Waste Management Division
PO Box 95, 29 Hazen Drive
Concord, NH 03302

Type of Submittal (Check One-Most Applicable)

☐ Work Scope ☐ Reimbursement Request	☐ Remedial Action • Remedial Action Plan • Bid Plans and Specifications • Remedial Action Implementation Report ☐ Treatment System and POE O&M ☐ Activity and Use Restriction
☐ UST Facility Report ☐ AST Facility Report	
☐ Emergency/Initial Response Action ☐ Groundwater Quality Assessment	☐ Temporary Surface Water Discharge Permit
☐ Initial Site Characterization ☐ Site Investigation • Site Investigation Report • Supplemental Site Investigation Report • GMZ Delineation • Source Area Investigation • Data Submittal • Annual Summary Report ☒ Unsolicited Work Plan ☐ Closure Documentation	☐ Groundwater Management Permit • Permit Application • Renewal Application • Deed Recordation Documentation • Abutter Notification Documentation • Release of Recordation ☐ Data Submittal ☐ Annual Summary Report

SITE SPECIFIC QUALITY ASSURANCE PROJECT PLAN

Colonial Theatre
609 Main Street
Laconia, New Hampshire
NHDES Site #201110037

Prepared For:

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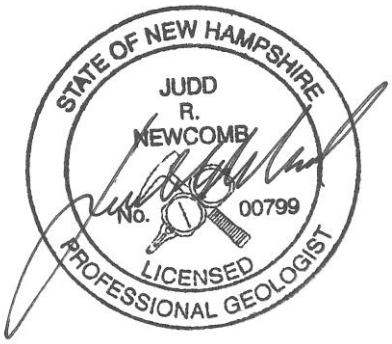

Prepared By:

CREDERE ASSOCIATES, LLC
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October 6, 2015

Recommended Risk Category (check one)

☐ 1. Immediate Human Health Risk (Impacted water supply well, etc.)	☐ 4. Surface Water Impact	☐ 7. Alternate Water Available/Low Level Groundwater Contamination (<1,000 X AGQS)
☐ 2. Potential Human Health Risk (Water supply well within 1,000' or Site within SWPA)	☐ 5. No Alternate Water Available/No Existing Wells in Area	☐ 8. No AGQS Violation/No Source Remaining
☐ 3. Free Product or Source Hazard	☐ 6. Alternate Water Available/High Level Groundwater Contamination (>1,000 X AGQS)	☐ Closure Recommended

1. TITLE AND APPROVAL PAGE

SITE-SPECIFIC QUALITY ASSURANCE PROJECT PLAN (SSQAPP)
ADDENDUM TO NEW HAMPSHIRE GENERIC QAPP RFA #14123

PROPERTY:
Colonial Theatre
609 Main Street, Laconia, New Hampshire
NHDES #20110037
EPA Brownfields Assessment Grant # BF-96176301

PREPARED BY:
Credere Associates, LLC
776 Main Street, Westbrook, Maine 04092
(207) 828-1272

October 6, 2015

Below is a listing of the names, titles, signatures, and signature dates of officials approving this Site Specific Quality Assurance Project Plan (SSQAPP) Addendum:

Alan Peterson — Date: 10/6/15
EPA Brownfields Project Officer

for — Date: 10/6/15
Nora Conlon, PhD
EPA Quality Assurance Officer

Date: 10/6/15
Jeff Hayes
Lakes Region Planning Commission, Brownfields Assessment Grantee

Date: 10.6.15
Michael McCluskey, PE
NHDES Project Manager

Date: 10-6-15
Robert Minicucci, PE
NHDES Assistant QA Manager

Judd R. Newcomb — Date: 10/6/2015
Judd Newcomb, PG, CG
Credere Associates, LLC QC Manager

Rip Patten — Date: 10/6/2015
Rip Patten, PE, LSP, LEED-AP
Credere Associates, LLC Program Manager

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APPENDICES

2. INTRODUCTION

Credere Associates, LLC (Credere) was retained by Lakes Region Planning Commission (LRPC) on behalf of 609 Main Street, LLC and Belknap Economic Development Council (BEDC) to prepare this Site-Specific Quality Assurance Project Plan (SSQAPP) to conduct assessment activities at the Colonial Theatre located at 609 Main Street in Laconia, New Hampshire (the Site). LRPC is using funding from a U.S. Environmental Protection Agency (EPA) Brownfields Assessment Grant (Grant number: BF-96176301) to conducted this assessment.

This SSQAPP presents the following information:

- The problem definition including a site description and summary of background information for the Site
- Project description and timeline
- A preliminary conceptual site model (CSM)
- The assessment objectives and proposed sampling design, techniques, and rationale
- Site-specific field sampling and analytical methodology
- Regulatory standards applicable to the Site for each proposed sampling media

This SSQAPP was prepared to be used in concert with Credere's Generic Quality Assurance Project Plan (QAPP) EPA Quality Assurance Tracking: Request for Assistance (RFA) #14123 revision dated September 4, 2014, which was prepared for all of Credere's EPA Brownfields work in New Hampshire. The quality assurance and quality control (QA/QC) procedures outlined in Credere's Generic QAPP will be followed for this investigation program including sample collection, handling, and analysis of samples; chain-of-custody; and data management, documentation, validation and usability assessment. Sampling as outlined in this SSQAPP will not occur until receipt of approval from EPA and the New Hampshire Department of Environmental Services (NHDES).

Figure 1 shows the general location of the Site in Laconia, New Hampshire; **Figure 2** presents pertinent Site features and proposed sampling locations; and **Figure 3** is Credere's Project Organization Flow Chart for the project team.

3. PROBLEM DEFINITION

3.1 SITE DESCRIPTION

The 0.48-acre Site is developed with a 48,315-square foot brick building that is currently owned by 609 Main Street, LLC, an entity of the BEDC, and is identified by the City of Laconia as Map 432, Block 142, Lot 22. The building was originally constructed between 1910 and 1913 as a theater with commercial storefronts along Main and Canal Streets and residences on the second and third floors along Main Street.

The theater portion of the Site was originally constructed as a large theater with a full stage, lower seating, and balcony; however, the theater was divided into a multiplex in 1983. The theater is accessed via the grand entrance off Main Street under the marquis. Other features of the theater portion of the Site include a concession stand, small kitchen, projector rooms (which still contain projector equipment), and storage closets. The theater is not currently in use and shows signs of wear, aging, and lack of adequate upkeep (e.g., peeling paint, water damage, rodent infestation).

Commercial storefronts along Main and Canal Street are currently occupied by an antique store, clothing store, beauty salons, frame shop, art gallery, and a dance studio. The commercial storefronts are in good condition and well-kept by their respective occupants.

The residential portion of the Site is accessed from beneath the marquis via a stairway to the second floor. Numerous small apartments are currently rented on a weekly basis and were in fair to poor condition with evidence of occupant damage and wear.

The basement of the Site building is divided into three areas that are not interconnected. The northernmost basement is accessed via a storage closet in the west side of the theater. The central basement is accessed from a ladder to the left of the theater entrance across from the projector booth. The southern basement is accessed from the back of the nail salon (Unit 621) or from a winding stairwell in the antique store (Unit 613). Generally, the basement was used to discard old theater equipment such as former seating, spot lights, and projector equipment.

The commercial portions of the building along Main Street are heated by a natural gas-fired furnace located in the southern basement. Evidence of a 275-gallon aboveground storage tank (AST) in the central basement was observed. The residential apartments located on the second and third floor are heated individually by natural gas-fired monitor heaters. The Canal Street portion of the Site is heated by a No. 2 fuel oil-fired hot air furnace located in the northern basement. Two 275-gallon aboveground storage tanks (ASTs) are located in the northwest corner of the northern basement. An active natural gas-fired furnace, out-of service transformer, non-operational former coal converted to oil furnace, and sump were also observed in the northern basement

Exterior portions of the Site consist of a small alleyway in the center of the Site, which is the only area not occupied by the Site building. Fire escapes occupy the overhead area of this alley.

Reportedly, oil was stored in an underground storage tank (UST) that was abandoned-in-place in the alleyway.

Potable water is provided to the Site by the City of Laconia Water Department. According to the Department, all properties in the vicinity of the Site are served by the public water supply. Wastewater service is available to the Site by the Winnipesauke River Basin Program (WRBP) sanitary sewer, a state owned and operated regional wastewater system serving 10 communities in the Lakes Region. Electricity is available to the Site from Eversource. Natural gas is supplied by National Grid from a gas main located on Main Street.

3.2 SITE HISTORY

Site

The Site was developed in at least 1892 with a residential dwelling; however, the date of original development is not known. Between 1892 and 1909 other small buildings were added including a paint shop, fruit store, and auto garage. By 1911, stores lined Main Street and by 1913, the Site had been developed with the current Site building as a large movie theater. In 1983, the larger theater was partitioned into a five screen multiplex.

Surrounding Area

The surrounding area was developed with residential and commercial properties by at least 1892. The surrounding downtown area has contained numerous commercial occupants through the years including a garage to the northeast of the Site and Carrier's Dry Cleaning office, which occupied the adjoining property south around 1937.

3.3 PRIOR INVESTIGATIONS

The following prior environmental reports were identified for the Site.

Phase I ESA, Credere, December 23, 2011

Credere completed a Phase I ESA on behalf of LRPC in December 2011. The report was prepared to identify recognized environmental conditions (RECs) that may be encountered during redevelopment of the property that was to include renovation of the Site building and subsequent redevelopment. Credere previously identified the following RECs, *de minimis* conditions (DMCs), and non-scope considerations (NCs) as part of the December 23, 2011, Phase I ESA:

- REC #1 – An abandoned-in-place No. 2 fuel oil UST of unknown condition with insufficient closure documentation
- REC #2 – Possible release from an electrical transformer in the northern basement
- DMC #1 – Staining observed on a concrete floor below an above ground storage tank in the central basement

- NCs – The presence of possible hazardous building materials including LBP, ACM, and PCB-containing building materials

Based on these environmental concerns, Credere made the following recommendations:

- A Phase II ESA to confirm or dismiss identified RECs and further investigate the closed UST and electrical transformer
- A Hazardous Building Material Survey (HBMS) to confirm or dismiss the presence of hazardous building materials
- Consolidation and proper disposal of universal waste as part of the redevelopment plans

Following completion of the Phase I ESA, the owner of the Site at that time opted not to proceed with the Phase II ESA.

Phase I ESA, Credere, July 1, 2015

Credere completed a Phase I ESA for the Site on behalf of BEDC and 609 Main Street, LLC on July 1, 2015, prior to 609 Main Street, LLC obtaining the Colonial Theatre from Ms. Patricia Baldi. Based on review of historical sources, environmental databases, interviews, User provided information, Site reconnaissance, and judgment by the Environmental Professional; no RECs were identified in connection with the Site except for the following:

- REC #1 – Unregistered abandoned-in-place UST

The following environmental findings, which do not meet the definition of a REC, historical REC (HREC), controlled REC (CREC), or DMCs as defined by the ASTM E 1527-13 standard; however, may represent some degree of business environmental risk and warrant the opinion of the environmental professional, were identified:

- Environmental Finding #1 – Documented offsite upgradient petroleum contamination
- Environmental Finding #2 – Possible polychlorinated biphenyl (PCB)-containing electrical transformer in Site basement
- Environmental Finding #3 – Possible asbestos–containing material (ACM) throughout the Site building
- Environmental Finding #4 – Potential presence of lead-based paint (LBP) coated surface throughout the Site building
- Environmental Finding #5 – Possible PCB-containing building materials
- Environmental Finding #6 – Potential for radon impacts to indoor air of the Site building
- Environmental Finding #7 – Observed universal/other waste, guano, and mold

4. PROJECT DESCRIPTION & TIMELINE

4.1 REDEVELOPMENT SCENARIO

BEDC plans to redevelop the Site back into a functioning civic theatre with storefronts along Main and Canal Street and market rate housing on the upper floors along Main Street.

4.2 PROPOSED PROJECT TIMELINE

The following schedule is proposed for the assessment work. This is a dynamic schedule and tasks may be performed later based on document regulatory review time and contractor availability.

TENTATIVE DATE	ACTION
September 2015	Submit DRAFT SSQAPP
September - October 2015	EPA and NHDES Review Period
October 2015	Finalize SSQAPP and Begin HBMS
November 2015	Complete HBMS and Receive Final Laboratory Analytical Data
December 2015	Submit Draft HBMS Summary Report
December - January 2015	NHDES Review Period
January 2015	Finalize HBMS Report

5. CONCEPTUAL SITE MODEL

A CSM was developed using the findings of the Phase I ESA and will be updated in subsequent reports as new information becomes available. This CSM includes a Site description, Site history, description of the physical setting of the Site, contaminants of concern (COCs), extent of contamination, exposure pathways, and potential human and environmental receptors.

5.1 SITE DESCRIPTION

A detailed Site description consisting of Site use, Site location as depicted on **Figure 1**, and Site utilities is included in **Section 3.1**.

5.2 SITE HISTORY

A description of Site history including historical information as it relates to current environmental conditions at the Site is included in **Section 3.2**.

5.3 PHYSICAL SETTING

Topography

Based on Credere's Site observations and the United States Geological Survey (USGS) Topographic Map of the Laconia Quadrangle, New Hampshire, the Site is located approximately 504 feet above mean sea level (MSL). Topography at the Site is generally flat and slopes locally to the east and slightly to the southeast toward the Ossipee Bay Reservoir channel. An excerpt from the USGS map has been included as **Figure 1**.

Geology

Surficial Geology

According to the Geohydrology, Yield, and Water Quality of Stratified Drift Aquifers in the Winnipesaukee River Basin, Central New Hampshire, USGS, Water Resources Investigations Report 94-4150, by Joseph D. Ayotte (1997), surficial materials at the Site consist of fine grained stratified drift materials or fine over coarse grained stratified drift materials having a transmissivity less than 1,000 square feet per day.

Bedrock Geology

According to the Bedrock Geologic Map of New Hampshire, bedrock beneath the Site consists of the Lower Silurian politic schist, metasedimentary rock, and calc-silicate rock of the upper Rangeley Formation. The Rangeley Formation is part of the Central Maine Trough, which is composed of variable metamorphosed sedimentary and volcanic rocks of the greenschist to granulite facies.

Hydrology

The Site is constructed over the concrete Perley Canal that was built in the early 1800's. The water was diverted from the Avery Dam to a power substation at the Laconia Car Company

turbine located on Beacon Street West. Reportedly the canal is now cut off at the dam; however, water is still present and flowing in the canal as observed through the floor opening to the canal in the northern basement. Although, the nearest surface water body is the Opechee Bay Reservoir channel located 300 feet east of the Site, this channel flows southwest through downtown Laconia.

Surface water at the Site is presumed to flow off the Site building via roof drains that enter the canal or discharge to the stormwater catch basins along Canal and Main Street.

Based on observed grades and mapped topography, groundwater in the area was assumed to flow generally to the east towards the Opechee Bay Reservoir channel.

5.4 SOURCE AREAS & CURRENT CONTAMINANTS OF CONCERN

Due to funding limitations, REC #1 - unregistered abandoned-in-place UST and Environmental Finding #1 - documented offsite upgradient petroleum contamination will not be assessed as part of this SSQAPP and will be assessed using private funds.

Source Areas

The following source areas (SAs) were identified at the Site based on the Phase I ESA and will be assessed in this SSQAPP:

- SA-1: Site building components and contents
- SA-2: Basement transformer
- SA-3: Naturally occurring radon emitting geology
- SA-4: Avian infestation of the Site building
- SA-5: Water infiltration to the Site building

Contaminants of Concern

Based on the potential source areas included in the SSQAPP the associated current COCs at the Site include the following:

- Lead in lead paint, and asbestos and PCBs in building materials from SA-1
- PCBs from transformer mineral oil dielectric fluid (MODF) from SA-2
- Radon in indoor air from SA-3
- Guano associated with SA-4
- Mold associated with SA-5

Various forms of universal or other wastes are likely present in the Site building; however, were observed in good conditions with no evidence of releases. Therefore, there are no COCs associated with universal/other waste.

5.5 MIGRATION ASSESSMENT & EXTENT OF CONTAMINATION

Lead in Paint

Due to the age of the Site building, there is likely lead paint present. During the Phase I ESA Site reconnaissance, paint throughout the building was observed to be in varying conditions from intact to flaking and chipping. Nearly all surfaces in the Site building were painted. Additionally, the vacant nature of the theatre portion of the Site building has likely contributed to areas of degradation, potentially creating a higher risk of exposure to lead due to mobilization of paint chips and dust. Generally, lead is presumed to be confined to the Site building.

Asbestos-Containing Materials

Potential ACM were observed throughout the Site building during the Site reconnaissance and the Sanborn Maps indicate an asbestos curtain was present in the main theater portion of the Site. Thermal system insulation (TSI) was observed through the three basements on piping and coating the boiler. The boiler insulation was observed to be sloughing and in poor condition. Additionally, the vacant nature of the theatre portion of the Site building has likely contributed to the degradation of the possible ACM, potentially creating a higher risk of cross-contamination to nearby innocuous materials. Generally, asbestos is presumed to be confined to the Site building.

PCBs in Building Materials and Concrete

Due to the age of the Site building and likely renovation/repairs to the Site building during the 1950s and 1960s, PCB-containing building materials may be present. Additionally, the vacant nature of the Site building may have contributed to the degradation of possible PCB-containing building materials, potentially resulting in mobilization of PCB-containing paint dust or exacerbated migration into porous materials (e.g., brick and concrete). Generally, PCBs are presumed to be confined to the Site building.

Additionally, a transformer is present in the basement that appeared original to construction of the Site building. The transformer may currently or have formerly contained PCB-containing MODF. Spills or leaks from the transformer may have resulted in a release of PCBs to concrete. If the released MODF contained PCBs at a concentration greater than 50 mg/kg, PCBs in the concrete would be regulated as remediation waste under the Toxic Substance Control Act (TSCA). If present, PCBs in concrete are presumed to be limited to the area immediately surrounding the transformer and within the small transformer closet.

Radon

According to the EPA Map of Radon Zones, the Site is within Zone 2 indicating predicted average indoor radon screening levels are between 2 and 4 picocuries per liter (pCi/L), which are the EPA's recommended action levels. The Site basement foundation was observed to contain water in certain areas indicating cracks are likely present in the foundation. These cracks are potential pathways for migration of radon into the Site building indoor air.

Guano

Guano was observed to have fallen to the floor in one theater there a ceiling tile had collapsed. Based on the quantity of guano above this one tile, it is presumed the entire area above the drop ceiling is covered in guano.

Mold

Mold was visually observed in small areas of the Site where water damage was present. A full mold inspection has not been conducted and the complete extent of mold within the Site building is not known.

5.6 EXPOSURE PATHWAYS AND POTENTIAL RECEPTORS

Exposure pathways describe how a human or environmental receptor comes into contact with contaminants that may be present at the Site. Potential migration pathways through ground water, surface water, air, soils, sediments, and biota were considered for each COC and each source. A migration pathway is considered an exposure pathway if there is a mechanism of contaminant release from primary or secondary sources, a transport medium, and a point of potential contact with a receptors. Both current and potential future releases and migration pathways to receptors are considered. Exposure pathways presented in the CSM include the following:

Active Ingestion:	The active ingestion pathway represents exposure which may occur through the active ingestion of contaminant concentrations via a drinking water supply well, through agricultural products, or through direct consumption of soil (e.g., typically by children or improper hygiene of construction workers).
Dermal Absorption:	Exposure via dermal absorption occurs when receptors are exposed to chemical concentrations present in soil, groundwater, surface water, or hazardous building materials through direct contact with the skin.
Incidental Uptake:	This pathway is applicable when receptors may incidentally inhale or ingest impacted media in the form of contaminated dust, chips, or airborne asbestos fibers.

Potential Receptors are categorized by duration of exposure and intensity of use at the Site. The receptor categories described in the CSM include the following:

Residential:	The residential receptor is defined by high durational exposure and high intensity usage which may occur through gardening, digging, and recreational sports. This group includes the occupants of a residential property or a residential neighborhood, or a daycare.
Recreational or Park User:	Park users are characterized by low duration (i.e., less than two hours per day) and low intensity usage such as that which would occur during activities such as walking, shopping, and bird watching.

Commercial Workers:	Commercial receptors are those which are present at the Site for long durations but with low intensity exposure such as indoor office workers.
Excavation or Construction Worker:	Excavation or construction workers are present at the Site for short durations though intensity of use is high, such as during non-routine activities including construction or utility work. Examples include utility and construction contractors and landscapers.

5.7 CONCEPTUAL SITE MODEL SUMMARY

COCs at the Site that are the subject of this SSQAPP include hazardous building materials including lead in paint, asbestos, and PCBs, guano, and mold. Based on the current condition of building materials throughout the Site building, receptors include current residents and commercial shop owners/workers. If not properly managed during redevelopment future receptors include construction workers during redevelopment, future employees/shop owners, future residents, and future patrons of the theatre.

Exposure pathways include active ingestion by construction workers or children; dermal absorption through any receptors' direct contact with COCs; and incidental uptake of contaminated dust or asbestos fibers both during construction and by future occupants.

