

# **A Look Back at the Prospect Generation of Cedar Hills-East and Lookout Butte Fields Williston Basin (The First Economic Resource Play), and Codell Resource Play North Denver Basin\***

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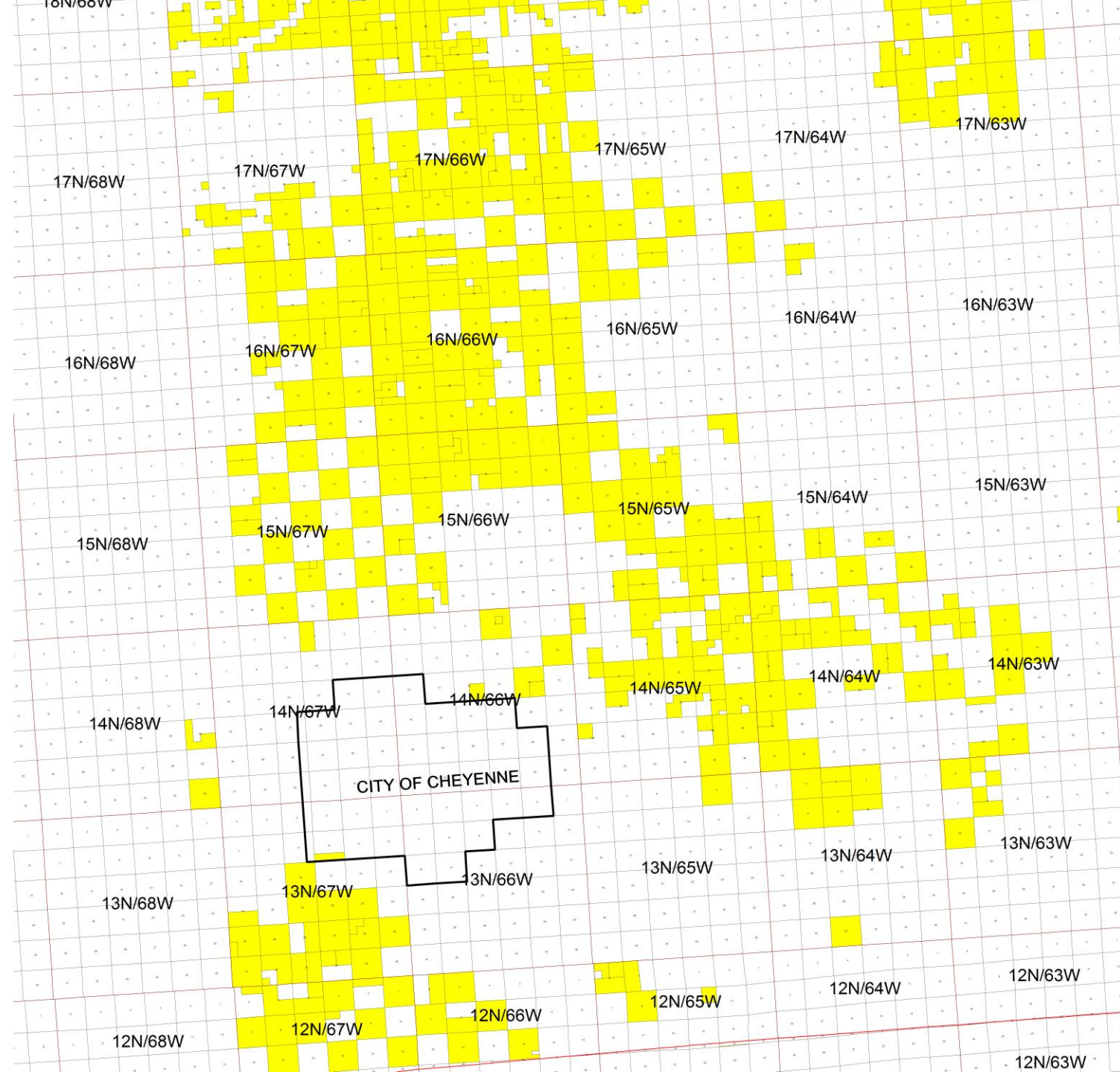
## **Abstract**

Pennel Southeast and Little Beaver East Prospect (the first economic resource play), now known as the Cedar Hills-East and Lookout Buttes fields, are located on the southeast flank of the Cedar Creek Anticline which at the time this prospect was generated (1988) had produced more than 350 million barrels of oil from 15 separate fields. Oil reservoirs include the Red River, Stony Mountain, Interlake, Duperow, Lodgepole and Mission Canyon formations. The Ordovician Red River B Zone, which is the most prolific of these reservoirs, has responded well to water flooding. The oil trapping mechanisms in the Red River B Zone have never been fully explained and very little Red River B Zone oil is trapped by four-way structural closure. Due to the complex nature of these Red River traps along the anticline, the oil-water contacts on the downdip east side of the fields were not defined. This fact was well documented by an active drilling program we initiated during the early 1980's when more than thirty producing wells were completed downdip of existing production at the Cabin Creek and Pennel fields. The downdip extension of production beyond the field boundaries suggests that a re-evaluation of the known limits of all the Cedar Creek Fields would be worthwhile. Pennel Southeast and Little Beaver East Prospects were defined simply by studying the well data on the east dip of the Cedar Creek Anticline. A cluster of by-passed and producing wells defined a large, undeveloped oil column downdip from the existing limits of Pennel - Lookout Butte and Little Beaver East fields with a 216 million barrel horizontal target using water flood support.

To date in these prospects 789 wells have been drilled and 190 million barrels of oil have been produced. The Codell Sandstone play was generated in 2005 looking for a resource that would compare favorably to the very successful Bakken carbonate play taking place in Richland County, Montana. The Codell had produced modestly in vertical wells in and south of the Silo Field in Laramie County, Wyoming setting up a focus area. To add to the intrigue a mud log was located that showed the Codell Sandstone was over pressured and attempted to blow out during the drilling of a J Sand test. Due to mineralogy and bound water, resistivity mapping would not define the resource. The resource boundaries were simply defined by a large cluster of good oil shows. This resource contains 1.65 billion barrels of oil in place and a recoverable 165 million barrel target was postulated. Currently there are 76 producing Codell wells, with 1,660 Codell locations permitted in the Wyoming portion of the play.

# A look back at the prospect generation of Cedar Hills-East Lookout Butte Fields Williston Basin (The First Economic Resource Play), Codell Resource Play North Denver Basin

Steve Kirkwood, Kirkwood Oil and Gas, LLC – Wesco Operating







Cedar Hills – East Lookout Butte Play  
Late 1980s

# Target – Red River Formation B-Zone



Red River Formation

Winnipeg Formation

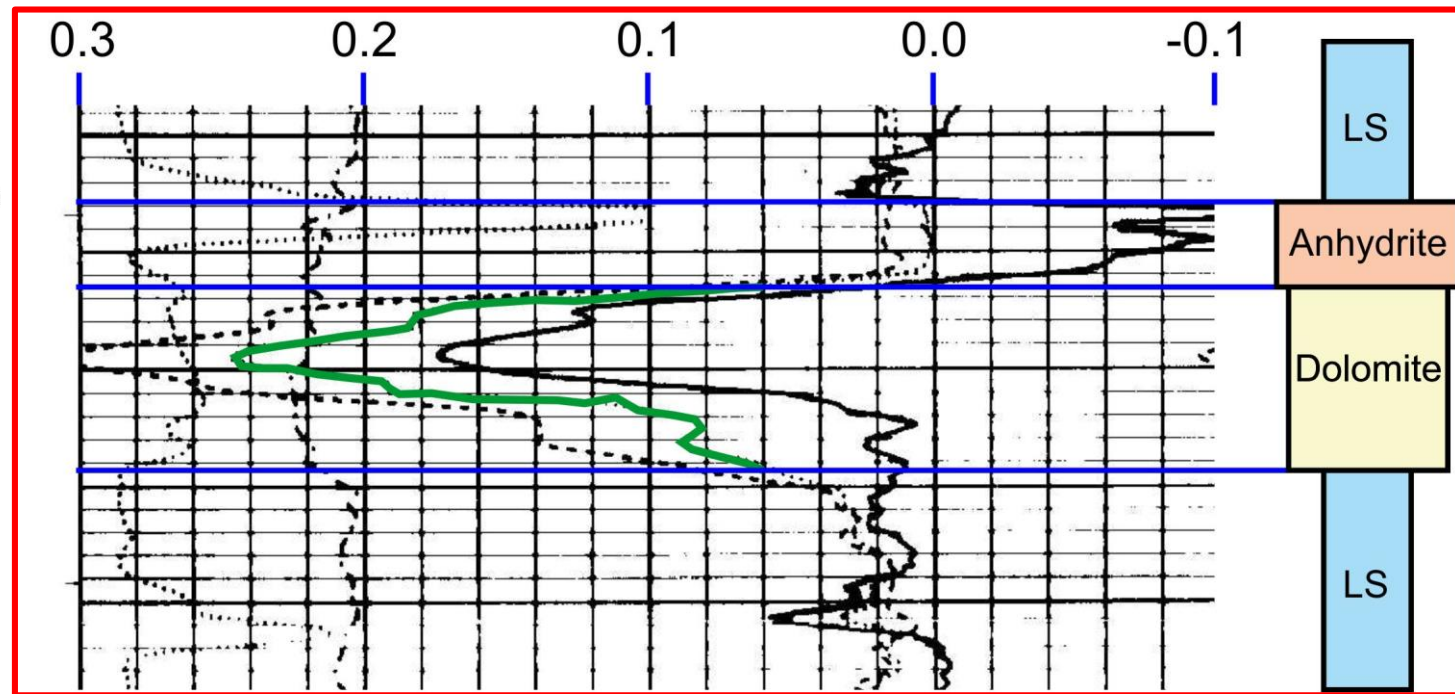
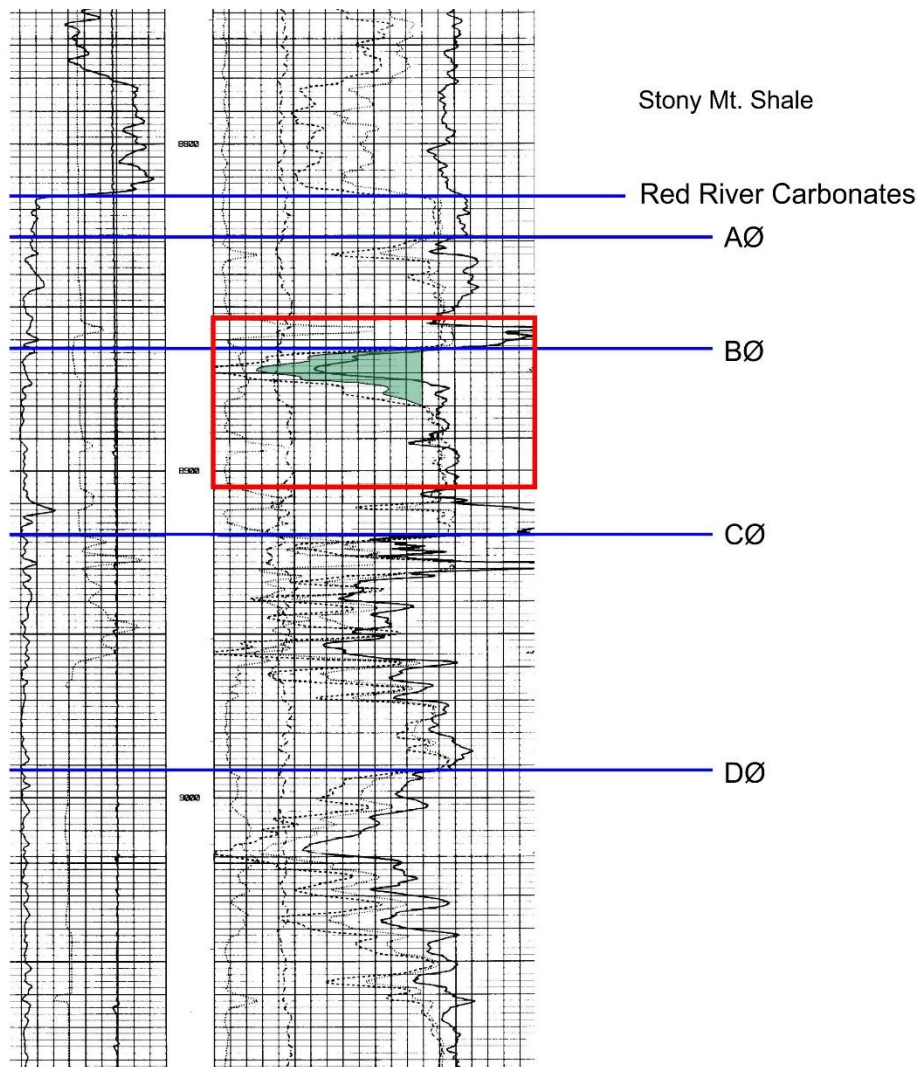
Hecla Island, Lake Winnipeg, Manitoba

ERA	PERIOD	FORMATION OR GROUP	
PALEOZOIC	PERMIAN	Minnekahta Limestone	
		Opeche Formation	
		Minnelusa Formation	
	PENNSYLVANIAN	Amsden Group	
		Tyler Formation	○
		Heath Formation	
	MISSISSIPPIAN	Otter Formation	
		Kibbey Formation	
		Charles Formation	◆○
		Mission Canyon Limestone	◆○
		Lodgepole Limestone	○
		Bakken Formation	○
		Three Forks Formation	
	DEVONIAN	Birdbear Formation	○
		Duperow Formation	
		Souris River Formation	
		Dawson Bay Formation	
		Prairie Formation	
		Winnipegosis Formation	
		Interlake Formation	◆
		Stony Mountain Formation	◆○
	ORDOVICIAN	Red River Formation	◆○
		Winnipeg Formation	○
	CAMBRIAN	Deadwood Formation	○
	PRECAMBRIAN	Pre-Beltian	

