

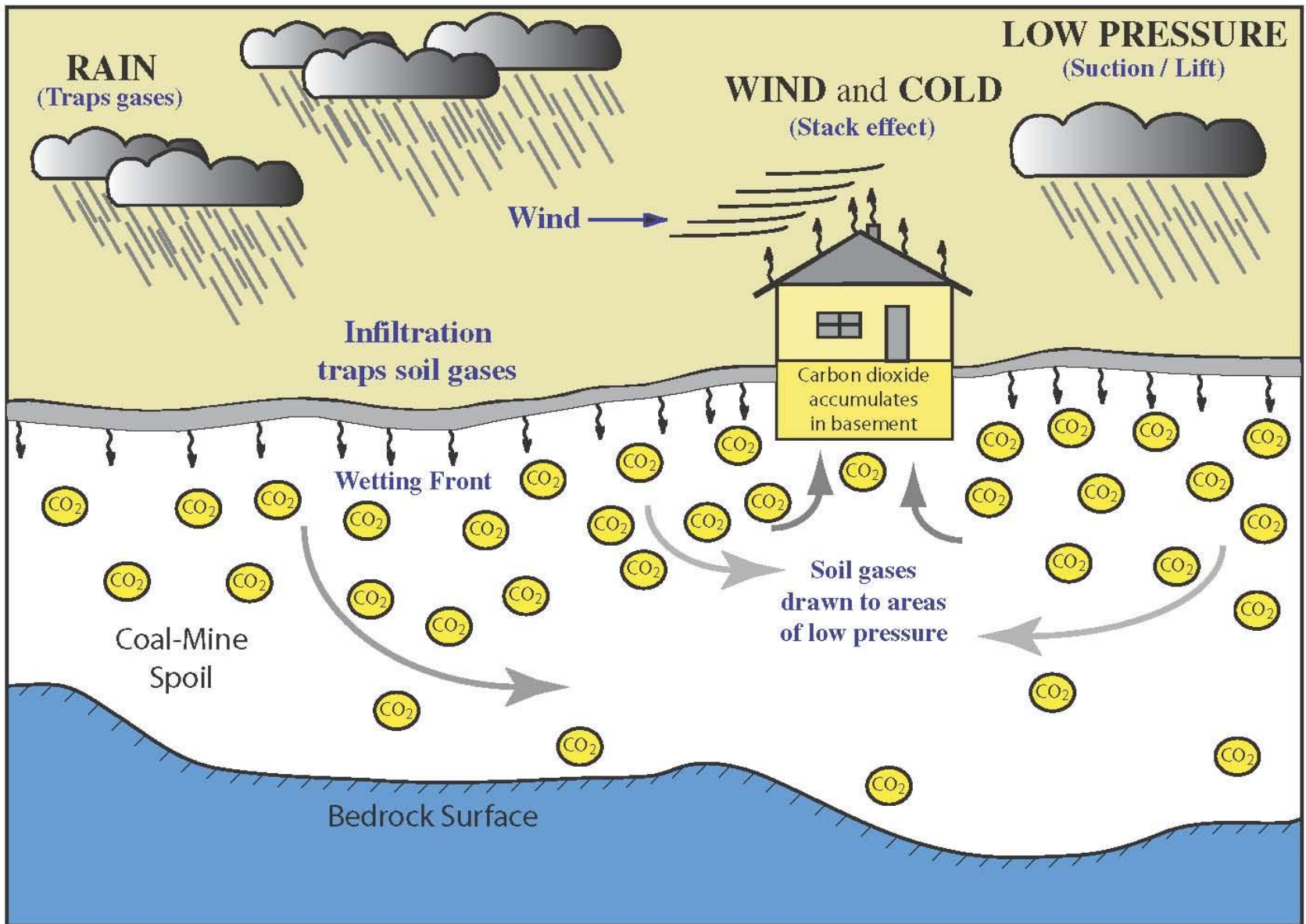
The Occurrence and Mitigation of Carbon Dioxide in Homes Built on Reclaimed Coal Mines

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A cooperative investigation by the
Indiana Dept. of Natural Resources, Div. of Reclamation
and the
U.S. Geological Survey

Soil-Gas Migration Model



Health Concerns



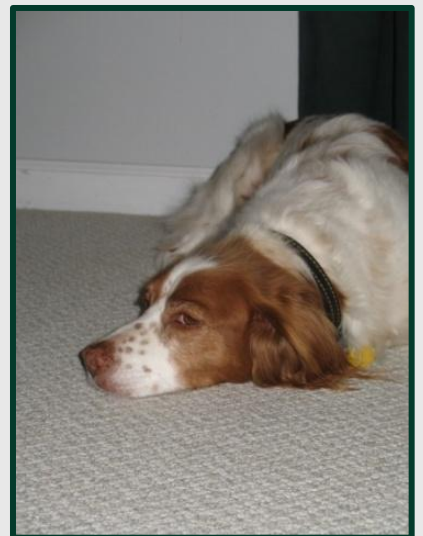
CO₂ cloud settles to floor level

Carbon Dioxide

- Heavy (SG: 1.524)
- Asphyxiant (Displaces O₂)

Oxygen Deficiency

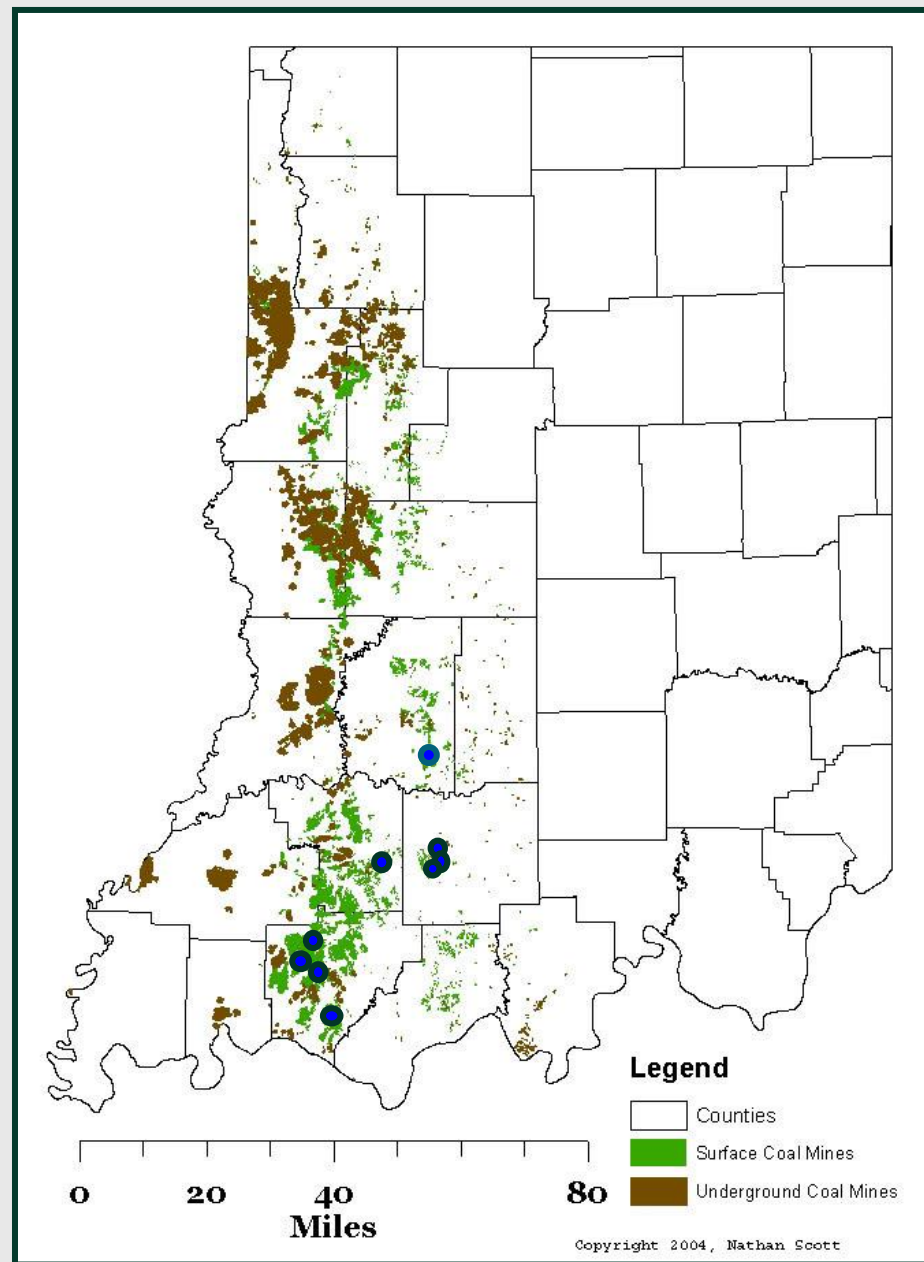
- Rapid breathing
- Dizziness
- Headaches
- Confusion
- Blackout
- Death



