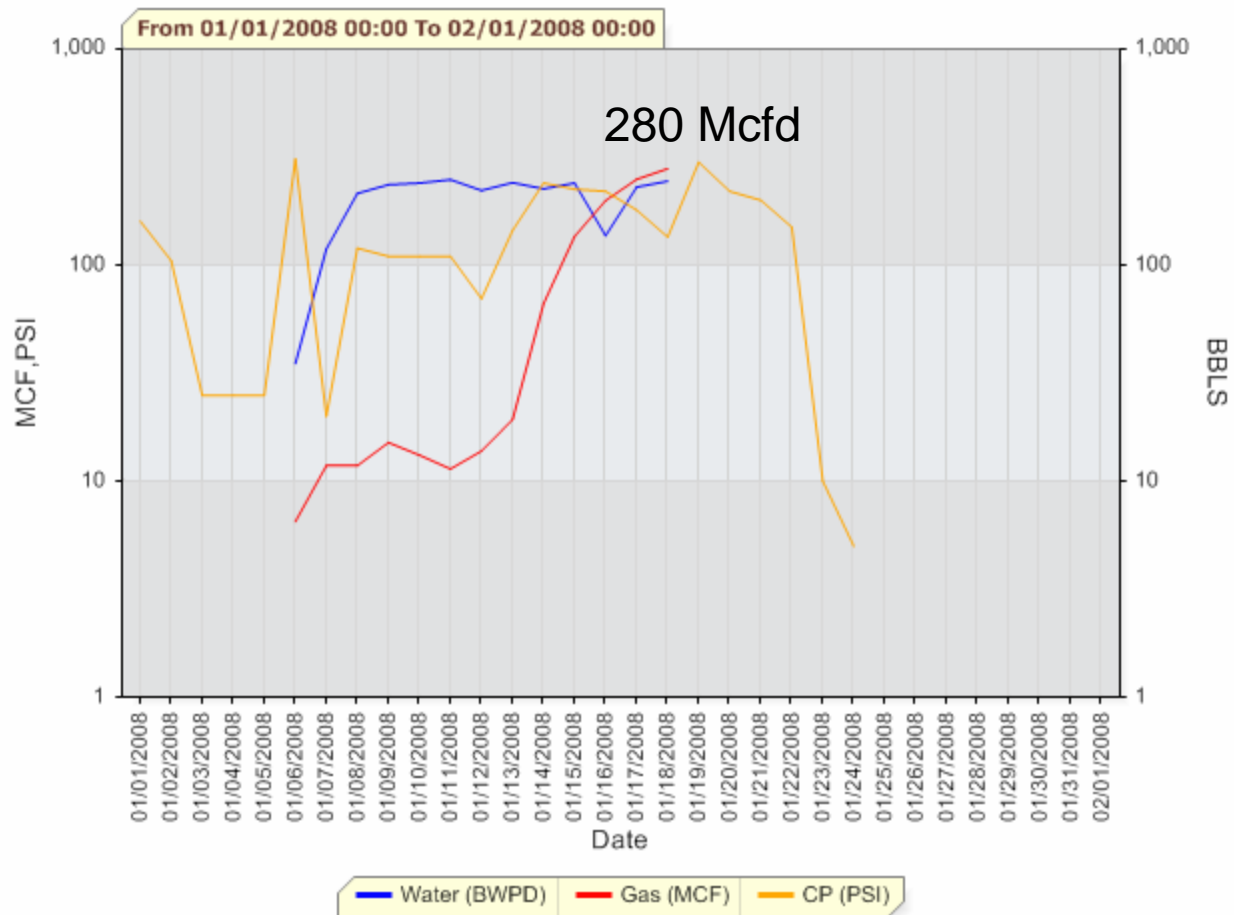
# Edwards 8-1



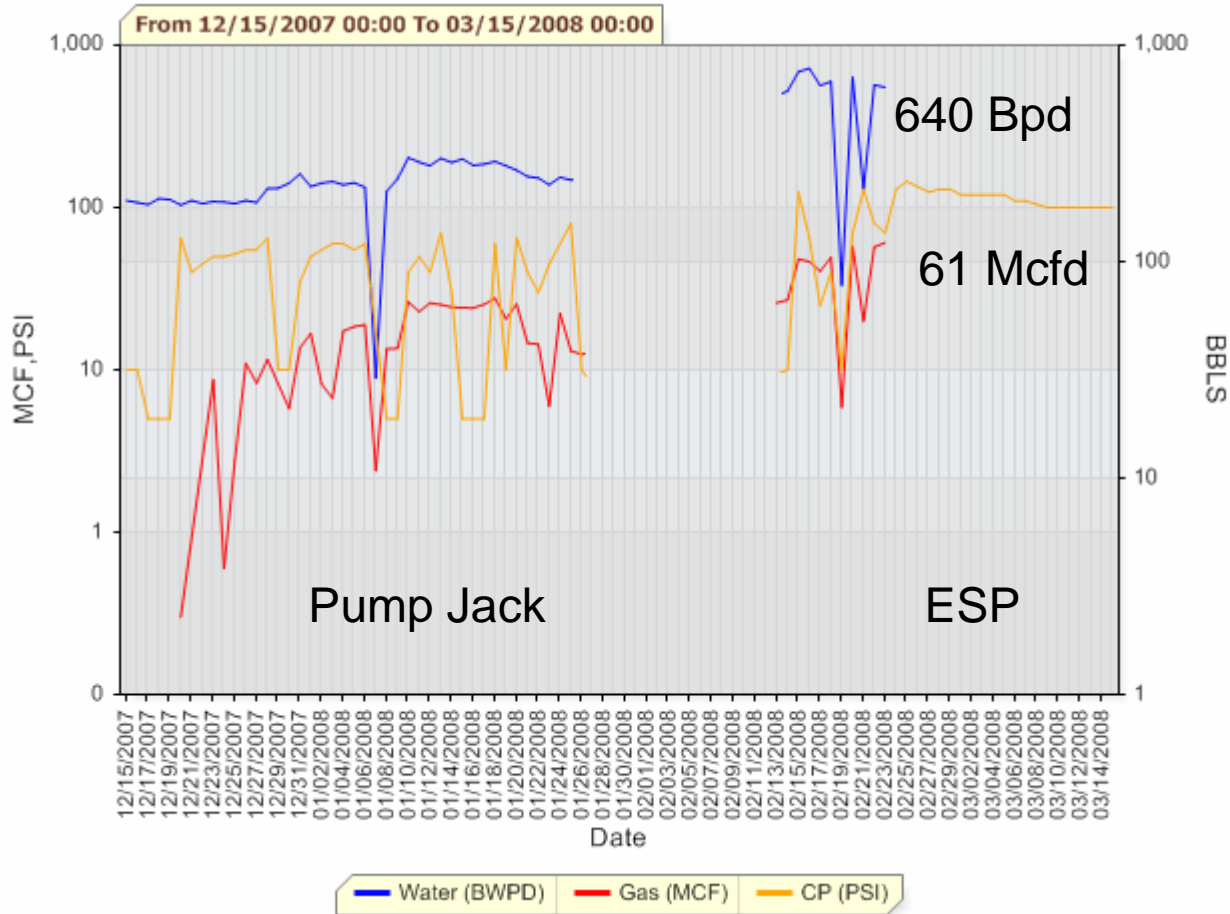
