Radon Guidance and Training

Mitigating Radon in Multifamily Buildings

June 30, 2021

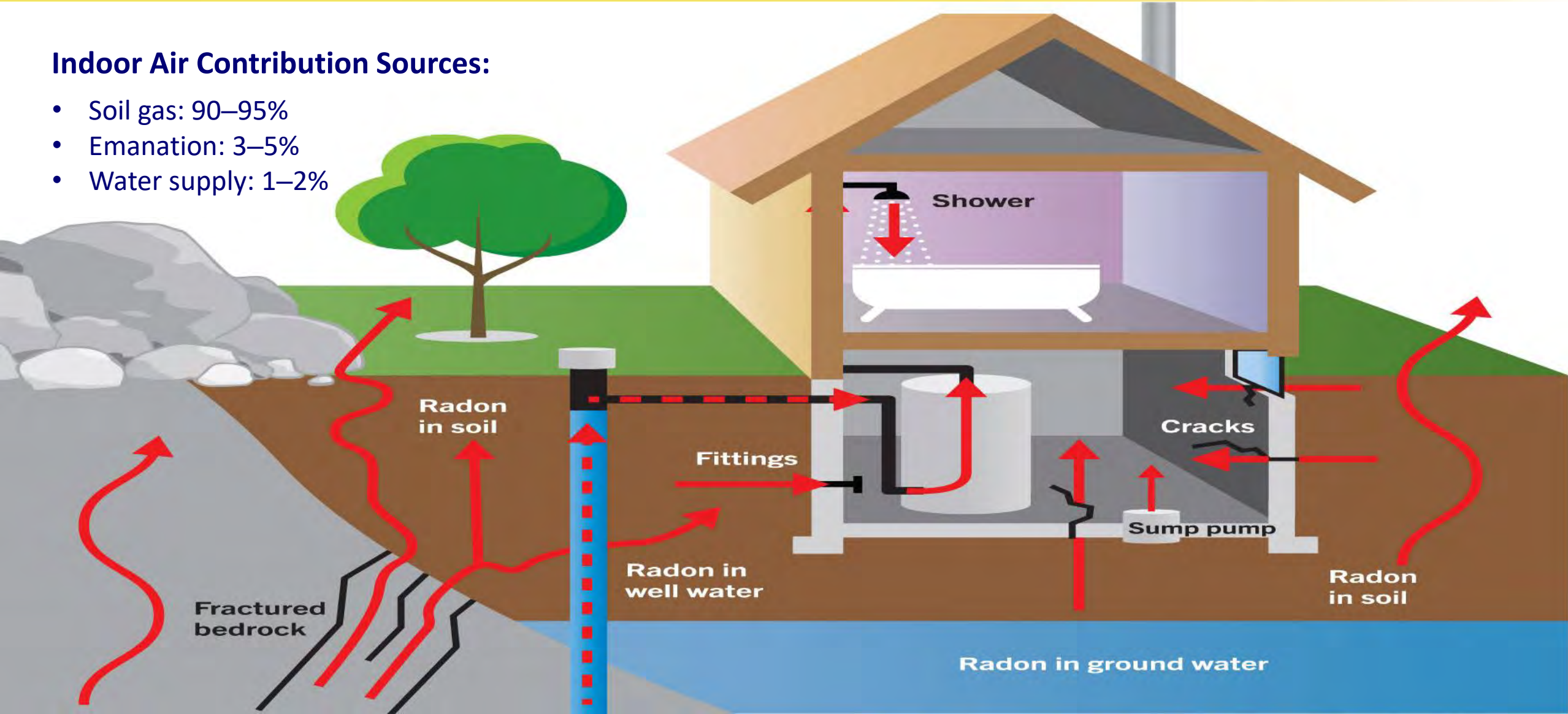
Developed by Kyle Hoylman, President at AARST and Chair at Standards Consortium.

ECONOMETRICA, INC.

Radon Sources and Entry Points

Indoor Air Contribution Sources:

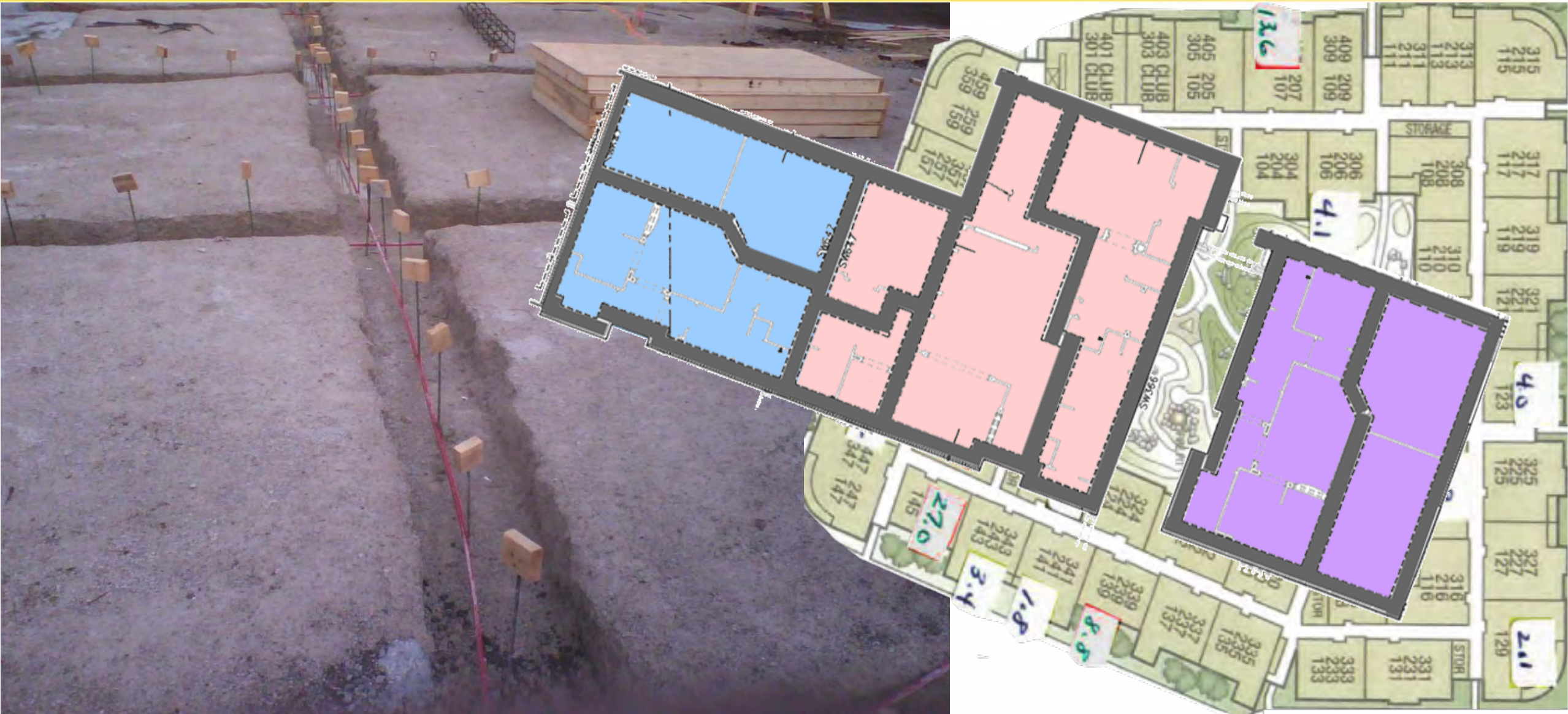
- Soil gas: 90–95%
- Emanation: 3–5%
- Water supply: 1–2%



