

# Case study: a field survey in response to claims of CO<sub>2</sub> leakage – Weyburn-Midale oilfield

Katherine Romanak  
George William Sherk



BUREAU OF  
ECONOMIC  
GEOLOGY

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# News of a “Leak” at the Kerr Farm

January 11, 2010


**THE GLOBE AND MAIL**  
IN PICTURES  
**Carbon capture leak forces Saskatchewan couple to leave farm**  
Published Tuesday, Jan. 11, 2011 6:12PM EST  
Pair abandon Saskatchewan farm because of blowouts, dead animals and algae



1 of 10

(Troy Fleeca/The Canadian Press)

**Carbon injected underground is leaking: Sask. farmers**



Cattle gathered in a pasture near a pumpjack in an oilfield outside of Weyburn, Sask. on Monday, June 6, 2009.

Text: [Icons]

The Canadian Press  
Published Tuesday, Jan. 11, 2011 11:37AM EST

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**CO2 leaks worry Sask. farmers**

Last Updated: Tuesday, January 11, 2011 | 8:49 PM ET Comments: 164 Reactions: 1

The Canadian Press

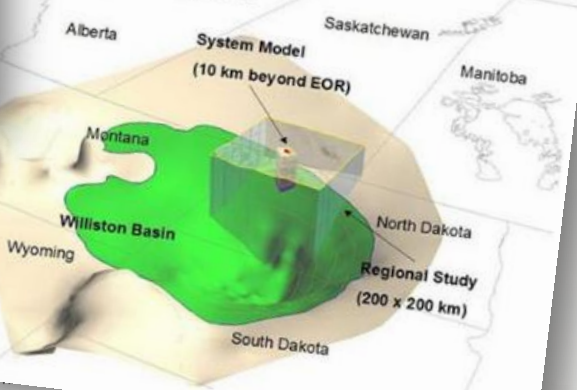
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Week in Pics: The News In Review  
Bacteria: Good, Bad, and Ugly  
The Week: In Animal Photos

**CO2 Levels at Leaking Canadian Carbon Storage Project Could Asphyxiate You In One Place**  
by Matthew McDermott, New York, NY on 01.12.11  
SCIENCE & TECHNOLOGY

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**Study Region**



**Land fizzing like soda pop: farmer says CO2 injected underground is leaking**

By: Bob Weber and Jennifer Graham, The Canadian Press  
Posted: 01/11/2011 10:22 AM | Comments: 9

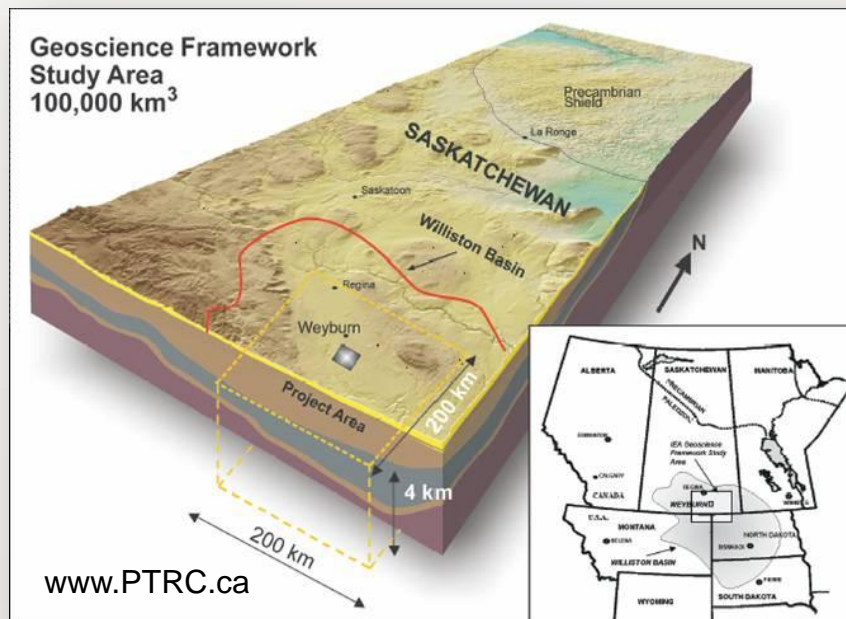
**Pffft Goes Promise Of Pumping Co2 Underground**



Jane Kerr took this picture of what they say is gas bubbling from water on their property.

