

# Crawl Space Research Project

**June 2003**

**by**

**Bill Warren, Project Manager**

*Warrenb@nc.rr.com, phone: 919/933-8151*



## Funding

# National Energy Technology Laboratory

*Project Officer: Parrish Galusky*

# U.S. Department of Energy

*Project Manager: Marc LaFrance*

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## Co-Funding & Project Management

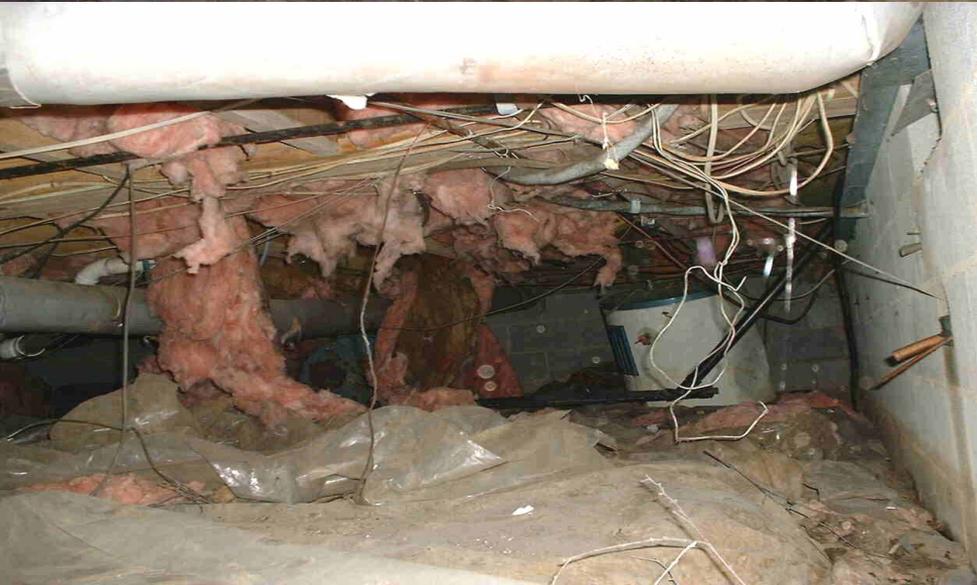
# Advanced Energy

*Project Director: Bruce Davis*

# Project Goals

- **Research:** Investigate thermal, IAQ & moisture performance of closed vs. wall vented crawl spaces
  - Field Study
  - ORNL Hygrothermal Study
- **Technology Transfer:** Accelerate acceptance of sustainable crawlspace systems

# Floor Insulation Problems



# Crawl Space Moisture Problems



# Why Crawl Space Ventilation?

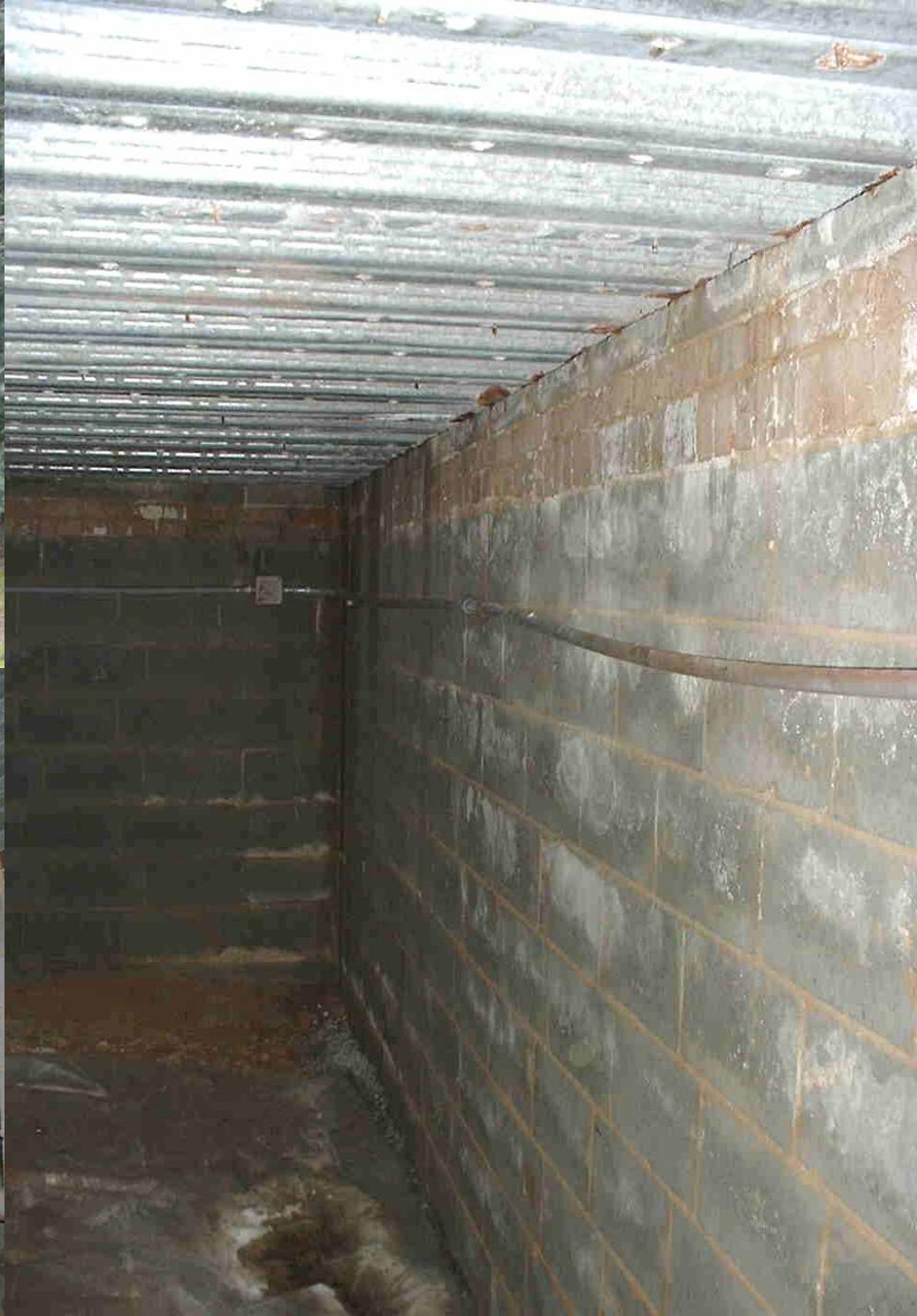
92/  
70%RH

72/  
100%RH

92/  
70%RH

# Condensing Surfaces Temperatures

- A/C ductwork: 55-65 °F
- Exposed joists beneath insulation, particularly with low cooling setpoints 68-70 °F
- Uninsulated cold water pipes & tanks: 55-65 °F
- Crawl earth floor: 65 °F and below



# Closed Crawl Spaces

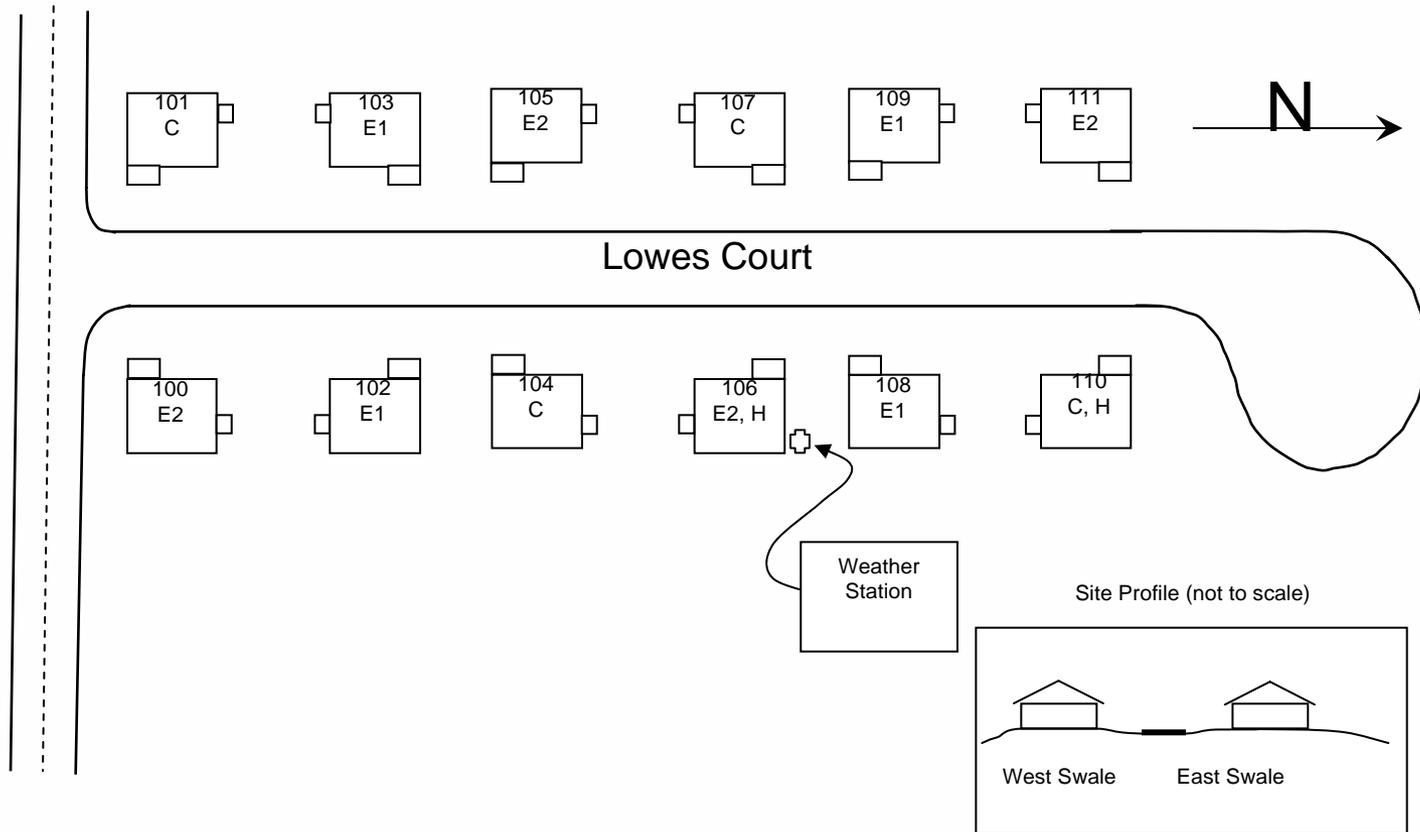
- Air sealed walls (no foundation vents)
- Liners or concrete floors
- Below grade wall moisture control: dampproofing & foundation drains
- Space moisture control:
  - Dehumidifier
  - Supply air dehumidification
  - Depressurization exhaust

