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Trials and Tribulations of a New Regulation: Coal Bed Methane Water Well Testing

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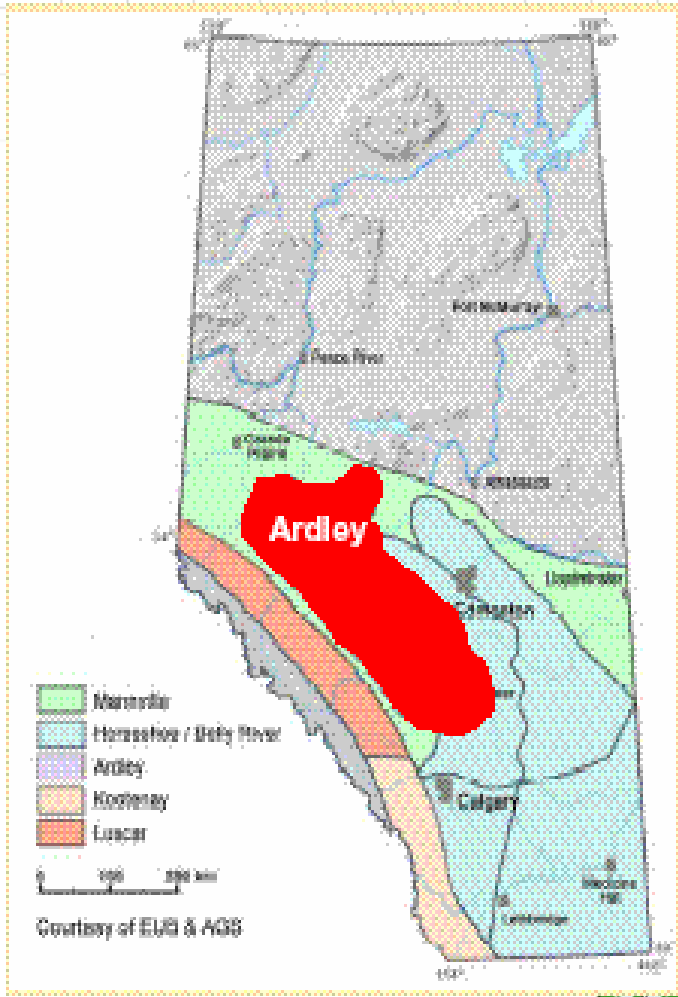
Remtech Oct 2006

Coal Bed Methane Activity in Alberta

- 3600 producing wells to date in Alberta (Jan 2006)
- Potential for 25 – 50000 wells
- Early focus on dry, shallow Horseshoe Canyon



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CBM Activity – Risks and Concerns

- Example from US – Produced water, improper surface disposal, saline soils
- Reduced water well yield
- Contamination of non-saline water
- Loss of water quality
  - Gas migration?
  - Drilling muds/frac fluids contamination?
- Surface footprint

Regulatory Initiatives

- AENV – CBM Multistakeholder Advisory Committee established in 2003.
- April 2004: AENV Groundwater Diversion Guidelines

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CanWest News Service

Jessica Ernst's water at her Rosebud home will actually light on fire if she places a flame near it.

Taps of fire near drill site spook resident

Southern Alberta woman suspects her polluted well may be linked to growing coal bed methane industry

But with the latest drilling boom comes fear because of what has happened south of the border.

In Wyoming and Colorado, coal bed methane development has caused serious land and water problems. In rare cases, methane has migrated from wells into well water.

More commonly, ranch land was reduced to hardpan by faulty water disposal and was further degraded by a dense cross-hatching of roads, well pads and pipelines.

Swann Defends Alberta Landowners with Coalbed Methane Concerns

Edmonton – Alberta Liberal Environment Critic David Swann is speaking out in defense of thousands of Alberta landowners, who were dismissed by Environment Minister Guy Boutilier yesterday for their concerns about the effects of coalbed methane development on their water quality.

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Politics…

- Edmonton Journal, March 2006. Landowner concerns expressed to media (Zimmerman) . Concerns for explosions, burning skin, cattle avoiding water. Claims landowner concerns ignored.
- Liberal Opposition calls for emergency debate and moratorium on drilling CBM.
- Environment Minister Guy Boutilier press release "I will use every fibre of energy in my body to protect and sustain our blue gold now and for the future"

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Regulatory Timeline

- **April 6th 2006: Announcement and release of AENV 2006 Standard for CBM Baseline Testing**
- May 1 2006: AENV Standard in effect.
- May 8 2006: EUB Directive 035
- June 15 2006: AENV Gas Sampling Protocol (how-to) released
- July 27 2006: EUB Directive 056: compliance and enforcement. Results to be submitted to landowner and AENV within 2 months
- July to Aug 2006. Public Town Meetings conducted by AENV and EUB
- Standard to be reviewed by AENV in 6 months and 1 yr from effective date. Review committee announced Sept 27 2006. AENV Database for submission still under construction.

