

Has That New Home Taken Your Breath
Away?
**Problems with Carbon Dioxide
Infiltration into Residences
Constructed Upon Reclaimed Surface
Mines**



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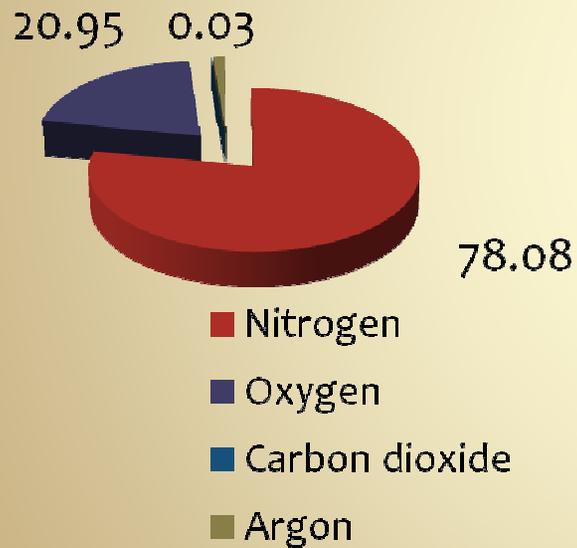
CO₂ Contamination Problems in Homes

- **“Blackdamp”**
- **Usually associated with communication of shallow abandoned mine atmosphere with surface structures via old shafts & entries**
 - **12 – 15 % CO₂ in abandoned mine atmosphere**
 - **CO₂ & Methane are natural products of coal**

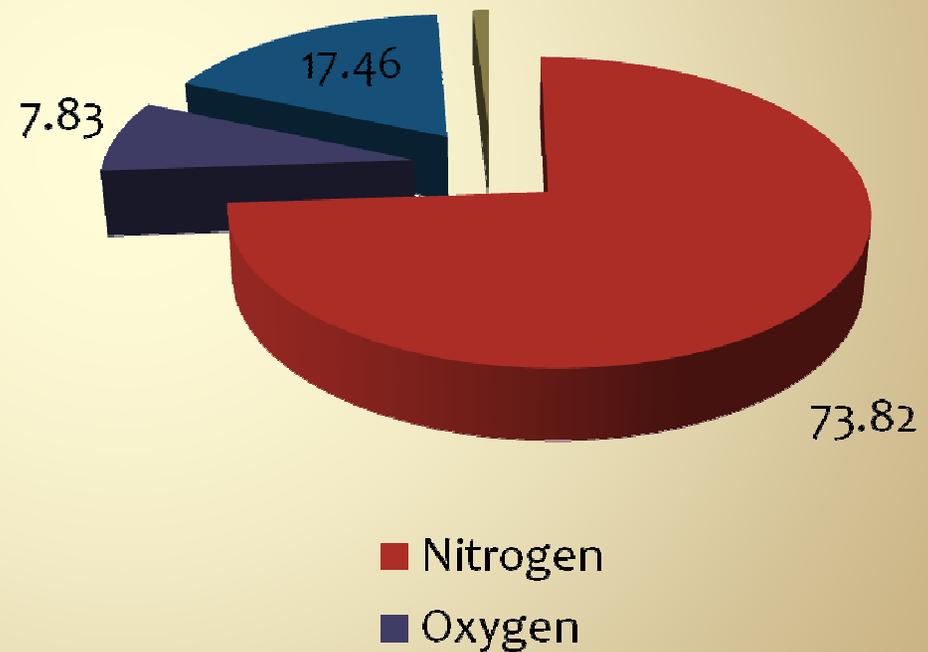


CO2 Replaces O2 and N2

Normal Air



Mine Gas



Physiological Effects of Carbon Dioxide

| % CO₂ in Air | Increase in Respiration |
|--------------------------------|--|
| 0.03 | Normal Air & Respiration |
| 0.05 | Slight Increase |
| 0.5 | TLV-TWA (8-hr max by law) |
| 2.0 | 50% more Respiration |
| 3.0 | 100% more Respiration TLV-STEL (max by law) |
| 5.0 | 300%, Laborious Breathing |
| 10.0 | Cannot be endured, unconsciousness |

Concentrations over 0.5% CO₂ produce relative decrease in O₂.