# McCollough 17-1



# Chase 8-2



# Chrisman 21-1



# *Reserve Potential*

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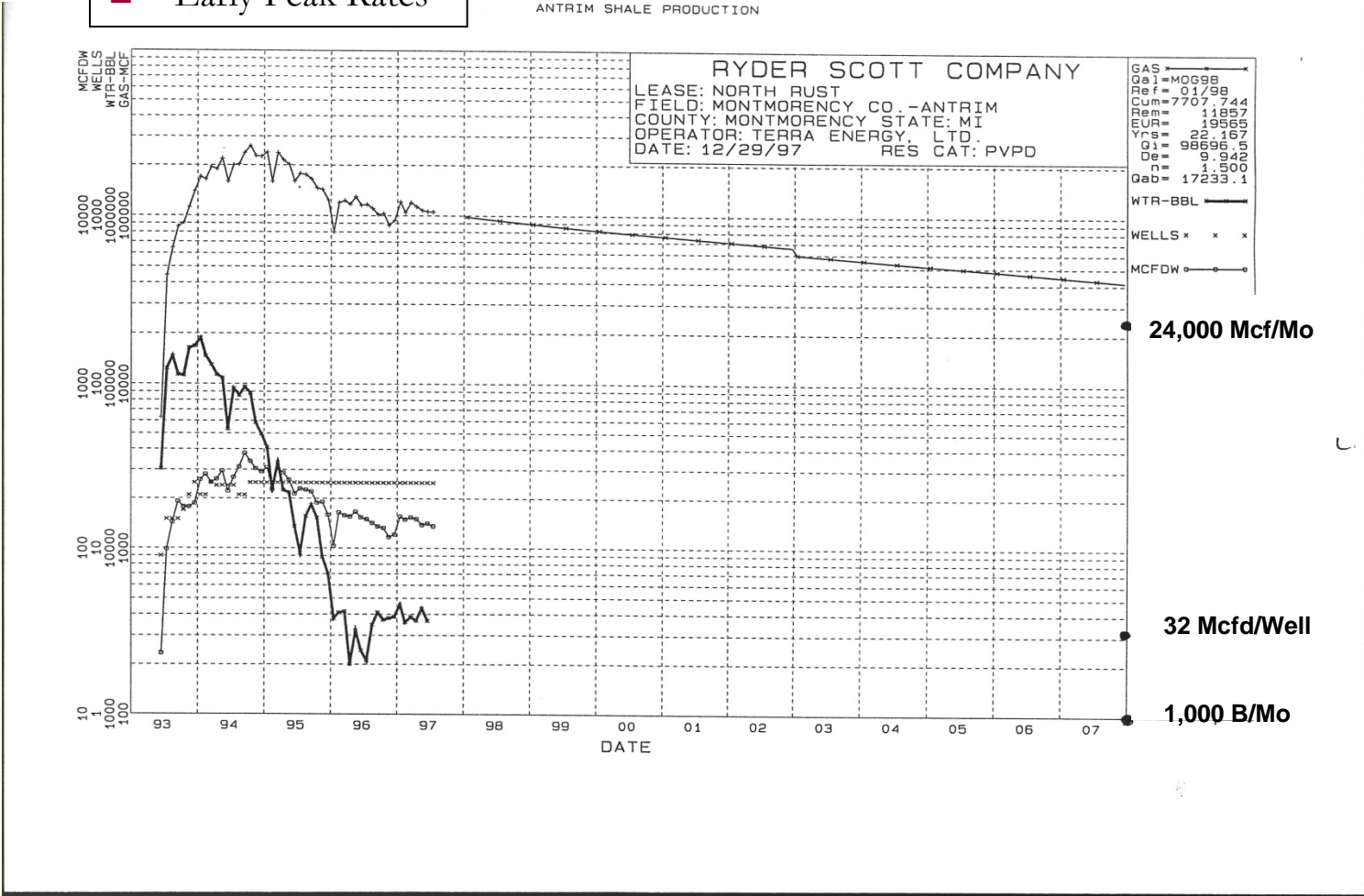
*The Antrim Shale is the analog to assess reserve potential in the play*



