

# Field Screening for Shallow Gas in North Dakota

NDGS, 2006



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# Definitions of Shallow Gas in North Dakota

- **Geologic** - Natural gas that is generated and accumulates within the near surface geology of the state typically sourced and contained within permeable organic laden glacial sediments or within fractured shale and sandstone reservoirs of Cretaceous and Jurassic age or combinations of each (Anderson, 2005).
- **Regulatory** - Gas that is produced from a shallow gas zone that consists of a strata or formation, including lignite or coal strata or seam, located above the depth of five thousand feet (1,524 meters) below the surface, or located more than five thousand feet (1,524 meters) below the surface but above the top of the Rierdon Formation (Jurassic), from which gas may be produced (NDO&GD, 2005).
- Early Gas Properties (Barry, 1908)
  - 886 BTU
  - 82.7 % Methane
  - 0.2 % Ethane
  - 12.4 % Nitrogen
  - 0.5 % Hydrogen
  - 1.2 % Carbon Monoxide (CO<sub>2</sub>?)

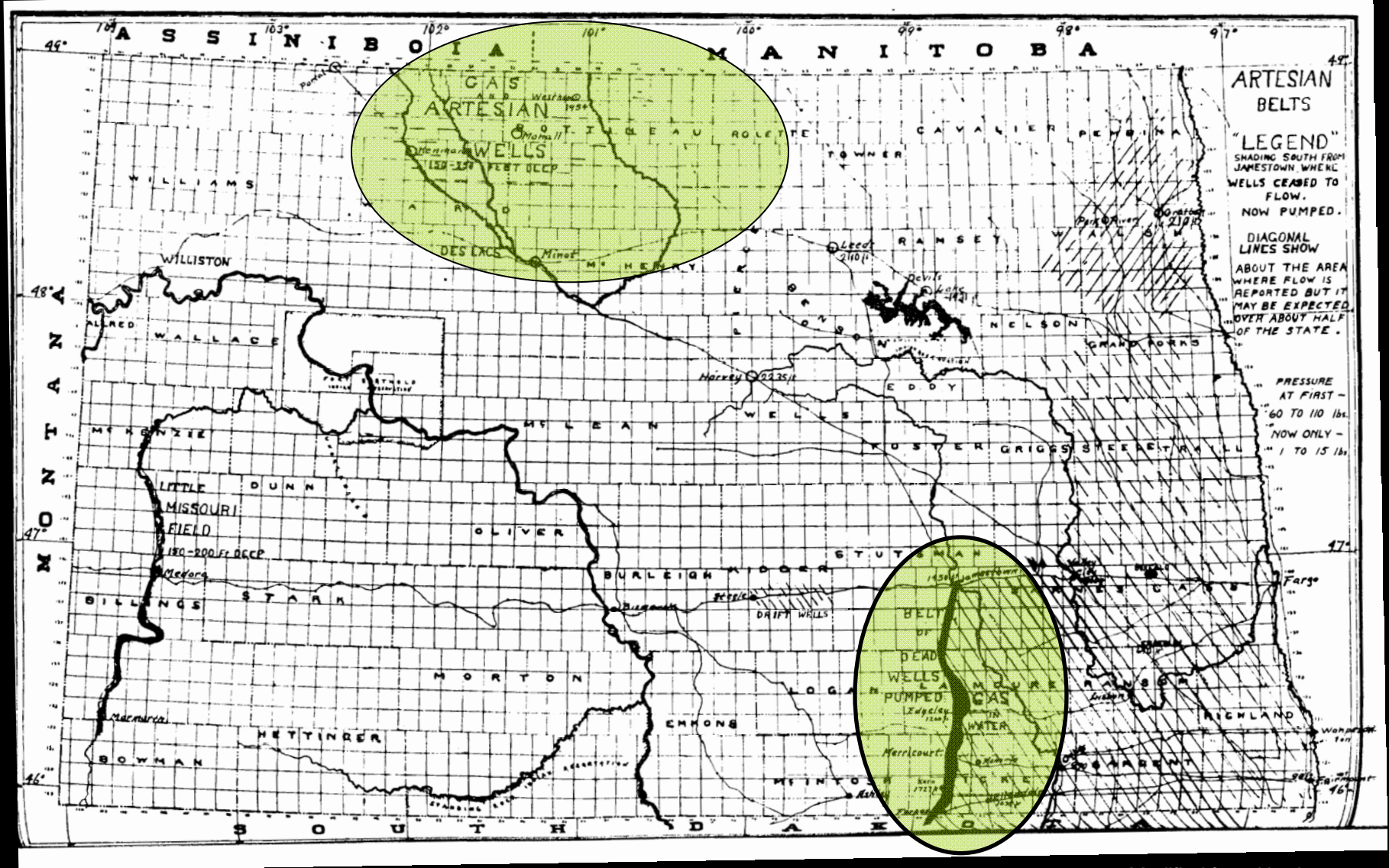


Gas flare on the Mohall "Dome" in the early 1920's.





# Areas of Historical Shallow Natural Gas Occurrence



Modified from Hard, 1920



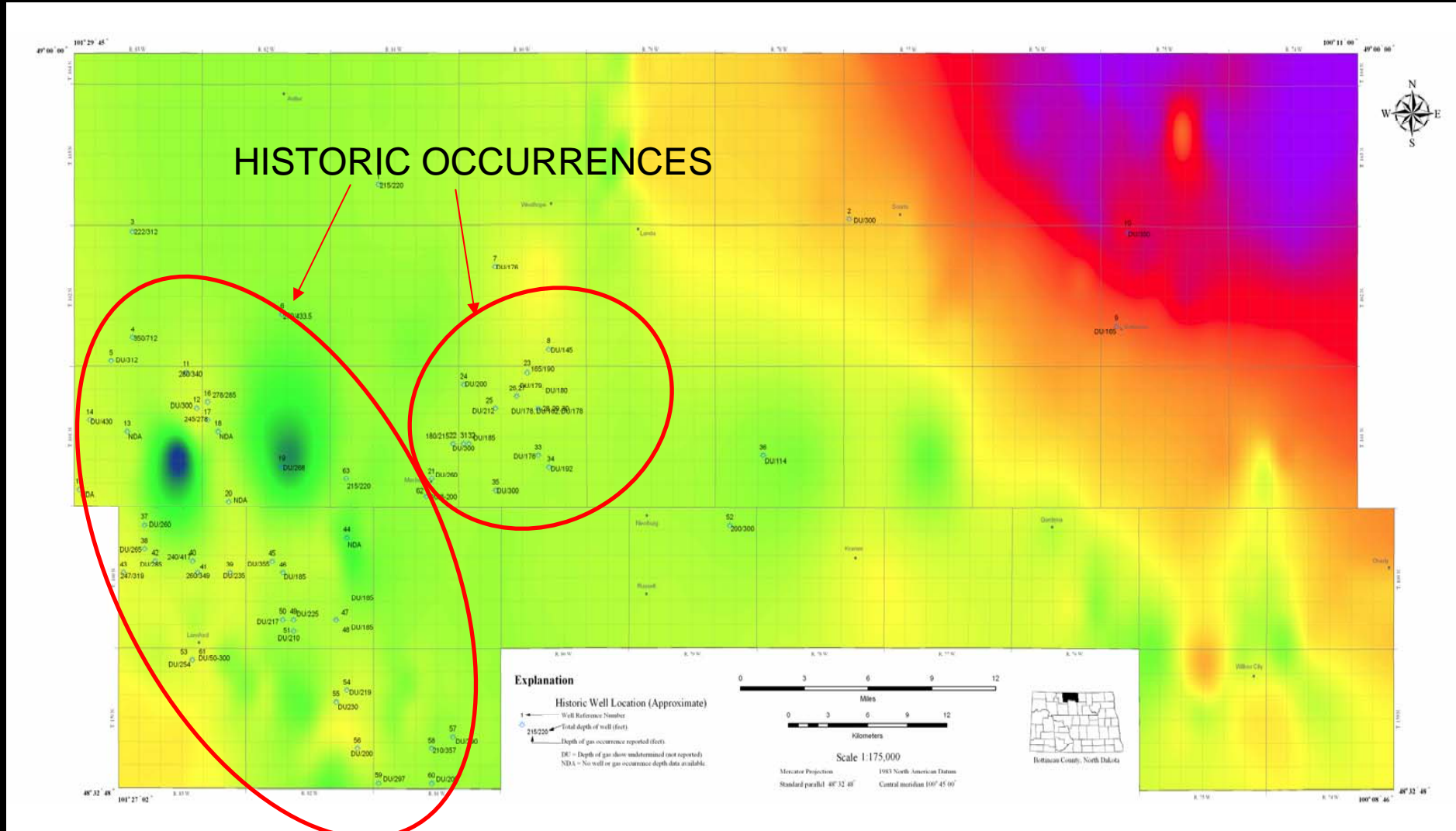
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# Bottineau County Historic Shallow Gas Occurrences



(Modified from Anderson, 2006)



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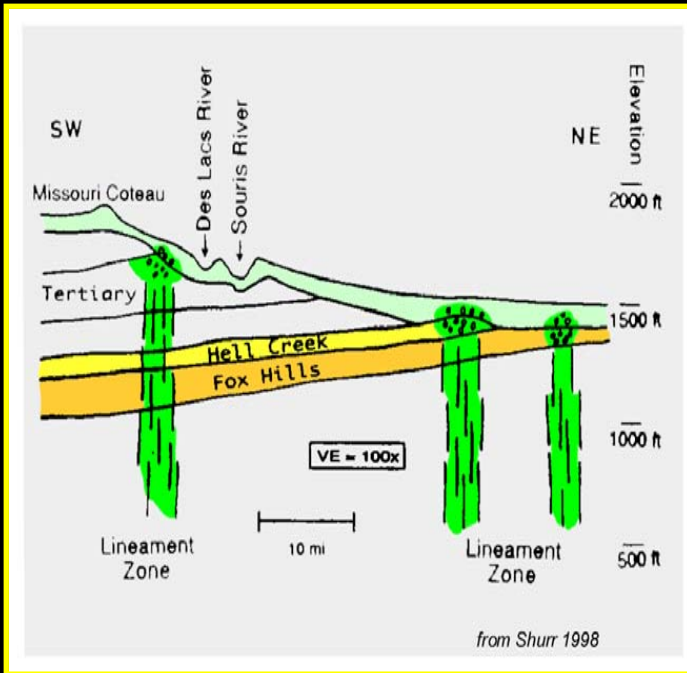
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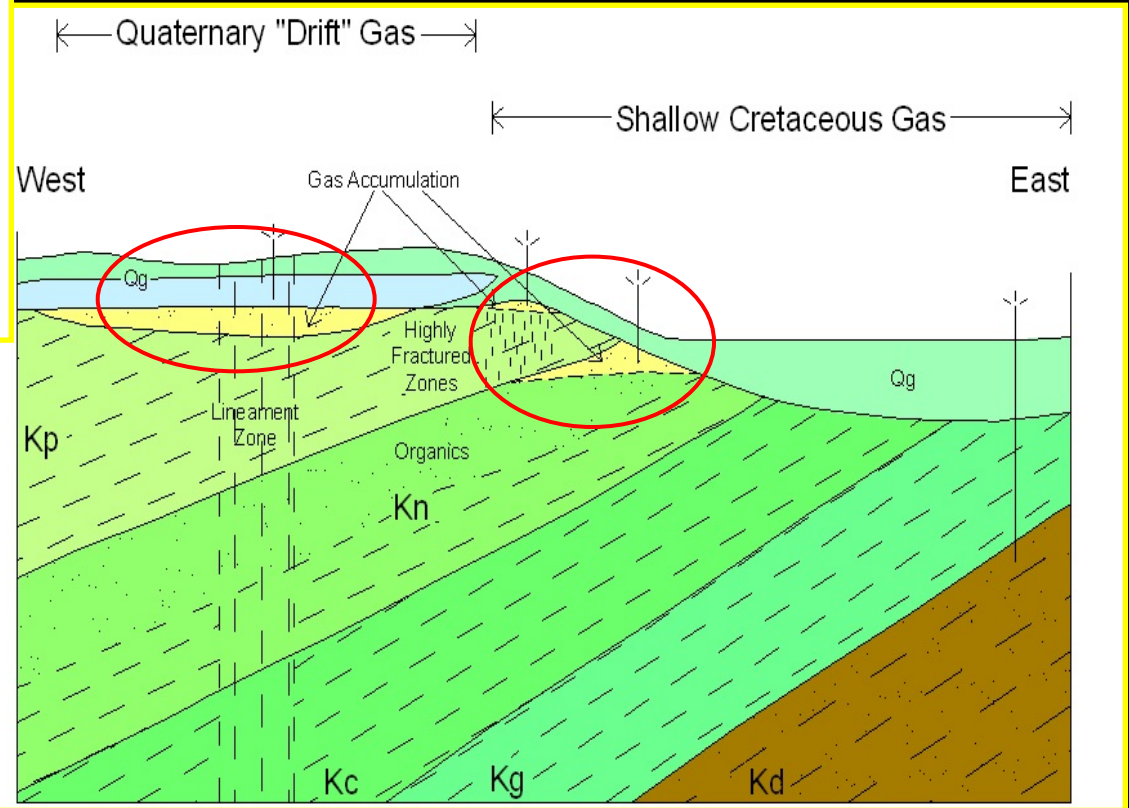


# Conceptual Shallow Gas Systems in North Dakota



(a) North-Central North Dakota.