# Field Study

*Field test the thermal, moisture & IAQ performance of closed versus wall vented crawl spaces*

- Closed experiment crawls continue to outperform control wall vented crawls.
  - Drier air and lower wood moisture content
  - Less visible and bioaerosol mold
  - Reduced duct and house air leakage
  - Lower space conditioning energy use
- One exception: Wall vented crawls have lower radon levels than closed crawls.

# 12 Home Crawl Space Field Study



# Elevated Site for Flood Protection



# Control Group: Wall Vented



# Experiment Group 1: Closed Crawl with No Insulation



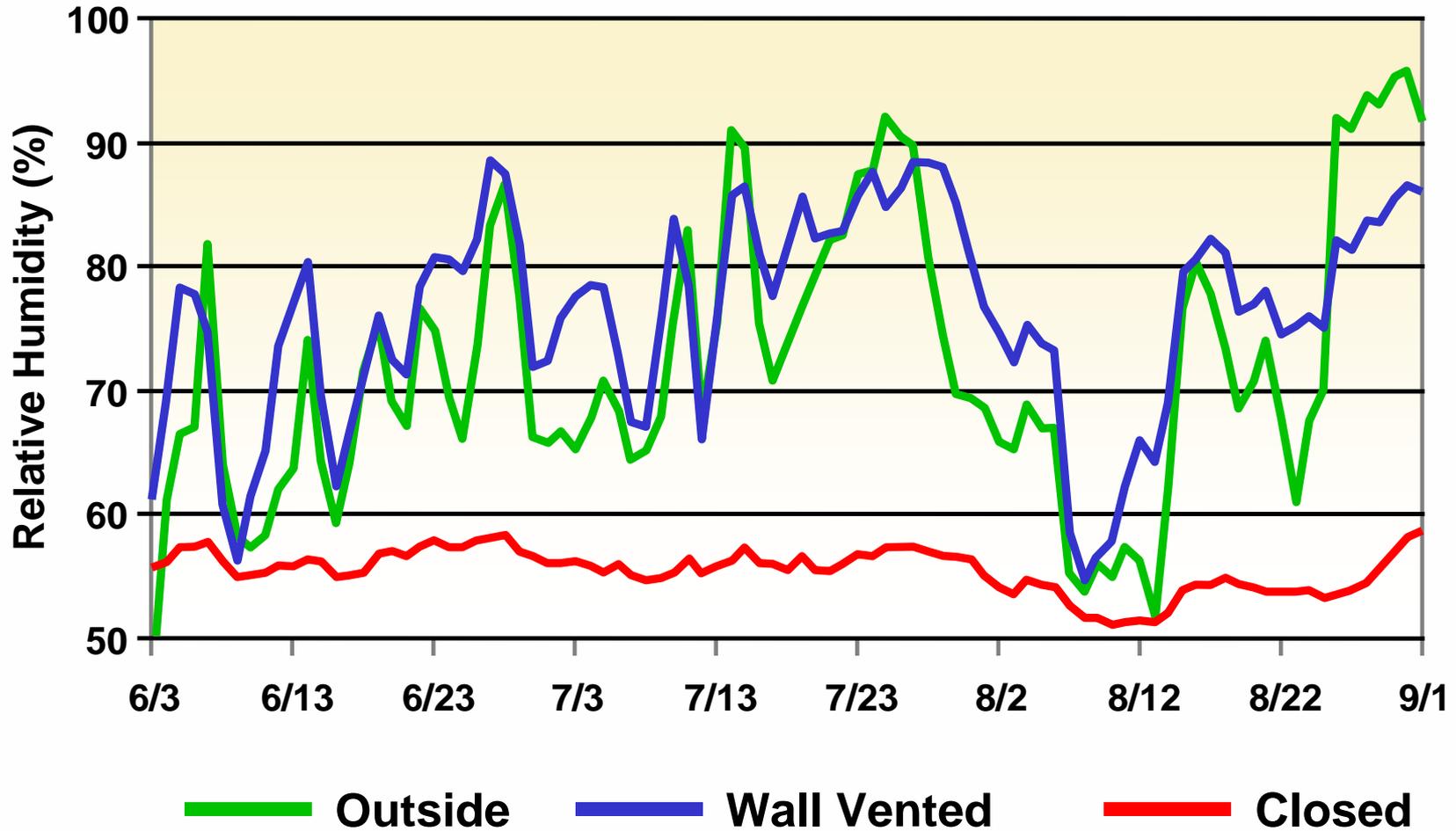
# Experiment Group 2: Closed Crawl with Wall Insulation



# Comparative Experiment Data

- Component air leakage testing
- Temperature and RH logging
- Pin wood moisture readings
- Bioaerosol mold Sampling
- Radon canisters
- Electric sub-meters on heat pump

# Crawlspace RH (Summer 2002)



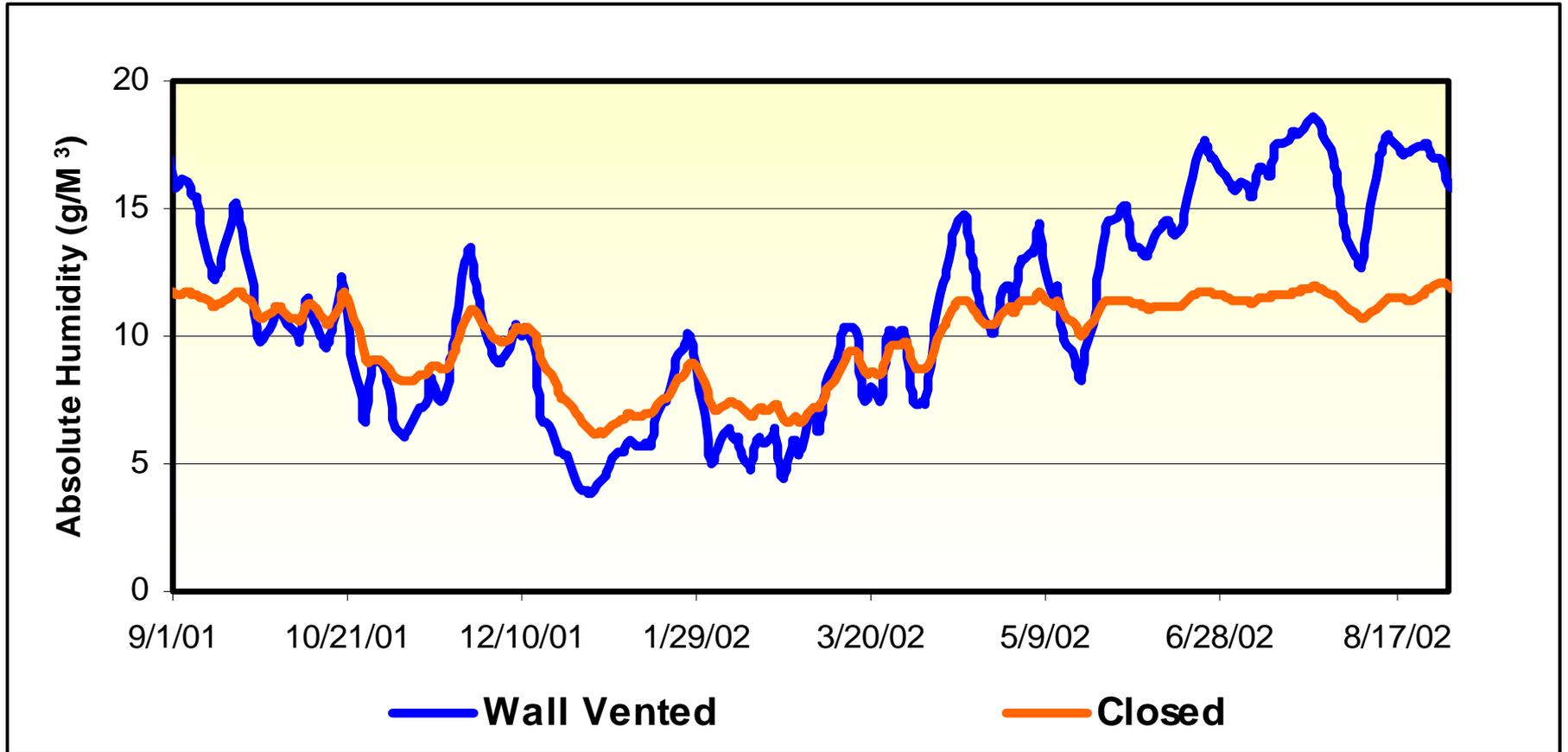
Will good ground poly  
control crawl moisture?