Physiological Effects of Oxygen

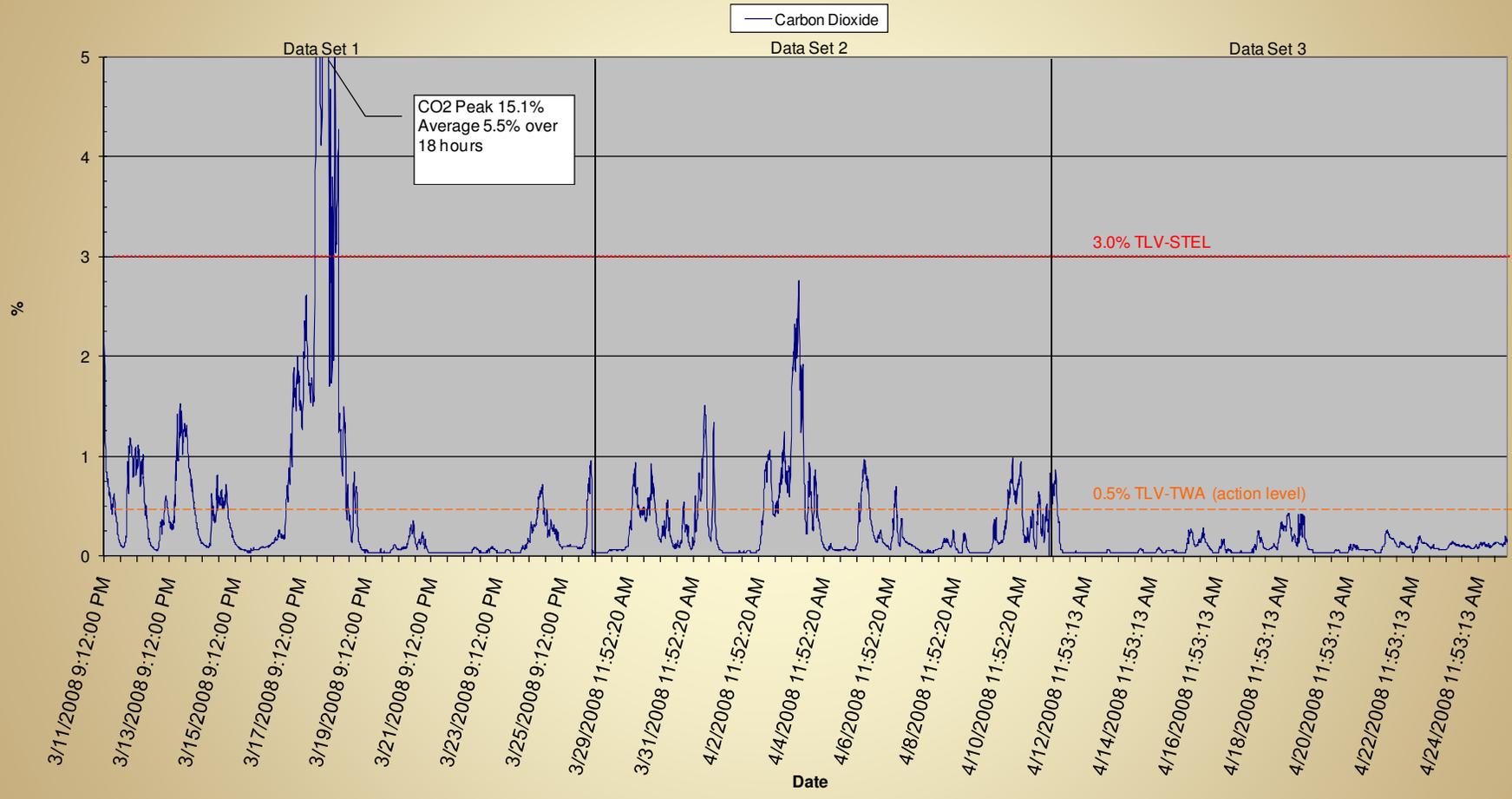
| O ₂ - Percent | Effect |
|--------------------------|--|
| 21% | Normal Breathing |
| 19.5% | Minimum Required by Law |
| 17% | Breathing Becomes Faster & Deeper |
| 16% | Pilot Light Extinguishes |
| 16-13% | Dizziness, Rapid Pulse, Headache, etc. |
| 9% | Unconsciousness |
| 6% | Convulsions and Death |