Cameron and ... above the Weyburn oilfield ... Saskatchewan, have released a consultant's report that claims to link high concentrations of carbon dioxide in their soil to gas injected underground

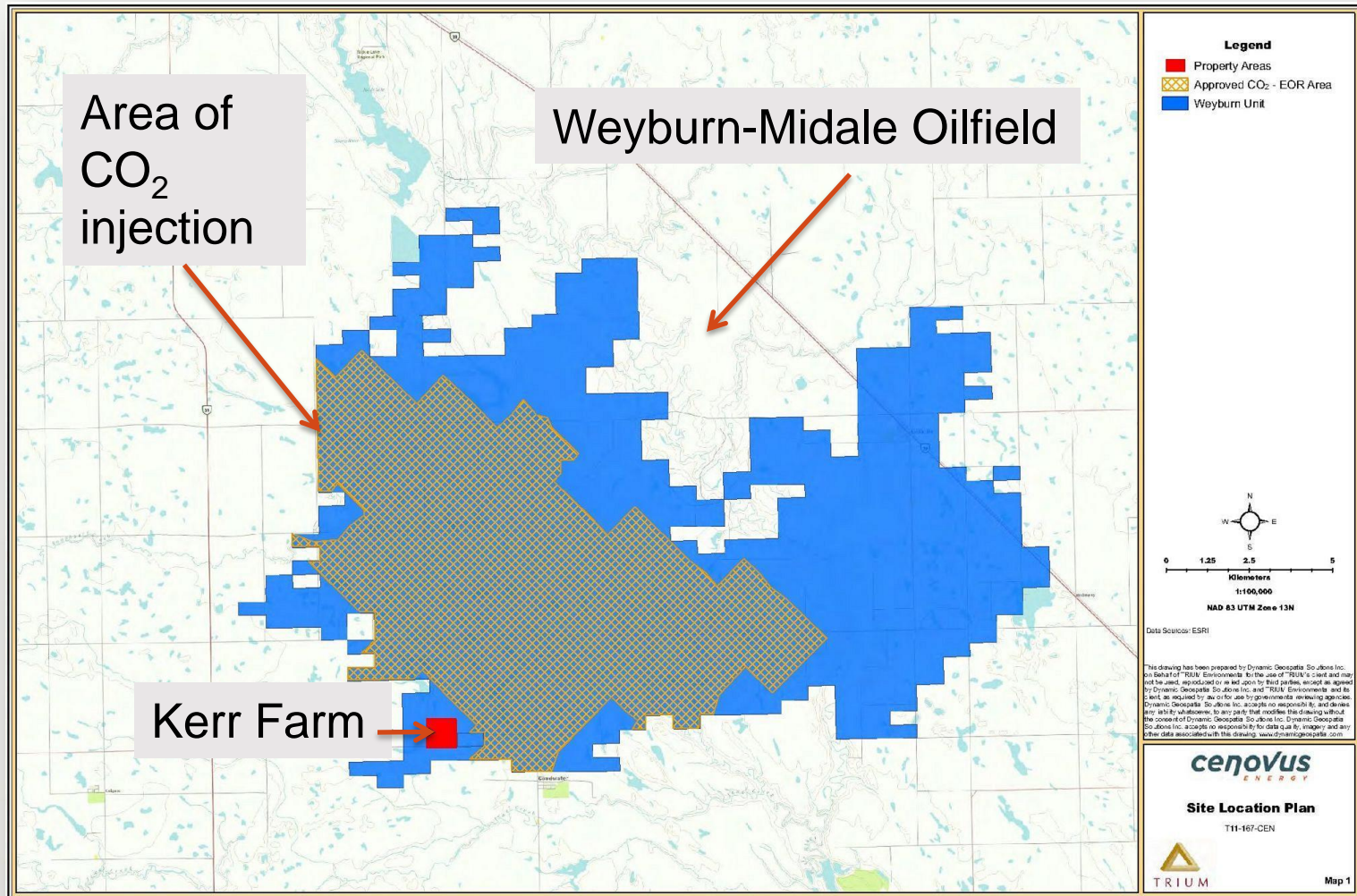
# IEAGHG Weyburn-Midale CO<sub>2</sub> Monitoring and Storage Project



Rostron and Whittaker, Energy Procedia 4 (2011)  
3636–3643

- Largest geologic CO<sub>2</sub> monitoring and storage project
- Since 2000 > 17 M tonnes of CO<sub>2</sub> injected
- CO<sub>2</sub>-EOR operated by Cenovus Energy
- Studied by an international team of CO<sub>2</sub> storage experts
- Managed by Petroleum Technology Research Centre (PTRC)