# Crawlspace Relative Humidity (RH) Summary

## June - August 2002

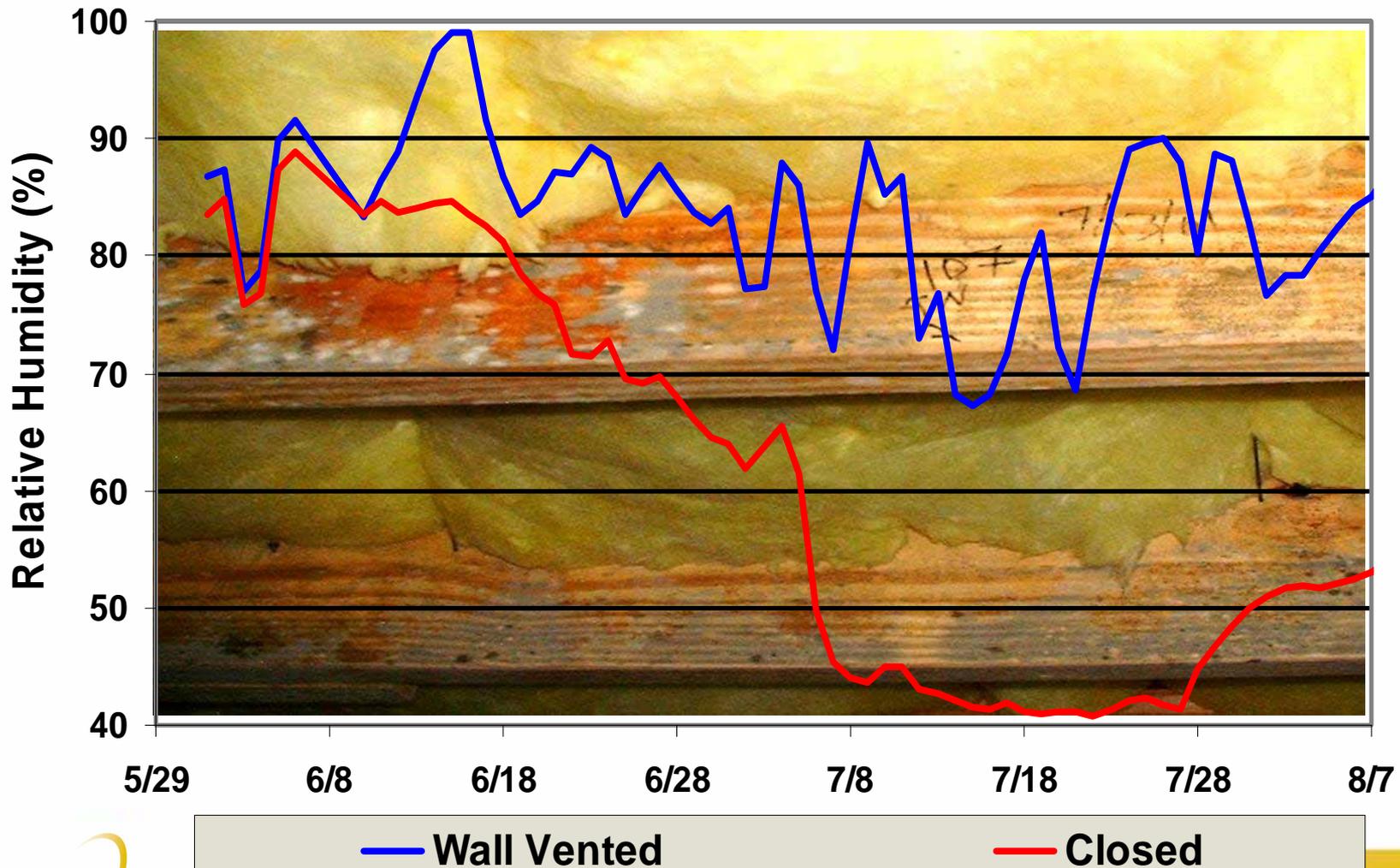
Percentage of Time	Vented	Closed
Above 80% RH	<b>39%</b>	<b>0%</b>
Above 70% RH	<b>79%</b>	<b>0%</b>
Above 60% RH	<b>94%</b>	<b>0%</b>
Above 50% RH	<b>100%</b>	<b>100%</b>

# Annual Crawl Space Moisture



What happens when  
you mix moisture and  
wood in a dark place?

