FINAL

Guidance for Evaluating Soil Vapor Intrusion in the State of New York

October 2006

NOTE: Updates to this final guidance are available at
health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Prepared by:

NEW YORK STATE DEPARTMENT OF HEALTH
Center for Environmental Health
Bureau of Environmental Exposure Investigation

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Contact Information

Comments and questions on the guidance may be sent to the following:

New York State Department of Health
Bureau of Environmental Exposure Investigation
Flanigan Square, Room 300
547 River Street
Troy, New York 12180-2216

Email: BEEI@health.state.ny.us
Telephone: 1-800-458-1158, extension 27850

New York State Departments of Health and Environmental Conservation — Web Sites on Soil Vapor Intrusion

This guidance, policy documents, training documents, fact sheets, etc. are available to the public on the following web sites:

New York State Department of Health
http://www.health.state.ny.us/environmental/indoors/vapor_intrusion

New York State Department of Environmental Conservation
http://www.dec.state.ny.us/website/der/guidance/vapor/index.html

As new information becomes available (e.g., revisions or amendments to the guidance, new fact sheets, etc.), these web sites will be updated accordingly.

NOTE: Updates to this final guidance are available at
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Preface

This guidance has been prepared by the New York State Department of Health (NYSDOH) in consultation with the New York State Department of Environmental Conservation (NYSDEC) — collectively referred to as "the State" throughout this document. It is intended as general guidance for parties evaluating soil vapor intrusion in the State of New York. The guidance is not a regulation, rule or requirement.

The guidance describes the State's methodology for evaluating soil vapor intrusion at a site. It reflects our experience in conducting soil vapor intrusion investigations and presents a reasonable and practical approach to identifying and addressing current and potential human exposures to contaminated subsurface vapors associated with known or suspected volatile chemical contamination. The approach presented is analogous to the approach taken when investigating contamination in other environmental media (e.g., groundwater, soil, etc.) and addressing corresponding exposure concerns.

The guidance is organized into five sections:

Section 1 introduces the concept of soil vapor intrusion, associated human exposure issues, factors affecting soil vapor intrusion, factors affecting indoor air quality, and the general approach recommended to evaluating vapor intrusion;

Section 2 provides guidance on collecting appropriate and relevant data that can be used to identify current or potential human exposures;

Section 3 discusses how the investigation data are evaluated, recommends actions based on the evaluation, and presents tools that are used when determining appropriate actions to address exposures;

Section 4 provides an overview of soil vapor intrusion mitigation methods and basic recommendations pertaining to their selection for use, installation and design, post-mitigation testing, operation, maintenance and monitoring, termination of operation, and annual certification; and

Section 5 describes outreach techniques commonly used to inform the community about soil vapor intrusion issues.

The State recommends that the guidance be considered anywhere soil vapor intrusion is evaluated in the State of New York — whether the evaluation is undertaken voluntarily by a corporation, a municipality, or private citizen, or whether it is performed under one of the State's environmental remediation programs.

PLEASE NOTE:

- While soil vapor intrusion can also occur with "naturally-occurring" subsurface gases (e.g., radon, methane and hydrogen sulfide), the document discusses soil vapor intrusion in terms of environmental contamination only.
- The guidance document addresses soil vapor intrusion. However, vapor intrusion can also occur through direct volatilization of contaminants from groundwater into indoor air. This can occur when, for example, a basement slab is in contact with contaminated groundwater, contaminated groundwater enters (floods) a basement or crawl space, or contaminated groundwater enters a sump pit drainage system. In such cases, volatile

chemicals can be transferred directly from groundwater to indoor air without the intervening contamination of soil vapor. Although exposures of this nature are not discussed in this guidance, they should be addressed on a site-specific and building-specific basis.

- Throughout the guidance references are made to specific brands of field equipment. These references are for discussion purposes only and are intended to be illustrative. They should not be interpreted as endorsements by the State of any one company or their products.

ACRONYMNS and ABBREVIATIONS

ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substance and Disease Registry
BASE	Building Assessment and Survey Evaluation
BTSA	[NYSDOH] Bureau of Toxic Substance Assessment
CME	Continuing Medical Education
CSEMs	Case Studies in Environmental Medicine
DUSR	Data Usability Summary Report
ELAP	Environmental Laboratory Approval Program
EPA	United States Environmental Protection Agency
GC	Gas Chromatograph
HEI	Health Effects Institute
HVAC	Heating, Ventilating and Air-conditioning
mcg/m^3	micrograms per cubic meter
MeCl	Methylene Chloride
MEK	Methyl Ethyl Ketone; 2-Butanone
MTBE	Methyl-*tert*-Butyl Ether
NAPL	Non-Aqueous Phase Liquid
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OM&M	Operation, Maintenance and Monitoring
OSHA	Occupational Safety and Health Administration
OVM	Organic Vapor Monitor
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethene or Perchloroethylene
PID	Photoionization Detector
QA/QC	Quality Assurance/Quality Control
RIOPA	Relationship of Indoor, Outdoor, and Personal Air
SF_6	Sulfur Hexafluoride
SSD	Sub-slab Depressurization System
SIM	Selective Ion Monitoring
SMD	Sub-Membrane Depressurization
SVE	Soil Vapor Extraction
SVOCs	Semi-volatile Organic Compounds
TAL	Target Analyte List
TCA	Trichloroethane
TCDD	Tetrachlorodibenzo-*p*-Dioxin Equivalents
TCE	Trichloroethene
TCL	Target Compound List
VOCs	Volatile Organic Compounds

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Table of Contents

Page

Appendices

Page

Tables

Figures

Inserts

Section 1: Introduction

This section introduces the concept of soil vapor intrusion, associated human exposure issues, factors affecting soil vapor intrusion, factors affecting indoor air quality, and the general approach to evaluating vapor intrusion.

1.1 Soil vapor intrusion

The phrase "soil vapor intrusion" refers to the process by which volatile chemicals migrate from a subsurface source into the indoor air of buildings. Soil vapor, also referred to as soil gas, is the air found in the pore spaces between soil particles (Figure 1.1). Primarily because of a difference between interior and exterior pressures, soil vapor can enter a building through cracks or perforations in slabs or basement floors and walls, and through openings around sump pumps or where pipes and electrical wires go through the foundation. For example, heating, ventilation or air-conditioning (HVAC) systems and/or the operation of large mechanical appliances (e.g., exhaust fans, dryers, etc.) may create a negative pressure that can draw soil vapor into the building. This intrusion is similar to how radon gas enters buildings from the subsurface.

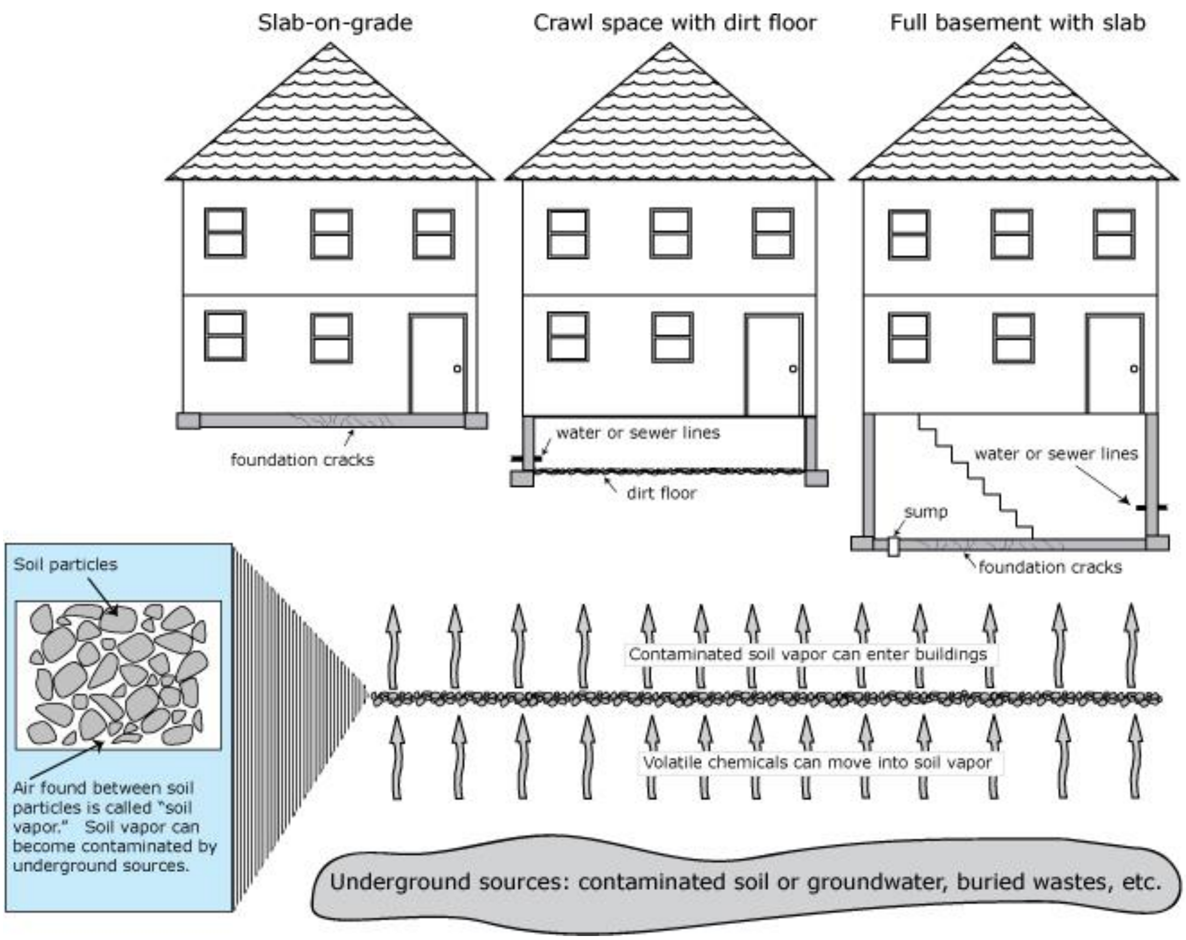

Figure 1.1
Generalized diagram of soil vapor intrusion

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Soil vapor can become contaminated when chemicals evaporate from subsurface sources. Chemicals that can emit vapors are called "volatile chemicals." Volatile chemicals include volatile organic compounds (VOCs), some semi-volatile organic compounds (SVOCs), and some inorganic substances such as elemental mercury. Subsurface sources of volatile chemicals can include the following:

a. groundwater or soil that contains volatile chemicals;

b. non-aqueous phase liquid (NAPL);

c. buried wastes; and

d. underground storage tanks or drums.

If soil vapor is contaminated and enters a building, indoor air quality may be affected.

When contaminated vapors are present in the zone directly next to or under the foundation of a building, vapor intrusion is possible. Soil vapor can enter a building whether the building is old or new, or whether it is on a slab or has a crawl space or basement (Figure 1.1). However, the subsurface source of the contaminated vapor (e.g., contaminated soil or groundwater) does not need to be directly beneath a structure to contaminate the vapor immediately beneath the building's foundation (as suggested in Figure 1.1).

1.2 Soil vapor intrusion and human exposure

Humans can be exposed to contaminated soil vapor when the vapor is drawn into the building due to pressure differences [Section 1.1] and mixed with the indoor air. Inhalation is the primary route of exposure, or the manner in which the volatile chemicals, once in the indoor air, actually enter the body.

Both current and potential exposures are considered when evaluating soil vapor intrusion at sites (i.e., locations of suspected or known environmental contamination). *Current* exposures exist when vapor intrusion is documented in an occupied building. *Potential* exposures exist when volatile chemicals are present in the vapor phase beneath a building, but have not affected indoor air quality due to current site conditions. Potential exposures also exist when there is a chance that contaminated soil vapors may move beneath existing buildings not currently affected, when indoor air is affected but the building is currently unoccupied, or when there is a chance that new buildings can be built over existing subsurface vapor contamination.

Exposure to a volatile chemical due to vapor intrusion does not necessarily mean that health effects will occur. Whether or not a person experiences health effects depends on several factors, including the length of exposure (short-term or acute versus long-term or chronic), the amount of exposure (i.e., dose), the frequency of exposure, the toxicity of the volatile chemical and the individual's sensitivity to the chemical.

1.3 Factors affecting soil vapor migration and intrusion

Predicting the extent of soil vapor contamination from soil or groundwater contamination, as well as the potential for human exposure from soil vapor intrusion into buildings, is complicated by factors that can affect soil vapor migration and intrusion. For example, soil vapor contaminant plumes may not mimic groundwater contaminant plumes since different factors affect the migration pattern of each medium. In addition to the operation of HVAC systems, the operation of kitchen vents in restaurants or of elevators in office buildings may induce pressure gradients that result in the migration of vapor-phase contaminants away from a groundwater source of vapors and toward these buildings. This is similar to when the pumping of production wells or water supply wells draws contaminated groundwater away from its natural flow path.

Factors that can affect soil vapor migration and intrusion generally fall into two categories: environmental and building factors. Examples of environmental factors are provided in Table 1.1, and examples of building factors in Table 1.2. These factors are considered when conducting an investigation of the soil vapor intrusion pathway [Section 2] and when evaluating the results [Section 3].

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Table 1.1 Environmental factors that may affect soil vapor intrusion

Environmental Factor	**Description**
Soil conditions	Generally, dry, coarse-grained soils facilitate the migration of subsurface vapors and wet, fine-grained or highly organic soils retard migration.
Volatile chemical concentrations	The potential for vapor intrusion generally increases with increasing concentrations of volatile chemicals in groundwater or subsurface soils, as well as with the presence of NAPL.
Source location	The potential for vapor intrusion generally decreases with increasing distance between the subsurface source of vapor contamination and overlying buildings. For example, the potential for vapor intrusion associated with contaminated groundwater decreases with increasing depth to groundwater.
Groundwater conditions	Volatile chemicals dissolved in groundwater may off-gas to the vadose zone from the surface of the water table. If contaminated groundwater is overlain by clean water (upper versus lower aquifer systems or significant downward groundwater gradients), then vapor phase migration or partitioning of the volatile chemicals is unlikely. Additionally, fluctuations in the groundwater table may results in contaminant smear zones. The "smear zone" is the area of subsurface soil contamination within the range of depths where the water table fluctuates. Chemicals floating on top of the water table, such as petroleum components, can sorb onto soils within this zone as the water table fluctuates. Sorption of chemicals can influence their gaseous and aqueous phase diffusion in the subsurface, and ultimately the rate at which they migrate.
Surface confining layer	A surface confining layer (e.g., frost layer, pavement or buildings) may temporarily or permanently retard the migration of subsurface vapors to outdoor air. Confining layers can also prevent rainfall from reaching subsurface soils, creating relatively dry soils that further increase the potential for soil vapor migration.
Fractures in bedrock and/or tight clay soils	Fractures in bedrock and desiccation fractures in clay can increase the potential for vapor intrusion beyond that expected for the bulk, unfractured bedrock or clay matrix by facilitating vapor migration (in horizontal and vertical directions) and movement of contaminated groundwater along spaces between fractures.
Underground conduits	Underground conduits (e.g., sewer and utility lines, drains or tree roots, septic systems) with highly permeable bedding materials relative to native materials can serve as preferential pathways for vapor migration due to relatively low resistance to flow.
Weather conditions	Wind and barometric pressure changes and thermal differences between air and surrounding soils may induce pressure gradients that affect soil vapor intrusion.
Biodegradation processes	Depending upon environmental conditions (e.g., soil moisture, oxygen levels, pH, mineral nutrients, organic compounds, and temperature), the presence of appropriate microbial populations, and the degradability of the volatile chemical of concern, biodegradation in the subsurface may reduce the potential for vapor intrusion. For example, readily biodegradable chemicals in soil vapor may not migrate a significant distance from a source area while less degradable chemicals may travel farther.

Table 1.2 Building factors that may affect vapor intrusion

Building Factor	**Description**
Operation of HVAC systems, fireplaces, and mechanical equipment (e.g., clothes dryers or exhaust fans/vents)	Operation may create a pressure differential between the building or indoor air and the surrounding soil that induces or retards the migration of vapor-phase contaminants toward and into the building. Vapor intrusion can be enhanced as the air vented outside is replaced.
Heated building	When buildings are closed up and heated, a difference in temperature between the inside and outdoor air induces a stack effect, venting warm air from higher floors to the outside. Vapor intrusion can be enhanced as the air is replaced in the lower parts of the building.
Air exchange rates	The rate at which outdoor air replenishes indoor air may affect vapor migration into a building as well the indoor air quality. For example, newer construction is typically designed to limit the exchange of air with the outside environment. This may result in the accumulation of vapors within a building.
Foundation type	Earthen floors and fieldstone walls may serve as preferential pathways for vapor intrusion.
Foundation integrity	Expansion joints or cold joints, wall cracks, or block wall cavities may serve as preferential pathways for vapor intrusion.
Subsurface features that penetrate the building's foundation	Foundation perforations for subsurface features (e.g., electrical, gas, sewer or water utility pipes, sumps, and drains) may serve as a preferential pathway for vapor intrusion.

1.4 Factors affecting indoor air quality

Chemicals are a part of our everyday life. They are found in the household products we use and in items we bring into our homes. As such, chemicals are found in indoor air of homes not affected by intrusion of contaminated soil vapor. Examples of alternate sources of volatile chemicals in indoor air are given in Table 1.3. Similarly, volatile chemicals can be in the outdoor air that enters a home or place of business. Certain commercial and industrial facilities, such as gasoline stations and dry cleaners, and vehicle exhaust are examples of possible sources of volatile chemicals in outdoor air.

Commonly found concentrations of these chemicals in indoor and outdoor air are referred to as "background levels." These levels are generally determined from the results of samples collected in homes, offices and outdoor areas not known to be affected by external sources of volatile chemicals (for example, a home not known to be near a chemical spill, a hazardous waste site, a dry-cleaner, or a factory). Background sources of volatile chemicals are considered when conducting an investigation of the soil vapor intrusion pathway [Section 2] and when evaluating the results [Section 3].

Table 1.3 Alternate sources of volatile chemicals in indoor air

Source	**Description**
Outdoor air	Outdoor sources of pollution can affect indoor air quality due to the exchange of outdoor and indoor air in buildings through natural ventilation, mechanical ventilation or infiltration. Outdoor sources of volatile compounds include automobiles, lawn mowers, oil storage tanks, dry cleaners, gasoline stations, industrial facilities, etc.
Attached or underground garages	Volatile chemicals from sources stored in the garage (e.g., automobiles, lawn mowers, oil storage tanks, gasoline containers, etc.) can affect indoor air quality due to the exchange of air between the garage and indoor space.
Off-gassing	Volatile chemicals may off-gas from building materials (e.g., adhesives or caulk), furnishings (e.g., new carpets or furniture), recently dry-cleaned clothing, or areas (such as floors or walls) contaminated by historical use of volatile chemicals in a building. Volatile chemicals may also off-gas from contaminated groundwater that infiltrates into the basement (e.g., at a sump) or during the use of contaminated domestic well water (e.g., at a tap or in a shower).
Household products	Household products include, but are not limited to, cleaners, mothballs, cigarette smoke, paints, paint strippers and thinners, air fresheners, lubricants, glues, solvents, pesticides, fuel oil storage, and gasoline storage.
Occupant activities	For example, in non-residential settings, the use of volatile chemicals in industrial or commercial processes or in products used for building maintenance. In residential settings, the use of products containing volatile chemicals for hobbies (e.g., glues, paints, etc.) or home businesses. People working at industrial or commercial facilities where volatile chemicals are used may bring the chemicals into their home on their clothing.
Indoor emissions	These include, but are not limited to, combustion products from gas, oil and wood heating systems that are vented outside improperly, as well as emissions from industrial process equipment and operations.

1.5 General approach to evaluating soil vapor intrusion

Since no two sites are exactly alike, the approach to evaluating soil vapor intrusion is dependent upon site-specific conditions. A thorough understanding of the site, including its history of use, characteristics (e.g., geology, geography, identified environmental contamination, etc.) and potentially exposed populations, is used to develop an investigation plan. Existing information is reviewed to determine what data are available and what additional data should be collected (i.e., to guide the investigation). In addition, factors affecting soil vapor migration and intrusion [Section 1.3] and indoor air quality [Section 1.4] are also considered when both conducting an investigation [Section 2] and evaluating the results [Section 3].

This data gathering and review process should be repeated until each of the following questions can be answered:

[1] Are subsurface vapors contaminated (i.e., soil vapor as defined in Section 1.1, including vapors located immediately beneath the foundation or slab of a building)? If so, what are the nature and extent of contamination? What is/are the source(s) of the contamination?

[2] What are the current and potential exposures to contaminated subsurface vapors via soil vapor intrusion?

[3] What actions, if any, should be taken to prevent or mitigate exposures related to soil vapor intrusion and to remediate subsurface vapor contamination?

When determining what actions, if any, are appropriate to mitigate current or prevent future human exposures, all information known about a site is considered (i.e., a "whole picture" approach is taken) because each site presents its own unique set of circumstances. This information includes, but is not limited to, the following: nature and extent of contamination in all environmental media, factors affecting vapor migration and intrusion, current and future site uses, off-site land uses, presence of alternate sources of volatile chemicals, and completed or proposed remedial actions.

Actions taken to minimize or prevent exposures typically do not preclude the site from being used for a desired purpose or from being developed. If appropriate, mitigation systems can be installed at existing buildings or installed during the construction of new buildings. In many cases, installation of mitigation systems on new buildings may be a prudent, proactive action. The costs associated with installing a system at the time of a building's construction are often considerably less than the costs associated with retrofitting a system to the building after construction is completed. Furthermore, in many parts of New York State, the mitigation system would also address concerns about human exposures to radon. To learn more about radon in New York State, please refer to the Radon: Frequently Asked Questions Fact Sheet in Appendix H or visit the NYSDOH's web site at http://www.health.state.ny.us/nysdoh/radon/radonhom.htm or contact the NYSDOH's Radon Program at 1-800-458-1158.

1.6 Conceptual site model

In accordance with the NYSDEC's *Draft DER-10 Technical Guidance for Site Investigation and Remediation* (NYSDEC 2002), subsurface vapors and soil vapor intrusion should be included in an overall conceptual model for the site. As described in the NYSDEC's technical guidance, a conceptual site model should be used to develop a general understanding of the site to evaluate potential risks to public health and the environment and to assist in identifying and setting priorities for the activities to be conducted at the site. The conceptual site model also identifies potential sources of contamination, types of contaminants and affected media, release mechanisms and potential contaminant pathways, and actual/potential human and environmental receptors.

The components of a conceptual site model specific to soil vapor intrusion are provided throughout Section 1 of the guidance. The general approach for evaluating soil vapor intrusion described in Section 1.5 is analogous to the development of a conceptual site model specific to soil vapor intrusion. For additional information about the use of conceptual site models in the investigation and remediation of sites or a description of the conceptual site model process, the reader is referred to the NYSDEC's technical guidance.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

1.7 Applicability of guidance

This guidance should be considered anywhere soil vapor intrusion is evaluated in the State of New York, whether the evaluation is being undertaken voluntarily by a corporation, a municipality, or private citizen, or under one of the state's environmental remediation programs.

1.7.1 Residential and non-residential settings

The guidance should be followed in residential and non-residential settings where people may be exposed involuntarily to chemicals from soil vapor intrusion.

1.7.2 Chlorinated and non-chlorinated volatile chemical sites

The guidance should be used when evaluating soil vapor intrusion at chlorinated and non-chlorinated volatile chemical sites, including petroleum hydrocarbon sites and manufactured gas plant sites. While the likelihood for exposures related to soil vapor intrusion may differ between sites due to site-specific conditions and chemical-specific properties, the extent of volatile chemical contamination and the nature of the contamination, these factors should be considered when developing the conceptual site model and implementing an investigation plan (as discussed in Sections 1.5 and 1.6). For example, if the conceptual site model suggests that soil vapor intrusion is not a concern at a petroleum hydrocarbon site due to biodegradation, the work plan might include the measurement of select bioparameters (e.g., oxygen, carbon dioxide, methane, etc.), along with the petroleum hydrocarbons, at varying depths to demonstrate bioattenuation in the vadose. The work plan might include sub-slab vapor sampling as well to demonstrate that conditions beneath nearby buildings are also resulting in bioattenuation of the petroleum hydrocarbons.

1.7.3 Current, new and past remedial sites

As discussed in the NYSDEC's Program Policy *DER-13: Strategy for Prioritizing Vapor Intrusion Evaluations at Remedial Sites in New York* (NYSDEC 2006), the soil vapor intrusion pathway will be evaluated at all completed, current and future remedial sites New York State. This soil vapor intrusion guidance document complements the NYSDEC's policy by providing recommendations on how to evaluate soil vapor intrusion. The combined goal of the policy and guidance documents is to conduct soil vapor intrusion evaluations as efficiently and effectively as possible at all remedial sites in New York.

1.8 Updates to the guidance

The investigation, evaluation, mitigation and remediation of soil vapor are evolving disciplines and this guidance document will be updated periodically, as appropriate. The history of the document's release is provided on the inside of the cover page. In addition, changes to the document are noted in Appendix A. The current version of the document supercedes previous versions. The current version of the guidance is available on the NYSDOH's web site (*http://www.health.state.ny.us/environmental/indoors/vapor_intrusion/*) or by contacting the NYSDOH's Bureau of Environmental Exposure Investigation [see Contact Information on the inside of the cover page]. Revisions or amendments to the guidance will be posted on the NYSDOH's web site.

Section 2: Investigation of the Soil Vapor Intrusion Pathway

Soil vapor is an environmental medium, like groundwater and soil, that should be characterized during the investigation of a site. This section provides guidance on collecting appropriate and relevant data that can be used to identify current or potential human exposures to contaminated subsurface vapors associated with a site. As discussed in Section 1.5, no two sites are exactly alike. Site-specific and/or building-specific conditions may warrant modifying the recommendations herein. Therefore, guidance provided in this section is presented in terms of general steps and strategies that should be applied when approaching an investigation of soil vapor intrusion.

2.1 Sites at which an investigation is appropriate

Data collected to date do not support the use of pre-determined concentrations of volatile chemicals (i.e., screening criteria) in either groundwater or soil to trigger a soil vapor intrusion investigation. Therefore, although the level of investigation may vary, the pathway should be investigated at any site with the following:

a. an existing subsurface source (e.g., on the basis of preliminary environmental sampling) or likely subsurface source (e.g., on the basis of known previous land uses) of volatile chemicals [Section 1.1]; and

b. existing buildings or the possibility that buildings may be constructed near a subsurface source of volatile chemicals.

2.2 Types of samples

The following are types of samples that are collected to investigate the soil vapor intrusion pathway:

a. subsurface vapor samples:
   1. *soil vapor* samples (i.e., soil vapor samples not beneath the foundation or slab of a building) and
   2. *sub-slab vapor* samples (i.e., soil vapor samples immediately beneath the foundation or slab of a building);

b. crawl space air samples;

c. indoor air samples; and

d. outdoor air samples.

The types of samples that should be collected depend upon the specific objective(s) of the sampling, as described below.

2.2.1 <u>Soil vapor</u>

Soil vapor samples are collected to determine whether this environmental medium is contaminated, characterize the nature and extent of contamination, and identify possible sources of the contamination. Our experience to date indicates soil vapor results alone typically cannot be relied upon to rule out sampling at nearby buildings. For example, concentrations of volatile chemicals in sub-slab vapor samples have been substantially higher (e.g., by a factor of 100 or more) than concentrations found in nearby soil vapor samples (e.g., collected at 8 feet below grade near the building). This may be due to differences in factors such as soil moisture content and pressure gradients. Therefore, exposures are evaluated primarily based on sub-slab vapor, indoor air and outdoor air sampling results and soil vapor results are primarily used as a tool to guide these investigations.

Soil vapor sampling results are also used when evaluating the effectiveness of direct or indirect measures to remediate contaminated subsurface vapors. (Soil vapor extraction is an example of a direct remedial measure, and groundwater pumping and treating an indirect measure.)

2.2.2 Sub-slab vapor

Sub-slab vapor samples are collected to characterize the nature and extent of soil vapor contamination immediately beneath a building with a basement foundation and/or a slab-on-grade. Sub-slab vapor sampling results are used in conjunction with indoor air and outdoor air sampling results when evaluating the following:

a. *current* human exposures;

b. the potential for *future* human exposures (e.g., if the structural integrity of the building changes or the use of the building changes); and

c. site-specific attenuation factors (i.e., the ratio of indoor air to sub-slab vapor concentrations).

Sub-slab vapor samples are often collected after soil vapor characterization and/or other environmental sampling (e.g., soil and groundwater characterization) indicate they are warranted. Sub-slab samples are typically collected concurrently with indoor and outdoor air samples. However, outside of the heating season, sub-slab vapor samples may be collected independently depending on the sampling objective (e.g., to characterize the extent of subsurface vapor contamination outside of the heating season to develop a more comprehensive, focused investigation plan for the heating season).

2.2.3 Crawl space air

Similar to sub-slab vapor samples, crawl space air samples are collected to characterize the nature and extent of contamination immediately beneath a building with a crawl space foundation. Crawl space air sampling results are used in conjunction with indoor air and outdoor air sampling results when evaluating the following:

a. *current* human exposures; and

b. the potential for *future* human exposures (e.g., if the structural integrity of the building changes or the use of the building changes).

2.2.4 Indoor air

Indoor air samples are collected to characterize exposures to air within a building, including those with earthen floors. Indoor air sampling results are used when evaluating the following:

a. *current* human exposures;

b. the potential for *future* exposures (e.g., if a currently vacant building should become occupied); and

c. site-specific attenuation factors (e.g., the ratio of indoor air to sub-slab vapor concentrations).

Indoor air samples are often collected after subsurface vapor characterization and other environmental sampling (e.g., soil and groundwater characterization) indicate they are warranted. When indoor air samples are collected, concurrent sub-slab vapor, crawl space air (if applicable) and outdoor air samples are collected to evaluate the indoor air results appropriately. However, indoor air and outdoor air samples, without sub-slab vapor samples, may be collected when confirming the effectiveness of a mitigation system [Section 4].

In addition, site-specific situations may warrant collecting indoor air samples prior to characterizing subsurface vapors and/or without concurrent sub-slab vapor sampling to examine immediate inhalation hazards. Examples of such situations may include, but are not limited to, the following:

a. in response to a spill event to qualitatively and/or quantitatively characterize the contamination;

b. if high readings are obtained in a building when screening with field equipment (e.g., a photoionization detector (PID), an organic vapor analyzer, or an explosimeter) and the source is unknown;

c. if significant odors are present and the source needs to be characterized; or

d. if groundwater beneath the building is contaminated, the building is prone to groundwater intrusion or flooding (e.g., sump pit overflows), and subsurface vapor sampling is not feasible. In these situations, the collection of water samples from the sump may also be appropriate.

2.2.5 Outdoor air

Outdoor air samples are collected to characterize site-specific background outdoor air conditions. Outdoor air samples should be collected simultaneously with indoor air samples to evaluate the potential influence, if any, of outdoor air on the indoor air sampled. Outdoor air samples may also be collected concurrently with soil vapor samples to identify potential outdoor air interferences associated with infiltration of outdoor air into the sampling apparatus while the soil vapor was collected.

2.3 Phase of a site investigation in which to sample

There is no single phase (e.g., preliminary site characterization or remedial investigation) of a site investigation during which sampling to evaluate the soil vapor intrusion pathway is appropriate. Initiation of investigation activities for this specific purpose should be determined on a site-by-site basis. However, if exposures due to soil vapor intrusion appear likely at any point during the investigation, evaluation of this exposure pathway should not be delayed.

If the locations of likely source areas are reasonably known, sampling earlier during the investigation of a site rather than later is recommended because of the iterative nature of the sampling process [Section 2.5]. However, if current site conditions are not well-defined, then sampling after contamination in other environmental media (e.g., groundwater and soil) has been characterized may be considered. In the latter scenario, groundwater, soil and other site information may be used to guide an investigation of the soil vapor intrusion pathway, such as selecting locations for subsurface vapor samples based on likely migration pathways and source areas [Sections 2.6.1 and 2.6.2]. At a minimum, depth to groundwater and soil stratigraphy should be identified prior to collecting soil vapor samples.

Sampling may be delayed at parcels that are undeveloped or contain unoccupied buildings provided

a. characterization of the parcel is not needed to
    1. address exposures in the surrounding area;
    2. design remedial measures for subsurface vapor contamination; or
    3. monitor or confirm the effectiveness of remedial measures; and
b. measures are in place that assure that the parcel will not be developed, or buildings occupied, without addressing exposure concerns [Section 3.6].

If exposures due to soil vapor intrusion appear likely, and a delay of sampling is contemplated, the State (i.e., the NYSDEC and NYSDOH) should be informed of the contemplated delay and the rationale for the delay. Furthermore, the party contemplating the delay should consider any comments the State may have on the information provided.

2.4 Time of year in which to sample

2.4.1 Soil vapor

Soil vapor samples are collected at any time during the year. Often, sampling is completed during the summer so the results can be used as a tool when selecting buildings to be sampled during the heating season.