# Site Location



# Kerr Farm History

Kerrs acquire  
the land  
South of  
Weyburn in  
1975

IEAGHG  
Weyburn  
Project  
Phase 1

Kerrs  
excavate  
gravel pit.  
CO<sub>2</sub> injected  
near land

Kerrs  
leave their  
property

Ongoing Allegations of CO<sub>2</sub> Leakage

1971 1995 1998 2000 2003 2004 2005 2006 2007 2008 2010 2011 2012



# Alleged Land Disturbances

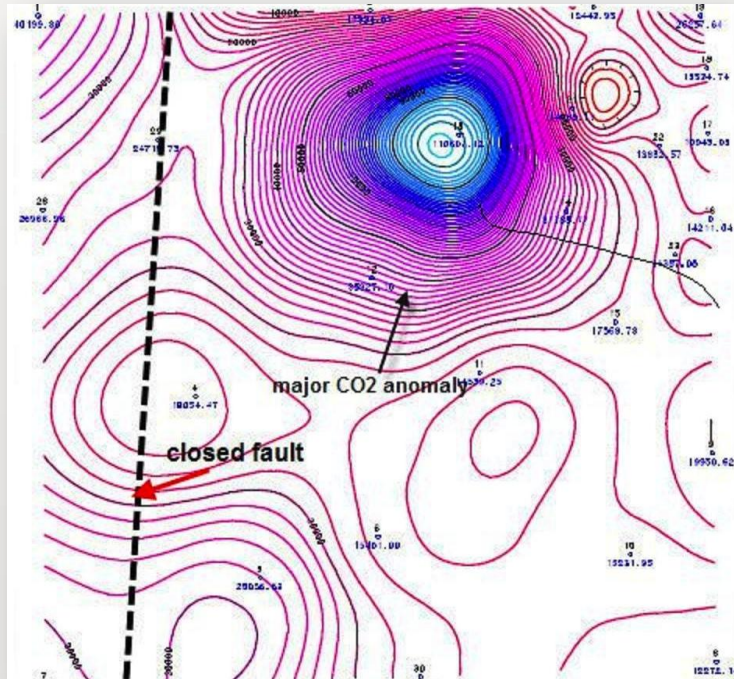


# Industry and Government Response

- **1998:** (Operator) Weyburn Pump and Water Conditioning, groundwater test report
- **2002 – 2005:** (Operator) Farmwell Inventory Project, regional groundwater analysis
- **2004:** (Operator) KBL Land Use Consulting Ltd., gravel pit water and soil samples
- **2005:** (Operator) Enviro-Test Analytical soil sample
- **2005:** (Government) Saskatchewan Health Provincial Laboratory, gravel pit and domestic well water
- **2006:** (Operator) Aqua Terre Solutions Inc., well and gravel pit water test
- **2006:** (Landowner) MR2 McDonald & Associates, water quality investigation
- **2007:** (Landowner) Consultation with Dr. Malcolm Wilson, Office of Energy & Environment, University of Regina
- **2008:** (Government) Ministry of Environment – Review of studies
- **2008:** (Government) SRC Analytical Laboratories, soil, water and air quality monitoring
- **2008:** (Government) Droycon Bioconcepts Inc., Bacteriological content of water
- **2010-2011** (Landowner) Petro-Find Geochem Ltd. Soil gas surveys.



# Petro-Find Conclusion




“The...source of the high concentrations of CO<sub>2</sub> in soils of the Kerr property is clearly the anthropogenic CO<sub>2</sub> injected into the Weyburn reservoir.”

Source: Lafleur, P. 2010. *Geochemical Soil Gas Survey: A Site Investigation of SW30-5-13-W2M Weyburn Field, Saskatchewan. Saskatoon, SK: Petro-Find Geochem Ltd.*)

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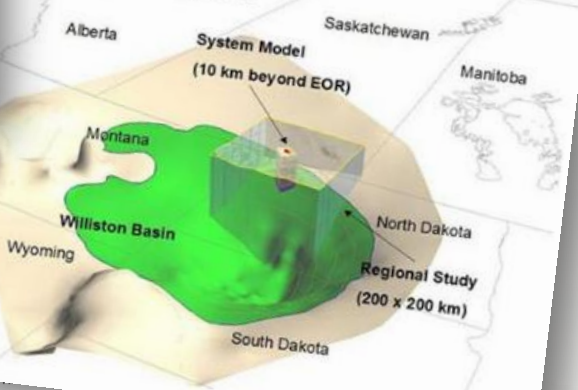
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## Pffft Goes Promise Of Pumping Co2 Underground

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# Petroleum Technology Research Centre Response

“Researchers, engineers, geologists and geophysicists involved in the IEAGHG project have reviewed the Petro-Find report and concluded that it does not support its claim.”