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Standard for Baseline Water-Well Testing for Coalbed Methane/Natural Gas in Coal Operations

- AENV. Effective May 1 2006.
- EUB enforced.
- All water wells within 600 m radium
- Water Yield Test
- Analytical Testing
  - Gas composition (20% of wells)
  - Isotopes
  - Routine water potability
  - Microbiology
- Post drill testing required upon landowner complaint

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Trials of a New Regulation

- Speed of implementing new regulation rapid
- Little to no consultation between regulators and industry prior to effective date
- Limited definition on what to test
- No guidance or protocol on how to sample until after Standard in effect
- No commercially available field equipment
- No regulatory defined analytical methods. Variation on methodology between labs may make comparison of data difficult or impossible
- What to do with the data? Submission, interpretation for landowner?

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Water Well Sampling

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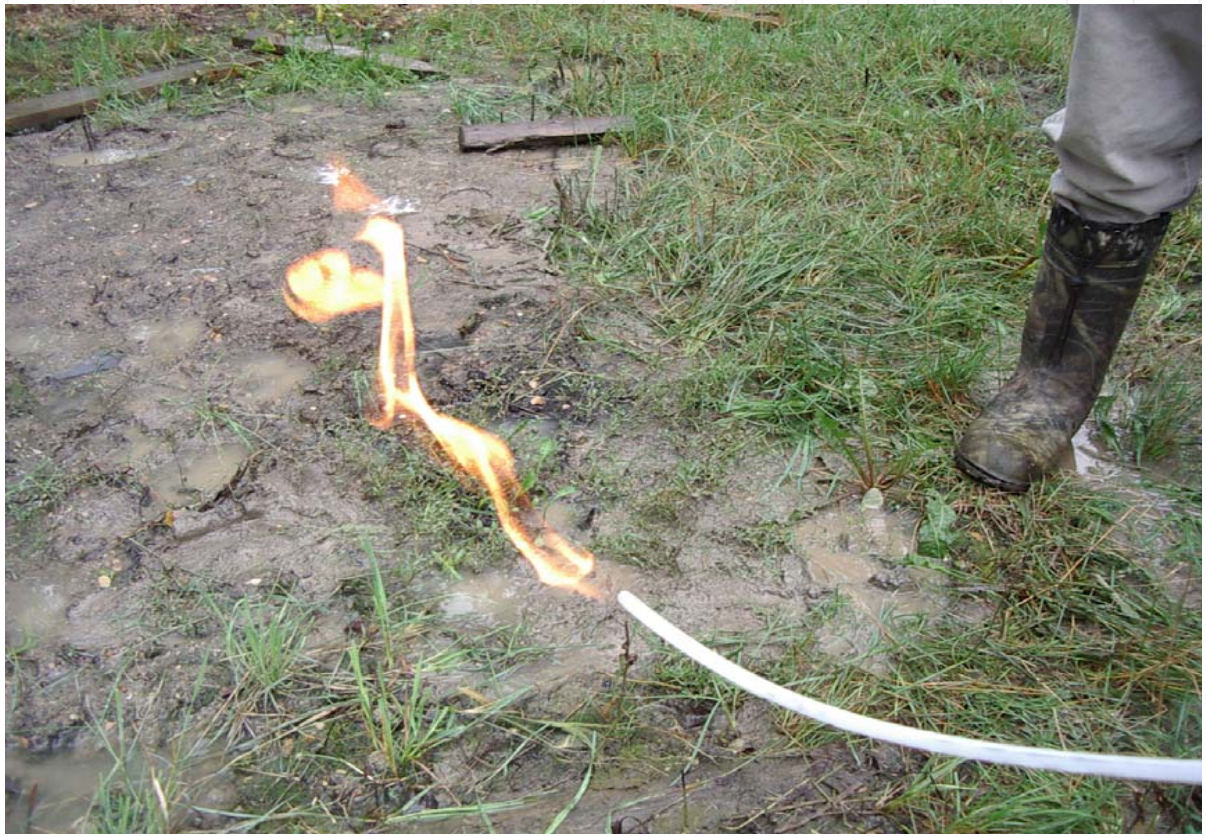
Water Well Sampling

Water Well Sampling



Methane

- Sources:
  - Thermogenic, natural gas fields, formation gas, coal (deep subsurface, high pressure and temperature).
    - Drill fraccing, Water wells through coal seams, leak around casings
  - Biogenic: shallow depths, formed by anaerobic decay of organic matter
- Significance in aquifers:
  - Nontoxic, odorless
  - Highly flammable, explosive, violently reactive with oxidizers and halogens

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Methane – Sampling and Analysis

- Methane Gas
  - Collection of gas from water in Tedlars. Gas composition required by AENV Standard. Requires obvious and large volumes of gas in water well
- Dissolved Methane
  - Not included in AENV Standard
    - Relatively low solubility in water at surface (35 mg/L)
    - Volatile
  - expected to be low to non-detectable in water well sampling
- Can dissolved methane analysis provide a simple screening tool for presence of methane contamination?