Equipment used to monitor ambient atmosphere levels



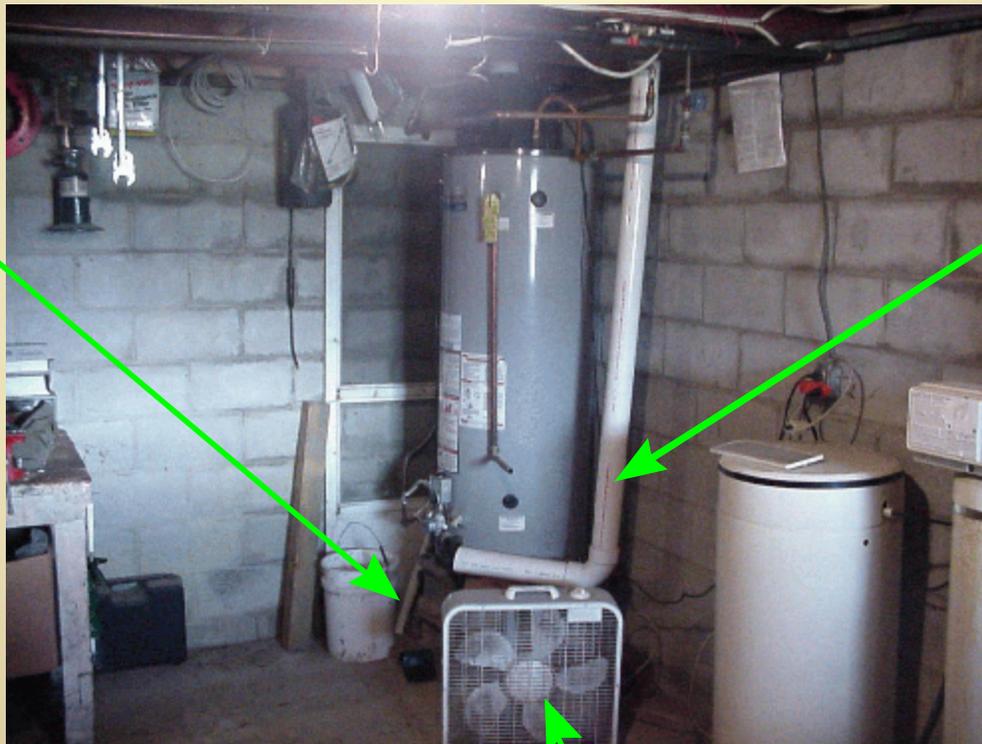
Data Set 1

• Typical Plot of Percent Carbon Dioxide over Time



Modifications to Hot Water Heater by Home Owner to address Blackdamp Problems

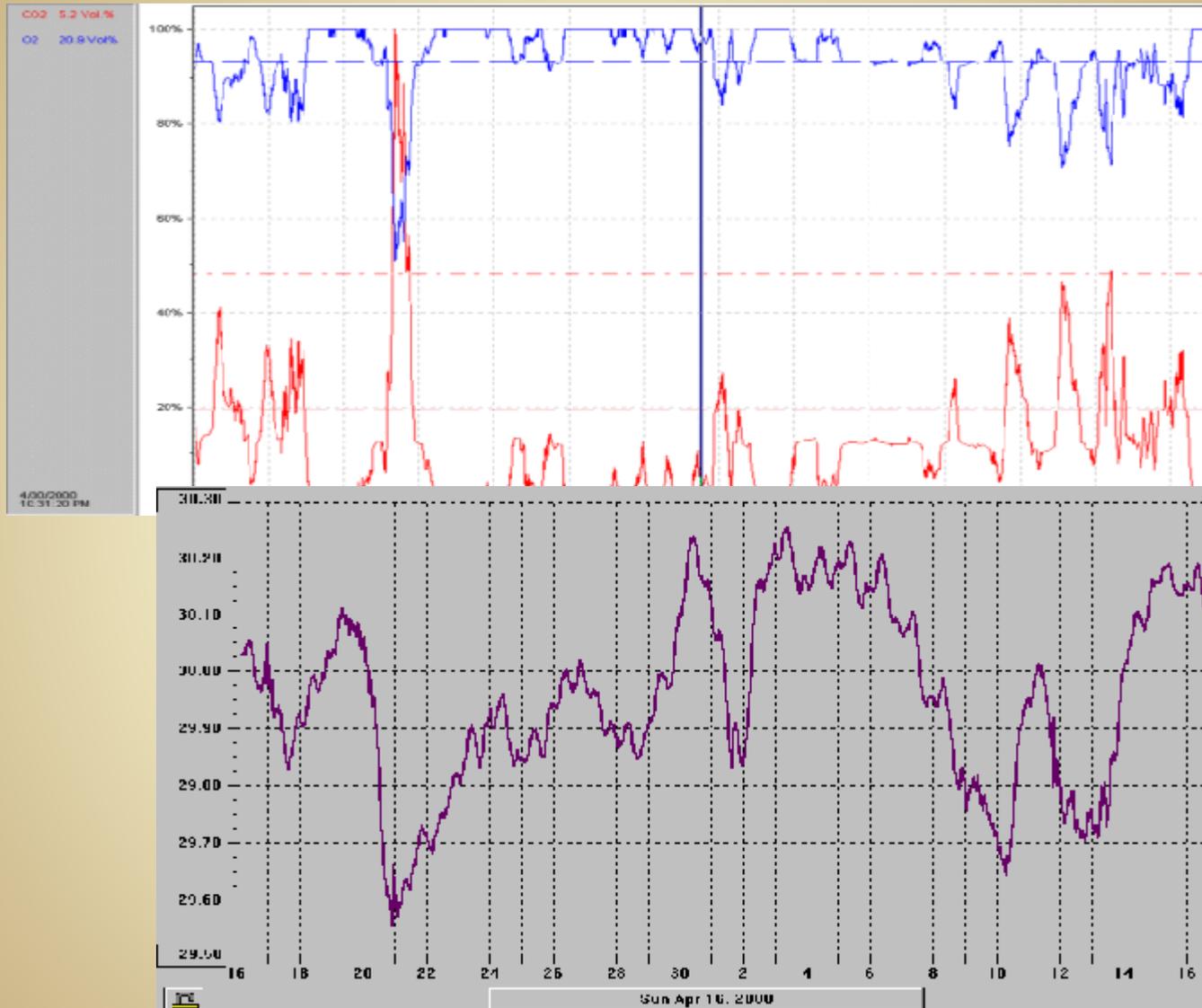
Base of Tank
Raised off of the
Floor



Fresh Air Inlet

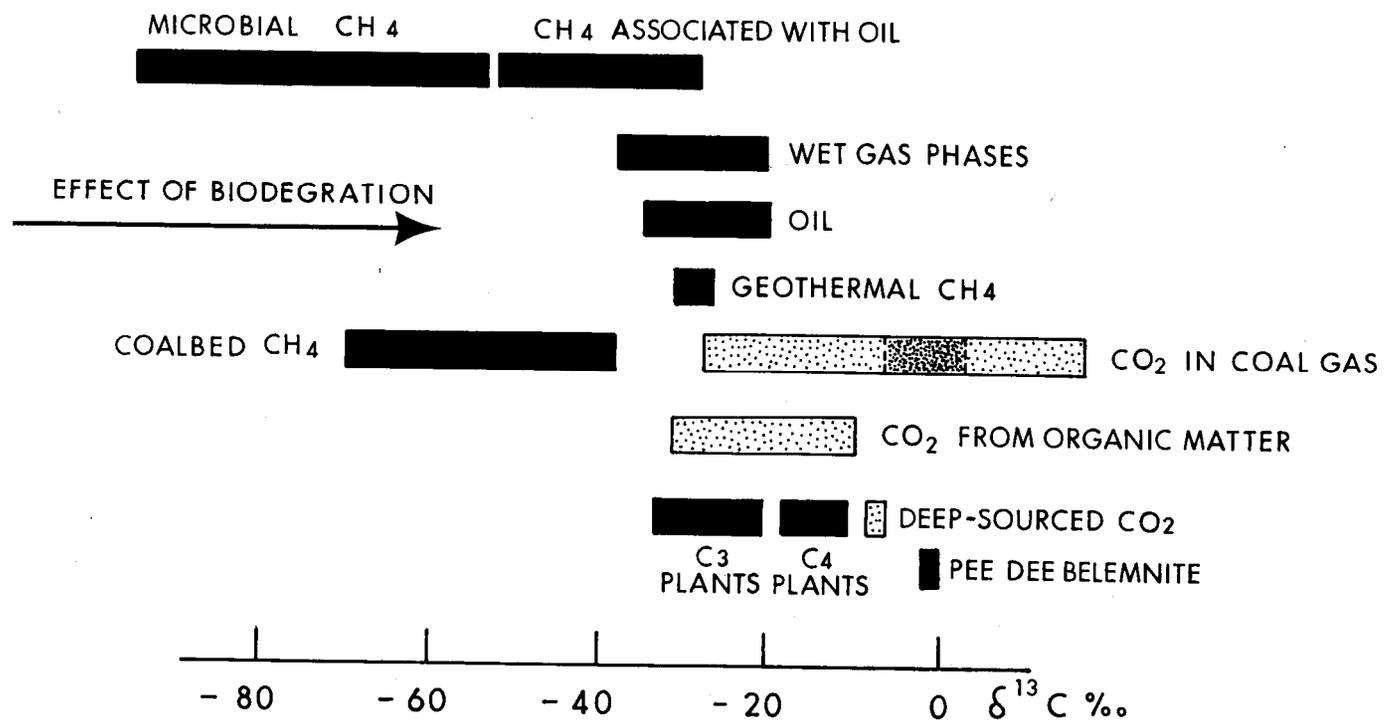
Box Fan to
Exhaust Air

Correlating Oxygen & Carbon Dioxide levels to Barometric pressure



Stable Isotope Geochemistry

- Isotopic ranges of natural gases are large in range, specific, predictable, and capable of providing diagnostic information on their source.
- Differences in isotopic mass lead to subtle but significant differences in the behavior of an element during natural processes (*fractionation*)
- $\delta^{13}\text{CO}_2 = R_{\text{sample}} - R_{\text{standard}} * 1000$ (permil)



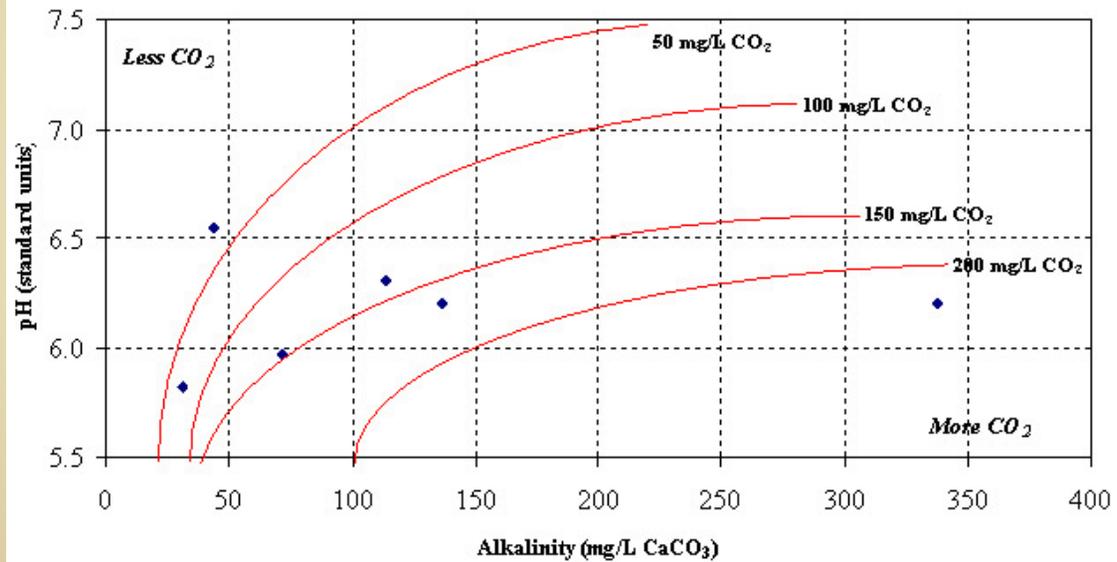
Overburden Characteristics

| Overburden Material | %-Total Sulfur | Neutralization Potential |