*PTRC Response to Petro-Find report*

*[www.ptrc.ca](http://www.ptrc.ca)*



# Investigations in Response to Allegation

Investigations of alleged CO<sub>2</sub> leakage in Weyburn, Canada in the context of longer term surface gas monitoring.

D. Azevedo<sup>1</sup>, T. Herten<sup>1</sup>, A. Berkefeld<sup>1</sup>, T. Lister<sup>1</sup>, M. Sireva<sup>1</sup>, V. Loshakov<sup>1</sup>, T. Bellomo<sup>1</sup>, A. Amannostelli<sup>1</sup>, S. Graziano<sup>2</sup>, S. Lombardi<sup>3</sup>, G. Healy<sup>4</sup>, F. Cap<sup>4</sup>, F. Joubert<sup>4</sup>, K. Miska<sup>4</sup>, C. Sandaa<sup>4</sup> and B. Rostava<sup>4</sup>

<sup>1</sup>British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham, NG12 5GG, UK  
<sup>2</sup>Università di Roma "La Sapienza", Dip. Scienze della Terra, P.le A. Moro 5, 00185 Roma, Italy  
<sup>3</sup>Università di Padova, Dipartimento di Scienze della Terra, Via U. Sestini 1, 35131 Padova, Italy  
<sup>4</sup>Orstom Centre 2, France

<sup>4</sup>Chemistry Martin, Cochrane, Alberta, Canada  
<sup>5</sup>University of Alberta, Department of Earth and Atmospheric Sciences, 1-26 Earth Sciences Building, University of Alberta, Edmonton, Alberta, Canada, T6G 2E3

## Abstract

The Weyburn oilfield in SE Saskatchewan, Canada has been in production for more than 30 years. A CO<sub>2</sub> flood was started in 2000 to enhance oil recovery. The gas is piped from a coal gasification plant across the US border in North Dakota. In addition to boosting oil production it is expected that about 30 million tonnes of CO<sub>2</sub> will be permanently stored in the reservoir, at a depth of about 1400 m, by the end of the 30 year lifetime of the project.

Near surface gas monitoring has been carried out from the early stages of CO<sub>2</sub> injection. It forms part of the IEAGHG Weyburn-Midale research project and has received additional support from 11 funded research projects and 11 national funding. The first surface gas measurements were made in July 2001, with subsequent surveys in the autumn of that year and then each autumn from 2002 to 2005. Repeat surveys were carried out in 2011 when new methods were trialled and specific investigations were made at a site of alleged CO<sub>2</sub> leakage.

An initial grid of soil gas and flux observations was made in 2001 covering some 15 km<sup>2</sup> (360 points at 20 m spacing) around the initial injection area. This was measured on each subsequent visit as well as a selection of more detailed profiles (25 m spaced observations) chosen on the basis of the grid results. In 2005 the scope of work was extended to investigate possible pathways for CO<sub>2</sub> migration towards the surface. This included the study of abandoned abandoned well sites and lineaments that might represent the surface expression of deeper faulting or thinning of the reservoir seal. A background site with similar characteristics to the main grid, but remote from the CO<sub>2</sub> injection area was also added. Measurements made at the field, field laboratory and laboratory included a range of gas species (e.g. CO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>, CH<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, C<sub>3</sub>H<sub>8</sub>, H<sub>2</sub>, He and Rn) and CO<sub>2</sub> flux. Radon probes were also buried at selected sites to monitor the temporal variations of this gas as a proxy for CO<sub>2</sub> migration.

In 2011 these measurements were supplemented by some continuous monitoring of CO<sub>2</sub> concentrations and fluxes using buried monitoring probes and an eddy covariance system. In addition, mobile open path laser measurements of CO<sub>2</sub> in the near ground atmosphere were made at selected sites. These methods were designed to address the potential need to locate spatially small surface leaks in a large project area and to deal with temporal variability.

Allegations of leakage of CO<sub>2</sub> to surface at the Kerr property, just SW of the CO<sub>2</sub> injection area, were made in early 2011. Consequently the area around the property was investigated with many of

cenovus  
ENERGY

## Site Assessment Weyburn Unit SW30-5-13W2

November 2011

www.cenovus.com

IEAG  
GHG



## THE KERR INVESTIGATION: FINAL REPORT

FINDINGS OF THE INVESTIGATION INTO THE  
IMPACT OF CO<sub>2</sub> ON THE KERR PROPERTY

DR. GEORGE WILLIAM SHERK  
PROJECT DIRECTOR  
CHIEF OPERATING OFFICER  
IPAC-CO<sub>2</sub> RESEARCH INC.

