WHOLE BUILDING VENTILATION OF HIGH RISE CONDOMINIUM WITH ELEVATED RADON FROM CONCRETE

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100 units in a five story building
900 ft^2 to 2000 ft^2 units

Post stressed concrete slabs, ceilings.

Concrete walls surrounding the stair wells.

All walls & ceilings dry walled

Although 1st floor units are ground contact the surrounding area has low radon potential

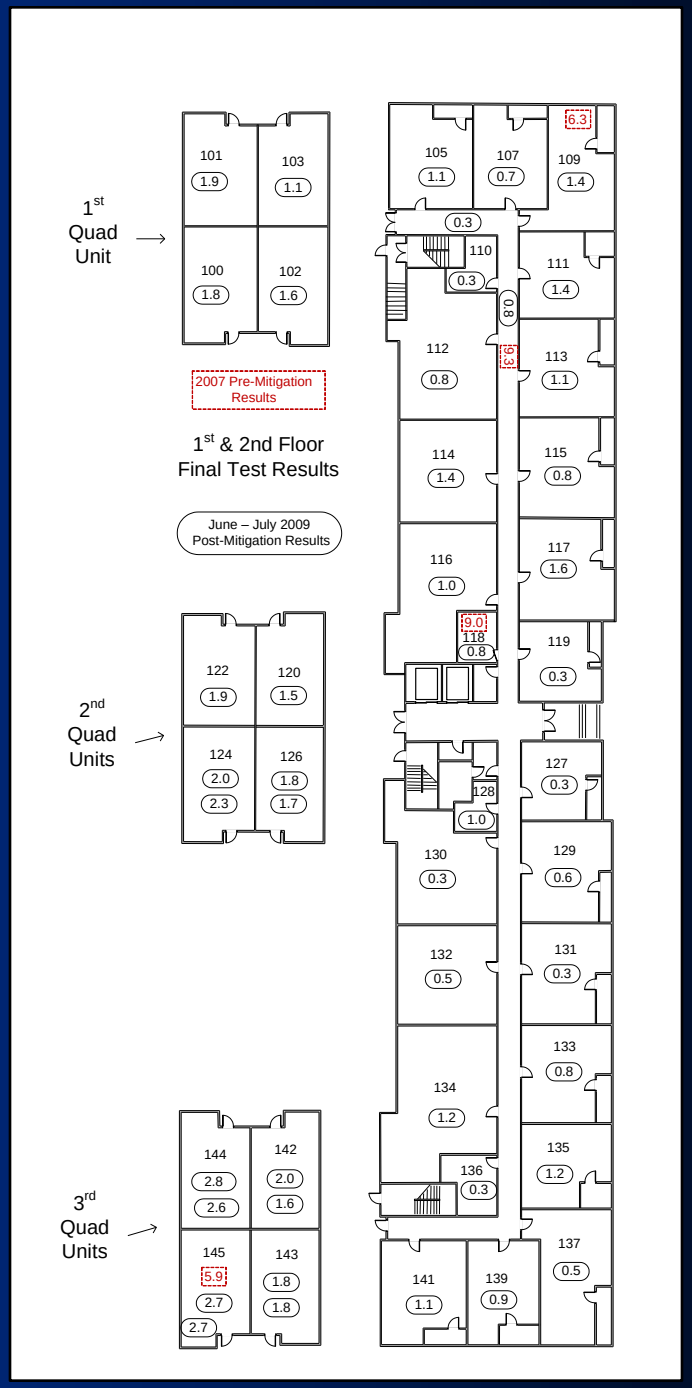
Building Layout

Ist Floor is two story units

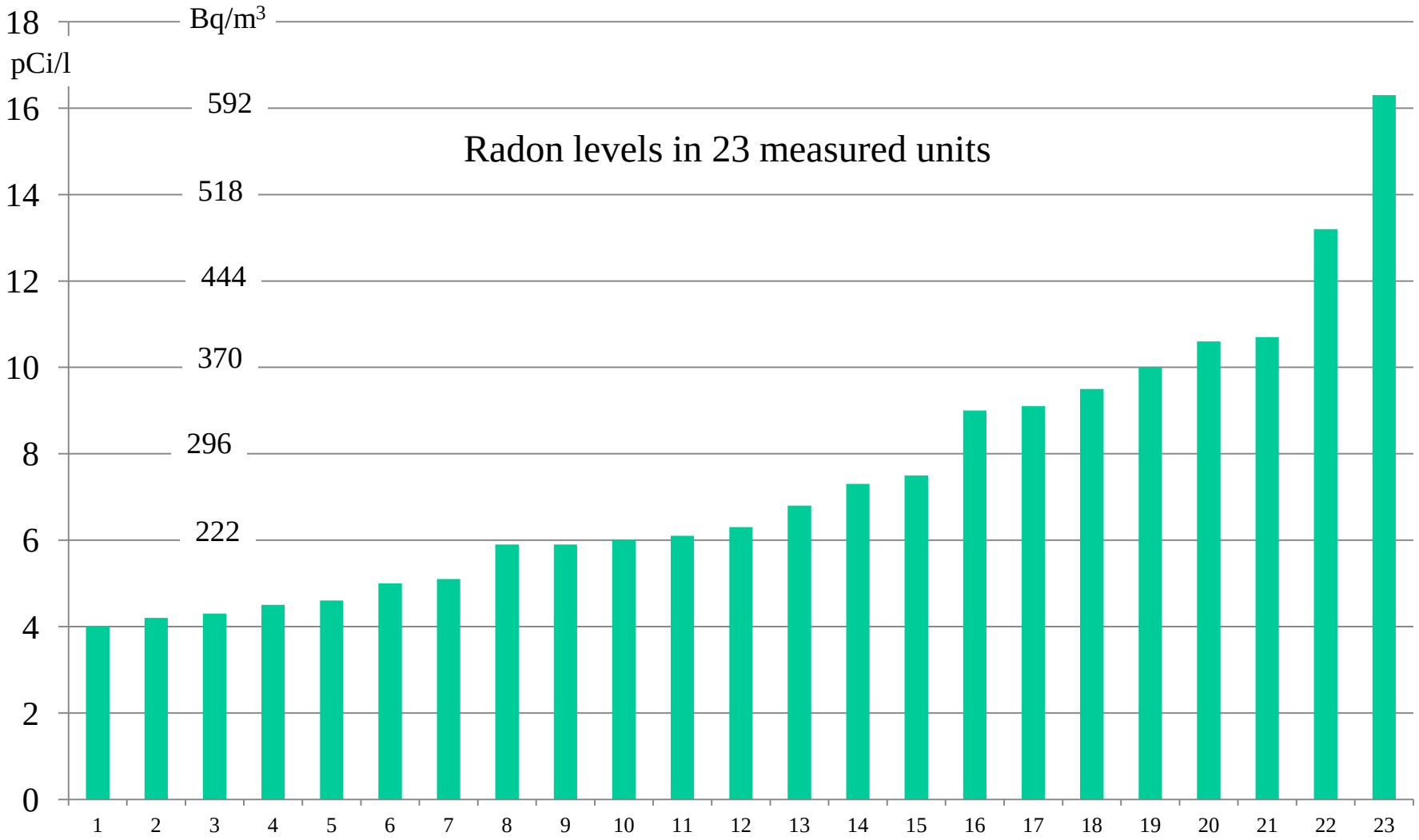
3rd – 4th – 5th Floor are single story units

Four plex (Quad) units were the most difficult to route ducts to

Four storage closets lined up on each floor



Elevated Radon levels on every floor of the Building



Radon Levels directly related to Ventilation Rate

If average concrete emanation rate is 60 pCi/ft^2/hour and ceiling is 9 feet tall than 120 pCi enters 255 liters per hour (9 cf X 28.3)

The following ventilation rates will induce pCi/l

0.3 ACH = 76 lph 120÷76 = 1.6 pCi/l

0.1 ACH = 25.5 lph 120÷25.5 = 4.7 pCi/l

0.05 ACH =12.7 lph 120÷12.8 = 9.4 pCi/l

Could Granite Counter Tops be the Source?

Lets assume the kitchen has 50 ft^2 of granite

Granite emanates uniform 500 $pCi/hr/ft^2$

Total emanation is 50X500 = 25,000 pCi/hr

1000 ft^2 of Condo = 2000 ft^2 of concrete

Concrete emits 60 $pCi/hr/ft^2$

Total emanation = 60X2000 = 120,000 pCi/hr