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	Methane	Ethane	Propane	Butane	N	O2	CO2	H	He	H2S
Mean	**58**	**0.019**	**0.002**	**0.001**	**39**	**2.0**	**0.53**	**0.001**	**0.011**	**0.6**
% > DL	**81**	**28**	**6**	**0**	**100**	**94**	**83**	**0**	**33**	**6**
Min	0.17	<0.01	<0.01	<0.01	5.22	0.01	0.01	<0.01	<0.01	<0.01
Max	93.47	0.12	0.03	0.01	97.45	10.91	3.71	0.01	0.02	9.9
95% Low	40	<0.01	<0.01	<0.01	22	0.80	0.07	<0.01	<0.01	<0.01
95% High	76	0.03	0.005	0.002	56	3.24	0.99	<0.01	0.01	1.72
SD	40	0.028	0.007	0.002	37	2.647	0.994	0.003	0.008	2.401
% CV	68	150	424	424	96	131	187	291	76	412
Median	79	0.01	0	0	19.2	1.09	0.135	0	0.01	0
Count	18	18	18	18	18	18	18	18	18	17
# > DL	18	5	1	0	18	17	15	0	6	1
% > DL	81	28	6	0	100	94	83	0	33	6

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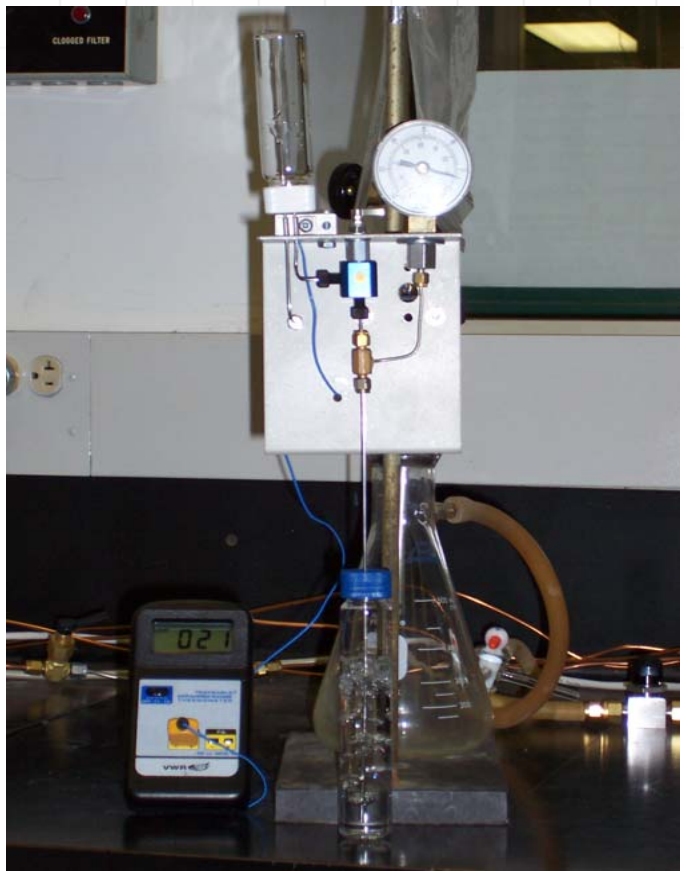
Methane – Sampling and Analysis

- Samples easily collected direct from well
- Collect in 40 mL vials, no headspace
- Simpler than gas collection in Tedlars – landowner can screen for gas contamination without specialized equipment



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Dissolved Methane in Water

	mg/L	mL gas/m³ water
Mean	**6.0**	**9125**
95% Low	3.9	5900
95% High	8.1	12300
% > MDL	**81**	**81**
percent > 1 ppm	**36**	
percent > 10 ppm	**21**	
SD	10.8	16417
% CV	179.9	180
Median	0.059	91
Min	<0.01	<100
Max	43.3	66000
Count	100	100

