3R-1009

"Good Well Investigation"

May 2012 Sampling Results Presentation

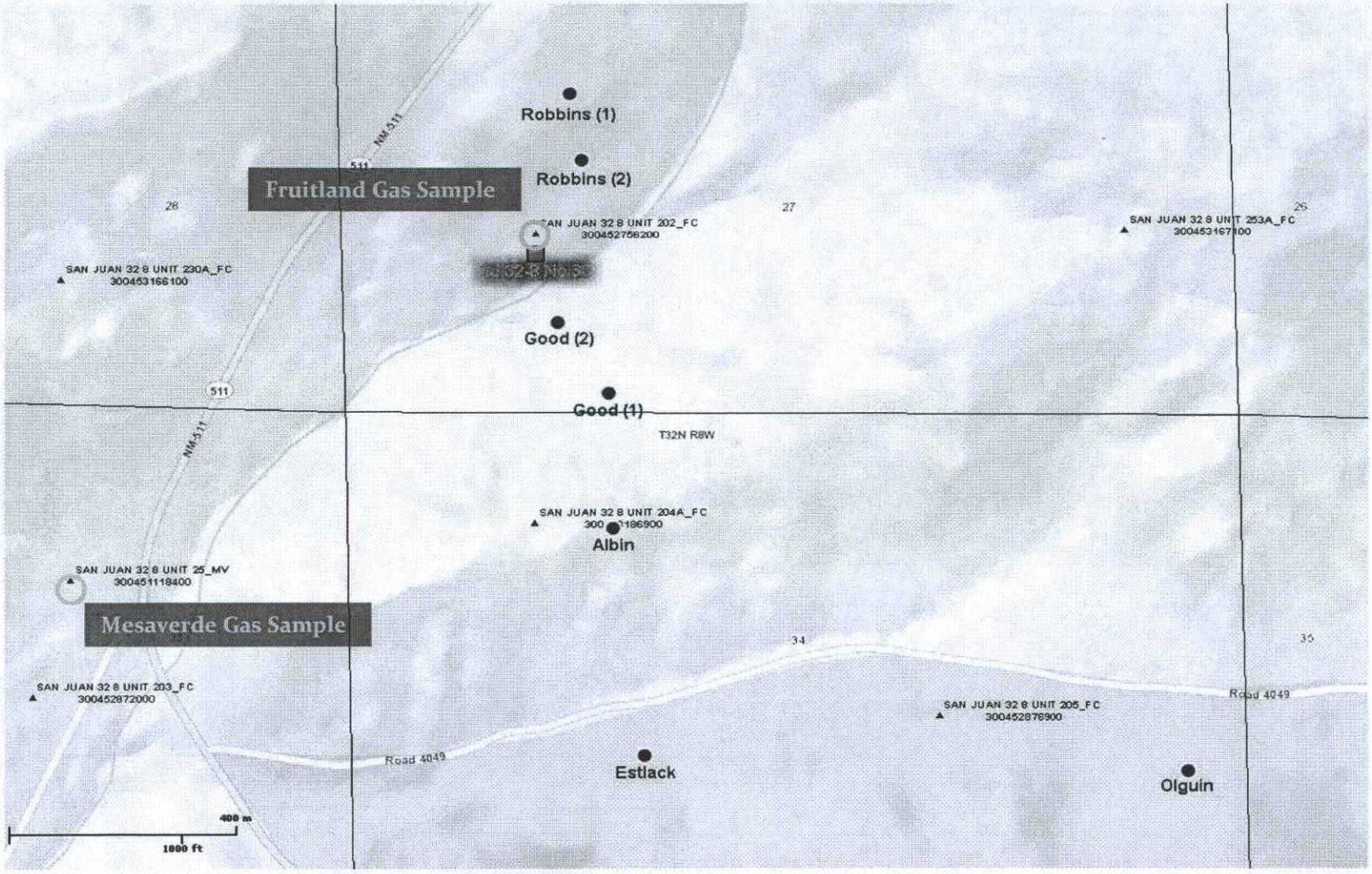
Date
2012-2013

29

Good Well Evaluation May Sampling Results

Preliminary Interpretation

Ground Water Solutions



San Juan 32-8 No. 30 Area

ESRI Streets

ConocoPhillips

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Olguin
Estlack
Albin
Good
San Juan 32-8 No. 30
Robbins
Robbins
S

Wells Sampled

- Six Residential Wells
- One Fruitland Well (San Juan 32-8 No. 202)
- One Mesaverde Well (San Juan 32-8 No. 25)

Isotech Lab Results

- Mole fractions of interest include: He, Ar, O_2, CO_2, N, C_1, C_2, C_3, iC_4, nC_4, iC_5, nC_5, C_6+
- Isotopes included: δD_{C1}, $\delta^{13}C_1$, δD_{C2}, $\delta^{13}C_2$
- Isotopes and molecular compositions are important tools to characterize hydrocarbon geochemistry (USGS, 1994)

$$\delta^{13}C_1 = (^{13}C_1/^{12}C_1)_{\text{sample}} - (^{13}C_1/^{12}C_1)_{\text{standard}}/(^{13}C_1/^{12}C_1)_{\text{standard}} \times 10^3 \text{ (o/oo)}$$

Note: No gas analysis for the Olguin well (wellhead sealed)

Preliminary Analysis

- Reviewed isotope and mole fraction results
- Evaluated gas wetness fraction of samples
- Evaluated C1/C2+
- Evaluated helium against C1/C2

Atmospheric Composition

Gas Name	Formula	Percent Volume
Nitrogen	N_2	78.08%
Oxygen	O_2	20.95%
Argon	Ar	0.94%
Carbon Dioxide	CO_2	0.036%
Neon	Ne	0.0018%
Helium	He	0.0005%
Methane	CH_4	0.00017%
Hydrogen	H	0.00005%
Nitrous Oxide	N_2O	0.00003%
Ozone	O_3	0.000004%