2.4.2 Buildings

Sub-slab vapor samples and, unless immediate sampling is appropriate, indoor air samples are typically collected during the heating season because soil vapor intrusion is more likely to occur when a building's heating system is in operation and doors and windows are closed. In New York State, heating systems are generally expected to be operating routinely from November 15th to March 31st. However, these dates are not absolute; the timeframe for sampling may vary depending on factors such as the location of the site (e.g., upstate versus downstate) and the weather conditions for a particular year.

A soil vapor intrusion investigation at a building may be conducted outside of the heating season if the concern for vapor intrusion is greater during another time of year. This may occur at certain industrial buildings, for instance, where HVAC systems are actively managed to control the ratio of recirculated indoor air to make-up air from outside the building. Information about the site and potentially affected structures, including the factors discussed in Section 1.3, should be considered in determining the timing of an investigation.

Samples may be collected at any time of year if exposures due to soil vapor intrusion appear likely. However, samples collected at times when soil vapor intrusion is not expected to have its greatest effect on indoor air quality (typically, samples collected outside of the heating season) should not be used to rule out exposures. For example, results indicating "no further action" or "monitoring required" should be verified when soil vapor intrusion is believed to be most likely to ensure these actions are protective throughout the year.

2.5 Number of sampling rounds

Investigating the soil vapor intrusion pathway usually involves more than one round of subsurface vapor, indoor air and/or outdoor air sampling, for reasons such as the following:

a. to characterize the nature and extent of subsurface vapor contamination (similar to the delineation of groundwater contamination) and to address corresponding exposure concerns;

b. to evaluate fluctuations in concentrations due to

   1. different weather conditions (e.g., seasonal effects),
   2. changes in building conditions (e.g., various operating conditions of a building's HVAC system),
   3. changes in source strength, or
   4. vapor migration or contaminant biodegradation processes (particularly when degradation products may be more toxic than the parent compounds); or

c. to confirm sampling results or the effectiveness of mitigation or remedial systems.

Overall, as discussed in Section 1.5, successive rounds of sampling should be conducted until the following questions can be answered:

a. Are subsurface vapors contaminated? If so, what are the nature and extent of contamination? What is/are the source(s) of the contamination?

b. What are the current and potential exposures to contaminated subsurface vapors?

c. What actions, if any, are appropriate to prevent or mitigate exposures and to remediate subsurface vapor contamination?

Toward this end, multiple rounds of sampling may be appropriate to characterize the nature and extent of subsurface vapor contamination such that

a. both potential and current exposures are addressed [Section 2.6];

b. measures can be designed to remediate subsurface vapor contamination, either directly (e.g., SVE system) or indirectly (e.g., soil excavation or groundwater remediation), given that monitoring and mitigation are considered temporary measures implemented to address exposures related to vapor intrusion until contaminated environmental media are remediated [Section 3.4]; and

c. the effectiveness of remedial measures can be monitored and confirmed (e.g., endpoint sampling) [Section 4.5].

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

2.6 Sampling locations

The general approach for selecting sampling locations as part of a soil vapor intrusion investigation is similar to the approach for the investigation of other environmental media (e.g., soil and groundwater). Sampling locations should be selected with consideration of the conceptual site model [Section 1.6]. These locations should be selected to meet the stated objectives of the sampling program. Additionally, similar to the investigation of soil and groundwater, it is typical to start at a known or suspected source and work outward. The specific approach, however, will be dependent upon site-specific and building-specific conditions.

2.6.1 Soil vapor

If available, existing environmental data (e.g., groundwater and soil data) and site background information should be used to select locations for sampling soil vapor as part of a vapor intrusion investigation. Locations will vary depending upon surface features (e.g., presence or absence of buildings, areas of pavement, or vacant lot) and subsurface characteristics (e.g., soil stratigraphy, buried structures, utility corridors, or clay lenses), as well as the specific purpose of the sampling. Therefore, a figure illustrating proposed sampling locations (with respect to both areal position and depth), actual locations sampled in the field, and relevant on-site and off-site features should be included in all sampling work plans and reports.

Examples of how locations may vary given the specific purpose of the sampling follow. They include general guidelines that should be followed when selecting soil vapor sampling locations:

a. to evaluate the **potential for current on-site or off-site exposures**, samples should be collected
    1. in the vicinity of a building's foundation [see special sampling consideration at the end of Section 2.6.1 if sampling around a building with no surrounding surface confining layer], as well as between the building's foundation and the source (if known and not located beneath the building),
    2. along the site's perimeter, and
    3. at a depth comparable to the depth of foundation footings (determined on a building-specific or site-specific basis) or at least 1 foot above the water table in areas where the groundwater table is less than 6 feet below grade;

b. to evaluate the **potential for future exposures if development** on a known or suspected contaminated area on-site or off-site is possible, representative samples should be collected
    1. in areas with either known or suspected subsurface sources of volatile chemicals, in areas where elevated readings were obtained with field equipment during previous environmental investigations, and in areas of varying concentrations of contamination in the upper groundwater,
    2. in a grid pattern across the area (at an appropriate spacing interval for the size of the area) if information is limited for the area, and
    3. at multiple depths from the suspected subsurface source, or former source, to a depth comparable to the expected depth of foundation footings;

c. to evaluate the **potential for off-site soil vapor contamination**, samples should be collected
    1. along the site's perimeter,
    2. in areas of potential subsurface sources of vapor contamination (e.g., a groundwater plume that has migrated off-site), and
    3. at a depth comparable to the depth of foundation footings (determined on a site-specific basis) or at least 1 foot above the water table in areas where the groundwater table is less than 6 feet below grade;
d. to evaluate on-site and off-site **preferential migration pathways** in areas with low permeability soils, samples should be collected
    1. along preferential soil vapor flow paths, such as sewer lines, utility corridors, trenches, pipelines, and other subsurface structures that are likely to be bedded with higher permeability materials, and
    2. at depths corresponding to these subsurface features (will depend on site-specific conditions);
e. to characterize on-site or off-site **contamination in the vadose zone**, samples should be collected
    1. in areas with either known or suspected sources of volatile chemicals, in areas where elevated readings were obtained with field equipment (e.g., PID) during previous soil and groundwater investigations, and in areas of varying concentrations of contamination in the upper groundwater regime, and
    2. at appropriate depths associated with these areas (will depend on site-specific conditions); and
f. to investigate the **influence of contaminated groundwater or soil on soil vapor** and to characterize the **vertical profile** of contamination, samples should be collected from clusters of soil vapor probes at varying depths in the vadose zone [Figure 2.2, Section 2.7.1] and preferably in conjunction with the collection of groundwater or soil samples.

Soil vapor samples collected at depths shallower than 5 feet below grade may be prone to negative bias due to infiltration of outdoor air. Therefore, samples from these depths should be collected only if appropriate (based on site-specific conditions), and sampling procedures and results should be reviewed accordingly. The depth of sampling near buildings with slab-on-grade foundations is dependent upon site-specific conditions (e.g., building surrounded by grassy or surface confining layer).

When collecting soil vapor samples around a building with no surrounding surface confining layer (e.g., pavement or sidewalk), samples should be located in native or undisturbed soils away from fill material surrounding the building (approximately 10 feet away from the building) to avoid sampling in an area that may be influenced by the building's operations. For example, operation of HVAC systems, fireplaces, or mechanical equipment (e.g., clothes dryers or exhaust fans/vents) in a building may exacerbate the infiltration of outdoor air into the vadose zone adjacent to the building. As a result, soil vapor samples collected in uncovered areas adjacent to the building may not be representative.

Investigations of soil vapor contamination should proceed outward from known or suspected subsurface sources, as appropriate, on an areal basis until the nature and extent of

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm
subsurface vapor contamination has been characterized and human exposures have been addressed.

2.6.2 Sub-slab vapor

Existing environmental data (e.g., soil vapor, groundwater and soil data), site background information, and building construction details (e.g., basement, slab-on-grade, or multiple types of foundations, HVAC systems, etc.) should be considered when selecting buildings and locations within buildings for sub-slab vapor sampling.

At a minimum, these general guidelines should be followed when selecting buildings to sample for sub-slab vapors:

a. buildings, including residential dwellings, located above or directly adjacent to known or suspected areas of subsurface volatile chemical contamination should be sampled;

b. buildings in which screening with field equipment (e.g., PID, ppbRAE, Jerome Mercury Vapor Analyzer, etc.) suggests a completed migration pathway, such as when readings are above background and from unidentified sources or when readings show increasing gradients, should be sampled; and

c. buildings within known or suspected areas of subsurface volatile chemical contamination that are used or occupied by sensitive population groups (e.g., daycare facilities, schools, nursing homes, etc.) should be given special consideration for sampling.

Investigations of sub-slab vapor and/or indoor air contamination should proceed outward from known or suspected sources, as appropriate, on an areal basis until the nature and extent of subsurface vapor contamination has been characterized and potential and current human exposures have been addressed. In cases of widespread vapor contamination and depending upon the basis for making decisions (e.g., a "blanket mitigation" approach within a specified area of documented vapor contamination [Section 3.3.1]), a representative number of buildings from an identified study area, rather than each building, may be sampled. Prior to implementation, this type of sampling approach should be approved by State agency personnel.

Within a building, sub-slab vapor samples should be collected

a. in at least one central location away from foundation footings, and

b. from the soil or aggregate immediately below the basement slab or slab-on-grade.

The number of sub-slab vapor samples that should be collected in a building depends upon the number of slabs (e.g., multiple slabs-on-grade in a large warehouse) and foundation types (e.g., combined basement and slab-on-grade in a residence). At least one sub-slab vapor sample should be collected from each representative area.

2.6.3 Indoor air

Existing environmental data (e.g., soil vapor, groundwater and soil data), site background information, and building construction details (e.g., basement, slab-on-grade, or multiple types of foundations; number and operation of HVAC systems; elevator shafts; tunnels or other confined-space entry points; etc.) should be considered when selecting buildings and locations within buildings for indoor air sampling. Indoor air samples are typically collected concurrently with sub-slab vapor and outdoor air samples [Section 2.2.4].

At a minimum, these general guidelines should be followed when selecting buildings to sample for indoor air:

a. where sub-slab vapor samples were collected without indoor air samples, buildings in which elevated concentrations of contaminants were measured in sub-slab vapor samples should be sampled;

b. buildings, including residential dwellings, located above or directly adjacent to known or suspected subsurface sources of volatile chemicals or known soil vapor contamination should be sampled;

c. buildings in which screening with field equipment (e.g., PID, ppbRAE, Jerome Mercury Vapor Analyzer, etc.) suggests a completed migration pathway, such as when readings are above background and from unidentified sources or when readings show increasing gradients, should be sampled; and

d. buildings within known or suspected areas of subsurface volatile chemical contamination that are used or occupied by sensitive population groups (e.g., daycare facilities, schools, nursing homes, etc.) should be given special consideration for sampling.

To characterize contaminant concentration trends and potential exposures, indoor air samples should be collected

a. from the crawl space area,

b. from the basement (where vapor infiltration is suspected, such as near sump pumps or indoor wells, or in a central location) at a height approximately three feet above the floor to represent a height at which occupants normally are seated and/or sleep,

c. from the lowest level living space (in centrally-located, high activity use areas) at a height approximately three feet above the floor to represent a height at which occupants normally are seated and/or sleep, and

d. if in a commercial setting (e.g., a strip mall), from multiple tenant spaces at a height approximately three feet above the floor to represent a height at which occupants normally are seated.

These locations are illustrated in Figure 2.1.

Investigations of indoor air contamination should proceed outward from known or suspected subsurface sources, as appropriate, on an areal basis until potential and current human exposures associated with soil vapor intrusion have been addressed. In cases of widespread vapor contamination and depending upon the basis for making decisions (e.g., a "blanket mitigation" approach within a specified area of documented vapor contamination), a representative number of buildings from an identified study area, rather than each building, may be sampled. Prior to implementation, this type of sampling approach should be approved by State agency personnel.

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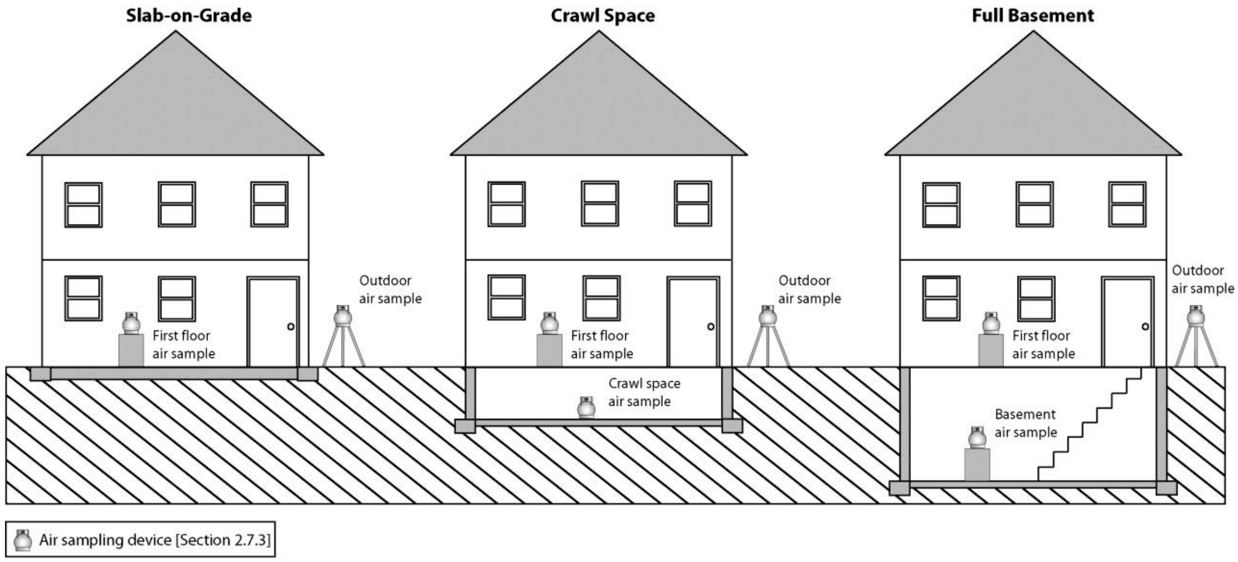

Figure 2.1
Schematic of indoor and outdoor air sampling locations

2.6.4 Outdoor air

Typically, an outdoor air sample is collected outside of each building where an indoor air sample is collected. However, if several buildings are being sampled within a localized area, representative outdoor air samples may be appropriate. For example, one outdoor air sample may be sufficient for three houses being sampled in a cul-de-sac. Outdoor air samples should be collected from a representative upwind location, away from wind obstructions (e.g., trees or bushes), and at a height above the ground to represent breathing zones (3 to 5 feet) [Figure 2.1]. A representative sample is one that is not biased toward obvious sources of volatile chemicals (e.g., automobiles, lawn mowers, oil storage tanks, gasoline stations, industrial facilities, etc.). For buildings with HVAC systems that draw outdoor air into the building, an outdoor air sample collected near the outdoor air intake may be appropriate.

2.7 Sampling protocols

The procedures recommended here may be modified depending on site-specific conditions, the sampling objectives, or emerging technologies and methodologies. Alternative sampling procedures should be described thoroughly and proposed in a work plan submitted for review by the State. The State will review and comment on the proposed procedure and consider the efficacy of the alternative sampling procedure based on the objectives of investigation. In all cases, work plans should thoroughly describe the proposed sampling procedure. Similarly, the procedures that were implemented in the field should be documented and included in the final report of the sampling results.

2.7.1 Soil vapor

Soil vapor probe installations [Figure 2.2] may be permanent, semi-permanent or temporary. In general, permanent or semi-permanent installations are preferred for data consistency reasons and to ensure outdoor air infiltration does not occur. Temporary probes should only be used if measures are taken to ensure that an adequate surface seal is created to prevent outdoor air infiltration and if tracer gas is used at every sampling location. [See Section 2.7.5 for additional information about the use of tracer gas when collecting soil vapor samples.] Soil vapor implants or probes should be constructed in the same manner at all sampling locations to minimize possible discrepancies. The following procedures should be included in any permanent construction protocol:

a. implants should be installed using an appropriate method based on site conditions (e.g., direct push, manually driven, auger — if necessary to attain the desired depth or if sidewall smearing is a concern, etc.);

b. porous, inert backfill material (e.g., glass beads, washed #1 crushed stone, etc.) should be used to create a sampling zone 1 to 2 feet in length;

c. implants should be fitted with inert tubing (e.g., polyethylene, stainless steel, nylon, Teflon®, etc.) of the appropriate size (typically 1/8 inch to 1/4 inch diameter) and of laboratory or food grade quality to the surface;

d. soil vapor probes should be sealed above the sampling zone with a bentonite slurry for a minimum distance of 3 feet to prevent outdoor air infiltration and the remainder of the borehole backfilled with clean material;

e. for multiple probe depths, the borehole should be grouted with bentonite between probes to create discrete sampling zones or separate nested probes should be installed [Figure 2.2]; and

f. steps should be taken to minimize infiltration of water or outdoor air and to prevent accidental damage (e.g., setting a protective casing around the top of the probe tubing and grouting in place to the top of bentonite, sloping the ground surface to direct water away from the borehole like a groundwater monitoring well, etc.).

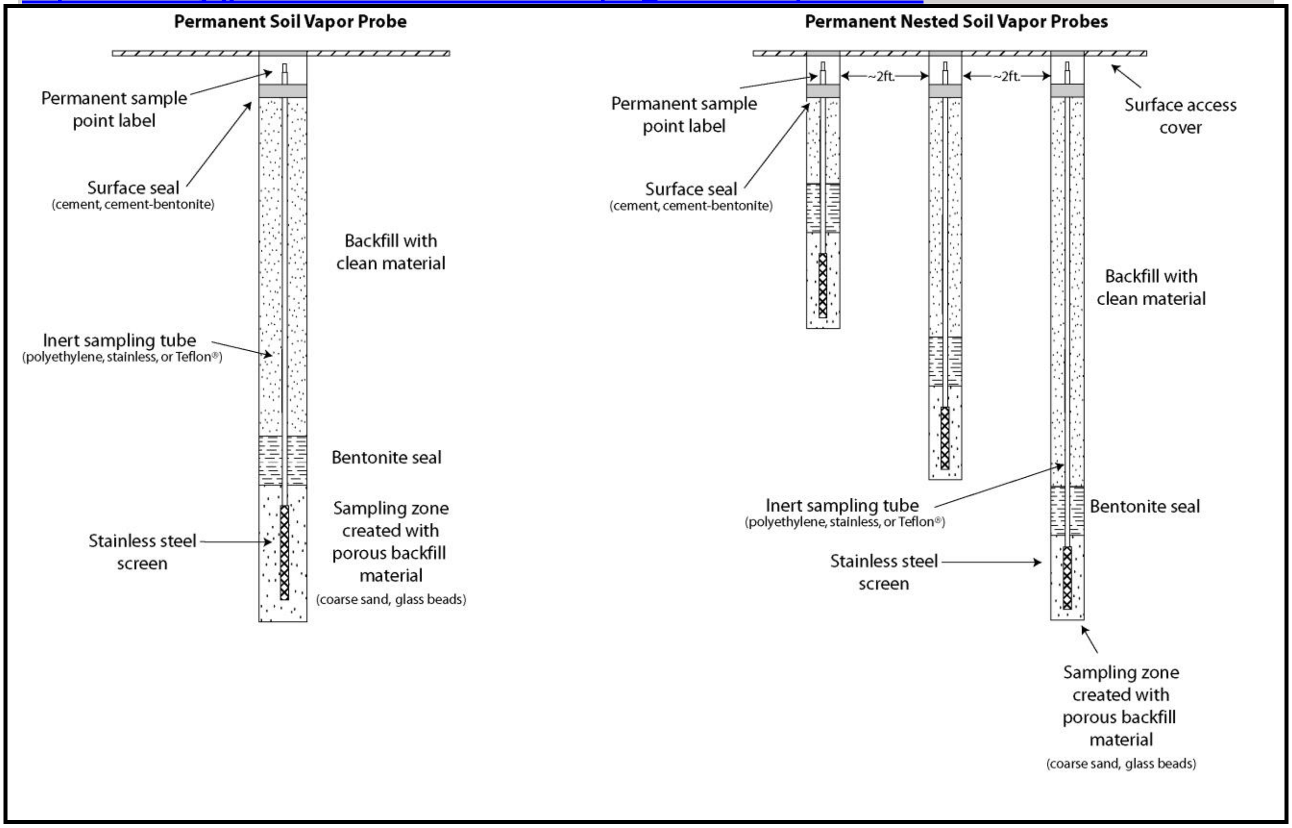

Figure 2.2

Schematics of a generic permanent soil vapor probe
and permanent nested soil vapor probes

[Note: Many variations exist and may be proposed in a work plan. Proposed installations should meet the sampling objectives and requirements of the analytical methods.]

To obtain representative samples and to minimize possible discrepancies, soil vapor samples should be collected in the following manner at all locations:

a. at least 24 hours after the installation of permanent probes and shortly after the installation of temporary probes, one to three implant volumes (i.e., the volume of the sample probe and tube) should be purged prior to collecting the samples;

b. flow rates for both purging and collecting should not exceed 0.2 liters per minute to minimize outdoor air infiltration during sampling;

c. samples should be collected, using conventional sampling methods, in an appropriate container — one which

    i. meets the objectives of the sampling (e.g., investigation of areas where low or high concentrations of volatile chemicals are expected; to minimize losses of volatile chemicals that are susceptible to photodegradation),

    ii. is consistent with the sampling and analytical methods (e.g., low flow rate; Summa® canisters if analyzing by using EPA Method TO-15), and

    iii. is certified clean by the laboratory;

d. sample size depends upon the volume of that will achieve minimum reporting limits [Section 2.9]; and

e. a tracer gas (e.g., helium, butane, sulfur hexafluoride, etc.) should be used when collecting soil vapor samples to verify that adequate sampling techniques are being implemented (i.e., to verify infiltration of outdoor air is not occurring) [Section 2.7.5].

In some cases, weather conditions may present certain limitations on soil vapor sampling. For example, condensation in the sample tubing may be encountered during winter sampling due to low outdoor air temperatures. Devices, such as tube warmers, may be used to address these conditions. Anticipated limitations to the sampling should be discussed prior to the sampling event so appropriate measures can be taken to address these difficulties and produce representative and reliable data.

When soil vapor samples are collected, the following actions should be taken to document local conditions during sampling that may influence interpretation of the results:

a. if sampling near a commercial or industrial building, uses of volatile chemicals during normal operations of the facility should be identified;

b. outdoor plot sketches should be drawn that include the site, area streets, neighboring commercial or industrial facilities (with estimated distance to the site), outdoor air sampling locations (if applicable), and compass orientation (north);

c. weather conditions (e.g., precipitation and outdoor temperature) should be noted for the past 24 to 48 hours; and

d. any pertinent observations should be recorded, such as odors and readings from field instrumentation.

Additional information that could be gathered to assist in the interpretation of the results includes barometric pressure, wind speed and wind direction.

The field sampling team should maintain a sample log sheet summarizing the following:

a. sample identification,

b. date and time of sample collection,

c. sampling depth,

d. identity of samplers,

e. sampling methods and devices,

f. purge volumes,

g. volume of soil vapor extracted,

h. if canisters used, the vacuum before and after samples were collected,

i. apparent moisture content (dry, moist, saturated, etc.) of the sampling zone, and

j. chain of custody protocols and records used to track samples from sampling point to analysis.

2.7.2 Sub-slab vapor

During colder months, heating systems should be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time. Prior to installation of the sub-slab vapor probe, the building floor should be inspected and any penetrations (cracks, floor drains, utility perforations, sumps, etc.) should be noted and recorded. Probes should be installed at locations where the potential for ambient air infiltration via floor penetrations is minimal.

Sub-slab vapor probe installations [Figure 2.3] may be permanent, semi-permanent or temporary. A vacuum should not be used to remove drilling debris from the sampling port. Sub-slab implants or probes should be constructed in the same manner at all sampling locations to minimize possible discrepancies. The following procedures should be included in any construction protocol:

a. permanent recessed probes should be constructed with brass or stainless steel tubing and fittings;
b. temporary probes should be constructed with inert tubing (e.g., polyethylene, stainless steel, nylon, Teflon®, etc.) of the appropriate size (typically 1/8 inch to 1/4 inch diameter), and of laboratory or food grade quality;
c. tubing should not extend further than 2 inches into the sub-slab material;
d. porous, inert backfill material (e.g., glass beads, washed #1 crushed stone, etc.) should be added to cover about 1 inch of the probe tip for permanent installations; and
e. the implant should be sealed to the surface with non-VOC-containing and non-shrinking products for temporary installations (e.g., permagum grout, melted beeswax, putty, etc.) or cement for permanent installations.

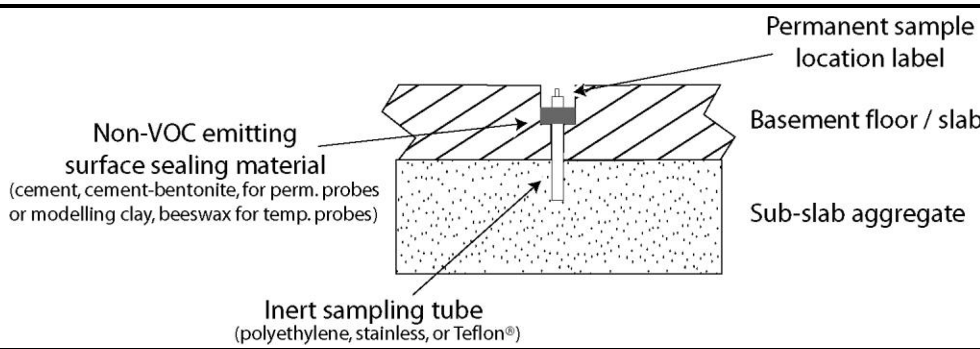

Figure 2.3

Schematic of a generic sub-slab vapor probe

[Note: Many variations exist and may be proposed in a work plan. Proposed installations should meet the sampling objectives and requirements of the analytical methods.]

To obtain representative samples that meet the data quality objectives, sub-slab vapor samples should be collected in the following manner:

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a. after installation of the probes, one to three volumes (i.e., the volume of the sample probe and tube) must be purged prior to collecting the samples to ensure samples collected are representative;

b. flow rates for both purging and collecting must not exceed 0.2 liters per minute to minimize ambient air infiltration during sampling; and

c. samples should be collected, using conventional sampling methods, in an appropriate container — one which

   i. meets the objectives of the sampling (e.g., investigation of areas where low or high concentrations of volatile chemicals are expected; to minimize losses of volatile chemicals that are susceptible to photodegradation),

   ii. is consistent with the sampling and analytical methods (e.g., low flow rate; Summa® canisters if analyzing by using EPA Method TO-15), and

   iii. is certified clean by the laboratory;

d. sample size depends upon the volume of that will achieve minimum reporting limits [Section 2.9], the flow rate, and the sampling duration; and

e. ideally, samples should be collected over the same period of time as concurrent indoor and outdoor air samples.

When sub-slab vapor samples are collected, the following actions should be taken to document conditions during sampling and ultimately to aid in the interpretation of the sampling results [Section 3]:

a. historic and current storage and uses of volatile chemicals should be identified, especially if sampling within a commercial or industrial building (e.g., use of volatile chemicals in commercial or industrial processes and/or during building maintenance);

b. the use of heating or air conditioning systems during sampling should be noted;

c. floor plan sketches should be drawn that include the floor layout with sampling locations, chemical storage areas, garages, doorways, stairways, location of basement sumps or subsurface drains and utility perforations through building foundations, HVAC system air supply and return registers, compass orientation (north), footings that create separate foundation sections, and any other pertinent information should be completed;

d. outdoor plot sketches should be drawn that include the building site, area streets, outdoor air sampling locations (if applicable), compass orientation (north), and paved areas;

e. weather conditions (e.g., precipitation and indoor and outdoor temperature) and ventilation conditions (e.g., heating system active and windows closed) should be reported; and

f. any pertinent observations, such as spills, floor stains, smoke tube results, odors and readings from field instrumentation (e.g., vapors via PID, ppbRAE, Jerome Mercury Vapor Analyzer, etc.), should be recorded.

Additional documentation that could be gathered to assist in the interpretation of the results includes information about air flow patterns and pressure relationships obtained by using smoke tubes or other devices (especially between floor levels and between suspected contaminant sources and other areas), the barometric pressure and photographs to accompany floor plan sketches.

The field sampling team should maintain a sample log sheet summarizing the following:

a. sample identification,
b. date and time of sample collection,
c. sampling depth,
d. identity of samplers,
e. sampling methods and devices,
f. soil vapor purge volumes,
g. volume of soil vapor extracted,
h. if canisters used, vacuum of canisters before and after samples collected,
i. apparent moisture content (dry, moist, saturated, etc.) of the sampling zone, and
j. chain of custody protocols and records used to track samples from sampling point to analysis.

2.7.3 Indoor air

[Reference: NYSDOH's *Indoor Air Sampling & Analysis Guidance (February 1, 2005)*]

During colder months, heating systems should be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time. If possible, prior to collecting indoor samples, a pre-sampling inspection [Section 2.11.1] should be performed to evaluate the physical layout and conditions of the building being investigated, to identify conditions that may affect or interfere with the proposed sampling, and to prepare the building for sampling. This process is described in Section 2.11.1.

In general, indoor air samples should be collected in the following manner:

a. sampling duration should reflect the exposure scenario being evaluated without compromising the detection limit or sample collection flow rate (e.g., an 8 hour sample from a workplace with a single shift versus a 24 hour sample from a workplace with multiple shifts). To ensure that air is representative of the locations sampled and to avoid undue influence from sampling personnel, samples should be collected for at least 1 hour. If the goal of the sampling is to represent average concentrations over longer periods, then longer duration sampling periods may be appropriate. Typically, 24 hour samples are collected from residential settings;
b. personnel should avoid lingering in the immediate area of the sampling device while samples are being collected;
c. sample flow rates must conform to the specifications in the sample collection method and, if possible, should be consistent with the flow rates for concurrent outdoor air and sub-slab samples; and
d. samples must be collected, using conventional sampling methods, in an appropriate container — one which

i. meets the objectives of the sampling (e.g., investigation of areas where low or high concentrations of volatile chemicals are expected; to minimize losses of volatile chemicals that are susceptible to photodegradation),

ii. is consistent with the sampling and analytical methods (e.g., low flow rate; Summa® canisters if analyzing by using EPA Method TO-15), and

iii. is certified clean by the laboratory.

At sites with tetrachloroethene contamination, passive air monitors that are specifically analyzed for tetrachloroethene (i.e., "perc badges") are commonly used to collect indoor and outdoor air samples. If site characterization activities indicate that degradation products of tetrachloroethene also represent a vapor intrusion concern, perc badges may be used to indicate the likelihood of vapor intrusion (i.e., by using tetrachloroethene as a surrogate) followed, as appropriate, by more comprehensive sampling and laboratory analyses to quantify both tetrachloroethene and its degradation products. Perc badge samples ideally should be collected over a twenty-four hour period, but for no less than eight hours.

The following actions should be taken to document conditions during indoor air sampling and ultimately to aid in the interpretation of the sampling results [Section 3]:

a. historic and current uses and storage of volatile chemicals should be identified, especially if sampling within a commercial or industrial building (e.g., use of volatile chemicals in commercial or industrial processes and/or during building maintenance);

b. a product inventory survey documenting sources of volatile chemicals present in the building during the indoor air sampling that could potentially influence the sample results should be completed [Section 2.11.2];

c. the use of heating or air conditioning systems during sampling should be noted;

d. floor plan sketches should be drawn that include the floor layout with sampling locations, chemical storage areas, garages, doorways, stairways, location of basement sumps or subsurface drains and utility perforations through building foundations, HVAC system supply and return registers, compass orientation (north), footings that create separate foundation sections, and any other pertinent information should be completed;

e. outdoor plot sketches should be drawn that include the building site, area streets, outdoor air sampling locations (if applicable), compass orientation (north), and paved areas;

f. weather conditions (e.g., precipitation and indoor and outdoor temperature) and ventilation conditions (e.g., heating system active and windows closed) should be reported; and

g. any pertinent observations, such as spills, floor stains, smoke tube results, odors and readings from field instrumentation (e.g., vapors via PID, ppbRAE, Jerome Mercury Vapor Analyzer, etc.), should be recorded.

Additional documentation that could be gathered to assist in the interpretation of the results includes information about air flow patterns and pressure relationships obtained by using smoke tubes or other devices (especially between floor levels and between suspected contaminant sources and other areas), the barometric pressure and photographs to accompany floor plan sketches.

The field sampling team should maintain a sample log sheet summarizing the following:

a. sample identification,
b. date and time of sample collection,
c. sampling height,
d. identity of samplers,
e. sampling methods and devices,
f. depending upon the method, volume of air sampled,
g. if canisters are used, vacuum of canisters before and after samples collected, and
h. chain of custody protocols and records used to track samples from sampling point to analysis.

2.7.4 Outdoor air

Outdoor air samples should be collected simultaneously with indoor air samples to evaluate the potential influence, if any, of outdoor air on indoor air quality. They may also be collected simultaneously with soil vapor samples to identify potential outdoor air interferences associated with infiltration of outdoor air into the sampling apparatus while the soil vapor was collected. To obtain representative samples that meet the data quality objectives, outdoor air samples should be collected in a manner consistent with that for indoor air samples (described in Section 2.7.3).

