



# Development of a 1-Million Tonne Demonstration of Carbon Sequestration from a Biofuel Source: The Illinois Basin - Decatur Project

Robert J. Finley,  
Principal Investigator

Midwest Geological Sequestration Consortium

Illinois State Geological Survey

University of Illinois

CSLF June 2012



**ILLINOIS STATE  
GEOLOGICAL SURVEY**  
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# Acknowledgements



- The Midwest Geological Sequestration Consortium is funded by the U.S. Department of Energy through the National Energy Technology Laboratory (NETL) via the Regional Carbon Sequestration Partnership Program (contract number DE-FC26-05NT42588) and by a cost share agreement with the Illinois Department of Commerce and Economic Opportunity, Office of Coal Development through the Illinois Clean Coal Institute.
- The **Midwest Geological Sequestration Consortium (MGSC)** is a collaboration led by the geological surveys of Illinois, Indiana, and Kentucky
- Landmark Graphics software via University Donation Program and Petrel software via Schlumberger Carbon Services



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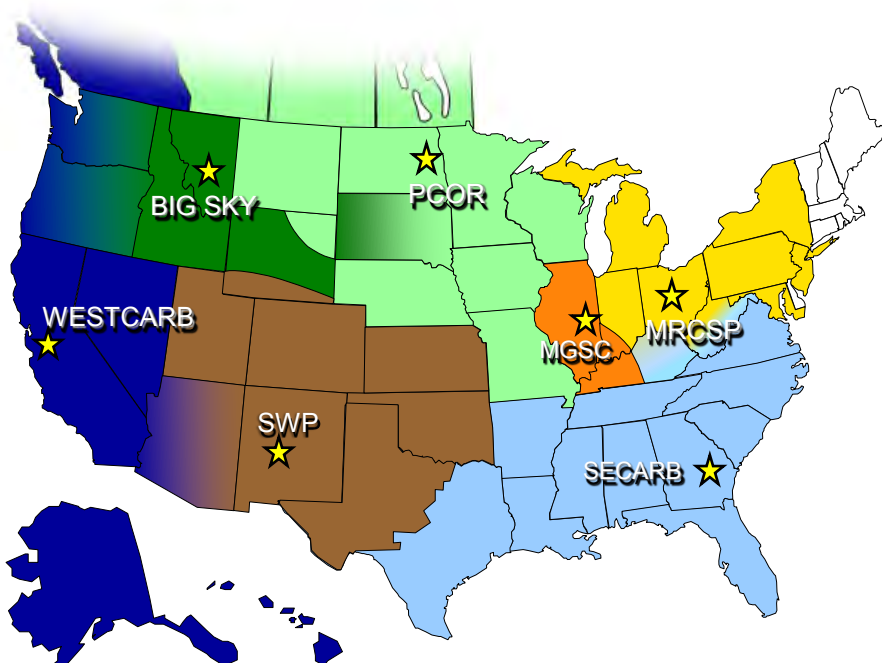


# DOE Regional Carbon Sequestration Partnerships

*Developing the Infrastructure for Wide Scale Deployment*

## Seven Regional Partnerships

*400+ distinct organizations, 43 states, 4 Canadian Provinces*



- Engage regional, state, and local governments
- Determine regional sequestration benefits
- Baseline region for sources and sinks
- Establish monitoring and verification protocols
- Address regulatory, environmental, and outreach issues
- Validate sequestration technology and infrastructure

### Characterization Phase (2003-2005)

Search of potential storage locations and CO<sub>2</sub> sources

Found potential for 100's of years of storage

### Validation Phase (2005-2011+)

19 injection tests in saline formations, depleted oil, unmineable coal seams, and basalt

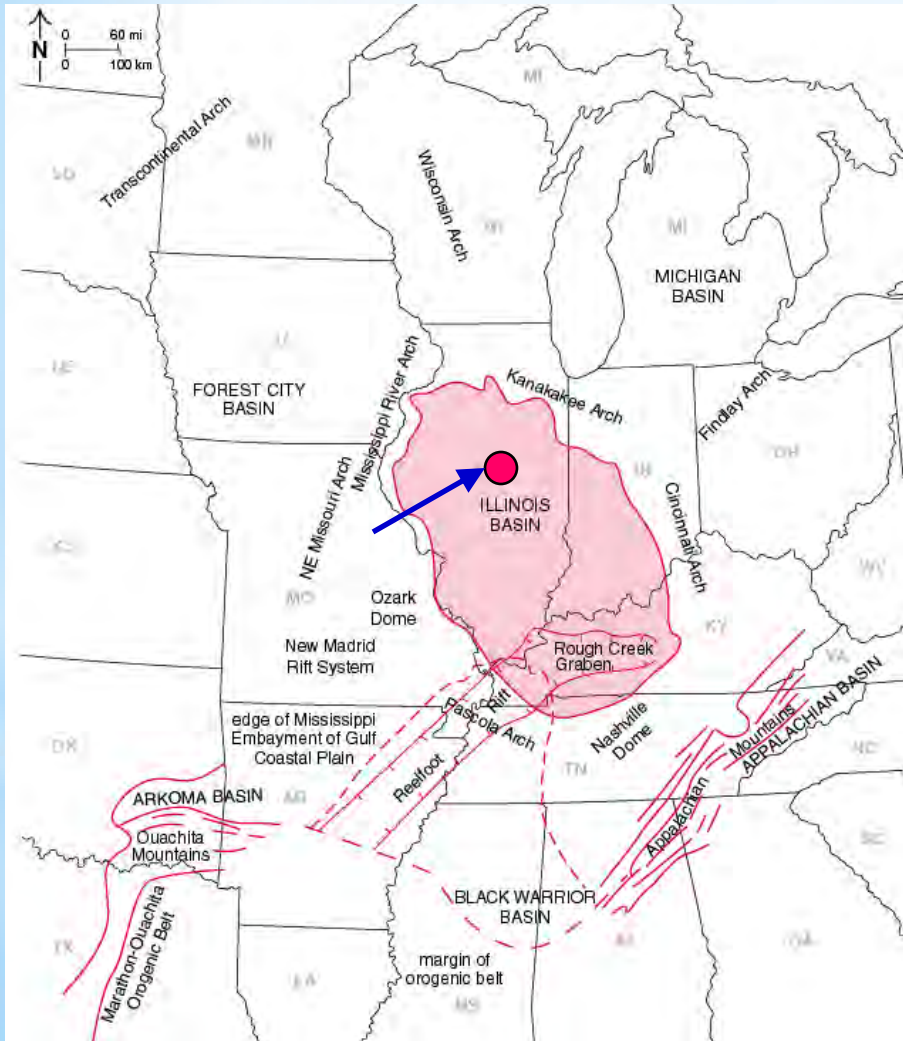
### Development Phase (2008-2018+)

Large scale injections

Commercial scale understanding

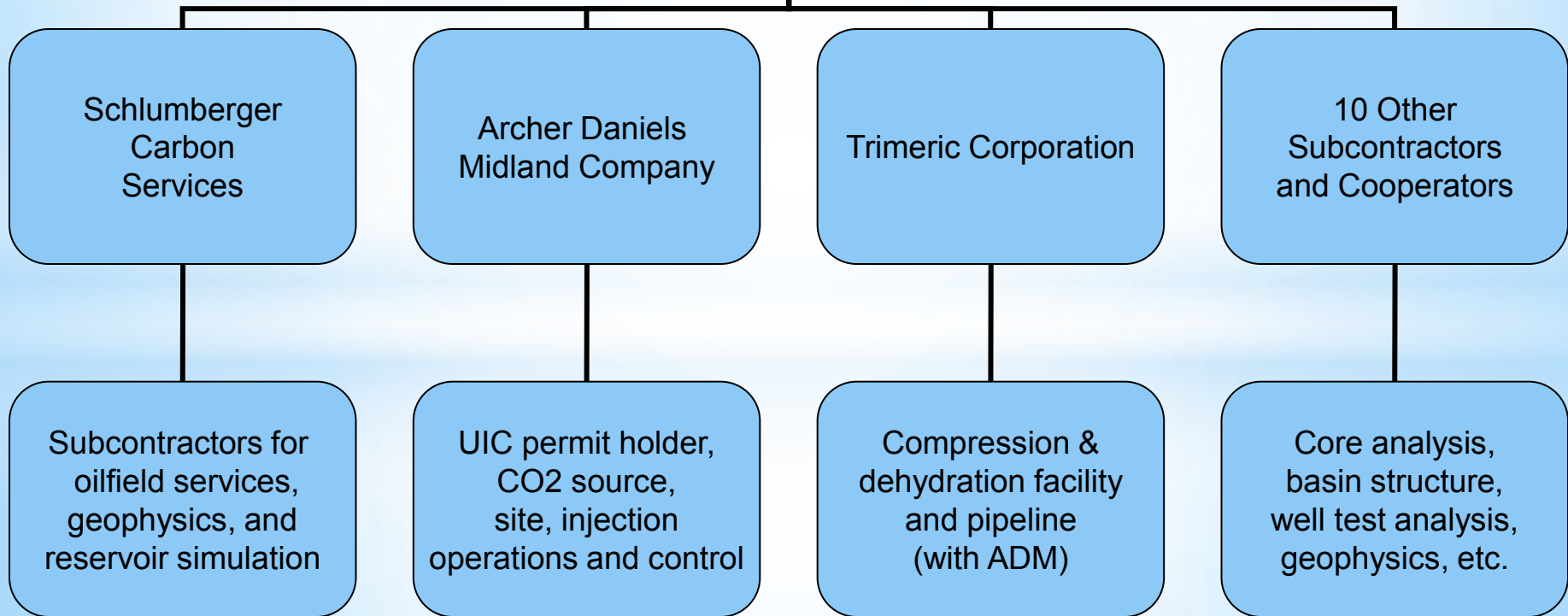
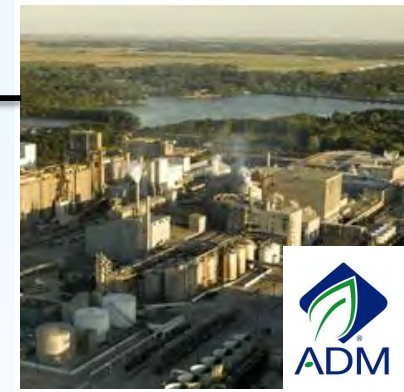
Regulatory, liability, ownership issues

# Where: Illinois Basin - Decatur Project Scope



- A collaboration of the Midwest Geological Sequestration Consortium, the Archer Daniels Midland Company (ADM), Schlumberger Carbon Services, and other subcontractors to inject 1 million metric tons of anthropogenic carbon dioxide at a depth of 7,000 +/- ft (2,000 +/- m) to test **geological carbon sequestration in a saline reservoir** at a site in Decatur, Illinois

# Who: Illinois Basin-Decatur Project Organization



# When: **Illinois Basin - Decatur Project**

## Major Project Elements MGSC Phase III

- UIC permitting: January 2008-ongoing
  - Application, hearing, minor modification, major modification
- **Injection well drilled:** February-May 2009
- **Geophone well drilled:** September-November 2009
- Baseline 3D seismic survey completed: January 2010
- Compression/dehy/pipeline facility: design, procure, construct, test: February 2009-October 2011
- **Monitoring well drilled, completed:** September-November 2010, March-June 2011
- **Authorization to inject:** November 2, 2011
- **Operational:** November 17, 2011

# Operational Injection: 17 November 2011



- **IBDP** fully operational 24/7
- **IBDP** is the first 1 million tonne carbon capture and storage project from a biofuel facility in the US
- Injection through fall 2014
- Intensive post-injection monitoring under MGSC through fall 2017



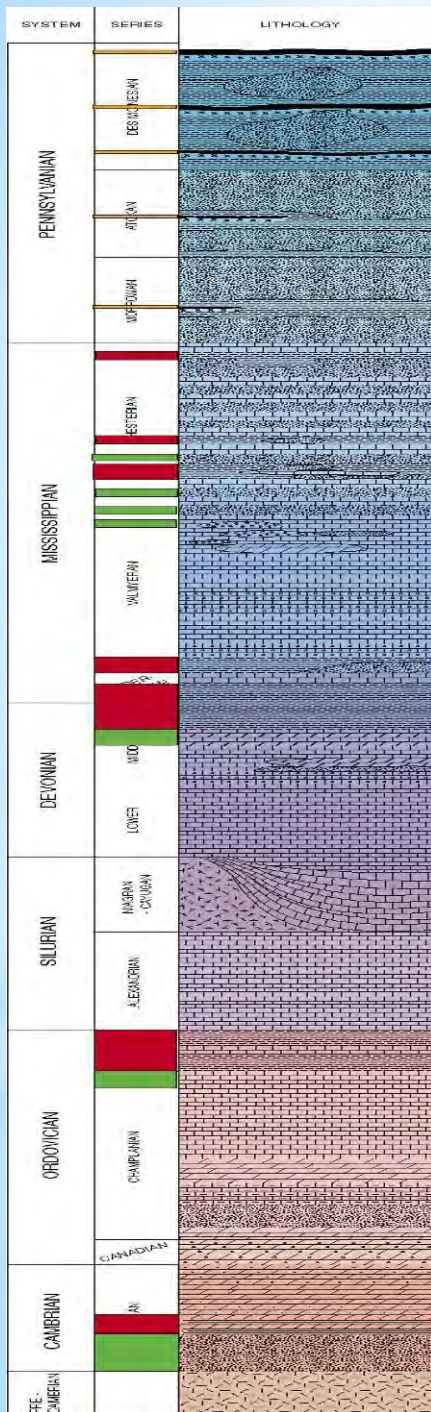
Cumulative Injection (7 June 2012):  
175,528 tonnes