◆ Producing Interval ○ Source Rock

# Density-Neutron (CHSU Larkin 14-18NH15)

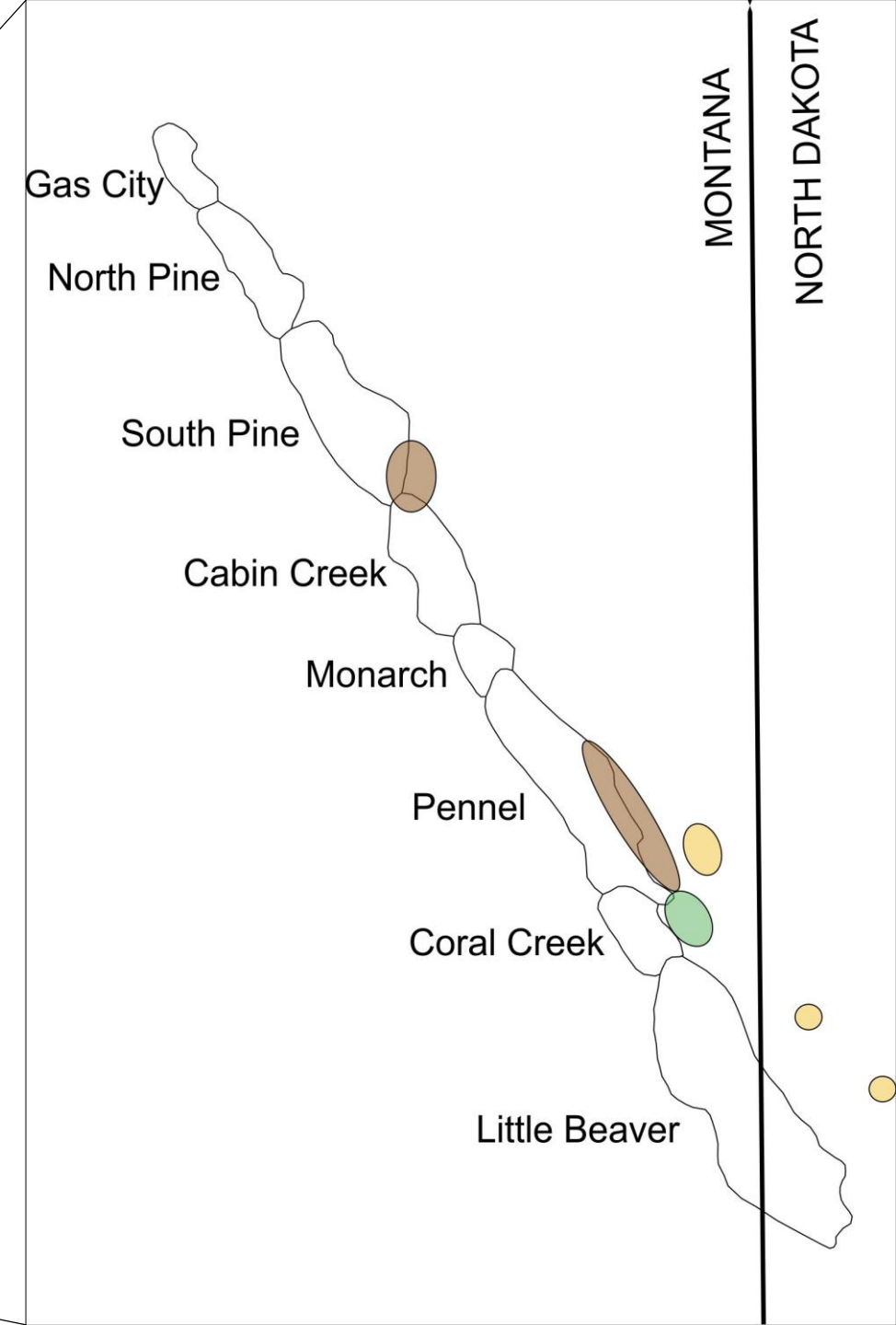
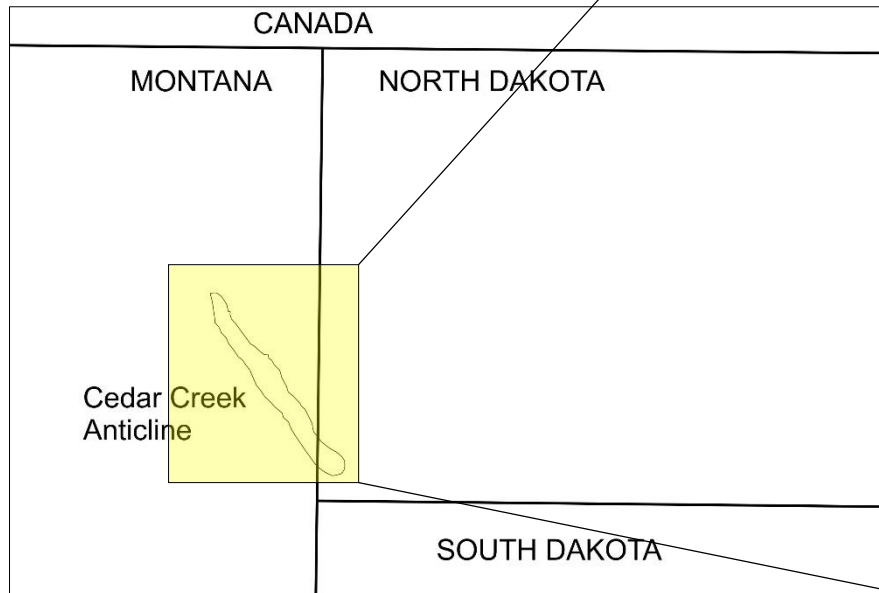
ORDOVICIAN



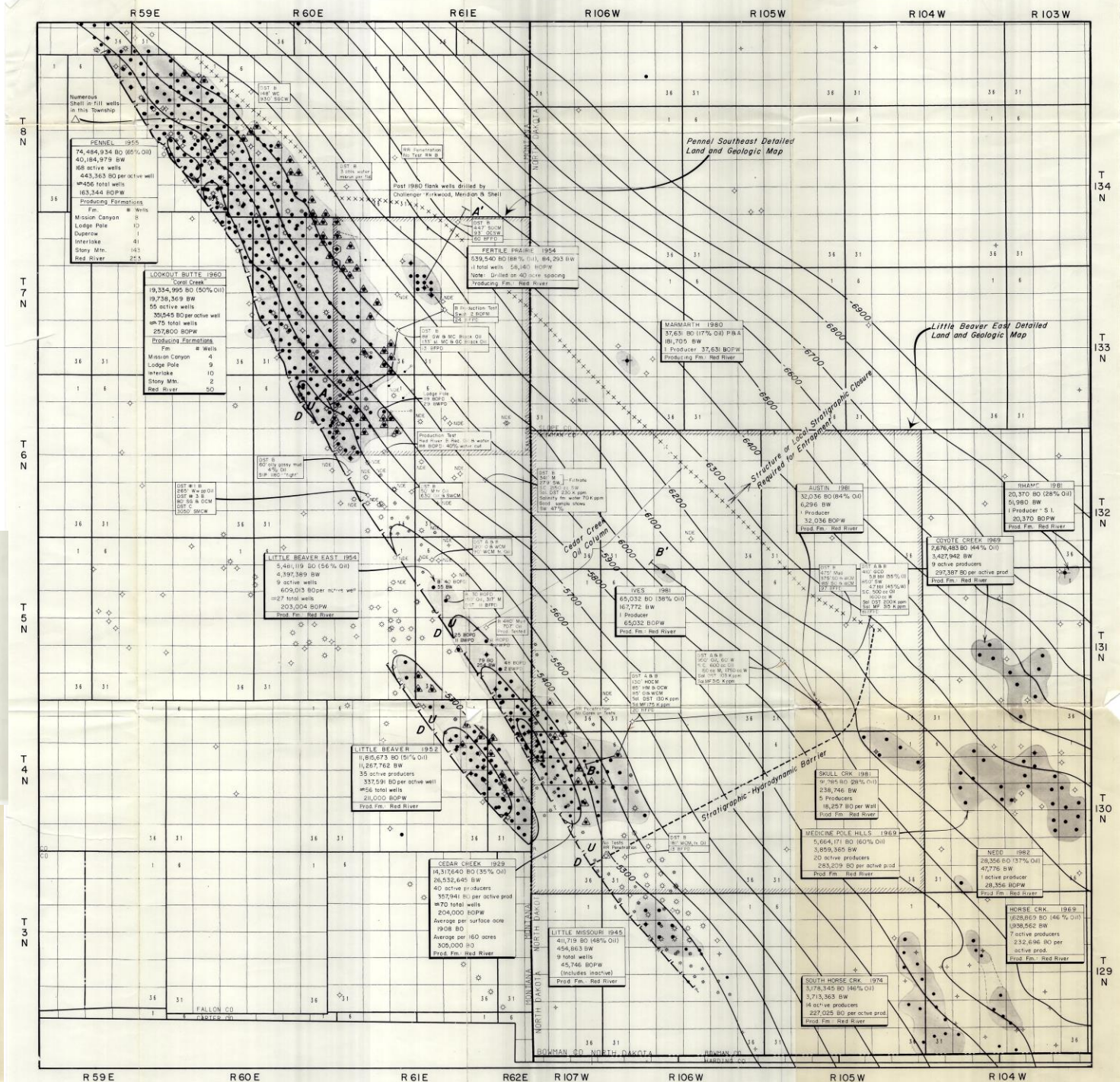
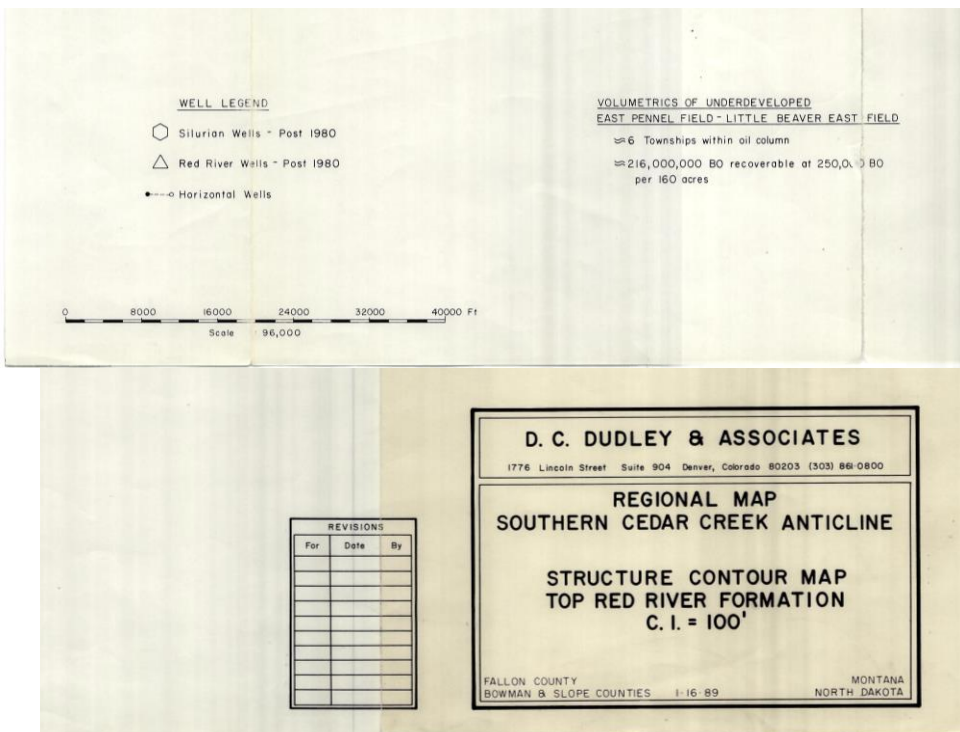
Thickness	9 ft.
Porosity	17%
Permeability	10 md.
Water Saturation	30%

# Cedar Creek Anticline; Initial Well Development

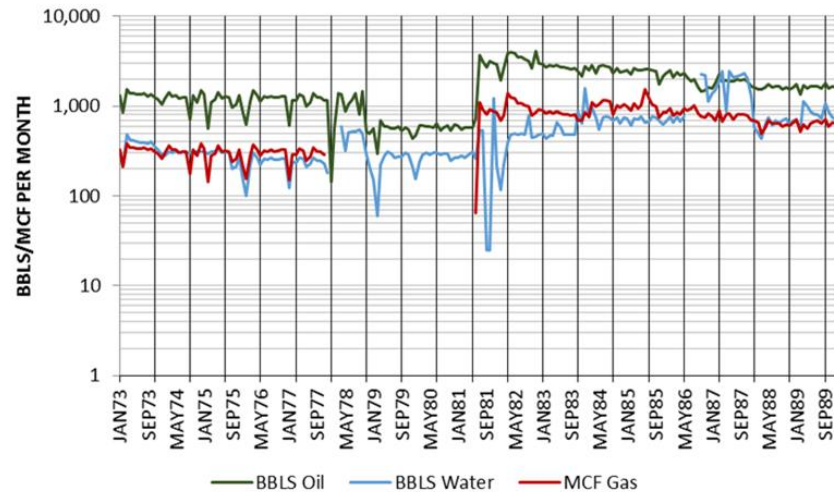
- Historic Dwindip Production
- 1980s Dwindip Extension
- Burlington Resources Horizontals – Late 1980s