The following actions should be taken to document conditions during outdoor air sampling and ultimately to aid in the interpretation of the sampling results [Section 3]:

a. outdoor plot sketches should be drawn that include the building site, area streets, outdoor air sampling locations, the location of potential interferences (e.g., gasoline stations, factories, lawn movers, etc.), compass orientation (north), and paved areas;
b. weather conditions (e.g., precipitation and outdoor temperature) should be reported; and
c. any pertinent observations, such as odors, readings from field instrumentation, and significant activities in the vicinity (e.g., operation of heavy equipment or dry cleaners) should be recorded.

2.7.5 Tracer gas

When collecting soil vapor samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance/quality control measure to verify the integrity of the soil vapor probe seal. Without the use of a tracer, there is no way to verify that a soil vapor sample has not been diluted by outdoor air.

Depending on the nature of the contaminants of concern, a number of different compounds can be used as a tracer. Typically, sulfur hexafluoride (SF_6) or helium are used as tracers because they are readily available, have low toxicity, and can be monitored with portable measurement devices. Butane and propane (or other gases) could also be used as a tracer in some situations. Compounds other than those mentioned here may be appropriate, provided they meet project-specific data quality objectives. Where applicable, steps should be taken to ensure that the gas used by the laboratory to clean the air sampling container is different from the gas used as a tracer during sampling (e.g., helium).

The protocol for using a tracer gas is straightforward: simply enrich the atmosphere in the immediate vicinity of the area where the probe intersects the ground surface with the tracer gas, and measure a vapor sample from the probe for the presence of high concentrations (> 10%) of the tracer. A cardboard box, a plastic pail, or even a garbage bag can serve to keep the tracer gas in contact with the probe during the testing. If there are concerns about infiltration of ambient air through other parts of the sampling train (such as around the fittings, not just at the probe/ground interface), then consideration should be given to ensuring that the tracer gas is in contact with the entire sampling apparatus. In these cases, field personnel may prefer to use a liquid tracer — soaking paper towels with a liquid tracer and placing the towels around the probe/ground interface, around fittings, and/or in the corner of a shroud.

There are two basic approaches to testing for the tracer gas:

1. include the tracer gas in the list of target analytes reported by the laboratory; or
2. use a portable monitoring device to analyze a sample of soil vapor for the tracer prior to and after sampling for the compounds of concern. (Note that the tracer gas samples can be collected via syringe, Tedlar® bag etc. They need not be collected in Summa® canisters or minicans.)

The advantage of the second approach is that the real time tracer sampling results can be used to confirm the integrity of the probe seals prior to formal sample collection.

Figure 2.4 depicts common methods for using tracer gas. In examples a, b and c, the tracer gas is released in the enclosure prior to initially purging the sample point. Care should be taken to avoid excessive purging prior to sample collection. Care should also be taken to prevent pressure build-up in the enclosure during introduction of the tracer gas. Inspection of the installed sample probe, specifically noting the integrity of the surface seal and the porosity of the soil in which the probe is installed, will help to determine the tracer gas setup. Figure 2.4a may be most effective at preventing tracer gas infiltration, however, it may not be appropriate in some situations depending on site-specific conditions. Figures 2.4b and 2.4c may be sufficient for probes installed in tight soils with well-constructed surface seals. Figure 2d provides an example of using a liquid tracer. In all cases, the same tracer gas application should be used for all probes at any given site.

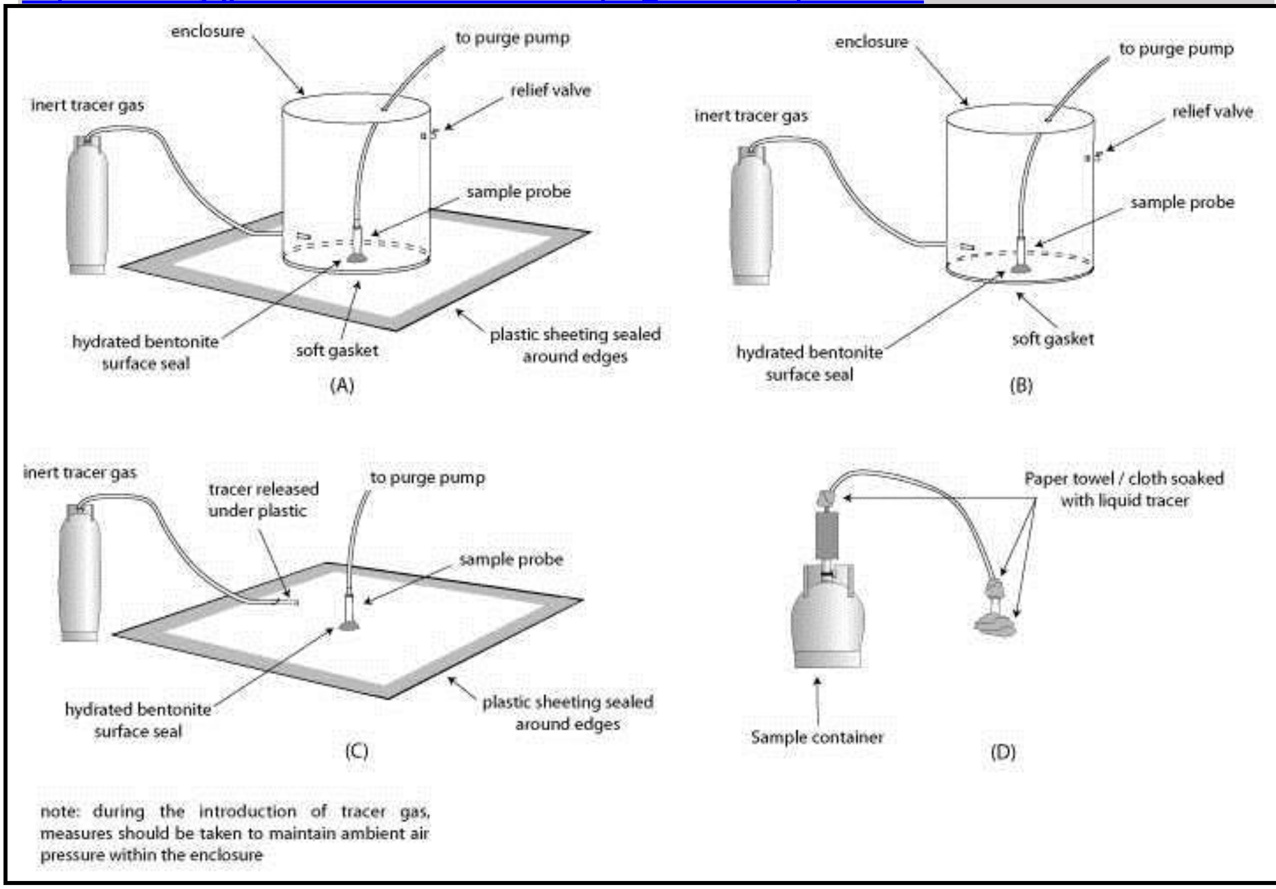

Figure 2.4
Schematics of generic tracer gas applications when collecting soil vapor samples

Because minor leakage around the probe seal should not materially affect the usability of the soil vapor sampling results, the mere presence of the tracer gas in the sample should not be a cause for alarm. Consequently, portable field monitoring devices with detection limits in the low ppm range are more than adequate for screening samples for the tracer. If high concentrations (> 10%) of tracer gas are observed in a sample, the probe seal should be enhanced to reduce the infiltration of outdoor air.

Where permanent or semi-permanent sampling probes are used, tracer gas samples should be collected at each of the sampling probes during the initial stages of a soil vapor sampling program. If the results of the initial samples indicate that the probe seals are adequate, reducing the number of locations at which tracer gas samples are employed may be considered. At a minimum, tracer gas samples should be collected with at least 10% of the soil vapor samples collected in subsequent sampling rounds. When using permanent soil vapor probes as part of a long-term monitoring program, annual testing of the probe integrity is recommended. Where temporary probes are used, tracer gas should be used at every sampling location, every time.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

2.8 Quality assurance/quality control (QA/QC)

[Reference: NYSDOH's *Indoor Air Sampling & Analysis Guidance (February 1, 2005)*]

In general, appropriate QA/QC procedures should be followed during all aspects of sample collection and analysis to ensure that sampling error is minimized and high quality data are obtained. Sampling team members should avoid actions (e.g., fueling vehicles, using permanent marking pens, wearing freshly dry-cleaned clothing or personal fragrances, etc.) which can cause sample interference in the field. Portable air monitoring equipment or field instrumentation should be properly maintained, calibrated and tested to ensure validity of measurements. Air sampling equipment should be stored, transported and between samples decontaminated in a manner consistent with the best environmental consulting practices to minimize problems such as field contamination and cross-contamination. Samples should be collected using certified clean sample devices. Where applicable, steps should be taken to ensure that the gas used by the laboratory to clean the sample device is different from the gas used as a tracer during sampling (e.g., helium). Samples should meet sample holding times and temperatures, and should be delivered to the analytical laboratory as soon as possible after collection. In addition, laboratory accession procedures should be followed, including field documentation (sample collection information and locations), chain of custody, field blanks, field sample duplicates and laboratory duplicates, as appropriate.

Some methods call for collecting samples in duplicate (e.g., indoor air sampling using passive sampling devices for tetrachloroethene) to assess errors. Duplicate and/or split samples should be collected in accordance with the sampling and analytical methods being implemented.

For certain regulatory programs, a Data Usability Summary Report (DUSR) or equivalent report may be required to determine whether or not the data, as presented, meets the site or project specific criteria for data quality and data use. This requirement may dictate the level of QC and the category of data deliverable to request from the laboratory. Guidance on preparing these reports is available by contacting the NYSDEC's Division of Environmental Remediation.

New York State Public Health Law requires laboratories analyzing environmental samples collected from within New York State to have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. If ELAP certification is not currently required for an analyte (e.g., trichloroethene), the analysis should be performed by a laboratory that has ELAP certification for similar compounds in air and uses analytical methods with minimum reporting limits similar to background (e.g., tetrachloroethene via EPA Method TO-15). Questions about a laboratory's current certification status should be directed to an ELAP representative at 518-485-5570 or by email at elap@health.state.ny.us.

The work plan should state that all samples that will be used to make decisions on appropriate actions to address exposures and environmental contamination will be analyzed by an ELAP-certified laboratory. The name of the laboratory should also be provided. Similarly, the name of the laboratory that was used should be included in the report of the sampling results. For samples collected and tested in the field for screening purposes by using field testing technology, the qualifications of the field technician should be documented in the work plan.

NOTE: Updates to this final guidance are available at http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

2.9 Analytical methods

[Reference: NYSDOH's *Indoor Air Sampling & Analysis Guidance (February 1, 2005)*]

Proposed analytical procedures should be identified in work plans. Similarly, the analytical procedures that were used and corresponding reporting limits should be identified when reporting the sampling results. When selecting an appropriate analytical method, the data quality objectives should be considered. As described in Section 3, comparing sampling results for volatile chemicals with background concentrations and with indoor air/sub-slab vapor matrices are critical components of the data evaluation process. Therefore, samples should be analyzed by methods that can achieve minimum reporting limits to allow for comparison of the results with background levels and with the levels presented in the matrices [Section 3.4.2]. If there are additional data quality objectives, they should be considered also. Typically, a minimum reporting limit of 1 microgram per cubic meter (1 mcg/m^3) or less is sufficient for most analytes. Examples of commonly used analytical methods include the following:

a. EPA Method TO-15 for a wide range of VOCs (e.g., samples from evacuated canisters),

b. NYSDOH Method 311-9 for tetrachloroethene (i.e., samples from perc badges),

c. EPA Method TO-17 for VOCs (e.g., samples collected with sorbent tubes), and

d. EPA Method TO-15 for VOCs with selective ion monitoring (SIM) (e.g., to achieve minimum reporting limits lower than those achieved with Method TO-15 alone).

The laboratory should verify that they are capable of detecting the appropriate analytes and can report them at the appropriate reporting limit.

2.9.1 <u>Subsurface vapor</u>

Soil vapor and sub-slab vapor samples should be analyzed for a wide range of volatile chemicals during the first round of sampling (at a minimum) — unless it can be demonstrated that an abbreviated or site-specific analyte list is appropriate. This is analogous to analyzing groundwater samples for a suite of compounds (e.g., EPA's target analyte list/target compound list (TAL/TCL) chemicals) during the initial rounds of site characterization. Based on the initial sampling results, development and application of a site-specific analyte list may be considered for analysis of subsequent soil vapor and sub-slab vapor samples.

If a site-specific analyte list is developed, it should include the following:

a. volatile chemicals which have been previously detected in environmental media (e.g., soil, groundwater and air) at the site;

b. volatile chemicals which are known or demonstrated constituents of the contamination in question (e.g., petroleum products or tars from former manufactured gas plants); and

c. expected degradation products of the chemicals mentioned in a or b.

A site-specific analyte list might also include indicator compounds to assist in identifying and differentiating subsurface sources of volatile chemical contamination. The following are examples of indicator compounds that have been included in site-specific analyte lists given the nature of the contamination or type of site:

a. gasoline: benzene, toluene, ethylbenzene, xylenes, trimethylbenzene isomers, individual C-4 to C-8 aliphatics (e.g., hexane, cyclohexane, dimethylpentane, 2,2,4-trimethylpentane, etc.), and appropriate oxygenate additives (e.g., methyl-*tert*-butyl ether, ethanol, etc.);

b. middle distillate fuels (#2 fuel oil, diesel and kerosene): n-nonane, n-decane, n-undecane, n-dodecane, ethylbenzene, xylenes, trimethylbenzene isomers, tetramethylbenzene isomers, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene;

c. manufactured gas plant sites: trimethylbenzene isomers, tetramethylbenzene isomers, thiopenes, indene, indane, and naphthalene;

d. natural gas: propane, propene, butane, iso-butane, methylbutane, and n-pentane with lower levels of higher molecular weight aliphatic, olefinic, and some aromatic compounds; and

e. solvent-using industries: the solvent and its expected degradation products (e.g., tetrachloroethene, trichloroethene, dichloroethene(s), and vinyl chloride).

2.9.2 Indoor air

Indoor and outdoor air samples should be analyzed for a wide range of volatile chemicals if there are no existing data for subsurface vapors — unless it can be demonstrated that an abbreviated or site-specific analyte list is appropriate. If indoor air sampling is appropriate based on the levels of volatile chemicals in subsurface vapors, analysis of indoor air samples specifically for those volatile chemicals may be considered.

2.9.3 Outdoor air

Outdoor air samples should be analyzed in a manner consistent with corresponding indoor air samples.

2.10 Field laboratories and mobile gas chromatographs (GCs)

Use of field laboratories and mobile GCs as screening tools when collecting soil vapor samples may be considered on a site-specific basis. However, without ELAP certification, screening tools such as these are not acceptable when collecting sub-slab vapor, indoor air and outdoor air samples for the purpose of evaluating exposures related to soil vapor intrusion. ELAP certification for a particular laboratory does not indicate mobile laboratory or GC certification. Mobile laboratories and GCs have specific certification requirements through ELAP. Questions regarding a mobile laboratory's certification should be directed to the laboratory itself.

2.11 Surveys and pre-sampling building preparation

[Reference: NYSDOH's *Indoor Air Sampling & Analysis Guidance (February 1, 2005)*]

2.11.1 Pre-sampling building inspection and preparation

A pre-sampling inspection should be performed prior to each sampling event to identify and minimize conditions that may interfere with the proposed testing. The inspection should evaluate the type of structure, floor layout, air flows and physical conditions of the building(s) being studied. This information, along with information on sources of potential

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm
indoor air contamination [Section 2.11.2], should be identified on a building inventory form. An example of a building inventory form is given in Appendix B. Items to be included in the building inventory include the following:

a. construction characteristics, including foundation cracks and utility penetrations or other openings that may serve as preferential pathways for vapor intrusion;

b. presence of an attached garage;

c. recent renovations or maintenance to the building (e.g., fresh paint, new carpet or furniture);

d. mechanical equipment that can affect pressure gradients (e.g., heating systems, clothes dryers or exhaust fans);

e. use or storage of petroleum products (e.g., fuel containers, gasoline operated equipment and unvented kerosene heaters); and

f. recent use of petroleum-based finishes or products containing volatile chemicals.

Each room on the floor of the building being tested and on lower floors, if possible, should be inspected. This is important because even products stored in another area of a building can affect the air of the room being tested.

The presence and description of odors (e.g., solvent, moldy) and portable vapor monitoring equipment readings (e.g., PIDs, ppbRAE, Jerome Mercury Vapor Analyzer, etc.) should be noted and used to help evaluate potential sources. This includes taking readings near products stored or used in the building. Where applicable, readings should be provided in units that denote the calibration gas (e.g., isobutylene-equivalent ppm, benzene-equivalent ppm, etc.).

Potential interference from products or activities releasing volatile chemicals should be controlled to the extent practicable. Removing the source from the indoor environment prior to testing is the most effective means of reducing interference. Ensuring that containers are tightly sealed may be sufficient. When testing for volatile organic compounds, containers should be tested with portable vapor monitoring equipment to determine whether compounds are leaking. The inability to eliminate potential interference may be justification for not testing, especially when testing for similar compounds at low levels. The investigator should consider the possibility that chemicals may adsorb onto porous materials and may take time to dissipate.

In some cases, the goal of the testing is to evaluate the impact from products used or stored in the building (e.g., pesticide misapplications, school renovation projects). If the goal of the testing is to determine whether products are an indoor volatile chemical contaminant source, the removing these sources does not apply.

Once interfering conditions are corrected (if applicable), ventilation may be appropriate prior to sampling to minimize residual contamination in the indoor air. If ventilation is appropriate, it should be completed 24 hours or more prior to the scheduled sampling time. Where applicable, ventilation can be accomplished by operating the building's HVAC system to maximize outside air intake. Opening windows and doors, and operating exhaust fans may also help or may be appropriate if the building has no HVAC system.

Air samples are sometimes designed to represent typical exposure in a mechanically ventilated building and the operation of HVAC systems during sampling should be noted on the building inventory form [Appendix B]. When samples are collected, the building's HVAC system should be operating in a manner consistent with normal operating conditions when the building is occupied (e.g., schools, businesses, etc.). Unnecessary building ventilation should be avoided within 24 hours prior to and during sampling. During colder months, heating systems should be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time.

Depending upon the goal of the indoor air sampling, some situations may warrant deviation from the above protocol regarding building ventilation. In such cases, building conditions and sampling efforts should be understood and noted within the framework and scope of the investigation.

To avoid potential interferences and dilution effects, occupants should make a reasonable effort to avoid the following for 24 hours prior to sampling:

a. opening any windows, fireplace dampers, openings or vents;
b. operating ventilation fans unless special arrangements are made;
c. smoking in the building;
d. painting;
e. using a wood stove, fireplace or other auxiliary heating equipment (e.g., kerosene heater);
f. operating or storing automobile in an attached garage;
g. allowing containers of gasoline or oil to remain within the house or garage area, except for fuel oil tanks;
h. cleaning, waxing or polishing furniture, floors or other woodwork with petroleum- or oil-based products;
i. using air fresheners, scented candles or odor eliminators;
j. engaging in any hobbies that use materials containing volatile chemicals;
k. using cosmetics including hairspray, nail polish, nail polish removers, perfume/cologne, etc.;
l. lawn mowing, paving with asphalt, or snow blowing;
m. applying pesticides;
n. using building repair or maintenance products, such as caulk or roofing tar; and
o. bringing freshly dry-cleaned clothing or furnishings into the building.

2.11.2 Product inventory

The primary objective of the product inventory is to identify potential air sampling interference by characterizing the occurrence and use of chemicals and products throughout the building, keeping in mind the goal of the investigation and site-specific contaminants of concern. For example, it is not appropriate to provide detailed information for each individual container of like items. However, it is appropriate to indicate that "20 bottles of perfume" or "12 cans of latex paint" were present with containers in good condition. This information is used to help formulate an indoor environment profile.

An inventory should be provided for each room on the floor of the building being tested and on lower floors, if possible. This is important because even products stored in another area of a building can affect the air of the room being tested.

The presence and description of odors (e.g., solvent, moldy) and portable vapor monitoring equipment readings (e.g., PIDs, ppbRAE, Jerome Mercury Vapor Analyzer, etc.) should be noted and used to help evaluate potential sources. This includes taking readings near products stored or used in the building. Where applicable, readings should be provided in units that denote the calibration gas (e.g., isobutylene-equivalent ppm, benzene-equivalent ppm, etc.).

Products in buildings should be inventoried every time air is tested to provide an accurate assessment of the potential contribution of volatile chemicals. If available, chemical ingredients of interest (e.g., analyte list) should be recorded for each product. If the ingredients are not listed on the label, record the product's exact and full name, and the manufacturer's name, address and telephone number, if available. In some cases, material Safety Data Sheets may be useful for identifying confounding sources of volatile chemicals in air. Adequately documented photographs of the products and their labeled ingredients can supplement the inventory and facilitate recording the information.

2.12 Role of modeling

At sites where there is a potential for human exposures to subsurface contamination due to soil vapor intrusion (as described in Section 2.1), use of modeling as the sole means of evaluating potential exposures should be avoided. The limitations of modeling (e.g., exclusion of preferential migration pathways) introduce uncertainty as to whether human exposure is occurring, in absence of actual field data. Conclusions drawn from modeling should be verified with actual field data. For example, if modeling results indicate indoor air concentrations are predicted to be below applicable guidelines or levels of concern, indoor air and/or sub-slab vapor sampling would be appropriate to verify a conclusion that mitigation or other actions are not needed.

Modeling may, however, be used as a tool in the evaluation process. Examples of situations in which modeling may be used as a tool include, but are not limited to, the following:

a. to help identify potential migration pathways on the basis of site-specific conditions;

b. to estimate potential exposures when field samples cannot be collected (e.g., access to collect the samples is denied or buildings have not yet been constructed over the subsurface contamination); and

c. to identify a preferred order for sampling buildings by predicting expected indoor air concentrations within each of the buildings if there are numerous buildings overlying the subsurface contamination.

Use of any model at a site should be discussed with the agencies prior to the model's development and application. If a model is used, it should incorporate site-specific parameters (e.g., attenuation factors, soil conditions, concentrations of volatile chemicals, depth to subsurface source, characteristics of subsurface source, and foundation slab thickness) as much as possible. Furthermore, both the limitations of the model (e.g., exclusion of preferential migration pathways) and the sensitivity of the variables in the model should be understood and identified with the modeling results.

Section 3: Data Evaluation and Recommendations for Action

Section 3 describes the process by which data obtained during the investigation are evaluated. The goals of the evaluation are as follows:

a. to determine what volatile chemicals, if any, are present in the investigated media;

b. to identify the likely cause(s) of their presence; and

c. to identify completed and potential human exposures whether actions to address exposures should be taken.

Also discussed are actions typically recommended based on the evaluation. Actions to remediate the source(s) of soil vapor contamination, such as soil excavation or air-sparge/soil vapor extraction systems, are beyond the scope of this guidance and are not included.

3.1 Data quality

Before the data are evaluated, their representativeness and reliability should be verified. To assess analytical errors and the usability of the data, a qualified person should review the analytical data package and all associated QA/QC information to make sure that

a. the data package is complete;

b. holding times have been met;

c. the QC data fall within the protocol limits and specifications;

d. the data have been generated using established and agreed upon analytical protocols;

e. the raw data confirm the results provided in the data summary sheets and QC verification forms; and

f. correct data qualifiers have been used.

As discussed in Section 2.8, for sites in an environmental remediation program (e.g., State Superfund), a DUSR or equivalent report should be generated in accordance with NYSDEC guidance and should be submitted for regulatory review and approval.

If the investigation was not completed in accordance with the guidelines set forth in Section 2, additional investigation may be appropriate to either replace or complement the existing data. For example, product inventories [Section 2.11.2] filled out incompletely or incorrectly may need to be redone (and in some cases with additional air sampling) so that likely sources of volatile chemicals in the indoor air can be identified and appropriate actions to mitigate exposures can be recommended.

3.2 Overview

The results of individual soil vapor, sub-slab vapor, indoor air and outdoor air samples are not reviewed in isolation. Rather, they are evaluated with the consideration of several additional factors, which include the following:

a. the nature and extent of contamination in *all* environmental media;

b. factors that affect vapor migration and intrusion;

c. completed or proposed remedial actions;

d. sources of volatile chemicals;

e. background levels of volatile chemicals in air;

f. relevant standards, criteria and guidance values; and

g. past, current and future land uses.

These factors are described in detail in this subsection.

3.2.1 Nature and extent of contamination in all environmental media

The type of volatile chemicals present and the extent of contamination in all environmental media — including soil, groundwater, subsurface vapors, indoor air and outdoor air — is considered when evaluating the data. Trends in environmental data (e.g., groundwater monitoring results show concentrations of volatile chemicals are decreasing) are also considered. This information is used to identify possible sources of contamination and migration pathways, as well as to recommend appropriate actions to address exposures.

3.2.2 Factors that affect vapor migration and intrusion

As discussed in Section 1.3, there are numerous site-specific environmental factors [Table 1.1] and building factors [Table 1.2] that can affect soil vapor migration and intrusion. This information is used to identify possible sources of contamination and migration pathways, as well as to recommend appropriate actions to address exposures.

3.2.3 Sources of volatile chemicals

An understanding of the likely sources of the chemicals is crucial for determining appropriate actions to address exposure, as well as identifying the parties responsible for implementing the actions. Volatile chemicals that are not site-related may be present in the investigated media for reasons such as the following:

a. *subsurface vapors* — misuse, misapplication, or improper disposal of the chemicals to the subsurface, unidentified subsurface sources of vapor contamination, presence of septic systems (where products, such as cleaning agents or degreasers, may be disposed), biodegradation of natural organic matter in soil, infiltration into the subsurface from a building under positive pressure in which the chemicals are heavily used (i.e., reverse process from soil vapor intrusion), etc.;

b. *indoor air* — use and storage (current or historic) of volatile chemical-containing products, off-gassing from building materials or new furnishings, use of contaminated groundwater during private well usage, infiltration of outdoor air containing volatile chemicals, etc. [Table 1.3]; and

c. *outdoor air* — emissions from automobiles, lawn mowers, oil storage tanks, gasoline stations, dry cleaners or other commercial/industrial facilities, etc. [Table 1.3].

Site-related chemicals may also be present for these same reasons. Information about household products and their ingredients are available on web sites, such as the National Institute of Health's site at http://householdproducts.nlm.nih.gov.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

3.2.4 Background levels of volatile chemicals in air

Chemicals are part of our everyday life [Section 1.4]. As such, they are found in the indoor air of buildings not affected by intrusion of contaminated soil vapor. They are also found in the outdoor air that enters a home or place of business. Commonly found concentrations of these chemicals in indoor and outdoor air are referred to as "background levels." Background levels of volatile chemicals are one of the factors considered when evaluating sampling results at a site [Section 3.3.2 – 3.3.4]. Estimates of background levels come from studies where air samples were collected in homes, offices and outdoor areas.

Several studies have been conducted, both nationally and in the State of New York, to provide information on indoor and outdoor air background levels in a variety of settings (e.g., residential or commercial buildings). Each of these studies offers useful information and has its own limitations. Each database provides statistical measures of background levels and the criteria used to select sampling locations. The criteria in some of the studies required that sampling locations not be located near known sources of volatile chemicals (for example, not near a chemical spill, hazardous waste site, dry-cleaner, or factory). The criteria may also have included checking containers of volatile chemicals in or near the building to make sure they are tightly closed or removing those products before samples are taken. Depending on the criteria for site selection and sampling conditions, statistical measures of background levels in a given study may differ from what would be expected if indoor air were sampled in randomly selected homes.

The background databases that are used for evaluating indoor and outdoor air data are introduced below. A more detailed description of each database along with statistical measures of background levels are provided in Appendix C.

a. *NYSDOH 2003: Study of Volatile Organic Chemicals in Air of Fuel Oil Heated Homes*
   Results of indoor and outdoor air samples collected from 104 single-family fuel oil heated homes throughout New York State. Samples collected in evacuated canisters and analyzed for 69 aromatic, aliphatic, and halogenated hydrocarbons, and ketones by modified EPA Method TO-15. Limitations: only fuel oil heated homes were included, homes were not randomly selected, and five boroughs of New York City were excluded.

b. *EPA 2001: Building Assessment and Survey Evaluation (BASE) Database*
   Study of measured concentrations of volatile organic compounds from 100 randomly selected public and commercial office buildings. Samples collected by evacuated canisters and/or tube methodologies. Limitations: only represents office settings, two methodologies used for sampling and analysis that are not completely overlapping and do not show agreement in results in some cases.

c. *NYSDOH 1997: Control Home Database*
   Indoor and outdoor air samples compiled from 53 residences in New York State that were considered "control Homes" with neighborhood, construction, and occupancy similar to potentially impacted homes that were being investigated at the time. Limitations: multiple methodologies for sampling and analysis, small sample size, and varying detection limits often higher than current background levels.

d. *EPA 1988: National Ambient Volatile Organic Compounds (VOCs) Data Base Update*
   Published and unpublished air data compiled by the EPA in 1988. The document includes data from studies between 1970 to 1987. The database covers more than

300 chemicals in indoor and outdoor settings. Limitations: data are compiled from numerous studies with limitations on selection or screening criteria, data are 20-35 years old, indoor air data include both residential and office spaces, sample size for some analytes is very small (less than 10). Outdoor air data include rural, suburban, urban, source dominated and remote locations.

e. *Health Effects Institute (HEI) 2005: Relationship of Indoor, Outdoor, and Personal Air (RIOPA)*

Indoor, outdoor and personal air concentrations of 18 VOCs, 10 carbonyl compounds and particulate matter (PM2.5) were measured in 100 homes in each of 3 cities between the summer of 1999 and the spring of 2001. Limitations: limited numbers of VOCs, passive organic vapor badge method is subject to sampling bias in stationary versus mobile locations, the passive organic vapor badge method is only approved for tetrachloroethene in New York State.

Among the databases, the Upper Fence (see *NOTE below) values from the NYSDOH Fuel Oil Study data may be used as initial benchmarks when evaluating residential indoor air (see Appendix C.1) and the 90th percentile values from the EPA BASE data for indoor air in office and commercial buildings (see Appendix C.2). These initial benchmark values should be considered along with the overall distribution of results in the background database to characterize sampling results from a single building or from multiple buildings in a community. The Health Effects Institute 2005 database and the older NYSDOH and EPA databases can also provide useful information on the range of concentrations found in air. The database or combination of databases that best represents site-specific conditions should be used as the basis for comparison. State agency personnel should review and have the opportunity to comment on the proposed use of other databases or subsets of data within a database for evaluating test results.

*NOTE: The Upper Fence is calculated as 1.5 times the interquartile range (difference between the 25th and 75th percentile values) above the 75th percentile value. It is a boundary estimate used to account for outliers in the data.

3.2.5 Relevant standards, criteria and guidance values

a. *Subsurface vapors*

The State of New York does not have any standards, criteria or guidance values for concentrations of volatile chemicals in subsurface vapors (either soil vapor or sub-slab vapor).

b. *Indoor and outdoor air*

The NYSDOH has developed several guidelines for chemicals in air. The development process is initiated for specific situations. For example, in New York State, particularly in New York City, dry cleaners are often located in apartment buildings. Because air in buildings mixes to some extent and the dry cleaning chemical tetrachloroethene (PCE) is volatile, it may migrate to residential apartments. When the NYSDOH became aware of this problem and how widespread it is, the NYSDOH developed an air guideline for PCE of 100 micrograms per cubic meter (mcg/m^3). In addition to PCE, the NYSDOH has developed guidelines for methylene chloride (also referred to as dichloromethane) and trichloroethene (TCE) in air, as well as dioxin and polychlorinated biphenyls (PCBs) in indoor air. Each guideline went through a peer review process, in which expert scientists outside of the NYSDOH reviewed the technical documentation that describes the scientific basis for the guidance value. The peer reviewers provided technical comments on the data and methods used to derive the guidelines, each of which were addressed by the NYSDOH. Upon completion of the reviews and responses to comments, the guidelines were finalized.

Air guideline values derived by the NYSDOH are summarized in Table 3.1. Additional information about these guidelines is provided in the following:

- Appendix D — overview of how the NYSDOH develops air guidelines; and
- Appendix H — copies of fact sheets that discuss the air guidelines for PCE and TCE.

The purpose of a guideline is to help guide decisions about the nature of efforts to reduce exposure to the chemical. Reasonable and practical actions should be taken to reduce exposures when indoor air levels are above background, even when they are below the guideline. The urgency to complete these actions increases with indoor air levels, particularly when air levels are above the guideline, and additional actions taken if the initial actions do not sufficiently reduce levels. In all cases, the specific corrective actions to be taken depend on a case-by-case evaluation of the situation. The goal of the recommended actions is to reduce chemical levels in indoor air to as close to background as practical.