# Key Points to Remember about the IBDP

- IBDP is the first demonstration-scale (1 million tonne) US project to use carbon dioxide (CO<sub>2</sub>) from an industrial source within the DOE Regional Carbon Sequestration Partnership (RCSP) program
- IBDP is a fully integrated demonstration, from a compression-dehydration facility and a pipeline to delivery of supercritical CO<sub>2</sub> to a three-well injection and observation system on an intensely monitored site
- IBDP is the product of four years of effort, from date of funding to CO<sub>2</sub> in the reservoir, including site characterization, permitting, 5,424 m (17,900 ft) of drilling, reservoir geology, engineering, and geophysics, risk assessment, outreach, and baseline monitoring



# Illinois Basin Stratigraphic Column



**Pennsylvanian coal seams**

**Mississippian sandstone and carbonate oil reservoirs**

**New Albany Shale**

back-up seals

**Maquoketa Shale**

**St. Peter Sandstone**

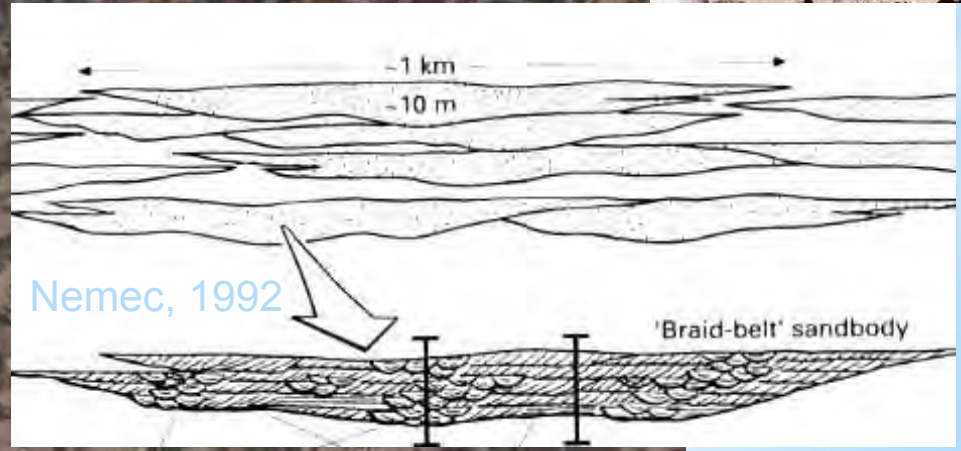
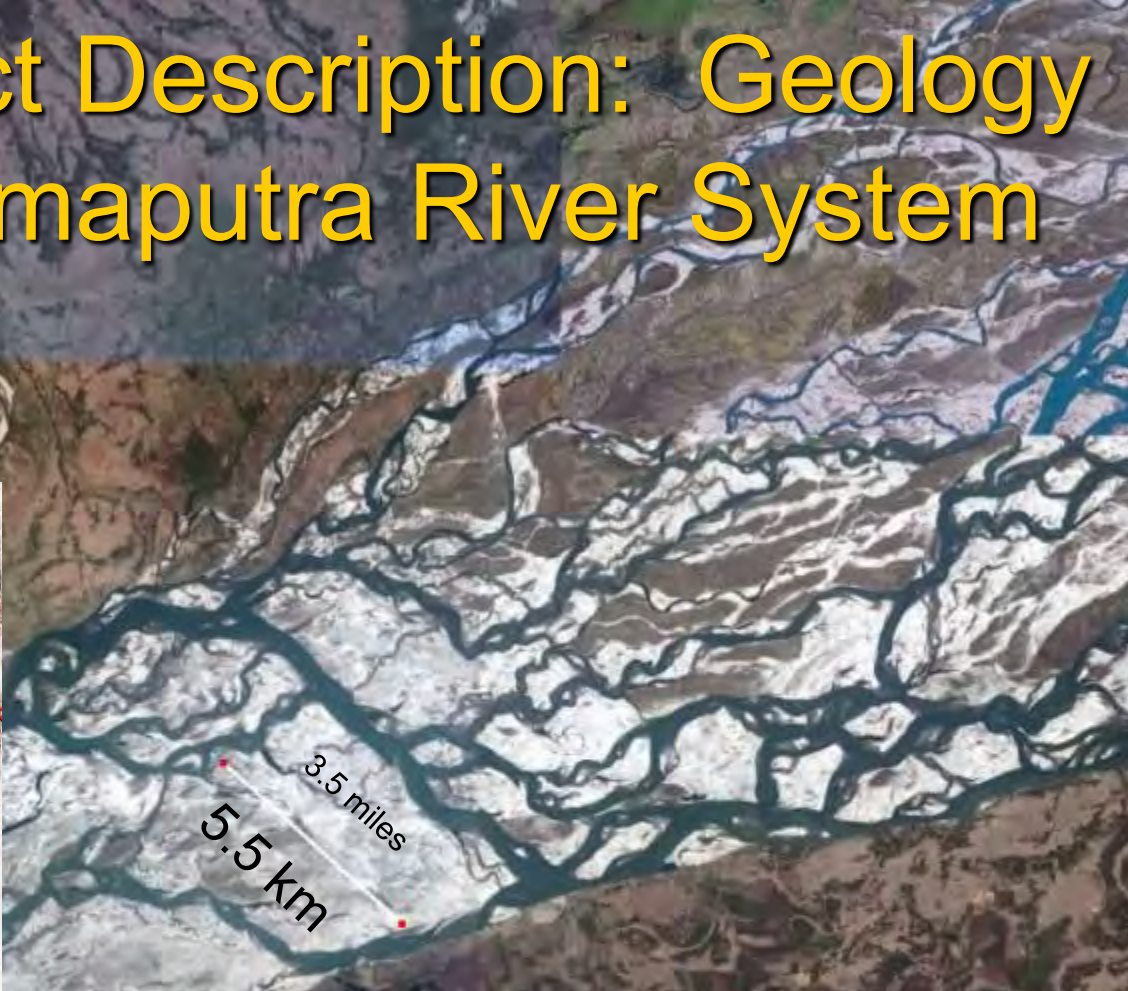
**Eau Claire Shale**

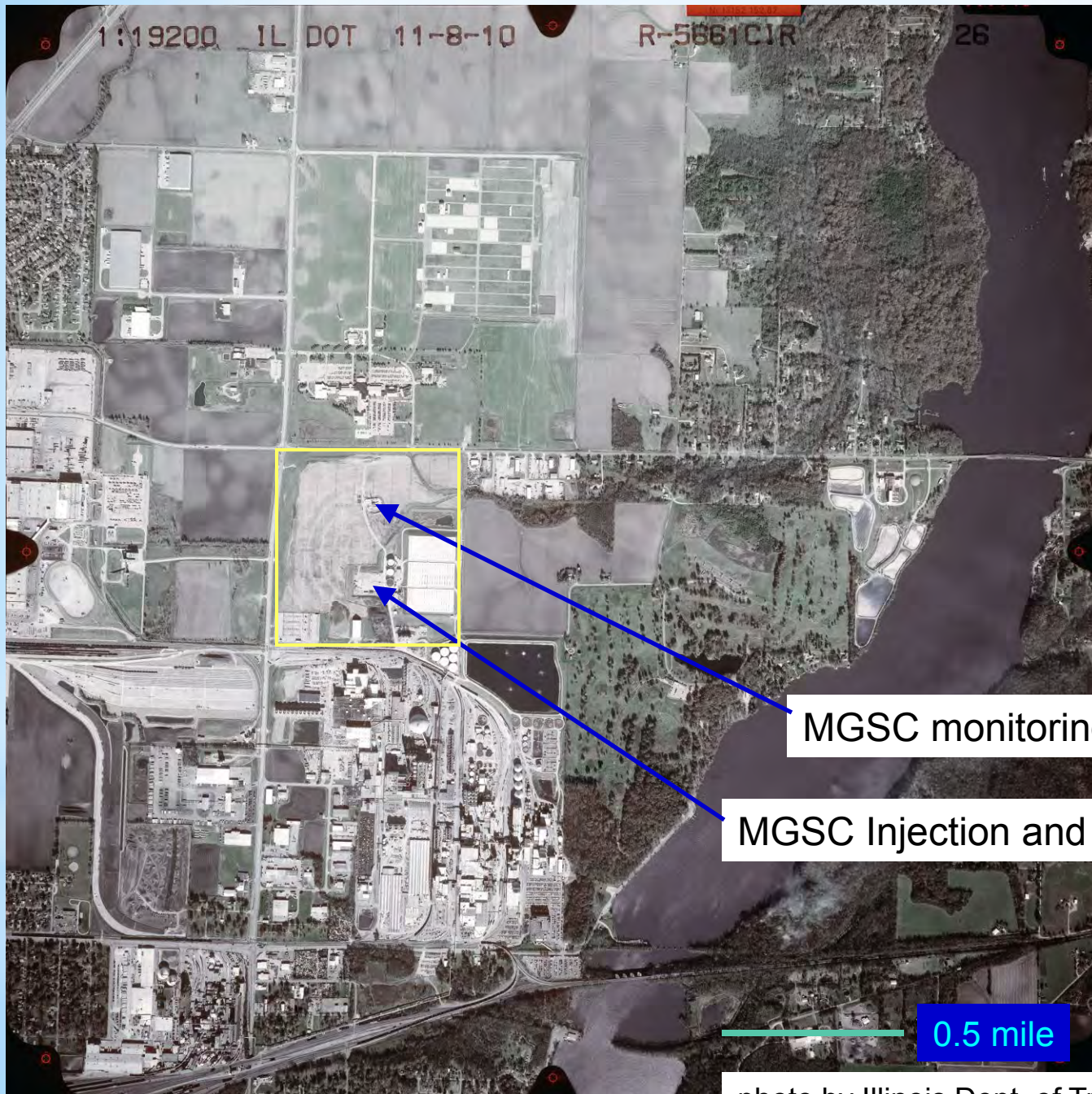
seal

**Mt. Simon Sandstone**

reservoir

# Project Description: Geology Brahmaputra River System





**MGSC  
Illinois  
Basin-  
Decatur  
Project  
(IBDP) Site**

MGSC monitoring well

MGSC Injection and geophone wells

0.5 mile

# Illinois Basin- Decatur Project Site

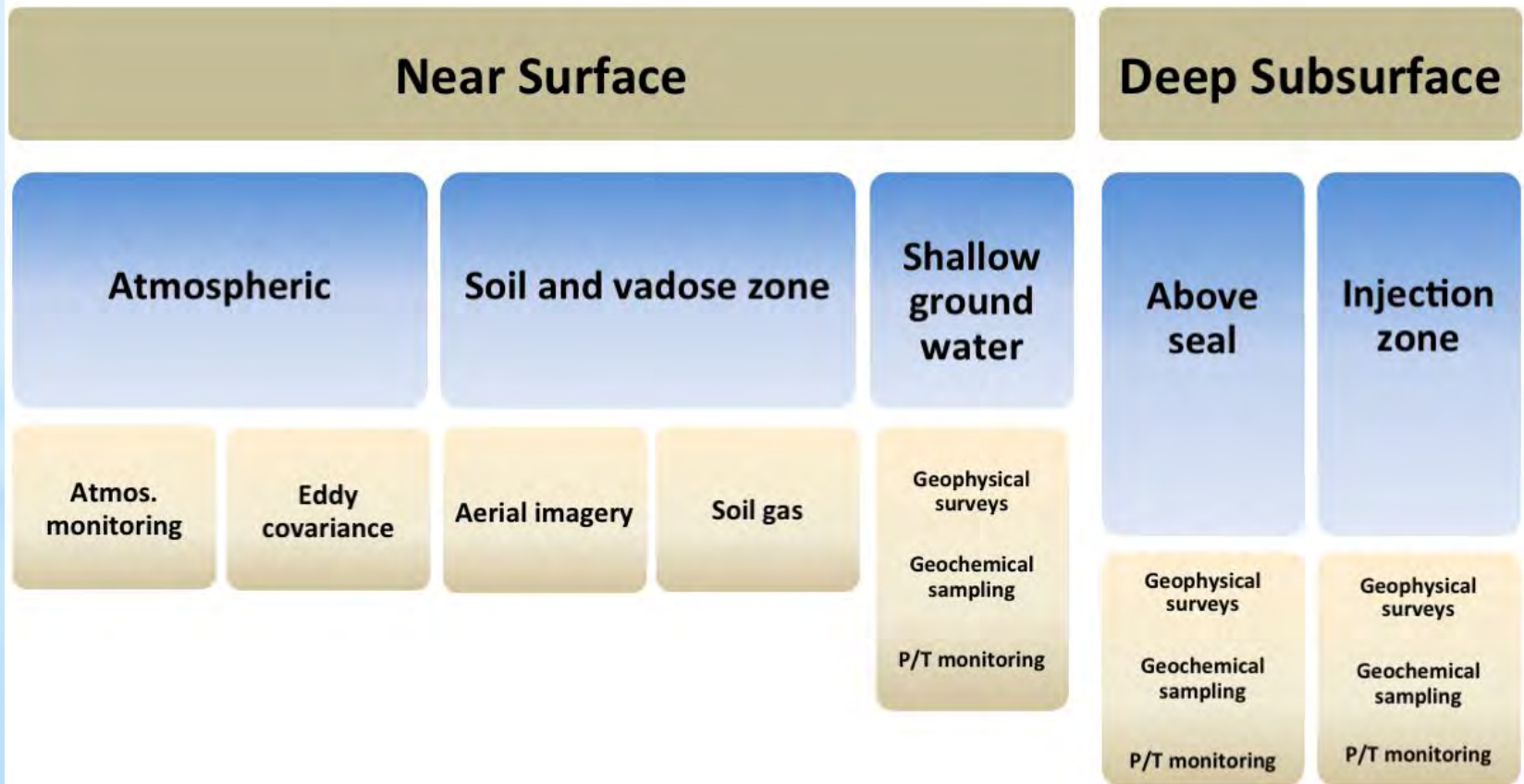
(on ADM industrial site)