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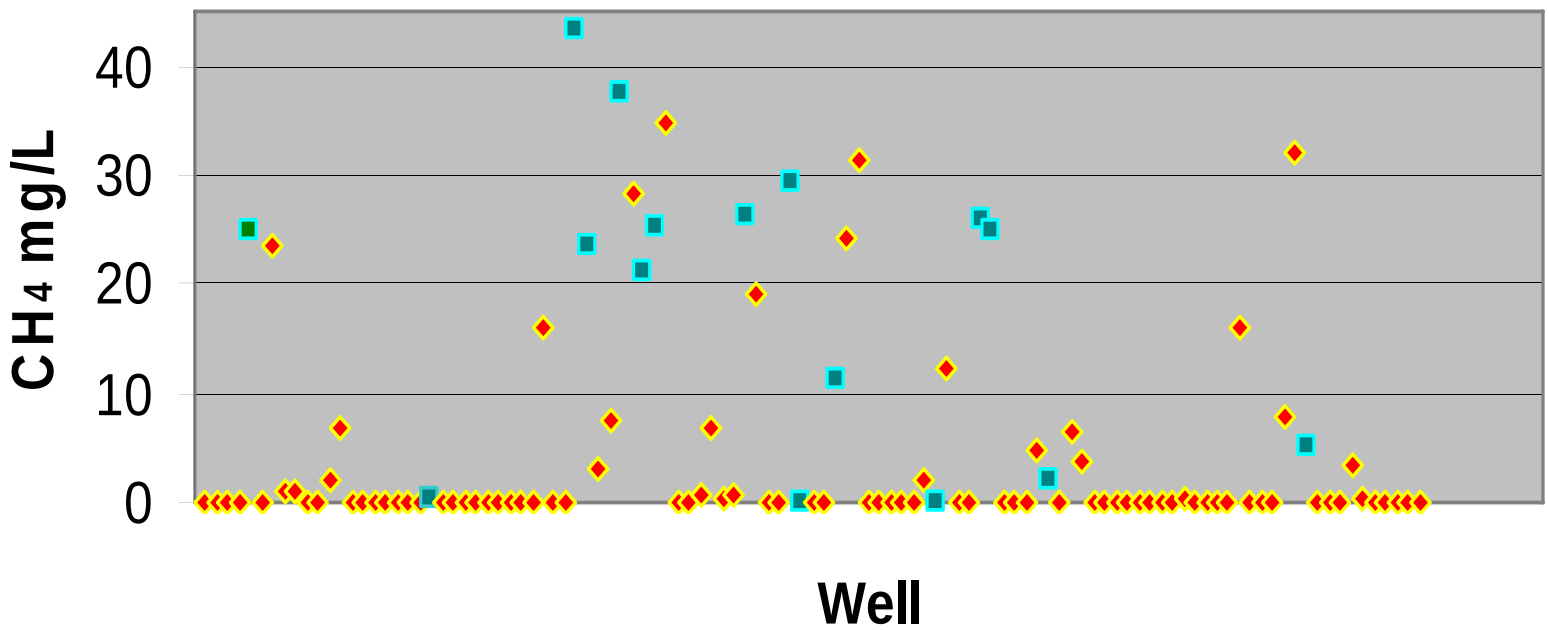
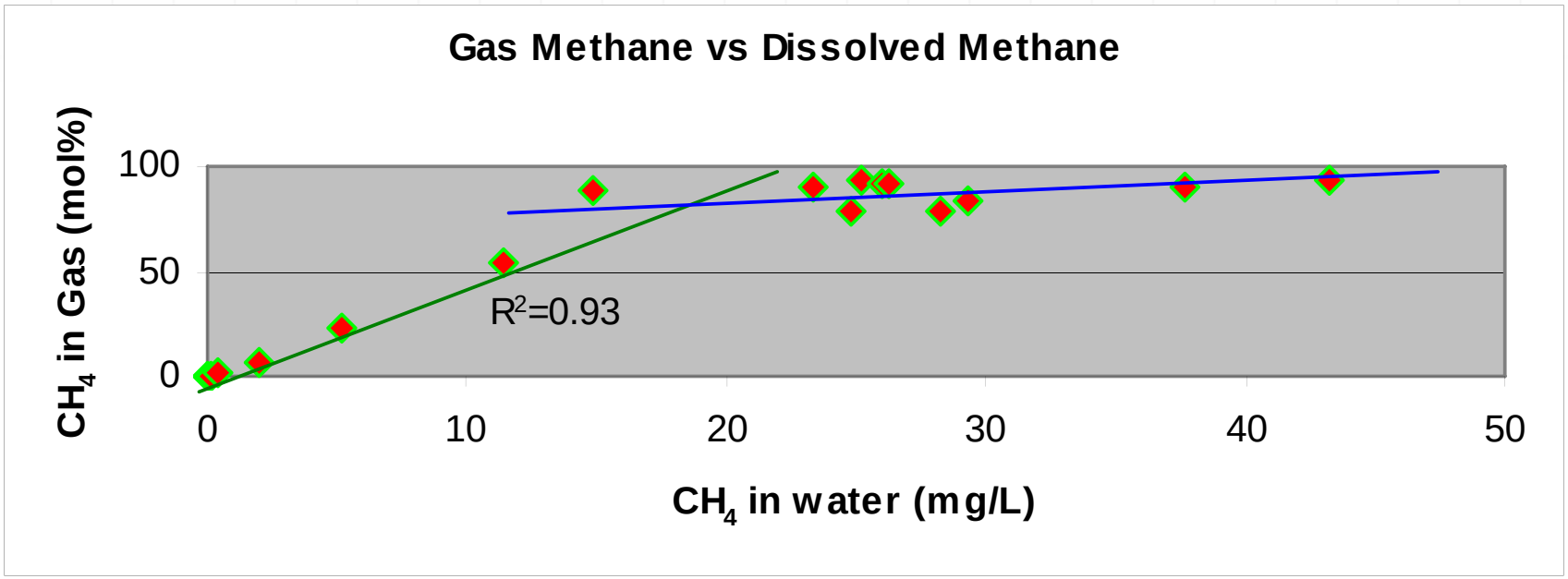

Dissolved Methane in Water
CH4 mg/L
40
30
20
10
0
Well


Gas Methane vs Dissolved Methane
CH4 in Gas (mol%)
100
50
0
R2=0.93
0
10
20
30
40
50
CH4 in water (mg/L)

Summary – Gas and Methane

- Dissolved methane water samples indicate potential as a screening tool, and complimentary in conjunction with gas sampling
  - Greater sensitivity than visible presence of gas
  - Eliminates perception/potential sampler bias
  - Where there is little gas evolved, still can provide a measure of total methane in the sample
  - Provide landowner peace of mind that his methane content is at a safe level even when no visible gas
- Simple to collect, relatively stable in proper sample bottles
- Further Research:
  - expand data points to evaluate relationship between presence of well gas, methane concentration, detecting C2 to C4, and source
  - Evaluate accuracy, stability of sampling techniques