|---------------------|----------------|--------------------------|
| Glacial till | 0.22 | 54.5 |
| Shale | 0.17 | 17.1 |
| Sandy Shale | 0.12 | 21.7 |
| Sandstone | 0.24 | 13.9 |
| Coal Refuse | 3.14 | 2.45 |

Possible Carbonate Sources

| Sample | State (Stratigraphy) | Neutralization Potential (tons/1000 tons) | % Sulfur |
|--|-------------------------------------|--|----------|
| Brush Creek Shale | Pennsylvania (Conemaugh) | 96.9 | 0.59 |
| Kanawha Black Flint | West Virginia (Kanawha) | 16.9 | 0.31 |
| Lower Kittanning Underclay | Pennsylvania (Allegheny) | 12.6 | 0.91 |
| Houchins Creek Shale | Indiana (Carbondale) | 43.6 | 5.15 |
| Middle Kittanning Sandstone | Pennsylvania (Allegheny) | 17.7 | 0.04 |
| Wadesville Sandstone | Pennsylvania (Anthracite region) | 261 | 0.01 |
| Valentine Limestone | Pennsylvania | 902 | 0.01 |
| Coal Refuse (From processing Kittanning seams) | Pennsylvania (Allegheny) | 0.9 | 1.68 |
| Redstone Limestone | West Virginia (Monongahela) | 467 | 0.38 |