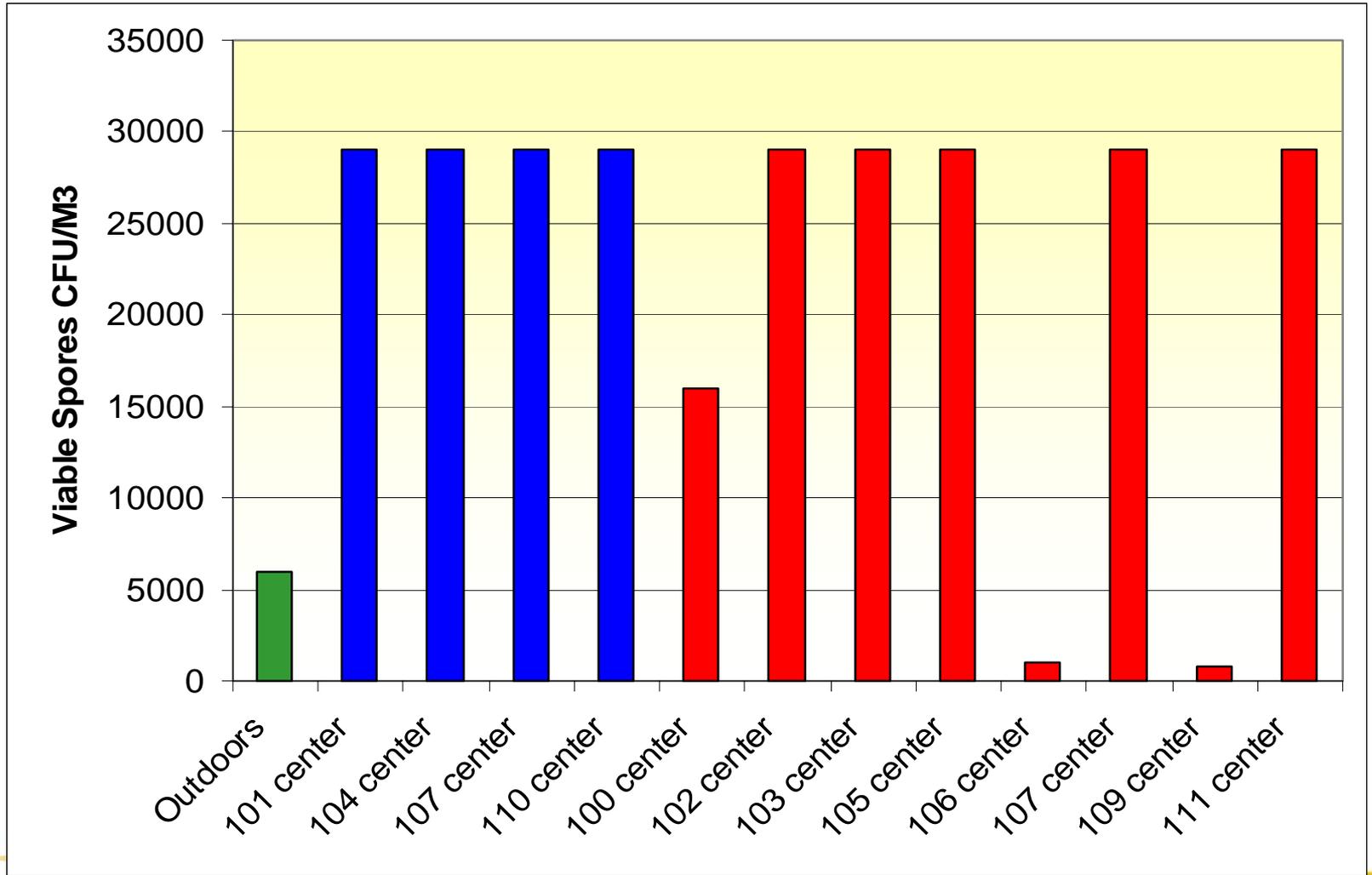
# June 2001 Mold Bloom



# Clean Wood = No Mold ?

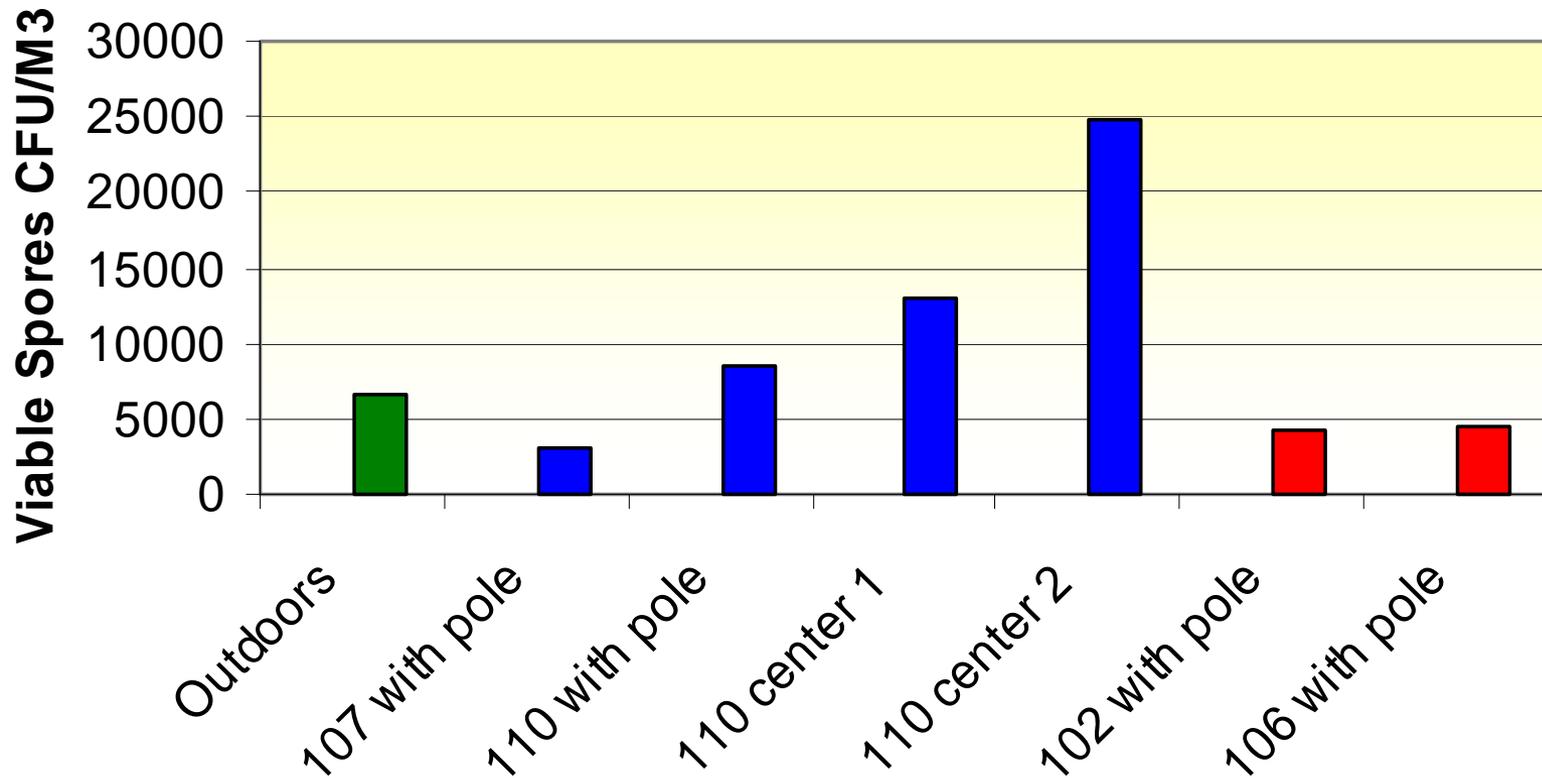


# Crawl Mold Sampling 2001

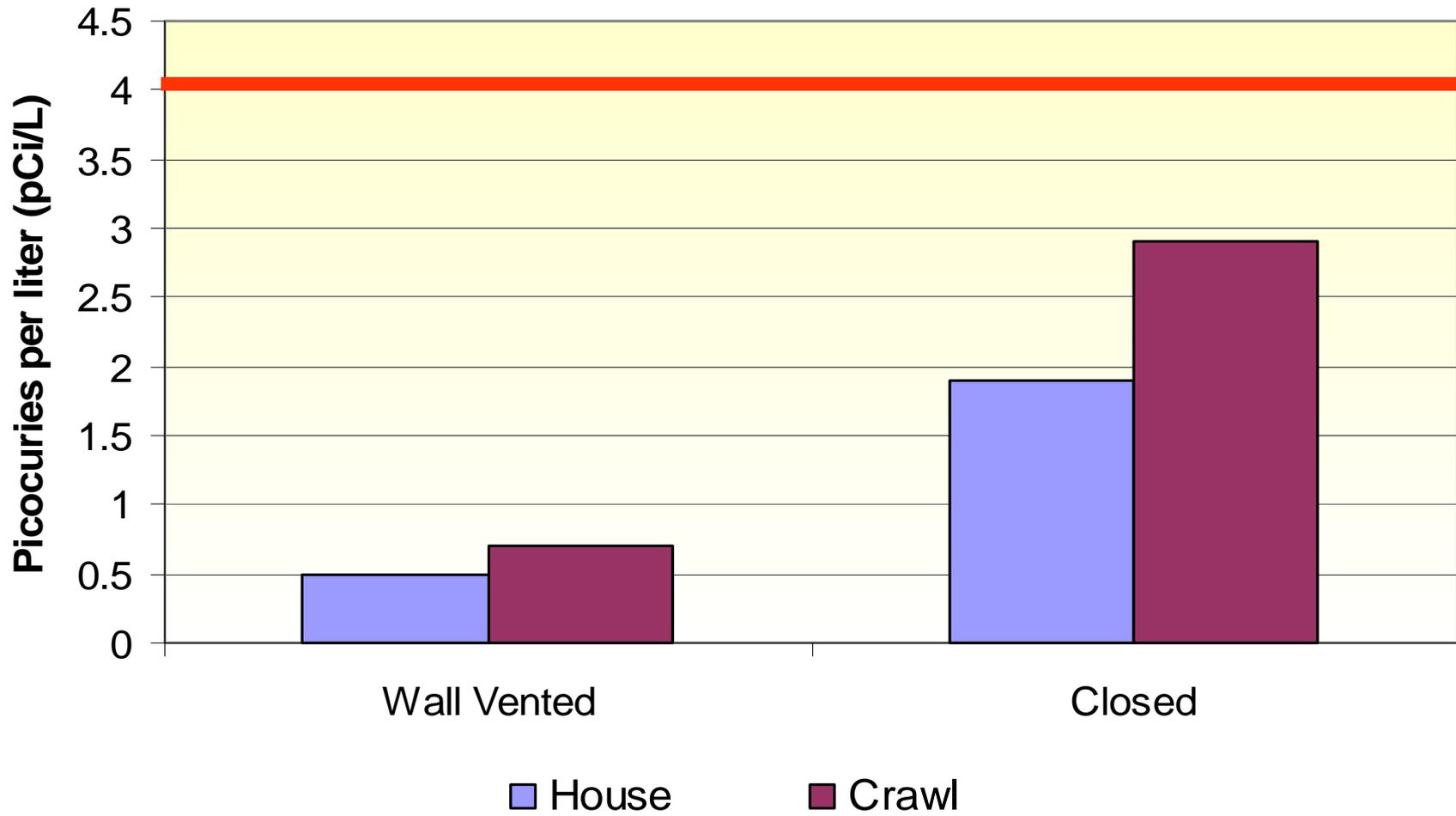


# Crawl Mold Sampling 2002

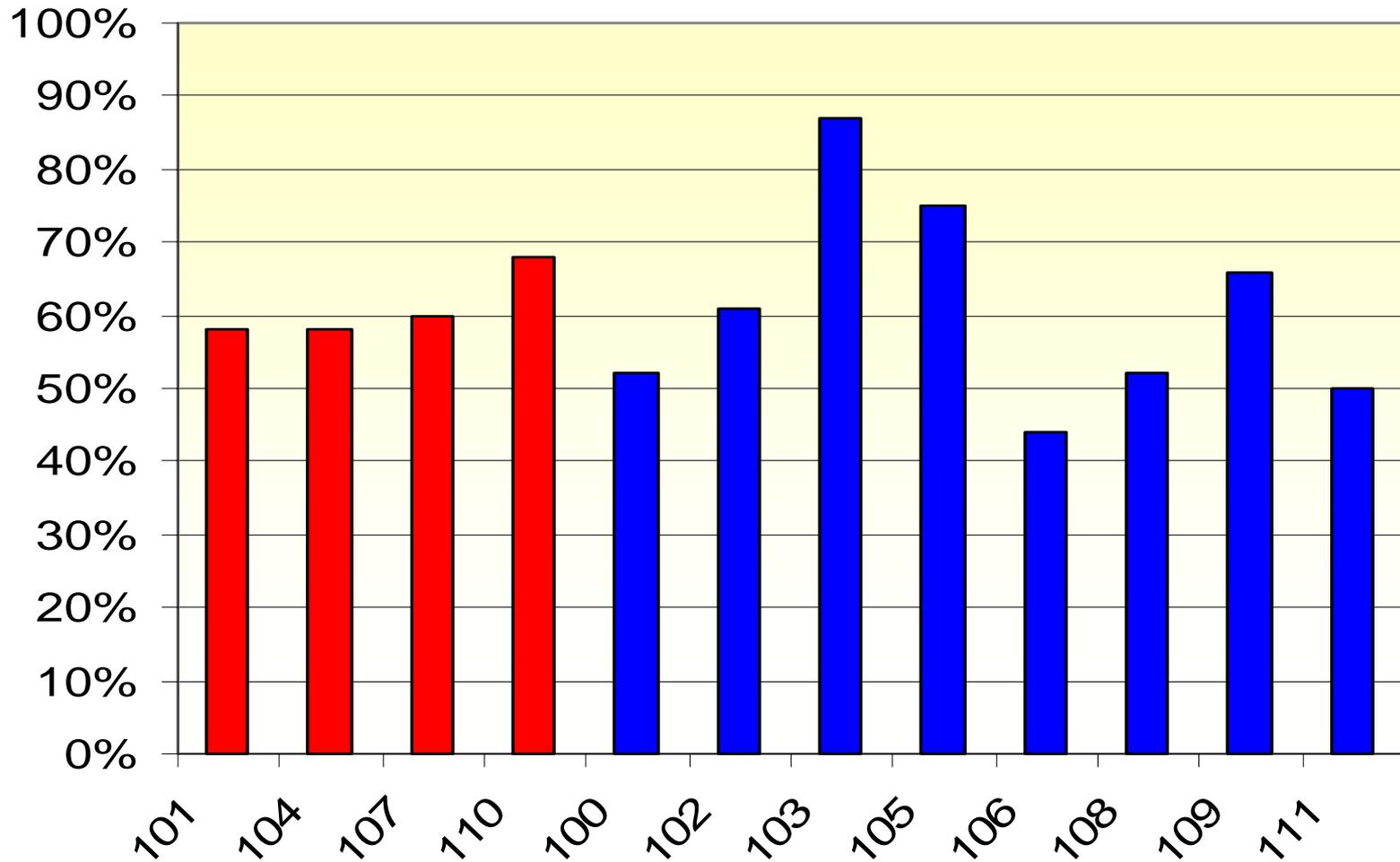
## Crawl Space Bioaerosol Levels July 2002



# Long Term Radon Levels

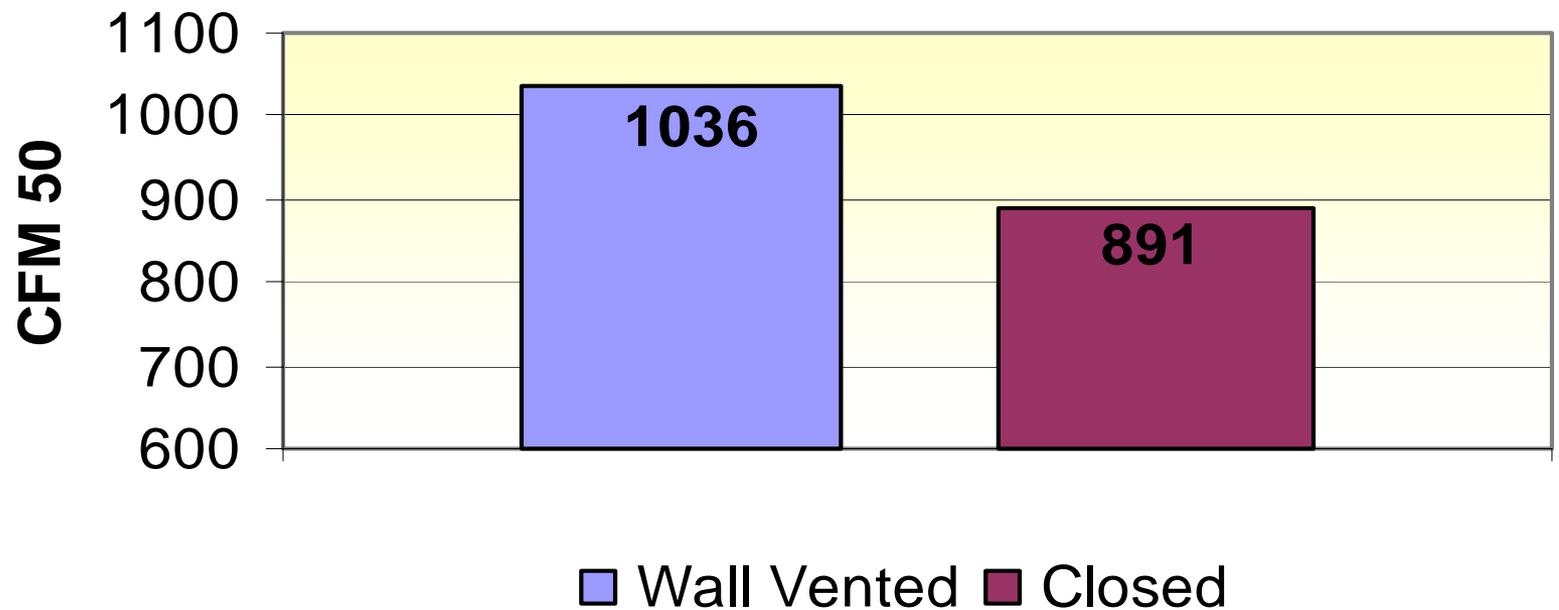


# Percentage of House Air from Crawl Spaces (Based on Radon Infiltration)



# Measured Air Leakage

**Total House Air Leakage  
(Includes Ducts)**



# Annual kWh Usage

	Wall Vented	Closed
Heating	2,104	2,255?
