



18 Aug 2015

Newfield Exploration, Bakken Petroleum System, North Dakota

Overview of NETL Field Studies Related to Oil and Gas Production

DOE Tribal Leaders Forum
Denver, Colorado



the ENERGY lab

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USDOE National Energy Technology Laboratory, Pittsburgh, PA

Program Objectives

- Reduce Environmental Impacts
- Demonstrate Safe/Reliable Operations
- Improve Efficiency of Hydraulic Fracturing



Monitoring of Oil and Gas Operations

- **Surface Monitoring**
 - Ambient Air Quality
 - Air Emissions
 - Ground Motion
 - Surface Water
- **Near-Surface Monitoring**
 - Spills and Leaks
 - Well-Bore Integrity
 - Abandoned Wells
- **Sub-Surface Monitoring**
 - Fracture Growth
 - Fluid/Gas Migration

Air Quality
Methane Emissions
Spills and Leaks



Fracture Growth



Surface Monitoring- Air Quality

Ambient Air Monitoring Laboratory

Measures air contaminants relevant to oil and gas exploration and production

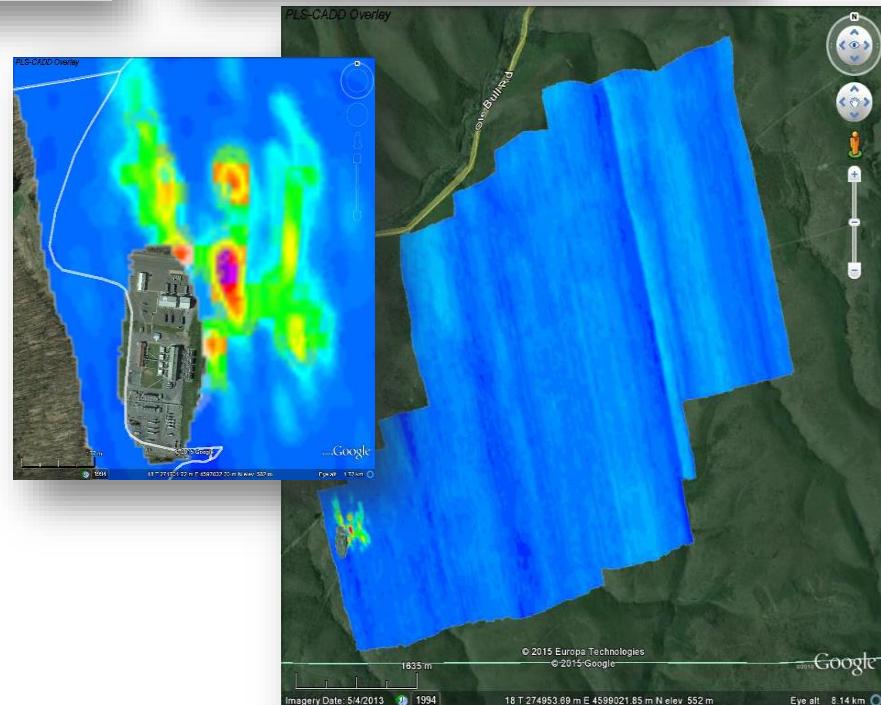
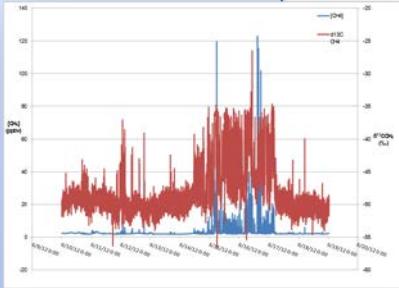
- VOC's
- CH₄ and CO₂ w/isotope speciation
- Ozone
- NO_x (NO, NO₂ and NO+NO₂)
- Organic/Elemental Carbon in Aerosols
- Ammonia
- Radon
- PM_{2.5} and PM₁₀
- SO₂
- Meteorological station



Surface Monitoring- Air Emissions

Methane Emissions

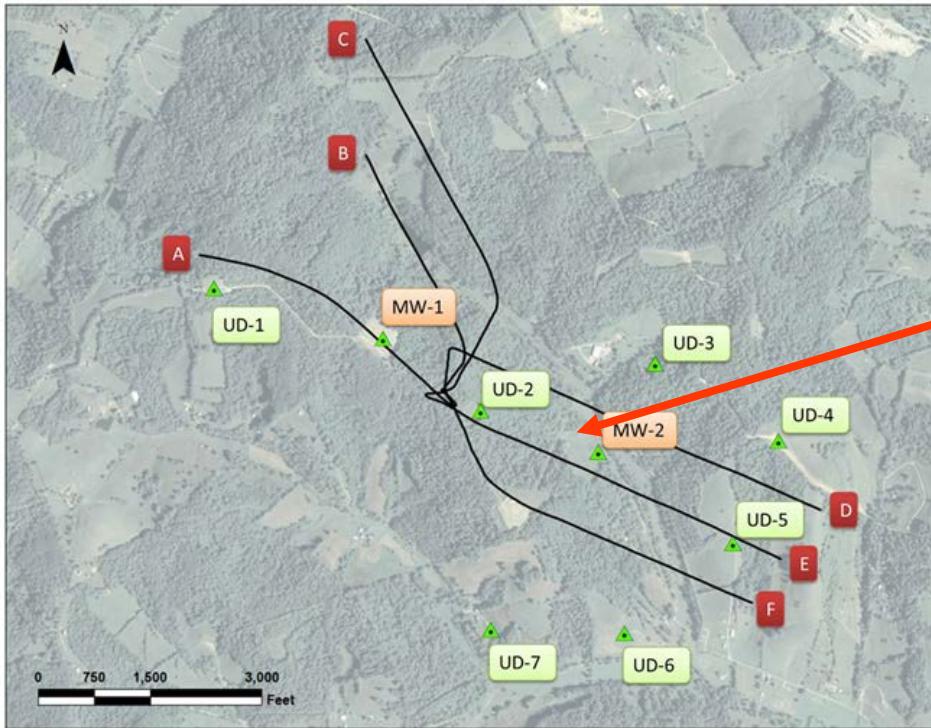
- Unconventional Well Development
 - Drilling
 - Hydraulic Fracturing
 - Flowback
 - Production
- Abandoned Wells
- Compressors
- Pipelines
 - Gathering
 - Transmission