Special concern

Identified CO₂ Problems

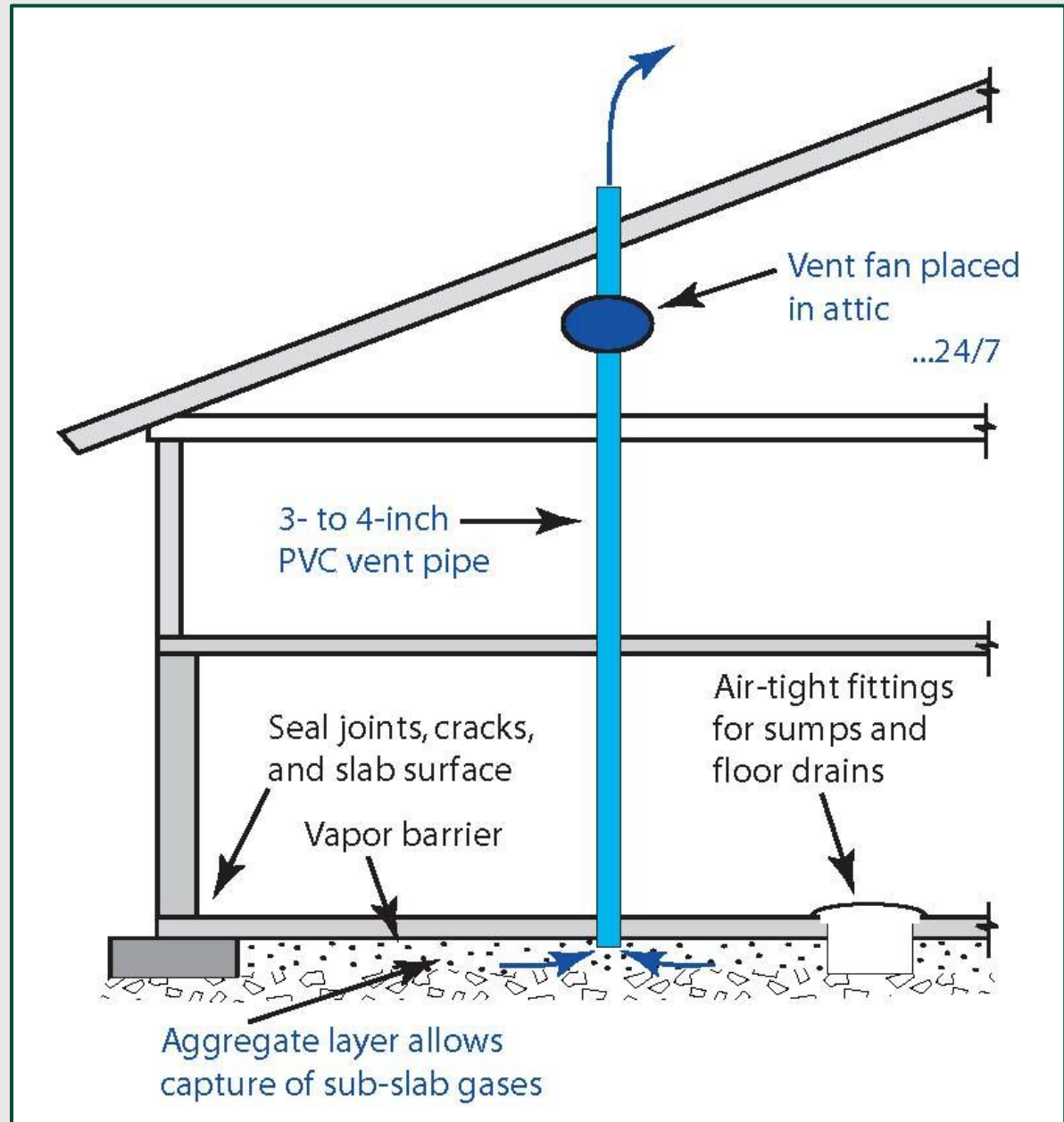
- Beginning in 2005
- New homes with basements
- On or near reclaimed mines
- Sporadic low-O₂ symptoms



Southwest Indiana's Mined Lands

“Radon Approach” to Mitigation

Sub-slab depressurization



Pike Co. Home

Classic CO₂ symptoms

- Pilot lights
- Loss of 5 cats
- Many health issues

Fresh air:

O₂ 21%

CO₂ 0.03%

Pike Co. Home:

O₂ <9%

CO₂ >15%

(no sub-slab aggregate)

(Front)



(Rear)



Soil-Gas Flux Distribution

85 Sampling Nodes

- CO₂ Flux
(Soil temperature)
- Soil pH
- Air temperature
- Barometric pressure

Results:

Fairly even flux
distribution



Groundwater's Role



Three pairs of nested wells

- Up gradient pair
- House pair
- Down gradient pair

Lake staff gage

Results:

- Five wells are dry.
- Lake is losing to groundwater.
- Groundwater is not a significant driver.