Table 3.1 Air guideline values derived by the NYSDOH

Chemical		Air Guideline Value (mcg/m^3)	Reference
methylene chloride (also referred to as dichloromethane)	MeCl	60	1
polychlorinated biphenyls	PCBs	1*	2,3
tetrachlorodibenzo-*p*-dioxin equivalents	TCDD	0.00001*	3,4
tetrachloroethene	PCE	100	5
trichloroethene	TCE	5	6,7

*The guideline is specific to indoor air.

References:

[1] NYSDOH. 1988. Letter from N. Kim to T. Allen, Division of Air, New York State Department of Environmental Conservation. November 28, 1988.
[2] NYSDOH. 1985. Binghamton State Office Building (BSOB) Re-Entry Guidelines: PCBs. Document 1330P. Albany, NY: Bureau of Toxic Substance Assessment.
[3] NYSDOH. 1988. Letter from D. Axelrod to J. Egan, New York State Office of General Services. March 8, 1988.
[4] NYSDOH. 1984. Re-Entry Guidelines. Binghamton State Office Building. Document 0549P. Albany, NY: Bureau of Toxic Substance Assessment.
[5] NYSDOH. 1997. Tetrachloroethene Ambient Air Criteria Document. Albany, NY: Bureau of Toxic Substance Assessment.
[6] NYSDOH. 2003. Letter from N. Kim to D. Desnoyers, Division of Environmental Remediation, New York State Department of Environmental Conservation. October 31, 2003. [Provided in Appendix D.]
[7] NYSDOH. 2006. Final Report: Trichloroethene (TCE) Air Criteria Document. Center for Environmental Health, Bureau of Toxic Substance Assessment. Troy, NY.

3.2.6 Completed or proposed remedial actions

The status and effectiveness of actions taken to remediate environmental contamination (e.g., soil removal, groundwater treatment, soil vapor extraction, etc.) are considered when making decisions pertaining to additional sampling and the selection of mitigation actions. For example,

a. if a comparison of pre-remediation and post-remediation subsurface vapor sampling results indicates negligible improvement in the quality of subsurface vapors,

    1. additional sampling may be appropriate to document a decreasing trend in subsurface vapor concentrations;

    2. termination of mitigation system operations may not be appropriate without additional sampling; or

    3. additional remedial actions may be appropriate to address contaminated subsurface vapors;

b. when monitoring a building is appropriate, it may be more cost-effective to install a mitigation system if subsurface contamination is wide-spread and is expected to take many years to remediate; and

c. if exposures in an on-site building will be addressed concurrently by a method selected to remediate subsurface contamination (e.g., a soil vapor extraction system), installation of a mitigation system may be redundant. However, if the remedial system is not expected to be operational in the immediate future, or if it is not expected to mitigate indoor air levels in a reasonable time frame, a mitigation system may still be appropriate. [Refer to Section 4.1 for a description of the appropriate use of concurrent techniques.]

3.2.7 Past, current and future land uses

Past, current and future land uses are considered when evaluating the investigation data and determining appropriate actions for further investigation or measures to address exposures. For example,

a. if the parcel or buildings were historically used for commercial or industrial purposes (e.g., gasoline station, automotive repair facility, electroplating facility, etc.), but are currently used for residential purposes or commercial or industrial purposes where volatile chemicals are not used in current operations, off-gassing of volatile chemicals from building materials [Table 1.3] or additional subsurface sources should be considered;

b. subsurface vapor sampling of a parcel that is undeveloped or contains unoccupied buildings may be appropriate based on the data evaluation. However, sampling may be delayed as discussed in Section 2.3;

c. air sampling of a building may be appropriate based on the data evaluation. However, provisions may be put in place to defer sampling until occupancy of the building is expected; or

d. if actions should be taken to mitigate exposures related to soil vapor intrusion should the site be developed, the appropriate mitigation method will depend upon the proposed land use — a parking lot, recreational field, single-family home, commercial building, high-rise building with underground parking, occupied or unoccupied building, etc. — since each presents a different exposure scenario.

3.3 Sampling results and recommended actions

This subsection describes the process for evaluating sampling results. It also describes actions that may be recommended based on the evaluation. The evaluation procedures and actions described may not be directly applicable to samples collected as part of an emergency response. For guidance on how to proceed in such situations, refer to Section 3.5.

3.3.1 Soil vapor

If soil vapor samples are collected from locations where there are no known sources of volatile chemicals, we do not expect the chemicals to reach detectable levels in the samples. However, concentrations of volatile chemicals in soil vapor are commonly detected. This is likely due to several factors, including infiltration of outdoor air into the subsurface (to a limited extent) and background interferences (similar to indoor and outdoor air [Section 3.2.4]).

New York State currently does not have any standards, criteria or guidance values for concentrations of compounds in soil vapor. Additionally, there are currently no databases available of background levels of volatile chemicals in soil vapor. In the absence of this information, soil vapor sampling results are reviewed "as a whole," in conjunction with the results of other environmental sampling and the site conceptual model, to identify trends and spatial variations in the data [Section 3.2.1]. To put some perspective on the data, soil vapor results might be compared to background outdoor air levels [Section 3.2.4], site-related outdoor air sampling results, or the NYSDOH's guidelines for volatile chemicals in air [Table 3.1].

These comparisons are used to

a. identify areas of relatively elevated concentrations of volatile chemicals in soil vapor;
b. select buildings for sub-slab vapor, indoor air and outdoor air sampling;
c. identify possible sources of subsurface vapor contamination;
d. monitor the progress, or verify the completion, of efforts to remediate subsurface vapor contamination (either directly or indirectly); and
e. characterize the nature and extent of subsurface vapor contamination.

When determining appropriate actions, the following should also be considered:

a. Soil vapor results may not indicate a traditional plume-like pattern of contamination (as is often described for groundwater). Rather, the nature and extent of contamination may follow a "hit and miss" pattern.

b. Our experience to date indicates soil vapor results alone typically cannot be relied upon to rule out sampling at nearby buildings. For example, concentrations of volatile chemicals in sub-slab vapor samples have been substantially higher (e.g., by a factor of 100 or more) than concentrations found in nearby soil vapor samples (e.g., collected at 8 feet below grade near the building). This may be due to differences in factors such as soil moisture content and pressure gradients. Therefore, exposures are evaluated primarily based on sub-slab vapor, indoor air and outdoor air sampling results and soil vapor results are primarily used as a tool to guide these investigations.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

There are no concentrations of volatile chemicals in soil vapor that automatically trigger action or no further action. Based on the comparisons and considerations described, the following actions may be recommended:

a. *No further soil vapor sampling*

The nature and extent of subsurface vapor contamination has been adequately characterized with respect to addressing exposures and designing measures to remediate subsurface vapor contamination (either directly or indirectly).

Sub-slab vapor samples, rather than soil vapor samples, will be used to identify potential exposures and to characterize the nature and extent of subsurface vapor contamination since soil vapor results are not following a consistent pattern (i.e., hit and miss).

b. *Additional soil vapor sampling*

To characterize the nature and extent of subsurface vapor contamination if soil vapor results are following a consistent pattern (e.g., traditional plume-like pattern).

To identify possible sources of subsurface vapor contamination.

To verify sampling results that appear inconsistent with previous sampling and/or the current understanding of the site [Sections 3.2.1 and 3.2.2].

To resample locations where results may have been invalidated by short-circuiting (outdoor air infiltration), cross contamination, or other problems.

To monitor the progress, or verify the completion, of efforts to remediate subsurface vapor contamination (either directly or indirectly).

c. *Sub-slab vapor, indoor air and outdoor air sampling*

Generally, if soil vapor results are fairly consistent throughout the study area, buildings closest to the site are sampled first. The investigation then proceeds outward, as appropriate, on an areal basis until potential and current human exposures have been adequately addressed. If there is an area of relatively elevated concentrations of volatile chemicals in soil vapor (when looking at the soil vapor results as a whole), then the buildings in this area are also sampled.

d. *Address exposures related to soil vapor intrusion*

Provisions on parcels may be appropriate so that the parcel will not be developed or buildings occupied without addressing exposure concerns [Sections 2.3 and 3.6].

As discussed previously, soil vapor sampling results alone typically do not drive actions to mitigate exposures in existing buildings. Rather, they guide sampling efforts in buildings. However, a "blanket mitigation" approach may be taken provided the nature and extent of soil vapor contamination has been sufficiently characterized. A "blanket mitigation" approach is where an area is defined within which each building may be offered a mitigation system. The offer is made regardless of what actions may be appropriate based on an evaluation of air results (e.g., no further action or monitoring).

Notes:

a. The recommended actions may be modified or supported upon consideration of the factors given in Section 3.2.

b. Additional sampling may become appropriate based on the migration of subsurface contamination (e.g., contaminated groundwater or vapors) or if environmental monitoring indicates a change in chemical constituents (e.g., the production of degradation products that may be more toxic than the parent compounds).

3.3.2 Sub-slab vapor

The goals of collecting sub-slab vapor samples are to identify potential and current (when collected concurrently with indoor and outdoor air samples) exposures associated with soil vapor intrusion and to characterize the nature and extent of subsurface vapor contamination. As discussed in Sections 3.2.5 and 3.3.1, New York State currently does not have any standards, criteria or guidance values for concentrations of compounds in sub-slab vapor. Additionally, there are no databases available of background levels of volatile chemicals in subsurface vapors.

The detection of volatile chemicals in sub-slab vapor samples does not necessarily indicate soil vapor intrusion is occurring or actions should be taken to address exposures. When making these decisions, the State considers the following:

a. the sampling results — sub-slab vapor, indoor air, outdoor air, soil vapor;

b. background concentrations of volatile chemicals in indoor air;

c. the NYSDOH's guidelines for volatile chemicals in air [Table 3.1];

d. human health risks (i.e., cancer and non-cancer health effects) associated with exposure to the volatile chemical in air;

e. attenuation factors (i.e., the ratio of indoor air to sub-slab vapor concentrations),

f. the NYSDOH's decision matrices [described in Section 3.4], and

g. the factors described in Section 3.2.

Based on this evaluation, the following actions may be recommended:

a. *No further action*

   When the volatile chemical is not detected in the indoor air and sub-slab sample results are not expected to substantially affect indoor air quality.

b. *Take reasonable and practical actions to identify source(s) and reduce exposures*

   The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile organic compound-containing products in places where people do not spend much time, such as a garage or outdoor shed). Resampling may be recommended to demonstrate the effectiveness of actions taken to reduce exposures.

c. *Resampling*

Resampling may also be recommended when the results are not consistent with the conceptual site model. For example, when the sub-slab vapor results of a building do not indicate a need to take action, but the sub-slab vapor results of adjacent buildings indicate a need to take actions to address exposures related to soil vapor intrusion.

Resampling may be appropriate if samples were collected outside of the heating season. As discussed in Section 2.4.2, results obtained outside of the heating season should not be used to rule out exposures related to soil vapor intrusion.

d. *Monitoring*

Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, may be recommended to determine whether concentrations in indoor air or sub-slab vapor have changed. It is also recommended to determine what affect, if any, active soil and groundwater remediation techniques (e.g., chemical oxidation, air sparging, etc.) may be having on subsurface vapor and indoor air quality. The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions.

e. *Mitigate*

Mitigation may be appropriate to minimize current or potential exposures associated with soil vapor intrusion. Mitigation methods are described in Section 4.

Notes:

a. The recommended actions may be modified or supported upon consideration of the factors given in Section 3.2.

b. Additional sampling may be appropriate based on the migration of subsurface contamination (e.g., contaminated groundwater or vapors) or if environmental monitoring indicates a change in chemical constituents (e.g., the production of degradation products that may be more toxic than the parent compounds).

c. Monitoring and mitigation measures to address exposures related to soil vapor intrusion are considered interim measures implemented until contaminated environmental media (e.g., soil, groundwater and/or soil vapor) are remediated.

d. Actions more protective of human health may be proposed. For example, such a decision may be based on a comparison of the costs associated with resampling or monitoring to the costs associated with installation and monitoring of a mitigation system.

e. Additional sampling associated with post-mitigation testing, operation, maintenance and monitoring activities, and termination of mitigation system operations is described in Section 4.

3.3.3 Indoor air

Indoor air samples are used to assess current exposures to volatile chemicals in air. The detection of volatile chemicals in indoor air samples does not necessarily indicate soil vapor intrusion is occurring or actions should be taken to address exposures. When making these decisions, the State considers the following:

a. the sampling results — sub-slab vapor, indoor air, outdoor air, soil vapor;

b. background concentrations of volatile chemicals in indoor air;

c. the NYSDOH's guidelines for volatile chemicals in air [Table 3.1];

d. human health risks (i.e., cancer and non-cancer health effects) associated with exposure to the volatile chemical in air;

e. attenuation factors (i.e., the ratio of indoor air to sub-slab vapor concentrations), and

f. the NYSDOH's decision matrices [described in Section 3.4], and

g. the factors described in Section 3.2.

When evaluating indoor air data, the results are compared to background levels of volatile chemicals in indoor air [Section 3.2.4], the NYSDOH's guidelines for volatile chemicals in air [Table 3.1], the NYSDOH's decision matrices [Section 3.4], and human health risks (i.e., cancer and non-cancer health effects) associated with exposure to the volatile chemical in air. This helps to put the results into perspective and to determine the need for action and the urgency with which actions should be taken. As discussed in Section 3.2.5, the urgency to complete reasonable and practical actions to reduce exposures increases with indoor air levels, particularly when air levels are above a guideline.

Generally, if the results are comparable to background levels, then no further action is needed to address *current* human exposures. However, additional sampling may be appropriate if

a. samples were collected at times when vapor intrusion is not expected to have its greatest effect on indoor air quality (typically, samples collected outside of the heating season). As discussed in Section 2.4, these results may not be used to rule out exposures related to soil vapor intrusion;

b. the potential for exposures related to soil vapor intrusion should be monitored based on the sub-slab vapor results [Section 3.3.2]; and/or

c. subsurface conditions change over time (e.g., due to the migration of contaminated groundwater or vapors).

If the concentrations of volatile chemicals are not consistent with background levels, then the likely cause of the exposure should be determined. Understanding the source is crucial for selecting the best method to address exposures. For example, although a volatile chemical may be detected in the sub-slab vapor sample, the results may indicate that indoor air effects are more likely to be coming from products stored in the building or from outdoor air rather than from contaminated soil vapors. Therefore, a sub-slab depressurization system to minimize exposures associated with soil vapor intrusion may not be appropriate.

As discussed in Sections 1.4 and 3.2.3, volatile chemicals may be present in the indoor air due to any one, or a combination, of the following:

a. the indoor environment itself and/or building characteristics;

b. off-gassing of volatile chemicals from contaminated water that may enter the building at the tap or shower head, or during flooding events, or contaminated water that rests in a sump or a subsurface drain;

c. outdoor sources; and/or

d. migration from the subsurface (i.e., soil vapor intrusion).

To determine the likely cause, the following assessment is completed:

a. qualitative and quantitative comparisons are made between the types and concentrations of the contaminants found in the indoor air sample(s) and those found in the outdoor air and sub-slab vapor sample;

b. qualitative and quantitative comparisons are made between indoor air results obtained in different locations of the building (e.g., different floors or rooms);

c. indoor air results are compared to the product inventory to evaluate the extent to which indoor sources are affecting indoor air quality; and

d. the indoor air quality questionnaire and building inventory form is reviewed to identify potential preferential pathways for soil vapor intrusion into the building, potential outdoor sources of volatile chemicals to the outdoor air (e.g., gasoline station or dry cleaner), and routes of air distribution within the building (e.g., HVAC system operations, airflow observations, etc.).

If a likely source or multiple sources can be identified from the available information, one or more of the following actions may be recommended given the source:

a. *Indoor source or building characteristics*

   Products containing volatile chemicals should be tightly capped. Alternatively, the products can be stored in places where people do not spend much time, such as a garage or outdoor shed. If the products are no longer needed, consideration should be given to disposing of them properly (e.g., hazardous waste cleanup days). The list of products and corresponding readings from field instrumentation provided in the product inventory [Appendix B] can help identify products that may be contributing to the levels that were detected in the indoor air.

   If exposures are assumed to be associated with off-gassing of new building materials, paint, etc., resampling may be appropriate to confirm this assumption or to confirm that actions taken to address these exposures have been effective.

b. *Off-gassing from contaminated groundwater within the building*

   Measures should be taken to prevent contaminated groundwater from entering the house (e.g., filter on private well supply, sealed sump, etc.).

c. *Outdoor source*

   No further action to address exposures related to soil vapor intrusion, unless the evaluation for soil vapor intrusion cannot be completed until outdoor interferences are addressed.

d. *Soil vapor intrusion*

Depending upon the relationship between indoor air concentrations and sub-slab vapor concentrations and the results of environmental sampling in the area, resampling, monitoring or mitigation may be recommended by the State.

1. Resampling, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, may be recommended when the results are not consistent with the conceptual site model. For example, when indoor air results are comparable or higher than the corresponding sub-slab vapor results and the results do not appear to be due to building characteristics or alternate sources (either indoor or outdoor).

2. Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, may be recommended to determine whether concentrations in indoor air or sub-slab vapor have changed. It is also recommended to determine what affect, if any, active soil and groundwater remediation techniques (e.g., chemical oxidation, air sparging, etc.) may be having on subsurface vapor and indoor air quality. The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions.

3. Methods to mitigate exposures related to soil vapor intrusion are described in Section 4.

The party responsible for implementing the recommended actions will differ depending upon several factors, including the identified source of the volatile chemicals, the environmental remediation program, and site-specific and building-specific conditions. For example, to the extent that all site data and site conditions demonstrate that soil vapor intrusion is not occurring and that the potential for soil vapor intrusion to occur is not likely, the vapor intrusion investigation would be considered complete. In general, if indoor exposures represent a concern due to indoor sources, then the State will provide guidance to the property owner and/or tenant on ways to reduce their exposure. If indoor exposures represent a concern due to outdoor sources, then the NYSDEC will decide who is responsible for further investigation and any necessary remediation. Depending upon the outdoor source, this responsibility may or may not fall upon the party conducting the soil vapor intrusion investigation.

Likely sources may not be evident given the information available. Therefore, the above recommendations cannot be made. This situation most often arises for the following reasons:

a. Interfering indoor sources are identified. However, the possibility of vapor intrusion cannot be ruled out due to the concentrations of the same volatile chemicals detected in the sub-slab vapor sample. Differentiating the contribution of each source is not possible.

b. Indoor air samples were collected without concurrent outdoor air and sub-slab vapor samples. Depending upon other information that may be available (e.g., building inventory and well-characterized subsurface vapor contamination), identifying likely sources and recommending appropriate actions may not be possible.

c. All appropriate air samples are collected. However, the indoor air quality questionnaire and building inventory forms are filled out incompletely or incorrectly. The contribution of indoor sources cannot be evaluated.

When the source(s) of volatile chemicals to indoor air cannot be identified with confidence, resampling is typically recommended with corrections made as appropriate. For example, using the three scenarios presented above:

a. resampling occurs after interferences are removed;

b. concurrent indoor air, outdoor air and sub-slab vapor samples are collected; and

c. an indoor air quality questionnaire and building inventory form is filled out completely and correctly when samples are collected.

Notes: See notes presented in Section 3.3.2.

3.3.4 <u>Outdoor air</u>

Outdoor air sampling results are primarily used to evaluate the extent to which outdoor air may be contributing to the levels of volatile chemicals detected in indoor air. However, people are also exposed to the outdoor air and the outdoor air results are indicative of outdoor air conditions. As such, outdoor air results are also reviewed to determine whether outdoor air conditions present a potential concern that requires further investigation.

As discussed in Sections 1.4 and 3.2.3, volatile chemicals may be present in outdoor air due to emissions from automobiles, lawn mowers, oil storage tanks, gasoline stations, and dry cleaners or other commercial and industrial facilities. To determine what extent, if any, outdoor air is affecting indoor air quality, indoor air results are compared to outdoor air results. To determine whether outdoor air conditions present a potential concern that requires further investigation, the State looks at the data set as a whole and considers the following:

a. background concentrations of volatile chemicals in outdoor air;

b. the NYSDOH's guidelines for volatile chemicals in air [Table 3.1];

c. human health risks (i.e., cancer and non-cancer health effects) associated with exposure to the volatile chemical in air; and

d. the factors described in Section 3.2.

3.4 Decision matrices

3.4.1 <u>Overview</u>

Decision matrices are risk management tools, developed by the NYSDOH in conjunction with other agencies, to provide guidance on a case-by-case basis about actions that should be taken to address current and potential exposures related to soil vapor intrusion. The matrices are intended to be used when evaluating the results from buildings with full slab foundations. The matrices encapsulate the data evaluation processes and actions recommended to address exposures discussed in Sections 3.3.2 and 3.3.3. The general format of a decision matrix is shown in Table 3.2.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Table 3.2 General format of a decision matrix

	Indoor Air Concentration of Volatile Chemical (mcg/m³)		
Sub-slab Vapor Concentration of Volatile Chemical (mcg/m³)	Concentration Range 1	Concentration Range 2	Concentration Range 3
Concentration Range 1	ACTION	ACTION	ACTION
Concentration Range 2	ACTION	ACTION	ACTION
Concentration Range 3	ACTION	ACTION	ACTION

Indoor air and sub-slab vapor concentration ranges in a matrix are selected based on a number of considerations in addition to health risks. For example, factors that are considered when selecting the ranges include, but are not limited to, the following:

a. human health risks (i.e., cancer and non-cancer health effects) associated with exposure to the volatile chemical in air;
b. the NYSDOH's guidelines for volatile chemicals in air [Table 3.1];
c. background concentrations of volatile chemicals in air [Section 3.2.4];
d. analytical capabilities currently available; and
e. attenuation factors (i.e., the ratio of indoor air to sub-slab vapor concentrations).

3.4.2 Matrices

The NYSDOH has developed two matrices, which are included at the end of Section 3.4, to use as tools in making decisions when soil vapor may be entering buildings. The first decision matrix was originally developed for TCE and the second for PCE. As summarized in Table 3.3, four chemicals have been assigned to the two matrices to date.

Table 3.3 Volatile chemicals and their decision matrices

Chemical	**Soil Vapor/Indoor Air Matrix***
Carbon tetrachloride	Matrix 1
Tetrachloroethene (PCE)	Matrix 2
1,1,1-Trichloroethane (1,1,1-TCA)	Matrix 2
Trichloroethene (TCE)	Matrix 1

*The decision matrices are available at the end of Section 3.4.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Because the matrices are risk management tools and consider a number of factors, the NYSDOH intends to assign chemicals to one of these two matrices, if possible. For example, if a chemical other than those already assigned to a matrix is identified as a chemical of concern during a soil vapor intrusion investigation, assignment of that chemical into one of the existing decision matrices will be considered by the NYSDOH. Factors that will be considered in assigning a chemical to a matrix include, but are not limited to, the following:

a. human health risks, including such factors as a chemical's ability to cause cancer, reproductive, developmental, liver, kidney, nervous system, immune system or other effects, in animals and humans and the doses that may cause those effects;

b. the data gaps in its toxicologic database;

c. background concentrations of volatile chemicals in indoor air [Section 3.2.4]; and

d. analytical capabilities currently available.

If the NYSDOH determines that the assignment of the chemical into an existing matrix is inappropriate, then the NYSDOH will either modify an existing matrix or develop a new matrix.

To use the matrices appropriately as a tool in the decision-making process, the following should be considered:

a. The matrices are generic. As such, it may be appropriate to modify a recommended action to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, resampling may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Additionally, actions more protective of public health than those specified within the matrix may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action is usually undertaken for reasons other than public health (e.g., seeking community acceptance, reducing excessive costs, etc.).

b. Indoor air concentrations detected in samples collected from the building's basement or, if the building has a slab-on-grade foundation, from the building's lowest occupied living space should be used.

c. Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of vapor contamination, nor does it preclude remediating contaminated soil vapors or the source of soil vapor contamination.

d. When current exposures are attributed to sources other than vapor intrusion, the agencies should be provided documentation(e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix and to support assessment and follow-up by the agencies.

3.4.3 Description of recommended actions

Actions recommended in the matrix are based on the relationship between sub-slab vapor concentrations and corresponding indoor air concentrations. They are intended to address both potential and current human exposures and include the following:

a. *No further action*

When the volatile chemical is not detected in the indoor air sample and the concentration detected in the corresponding sub-slab vapor sample is not expected to substantially affect indoor air quality.

b. *Take reasonable and practical actions to identify source(s) and reduce exposures*

The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile chemical-containing products in places where people do not spend much time, such as a garage or shed). Resampling may also be recommended to demonstrate the effectiveness of actions taken to reduce exposures.

d. *Monitor*

Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, is appropriate to determine whether concentrations in the indoor air or sub-slab vapor have changed. Monitoring may also be appropriate to determine whether existing building conditions (e.g., positive pressure HVAC systems) are maintaining the desired mitigation endpoint and to determine whether changes are appropriate.

The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions.

e. *Mitigate*

Mitigation is appropriate to minimize current or potential exposures associated with soil vapor intrusion. Methods to mitigate exposures related to soil vapor intrusion are described in Section 4.

f. *Monitor / Mitigate*

Monitoring or mitigation may be recommended after considering the magnitude of sub-slab vapor and indoor air concentrations along with building- and site-specific conditions.

NOTE: Updates to this final guidance are available at http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Soil Vapor/Indoor Air Matrix 1

October 2006

	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m³)			
SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m³)	< 0.25	0.25 to < 1	1 to < 5.0	5.0 and above
< 5	1. No further action	2. Take reasonable and practical actions to identify source(s) and reduce exposures	3. Take reasonable and practical actions to identify source(s) and reduce exposures	4. Take reasonable and practical actions to identify source(s) and reduce exposures
5 to < 50	5. No further action	6. MONITOR	7. MONITOR	8. MITIGATE
50 to < 250	9. MONITOR	10. MONITOR / MITIGATE	11. MITIGATE	12. MITIGATE
250 and above	13. MITIGATE	14. MITIGATE	15. MITIGATE	16. MITIGATE

No further action:
Given that the compound was not detected in the indoor air sample and that the concentration detected in the sub-slab vapor sample is not expected to significantly affect indoor air quality, no additional actions are needed to address human exposures.

Take reasonable and practical actions to identify source(s) and reduce exposures:
The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile organic compound-containing products in places where people do not spend much time, such as a garage or outdoor shed). Resampling may be recommended to demonstrate the effectiveness of actions taken to reduce exposures.

MONITOR:
Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, is needed to determine whether concentrations in the indoor air or sub-slab vapor have changed. Monitoring may also be needed to determine whether existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

MITIGATE:
Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system, and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

MONITOR / MITIGATE:
Monitoring or mitigation may be recommended after considering the magnitude of sub-slab vapor and indoor air concentrations along with building- and site-specific conditions.

See additional notes on page 2.

ADDITIONAL NOTES FOR MATRIX 1

This matrix summarizes the minimum actions recommended to address current and potential exposures related to soil vapor intrusion. To use the matrix appropriately as a tool in the decision-making process, the following should be noted:

[1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, resampling may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Additionally, actions more protective of public health than those specified within the matrix may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action is usually undertaken for reasons other than public health (e.g., seeking community acceptance, reducing excessive costs, etc.).

[2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of vapor contamination, nor does it preclude remediating contaminated soil vapors or the source of soil vapor contamination.

[3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 0.25 microgram per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples, a minimum reporting limit of 5 micrograms per cubic meter is recommended for buildings with full slab foundations, and 1 microgram per cubic meter for buildings with less than a full slab foundation.

[4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion to occur is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions may be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.

[5] When current exposures are attributed to sources other than soil vapor intrusion, the agencies should be given documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.

[6] The party responsible for implementing the recommended actions will differ depending upon several factors, including the identified source of the volatile chemicals, the environmental remediation program, and site-specific and building-specific conditions. For example, to the extent that all site data and site conditions demonstrate that soil vapor intrusion is not occurring and that the potential for soil vapor intrusion to occur is not likely, the soil vapor intrusion investigation would be considered complete. In general, if indoor exposures represent a concern due to indoor sources, then the State will provide guidance to the property owner and/or tenant on ways to reduce their exposure. If indoor exposures represent a concern due to outdoor sources, then the NYSDEC will decide who is responsible for further investigation and any necessary remediation. Depending upon the outdoor source, this responsibility may or may not fall upon the party conducting the soil vapor intrusion investigation.

NOTE: Updates to this final guidance are available at http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Soil Vapor/Indoor Air Matrix 2

October 2006

	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m^3)			
SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m^3)	< 3	3 to < 30	30 to < 100	100 and above
< 100	1. No further action	2. Take reasonable and practical actions to identify source(s) and reduce exposures	3. Take reasonable and practical actions to identify source(s) and reduce exposures	4. Take reasonable and practical actions to identify source(s) and reduce exposures
100 to < 1,000	5. MONITOR	6. MONITOR / MITIGATE	7. MITIGATE	8. MITIGATE
1,000 and above	9. MITIGATE	10. MITIGATE	11. MITIGATE	12. MITIGATE

No further action:
Given that the compound was not detected in the indoor air sample and that the concentration detected in the sub-slab vapor sample is not expected to significantly affect indoor air quality, no additional actions are needed to address human exposures.

Take reasonable and practical actions to identify source(s) and reduce exposures:
The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile organic compound-containing products in places where people do not spend much time, such as a garage or outdoor shed). Resampling may be recommended to demonstrate the effectiveness of actions taken to reduce exposures.

MONITOR:
Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, is needed to determine whether concentrations in the indoor air or sub-slab vapor have changed. Monitoring may also be needed to determine whether existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

MITIGATE:
Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system, and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

MONITOR / MITIGATE:
Monitoring or mitigation may be recommended after considering the magnitude of sub-slab vapor and indoor air concentrations along with building- and site-specific conditions.

See additional notes on page 2.

ADDITIONAL NOTES FOR MATRIX 2

This matrix summarizes the minimum actions recommended to address current and potential exposures related to soil vapor intrusion. To use the matrix appropriately as a tool in the decision-making process, the following should be noted:

[1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, resampling may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Additionally, actions more protective of public health than those specified within the matrix may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action is usually undertaken for reasons other than public health (e.g., seeking community acceptance, reducing excessive costs, etc.).

[2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of vapor contamination, nor does it preclude remediating contaminated soil vapors or the source of soil vapor contamination.

[3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 3 micrograms per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples, a minimum reporting limit of 5 micrograms per cubic meter is recommended.

[4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion to occur is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions may be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.

[5] When current exposures are attributed to sources other than soil vapor intrusion, the agencies should be given documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.

[6] The party responsible for implementing the recommended actions will differ depending upon several factors, including the identified source of the volatile chemicals, the environmental remediation program, and site-specific and building-specific conditions. For example, to the extent that all site data and site conditions demonstrate that soil vapor intrusion is not occurring and that the potential for soil vapor intrusion to occur is not likely, the soil vapor intrusion investigation would be considered complete. In general, if indoor exposures represent a concern due to indoor sources, then the State will provide guidance to the property owner and/or tenant on ways to reduce their exposure. If indoor exposures represent a concern due to outdoor sources, then the NYSDEC will decide who is responsible for further investigation and any necessary remediation. Depending upon the outdoor source, this responsibility may or may not fall upon the party conducting the soil vapor intrusion investigation.

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http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

3.5 Emergency response

The NYSDOH's staff are responsible for recommending that residents relocate in cases where there may be health risks resulting from exposure to petroleum spills. These roles and responsibilities are outlined in Environmental Health Manual Technical Reference and Procedural Items BTSA-01. Air sampling is appropriate in some cases for demonstrating that spill cleanup and engineering controls have been effective in reducing indoor air impacts and associated health risks to residents. At a minimum, air samples are collected from the basement, first floor and from outdoors. Whether sub-slab or soil gas samples will be taken is evaluated on a case-by-case basis. Air testing data are sometimes used as the basis for ending emergency relocation financial support. For additional information, please contact the NYSDOH's Bureau of Toxic Substance Assessment by calling 1-800-458-1158.

Emergency actions not related to petroleum spills are handled on a case-by-case basis.

3.6 Parcels that are undeveloped or contain unoccupied buildings

If investigation of a parcel that is undeveloped or contains unoccupied buildings is being delayed until the site is being developed or occupied, measures should be in place that assure the State that no development or occupation will occur without addressing the exposures. Institutional controls may be used for this purpose. An institutional control is any non-physical means of enforcing a restriction on the use of real property that

a. limits human or environmental exposure,
b. provides notice to potential owners, operators or members of the public, or
c. prevents actions that would interfere with the effectiveness of remedial actions or with the effectiveness and/or integrity of operation, maintenance or monitoring activities at a site.

An institutional control that is often used is an environmental easement. An environmental easement is an enforced mechanism used for property where the remedial actions leave residual contamination that makes the property suitable for some, but not all uses, or includes engineering controls that must be maintained for the easement to be effective. The purpose of the easement is to ensure that such use restrictions or engineering controls remain in place. An environmental easement

a. can only be created by the property owner (the *grantor*) through a written instrument recorded in the appropriate county recording office. It can only be granted to the State (the *grantee*) and can only be extinguished or amended by a written instrument executed by the Commissioner of the Department of Environmental Conservation and duly recorded;
b. is binding upon all subsequent owners and occupants of the property. The deed or deeds for the property (as well as any other written instruments conveying any interest in the property) must contain a prominent notice that it is subject to an environmental easement; and
c. may be enforced in perpetuity against the *grantor*, subsequent owners of the property, lessees, and any person using the property by its grantor, by the State, or by the municipality in which the property is located.