Surface Monitoring- Ground Motion

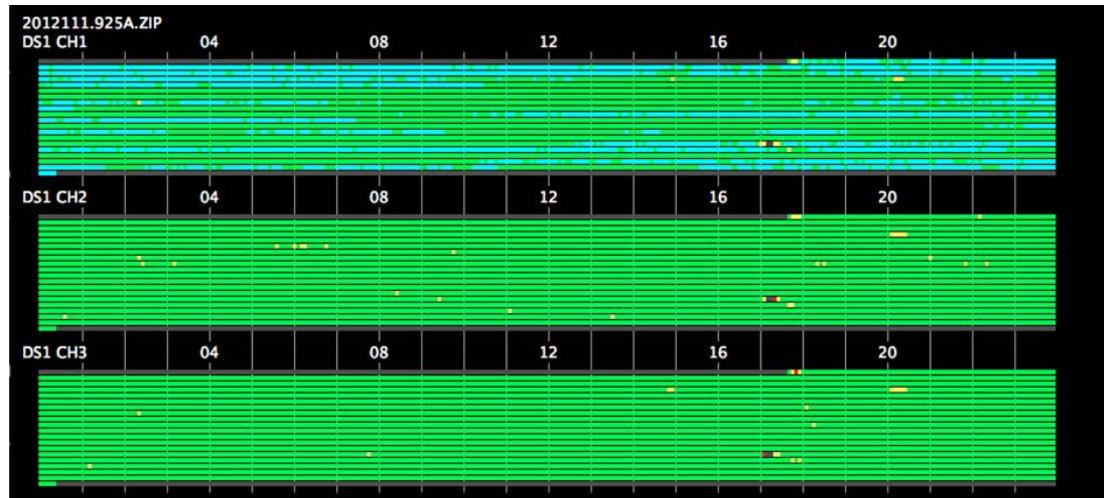
Ground Motion - Hydraulic Fracturing

1. Surface above Marcellus Wells
2. Underground Document Repository

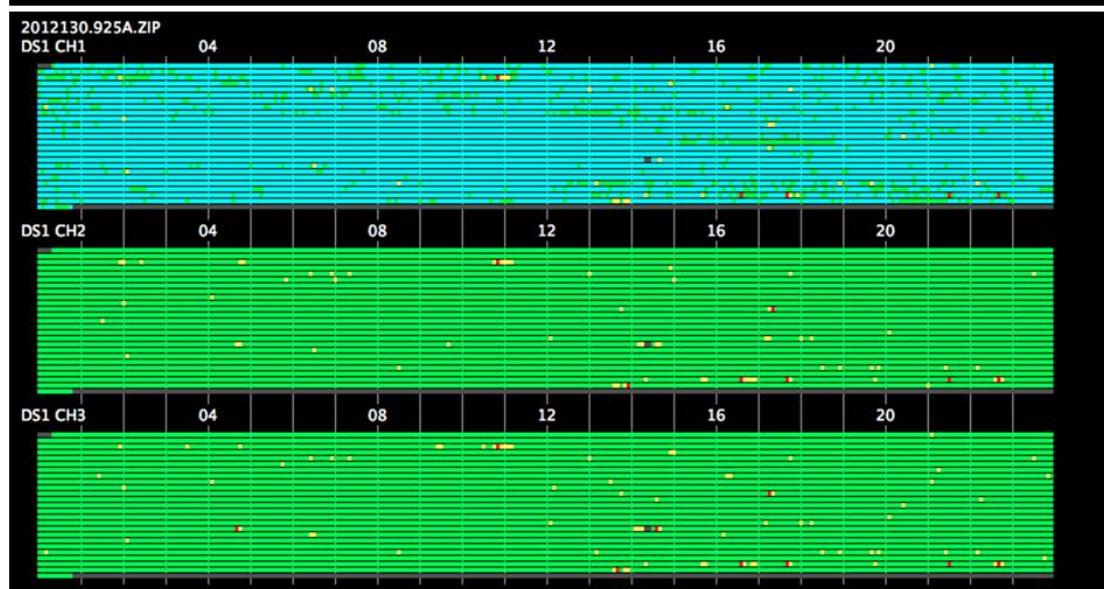


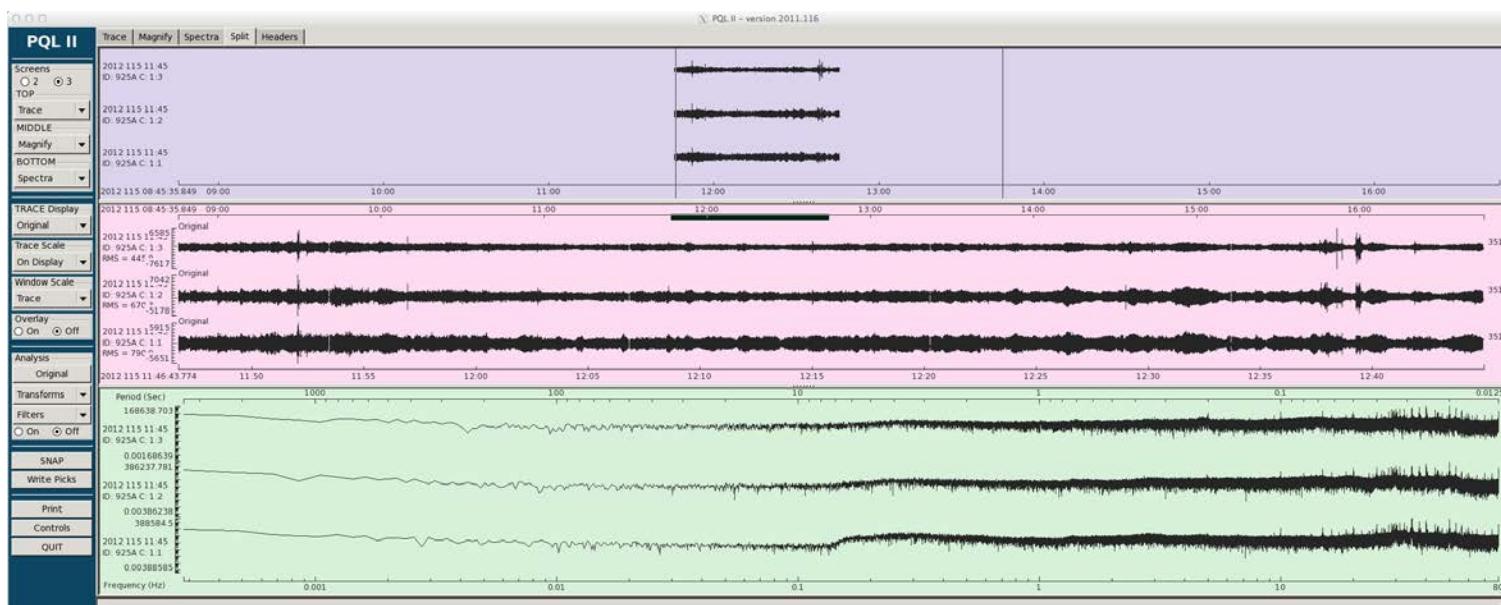
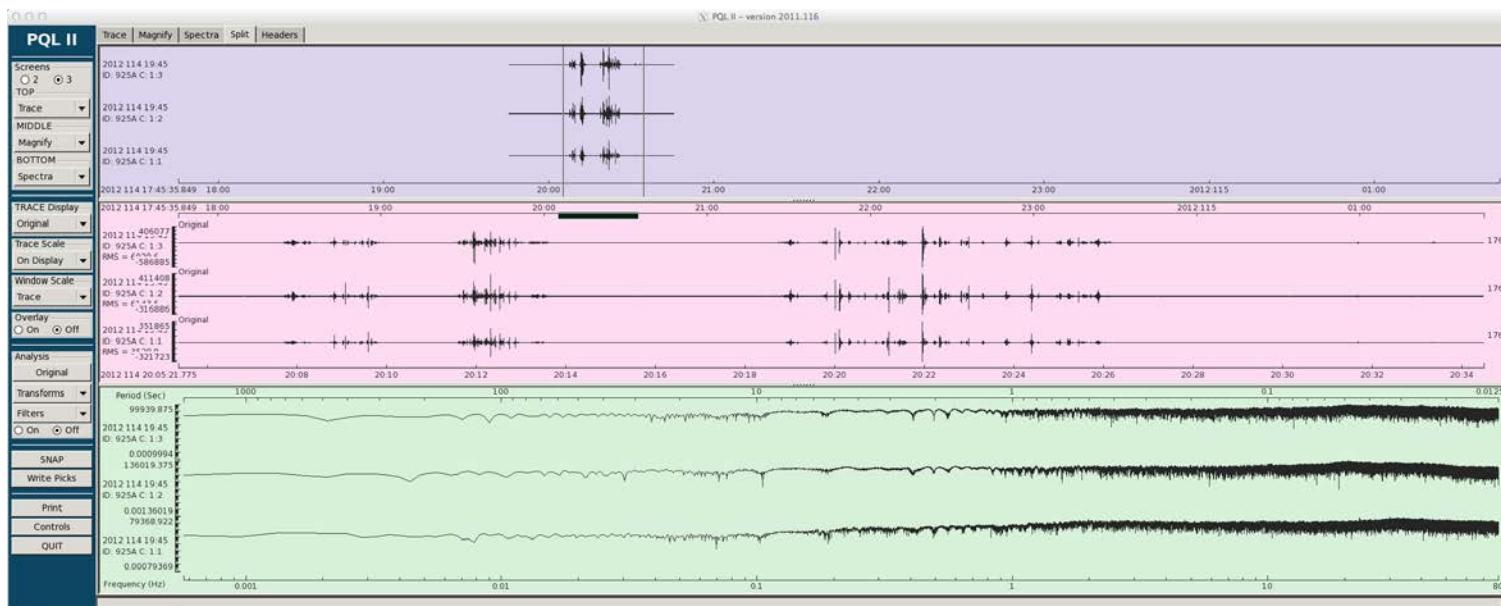
Surface Monitoring- Ground Motion