6. SAMPLING DESIGN

6.1 OBJECTIVE

The main goal of this investigation is to assess the hazardous building materials identified as environmental findings in the Phase I ESA and to confirm or dismiss the presence of COCs at the Site. To achieve this goal, the following site-specific objectives have been established:

- Assess for evidence of a release from the possible PCB-containing electrical transformer in the Site basement (Environmental Finding #2)
- Assess the presence of ACM in the Site building (Environmental Finding #3)
- Assess the presence of lead paint coated surfaces in/on the Site building (Environmental Finding #4)
- Assess the presence of possible PCB-containing building materials (Environmental Finding #5)
- Assess for migration of radon to indoor air in the Site building (Environmental Finding #6)
- Inventory quantities of universal/other waste, locations of mold, and approximate square footage of guano impacted ceiling in the Site building (Environmental Finding #7)

As funding for this assessment is being provided by LRPC's Hazardous Substances Assessment Grant, assessment of the petroleum onsite UST (REC #1) and potential migration of upgradient petroleum onto the Site (Environmental Finding #1) is not planned at this time. Additionally, Environmental Finding #7 has already been confirmed through observation of the universal/hazardous/other wastes, guano and mold; therefore, additional confirmation of these materials is not warranted at this time. These materials will only be inventoried as part of this assessment.

The following tasks are proposed to address these objectives:

- Collect a concrete sample from area adjacent to the basement transformer
- Perform a survey of the Site building and collect samples of suspect ACM
- Perform a lead paint screening of the Site building to identify the presence of lead-based paint (LBP) or lead-containing paint (LCP)
- Perform PCB-containing building material survey of the Site building and collect samples of suspect PCB-containing materials
- Perform an inventory of universal and/or other wastes, locations of topical mold, and the approximate square footage of guano above the ceiling present in the Site building

Specific sampling methodologies are described in **Section 7**. **Table 1** includes the number and type of samples that are proposed to be collected. **Table 2** is a Standard Operating Procedure

(SOP) reference table detailing the version of each SOP that will be used during the field sampling program.

6.2 CONCRETE SAMPLING

One (1) concrete sample (CA-CC-1) will be collected from adjacent to the basement transformer from an area of greatest observed staining. If no staining is observed, the sample will be collected from immediately beneath any observable drain/spigot, etc., otherwise from a random point around the perimeter of the transformer. The sample will be analyzed for PCBs to assess if the concrete floor is regulated as PCB remediation waste as a result of a historical release of presumably PCB-containing mineral oil dielectric fluid (MODF). The approximate concrete sample location is depicted on **Figure 2**.

6.3 ASBESTOS SAMPLING

Credere will perform a survey of the Site building to identify suspect ACM and each suspect ACM will be sampled. Sample results will be used to properly manage ACM during future renovation of the Site building. Credere anticipates up to 40 different suspect ACM samples (CA-PACM-1 through CA-PACM-40) will be collected in triplicate (i.e., 120 total samples). This sampling will be performed in accordance with NHDES Chapter Env-A 1800 – Asbestos Management and Control. The number of samples actually collected will be dependent on the number and volume of suspect materials that are encountered.

6.4 LEAD PAINT SCREENING

Painted surfaces throughout the Site buildings will be screened for lead in paint. The number of screening points will be dependent on the number of different types/colors of painted surfaces encountered in/on the Site buildings. Data will be used to properly manage painted building components that may contain lead during restoration of the Site building.

6.5 PCB-CONTAINING BUILDING MATERIAL SAMPLING

Up to 12 samples of materials most likely to contain PCBs will be collected for analysis; however, the number of samples actually collected will be dependent on the number and volume of suspect materials that are encountered. Samples will be collected to assess if any hazards are present associated with PCBs in building materials and if the building materials are regulated as PCB bulk product waste as defined by 40 CFR 761.3. If based on the initial results, additional assessment of PCB-containing building materials is needed, approval for additional samples will be proposed and approved under a separate SSQAPP amendment. Data will be used to properly manage building materials that may contain PCBs during restoration of the Site building.

6.6 RADON

Credere will perform a radon gas inspection in the Site building. Sample results will be used to properly manage radon during future use of the Site building. Credere anticipates up to 4 radon samples (CA-RAD-1 through CA-RAD-4) will be collected. Testing will be conducted

according to the requirements of *ANSI/AARST MAMF-2010 Protocol for Conducting Radon and Radon Decay Product Measurement in Multifamily Buildings*.

6.7 UNIVERSAL/ OTHER WASTE, GUANO AND MOLD INVENTORY

Materials that once removed from use meet the definition of a universal waste per 40 CFR part 273, a hazardous waste, or other wastes that require special disposal include; but are not limited to, fluorescent lighting and ballasts, fire alarms, thermostats (containing mercury), lead-acid batteries, Freon-containing equipment, miscellaneous containers, and cathode ray tubes. These types of materials at the Site will be inventoried. Locations of topical mold and an approximate square footage of guano covered ceiling will also be recorded. Inventory results will be used to properly manage universal, hazardous, and/or other wastes prior to demolition of the Site building.

7. SAMPLING & ANALYTICAL METHODS REQUIREMENTS

The proposed sampling activities will be conducted according to **Table 1**. Field activities will be conducted in accordance with Credere's Generic QAPP RFA #14123 and the SOPs referenced on **Table 2**.

7.1 CONCRETE SAMPLING

A hammer drill with a 1-inch carbide drill bit will be used to pulverize the concrete for sampling. A half inch depth will be measured and marked on the drill bit. An aluminum foil mat with a 1-inch diameter hole will be placed over the location to be sampled. A 0.5-inch depth hole will be advanced through the aluminum foil hole using the hammer drill. Concrete dust will be collected in a glass container. Multiple 0.5-inch holes in adjacent locations may be advanced to obtain adequate volume for sample analysis. Additionally, a stainless steel scoopula or bulb syringe may be used to extract concrete dust from the 0.5-inch hole. Dedicated sampling tools will be used to prevent cross contamination. Samples will be submitted to Absolute Resource Associates (ARA) of Portsmouth, New Hampshire for analysis of PCBs by EPA Method 8082A using soxhlet extraction method 3540C.

7.2 ASBESTOS SAMPLING

Any sampling of suspect ACM at the Site will be conducted by a New Hampshire Certified Asbestos Inspector and in accordance with NHDES Chapter 1800. Minor destructive sampling may be required. Samples will be collected with hand tools and placed in appropriately labeled zip-lock bags. Samples will be analyzed by EMSL Analytical, Inc. (EMSL) of South Portland, Maine, using Polarized Light Microscopy (PLM) according to EPA Method 600/R-93/116.

7.3 LEAD PAINT SCREENING

Painted surfaces will be screened for the presence of lead in paint using an X-ray fluorescence (XRF) meter. Each accessible color and type of paint throughout the Site building will be screened. Paints with screening concentrations of lead exceeding 1.0 milligrams per square centimeter (mg/cm^2) will be considered LBP. Paints containing any concentration of lead will be considered LCP.

7.4 PCB-CONTAINING BUILDING MATERIAL SAMPLING

To assess the potential presence of PCB-containing building materials, the Site building will be inspected and suspect materials will be inventoried and considered for sampling. Materials that typically contain PCBs include caulk/sealants, paint, and mastics/adhesives that were manufactured between approximately 1930 and 1980 and are most commonly in areas that endure high wear, weather, high heat, or moisture. Example typical materials and locations that PCBs are encountered include, but are not limited to:

- exterior caulks and sealants around doors and windows or within expansion joints
- wall paints in high heat or moisture areas such as boiler rooms, equipment rooms, or basements

- floor paints in high traffic areas such as hallways or building entrances
- mastics beneath floor tiles

The buildings will be surveyed to locate the materials that in Credere's experience are more likely to contain concentrations of PCBs exceeding the PCB bulk waste criteria. Samples will be collected using dedicated disposable tools and placed in laboratory provided glassware. Samples will be submitted to ARA for analysis of PCBs by EPA Method 8082A using soxhlet extraction method 3540C.

7.5 RADON

All radon sampling will be in accordance with the requirements of *ANSI/AARST MAMF-2010 Protocol for Conducting Radon and Radon Decay Product Measurement in Multifamily Buildings*. Four (4) radon testing canisters will be deployed in the basement level of the building as well as one (1) duplicate. Samples will be submitted to AccuStar labs of Medway, Massachusetts, for radon in air using charcoal canisters analysis in accordance with EPA method #402-R-93-004 079. Field and laboratory SOPs for radon were not included in Credere's Generic QAPP.; therefore, these SOPs are included in **Appendix B**.

7.6 UNIVERSAL/HAZARDOUS/OTHER WASTE INVENTORY

Materials as described in **Section 6.7** will be manually counted to inventory what will require disposal as universal or other wastes prior to building renovation and preparation of the Site for reuse. Locations of mold in the Site building will be noted with a description of their location. The approximately square footage of guano covered ceilings will be estimated by measuring the square foot of the theaters where the drop ceiling is located. Access to the space above the ceilings is not available.

8. REGULATORY CRITERIA

Sample results will be compared to the applicable state and/or federal standards/guidelines described below. **Appendix A** includes Analytical Sensitivity and Project Criteria Tables for the Site, which compares regulatory standards for each contaminant to the analytical limits of the laboratory method used.

8.1 CONCRETE ANALYTICAL RESULTS

In accordance with 40 CFR 761.61, PCB results from the concrete sample will be compared to the remediation waste cleanup guidelines of 1 or 25 milligrams per kilogram (mg/kg) for low or high occupancy areas, respectively, based on the future reuse of the basement.

8.2 ASBESTOS RESULTS

Laboratory analytical results for asbestos bulk samples will be compared to the 1% limit specified in Chapter Env-A 1800 – Asbestos Management and Control.

8.3 LBP SCREENING RESULTS

LBP is defined as paint with a lead concentration of 1.0 mg/cm^2 or greater in accordance with the United States Department of Housing, Chapter 7: Lead-Based Paint Inspections, 1997 Revision (HUD Guidelines). Screening results will be compared to the 1.0 mg/cm^2 HUD Guideline for areas planned for residential redevelopment. For non-residential areas of the Site building, any concentration of lead in paint (LCP) will require proper management during renovation activities according to the OSHA Lead in Construction Standard (29 CFR 1926.62).

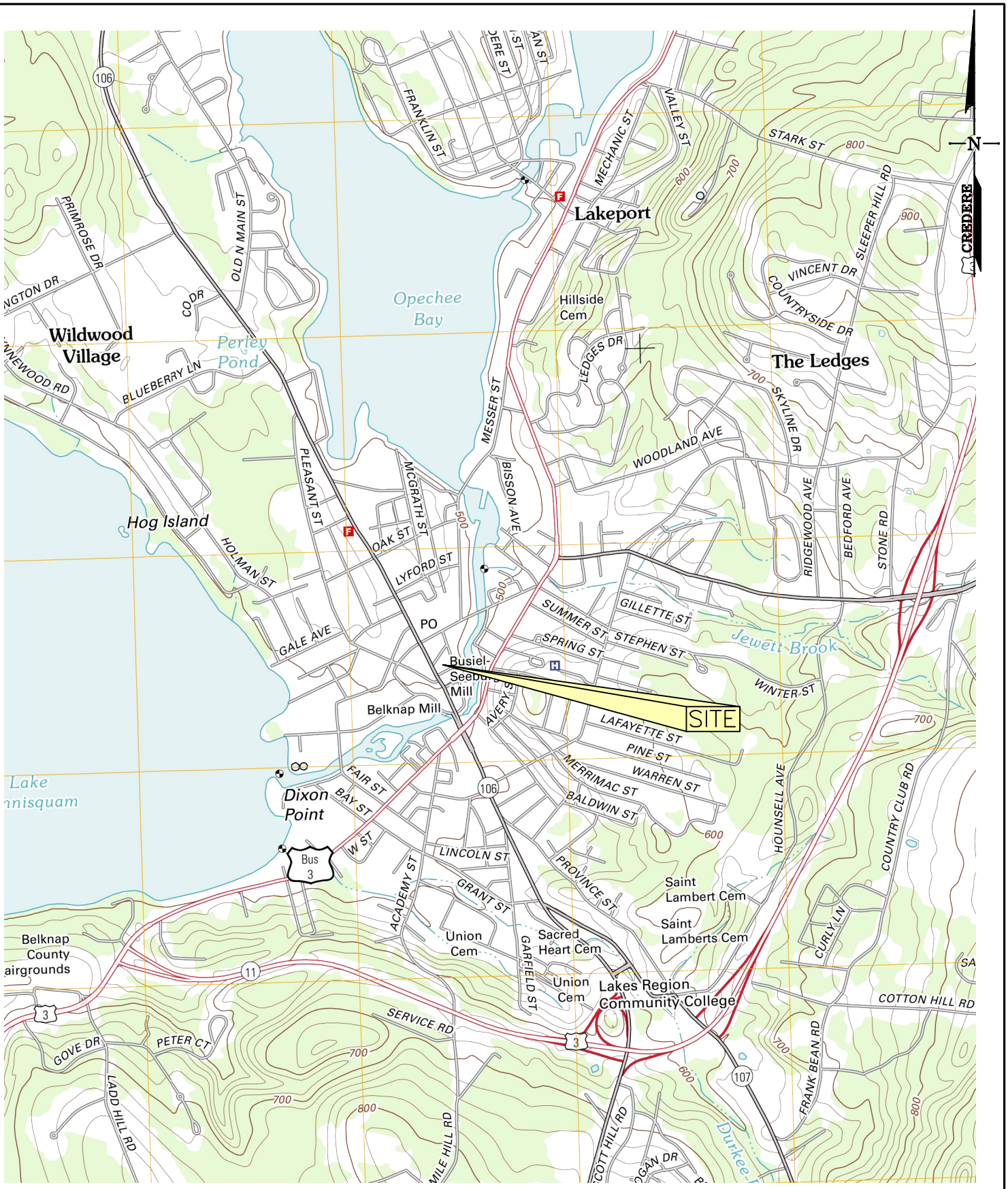
8.4 PCBS IN BUILDING MATERIALS RESULTS

PCB sample results will be compared to the 40 CFR 761.3 definition of PCB bulk product waste (50 mg/kg threshold criteria). Materials that have been analyzed to contain total PCBs at a concentration of equal to or greater than 1 mg/kg but less than 50 mg/kg are not regulated by TSCA for disposal as long as they remain in use. However, if these materials are removed from use (e.g., during renovations), they must be disposed at a facility that is licensed to accept this waste. Building materials that have been analyzed to contain total PCBs at a concentration of less than 1 mg/kg are unrestricted for future use and/or disposal.

8.5 RADON

Radon in air analytical results will be compared to the 4.0 pCi/L ANSI/AARST Standard: *Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings.* If results do not exceed the 4.0 picocuries per liter (pCi/L) threshold, results will also be compared to the 2.0 pCi/L threshold for tentative consideration of mitigation.

FIGURES



USGS QUADRANGLE INFORMATION: LACONIA, NEW HAMPSHIRE 7.5–MINUTE USGS QUADRANGLE, 2012

DRAWN BY: MTG	DATE: 07/01/15
CHECKED BY: ASD	PROJECT: 15001294

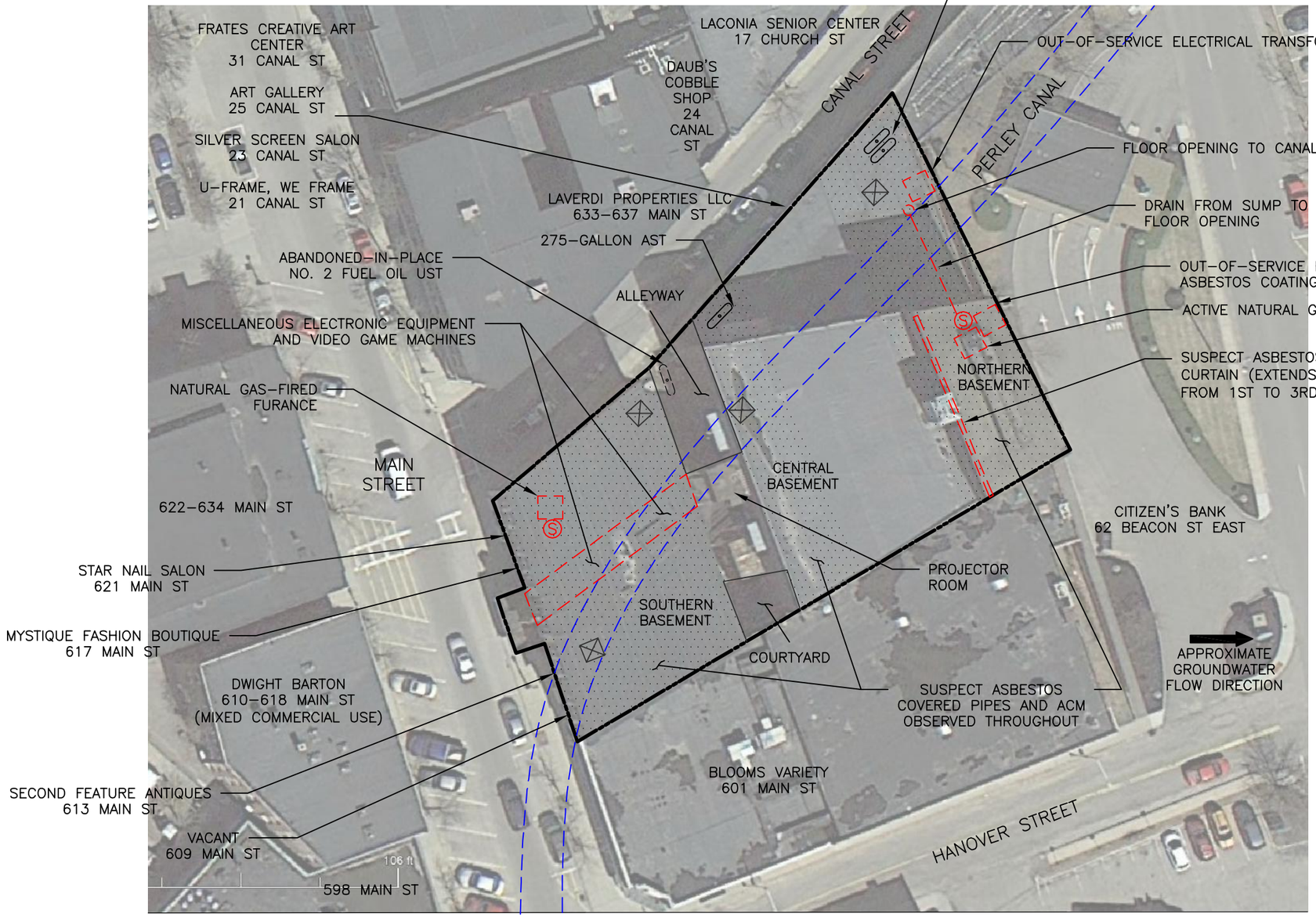
FIGURE 1 - SITE LOCATION

CREDERE ASSOCIATES, LLC
776 MAIN STREET
WESTBROOK, MAINE 04092
TEL: 207.828.1272
FAX: 207.887.1051
WWW.CREDERELLC.COM

COLONIAL THEATRE
609 MAIN STREET
LACONIA, NEW HAMPSHIRE

GRAPHIC SCALE
2000 0 1000 2000
1 inch =2000ft.

J:\CREDERE\10001086\Colonial Theater\Colonial Theater_Figures-update.dwg plot date: 7/1/2015 1:40 PM



LEGEND

- SUBJECT PROPERTY BOUNDARY
- APPROXIMATE LOCATION OF PERLEY CANAL
- AREA OF CONCERN
- BUILDING
- BASEMENT AREA/SUSPECT ACM OBSERVED
- SUMP
- ABOVEGROUND STORAGE TANK (AST)
- UNDERGROUND STORAGE TANK (UST)
- BASEMENT ACCESS

NOTES

1. EXISTING CONDITION FEATURES SHOWN ON THIS PLAN ARE APPROXIMATE AND ARE BASED ON INFORMATION OBTAINED FROM THE CITY OF LACONIA, 2014 GOOGLE EARTH AERIAL IMAGE, AND THE SITE RECONNAISSANCE PERFORMED BY CREDERE PERSONNEL ON JUNE 17, 2015.

DRAWN BY: MTG	DATE: 07/01/15
CHECKED BY: ASD	PROJECT: 15001294

CREDERE ASSOCIATES, LLC
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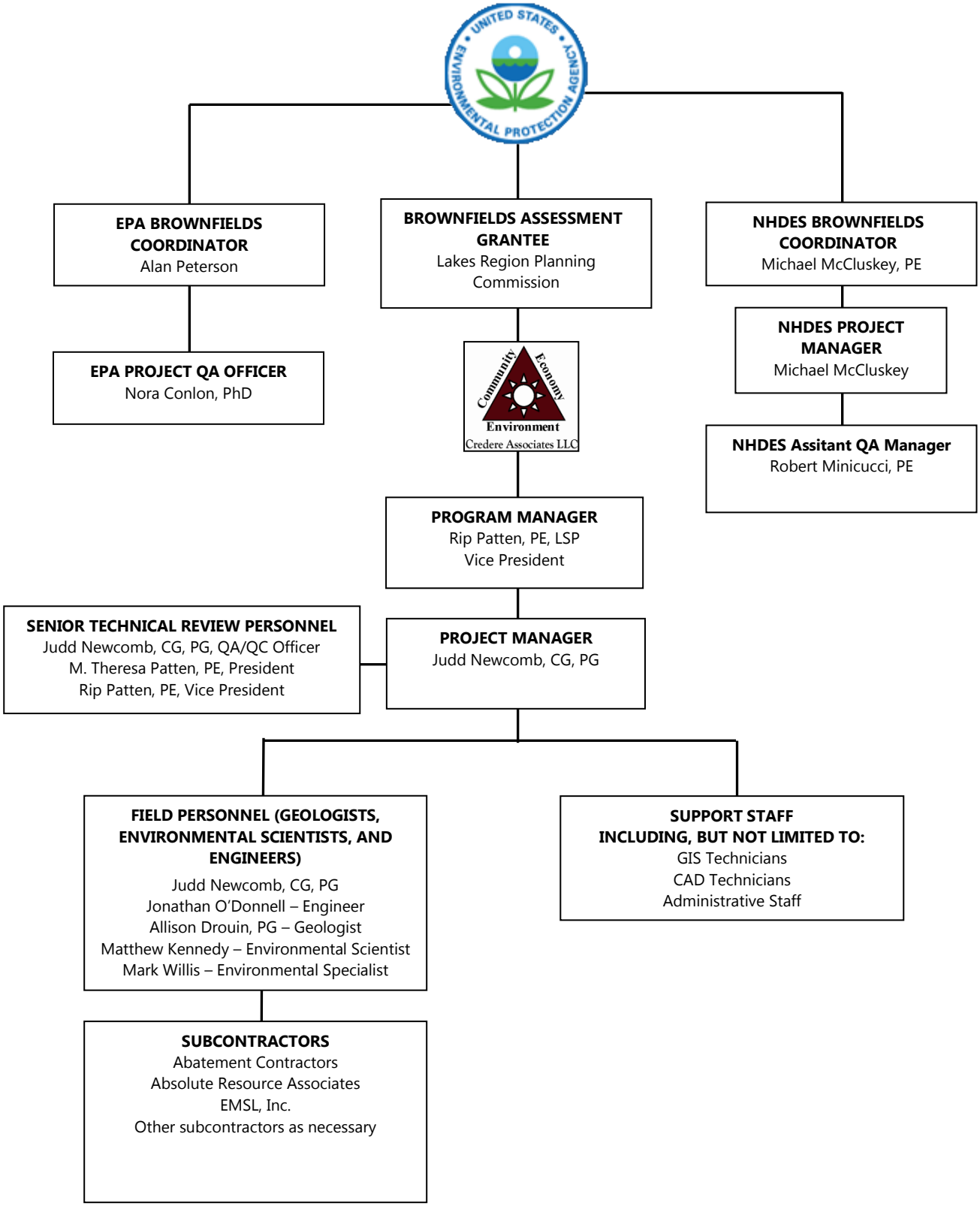
FIGURE 2
DETAILED SITE PLAN

COLONIAL THEATRE
609 MAIN STREET
LACONIA, NEW HAMPSHIRE

GRAPHIC SCALE
40 0 20 40
1 inch = 40 ft.