On-site Weather Station

- Precipitation
- Temperature
- Pressure
- Relative humidity
- Wind speed
- Wind direction

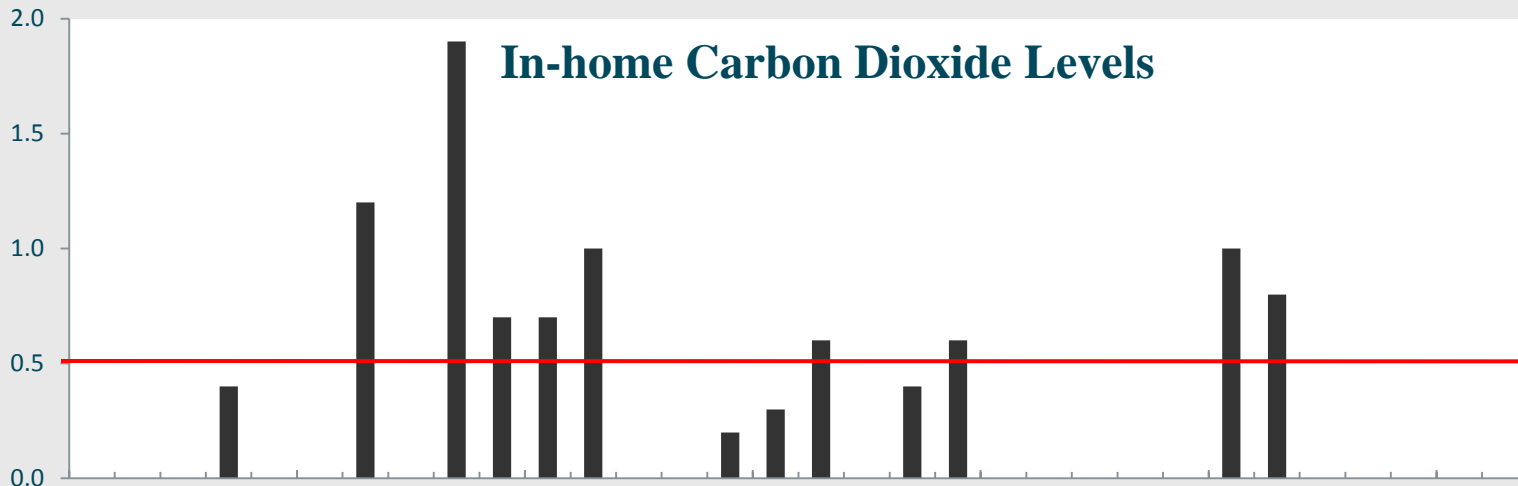
Results:

Pressure drops and precipitation
are significant drivers

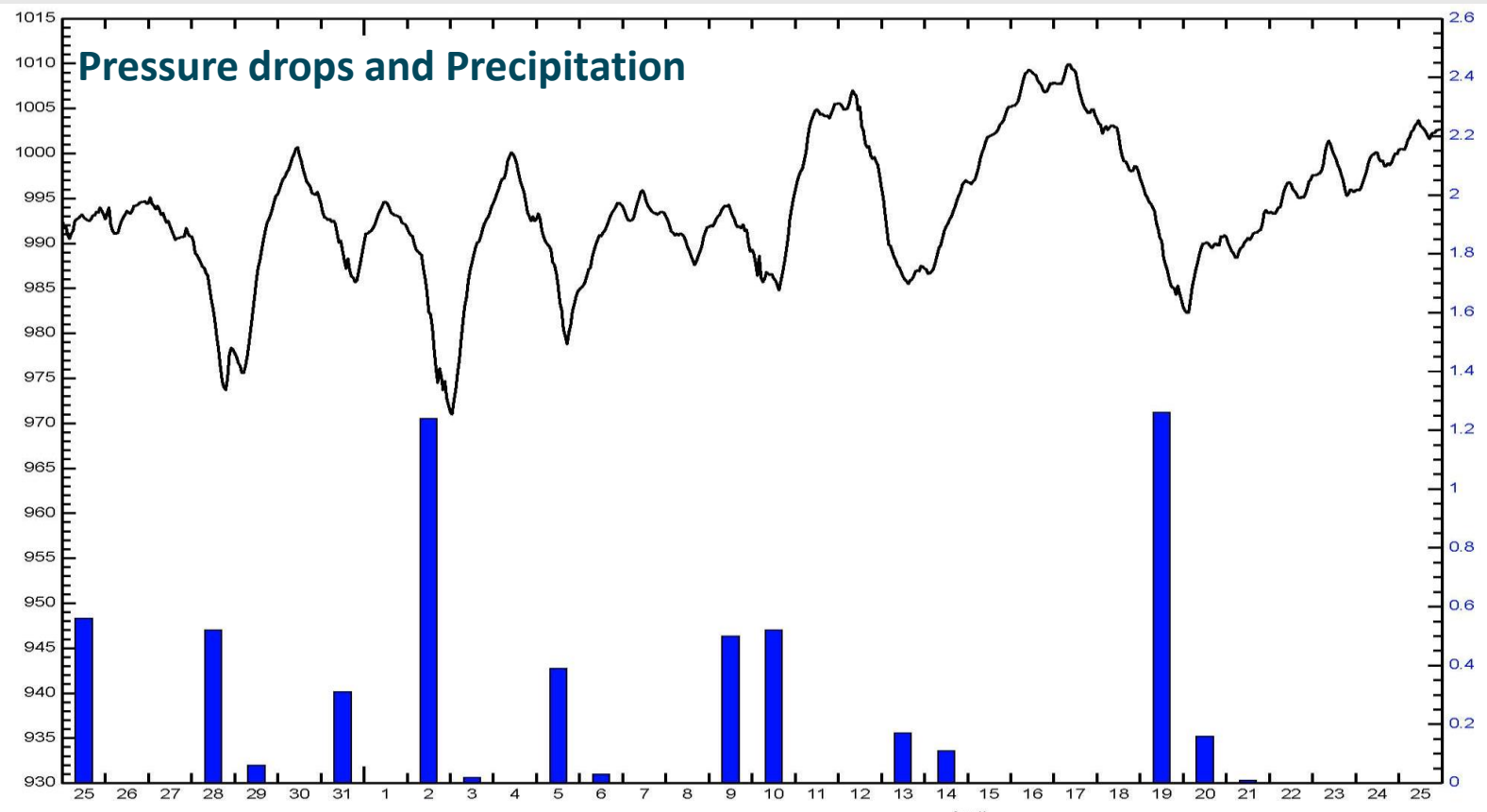


Records and transmits (near real-time web)

Carbon Dioxide
(percent)



Barometric Pressure (mb)



Precipitation (in)