IEAG  
GHG

European  
Research Team

The Operator

Independent study

# Incident Response Protocol

*Response to report of an unintentional release of a gas or gases associated with a specific CCS project.*

1. Validate the allegation
2. Correspondence and document review
  - The operator of the CCS project
  - The provincial and federal governments
  - Other participants in the CCS project



Tested at  
Kerr site

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If a release has occurred

3. Substances released and scope of the release
4. Release mechanisms
5. Time release was detected
6. Response to the release
7. Consequences of the release
8. Compliance with applicable industry performance standards/best practices
9. Conclusions and recommendations



Not tested  
at Kerr site

# Protocol Step 1- Validating the Allegation

## Review of Allegations

- Site History, SW30-5-13-W2M Near Weyburn, Saskatchewan, Cameron and Jane Kerr. Calgary, Alberta: 2010, Ecojustice.
- Geochemical Soil Gas Survey: A Site Investigation of SW30-5-13-W2M Weyburn Field, Saskatchewan. Saskatoon, SK: 2010, Petro-Find Geochem Ltd.
- Geochemical Soil Gas Survey: A Site Investigation of SW30-5-13-W2M, Weyburn Field, Saskatchewan, Monitoring Project Number 2. Saskatoon, SK: 2011, Petro-Find Geochem Ltd.
- Site-specific documentation

# Protocol Step 1- Validating the Allegation

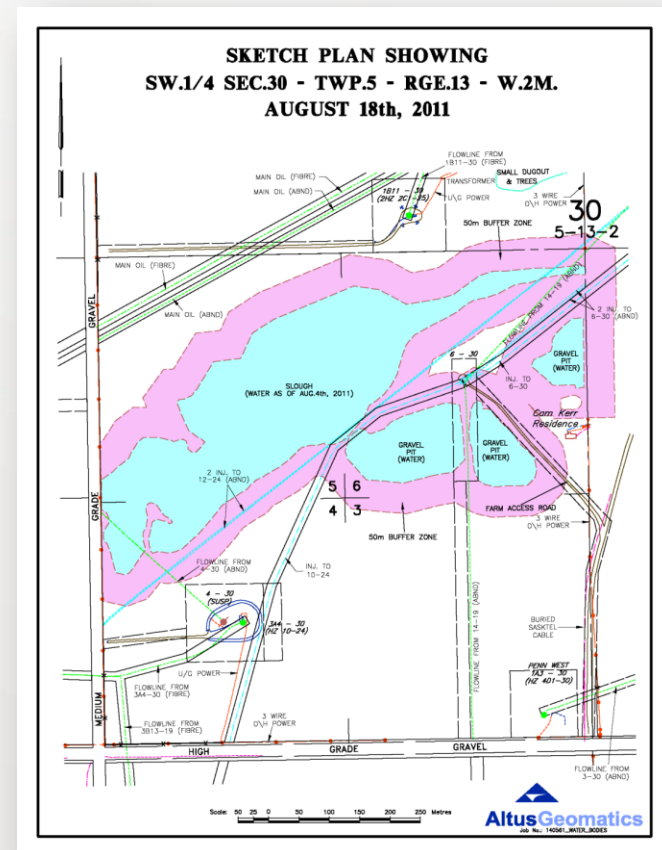
## Vicinity history:

- Chronology of events
- Results of previous testing
- Injection history (substances, depth, formations)
- Land use history
- Incidents in vicinity (e.g., hydrocarbon spills)
- Release history (if any)

# Protocol Step 1- Validating the Allegation

Vicinity inspection to identify potential areas of release and monitoring sites:

- Overview
- Existing wells
- Pipelines
- Injection sites
- Endangered Species
- Monitoring sites
- Study sites





# Protocol Step 1- Validating the Allegation

Reconnaissance environmental survey  
to choose appropriate technical  
method

- Direct methods (e.g., analysis of ground water, surface water, soil, soil-gas, vegetation, mineralogy)
- Indirect methods (e.g., geophysical modeling, seismic imaging, microseismic monitoring, electromagnetic surveys, land/surface deformation)



# Protocol Step 1- Validating the Allegation

## Detailed fingerprinting of anomalies:

- Vertical and horizontal soil-gas gradients
  - Gas transport
  - Refinement of reconnaissance surveys as needed
- Outcome of Step 1: Was there an unintentional release of gas associated with a specific CCS project?