Cooling	2,292	1,410
<b>TOTAL</b>	<b>4,396</b>	<b>3,665</b>

# New Experiments Spring 2003

- Sub-meter all heat pumps
- Air seal all floors & crawl space ductwork
- Test 2 new closed insulation systems
  - R-19 floor batts
  - Rigid board wall insulation
- Minimum supply air ventilation for closed crawls (*1 cfm per 50 square feet*)

# All Homes Air Sealed

Floor penetrations



Crawl Ducts

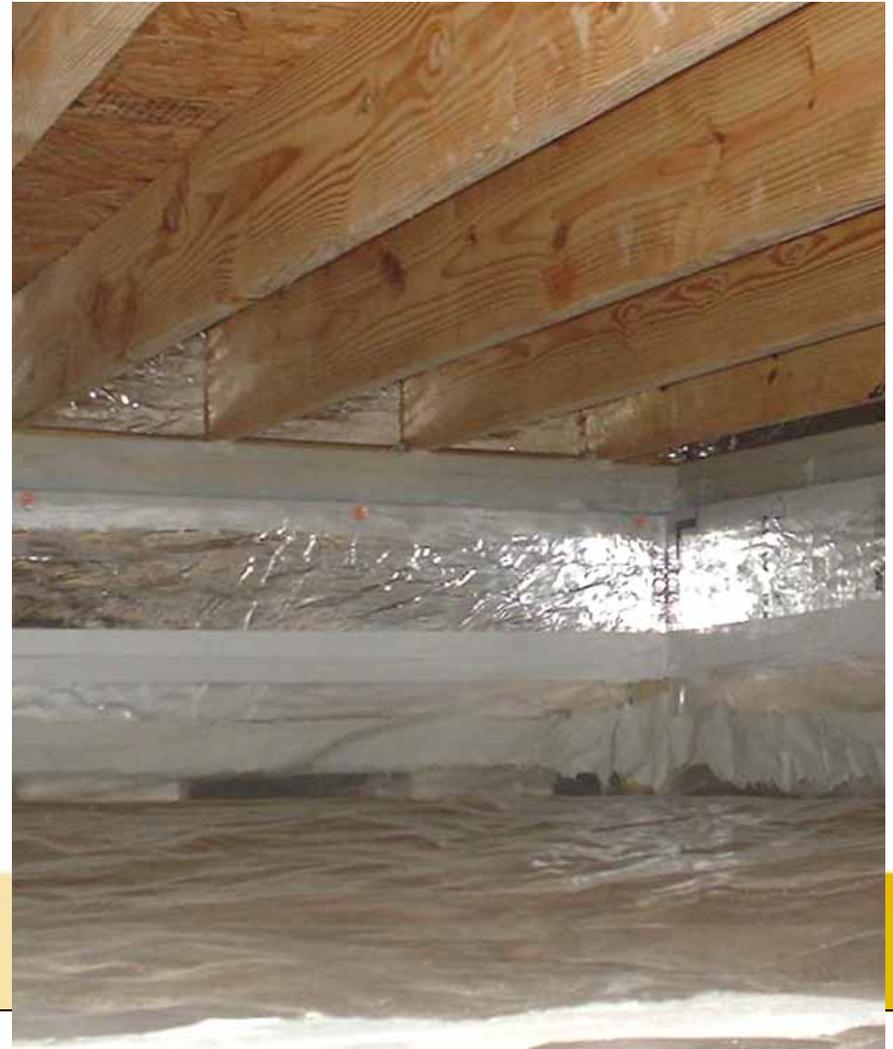


# New Insulation Systems

Exp1: Floor Batts



Exp 2: Rigid Wall



# Hygrothermal Study

*Develop & test analytical model to improve crawl space thermal & moisture performance*