Conceptual diagrammatic geologic sections depicting typical potential shallow gas settings in north-central (a) and eastern (b) North Dakota.



(b) Eastern North Dakota.

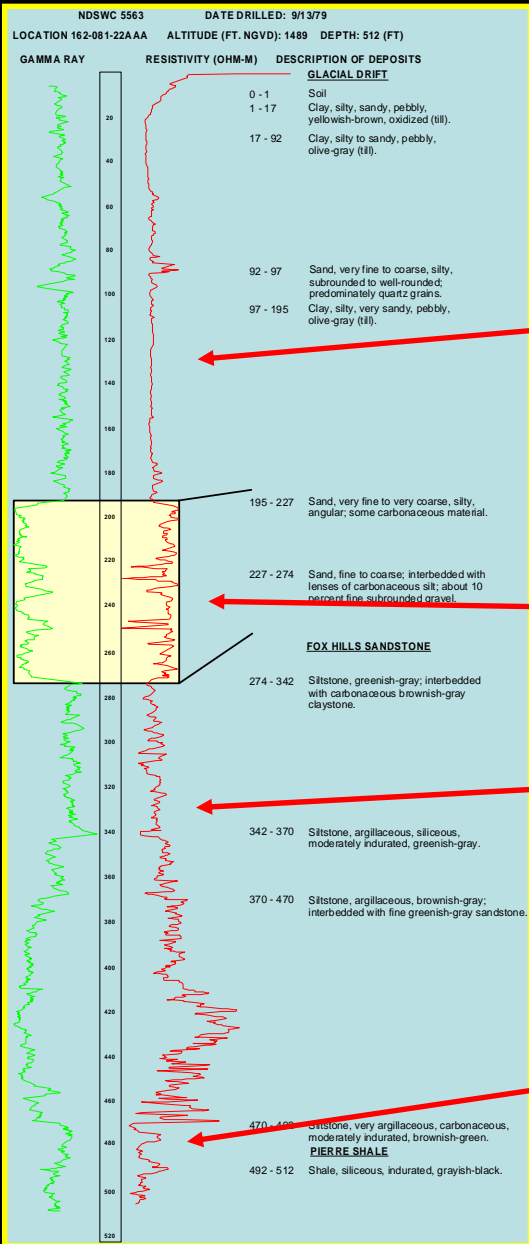


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# Typical Log Characteristics and Stratigraphic Relationships

Low permeability glacial sediment (till or glaciolacustrine sediments).

Basal outwash sands (detrital lignite common).

Underlying permeable Cretaceous bedrock (Fox Hills/Hell Creek Formation).

Deeper basal Cretaceous marine shales (Pierre Fm).

(Modified from Randich and Kuzniar, 1984)



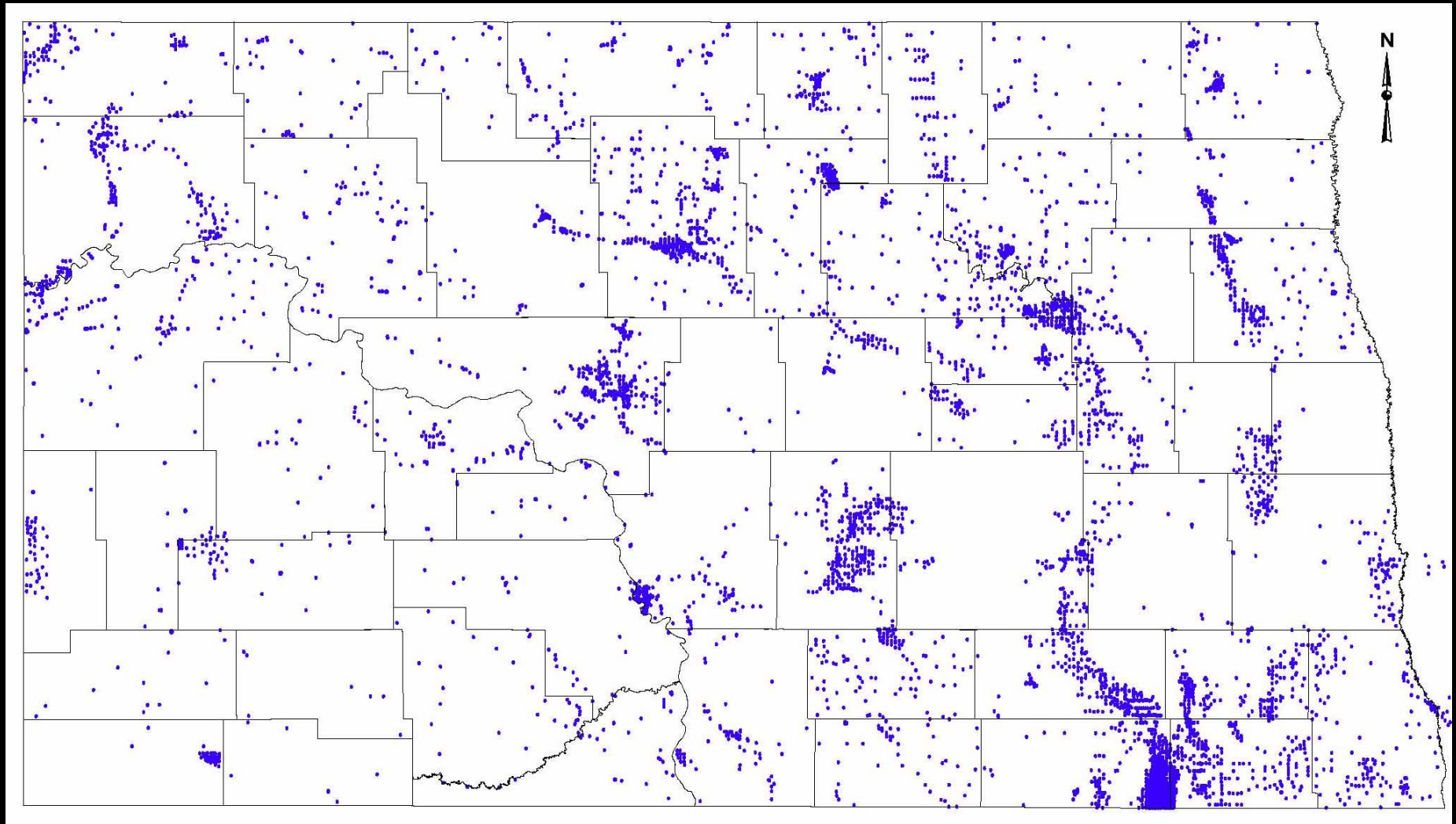
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# Location of Ground-Water Observation Wells in North Dakota



*Data from NDSWC, 2006*



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# Reconnaissance Level Field Screening Investigation

- Screening of existing monitoring wells with portable analytical instrumentation:

## Flame Ionization Detector (FID)



Multi-Gas Meters



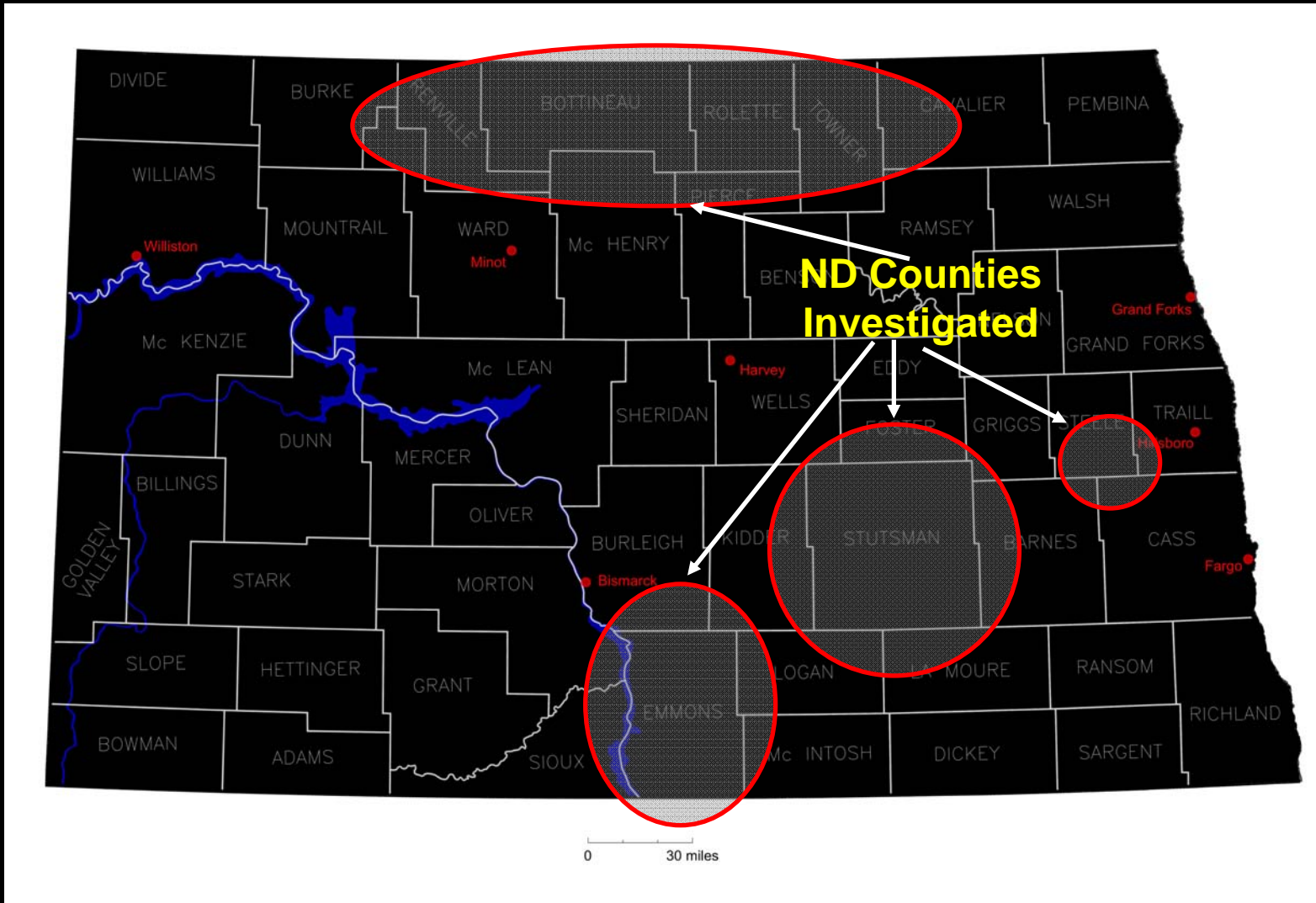


# Field Screening Investigative Highlights

- Steele County  
Pierre/Niobrara Shale Gas Conceptual Model
- Bottineau County  
Combined “Drift Gas” and Upper Cretaceous Shallow Bedrock
- Renville County  
Continuation of Bottineau Area Trend
- Emmons County  
– Cretaceous Fox Hills/Hell Creek Formation
- Stutsman County
- Rolette County
- Towner County