# Cedar Creek Anticline(1989)



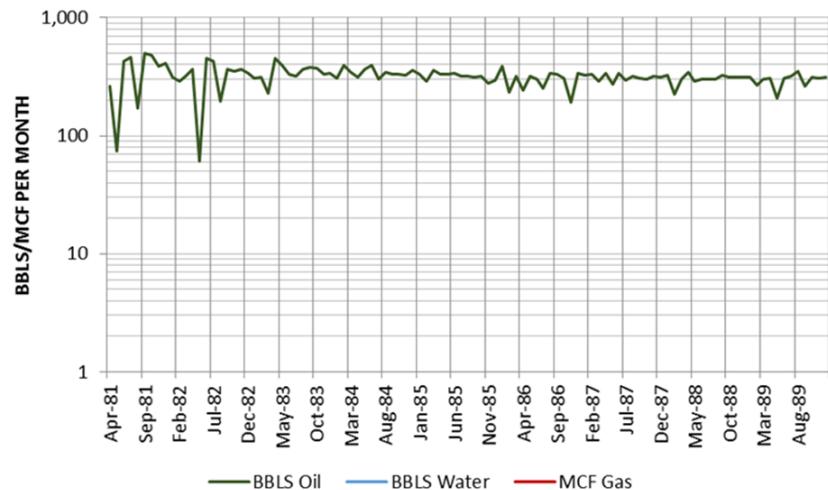
### FERTILE PRAIRIE FIELD PRODUCTION



640,000 BO  
82,000 BW

88% Oil

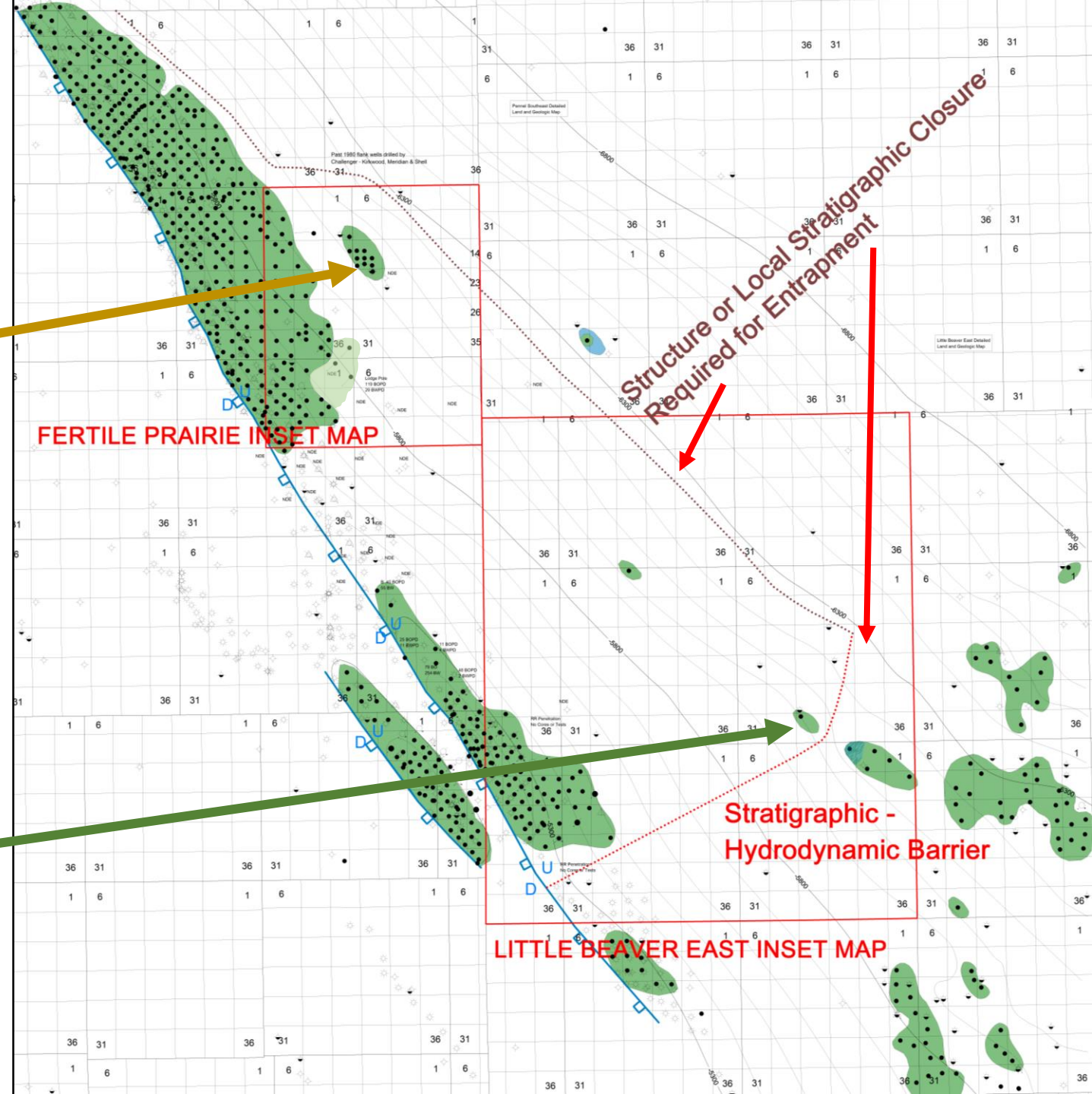
### AUSTIN FIELD - SOUTH RED RIVER B PRODUCTION