If these actions cannot be implemented, alternative measures should be in place that assure the State that the parcel will not be developed or buildings occupied without addressing the exposure concerns. For example, arrangements should be made for the town, village or city to notify the appropriate party when new construction or tenants are proposed for the parcel (e.g., permit applications and grants) or ownership of the parcel changes.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Section 4: Soil Vapor Intrusion Mitigation

As discussed in Section 1.1, soil vapor can enter a building through cracks or perforations in slabs or basement floors and walls, and through openings around sump pumps or where pipes and electrical wires go through the foundation primarily because of a difference between interior and exterior pressures. This intrusion is similar to how radon gas enters buildings from the subsurface. Fortunately, given this similarity, well-established techniques for mitigating exposures to radon may also be used to mitigate exposures related to soil vapor intrusion.

Once it is determined that steps should to be taken to address exposures associated with soil vapor intrusion, they should be implemented with all due expediency. This section provides an overview of:

a. methods of mitigation,

b. installation and design of mitigation systems,

c. post-mitigation testing,

d. operation, maintenance and monitoring of mitigation systems,

e. termination of mitigation system operations, and

f. annual certification.

Mitigation is considered to be an interim measure to address exposures until contaminated environmental media are remediated, or until mitigation is no longer needed to address exposures related to soil vapor intrusion.

4.1 Methods of mitigation

The most effective mitigation methods involve sealing infiltration points and actively manipulating the pressure differential between the building's interior and exterior (on a continuous basis). As discussed in the following subsections, the appropriate method to use will largely depend upon the building's foundation design. Furthermore, buildings having more than one foundation design feature (e.g., a basement under one portion of the house and a crawl space beneath the remainder) may require a combination of mitigation methods. This section describes methods of mitigation that are expected to be the most reliable options under a wide range of circumstances. Occasionally, there are site-specific or building-specific conditions under which alternative methods (such as HVAC modification, sealing, room pressurization, passive ventilation systems, or vapor barriers) may be more appropriate. Such mitigation proposals may be considered on a case-by-case basis.

4.1.1 <u>Buildings with a basement slab or slab-on-grade foundation</u>

In conjunction with *sealing* potential subsurface vapor entry points, an active *sub-slab depressurization system* (SSD system) is the preferred mitigation method for buildings with a basement slab or slab-on-grade foundation. A SSD system uses a fan-powered vent and piping to draw vapors from the soil beneath the building's slab (i.e., essentially creating a vacuum beneath the slab) and discharge them to the atmosphere. This results in lower sub-slab air pressure relative to indoor air pressure, which prevents the infiltration of sub-slab vapors into the building.

The most common approach to achieving depressurization beneath the slab is to insert the piping through the floor slab into the crushed rock or soil underneath. However, the EPA, in their "Consumer's Guide to Radon Reduction" (EPA 402-K-03-002; revised February 2003), lists the following approaches as ways to reduce radon levels in a building, either in place of the more common sub-slab suction point method or in conjunction with that method:

a. *Drain tile suction* — Some houses have drain tiles or perforated pipe to direct water away from the foundation of the house. Suction on these tiles or pipes is often effective;

b. *Sump hole suction* — If the building has a sump pump to remove unwanted water, the sump can be capped so that it can continue to drain water and serve as the location for piping. If the sump is not used as the suction or extraction point, the associated wiring and piping should be sealed and an air-tight cover should be installed to enhance the performance of the SSD system; and

c. *Block wall suction* — If the building has hollow block foundation walls, the void network within the wall may be depressurized by drawing air from inside the wall and venting it to the outside. This method is often used in combination with sub-slab depressurization.

The depressurization approach, or combination of approaches, selected for a building should be determined on a building-specific basis due to building-specific features that may be conducive to a specific depressurization approach. For example, if the contaminants are entering the building through a block wall, block wall suction in conjunction with traditional sub-slab depressurization may be more effective at minimizing exposures related to soil vapor intrusion rather than sub-slab depressurization alone.

Although sealing is not a reliable mitigation technique on its own, it can significantly improve the effectiveness of a SSD system since it limits the flow of subsurface vapors into the building. All joints, cracks and other penetrations of slabs, floor assemblies and foundation walls below or in contact with the ground surface should be sealed with materials that prevent air leakage.

If the State concurs that a SSD system is not a practicable alternative or that exposures will be mitigated concurrently by a method selected to remediate subsurface contamination, alternative mitigation methods may be considered, such as the following:

a. *HVAC modification* — a technique where the building's HVAC system is modified to avoid depressurization of the building relative to underlying and surrounding soil (i.e., to maintain a positive pressure within the building); and

b. S*oil vapor extraction (SVE) system* — a technique used to remediate contaminated subsurface soil vapor. SVE systems use high flow rates, induced vacuum or both to collect and remove contamination, while SSD systems use a minimal flow rate to effect the minimum pressure gradient (see the EPA's technical guidance documents for recommended gradients; Section 4.2.3) needed to reverse air flow across a building's foundation. Depending upon the SVE system's design, the system may also serve to mitigate exposures. For example, the SVE system's radius of influence includes the subsurface beneath affected buildings or horizontal legs of the system will be installed beneath affected buildings. However, complications can arise if the SVE system is no longer effective at remediating contaminated vapors, exposures should still be mitigated due to residual vapor contamination.

4.1.2 Buildings with a crawl space foundation

A *soil vapor retarder* with *sub-membrane depressurization (SMD) system* is the preferred mitigation method for buildings with a crawl space foundation. A soil vapor retarder is a synthetic membrane or other comparable material that is placed on the ground in the crawl space to retard the flow of soil vapors into the building. A SMD system is similar to a SSD system. It uses a fan-powered vent and piping to draw vapors from beneath the soil vapor retarder and discharge them to the atmosphere. This results in lower air pressure beneath the membrane relative to air pressure in the crawl space, which prevents the infiltration of subsurface vapors into the building.

If the State concurs that a soil vapor retarder with a SMD system is not a practicable alternative or that exposures will be mitigated concurrently by a method selected to remediate subsurface contamination, alternative mitigation methods may be considered, such as the following:

a. *HVAC modification* — a technique where the building's HVAC system is modified to avoid depressurization of the building relative to the crawl space;

b. C*rawl space ventilation with sealing* — a technique that uses a fan to draw air out of the crawl space; and

c. *SVE system* [Section 4.1.1].

4.1.3 Buildings with dirt floor basements

Either a SSD system with a newly poured slab or a SMD system with a soil vapor retarder may be used. However, the former method is preferred.

4.1.4 Buildings with multiple foundation types

Mitigation in a building with a combination of foundations should be achieved by applying the specific methods described previously [Sections 4.1.1 through 4.1.3] to the corresponding foundation segments of the building. Special consideration should be given to the points at which different foundation types join, since additional soil vapor entry routes exist in such locations. Often, the various systems can be installed and connected to a common depressurization system and fan.

4.1.5 Undeveloped parcels

If sampling results indicate a mitigation system is recommended to address exposures in buildings that may be constructed, then a SSD system with sealing, or a SMD system with a soil vapor retarder, or a combination of these methods is recommended, as appropriate to the design of the proposed buildings.

4.1.6 Additional references

The following documents provide additional information on selecting an appropriate mitigation method:

a. *A Consumer's Guide to Radon Reduction*
EPA [EPA 402-K-03-002, revised February 2003]

This document provides assistance in selecting a qualified radon mitigation contractor to reduce the radon levels in a home, determining an appropriate radon reduction method, and maintaining a radon reduction system. It is available at the EPA's web site: http://www.epa.gov/iaq/radon/pubs/index.html; and

b. *Reducing Radon in Schools: A Team Approach*
EPA [EPA 402-R-94-008, April 1994]

This document will provide assistance in determining the best way to reduce elevated radon levels found in a school. It provides guidance on the process of confirming a radon problem, selecting the best mitigation strategy, and directing the efforts of a multidisciplinary team assembled to address elevated radon levels in a way that will contribute to the improvement of the overall indoor air quality of the school. Copies can be ordered from the EPA's Indoor Air Quality Information Clearinghouse at 1-800-438-4318.

4.2 Design and installation of mitigation systems

Once a mitigation method is selected, it should be designed and installed. The components of the design and installation of mitigation systems, the procedures for specific mitigation techniques, and references for technical guidance are provided in the following subsections.

4.2.1 General recommendations

Systems should be designed and installed by a professional engineer or environmental professional. In most areas of the state, there are contractors who have met certain requirements and are trained to identify and fix radon problems in buildings. To obtain the names of local contractors, contact the NYSDOH's Radon Program at 1-800-458-1158, extension 27556, or visit the National Radon Safety Board's web site (www.nrsb.org) or National Environmental Health Association's web site (www.neha.org).

Typically, the party responsible for remediating the site is responsible for arranging design and installation activities. If no responsible party is available, the State will arrange for the design and installation of the system. All design and installation activities should be documented and reported to the agencies. Furthermore, once a mitigation system is installed, an information package should be given to the building's owner and tenants, if applicable, to facilitate their understanding of the system's operation, maintenance and monitoring [Section 5.6].

With the exception of SVE systems, the mitigation methods introduced in Section 4.1 are not intended to remediate the source of subsurface vapors (e.g., contaminated groundwater, soil, etc.). Rather, they are designed to minimize the infiltration of subsurface vapors into a building. For consistency in implementing the techniques in residential buildings, mitigation systems should be designed and installed in accordance with the following:

a. *Standard Practice for Installing Radon Mitigation Systems in Existing Low-rise Residential Buildings* (ASTM E-2121)

American Society for Testing and Materials (ASTM) International [ASTM E-2121-03, February 10, 2003]

This document applies to existing buildings. The purpose of this document is to provide radon mitigation contractors with uniform standards that will ensure quality and effectiveness in the design, installation, and evaluation of radon mitigation systems in detached and attached residential buildings three stories or less in height. Information on how to obtain a copy of this standard is available in Appendix E; and

b. *Model Standards and Techniques for Control of Radon in New Residential Buildings* EPA [EPA 402-R-94-009, March 1994]

This document applies to new construction and contains information on how to incorporate radon reduction techniques and materials in residential construction. A copy of this document is provided in Appendix F.

4.2.2 <u>System-specific recommendations</u>

Basic design and installation recommendations for mitigation systems follow. These are based upon recommendations and requirements given by the EPA for mitigating exposures related to radon intrusion (for additional information see EPA's web site on radon at http://www.epa.gov/iaq/radon/pubs/index.html).

a. *Sealing* — To improve the effectiveness of depressurization and ventilation systems and to limit the flow of subsurface vapors into the building, materials that prevent air leakage should be used, such as elastomeric joint sealant (as defined in ASTM C920-87), compatible caulks, non-shrink mortar, grouts, expanding foam, "Dranjer" drain seals, or airtight gaskets. Some effective sealants may contain volatile organic compounds; in some situations, this may be a consideration in choosing an appropriate sealing material.

b. *Soil vapor retarder (membrane)* —

   1. To retard the infiltration of subsurface vapors into the building and enhance the performance of a SMD system, a minimum 6 mil (or 3 mil cross-laminated) polyethylene or equivalent flexible sheeting material should be used.

   2. The sheet should cover the entire floor area and be sealed at seams (with at least a 12 inch overlap) and penetrations, around the perimeter of interior piers and to the foundation walls.

   3. Enough of the sheeting should be used so it will not be pulled away from the walls when the depressurization system is turned on and the sheet is drawn down.

   4. If a membrane is installed in areas that may have future foot traffic (e.g., a dirt floor in a basement), consideration should be given to also installing a wearing surface such as sand or stone to protect the integrity of the membrane. Additionally, a layer of fine sand may be prudent beneath the membrane to protect it from penetrations by sharp objects in the dirt floor.

c. *Depressurization systems —*

1. The systems should be designed to avoid the creation of other health, safety, or environmental hazards to building occupants (e.g., backdrafting of natural draft combustion appliances).

2. The systems should be designed to minimize soil vapor intrusion effectively while minimizing excess energy usage, to avoid compromising moisture and temperature controls and other comfort features, and to minimize noise.

3. To evaluate the potential effectiveness of a SSD before it is installed, a diagnostic test (commonly referred to as a "communication" test) should be performed to measure the ability of a suction field and air flow to extend through the material beneath the slab. This test is commonly conducted by applying suction on a centrally located hole drilled through the concrete slab and simultaneously observing the movement of smoke downward into small holes drilled in the slab at locations separated from the central suction hole. A similar quantitative evaluation may also be performed by using a digital micromanometer or comparable instrument. Depending on test results, multiple suction points may be needed to achieve the desired effectiveness of the system.

4. Passive systems (i.e., a SSD system without a vent fan) are not as effective as active systems and their performance varies depending upon ambient temperatures and wind conditions. Therefore, active systems should be used to ensure exposures are being addressed.

5. The vent fan and discharge piping should not be located in or below a livable or occupied area of the building to avoid entry of extracted subsurface vapors into the building in the event of a fan or pipe leak.

6. To avoid entry of extracted subsurface vapors into the building, the vent pipe's exhaust should be

   i. above the eave of the roof (preferably, above the highest eave of the building at least 12 inches above the surface of the roof),

   ii. at least 10 feet above ground level,

   iii. at least 10 feet away from any opening that is less than 2 feet below the exhaust point, and

   iv. 10 feet from any adjoining or adjacent buildings, or HVAC intakes or supply registers.

7. Rain caps, if used, should be installed so as not to increase the potential for extracted subsurface vapors to enter the building.

8. To avoid accidental changes to the system that could disrupt its function, the depressurization system should be labeled clearly. An example of such labeling is shown in Figure 5.1.

9. A warning device or indicator should be installed to alert building occupants if the active system stops working properly. Examples of system failure warning devices and indicators include the following: a liquid gauge (e.g., a

manometer), a sound alarm, a light indicator, and a dial (needle display) gauge. The warning device or indicator should be placed where it can be easily heard or seen. The party installing the system should verify the warning device or indicator is working properly. Building occupants should be made aware of the warning device or indicator (what it is, where it is located, how it works, how to read/understand it, and what to do if it indicates the system is not working properly).

d. *HVAC systems* — HVAC systems should be carefully designed, installed and operated to avoid depressurization of basements and other areas in contact with the soil.

e. *Crawl space ventilation* —

1. Ventilation systems should be designed to avoid the creation of other health, safety, or environmental hazards to building occupants (e.g., backdrafting of natural draft combustion appliances).

2. Openings and cracks in floors above the crawl space that would permit conditioned air to pass into or out of the occupied spaces of the building, should be identified, closed and sealed.

f. *SVE systems designed to also mitigate exposures* —

1. The systems should be designed to avoid the creation of other health, safety, or environmental hazards to building occupants (e.g., backdrafting of natural draft combustion appliances).

2. To avoid reentry of soil vapor into the building(s), the exhaust point should be located away from the openings of buildings and HVAC air intakes. Depending upon the concentrations of volatile chemicals in subsurface vapors and the expected mass removal rate, treatment (e.g., via carbon filters) of the SVE system effluent may be appropriate to minimize outdoor air effects.

3. The SVE system's radius of influence should adequately address buildings requiring mitigation, as well as subsurface sources requiring remediation. If it does not, additional actions may be appropriate. For example, if the radius of influence does not completely extend beneath a building, a complementary air monitoring program may be appropriate to confirm that exposures are being addressed adequately while the SVE system is operating.

4.2.3 Technical guidance

To address exposures effectively in larger buildings, some of the same techniques used in residential buildings can be scaled up in size, number, or performance (e.g., adjustments in the size and air movement capacity of the vent pipe fan, or installation of multiple suction points through the slab instead of a single point). The design of the techniques may also be modified (e.g., installation of horizontal pipes beneath the building instead of a single suction point).

Detailed technical guidance on designing and installing mitigation systems in residential and non-residential buildings is provided in various documents, such as the following, released by the EPA and others:

a. References provided in ASTM's E-2121 (see Appendix E for information on how to obtain a copy) and the EPA's *Model Standards and Techniques for Control of Radon in New Residential Buildings* (Appendix F);

b. *Radon Reduction Techniques for Existing Detached Houses: Technical Guidance (Third Edition) for Active Soil Depressurization Systems*
EPA [EPA 625/R-93-011, October 1993]

   This technical guidance document has been prepared to serve as a comprehensive aid in the detailed selection, design, installation, and operation of indoor radon reduction measures for existing houses based on active soil depressurization techniques. It is intended for use by radon mitigation contractors, building contractors, concerned homeowners, state and local officials and other interested persons. Copies can be ordered from the EPA's Indoor Air Quality Information Clearinghouse at 1-800-438-4318;

c. *Protecting Your Home From Radon: A Step-by-Step Manual for Radon Reduction*
Kladder *et al.*, 1993

   This manual is designed to provide sufficient information to a homeowner to make many of the basic repairs that can significantly reduce radon levels in the home;

d. *Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes*
EPA [EPA 402-K-01-002, April 2001]

   This fully illustrated guide contains all the information needed in one place to educate home builders about radon-resistant new construction (RRNC), including the following: basic questions and detailed answers about radon and RRNC, specific planning steps before installing a system, detailed installation instructions with helpful illustrations, tips and tricks when installing a system, marketing know-how when dealing with homebuyers, and architectural drawings. This document is available at the EPA's web site: http://www.epa.gov/iaq/radon/pubs/index.html; and

e. *Radon Prevention in the Design and Construction of Schools and Other Large Buildings*
EPA [EPA 625-R-92-016, June 1994]

   It is typically easier and much less expensive to design and construct a new building with radon-resistant and/or easy-to-mitigate features, than to add these features after the building is completed and occupied. Specific guidelines on how to incorporate radon prevention features in the design and construction of schools and other large buildings are detailed in this manual. Copies can be ordered from the EPA's Indoor Air Quality Information Clearinghouse at 1-800-438-4318. This document is also available on the EPA Office of Research and Development's web site: http://www.epa.gov/ORD/NRMRL/pubs/625r92016/625r92016.htm.

4.3 Post-mitigation or confirmation testing

Once a mitigation system is installed, its effectiveness and proper installation should be confirmed. The party that installed the system should conduct post-mitigation testing and for developing a post-mitigation testing plan. Minimum objectives for post-mitigation testing associated with specific mitigation methods are provided in the following subsections. All post-mitigation testing activities should be documented and reported to the agencies.

4.3.1 SSD systems with sealing

a. Reasonable and practical actions should be taken to identify and fix leaks. With the depressurization system operating, smoke tubes are used to check for leaks through concrete cracks, floor joints, and at the suction point. Any leaks identified should be resealed until smoke is no longer observed flowing through the opening.

b. Once a depressurization system is installed, its operation may compete with the proper venting of fireplaces, wood stoves and other combustion or vented appliances (e.g., furnaces, clothes dryers, and water heaters), resulting in the accumulation of exhaust gases in the building and the potential for carbon monoxide poisoning. Therefore, in buildings with natural draft combustion appliances, the building should be tested for backdrafting of the appliances. Backdrafting conditions should be corrected before the depressurization system is placed in operation.

c. The distance that a pressure change is induced in the sub-slab area (i.e., a pressure field extension test) should be conducted. Analogous to a communication test, this test is commonly conducted by operating the depressurization system and simultaneously observing the movement of smoke downward into small holes (e.g., 3/8 inch) drilled through the slab at sufficient locations to demonstrate that a vacuum is being created beneath the entire slab. A similar quantitative evaluation may also be performed by using a digital micromanometer or comparable instrument. If adequate depressurization is not occurring, the reason (e.g., improper fan operation) should be identified and corrected.

d. Adequate operation of the warning device or indicator should be confirmed.

e. Except as indicated below, post-mitigation indoor and outdoor air sampling should be conducted in all buildings where pre-mitigation samples were collected and in all buildings where physical data suggest possible impediments to comprehensive sub-slab communication of the depressurization system (i.e., locations with wet or dense sub-slab soils, multiple foundations and footings, minimal pressure differentials between the interior and sub-slab). Generally, indoor and outdoor air sampling locations, protocols and analytical methods should be consistent between pre-mitigation and post-mitigation sampling, where applicable. In buildings with basements, post-mitigation indoor air sampling from the basement alone (i.e., without a concurrent indoor air sample from the first floor) is recommended in most circumstances.

   Typically, post-mitigation sampling should be conducted no sooner than 30 days after installing a depressurization system. If the system is installed outside of the heating season or at the end of a season, post-mitigation air sampling may be postponed until the heating season.

   In cases of widespread mitigation due to vapor contamination and depending upon the basis of making decisions (e.g., a "blanket mitigation" approach within a specified area of documented vapor contamination [Section 3.3.1]), a representative number of buildings from an identified study area, rather than each building, may be sampled. Prior to implementation, this type of post-mitigation sampling approach should be approved by State agency personnel.

In newly constructed buildings, a site-specific and building-specific indoor air sampling plan is recommended due to potential interferences caused by the off-gassing of volatile chemicals in new building materials (e.g., paints, carpets, furniture, etc. [Section 1.4]). In these situations, if indoor air sampling is appropriate samples should be

i. collected while the system is operational but before potentially interfering factors are brought into the building,

ii. analyzed for a targeted list of volatile chemicals based on previous environmental sampling (e.g., groundwater, soil, soil vapor, etc.), and/or

iii. collected while the system is operational but after potentially interfering factors have had an opportunity to off-gas.

If post-mitigation sampling results do not indicate a significant decrease in the concentrations of volatile chemicals previously believed to be present in the indoor air due to soil vapor intrusion, the reason (e.g., indoor or outdoor sources, improper operation of the mitigation system, etc.) should be identified and corrected as appropriate.

4.3.2 SMD systems with soil vapor retarder

a. Reasonable and practical actions should be taken to identify and fix leaks. With the depressurization system operating, smoke tubes are used to check for leaks in the membrane at seams, edge seals and at locations where the sheet was sealed around obstructions. Any leaks identified should be resealed until smoke is no longer observed flowing through the opening.

b. Backdrafting conditions should be evaluated and corrected [Section 4.3.1].

c. Adequate operation of the warning device or indicator should be confirmed.

d. Post-mitigation indoor and outdoor air testing should be conducted in buildings where pre-mitigation samples were collected [as discussed in Section 4.3.1].

4.3.3 HVAC modifications

a. Check the building for positive pressure conditions (e.g., verify a pressure controller is maintaining the desired pressure differential and/or measure the pressure differential between the sub-slab and indoor air by using field instruments).

b. Backdrafting conditions should be evaluated and corrected [Section 4.3.1].

c. Adequate operation of the warning device or indicator, if applicable, should be confirmed.

d. Post-mitigation indoor and outdoor air testing should be conducted in buildings where pre-mitigation samples were collected [Section 4.3.1].

4.3.4 Crawl space ventilation and sealing

a. Reasonable and practical actions should be taken to identify and fix leaks. With the ventilation system operating, smoke tubes are used to check for leaks in openings and cracks in floors above the crawl space that were sealed during installation of the system. Any leaks identified should be resealed until smoke is no longer observed flowing through the opening.

b. Backdrafting conditions should be evaluated and corrected [Section 4.3.1].

c. Adequate operation of the warning device or indicator, if applicable, should be confirmed.

d. Post-mitigation indoor and outdoor air testing should be conducted in buildings where pre-mitigation samples were collected [as discussed in Section 4.3.1].

4.3.5 SVE systems designed to also mitigate exposures

a. Backdrafting conditions should be evaluated and corrected [Section 4.3.1].

b. The distance that a pressure change is induced in the sub-slab area should be conducted. This may be done by operating the SVE system and simultaneously observing the movement of smoke downward into small holes (e.g., 3/8 inch) drilled through the building's slab at sufficient locations to demonstrate that a vacuum is being created beneath the entire slab.

c. Adequate operation of the warning device or indicator, if applicable, should be confirmed.

d. Post-mitigation indoor and outdoor air testing should be conducted in buildings where pre-mitigation samples were collected [Section 4.3.1].

4.4 Operation, maintenance and monitoring of mitigation systems

When mitigation systems are implemented at a site, the operation, maintenance and monitoring (OM&M) protocols for the systems should be included in a site-specific site management plan (formerly referred to as operation, maintenance and monitoring plan). The party that installed the system should conduct OM&M activities and should develop the site management plan. Recommendations for minimum OM&M activities associated with specific mitigation methods are provided in the following subsections. Also included is a discussion of non-routine maintenance. All routine and non-routine OM&M activities should be documented and reported to the agencies.

4.4.1 SSD and SMD systems

Routine maintenance should commence within 18 months after the system becomes operational, and should occur every 12 to 18 months thereafter. Based upon a demonstration of the system's reliability, the State recommends that, if a different frequency is desired, a petition describing the alternative frequency and the reasons that frequency is preferred be submitted to the State. Any comments the State may have on the petition should be considered before the frequency is altered.

During routine maintenance, the following activities (at a minimum) should be conducted:

a. a visual inspection of the complete system (e.g., vent fan, piping, warning device or indicator, labeling on systems, soil vapor retarder integrity, etc.),

b. identification and repair of leaks [Sections 4.3.1 and 4.3.2], and

c. inspection of the exhaust or discharge point to verify no air intakes have been located nearby.

As appropriate preventative maintenance (e.g., replacing vent fans), repairs and/or adjustments should be made to the system to ensure its continued effectiveness at mitigating exposures related to soil vapor intrusion. The need for preventative maintenance will depend upon the life expectancy and warranty for the specific part, as well as visual observations over time. The need for repairs and/or adjustments will depend upon the results of a specific activity compared to that obtained when system operations were initiated.

If significant changes are made to the system or when the system's performance is unacceptable, the system may need to be redesigned and restarted. Many, if not all, of the post-mitigation testing activities, as described in Sections 4.3.1 and/or 4.3, may be appropriate. The extent of such activities will primarily depend upon the reason for the changes and the documentation of sub-slab depressurization.

Generally, air monitoring is not recommended if the system has been installed properly and is maintaining a vacuum beneath the entire slab.

In addition to the routine OM&M activities described here, the building's owner and tenants are given information packages that explains the system's operation, maintenance and monitoring [Section 5.6]. Therefore, at any time during the system's operation, the building's owner or tenants may check that the system is operating properly.

4.4.2 Other mitigation systems

For other mitigation systems (e.g., HVAC modifications, crawl space ventilation, etc.), routine maintenance activities are generally comparable to post-mitigation testing activities [Section 4.3]. Activities typically include a visual inspection of the complete system, and identification and repair of leaks. System performance checks, such as air stream velocity measurements of ventilation systems, also should be performed.

As appropriate, preventative maintenance (e.g., replacing filters, cleaning lines, etc.), repairs and/or adjustments should be made to the system to ensure its continued effectiveness at mitigating exposures related to soil vapor intrusion. If significant changes are made to the system or when the system's performance is unacceptable, redesigning and restarting the system may be appropriate[Section 4.4.1].

Air monitoring, such as periodic sub-slab vapor, indoor air and outdoor air sampling, may be appropriate to determine whether existing building conditions are maintaining the desired mitigation endpoint and to determine whether changes are appropriate. The type and frequency of monitoring is determined based upon site-specific and building-specific conditions, taking into account applicable environmental data, building operating conditions, and the mitigation method employed.

4.4.3 Non-routine maintenance

Non-routine maintenance may also be appropriate during the operation of a mitigation system. Examples of such situations include the following:

a. the building's owners or occupants report that the warning device or indicator indicates the mitigation system is not operating properly;

b. the mitigation system becomes damaged; or

c. the building has undergone renovations that may reduce the effectiveness of the mitigation system.

Activities conducted during non-routine maintenance visits will vary depending upon the reason for the visit. In general, building-related activities may include examining the building for structural or HVAC system changes, or other changes that may affect the performance of the depressurization system (e.g., new combustion appliances, deterioration of the concrete slab, or significant changes to any of the building factors listed in Table 1.2). Depressurization system-related activities may include examining the operation of the warning device or indicator and the vent fan, or the extent of sub-slab depressurization. Repairs or adjustments should be made to the system as appropriate. If appropriate, the system should be redesigned and restarted [Section 4.4.1].

4.5 Termination of mitigation system operations

Mitigation systems should not be turned off, until the State receives, and has had the opportunity to comment on, a proposal to turn off mitigation systems. The party seeking to turn off the mitigation systems should consider any comments the State may have on the proposal, except in emergency situations. Systems should remain in place and operational until they are no longer needed to address current or potential exposures related to soil vapor intrusion. This determination should be based upon several factors, including the following:

a. subsurface sources (e.g., groundwater, soil, etc.) of volatile chemical contamination in subsurface vapors have been remediated based upon an evaluation of appropriate post-remedial sampling results;

b. residual contamination, if any, in subsurface vapors is not expected to affect indoor air quality significantly based upon soil vapor and/or sub-slab vapor sampling results;

c. residual contamination, if any, in subsurface vapors is not affecting indoor air quality when active mitigation systems are turned off based upon indoor air, outdoor air and sub-slab vapor sampling results at a representative number of buildings; and

d. there is no "rebound" effect for which additional mitigation efforts would be appropriate observed when the mitigation system is turned off for prolonged periods of time. This determination should be based upon indoor air, outdoor air and/or sub-slab vapor sampling from the building over a time period, determined by site-specific conditions.

Given the prevalence of radon throughout the State of New York, consideration should be given to leaving the system in place and operating to address exposures related to radon intrusion after concurrence is reached that the system is no longer needed to mitigate exposures related to soil vapor intrusion. This action should be done only with permission of the property owner and after the property owner is aware of their responsibilities in operating, monitoring and maintaining the system for this specific purpose. If the property owner declines the offer, the system should be shut down and, if requested, removed in a timely manner.

4.6 Annual certification and notification recommendations

Mitigation systems are considered engineering controls, defined as any physical barrier or method employed to

1. actively or passively contain, stabilize, or monitor hazardous waste or petroleum,
2. restrict the movement of hazardous waste or petroleum to ensure the long-term effectiveness of remedial actions, or
3. eliminate potential exposure pathways to hazardous waste or petroleum.

Therefore, depending upon the remedial program, submission of an annual certification to the State may be required. This certification must be prepared and submitted by a professional engineer or environmental professional and affirm that the engineering controls are in place, are performing properly and remain effective. This requirement of certification remains in effect until the State provides notification, in writing, that this certification is no longer needed.

If a property owner declines a mitigation system, the party responsible for arranging the design and installation of the system should renew the offer on an annual basis, unless they demonstrate environmental conditions have changed such that a system is no longer needed.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Section 5: Community Outreach

While community outreach is an essential component of the investigation and remediation of any site, it is particularly critical when evaluating soil vapor intrusion at a site due to the following:

a. a heightened awareness by environmental professionals and the general public (both nationally and state-wide) for the importance of soil vapor intrusion;

b. the relatively complicated nature of the exposure pathway (e.g., chemicals in groundwater or soil ending up in the indoor air of buildings versus contaminated groundwater entering the house through the use of a private well);

c. the unknowns associated with the evolving science of investigating, evaluating, and mitigating exposures related to soil vapor intrusion; and

d. the relatively complicated nature of mitigating the exposure pathway (e.g., the design, installation and operation of a sub-slab depressurization system in a home versus an immediate switch from using private well water to using bottled water).

When people have been or may be exposed to contamination, providing them with accurate and timely information about those exposures is extremely important. This information should include details about the types of chemicals, the levels of exposure, and possible health effects from those exposures. In addition, information should include details about the planning and progress of the investigation and remediation efforts. Techniques commonly used to inform the community about soil vapor intrusion issues are described in this section. The type, or types, of techniques selected for a site will vary depending upon the community's needs, site-specific conditions and remedial program-specific requirements.

5.1 Site contact list

A contact list contains names, addresses and telephone numbers of individuals and organizations with interest or involvement in a site. They may be affected by or interested in the site, or have information that staff needs to make effective remedial decisions. Contact lists typically include residents near the site, elected officials, appropriate federal, state, and local government contacts, local media, organized environmental groups and the responsible party, as well as local businesses, civic and recreational groups, religious facilities, school district officials, and all staff (NYSDEC, NYSDOH, county health department, EPA, etc.) involved in the site. The checklist provided in Appendix G.1 will help to identify who should be included in a particular site's contact list.

With respect to soil vapor intrusion, the site contact list is often used to

a. send a fact sheet announcing a proposed investigation in the area, a major project decision or proposal, the project's status or progress, a public meeting or availability session, or the availability of documents in the repositories;

b. contact building owners and tenants to arrange sampling dates and times and to transmit sampling results (in written form and/or verbally); and

c. provide community members with verbal updates on the project's status or progress.

The member of the project team (defined as the NYSDEC, NYSDOH, responsible party, etc.) that develops and maintains the site contact list is determined on a site-specific and/or program-specific basis. Development and revision of the contact list are ongoing activities throughout the site's investigation and remediation. Guidance on how to create a site contact list is provided in Appendix G.1.

5.2 Project staff contact sheet

As implied by the name, this is a summary of the contact information for staff working on the site that can be handed out to the community. Often included on the sheet are the name, title, affiliation, role or area of expertise, address, telephone number, email address, facsimile number for each staff member. The contact sheet provides the community with a quick reference on whom to call with questions, comments or concerns about the site. Project staff may also use the site contact sheet to direct inquiries to the most appropriate person. This is particularly useful when there are many agencies working on the site and many issues, such as site investigation, health studies, medical outreach, etc., being addressed.