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Gas Isotopes

Fingerprinting stable isotopes of methane, ethane propane and butane can assist in determining gas source because of two effects:

- Thermogenic Methane Production:
  - characteristic C1 – C4 fingerprint of stable isotope difference between C12 and C13 abundance for different formations at different depths.
  - Thermogenic gases cover a δ 13C range of -15 to -60‰
- Bacteriogenic methane production:
  - decomposition of the organic matter follows a kinetic pathway by which the light isotopes (12C and 1H) are preferentially selected over the heavy isotopes; therefore C1 to C4 gases are lower in ^{13}C abundance than thermogenic (or more highly negative
- The stable carbon isotope ratio of biogenic gases fall in the δ 13C range of -45 to -100‰

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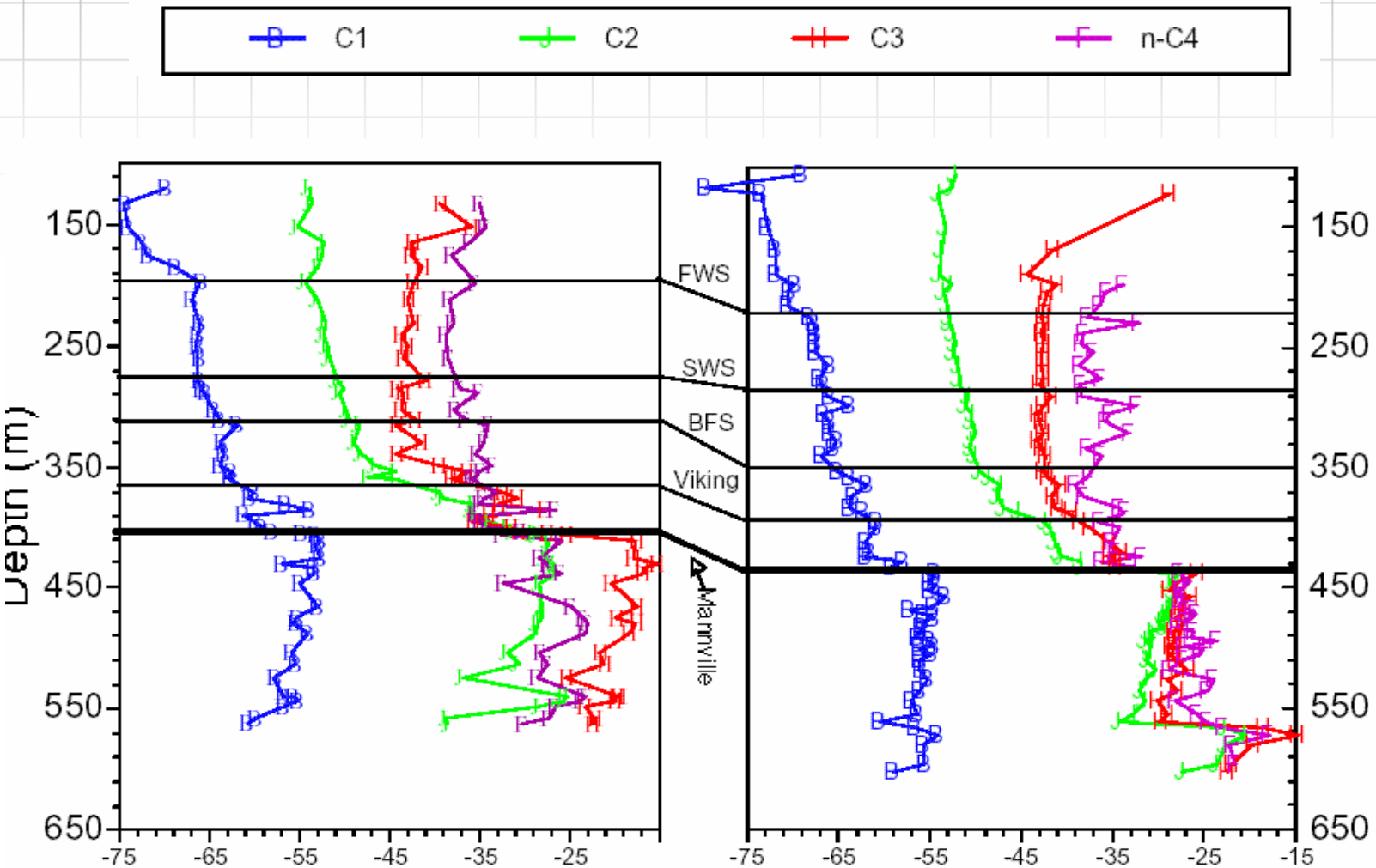
Carbon Isotope Value