Methane in Water

Henry's Constant (K_{HCH4}) = 1.34 E^{-3} moles L-1 atm-1

Partial Pressure (P_i) = 0.00017 atm

$C_{CH4} = (K_{HCH4}) \times (P_i)$

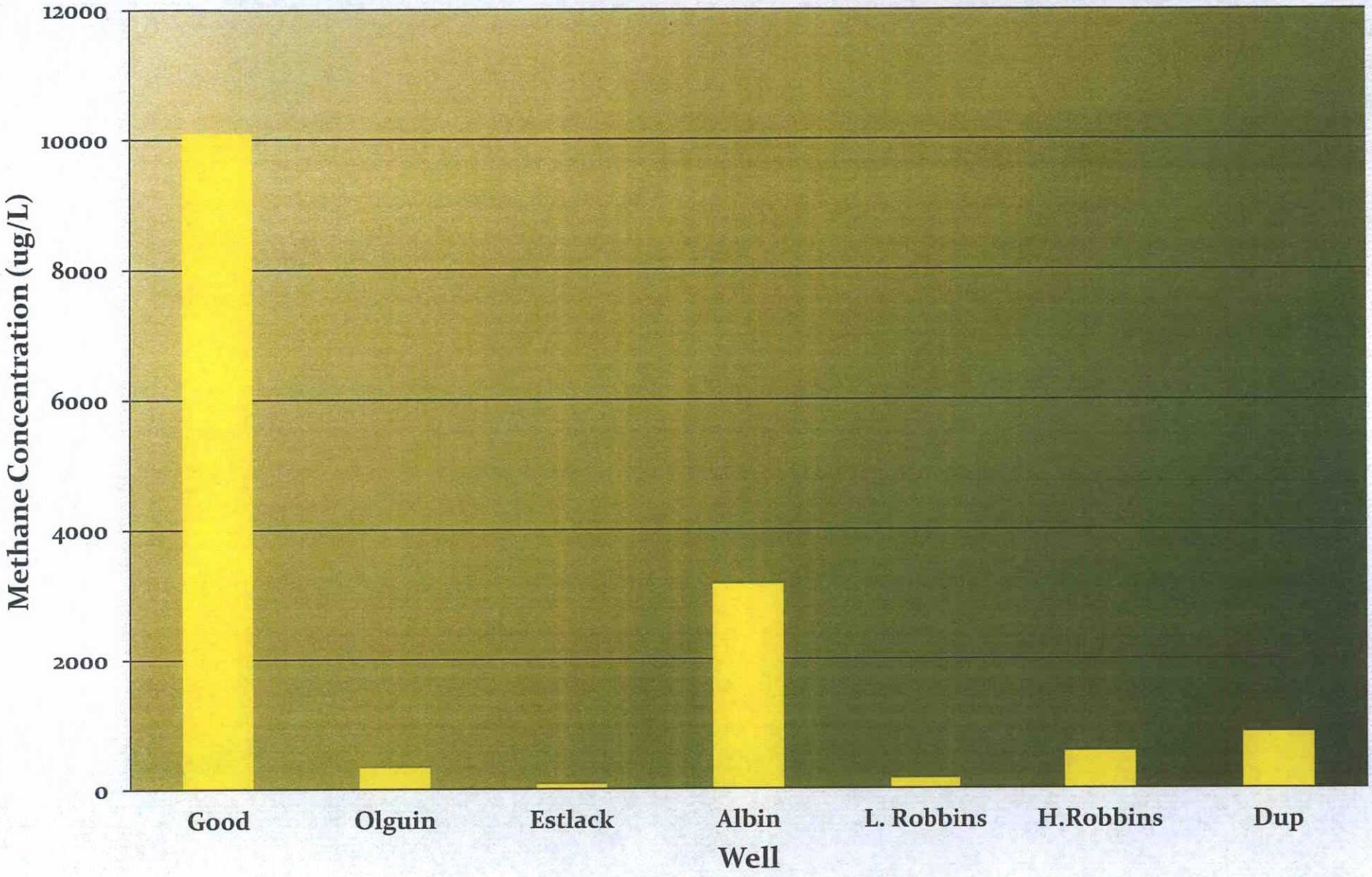
C_{CH4} = 2.28 E^{-7} moles/L

Mol. Wt. CH_4 = 16 g/L; therefore,

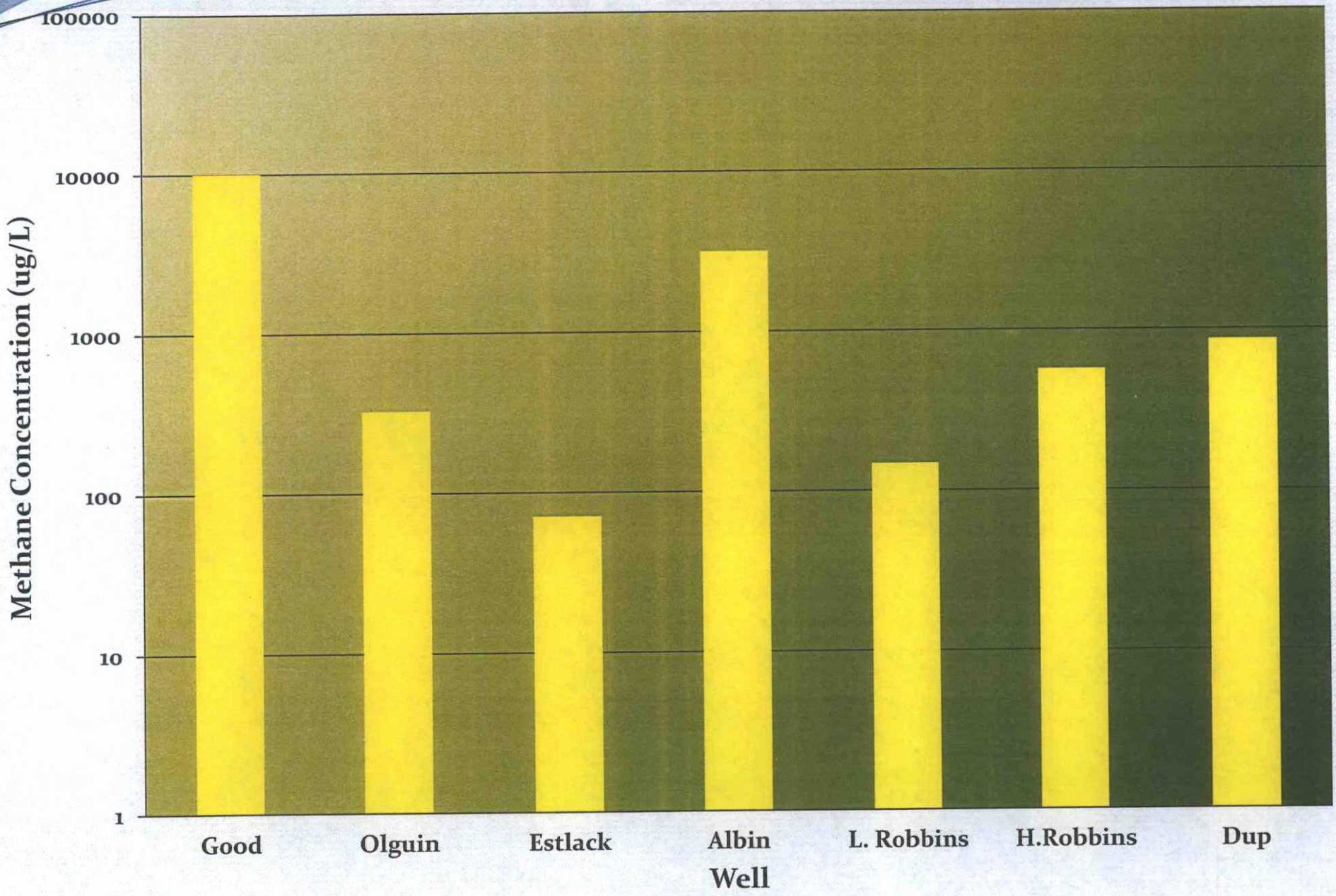
2.28 E^{-7} moles/L X 16 g/L X 1,000mg/g = 0.00364 mg/L or 3.64 ug/L