- ORNL: Achilles Karagiozis Principal Investigator
- Matched paired instrumentation study is setup and producing extensive comparative data
- Experiment design works: Experiment crawl space is significantly drier than control crawl space

# Technology Transfer

- Outreach, TA, training, website for key stakeholders: Builders, Homeowners, Code, Pest Management

[www.crawlspaces.org](http://www.crawlspaces.org)

- Best Practice Guidelines
- Fact sheet
- Training CD

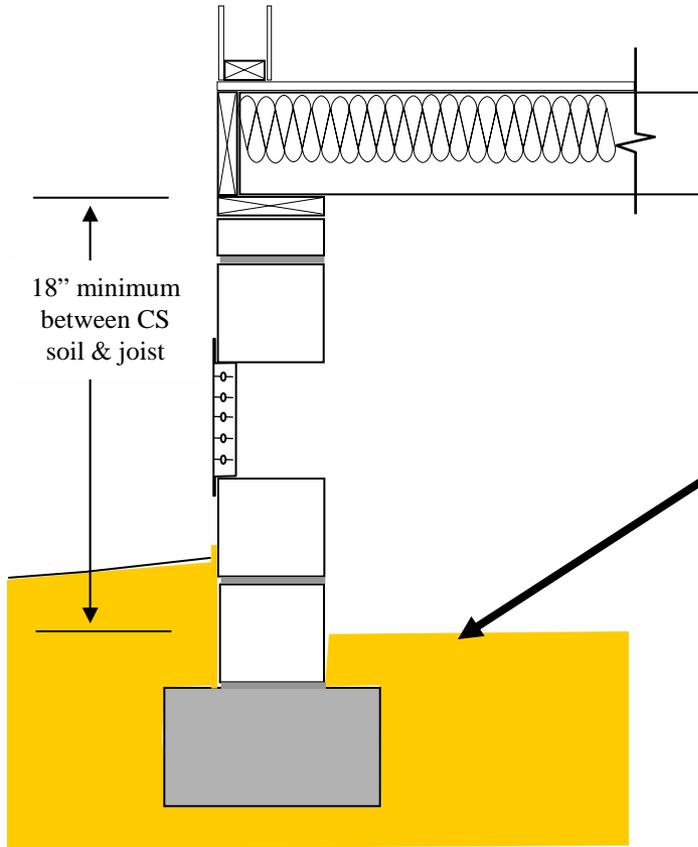
# Real World Research



# Code & Construction Details

- 2000 IRC: Section R408 requires foundation vents in crawls with earth floors.
- R408 Exceptions allow foundation vents to be deleted when:
  - Vapor retarder on ground, and
  - Crawl is continuously ventilated (Exception 4)
  - Crawl is conditioned (Exception 5),
- NC Moisture Ad Hoc Committee approved changes follow