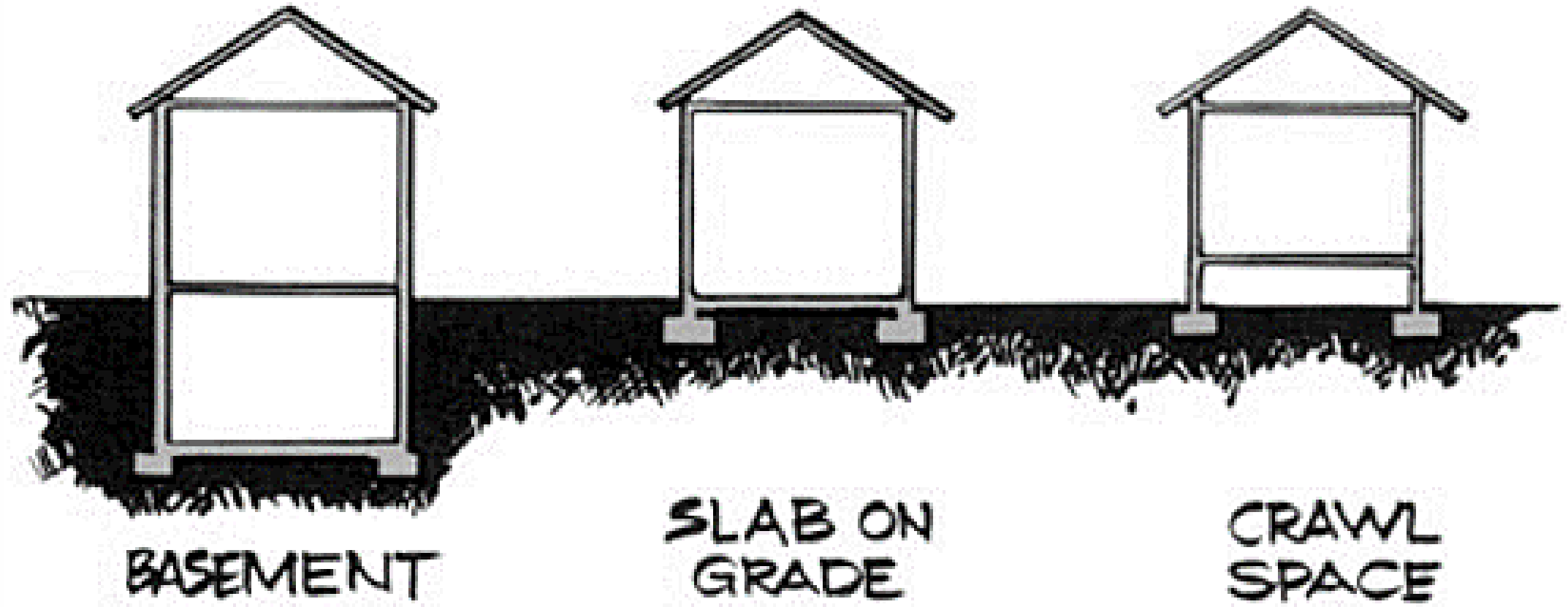
Preferential Pathways (1)



Preferential Pathways (2)



Foundation Types (1)



Foundation Types (2)



Foundation Types (3)



Qualified Radon Professional (QRP)

- Credentialed by the National Radon Proficiency Program (NRPP) or National Radon Safety Board (NRSB) and certification/licensure for state where work is being done, if applicable.
- Direct (onsite) supervision for all radon testing and mitigation activities.
- Responsible for all radon reporting; testing and mitigation supervision; and operation, maintenance, and monitoring (OM&M) supervision.

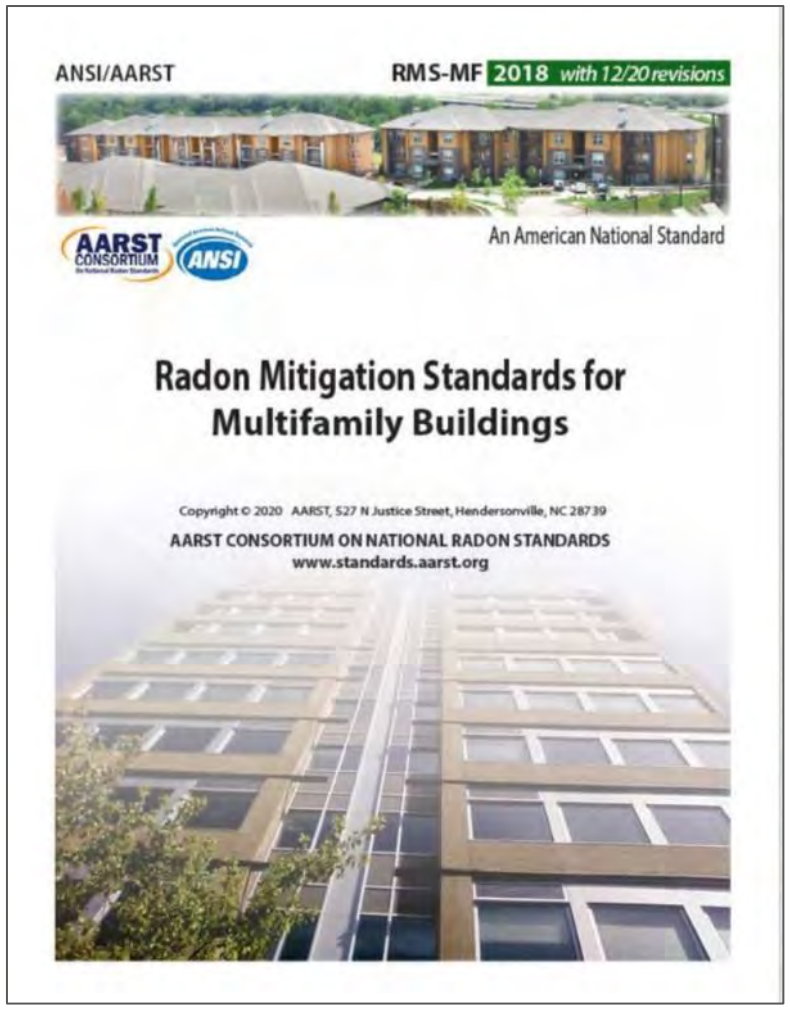
NRPP™ NATIONAL RADON PROFICIENCY PROGRAM

National Radon Safety Board NRSB Certified Radon Professionals



Environmental Law Institute | Database of State Indoor Air Quality Laws – Radon Excerpt | eli.org 40 states with radon law(s) in effect

Multifamily Mitigation Standard (RMS-MF)

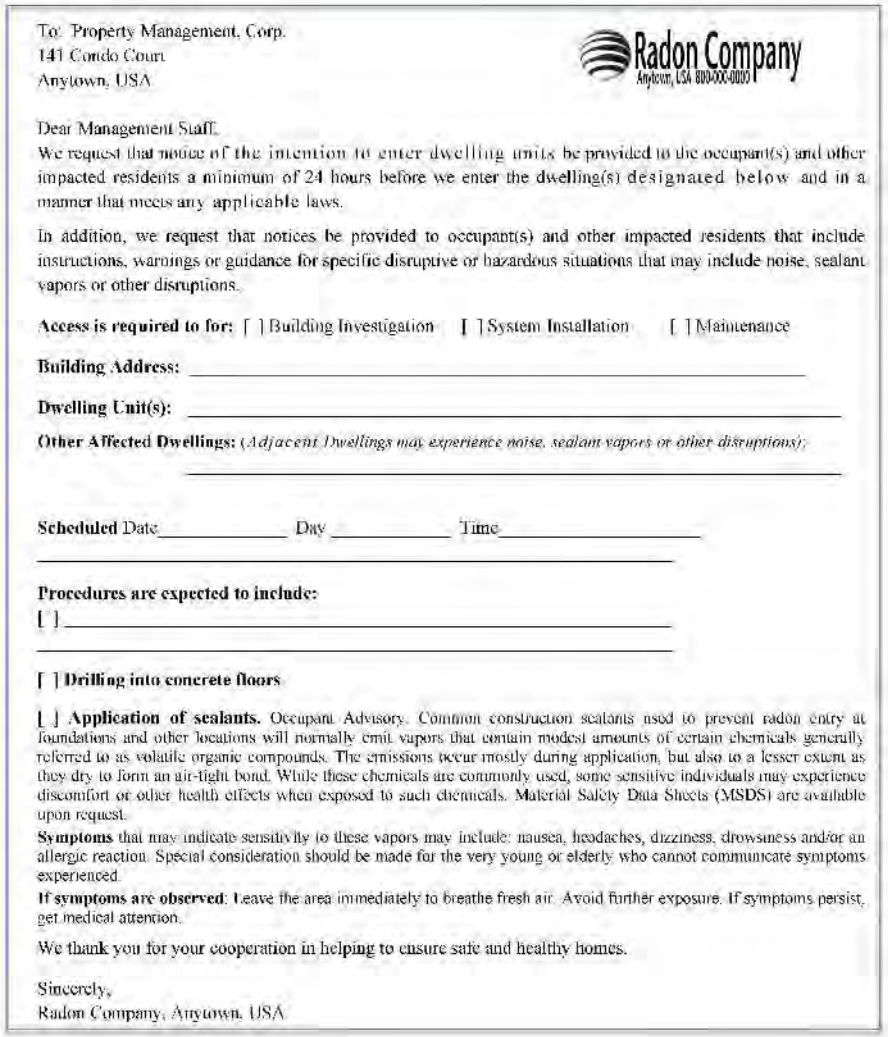


standards.aarst.org

Key Components:

- RMS-MF 2018 w 12/20 Revisions
- Qualified Contractors
- Health and Safety
- Project Communication
- System Design
- System Installation
- Building Clearance
- OM&M
- Chemical Vapor Intrusion

Project Communication: Staff



To: Property Management, Corp.
141 Condo Court
Anytown, USA

Radon Company
Anytown, USA 800-000-0000

Dear Management Staff,
We request that notice of the intention to enter dwelling units be provided to the occupant(s) and other impacted residents a minimum of 24 hours before we enter the dwelling(s) designated below and in a manner that meets any applicable laws.