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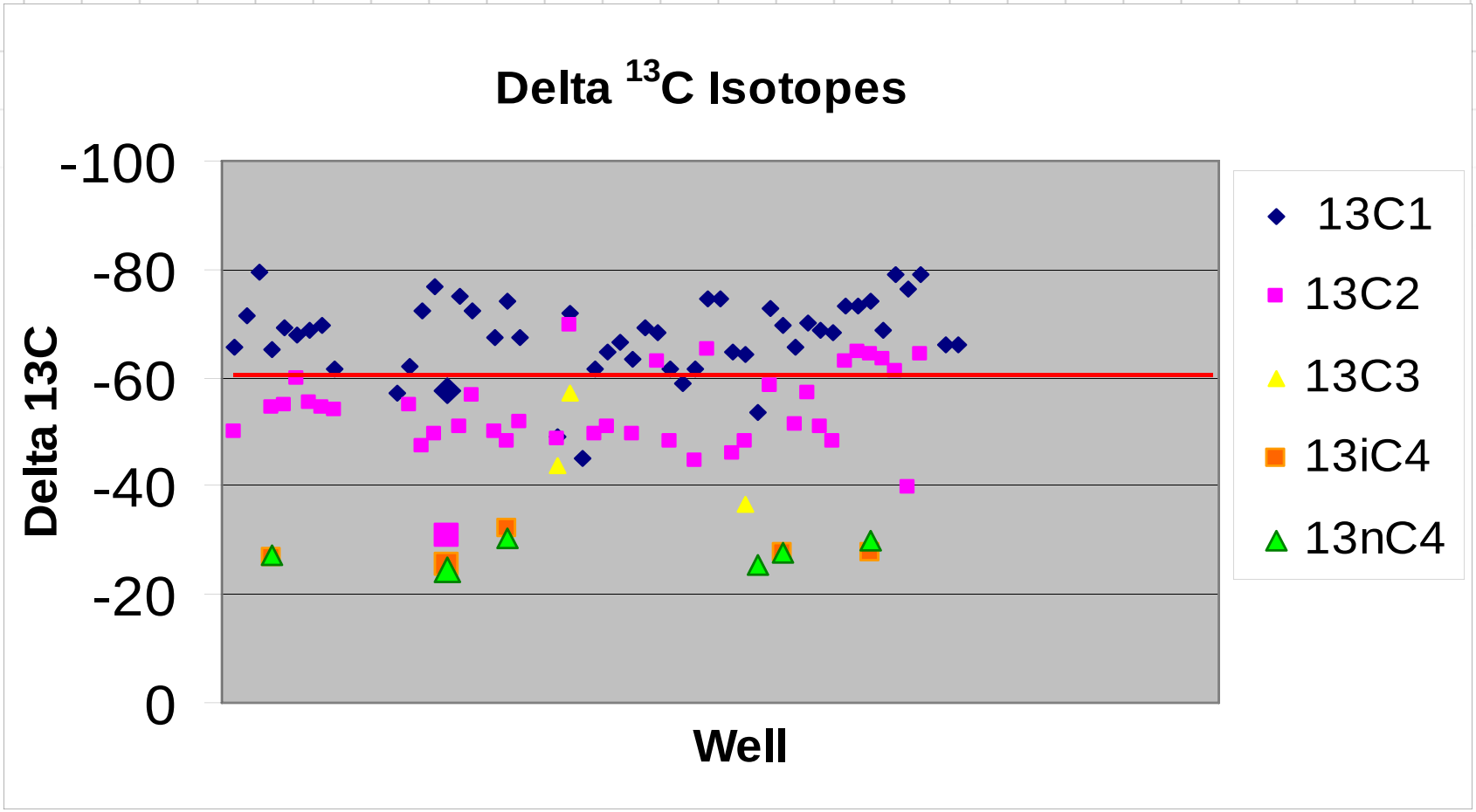
Delta 13C Isotopes
-100
-80
-60
-40
-20
0
Delta 13C
Well
13C1
13C2
13C3
13iC4
13nC4

Summary – Gas and Isotopes

- Isotopes fingerprinting, in combination with gas composition (C2 and greater) has the potential to suggest gas in water well may have origins from a formation.
- However, interpretation is not simple or exact.
- Require database of formation gases with depth for better determination of source
- Recommend establishing a public domain database of isotopes in formations
- Evaluate detailed isotopes on site specific formation upon landowner complaint, add to public database.
- Data Interpretation?

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Routine Potability

	Health Based Guidelines (MAC, mg/L)		
	F	**Nitrate - N**	**Nitrite - N**
Mean	**0.92**	**1.06**	**0.02**
95% Range	**0.8 – 1.0**	**0.2 – 1.9**	**<0.01 – 0.02**
CDWG	**1.5**	**10**	**1**
% > CDWG	**22**	**2**	**0**
Median	0.65	0.02	0.005
SD	0.91	8.08	0.04
% CV	99	763	286
Min	<0.05	<0.01	<0.005
Max	4.87	130	0.668
Count	370	371	371

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Aesthetic Objectives (mg/L)