# NDGS Reconnaissance Observation Well Field Screening Investigations



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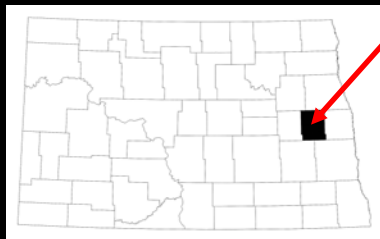
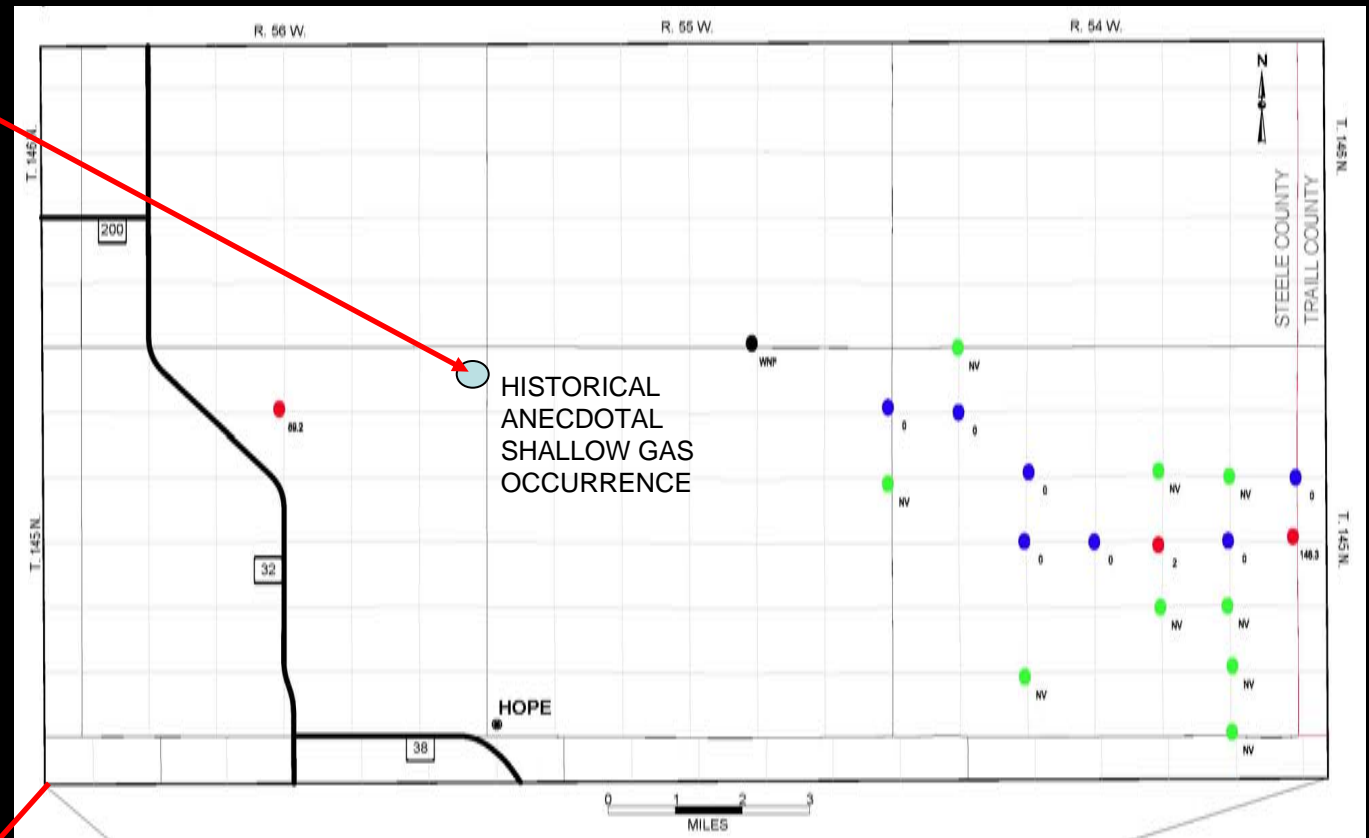
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# Steele County - North Dakota

- Historical anecdotal occurrence prompted investigation
- 21 Wells Investigated
- 9 Wells Field Screened
- 3 Wells with a positive numerical response for CH<sub>4</sub>
- 6 wells with no FID response
- FID response range of 2.0 – 146.3 ppm as CH<sub>4</sub>
- 11 wells not visited
- Well screened in Pierre Shale produced an 86 ppm CH<sub>4</sub> FID response



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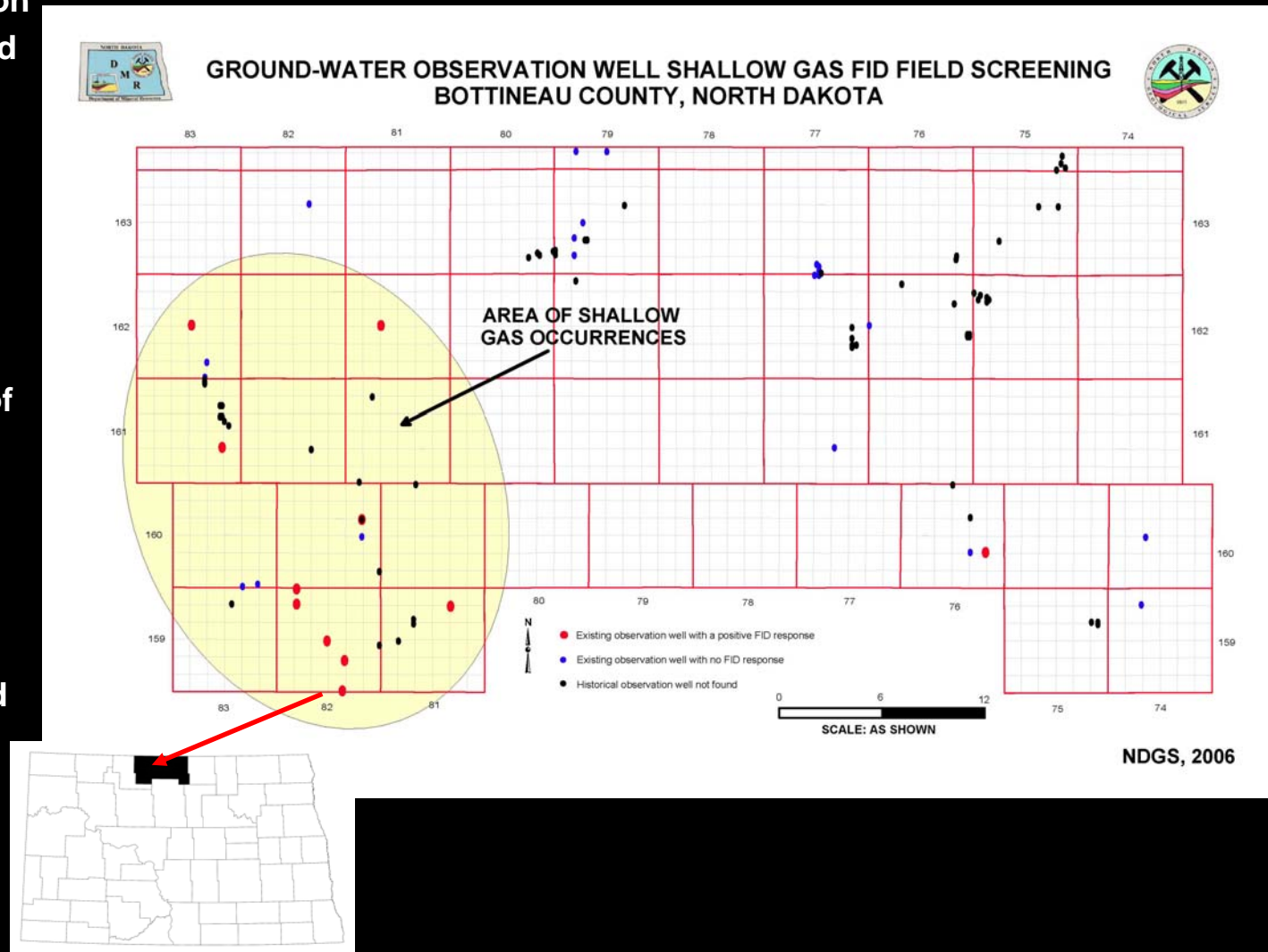
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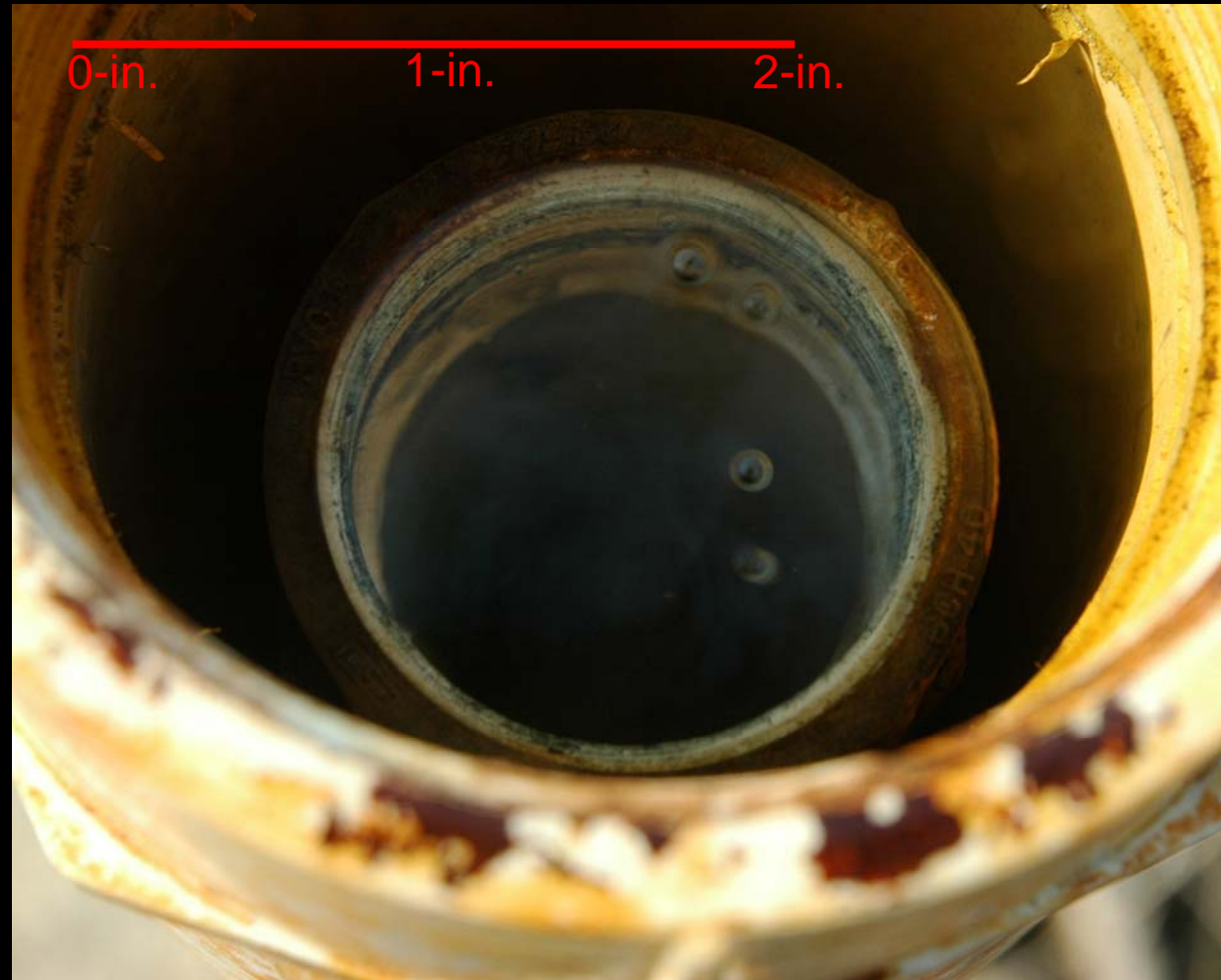
# Bottineau County - North Dakota