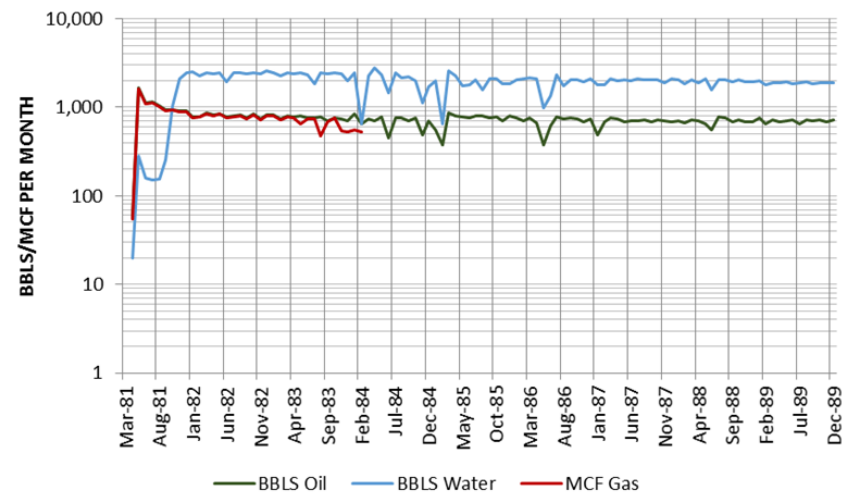
32,000 BO  
6,000 BW

84% Oil

### FERTILE PRAIRIE INSET MAP

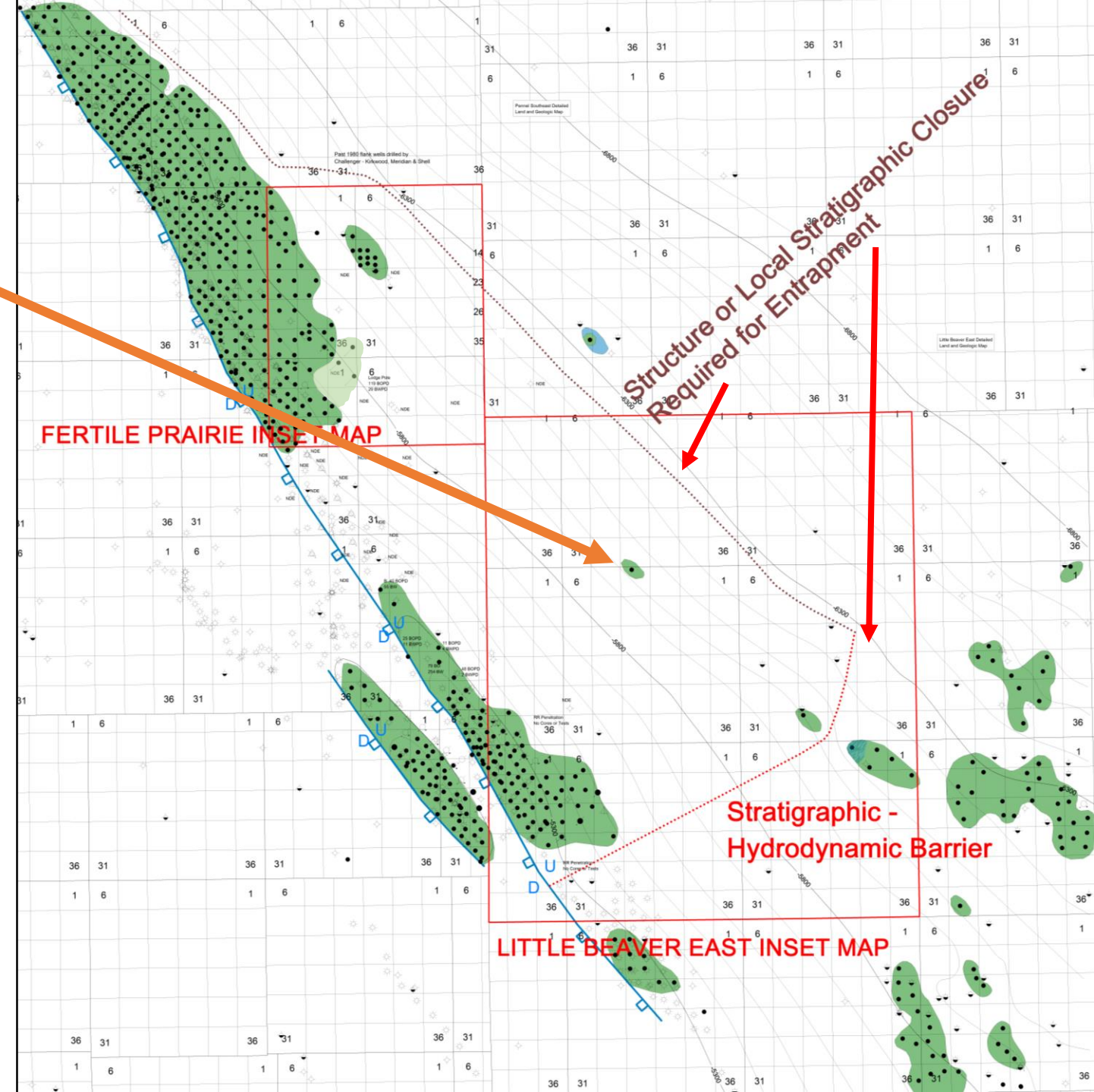


# IVES FIELD PRODUCTION

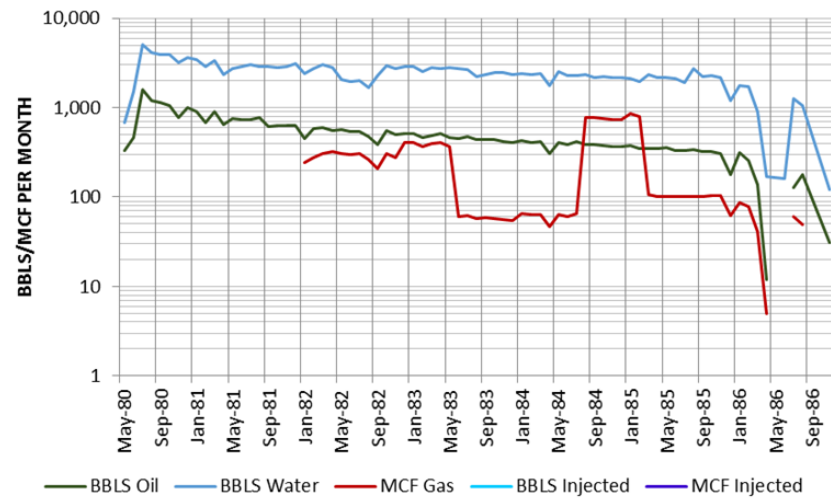


65,000 BO  
167,000 BW

28% Oil



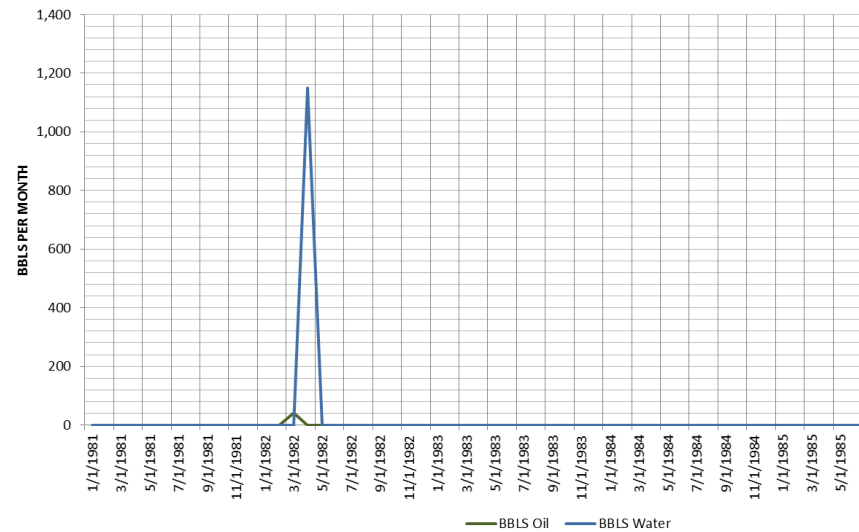
# MARMARTH FIELD PRODUCTION



38,000 BO  
182,000 BW

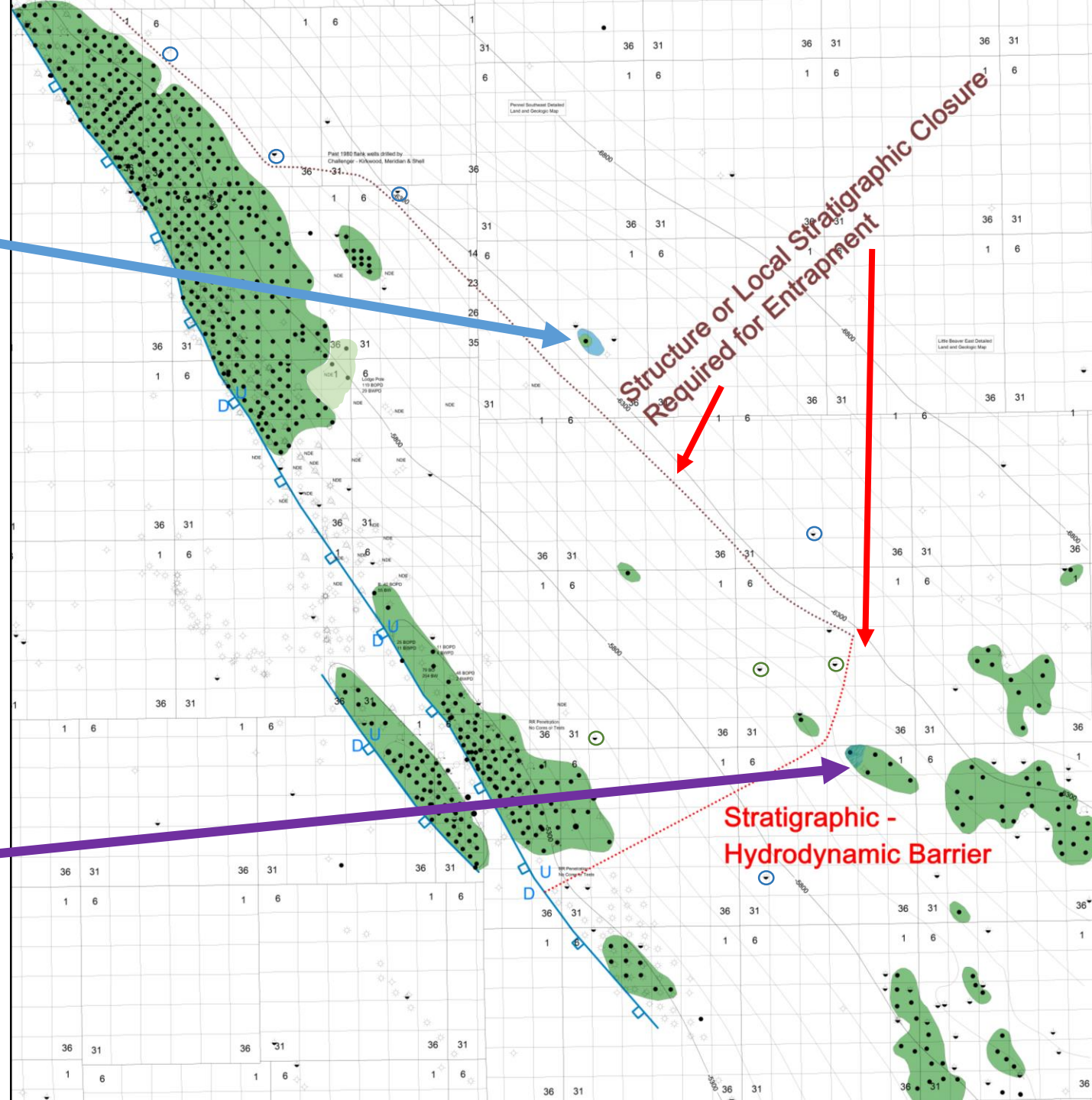
17% Oil

# SKULL CREEK PRODUCTION



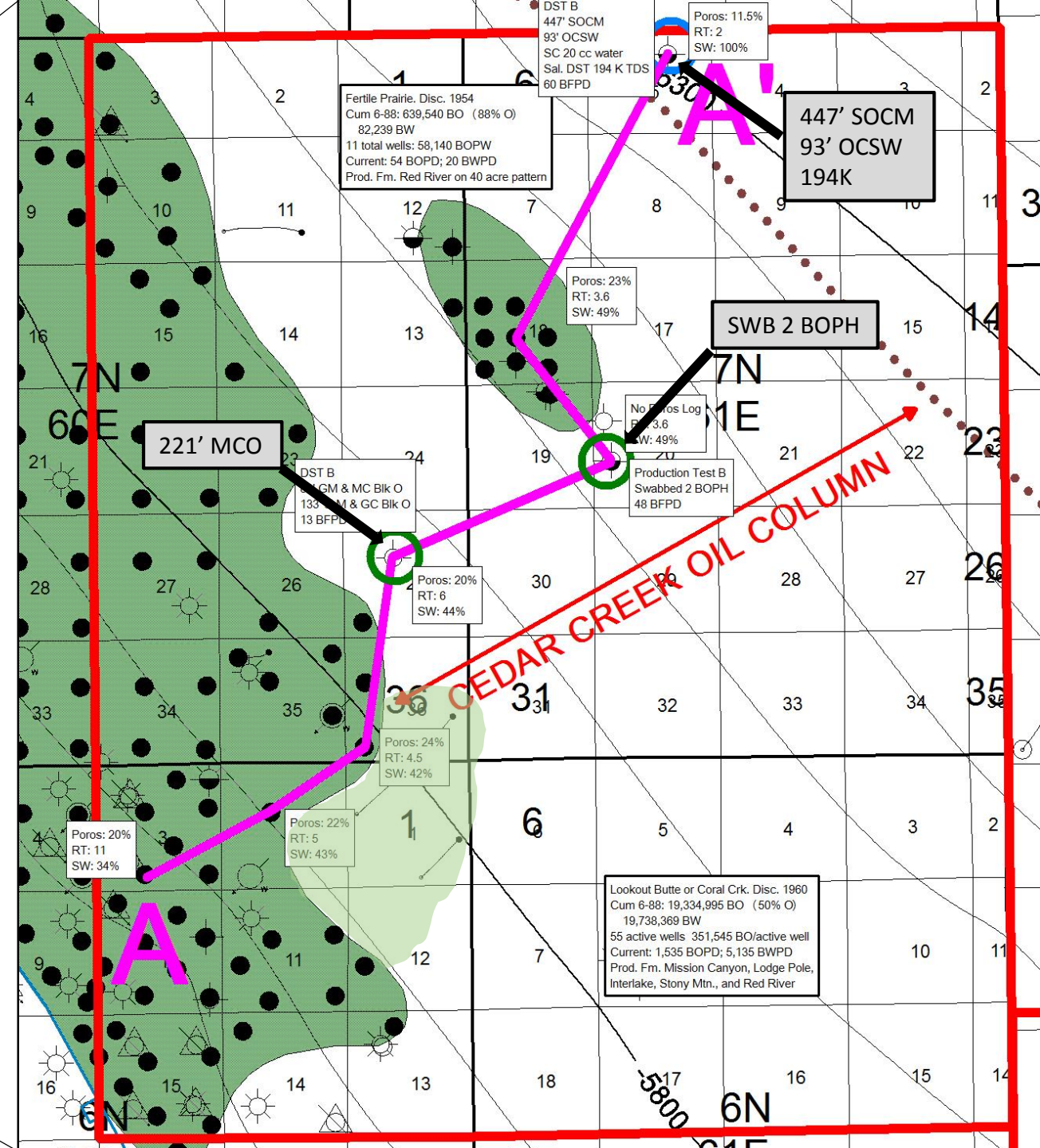
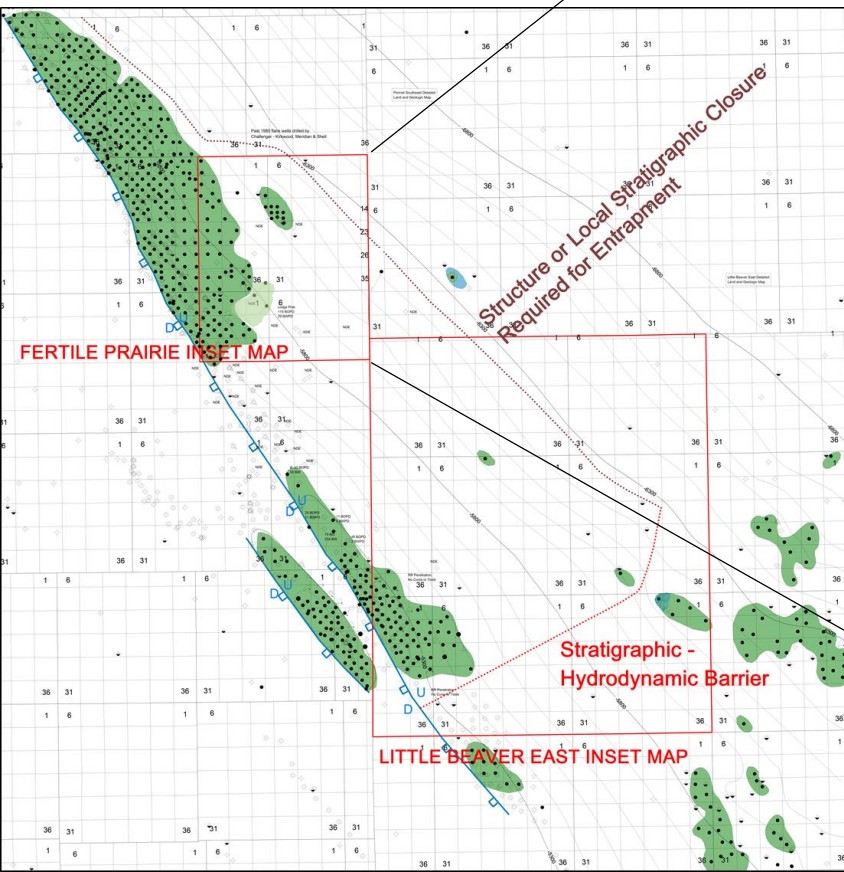
42 BO  
1,150 BW

4% Oil



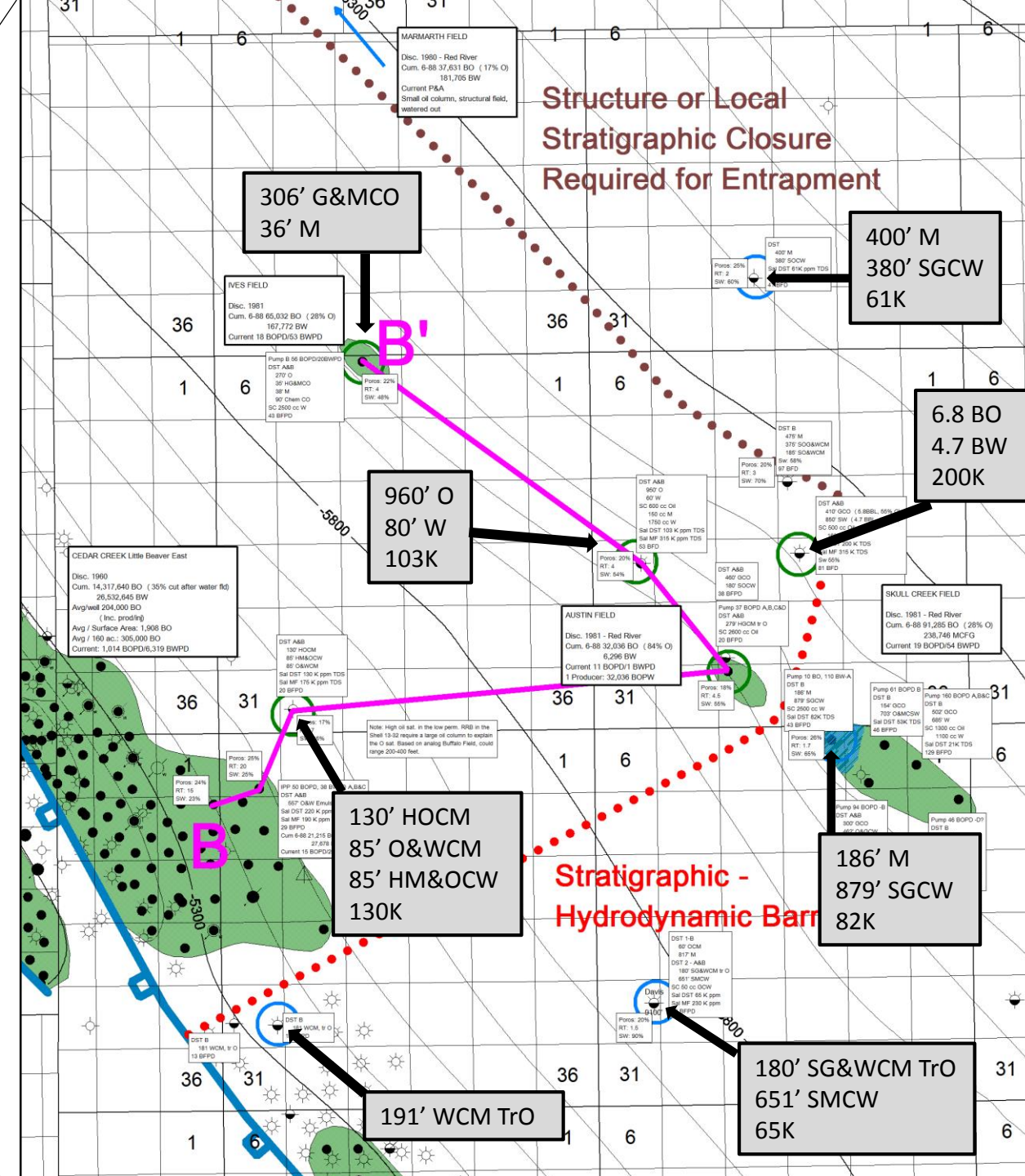
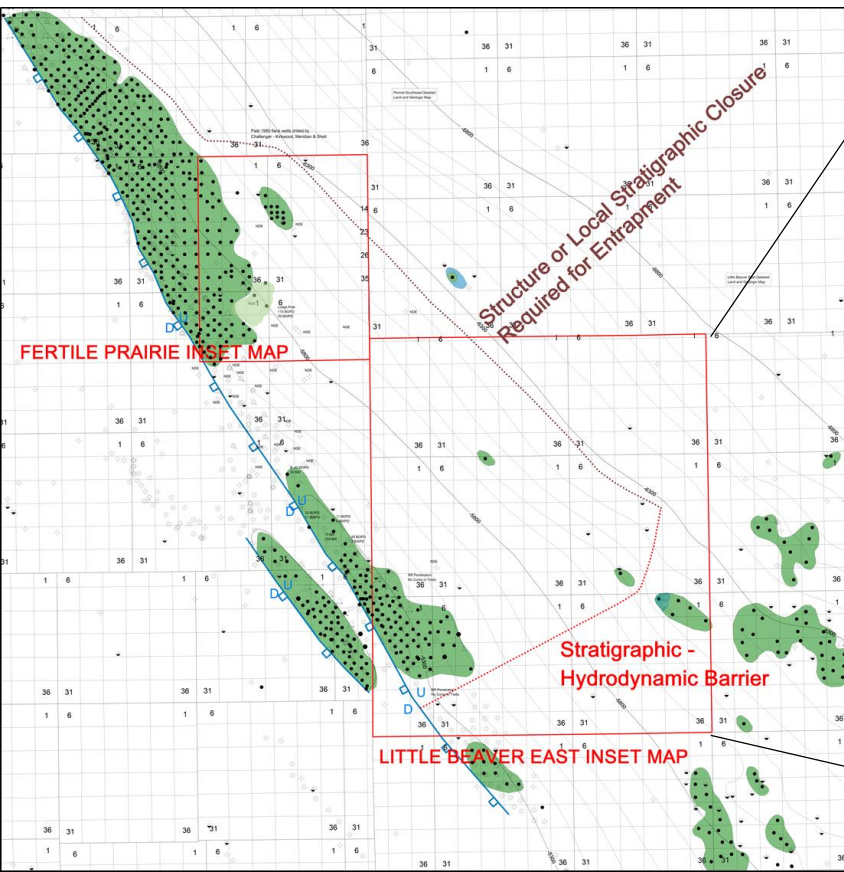
# Fertile Prairie – 1989