Figure 3 – Project Organization Flow Chart



TABLES

Table 1: Sample Reference Table
Colonial Theatre, NHDES #201110037
609 Main Street, Laconia, New Hampshire

Media to be Collected	Proposed Sample IDs	Sample Type	Sample Rational	Sample Depth (feet bgs)	Field Analysis/ Observations	No. of Samples for Analysis	QA/QC Samples	Analytical Method	Sample Container Information & Preservative (per location)*,[1]	Laboratory To be Used
Building Materials	CA-CC-1	Concrete	-To assess for evidence of a release of PCB-containing MODF from the out-of-service electrical transformer in the Site basement.	0 to 0.5-inches	Visual observation of condition	1	1 Field duplicate	PCBs (EPA Method 8082A with soxhlet extraction method 3540C)	1 - 4 oz glass	Absolute Resource Associates, Portsmouth, NH
	CA-PACM-1 (A-C) through CA-PACM-40 (A-C)	Suspect asbestos containing material	-Three samples will be collected from each suspected asbestos-containing material	NA		120	Triplicate Sampling	Polarized Light Microscopy EPA 600/R-93/116	Plastic zipper bags	EMSL Analytical, Inc., South Portland, ME
	Consecutively numbered screening point (1 through etc.)	Lead paint screening point	-To assess for the presence of lead in paint throughout the Site building	NA	XRF meter Visual observation of condition	TBD	None	NA	NA	NA
	CA-PCB-1 through CA-PCB-12	PCB-containing building materials	-To assess for the presence of PCB containing building materials in the Site building.	NA	Visual observation of condition	12	2 Field Duplicates (1 caulk/sealant/adhesive type material and 1 paint)	PCBs (EPA Method 8082A with soxhlet extraction method 3540C)	1 - 4 oz glass	Absolute Resource Associates, Portsmouth, NH
	NA	Universal/hazardous/ other waste inventory	-To document universal/hazardous/other wastes contained in the Site building that may require proper disposal during redevelopment	NA		NA	NA	NA	NA	NA
Radon	CA-RAD-1 through CA-RAD-4	Radon in air	-To assess radon gas infiltration to the building in preparation for residential occupancy	NA	NA	4	1 Field duplicate	EPA #402-R-93-004 079	1 - Metal charcoal canister	AccuStar Medway, MA

Notes:

1 - All samples will be chilled to 4°C (+/- 2°C) and submitted to the laboratory on ice.

* - Additional details regarding analytical method, sample preservation, sample volume, and hold times can be found in Appendix D of Credere's Generic New Hampshire QAPP.

PCB - polychlorinated biphenyl
NA - not applicable
bgs - below ground surface
MODF - mineral oil dielectric fluid
XRF - X-ray fluorescence meter
TBD - to be determined based on field observations

Table 2: Standard Operating Procedure (SOP) Reference Table
Colonial Theatre, NHDES #201110037
609 Main Street, Laconia, New Hampshire

Field SOPs

SOP	SOP Description	Date
Credere-004	SOP for Log Book Entries	October 2006
Credere-009	SOPs for Typical Asbestos Bulk and Air Sampling (SOP by: Environmental Safety & Hygiene Associates, Inc.)	NA
HWRB-18	Chain of Custody, Sample Handling & Shipping, Revision 2	January 2012
RWM-DR-025	Protocol for Collecting Data Using an Innov-X Field Portable X-Ray Fluorescence Spectrometer for Certain metals in Solid Media (Included in Appendix B)	Febraury 29, 2009
EIASOP_POROUSSAMPLING1	Standard Operating Procedure for Sampling Porous Surfaces for PCBs	May 5, 2011
EPA 600/R-93/116	Method for the Determination of Asbestos in Bulk Building Materials	July 1993
ANSI/AARST Standard	Protocal for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings (Included in Appendix B)	June 2009

Laboratory SOPs

SOP	SOP Description	Date
EMSL: PLM SOP	Polarized Light Microscopy	November 12, 2010
RL-4	Analysis of Polychlorinated Biphenyls in Soil and Water Extracts by EPA 8082	January 2013
RL-28	Soxhlet Extraction by EPA method 3540C	August 2011
AccuStar Radon	Radon in Air using Charcoal Canisters by EPA #402-R-93-004 079 (Included in Appendix B)	October 2014

APPENDIX A

Analytical Sensitivity and Project Criteria Tables

As of the date of this SSQAPP Addendum, the current state and/or federal standards have been reviewed for accuracy.

Radon in Air via Carbon Cartridge by EPA #402-R-93-004 079			
Analyte	**Laboratory Practical Quantitation Limit (pCi/L)**	**Regulatory Standard[1,2] (pCi/L)**	
		Tentative Mitigation Recommended	**Mitigation Recommended**
Radon	0.4	2.0	4.0

Notes:

pCi/L - picocuries per liter

PQL from Accustar of Medway, Massachusetts

1 - ANSI/AARST MAMF-2010 Protocol for Conducting Radon and Radon Decay Product Measurement in Multifamily Buildings

PCBs in Building Materials by EPA Method 8082A

Analyte	Laboratory Practical Quantitation Limit	Remediation Waste Cleanup Goals 40 CFR 761.61		Regulatory Standard (40 CFR 761.3)
		High Occupancy	Low Occupancy	
PCB-1016	0.2	1 (Total)	25 (Total)	50 (Total)
PCB-1221	0.2			
PCB-1232	0.2			
PCB-1242	0.2			
PCB-1248	0.2			
PCB-1254	0.2			
PCB-1260	0.2			

Notes:
All values are in mg/kg.

Asbestos in Solids by PLM by EPA Method 600/R		
Analyte	**Laboratory Practical Quantitation Limit**	**Regulatory Standard[1]**
Asbestos	0.20%	1%

Notes:

1 - New Hampshire Department of Environmental Services Chapter 1800: Asbestos Management Control, October 21, 2008.
PQL from EMSL of Cinnamonsin, New Jersey

APPENDIX B

Radon Analysis Field and Laboratory Standard Operating Procedure

Protocol for Conducting Radon and Radon Decay Product Measurements In Multifamily Buildings

For Residence Managers and Measurement Professionals

Designation: MAMF *Clean Read Draft 06-09*

AARST CONSORTIUM ON NATIONAL RADON STANDARDS

SCOPE:

This standard specifies procedures, minimum requirements and general guidance for measurement of radon and radon decay product concentrations in Multifamily buildings comprised of more than three attached dwellings.

THIS DOCUMENT INCLUDES:

1) Introduction to Radon.

2) Introductory Guidance for Residence Managers.

3) Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings: Specific testing protocols that include instructions on where to test, strategies for conducting reliable tests, reporting and associated quality control measures.

Significance of Use:

This document contains protocols and guidance designed to respond to the health threat of radon in dwellings in Multifamily buildings.

Radon has been determined to be the leading cause of lung cancer among nonsmokers in the United States. It is believed that most people receive their greatest exposure to radon in their home or dwelling. The U.S. EPA and the Surgeon General state that "Indoor radon is the second-leading cause of lung cancer [after cigarette smoking] in the United States and breathing it over prolonged periods can present a significant health risk to families all over the country." *(Health Advisory, January 13, 2005)*

The purpose of performing radon measurements is to identify locations that have elevated radon concentrations and to determine if radon mitigation is necessary in order to protect current or future occupants. The purpose of test protocols is to help achieve reliable radon measurements. This standard addresses the needs of citizens, radon service providers, property owners, residence/facility managers, consultants, manufacturers and regulators concerned with radon measurements in Multifamily buildings.

Introduction

History: The United States Environmental Protection Agency (EPA) developed measurement guidelines in the *Home Buyer's and Seller's Guide to Radon* and the *Citizen's Guide to Radon. For the current versions see: http://www.epa.gov/radon/pubs*. These measurement strategies assess radon concentrations in homes for the purpose of determining the need for remedial action. Guidelines or protocols also appear in the EPA documents "Indoor Radon and Radon Decay Product Measurement Device Protocols" and "Protocols for Radon and Radon Decay Product Measurements in Homes. The protocols and guidance herein include the best practices from those documents, additional technical descriptions of requirements and recommendations, and guidelines for the interpretation of measurement results.

The Stewart McKinney Amendments to the 1988 Indoor Radon Abatement Act require U.S. Housing and Urban Development (HUD) to develop an effective departmental policy for dealing with radon contamination using available guidelines and standards to ensure that occupants of housing subsidized by HUD are not exposed to hazardous concentrations of radon. At the request of Congress, the document "Radon Measurement in HUD Multifamily Buildings" was developed to enable HUD to comply with the requirements of the legislation. The document was completed during 1995 by the EPA for the HUD under interagency agreement. The American Association of Radon Scientists and Technologists document "AARST Interim Protocols for Conducting Radon Measurements in Multifamily Buildings (MAMF October, 2004)" built on that document and added consortium review and revision. The document herein reflects a significant degree of continued review and amendment.

Applicability and use of this document: If the minimum requirements of this document exceed local, state, or federal requirements for the locale in which the radon test is performed, then this document's minimum requirements should be followed. This document is intended to aid multifamily building owners/managers, residents and staff, professionals, state radiation control programs or anyone involved in the measurement of radon in Multifamily buildings to assess the need for mitigation and to provide radon risk information for the benefit of occupants. These

guidelines can be adopted as part of a state program or can be provided as recommendations by states to testing companies and interested individuals. AARST recommends that any authority or jurisdiction that is considering substantial modifications of this document as a condition of its use seek consensus within the consortium process at AARST Consortium on National Radon Standards prior to adopting a modified version. This provides the jurisdiction with a higher degree of expertise and an opportunity for the Consortium on National Radon Standards to update its document if appropriate.

Keywords:

Radon, Multifamily, Radon Measurement, Radon Testing, Radon Test

Normative References:

- EPA Guidance on Quality Assurance (402-R-95-012, October 1997)"
- "Indoor Radon and Radon Decay Product Measurement Device Protocols," EPA 402-R-92-004, July 1992.

For the latest versions of USEPA documents see:
http://www.epa.gov/radon/pubs

Referenced Publications:

- "A Citizen's Guide To Radon" EPA 402-K02-006, September 2005.
- "Home Buyers and Sellers Guide to Radon," EPA 402-K-06-093, November 2006.

For the latest versions of USEPA documents see:
http://www.epa.gov/radon/pubs

- "Protocols For Radon Measurements In Homes", (AARST- MAH September 2005). *For the current version see: http://www.aarst.org*

Consensus Process

The consortium processes developed for the AARST Consortium on National Radon Standards as accredited to meet essential requirements for American National Standards by the American National Standards Institute (ANSI) have approved this document. This Standard is to be reviewed and updated every five years at a minimum.

Notice regarding unresolved objections: While each committee seeks to resolve objections, please notify the committee responsible for an action or inaction if you desire to recirculate any unresolved objections to the committee for further consideration. **Notice of right to appeal.** (See Bylaws for the AARST Consortium on National Radon Standards - Operating Procedures for Appeals available at www.radonstandards.us, Standards Forum, Bylaws): (2.1) Persons or representatives who have materially affected interests and who have been or will be adversely affected by any substantive or procedural action or inaction by AARST Consortium on National Radon Standards committee(s), committee participant(s), or AARST have the right to appeal; (3.1) Appeals shall first be directed to the committee responsible for the action or inaction.

Contact information:
AARST Consortium on National Radon Standards.
Email: standards@aarst.org
Efax: 913-273-0134
Website: www.radonstandards.us
P.O. Box 2109, Fletcher, North Carolina 28732

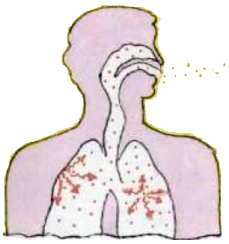
TABLE OF CONTENTS

Section I: Introduction to Radon

(This section is intended for informational purposes only. For radon testing protocol, see Section III.)

A. Radon Facts

Radon is a naturally-occurring radioactive gas. It comes from the breakdown (radioactive decay) of uranium that is found in soil and rock all over the United States. Radon is a component of the air in soil that enters buildings through cracks and other pathways in the foundation. Eventually, it decays into radioactive particles (decay products) that can become trapped in your lungs when you inhale. As these particles decay in turn, they release small bursts of radiation. This radiation can damage lung tissue and lead to lung cancer over the course of your lifetime. EPA studies have found that radon concentrations in outdoor air average about 0.4 pCi/L (picocuries per liter) of air. However, radon and its decay products can reach much higher concentrations inside a building.



Radon gas is colorless, odorless, and tasteless. The only way to know whether elevated concentrations of radon are present in any building is to test.

B. Radon's Health Effects

Radon is a known human carcinogen. Prolonged exposure to elevated radon concentrations causes an increased risk of lung cancer. Like other environmental pollutants, there is some uncertainty about the magnitude of radon health risks. EPA estimates that radon may cause 21,000 lung cancer deaths in the U.S. each year. The U.S. Surgeon General has warned that radon is the second-leading cause of lung cancer deaths in the U.S. Only smoking causes more lung cancer deaths.

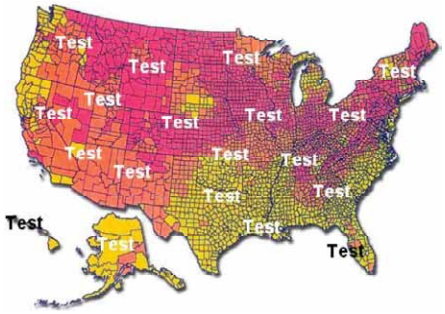
Not everyone who breathes radon decay products will develop lung cancer. An individual's risk of getting lung cancer from radon depends mostly on three factors: the concentration of radon, the duration of exposure, and the individual's smoking habits. In addition, some people are more susceptible to lung cancer than others.

Risk increases as an individual is exposed to higher concentrations of radon over a longer period of time. Smoking combined with radon is an especially serious health risk. The risk of dying from lung cancer caused by radon is much greater for smokers than it is for non-smokers.

C. Radon Exposure

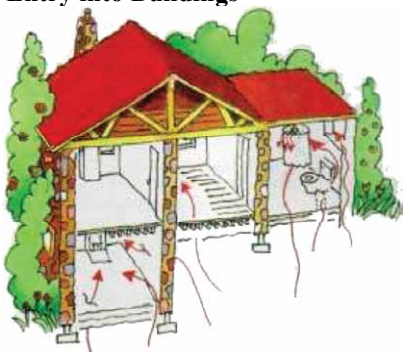
Because many people spend much of their time at home, the home is likely to be the most significant source of radon exposure. According to EPA, nearly 1 out of every 15 homes in the United States is estimated to have radon concentrations that exceed the EPA action level.

Elevated concentrations of radon have been found in homes and buildings in every state. While elevated radon may be more common in some areas, any building can have a problem. EPA recommends that ALL buildings should be tested regardless of the area of the country and that maps such as this should not be used to determine whether to test. More specific information on the likelihood of elevated radon in your area can frequently be found at your state or county radon offices.



The concentration of radon in the air within a building should be reduced below **EPA's radon action level of 4 pCi/L.** Any radon exposure creates some risk; no concentration of radon is safe. Even radon concentrations below 4 pCi/L pose some risk, and the risk of lung cancer can be reduced by lowering indoor radon concentrations. This action level is based largely on the ability of current mitigation technologies to consistently reduce radon concentrations below 4 pCi/L. Depending on the building characteristics, radon concentrations in some buildings can be reduced well below 4 pCi/L. In others, reducing radon concentrations to below 4 pCi/L may be more difficult.

D. Radon Entry into Buildings



Radon in soil gas is the main source of radon problems. Pathways for radon to enter a building include cracks in the slabs and walls, the expansion joints between floor and walls, porous concrete block walls, open sump pits, crawlspaces and openings around utility penetrations. Some buildings have other pathways for radon to enter a building such as sub-slab utility tunnels and heating, ventilating and air conditioning (HVAC) ducts.

Radon gas may also enter buildings in well water. Radon from well water use in a building can off gas and raise the concentrations above the action level. For dwellings or small communities serviced by well water, the water should be tested at the same time air is tested, especially if the building is vacant or there is no water use in the tested dwellings. Radon in water testing is covered in a separate document and is beyond the scope of this testing protocol. For more information on radon in drinking water you can contact your state radon contact, your state drinking water program, EPA's Drinking Water Hotline (800) 426-4791, or visit http://www.epa.gov/safewater/radon.html,

Sometimes building materials that contain uranium and radium can produce radon. A radiation professional or your State radiation program can help you evaluate this possibility.

Factors Influencing Radon Entry

Many factors contribute to the entry of radon gas into buildings. As a result, residence managers cannot know without testing if elevated concentrations of radon are present in their building complex. The following factors determine why some buildings have elevated radon concentrations and others do not:

- The concentration of radon in the soil gas **(source strength);**
- The permeability of the soil or sub-surface geology **(gas mobility)** under the building;
- The **structure and construction** of a building; and,
- The type, design, operation, and maintenance of the heating, ventilating and air-conditioning **(HVAC)** system.

Source strength: The radon concentration in soil gas can vary greatly from building to building. It can even vary greatly under different parts of the same building.

Gas mobility: Certain geological features beneath a building, such as cracks, fissures, or solution cavities, can serve as a direct connection between the radon-producing minerals and the building's foundation. Such a direct connection can cause one unit of a building to have a radon concentration significantly higher than other units in the area. The permeability of the soil under a building, along with the differences between the air pressure inside a building and the air pressure under a building's foundation influence the rate at which radon enters a building. For example, if the air pressure in the building is greater than the air pressure under the building's foundation, radon should not enter through the openings of a building's foundation. If the air pressure in the building is less than the air pressure under the building's foundation, radon in the soil gas will enter through any openings in the building's foundation.

Structure and construction: Any building design can have a radon problem. Without testing, you cannot know if elevated concentrations of radon are present.

HVAC: Depending on their design and operation, HVAC systems can influence radon concentrations in buildings:

- Poor ventilation allows radon gas concentration to build up.
- Increasing ventilation helps dilute indoor radon concentrations with outdoor air however, radon's source strength can overwhelm the practical limits of increasing ventilation.
- Depressurized buildings draw radon inside.
- Pressurizing a building helps keep radon out.

The frequency and thoroughness of HVAC maintenance can sometimes play an important role. For example, air intake filters that are not periodically cleaned and changed can significantly reduce the amount of outdoor air ventilating the indoor air environment. An understanding of the design, operation, and maintenance of a building's HVAC system and how it influences indoor air conditions is helpful for understanding and managing a radon problem, as well as many other indoor air quality concerns in buildings. However, since HVAC systems are only one of many factors that affect radon concentrations in a building, HVAC system modifications alone are often not an effective radon mitigation strategy.

E. Contacts for Additional Information

- EPA Website
  http://www.epa.gov/iaq/radon
- State radon offices:
  http://www.epa.gov/iaq/whereyoulive.html
- Indian Nation radon offices:
  http://www.epa.gov/epahome/tribal.htm
- Regional EPA offices:
  http://www.epa.gov/epahome/locate2.htm
- The National Radon Safety Board (NRSB) - Radon Proficiency Program: www.nrsb.org
- The NEHA (National Environmental Health Association) National Radon Proficiency Program:
  www.neha-nrpp.org

SECTION II:
INTRODUCTORY GUIDANCE FOR RESIDENCE MANAGERS

(This section is intended for informational purposes only. For radon testing protocol, see Section III.)

A. Introduction

The purpose of testing is to identify locations that have elevated radon concentrations and to determine if radon mitigation is necessary to protect current or future occupants.