- Historical occurrence and production prompted investigation
- 110 Wells Investigated
- 33 Wells Field Screened
- 11 Wells with a positive numerical response for CH<sub>4</sub>
- 22 wells with no FID response
- FID response range of 2.4 – 30,362 ppm as CH<sub>4</sub>
- 10 wells not visited
- Flowing head well screened in Cretaceous sandstones produced an 236 ppm CH<sub>4</sub> FID response and associated [8.3 mg/L CH<sub>4</sub>] in groundwater



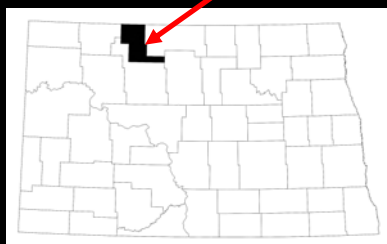
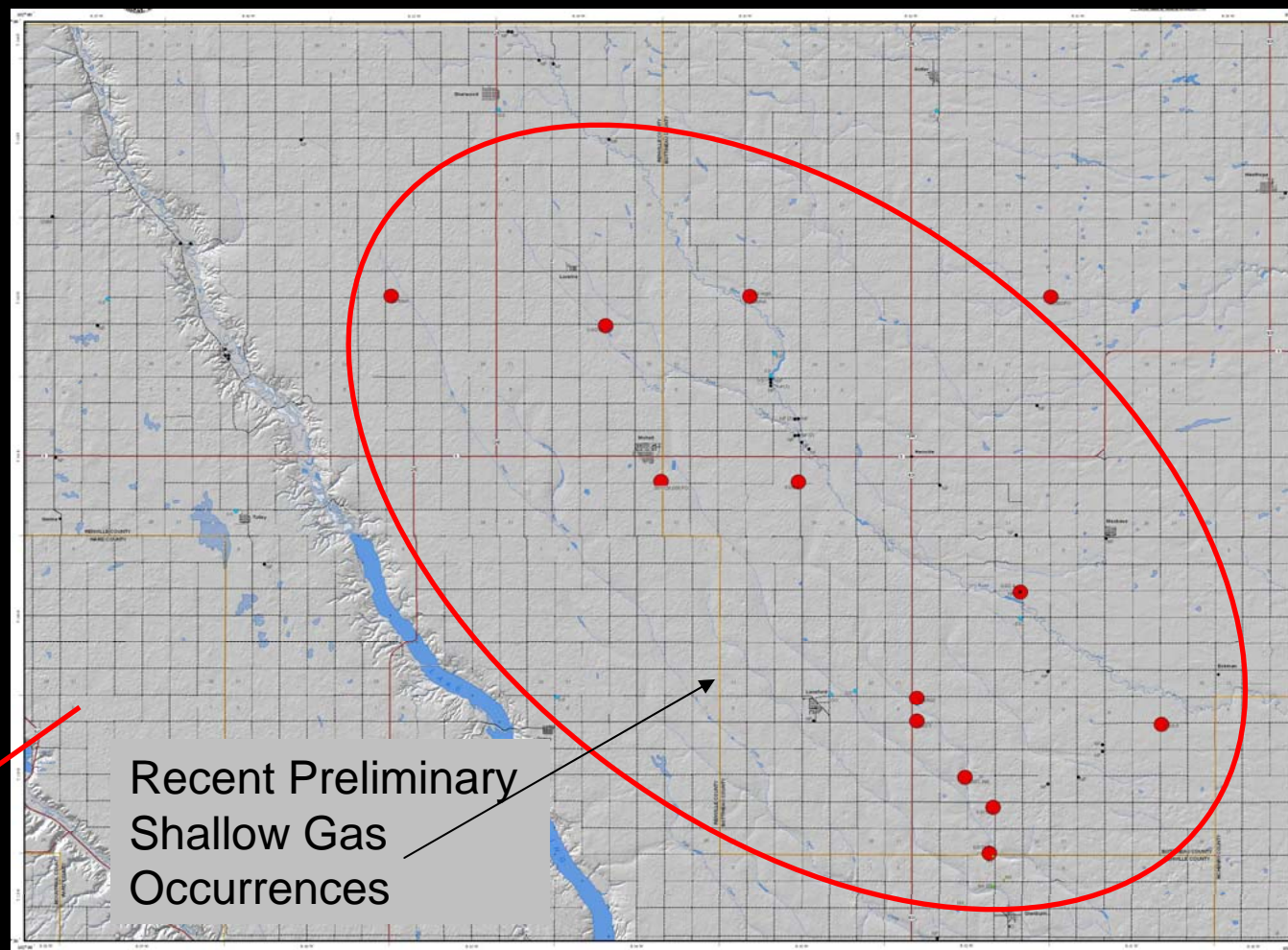
# Recent Shallow Gas Occurrences

- Observation Well:  
162-83-15CCC
- FID Instrument  
Response = 236 ppm  
(as methane)
- Flowing head well  
( $<1$  gpm)
- [Methane] in  
groundwater = 8.3  
mg/L
- Located in area of  
historic shallow  
natural gas occurrence  
(western Bottineau  
Co.)
- Bubbling continuously  
at top of well  
(approx 2-3 bubbles/5  
sec.)



## Renville County, North Dakota

- 34 Wells Investigated
- 8 Wells Field Screened
- 3 Wells with a positive numerical response for CH<sub>4</sub>
- 5 wells with no FID response
- FID response range of 20.6 – 28,000 ppm as CH<sub>4</sub>
- 6 wells not visited



*Continuation of the Bottineau Area Trend*



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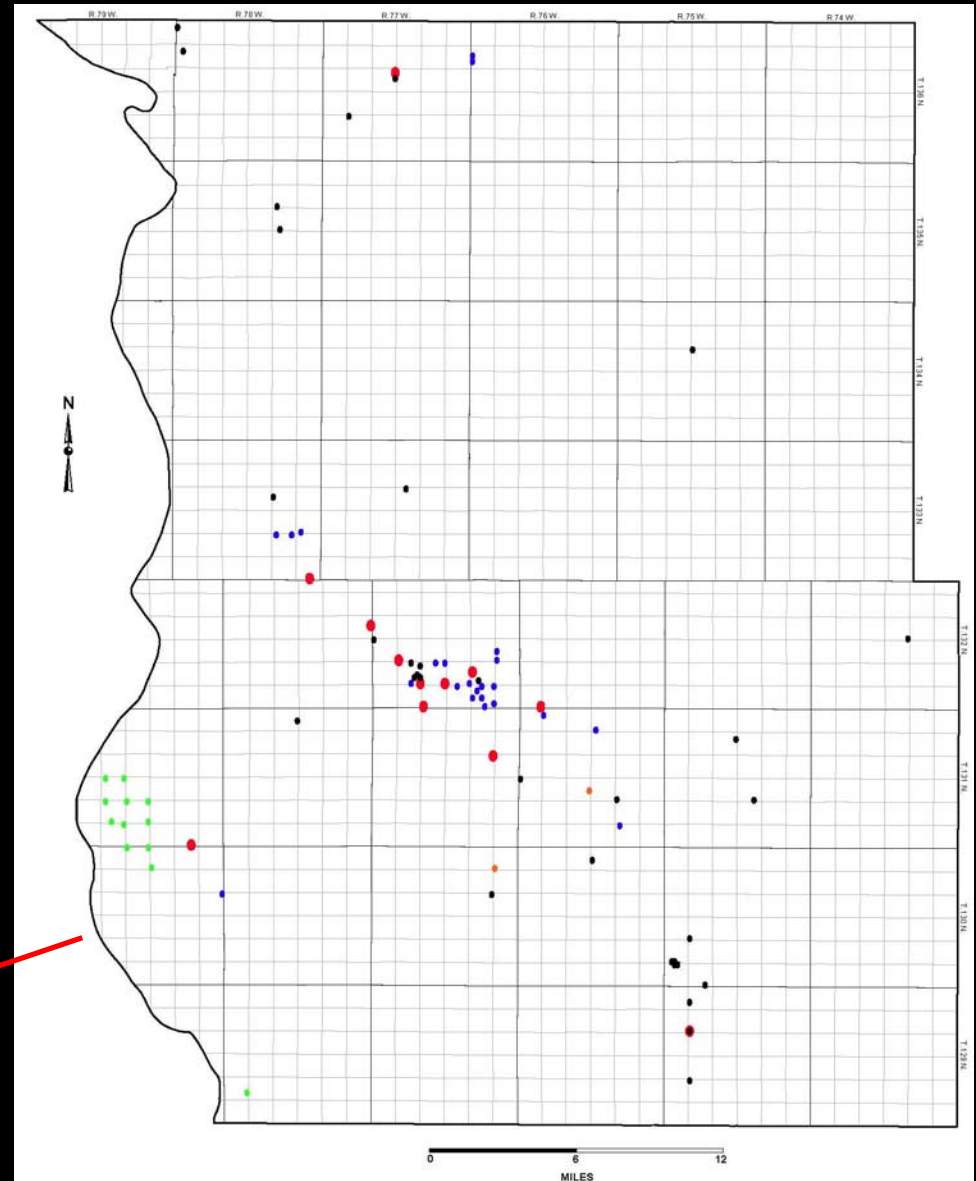
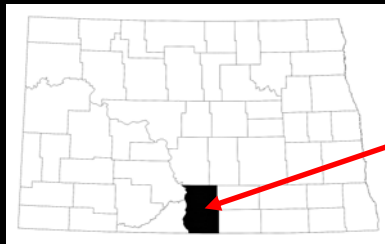
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# Emmons County North Dakota

- 109 Wells Investigated
- 92 Wells Field Screened
- 12 Wells with a positive numerical response for CH<sub>4</sub>
- 38 wells with no FID response
- FID response range of 1.6 – 775 ppm as CH<sub>4</sub>
- 17 wells not visited