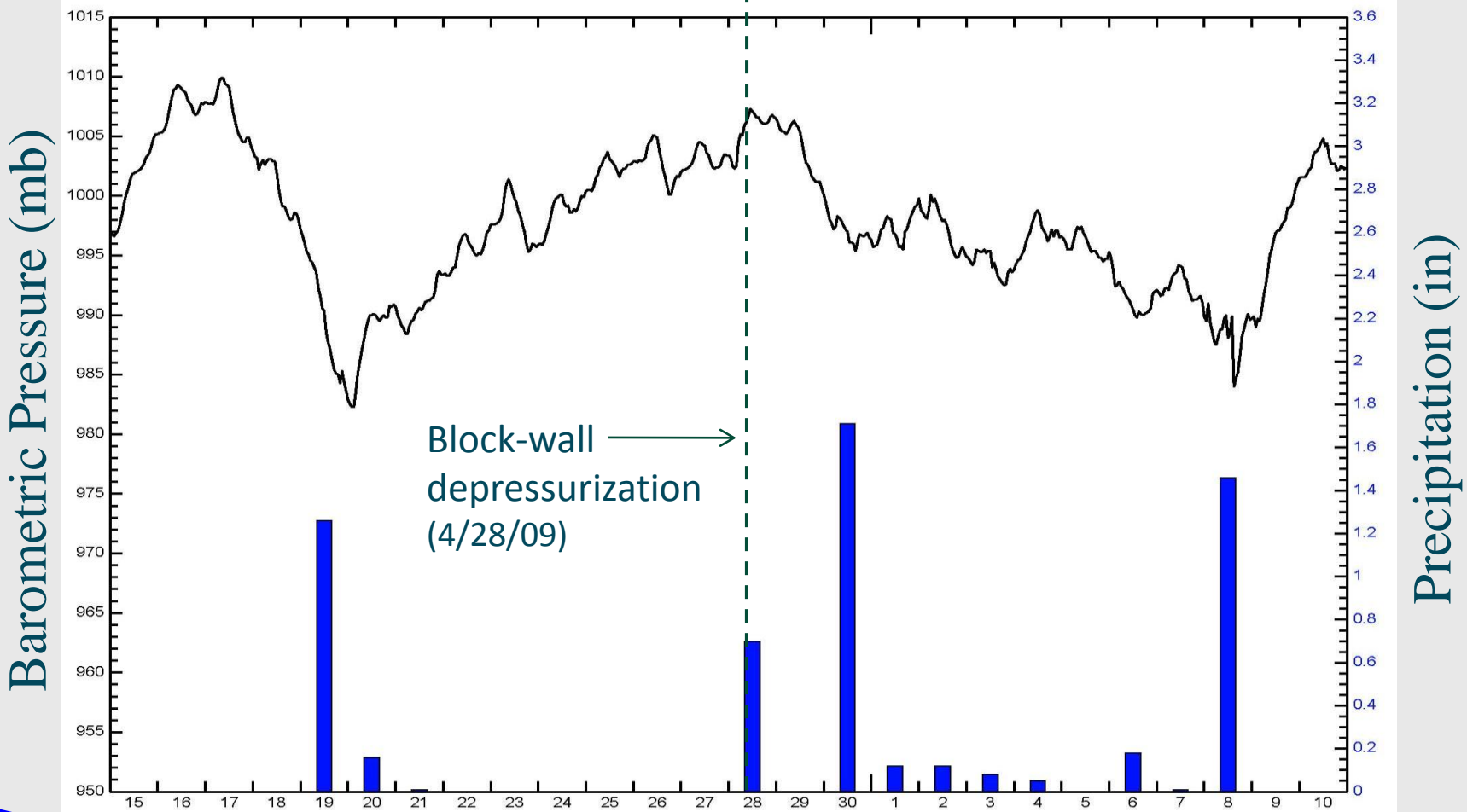
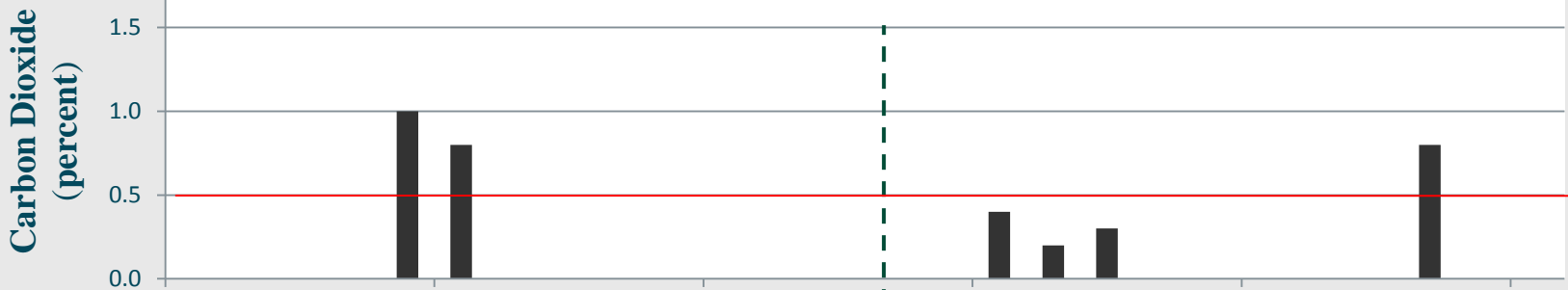


March 25 to April 25, 2009

Mitigation (Trial 1) ...Block-wall depressurization



In-home Carbon Dioxide Levels



April 15 to May 10, 2009



Mitigation (Trial 2)