- **A** Dehydration/  
compression facility  
location
- **B** Pipeline route (1.9 km)
- **C** Injection well site
- **D** Verification/  
monitoring  
well site
- **E** Geophone well



# Monitoring, Verification and Accounting

## Example Environmental Monitoring Framework



# Surface Environmental Monitoring

Soil flux



Groundwater



Eddy Covariance

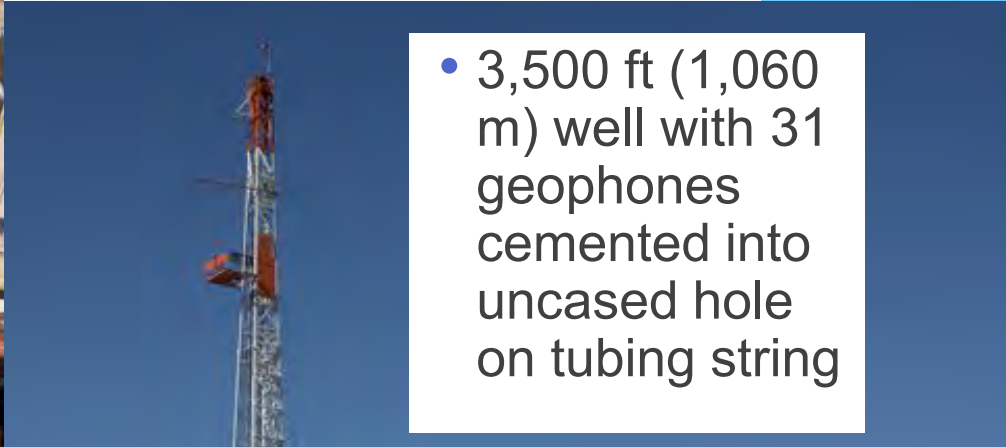


# Geophone Well Completed November 2009

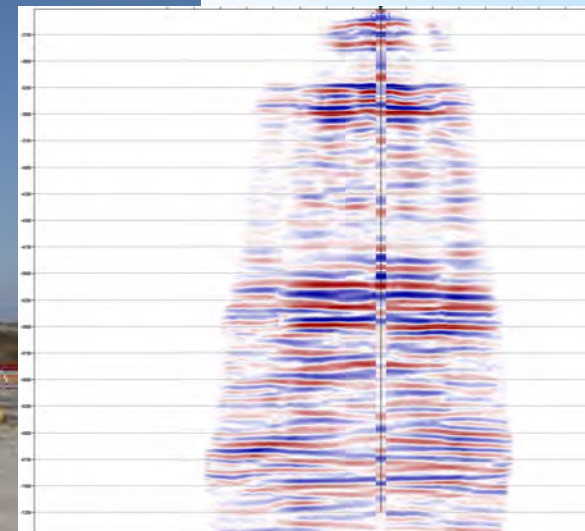


Geophone in special carrier strapped to 3.5 inch (8.9 cm) tubing

- 3,500 ft (1,060 m) well with 31 geophones cemented into uncased hole on tubing string



Injection Well



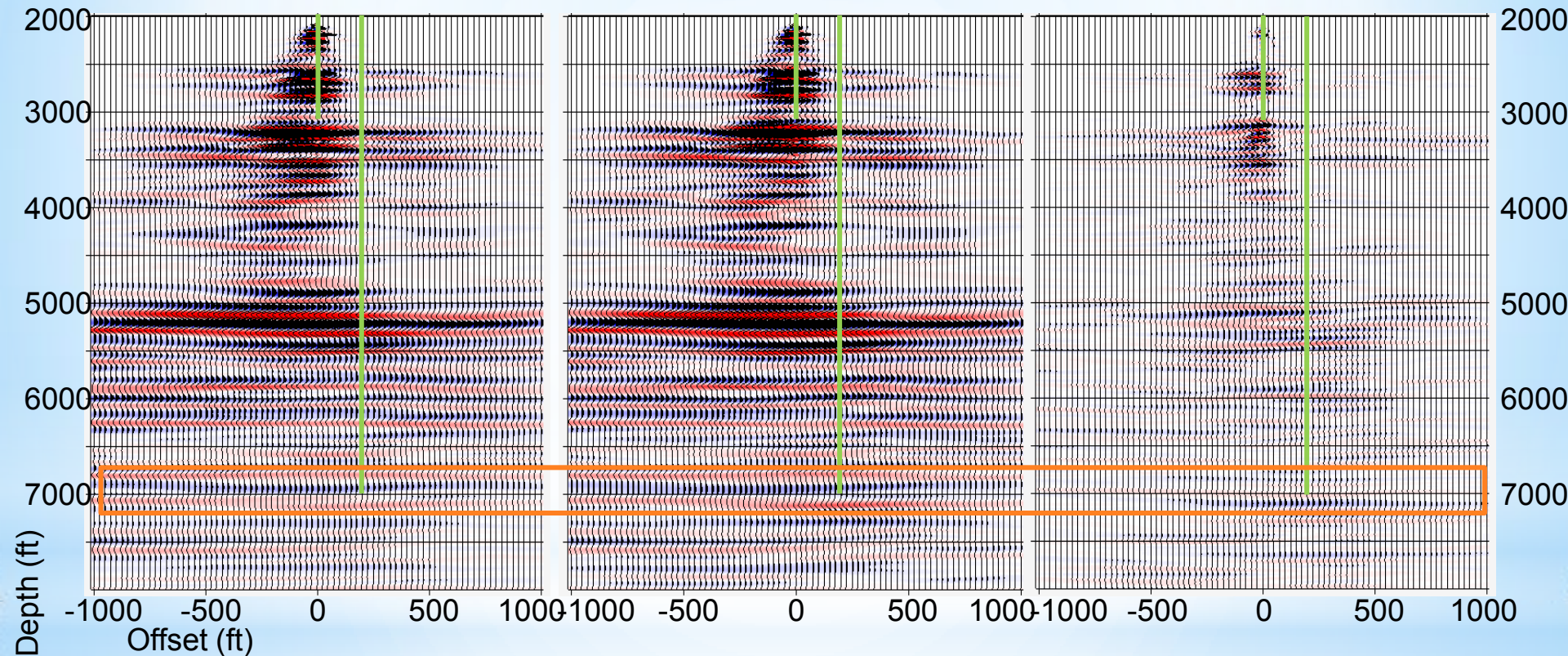


# Time-lapse 3D VSPs: Final Migrated Image of Cross-Equalized Data

Baseline 2 Image

Monitor 1 Image

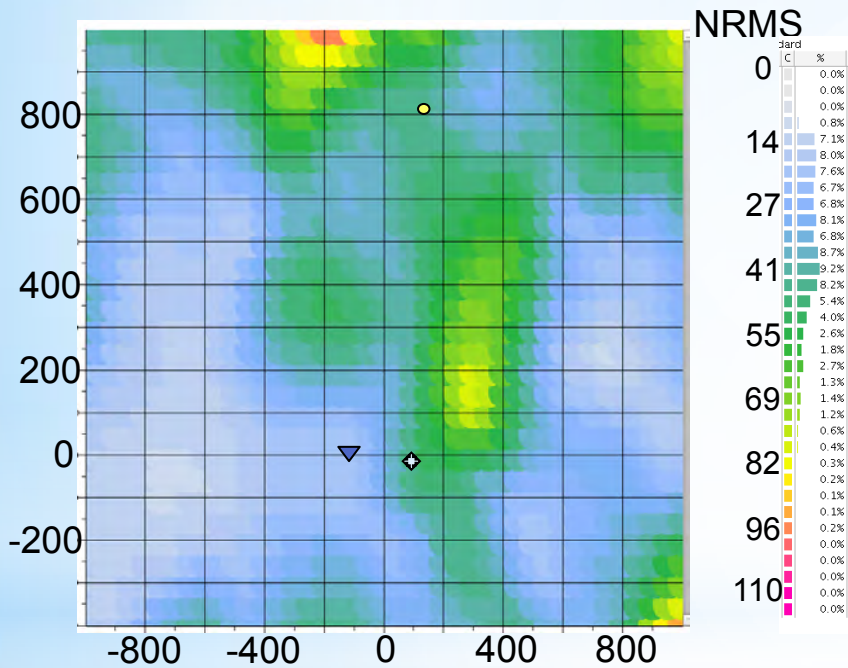
Difference Image



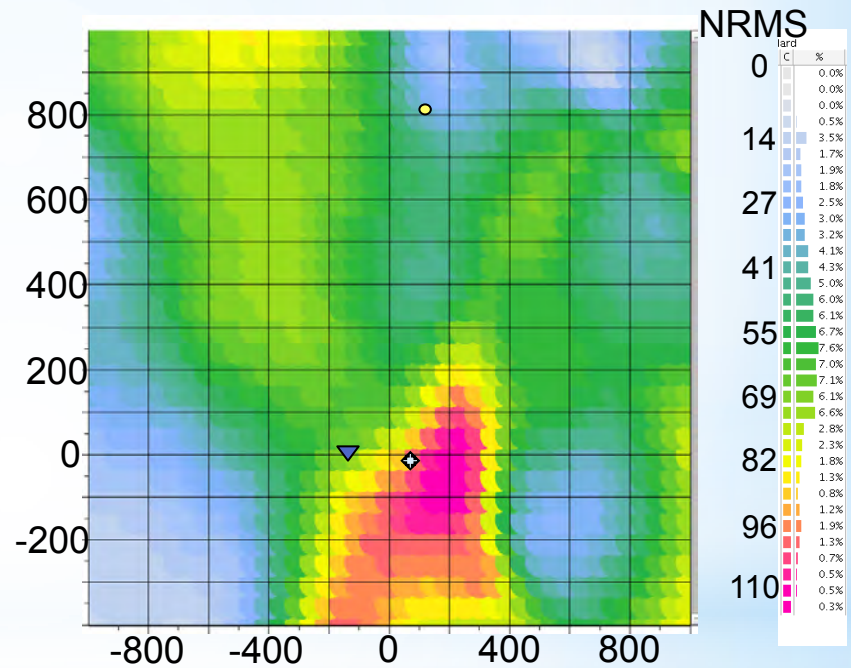
- Shown above in the left two panels is a west-east image section
- Rightmost panel is the difference of the two
- The input to migration is the processed and cross-equalized, notch filtered upgoing data