# Antrim Shale Decline Curves

- High Permeability
- Early Peak Rates

**2008 Cum = 12 Bcf: ~0.5 Bcf/Well**

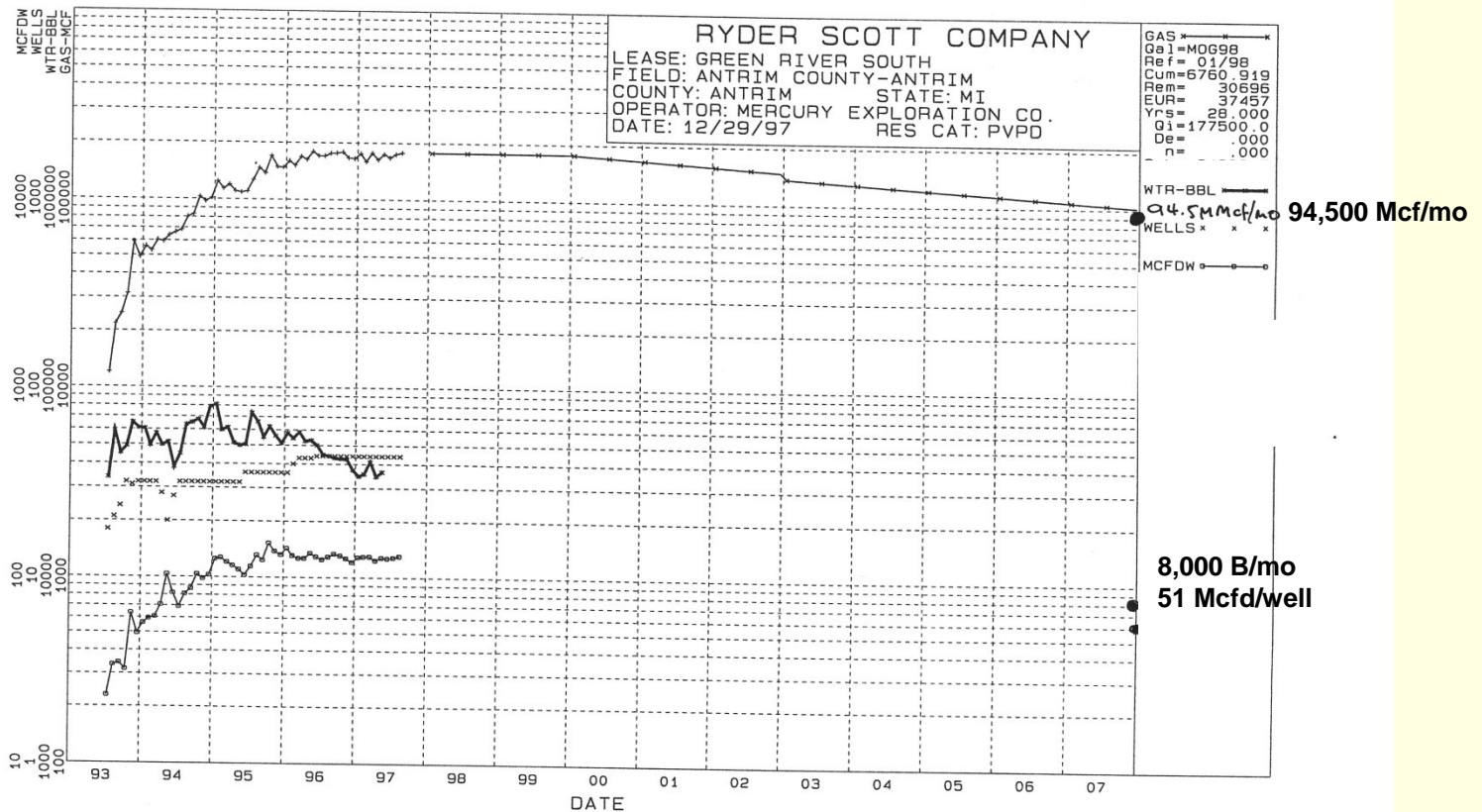


# Antrim Shale Decline Curves

■ Lower Permeability

2008 Cum 21.5 Bcf: ~0.3 Bcf/well

ANTRIM SHALE PRODUCTION



# Drilling

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- *Air rigs*
- *2 days per well*
- *120 feet of surface pipe*
- *7 7/8" hole to TD*
- *Cement 5 1/2" casing to surface*
- *TD with 200 feet of rat hole*

# Completion

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- *Cased, perforated and fracture stimulated*
  - *15% HCL*
  - *Resin coated sand*
  - *N<sub>2</sub> 70/30 quality foam*
  
- *2 open hole horizontal wells drilled*
  - *Promising results - no horizontal fracs to date*

# *Production Practices*

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- *Utilize electric submersible pumps (ESP) with surface controllers*
- *Lowering and monitoring fluid level important*
- *Lifting water efficiently is key*
- *Dispose of water in Arbuckle injection wells*