Dissolved CH_4 above ~ 5 ug/L is likely due to a source other than atmospheric

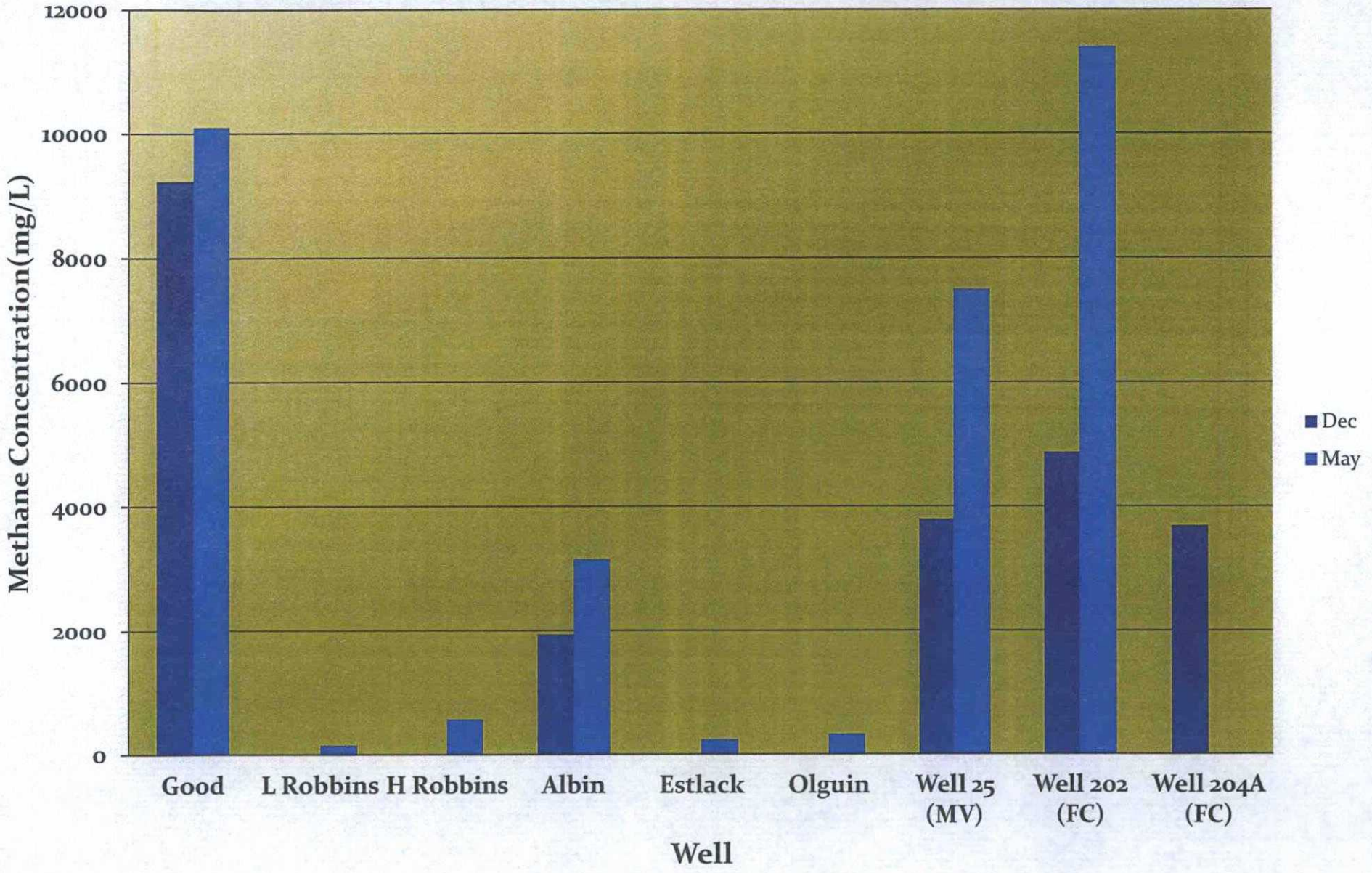
Dissolved Methane in Water Wells
May, 2012