Background

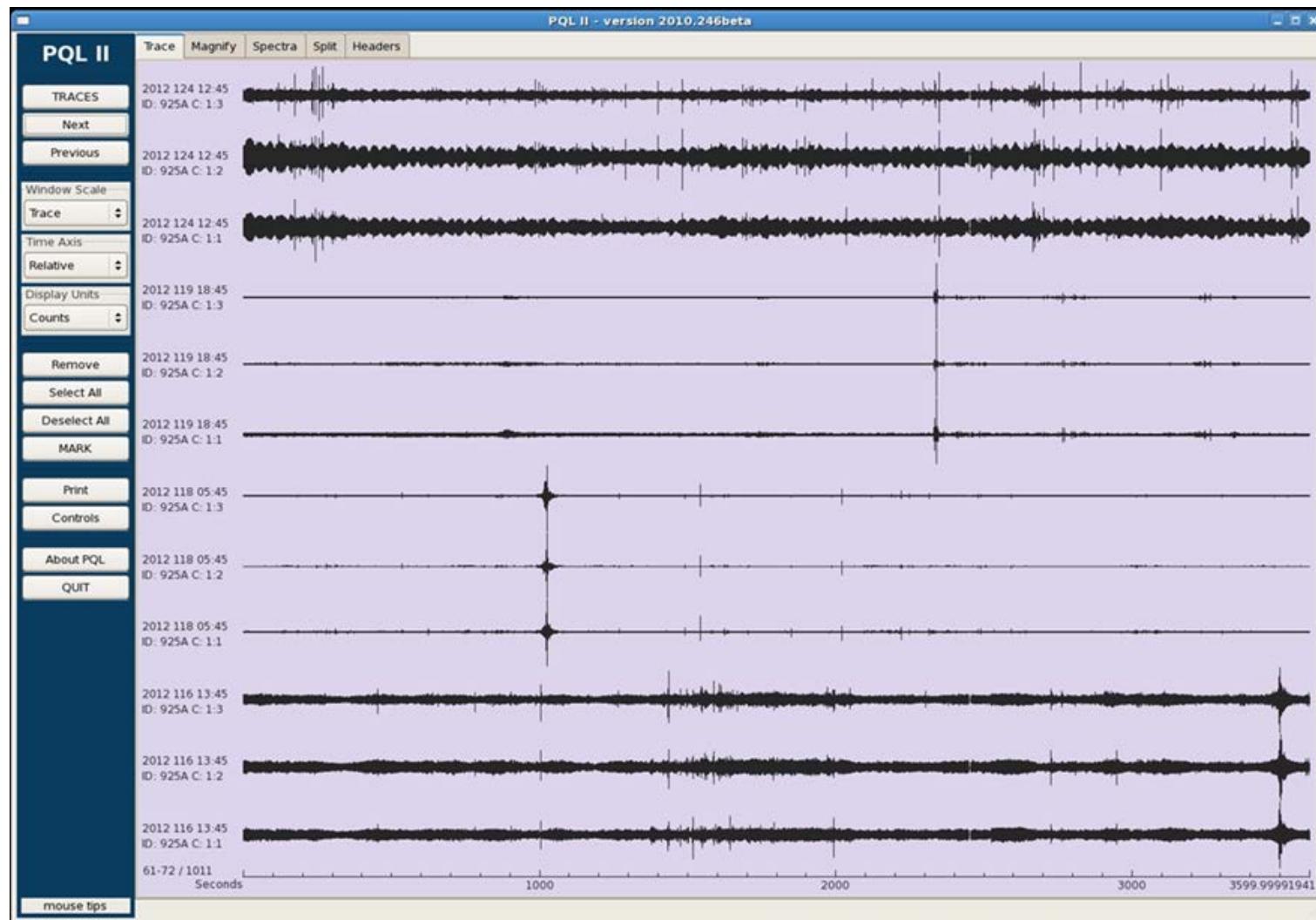


During Frac





Surface Monitoring- Ground Motion



Surface Monitoring- Ground Motion

Ground Motion - Hydraulic Fracturing

1. Surface above Marcellus Wells
2. Underground Document Repository



Observed Events

BHE Vel (m/s)	BHN Vel (m/s)	BHZ Vel (m/s)	Peak Velocity m/s
5.00E-06	2.00E-05	2.00E-06	2.07E-05
3.00E-06	2.00E-06	2.00E-06	4.12E-06
2.00E-06	2.00E-06	2.00E-06	3.46E-06

Guidelines m/s

Human Sensitivity	2.5E-03
Building Safety	5.0E-01

Surface Monitoring- Water Quality

Surface Water

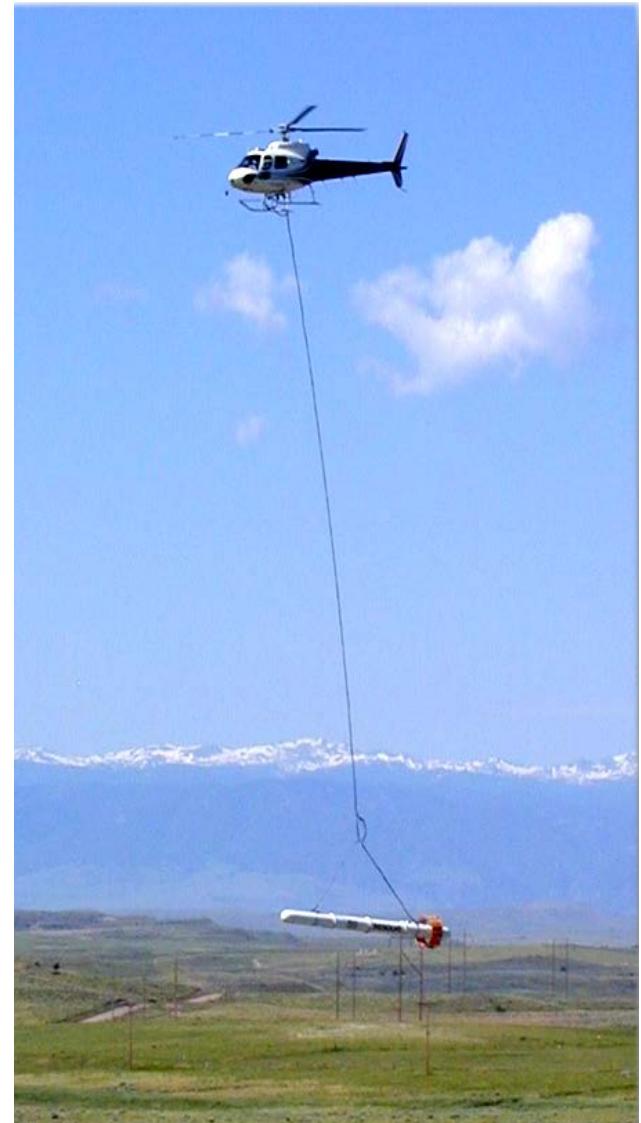
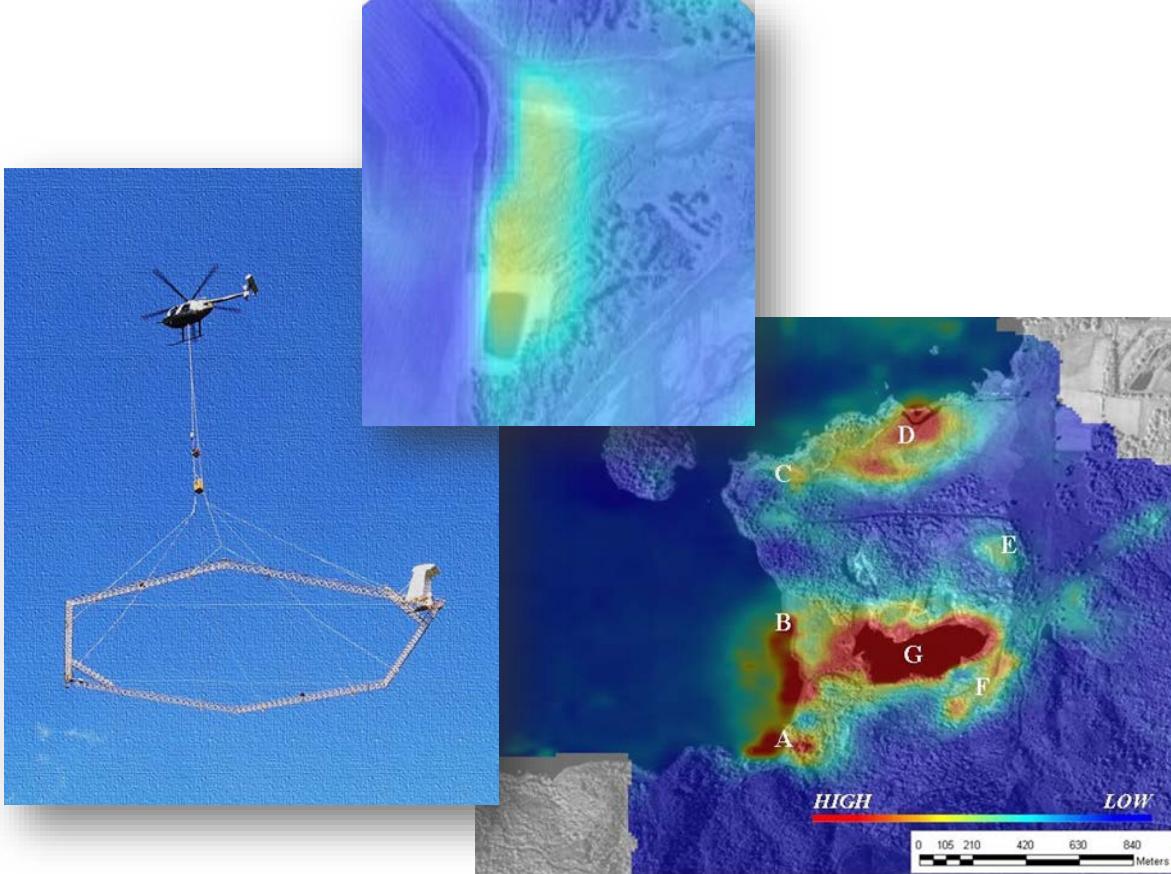
1. Water Quality
2. Water Quantity
3. Erosion and Sedimentation