	Colour	Turbidity NTU	pH	TDS	Hard.	Cl	SO4	Mn	Na
Mean	**18**	**13**	**8.3**	**993**	**147**	**23**	**251**	**0.11**	**326**
95% Low	**16**	**9**	**8.31**	**910**	**123**	**17**	**194**	**0.08**	**300**
95% High	**20**	**18**	**8.39**	**1077**	**170**	**30**	**308**	**0.14**	**352**
CDWG	**15**	**0.1**	**6.5-8.5**	**500**	**500**	**250**	**250**	**0.05**	**200**
% > DWG	**36**	**95**	**42**	**88**	**7**	**2**	**30**	**25**	**77**
Median	11	1	8.44	812	28	5.5	104	0.013	309
SD	17	46	0.4	823	231	61.18	559.12	0.34	254
% CV	97	345	5	83	157	262	223	307	78
Min	**5**	**0.1**	**6.93**	**160**	**2**	**0.4**	**0.9**	**0.005**	**1.9**
Max	**60**	**497**	**9.05**	**13700**	**1930**	**625**	**9390**	**4.93**	**3470**
Count	370	366	371	371	367	369	371	371	371

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Routine Potability

	Parameters with No DWQ Guidelines (mg/L)						
	Ca	Mg	K	EC (µS/cm)	Bicarb.	Carbonate	Alkalinity
Mean	**37**	**13**	**2.54**	**1503**	**666**	**25**	**569**
95% Low	31	11	2.15	1421	645	23	552
95% High	43	15	2.93	1586	686	26	586
Median	8	1.2	1.8	1300	634	23.5	556
SD	58.1	21.9	3.8	811	200	10.6	166
% CV	156	172	151	54	30	43	29
Min	0.9	0.1	0.4	275	112	7	92
Max	429	210	64	11100	2060	54	1690
Count	371	371	371	371	371	210	371

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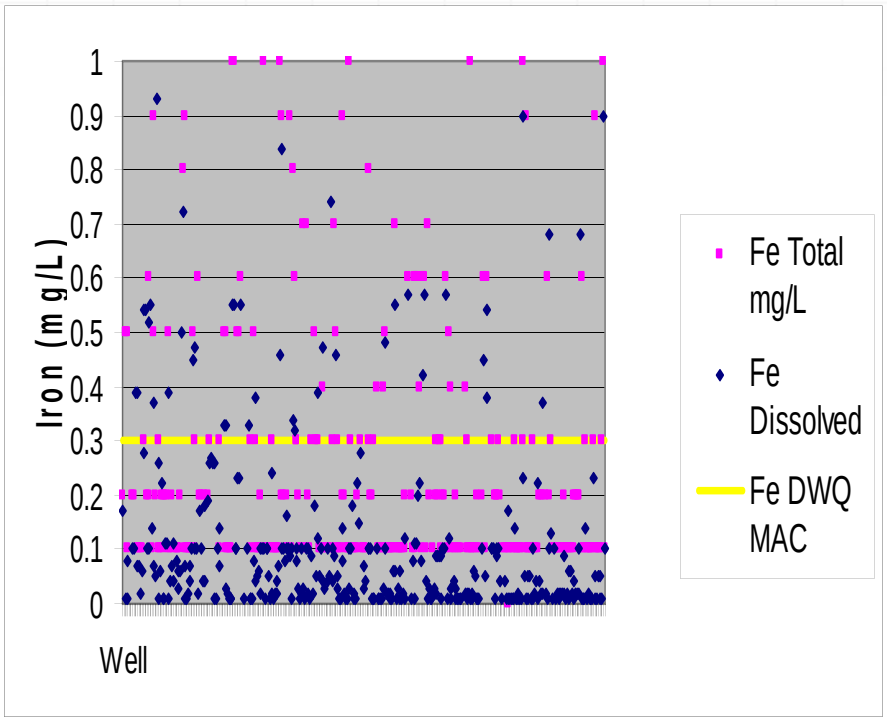
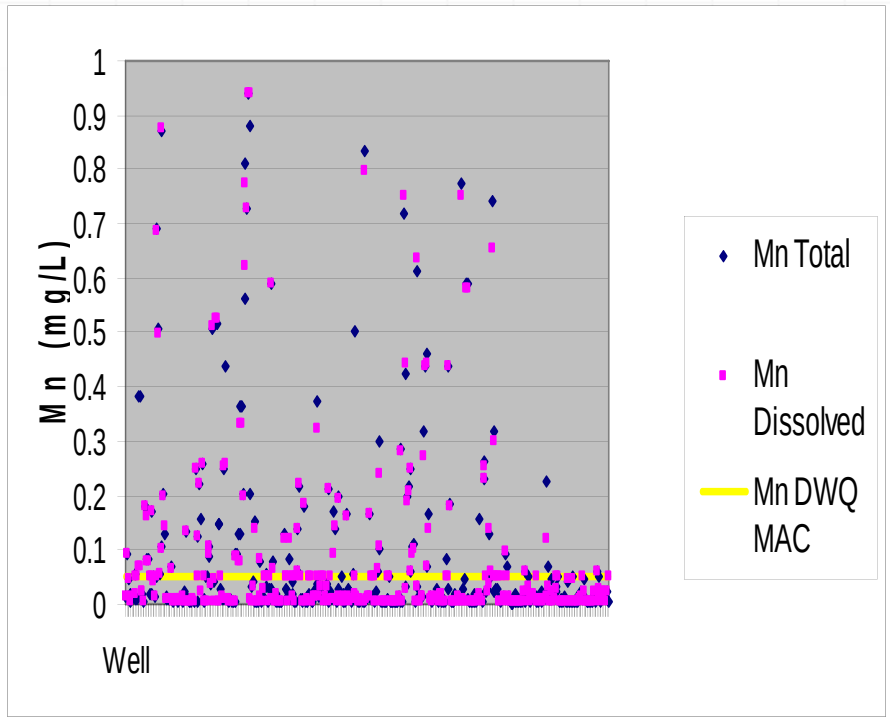
Fe and Mn, Total vs. Dissolved