Carbon Dioxide Concentrations at Varying pH and Alkalinity Values



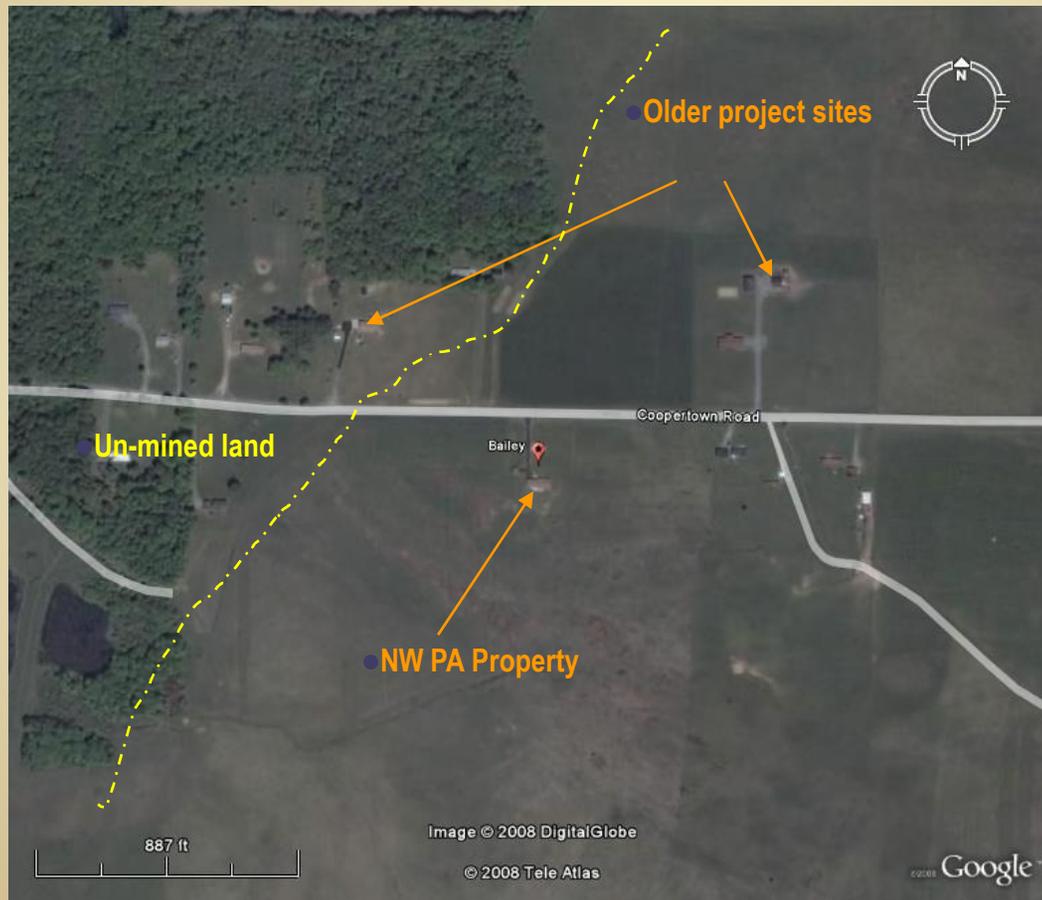
CO₂ Contamination Problem in Northwestern Pennsylvania

**NW PA Residence, Volant, Lawrence County
2006**

- **CO₂ ambient levels up to 3.0% measured inside the home**
- **O₂ levels depressed as low as 18% inside the home**
- **CO₂ levels more than 25% measured in cracks and holes in the foundation around the home**
- *Low barometric pressure*