...Sub-slab depressurization



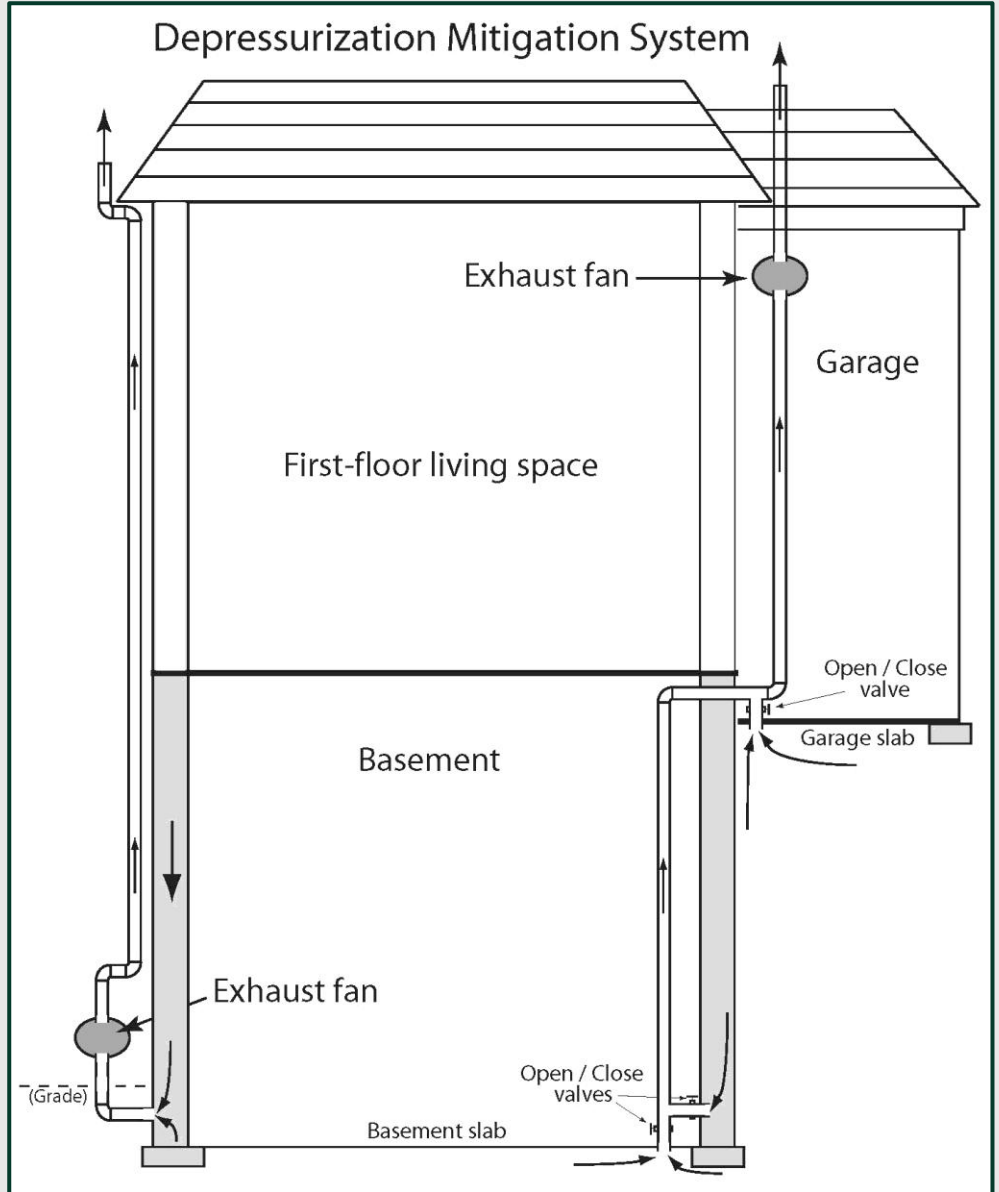
1. Core through slab

2. Excavate a soil-gas suction pit



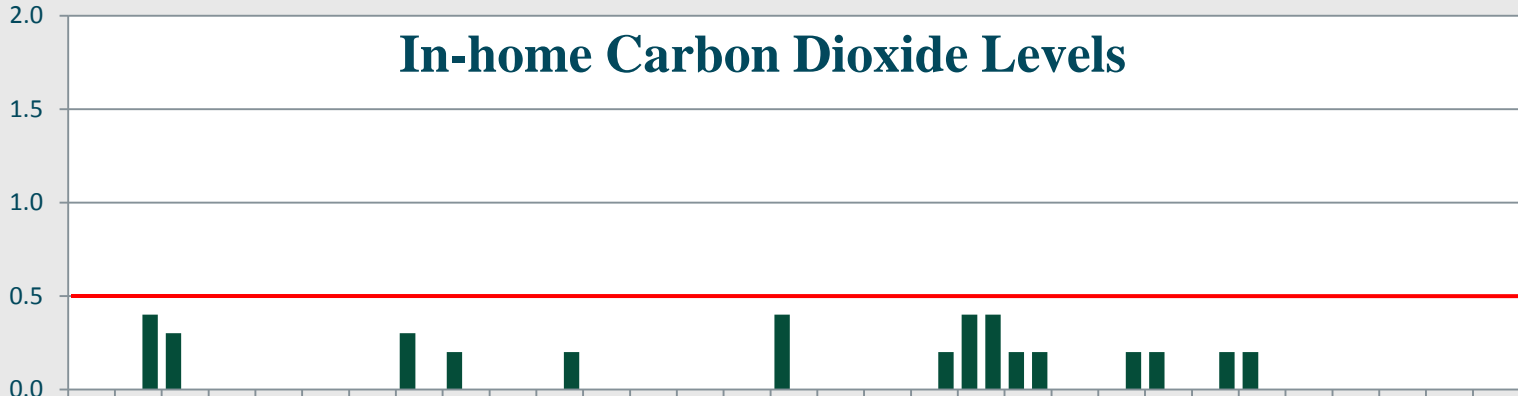
3. Hope for desiccation cracks

Mitigation Design (Trial 2)

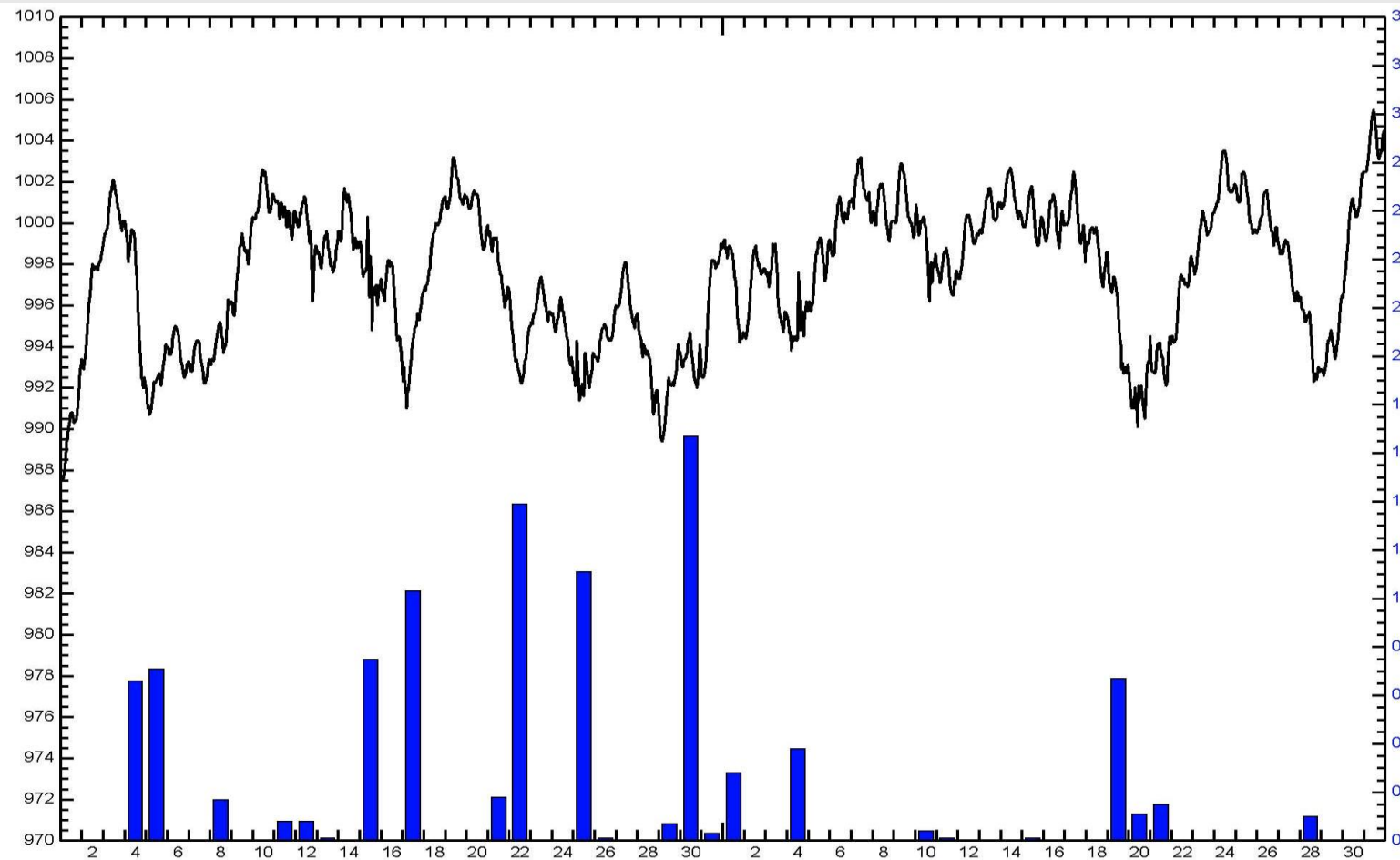


Carbon Dioxide
(percent)

In-home Carbon Dioxide Levels



Barometric Pressure (mb)