The site contact sheet should be handed out at public meetings or availability sessions, when door-to-door visits and sampling are conducted, and in conjunction with other appropriate outreach activities. The sheet should be developed early on in the process and kept up-to-date. The member of the project team that develops and maintains the staff contact sheet is determined on a site-specific and/or program-specific basis.

5.3 Fact sheets

A fact sheet is a written summary of important information about a site. It presents information in clear and concise terms for the community. Fact sheets aid consistent distribution of information and citizens' understanding of significant issues associated with site-related activities. With respect to soil vapor intrusion, fact sheets are often used to

a. announce a proposed soil vapor intrusion investigation in the area, either as a stand-alone activity or in conjunction with the site's overall investigation;
b. summarize the results of an investigation and the anticipated next steps in the process;
c. invite the public to a meeting or availability session to discuss the proposed investigation, the results of a recently completed investigation, the anticipated next steps, etc.; and
d. provide additional information on topics associated with soil vapor intrusion, such as specific air guidelines for volatile chemicals.

The member of the project team that plans, develops and distributes the fact sheet is determined on a site-specific and/or program-specific basis. Factors to consider when designating the lead include the site's remedial program, the expected content of the fact sheet, and the relationship of various team members with the community. For example, if the community strongly distrusts the responsible party and wants to know how the state is determining that their actions are appropriate, the state should be the lead. A combination of team members may also be suitable.

All team members should be included in reviewing and finalizing the fact sheet. Once the state approves the fact sheet, it may be released to the public. Timely distribution of the fact sheet is important. Sufficient time should be allowed in the development and review schedule to ensure that the fact sheet is distributed — *and that it is received* — before the critical activity takes place. Specific timeframes for release include the following:

a. 2 weeks prior to a public meeting or availability session, or commencement of field activities;

b. within 24 hours of receiving a specific request for an available fact sheet from the community (e.g., members of the community that did not receive a copy of the fact sheet in the mail);

c. if applicable, before a comment period begins (otherwise a 30-day comment period becomes, in reality, a 25-day comment period); and

d. if appropriate, concurrently with letters to the community explaining sampling results.

Copies of fact sheets commonly used to supplement discussions related to soil vapor intrusion are provided in Appendix H. They are also available from the NYSDOH's soil vapor intrusion web page: http://www.health.state.ny.us/environmental/indoors/vapor_intrusion/. Additional guidance on how to plan, develop and distribute fact sheets is provided in Appendix G.2.

5.4 Public gatherings

The following are several types of public gatherings where project staff can meet with the community:

a. Traditional Public Meetings: Project staff generally present information and answer questions. Citizens are encouraged to ask questions and provide comments;

b. Public Availability Sessions: The session is held in a casual setting, without a formal agenda and presentation. Staff generally conduct an availability session about a specific aspect of a site, which it publicizes ahead of time. The format promotes detailed individual or small group discussion between staff and the public. An availability session may be targeted to a specific subgroup of the overall community. For example, a session may be held where project staff meet with building owners and tenants to discuss their individual sampling results;

c. Public Forum: The forum is held in a casual setting, without a formal presentation. Typically, the format is one of "question and answer" — a panel of project staff (or, if applicable, outside experts) answer questions asked by community members in an open discussion; and

d. Other: Project staff may be invited to give presentations or to make themselves available for questions at community group meetings, such as community or neighborhood board meetings, school board meetings, etc.

If appropriate, a combination of the above may be used. The type, or combination of types, of gathering (if any) selected should be decided based on site-specific, program requirements and community-specific conditions, such as the following:

a. Is the investigation limited to on-site buildings, to a localized area of off-site buildings, or to the off-site neighborhood surrounding the site?;

b. Is the soil vapor investigation being performed as part of ongoing site investigation activities (and consequently ongoing outreach activities), or is this issue being revisited at a site where remediation was considered "complete?";

c. What type of outreach has the community favored in the past?;

d. What are the objectives of the meeting? Can one meeting type accomplish each of the objectives or are different meeting types needed on successive days (e.g., public meeting followed by an availability session)?; and

e. Who is the desired audience? Should the meeting be held in the afternoon to accommodate an elderly population and repeated in the evening for people who work during normal business hours?

The member of the project team that coordinates and implements the gathering is determined on a site-specific and/or program-specific basis. Factors to consider when designating the lead include the site's remedial program, the expected subject of the meeting, and the relationship of various team members with the community. A combination of team members may also be appropriate.

Additional guidance on how to plan and conduct a public meeting and an availability session is provided in Appendices G.3 and G.4.

5.5 Letters transmitting results

When indoor air and/or sub-slab vapor samples are collected from within or beneath a building, a letter providing the sampling results and the conclusions drawn from the data evaluation should be transmitted to the building's owner. If the building is a rental property, the transmittal letter should be sent to the tenants residing in the areas where the samples were collected and a copy to the property owner/landlord. In some cases where responsible parties are carrying out indoor air sampling, access agreements are commonly executed between such a party and the property owner. Consequently, the transmittal letter may be sent to the property owner, and where feasible by prior arrangement with the property owner and/or tenant, with a copy to the tenant.

A transmittal letter should include the following (as applicable):

a. the address of the building sampled;

b. the date samples were collected;

c. the type of samples collected (e.g., sub-slab vapor, indoor air and outdoor air);

d. indoor air sampling locations (e.g., basement, crawl space, first floor living room, etc.)

e. who collected the samples (e.g., the state, or [Consultant Name] on behalf of [Responsible Party name], etc.);

f. why samples were collected (e.g., to evaluate the potential for exposures associated with soil vapor intrusion);

g. the site name and number (usually included in the subject line);

h. the compound(s) or group of compounds of concern (e.g., trichloroethene or volatile organic compounds);

i. an overview of the sampling results (e.g., a table summarizing compounds detected in each sample and/or a figure illustrating sampling locations and corresponding results);

j. copies of the laboratory sheets for each sample collected and the completed building questionnaire/inventory;

k. a statement of the conclusions drawn and the next steps (e.g., soil vapor intrusion appears to be the likely source of volatile chemicals in your indoor air and we would like to install a sub-slab depressurization system to minimize exposures);

l. if applicable, what information should be shared with employees and/or patrons of the facility (e.g., the transmittal letter and enclosed fact sheets, a situation-specific fact sheet and cover memorandum, etc.);

m. contact information for project staff; and

n. fact sheets that supplement information provided in the letter.

The member of the project team that transmits the letter is typically the member that conducted the investigation. A representative of each member should be copied on each transmittal. For example, for investigations conducted by the state, letters are transmitted by the NYSDOH; state and local agencies, as well as a representative for the responsible party (or other non-agency project staff), should be copied. For investigations conducted by the responsible party, the responsible party should transmit letters that have been reviewed and approved by the state, and copy state and local agency representatives.

The level of detail provided in the letter will depend upon who transmits the letter. For example, letters written by the NYSDOH may recommend actions to reduce exposures to indoor sources (i.e., not site-related sources) of volatile chemicals, or address expected risks associated with an identified exposure. Letters transmitted by a responsible party generally focus on site-related contamination and their identified next steps. These letters generally refer the recipients to the state for questions regarding non-site-related compounds and health concerns. For additional guidance on the content of the transmittal letters, contact the NYSDOH's Bureau of Environmental Exposure Investigation at 1-800-458-1158, extension 27850.

Timely distribution of the transmittal letter is important. Generally, final (i.e., verified) sampling results from the laboratory are available 6 to 8 weeks after the samples are submitted. As soon as they are available, final results should be forwarded to the team member that is transmitting them. Sufficient time should be allowed in the development and review schedule to ensure that the letter is transmitted within 2 weeks after final results are available.

If there is significant community interest in the sampling results, reasonable attempts should be made to inform the building owners and tenants of their results verbally in addition to sending a transmittal letter. Other interested community members, such as residents, press and elected officials, may be given an overview of the investigation results and the conclusions drawn *after* each building owner and tenant has been notified.

5.6 Soil vapor intrusion mitigation information

Once a mitigation system (e.g., sub-slab depressurization system) is installed in a building, an information package should be given to the building's owner and tenants, if applicable, to facilitate their understanding of the system's operation, maintenance and monitoring. This package should include the following:

a. a description of the mitigation system installed and its basic operating principles;

b. how the owner or tenant can check that the system is operating properly;

c. how the system will be maintained and monitored and by whom;

d. a list of appropriate actions for the owner or tenant to take if the system's warning device or indicator (e.g., pressure gauge, alarm, etc.) indicates system degradation or failure; and

e. contact information (e.g., names, telephone numbers, etc.) if the owner or tenant has questions, comments or concerns.

The building's owner should also receive the following information:

a. any building permits required by local codes;

b. copies of contracts and warranties; and

c. a description of the proper operating procedures of any mechanical or electrical system installed, including manufacturer's operation and maintenance instructions and warranties.

Wherever possible, illustrations should be provided. For example, pictures of a manometer under normal operating conditions [Figure 5.1], as well as drawings or schematics showing the system at work [Figure 5.2].

The member of the project team who provides this information is the member who installed the mitigation system.

Figure 5.1
Manometer indicating the SSD system is operating properly.

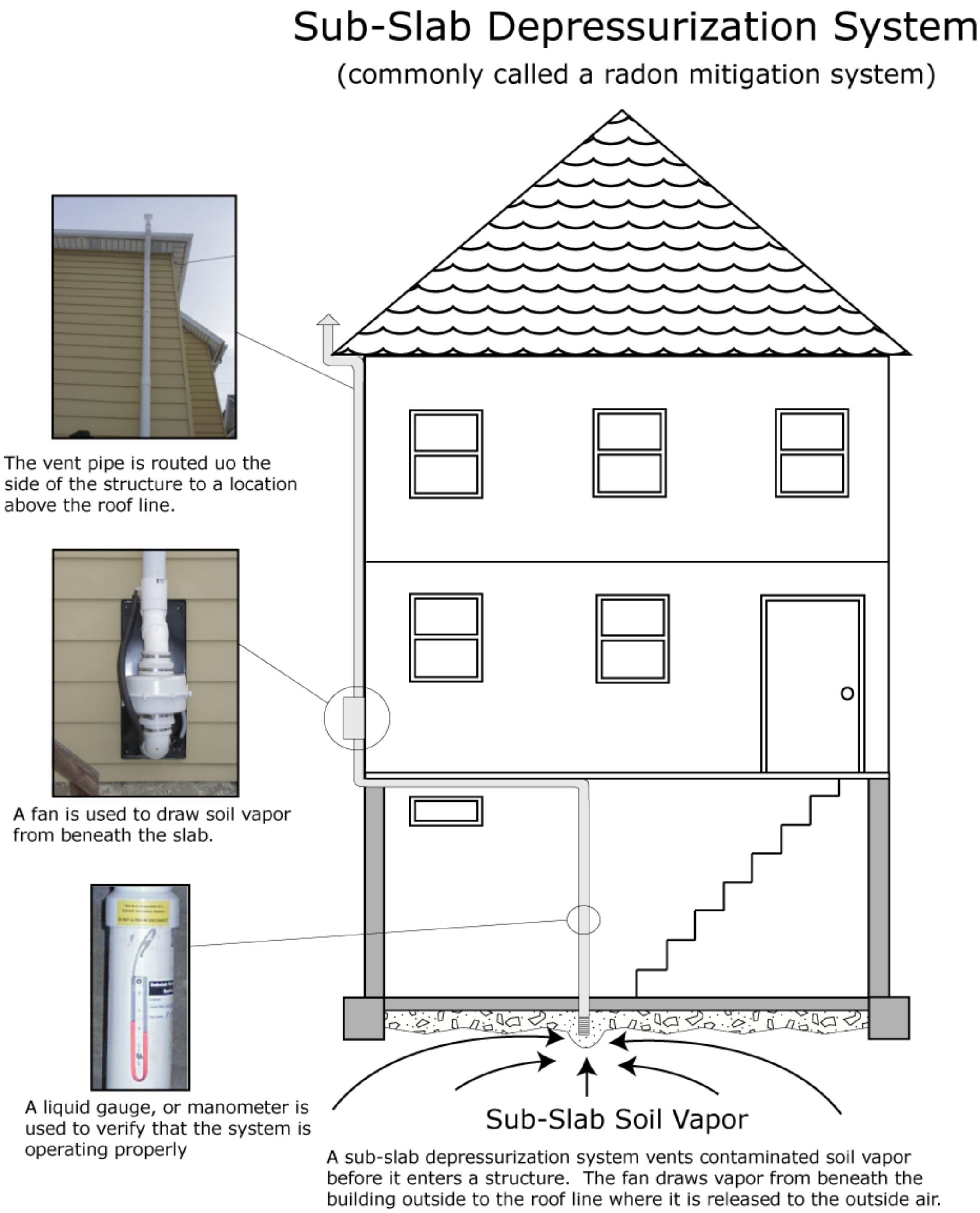

Figure 5.2
Example of an illustration showing how a SSD system works.

5.7 Toll-free "800" numbers

Toll-free information numbers provide quick, easy access for people who have questions, comments or concerns about a site. At a minimum, the NYSDOH site project manager's name and the following "800" number should be shared with the community in fact sheets and transmittal letters, at public gatherings, when samples are collected, and with other outreach techniques for their use if they have health-related questions, concerns or comments related to soil vapor intrusion at the site.

NYSDOH
Center for Environmental Health
Bureau of Environmental Exposure Investigation
Toll-free Information Line

1-800-458-1158, ext. 27850

Note: The "800" number is an *information* line — not a "*hotline*" — because callers may not receive immediate response, such as on nights or weekends.

Similarly, applicable toll-free numbers setup and maintained by other project team members should also be shared with the community whenever appropriate. Additional information on the use of toll-free "800" numbers as an outreach tool is provided in Appendix G.5.

5.8 Door-to-door visits

Door-to-door visits involve gathering or distributing site information by meeting individuals at their residences or businesses. Typically, this outreach technique is used to supplement other communication, such as telephone calls and letters. With respect to soil vapor intrusion, project staff may visit residents near a site to provide information, answer questions, or obtain permission for activities on private properties. All team members should be aware of the specifics of the door-to-door visits (e.g., who will be conducting the visits, the reason, the dates, etc.).

Additional information on conducting door-to-door visits is provided in Appendix G.6.

5.9 Document repositories

A document repository is a collection of documents and other information developed during the investigation and remediation of a site. It is located in a convenient, public facility, such as a library, so that affected and interested members of the public can easily access and review important information about the site. A repository is maintained through the site's operation and maintenance phase, or until its release from the applicable remedial program.

A site document repository helps the public review

a. documents about which the state is seeking public comment;
b. studies, reports and other information; and
c. complete versions of documents summarized in fact sheets, meeting presentations or media releases (summaries should note the locations of local repositories where the complete documents are available).

The member of the project team that establishes and maintains the document repository is determined on a site-specific and/or program-specific basis. Additional guidance on how to establish and maintain a document repository is provided in Appendix G.7.

5.10 Medical community outreach

Outreach to the medical community is an activity or combination of activities undertaken to assist local health care providers in caring for people who have concerns about site-specific environmental exposures. The goal of this type of outreach is to assist the individual provider by giving him/her much of the site-specific information related to the contaminants and to provide information about the site itself. This type of outreach is undertaken whenever the NYSDOH and/or other health agencies determine that the site-specific contaminants may be unfamiliar to the local medical community. Conversely, this outreach can be undertaken when community members express the concern that their health care providers may be unfamiliar with potential adverse health effects related to contaminants at the site.

The targeted audience for this type of outreach consists of specific groups of health care providers most likely to treat people with concerns about potential environmental exposures. Some examples of targeted groups of specialists could include any combination of the following: Family Practice, Internal Medicine, Preventive Medicine, Oncology, Neurology, Allergy, Pediatrics, Obstetrics, Dermatology and Emergency Medicine. Likewise, materials can be sent to medical and nursing schools, residency programs, and medical libraries if they are located nearby. Developing the targeted list of health-care providers is a cooperative effort between local and state departments of health, with input from the community as well.

The NYSDOH, in partnership with the Agency for Toxic Substance and Disease Registry (ATSDR) and the local health department, can conduct these activities, which could include any one or a combination of the following:

a. announcements made at public meetings that the NYSDOH Center for Environmental Health will mail out information packets to individual physicians at the request of any concerned citizen;

b. an article placed in a local newspaper, or, if applicable, in a newsletter periodically sent to residents, stating that the NYSDOH Center for Environmental Health will mail out packets to individual physicians at the request of any concerned citizen. The NYSDOH "800" number and two NYSDOH contact names would be given;

c. an article submitted to the newsletter of the local county medical society, stating that the NYSDOH and the ATSDR have information to help providers with questions about site-related contamination in the area of the site. The NYSDOH "800" number and two NYSDOH contact names would be given; and

d. materials sent to medical and nursing schools, residency programs, and medical libraries if they are located nearby.

Local and state departments of health, and ATSDR, have developed appropriate outreach materials. The information packets should contain a letter to the physician, site-specific fact sheets, brochures, and booklets about potential exposures and about the contaminants in the area of the site. As an example, here is a list of fact sheets and pamphlets that an information packet for a site with PCE and TCE as contaminants of concern might contain:

a. a letter of explanation to the provider, including the NYSDOH "800" number to call for access to more information, as well as two NYSDOH contacts with whom to speak initially;

b. a site-specific fact sheet written for the community, explaining various site-related issues;

c. a compact disc of ATSDR case studies in environmental medicine (CSEMs), with opportunities for earning many free continuing medical education (CME) credits through the Centers for Disease Control and Prevention;

d. a hard copy of both the "Trichloroethylene (TCE) Toxicity" and "Taking an Environmental Exposure History" case studies;

e. two small "quick reference guides" produced by ATSDR about evaluating environmental exposures and doing an exposure history;

f. a NYSDOH fact sheet on Trichloroethene (TCE) in indoor and outdoor air;

g. an ATSDR fact sheet on Trichloroethylene (TCE);

h. a NYSDOH fact sheet on Tetrachloroethene (PERC) in indoor and outdoor air; and

i. an ATSDR fact sheet on Tetrachloroethylene (PERC).

For additional information on this outreach tool, please contact the NYSDOH Center for Environmental Health's Outreach and Education Unit at 1-800-458-1158, extension 27530.

References

American Society for Testing and Materials (ASTM) International. 2003. "Standard Practice for Installing Radon Mitigation Systems in Existing Low-rise Residential Buildings" (ASTM E-2121-03, February 10, 2003).

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New York State Department of Environmental Conservation. "Draft DER-10 Technical Guidance for Site Investigation and Remediation." Division of Environmental Remediation. December 2002.

New York State Department of Environmental Conservation. 2006. "Program Policy DER-13: Strategy for Prioritizing Vapor Intrusion Evaluations at Remedial Sites in New York." Division of Environmental Remediation. October 2006.

New York State Department of Health. 2005. "Indoor Air Sampling and Analysis Guidance." February 1, 2005. Available on the NYSDOH's web site at http://www.health.state.ny.us/nysdoh/indoor/guidance.htm.

United State Environmental Protection Agency. 1993. "Radon Reduction Techniques for Existing Detached Houses: Technical Guidance (Third Edition) for Active Soil Depressurization Systems" (EPA 625/R-93-011, October 1993).

United State Environmental Protection Agency. 1994a. "Model Standards and Techniques for Control of Radon in New Residential Buildings" (EPA 402-R-94-009; March 1994).

United State Environmental Protection Agency. 1994b. "Radon Prevention in the Design and Construction of Schools and Other Large Buildings" (EPA 625-R-92-016, June 1994).

United State Environmental Protection Agency. 1994c. "Reducing Radon in Schools: A Team Approach" (EPA 402-R-94-008, April 1994).

United State Environmental Protection Agency. 2001. "Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes" (EPA 402-K-01-002, April 2001).

United State Environmental Protection Agency. 2003. "Consumer's Guide to Radon Reduction" (EPA 402-K-03-002; revised February 2003).

NOTE: Updates to this final guidance are available at http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Appendix A
Highlights of document revisions

February 2005 Public Comment Draft → October 2006 Final Guidance

- Throughout: Revised language to clarify that the guidance is not a rule, regulation or requirement, and to eliminate text that might create a contrary impression.
- Preface: Revised to clarify that the guidance was developed in consultation with the NYSDEC and that it represents the State's methodology and our experience. Added notes for special considerations (e.g., naturally-occurring subsurface gases).
- Section 1: Replaced image in Figure 1.1. Identified additional factors in Table 1.1. Added section on conceptual site models. Provided additional information regarding the applicability of the guidance to specific scenarios (such as residential and non-residential settings and petroleum hydrocarbon sites).
- Section 2: Revised the discussion in Section 2.2.1 to clarify the use of soil vapor samples. Included crawl space air samples. Expanded the discussion on time of year in which to sample. Revised text to emphasize the importance of selecting methods that meet the data quality objectives. Clarified which information is highly recommended to gather at the time of sampling. Included liquid tracers in the section on tracer gas. Added QA/QC considerations. Revised text on target analyte lists. Relocated guidance on applicability in non-residential settings to Section 1.7.
- Section 3: Revised text and removed summary table in Section 3.2.4 to clarify that background levels are not defined as levels within a 25th to 75th percentile range. Added a summary of a recently published Health Effects Institute database to the discussion on background databases. Included "resampling" as one of the potential recommended actions in Section 3.3.2 and 3.3.3. Added text to clarify who is responsible for implementing recommended actions. Revised the outdoor air evaluation section to clarify that outdoor air samples are not collected and evaluated as part of a comprehensive assessment of outdoor air.
- Matrix 1: Based on comments received on the NYSDOH's TCE Criteria Document (NYSDOH 2006), the following two revisions were made to Matrix 1: changed the boundary between the indoor air concentration ranges in Columns 2 and 3 from 2.5 to 1 mcg/m^3 and added "Monitor/Mitigate" as a recommended action in Box 10 (see memorandum from N. Kim to R. Tramontano dated October 12, 2006, provided on p. A-3 for additional information). Removed Monitor action from Box 3. Removed Mitigate and Monitor actions from Box 4. Revised the definitions of actions and the additional notes, including a definition of "Monitor/Mitigate" and a recommendation that resampling may be necessary to demonstrate the effectiveness of actions taken to reduce exposures.
- Matrix 2: Removed Monitor action from Box 3. Removed Mitigate and Monitor actions from Box 4. Added Monitor/Mitigate action to Box 6 (see memorandum from N. Kim to R. Tramontano dated October 12, 2006, provided on p. A-3 for additional information). Similar to Matrix 1, revised the definitions of actions and the additional notes.
- Section 4: Revised text to clarify that we are emphasizing preferred mitigation methods and not precluding the use of other mitigation methods. Added text to Section 4.3 about post-mitigation indoor air sampling in buildings with basements. Replaced EPA's *Radon Mitigation Standards* with ASTM E-2121. Replaced references to Operation, Maintenance and Monitoring Plans to Site Management Plans.
- Section 5: Replaced image in Figure 5.2.

- Appendix C: Added a discussion on a recently published Health Effects Institute database. Added tables for each database with additional volatile chemicals and statistical measures of background levels.
- Appendix E: Removed EPA's *Radon Mitigation Standards*. Provided EPA's web site explaining how to get copies of the recommended ASTM E-2121.

The reader is also referred to the NYSDOH's complementary document titled "Response to Comments received on the New York State Department of Health's *Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (Public comment draft dated February 2005)."

STATE OF NEW YORK - DEPARTMENT OF HEALTH
INTEROFFICE MEMORANDUM

TO: Ronald Tramontano, Director
Center for Environmental Health

FROM: Nancy K. Kim, Director N.K.
Division of Environmental Health Assessment

SUBJECT: Trichloroethene

DATE: October 12, 2006

Center for Environmental Health staff in the New York State Department of Health (DOH) have written several documents to address health concerns about exposure to trichloroethene (TCE) from soil vapor intrusion and are revising those documents in response to comments from a scientific review panel and the public. The documents and related reports are:

Draft Report Trichloroethene Air Criteria Document (DOH, 2005)(contains the derivation of the TCE guideline),
Comments of the Trichloroethene (TCE) Panel (letter from Henry Anderson, M.D. to Nancy K. Kim, Ph.D. dated November 1, 2005),
Guidance for Evaluating Soil Vapor Intrusion in the State of New York, Public Comment Draft (DOH, 2005), which includes the

Soil Vapor/Indoor Air Matrix 1 and Matrix 2 (both are a decision making tool for soil vapor and indoor air levels), and
TCE in Indoor and Outdoor Air (fact sheet), and

Assessing the Human Health Risks of Trichloroethylene: Key Scientific Issues, a report issued by the National Research Council (NRC) of the National Academy of Sciences (July, 2006).

After reviewing these materials, I am recommending that we change Matrix 1. The 2.5 micrograms of trichloroethene per cubic meter of indoor air (2.5 mcg/m^3) in the column headings for Indoor Air Concentration of Compound in Matrix 1 should be reduced to 1.0 mcg/m^3. I am also recommending that mitigate be included as an option in Box 10 of Matrix 1 and Box 6 of Matrix 2.

Use of the Air Guideline

The purpose of the air guideline for TCE of 5 mcg/m^3 given in the fact sheet, "...is to help guide decisions about the nature of the efforts to reduce TCE exposures. Reasonable and practical actions should be taken to reduce TCE exposure when indoor air levels are above background, even when they are below the guideline of 5 mcg/m^3. The urgency to take actions increases as indoor air levels increase, especially when air levels are above the guideline. In all cases, the specific corrective actions to be taken depend on a case-by-case evaluation of the situation. The goal of the recommended action is to reduce TCE levels in indoor air to as close to background as practical." This general advice applies to all situations including the following:

- an individual wants to know if he should keep a closed bottle of TCE in his house,
- a school asks DOH if it has a problem with a bottle of TCE being in a shop, and
- an office wants to know if it should do anything about residual exposure from past TCE use.

DOH also uses the guideline to make decisions about the need for remedial actions because of state regulated sources or sites. DOH would use this value to decide if it needs to work with the New York State Department of Environmental Conservation to reduce outdoor air levels of TCE. DOH also uses this value in Matrix 1, a decision making tool for responding to soil vapor intrusion problems; for this use, the guideline is considered to be a TCE concentration that should not be exceeded in indoor air.

Indoor Air Concentrations

Several different studies provide information about background levels of TCE in indoor air. These data differ because of a number of factors such as the criteria for choosing sampling locations, the time period of the studies, etc. Three studies give a 50^{th} percentile (less than 0.25 mcg/m^3, less than 1.4 mcg/m^3 and 0.12 mcg/m^3) and a 95^{th} percentile (less than 0.25 mcg/m^3, 1.36 mcg/m^3 and 4.2 mcg/m^3). Two studies provide a 75^{th} percentile (less than 0.25 mcg/m^3 and 1.2 mcg/m^3). One way to characterize these values is to state that background values are mostly less than 1 mcg/m^3 and frequently less than 0.25 mcg/m^3. (References: DOH 2003, USEPA 2001, and HEI, 2005)

Peer Review of the Derivation of the TCE Air Guideline

After receiving the TCE panel's comments, the Department considered changes in the guideline or Matrix 1. The TCE panel was asked to answer technical questions about the derivation of the guideline and a specific question on the guideline itself (Is the summary transparent and does it adequately justify the guideline of 5 mg/m^3?). In responding to the latter question, several panel members voiced their opinion about what they would select as a guideline. The consensus comment from the panel was "Some panel members suggested that additional consideration be given to lowering the guideline value."

The panel also commented on aspects of the guideline when answering questions about cancer risk estimates.

One of the panel's consensus comment was:

"The fact that TCE is a multi-species and multi-site carcinogen with a combination of both malignant and benign tumors should be further emphasized in the document because these data coupled with the human data have led several authoritative bodies (EPA, NTP, & IARC) to the conclusion that TCE is on the cusp between a known and probable (likely, reasonably anticipated to be) human carcinogen. Thus, the NYSDOH should have flexibility in using risk levels of both 1 in 10^{-6} and 1 in 10^{-5}." (Part of response to question 4 of the TCE Panel's comments.)

Another consensus comment was:

"The rationale to utilize the human epidemiologic studies for weight of evidence support for the animal carcinogenicity studies rather than as the primary for the quantitative cancer risk assessment is appropriate. The weaknesses of the exposure estimates and potential confounding exposures support this decision. However, the DOH may want to consider the human studies to a greater extent when weighting the cancer evidence to establish a guideline." (Part of response to question 5 of the TCE Panel's comments)

Other, individual comments on the guideline follow.

George Lucier, Ph.D.

"Based on the available data, especially the cancer data, a guideline in the range of 1-5 mcg/m^3 could be justified. After all, a linear model cannot be rejected, for some sites acceptable risk levels are less than 5 mcg/m^3 and in some cases less than 1 mcg/m^3 and EPA has stated that TCE is highly likely to be a human carcinogen. The NYSDOH may wish to consider an acceptable risk level to be 3-5 cancers per million since TCE appears to be on the cusp between a known human carcinogen and a probable human carcinogen**."**

James Dix, Ph.D.

"The extensive review of the cancer literature in the draft document seems to indicate TCE levels giving 1×10^{-6} increased cancer risk can be in the range 0.1-1 mcg/m^3 (e.g., p. 132, 133, 141, 147, 149, and 150 of the draft document), which prima facia (sic) would support an air criterion of below 1 μ/m^3(sic). The DOH weighted these studies less. However, given the support on this scientific review panel for weighting the non-Hodgkin's lymphoma more strongly, an air criterion of less than 1 μg/m^3 might be justified."

NRC Report on Trichloroethene

In July 2006, the NRC released its report on TCE. We have reviewed that report. The approaches and methods we used to derive health-based air criteria for TCE are consistent with the recommendations of the NRC Committee. For example, both NRC and DOH identified kidney cancer, liver cancer, central nervous system effects, reproductive problems and developmental problems as human health endpoints that might be sensitive to the effects of TCE. NRC recommended that animal data, not human health data, be used to derive quantitative estimates of human cancer risks from TCE exposure and that the available human data be used only for validation. DOH used this approach in evaluating cancer risks.

Integration, Matrix 1 and Matrix 2

The attached tables compare the TCE criteria in the draft document with the revised TCE criteria in the final document. These data indicate that the guideline of 5 mcg/m^3 is below the recommended health-based criteria for non-cancer effects and that the excess lifetime cancer risks at the guideline are in the lower end of the risk range that is generally used by regulatory agencies when setting guidelines or standards. However, Matrix 1 is a major determinant for remediation in the soil vapor intrusion program, a state program addressing involuntary risks, and two revisions would help to align decisions in that program with the goals stated in the DOH TCE fact sheet and with the requirements of the Brownfields legislation.

In the current state program, mitigation is recommended when the potential for soil vapor intrusion to affect indoor air is high (sub-slab levels are equal to or greater than 250 mcg/m^3) regardless of the measured indoor air levels. However, when the potential for soil vapor intrusion to affect indoor air is moderate (sub-slab concentrations are equal to or greater than 50 mcg/m^3, but less than 250 mcg/m^3), mitigation is only recommended when an indoor air level is equal to or greater than 2.5 mcg/m^3. The excess risk levels associated with 2.5 mcg/m^3 range from 0.3 to 8 x 10^{-6}; the upper end of this range exceeds the 3 to 5 cancers per million recommended by Dr. Lucier and the 1 x 10^{-6} risk level given in the Brownfields legislation. This concentration also exceeds most background concentrations for TCE, a goal stated in the TCE fact sheet. Reducing 2.5 mcg/m^3 to 1.0 mcg/m^3 in Matrix 1 would result in recommending remediation at levels above most background levels and at risk levels of 0.1 to 3 x 10^{-6}.

In Matrix 1 of the draft soil vapor intrusion guidance, Box 10 (sub-slab vapor levels of 50 mcg/m^3 or greater to less than 250 mcg/m^3 and indoor air levels of 0.25 mcg/m^3 or greater to less than 2.5 mcg/m^3) recommends monitoring. (The recommendation in the previous paragraph would change 2.5 mcg/m^3 to 1.0 mcg/m^3.) Box 10 addresses situations where the potential for soil vapor to affect indoor air is moderate, but indoor air levels are in the range of most background levels. Recommending an option for mitigation in Box 10 when environmental factors for a specific site suggest a high potential for indoor air concentrations to increase is consistent with the goals outlined in the previous paragraph. A similar mitigation option is recommended for Box 6 of Matrix 2.

Attachments

P:\Trichloroethene\RT memo.doc

Table 1. Non-Carcinogenic Effects: Draft and Final Criteria Used in Guideline Derivation.

Organ/System/ Lifestage	Study*	Recommended TCE Air Criteria (mcg/m^3)			
		Draft		Final	
		Study	System	Study	System
CNS	Arito et al. (1994)	40	40	4 (childhood)	10
	Rasmussen et al. (1993)	40		11 (adult & childhood)	
Liver	Kjellstrand et al. (1983)	160	160	160 (adult & childhood)	160
Kidney	Kjellstrand et al. (1983)	165	165	160 (adult & childhood)	160
Reproduction	Land et al. (1981)	32	32	32	20
	DuTeaux et al. (2004)	110		110	
	Kumar et al. (2000; 2001a)	not done		20	
	NTP (1986)	not done		110	
Developmental	Dawson et al. (1993)	11	11	11 (supporting study)	20
	Healy et al. (1982)	38		38	
	Isaacson & Taylor (1989)	19		19	
	NTP (1986)	not done		22	

*References from Trichloroethene Air Criteria Document.