# Time-lapse 3D VSPs: NRMS Maps with 50 x 50 ft Bin

NRMS computed between  
5000-5500 ft (1524-1677 m) depth



NRMS computed between  
6950-7100 ft (2119-2165 m) depth



- ▽ VSP well
- ◇ Injection well
- Verification well

*Preliminary Analysis*

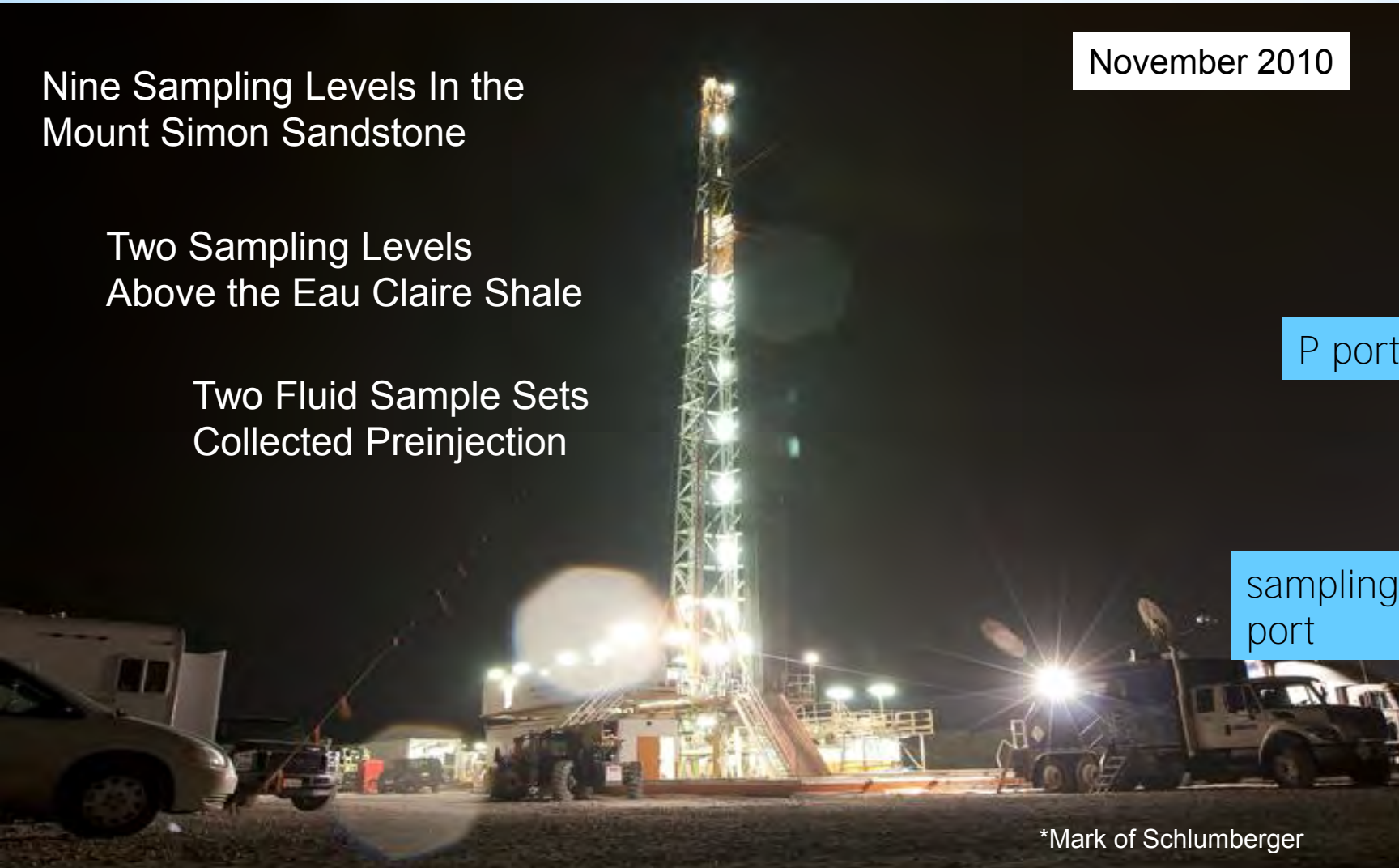
# Schlumberger Westbay\* System First-in-the-World Deployment at 2,200 m+ for Eleven Sampling Levels

Nine Sampling Levels In the  
Mount Simon Sandstone

Two Sampling Levels  
Above the Eau Claire Shale

Two Fluid Sample Sets  
Collected Preinjection

November 2010



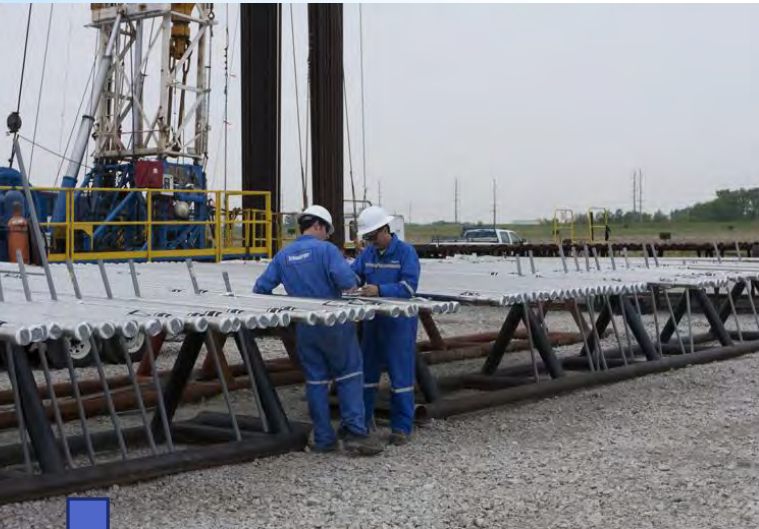
P port

sampling  
port

\*Mark of Schlumberger



# Westbay Installation and Sampling



June-August 2011

# Water Quality Comparison

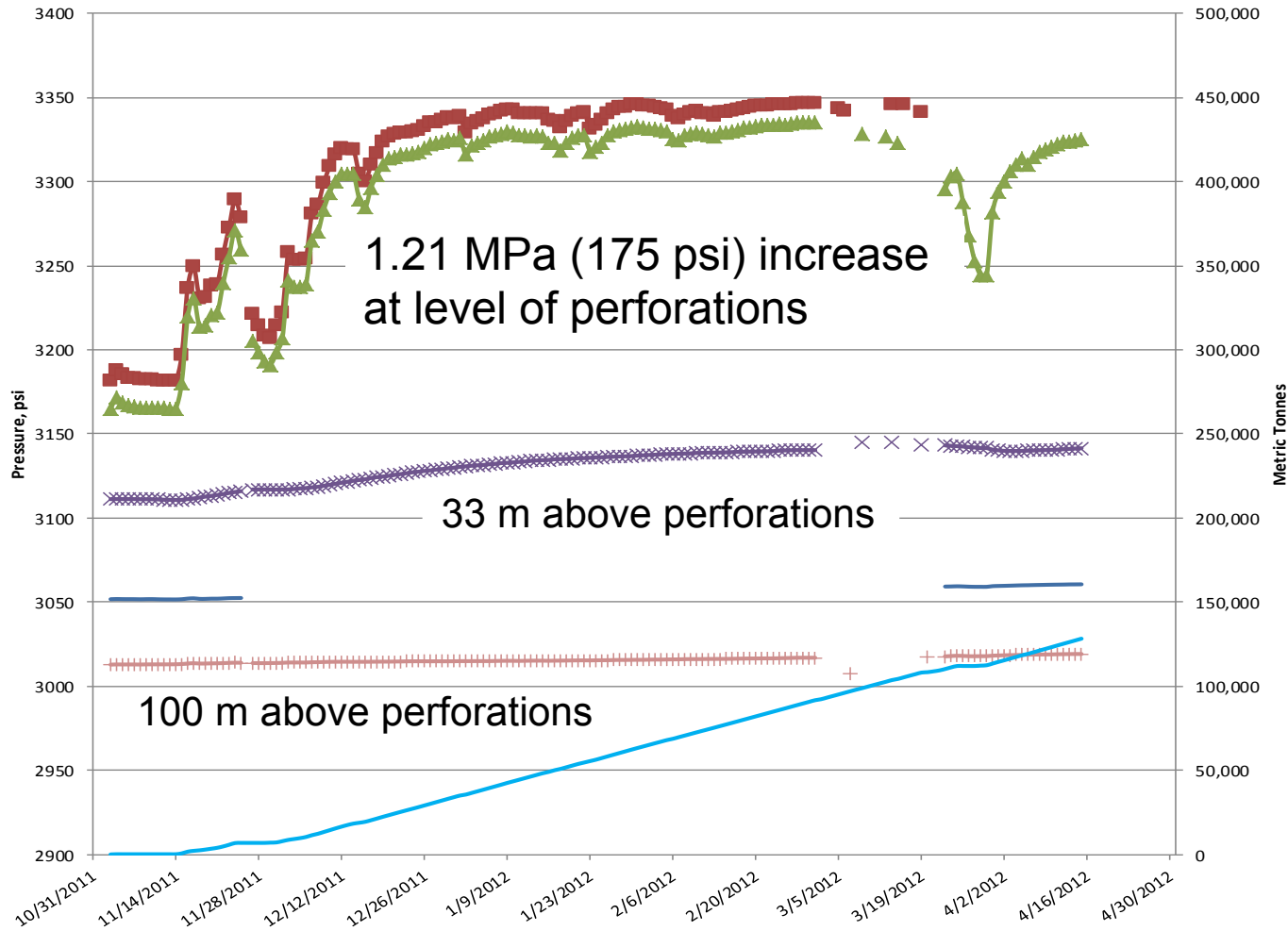
Constituent	Shallow Groundwater	Ironton-Galesville	Mt. Simon (injection formation)
Conductivity (mS/cm)	1.5	80	170
TDS (mg/L)	1,000	65,600	190,000
Cl <sup>-</sup> (mg/L)	170	36,900	120,000
Br <sup>-</sup> (mg/L)	1	180	680
Alkalinity (mg/L)	380	130	80
Na <sup>+</sup> (mg/L)	140	17,200	50,000
Ca <sup>2+</sup> (mg/L)	100	5,200	19,000
K <sup>+</sup> (mg/L)	1	520	1,700
Mg <sup>2+</sup> (mg/L)	50	950	1,800
pH (units)	7.2	6.9	5.9

- Shallow groundwater (16 well average)
- Ironton-Galesville (2 zone average; swab only)
- Mt. Simon (9 zone average)

# Westbay System Response 300 m from Injector

Illinois Basin Decatur Project  
 Pressure data as observed in Verification Well #1 (VW1)  
 VW1 is 1000 ft from Injection Well CCS#1

Plotted pressure data is based on averages for each day.



CCS#1 Perforated Zone Summary		
Zone #	Top	Bot
2	6982.0	7012.0
1	7025.0	7050.0

VW1 Perforated Zone Summary		
Zone #	Top	Bot
11	4917.5	4920.5
10	5000.7	5003.7
9	5653.8	5557.3
8	5840.4	5843.9
7	6416.2	6419.7
6	6632.3	6635.8
5	6720.3	6723.8
4	6837.1	6840.6
3	6945.6	6949.1
2	6983.0	6985.5
1	7061.2	7064.2

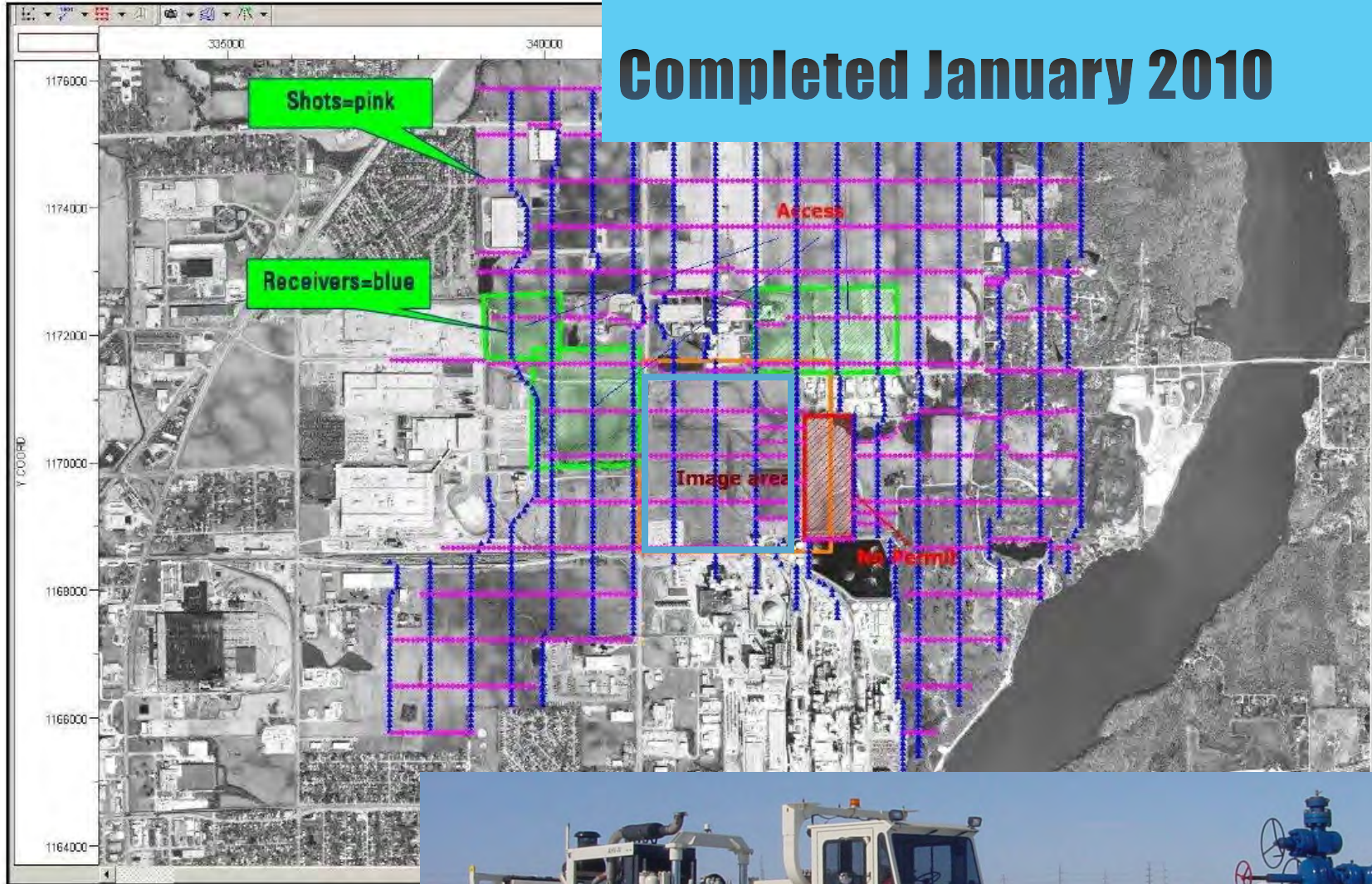
- Perf\_Z2\_Pressure
- ▲ Perf\_Z3\_Pressure
- × Perf\_Z4\_Pressure
- Perf\_Z5\_Pressure
- + Perf\_Z6\_Pressure
- Cumulative Injection (tons)

from Schlumberger  
 Carbon Services  
 multilevel  
 groundwater  
 characterization and  
 monitoring system