In addition, we request that notices be provided to occupant(s) and other impacted residents that include instructions, warnings or guidance for specific disruptive or hazardous situations that may include noise, sealant vapors or other disruptions.

Access is required to for: [ ] Building Investigation [ ] System Installation [ ] Maintenance

Building Address: _____

Dwelling Unit(s): _____

Other Affected Dwellings: (*Adjacent Dwellings may experience noise, sealant vapors or other disruptions*):
_____

Scheduled Date_____ Day _____ Time_____
_____

Procedures are expected to include:
[ ] _____
_____

[ ] Drilling into concrete floors

[ ] Application of sealants. Occupant Advisory: Common construction sealants used to prevent radon entry at foundations and other locations will normally emit vapors that contain modest amounts of certain chemicals generally referred to as volatile organic compounds. The emissions occur mostly during application, but also to a lesser extent as they dry to form an air-tight bond. While these chemicals are commonly used, some sensitive individuals may experience discomfort or other health effects when exposed to such chemicals. Material Safety Data Sheets (MSDS) are available upon request.
Symptoms that may indicate sensitivity to these vapors may include: nausea, headaches, dizziness, drowsiness and/or an allergic reaction. Special consideration should be made for the very young or elderly who cannot communicate symptoms experienced.
If symptoms are observed: Leave the area immediately to breathe fresh air. Avoid further exposure. If symptoms persist, get medical attention.

We thank you for your cooperation in helping to ensure safe and healthy homes.

Sincerely,
Radon Company, Anytown, USA



Property Management Company
Anytown, USA 800-000-0000

Dear Custodial, Maintenance and Educational Staff,
Important steps are being taken to lower the risk to occupants in this building from soil gas pollutants. In particular, radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in nonsmokers in the U.S.

Your staff member contacts:
Staff authorized for responding to public inquiries _____ Phn#_____
For logistics of onsite activities, contact: _____ Phn#_____

Access is needed and scheduled for:

Building:

Building Area(s): _____

Scheduled Date_____ **Day** _____ **Time**_____

Access is required to for: [ ] Building Investigations [ ] System Installation [ ] Maintenance

Procedures are expected to entail:

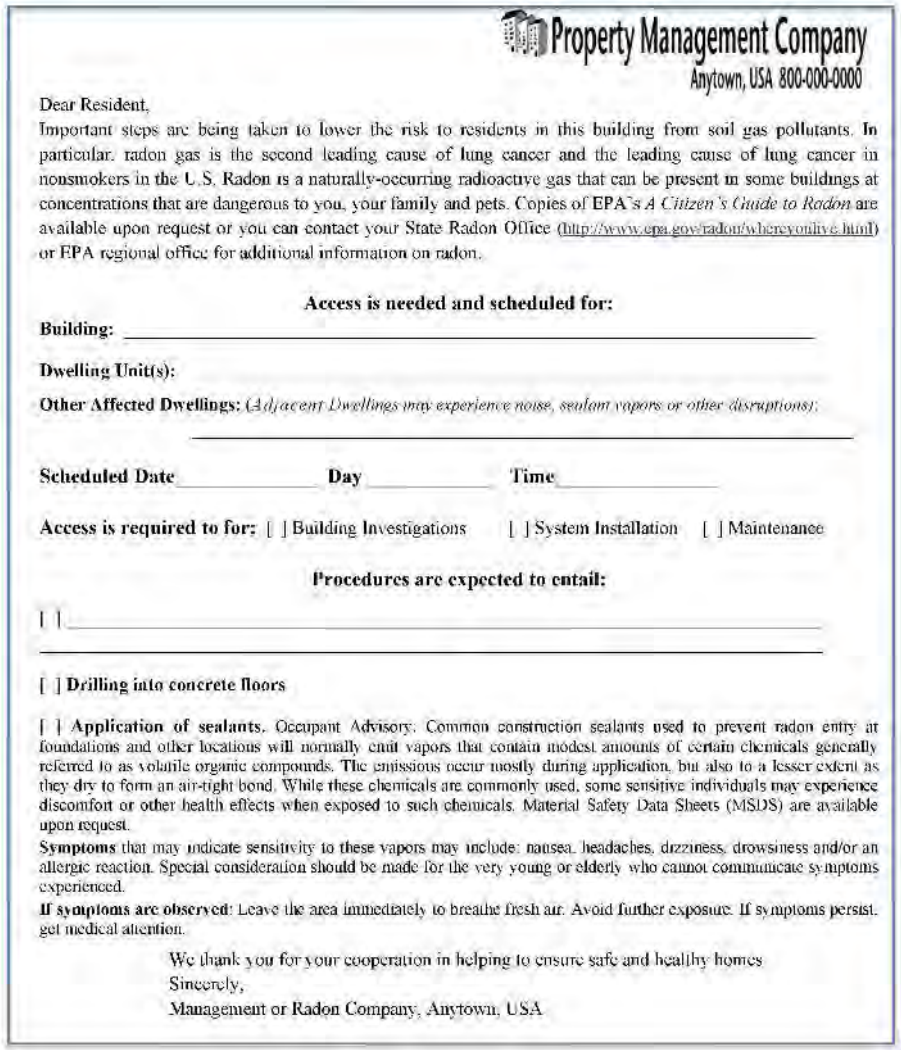
[ ] _____
_____

[ ] Drilling into concrete floors

[ ] Application of sealants. Occupant Advisory: Common construction sealants used to prevent radon entry at foundations and other locations will normally emit vapors that contain modest amounts of certain chemicals generally referred to as volatile organic compounds. The emissions occur mostly during application, but also to a lesser extent as they dry to form an airtight bond. While these chemicals are commonly used, some sensitive individuals may experience discomfort or other health effects when exposed to such chemicals. *Material Safety Data Sheets (MSDS) are available upon request.*
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We thank you for your cooperation in helping to ensure safe and healthy homes.
Sincerely,
Management or Radon Company, Anytown, USA

Project Communication: Residents



Property Management Company
Anytown, USA 800-000-0000

Dear Resident,

Important steps are being taken to lower the risk to residents in this building from soil gas pollutants. In particular, radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in nonsmokers in the U.S. Radon is a naturally-occurring radioactive gas that can be present in some buildings at concentrations that are dangerous to you, your family and pets. Copies of EPA's *A Citizen's Guide to Radon* are available upon request or you can contact your State Radon Office (http://www.epa.gov/radon/whereyoulive.html) or EPA regional office for additional information on radon.

Access is needed and scheduled for:

Building: _____

Dwelling Unit(s):

Other Affected Dwellings: *(Adjacent Dwellings may experience noise, sealant vapors or other disruptions):*

_____

Scheduled Date_____ **Day** _____ **Time**_____

Access is required to for: [ ] Building Investigations [ ] System Installation [ ] Maintenance

Procedures are expected to entail:

[ ] _____

_____

[ ] Drilling into concrete floors

[ ] Application of sealants. Occupant Advisory: Common construction sealants used to prevent radon entry at foundations and other locations will normally emit vapors that contain modest amounts of certain chemicals generally referred to as volatile organic compounds. The emissions occur mostly during application, but also to a lesser extent as they dry to form an air-tight bond. While these chemicals are commonly used, some sensitive individuals may experience discomfort or other health effects when exposed to such chemicals. Material Safety Data Sheets (MSDS) are available upon request.