Concrete produces 4.8 times more Radon
than hottest Granite!

Adjacent unit used ERV's installed in every unit

Only Solution is Ventilation Increase

Ventilation Choices

Introduction of unconditioned air (not considered)
Ventilation with Energy Recovery Ventilator (ERV)
Introduction of Central Supply Conditioned Air (CSCA)

Pros & Cons ERV vs CSCA CSCA is more expensive

Easy to adjust airflow with CSCA (need 50 to 110 CFM)
ERV will contribute humidity - CSCA will reduce humidity
ERV requires multiple penetrations of exterior shell
ERV requires exterior penetrations be separated
ERV inlets at deck bring in odors from adjoining units
ERV's have poor cooling recovery
ERV unit takes up interior finished space
ERV ductwork requires drywall and finish work
ERV would require replacing 100 filters 2X per year
CSCA is quieter and any maintenance is non-obtrusive

Condo Association decided to have a central ventilation system distribute conditioned air to each unit.

An Engineering Company was hired to design the ventilation system

HVAC does not run a lot in the winter months

WPB was hired to determine the necessary ventilation rate and to determine if single point ventilation would reduce radon levels in bedrooms if doors were closed and HVAC was off

Knowing the:

1) Volume of the Space
2) Area of Concrete Exposure
3) Radon Level reduction from Induced Ventilation

Allows you to determine the:

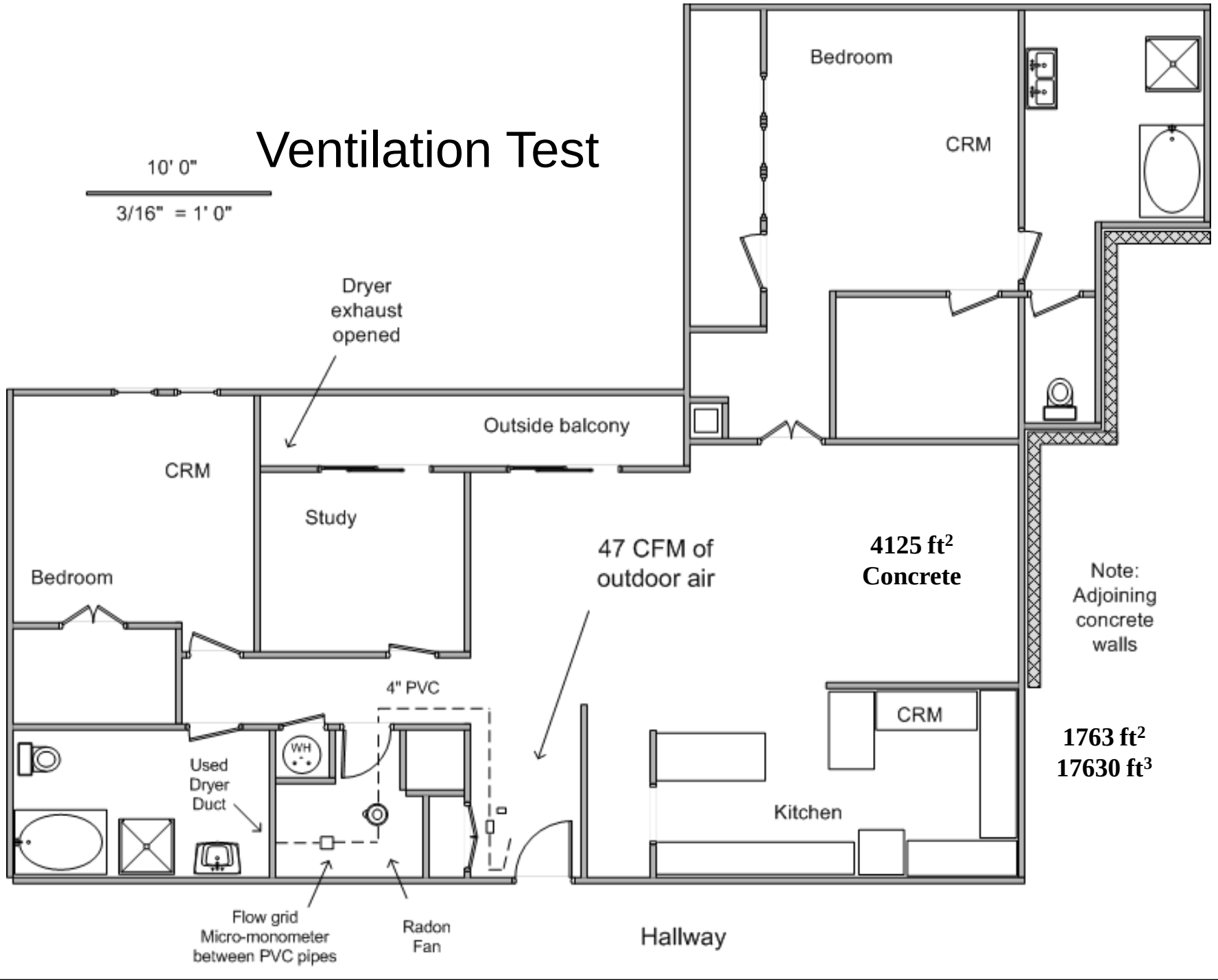
1) Existing Natural Ventilation Rate

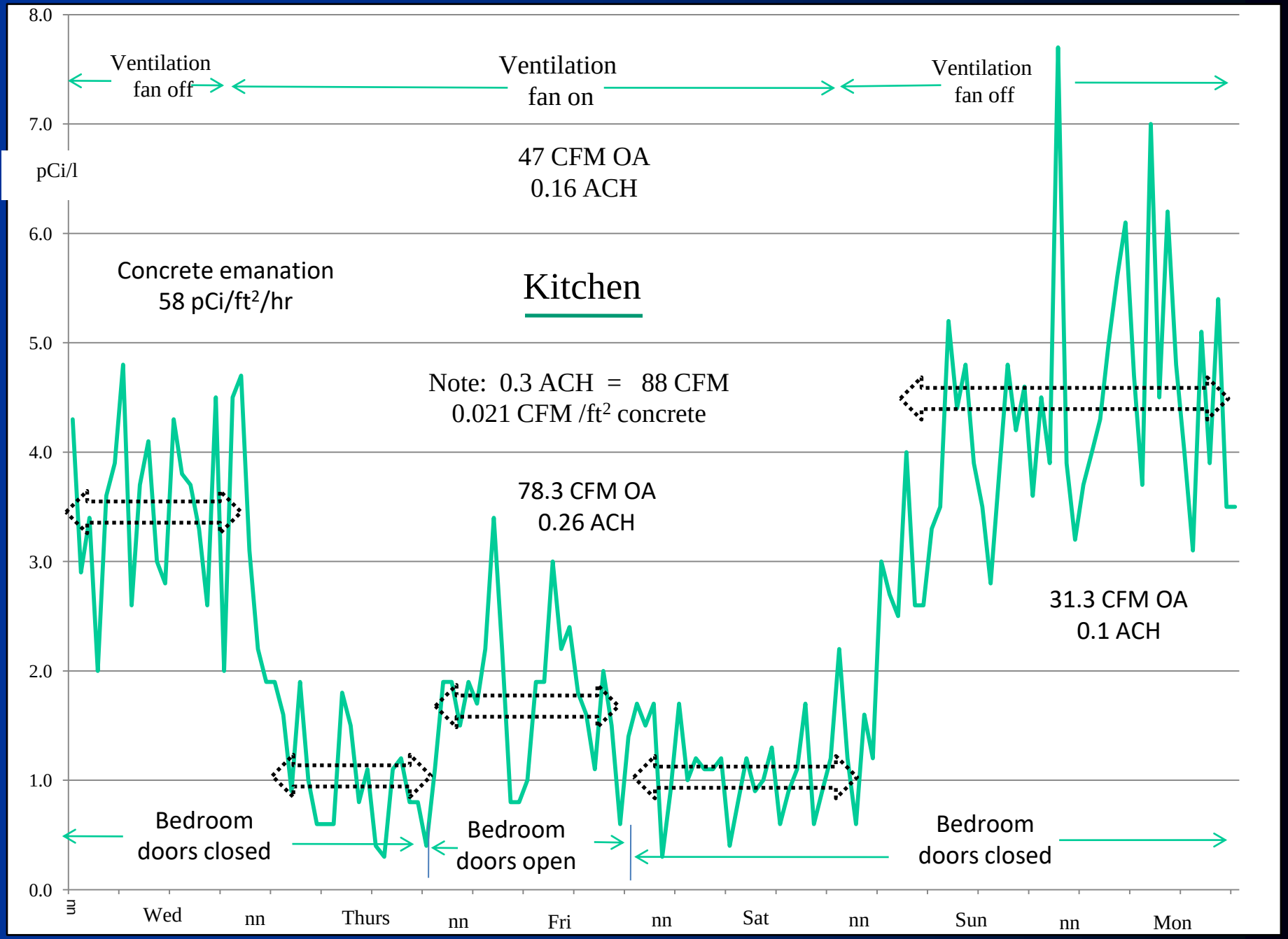
