Long-Term Variability in Methane in Domestic Water Wells in Northeast Pennsylvania

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Study Background

- Methane (CH₄) Prevalence and Variability
  - Lack of water well construction standards
  - General findings from extensive pre-drill data
    - Water well samples collected (2009-2011): 11,312
    - Methane detections (>0.026 mg/L): 2,740 (24.2%)
      - >0.026 to 3 mg/L: 2,064 (18.2%)
      - >3 to 7 mg/L: 287 (2.5%)
      - >7 to 20 mg/L: 270 (2.4%)
      - >20 mg/L: 119 (1.1%)
  - Limited understanding of natural methane variation and occurrence related to complaints
Long-Term Monitoring: Domestic Wells

- Address gaps in understanding
- Quantify natural variation in methane levels

Relevance

- Significant importance in assessing natural methane variation and occurrence

Study Objective

- Gain understanding of long-term variability of methane in domestic water wells and correlation to other parameters, such as well usage and pumping
Study Design

- **11 domestic water wells**
  - Pre-drill (baseline) sampling data used to select sites
  - 3 categories of baseline dissolved methane levels
    - Low: < 5 mg/L
    - Medium: 5 to 15 mg/L
    - High: > 15 mg/L
  - 3-4 wells from each category
    - Depths: 40 to 300 feet
  - Located across Bradford and Sullivan Counties in Northeastern Pennsylvania
- **12 months of monitoring**
General Outline: Study Parameters

- Local and Regional Geology
- Supply Well Construction and Conditions
- Manual Water Sampling for Laboratory Analysis
  - No dissolved methane sensor available
- Continuous Remote Monitoring
  - Headspace gas parameters (\(\text{CH}_4, \text{CO}_2, \text{O}_2\))
  - Water well parameters (water levels, turbidity)
- Weather Parameters
  - Data logged and manually downloaded (temperature, barometric pressure, humidity, wind, precipitation)
Preparation of Study Water Wells

- Water treatment system installation or upgrade
- Borehole geophysics
- Downhole InSitu water quality logging (pH, temp., cond.)
- Supply well power re-configuration
- Jet pumps replaced with submersible pumps (2 wells)
Remote Real-Time Monitoring Parameters

- **Well Headspace**
  - CH$_4$ (10 ppm to 100% volume, 2 sensors)
  - O$_2$
  - CO$_2$
  - Gas flow
  - Gas pressure

- **Down Well**
  - Water level
  - Turbidity
  - Pump flow rate
Real-Time Data

- Data logged every minute
- Transferred via cell modem
- Uploaded to custom software
- Uploaded to secure website
  - Choose location via list or map
  - Graphs, statistics, raw data
- Data integrated with Microsoft® Access, EarthSoft EQuIS™ and other data management tools
Equipment Setup

- Equipment customized at each site
- Headspace gas drawn from ~2 feet below well grade using sample pump
- Weather Stations at 6 locations
  - Barometric pressure
  - Precipitation
  - Temperature
  - Wind
  - Humidity
## Water Type and Geologic Setting

<table>
<thead>
<tr>
<th>Location</th>
<th>Mapped Bedrock Formation</th>
<th>Water-Type</th>
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<tbody>
<tr>
<td>MB</td>
<td>Lock Haven</td>
<td>Sodium - Bicarbonate</td>
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<tr>
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<td>DV</td>
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<td>Catskill</td>
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<tr>
<td>EH</td>
<td>Catskill</td>
<td>Calcium/Sodium - Bicarbonate</td>
</tr>
</tbody>
</table>
Analytical Data Assessment

- Tracking data to determine relationships with methane and key dissolved constituents:
  - Sulfate
  - Chloride
  - Barium
  - Lithium
  - Strontium

Methane and Sulfate in Water: Site R
Dissolved Methane Variability: Site EH

Methane, mg/L

Baseline
Sample

Dissolved Methane Variation: “Low” Level (<5 mg/L)
Dissolved Methane Variation: “Medium” Level (5-15 mg/L)
Dissolved Methane Seasonal Variation: “Medium” Level (5-15 mg/L)

Number of Samples
Spring: 48
Summer: 21
Fall: 23
Winter: 48
Dissolved Methane Variation: “High” Level (>15 mg/L)
Dissolved Methane Seasonal Variation: “High” Level (>15 mg/L)

Number of Samples
Spring: 39
Summer: 14
Fall: 9
Winter: 19
Turbidity vs Water Level: Site B
Headspace Methane vs Water Level: 24 Hours (Site EH)
Observing Methane Trends over Different Time Intervals

Headspace Methane vs. Water Level Change in 24 Hours

Headspace Methane vs. Water Level Change in 72 Hours

Headspace Methane vs. Water Level Change in 7 Days

EH Location

1 Day Duration

3 Day Duration

7 Day Duration
Headspace Methane vs Water Level: Site MB

- Depth to Water (feet below grade)
- Methane, ppm

Graph showing the relationship between Headspace Methane and Depth to Water from 5/3/2013 to 5/7/2013.

Key:
- Red: Headspace Methane
- Blue: Depth to Water
- Black: Fracture
Headspace Methane vs Water Level Change in 6 Hours

Headspace Methane vs Water Level: 6 Hours (Site DV)
Comparison Between Groundwater Methane vs. Headspace Methane Over Time
Variability in Headspace Methane over Time:
Site EH

January 2012

July 2012

October 2012
Headspace Methane vs Water Temp vs Air Temp vs Water Level: Site G

Note: All data is preliminary

0.5% Vol = 5,000 ppm = 10% LEL
Methane vs Carbon Dioxide
Well Headspace: Site MB

Note: All data is preliminary

0.5% Vol = 5,000 ppm = 10% LEL
Preliminary Findings

- Methane occurs naturally and highly variable:
  - Spatially and temporally
  - Weather
  - Man-induced changes (water well pumping)

- Single pre-drill baseline methane sample may not represent the full range of natural variability

- Natural methane levels (headspace and dissolved) may be influenced by pumping or water level fluctuations

- Water level declines (pumping or natural) may increase natural methane headspace concentrations

- Natural methane concentrations may vary seasonally
Thank You!

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