Planning

Planning to test your building for radon requires a basic understanding of the radon testing process and the steps that are necessary to ensure your radon test results are reliable. Specifically, to plan for radon testing, you will need to:

- ❖ Become familiar with testing methods and building conditions required to perform reliable radon tests;
- ❖ Determine an appropriate and practical testing strategy. (See Section III) Review logistics and estimate the number of detectors including detectors for quality assurance (QA) requirements to aid in evaluating costs and competitive bids from companies providing radon testing services;
- ❖ Investigate whether any residents have independently tested their dwelling for radon and collect any test results;
- ❖ Communicate information to your residents about your radon testing activities;
- ❖ Become familiar with guidance for when radon reduction is recommended.

A responsible and reliable plan for radon measurement requires technical knowledge, attention to detail, and planning. **You should use a measurement contractor that is state licensed or nationally certified by NEHA-NRPP or NRSB if no state licensing program exists in the state where the measurements are performed.** (See below for information on finding a qualified contractor for your area.) A qualified contractor can help assess the nature of your building complex and help you choose a responsible and reliable measurement plan.

See APPENDIX E for a step-by-step checklist on planning and testing.

B. Communicating with Residents Prior to Testing

It is important to notify and inform residents prior to testing about what to expect during the testing process. Plan to:

- ❖ Distribute an appropriate ***notice of inspection (for radon testing)*** at least two weeks in advance of testing and again a few days prior to the test that provides the likely placement and retrieval dates and required building conditions prior to and during the test. The notice should stress the importance of providing access to test locations and maintaining proper test conditions. Include advice that interfering with the test device or building conditions can invalidate the test results. It should also stress that the test is being performed to help ensure the occupants' safety. Inform residents how they might inquire to gain clarity or further information. See Exhibits 6 through 10 for sample notification forms.
- ❖ Inform residents that test devices are not dangerous in any way and that a sample test device is available if residents wish to see the device.
- ❖ Inform residents when test results might be available and that copies of EPA's current *A Citizen's Guide to Radon, current comparable EPA documents* or state-approved radon documents are available upon request to residents who want additional information on radon. For copies of these guides, contact your State Radon Office or access http://www.epa.gov/iaq/whereyoulive.htm.

C. Selecting Radon Service Contractors

As with other activities that require contracted services, your goal is to select a contractor who will provide services using reliable techniques at a reasonable cost.

When seeking radon services, request bids from contractors who are state licensed (where applicable) or certified by either the National Radon Proficiency Program (NEHA-NRPP) or the National Radon Safety Board (NRSB) and who use ~~certified~~ approved devices.

Contact your State Radon Office for a *list of licensed or certified contractors* (http://www.epa.gov/iaq/whereyoulive.htm). State regulations will take precedence when they are more stringent. Listings for certified contractors can also be found at www.neha-nrpp.org or www.nrsb.org. (For more information on private radon proficiency programs, visit www.epa.gov/radon/proficiency.html).

Individuals placing and retrieving detectors should have an identification card or letter verifying their participation in State, NEHA-NRPP or NRSB Radon Proficiency Programs. Devices used for the measurements should also be approved by ~~your State~~, NEHA-NRPP or NRSB Radon Proficiency Programs.

D. Role of Maintenance Personnel

Because maintenance personnel frequently have knowledge of the building and the occupants, they can

play a key role during the testing process, especially in planning and scheduling. By providing access to residences and supplying floor plans when available, the maintenance personnel can help the measurement service to quickly identify appropriate testing locations, and plan testing strategy within a building complex.

In states with no radon measurement regulations, it is highly recommended that untrained personnel serve only in these support functions for trained and licensed professionals. In regulated states, all parties including unlicensed and untrained personnel must abide by state regulations.

E. Documenting the Testing Program

A record of the testing program should be maintained by the client for future reference. This record should contain the following information:

- A copy of the final report submitted by the measurement service that conducted the tests and the measurement service's statement outlining any recommendations concerning retesting or mitigation. (SECTION III 8.0 describes appropriate documentation.)
- All correspondence between you and the measurement service.

F. When to Test

Short-term radon tests (tests lasting just a few days) require minimizing air exchange into and out of a building: closed-building conditions. For testing programs where the occupants may not be active participants in the testing process, actions must be considered to help ensure closed-building conditions for short term tests.

Choosing a time of year when required closed-building conditions are a normal condition will aid in ensuring reliable measurements. For example: In cooler climates it is recommended that you schedule short-term testing during the colder months of the year (i.e. heating seasons such as October through March).

- *Real-Estate Transactions*: Testing for radon prior to every transfer of a residential dwelling to a new owner is recommended. Even if a building has been tested before, additional measurements help to ensure that conditions, including structure and ventilation, have not changed. (Note that disclosure regarding inspections and radon levels found are usually required during real-estate transactions. Your State Radon Office or other local authority may be able to provide additional information.) Property owners should also consider testing in advance of initiating a real estate sale so that the transaction will not later be delayed.
- *Non-Real-Estate Testing*: Although radon testing can begin at any time during the year, consider conducting measurements during a time of year when required closed-building conditions are the normal conditions. Contact your State Radon Office for information on seasonal variations.

G. Retesting

Many factors can cause indoor radon concentrations in your building to change over time. New openings to the earth may develop due to settling/deterioration of the building structure and/or construction or renovation work including energy upgrades. Pressure relationships can change if HVAC equipment is added, removed, replaced, operated differently or improperly maintained. These changes may produce elevated radon concentrations in rooms in which the initial radon test results were below 4 pCi/L (148 Bq/m^3). Therefore, ***retesting*** the building every five years is recommended.

When tests indicate low concentrations, consider confirming low concentrations by repeating tests during different seasons and weather conditions to account for possible seasonal variations.

In addition, radon concentrations should be retested when the following occur:

- A new addition is added,
- Significant changes to the slab or foundation occur such as major cracks or penetrations that occur due to natural settling, water proofing or groundwater control efforts,
- Significant construction blasting or earthquakes occur nearby,
- An installed mitigation system is altered, modified or repaired,
- A ground contact area that was not previously tested is occupied.

Retests after mitigation: To provide an initial measure of radon reduction system effectiveness, a short-term measurement must be performed no sooner than 24 hours after a radon reduction system is operational and within 30 days after installation of system. The test must be made in the same location as the pre-mitigation test location or the lowest livable area. A post-mitigation test must also be made in the lowest livable area above any crawl space that is structurally isolated. It is recommended that additional measurements be made in the lowest livable area above each other unique structural area. Additional testing should be performed in the areas that were mitigated at least every two years to ensure that the system remains effective, and testing may be performed as often as desired.

H. Actions Recommended Based Upon Test Results

4 pCi/L (148 Bq/m^3) **or greater.**

If testing indicates radon concentrations equal to or greater than 4 pCi/L in any apartment, ~~or~~ office area, exercise facility, meeting room, dining area or other common area, you should reduce the radon to below 4 pCi/L. The higher the radon concentration, the more quickly action should be taken to reduce the concentrations.

Below 4 pCi/L (148 Bq/m^3).

Radon concentrations below 4 pCi/L still pose some risk. If test results are below 4 pCi/L, confirm the low results by testing again, at least every five years and whenever significant changes to the building's structure or mechanical systems occur. (See Section G above for more information.)

You may also consider performing a long-term test or several short-term tests in different seasons of the year. The closer a long-term measurement is to 365 days, the more representative it will be of annual average radon concentrations. Such considerations may be especially important in regions where geology or other factors may cause wide variations in radon concentrations.

Between 2 and 4 pCi/L (Between 74 and 148 Bq/m^3)

If the test results are between 2 and 4 pCi/L, you should consider taking measures to reduce the concentrations in the building. (Note that reducing and accurately confirming radon concentrations of about 2.0 pCi/L or below may be difficult.)

100 pCi/L (3,700 Bq/m^3) **or greater**

Call the State Radon Office or Department of Health for immediate protective action recommendations if radon test results approach 100 pCi/L or greater.

For Non-Residential Rooms/Enclosed Spaces:

Reduce the radon concentration

1. if testing indicates radon concentrations equal to or greater than 4 pCi/l in these locations (See Section III for complete testing protocol)

   AND

2. if either (a) these areas are occupiable with little or no modification, or (b) these areas serve as a source of radon into apartments and offices of upper story floors that have radon concentrations equal to or greater than 4 pCi/l.

How quickly to begin the mitigation process will depend on the radon concentration detected. Elevated radon concentrations of more than twice the action level [or more than 8 pCi/L (296 Bq/m^3)] demand a quicker response.

I. How to Mitigate

To successfully lower radon concentrations, conditions in the entire building must be evaluated. Reducing radon concentrations requires *diagnostics and mitigation*.

- Diagnostics may include evaluation of radon entry points, air pressure relationships within and under a building and other factors. Diagnostics are often needed to identify the appropriate radon reduction technique and design.
- Mitigation is the design and implementation of a radon reduction system.

You should use a contractor who is trained and certified to fix radon problems. A qualified contractor can investigate a radon problem in your building and help you choose the right treatment method. Lowering high radon concentrations requires technical knowledge and special skills.

Section III:

Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings

1.0 Purpose and Scope

1.1 Purpose: The purpose of performing radon measurements is to identify locations that have elevated radon concentrations and to determine if radon mitigation is necessary in order to protect current or future occupants. The purpose of test protocols is to help achieve reliable radon measurements.

1.2 Scope: These protocols address measuring radon concentrations in Multifamily buildings comprised of more than three attached dwellings. When testing single-family residences or buildings comprised of three or fewer attached dwellings, see *Protocols For Radon Measurements In Homes (AARST- MAH September 2005).*

1.3 Limitations: Suggested best practices to help ensure testing quality have been included, however:

1.3.1 This document is not intended to address all detailed technical aspects of measurement device technology or quality assurance.

1.3.2 HVAC System: This testing protocol is primarily designed for Multifamily housing with ducted, constant-volume, forced-air systems with a centralized return (i.e. each unit has its own air handler as typically seen in single detached housing). Other types of heating and air-conditioning (HAC) systems can cause significant room-to-room variations in the radon concentration and an adjustment to the strategy and the number of rooms tested should be considered (see 3.6 below).

1.3.3 Radon Decay Products: Due to difficulties establishing appropriate controlled conditions and other related concerns, the consensus of stakeholders found that radon decay product measurements require additional steps to create the conditions in residences that would allow them to be used to make radon mitigation decisions. Therefore, the use of working level monitors and any conversions between pCi/L and WL will be subject to the conditions described in Appendix B, and the use of radon decay product measurements to make mitigation decisions in Multifamily buildings is not currently supported by this standard.

1.3.4 Other special considerations. See 3.6 and 3.7 for discussions of situations that may indicate additional steps beyond these minimum protocols to be appropriate for consideration.

2.0 Preparing for the Measurement

2.1 Devices and personnel:

2.1.1 All devices used for measuring radon in buildings shall meet state requirements and be approved by NEHA-NRPP or NRSB. All devices shall be used in strict accordance with manufacturer's instructions.

2.1.2 Consult the manufacturer to determine whether the devices are capable of measuring over the chosen deployment period.

2.1.3 In addition, individuals who place or analyze radon measurement devices shall meet state licensing requirements or should be certified by the NEHA-NRPP or NRSB.

2.1.4 For large testing projects, additional Quality Control procedures should begin prior to deployment. (See Section 5.0 and 5.4 below).

2.2 Prior Notification and Closed-building compliance

Test conditions shall be controlled prior to and during testing. ***Closed-building protocol*** shall be maintained for short-term tests.

2.2.1 Ensure Occupant Notification: Failing to comply with required conditions is most likely to occur when residents are not properly informed about the necessary test conditions.

2.2.1.1 Seek to determine whether the building is new, occupied, and who will be responsible for closed-building conditions prior to and during the measurement period.

2.2.1.2 Prior to placing devices, ensure that an appropriate ***notice of inspection*** is distributed to residents at least two weeks in advance of testing and again a few days prior to the test for both tested and non-tested locations. (See example Exhibits 6 and 9) This will also help residents become familiar with the purpose of testing and the dates of testing the building.

2.2.1.3 Upon initiation of a short-term test, post ***"Radon Survey in Progress"*** notifications (See Exhibit 8) in conspicuous locations stating the conditions of the test.

2.2.1.4 Request occupant of tested locations sign a ***non-interference statement form*** (See Exhibit 7). This can also help ensure that the occupant was able to comply with the required conditions and did not tamper with the test devices or conditions.

2.2.1.5 It is also recommended to request signatures on a ***non-interference statement form*** from occupants of **all** other locations not being tested in the building. (See Exhibit 10.)

3.0 Where to Test

3.1 Conduct a measurement in each ground-contact apartment, dwelling, and room used as office space associated with the building complex. This means each unit that has floor(s) and/or wall(s) in contact with the ground. In addition, conduct a measurement in each such location that exists over crawl spaces, utility tunnels or enclosed parking garages.

If the lowest level is not currently used but could serve as a den, playroom, office, work area or an additional bedroom at some time in the future, conduct a test in this level. Test each dwelling in a room located in the lowest livable level that is in contact with the ground or above a crawl space, utility tunnel or garage.

See placement example diagrams in EXHIBITS 1a and 1b.

3.2 Also conduct a measurement in non-residential ground-contact rooms or areas (e.g. utility rooms, storage rooms, and maintenance rooms) that are:

- ❖ occupiable with little or no modification;
- ❖ occupied more than four hours per day; and
- ❖ areas that have air communication with occupiable areas (e.g. stairwells and elevator shafts).

When in doubt, test the area. Results from testing these unoccupied areas provide assurance regarding current or future use of the building, and they may indicate a need for additional testing in upper areas. These unoccupied areas may serve as a pathway for radon into apartments and offices of upper floors.

3.3 For large rooms or open areas – Place one detector every 2,000 square feet (186 square meters) (e.g., a square area with each side 45 feet (13.7 meters) in length).

3.4 On the higher floors, a measurement shall be made in at least one apartment on each floor; the measurements shall include at least 10 % of the dwellings on the higher floors. It is recommended that the upper floor test locations be selected so that units on one floor are not directly above or below units being tested on other floors. See placement example diagrams in EXHIBIT 1c.

3.5 Test all areas during the same time period (days or phase).

3.6 Considerations Regarding Complex Heating/Cooling /Ventilation Systems:

Some Multifamily buildings have heating, ventilating and air conditioning (HVAC) systems that supply conditioned air and ventilation to dwellings. Many have heating and air conditioning systems that do not supply additional fresh air for ventilation (HAC) such as normally seen in single-family residences. Radon concentrations can vary widely from test to test based on the operational variances that occur when fresh air ventilation is supplied to a building.

In addition, if the Multifamily building to be tested does not have a ducted, constant-volume, forced-air system with a centralized return (i.e. each unit has its own air handler as typically seen in single detached housing), the number of rooms to be tested may need to be adjusted. Depending on the type and configuration of an HAC (that does not supply fresh air ventilation), testing of all routinely occupied ground-contact rooms within each unit may be required.

Examples of systems where testing has shown significant room-to-room variation are dwellings or buildings equipped with:

Group 1: Variable air distributions
• Variable Air Volume (VAV) systems where the airflow from a single air handler is distributed to multiple dwellings or locations by way of independent controls for duct dampering.
• Multi-zone systems where different air handlers are employed and independently controlled for different areas within the same dwelling
• Whole building ducted forced air systems with individual room returns
• Unit Ventilator (sometimes referred to as a through the wall package unit)
Group 2: Non-ventilating
• Individual Room Ductless Split Systems
• Baseboard heating, and/or window air-conditioners
• Non-Forced-Air Hot and Cold Water Circulation.

If you are unsure as to the type of system that is present, consult with the building representative, a mechanical engineer or a heating and air-conditioning contractor.

There are currently no techniques to readily determine the number of additional rooms that require testing for Multifamily buildings equipped with either Group 1 or Group 2 types of systems. In instances where ventilation systems may cause significant pressure differences, testing of additional locations is recommended.

Testing of all routinely occupied ground contact rooms within each unit is the best way to evaluate a radon risk in Multifamily buildings with Group 1 or 2 types of systems. If additional testing is warranted, suggested rooms to test are all ground contact bedrooms and any rooms that can be closed off from the main part of the unit.

When in doubt, test the area.

3.7 Testing in Areas with Geologic Considerations:

Local geologic and topographic characteristics have been correlated with unusual or sizable variations in indoor radon concentrations. If a foundation is connected to a sub-surface cavity system, which connects to the radon-producing strata, large variations can occur. The most common examples are buildings found in limestone-rich areas where groundwater has eroded passages in the underlying rock (*karst*) or areas with faulting which could allow radon to be transported in an unusual manner.

Structures in regions where these geologic characteristics exist have been shown to have the potential for wide variations in radon concentrations. Confirming low results by repeating tests during different seasons and weather conditions or with long term testing is especially important for such regions.

Radon offices in some states may have information on the presence of geologic characteristics that can create unpredictable radon entry behavior. If you are uncertain whether these conditions exist in your area, contact your State Radon Office.

3.8 Choosing a location in a room

The following criteria shall be used to select a location in a room to place detectors:

3.8.1 Place the detectors within the general ***breathing zone***. Locate the detectors **no less than**:

- Three feet (90 centimeters) from exterior doors and windows or other potential openings to the outdoors
- One foot (30 centimeters) from the exterior wall of the building
- 20 inches (50 centimeters) from the floor
- Four inches (10 centimeters) from other detectors and surrounding objects or as recommended by the manufacturer or laboratory.
- For those detectors that may be suspended, an optimal height is no higher than eight feet (2.5 meters) from the floor and a minimum of one foot (30 centimeters) below the ceiling.

3.8.2 Select a position where the detectors will not be disturbed during the measurement period. The detectors must not be moved, covered or have its performance altered during the test.

3.8.3 *Do not* place detectors inside closets, crawl spaces or hallways or in enclosed areas of high humidity or high air velocity. The latter may include kitchens, laundry rooms, and bathrooms.

3.8.4 *Do not* place detectors inside cupboards, sumps, or nooks within the building foundation.

3.8.5 *Do not* place detectors near drafts caused by heating, ventilating and air conditioning vents, or fans.

3.8.6 *Do not* place detectors near heat sources, such as on appliances, near fireplaces or in direct sunlight.

3.8.7~~8~~ *Avoid* placing detectors on or near stone fixtures, e.g. granite counters, hearths or slate pool tables.

4.0 Testing Strategies

Any of the following test strategies may be employed for testing structures including tests performed for non real estate purposes or when associated with a real estate transaction. Tests performed for an individual dwelling may employ these strategies yet still require test conditions for the entire building that meet the requirements of Section 6.

See Appendix E "Procedural Checklist For Testing" and Exhibits 1-5 for calculating the

number of test devices that will be needed for each strategy option.

Acceptable strategies:

A. **Extended** Test Protocol *[corresponding to EPA's Citizen's to Guide to Radon (or latest comparable EPA document) for homeowners and non-real estate situations]*. (See Figure 1)

The ***Extended testing protocol*** entails a quick and cost-effective initial test with follow-up testing in locations where elevated radon concentrations were initially measured. The ***Extended testing protocol*** is an option when time constraints are not prohibitive and when occupant relations allow the performance of a second test when needed. Follow-up tests may be short-term tests or, when initial tests indicate concentrations of ~~4.0~~ to 8~~.0~~ pCi/L (148 to 296 Bq/m^3), long-term follow-up tests may be employed to provide a better understanding of the year-round average radon concentration for those occupants and to be more certain that you should mitigate. There are still potential health risks at radon concentrations below 4 pCi/L (148 Bq/m^3) and long term retesting should be considered if results are between 2 and 4 pCi/L (74 to 148 Bq/m^3).

B. The **Time-Sensitive** test protocol *corresponding to EPA's Home Buyer's and Seller's Guide to Radon (or latest comparable EPA document)* (See Figure 2)

Time-Sensitive testing protocols require certain additional features to aid reliability of results during a single phase of testing. ***Time-Sensitive testing protocols*** may be appropriate for situations where quick decisions are needed or when other strategies are unacceptable. Time-sensitive situations may include: real estate transactions; planned renovations; or other situations that require a quick evaluation of whether radon mitigation is needed. Options provided in this protocol might also be desired when logistics or public relations with occupants render other strategies unacceptable (i.e. when occupants might consider repeated access and closed-building requirements to be disturbing intrusions into their homes.)

4.1 Extended Protocol

Extended Testing Protocol (corresponding to EPA's Citizen's Guide to Radon for homeowners - non-real-estate circumstances)	
TYPE OF TEST (passive devices)	*What to do next if the test result is 4.0 pCi/L or greater*
Single Short-Term Test	*Test this location again ** **If the first short term test is greater than 8.0 pCi/L, take a second short-term test immediately. If the first short term test is 4.0 to 8.0 pCi/L, take either a short term or a long-term test.*
Average of 2 Short-Term Tests	*Fix the building* *Consider fixing between 2.0 and 4.0 pCi/L*
A Long-Term Test	*Fix the building* *Consider fixing between 2.0 and 4.0 pCi/L*
Less than 4.0 pCi/L: Confirm the low result by testing again every five years and whenever significant changes to the building's structure or mechanical systems occur. Testing during a different season and different weather conditions or with long-term testing is recommended.	

4.1.1 **Step 1: Initial Measurements**:

Conduct initial measurements under closed building protocols (See Section 6) for at least 48 hours using short-term tests (i.e. 2 to 90 days) to provide a quick answer to whether high radon concentrations are present.

Test periods of at least 4 to 5 days are recommended for multifamily buildings when short-term tests are employed, because it is sometimes difficult to ensure closed-building conditions existed 12 hours prior to the test at every dwelling.

4.1.1.1 ***Quality control:*** The number of duplicate measurements needed should be at least **10 percent** of all the testing locations. The number of blank measurements needed is equal to **5 percent** of all the testing locations. (See Section 5 for additional quality control requirements and Appendix A for additional information.)

4.1.2 Step 2: Follow-up Measurements

Do not use the results of a single short-term passive test device as the basis for determining whether to mitigate an area.