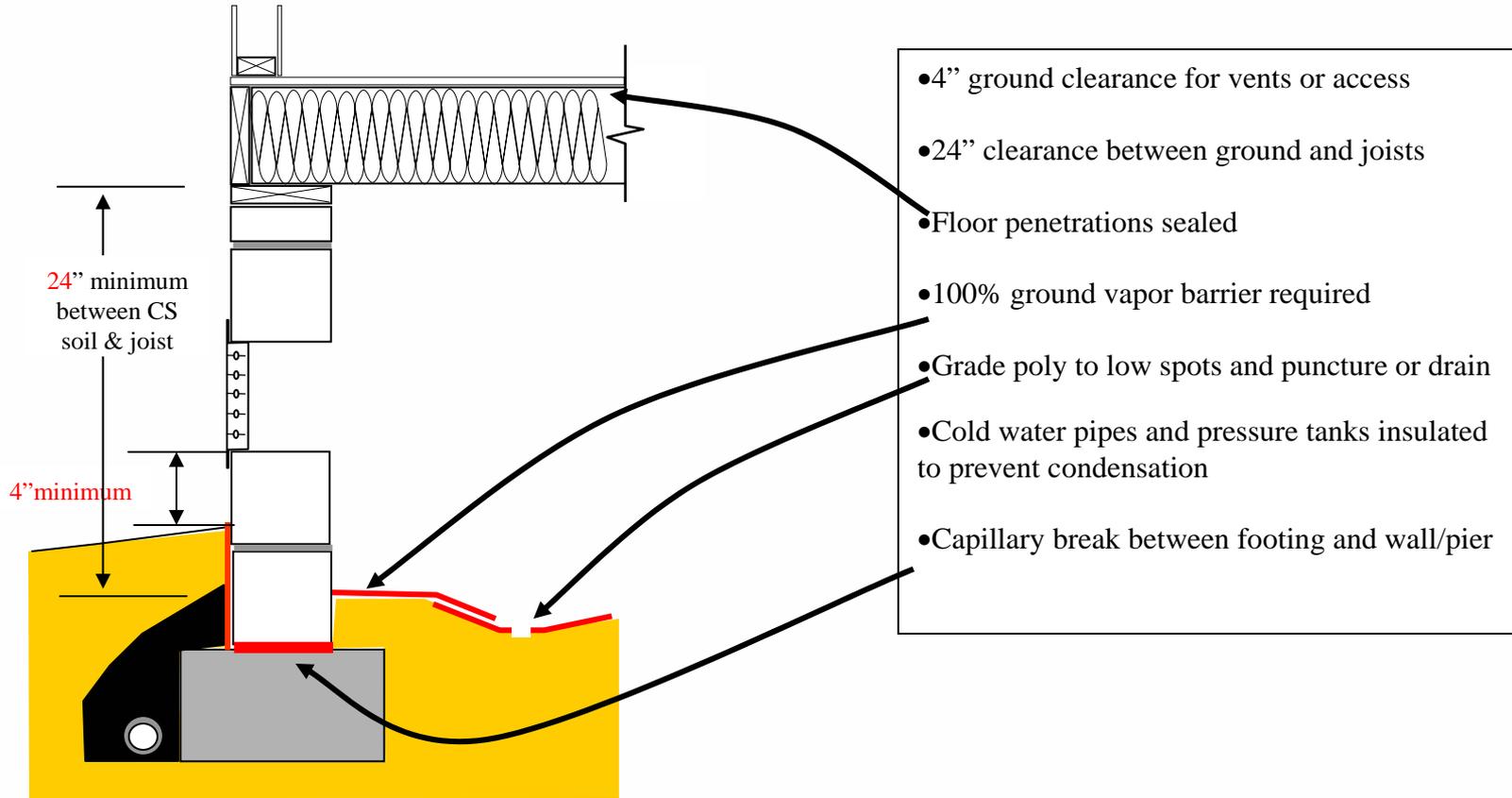
# Current Code Wall Vented



18" minimum  
between CS  
soil & joist

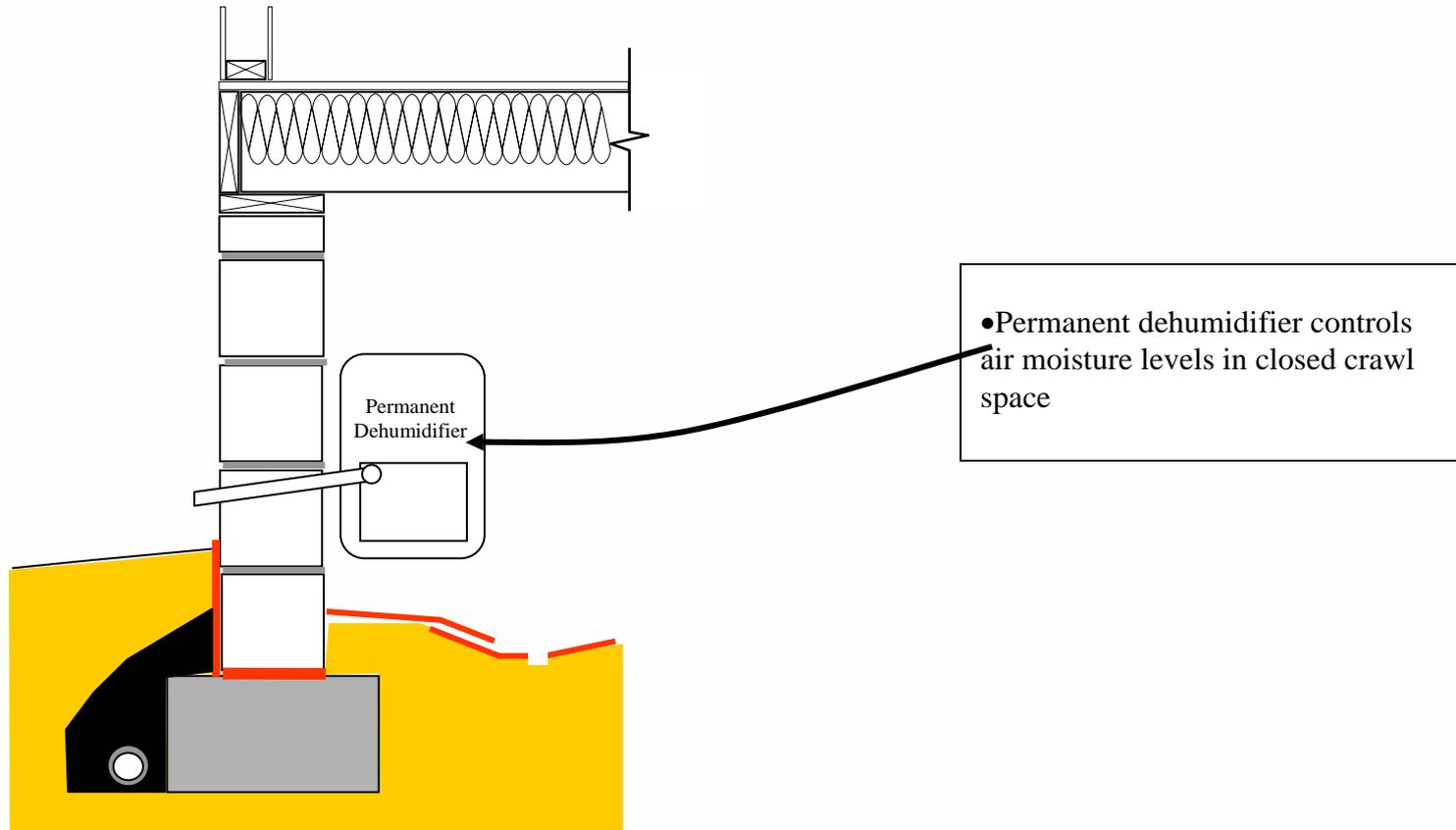
- No height clearance for vents or access
- 18" clearance between ground and joists
- Ground vapor barrier not required
- No interior drainage required
- Floor penetrations not sealed
- Insulation batts in floor
- Gravity vented heaters allowed
- Combustion air from crawlspace

# NC: Improved Wall Vented

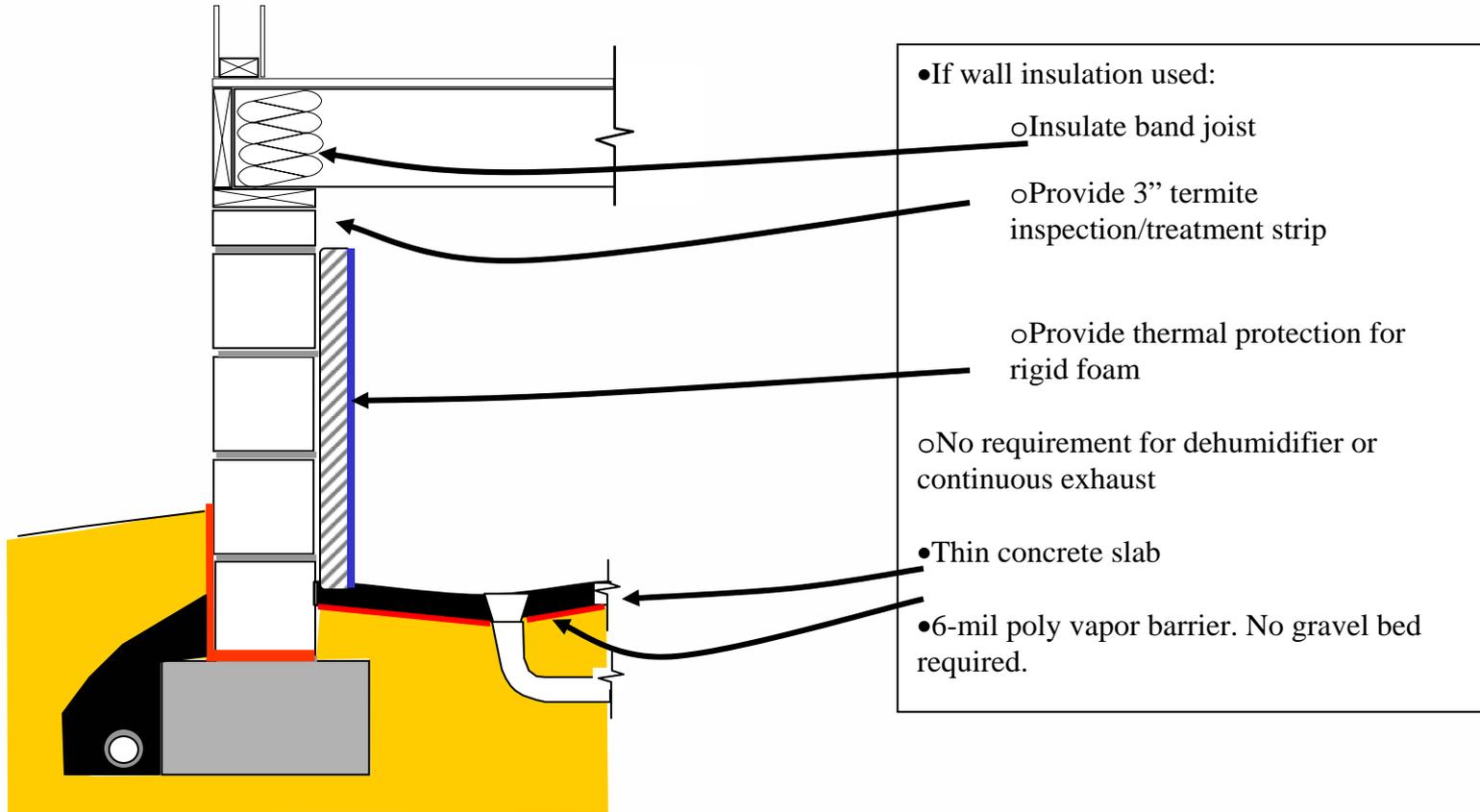


- 4" ground clearance for vents or access
- 24" clearance between ground and joists
- Floor penetrations sealed
- 100% ground vapor barrier required
- Grade poly to low spots and puncture or drain
- Cold water pipes and pressure tanks insulated to prevent condensation
- Capillary break between footing and wall/pier