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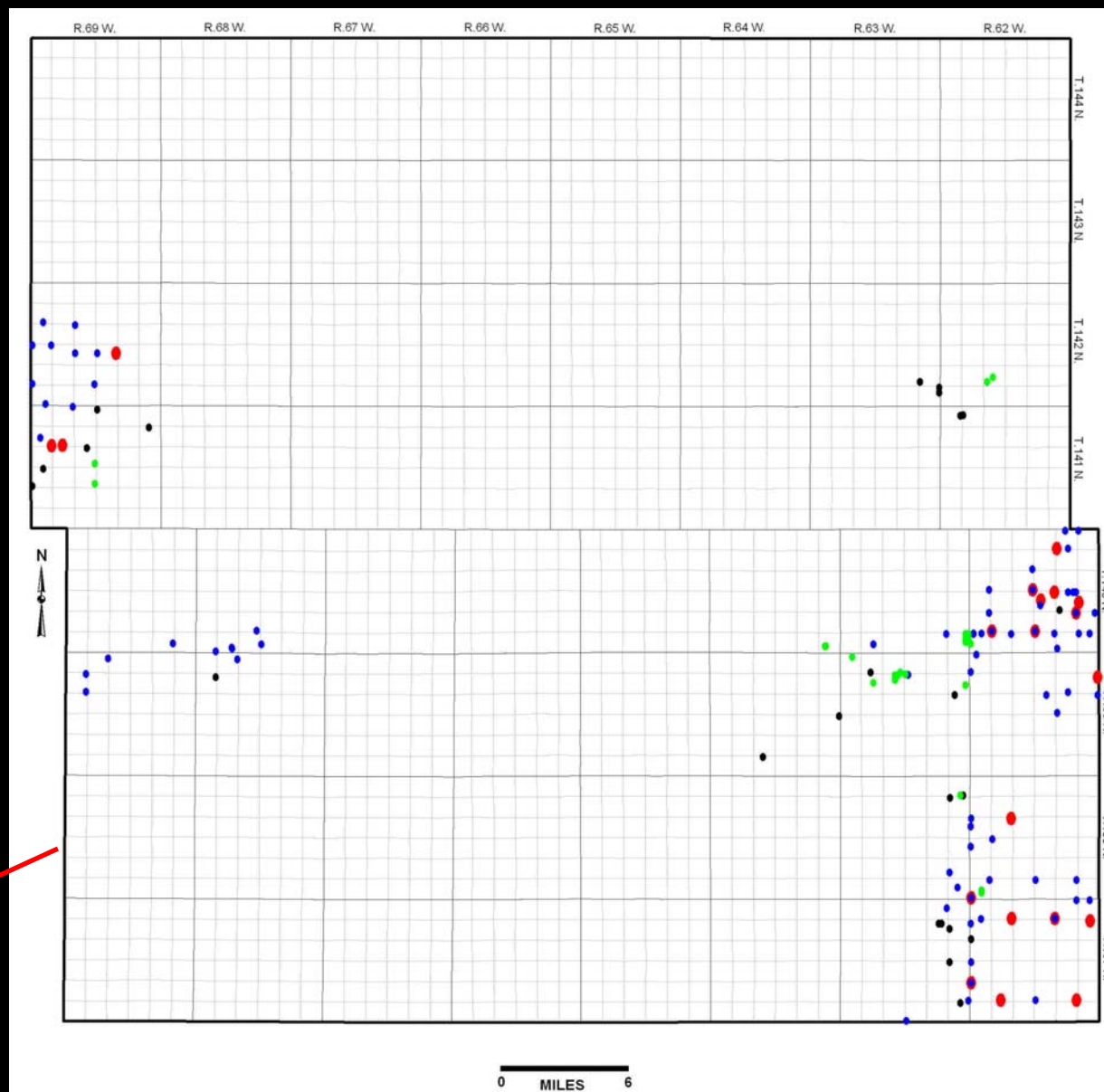
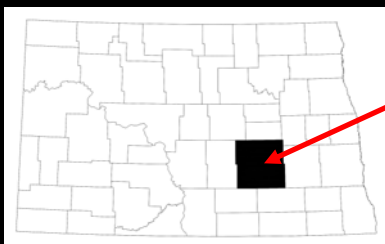
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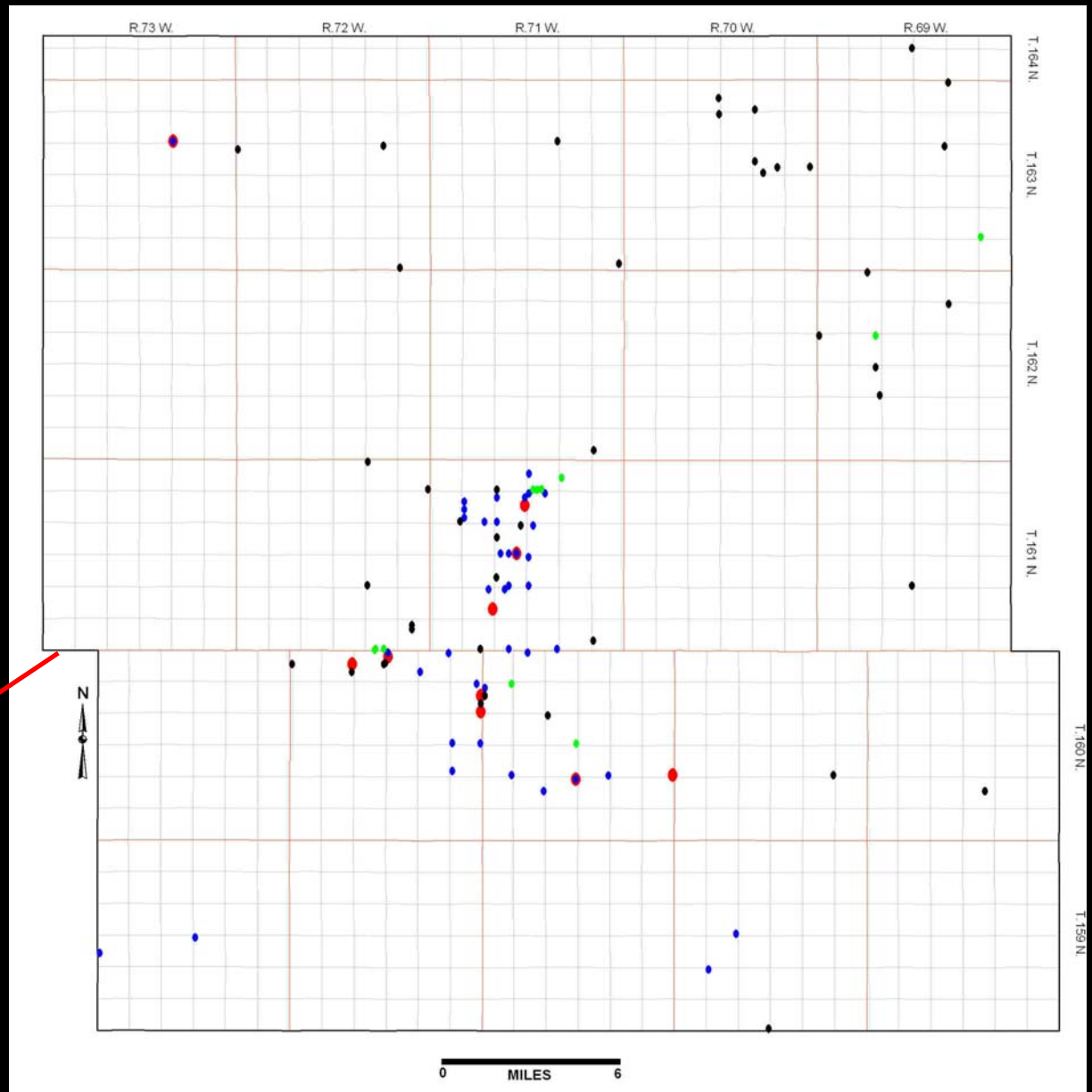
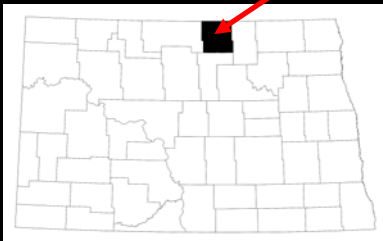
# Stutsman County - North Dakota

- 170 Wells Investigated
- 106 Wells Field Screened
- 21 Wells with a positive numerical response for CH<sub>4</sub>
- 86 wells with no FID response
- FID response range of 0.4 – 182 ppm as CH<sub>4</sub>
- 40 wells not visited (access and time restraints)



# Rolette County - North Dakota

- 114 Wells Investigated
- 52 Wells Field Screened
- 10 Wells with a positive numerical response for CH<sub>4</sub>
- 42 wells with no FID response
- FID response range of 0.6 – 15.2 ppm as CH<sub>4</sub>
- 16 wells not visited



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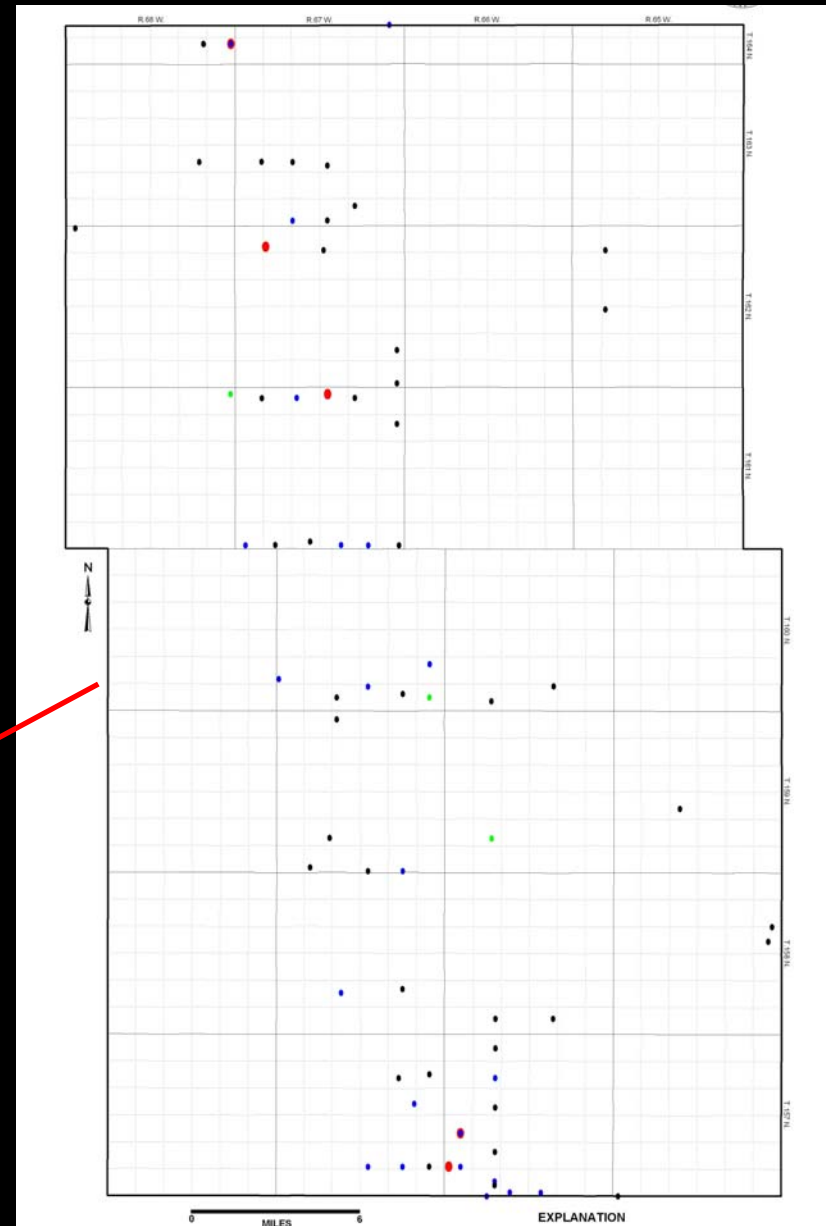
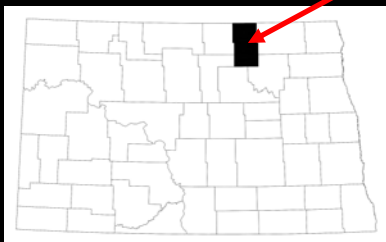
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# Towner County - North Dakota