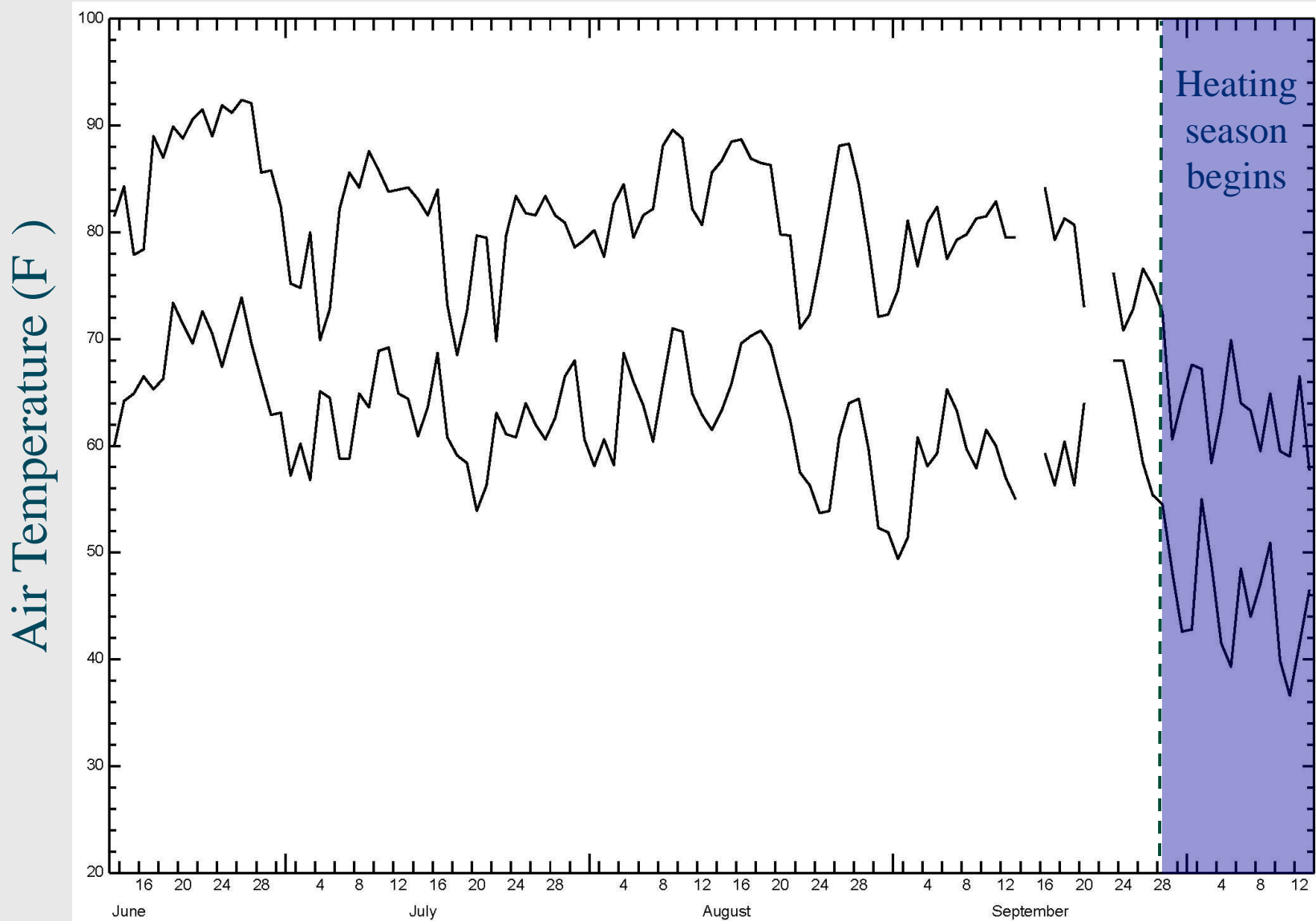
Precipitation (in)



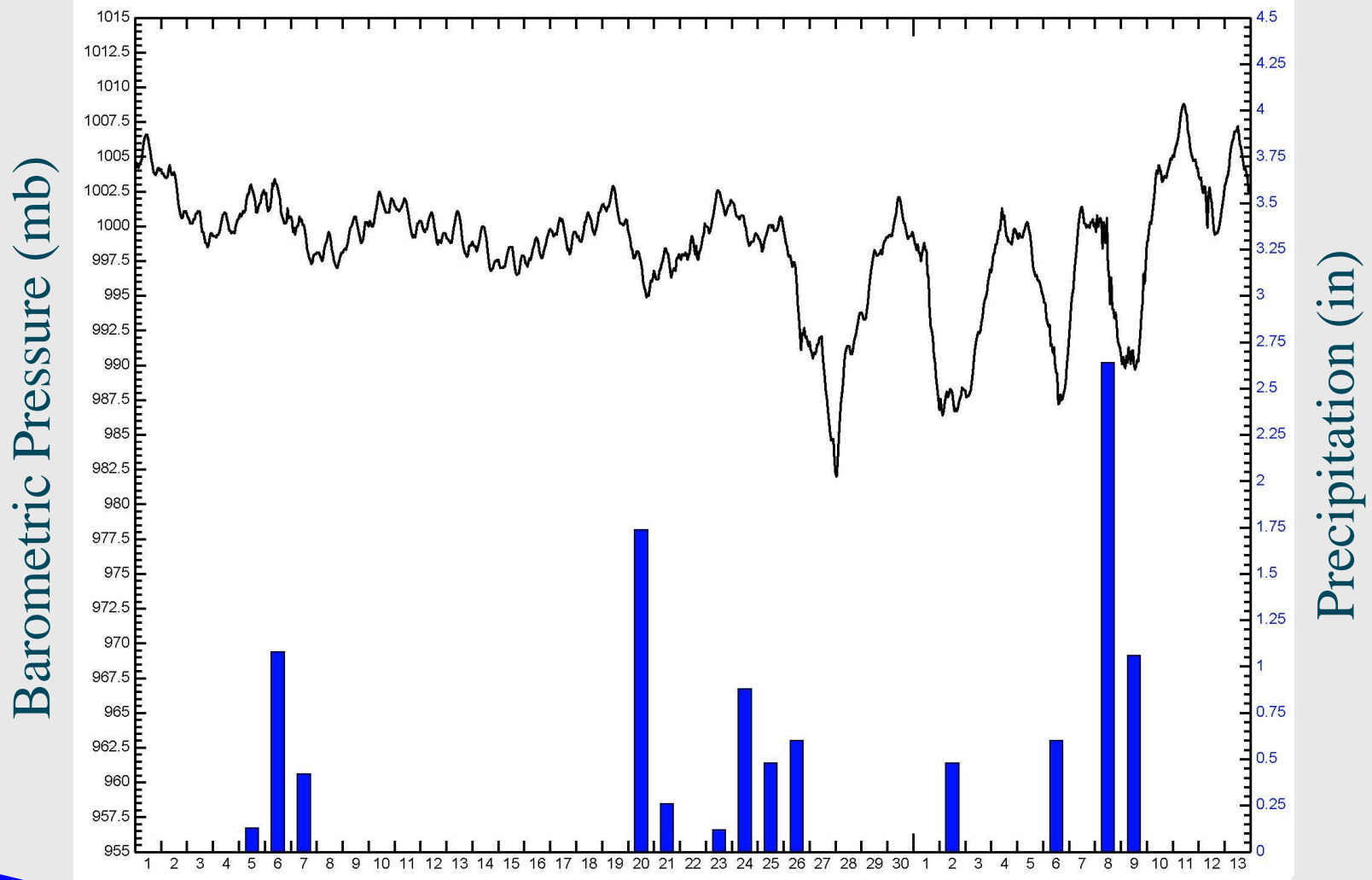
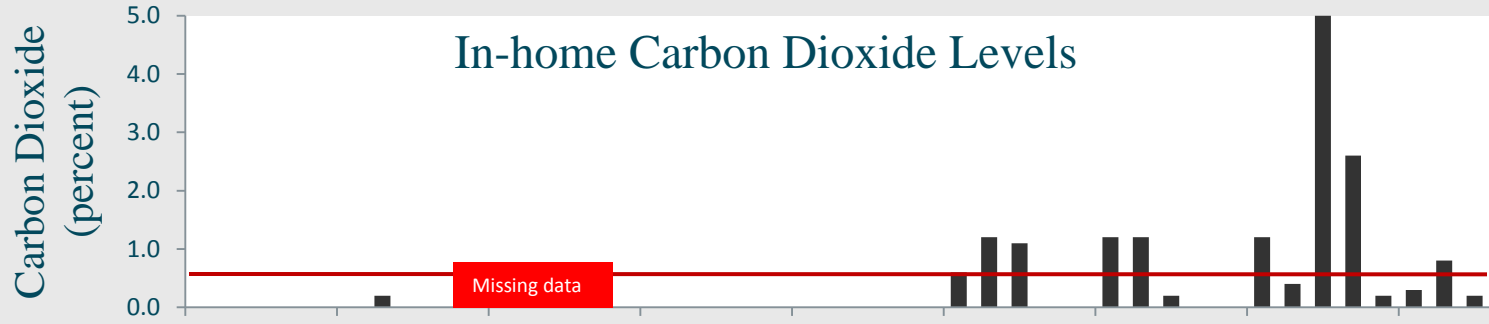
July