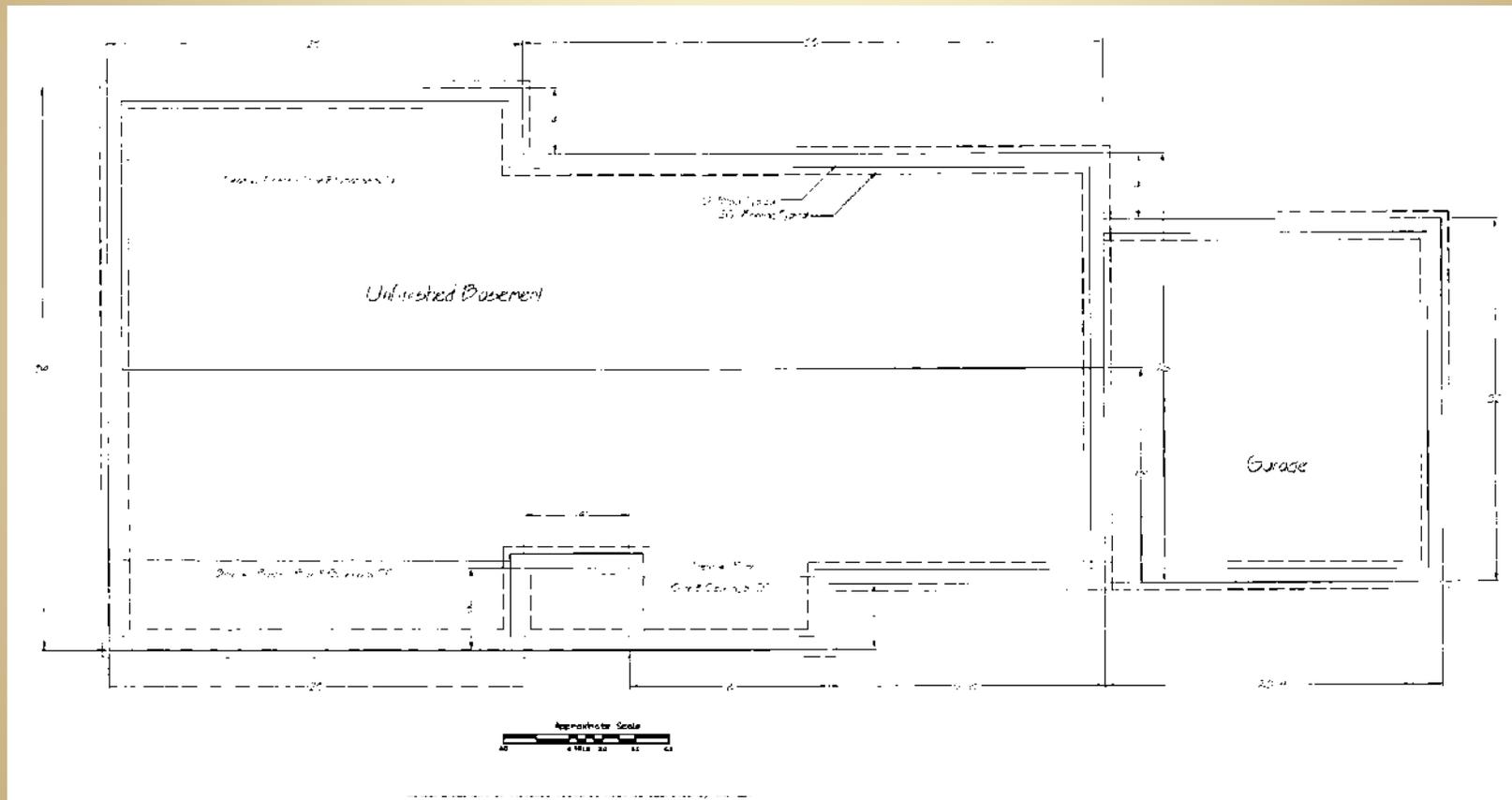
Aerial View of NW PA



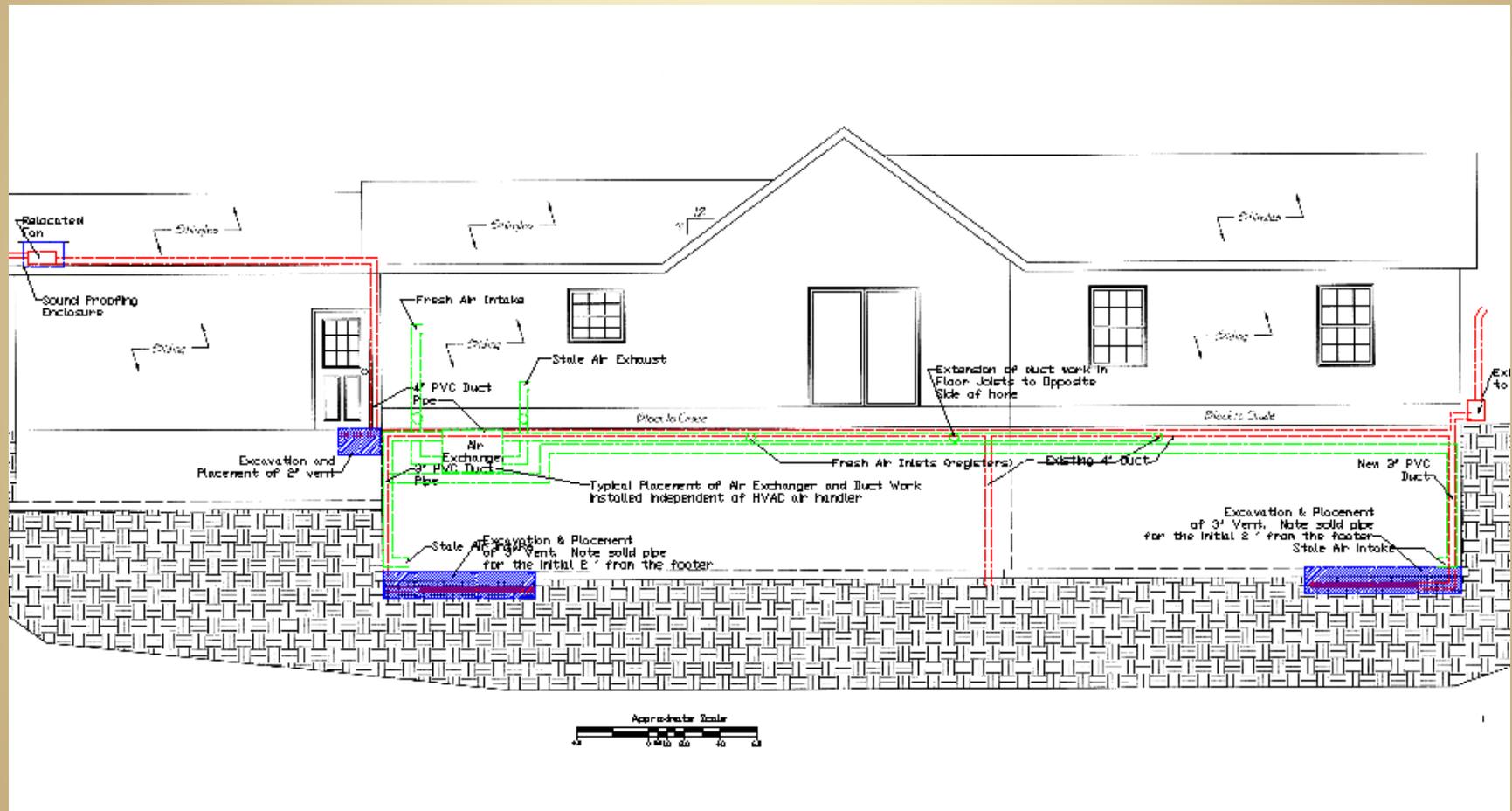
NW PA Property



NW PA Basement floor Plan



NW PA Elevation



Cost / Benefits

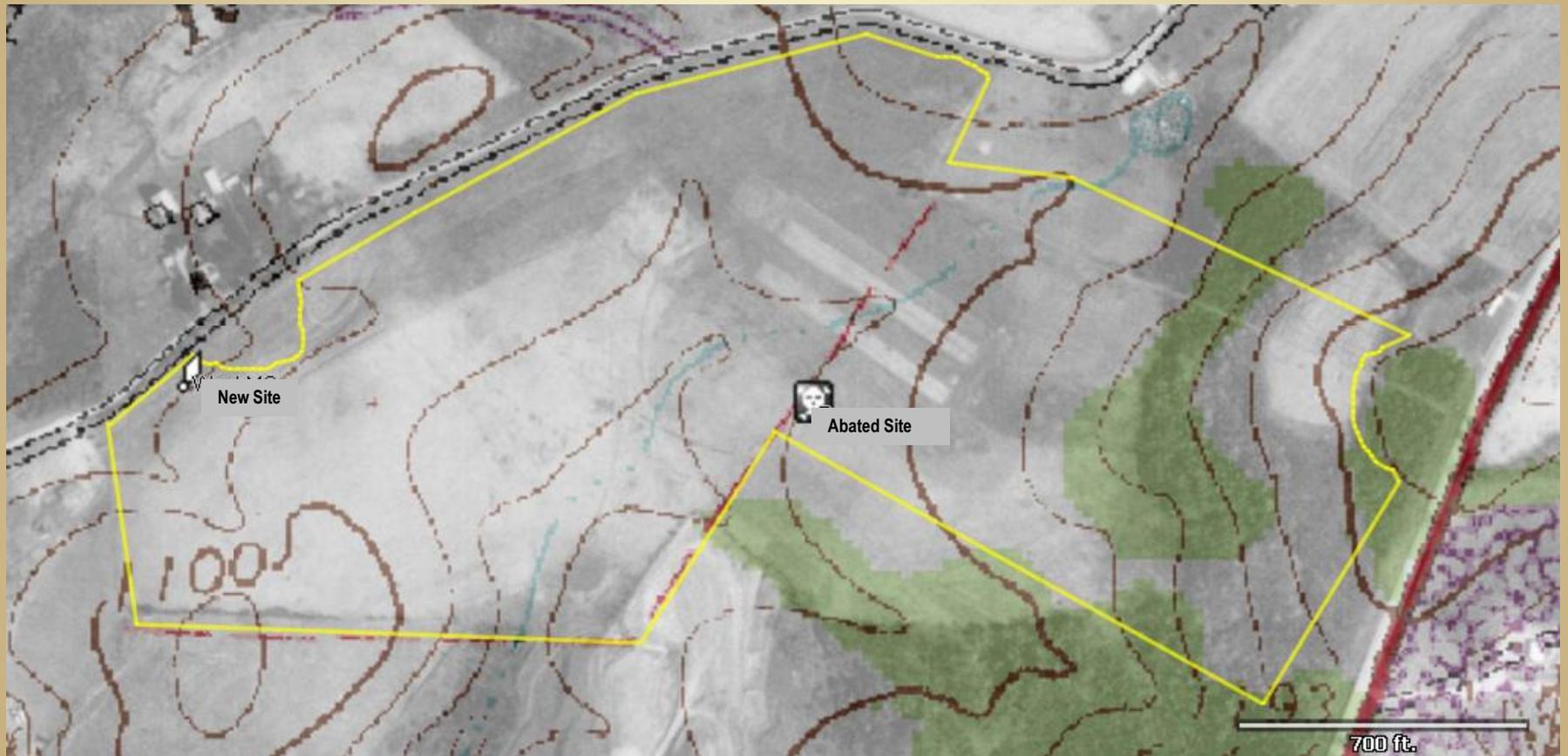
- Cost: \$23,000
- Construction Period: 15 Days
- Power consumption: 350watts
- Noise
- Temperature differential in basement
- Long-term Maintenance

CO₂ Contamination Problem in Southwestern Pennsylvania

**SW PA residence, Fairchance, Fayette County
2006**

- **CO₂ ambient levels up to 6.3% measured inside the home**
- **O₂ levels depressed as low as 16% inside the home**
- **CO₂ levels more than 25% measured in cracks and holes in the foundation around the home**
- *Low barometric pressure*