# Well Location



06/06/2008

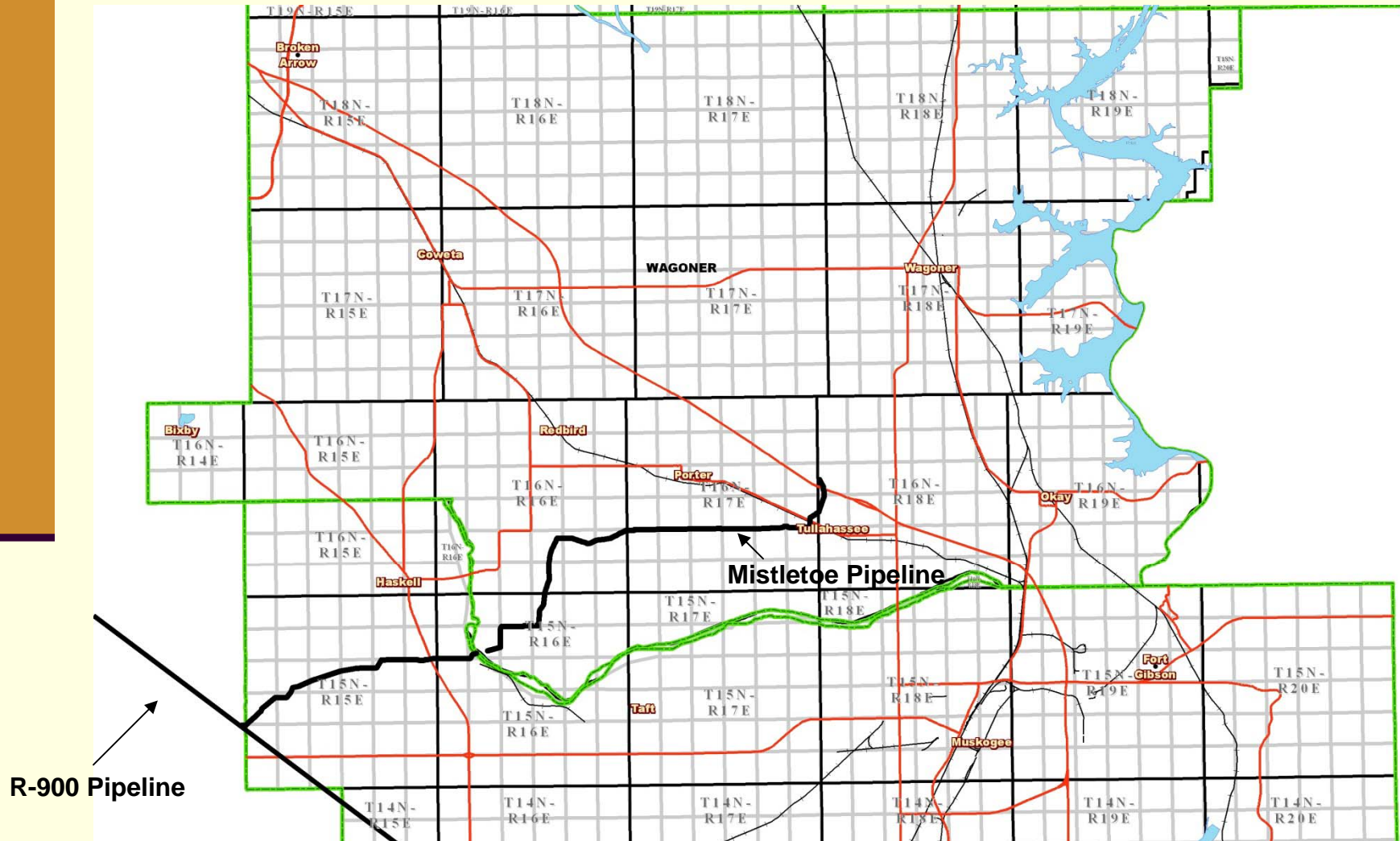
# *Water Disposal Facility*





# Gas Transportation

*Built a 26 mile pipeline connected to R-900*





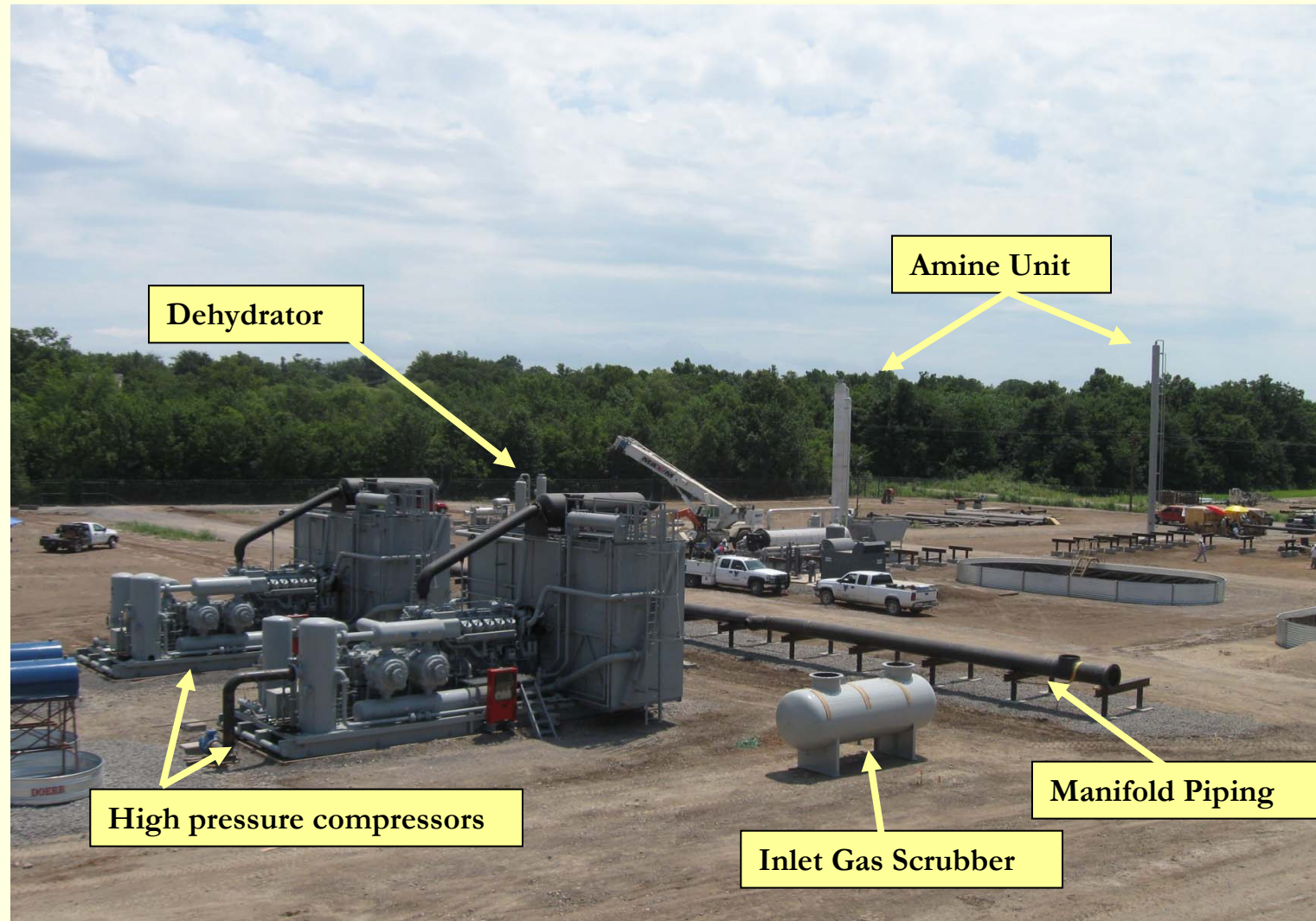
# Gas Transportation

*Pipe is 12" Steel (900 psi) and 16" Poly (90psi)*



# Gas Transportation

*Compressor Station Takes 90 psi Line to 900 psi -  
Amine Unit for CO<sub>2</sub>*



# Summary

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- *Appears to be a desorption driven system - dewatering results in inclining gas rates*
- *Average observed well rates (>150 Mcfd) are highly economic at current well costs*
- *Biogenic component to gas*
- *Convenient water disposal in the Arbuckle*
- *Large pipeline project completed*
- *Antrim Shale analog - Typical Reserves (0.3-0.5 Bcf/well)*