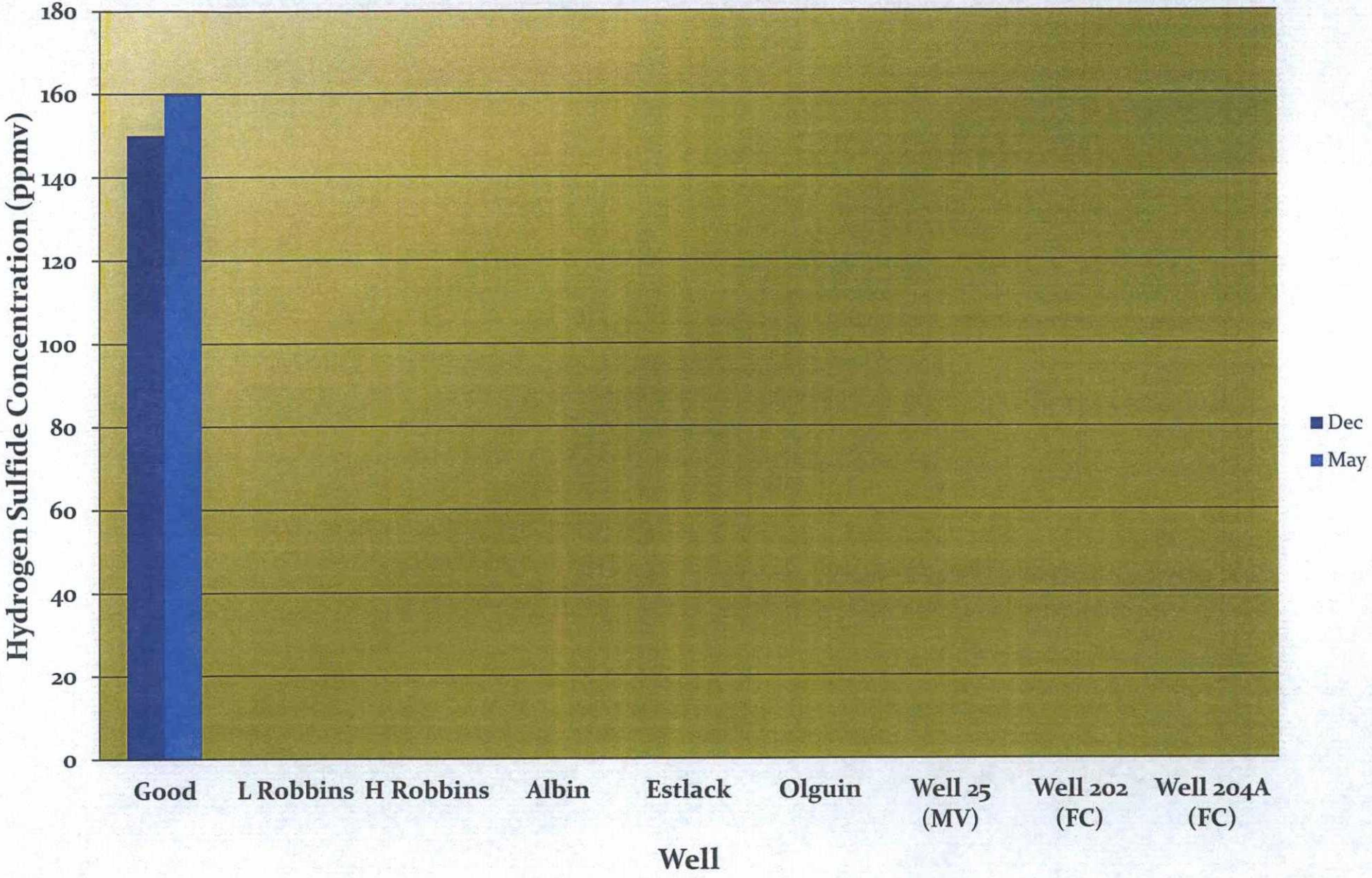
Dissolved Methane in Water Wells



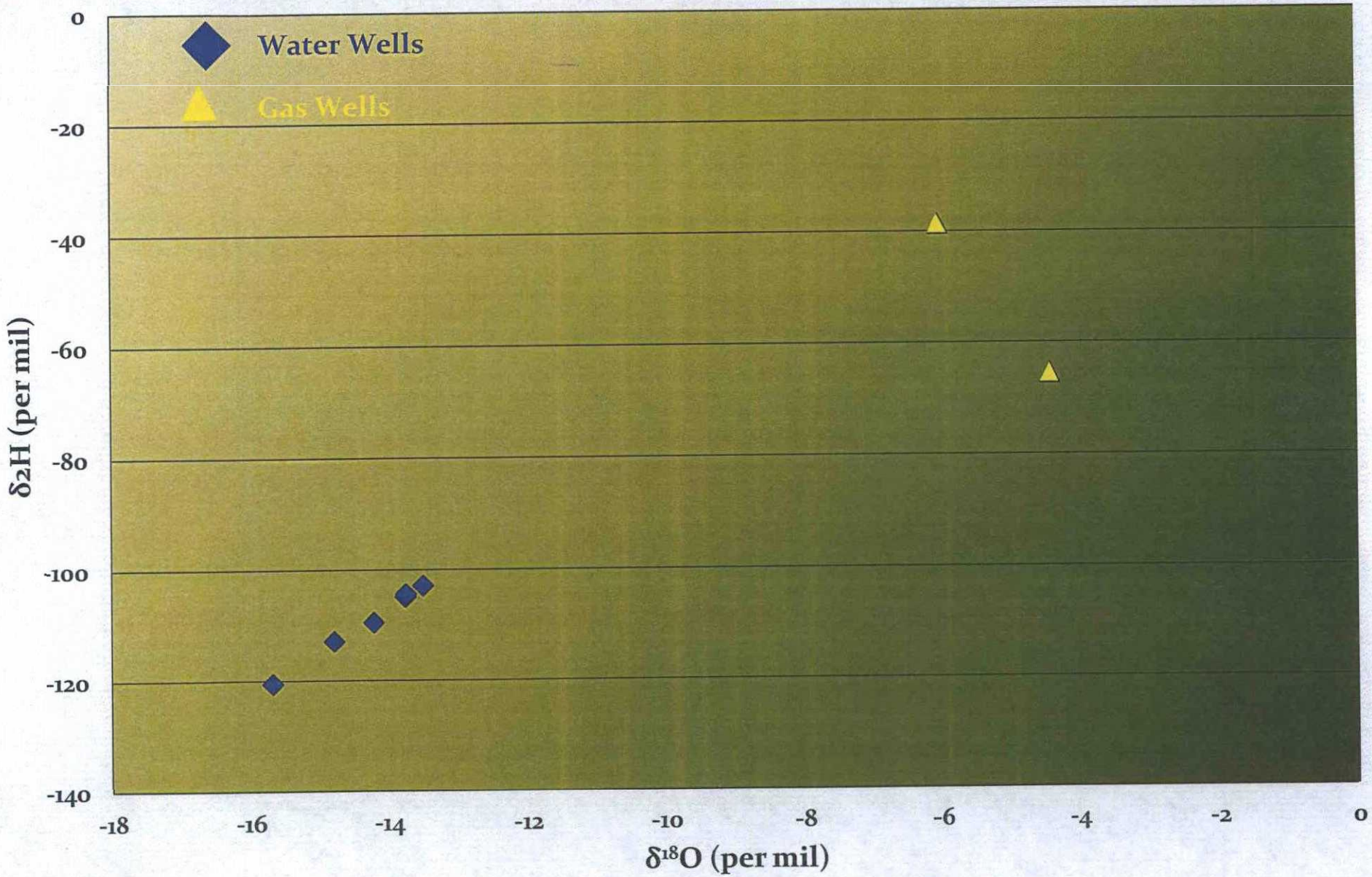
Methane Concentrations
December, 2011 & May, 2012



Hydrogen Sulfide Results
December, 2011 & May, 2012



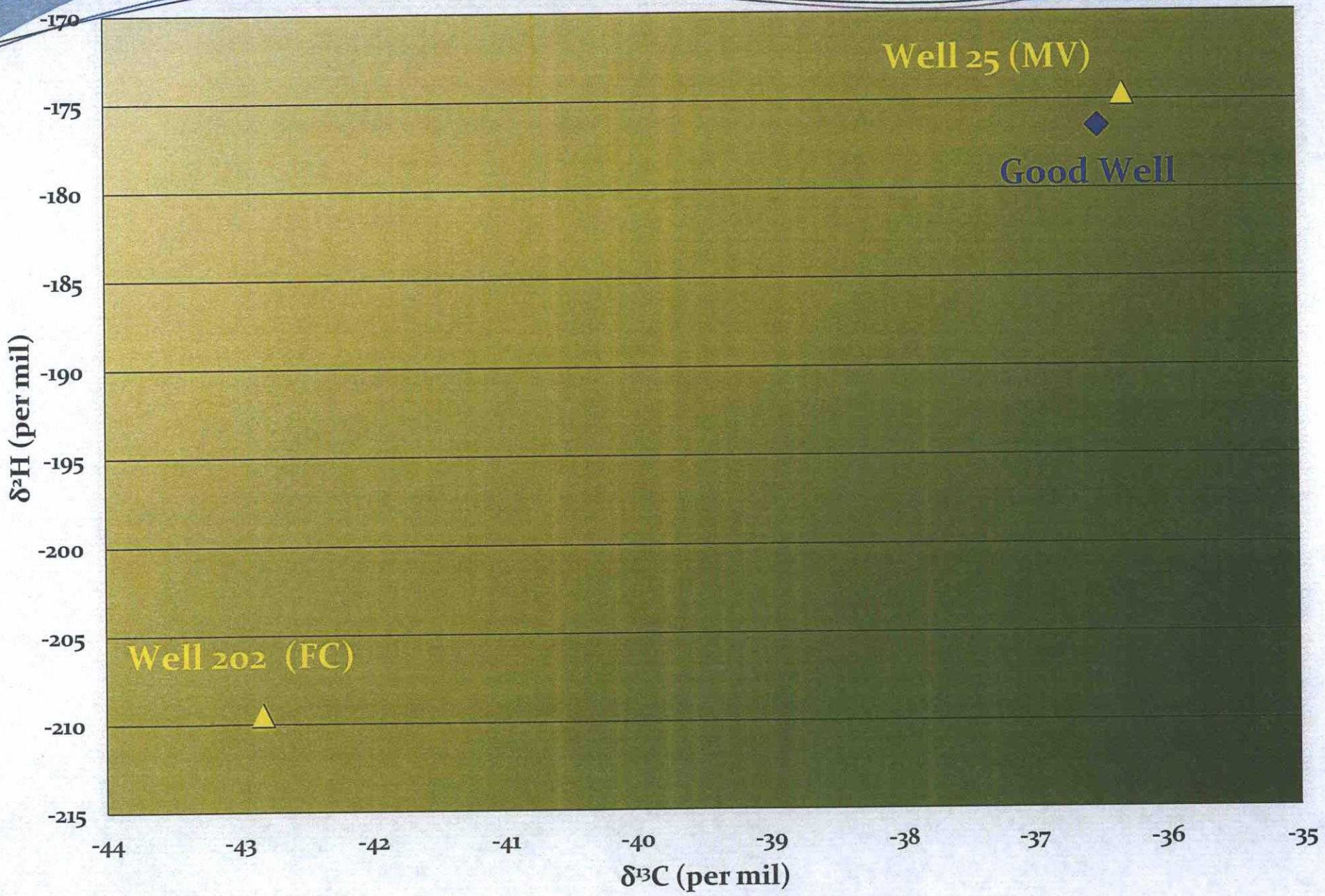
Stable Isotopes of Ground Water and Produced Water
May, 2012