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Sincerely,

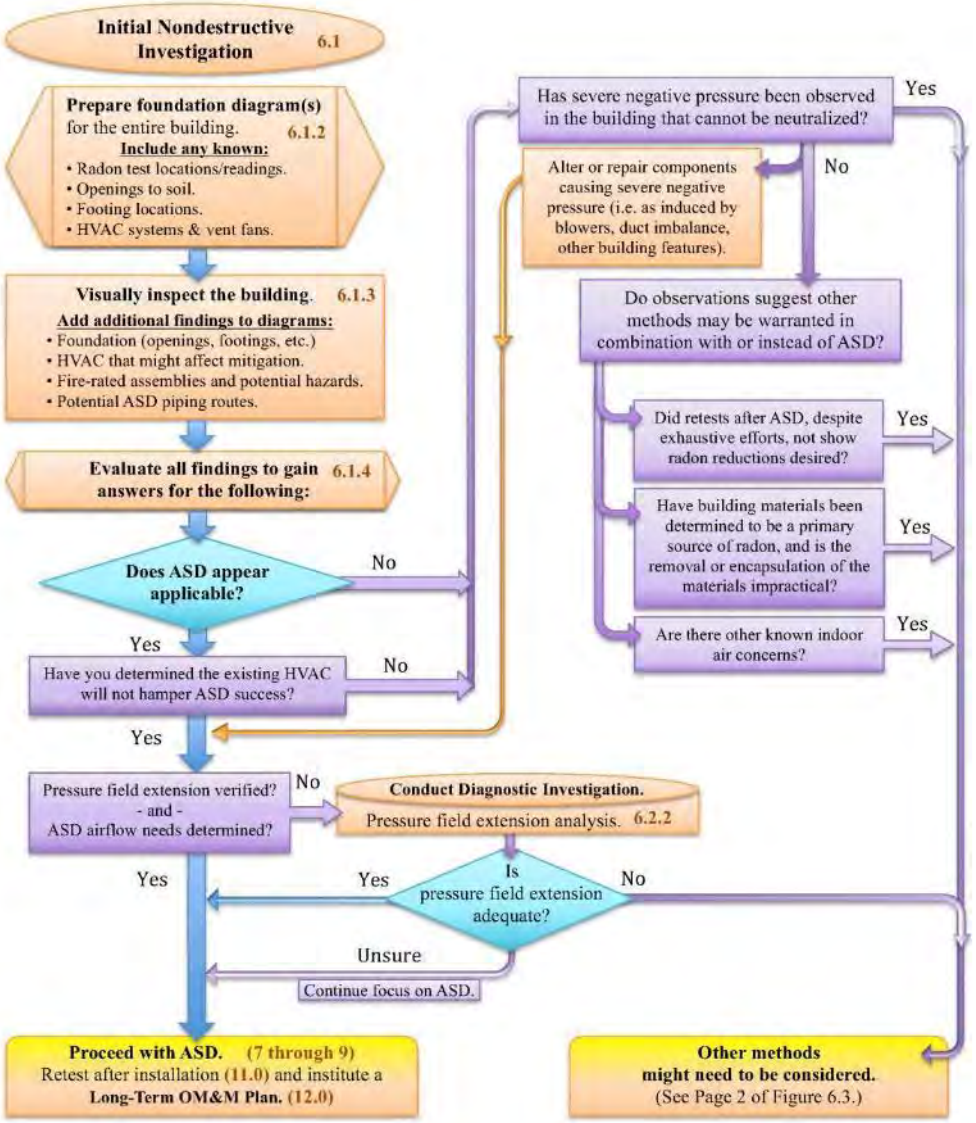
Management or Radon Company, Anytown, USA

"**Occupant Advisory:** *Common construction sealants used to prevent radon entry at foundations and other locations will normally emit vapors that contain modest amounts of certain chemicals generally referred to as volatile organic compounds. The emissions occur mostly during application, but also to a lesser extent as they dry to form an air-tight bond. While these chemicals are commonly used, some sensitive individuals may experience discomfort or other health effects when exposed to such chemicals.*

***Symptoms** that may indicate sensitivity to these vapors may include: nausea, headaches, dizziness, drowsiness and/or an allergic reaction. Special consideration should be made for the very young or elderly who cannot communicate symptoms experienced. Material Safety Data Sheets (MSDS) are available upon request.*

***If symptoms are observed:** Leave the area immediately to breathe fresh air. Avoid further exposure. If symptoms persist, get medical attention."*

Mitigation System Design – Decision Flowchart



Key Components:

- Documentation Review (offsite)
  - Measurement Report
  - Known Hazards
  - Building Plans/Operation Specifications
- Building Investigation (onsite/offsite)
  - Foundation Type/Condition
  - HVAC System/Specifications
  - Other Mechanical Systems/Specifications
  - Extraction Point/System Routing Options
  - Electrical Options
- Diagnostic Investigation (onsite)
  - Pressure Field Extension (PFE) Analysis
  - Collateral Mitigation Analysis

Mitigation System Design – Building/Diagnostic Investigations (1)



Pilot Test:

- Pressure, Resistance, Vacuum
- Radius of Influence (ROI)
- Sub-Slab Obstructions
- Collateral Mitigation

  *GPR/Utility Clearance

Building Evaluation:

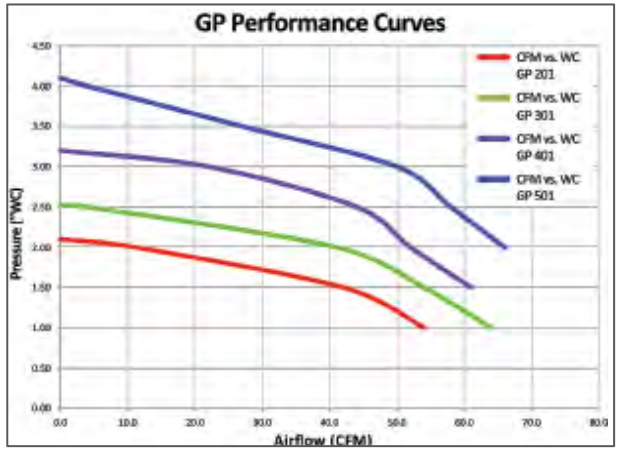
- Vent Pipe Routing
- Fan Location
- Discharge Location
- Electrical Configuration

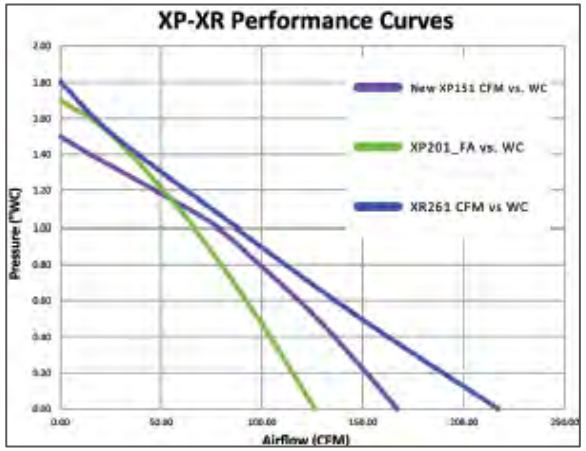
Mitigation System Design – Building/Diagnostic Investigations (2)

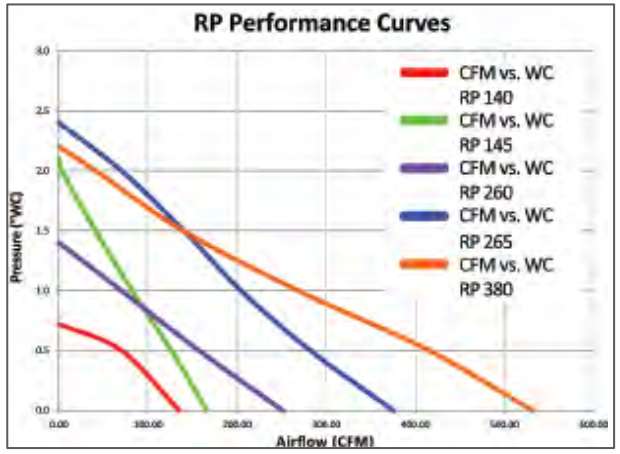
Extraction Point (EP)	Operating Pressure ("w.g.)
EP01	3.5
EP02	3.5