Near-Surface Monitoring

Spills and Leaks

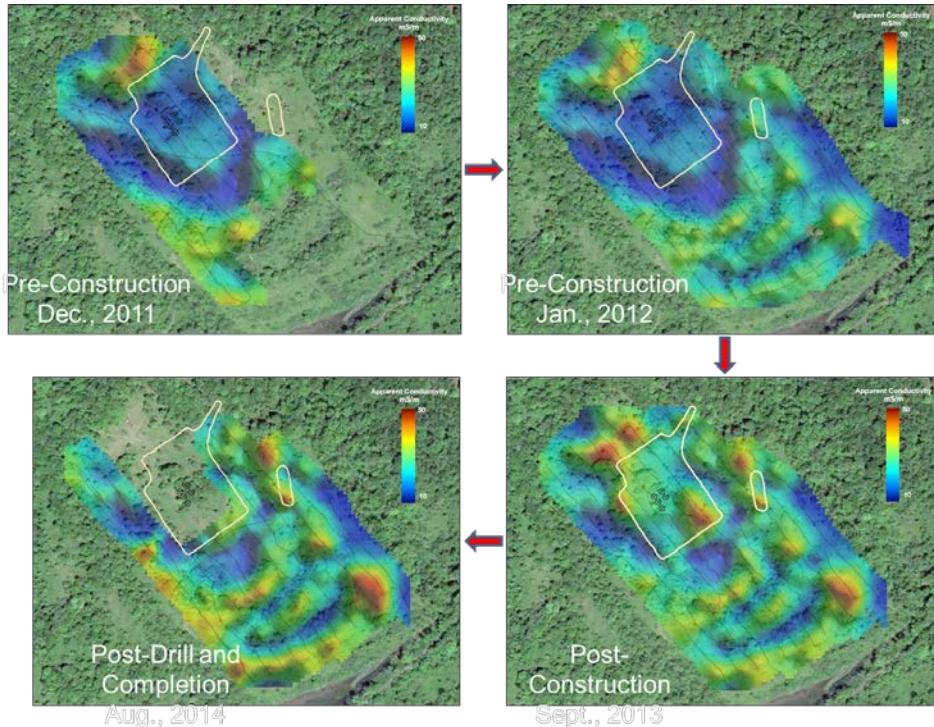
1. Airborne Electromagnetic Surveys
 2. Ground Electromagnetic Surveys



Near-Surface Monitoring

Spills and Leaks

1. Airborne Electromagnetic Surveys
2. **Ground Electromagnetic Surveys**
3. Groundwater Monitoring



Near-Surface Monitoring

Spills and Leaks

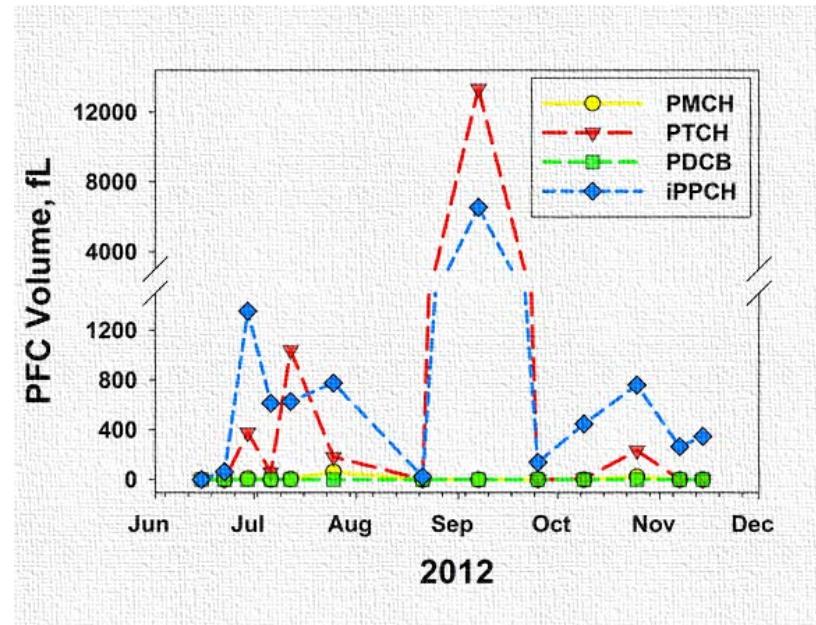
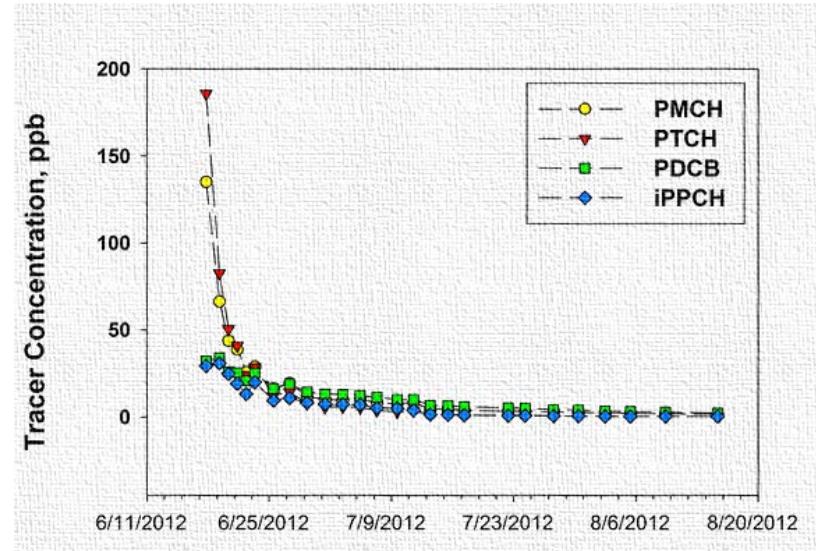
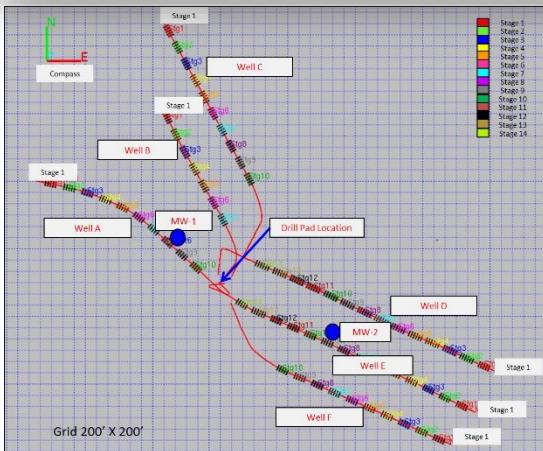
1. Airborne Electromagnetic Surveys
2. Ground Electromagnetic Surveys
3. **Groundwater Monitoring**