Hydrogen& Carbon Isotope Discussion

- Compared $\delta^{13}C_1$ to δD_1
- Graph shows similar isotopic signatures for gas in the Mesaverde well (25) and Good well
- No relationship is seen between the Fruitland well (202) and the Good well

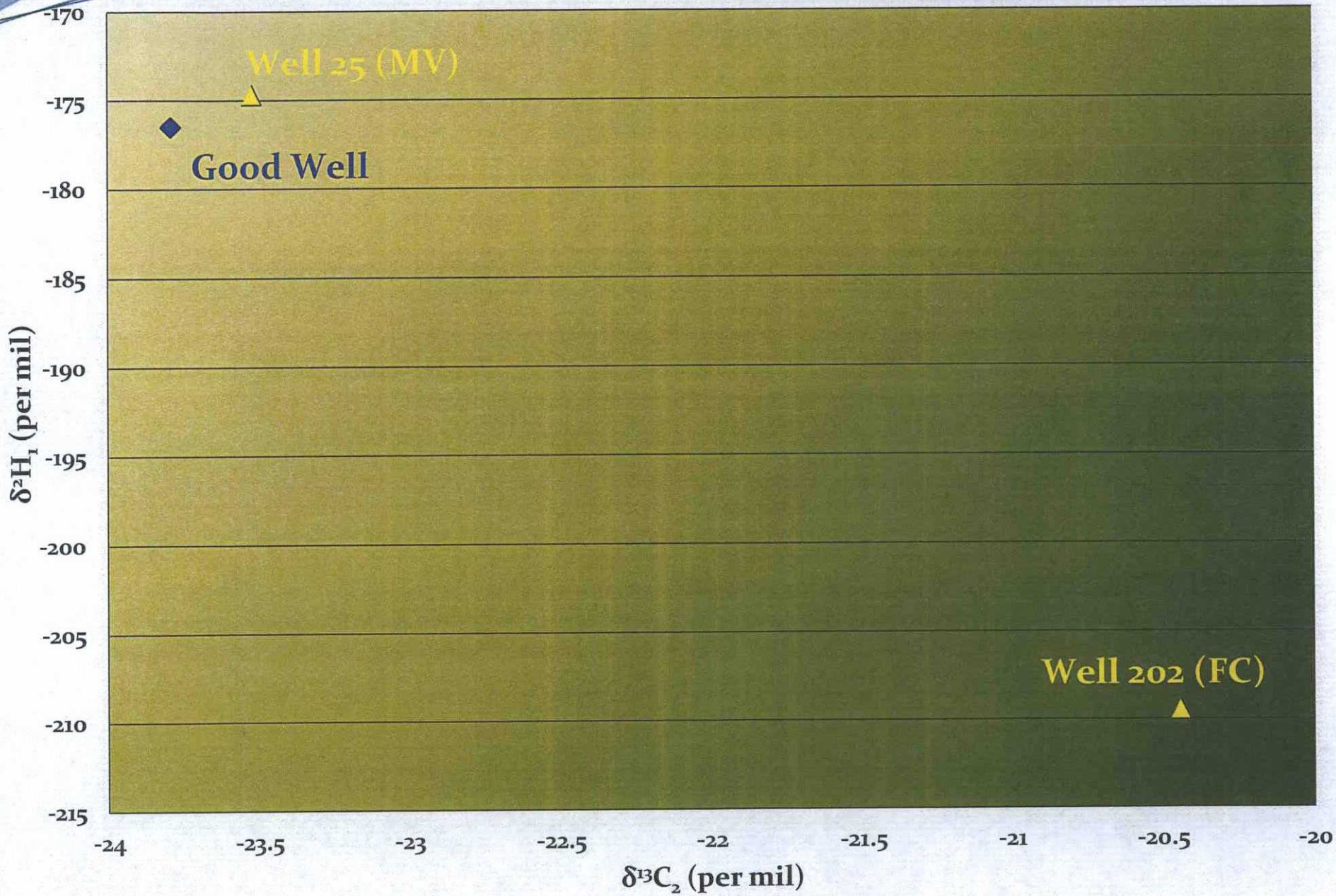
Stable Isotopes Results $\delta^{13}C_1$ vs $\delta^{2}H_1$



Hydrogen & Carbon Isotope Discussion

- Compared the carbon isotope of ethane ($\delta^{13}C_2$) against δD_1
- Graph shows similar isotopic signatures for gas in the Mesaverde well (25) and the Good well
- No relationship is seen between the Fruitland well (202) and the Good well

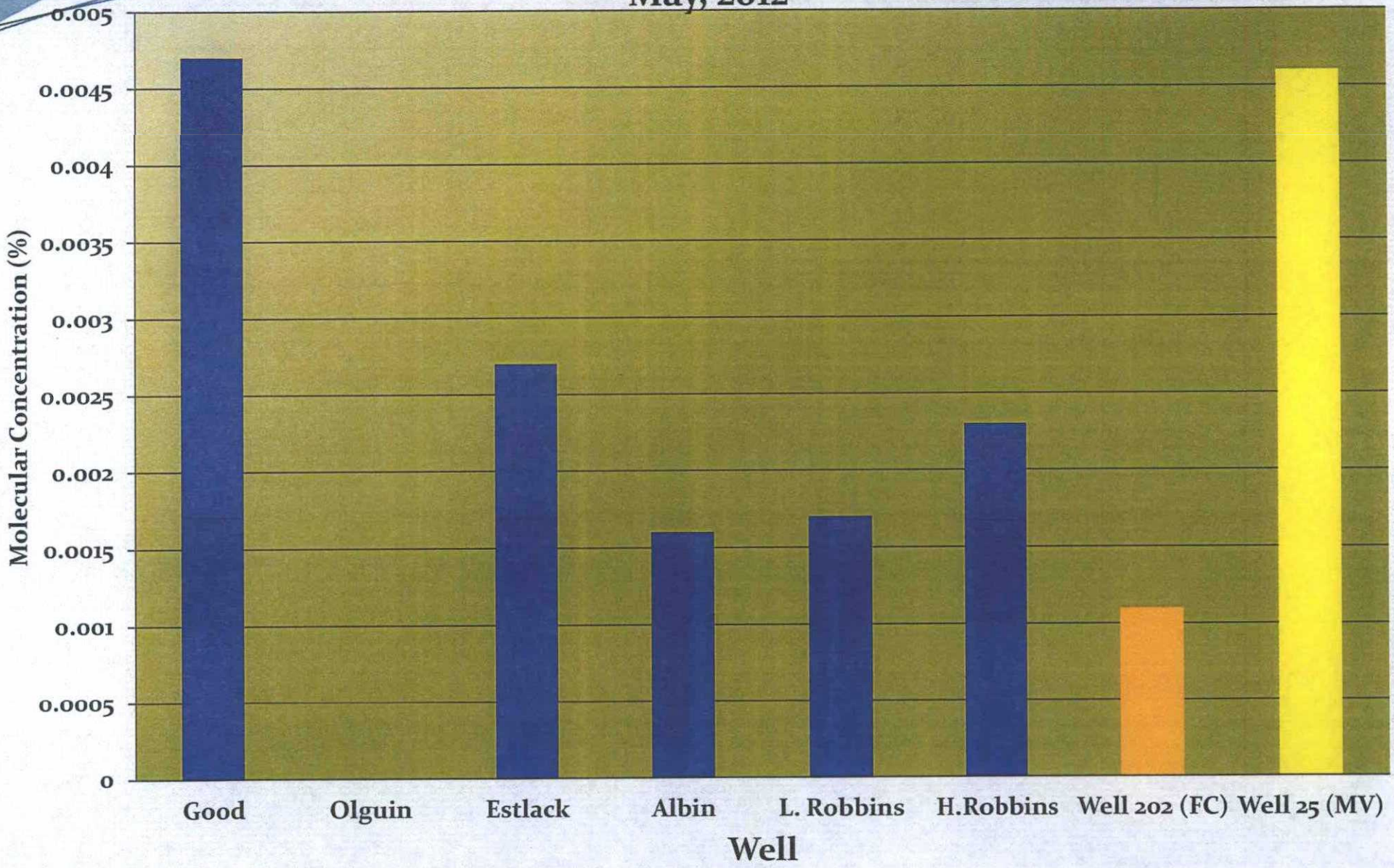
Stable Isotope Results $\delta^{13}C_2$ vs $\delta^{2}H_1$