## Bowman County, North Dakota



# Little Beaver East – 1989

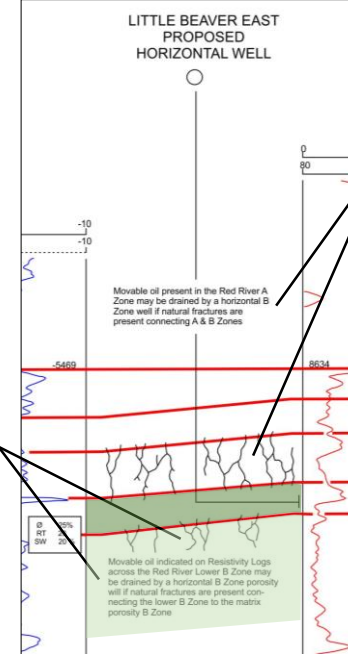
## Bowman County, North Dakota



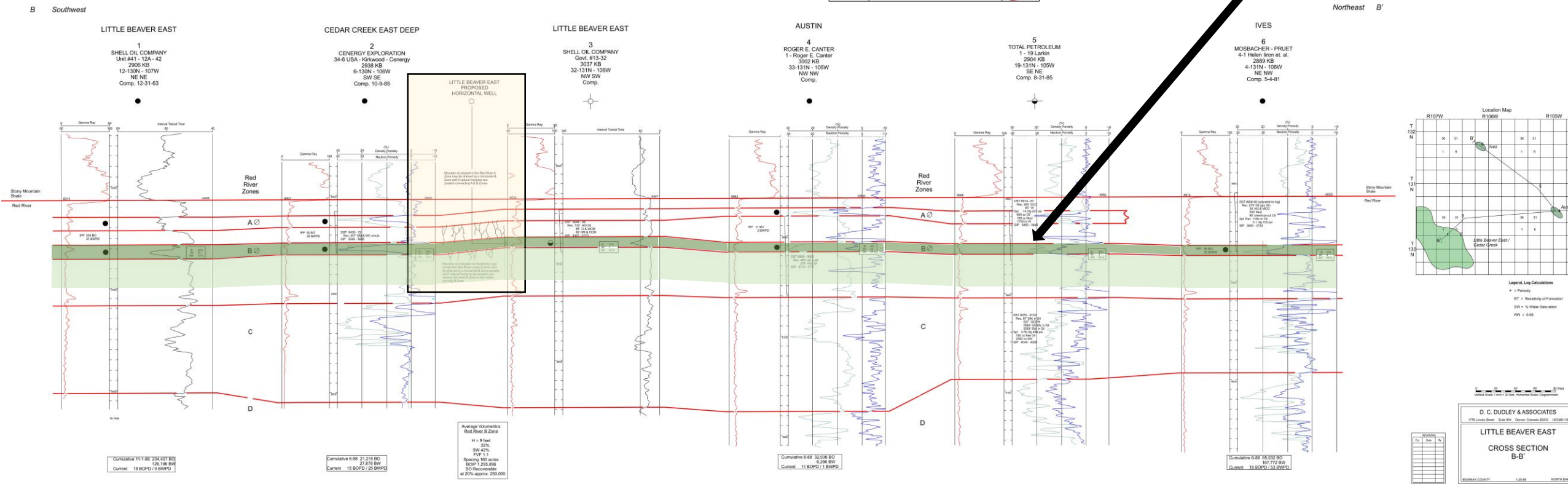
# B-B' Cross Section, Little Beaver East

Movable oil indicated on Resistivity Logs across the Red River Lower B Zone may be drained by a horizontal B zone porosity well if natural fractures are present connecting the lower B Zone to the matrix porosity B Zone (Conduit)

Movable Oil Present in the Red River A Zone may be drained by a horizontal B Zone well if natural fractures are present connecting A & B Zones



B-Zone  
Conduit



# Cedar Creek Anticline

## 1989

### VOLUMETRICS OF UNDERDEVELOPED EAST PENNEL FIELD - LITTLE BEAVER EAST FIELD

≈ 6 Townships within oil column

≈ 216,000,000 BO recoverable at 250,000 BO  
per 160 acres

#### D. C. DUDLEY & ASSOCIATES

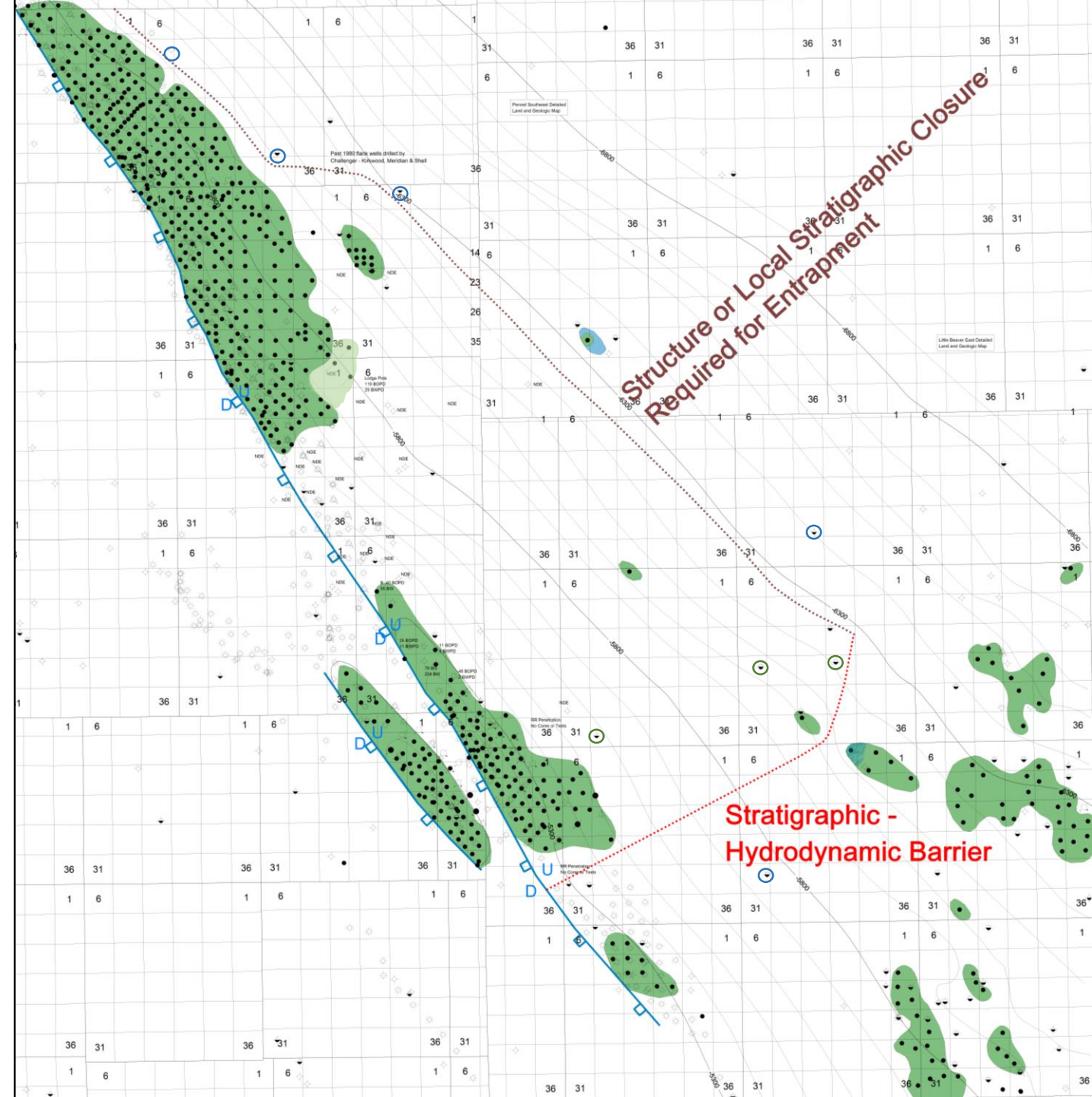
1776 Lincoln Street Suite 904 Denver, Colorado 80203 (303) 861-0800