Conduct a follow-up test, at a minimum, in every testing location with an initial short-term test result of 4 pCi/L (148 Bq/m^3) or greater. Test additional locations as necessary, e.g. invalid tests from the original testing series, other locations surrounding original elevated locations, and locations or pathways that may influence elevated radon concentrations in the building. All follow-up measurements should be initiated during the same time period (or phase) and placed in the same locations as the initial measurements.

4.1.2.1 Use a *short-term, follow-up* test if results are needed quickly.

The higher the initial short-term test result, the more certain you can be that a short-term follow up test should be used rather than a long-term follow-up test.

If the initial short-term measurement for a testing location *is more than twice* the EPA's radon action level of 4 pCi/L (148 Bq/m^3), a short-term follow-up measurement should be taken immediately. Use the average of the initial and follow-up test results to determine if this location needs mitigation.

All short-term tests should produce results in the same measurement units and should be made in the same locations and under the same conditions as the initial tests (to the extent possible).

4.1.2.2 Use a *long-term, follow-up* test to better understand the year-round average radon concentration and to be more certain that you should mitigate.

For a better understanding of your year-round average radon concentration or when an initial test indicates 4.0 to 8.0 pCi/L (148 to 296 Bq/m^3), you may consider a long-term follow-up test performed as close to a year as possible ensuring that the test period includes multiple seasons. Closed-building conditions are not required for test periods lasting longer than 90 days. Long-term tests must be deployed for *a minimum of 91 days* and closed-building conditions are not required for test periods lasting longer than 90 days. You may use the result of this test to determine if this location needs mitigation.

4.2 Time-Sensitive Protocol

Time-Sensitive Testing Protocols (corresponding to EPA's "Home Buyer's and Seller's Guide to Radon")	
TYPE OF TEST	*What to do next if the location is 4.0 pCi/L or greater*
Passive Devices: *(Passive devices do not provide hourly measurements)* **Simultaneous Testing**: Take two short-term tests at the same time in the same location for at least 48 hours. Locate devices no less that 4 inches (10 centimeters) from other test devices and surrounding objects or as recommended by the manufacturer or laboratory. **Average the results**.	*Fix the building if the average is 4.0 pCi/L or greater* *Consider fixing between 2.0 and 4.0 pCi/L*
Continuous Monitor (Active) Devices: *(These devices provide hourly measurements.)* Test the room with a continuous monitor for at least 48 hours.	*Fix the building.* *Consider fixing between 2.0 and 4.0 pCi/L*

4.2.1 Time-Sensitive Measurement Options:

These measurement strategies involve a single phase of testing and therefore require certain features to aid reliability of results when making mitigation decisions based upon a single phase of testing.

4.2.1.1 Simultaneous Testing: Conduct the measurement at each location with two short-term passive test devices at the same time in the same location for at least 48 hours under closed building protocols. (See Section 6). Test periods of at least 4 to 5 days are recommended for multifamily buildings when short-term tests are employed, because

it is sometimes difficult to ensure closed-building conditions existed 12 hours prior to the test at every dwelling.

Locate devices no less that 4 inches (10 centimeters) from other test devices and surrounding objects or as recommended by the manufacturer or laboratory. The results of both measurements should be reported. Use the average of the two results to determine if this location needs mitigation.

4.2.1.1.1 Quality control: This option results in **100 percent** duplicates. The number of blank measurements needed is equal to **5 percent** of all the testing locations. (See Section 5 for additional quality control requirements and Appendix A for additional information.

4.2.1.3 Continuous Monitor devices: A continuous monitor is capable of providing and averaging reviewable hourly readings. Conduct short-term tests for at least 48 hours under closed building protocols. (See Section 6). Test periods of at least 4 to 5 days are recommended for multifamily buildings when short-term tests are employed, because it is sometimes difficult to ensure closed-building conditions existed 12 hours prior to the test at every dwelling.

This option may only be cost-effective for very small building complexes. However, continuous monitors might be chosen for areas of the building(s) where a more detailed assessment of radon fluctuations is appropriate (i.e. locations where significant fluctuations in pressure or ventilation might be expected). Use the average result of this test to determine if the location needs mitigation.

4.2.1.3.1 Quality control: The required number of duplicate measurements is at least **10 percent** of all the testing locations. (See Section 5 for additional quality control requirements and Appendix A for additional information.

4.3 Retests after mitigation

To provide an initial measure of radon reduction system effectiveness, conduct a short-term measurement no sooner than 24 hours after a radon reduction system is operational and within 30 days after installation of system. Conduct the post-mitigation testing in the areas that were mitigated and in the same locations as the pre-mitigation test locations.

Test additional locations as necessary including other locations surrounding original elevated locations, in the lowest livable area above any crawl space that is structurally isolated and in the lowest livable area above each other unique structural area.

Conduct additional testing in the areas that were mitigated at least every two years to ensure that the system remains effective, and testing may be performed as often as desired.

5.0 Quality Control In Testing Multifamily Buildings

Testing requires an overall quality assurance plan for tracking precision and bias that includes duplicate, blank and spiked measurements. (See Appendix A.) These measurements should be evaluated and reported as they represent an "early warning system" to identify problems that may have developed during the testing of Multifamily buildings. Quality Assurance (QA) and related standard operating procedures are an inherent requirement of any measurement program or project.

5.1 Blanks and duplicates shall be part of a measurement professional's quality assurance plan and shall be included in the final report documentation (see 8.5.5).

Duplicate Measurements (side-by-side devices)	**Blank Measurements** (unexposed devices)
The number of duplicate measurements shall be equal to or greater than 10% of all testing locations (or as specified by the test strategy chosen.) See Section 4.0.	The number of blank measurements shall be equal to 5% of all testing locations. Field blanks (blanks deployed at the testing location) are not required. However, allocating 3% field blanks and 2% office/laboratory blanks is recommended.

See APPENDIX A for additional information on QC.

5.2 Field blanks are generally not required to be deployed at the testing site. However, radon professionals should consider deploying 3% field blanks and 2% office blanks to evaluate background exposures throughout the sampling process. Office blanks remain in the office setting. Field blanks are taken to the site and left on site to parallel sampling conditions.

5.3 **Special considerations for blank devices in large deployments.** As the number of units to be tested in a complex increases, the need for specialized blank procedures also becomes greater. With a larger number of testing locations and devices, the

investiture of time and money for the client and the professional becomes great enough that an early detection procedure should be included in the blanks deployment protocol.

At a minimum of 50 test devices deployed, testers should increase the number of blanks to 9 devices:
• 3 blanks should be returned to the laboratory immediately so that elevated background concentrations will be evident prior to beginning device deployment;
• 3 blanks should be treated as "office blanks" remaining in a known low-radon environment and returned to the laboratory with the sampling devices per normal procedure;
• 3 blanks should be deployed in the field with the sampling devices to track handling procedures. These devices accompany the sampling devices and are opened onsite, immediately closed, and left closed on site. They are retrieved with the sampling devices and returned to the laboratory per normal procedure.
Manufacturer/laboratory recommendations for device-specific field blank procedures should be followed.
If more than 180 test devices are deployed, the standard 5% blanks number can be resumed, however, the practice of using pre-test blank evaluation and office plus field blanks should be continued.

5.4 **Spiked measurements and special considerations for spiked measurements in large deployments.** Spiked measurements for the testing project (or from the measurement professionals QC plan) shall also be included in the final report documentation (see 8.5.5). As the number of units to be tested in a complex increases, the need for specialized spike procedures also becomes greater. With a larger number of testing locations and devices, the investiture of time and money for the client and the professional becomes great enough that an early detection procedure should be included in the spike protocol.

- At a minimum of 100 units to be tested, testers should ensure that the result of three spiked devices from the sampling program batch have been received and are satisfactory (±25 % of the reference value) prior to beginning the sample deployment.

6.0 Conditions required before and during the test

Long-term tests (those lasting 91 days or more) do not require closed-building conditions. It is recommended that long term tests be performed as close to a year as possible ensuring that the test period includes multiple seasons.

Short-term tests are conducted for two days to 90 days; **closed-building conditions are required**.

Purpose of Closed-building Conditions: Closed-building conditions are required for short-term measurements to stabilize radon concentrations and entry rates and increase the reproducibility of the measurement. Without these controlled conditions, measurements can indicate higher or lower readings than are typically present.

6.1 Closed-building Protocol

- Closed-building conditions shall be maintained throughout the test period and for 12 hours prior to the initiation of measurements lasting less than four days
- All windows on all levels of the building shall be kept closed and all external doors shall be kept closed (except for momentary entry and exit). This includes areas not being tested.
- Heating and cooling systems shall be set to normal, occupied, operating temperatures; fan/blower controls shall be set to intermittent activity unless the system is designed to only run the fan continuously.
- Whole house fans shall not be operated.
- Occupants should avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air into and out of the building.
- Solid, liquid, or gas fuel burning fireplaces shall not be operated unless they are the primary/normal sources of heat for the dwelling.
- Additional closed-building conditions
  - Window air-conditioning units shall only be operated in a re-circulating mode.
  - Equipment that supplies fresh air to the dwelling shall be deactivated unless it is an integral part of the HVAC system or supplies make-up air to a combustion appliance.
  - Window fans shall be removed or sealed shut.

- Fans installed in attics to control only attic air and not whole-building temperature or humidity may continue to operate.
- Air exchangers: Normal operation of permanently installed ventilation systems such as energy recovery ventilators (also known as heat recovery ventilators or air-to-air heat exchangers) may continue during closed-building conditions so long as the system is regularly maintained and continuously operational. Should such a system be labeled or intended to serve as a radon control system, see below under "Special considerations, Radon Mitigation Systems".
- New construction, renovations and repairs: Items that shall be completed or installed before the radon test is initiated include:
  - all insulation,
  - all exterior doors and hardware,
  - all windows,
  - all fireplaces and fireplace dampers,
  - all heating/cooling appliances (functioning and set to run at normal occupied temperatures),
  - all ceiling coverings,
  - all interior trim and wall coverings,
  - all exterior siding, weatherproofing and caulking.
  - Structural openings to the **exterior** as a result of incomplete construction, structural defect, disrepair, or the like shall be closed or repaired 12 hours prior to initiating the test.

6.2 Special considerations

- **Severe Weather:** Short-term tests lasting less than four days should not be conducted during unusually severe storms or periods of unusually high winds.
- **Radon Mitigation Systems:** Prior to beginning a test, a permanently installed active radon reduction system shall have been operating for at least 24 hours and shall continue to operate during the test period. In addition, Closed-building conditions shall be maintained 12 hours prior to initiating a valid test period and throughout test.

6.3 Device Deployment Periods

6.3.1 Short-Term Devices: Short-term devices shall be deployed for two to 90 days.

Test periods of at least 4 to 5 days are recommended for multifamily buildings when short-term tests are employed, because it is sometimes difficult to ensure closed-building conditions existed 12 hours prior to the test at every dwelling.

Since terminating a measurement at exactly 48 hours is often impractical, some flexibility is allowed:

6.3.1.1 For integrating or equilibrating devices, retrieval of devices after 46 hours is allowed (assuming Closed-building Protocol requirements are met).

6.3.1.2 For continuous monitors, the first four hours of data may be discarded or incorporated into the result using system correction factors (EPA 402-R-92-004; EPA 1992). There must be at least 44 **contiguous** hours of usable data to produce a valid average. The "backing out" of data (i.e., removal of portions imbedded in the two days) to account for weather or other phenomena will invalidate the measurement. The periodic results shall be averaged to produce a result that is reported to the client and used to make mitigation decisions.

6.3.1.3 Termination of a short term test that is longer than two days should be done as close as possible to 24-hour increments to help ensure diurnal fluctuations in radon concentrations within a dwelling are reflected in the results evenly.

6.3.1.4 If a monitor cannot integrate readings each hour or less or is not set to record readings each hour or less, **then it is functioning as an integrating device and is not considered a continuous monitor** under these protocols.

6.3.1.5 Due to difficulties in establishing appropriate controlled conditions and several other related concerns, the consensus of stakeholders found that radon decay product measurements require additional steps to create the conditions in residences that would allow them to be used to make radon mitigation decisions in homes. Therefore, the use of working level monitors and any conversions between pCi/L and WL will be subject to the conditions described in Appendix B The use of radon decay product measurements to make mitigation decisions

in Multifamily buildings is not currently supported by this standard.

6.3.2 Long-Term Devices: Long-term devices shall be deployed for a minimum of 91 days. It is recommended that they be deployed for a minimum of six months over different seasons to reflect seasonal changes in radon concentrations and building operation. Closed-building conditions are not required, but are recommended. State Radon Offices may have information on seasonal variation.

6.4 Test Condition Verification: The test should include methods to prevent or detect interference with testing conditions or with the testing device itself. The measurement professional or occupant should be able to verify or provide documentation asserting that testing conditions were not violated during the testing period. A test company's minimum requirements for verifying test conditions shall be fulfilled by the following:

6.4.1 Informing the person responsible for building operation of the required test conditions;

6.4.2 Obtaining or attempting to obtain a signed noninterference agreement;

6.4.3 Posting a *Radon Test in Progress* notification form;

6.4.4 Conducting a visual inspection of the dwelling upon placement to assure all closed-building conditions are intact;

6.4.5 Conducting a visual inspection of the dwelling upon retrieval of the detector including:

6.4.5.1 Closed-building conditions are still being maintained,

6.4.5.2 Changes in the detector placement,

6.4.5.3 Condition of all tamper seals (See Section 6.5).

6.4.6 The measurement professional is not responsible for inspecting for closed-building conditions 12 hours before the start of the test or between placement and retrieval of the detectors.

6.4.7 If, at the initiation of the test, the measurement professional discovers or observes that closed-building conditions were not maintained, one of the following options is required:

- The radon test can be postponed until at least twelve hours of closed-building conditions have been maintained prior to the test;
- The radon test period can be extended to four days or more with an appropriate detector after closed-building conditions are initiated;
- For continuous monitors, device features or methods may be used to obtain an average reading that represents at least 48 hours of contiguous data collected after at least twelve hours of closed-building conditions have been maintained (e.g. a test may be run for 60 hours, the first 12 hours discarded and the last 48 averaged manually).

6.5 Other controls and aids for detecting failed compliance or interference

❖ *Placement Indicators:* A position for the device can be chosen and noted so that, upon retrieval, any handling or covering of the device can be detected.

❖ *Seals:* Non-re-sealable caulks and/or tapes can be used to verify that devices have not been altered or moved; in addition, they can be used to verify that windows or non-primary exterior doors have not been opened during the test. If broken, seals may help determine if testing conditions were altered or a device was disturbed. For a seal to be effective, it needs at least the following unique qualities:

- The seal must adhere readily to a multitude of surfaces yet be easily removed without marring the surface;
- It needs to be non-re-sealable or show evidence of disturbance;
- It must be unique enough to prevent easy duplication; and,
- It should be visible enough to discourage tampering.

(Most paper or plastic tapes and caulks have only some of these qualities. There are, however, a number of seals manufactured specifically for radon testing. It would be advisable to use one of these products and follow the manufacturer's recommendations for installation. The best caulking to use as a seal is a removable weather-stripping caulk. This type of caulking adheres readily to most surfaces yet comes off easily without leaving a mark or being re-sealable.)

❖ *Control Monitors:* The inclusion of at least a few devices that provide hourly data for fluctuations in radon can be helpful to aid confidence that no unusual conditions affected the measurement results. Hourly data for fluctuations of environmental factors such as temperature,

humidity and barometric pressure can also aid identification of unusual conditions.

7.0 Special Consideration for Large Disagreement between Duplicate (or Collocated) Results

Minor variation between the results of duplicate devices is typical. However, if the variation is unusually large, it may be indicate problems in the measurement system which could adversely affect the entire testing series.

One situation requires special attention: Where one test result is 4.0 pCi/L or greater and the test result of the collocated device is less than 4.0 pCi/L, i**f the higher result is twice or more the lower result, a repeat test is required.**

See Appendix A for additional information on Duplicate results.

8.0 Documentation

The device placement log and supporting documentation shall be maintained for at least 6 (six) years after testing. Sufficient information about each measurement shall be recorded in this permanent log to allow for future comparisons, interpretations, and reporting to residence managers.

Final report documentation shall include:

8.1 **Test Site:** The address of the building(s) tested, including zip code.

8.2 **Testing Service** information:

8.2.1 The company/measurement professional's name, contact information and current certification ID number or equivalent state certification ID number as applicable,

8.2.2 The name and identification number of the service or organization used to analyze devices.

8.3 **State Radon Office** contact information.

8.4 **A summary of measurement results** and a statement outlining any recommendations concerning actions for retesting or mitigation. Interpretations and recommendations both written and verbal should reflect guidance provided in the "Introductory Guidance to Residence Managers" (attached above) and shall be provided in accordance with the latest versions of EPA's *Home Buyer's and Seller's Guide to Radon,* EPA's *Citizen's Guide to Radon,* or as recommended or required by the state radon office for the location of buildings being tested.

8.5 **The report shall contain all valid individual measurement results.**

8.5.1 When using continuous radon monitors, hourly readings shall be included.

8.5.2 Measurements made in separate locations shall NOT be averaged. They must be reported individually.

8.5.3 Radon gas results reported in picocuries per liter (pCi/L) shall be reported to only one figure after the decimal (e.g. 3.2 pCi/L). The average of collocated measurement devices shall be reported as well as the individual results. (Note: If the average of two measurements produces a result of 3.95 pCi/L, standard mathematical rules should be followed and such average shall be reported as 4.0 pCi/L.)

8.5.4 Any quality control measurements shall be reported as such.

8.5.5 Any reports or test data acquired from residents who have independently tested.

8.6 **Device and location information:**

8.6.1 Documentation of the locations of all devices deployed. It is advisable to diagram the test area noting the location and measurement results of the device. Supplemental photographic records for test locations are advised. See EXHIBIT 3 for an example *device placement log*.

8.6.1.1 Documentation regarding locations that should have been tested, but were not tested, with an explanation of the reasons why tests were not conducted.

8.6.1.2 Documentation of missing, lost and non-retrievable devices.

8.6.2 The exact start and stop dates and times of the measurement exposure period

8.6.3 A description of the devices used including its identification/serial numbers.

8.6.4 A record of quality control measures associated with the test such as results of duplicate and blank measurements.

8.7 **Test Conditions**

The Report shall contain sufficient information to allow clients to evaluate the data, interpretations and also make comparisons to any previous or future tests.

8.7.1 **Protocol Conditions:** A description of any observed deviations from appropriate measurement procedures that may affect the measurement results shall be included.

- Observed non-compliance with or deviations from required conditions such as closed-building conditions, prior to or during the test period.

- Observed deviation from a normal occupied temperature.
- Changes in the device's placement, whether any seal has been altered or test interfered with.
- Any observed anomalies in data printed from a continuous radon monitor that may indicate interference with the device or test conditions or non-standard testing conditions.
- A description of any unusual or severe weather conditions.

8.7.2 **Non-interference controls**

- A description of any non-interference controls used such as tamper seals, control monitors or other methods should be included.
- Whether the responsible individual signed the noninterference agreement **shall** be included.
- Copies of signed noninterference agreements should be included.

8.7.4 **Mitigation System Status** (if applicable)

- The test company shall include a statement in the test report if a mitigation system was observed in a dwelling during the placement or retrieval of the detector(s).
- Whether the mitigation system fan was operating.
- A statement may be included in the report that the test company offers no findings as to the proper operation of the system.

8.7.5 **Temporary Conditions**: A description of observed building conditions or other factors that are temporary in nature and may affect the measurement results shall be included**.** The report shall also document for the client that the test may not reflect the client's risk from radon if such conditions are altered from the condition existing during the test period.

Temporary conditions include:

- Units that were tested and vacant during the test period
- The condition of any temporary radon mitigation methods that are not permanent installations;
- The condition of any permanent vents (open/closed or n/a) such as crawl space vents;
- The condition of active or passive air supplies to the building or to combustive appliances.
- If a permanently installed ventilation system, such as a heat recovery ventilator or air-to-air heat exchanger, is active during the test yet ready access exists for deactivation or if the system functions intermittently.
- Conditions of unusually severe storms or periods of unusually high winds.