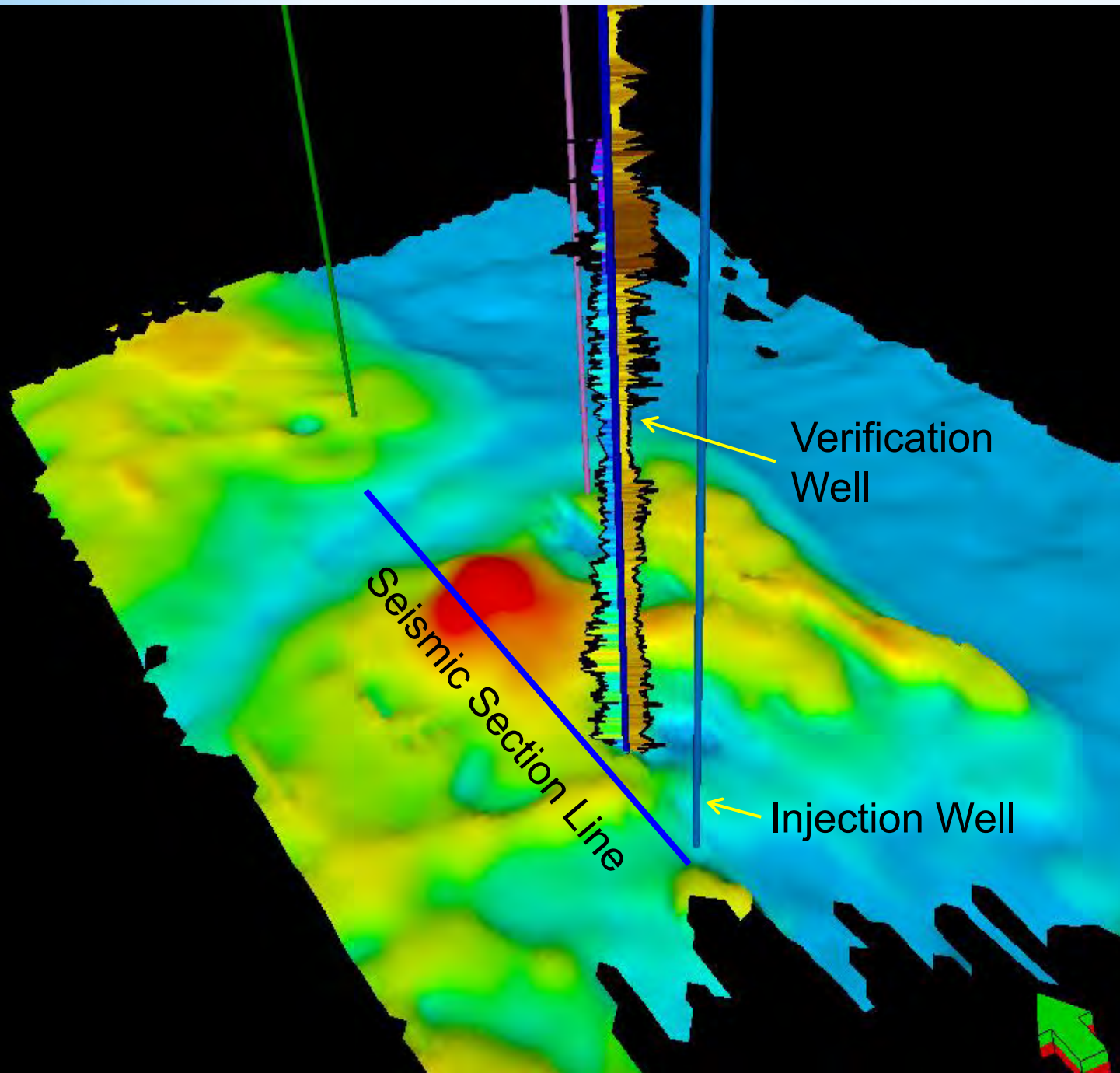
# Baseline 3D Geophysical Survey

Completed January 2010

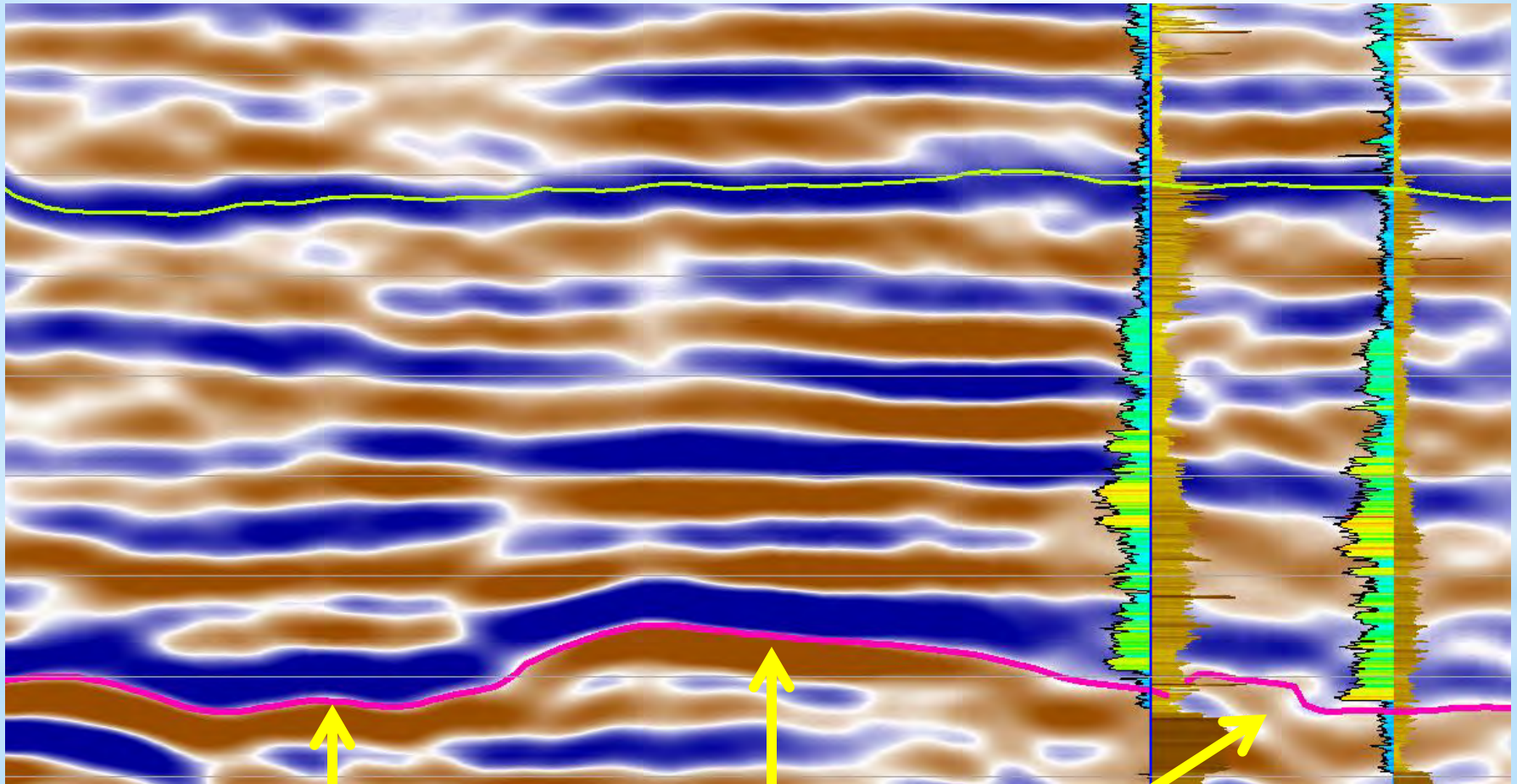




**Topography  
on the  
Unconformity  
Impacts CO<sub>2</sub>  
Distribution**



# Precambrian Topography Deflects CO<sub>2</sub>



Valley eroded into Precambrian

Precambrian High

Injection  
Well

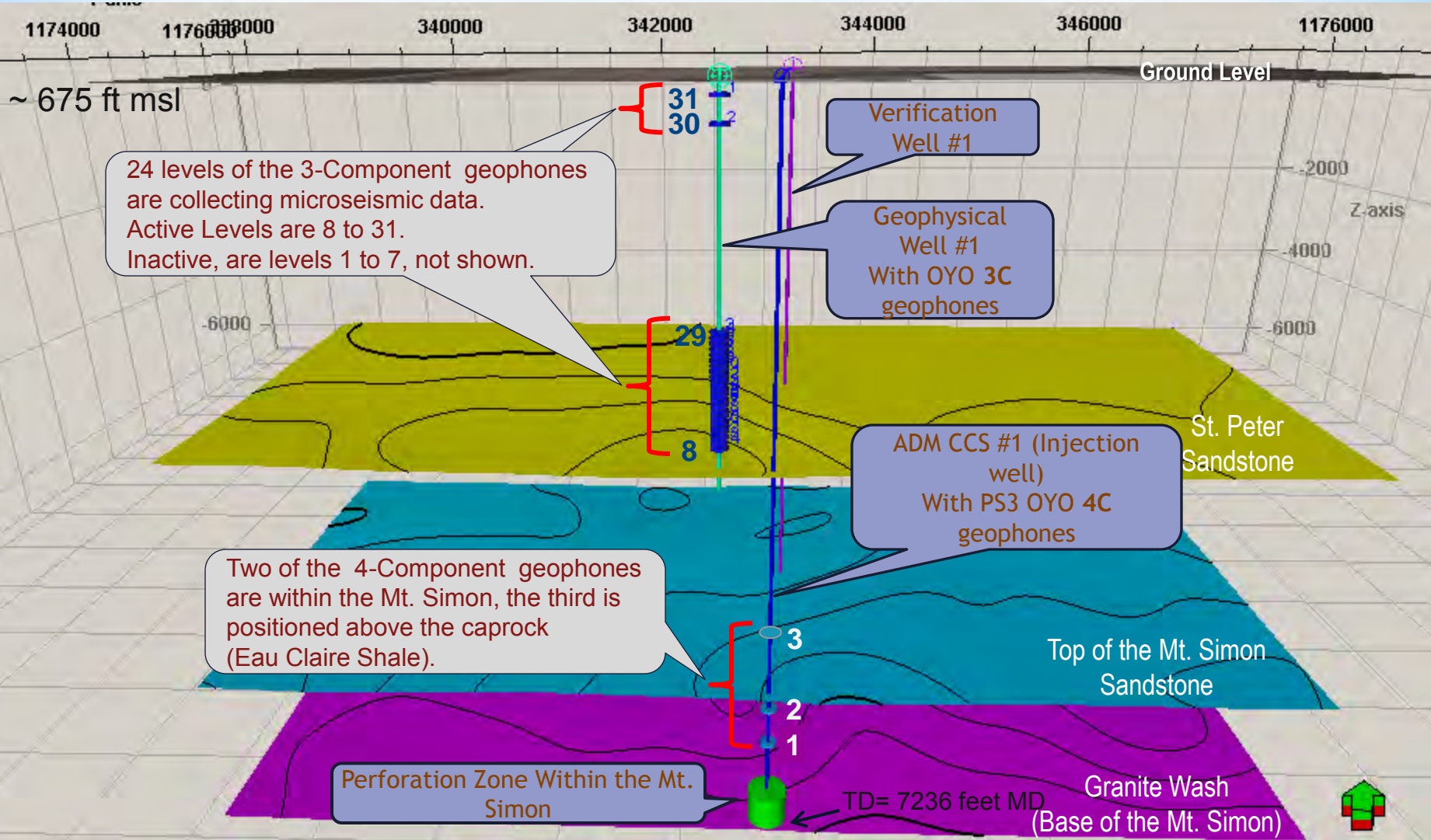
Verification  
Well

Mount Simon Sandstone  
Deposition on Pre-existing  
Topography  
(4.3 m [14 ft] depth steps)