Near-Surface Monitoring

Wellbore Integrity

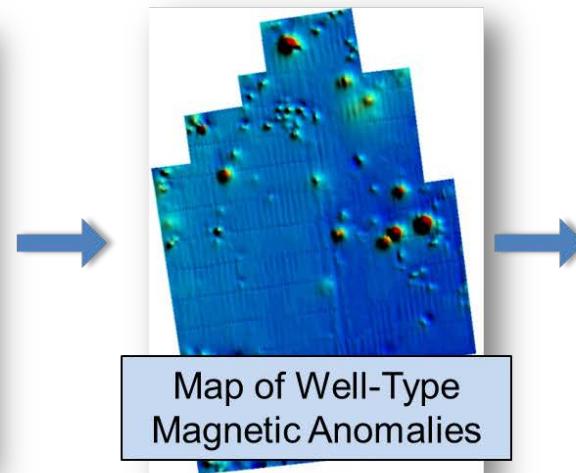
1. Man-Made Tracers



Near-Surface Monitoring

Locating Abandoned Wells

1. Airborne Magnetic Surveys
2. Ground Magnetic Surveys



Navigating to Magnetic Anomaly Location



Locating Magnetic Anomaly on the Ground

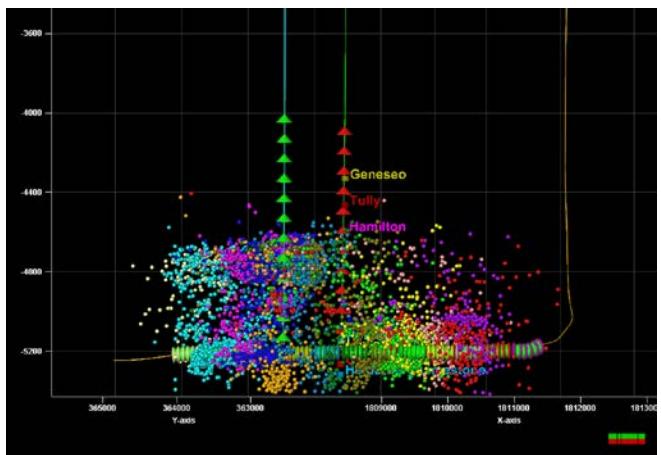
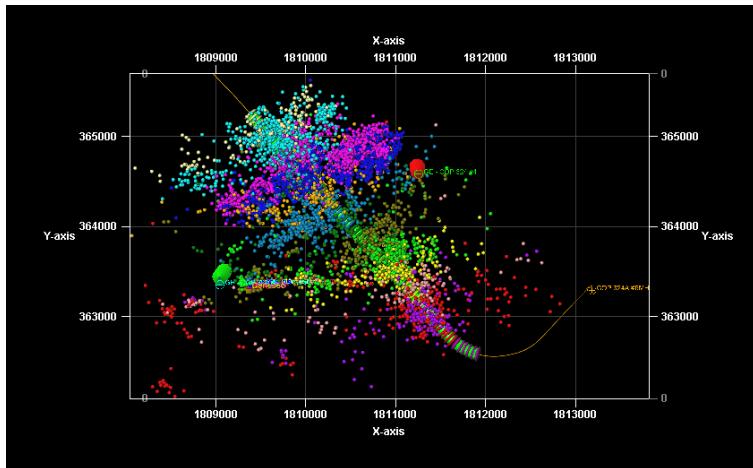


Excavation to Confirm Well Location

Sub-Surface Monitoring

Fracture Growth

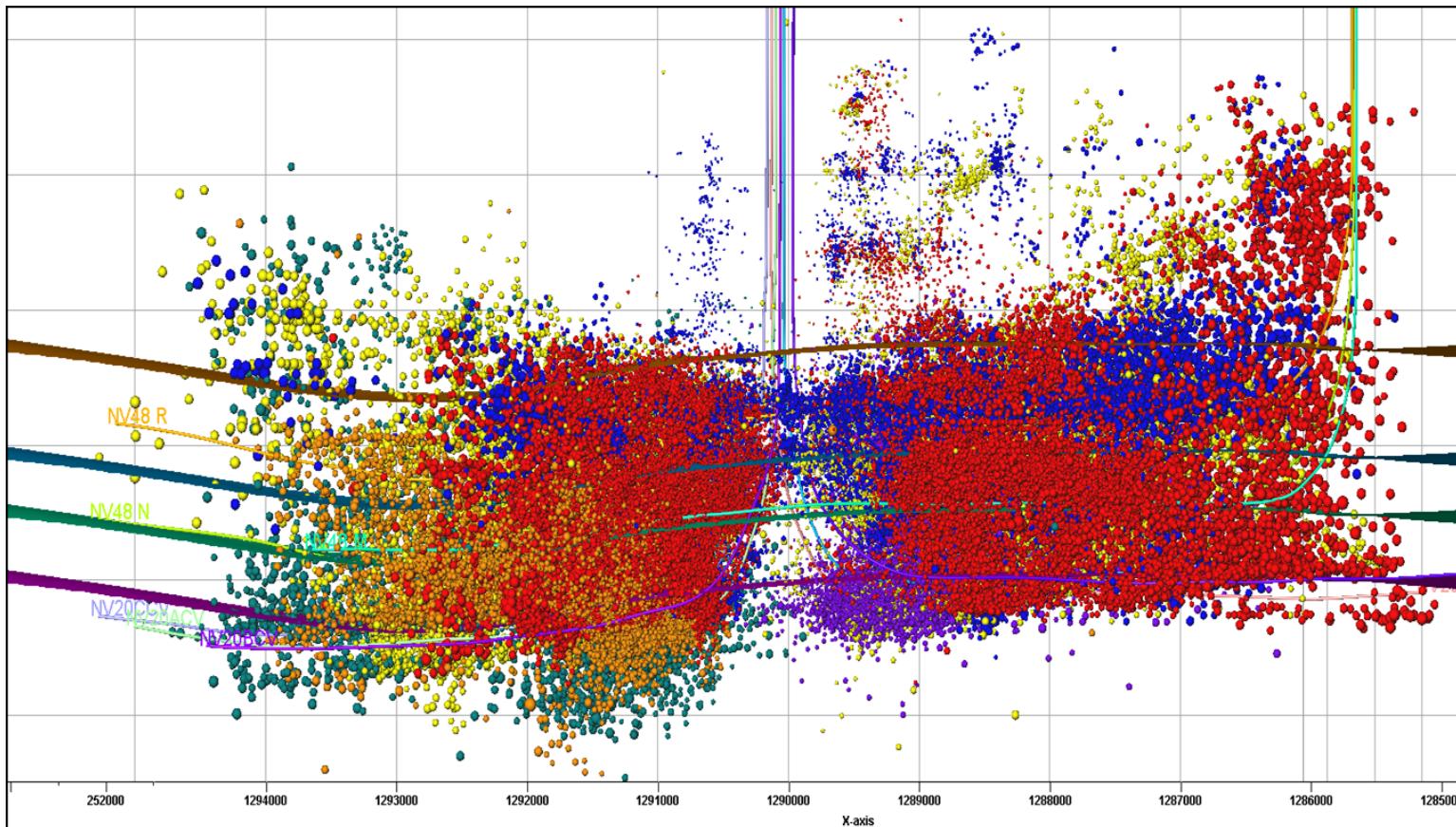
1. Microseismic Monitoring
2. Cross-Well Seismic Tomography