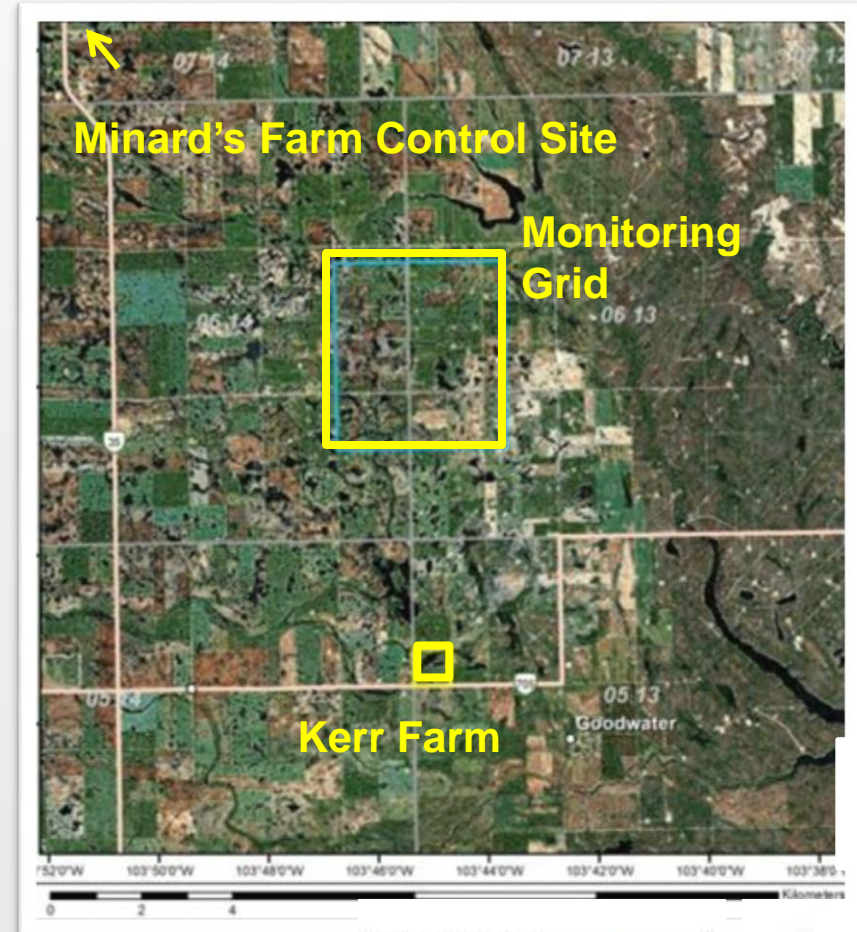
# Fingerprinting Gas Anomalies

- Identify a leakage signal from background noise
  - Soil CO<sub>2</sub> is naturally variable in space and time
  - Injected (anthropogenic) CO<sub>2</sub> is chemically indistinguishable from natural CO<sub>2</sub>



# Current Leakage Detection Approach

- Measure natural “background” CO<sub>2</sub> concentrations over years.
- Compare anomaly values with background ranges.
- Statistical difference could signal a release.
- Kerr Farm not in 2000-2005 monitoring areas

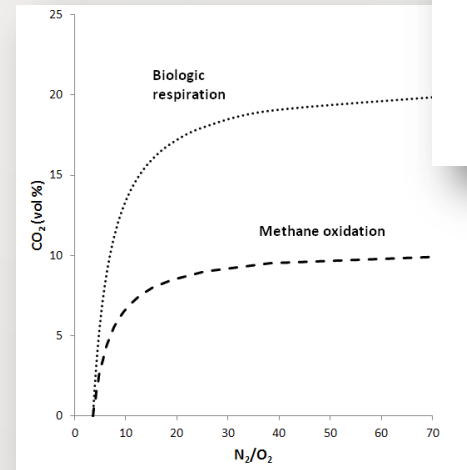
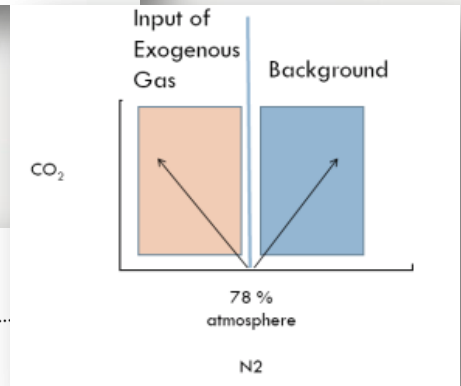
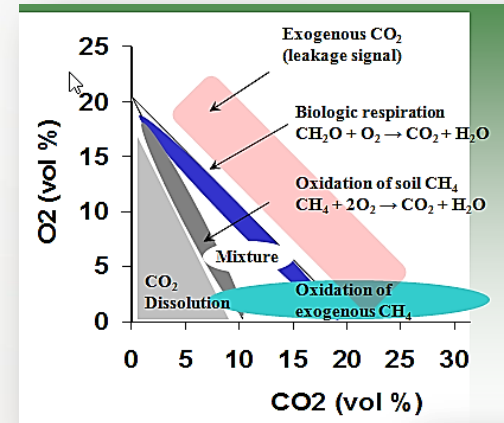