August

Daily High and Low Air-Temperatures

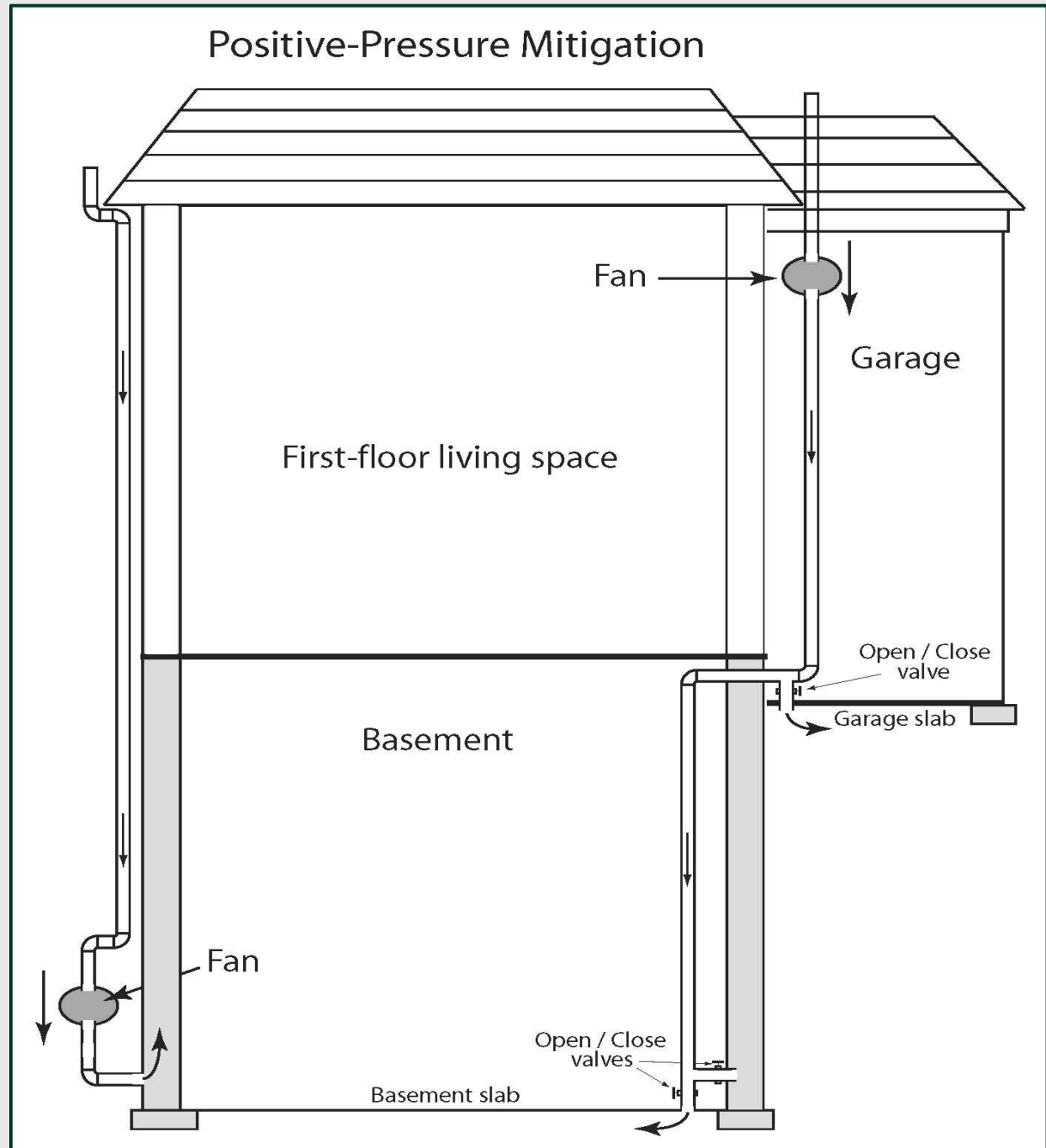


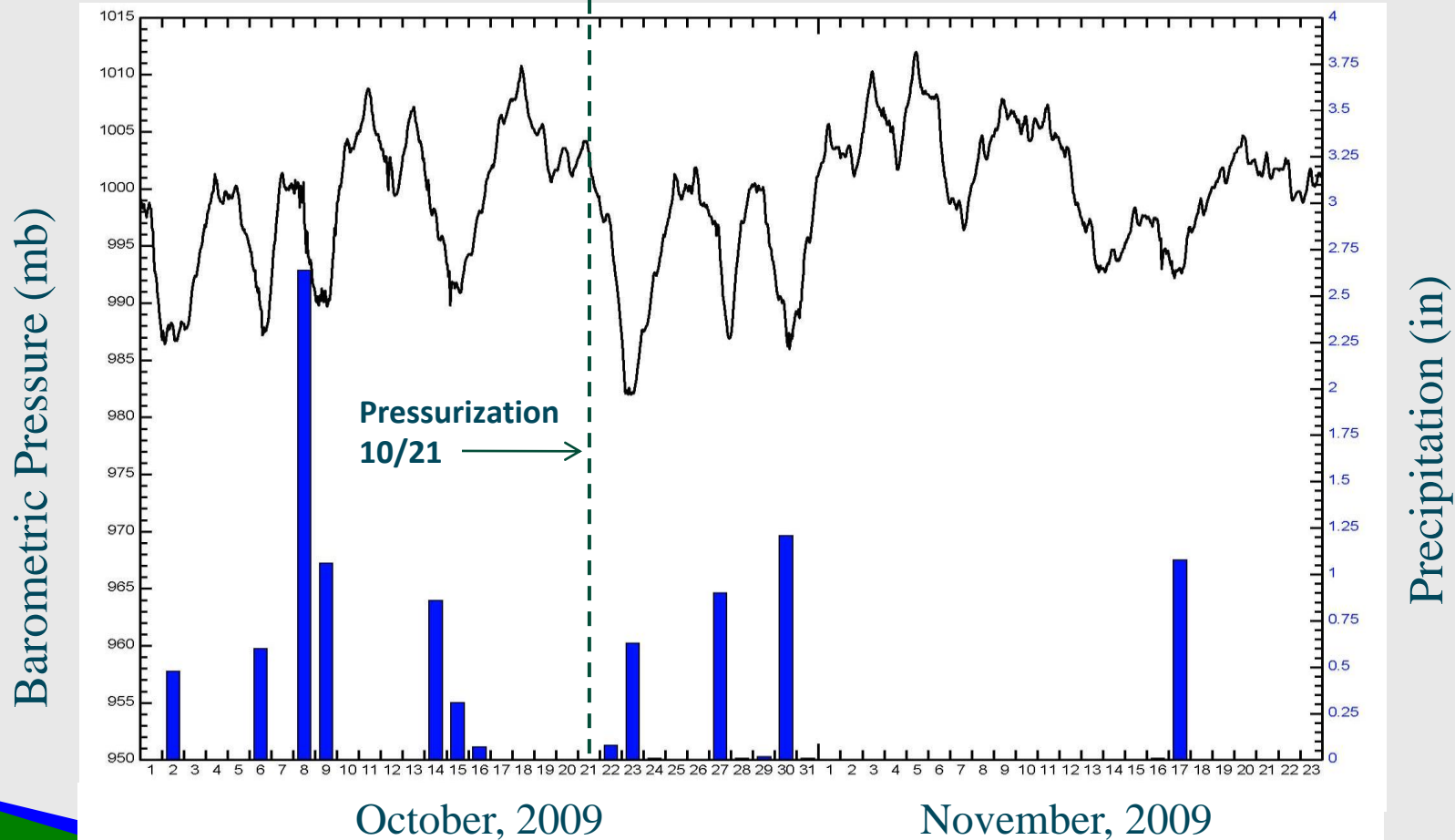
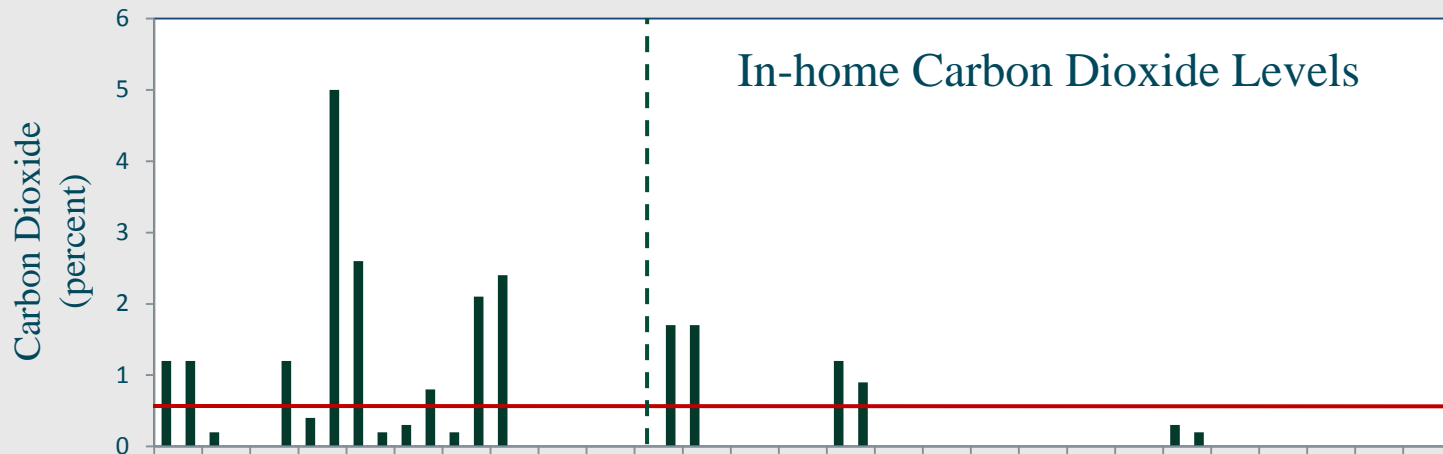
2009



Mitigation (Trial 3)

...Positive Pressure
(sub-slab and walls)





Significant Findings