Iron and Manganese (AO, mg/L)

	Fe Total	Fe Dissolved	Mn Total	Mn Dissolved
Mean	**1.80**	**0.11**	**0.12**	**0.11**
CDWQG	**0.3**	**0.3**	**0.05**	**0.05**
# > CDWQG	148	79	118	99
% > CDWQG	**38**	**20**	**30**	**25**
Median	6.95	0.01	0.38	0.34
% CV	386	548	304	303
SD	0.2	0.59	0.016	0.013
Min	**0.1**	**0.005**	**0.005**	**0.005**
Max	**85.9**	**5.55**	**5.83**	**4.93**
Count	388	118	388	389

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	Health Based Objectives (MAC, mg/L)								Aesthetic Objectives (AO, mg/L)	
	Hg	As	Ba	B	Cr	Pb	U	Zn	Cu	Al
Mean	0.0001	0.0029	0.12	0.29	0.0025	0.0016	0.0026	0.32	0.01	0.11
DWQG	0.01	0.010	1	5	0.05	0.01	0.02	5	1	0.1
% > DWG	0	5.1	0	0	0	2.5	0	1.7	0	10.2
Median	0.0001	0.0008	0.064	0.23	0.0019	0.0004	0.0005	0.015	0.002	0.007
SD	0.00001	0.0060	0.155	0.23	0.0026	0.0045	0.0037	1.55	0.031	0.594
% CV	13	209	130	80	103	286	143	494	324	548
Min	0.0001	0.0002	0.001	0.002	0.0005	0.0001	0.0005	0.001	0.001	0.005
Max	0.0002	0.0392	0.9	1.57	0.0212	0.0325	0.02	14	0.289	5.55
Count	118	118	118	118	118	118	118	118	118	118

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Summary - Routine Water Potability

- water wells demonstrate a wide range of conditions, probably reflecting regional aquifer conditions and inadequate well maintenance.
- Health Objective concerns: fluoride
- Aesthetic Objectives frequently fail:
  - TDS, salts, pH, color, turbidity, hardness
  - Iron and manganese: 20-30% for both total and dissolved
  - Consider changing required analysis to extractable metals
- Trace metals MAC (arsenic, lead, zinc). Significant health impact, therefore include GCDWQ trace metals in standard testing requirements.

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Microbiology

- Total and Fecal Coliforms
  - GCDWQ MAC limits of total coliforms and E. coli as "none detected per 100 mL
  - Standard requires testing of Total and Fecal Coliforms
  - Health concerns, presence of fecal contamination
- Iron and Sulfate Reducing Bacteria
  - Nuisance bacteria
  - May indicate potential for poor water quality
  - odor (H2S), taste, turbidity, color, slime deposits, biofouling, pipe corrosion and plugging of wells

Microbial Test Results

	Total Coliforms Membrane Filtration CFU/100 mL	Fecal Coliforms Membrane Filtration CFU/100 mL	IRB BART Kit CFU/mL	SRB MPN MPN/mL
Mean	**7**	**0.9**	**11800**	**36**
% Positive	**12**	**2.1**	**95**	**92**
SD	39	14	30034	139
% CV	595	1461	255	382
Median	<1	<1	2300	2.3
Min	<1	<1	25	<1
Max	400	250	140000	1100
Count	382	381	239	379

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SRB/IRB Method Validation

- SRB and IRB taxonomic diversity is large
- Anaerobic, difficult to culture consistently
- Several methods and kits available, selection of which test method to use for CBM testing left to the lab
- Difficult to standardize –
  - no formal standards
  - No performance evaluation studies/interlaboratory studies
  - sample population stability problems
- Norwest Labs-Bodycote Method Evaluation Study –In Progress
  - Comparison of methods using real samples
  - Comparison of methods and results among select Alberta labs

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SRB/IRB Method Validation

- Preliminary data suggests that variability between labs with the same test method is substantial.
  - Bart Kits (presence/absence – population estimate)
  - APHA
  - NACE
  - Other plate methods
- Preliminary data also suggests that different SRB test methods can have substantially different results for the same sample.
  - AENV CBM data evaluation may have difficulties comparing and analyzing data from different labs

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Microbial Testing Summary

- Relatively few positive coliforms in wells analyzed
  - Consider following Health Canada's recommendation of testing for E. coli instead of fecal coliforms
- Most wells demonstrated positive presence for iron and sulfate bacteria
  - Value of testing? Not necessary correlated with poor water quality.
- **Recommended Research**:
  - evaluate water sulfide concentration/turbidity, other parameters, with presence and concentration of SRB and IRB bacteria as an indication of poor water quality
  - Fully evaluate methodology, sample preservation and hold times for SRB and IRBs

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