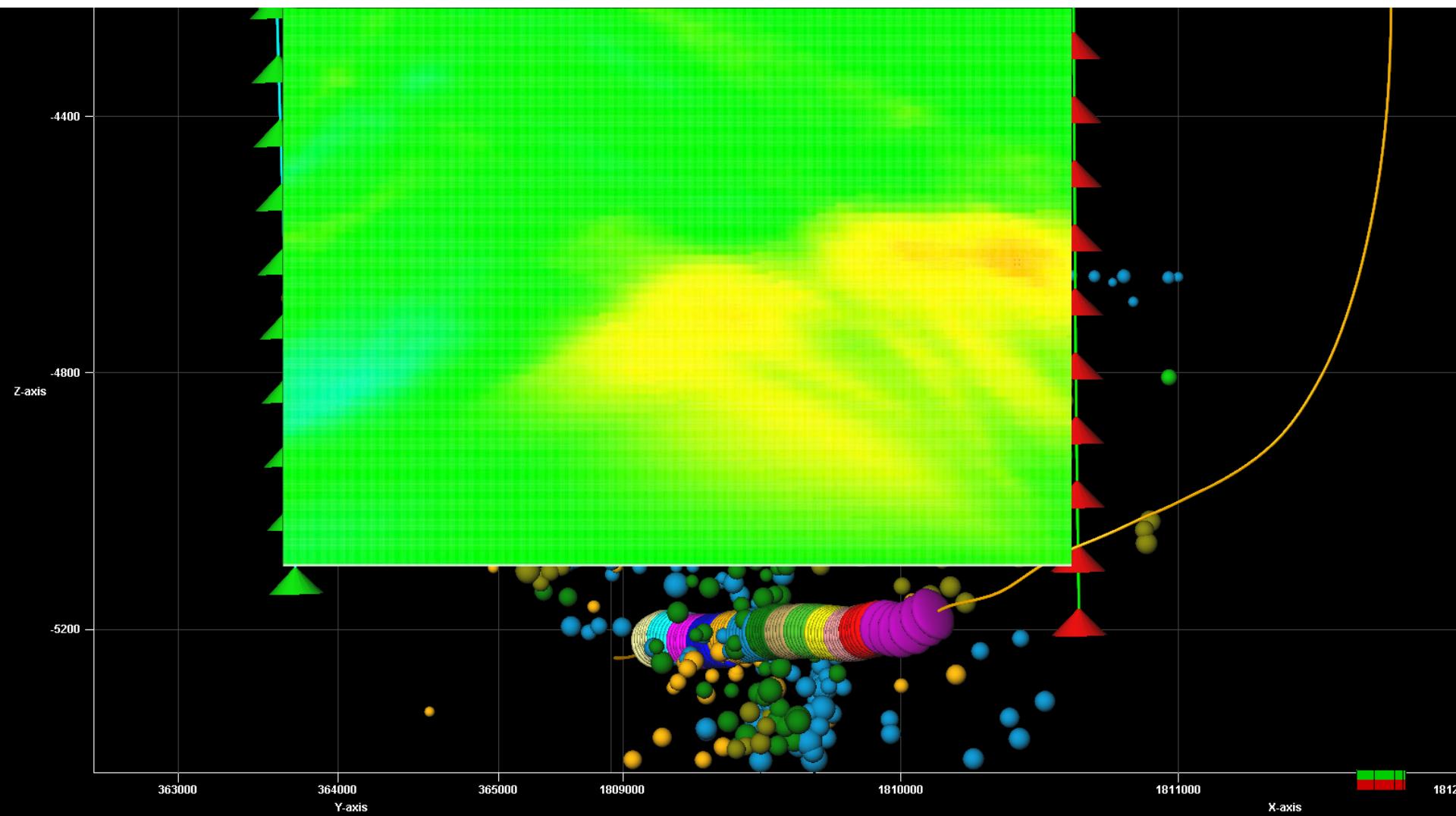
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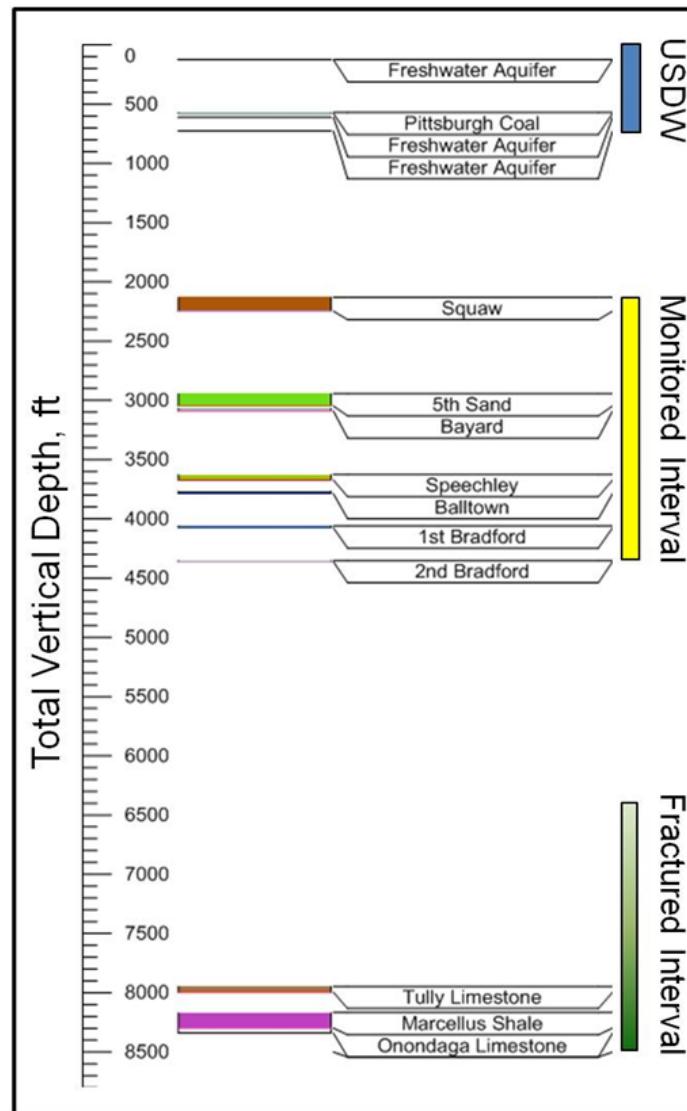
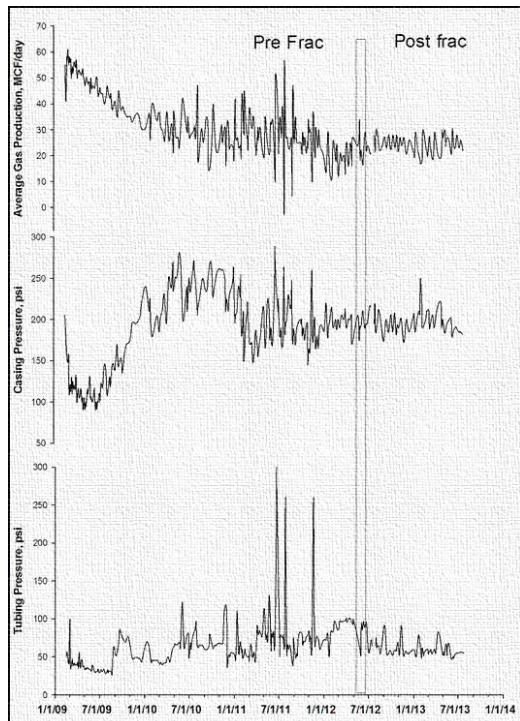
Cross-Well Seismic Tomography



Sub-Surface Monitoring

Fluid/Gas Migration

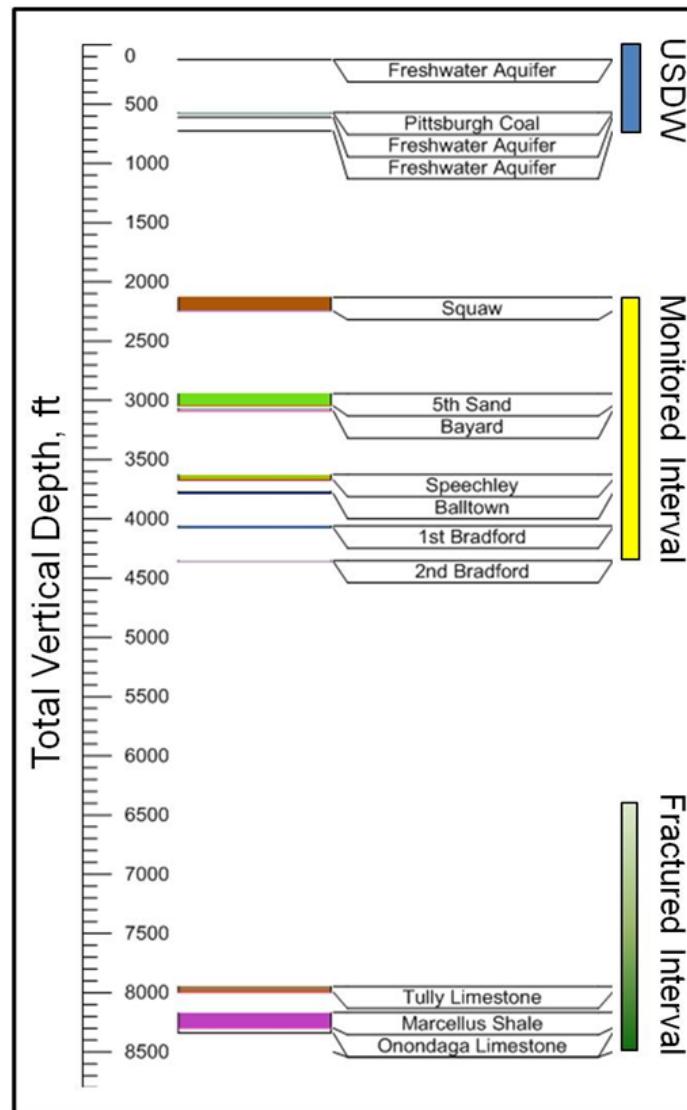
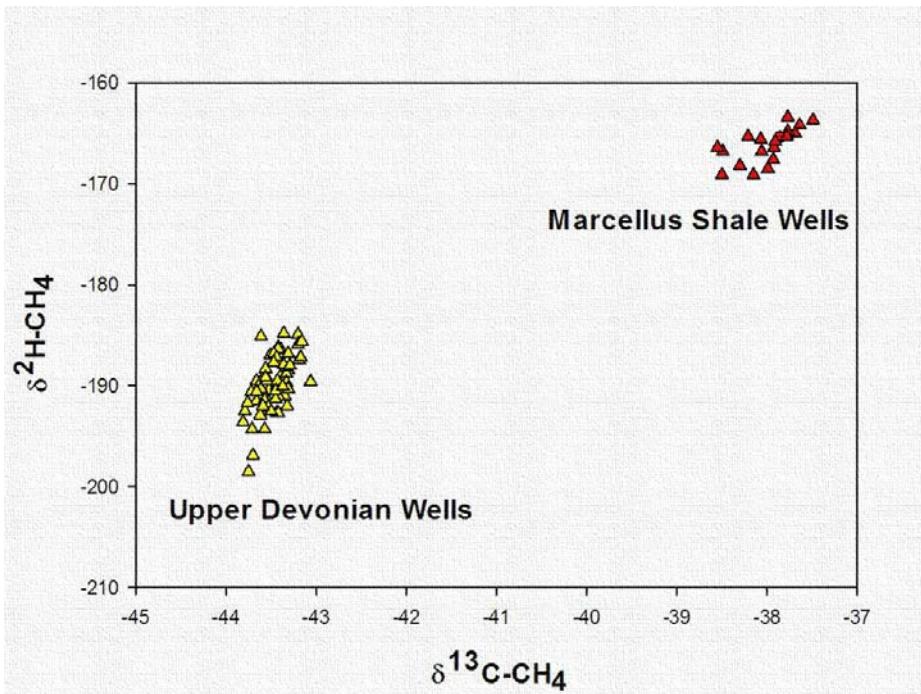
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2. Natural Gas Isotopes
3. Produced Water Isotopes
4. Man-Made Tracers