#### REGIONAL MAP SOUTHERN CEDAR CREEK ANTICLINE

#### STRUCTURE CONTOUR MAP TOP RED RIVER FORMATION C. I. = 100'

FALLON COUNTY  
BOWMAN & SLOPE COUNTIES 1-16-89

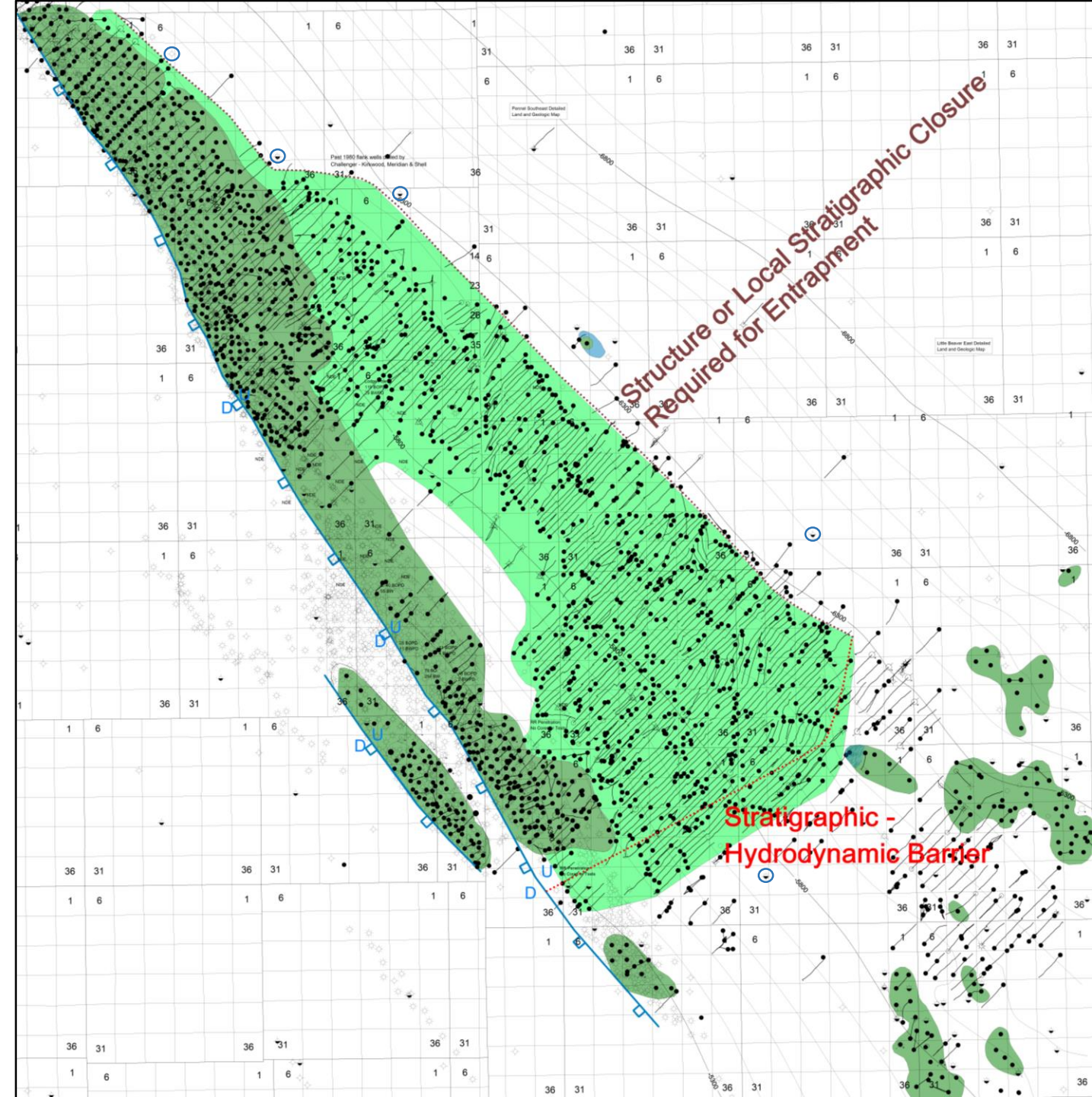
MONTANA  
NORTH DAKOTA



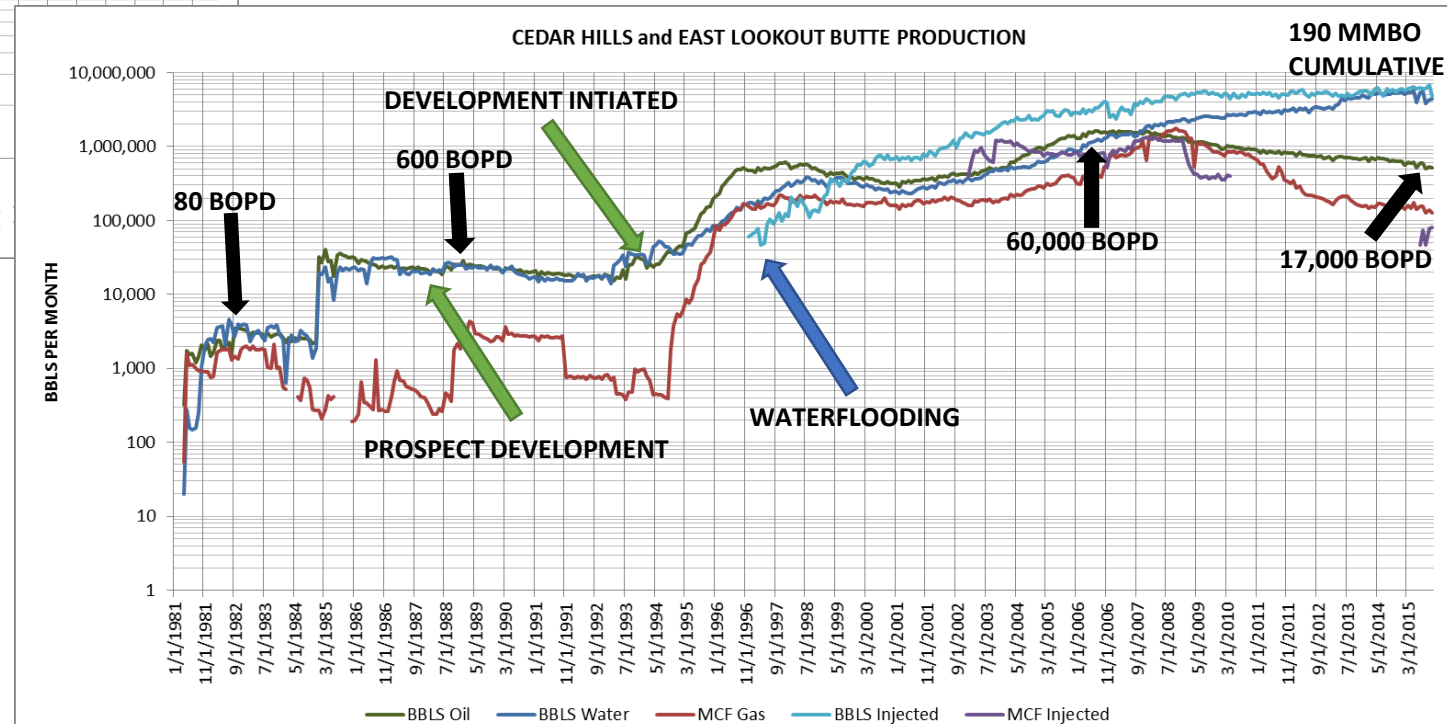
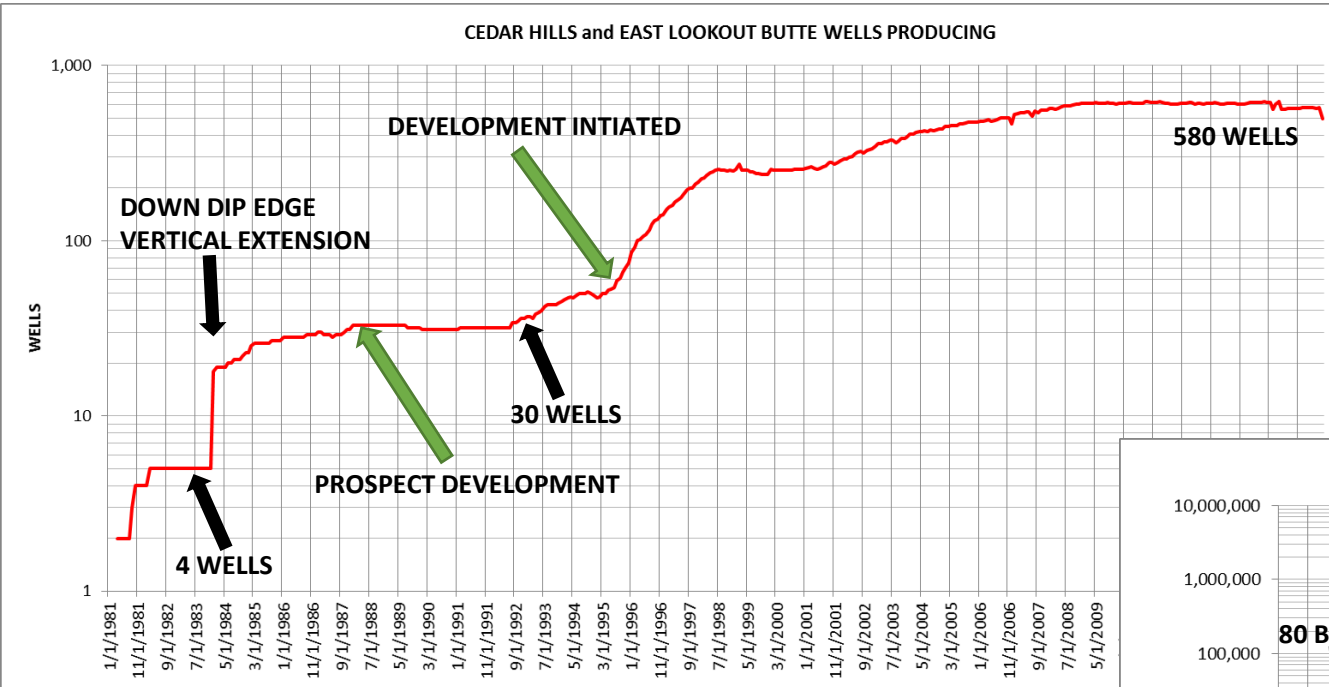
# Cedar Creek Anticline

## 2015

1989 Estimates	2015 Realities
~216 MMBO Recoverable	~190 MMBO so far...
Large Oil Column	Present

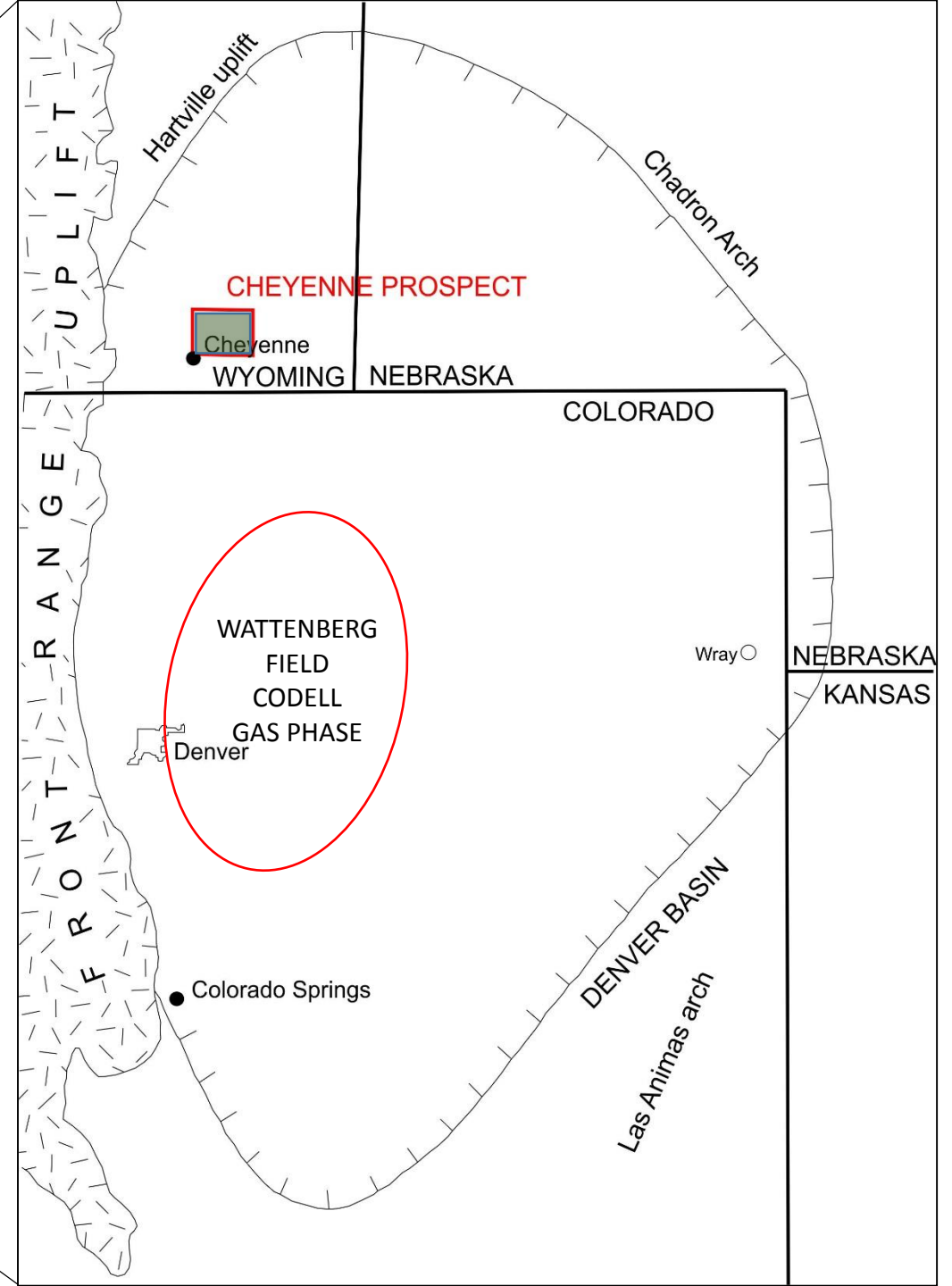
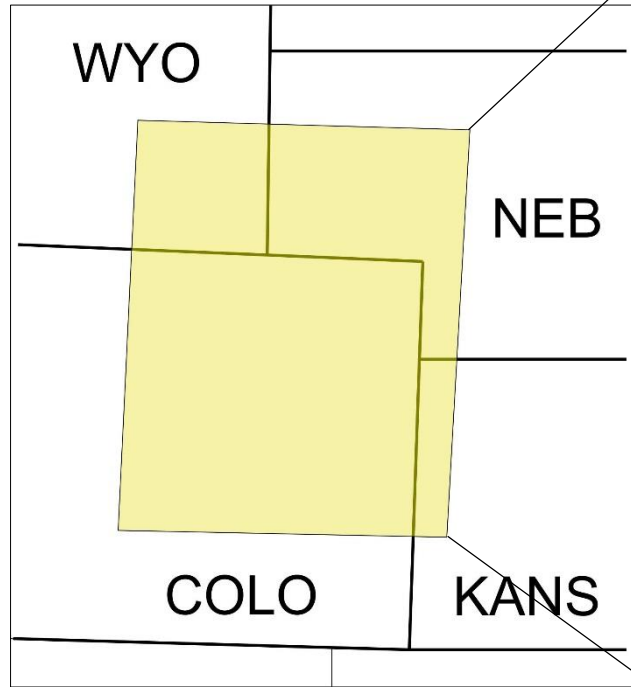


# Current Decline Curves with Current Cumulatives



# Codell Play 2005

# Cheyenne Prospect, Laramie County, WY



# Target: Codell Sandstone

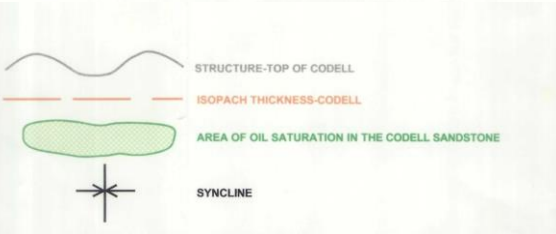



Era	Period		Subsurface Denver Basin	Source rock interval	Producing units
CENOZOIC	TERTIARY	Oligocene	White River Fm	<div><div>HORIZONTAL TARGET</div><div>SOURCE ROCK</div></div>	<div><div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><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# Cheyenne Prospect; Laramie County, WY

## LEGEND

● APD DENIED	○ SURFACE LOCATION	NP DOES NOT PENETRATE CODELL
○ DISPOSAL WELL	● BOTTOM HOLE	ND NO GEOLOGIC SAMPLE DATA FOR WELL
○ EXPIRED PERMIT	● POOR OIL SHOWS	NL NOT LOGGED
○ INJECTOR	● FAIR OIL SHOWS	20 THICKNESS - CODELL SS
○ OIL WELL	● GOOD OIL SHOWS	-2000 SUBSEA - TOP OF CODELL SS
○ PLUGGED & ABANDONED - OIL WELL	○ CODELL PERFORATED	
○ PLUGGED & ABANDONED - GAS WELL	★ CODELL OR FORT HAYS PRODUCER	
○ WELL LOCATION		
● SHUT IN		
○ ABANDONED LOCATION		