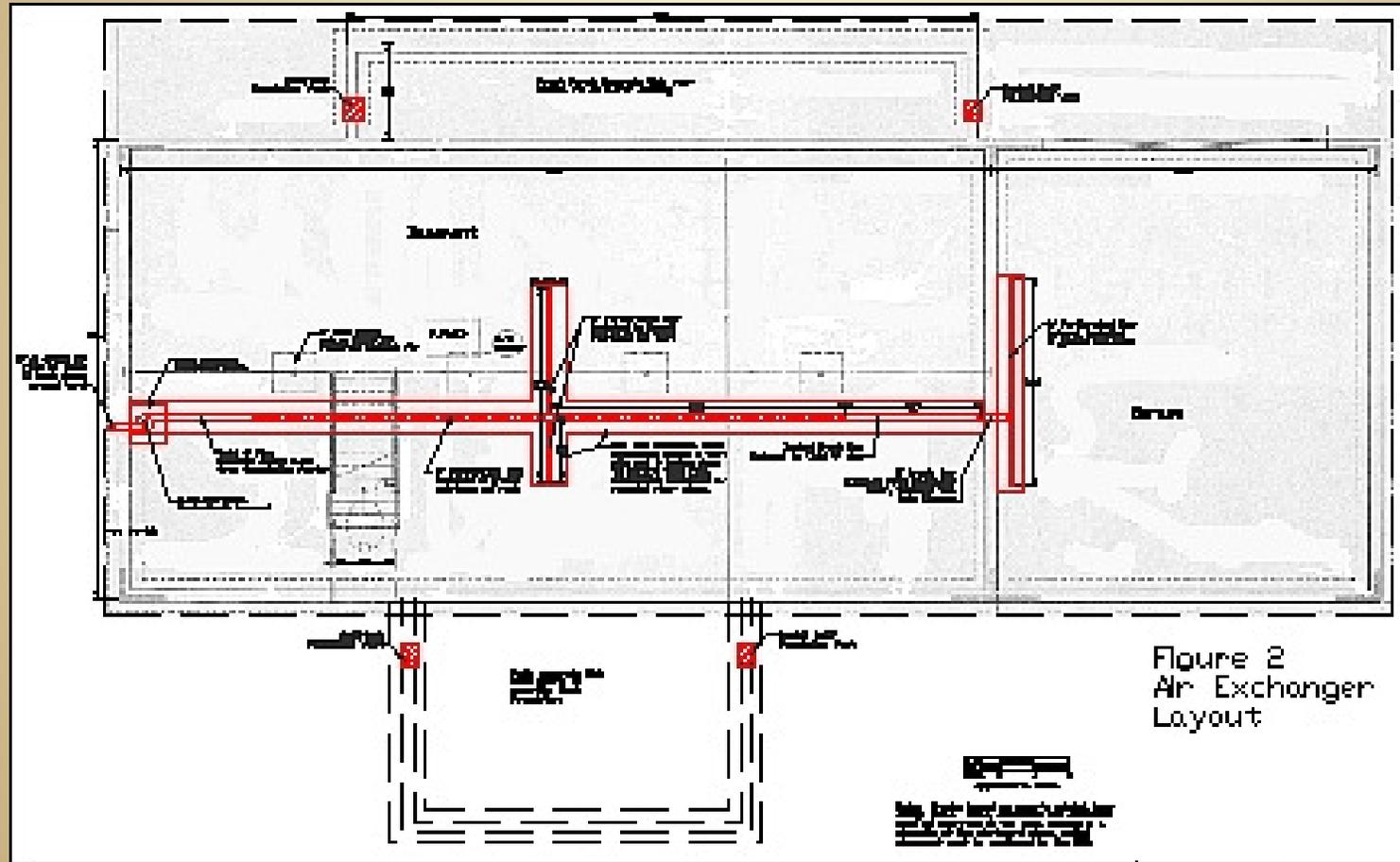
SW PA Location



SW PA Property



SW PA SSPP system



SW PA Construction Photos



SSPP inlet location & restored floor



Air inlets for SSPP & Air Exchanger

Cost / Benefits

- Cost: \$23,000
- Construction Period: 15 Days
- Power consumption: 350watts
- Noise
- Temperature differential in basement
- Long-term Maintenance

CO₂ Contamination Problem in Southwestern Indiana

**SW IN residence, Velpen, Pike County
2008**

- **CO₂ ambient levels up to 9.0% inside the home**
- **O₂ levels depressed as low as 12% inside the home**
- **CO₂ levels more than 25% measured in cracks and holes in the foundation around the home**
- **Resulted in death of two family cats**
- *Low barometric pressure and heavy rains*

Post Bond Permit Area



SW IN Property



Problems at SW IN Site



Conclusions

- **In Pennsylvania and Indiana, three homes on a reclaimed strip mine were contaminated with dangerous amounts of CO₂ (up to 25%) and correspondingly low levels of O₂ (as low as 10%).**
- **There was no evident association of the CO₂ contamination from underground mining.**
- **Events were severe during periods of low Barometric Pressure**

Conclusions

- $\delta^{13}\text{CO}_2$ of gases collected from the homes and monitoring wells indicates a carbonate source.
- Groundwater at the site is under saturated with respect to calcite and dolomite and PCO_2 is adequate to produce the observed gas volumes.
- Glacial till used for strip mine fill contains enough carbonate to react with AMD from an abandoned deep mine to produce the observed volumes of CO_2 .

Conclusions

- Remediation involved making the foundations as impermeable to gas as possible and installing a system to create positive pressure in the sub-base material (fresh atmosphere buffer between basement and CO₂).
- This one project cost taxpayers \$120,000.
- Abatement is energy - consuming and this cost will be borne by the home owners

Will this site take your breath Away?