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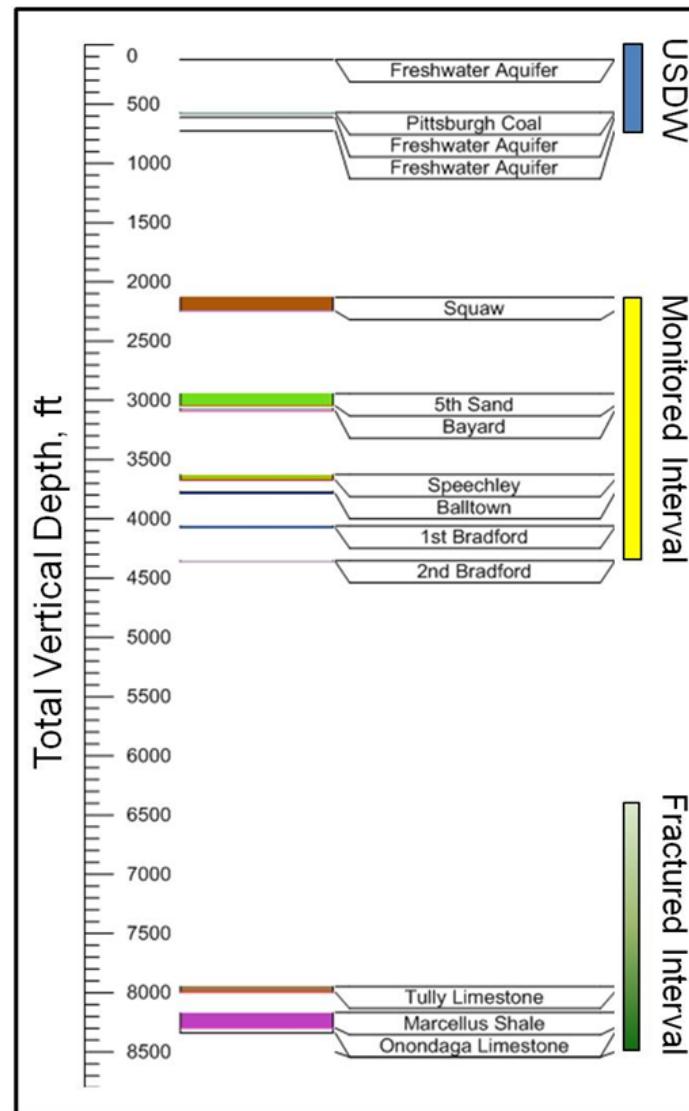
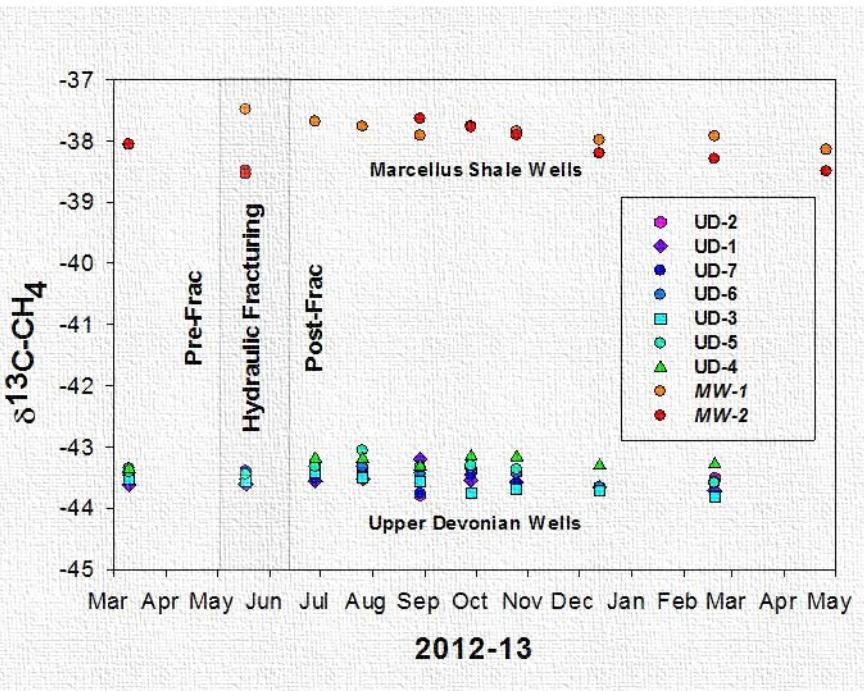
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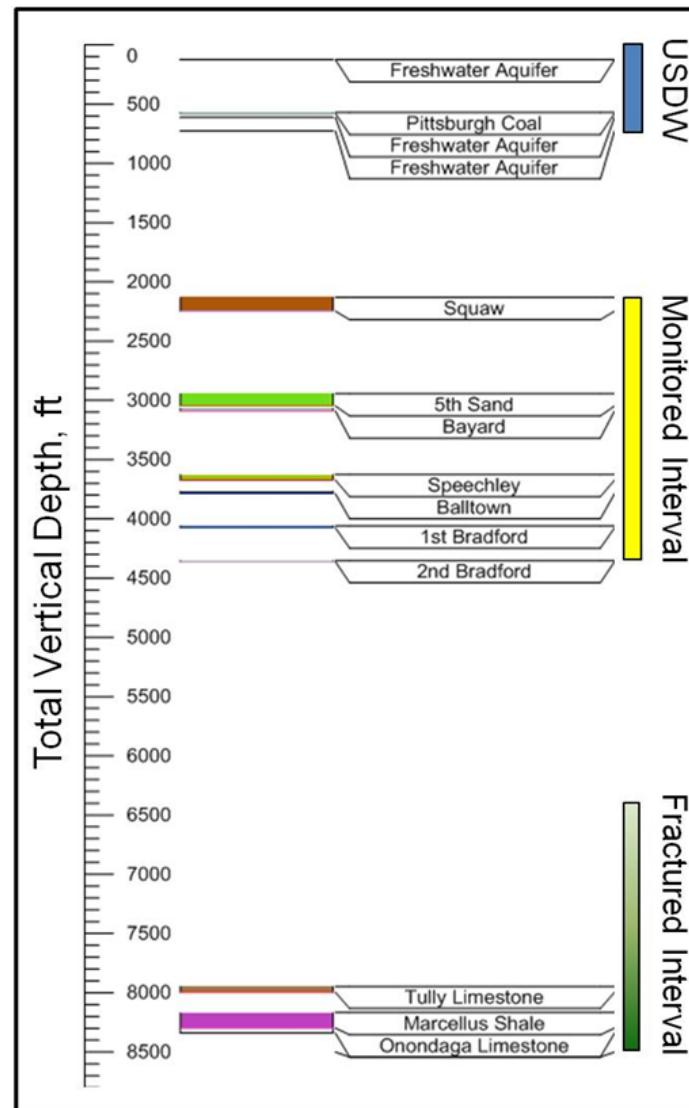
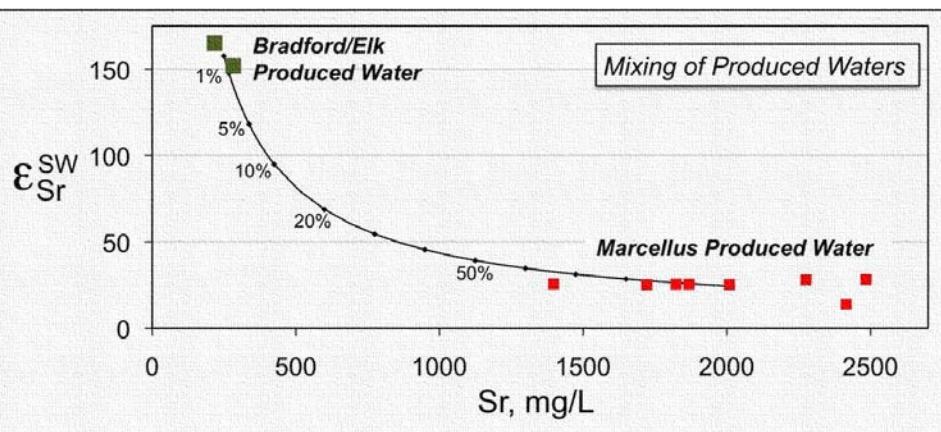
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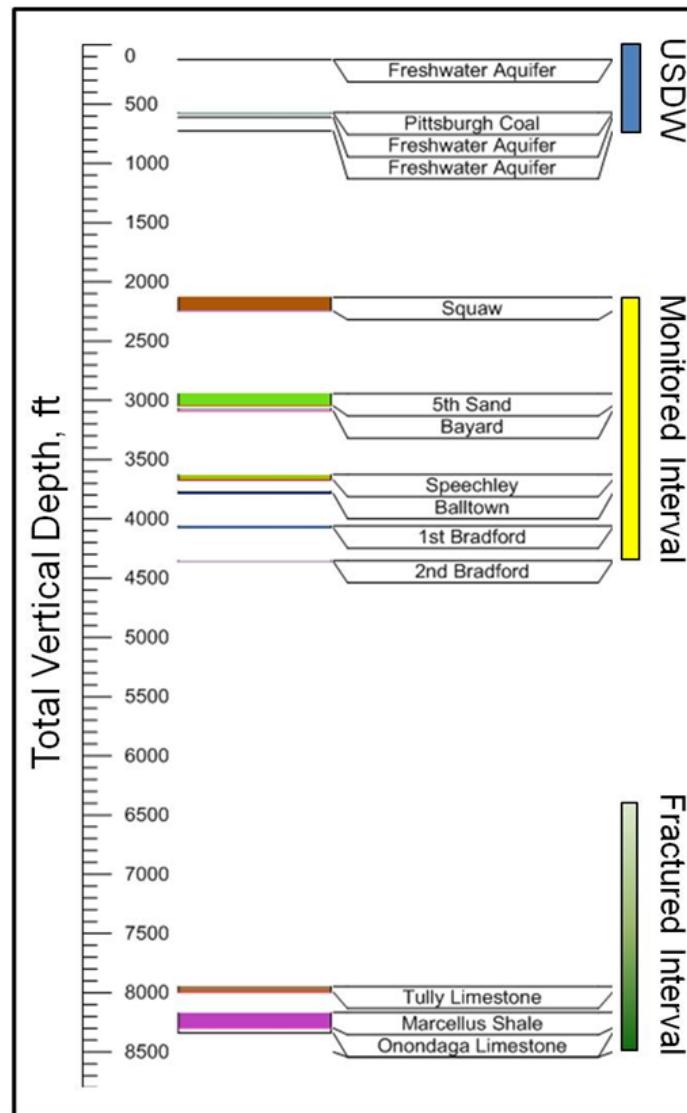