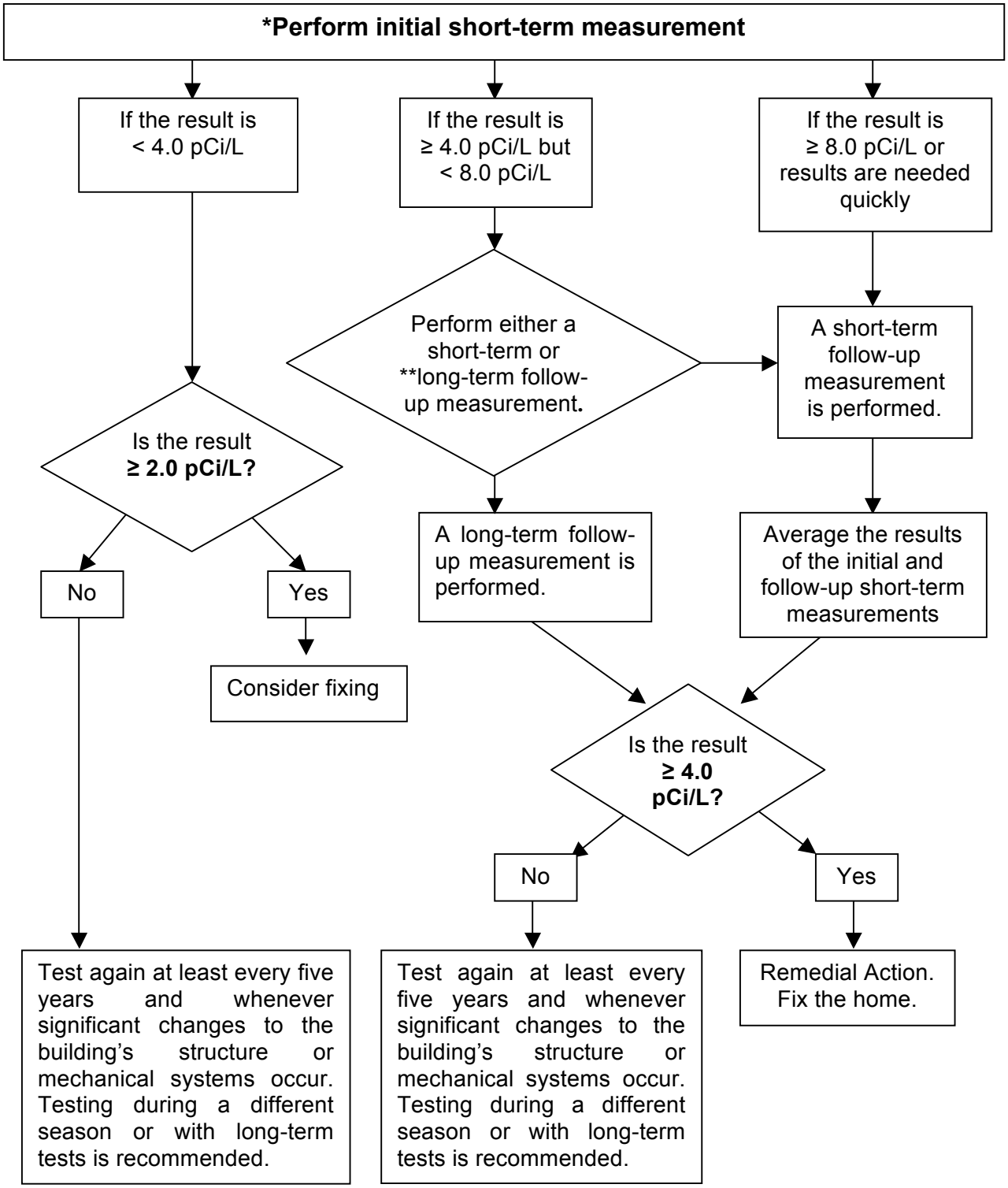
8.10 **Statement of Test Limitations**

The report should describe the general limitations of the test.

8.10.1 An example is the following: "There is an uncertainty with any measurement result due to statistical variations and other factors such as daily and seasonal variations in radon concentrations. Variations may be due to changes in the weather, operation of the dwelling, or possible interference with the necessary test conditions."

Figure 1

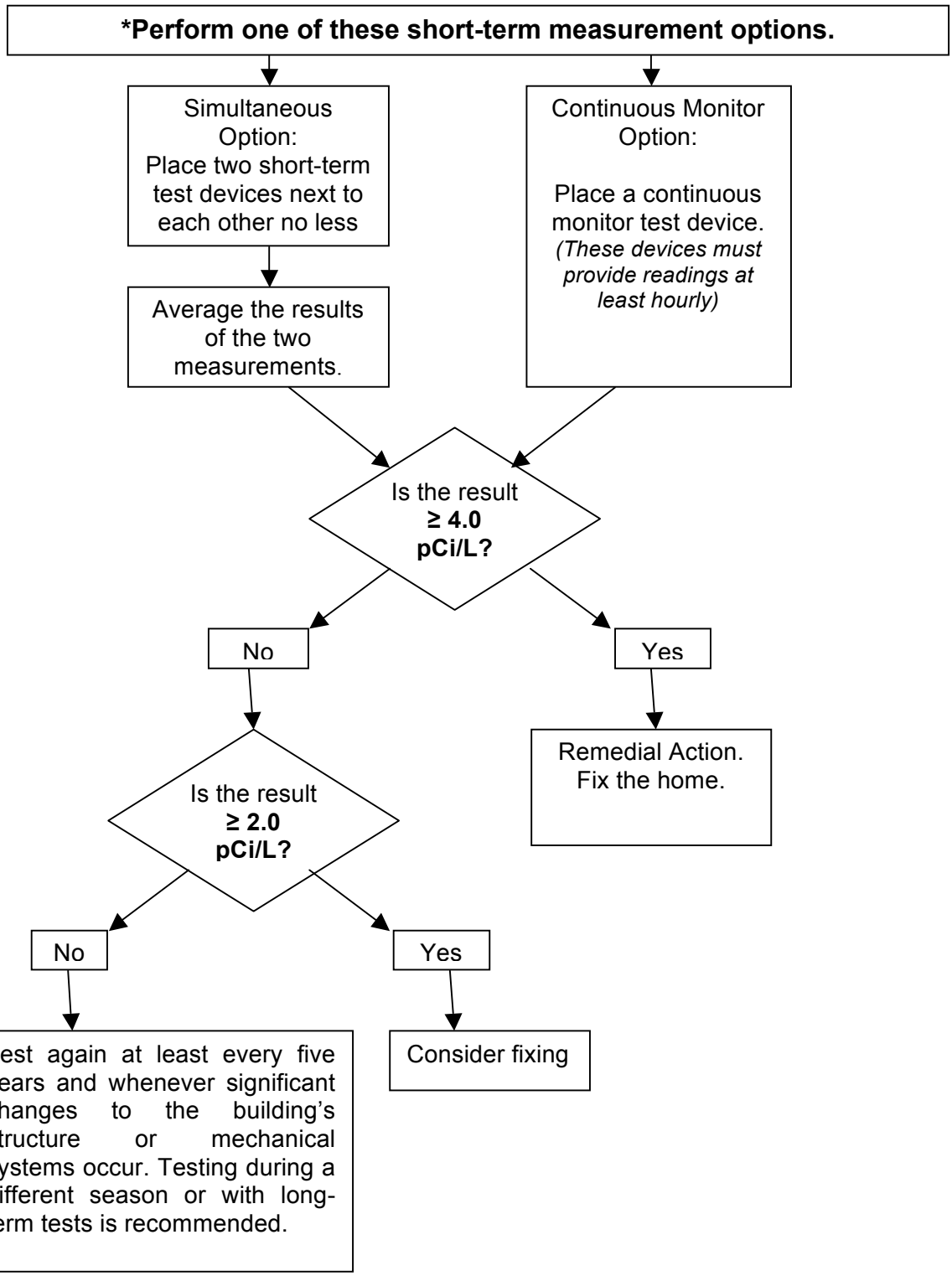
Extended Testing Process



**Choosing a time of year when closed-building conditions are a normal condition will aid in ensuring reliable measurements.*
***Long-term tests should be performed as close to a year as possible ensuring that the test period includes multiple seasons.*

Figure 2

Time-Sensitive Testing



**Choosing a time of year when closed-building conditions are a normal condition will aid in ensuring reliable measurements.*

Appendix A

DESCRIPTIONS OF MEASUREMENT DEVICES AND QUALITY CONTROL MEASURES

(This section is intended for informational purposes only. For radon testing protocol, see Section III.)

DESCRIPTIONS OF MEASUREMENT DEVICES

Integrating or Equilibrating Devices: A radon measurement system in which the sampling device, detector, and analysis system often do not function as a stand-alone unit. Integrating devices include electret ion chambers, alpha track monitors, and continuous monitors that are not set to, or are incapable of, recording radon concentration in time increments of one hour or less. Equilibrating devices include activated charcoal kits and liquid scintillation vials. *Integrating* and *Equilibrating* devices often require laboratory analysis.

Continuous Device: Test device that records reviewable measurements of radon or radon decay products (progeny) concentration in time increments of one hour or less.

Abbreviations for Devices referenced in this document

Integrating Devices
ES -- Electret Ion Chamber (short-term)
EL -- Electret Ion Chamber (long-term)
AT – Alpha Track (filtered)
Other - Designed or set to not record hourly
Equilibrating Devices
AC – Activated Charcoal
LS -- Charcoal Liquid Scintillation
Continuous Devices
CR – Continuous Radon Monitor
CW – Continuous Radon Decay Product Monitor

Equilibrating Devices

AC – Activated Charcoal Devices

ACs are equilibrating devices. The charcoal within these devices has been activated to increase its surface area which increases the ability to adsorb gases. The equilibrating nature of the activated charcoal allows continual adsorption and desorption of radon. During the entire measurement period (typically forty-eight hours to seven days), the adsorbed radon undergoes radioactive decay. ACs should be promptly returned to the laboratory after the exposure period (by service that guarantees delivery within two to three days at maximum). AC devices are analyzed by gamma-ray spectroscopy which measures the emissions of gamma rays from two short-lived decay products of radon, ^{214}Pb and ^{214}Bi.

LS – Charcoal Liquid Scintillation Devices

Charcoal liquid scintillation (LS) devices are equilibrating devices that function on the same principle as AC devices. LS devices adsorb radon onto the charcoal in a vial. LS devices must be resealed and sent to the laboratory for analysis promptly after the exposure period (by service that guarantees delivery within two to three days).They are called "liquid scintillation" devices because they are analyzed by mixing the charcoal containing the radon with an organic "cocktail" and then counting, in a liquid scintillation counter, light pulses emitted due to the emission of alpha and beta particles from radon and its short-lived decay products.

Integrating Devices

EL/ES – Electret Ion Chambers

Electret-ion chamber devices (EL/ES's) are integrating devices that allow radon to diffuse into a chamber through a filter. Radiation emitted from the decay of radon and its decay products produces charged particles (ions) within the chamber. The negative ions are attracted to the positively charged electret and discharge it. The electret is removed from the canister and its voltage measured with a special surface electrostatic voltmeter both before and after the exposure period. The difference between these two voltage readings is used to calculate the average radon concentration. The devices are analyzed by a certified individual or laboratory using a special electrostatic voltmeter that can measure the decrease in voltage.

EL/ES's are designed to measure for short periods of time (e.g. 2 to 5 days) or for long periods of time (e.g. 9 months). The type of the electret (i.e. short or long-term) and chamber volume determine the usable measurement period. The electret readings are affected by ambient gamma radiation ionizing air inside the chamber, and the readings must be corrected for external gamma-rays.

AT – Alpha Track Devices

An alpha track device (AT) is an integrating device consisting of a small piece of plastic or film (the sensor)

enclosed in a housing with a filtered opening. Radon diffuses through the filter into the housing where it undergoes radioactive decay. This decay produces alpha particles that strike the sensor and generate submicroscopic damage called alpha tracks. The damaged portions of the plastic can be made visible by etching in a caustic solution, because the damaged areas are more soluble in caustic than the undamaged plastic. The etched areas can be seen using a microscope. The tracks are typically counted using computer recognition and automated scanning. The number of tracks per unit area is proportional to the integrated average radon concentration in pCi-days/liter. AT's are most commonly used for measurements of 91 to 365 days.

Other Integrating Devices:
Devices that use various other sensors and technologies for integrating data over time. If such device cannot integrate or record readings each hour or less or is not set to record readings each hour or less, then it is functioning as an integrating device.

Continuous Monitors

CR and CW – Continuous Radon Monitors and Radon Decay Product Monitors

Continuous monitors are the only electronic devices mentioned in this list. They use various types of sensors. Some collect air for analysis with a small pump while others allow air to passively diffuse into a sensor chamber. All have electrical circuitry capable of producing and recording integrated radon concentrations for periodic intervals of one hour or less.

Continuous radon monitors measure radon gas. Continuous radon decay product monitors measure radon decay product concentrations and require a pump to sample air containing radon decay products onto a filter assembly.

DEVICE QUALITY CONTROL

Terminology associated with *quality control (QC)* is briefly explained below.

Quality Assurance (QA) and related standard operating procedures are an inherent requirement of any measurement program or project. In lieu of other consensus protocols that may be developed, see EPA Guidance on Quality Assurance (402-R-95-012, October 1997) for details on quality assurance and additional specific requirements for each device can be found in EPA's "Indoor Radon and Radon Decay Product Measurement Device Protocols." Written Quality Assurance Plans are required of professional testers and labs who are state licensed or certified by NEHA-NRPP or NRSB.

Duplicate (Collocated) Measurements

Duplicates are pairs of devices or monitors deployed in the same location, side-by-side for the same measurement period. The purpose of duplicates is to evaluate precision or agreement between devices. (Note: Duplicates do not evaluate accuracy; for accuracy, see spiked measurements below.) Duplicates may help identify problems that may introduce error into the test results. Duplicates are typically deployed at a rate of 10% of the measurement locations. When establishing a testing service's overall quality control plan up to fifty duplicates per month are recommended. However, a specific testing program such as discussed herein for Multifamily buildings may require additional duplicate measurements.

Field duplicates should provide the same or similar radon results. Duplicate pairs of measurements greater than or equal to 4 pCi/L should produce a Relative Percent Difference (RPD) greater than 36% no more than 1% of the time. Greater than 1% duplicates above 4 pCi/L with an RPD greater than 36% indicates the measurement system is "out of control," and all measurements are questionable.

See Appendix C "Definition of Terms" for information on calculating the RPD.

If one duplicate is equal to or greater than 4 pCi/L and the other below, the higher result may not be twice or more than the other. Such measurements must be repeated.

Blank Measurements

Blanks are integrating or equilibrating devices that are not exposed to indoor air (i.e. not unsealed to permit radon to enter the device). Blanks help evaluate any detector response from sources other than radon exposure at a testing location such as in the manufacturing process, shipping, storage, handling and the like. Blanks are typically deployed at a rate of 5% of the measurement locations. When establishing a testing service's overall quality control plan up to 25 blanks per month are recommended. However, a specific testing program such as herein discussed for Multifamily buildings may require additional blank devices.

Blanks are unwrapped (but not opened) and immediately re-wrapped to give the appearance that they have been used in testing. The blanks are then shipped with the exposed devices so that the laboratory cannot distinguish them.

Since blanks are not exposed, their measurement value should not be above the lower limit of detection (LLD—the radon concentration below which the measurement system cannot accurately measure). Depending on the device, if one or more results are greater than the LLD, this may indicate defective devices, poor quality control or improper procedures. If a problem is identified, the device supplier should be contacted to evaluate and institute corrective procedures.

Spiked Measurements

Spikes are devices that have been exposed in a NEHA-NRPP or NRSB approved chamber to a known concentration of radon (i.e. "spiked" with radon). Using spiked measurements can help evaluate the accuracy of a laboratory analysis and/or how accurately devices supplied by a laboratory measure radon.

Detectors from the same batch as those slated for the sampling program are spiked and returned to the laboratory for analysis as near the sampling period as possible. Many devices are time sensitive and require being returned to the laboratory for analysis immediately after spiking. In general, spikes are included at a rate of no less than 3 per 100 sampling locations. When establishing a testing service's overall quality control plan, up to six spikes per month and a minimum of three per year are standard operating procedure. However, a specific testing program such as discussed herein for Multifamily buildings may require additional spiked devices. If the result of a spike differs greatly from the spike's known concentration, it may indicate that the devices are defective or the laboratory procedures are faulty.

The results from spikes are compared to the known value provided by the reference facility where they are spiked using the formula for Relative Percent Error (RPE). The RPE is plotted on a control chart. EPA 402-R-95-012, *Guidance on Quality Assurance* provides guidance on how to set warning and control limits. In general, the expectation is that the values of RPE fall between +10% and -10%, but the entire range of +20% to -20% is considered "in control." Outside of +/-20% but inside +/-30% is the warning level and outside of +/-30% is the control limit.

See Appendix C "Definition of Terms" for information on calculating Relative Percent Error.

Quality Control for Continuous Monitors

Continuous radon monitors require calibration and background checks within the timeframe recommended and at facilities approved by certification or state licensure requirements or the manufacturer's recommendation, whichever is more stringent. Annual calibrations are commonly a minimum requirement. Cross-checks should be performed at least every six months. Duplicates using a continuous monitor are to be deployed in 10% of the measurement locations. The agreement of duplicate results are calculated using the RPD as above and plotted on control charts. An informal intercomparison with a co-located device that reads in the same units (pCi/L) can also aid for checking quality.

Appendix B

Radon Decay Product Measurement:

The scope of this measurement standards document includes reconciling previous standards documents and guidance publications and adding updated information that relates to home measurement in order to achieve a protocol deemed credible by the stakeholder delegates.

Items specific to radon decay product measurements in homes were reviewed and considered in an open forum as well as within the subcommittee of stakeholder delegates. Considerations particular to radon decay product measurements include specific controls for closed building test conditions and specific considerations for reporting test results and any conversions between units of measurement. At this time, existing documents were not found to adequately address these considerations and science has not been presented regarding establishing appropriate conditions for radon decay product measurements in homes.

Therefore, Appendix B has been designated as the location in this document for additional protocols specific to the measurement of radon decay products in homes. Scientific studies delineating appropriate protocols are being solicited for review and evaluation through the stakeholder process. Until completion of that process, the use of radon decay product measurements to make mitigation decisions in residences is not supported by this standard.

NOTICE

The committee is formally soliciting suggestions on the wording of the protocol that will standardize testing conditions in residences sufficiently to provide confidence in radon decay product measurements for residential real estate transactions and consumers' interest, and on wording for appropriately using conversion information and conversion factors. Since a comparatively small pool of existing protocol text exists regarding specific considerations for working level measurements, supporting scientific documentation will be needed for proposed wording in order to maintain the integrity of the document and confidence of those using the protocol.

The committee is looking forward to active participation from all interested parties in developing a protocol that will be respected by stakeholders across the spectrum.

All such submissions must be forwarded to standards@aarst.org or faxed to (913) 273-0134 in order to receive consideration. Submissions will then be posted by AARST staff for workgroup and committee review.

Appendix C

Definition of Terms

Becquerel per cubic meter (Bq/m³): The metric unit of measurement for activity concentration of radon gas in air that corresponds to Picocurie per liter. 1 pCi/L = 37 becquerels per cubic meter (Bq/m^3).

Client: The individual or parties who hire(s) and/or pay(s) for the radon test.

Collocated: Two or more simultaneous measurements in the same location, or side-by-side

Continuous Radon Monitor (CR or CRM): Test devices that are capable of, and set to, record and review radon in time increments of one hour or less.

Crawl space: An open area beneath part or all of the livable space of a dwelling that typically has either a concrete slab or dirt floor. The dirt floor may be covered with gravel or a membrane. The crawl space can have an open height of a few inches to several feet. The crawl space can be storage space but is not living space, and may or may not be ventilated to the outside.

Crawl Space Depressurization (CSD): For the purposes of this document, a radon reduction technique seeking to achieve lower air pressure in a crawlspace than in the rooms bordering and above the crawlspace. A soil depressurization fan draws air from the entire crawl space rather than from under a plastic membrane (as employed for Submembrane Depressurization that is preferred when practical). Crawlspace depressurization is intended to mitigate rooms bordering and above the crawlspace but not the crawlspace itself.

Crawl Space Isolation (CSI): For the purposes of this document, isolation of crawlspace air from rooms bordering and above a crawlspace.

Equilibrating device: A device which functions by adsorbing and/or desorbing radon from or to the ambient air until an equilibrium condition is reached between the radon concentration in the device and the radon concentration in the ambient air. Equilibrating devices include 1) activated charcoal in containers, such as canisters, bags or trays, which are analyzed in a laboratory using gamma-ray spectroscopy and 2) activated charcoal in containers, such as cartridges or vials, which are analyzed in a laboratory using liquid scintillation spectroscopy.

Exposure time: The length of time a device must sample for radon to get an accurate measurement. Also called "exposure period," or "duration of exposure."

Extended Testing: An initial short-term test is followed up by a short- or long-term test if a radon concentration is found to be elevated. The decision to mitigate is based on the average of two short-term tests or the result of the long-term test.

Integrating device: A device that records, or registers in some manner, information that is directly related to the integral of ambient radon concentration over time within the operating range of the device. Integrating devices include 1) electret ion chambers which are analyzed after the fact by measuring a decrease in electrical potential on the electret, 2) alpha-track devices which are analyzed after the fact by etching and measuring the track density in a plastic matrix and 3) electronic devices that are not set to, or are incapable of, recording radon concentration in time increments of one hour or less and may or may not produce measurements in real time.

HAC Systems: Heating and cooling (air conditioning) systems that are not designed to also supply fresh air ventilation. HAC systems are common to single-family residences. If they also provide fresh air ventilation, they are more technically referred to as HVAC systems.

HVAC System: Heating and cooling (air conditioning) systems that are additionally capable of supplying fresh air ventilation. If they do not supply fresh air ventilation, they are more technically referred to as HAC systems.

Measurement professional: Any State Licensed or Nationally certified person, persons or entity who performs radon testing for remuneration. This professional shall hold a current radon license if testing is being conducted in a state where radon testing services are regulated. If the testing is being conducted in a non-regulated state, then the professional should have current certification recognized by the non-regulated state.

Mitigation system: Any system designed to reduce radon concentrations in the indoor air of a building.

Multifamily building: A building with more than three attached dwellings.

Picocurie (pCi): One pCi is one trillionth of a curie (10^{-12}) or 0.037 disintegrations per second or 2.22 disintegrations per minute. One curie = the amount of radiation in one gram of pure radium."

Picocurie per liter (pCi/L): A unit of concentration of radioactivity corresponding to 0.037 decays per second or 2.22 decays per minute in a liter of air or water. 1 pCi/L = 37 becquerels per cubic meter (Bq/m^3).

Primary test location: A location where test results will be used to make a mitigation decision. All relevant testing protocols must be followed for each primary testing location.

Quality Assurance (QA): A complete program designed to produce results which are valid, scientifically defensible, and of known precision, bias, and accuracy. Includes planning, documentation, and quality control (QC) activities.

Quality Control (QC): The system of activities to ensure a quality product, including measurements made to ensure and monitor data quality. Includes calibrations and backgrounds, duplicate, blank, and spiked measurements interlaboratory comparisons, audits, and other control activities.