- 78 Wells Investigated
- 31 Wells Field Screened
- 6 Wells with a positive numerical response for CH<sub>4</sub>
- 25 wells with no FID response
- FID response range of 0.2 – 32.8 ppm as CH<sub>4</sub>
- 4 wells not visited



# Summary of Field Screening Results

County	Wells Studied	Wells Field Screened	Positive FID response	No FID response	Range of FID Response (ppm as CH <sub>4</sub> in air)	Wells Not Visited
SE Steele	21	9	3	6	2.0 – 146.3	11
Bottineau	110	33	11	22	2.4 - 30,362	10
Renville	34	8	3	5	20.6 – 28,000	6
Emmons	109	92	12	38	1.6 - 775	17
Stutsman	170	106	21	86	0.4 - 182	40
Rolette	114	52	10	42	0.6 – 15.2	16
Towner	78	31	6	25	0.2 – 32.8	4
<b>Totals</b>	<b>636</b>	<b>331</b>	<b>66</b>	<b>224</b>	<b>0.3 – 30,362</b>	<b>104</b>



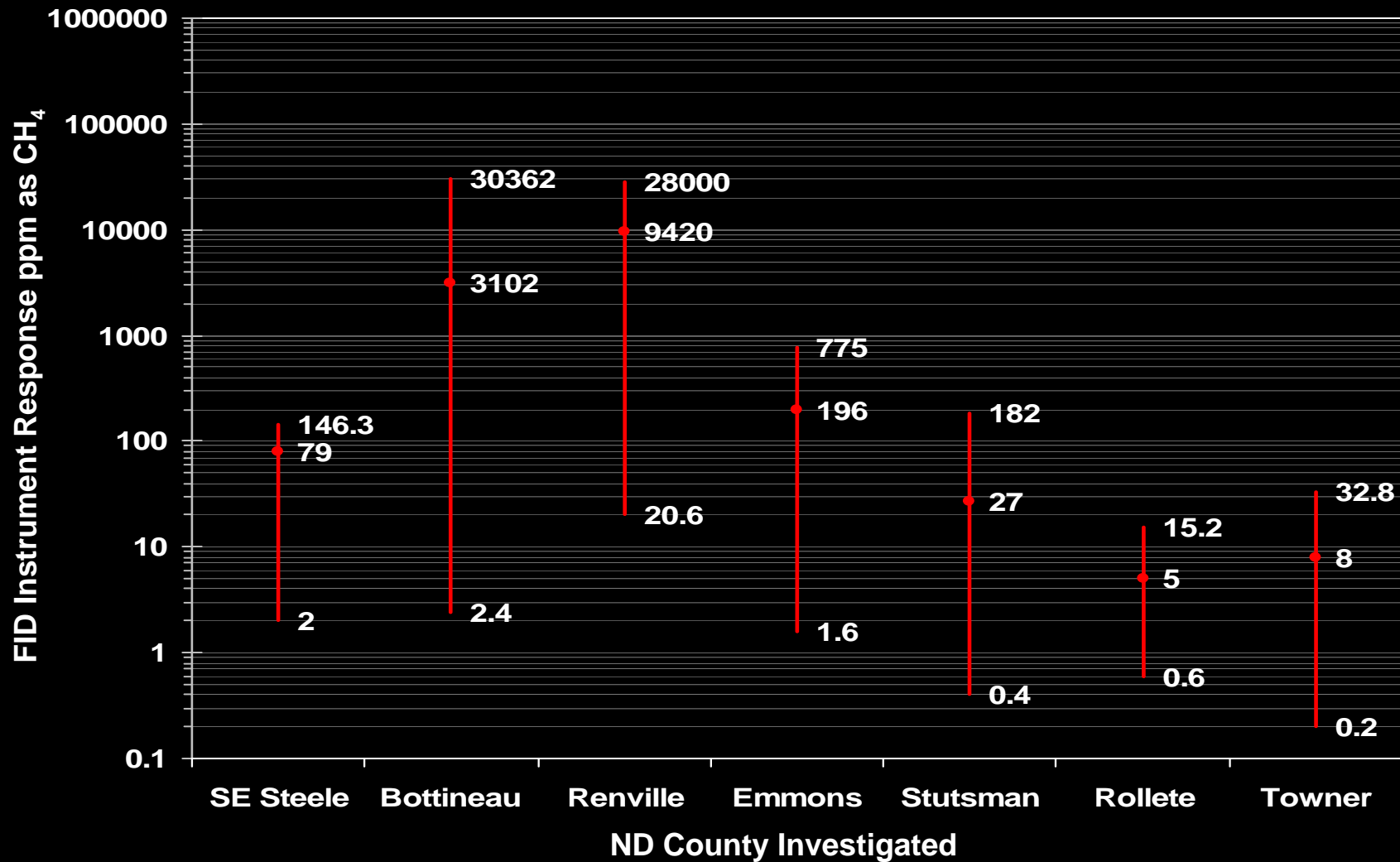
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# Ranges of FID Responses from Observation Wells in Selected North Dakota Counties



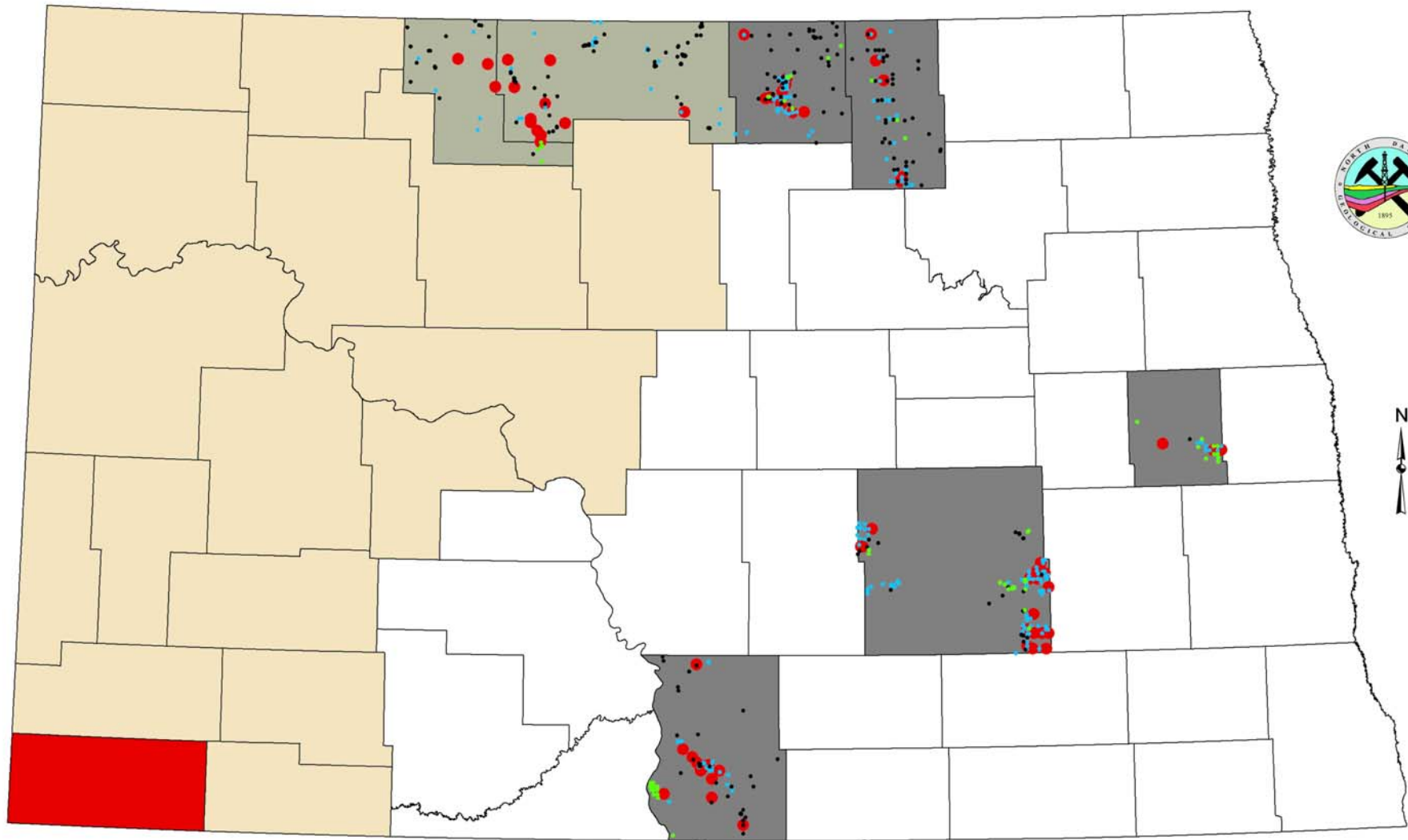
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# Recent ND FID Field Screening Results Summary