# NC: Conditioned Closed Crawl



# NC: Closed with Concrete Floor



# Best Practice: Closed with Supply Air

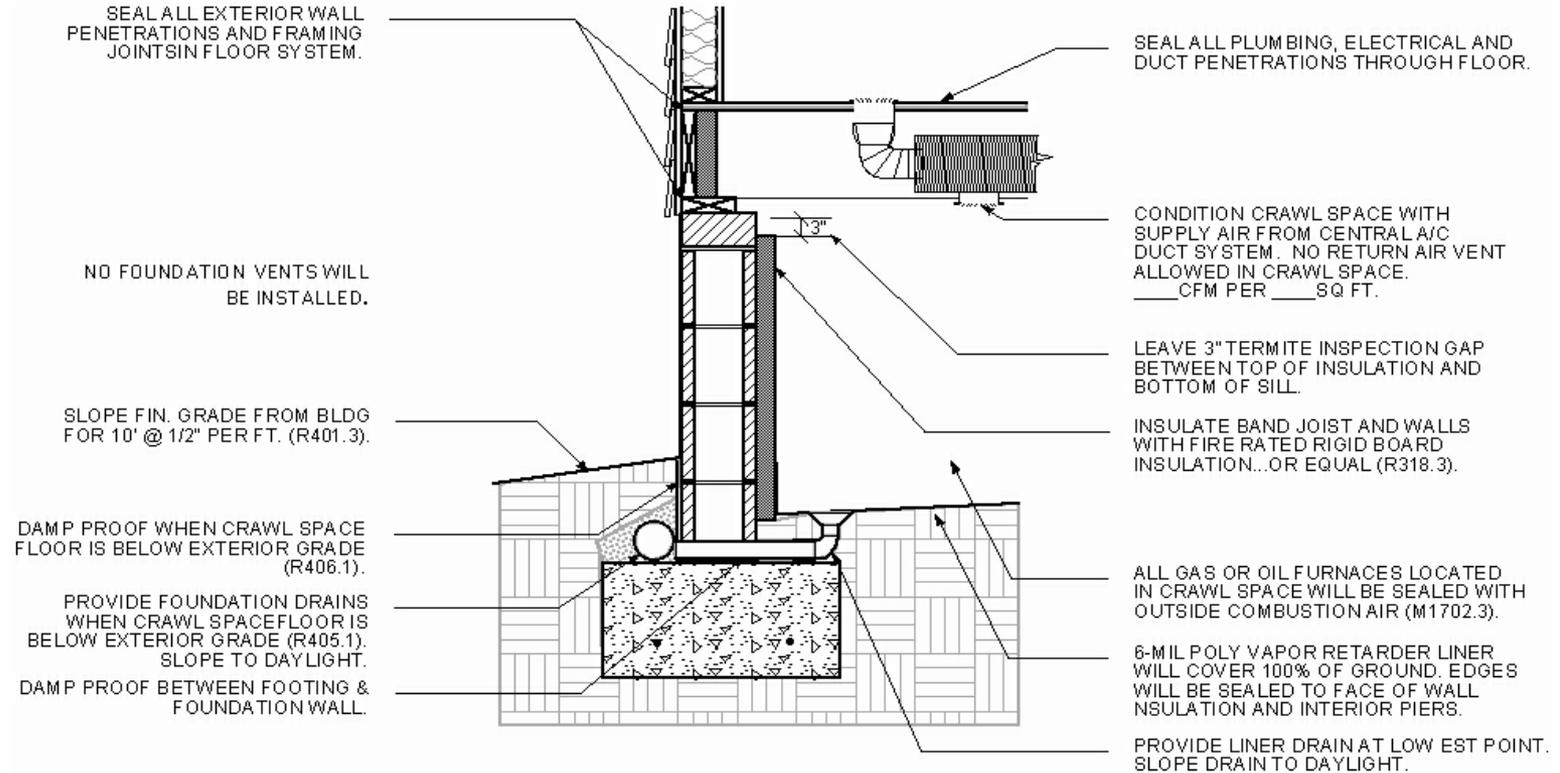


FIGURE 10-10  
SCALING DRAFT AIR

# Best Practice: Closed w/ Dehumidifier

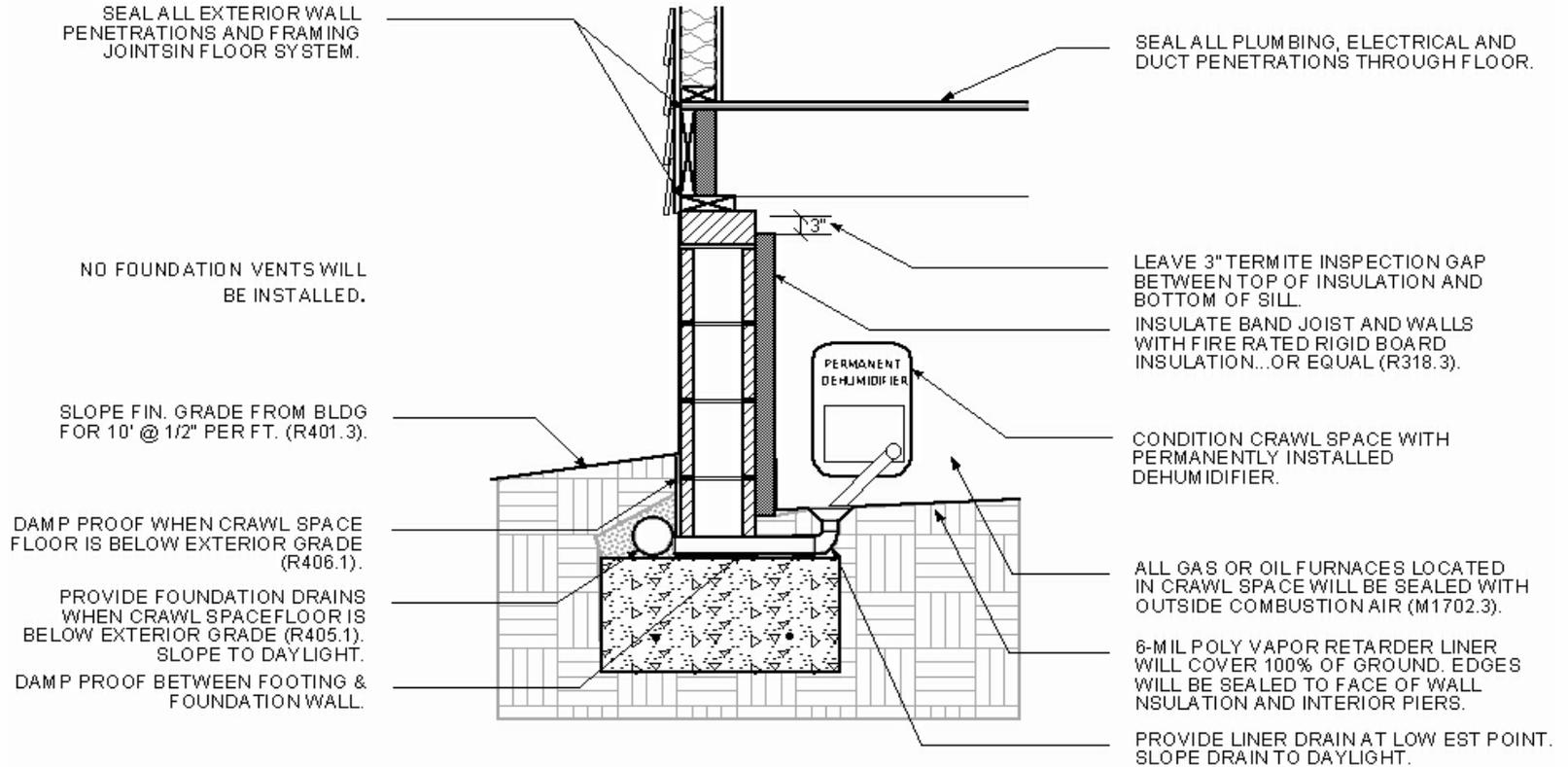


FIGURE 10-10 DEHUMIDIFIER  
SCALE: 1/4" = 1'-0"

# Best Practice: Closed w/ Cont. Exhaust

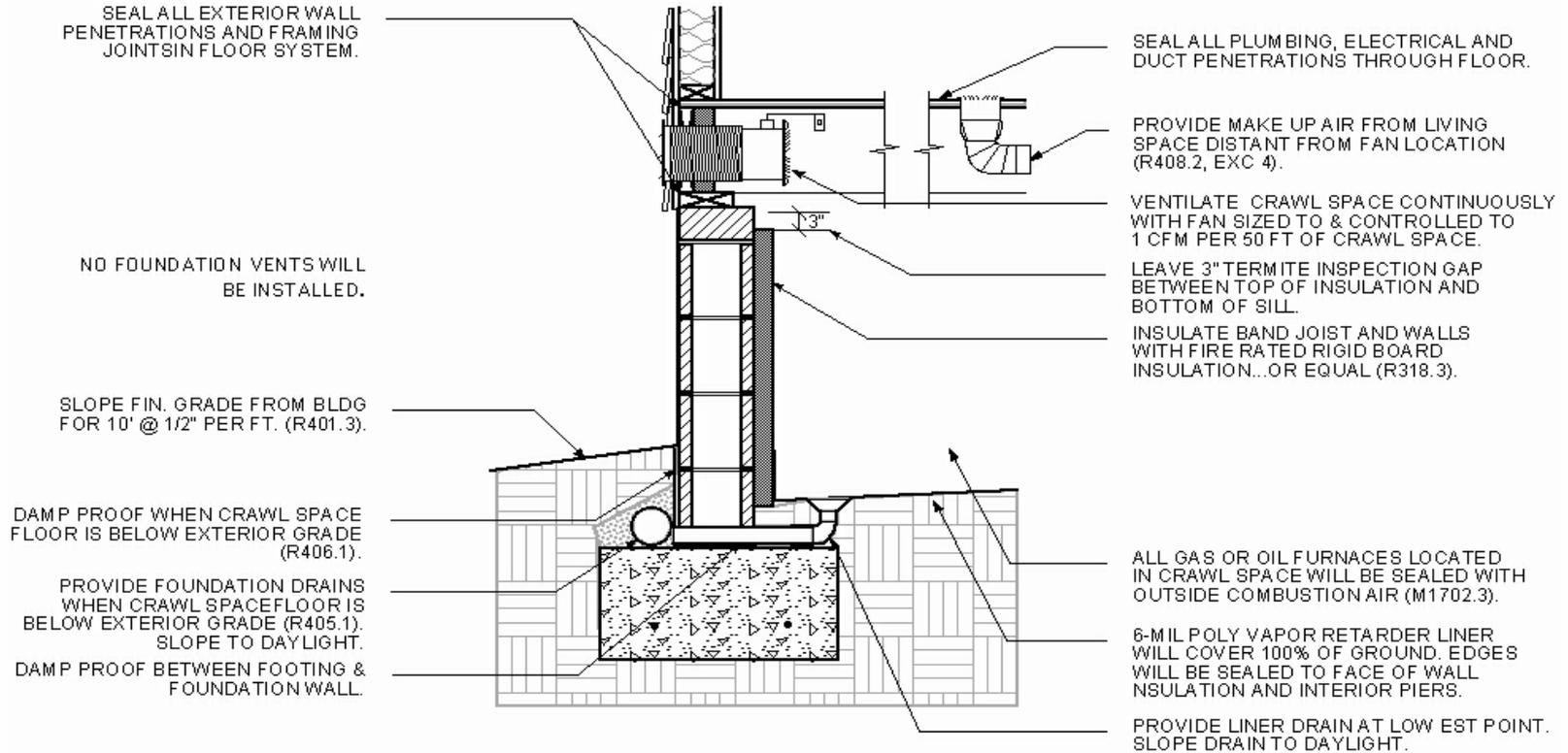


FIGURE 1 CONTINUOUS EXHAUST  
SCALE: 1/4" = 1'-0"  
**Draft**