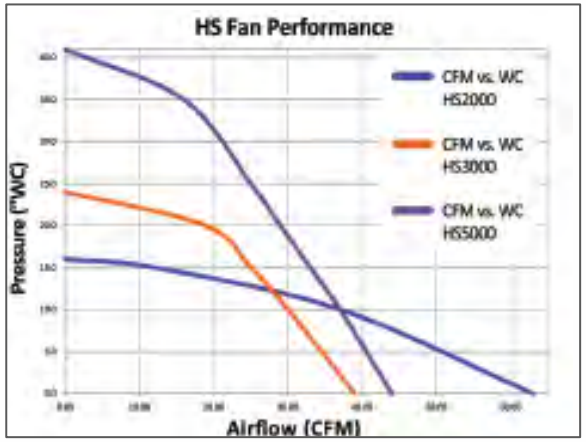
Test Point (TP)	Pressure Field Extension ("w.g.)
EP01/TP01	-.940
EP01/TP02	-.147
EP01/TP03	-.260
EP01/TP04	-.135
EP01/TP05	-.060
EP01/TP06	-.070
EP01/TP07	-.020
EP01/TP08	-.020
EP01/TP09	-.023
EP01/TP10	-.010
EP01/TP11	-.005
EP02/TP04	-.016
EP02/TP05	-.005
EP02/TP06	-.005
EP02/TP07	-.016
EP02/TP08	-.027
EP02/TP09	-.061
EP02/TP10	-.157



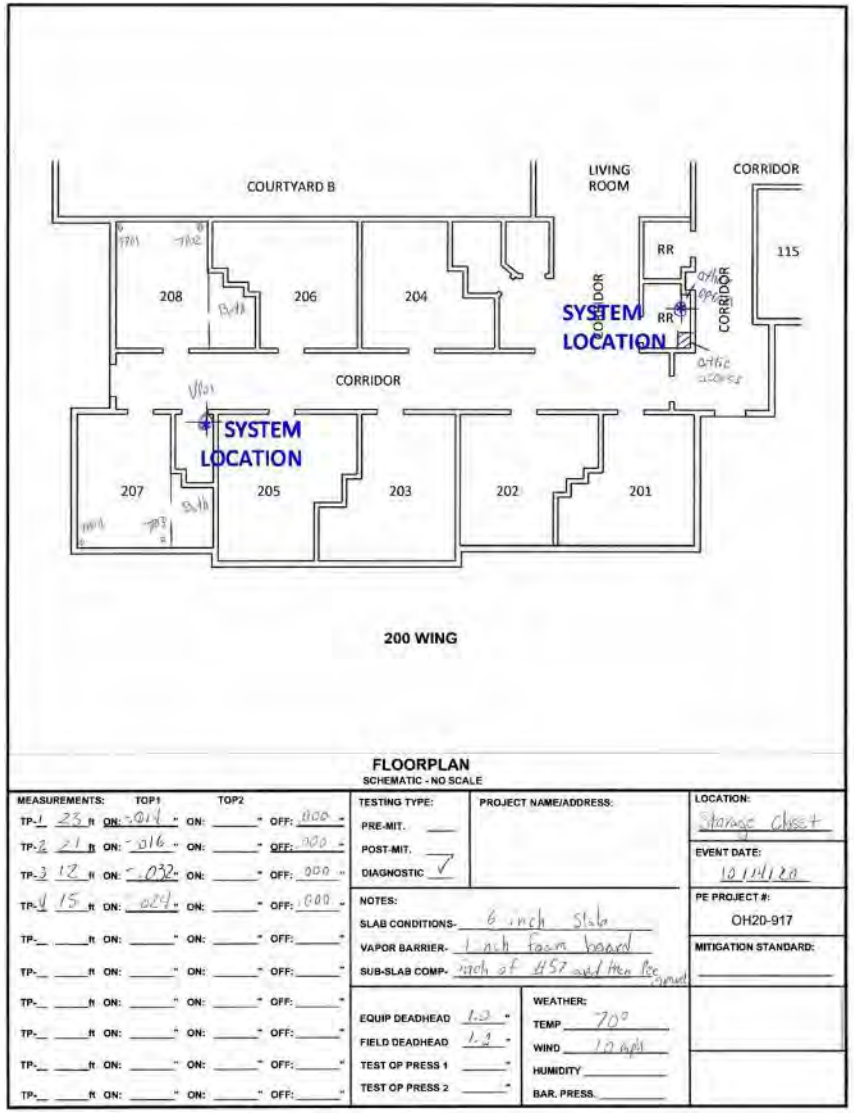








Mitigation System Design – Building/Diagnostic Investigations (3)



System Design Specifications

System Type: ASD ☑ AMD ☐ SPD ☐	**System Monitor Type:** 4WC" U-Tube ☑ Magnahelic ☐	**Electrical Connection Type:** Exterior Switch ☐ Interior Outlet ☑
Fan Model: RP145 ☐ RP265 ☑ GP501 ☐ HS5000 ☐	**Fan Location:** Exterior ☐ Interior ☑ Security Cover ☐ Location: Attic	**Power Source:** Common ☑ Resident ☐ Photocell ☐
Vent Piping Options: Attic Routing ☑ 10' LF Pipe Dia. 4" Exterior Exhaust ☐ ____ LF Pipe Dia. ____" Interior Routing ☑ 10' LF Pipe Dia. 4" Roof Exhaust ☐ ____ LF Pipe Dia. ____" Fire Collars ☐		**Sealing Options:** Prep/caulk foundation cracks ☐ ____ LF Prep/foam foundation penetrations ☐ ____ Cans **Crawlspace Options:** Wall Encapsulation ☐ ____ LF Floor Encapsulation ☐ ____ SqFt Pier Encapsulation ☐ ____ (tot) Crawlspace Prep ☐ ____ SqFt Clearance Add-on (<30") ☐

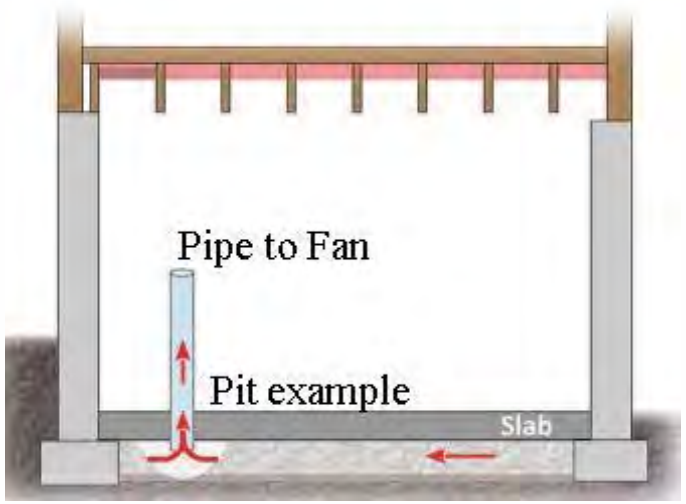
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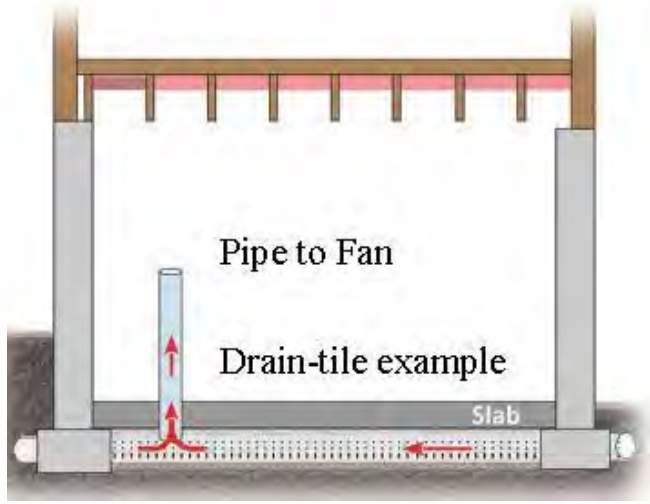
Building Evaluation

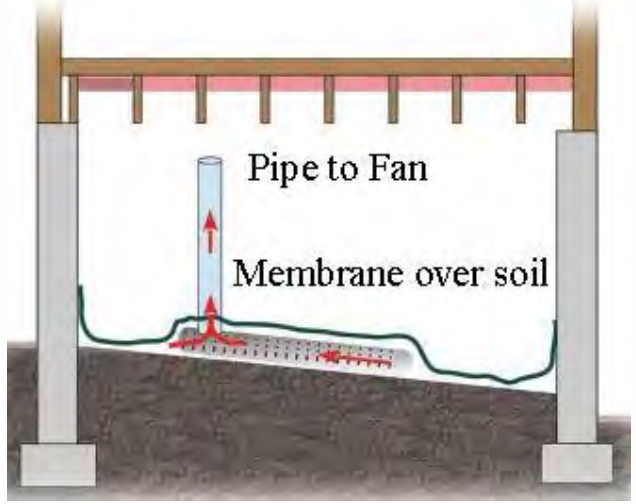
Year Built:	**Approximate Square Footage:** Ground-Contact ____ Total ____		
Building Type: 1-Story ☑ 2-Story ☐ 3-Story ☐ Other	**Exterior:** Stone ☐ Brick ☑ Stucco ☐ Vinyl ☐ Wood ☐ Aluminum ☐ Other	**Attic Access:** Common ☑ Resident ☐ Location: Storage Closet	**Roof:** Asphalt ☑ Metal ☐ Tile ☐ Flat ☐ Type
Elevator ☐	Multi-Story Unit Stack Configuration		
Foundation Type: Block ☐ Slab-on-grade ☑	**Foundation Details:** Basement ☐ Crawlspace ☐ Finished? Y____(%) N____	**Cracking:** Floor ☐ Floor-Wall Joint ☐ Wall ☐	
HVAC Type: Gas ☐ Electric ☐	**HVAC Details:** Buried Ductwork ☐ Piping ☐ Exposed Filter ☐ Fresh Air In ☐ Heated Floors ☐	**Electric Service:** 1-phase ☐ 3-phase ☐	