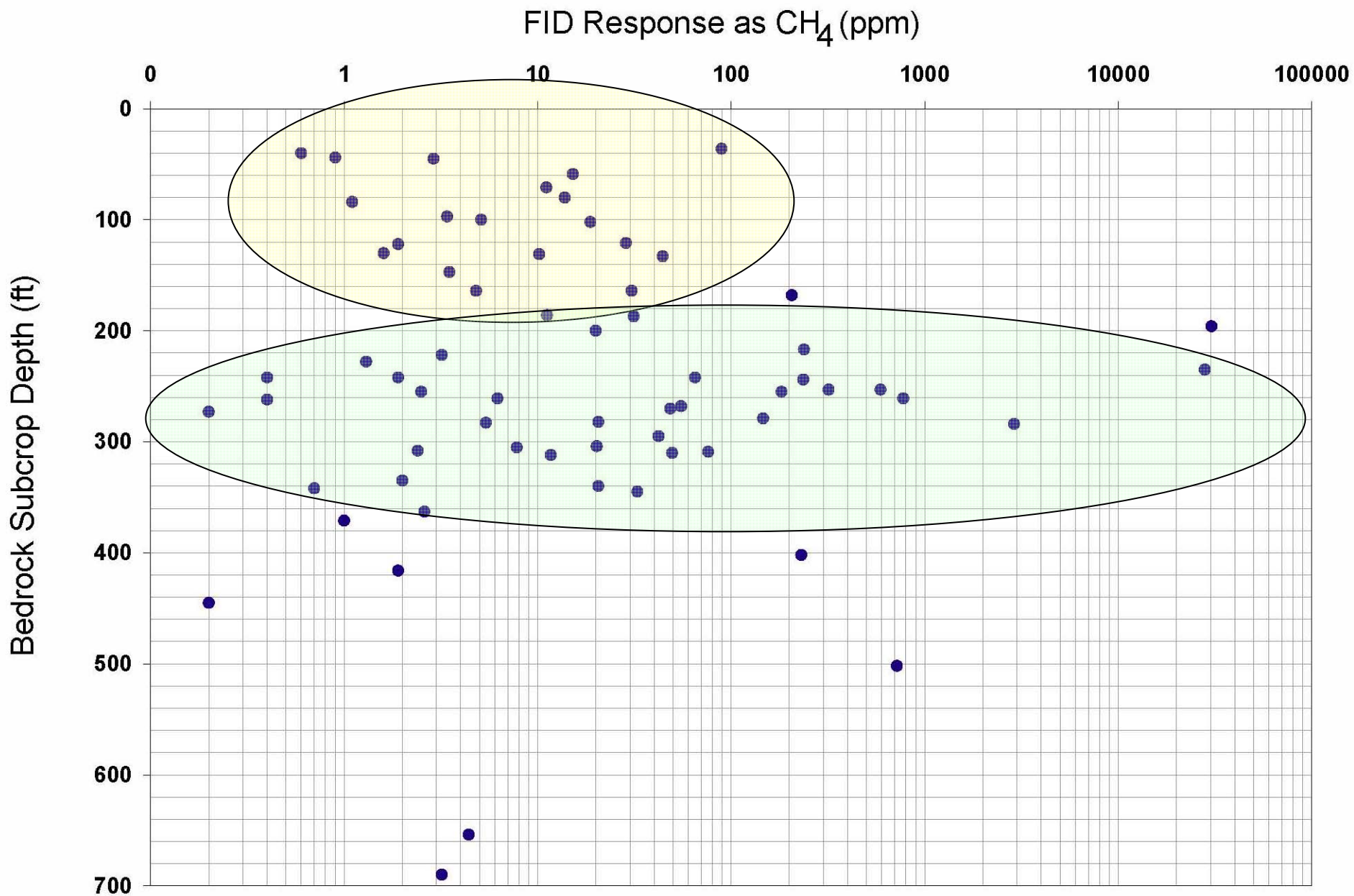


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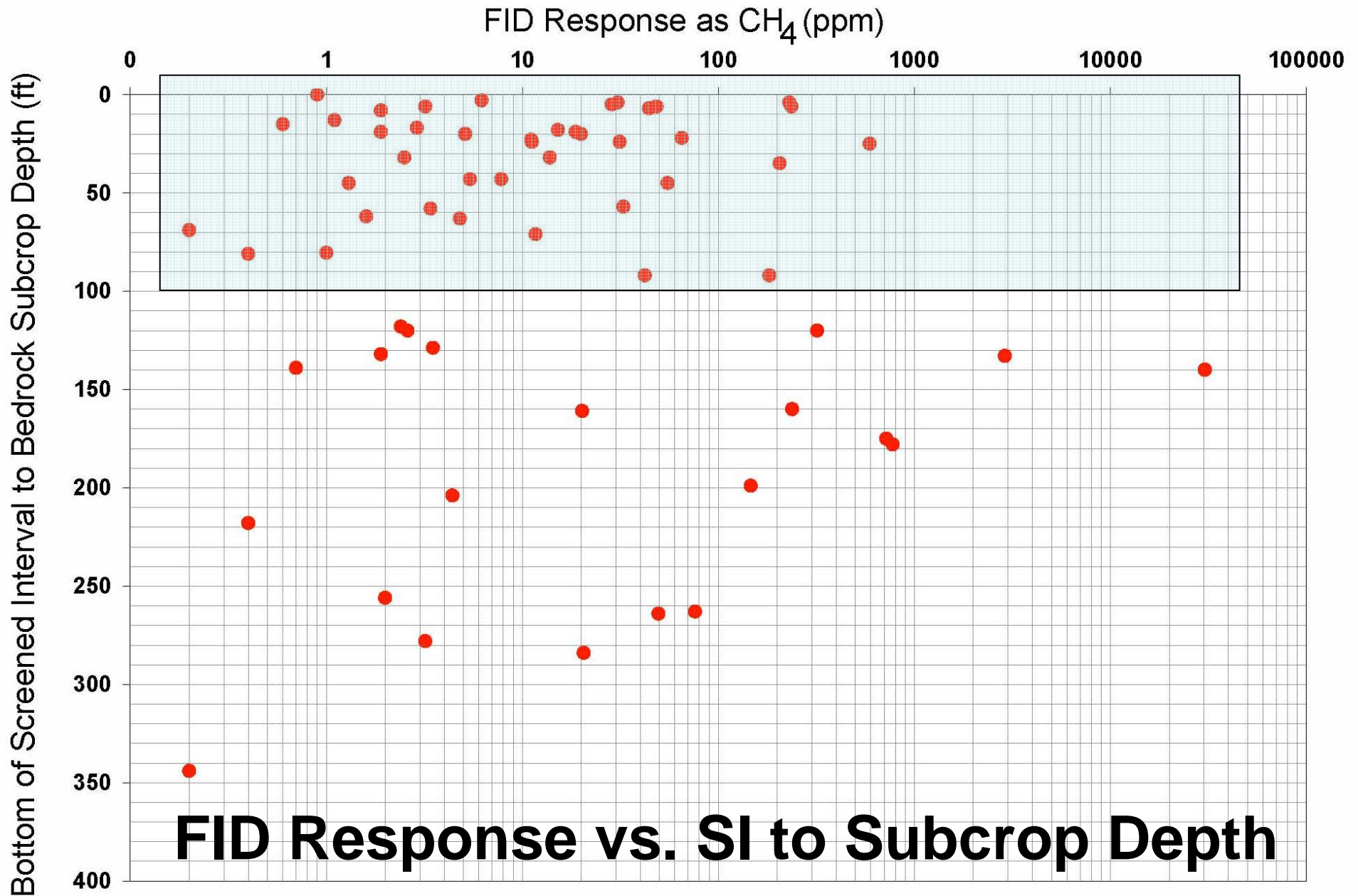


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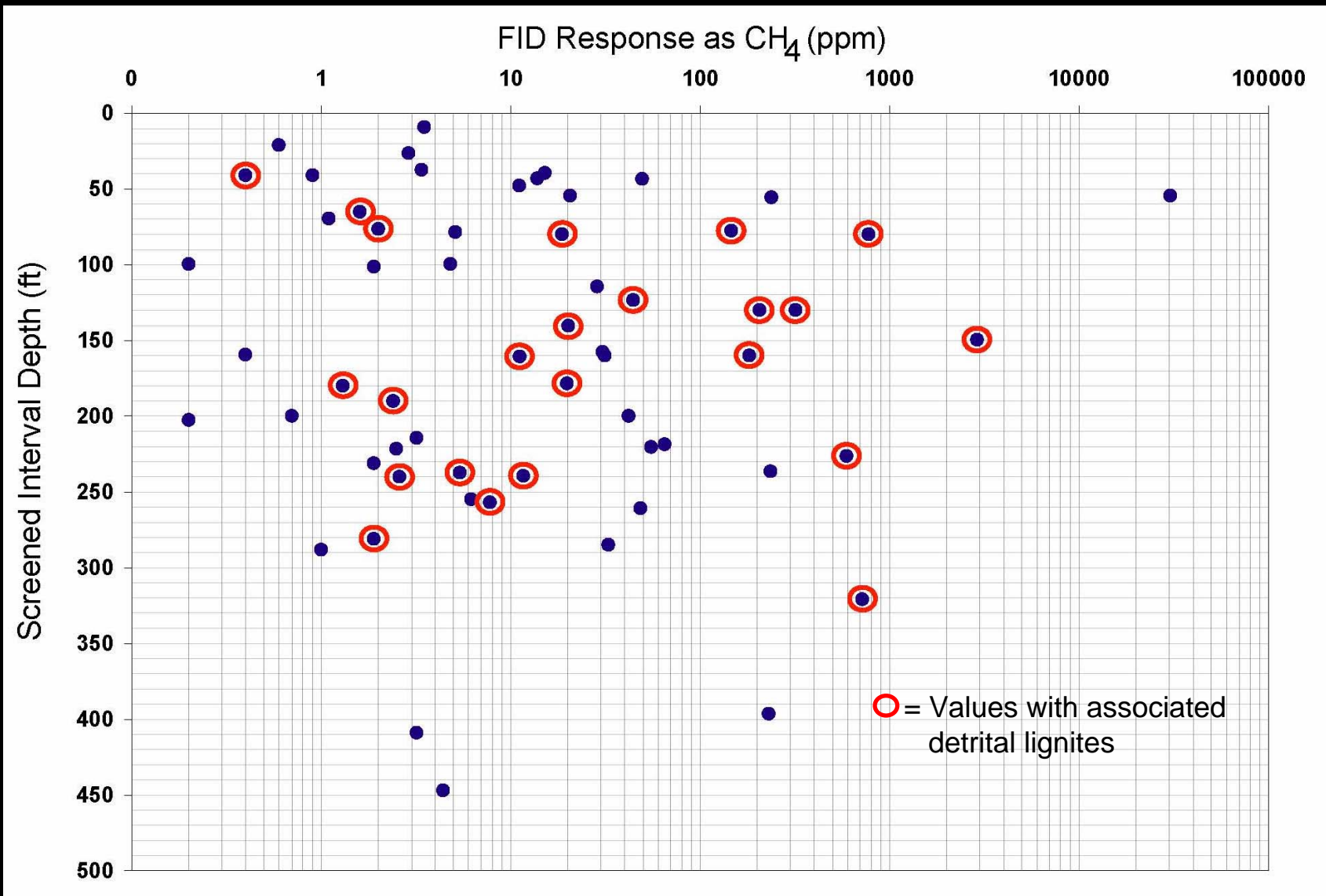
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# FID Response vs. SI with Detrital Lignites





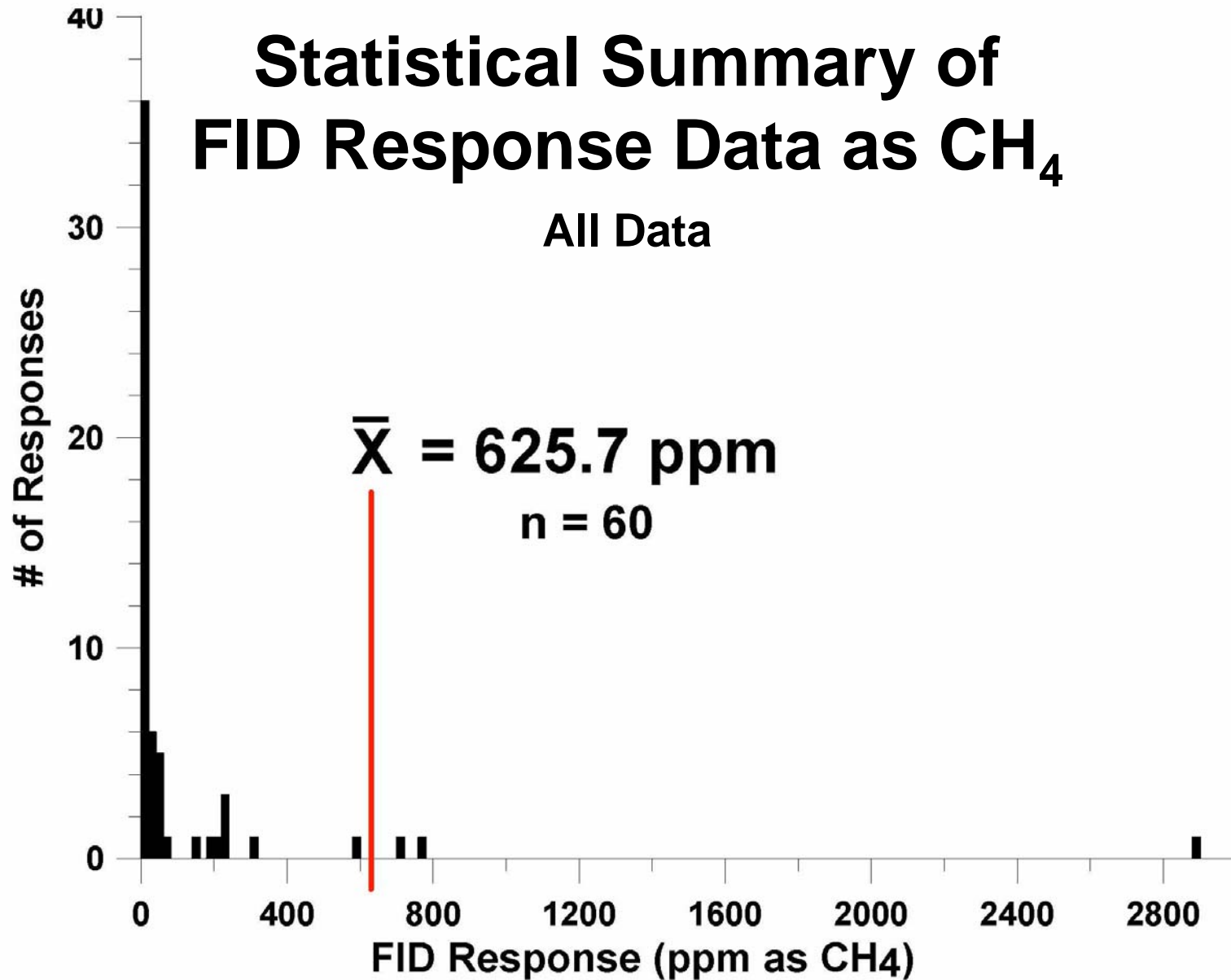
# Influence of Detrital Lignites on [CH<sub>4</sub>]

Instrument Response Type	FID Instrument Response Statistical Summary				
	Minimum (ppm)	Maximum (ppm)	Range (ppm)	Mean (ppm)	n
FID CH <sub>4</sub> <sup>1</sup>	0.2	238	237.8	32.3	34
FID CH <sub>4</sub> -DL	0.4	2896	2895.6	243.3	25
FID CH <sub>4</sub>	0.2	30362	30,361.8	625.7	60
FID CH <sub>4</sub> -DL - FID CH <sub>4</sub>				211	
<sup>1</sup> Anomalously high value of 30,362 ppm removed from the data set w/out detrital lignite for analysis and comparison.					