# Challenges of Concentration-Based

- 1-3 years cannot capture the full variation in natural CO<sub>2</sub>.
- Background measurements time, cost, and labor intensive.
- Leakage signals smaller than natural variability may be overlooked
- Background concentrations cannot be measured everywhere within the area of review.
- An incident can occur in an area with no background monitoring.

# Process-Based Soil Gas Method

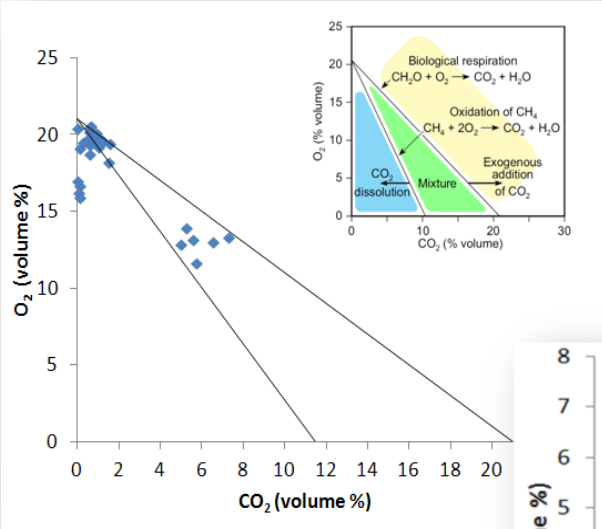
- Does not rely on background CO<sub>2</sub> measurements
- Uses ratios among major gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>, O<sub>2</sub>)
- Discerns process
  - In-situ from exogenous gas
  - Mixing with air
  - CO<sub>2</sub> dissolution
  - Oxidation of CH<sub>4</sub> into CO<sub>2</sub>
    - **Important for CCUS monitoring**
- Being developed for groundwater and marine environments



# Validating the Allegation

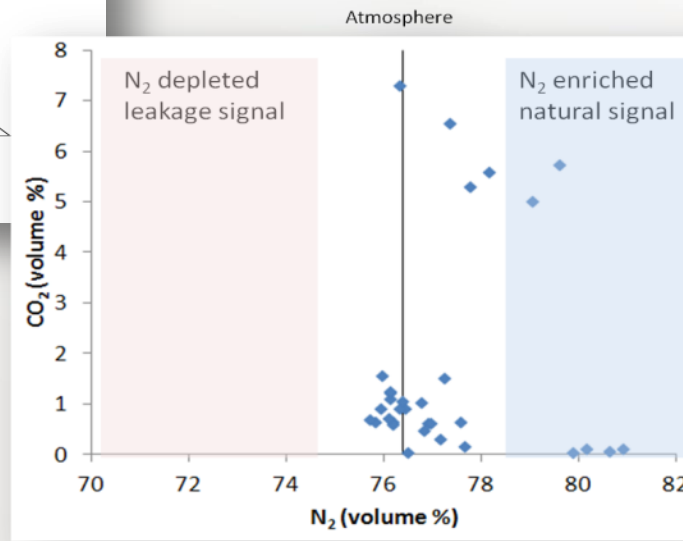


- Targeted approach based on Petrofind anomaly
- 10 sampling locations
- Minimal number of analytes
- Process-based method with no need for complex data sets or statistical analyses



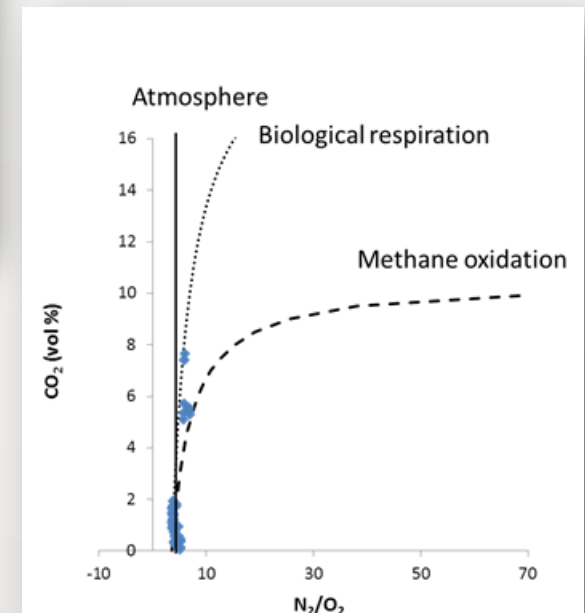
# Results

CO<sub>2</sub> is from biologic respiration with some dissolution of CO<sub>2</sub> into groundwater.