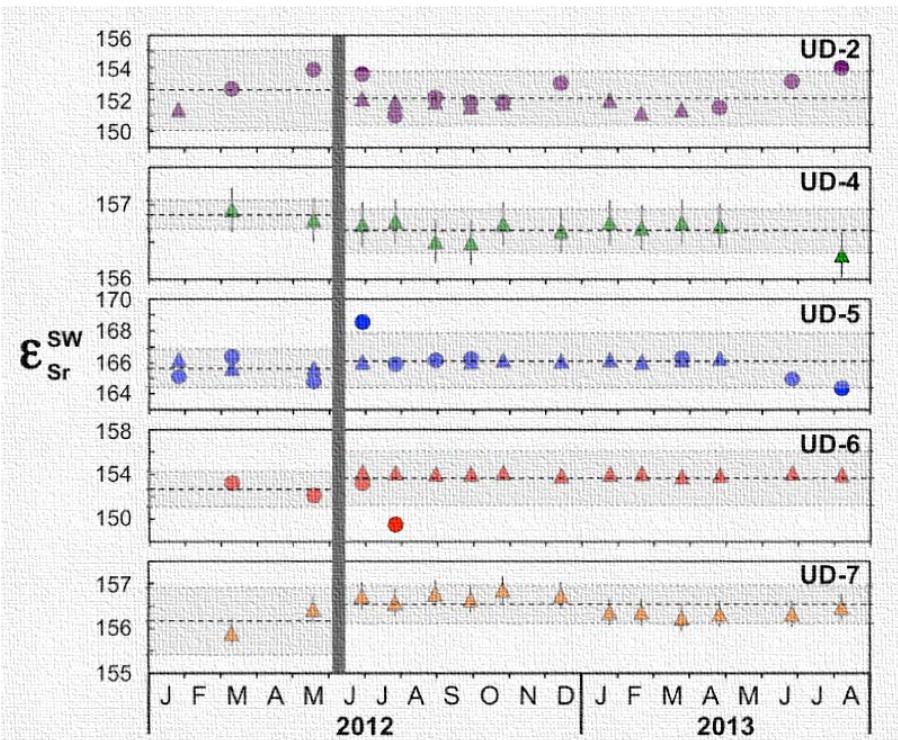
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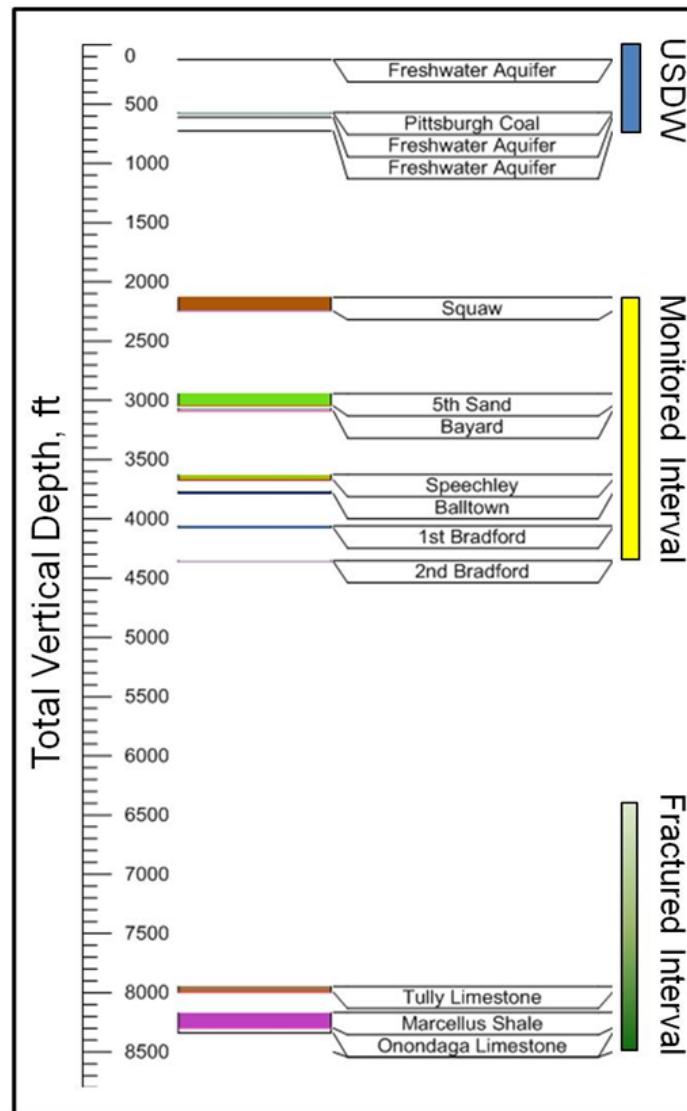
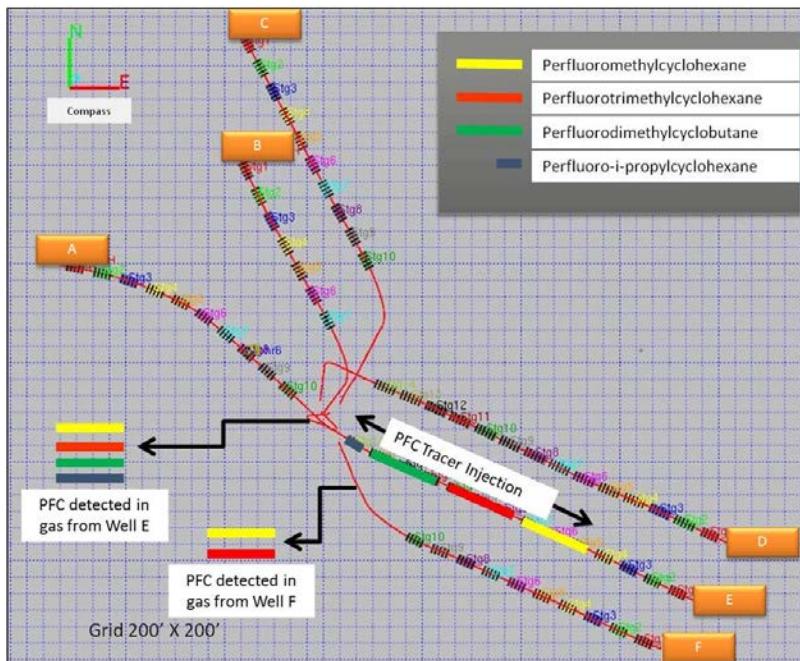
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Sub-Surface Monitoring

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