2) Radon Emanation Rate of the Concrete

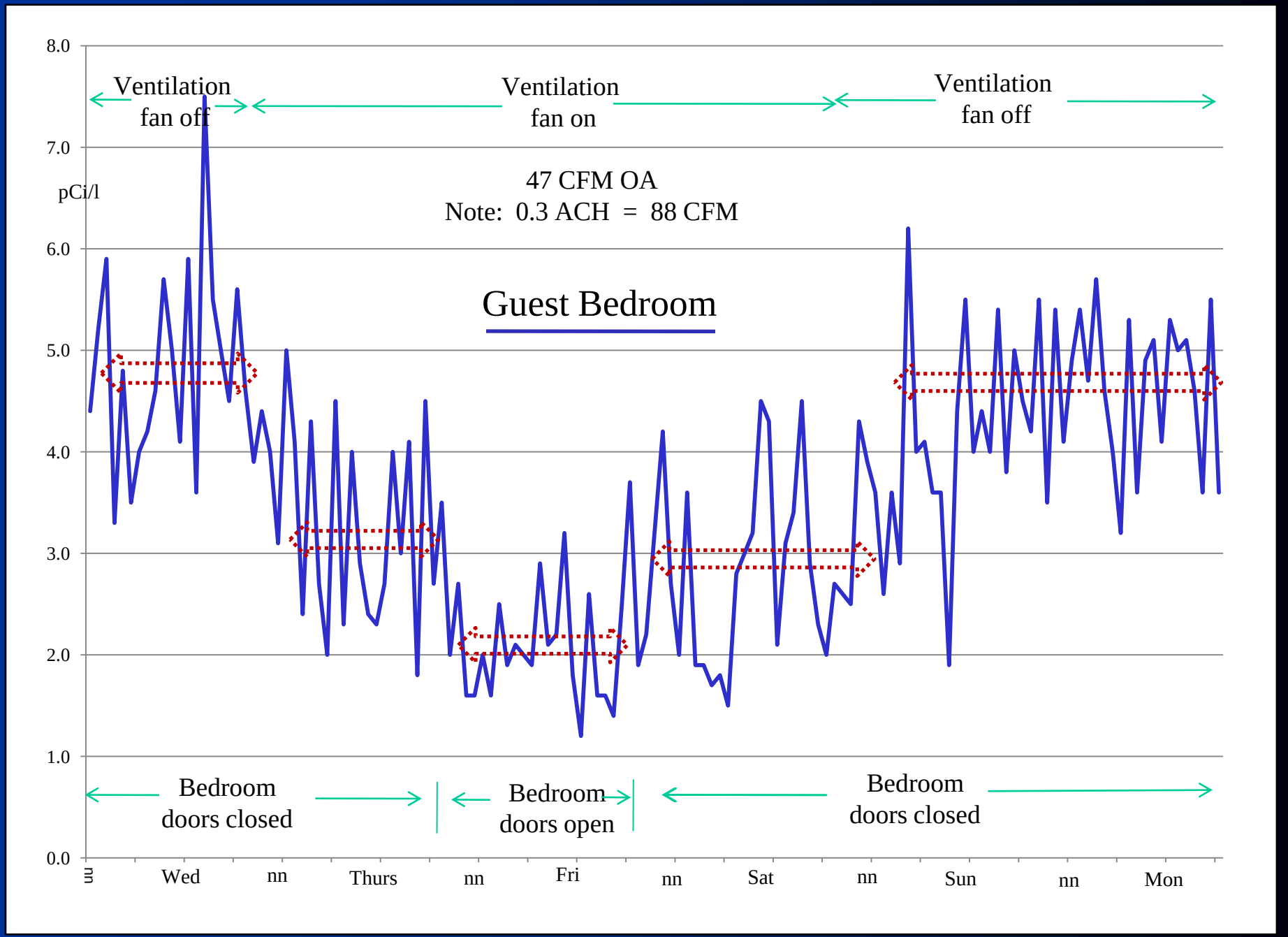
3) Ventilation Rate during Previous Radon Testing