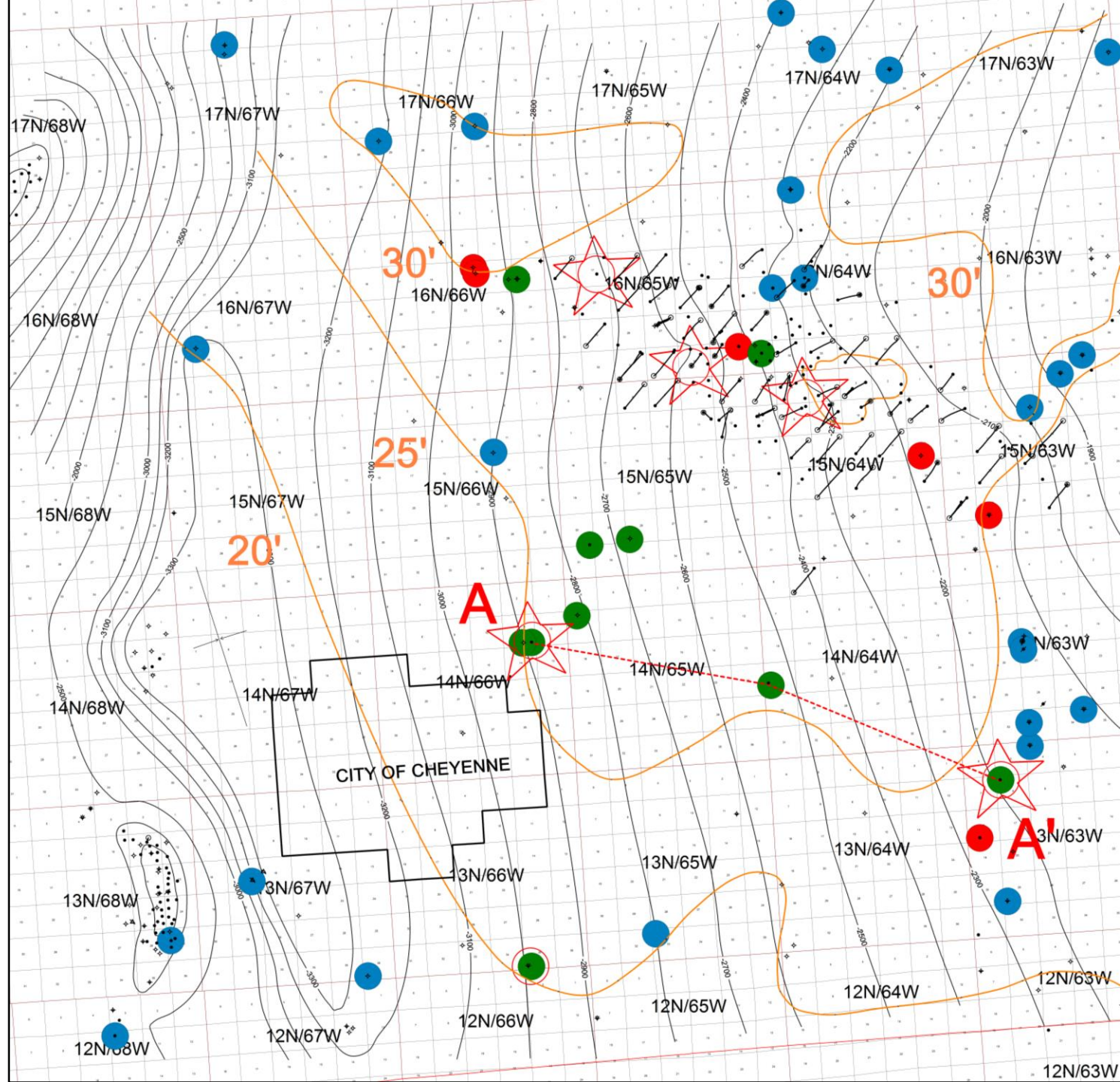
**KIRKWOOD**  
Oil & Gas LLC

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**CHEYENNE PROSPECT**  
Laramie County, WY

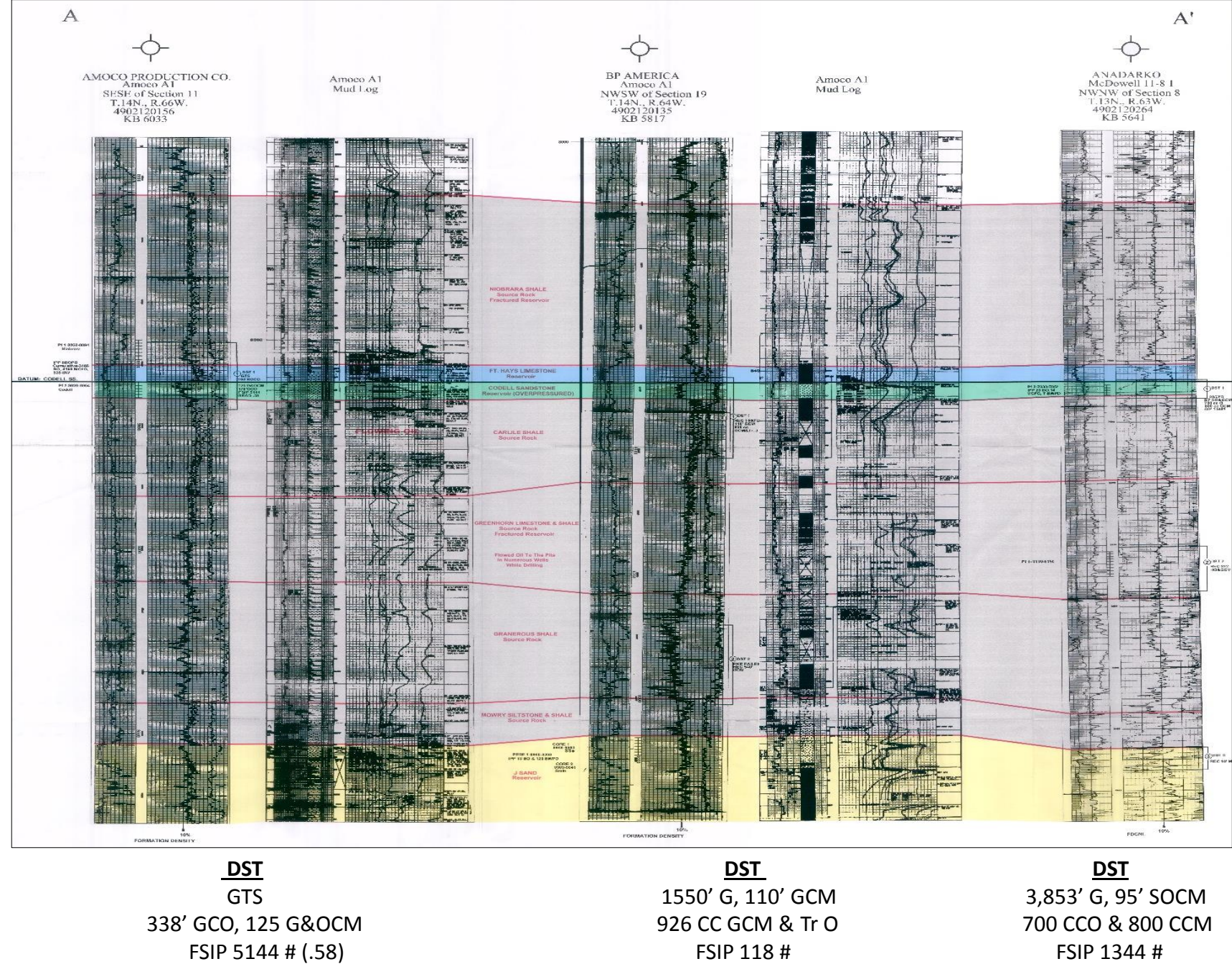
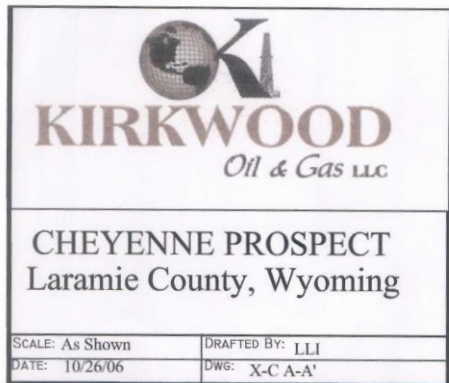
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DATE: 7/18/08	DWG: Base Map



# Cheyenne Prospect; Laramie County, WY

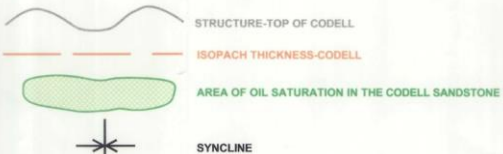
-  : Source Rock
-  : Ft. Hays Limestone
-  : Codell Sandstone
-  : J Sand




# Cheyenne Prospect; Laramie County, WY

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● SHUT IN		
○ ABANDONED LOCATION		





**KIRKWOOD**  
Oil & Gas LLC

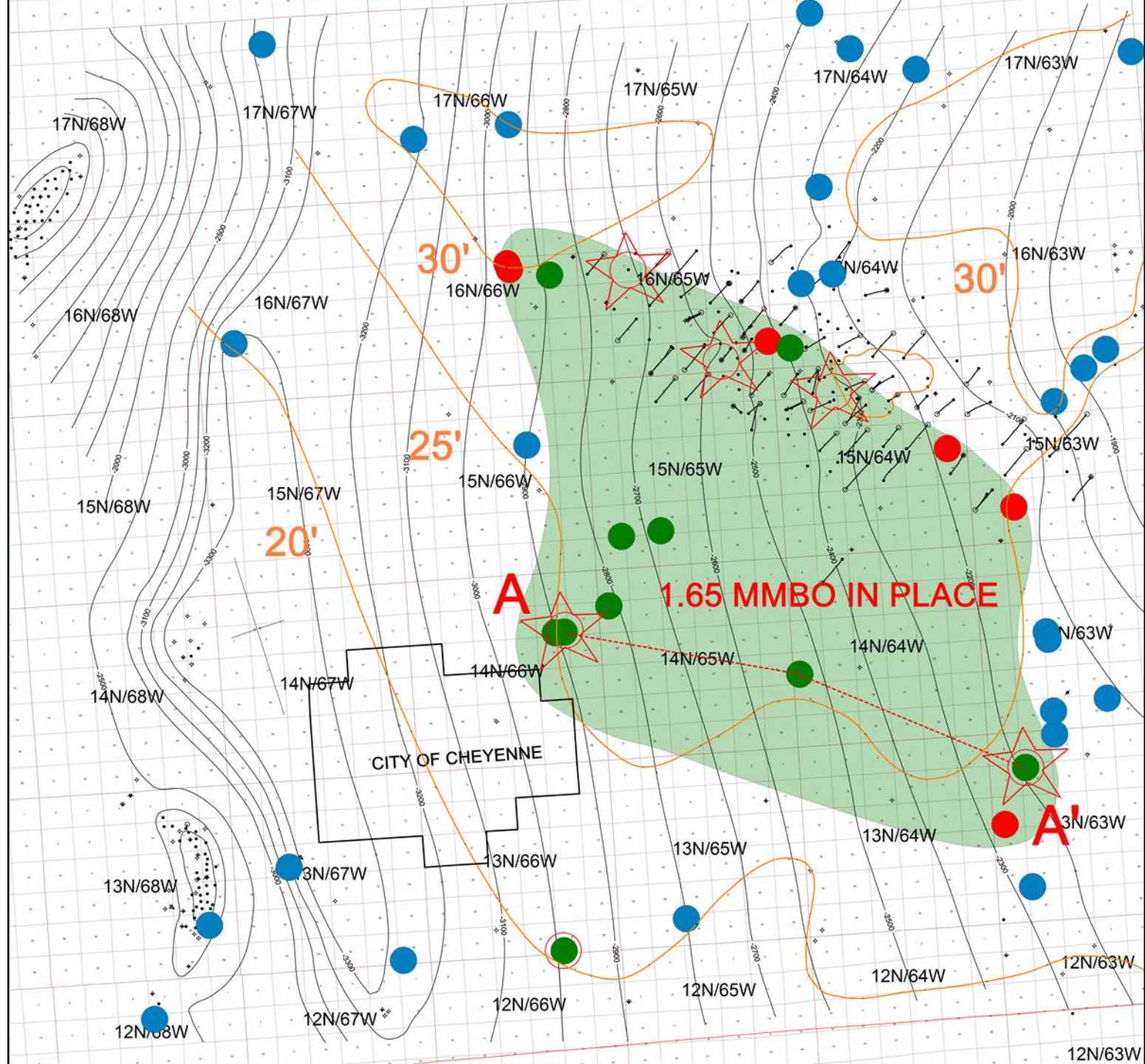
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**CHEYENNE PROSPECT**  
Laramie County, WY

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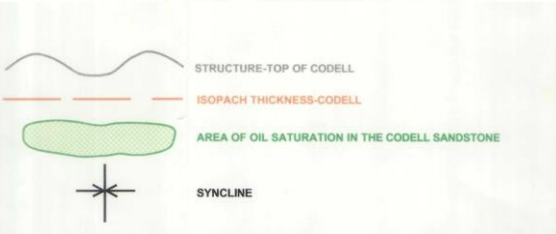
# Reservoir Analog


	Reservoir	
	Codell Sandstone – DJ Basin	Bakken - Richland Co., MT Elm Coulee (Comparison)
Porosity	10.5%	12%
Permeability	0.44 MD	0.06 MD
Oil Saturation	60%	80%
FVF	1.15	1.4
Thickness	27'	10'
Pressure	Overpressure indicated	Overpressure
Gravity	35° Sweet	42° Sweet
Recovery Factor	10%	10%
Drilling Depth (Vertical)	8900'	9500'

# Cheyenne Prospect; Laramie County, WY

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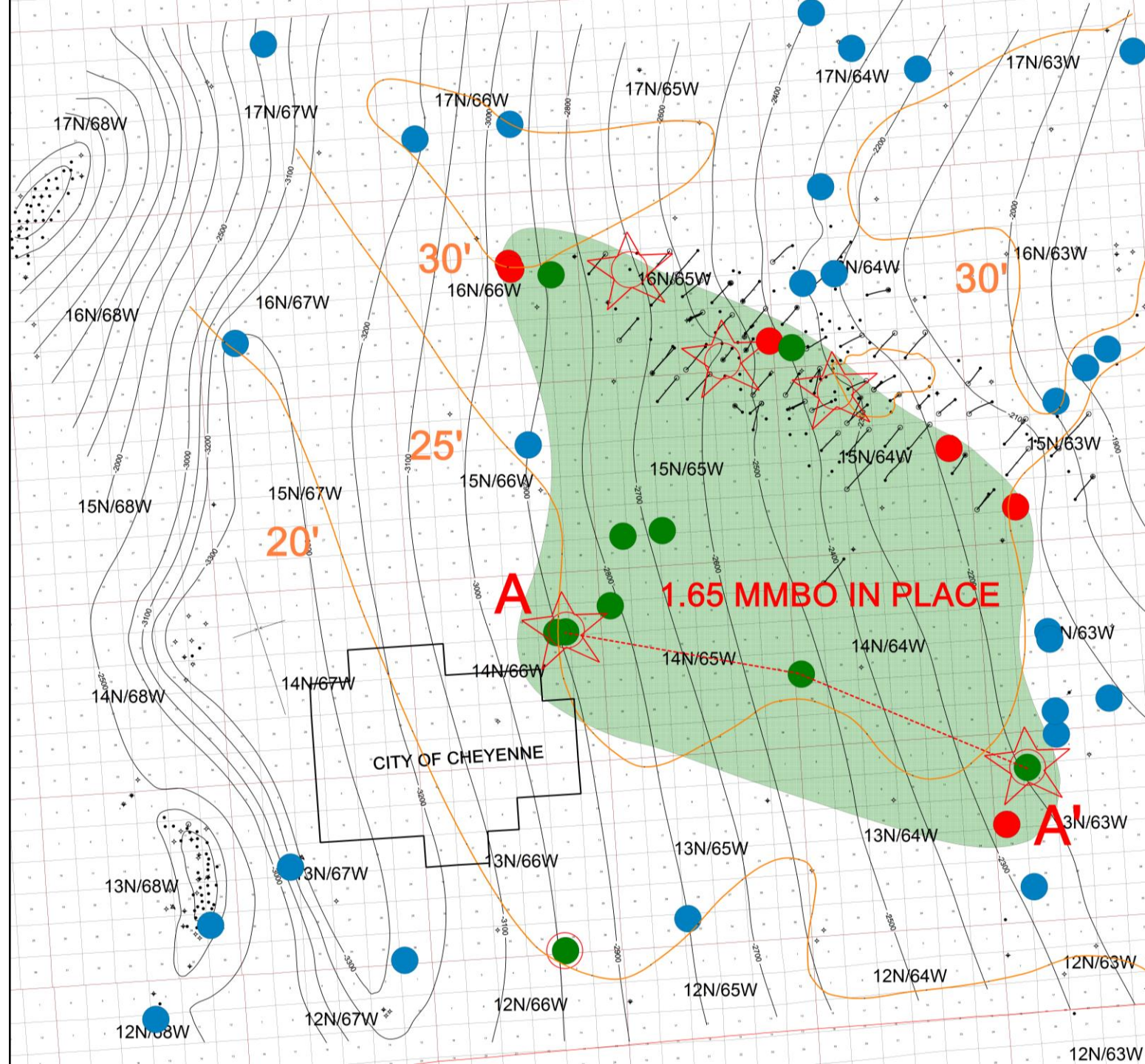
**KIRKWOOD**  
Oil & Gas LLC