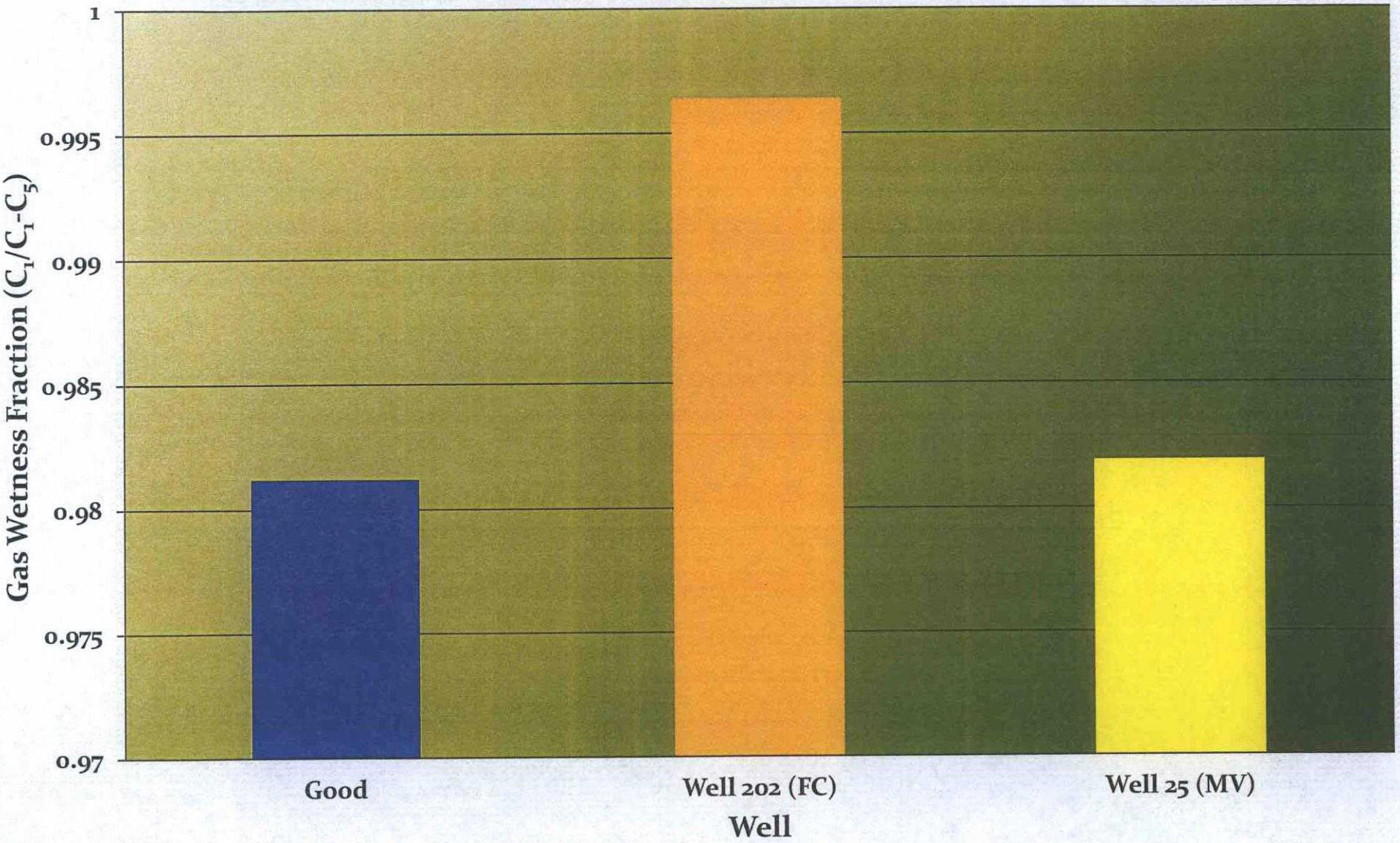
Helium Discussion

- Helium was found in all wells with gas analyses
- Good Well matched with the 25 Well (Mesaverde)
- Remaining Residential wells did not match either the 25 Well or 202 Well
- Compared helium to methane/ethane+
- Good Well and 25 Well (Mesaverde) had similar methane/ethane+
- Graph shows a strong relationship between 25 Well (Mesaverde) and Good Well