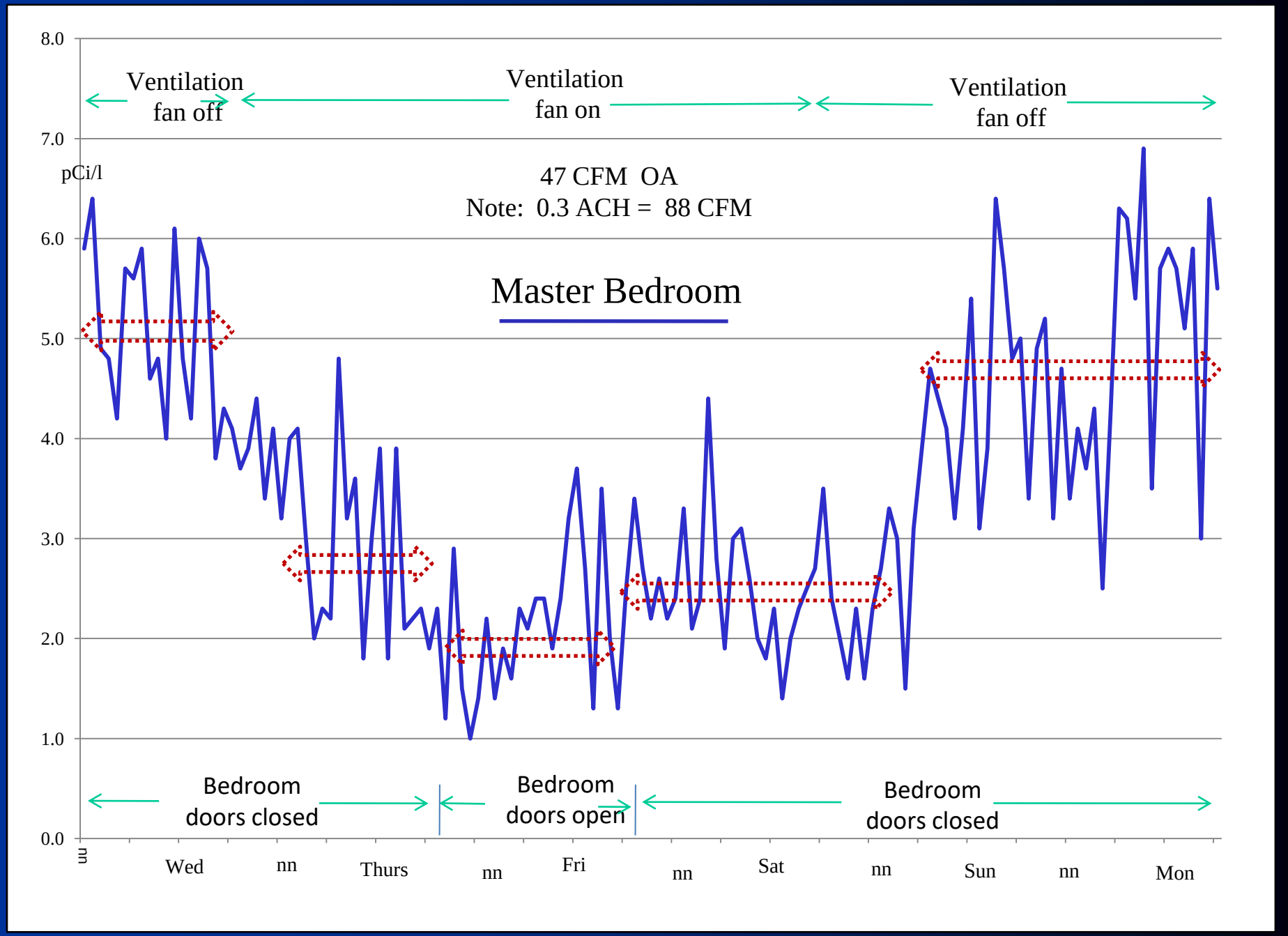
4) Necessary ventilation to maintain low radon levels