# Geophones, wells, and reservoir details

From Schlumberger Carbon Services

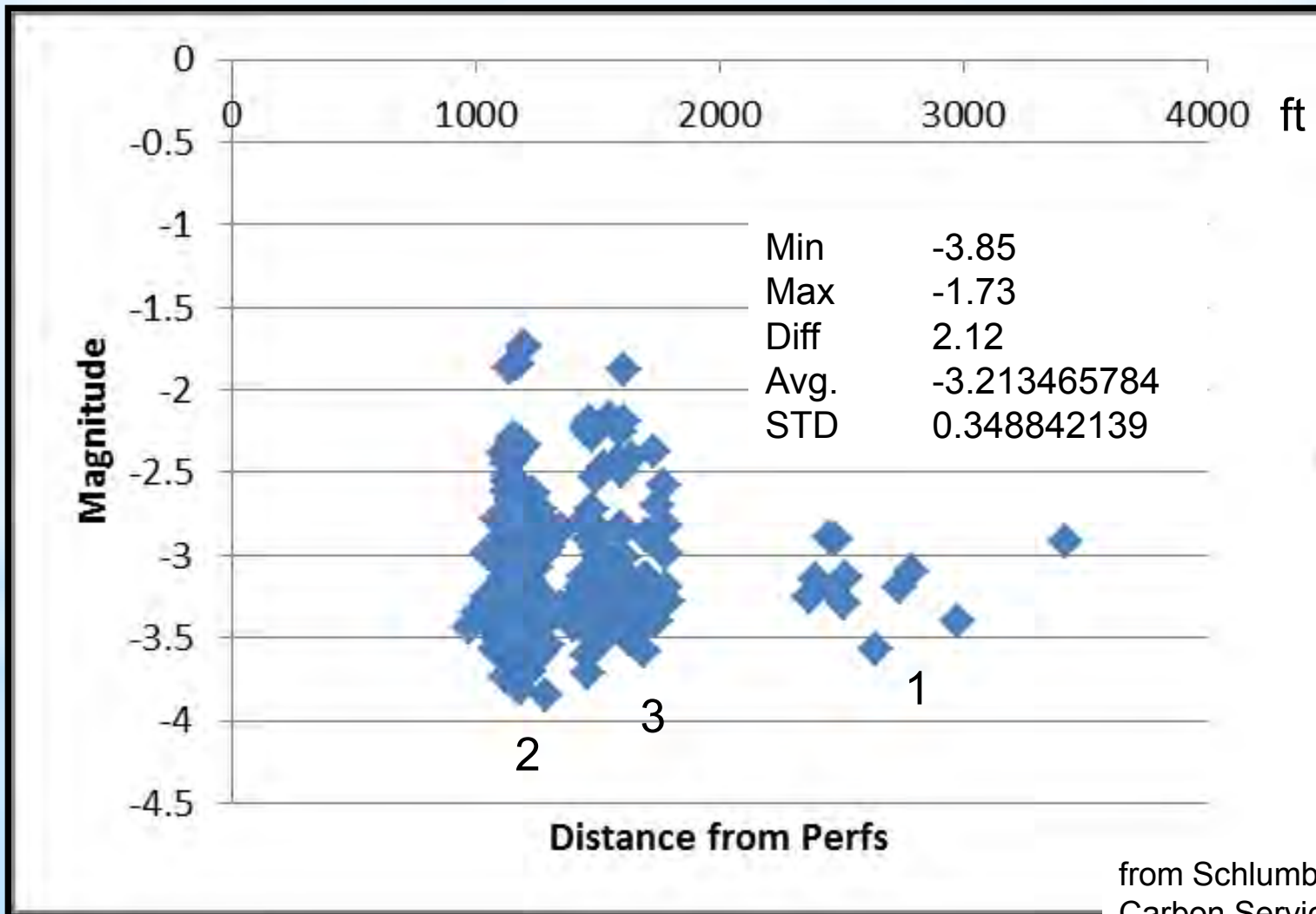




**Multicomponent  
Geophones<sup>1</sup>  
Installed on  
Tubing String in  
Injection Well**

<sup>1</sup>Schlumberger PS<sup>3</sup> System

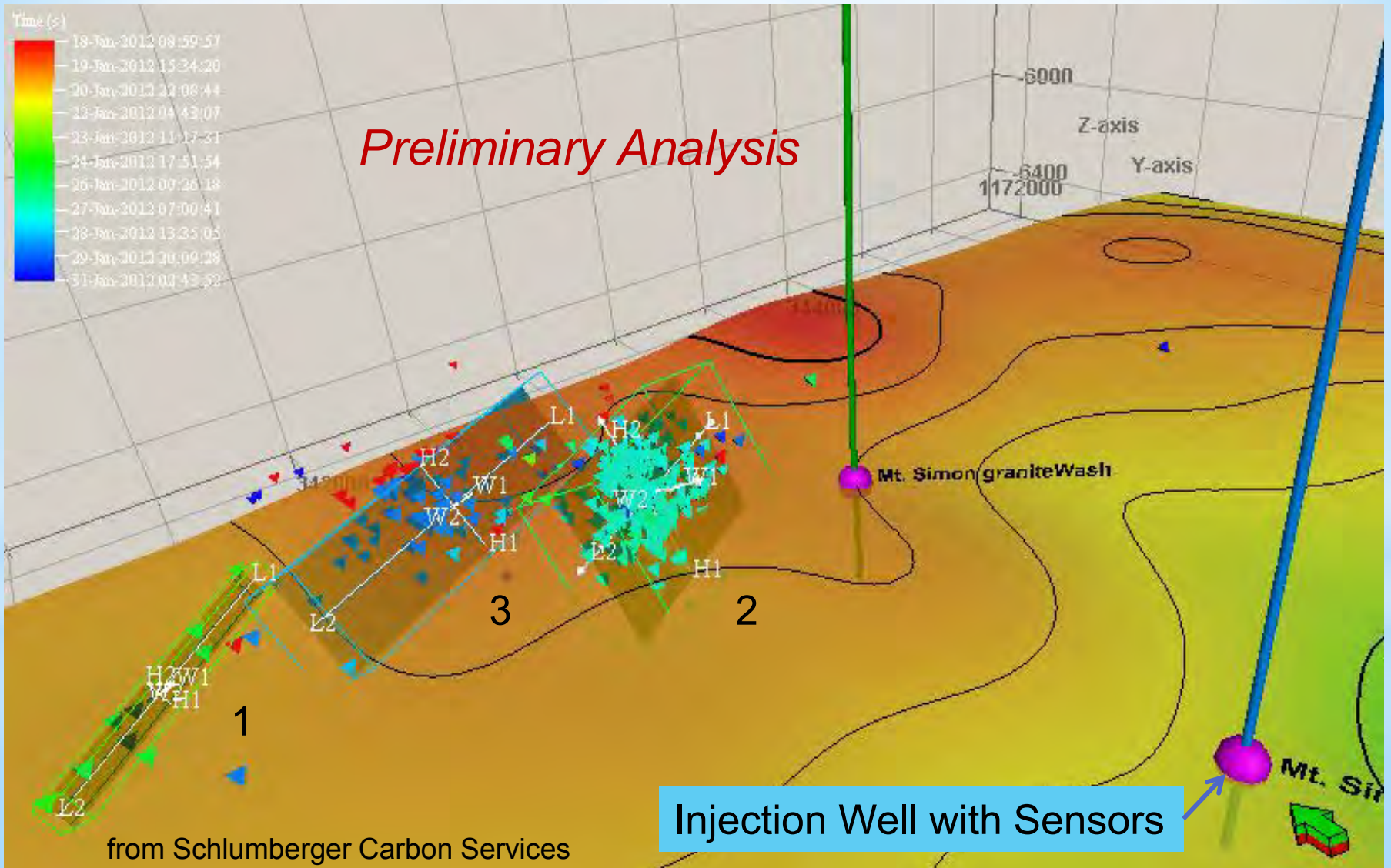
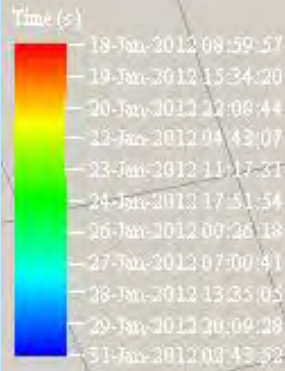
# Microseismic Magnitude vs. Distance from Injection Well



from Schlumberger  
Carbon Services

# Microseismic Events Recorded NW of Verification Well

*Preliminary Analysis*

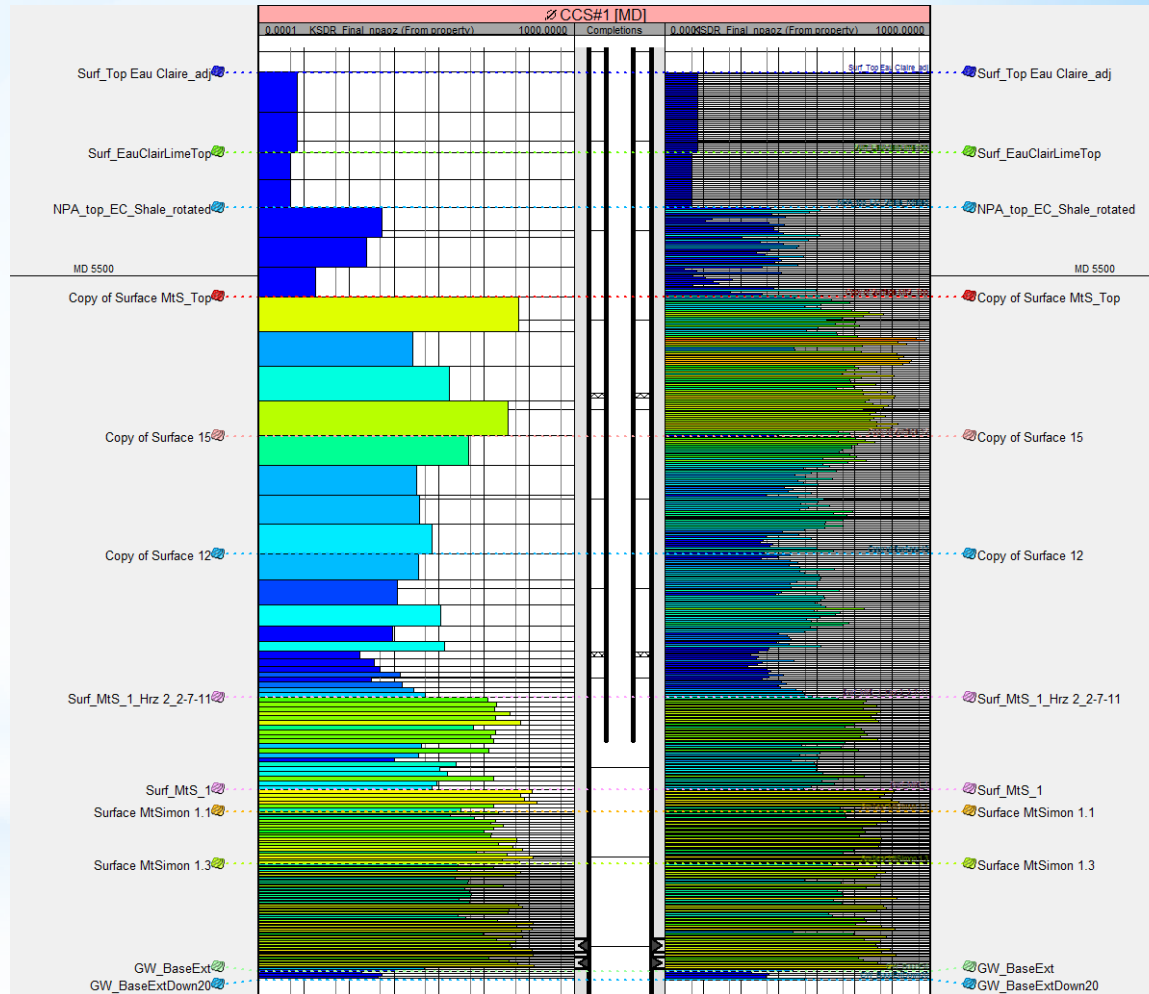


from Schlumberger Carbon Services

# Reservoir Simulation Development

- Reservoir Model:

- Eclipse 2011.2
- 20 × 20 mile coverage
- ~ 3M Cells, 143 × 143 × 148
- Cell Horizontal Dimensions are from 5 ft and 50 ft at wells to 1500 ft at the model boundaries
- Cell Vertical Dimensions from 3 ft to 30 ft
- Infinite acting boundary conditions