Table 2. Carcinogenic Effects: Draft and Final Criteria Used in Guideline Derivation.

Cancer	Recommended TCE Air Criteria (mcg/m^3)*					
	Draft			Final		
	LADE		LADD (PBPK)	LADE		LADD (PBPK)
	Unadjusted	Adjusted**		Unadjusted	Adjusted**	
Animal Data (Fukuda et al., 1983; Henschler et al., 1980; Maltoni et al., 1986)***						
liver	1.8	not done	1.4	1.8	1.1	1.4
kidney	13	not done	3100	13	7.8	3100
lymphoma	not a recommended site			0.3	not done	not done given uncertainty in appropriate internal dose & mode of action
testes (benign)	not a recommended site					
lung	not a recommended site					
Human Data (Hansen et al., 2001)***						
esophagus	0.077 – 1.2#	not done	not done	0.36 – 1.2##	not done	not done
NHL	0.062 – 0.91#	not done	not done	0.29 – 0.91##	not done	not done

*Air concentrations associated with an excess lifetime human risk of 1 x 10^{-6} are provided for comparative purposes, air concentrations associated with excess risks 1 x 10^{-5} and 1 x 10^{-4} are 10X and 100X the given concentration.

**The LADE (lifetime average daily exposure) estimates based on linear low-dose extrapolation are unadjusted and adjusted for the potential increased sensitivity of children to the early-life TCE exposures following US EPA guidance. Adjusted values were not calculated using age-specific internal dose metrics (LADD, lifetime average daily dose) because validated TCE PBPK models for children are unavailable and because of additional uncertainties associated with estimating model parameter values for children. Adjusted values were not calculated based on lymphomas because the mode-of-action for those cancers is unknown, and in such cases, the US EPA guidance recommends using unadjusted values.

***References from Trichloroethene Air Criteria Document.

Range of values based on two measures of relative risk, two occupational exposure levels, and three estimates of exposure duration.

Range of values based on two measures of relative risk, one occupational exposure level, and three estimates of exposure duration.

Soil Vapor/Indoor Air Matrix 1

WORKING DRAFT 02.23.05 SUBJECT TO CHANGE

	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m^3)			
SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m^3)	0.25	0.25 to 2.5	2.5 to 5.0	5.0 and above
5	1. No further action	2. Take reasonable and practical actions to identify source(s) and reduce exposures	3. Take reasonable and practical actions to identify source(s) and reduce exposures and Monitor	4. MITIGATE or Take reasonable and practical actions to identify source(s) and reduce exposures and Monitor
5 to 50	5. No further action	6. Monitor	7. Monitor	8. MITIGATE
50 to 250	9. Monitor	10. Monitor	11. MITIGATE	12. MITIGATE
250 and above	13. MITIGATE	14. MITIGATE	15. MITIGATE	16. MITIGATE

No further action: Given that the compound was not detected in the indoor air sample and that the concentration detected in the sub-slab vapor sample is not expected to significantly affect indoor air quality, no additional actions are needed to address human exposures.

Take steps to identify source(s) and reduce exposures: The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile organic compound-containing products in places where people do not spend much time, such as a garage or outdoor shed).

Monitor as appropriate: Monitoring is needed to confirm concentrations in the indoor air have not increased due to changes in pressure gradients (e.g., deterioration of building foundation) or to evaluate temporal trends for relevant environmental data. Monitoring may also be needed to verify that existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are minimizing potential effects associated with soil vapor intrusion. The type and frequency of monitoring is determined on a site-specific basis, taking into account applicable environmental data and building operating conditions. Monitoring is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

Mitigate: Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system, and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

See additional notes on page 2.

ADDITIONAL NOTES FOR MATRIX 1

This matrix provides guidance on actions that should be taken to address current and potential exposures related to soil vapor intrusion. To use the matrix accurately as a tool in the decision-making process, the following must be noted:

[1] The matrix is generic. As such, it may be necessary to modify recommended actions to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or site-specific conditions (e.g., proximity of building to identified subsurface contamination) for the protection of public health. Additionally, actions more conservative than those specified within the matrix may be implemented at any time. For example, the decision to implement more conservative actions may be based on a comparison of the costs associated with resampling or monitoring to the costs associated with installation and monitoring of a mitigation system.

[2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude the need to investigate possible sources of vapor contamination, nor does it preclude the need to remediate contaminated soil vapors or the source of soil vapor contamination.

[3] Extreme care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples must be analyzed by methods that can achieve a minimum reporting limit of 0.25 microgram per cubic meter for indoor and outdoor air samples, and typically 1 microgram per cubic meter for subsurface vapor samples.

[4] Sub-slab vapor and indoor air samples are typically collected during the heating season since soil vapor intrusion is more likely to occur when a building's heating system is in operation and air is being drawn into the building. If samples are collected during other times of the year, it may be necessary to resample during the heating season to evaluate exposures accurately.

[5] When current exposures are attributed to sources other than vapor intrusion, the agencies must be provided documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.

Soil Vapor/Indoor Air Matrix 2

WORKING DRAFT 02.23.05 SUBJECT TO CHANGE

	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m³)			
SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m^3)	3	3 to 30	30 to 100	100 and above
100	1. No further action	2. Take reasonable and practical actions to identify source(s) and reduce exposures	3. Take reasonable and practical actions to identify source(s) and reduce exposures and Monitor	4. MITIGATE or Take reasonable and practical actions to identify source(s) and reduce exposures and Monitor
100 to 1,000	5. Monitor	6. Monitor	7. MITIGATE	8. MITIGATE
1,000 and above	9. MITIGATE	10. MITIGATE	11. MITIGATE	12. MITIGATE

No further action: Given that the compound was not detected in the indoor air sample and that the concentration detected in the sub-slab vapor sample is not expected to significantly affect indoor air quality, no additional actions are needed to address human exposures.

Take steps to identify source(s) and reduce exposures: The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile organic compound-containing products in places where people do not spend much time, such as a garage or outdoor shed).

Monitor: Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, is needed to determine whether concentrations in the indoor air or sub-slab vapor have changed. Monitoring may also be needed to determine whether existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

Mitigate: Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system, and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is an interim measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

See additional notes on page 2.

ADDITIONAL NOTES FOR MATRIX 2

This matrix provides guidance on actions that should be taken to address current and potential exposures related to soil vapor intrusion. To use the matrix accurately as a tool in the decision-making process, the following must be noted:

[1] The matrix is generic. As such, it may be necessary to modify recommended actions to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or site-specific conditions (e.g., proximity of building to identified subsurface contamination) for the protection of public health. Additionally, actions more conservative than those specified within the matrix may be implemented at any time. More conservative actions are often cost-based (e.g., the cost of additional sampling versus the cost of mitigation) rather than health-based.

[2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude the need to investigate possible sources of vapor contamination, nor does it preclude the need to remediate contaminated soil vapors or the source of soil vapor contamination.

[3] Extreme care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples must be analyzed by methods that can achieve a minimum reporting limit of 3 micrograms per cubic meter.

[4] Sub-slab vapor and indoor air samples (basement and lowest occupied living space) are typically collected during the heating season since soil vapor intrusion is more likely to occur when a building's heating system is in operation and air is being drawn into the building. If samples are collected during other times of the year, it may be necessary to resample during the heating season to evaluate exposures accurately.

[5] When current exposures are attributed to sources other than vapor intrusion, the agencies must be provided documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.

Soil Vapor/Indoor Air Matrix 1

October 2006

	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m^3)			
SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m^3)	0.25	0.25 to 1	1 to 5.0	5.0 and above
5	1. No further action	2. Take reasonable and practical actions to identify source(s) and reduce exposures	3. Take reasonable and practical actions to identify source(s) and reduce exposures	4. Take reasonable and practical actions to identify source(s) and reduce exposures
5 to 50	5. No further action	6. MONITOR	7. MONITOR	8. MITIGATE
50 to 250	9. MONITOR	10. MONITOR / MITIGATE	11. MITIGATE	12. MITIGATE
250 and above	13. MITIGATE	14. MITIGATE	15. MITIGATE	16. MITIGATE

No further action:
Given that the compound was not detected in the indoor air sample and that the concentration detected in the sub-slab vapor sample is not expected to significantly affect indoor air quality, no additional actions are needed to address human exposures.

Take reasonable and practical actions to identify source(s) and reduce exposures:
The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile organic compound-containing products in places where people do not spend much time, such as a garage or outdoor shed). Resampling may be recommended to demonstrate the effectiveness of actions taken to reduce exposures.

MONITOR:
Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, is needed to determine whether concentrations in the indoor air or sub-slab vapor have changed. Monitoring may also be needed to determine whether existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

MITIGATE:
Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system, and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

MONITOR / MITIGATE:
Monitoring or mitigation may be recommended after considering the magnitude of sub-slab vapor and indoor air concentrations along with building- and site-specific conditions.

See additional notes on page 2.

ADDITIONAL NOTES FOR MATRIX 1

This matrix summarizes the minimum actions recommended to address current and potential exposures related to soil vapor intrusion. To use the matrix appropriately as a tool in the decision-making process, the following should be noted:

[1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, resampling may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Additionally, actions more protective of public health than those specified within the matrix may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action is usually undertaken for reasons other than public health (e.g., seeking community acceptance, reducing excessive costs, etc.).

[2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of vapor contamination, nor does it preclude remediating contaminated soil vapors or the source of soil vapor contamination.

[3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 0.25 microgram per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples, a minimum reporting limit of 5 micrograms per cubic meter is recommended for buildings with full slab foundations, and 1 microgram per cubic meter for buildings with less than a full slab foundation.

[4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion to occur is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions may be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.

[5] When current exposures are attributed to sources other than soil vapor intrusion, the agencies should be given documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.

[6] The party responsible for implementing the recommended actions will differ depending upon several factors, including the identified source of the volatile chemicals, the environmental remediation program, and site-specific and building-specific conditions. For example, to the extent that all site data and site conditions demonstrate that soil vapor intrusion is not occurring and that the potential for soil vapor intrusion to occur is not likely, the soil vapor intrusion investigation would be considered complete. In general, if indoor exposures represent a concern due to indoor sources, then the State will provide guidance to the property owner and/or tenant on ways to reduce their exposure. If indoor exposures represent a concern due to outdoor sources, then the NYSDEC will decide who is responsible for further investigation and any necessary remediation. Depending upon the outdoor source, this responsibility may or may not fall upon the party conducting the soil vapor intrusion investigation.

Soil Vapor/Indoor Air Matrix 2

October 2006

	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m^3)			
SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m^3)	3	3 to 30	30 to 100	100 and above
100	1. No further action	2. Take reasonable and practical actions to identify source(s) and reduce exposures	3. Take reasonable and practical actions to identify source(s) and reduce exposures	4. Take reasonable and practical actions to identify source(s) and reduce exposures
100 to 1,000	5. MONITOR	6. MONITOR / MITIGATE	7. MITIGATE	8. MITIGATE
1,000 and above	9. MITIGATE	10. MITIGATE	11. MITIGATE	12. MITIGATE

No further action:
Given that the compound was not detected in the indoor air sample and that the concentration detected in the sub-slab vapor sample is not expected to significantly affect indoor air quality, no additional actions are needed to address human exposures.

Take reasonable and practical actions to identify source(s) and reduce exposures:
The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile organic compound-containing products in places where people do not spend much time, such as a garage or outdoor shed). Resampling may be recommended to demonstrate the effectiveness of actions taken to reduce exposures.

MONITOR:
Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, is needed to determine whether concentrations in the indoor air or sub-slab vapor have changed. Monitoring may also be needed to determine whether existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

MITIGATE:
Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system, and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

MONITOR / MITIGATE:
Monitoring or mitigation may be recommended after considering the magnitude of sub-slab vapor and indoor air concentrations along with building- and site-specific conditions.

See additional notes on page 2.

ADDITIONAL NOTES FOR MATRIX 2

This matrix summarizes the minimum actions recommended to address current and potential exposures related to soil vapor intrusion. To use the matrix appropriately as a tool in the decision-making process, the following should be noted:

[1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, resampling may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Additionally, actions more protective of public health than those specified within the matrix may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action is usually undertaken for reasons other than public health (e.g., seeking community acceptance, reducing excessive costs, etc.).

[2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of vapor contamination, nor does it preclude remediating contaminated soil vapors or the source of soil vapor contamination.

[3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 3 micrograms per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples, a minimum reporting limit of 5 micrograms per cubic meter is recommended.

[4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion to occur is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions may be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.

[5] When current exposures are attributed to sources other than soil vapor intrusion, the agencies should be given documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.

[6] The party responsible for implementing the recommended actions will differ depending upon several factors, including the identified source of the volatile chemicals, the environmental remediation program, and site-specific and building-specific conditions. For example, to the extent that all site data and site conditions demonstrate that soil vapor intrusion is not occurring and that the potential for soil vapor intrusion to occur is not likely, the soil vapor intrusion investigation would be considered complete. In general, if indoor exposures represent a concern due to indoor sources, then the State will provide guidance to the property owner and/or tenant on ways to reduce their exposure. If indoor exposures represent a concern due to outdoor sources, then the NYSDEC will decide who is responsible for further investigation and any necessary remediation. Depending upon the outdoor source, this responsibility may or may not fall upon the party conducting the soil vapor intrusion investigation.

Appendix B

Indoor air quality questionnaire and building inventory

As discussed in Section 2.11, products in buildings should be inventoried every time indoor air is sampled to provide an accurate assessment of the potential contribution of volatile chemicals. In addition, the type of structure, floor layout and physical conditions of the building being studied should be noted to identify (and minimize) conditions that may interfere with the proposed testing.

Toward this end, a blank copy of the NYSDOH Center for Environmental Health's Indoor Air Quality Questionnaire and Building Inventory is provided in this appendix. Also provided is an example that demonstrates how the form should be completed properly.

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NEW YORK STATE DEPARTMENT OF HEALTH
INDOOR AIR QUALITY QUESTIONNAIRE AND BUILDING INVENTORY
CENTER FOR ENVIRONMENTAL HEALTH

This form must be completed for each residence involved in indoor air testing.

Preparer's Name ________________________________ Date/Time Prepared ____________

Preparer's Affiliation ____________________________ Phone No.____________________

Purpose of Investigation____

1. OCCUPANT:

Interviewed: Y / N

Last Name: ______________________ First Name: ______________________

Address: ____

County: _______________

Home Phone: __________________ Office Phone: __________________

Number of Occupants/persons at this location ______ Age of Occupants ____________________

2. OWNER OR LANDLORD: (Check if same as occupant ___)

Interviewed: Y / N

Last Name: ______________________First Name: ________________________

Address: ____

County: _______________

Home Phone: __________________ Office Phone: __________________

3. BUILDING CHARACTERISTICS

Type of Building: (Circle appropriate response)

Residential	School	Commercial/Multi-use
Industrial	Church	Other: _______________

If the property is residential, type? (Circle appropriate response)

Ranch	2-Family	3-Family
Raised Ranch	Split Level	Colonial
Cape Cod	Contemporary	Mobile Home
Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other:_______________

If multiple units, how many? ________

If the property is commercial, type?

Business Type(s) ______________________________________

Does it include residences (i.e., multi-use)? Y / N If yes, how many? ______

Other characteristics:

Number of floors______ Building age______

Is the building insulated? Y / N How air tight? Tight / Average / Not Tight

4. AIRFLOW

Use air current tubes or tracer smoke to evaluate airflow patterns and qualitatively describe:

Airflow between floors

____

____

____

Airflow near source

____

____

____

Outdoor air infiltration

____

____

____

Infiltration into air ducts

____

____

____

5. BASEMENT AND CONSTRUCTION CHARACTERISTICS (Circle all that apply)

a. Above grade construction:	wood frame	concrete	stone	brick
b. Basement type:	full	crawlspace	slab	other ________
c. Basement floor:	concrete	dirt	stone	other ________
d. Basement floor:	uncovered	covered	covered with ________________	
e. Concrete floor:	unsealed	sealed	sealed with _________________	
f. Foundation walls:	poured	block	stone	other ________
g. Foundation walls:	unsealed	sealed	sealed with _________________	
h. The basement is:	wet	damp	dry	moldy
i. The basement is:	finished	unfinished	partially finished	
j. Sump present?	Y / N			

k. Water in sump? Y / N / not applicable

Basement/Lowest level depth below grade: ________(feet)

Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains)

____

____

6. HEATING, VENTING and AIR CONDITIONING (Circle all that apply)

Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation	Heat pump	Hot water baseboard	
Space Heaters	Stream radiation	Radiant floor	
Electric baseboard	Wood stove	Outdoor wood boiler	Other ___________

The primary type of fuel used is:

Natural Gas	Fuel Oil	Kerosene
Electric	Propane	Solar
Wood	Coal	

Domestic hot water tank fueled by: ______________________________

Boiler/furnace located in:	Basement	Outdoors	Main Floor	Other____________
Air conditioning:	Central Air	Window units	Open Windows	None

Are there air distribution ducts present? Y / N

Describe the supply and cold air return ductwork, and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.

____

____

____

____

7. OCCUPANCY

Is basement/lowest level occupied? Full-time Occasionally Seldom Almost Never

Level	General Use of Each Floor (e.g., familyroom, bedroom, laundry, workshop, storage)
Basement	____________________
1st Floor	____________________
2nd Floor	____________________
3rd Floor	____________________
4th Floor	____________________

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

a. Is there an attached garage? Y / N

b. Does the garage have a separate heating unit? Y / N / NA

c. Are petroleum-powered machines or vehicles stored in the garage (e.g., lawnmower, atv, car) Y / N / NA Please specify____________

d. Has the building ever had a fire? Y / N When?____________

e. Is a kerosene or unvented gas space heater present? Y / N Where? ____________

f. Is there a workshop or hobby/craft area? Y / N Where & Type? ____________

g. Is there smoking in the building? Y / N How frequently? ____________

h. Have cleaning products been used recently? Y / N When & Type? ____________

i. Have cosmetic products been used recently? Y / N When & Type? ____________

j. Has painting/staining been done in the last 6 months? Y / N Where & When? ________________

k. Is there new carpet, drapes or other textiles? Y / N Where & When? ________________

l. Have air fresheners been used recently? Y / N When & Type? _________________

m. Is there a kitchen exhaust fan? Y / N If yes, where vented?_____________

n. Is there a bathroom exhaust fan? Y / N If yes, where vented?_____________

o. Is there a clothes dryer? Y / N If yes, is it vented outside? Y / N

p. Has there been a pesticide application? Y / N When & Type?__________________

Are there odors in the building? Y / N
If yes, please describe: ____

Do any of the building occupants use solvents at work? Y / N
(e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist

If yes, what types of solvents are used? ____

If yes, are their clothes washed at work? Y / N

Do any of the building occupants regularly use or work at a dry-cleaning service? (Circle appropriate response)

Yes, use dry-cleaning regularly (weekly) No
Yes, use dry-cleaning infrequently (monthly or less) Unknown
Yes, work at a dry-cleaning service

Is there a radon mitigation system for the building/structure? Y / N Date of Installation: _____________
Is the system active or passive? Active/Passive

9. WATER AND SEWAGE

Water Supply: Public Water Drilled Well Driven Well Dug Well Other: ________

Sewage Disposal: Public Sewer Septic Tank Leach Field Dry Well Other: ________

10. RELOCATION INFORMATION (for oil spill residential emergency)

a. Provide reasons why relocation is recommended: ____

b. Residents choose to: remain in home relocate to friends/family relocate to hotel/motel

c. Responsibility for costs associated with reimbursement explained? Y / N

d. Relocation package provided and explained to residents? Y / N

11. FLOOR PLANS

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note.

Basement:

First Floor:

12. OUTDOOR PLOT

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s) and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.

13. PRODUCT INVENTORY FORM

Make & Model of field instrument used: ____

List specific products found in the residence that have the potential to affect indoor air quality.

Location	Product Description	Size (units)	Condition*	Chemical Ingredients	Field Instrument Reading (units)	Photo ** Y / N

* Describe the condition of the product containers as **Unopened (UO), Used (U),** or **Deteriorated (D)**
** Photographs of the **front and back** of product containers can replace the handwritten list of chemical ingredients. However, the photographs must be of good quality and ingredient labels must be legible.

NEW YORK STATE DEPARTMENT OF HEALTH
INDOOR AIR QUALITY QUESTIONNAIRE AND BUILDING INVENTORY
CENTER FOR ENVIRONMENTAL HEALTH

This form must be completed for each residence involved in indoor air testing.

Preparer's Name Mary Jones Date/Time Prepared 10/22/04 10:00am

Preparer's Affiliation XYZ Consulting Phone No. 518-555-1212

Purpose of Investigation Thomasville Soil Vapor Intrusion Investigation (Site#32141)

1. OCCUPANT:

Interviewed: Y / N

Last Name: Smith First Name: Carol

Address: 25 Main Street Thomasville, New York 25230

County: Albany

Home Phone: 518-556-2222 Office Phone: 518-556-2400

Number of Occupants/persons at this location 2 Age of Occupants 36, 10

2. OWNER OR LANDLORD: (Check if same as occupant ___)

Interviewed: Y / N

Last Name: White First Name: Frank

Address: 64 Mountain Road Bainbridge, New York 26390

County: Dutchess

Home Phone: 845-876-1301 Office Phone: 845-227-2430

3. BUILDING CHARACTERISTICS

Type of Building: (Circle appropriate response)

Residential School Commercial/Multi-Use
Industrial Church Other: ________________

Example Correct

If the property is residential, type? (Circle appropriate response)

Ranch	2-Family	3-Family
Raised Ranch	Split Level	Colonial
Cape Cod	Contemporary	Mobile Home
Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other:__________

If multiple units, how many? NA

If the property is commercial, type?

Business Type(s) NA

Does it include residences (i.e. multi-use)? Y / N   If yes, how many? ______

Other characteristics:

Number of floors 1   Building age 20 years

Is the building insulated? Y / N   How air tight? Tight / Average / Not Tight

4. AIRFLOW

Use air current tubes or tracer smoke to evaluate airflow patterns and qualitatively describe:

Airflow between floors

Basement air flows up to 1st floor through plumbing waste line and domestic water line floor penetrations

Airflow near source

Yes, furnace/oil tank area open to rest of basement

Outdoor air infiltration

Outdoor air enters at loose bilco doorway openings, and at sill plate near furnace.

Infiltration into air ducts

Basement air flows into bottom of hot air unit and in loose cold air return joints.

Example Correct

5. **BASEMENT AND CONSTRUCTION CHARACTERISTICS** (Circle all that apply)

a. Above grade construction:	wood frame	concrete	stone	brick
b. Basement type:	full	crawlspace	slab	other ________
c. Basement floor:	concrete	dirt	stone	other ________
d. Basement floor:	uncovered	covered	covered with ____________	
e. Concrete floor:	unsealed	sealed	sealed with ____________	
f. Foundation walls:	poured	block	stone	other ________
g. Foundation walls:	unsealed	sealed	sealed with ____________	
h. The basement is:	wet	damp	dry	moldy
i. The basement is:	finished	unfinished	partially finished	
j. Sump present?	Y N			
k. Water in sump?	Y / N / not applicable			

Basement/Lowest level depth below grade: 6 (feet)

Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains)

Floor drain in laundry area

6. **HEATING, VENTING and AIR CONDITIONING** (Circle all that apply)

Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation	Heat pump	Hot water baseboard	
Space Heaters	Stream radiation	Radiant floor	
Electric baseboard	Wood stove	Outdoor wood boiler	Other ________

The primary type of fuel used is:

Natural Gas	Fuel Oil	Kerosene
Electric	Propane	Solar
Wood	Coal	

Domestic hot water tank fueled by: gas

Boiler/furnace located in: Basement Outdoors Main Floor Other ________

Air Conditioning: Central Air Window units Open Windows None

Example Correct

Are there air distribution ducts present? Y / N

Describe the supply and cold air return ductwork, and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.

Cold air return ductwork on ceiling in basement. Cold air return joints appear loose.

7. OCCUPANCY

Basement / Is lowest level occupied? Full time Occasionally Seldom Almost Never

Level	**General Use of Each Floor (e.g., familyroom, bedroom, laundry, workshop, storage)**
Basement	Storage and laundry
1st Floor	living area and bedrooms
2nd Floor	
3rd Floor	
4th Floor	

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

a. Is there an attached garage? Y / N

b. Does the garage have a separate heating unit? Y / N / NA

c. Are petroleum-powered machines or vehicles stored in the garage (e.g., lawnmower, atv, car etc.) Y / N / NA
Please specify lawnmower, car

d. Has the building ever had a fire? Y / N When? ______

e. Is a kerosene or unvented gas space heater present? Y / N Where? ______

f. Is there a workshop or hobby/craft area? Y / N Where & Type? ______

g. Is there smoking in the building? Y / N How frequently? ______

h. Have cleaning products been used recently? Y / N When & Type? w/in week - windex, tilex

i. Have cosmetic products been used recently? Y / N When & Type? yesterday - hairspray

Example Correct

j. Has painting/staining been done in the last 6 months? Y / N Where & When? ______________

k. Is there new carpet, drapes or other textiles? Y / N Where & When? carpet in dining room

l. Have air fresheners been used recently? Y / N When & Type? ______________

m. Is there a kitchen exhaust fan? Y / N If yes, where vented? outside

n. Is there a bathroom exhaust fan? Y / N If yes, where vented? ______________

o. Is there a clothes dryer? Y / N If yes, is it vented outside? Y / N

p. Has there been a pesticide application? Y / N When & Type? ______________

Are there odors in the building? Y / N
If yes, please describe: ____

Do any of the building occupants use solvents at work? Y / N
(e.g., chemical manufacturing or laboratory, automechanic or autobody shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist etc.)

If yes, what types of solvents are used? hair salon dyes, alcohols, peroxides, acetone

If yes, are their clothes washed at work? Y / N

Do any of the building occupants regularly use or work at a dry-cleaning service? (Circle appropriate response)

Yes, use dry-cleaning regularly (weekly) — No
Yes, use dry-cleaning infrequently (monthly or less) — Unknown
Yes, work at a dry-cleaning service

Is there a radon mitigation system for the building/structure? Y / N Date of Installation: June 2000
Is the system active or passive? Active/Passive

9. WATER AND SEWAGE

Water Supply:	Public Water	Drilled Well	Driven Well	Dug Well	Other: _______
Sewage Disposal:	Public Sewer	Septic Tank	Leach Field	Dry Well	Other: _______

10. RELOCATION INFORMATION (for oil spill residential emergency)

a. Provide reasons why relocation is recommended: not applicable

b. Residents choose to: remain in home relocate to friends/family relocate to hotel/motel

c. Responsibility for costs associated with reimbursement explained? Y / N

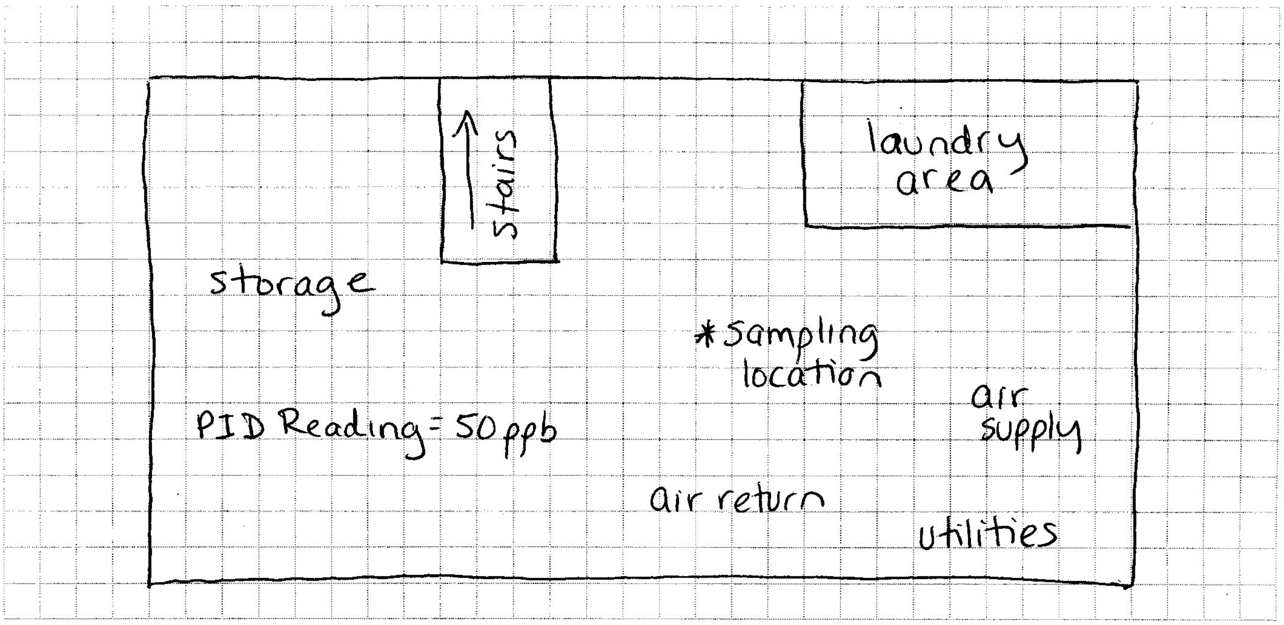
d. Relocation package provided and explained to residents? Y / N

Example Correct

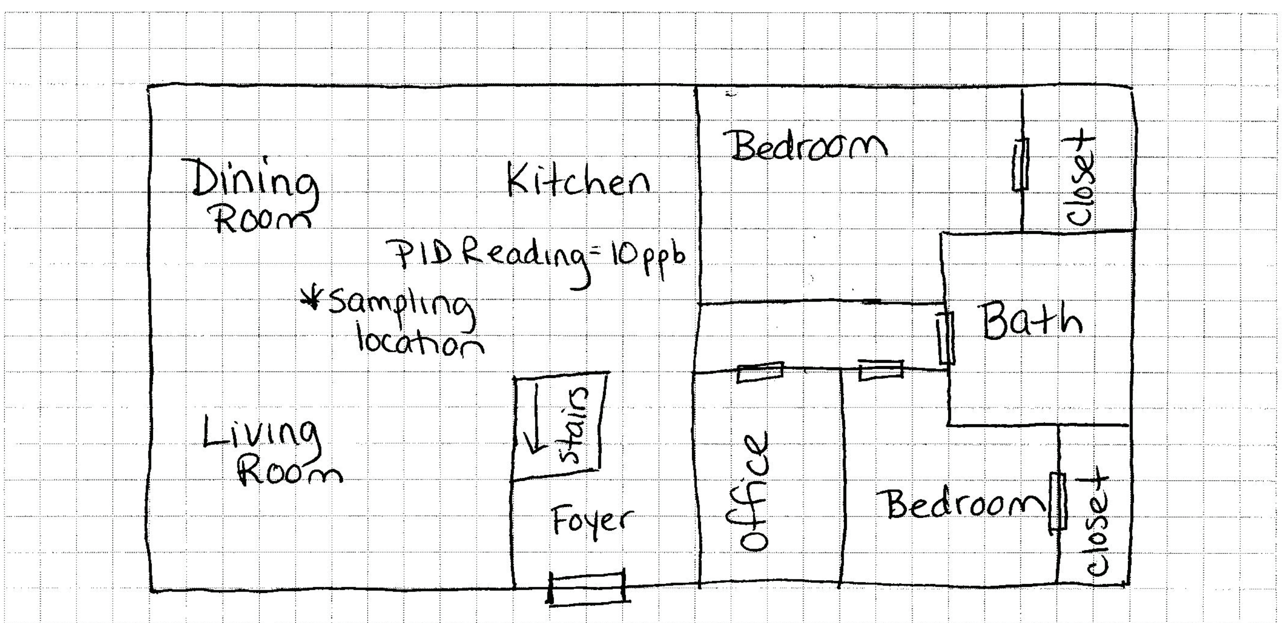
11. FLOOR PLANS

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note.