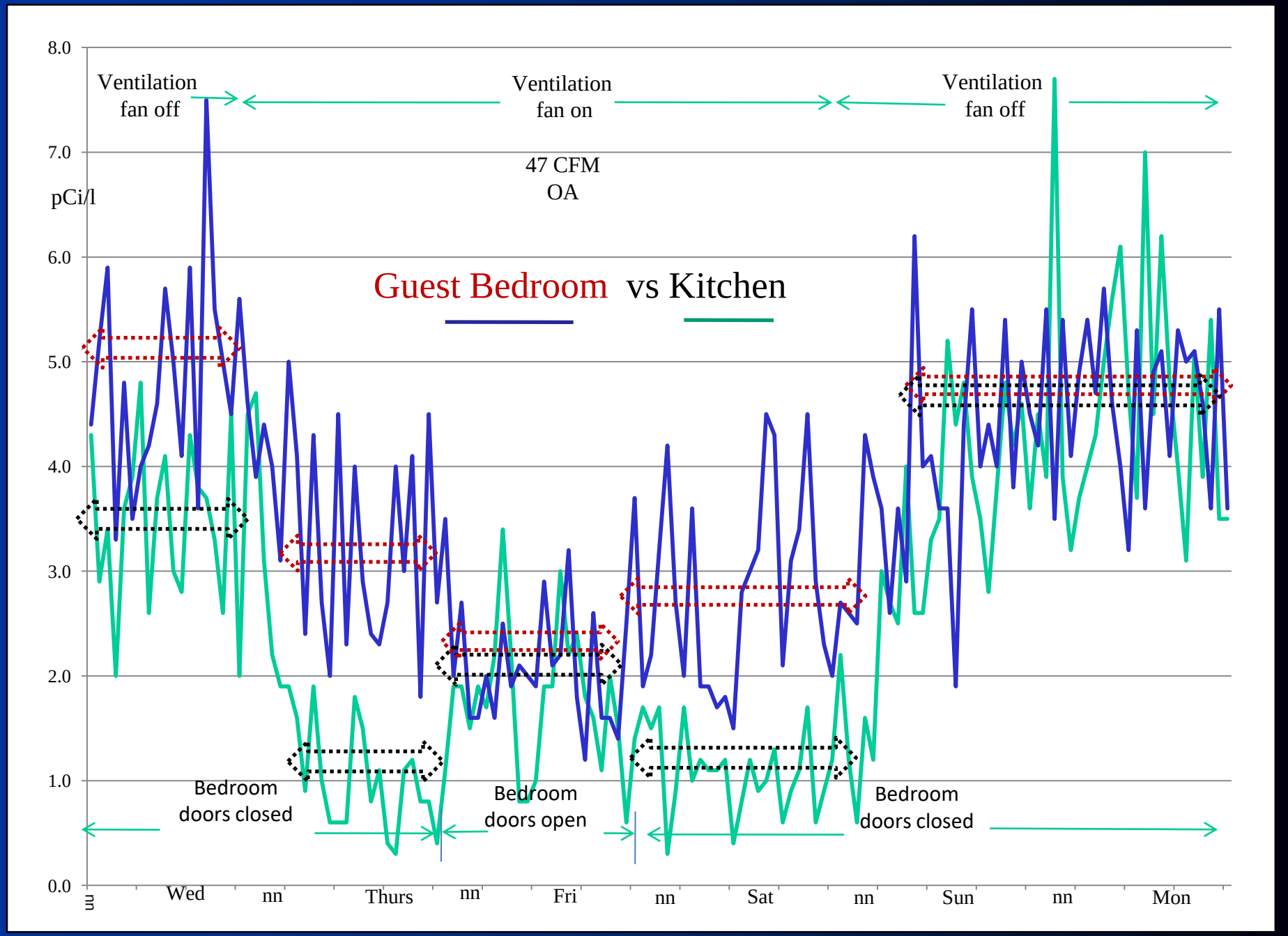
Ventilation Test

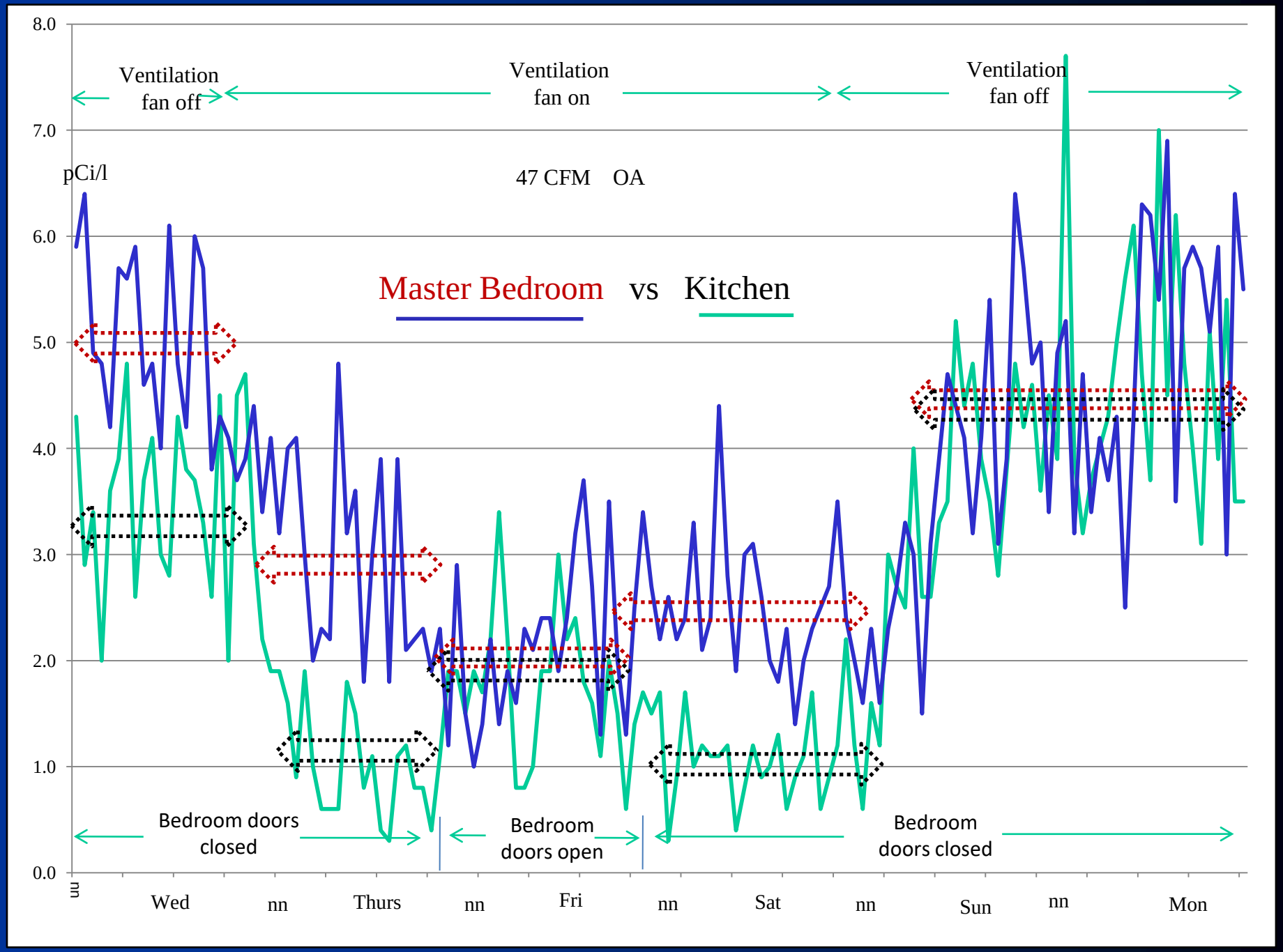



8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
pCi/l
Ventilation fan off
Ventilation fan on
Ventilation fan off
47 CFM OA
0.16 ACH
Concrete emanation
58 pCi/ft²/hr
Kitchen
Note: 0.3 ACH = 88 CFM
0.021 CFM /ft² concrete
78.3 CFM OA
0.26 ACH
31.3 CFM OA
0.1 ACH
Bedroom doors closed
Bedroom doors open
Bedroom doors closed
nn
Wed
nn
Thurs
nn
Fri
nn
Sat
nn
Sun
nn
Mon


8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
pCi/l
Ventilation fan off
Ventilation fan on
Ventilation fan off
47 CFM OA
Note: 0.3 ACH = 88 CFM
Guest Bedroom
Bedroom doors closed
Bedroom doors open
Bedroom doors closed
nn
Wed
nn
Thurs
nn
Fri
nn
Sat
nn
Sun
nn
Mon


Ventilation fan off
Ventilation fan on
Ventilation fan off
pCi/l
47 CFM OA
Note: 0.3 ACH = 88 CFM
Master Bedroom
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Bedroom doors closed
Bedroom doors open
Bedroom doors closed
nn
Wed
nn
Thurs
nn
Fri
nn
Sat
nn
Sun
nn
Mon


8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
pCi/l
Ventilation fan off
Ventilation fan on
47 CFM OA
Ventilation fan off
Guest Bedroom vs Kitchen
Bedroom doors closed
Bedroom doors open
Bedroom doors closed
nn
Wed
nn
Thurs
nn
Fri
nn
Sat
nn
Sun
nn
Mon


8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
pCi/l
Ventilation fan off
Ventilation fan on
Ventilation fan off
47 CFM OA
Master Bedroom vs Kitchen
Bedroom doors closed
Bedroom doors open
Bedroom doors closed
nn
Wed
nn
Thurs
nn
Fri
nn
Sat
nn
Sun
nn
Mon