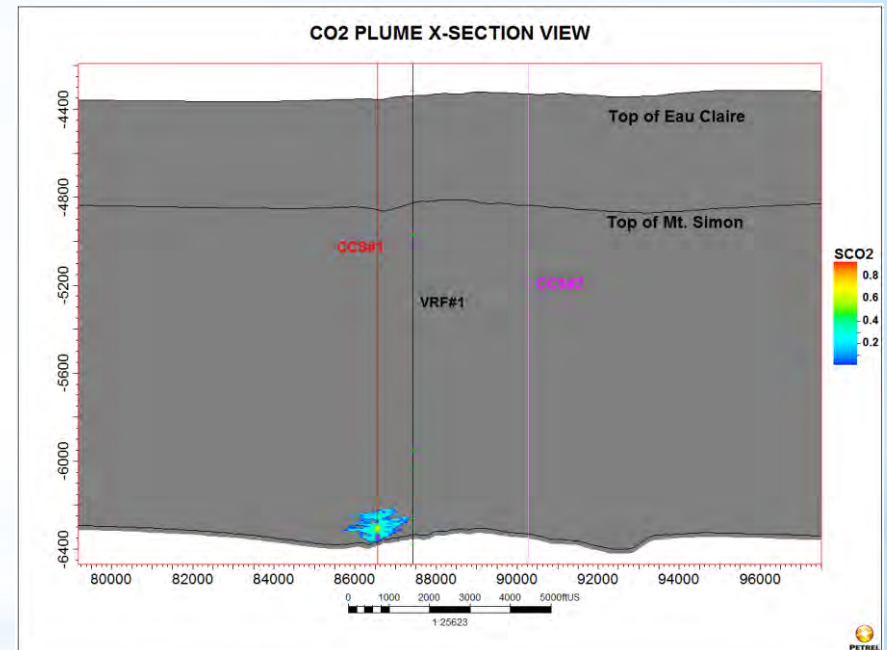
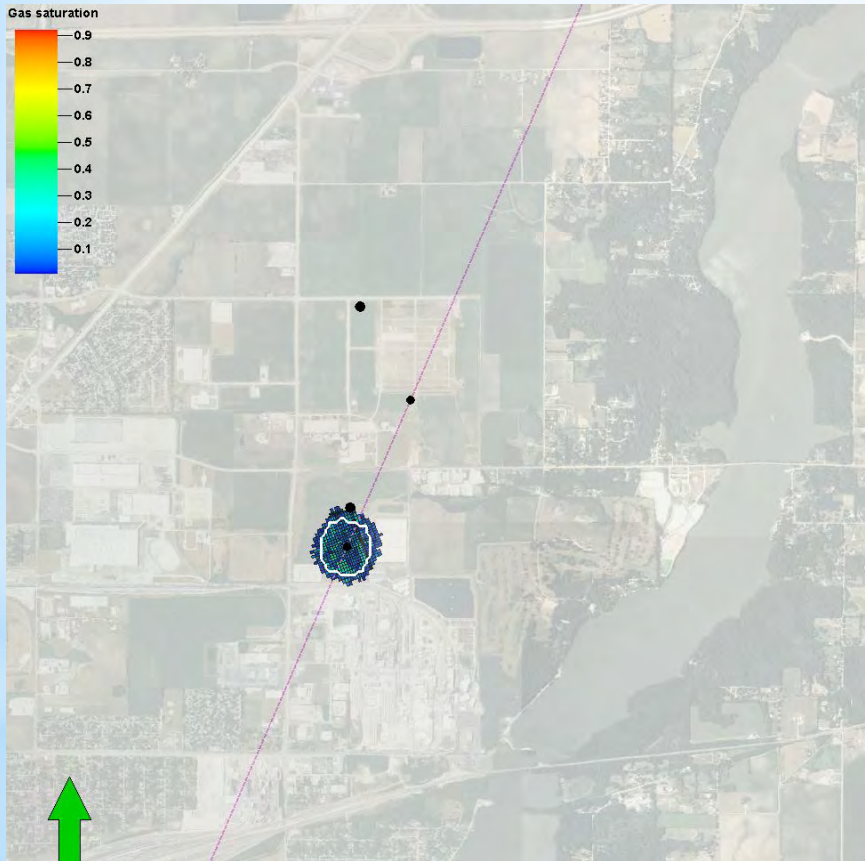
Reservoir Model

Static Model



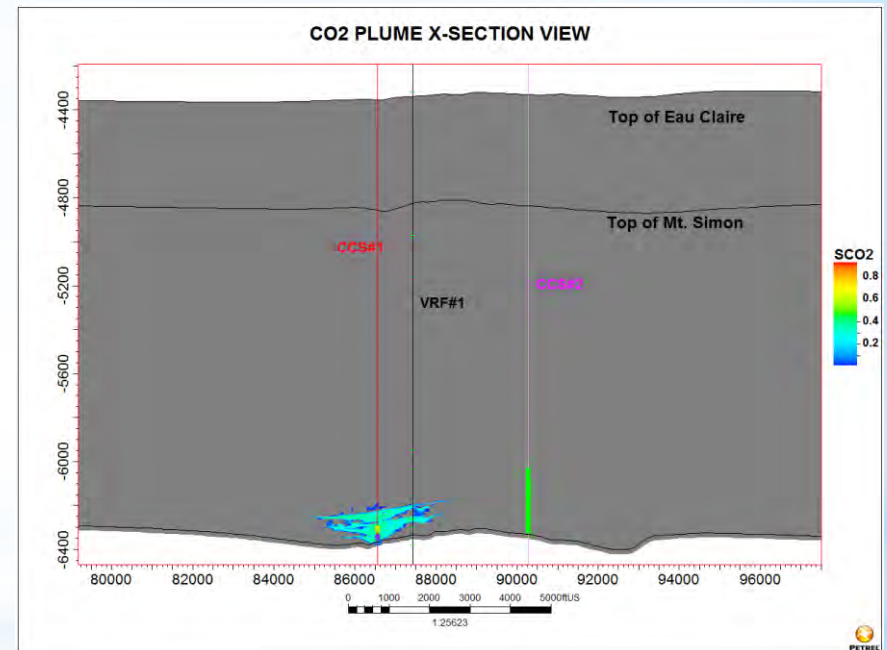
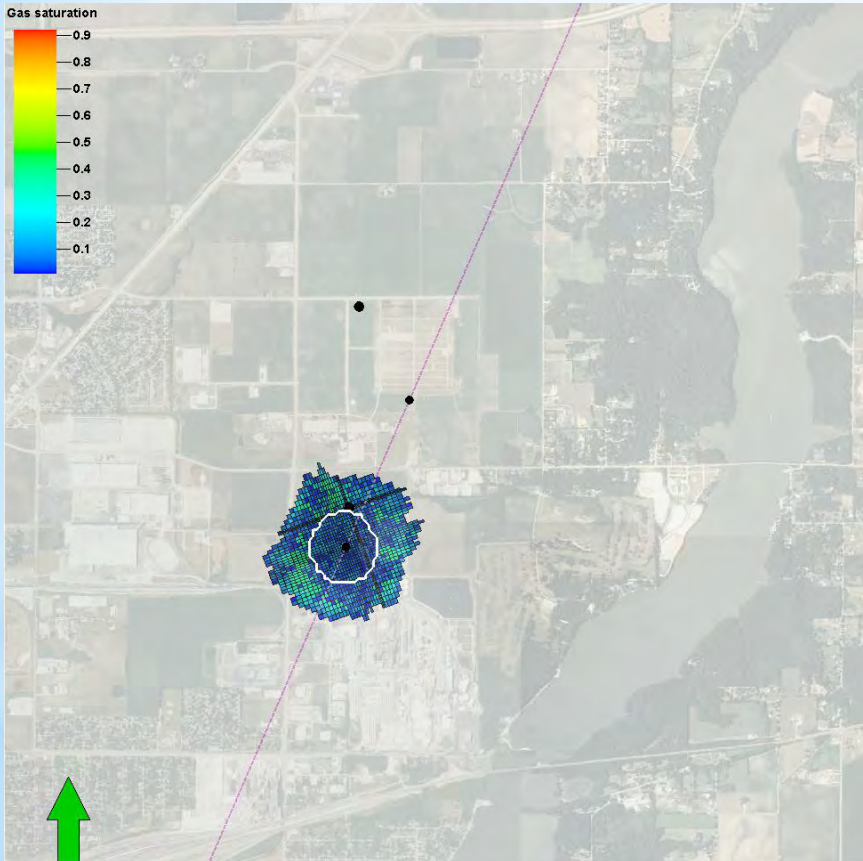
# IBDP - CO<sub>2</sub> Plume & Pressure Pulse Evolution

March 2012



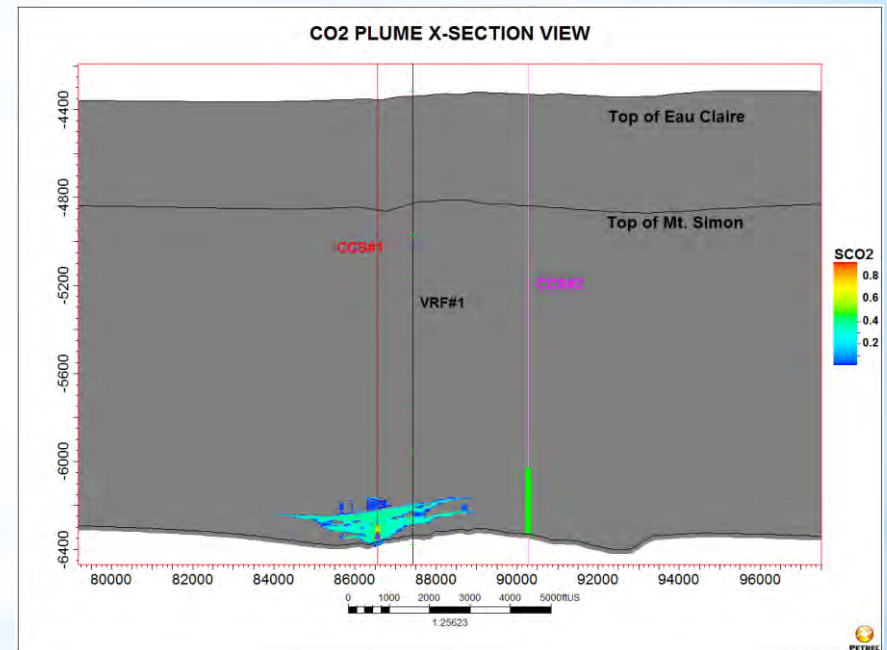
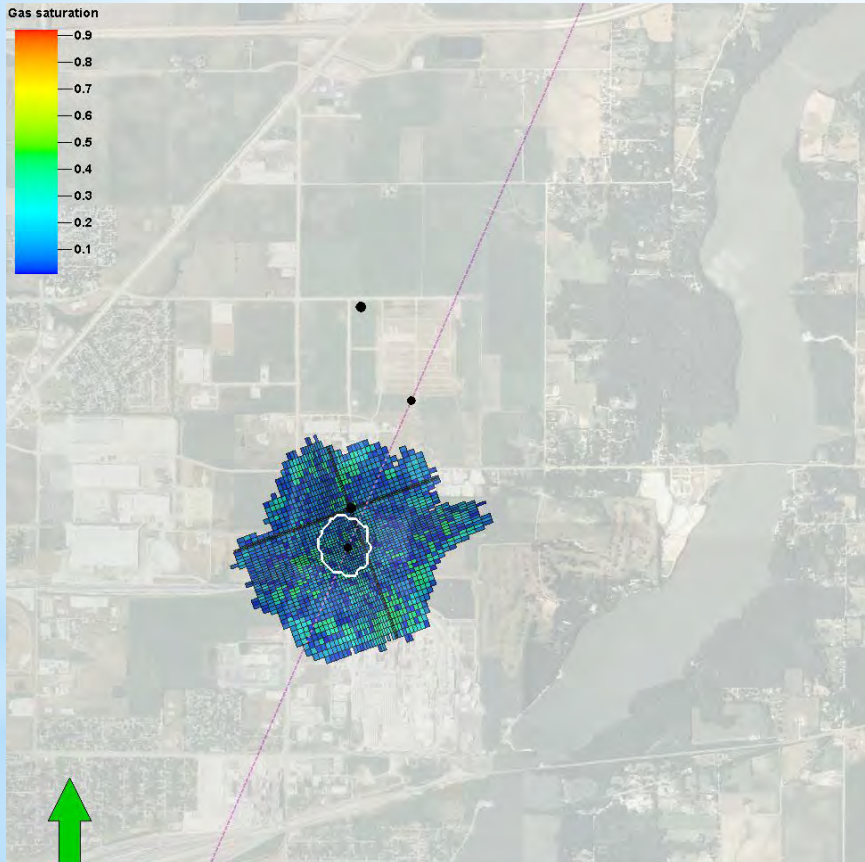
# IBDP - CO<sub>2</sub> Plume & Pressure Pulse Evolution