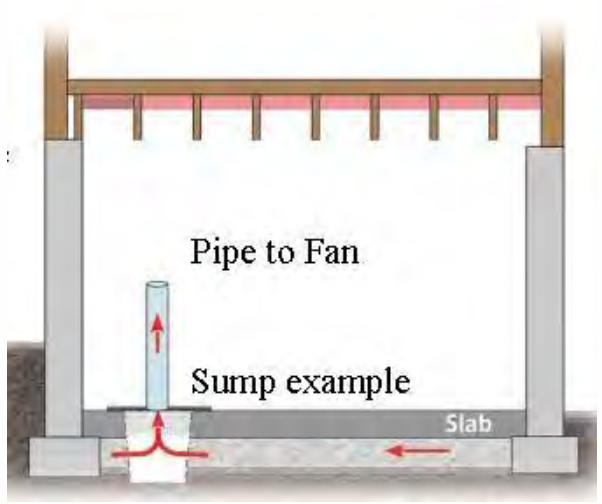
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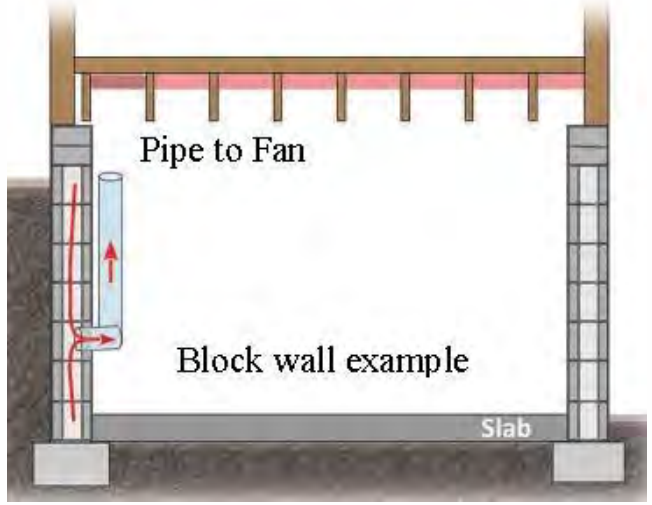
Mitigation System Installation – Extraction Point Options



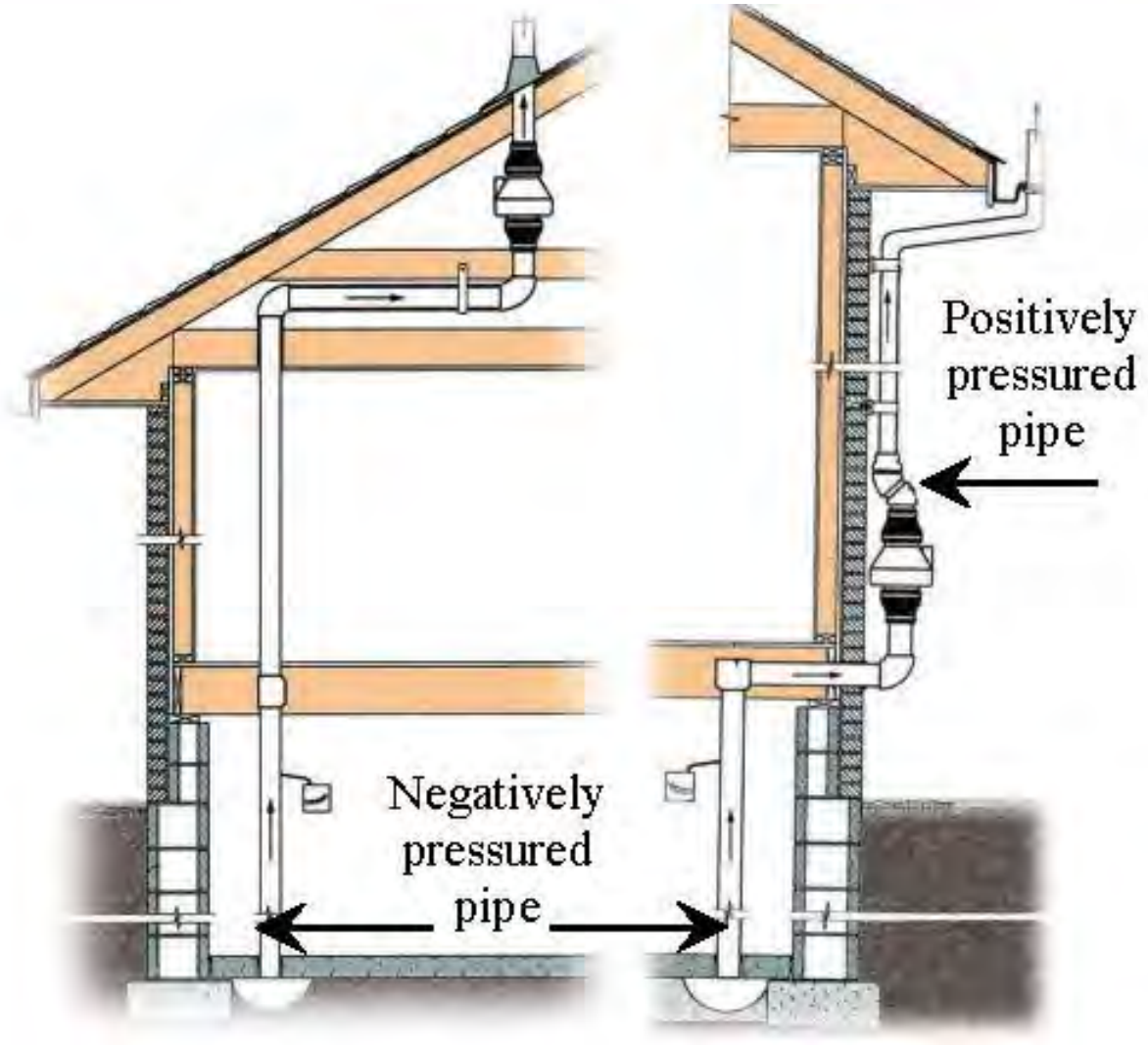




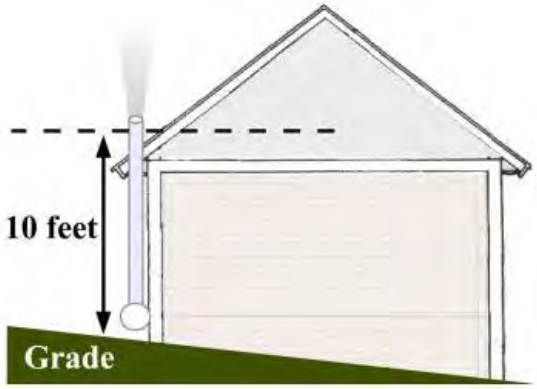




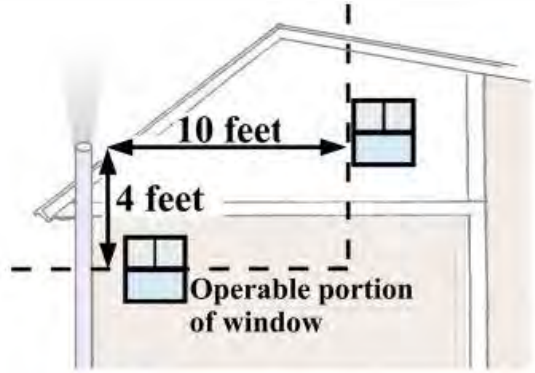
Mitigation System Installation – Routing Options