# Statistical Summary of FID Response Data as CH<sub>4</sub>

All Data



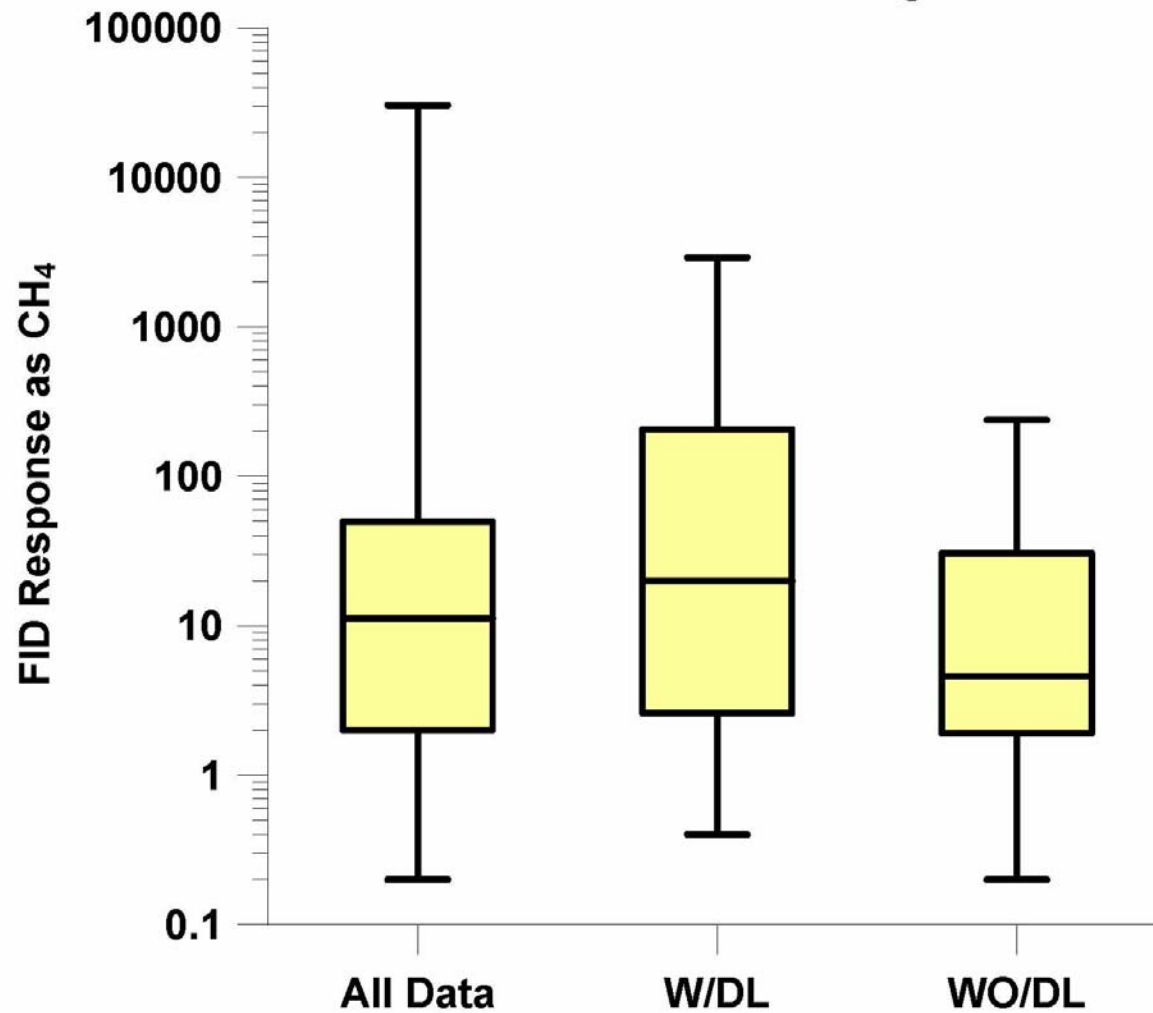
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## Comparison of FID response as [CH<sub>4</sub>] for all wells sampled and wells with and without Detrital Lignites



# Field Instrumentation

<b>Size:</b>	43.4 cm (17.1") long, 9.8 cm (3.85") wide, 18.8 cm (7.4") high
<b>Weight:</b>	8.1 lb (3.7 kg)
<b>Operating Temperature Range:</b>	41°F to 105°F (5°C to 45°C)
<b>Operating Humidity:</b>	0-100% Relative Humidity (non-condensing)
<b>Operating Concentration Range (Low Range):</b>	0.5 PPM to 2000 PPM methane equivalent (Low Range)
<b>Operating Concentration Range (High Range):</b>	10 PPM to 50,000 PPM methane equivalent (High Range)
<b>Accuracy:</b>	0.5 PPM methane within $\pm 0.5$ PPM or $\pm 10\%$ of actual methane concentration (0.5 PPM to 2000 PPM range)
<b>Precision:</b>	$\pm 0.3$ ppm or $\pm 5\%$ (0.5 to 2000ppm range) and $\pm 3$ or $\pm 5\%$ (10 to 50,000 ppm methane range)
<b>Response Time:</b>	Less than 3 seconds Methane (after calibration with zero air and 500 PPM methane gas)



Photovac® – MicroFID







**Field Screening a typical observation well at the Top of Casing (TOC) in Emmons County, North Dakota.**

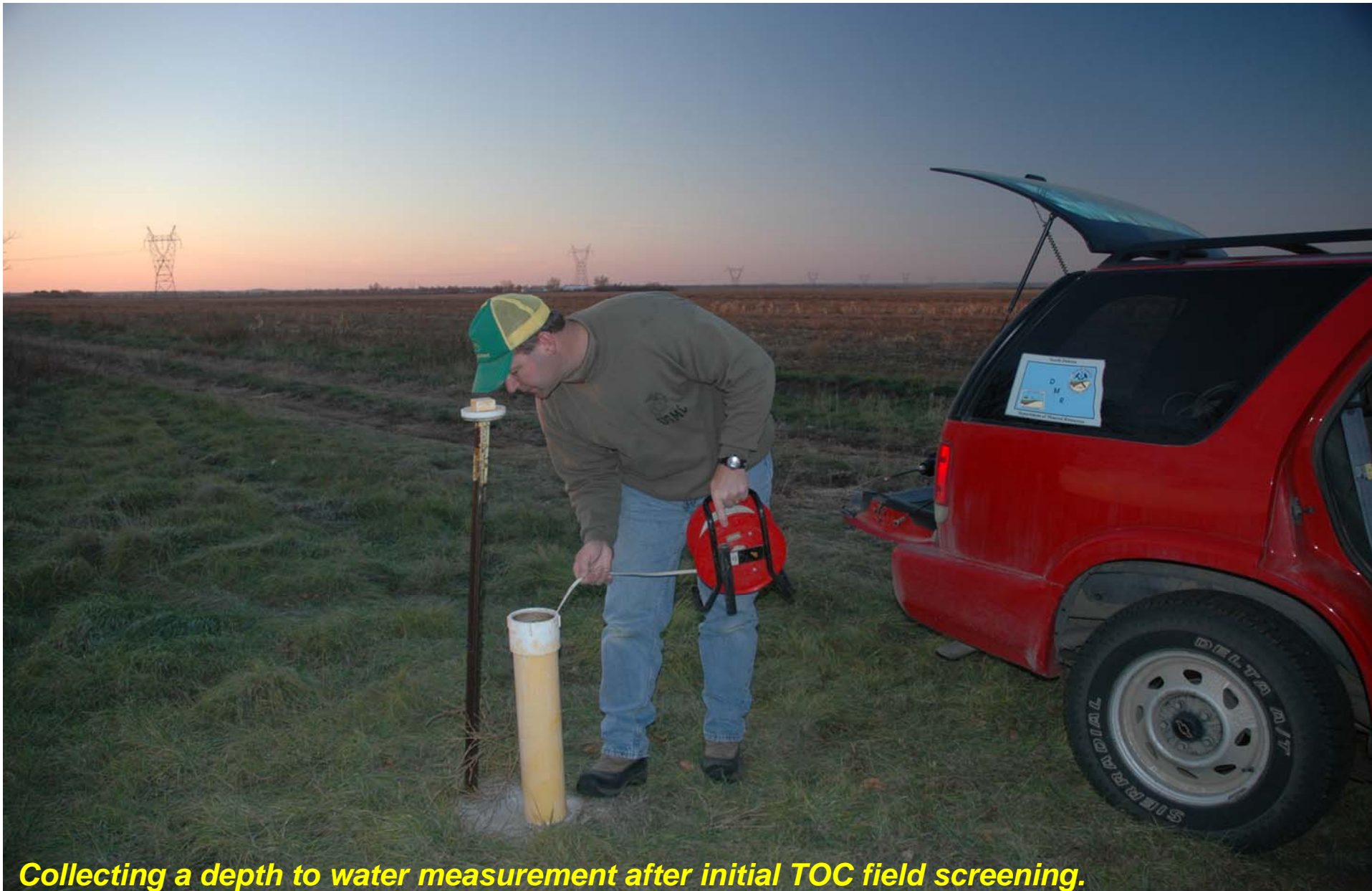


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***Collecting a depth to water measurement after initial TOC field screening.***



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***FID field screening at the GWI via an extended sample probe.***



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# Field Equipment Setup

Field Laptop

Sample Hose

Distilled  
H<sub>2</sub>O

WLI

FID

Cal Bag

Field Map

Instrument Case

Cal Gases, etc.

Field Book/Logs



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# Conclusions

- Portable analytical instrumentation can be used to detect and measure [CH<sub>4</sub>] in ground-water monitoring wells, in the shallow subsurface, in central and eastern North Dakota.
- Detectable [CH<sub>4</sub>] were discovered in two distinct shallow gas systems; those within shallow ground-water monitoring wells screened solely in Pleistocene glacial sediments and from wells screened in slightly deeper upper-Cretaceous bedrock zones. Detrital lignite was found to be present in both systems.
- The presence of detrital lignites within a monitored zone provides a source of organics for methanogenesis and is in part responsible for a portion of the CH<sub>4</sub> present in these systems
- Shallow gas is also found within wells screened in shallow upper-Cretaceous bedrock and Pleistocene glacial sediments, with little or no accumulated organics, suggesting sourcing and migration from underlying upper-Cretaceous shales present in the shallow subcrop.
- The [CH<sub>4</sub>] detected were higher, on average, by a factor of 7.5, in wells where detrital lignite was present.
- Further investigation into overall gas compositions and character of carbon isotopes present is required to fully understand sourcing and migration mechanisms and pathways.



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<http://www.state.nd.us/ndgs/>



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