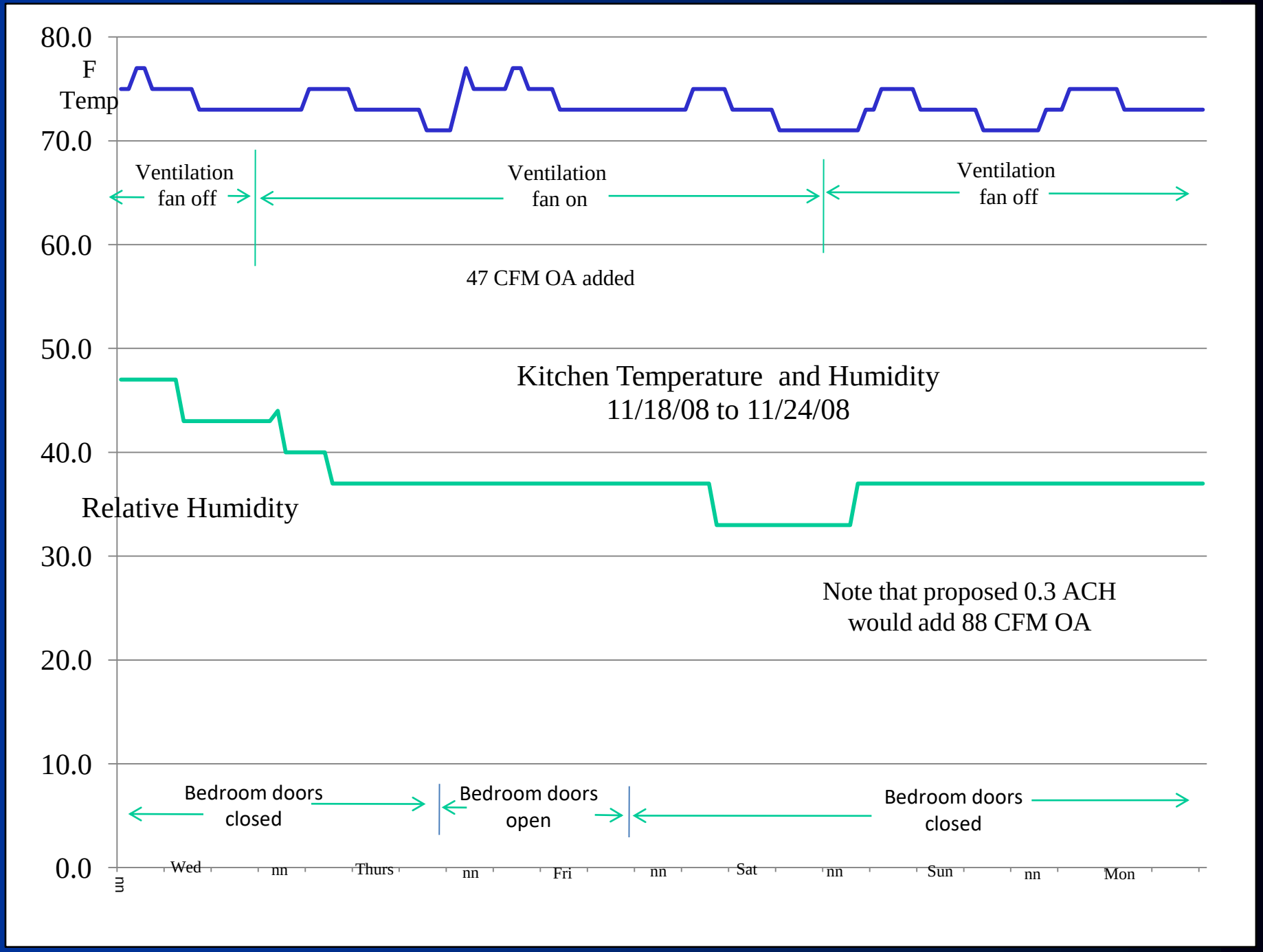
Unit #	pCi/ft^2/hr concrete	Fan Induced ACH	0.03 ACH Mild Weather pCi/L	0.10 ACH Cold Windy pCi/L	Mild weather Bedroom closed doors No HVAC
L-504		0.20	2.1	1.6	3.1
L-504	58.0	0.25	1.7	1.4	2.6
L-504		**0.30**	**1.5**	**1.2**	**2.2**
E-619		0.20	2.4	1.8	3.6
E-619	59.0	0.25	2.0	1.6	3.0
E-619		**0.30**	**1.7**	**1.4**	**2.5**
E-511		0.20	2.6	2.0	3.8
E-511	60.0	0.25	2.1	1.6	3.0
E-511		**0.30**	**1.8**	**1.5**	**2.7**
L-408		0.20	1.4	1.1	2.1
L-408	39.0	0.25	1.2	0.9	1.7
L-408		**0.30**	**1.0**	**0.8**	**1.5**
L-318		0.20	2.6	2.0	3.8
L-318	61.0	0.25	2.1	1.7	3.1
L-318		**0.30**	**1.8**	**1.5**	**2.7**

It may not be necessary in Condominium Buildings to add supplemental heat to ventilation air

Outdoor High & Low Temperatures During ventilation Test

Date	Tues	Wed	Thurs	Fri	Sat	Sun	Mon
High	43°	45°	61°	44°	45°	53°	47°
Low	24°	18°	26°	21°	13°	29°	30°

Even though temperatures were record lows for North Carolina the interior temperatures never decreased when 47 CFM of outdoor air was introduced and the unit was not occupied


80.0
F
Temp
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Ventilation fan off
Ventilation fan on
Ventilation fan off
47 CFM OA added
Kitchen Temperature and Humidity
11/18/08 to 11/24/08
Relative Humidity
Note that proposed 0.3 ACH would add 88 CFM OA
Bedroom doors closed
Bedroom doors open
Bedroom doors closed
nn
Wed
nn
Thurs
nn
Fri
nn
Sat
nn
Sun
nn
Mon

Final Ventilation Design – 100% conditioned air

Two Roof Top 20 ton – 3500 cfm units
Air supplied to each unit @
Heating 70º (21c) at 20% rh
Cooling 68º (18c) at 50% rh

Cooling cycle - ½ gal/min condensation / unit

Each Condo unit received 0.3 ACH of air

Two story units on 1st floor received 0.4 ACH to compensate for single delivery to one floor.

Construction Issues

Post Stressed Concrete steel cables could not be cut. All slab cuts were first X-Ray scanned. Rebar could be cut.

There were utility rooms that stacked from the roof to the 1st floor that allowed two major trunks down.

All the hard ducted runs to the individual units had to be routed above a 12” drop ceiling that was already filled with other utilities

Fire stop dampers included at each floor and into each unit

More Construction Issues

The duct into each unit include adjustable airflow damper

Most units only required a single grill above the entrance door

Some units required more elaborate duct runs that needed to be drywalled and finished.

Each floor hallway had five equally space supply diffusers.

A balancing company was used to set the adjust the final airflow to each unit

2 - 3500 CFM Air Handlers lifted to roof

½ gallon minute of condensation 2” drain

X-ray of slab showing post stressed steel and rebar. Engineers allowed rebar to be cut

X-Ray Company Owner's Car

Slab cut by multiple core holes

Slab was 9” thick

Ductwork installed above drop ceiling in the hallways

All ducts were
carefully sealed

Duct run to the Quad units was difficult

These units had the least radon reduction

All units had balancing dampers

Fire stops installed at each fire barrier penetration

Professional balancing done on all supply grills

Minimal intrusive supply grill in each unit

Final Radon Reductions were excellent

Units Tested	Average Post Mitigation Radon Level
1st Floor Quad units	2.1
1st Floor units	1.2
1st Floor without Quad units	0.8
3rd Floor units	0.8
4th Floor units	0.8
5th Floor units	0.7
Hallways	0.6

Quad Units required extra long duct runs