Radon (Rn): A colorless, odorless, naturally occurring, radioactive, inert, gaseous element formed by radioactive decay of radium (Ra-226) atoms. The atomic number is 86. Although other isotopes of radon occur in nature, in this document, radon refers to the gas Rn-222.

Relative Percent Difference (calculations): The relative percent difference between a pair of duplicate measurement devices is calculated by dividing the difference between the two results by the average of the two results and multiplying by 100.

$RPD = [(|X_1 - X_2|)/X_{ave}] \times 100\%$

where:

X_1 = result of detector 1

X_2 = result of detector 2

$|X_1 - X_2|$ = absolute value of the difference between detectors 1 and 2

X_{ave} = average concentration = $((X_1 + X_2)/2)$

example:

$X_1 = 9.0$ and $X_2 = 8.0$

RPD = [(|9 – 8|)/8.5] x 100% = 1/8.5 x 100% = 11.8%

Relative Percent Error (calculations):

The relative percent error (RPE) is the difference between the known or reference concentration of radon used by a chamber to spike a device and the measured concentration of the spiked sample, expressed as a percentage of the known concentration. The RPE may be either a positive or negative number, indicating whether the measured concentration is higher or lower, respectively, than the known concentration. RPE is calculated by subtracting the known concentration from the measured concentration, dividing by the known concentration, and multiplying the result by 100%.

RPE = (MV – TV)/TV x 100%

where:

MV = measured value of detector

TV = target value of radon chamber

example:

MV = 11.0 and TV = 10.0

RPE = (11-10)/10 x 100% = 10%

Single family dwelling:

A residence or home intended to house a single family and requiring discrete testing location(s).

Standard Operating Procedure:

A written document which details an operation, analysis, or action whose mechanisms are prescribed thoroughly and which is commonly accepted as the method for performing certain routine or repetitive tasks.

Test interference:

The altering of test conditions prior to or during the measurement in order to change the radon or radon decay product concentrations, or the altering of the performance of the measurement equipment.

Time Sensitive:

A measurement strategy that involves a single phase of testing, requiring enhanced quality control measures. Time-sensitive tests included Simultaneous, and Continuous Monitor Device testing.

Appendix D

(This section is intended for informational purposes only. For radon testing protocol, see Section III.)

CHECKLIST FOR SELECTING A SERVICE

Selecting a Measurement Service

1. Contact your State Radon Office (http://www.epa.gov/iaq/whereyoulive.html) and request a list of State-Licensed professionals where applicable or seek professionals certified by either of the two nationally recognized certification programs: The National Environmental Health Association – National Radon Proficiency Program (NEHA-NRPP.org); or the National Radon Safety Board (NRSB.org).
2. Verify the state license (or NEHA-NRPP or NRSB certification) of the professionals performing the tests and the firms analyzing the detectors by requesting a copy of their current License or Certification Card.
3. Consider checking their references and business history regarding complaints or regulatory actions and any resolutions with your State Radon Office, Better Business Bureau, and State Office of Consumer Protection.

Requesting a Cost Estimate

4. Invite the measurement professional to walk through your building(s) before formulating their estimate. Request that they complete *Steps 1 through 4* of APPENDIX E. These steps serve as a guide for estimating the number of detectors needed and the time that is required to test your building.

Developing a Contract

5. After selecting a measurement contractor, request that they prepare a contract detailing the terms described in the proposal. Carefully read the contract before signing. Consider including the following in the contract:
   - A limit on the time required to report the measurement (often within 30 calendar days after completion of testing).
   - A description of exactly what work will be done prior to and during the testing period, the time and logistics required to complete the work, and the total cost of the job including all applicable taxes, permit fees, down payment (if any), and terms of payment.
   - A statement that the measurements will meet the standards herein or as recognized by your State, the USEPA, or nationally recognized radon certification program. A statement that they adhere to a QA and QC plan.
   - An outline of the responsibilities of each party in the event that measurements do not fully meet these standards. When the fault is the contractor's, provisions might include re-testing affected dwellings at no cost to the property owner. When the fault is beyond the control of the contractor (i.e. occupants losing detectors, occupant non-compliance, occupants refusing access, etc.) provisions might include a description of possible remedies and related additional expense.
   - A statement that liability insurance and applicable worker's compensation coverage is carried by the organization in the event of injury to persons or damage to property during the measurement process.
   - A statement that the tests will be performed by State licensed, or Nationally certified individuals (as appropriate).
   - A statement that the license or certification number of the individual placing/retrieving the test kits, their signature, and the date will be on the documentation for test results.
   - A statement that the contract will be dated and signed by all parties,
   - That the contract will is on company letterhead.
   - A statement of commitment that copies of the signed contract will be distributed to all signatories,
   - A statement of commitment that records of the testing project and the contract will to be kept on file for six (or more) years as recommended elsewhere in the standard.

Appendix E

(This section is intended for informational purposes only. For radon testing protocol, see Section III.)

PROCEDURAL CHECKLIST FOR TESTING

The following procedural checklist represents a step-by-step guide for conducting a radon testing program for a Multifamily, residential building. One should be familiar with the issues discussed in SECTIONS II and III of this document before using this checklist. In addition, the one should review and understand each section of this checklist before proceeding through the steps.

Planning a Test

1. Develop a floor plan that identifies all the testing locations that are in contact with the ground, are above a crawl space or as otherwise required herein for test locations. In addition to ground contact plans, floor plans for upper floors will be helpful in selecting the location for the upper floor (10%) requirement. It is recommended that the upper floor test locations be selected so that units on one floor are not directly above or below units being tested on other floors. That will increase the likelihood that the distribution of test devices identifies any pathways for radon migration into upper floors or any different batches of building material. Note, the residential manager or head maintenance person may have floor plans available. You might consider scheduling a time with maintenance personnel to perform a "walk through" of the building complex to identify testing locations.

2. Mark an "X" on the floor plan for areas appropriate for testing.
   a. Note any obstacles that may prevent access or appropriate test conditions. (i.e. Is there a personal lock on door and no key available to open the door?)
   b. Make appropriate considerations for detector placement within the area to be tested.
      - Will you need any special material (e.g. tape, thumb tacks, scissors, string, etc.) to place the device?
      - What technique(s) will you use to detect tampering?

3. Choose a test strategy that fits your situation (Extended or Time Sensitive Protocols). Take note of quality control requirements for the strategy chosen.

4. Duplicates: Mark a "D" on your floor plan for each testing location expected to receive a duplicate measurement. One duplicate measurement is required for every ten measurement locations unless a 100% duplicate testing strategy has been chosen. (See Extended or Time Sensitive protocols.)

5. Blanks: Account for blank measurements (5% of test locations - See Section III, 5.0 for specific guidance). For example: Randomly mark a "B" on your floor plan for locations that will receive blanks. Avoid placing a "B" in a testing location that already contains a "D". This strategy for recording duplicates and blanks will enable you to intersperse these QC measurements on the log sheets so that the laboratory analyzing your detectors will not be able to identify which recorded measurements are blanks and duplicates. See EXHIBIT 2 at the end of this appendix for an EXAMPLE FLOOR PLAN.

6. Spikes: Account for spiked measurements (See Section III, 2.1.4, 5.0 and 5.4 for specific guidance). For example: Randomly mark an "S" on your floor plan to indicate spiked measurements as required. This strategy will enable you to intersperse these QC measurements on the log sheets so that the laboratory analyzing your detectors will not be able to identify which recorded measurements are spikes.

7. Choose the appropriate device and verify that it is suitable for the times projected for deployment. When selecting the test device vendors, make sure that the reporting and QC expectations will be able to be supported by the company providing the final reports, whether it is a testing professional or testing laboratory. Some laboratories may have preferred chain-of-custody/log sheet formats and processing options (i.e., electronic submission,) so make sure that your record keeping procedures match the capabilities and requirements of the laboratory.

8. Purchase devices and schedule pre-test QC measurements if appropriate.

Scheduling the Deployment/Retrieval of Detectors

9. Schedule a time with the maintenance personnel for deployment and retrieval of detectors. Provide the number of days that will be needed to deploy and retrieve the detectors so that the maintenance personnel can make the necessary arrangements in their schedules for placement and retrieval at close to 24 hour increments for short term tests.

10. Prepare Resident Notifications (i.e. advance notices for residents, non-interference agreements and "test in progress" signs, etc.)

11. Ensure that reasonable advance notification is provided to residents of the dwelling regarding likely deployment/retrieval dates, required test conditions and other information as appropriate. See EXHIBITS 6 - 10.

12. Reconfirm your scheduled deployment date(s) and time(s) with the maintenance personnel no later than 2 to 3 days prior to testing.

Preparing Deployment Documentation

13. Prepare log sheets and floor plan drawings.

- ❖ Record the name of the building that you are testing in the space provided on the top right corner of each device placement log sheet (hereafter, log sheet).
- ❖ Using your floor plan as a reference, record the apartment number or other identifier in the appropriate column of the log sheet for each testing location in the order that you plan to test.
- ❖ For testing locations marked with a "B," indicating a blank detector, record a "B" in the "Room #/Name" column and "Location" column just below the testing location marked with a "B"

  For testing locations receiving duplicate pairs (i.e. locations marked with a "D") record a "D" in the "Room #/Name" column and "Location" column just below the room receiving duplicates. See EXHIBIT 4 SAMPLE DEVICE PLACEMENT LOG for a sample log sheet.
- ❖ Note the *location* where you plan to place the detector for each apartment or enclosed space.

Deploying the Detectors

14. Before entering a testing location, verify its room number or name with the one on the log sheet.

15. Place the detector and record the detector's serial number in *Serial # column.* Record the date and time of deployment.

16. Place the "Radon Survey In Progress" notice and compliance statement in a conspicuous place. (See EXHIBIT 7.)

17. Remember to place two detectors or *duplicates* in testing locations preceding a log entry containing a "D". When recording the deployment time for duplicates, consider adding a few minutes (e.g. 2 to 5 minutes) to the starting time so that the laboratory will not know they are duplicates.

18. If *blanks* are not actually deployed, it is still important to record plausible deployment dates, times and locations for these devices. *Field blanks* are typically transported to the test site, but are not deployed. *Office/laboratory blanks* may be stored in an office of the building being tested for radon, or placed on site with other test devices. (See Section 5 for specifics.)

19. Identify the name of the person placing/retrieving test devices in the space provided at the end of each log sheet.

Retrieving the Detectors

20. When picking up each detector, check its location and serial number with what was recorded during deployment. Note any discrepancies, test interference or non-compliance of required conditions in the *Comments column* of the log sheet. If the serial number does not agree with the one listed, change the number to the "new" one and note the change as a comment.

21. Record the date and time of retrieval in the log sheet for each device. Do the same for *duplicates and blanks.*

22. Identify the name of the person placing/retrieving test devices in the space provided at the end of each log sheet.

Preparing Detectors for Analysis

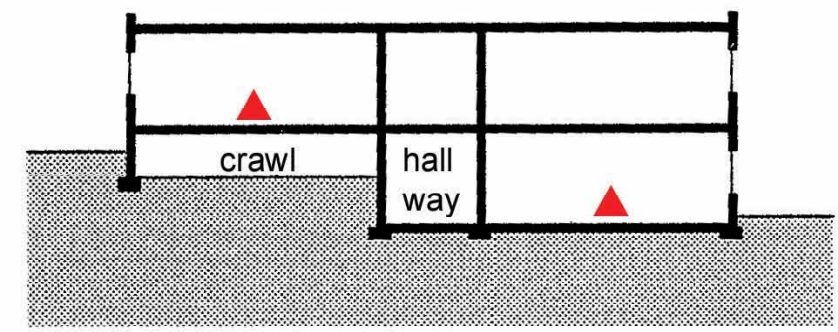
23. The laboratory analyzing the detectors should not be able to recognize *blanks* or *duplicates*. For example, after retrieving the exposed detectors, *field blank* devices must be mixed in with the exposed detectors for shipment. Therefore, any seals on the blanks must be broken (in some cases, the detector must be opened and immediately closed) and resealed in the same manner as the deployed detectors. Log sheets provided to the laboratory should also obscure which devices are *blanks* and *duplicates*.

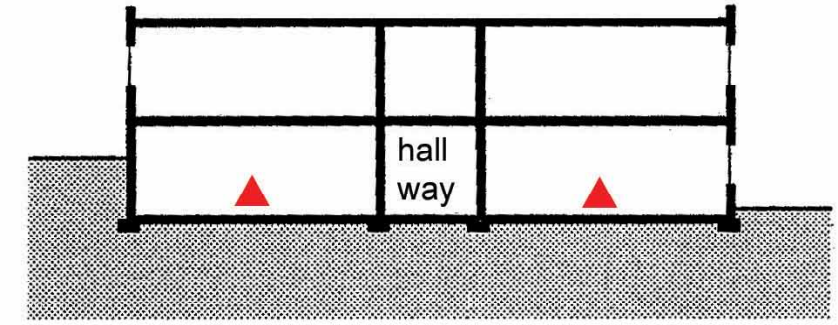
24. Ensure detectors are delivered to the analyzing laboratory within their stated timeframe.

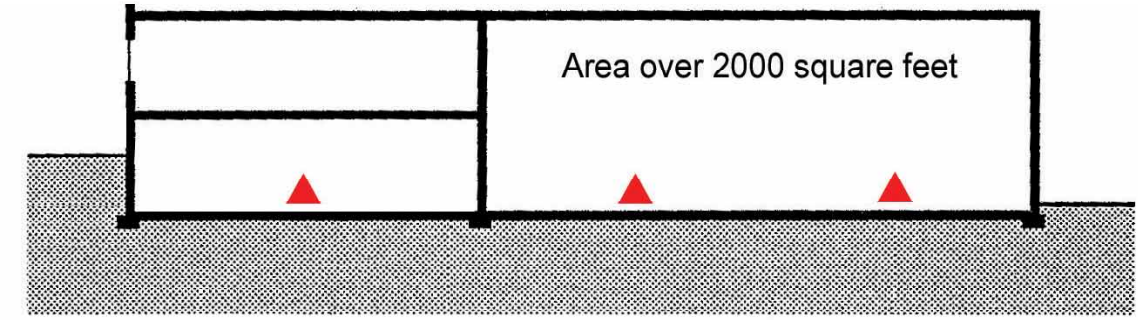
Preparing Report Documents

25. Compile test data into a report form (See Section III, 8.0).

EXHIBIT 1-a
GROUND CONTACT TEST LOCATION EXAMPLES



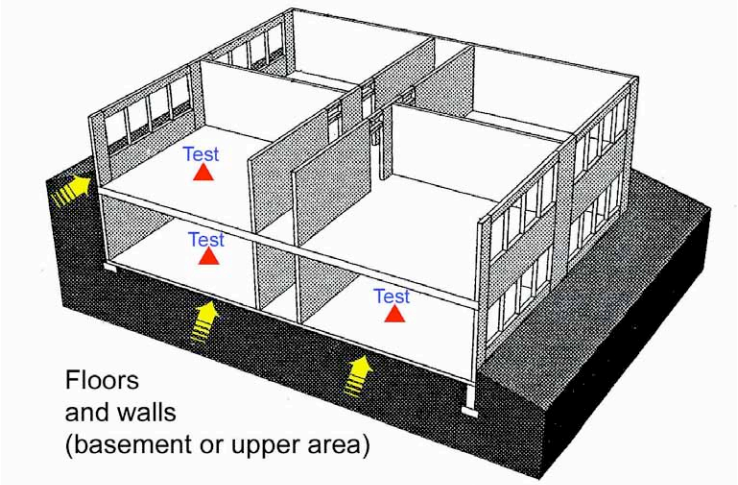


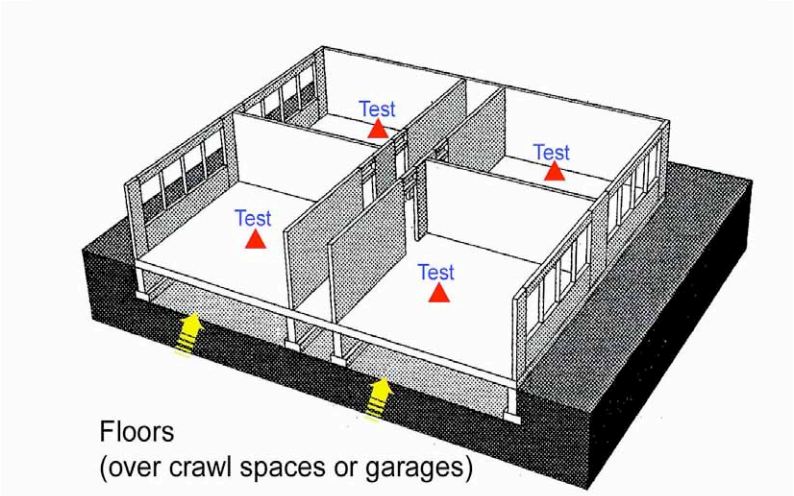


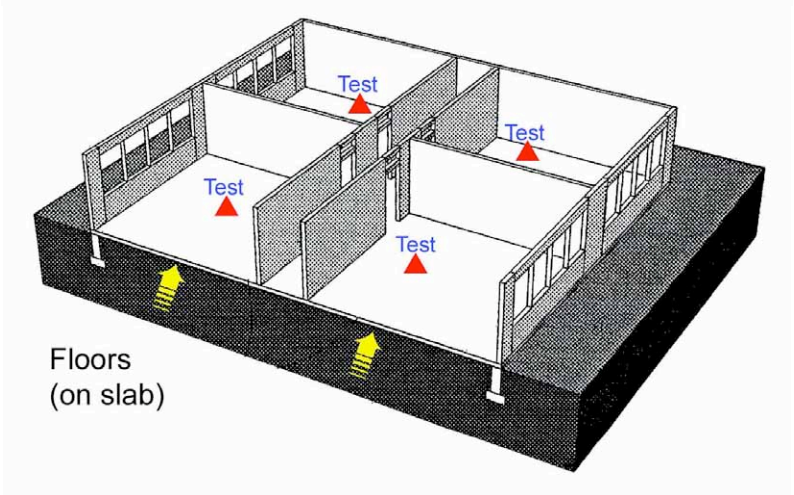
Devices must be placed at least 20" (50 centimeters) above the floor. For large rooms or open areas – Place one device every 2,000 square feet (186 square meters) (e.g., a square area with each side 45 feet (13.7 meters) in length). See section 3.0 "Where to Test" including 3.6 "Choosing a location within a Room" for other details.

EXHIBIT 1-b

GROUND CONTACT TEST LOCATION EXAMPLES

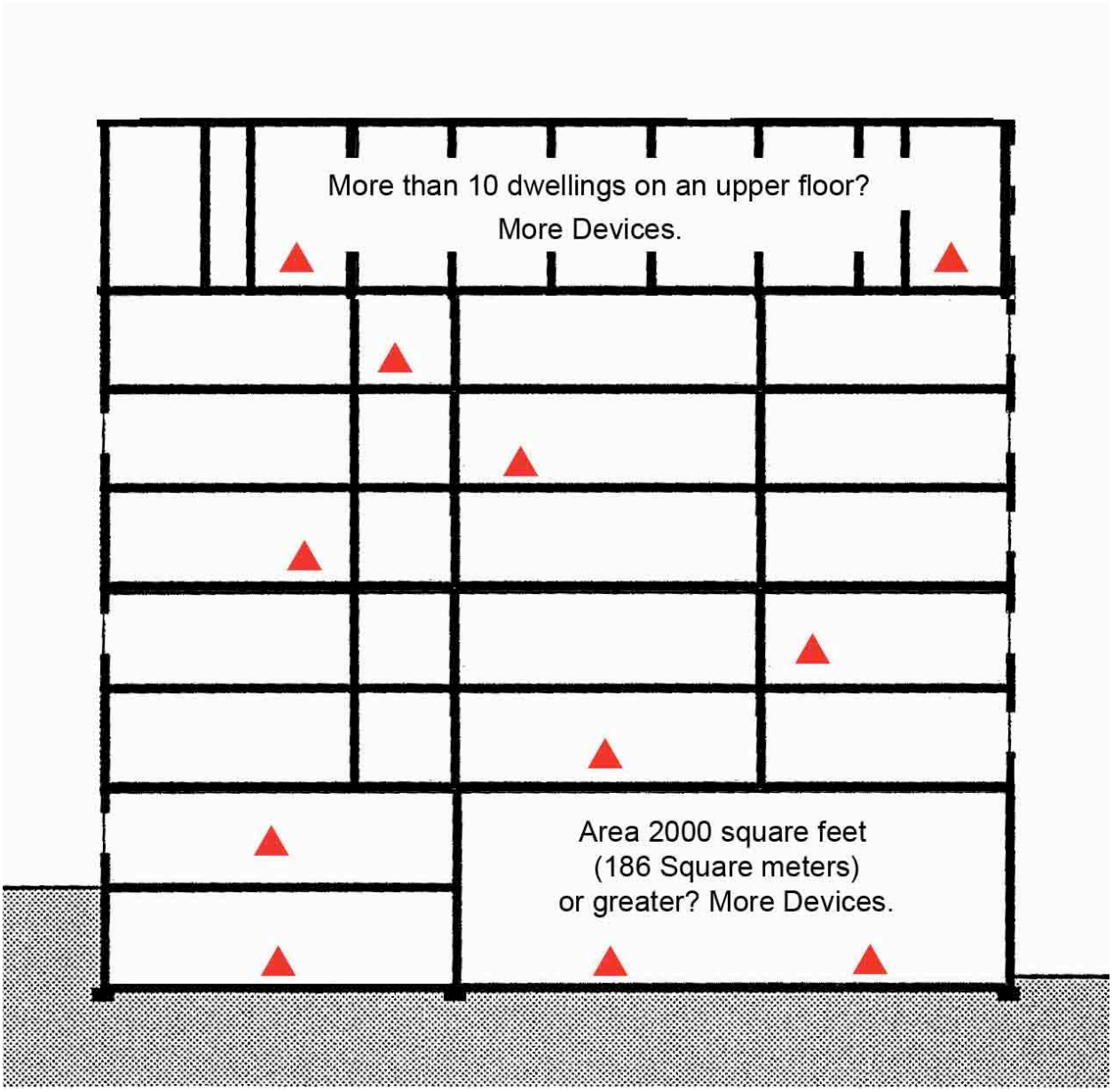






Devices must be placed at least 20" (50 centimeters) above the floor. For large rooms or open areas – Place one device every 2,000 square feet (186 square meters) (e.g., a square area with each side 45 feet (13.7 meters) in length). See section 3.0 "Where to Test" including 3.6 "Choosing a location within a Room" for other details.