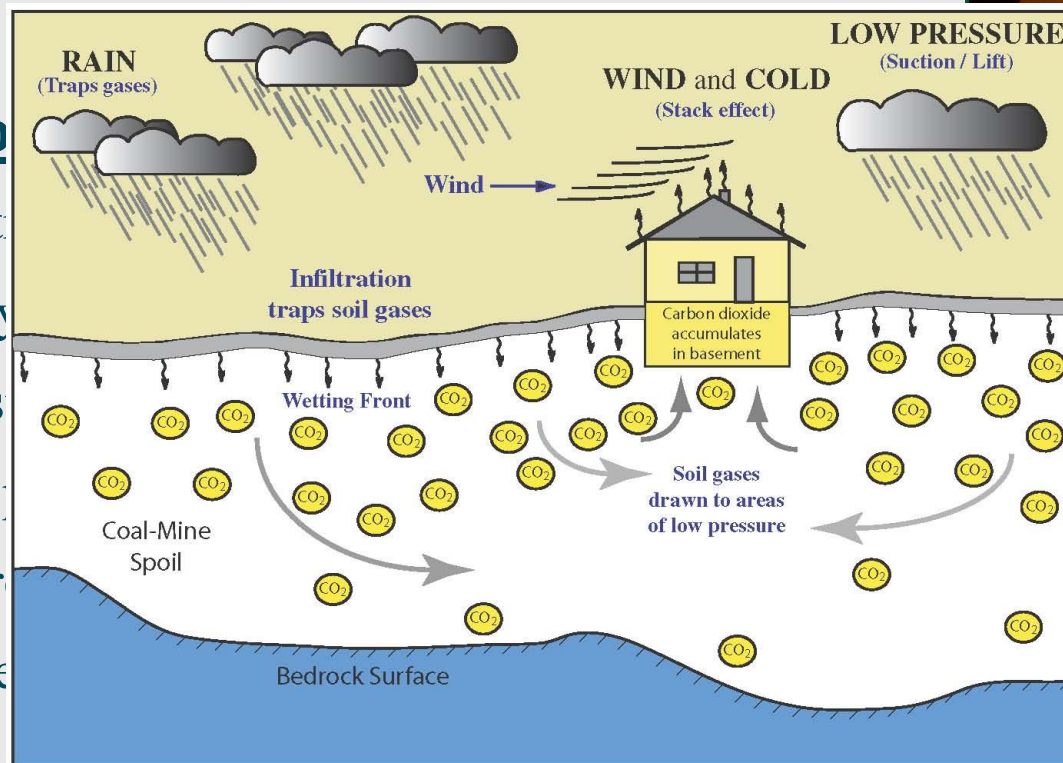
Occurrence

- Precipitation / Infiltration trap soil gases
- Heating a cold house causes a chimney effect
- Barometric pressure drop draws soil gases in and up



Mitigation

- Pre-const
- Don't rely
- "Radon-s
- Sub-slab
- PA resear
- Remember



ressurization