2013



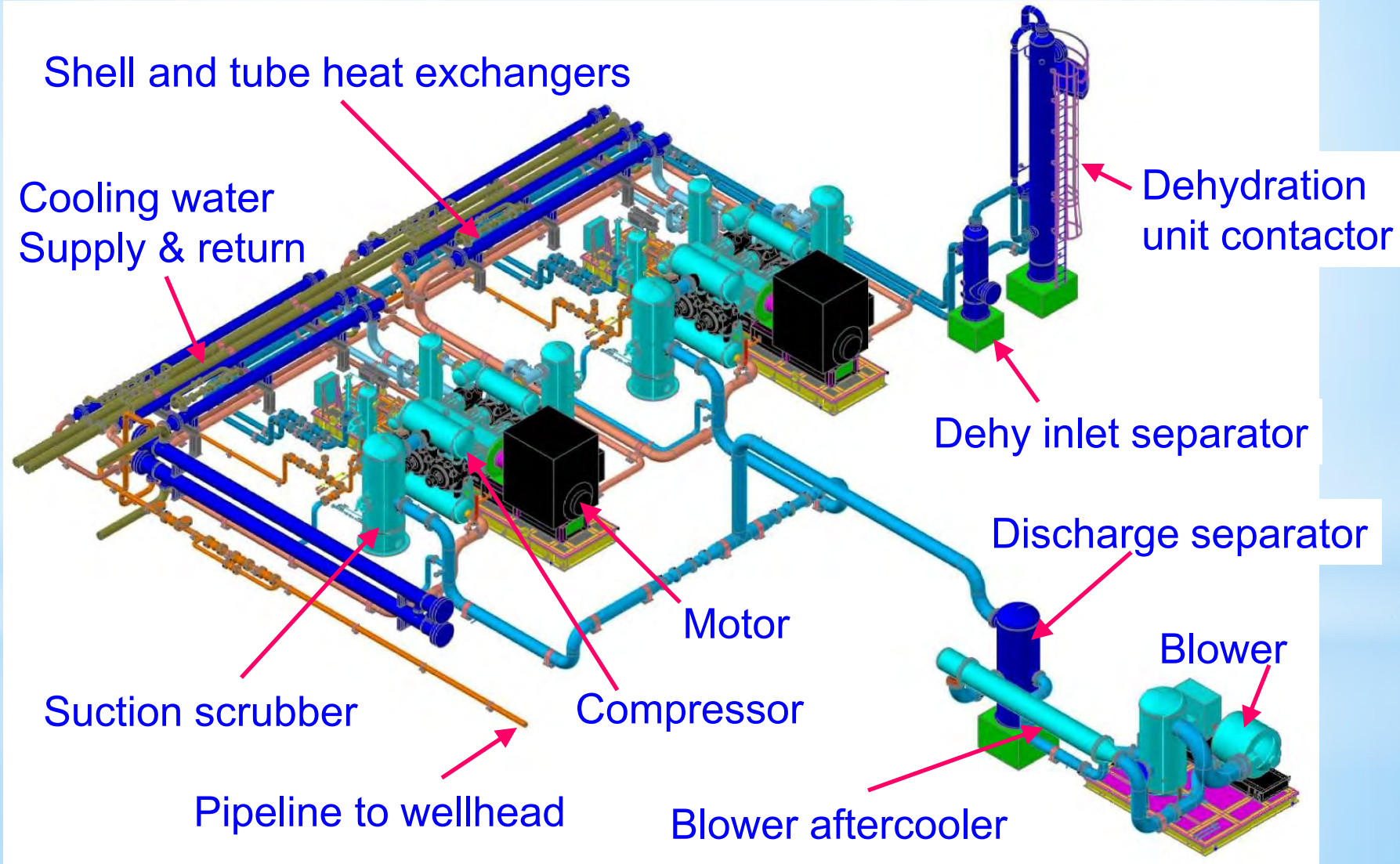
# IBDP - CO<sub>2</sub> Plume & Pressure Pulse Evolution

2014



from Schlumberger Carbon Services

# Dual 550 TPD Reciprocating Compressors with Glycol Dehydration



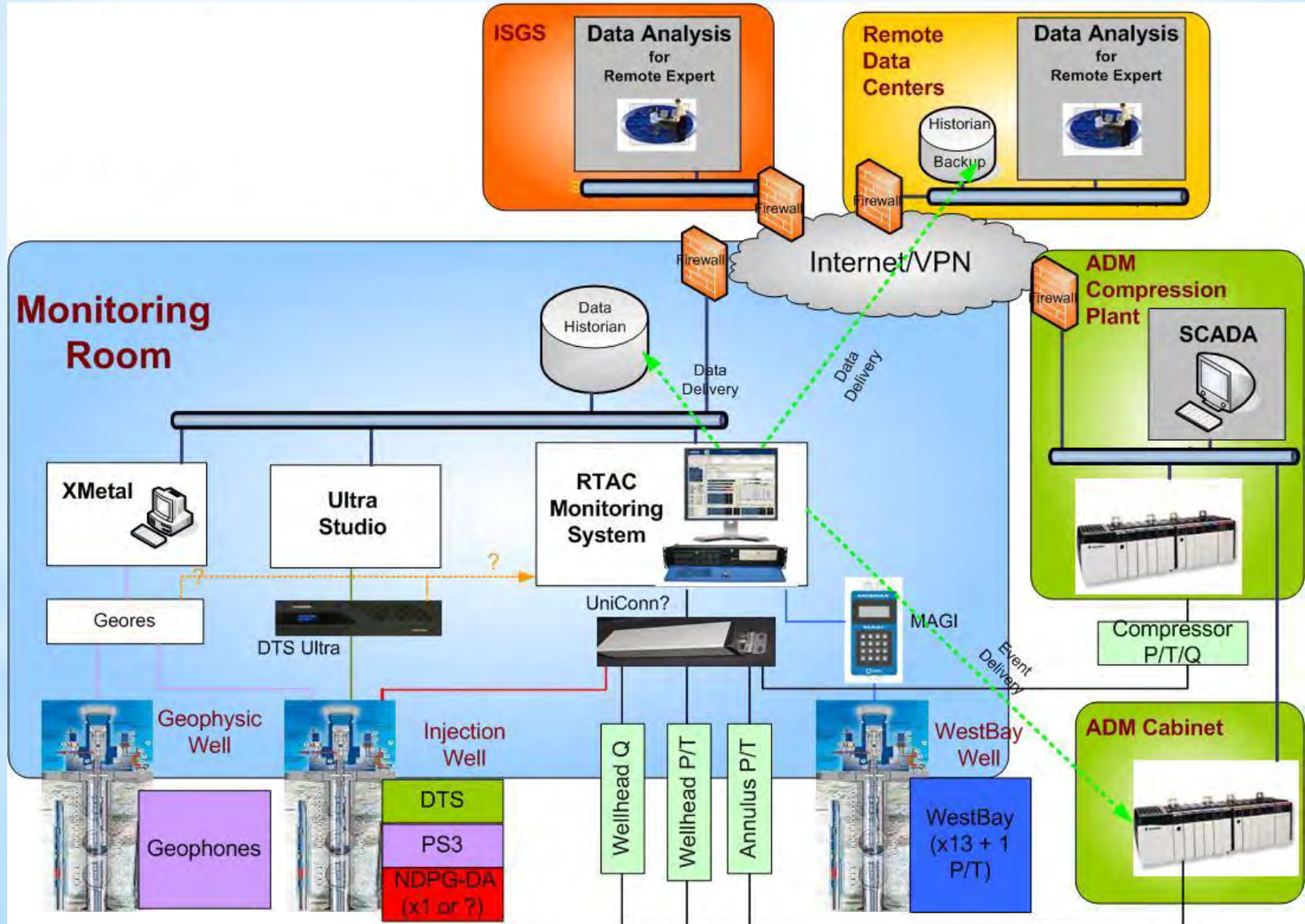


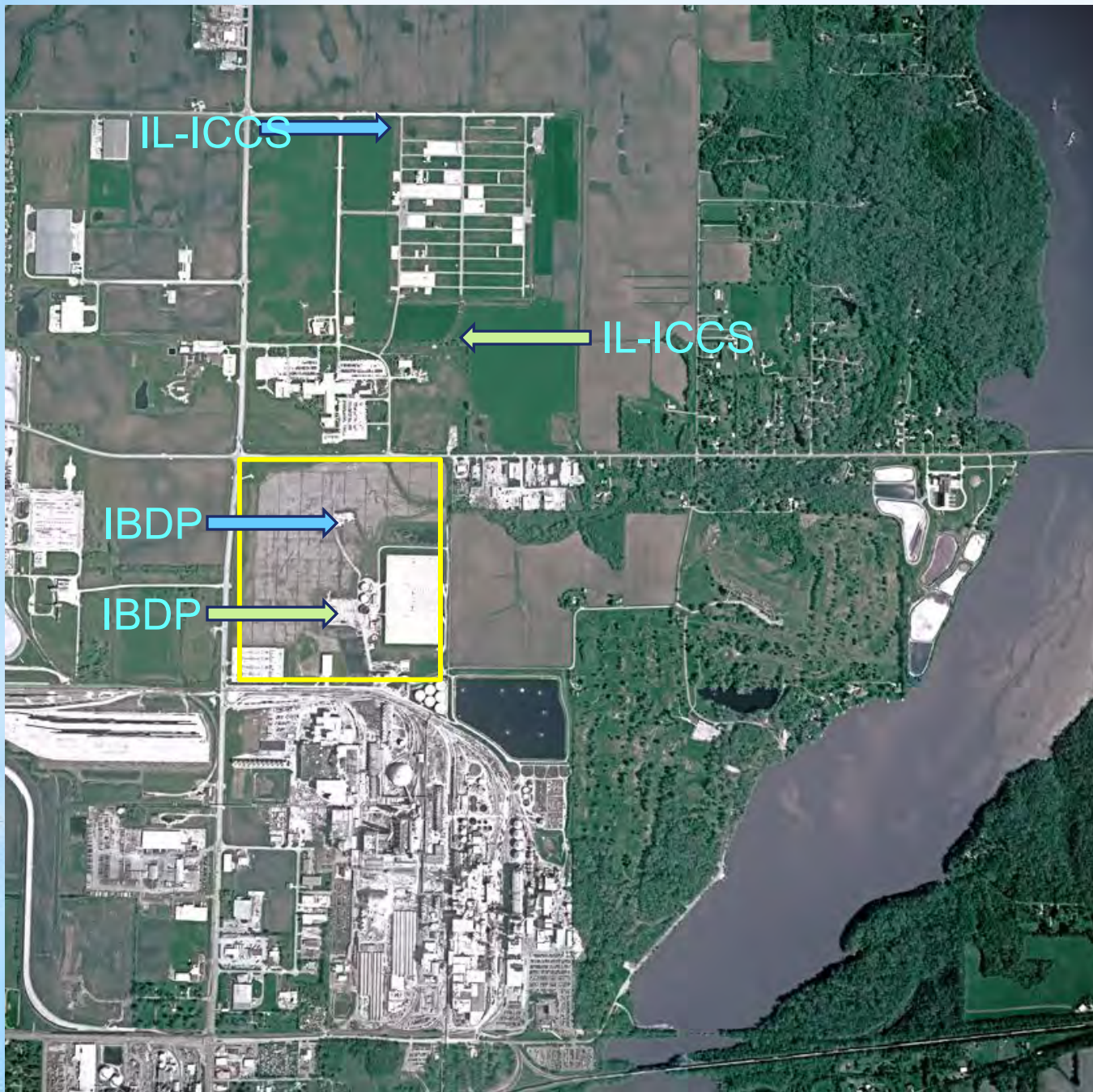
# Blower, Compressor Output, Compressor Motor



# Data Collection System

courtesy Schlumberger Carbon Services



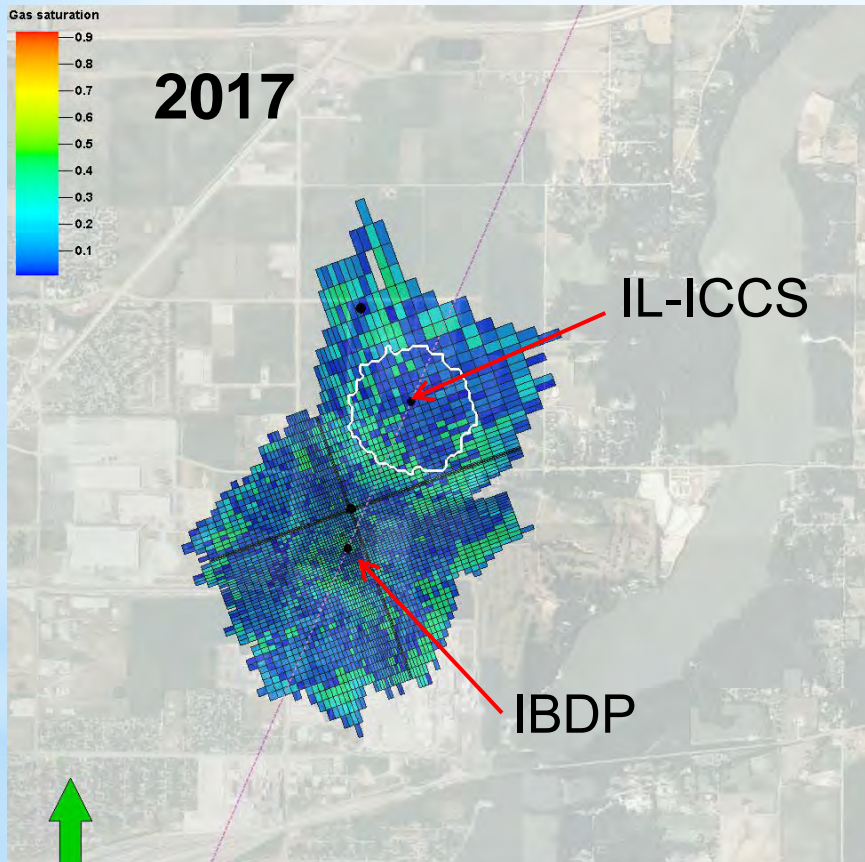


**Industrial Carbon  
Capture and  
Storage (ICCS)  
Wells Currently  
in UIC Class VI  
Permit Process**

-  Injection
-  Verification

# Illinois Industrial Carbon Capture and Storage

(IL ICCS) Project will Prove CCS at Scale



- Commercial scale operations of one million metric tons per year will be achieved
- Will build on the leading-edge technology of the Illinois Basin - Decatur Project by expanding injected volumes
- Will add an education and training component through Richland Community College, National Sequestration Education Center
- **IBDP** and **IL ICCS** will be a first in the world to assess two injected carbon dioxide plumes in the same reservoir that resemble volumes derived from a commercial coal-fired power plant





Midwest Geological  
Sequestration Consortium  
[www.sequestration.org](http://www.sequestration.org)  
[finley@illinois.edu](mailto:finley@illinois.edu)



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