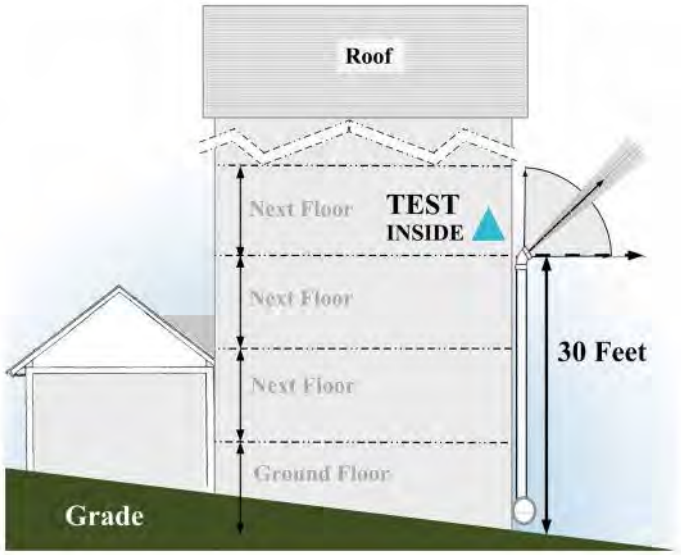


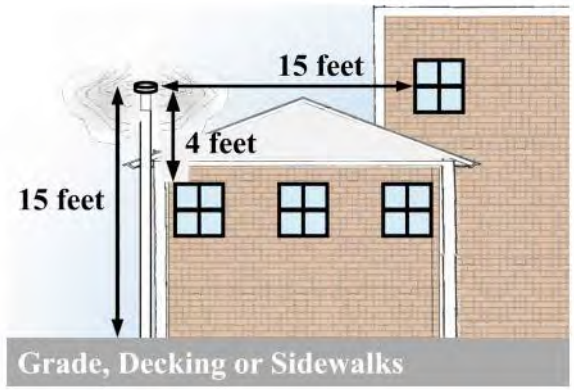
Mitigation System Installation – Discharge Options

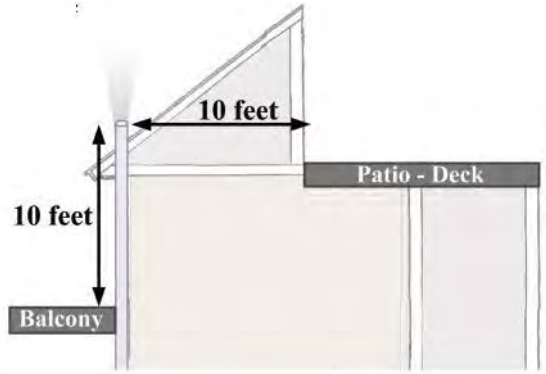




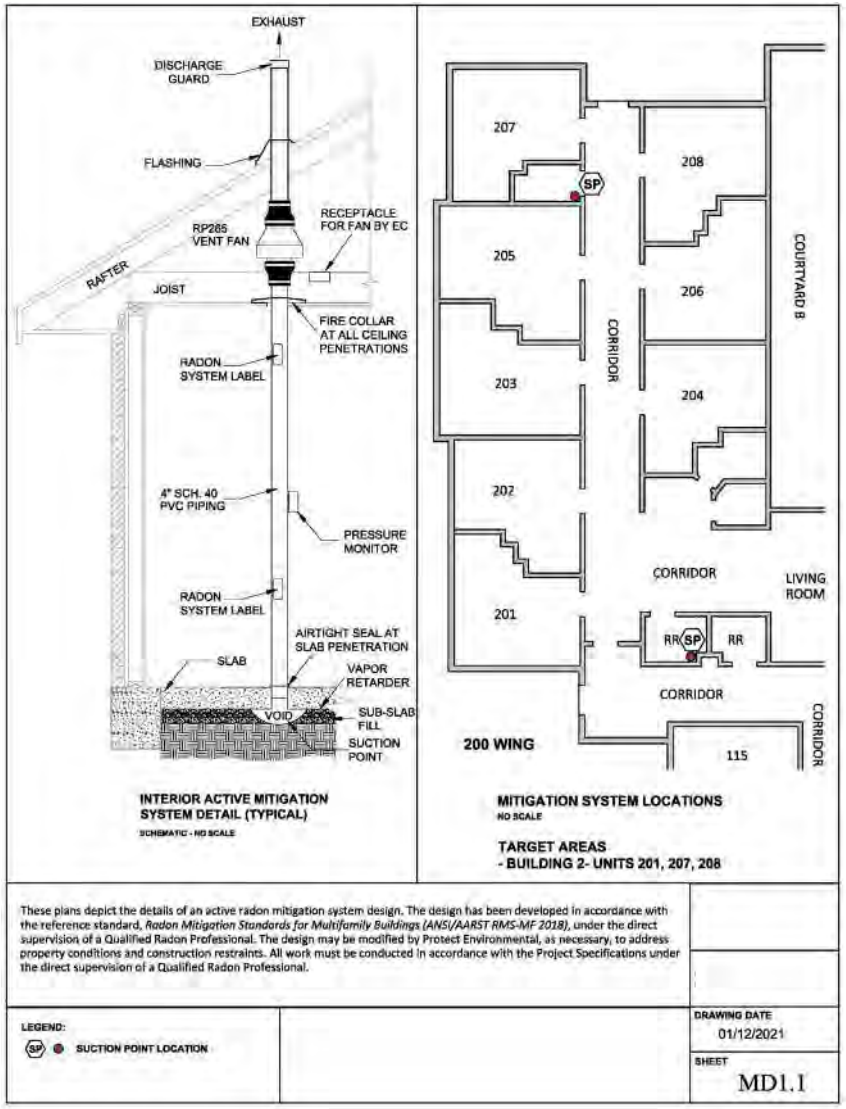








Mitigation System Design – Design Documentation



Key Components:

- Extraction Point Location/Specs
- Vent Pipe Location/Specs
- Discharge Point Location/Specs
- Fan Location/Specs
- Sealing Specifications
- Electrical Specifications
- Other Project Specifications
  - Worker Health and Safety
  - Post-Mitigation Testing Specifications
  - OM&M Specifications

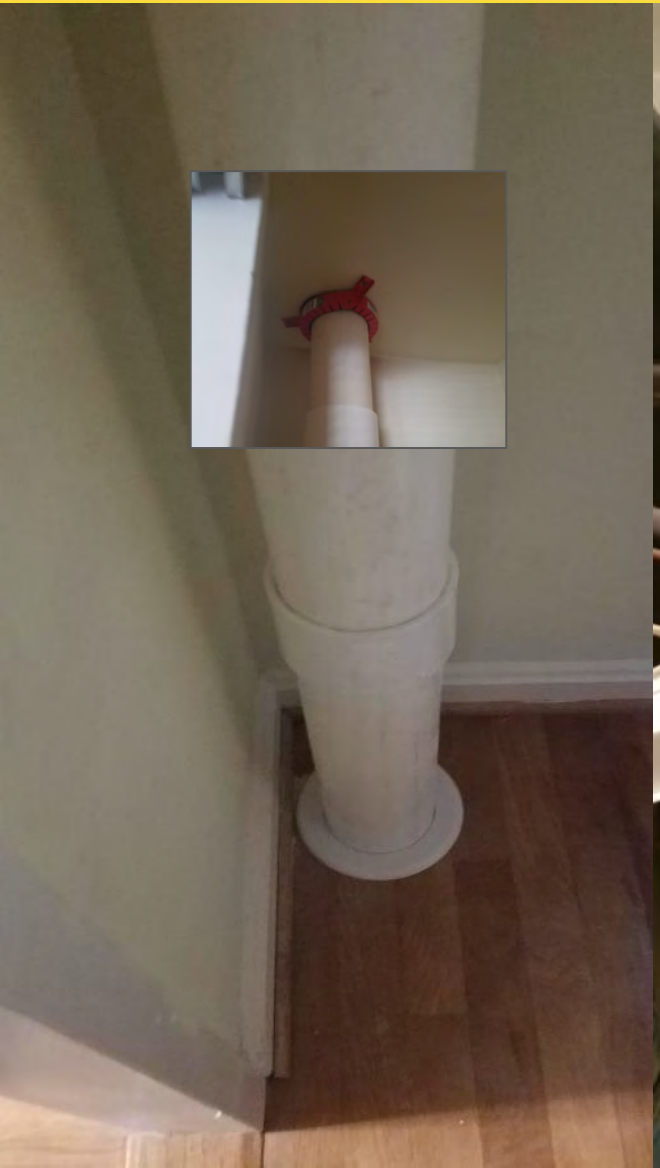
Mitigation System Installation, Exterior