No input of exogenous gas from depth

Methane oxidation is negligible





# Leakage Allegation Discounted

“In a media release, Ecojustice lawyer Barry Robinson, who represented the Kerrs, accepted the IPAC-CO<sub>2</sub> study’s findings while emphasizing its necessity, saying that “without a full scale investigation, it has been impossible until now to rule out CO<sub>2</sub> contamination.”

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**FOR IMMEDIATE RELEASE**

**Long-awaited investigation into CO<sub>2</sub> impacts a 'win for all Canadians'**

DEC 12, 2011 09:37 AM

**ACN** Canadian Chemical News  
L'Actualité chimique canadienne

## Weyburn CO<sub>2</sub> leak a false alarm

By Tyler Irving  
Posted February 2012

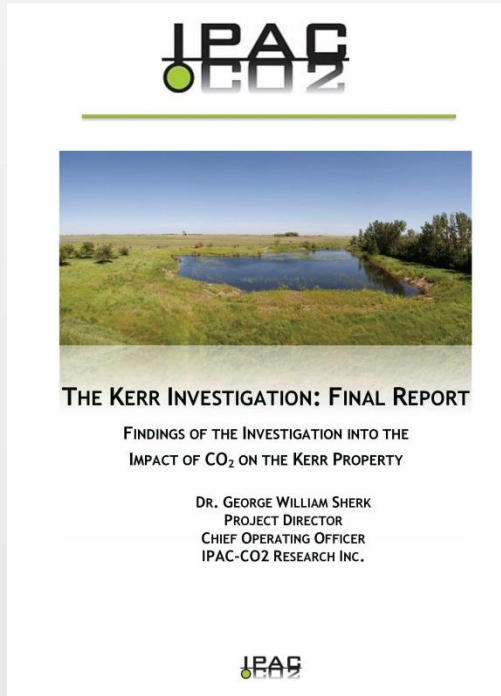
In January 2011, Cameron and Jane Kerr alleged that CO<sub>2</sub> from a nearby experimental carbon storage project was leaking onto their farm near Weyburn, Sask. A year later, two independent investigations have concluded that this is not the case.

The project consists of piping CO<sub>2</sub> from a coal gasification plant in North Dakota into an oil field operated by Canadian oil company Cenovus. Last summer, Cenovus contracted TRIUM Environmental to undertake extensive soil and surface water sampling operations on the property. The results, delivered last November, show CO<sub>2</sub> concentrations consistent with what is commonly found in prairie soil gas in summer. Moreover, carbon levels were inversely correlated with oxygen levels, a sign that the CO<sub>2</sub> was produced by biological respiration. Finally, the presence of unstable <sup>14</sup>C indicated a young carbon source. Since <sup>14</sup>C has a half-life of about 5,730 years, it would have been absent in CO<sub>2</sub> from the several million-year-old coal deposits.

# Summary

- The IPAC-CO<sub>2</sub> Kerr investigation is a case study in incident response.
- Adopting an incident response plan in advance of a CCS project is beneficial for avoiding :
  - Long-running allegations,
  - Unqualified sources reaching incorrect conclusions
  - Inaccurate information affecting public perception of CCS.
- Relatively simple tools for incident response are available
  - A process based approach to fingerprinting anomalies is cost effective, accurate, relatively simple and can be used in areas lacking background data.

# More Information



## [IPAC-CO2: The Kerr Investigation - YouTube](#)



[www.youtube.com/watch?v=wcxIXpl21IQ](http://www.youtube.com/watch?v=wcxIXpl21IQ)

Dec 7, 2011 - 28 min - Uploaded by ipacco2

A video documenting **IPAC-CO2's** independent investigation into the source of carbon dioxide on ...

Romanak, K. D., Bennett, P. C., Yang, C., and Hovorka, S. D., 2012, Process-based approach to CO<sub>2</sub> leakage detection by vadose zone gas monitoring at geologic CO<sub>2</sub> storage sites: Geophysical Research Letters, v. 39, L15405, doi:10.1029/2012GL052426.

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<http://www.ipac-co2.com/projects/investigations>