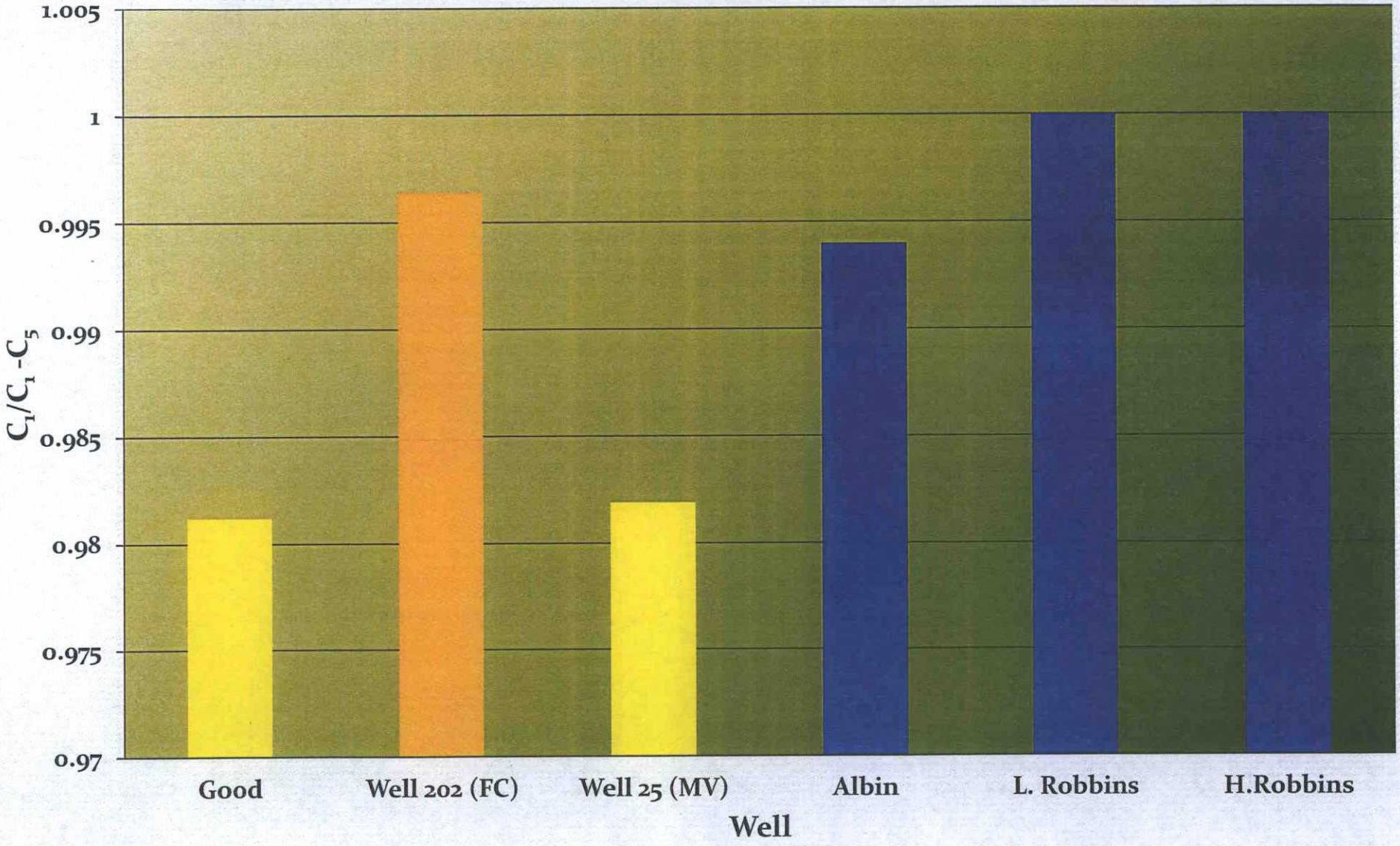
Helium Results
May, 2012



Gas Wetness Fraction
$C_1/C_1 - C_5$
May, 2012



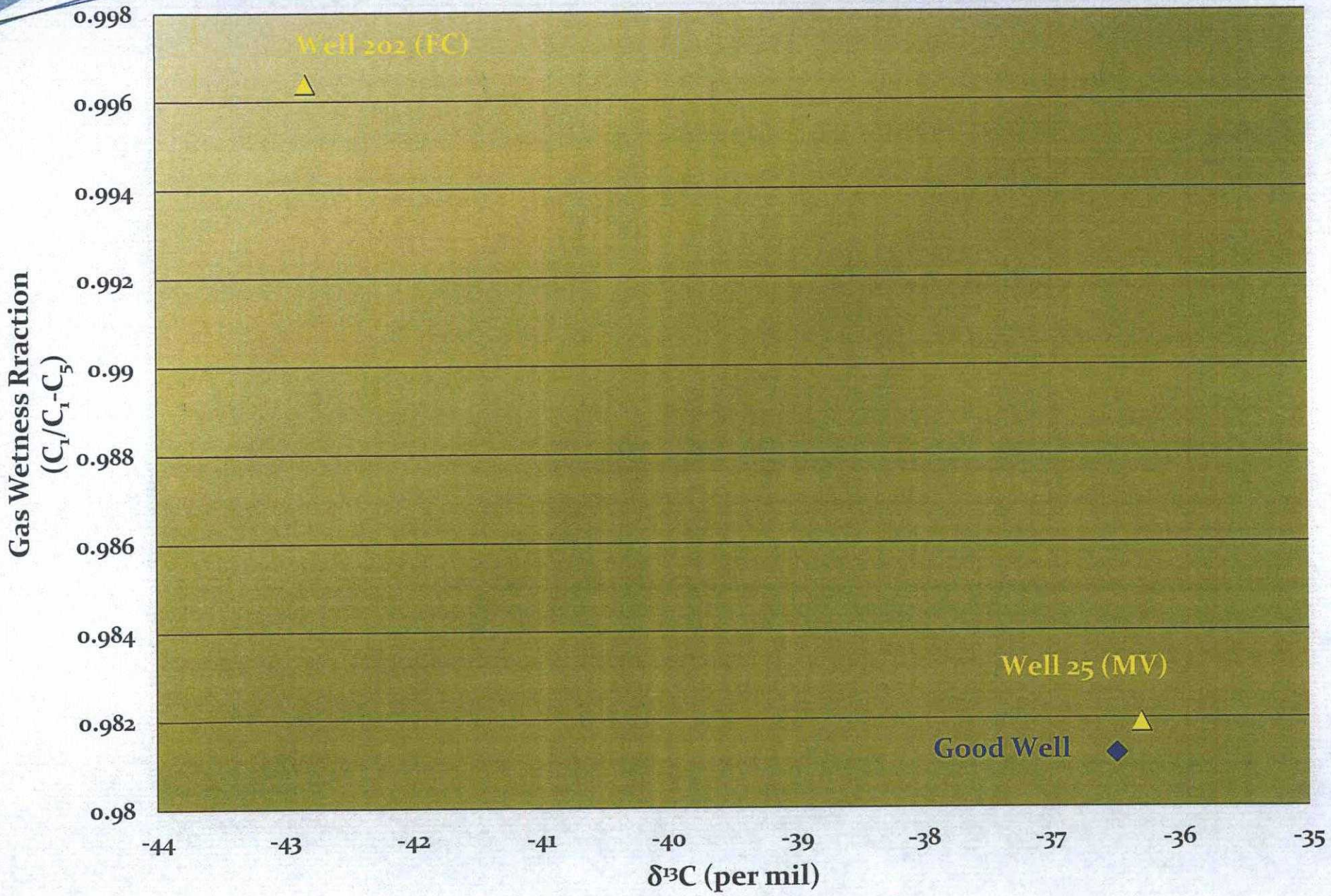
Gas Wetness Results (C_1/C_1-C_5)
All Wells
May, 2012