EXHIBIT 1-c
UPPER FLOOR TEST LOCATION EXAMPLE



Devices must be placed at least 20" (50 centimeters) above the floor. For large rooms or open areas – Place one device every 2,000 square feet (186 square meters) (e.g., a square area with each side 45 feet (13.7 meters) in length). See section 3.0 "Where to Test" including 3.6 "Choosing a location within a Room" for other details.

EXHIBIT 2

SAMPLE FLOOR PLAN

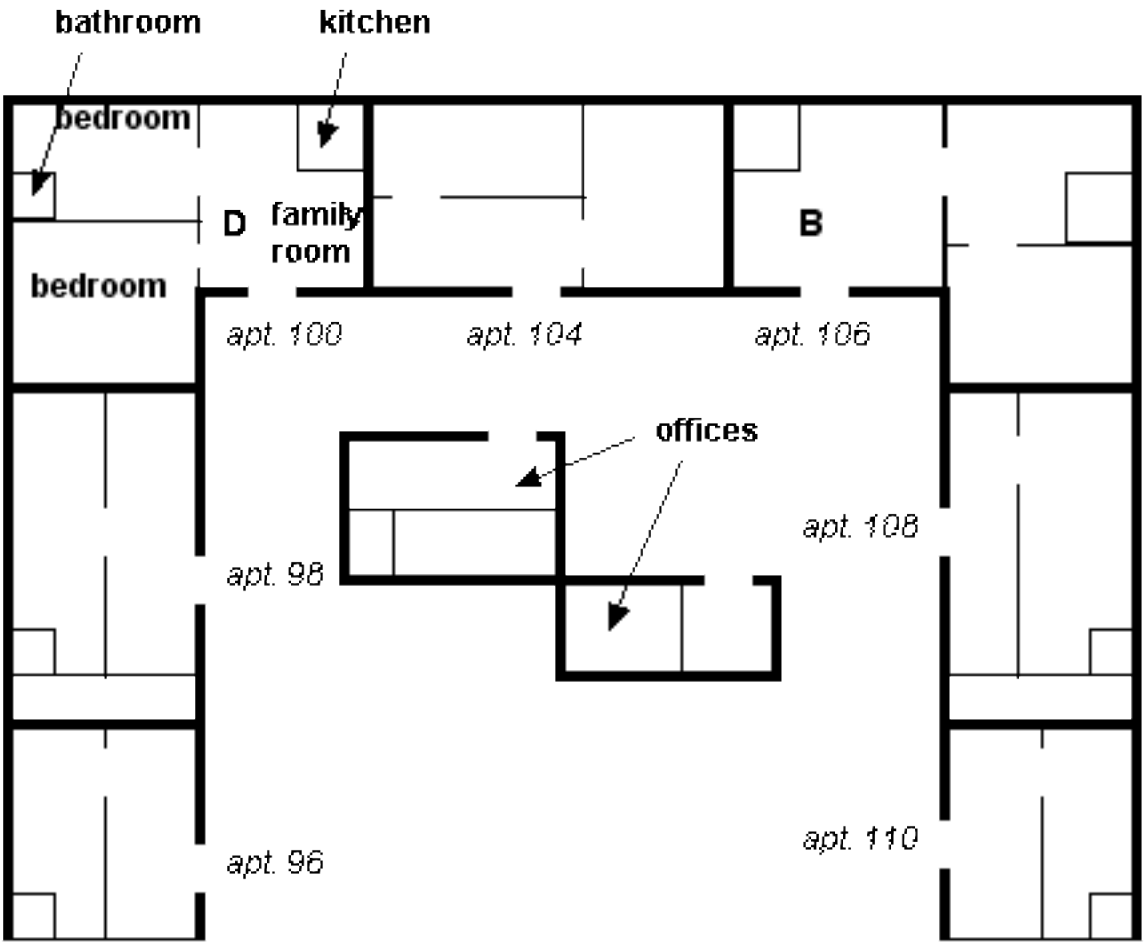


EXHIBIT 3
SAMPLE: CHAIN-OF-CUSTODY / DATA LOG

This form is an example and not intended to prescribe all manners that may be desired or required for tracking.

Form# _____ / Rev# _____ / Effective Date _____

Building Name: _____ **Testing Contractor:** _____

Address: _____ **Contractor Phone:** _____

_____ **Contractor Address:** _____

Contact Name: _____ _____

Contact Phone: _____ _____

Serial Number	Apartment / Room No.	Room	Placement Location	Start Date	Start Time	Stop Date	Stop Time	Floor	Comments	Tech. Place	Tech. PU

Indicate Time Standard used: [ ]AM-PM [ ]Military **Time Zone:** _____

Technician _____ Initials _____ License# _____
Technician _____ Initials _____ License# _____
Technician _____ Initials _____ License# _____

"D" = Duplicate
"B" = Blank
"S" = Spike

EXHIBIT 4

SAMPLE: DATA ENTRY FOR CHAIN-OF-CUSTODY / DATA LOG

This form is an example and not intended to prescribe all manners that may be desired or required for tracking.

Form# RT1001 / Rev# 2 / Date 09-20-06

Building Name: _____ **Testing Contractor:** _____

Address: _____ **Contractor Phone:** _____

_____ **Contractor Address:** _____

Contact Name: _____ _____

Contact Phone: _____ _____

Serial Number	Apartment / Room No.	Room	Placement Location	Start Date	Start Time	Stop Date	Stop Time	Floor	Comments	Tech. Place	Tech. PU
12345	100	Family	S Wall	2/5/2008	11:00 a.m.	2/9/2008	11:30 a.m.	1		SH	SH
12346	100	Family	S Wall - D	2/5/2008	11:02 a.m.	2/9/2008	11:30 a.m.	1		SH	SH
12347	104	Family	S Wall	2/5/2008	11:08 a.m.	2/9/2008	11:35 a.m.	1		SH	SH
12348	106	Family	S Wall	2/5/2008	11:14 a.m.	2/9/2008	11:37 a.m.	1	D	SH	SH
12349	106	Bedroom	B	2/5/2008	11:15 a.m.	2/9/2008	11:37 a.m.	1		SH	SH
12350	108	Family	N Wall	2/5/2008	11:22 a.m.	2/9/2008	11:40 a.m.	1	Detector was moved	SH	SH
12351	110	Bedroom	Night Stand	2/5/2008	11:25 a.m.	2/9/2008	11:42 a.m.	1		SH	SH
12352	112	Family	Bookshelf	2/5/2008	11:30 a.m.	2/9/2008	11:45 a.m.	1	B	SH	SH
12353	114	Living	N Wall	2/5/2008	11:33 a.m.	2/9/2008	11:50 a.m.	1		GJ	SH
12354	116	Family	E Wall	2/5/2008	11:39 a.m.	2/9/2008	11:53 a.m.	1		GJ	SH
12355	118	Living	E Wall	2/5/2008	11:42 a.m.	2/9/2008	11:56 a.m.	1	D	GJ	SH
12356	120	Bedroom	Dresser	2/5/2008	11:45 a.m.	2/9/2008	12:00 p.m.	1	Window Open	GJ	SH
12357	202	Family	S Wall	2/5/2008	11:55 a.m.	2/9/2008	12:08 p.m.	2		GJ	SH
12358	212	Family	Corner Table	2/5/2008	12:00 p.m.	2/9/2008	12:11 p.m.	2		GJ	SH
12359	306	Living	S Wall	2/5/2008	12:04 p.m.	2/9/2008	12:15 p.m.	3		GJ	SH
12360	318	Bedroom	E Wall	2/5/2008	12:08 p.m.	2/9/2008	12: 18 p.m.	3		GJ	SH
12361	318	Bedroom	E Wall - D	2/5/2008	12:10 p.m.	2/9/2008	12:18 p.m.	3		GJ	SH

Indicate Time Standard used: [X]AM-PM [ ]Military **Time Zone:** Central Daylight

Technician George Jackson Initials GJ License# G100225
Technician Sam Hayes Initials SH License# G107809
Technician _____ Initials _____ License# _____

"D" = Duplicate
"B" = Blank
"S" = Spike

EXHIBIT 5
EXAMPLE OF INFORMATION PROVIDED TO A LABORATORY

Tracking quality control independently from a laboratory is a component of a quality assurance program. Several methods exist to prevent a laboratory from identifying quality control measurements (i.e. duplicate and blank detectors). This is only one example of how to obscure quality control measurements from the laboratory.

SAMPLE: CHAIN-OF-CUSTODY / DATA LOG

Building Name: _____ **Testing Contractor:**_____

Address: _____ **Contractor Phone:** _____

_____ **Contractor Address:** _____

Contact Name: _____ _____

Contact Phone: _____ _____

Serial Number	Apartment / Room No.	Room	Placement Location	Start Date	Start Time	Stop Date	Stop Time	Floor	Comments
12345	100	[redacted]		2/5/2008	11:00 a.m.	2/9/2008	11:30 a.m.	1	
12346	100			2/5/2008	11:02 a.m.	2/9/2008	11:30 a.m.	1	
12347	104			2/5/2008	11:08 a.m.	2/9/2008	11:35 a.m.	1	
12348	106			2/5/2008	11:14 a.m.	2/9/2008	11:37 a.m.	1	
12349	106			2/5/2008	11:15 a.m.	2/9/2008	11:37 a.m.	1	
12350	108			2/5/2008	11:22 a.m.	2/9/2008	11:40 a.m.	1	Detector was moved
12351	110			2/5/2008	11:25 a.m.	2/9/2008	11:42 a.m.	1	
12352	112			2/5/2008	11:30 a.m.	2/9/2008	11:45 a.m.	1	
12353	114			2/5/2008	11:33 a.m.	2/9/2008	11:50 a.m.	1	
12354	116			2/5/2008	11:39 a.m.	2/9/2008	11:53 a.m.	1	
12355	118			2/5/2008	11:42 a.m.	2/9/2008	11:56 a.m.	1	
12356	120			2/5/2008	11:45 a.m.	2/9/2008	12:00 p.m.	1	Window Open
12357	202			2/5/2008	11:55 a.m.	2/9/2008	12:08 p.m.	2	
12358	212			2/5/2008	12:00 p.m.	2/9/2008	12:11 p.m.	2	
12359	306			2/5/2008	12:04 p.m.	2/9/2008	12:15 p.m.	3	
12360	318			2/5/2008	12:08 p.m.	2/9/2008	12: 18 p.m.	3	

Indicate Time Standard used: [ ]AM-PM [ ]Military **Time Zone:** _____

EXHIBIT 6

SAMPLE: NOTICE OF INSPECTION

Management or Radon Company
Anytown, USA 800-000-0000

Dear Resident,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers. Radon is a naturally occurring radioactive gas that can be present in some homes at concentrations that are dangerous to you, your family and pets.

An important step is being taken to lower your risk of lung cancer. A radon test is being scheduled for the property.

Radon test devices will be placed in your home for several days to take a reading.

It is important that we can gain access to place test devices and that required test conditions are maintained.

Required Closed-building conditions

- Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to combustion appliances.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

Tentative device placement Day _____ Date_____ Time_____

We will request your signature and any comments on a form left with the test device.

Tentative device pick-up Day _____ Date_____ Time_____

Test devices are not dangerous in any way and a sample test device is available ~~at our office~~ for you to examine if you wish. Copies of EPA's *A Citizen's Guide to Radon* are available upon request or you can contact your State Radon Office or EPA regional office for additional information on radon.

For any questions, concerns or if you have independently performed radon testing in your home, please contact: _____

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

Sincerely,

Management or Radon Company, Anytown, USA

EXHIBIT 7

SAMPLE FORM: Compliance Statement

Radon Survey in Progress

Management or Radon Company
Anytown, USA 800-000-0000

Dear Resident,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers. Radon is a naturally occurring radioactive gas that can be present in some homes at concentrations that are dangerous to you, your family and pets.

An important step is being taken to lower your risk of lung cancer from radon in your home. A radon test is being scheduled for the property.

It is important that required test conditions stated below are maintained.

Please sign this form and add any comments to help ensure accurate tests:

To the best of my knowledge, the required conditions stated below were kept during the test.

Occupant X_____ **Date** _____

Address: _____

Comments if any: _____

_____

Device Placed Day_____Date _____Time_____

Device Pick-up Day_____Date _____Time_____

Required Closed-building conditions

- Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to a combustion appliance.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

For any questions or concerns, please contact: _____

Please leave this form with the test kit or return to: _____

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

Sincerely,

Management or Radon Company, Anytown, USA

EXHIBIT 8
SAMPLE FORM: Onsite Sign or Notice

Radon Survey in Progress

Management or Radon Company
Anytown, USA 800-000-0000

Dear Resident,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers. Radon is a naturally occurring radioactive gas that can be present in some homes at concentrations that are dangerous to you, your family and pets.

An important step is being taken to lower your risk of lung cancer from radon in your home. A radon test is being scheduled for the property.

It is important that required test conditions stated below are maintained throughout the building.

Test Deployment: Day_____Date _____Time_____

Test Pick-up: Day_____Date _____Time_____

Required Closed-building conditions

- Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to a combustion appliance.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

For any questions, concerns or if you have independently performed radon testing in your home, please contact:

_____

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

Sincerely,

Management or Radon Company, Anytown, USA

EXHIBIT 9

SAMPLE: NONTESTED DWELLINGS - NOTICE OF INSPECTION

Management or Radon Company
Anytown, USA 800-000-0000

Dear Resident,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers. 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.

An important step is being taken to lower the risk of lung cancer from radon to residents in this building. A radon test is being scheduled for the lowest floors where radon is normally found.

Radon test devices will be placed in the lowest areas of the building for several days. Other strategic locations may also be chosen. Test devices are not dangerous in any way and a sample test device is available for you to examine if you wish. Copies of EPA's *A Citizen's Guide to Radon* are available upon request or you can contact your State Radon Office or EPA regional office for additional information on radon.

Even though ground contact areas are typically tested for an initial assessment, protocols recommend and encourage that you consider testing your own dwelling for personal verification of low radon exposures. This can be done during these tests or in the future when the following Closed-building conditions are a normal condition for the building. Inexpensive home test devices are readily available.

Even though test devices may not be placed in your dwelling, it is important that required test conditions are maintained throughout the building.

Required Closed-building conditions

- Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to combustion appliances.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

Tentative device placement Day_____ Date _____Time_____

Tentative device pick-up Day_____ Date _____Time_____

We will request your signature and any comments on a form left during the test.

For any questions, concerns or if you have independently performed radon testing in your home, please contact:

_____

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

Sincerely,

Management or Radon Company, Anytown, USA

EXHIBIT 10

SAMPLE FORM: NONTESTED DWELLING - Compliance Statement

Radon Survey in Progress

Management or Radon Company
Anytown, USA 800-000-0000

Dear Resident,

Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer in non-smokers. Radon is a naturally occurring radioactive gas that can be present in some homes at concentrations that are dangerous to you, your family and pets.

An important step is being taken to lower your risk of lung cancer from radon in your home. A radon test is being scheduled for the property in the lowest areas of the building.

Even though devices may not be placed in your dwelling, it is important that required test conditions stated below are maintained.

Device placement: Day_____ Date _____Time_____

Device Pick-up: Day_____ Date _____Time_____

Please sign this form and add any comments to help ensure accurate tests:

To the best of my knowledge, the required conditions stated below were kept during the test.

Occupant X_____ Date _____

Address: _____

Comments if any: _____

Required Closed-building conditions

- Closed-building conditions must be maintained for 12 hours prior to the initiation of the test and during the test.
- All windows on all levels and external doors must be kept closed (except for momentary events such as normal entry and exit) before and during the test period.
- Heating and cooling systems must be set to normal occupied operating temperatures and their fan/blower controls must be set to normal intermittent activity unless continuous activity is a permanent setting. Window air conditioning units must only be operated in a recirculating mode. Equipment that supplies fresh air to the dwelling must be deactivated except for make-up air to a combustion appliance.
- Whole house fans must not be operated. Window fans should be removed or sealed shut. Wood burning fireplaces must not be operated unless they are the primary sources of heat for the dwelling. Avoid excessive operation of clothes dryers, range hoods, bathroom fans and other mechanical systems that draw air out of the building.

NOTE: Even though ground contact areas are typically tested for an initial assessment, protocols recommend and encourage that you consider testing your own dwelling for personal verification of low radon exposures. This can be done during these tests or in the future when the above Closed-building conditions are a normal condition for the building. Inexpensive home test devices are readily available.

For any questions or concerns, please contact: _____

Please return this form to: _____

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

Sincerely, Management or Radon Company, Anytown, USA

Description of Quality Assurance and Methods in use

AccuStar Labs analyzes a variety of test devices used for the collection of radon and radon daughters, including charcoal canisters, liquid scintillation vials, and alpha track devices. Clients collect radon samples using the radon collection devices according to standard protocols. The devices are then returned to the laboratory where they are analyzed to determine the radon concentration in air or water.

Our services provide analytical support for the radon measurement and mitigation industry. Our client list includes home inspectors, risk assessors, radon mitigation contractors, owners or representatives of commercial buildings, public and private school administrators, municipal officials, other commercial entities, as well as the public. Our analytical methods are well documented and are known to be capable of producing accurate and precise results.

Each analytical method includes a section detailing the number and type of quality control samples that will be included with each run to measure precision and bias.

All procedures must include:

An Instrument Performance Check to ensure all settings and physical parameters correct for the procedure in use.

A laboratory or method blank to monitor and subtract background radiation is used.

Blank measurements equal to 5% of the samples, with at least one in every batch and run, to measure the effectiveness of any background subtraction and to verify the instrument is capable of producing readings below the Lower Limit of Detection (LLD).

A standard or check source of known quantity traceable to the National Institute of Standards (NIST) to verify instrument response. The standard must be analyzed before and after analysis of samples.

Duplicate measurements equal to 5% of the samples in a run to measure the precision of instrumentation.

Field duplicates or “side-by-side” measurements equal to 10% of the samples in a run to measure the precision of the sample collection.

Control charts will be maintained for the Blank, Standard and Duplicate measurements. Control charts for blanks and standards have warning limits of two standard deviations and control limits at three standard deviations. Duplicate measurements are compared by calculating the relative percent difference (RPD). RPD results are monitored on a control chart.

Bowser Morner provides monthly quality control reference samples. Bowser Morner is an EPA certified Radon chamber. Bowser Morner also performs annual blind proficiency checks for AccuStar Labs. Spikes are performed at a rate of six (6) a month, and proficiencies are performed twice a year.

Methods in Use

The analytical methods of AccuStar Labs have been adapted for use in our laboratories from EPA approved methods. The methodologies are widely accepted and have been proven to produce reliable results. We currently analyze for radon and radon progeny in air and water using several collection and analytical procedures. Detailed procedures are described in the relevant SOP. These SOP's are readily available to staff and are updated regularly.

Radon in Air using Alpha Track devices Method Reference EPA #402-R-93-004-079.

An alpha track device is exposed to the atmosphere for 30 to 365 days. After exposure, the test device is returned to the laboratory for analysis. The track registration foils are removed from their protective casings, placed in an etching bath and a voltage applied to enlarge the tracks left by the passage of nuclear particles. The enhanced tracks are than counted by a computer-controlled video imaging system; a background track count is then subtracted from the raw count. The net counts are entered into a computer program with other relevant data yielding quantitative results in pCi/L, pCi/l-days, KBq/m3hr, or Bq/m3 dependent on the requirements of the client.

Radon in Air using Charcoal Canisters Method Reference EPA #402-R-93-004 079.

A charcoal canister test device is exposed to an indoor atmosphere under controlled conditions for 46-96 hours or 46-168 hours if a diffusion barrier is used. The client records information pertinent to the control and analysis of the canister. Canisters are securely placed within a lead-shielded chamber in contact with a sodium iodide (NaI) crystal. The gamma radiation from the elements adsorbed onto the charcoal causes a light signal in the NaI crystal, which is electrically enhanced and counted using a rate meter. Background counts are subtracted and the net counts are entered into a formula with other relevant data yielding quantitative results stated in picoCuries per Liter (pCi/L).

Radon in Air using Liquid Scintillation Method Reference EPA #402-R-93-004 079.

A liquid scintillation vial containing a small amount of charcoal is exposed to an indoor atmosphere under controlled conditions for 46-96 hours. After exposure, the vial is returned to the laboratory for analysis. A scintillation cocktail is added and the radon allowed to elute for several hours. The scintillation's produced in the vial are then counted in a shielded chamber. Background counts are subtracted and the net counts are entered into a formula with other relevant data yielding quantitative results stated in picoCuries per Liter (pCi/L).

Radon in Water using Liquid Scintillation Method Reference EPA #402-R-93-004 079.

A Teflon septa cap borosilicate glass vial is filled with drinking water so that there are no air bubbles in the sample. The sample is returned to the laboratory for analysis. A scintillation cocktail is added and the sample allowed to elute for several hours. The scintillation's produced in the vial are counted in a shielded chamber. Background counts are subtracted and the net counts are entered into a formula with other relevant data yielding quantitative results stated in pCi/L.