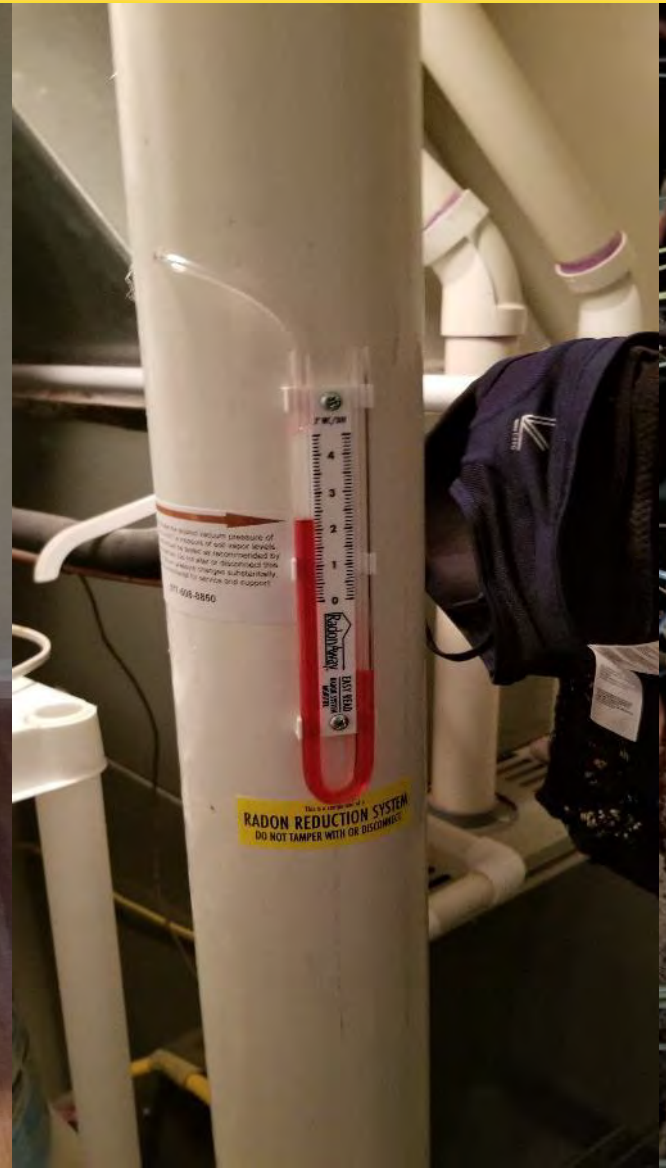






Mitigation System Installation, Interior









Mitigation Project Clearance/Long-Term Stewardship

Key Components:

- Building Clearance – MAMF 2017 w 1/21 Revisions
  - 100% Ground Contact / 10% Upper Level
- OM&M Program
  - Quarterly Inspections
  - Annual Inspections
  - 2-Year Testing (Impacted Locations)
  - 5-Year Testing (Property)
  - Routine/Non-Routine Maintenance

Documentation Controls and Mechanical System Monitors	Maintenance Inspections of Controls and Monitors	Frequency of Inspection
Document Startup Details A description shall be provided for the fan monitors, control settings and other operating parameters that existed at the time successful mitigation was initially achieved. The description should include explicit detail for comparison during inspections and repair, including: a) descriptions of equipment labeling and annotations for fan monitors, control settings and other operating parameters; b) exact locations of fan monitors, electronic telemetry/monitoring equipment, electrical disconnects and other components; c) instructions for equipment sufficient to interpret labels, annotations and the designed operating parameters for the equipment. When applicable, include manufacturer instructions; d) a list of appropriate actions for the Client(s) to take if fan monitor devices or inspections indicate a system is not operating as designed; and e) documented measurements for balance of airflow in and airflow out of HVAC system(s) when a component of a mitigation system.	The following inspections shall be written into the OM&M plan as required actions: a) inspection of fan monitors. control settings and other operating parameters to ensure systems are operating as designed; b) investigation and correction of any conditions that are found to indicate component failure or inconsistencies with designed operating parameters; and c) recording and maintenance of records that are to be assimilated into the overall building OM&M documentation. The plan shall stipulate that a qualified professional should perform these inspections and if performed by in house maintenance staff, such staff shall be trained in system operations.	The plan shall stipulate recommendations and any requirements for the frequency of inspections, as deemed by the contractor as appropriate to the situation. It is recommended that the plan stipulate inspections be conducted at least quarterly of all fan monitors, controls, and as applicable, filters and vent openings. The plan should also recommend inspections subsequent to: a) system shutdown due to building power failure or emergency; and b) any catastrophic event that could damage system components.
Documentation Mechanical Equipment	**Mechanical Equipment Inspections**	**Frequency of Inspection**
Equipment Details and Instructions a) Include manufacturer instructions and instructions specific to design configurations, as appropriate; b) Include exact locations of fans, electrical disconnects and other components; and c) Include a list of appropriate actions for the Client(s) to take if the fan monitor warning device indicates system degradation or failure. d) Include a list of potential repair items for ASD systems that should include: i. fan monitor repair or replacement (e.g., reconnect or replace oil in U tube); ii. electrical repair; iii. fan or boot replacement; and iv. sealing openings to soil or piping connections.	The OM&M plan shall observe that mechanical equipment inspections should include all seals, straps, fasteners, electrical system (including switch operation), boots, performance indicators, labels, pipe condition, filters, inlet grills and fan operation. When HVAC is a component of the mitigation system(s), provide a list of inspection items that includes: i. HVAC airflow in and airflow out of the air handler; ii. functionality of HVAC filters; iii. room differential pressure test; iv. fresh-air damper settings; and v. verification for supply air into rooms of interest.	The plan shall stipulate that a detailed inspection of all components is to be conducted at least every 2 years by a qualified professional.
Monitoring Continued Effectiveness The plan shall include notice of applicable retesting guidance found in ANSI/AARST publication MAMF: *Protocol for Conducting Measurements of Radon and Radon Decay Products In Multifamily Buildings.*		

Mitigation Costs

Average radon testing and/or mitigation costs in single-family, multifamily, and large buildings developed for FHA-insured properties.

- Single-Family Residential Buildings
  - Average cost range for testing: $100 to $275 per unit
  - Average cost range for mitigation: $1,500 to $3,000 per unit
- Multifamily and Large Buildings
  - Average cost range for testing: $50 to $80 per unit
  - Average cost range for mitigation: $2,500 to $4,000 per unit

Notes:

- Average testing cost range assumes one short-term device deployed over one foundation area; required QA controls are implemented.
- Average mitigation cost range assumes use of sub-slab depressurization mitigation technology, and all mitigation costs are included: (1) diagnostic design testing; (2) mitigation system installation; (3) post-mitigation testing; and (4) final report with OM&M program plan.
- The costs for radon testing and/or mitigation in a specific geographical location may vary.

Mitigation Project Example – Costing

Installation Cost – 26 GCU ≥ 4.0 pCi/L	Contractor A	Contractor B
Pre-mitigation clearance testing – 9 units ▪ 4 units removed from mitigation plan – Contractor B	$0	$1,435
Pilot testing/building characterization	$0	$6,000
Mitigation system installation ▪ Per unit cost: $1,285 – Contractor A, 26 Systems ▪ Per unit cost: $2,350 – Contractor B, 16 Systems	$33,410	$37,600
Post-mitigation clearance testing – 26 Units	$1,500	$2,025
OM&M program plan	$0 (not included)	$500
Installation Cost Total	**$34,910**	**$47,560**

Mitigation Project Example – Costing

OM+M – 26 GCU ≥ 4.0 pCi/L	Contractor A	Contractor B
2-Year Testing Cycle – Mitigation ▪ $2,000(+/-), 26 Units	$34,000	$34,000
5-Year Testing Cycle – Non-Mitigation ▪ $7,500 (+/-), 140 Units	$45,000	$45,000
5-Year Mitigation System Maintenance ▪ $550 (+/-) per system, routine/non-routine	$85,800	$52,800
1-Year Mitigation System Operation ▪ $168 (+/-) per system, electric consumption, air leakage	$152,880	$94,080
OM&M Cost Estimate Total (35-Year Assumption)	**$317,680**	**$225,880**

< 5 years to return 100% of installation cost difference, $92,000 (+/-) cost of ownership advantage

Contact Information

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