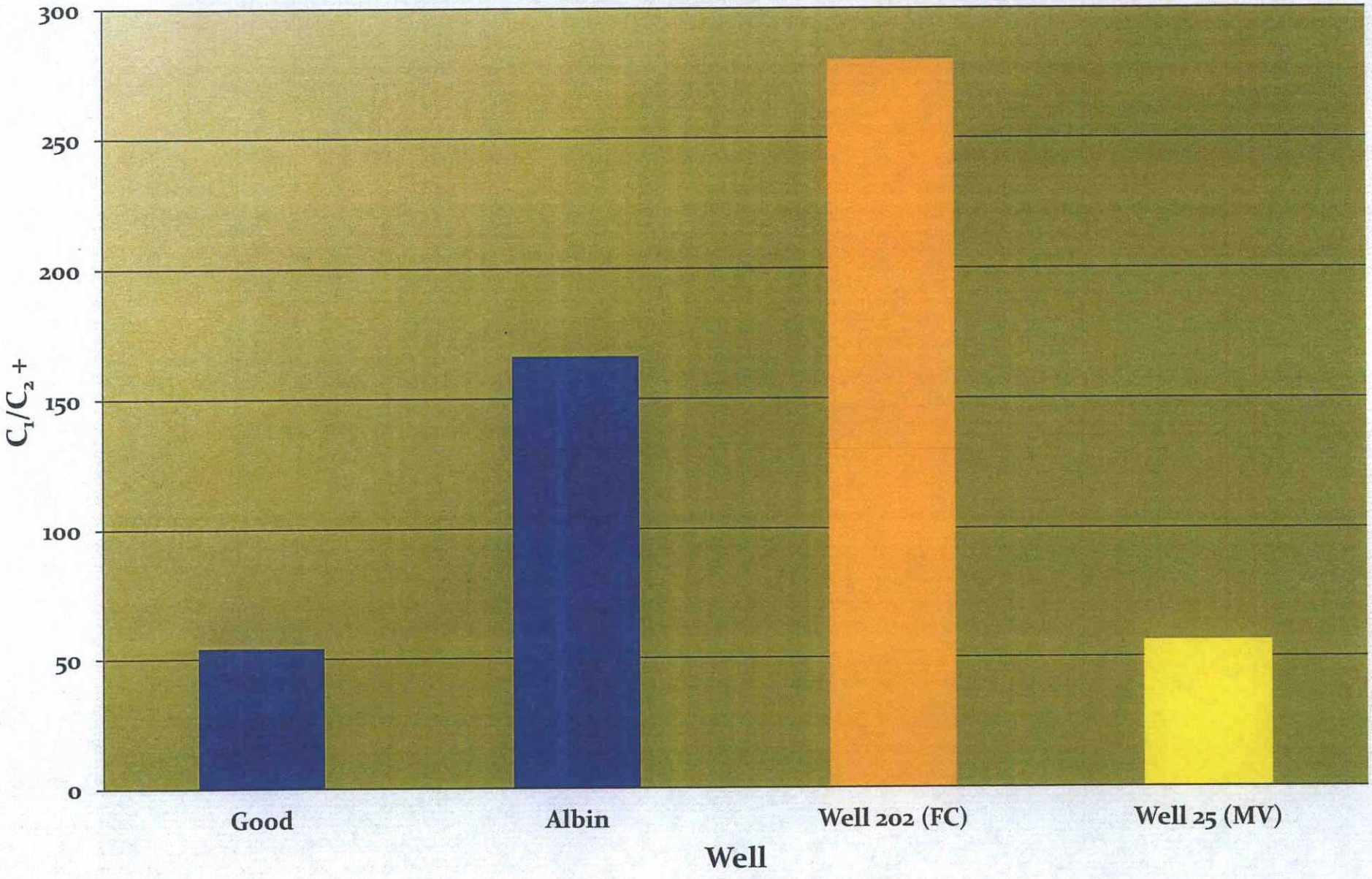
Gas Wetness Discussion

- Good well a wet, gas-condensate type gas ($C_1/C_{1-5} < 0.99$) is indicated
- Wells 202 and 204A (previous analysis) both showed dry type gas ($C_1/C_{1-5} > 0.99$)
- C_1/C_{1-5} of 1.00 in both Robbins' wells may indicate a biogenic source of methane
- Well 25 (Mesaverde) showed similar gas wetness to Good Well
- Gas wetness alone may not be conclusive due to oxidation of methane

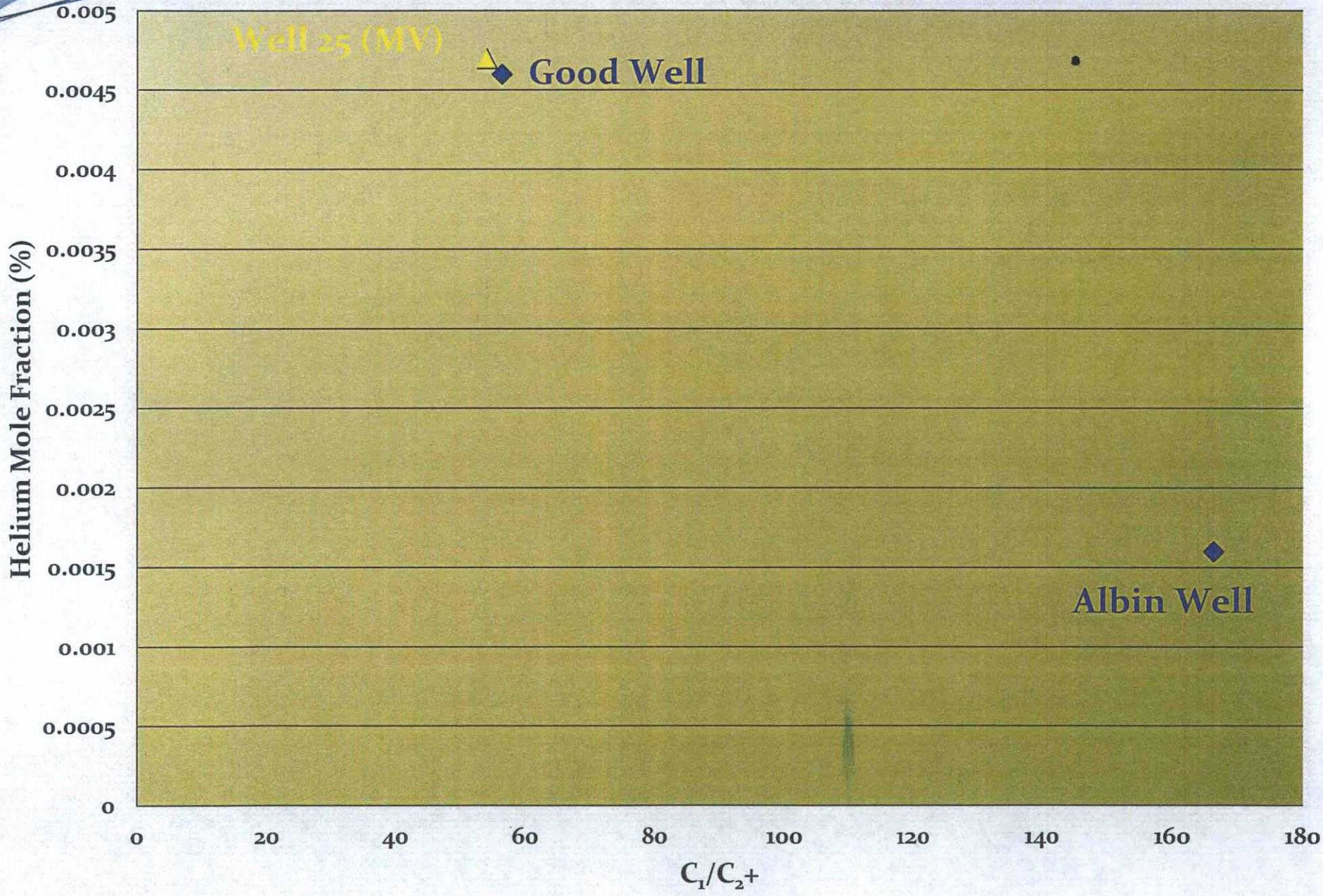
Preliminary $\delta^{13}C$ vs Gas Wetness Fraction (C_1/C_1-C_5)



C1/C2 + Results
May, 2012



Methane/Ethane + vs Helium



Residential Gas Analysis

- Results for H. Robbins, L. Robbins, Albin, and Estlack
- Ar, N, and O mole fractions are nearly identical to atmosphere
- CO_2 fractions are higher than atmosphere but significantly lower than values for the Mesaverde and Fruitland
- Helium fractions do not match Mesaverde or Fruitland
- No isotope results for these wells
- Gas results were not obtained for Olguin

Possible Reasons for CH_4 Changes between December and May

- Barometric pressure differences between December and May
- Significant drop in ground water level
- Differences in sampling & analytical methods

Preliminary Interpretation

- Isotope results show a close relationship between the gas in the Good Well and gas from 25 Well (Mesaverde)
- The isotope results do not show a relationship between the Good Well and Wells 202 & 204A (Fruitland)
- Mole fraction results also demonstrate a close relationship between the gas in the Good Well and gas in the 25 Well (Mesaverde)
- The gas in the Good Well is considered to be from the Mesaverde, not the Fruitland
- Helium results indicate that the methane in the other residential wells is derived from a source other than the Mesaverde, Fruitland, or atmosphere