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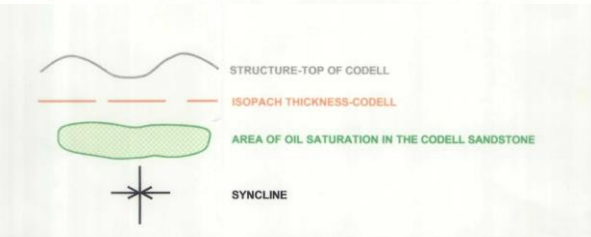
**CHEYENNE PROSPECT**  
Laramie County, WY

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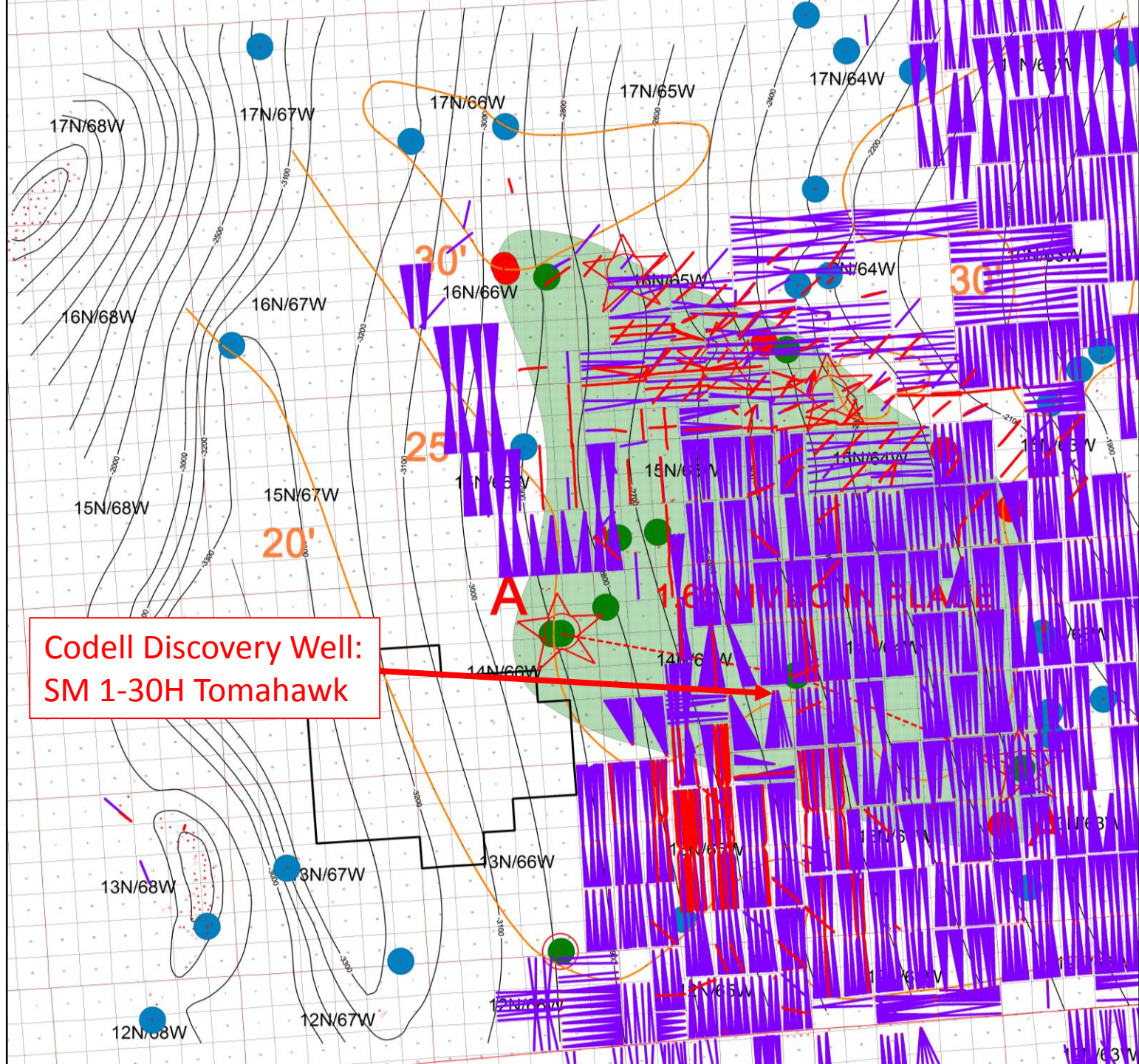
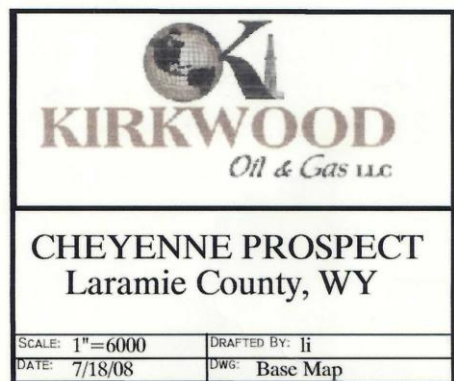
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# Cheyenne Prospect; Laramie County, WY

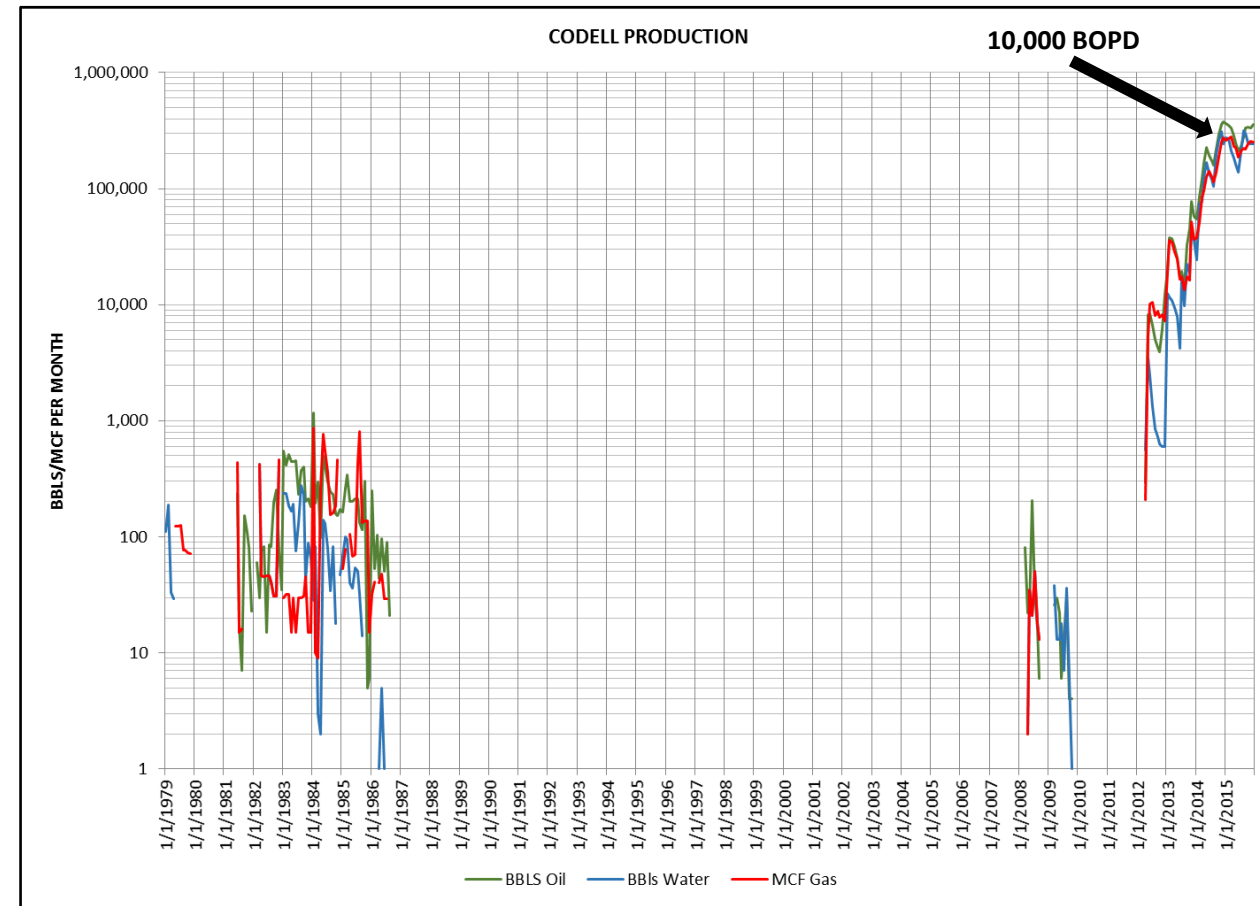
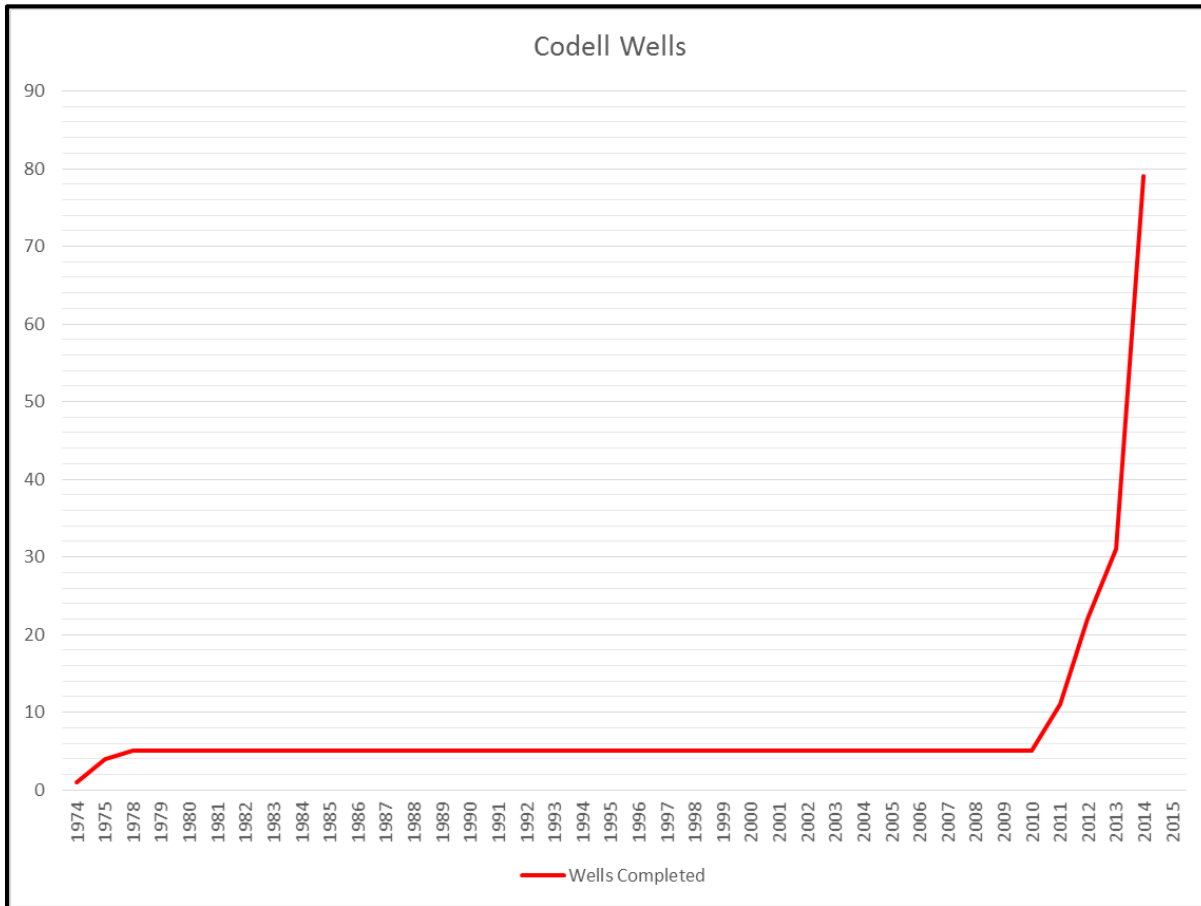


CODELL PERMITTED LOCATIONS (2015)



**Codell Discovery Well:  
SM 1-30H Tomahawk**

# Decline Curves with Cumulatives - Codell



# POST GENERATION HISTORY AND LESSONS LEARNED

“NO GREAT DISCOVERY WAS EVER MADE  
WITHOUT A BOLD GUESS” – Isaac Newton