Basement:



First Floor:

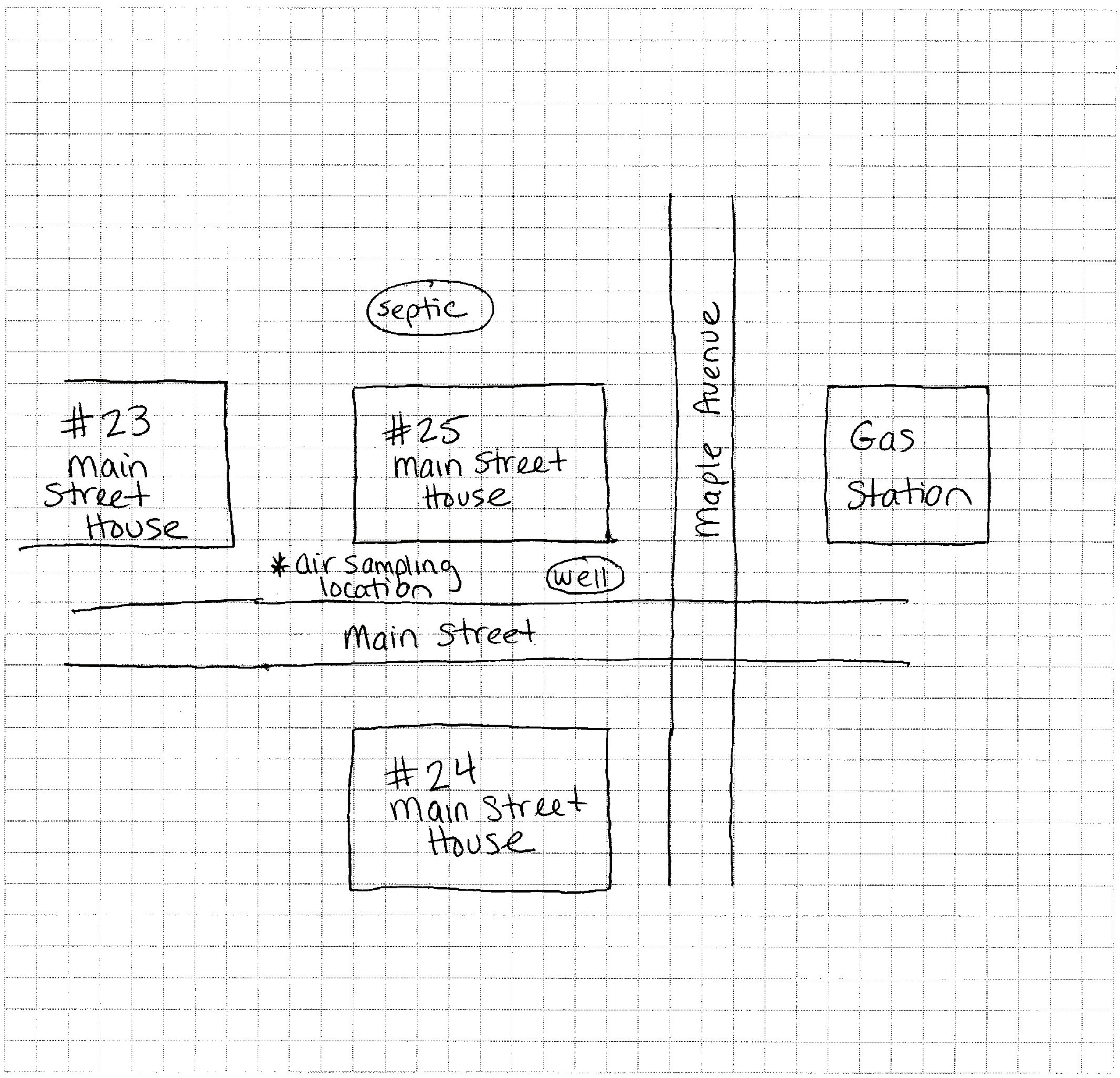


Example Correct

12. OUTDOOR PLOT

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s) and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.



N

Wind direction = NE

Example Correct

13. PRODUCT INVENTORY FORM

Make & Model of field instrument used: RAE photoionization detector

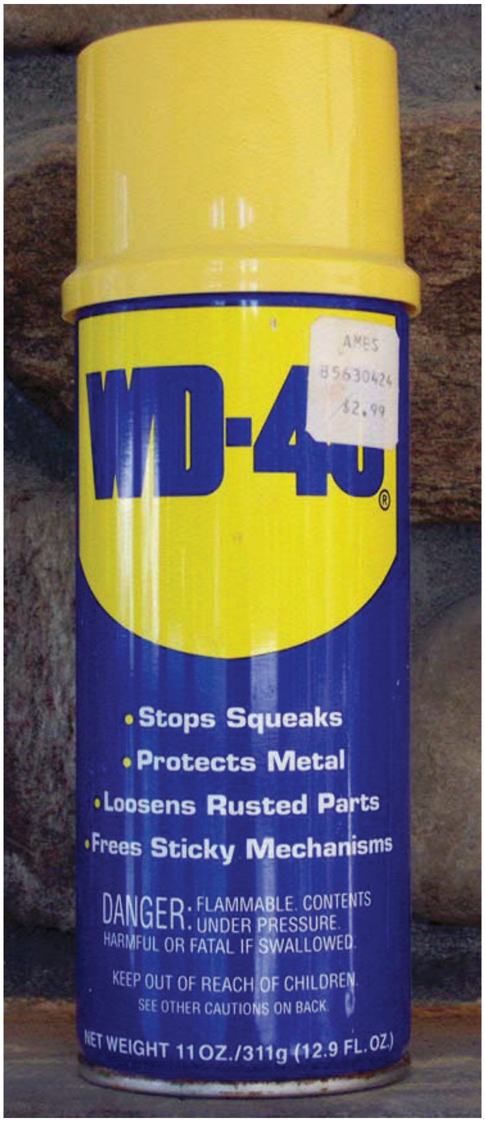
List specific products found in the residence that have the potential to affect indoor air quality.

Location	Product Description	Size (oz.)	Condition*	Chemical Ingredients	Field Instrument Reading	Photo ** Y / N
Kitchen	WD-40	12oz	UO	See photo	10 ppb	Y
garage	mineral spirits	24oz	U	benzene, toluene	15 ppb	N
garage	American Semi-Gloss latex paint	64oz	U	titanium dioxide, ethylene, glycol, aluminum hydroxide, 2,2,4-trimethyl 1-1,3-pentanediol isobutyrate, Vinyl acetate	2 ppb	N
garage	Krylon Semi-gloss oil paint	64oz	D	butane, propane, titanium dioxide, xylene, ethylbenzene, acetone, MEK, butanol, MIK	10 ppb	N
garage	Rustoleum	12oz	U	talc, calcium carbonate, titanium dioxide, xylene, ethylbenzene, acetone, liquified petroleum gases, pentaerythritol	4 ppb	N
garage	Deep Woods Double Strength Insect Repellent	8oz	D	propane, isobutane, N,N-Diethyl-meta-toluamide, Di-n-propyl isocinchomeronate	0.5 ppb	N
base-ment	12 cans latex paint	128oz	U	talc, titanium dioxide, Kaolin clay, 2,24-trimethyl -1,3 pentanediol isobutyrate, vinyl acetate	0	N

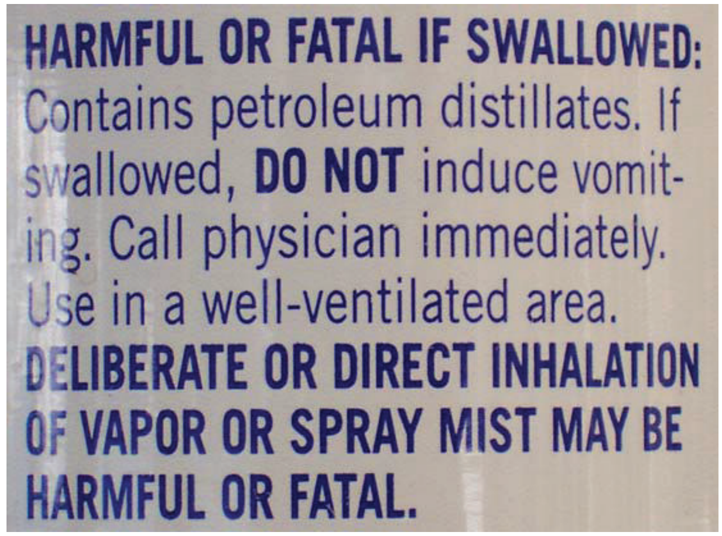
* Describe the condition of the product containers as **Unopened (UO), Used (U),** or **Deteriorated (D)**
** Photographs of the **front and back** of product containers can replace the handwritten list of chemical ingredients. However, the photographs must be of good quality and ingredient labels must be legible.

Product Inventory Attachment — 25 Main Street, City

WD-40 FRONT



WD-40 INGREDIENTS



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NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Appendix C
Volatile organic chemicals in air — summary of background databases

A detailed description of each background database introduced in Section 3.2.4 is provided in this appendix.

C.1 NYSDOH 2003: Study of Volatile Organic Chemicals in Air of Fuel Oil Heated Homes

Between 1997 and 2003, the New York State Department of Health (NYSDOH) conducted a study of the occurrence of volatile organic chemicals (VOCs) in the indoor air of homes that heat with fuel oil. The purpose of the study was to characterize the indoor environment of fuel oil heated homes as a means of evaluating post clean-up conditions in residences affected by petroleum spills. The study included basement, living space and outdoor samples from 104 homes, tested during both heating and non-heating seasons. Most of the more than 600 samples collected in the study were analyzed for 69 individual VOCs. This summary report presents the results to help characterize commonly found concentrations of these 69 compounds in the indoor and outdoor air of residential settings heated with fuel oil.

The study is comprised of single family homes heated with fuel oil. With the exception of New York City, homes from across the state were included in the study, with the majority of the homes being near the Albany area. Prospective residences were required to have no past oil spills, no hobbies or home business that regularly use products containing VOCs, and no recent activities utilizing products that contain VOCs (e.g. painting, staining). A pre-sampling inspection was conducted in each home and included completing a building questionnaire to gather building information such as age, basement characteristics, heating and ventilation parameters, location of fuel oil tank, garage placement, etc. and an inventory of products that might be sources of indoor VOCs. When present, the products and their ingredients were listed on the inventory form. In addition, the product containers were screened with a photoionization detector (PID) to identify potential chemical interference during each sampling event and elevated readings were noted on the inventory forms. In most homes, gross sources of VOCs were not identified and containers were generally found to be sealed tightly. In some homes the PID detected elevated VOC levels associated with a product; however, the products were not removed and samples were still collected.

Sampling was performed in a manner consistent with the NYSDOH's February 1, 2005, Indoor Air Sampling and Analysis Guidance (available on the NYSDOH's web site at http://www.health.state.ny.us/nysdoh/indoor/guidance.htm). Two-hour samples were collected in 6-liter pre-cleaned, passivated, evacuated whole air canisters prepared and analyzed at the NYSDOH's Wadsworth Center laboratory. The samples were analyzed in accordance with EPA Method TO-15 utilizing a Tekmar® AutoCan® concentrator / Agilent® 6890/5973 GC/MSD analytical system. The method detection limits for all compounds except hexachlorobutadiene were 0.25 micrograms per cubic meter (mcg/m^3). The method detection limit for hexachlorobutadiene was 0.43 mcg/m^3.

The dataset exhibits a lognormal distribution typical of environmental data. Table C1 provides a summary of the indoor and outdoor air data. It contains the mean, 25^{th}, 50^{th},

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

75th, 90th percentile values and the upper fence value for each compound. The upper fence is calculated as 1.5 times the interquartile range (difference between the 25th and 75th percentile values) above the 75th percentile value. The upper fence is a boundary used for identifying the presence of outliers in the data. In cases where the 25th or 75th percentiles were below the laboratory detection limit of 0.25 mcg/m^3, randomly generated values between 0.000 and 0.250 were used in calculating the upper fence. All of the values calculated for the lower fence were negative and are not included in the table. For hexachlorobutadiene, the randomly generated values used to calculate the upper fence ranged from 0.000 to 0.430. All of the values are adjusted to two significant figures. A summary of the study can be obtained at the NYSDOH's web site: http://www.health.state.ny.us/nysdoh/indoor/fuel_oil.htm.

C.2 EPA 2001: Building Assessment and Survey Evaluation (BASE) Database

From 1994 through 1996, the EPA conducted a study of indoor air quality referred to as the Building Assessment and Survey Evaluation (BASE '94-'96). The study included measurement of VOCs, radon, formaldehyde, carbon monoxide, carbon dioxide, and particulates in indoor and outdoor air at 100 randomly selected public and commercial office buildings across the United States. Each building was sampled for a one-week period in either winter or summer. Buildings had a targeted occupancy of no less than 50 full-time employees and were served by no more than two air handling units. Physical characteristics of the buildings such as size, age, construction and heating and ventilation parameters were recorded. Ambient sources of VOCs were also characterized for the entire building and in the individual sample locations. The study excluded any buildings with highly publicized indoor air quality complaints; therefore, data from the study should be representative of conventional office buildings.

Two methods were used to measure VOC concentrations in the BASE study. Air samples were collected into passivated, evacuated whole air canisters (SUMMA®, TO-Can®, etc.) from all 100 buildings. In addition, air samples were concurrently collected on multisorbent tubes from 70 of the 100 buildings. Six-liter canister air samples were collected over a nominal nine-hour period and analyzed by gas chromatography/mass spectroscopy using EPA Method TO-14. The multisorbent tubes were filled with glass beads, Tenax TA, Ambersorb XE-340, and activated carbon and 2.5 liters of ambient air were collected over an eight-hour period. The tube samples were thermally desorbed and analyzed by gas chromatography/mass spectrometry using EPA Method TO-1. Method reporting limits ranged from 0.2 to 7.0 mcg/m^3.

BASE '94-'96 VOC data was received from the EPA in late 2001. Minimum, maximum, means and the 25th, 50th, 75th, 90th, 95th and 99th percentile values were calculated. For data analysis, all voided samples, blank samples, and samples that could not be analyzed were removed. The result for any sample or analyte that was marked as below the detection limit was assigned the value of one half the detection limit. Buildings in the BASE '94-'98 study generally had three indoor air VOC samples and one VOC outdoor sample for each method. Table C2 provides a summary of the indoor and outdoor air samples analyzed by SUMMA® canisters only. The table will be revised after EPA releases their final version of the study.

C.3 NYSDOH 1997: Control Home Database

From 1989-1996, the NYSDOH collected 228 indoor and outdoor air samples from 53 residences used as control homes in New York State investigations. Control homes were defined and selected to represent homes with neighborhood, construction, and occupancy similar to homes being investigated for VOC impacts on indoor air. Control homes also had no unusual source of VOCs, such as a past oil spill, recent refinishing or painting activities, or proximity to the VOC source being investigated.

Air samples in control homes were collected from the basement, a room considered a living space (such as a living room, dining room, or bedroom), and outdoors. An inventory of recent activities, stored household products and heating fuel type was made at the time of sampling. Air samples were collected by one of two methods: 6-liter pre-cleaned, passivated, evacuated whole air canisters (SUMMA®, TO-Can®, etc.), analyzed with Method TO-14 (EPA 1988), or Porapak adsorbent tubes, analyzed using NYSDOH method 311-6 (NYSDOH 1991). Through 1992, both methods were used about equally. After 1992, most samples were collected with Summa® canisters. About 20% of the samples were collected with a sampling time of 12 hours. The rest of the samples had sampling times of one to four hours. The NYSDOH Wadsworth Center Laboratories analyzed all samples.

The reporting limits for some compounds in samples from 1989 and 1990 were sometimes higher than 10 mcg/m^3. Analyses where compounds were reported as not detected with reporting limits greater than 10 mcg/m^3 were excluded from the database. In the 1990s reporting limits were lowered (due to improvements made in analytical equipment and methods) and some compounds were detected more frequently. Data from the later years of this study demonstrated that median levels of all compounds (except toluene) were less than 10 mcg/m^3.

The minimum, maximum, mean, median, 5^{th}, 25^{th}, 50th, 75^{th}, 95^{th} and 99^{th} percentiles were calculated. To calculate these descriptive statistics, compounds not detected in the samples and compounds reported as present but less than the reporting limit were assigned a value equal to one half the reporting limit. Table C3 provides a summary of these data.

C.4 EPA 1988: National Ambient Volatile Organic Compounds (VOCs) Data Base Update

This database is a compilation of available air data published for the EPA in 1988. The document includes data from the original EPA database published in 1983 (Brodzinsky and Singh, 1983), which was an evaluation of 241 published reports from the years 1970 to 1980. Additional published and unpublished data for VOCs were also evaluated and included through 1987. The database covers the concentrations of more than 300 VOCs in outdoor (urban, rural, remote, source-dominated) and indoor settings. Indoor air data are limited to residential and office space, and excludes studies of emissions or sources, solely health-related studies, laboratory or modeling studies, and industrial workplace studies. Outdoor air data are limited to locations beyond the fence line of industrial and commercial facilities releasing VOCs.

Each data record includes maximum and minimum concentrations; the total number of measurements included in the average and the number of those that were below the detection limit or equal to zero. The 25^{th}, 50^{th} (median) and 75^{th} percentiles were also calculated. Table C4 provides a summary of these data for a limited number of compounds reported in the publication.

C.5 Health Effects Institute 2005: Relationship of Indoor, Outdoor and Personal Air

The Relationships of Indoor, Outdoor and Personal Air (RIOPA) study was designed to provide information in assessing the possible public health risks from air toxics and particulate matter in the urban environment for a large number of VOCs, carbonyl compounds and $PM_{2.5}$. The investigators measured indoor, outdoor and personal exposure concentrations of 16 VOCs, 10 carbonyls and PM during two 48-hour sampling periods in different seasons between the summer of 1999 and the spring of 2001. The study included 100 homes with 100 adult residents in each of three cities with different air pollution sources and weather conditions: Los Angeles, CA; Houston, TX; and Elizabeth, NJ. Children in each of the homes sampled were recruited to the best extent practical. Only 18 VOCs are summarized in this guidance document (Table C5). Refer to the original RIOPA report (Weisel *et al.*, 2005) for information about the carbonyl and particulate matter sampling and results.

The report (1) compares concentrations of the pollutants measured in indoor, outdoor and personal air, (2) examined the effects of city , season, type of home, and other variables on measured concentrations, and (3) quantified how much outdoor sources contributed to the indoor concentrations using measurements of outdoor-indoor air exchange rates.

All the VOC air samples were collected on 3M Brand Organic Vapor Monitor (OVM) badges. The badges are passive sampling devices that allow VOCs in air to pass through a diffusion membrane and are adsorbed onto carbon impregnated pads. A solvent is used to extract the VOCs from the pad and the extract is analyzed by gas chromatography/mass spectroscopy.

The published report provides descriptive summary statistics for all the tested compounds and parameters including: sample size, mean and standard deviation. Concentrations are also provided for the 1^{st}, 5^{th}, 50^{th} (median), 95^{th}, and 99^{th} percentile. Table C5 provides a summary of the indoor, outdoor, adult and child personal air data for 16 VOCs and 2 carbonyl compounds.

C.6 References

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Table C1. NYSDOH 2003: Study of volatile organic chemicals in air of fuel oil heated homes

All results are micrograms per cubic meter (mcg/m^3).

Compound	INDOOR AIR												
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max	Upper F
1,1,1-TRICHLOROETHANE	166	41.5%	400	2	<0.25	<0.25	0.3	1.1	3.1	6.9	41	110	2.5
1,1,2,2-TETRACHLOROETHANE	386	96.5%	400	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.8	2.7	0.4
1,1,2-TRICHLOROETHANE	384	96.0%	400	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	1	6.2	0.4
1,1,2-TRICHLOROTRIFLUOROETHANE	178	44.5%	400	0.8	<0.25	<0.25	0.5	1.1	1.8	3.4	5.9	7.4	2.5
1,1-DICHLOROETHANE	396	99.0%	400	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.4	4.4	0.4
1,1-DICHLOROETHENE	373	93.3%	400	1.4	<0.25	<0.25	<0.25	<0.25	<0.25	0.7	6.3	430	0.4
1,2,3-TRIMETHYLBENZENE	164	41.0%	400	1.2	<0.25	<0.25	0.4	1.1	2.7	5	11	37	2.5
1,2,4-TRICHLOROBENZENE	319	79.8%	400	1.3	<0.25	<0.25	<0.25	<0.25	3.4	6.3	26	37	0.5
1,2,4-TRIMETHYLBENZENE	49	12.3%	400	4.8	<0.25	0.7	1.9	4.3	9.5	18	35	260	9.8
1,2-DIBROMOETHANE	397	99.3%	400	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	1.1	0.4
1,2-DICHLOROBENZENE	315	78.8%	400	0.3	<0.25	<0.25	<0.25	<0.25	0.7	1	2.3	4.9	0.5
1,2-DICHLOROETHANE	394	98.5%	400	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.4	4.9	0.4
1,2-DICHLOROPROPANE	391	97.8%	400	0.4	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	9	34	0.4
1,2-DICHLOROTETRAFLUOROETHANE	349	87.3%	400	1	<0.25	<0.25	<0.25	<0.25	0.5	1.2	23	120	0.4
1,3,5-TRIMETHYLBENZENE	100	25.0%	400	2	<0.25	0.3	0.6	1.7	3.6	6.5	25	97	3.9
1,3-DICHLOROBENZENE	316	79.0%	400	0.3	<0.25	<0.25	<0.25	<0.25	0.6	0.9	1.6	2.5	0.5
1,4-DICHLOROBENZENE	266	66.5%	400	3.7	<0.25	<0.25	<0.25	0.5	1.3	2.6	24	770	1.2
2,3-DIMETHYLPENTANE	129	32.3%	400	3.8	<0.25	<0.25	0.7	2.2	7.5	16	50	210	5.2
2,4-DIMETHYLPENTANE	143	35.8%	400	3.2	<0.25	<0.25	0.6	2	7.7	15	52	120	4.7
ACETONE	12	5.3%	227	42	<0.25	9.9	21	52	110	140	200	690	115
ALPHA-PINENE	79	19.8%	400	5.8	<0.25	0.3	1.5	4.4	14	27	63	91	10
BENZENE	28	7.0%	400	8.3	<0.25	1.1	2.1	5.9	15	29	120	460	13
BROMOMETHANE	308	77.0%	400	0.3	<0.25	<0.25	<0.25	<0.25	0.6	0.9	3.2	23	0.5
CARBON TETRACHLORIDE	201	50.3%	400	0.4	<0.25	<0.25	<0.25	0.6	0.8	1.1	3.2	4.2	1.3
CHLOROBENZENE	398	99.5%	400	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.6	0.4
CHLOROETHANE	361	90.3%	400	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	0.6	0.9	4.5	0.4
CHLOROFORM	212	53.0%	400	0.9	<0.25	<0.25	<0.25	0.5	1.4	4.6	13	25	1.2
CHLOROMETHANE	184	46.0%	400	2	<0.25	<0.25	0.5	1.8	3.3	5.2	14	260	4.2
CIS-1,2-DICHLOROETHENE	364	91.0%	400	0.3	<0.25	<0.25	<0.25	<0.25	<0.25	1.2	4.6	7.4	0.4
CIS-1,3-DICHLOROPROPENE	388	97.0%	400	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	2.1	3.5	0.4
CYCLOHEPTANE	159	39.8%	400	1.2	<0.25	<0.25	0.5	1.3	3.1	5.1	11	23	2.9
CYCLOHEXANE	125	31.3%	400	6	<0.25	<0.25	0.8	2.6	8.1	19	88	510	6.3
DICHLORODIFLUOROMETHANE	215	53.8%	400	7.9	<0.25	<0.25	<0.25	4.1	15	26	180	300	10
d-LIMONENE	77	19.3%	400	8.9	<0.25	0.5	2.8	8.4	24	45	93	120	20
ETHYL ALCOHOL	3	1.3%	227	610	<0.25	27	160	540	1400	3000	6900	16000	1300
ETHYLBENZENE	58	14.5%	400	3.7	<0.25	0.4	1	2.8	7.3	13	26	340	6.4
ETHYLCYCLOHEXANE	149	37.3%	400	1.1	<0.25	<0.25	0.4	1.2	2.6	4.4	10	28	2.8

(Continued)

Table C1. NYSDOH 2003: Study of volatile organic chemicals in air of fuel oil heated homes -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	INDOOR AIR												
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max	Upper F
ETHYLMETHACRYLATE	215	94.7%	227	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	0.3	1	2.9	0.4
HEXACHLORO-1,3-BUTADIENE	304	76.0%	400	1.8	<0.25	<0.25	<0.25	<0.25	4.6	11	29	51	0.5
ISO-OCTANE	130	32.5%	400	5.5	<0.25	<0.25	0.6	2.1	6.5	14	63	870	5.0
ISOPRENE	44	11.0%	400	4.1	<0.25	0.8	2	4.3	8.8	15	43	81	9.5
ISOPROPYLBENZENE	259	64.8%	400	0.4	<0.25	<0.25	<0.25	0.4	0.9	1.3	2.7	27	0.8
M,P-XYLENE	54	13.5%	400	5.9	<0.25	0.5	1.5	4.6	12	21	46	550	11
METHYL ETHYL KETONE	20	8.8%	227	8.4	<0.25	1.4	3.4	7.3	16	39	79	180	16
METHYL ISOBUTYL KETONE	102	44.9%	227	1.2	<0.25	<0.25	0.3	0.9	2.2	5.3	16	36	1.9
METHYLCYCLOHEXANE	112	28.0%	400	4.9	<0.25	<0.25	0.7	1.9	6.4	12	32	620	4.5
METHYLENE CHLORIDE	89	22.3%	400	17	<0.25	0.3	1.4	6.6	22	45	310	2100	16
METHYLMETHACRYLATE	197	86.8%	227	0.6	<0.25	<0.25	<0.25	<0.25	0.4	1.1	5.3	66	0.4
METHYL-tert-BUTYL ETHER	69	30.4%	227	13	<0.25	<0.25	0.8	5.6	26	71	230	340	14
n-BUTYLBENZENE	222	55.5%	400	0.6	<0.25	<0.25	<0.25	0.5	1.2	2.1	4.9	33	1.1
n-DECANE	40	10.0%	400	7.7	<0.25	1.2	2.7	6.6	16	31	83	190	15
n-DODECANE	73	18.3%	400	5.6	<0.25	0.4	1.5	3.9	11	19	61	420	9.2
n-HEPTANE	19	4.8%	400	9.7	<0.25	1	2.8	7.6	19	33	72	670	18
n-HEXANE	50	12.5%	400	9.5	<0.25	0.6	1.6	5.9	18	35	93	950	14
n-NONANE	65	16.3%	400	3.8	<0.25	0.4	1.3	3.4	8.8	13	50	89	7.9
n-OCTANE	84	21.0%	400	1.9	<0.25	0.3	0.9	2.3	4.2	5.5	16	80	5.2
n-PROPYLBENZENE	206	51.5%	400	0.8	<0.25	<0.25	<0.25	0.7	1.7	2.8	8.2	41	1.5
n-UNDECANE	59	14.8%	400	5.4	<0.25	0.6	1.8	5	12	20	61	290	12
O-XYLENE	71	17.8%	400	3.8	<0.25	0.4	1.1	3.1	7.6	13	32	310	7.1
sec-BUTYLBENZENE	225	56.3%	400	0.5	<0.25	<0.25	<0.25	0.6	1.2	1.7	4.1	11	1.2
STYRENE	175	43.8%	400	0.8	<0.25	<0.25	0.3	0.6	1.3	2.3	6.2	50	1.4
tert-BUTYLBENZENE	228	57.0%	400	0.7	<0.25	<0.25	<0.25	0.6	1.6	2.8	5.3	36	1.3
TETRACHLOROETHENE	187	46.8%	400	1.3	<0.25	<0.25	0.3	1.1	2.9	4.1	20	51	2.5
TETRAHYDROFURAN	164	72.2%	227	2.1	<0.25	<0.25	<0.25	0.4	3.3	9.4	19	180	0.8
TOLUENE	25	6.3%	400	26	<0.25	3.5	9.6	25	58	110	300	510	57
TRANS-1,3-DICHLOROPROPENE	400	100.0%	400	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	NC
TRICHLOROETHENE	323	80.8%	400	0.4	<0.25	<0.25	<0.25	<0.25	0.5	0.8	7.4	25	0.5
TRICHLOROFLUOROMETHANE	42	10.5%	400	7.5	<0.25	1.1	2.9	5.4	17	30	95	190	12
VINYL CHLORIDE	387	96.8%	400	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.8	1	0.4

(Continued)

Table C1. NYSDOH 2003: Study of volatile organic chemicals in air of fuel oil heated homes -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	OUTDOOR AIR												
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max	Upper F
1,1,1-TRICHLOROETHANE	125	62.5%	200	0.3	<0.25	<0.25	<0.25	0.3	0.6	0.7	3.8	8.4	0.6
1,1,2,2-TETRACHLOROETHANE	199	99.5%	200	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.5	0.4
1,1,2-TRICHLOROETHANE	199	99.5%	200	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	6.3	0.3
1,1,2-TRICHLOROTRIFLUOROETHANE	97	48.5%	200	0.9	<0.25	<0.25	0.5	1.1	1.9	3.6	6	11	2.5
1,1-DICHLOROETHANE	200	100.0%	200	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	NC
1,1-DICHLOROETHENE	199	99.5%	200	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	1	0.4
1,2,3-TRIMETHYLBENZENE	165	82.5%	200	0.2	<0.25	<0.25	<0.25	<0.25	0.4	0.6	1.4	2.5	0.5
1,2,4-TRICHLOROBENZENE	168	84.0%	200	0.8	<0.25	<0.25	<0.25	<0.25	2.3	4.8	12	21	0.4
1,2,4-TRIMETHYLBENZENE	109	54.5%	200	0.9	<0.25	<0.25	<0.25	0.8	1.7	2.5	8.2	50	1.9
1,2-DIBROMOETHANE	199	99.5%	200	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	8.2	0.4
1,2-DICHLOROBENZENE	166	83.0%	200	0.2	<0.25	<0.25	<0.25	<0.25	0.6	0.9	1.6	6.1	0.4
1,2-DICHLOROETHANE	199	99.5%	200	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.3	0.4
1,2-DICHLOROPROPANE	194	97.0%	200	0.4	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	11	22	0.4
1,2-DICHLOROTETRAFLUOROETHANE	169	84.5%	200	0.3	<0.25	<0.25	<0.25	<0.25	0.6	1.3	2.4	4.5	0.5
1,3,5-TRIMETHYLBENZENE	143	71.5%	200	0.3	<0.25	<0.25	<0.25	0.3	0.7	1	2.4	2.5	0.7
1,3-DICHLOROBENZENE	170	85.0%	200	0.3	<0.25	<0.25	<0.25	<0.25	0.5	0.7	1.6	10	0.4
1,4-DICHLOROBENZENE	164	82.0%	200	0.3	<0.25	<0.25	<0.25	<0.25	0.5	0.8	1.8	7.1	0.5
2,3-DIMETHYLPENTANE	147	73.5%	200	0.5	<0.25	<0.25	<0.25	0.3	1	2	8.6	13	0.7
2,4-DIMETHYLPENTANE	139	69.5%	200	0.7	<0.25	<0.25	<0.25	0.4	0.8	1.8	14	43	0.8
ACETONE	7	6.1%	114	16	<0.25	3.4	6.4	14	44	58	170	200	30
ALPHA-PINENE	122	61.0%	200	0.9	<0.25	<0.25	<0.25	0.5	2	3.8	12	18	1.2
BENZENE	18	9.0%	200	1.9	<0.25	0.6	1.3	2.2	4.3	5.8	13	17	4.8
BROMOMETHANE	162	81.0%	200	0.4	<0.25	<0.25	<0.25	<0.25	0.5	0.9	3.1	27	0.5
CARBON TETRACHLORIDE	108	54.0%	200	0.4	<0.25	<0.25	<0.25	0.6	0.8	1	3.3	3.6	1.2
CHLOROBENZENE	200	100.0%	200	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	NC
CHLOROETHANE	188	94.0%	200	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	0.4	0.7	1.4	0.4
CHLOROFORM	168	84.0%	200	0.2	<0.25	<0.25	<0.25	<0.25	0.4	0.5	0.8	1.3	0.5
CHLOROMETHANE	96	48.0%	200	1.3	<0.25	<0.25	0.5	1.8	3.2	4.6	7.6	13	4.3
CIS-1,2-DICHLOROETHENE	193	96.5%	200	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	1.8	2.7	0.4
CIS-1,3-DICHLOROPROPENE	195	97.5%	200	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	2.4	3.3	0.4
CYCLOHEPTANE	148	74.0%	200	0.4	<0.25	<0.25	<0.25	0.3	0.7	1.1	4.8	12	0.6
CYCLOHEXANE	137	68.5%	200	1.5	<0.25	<0.25	<0.25	0.4	1.3	3	16	170	0.9
DICHLORODIFLUOROMETHANE	108	54.0%	200	2.8	<0.25	<0.25	<0.25	4.2	7.5	11	23	38	10
d-LIMONENE	155	77.9%	199	1	<0.25	<0.25	<0.25	<0.25	0.8	1.5	24	83	0.5
ETHYL ALCOHOL	1	0.9%	114	35	<0.25	3.3	6.9	16	31	220	610	930	34
ETHYLBENZENE	107	53.5%	200	0.8	<0.25	<0.25	<0.25	0.5	1.1	1.9	19	21	1.0
ETHYLCYCLOHEXANE	164	82.0%	200	0.4	<0.25	<0.25	<0.25	<0.25	0.5	1	5.7	14	0.5

(Continued)

Table C1. NYSDOH 2003: Study of volatile organic chemicals in air of fuel oil heated homes -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	OUTDOOR AIR												
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max	Upper F
ETHYLMETHACRYLATE	114	100.0%	114	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	NC
HEXACHLORO-1,3-BUTADIENE	162	81.0%	200	1.2	<0.25	<0.25	<0.25	<0.25	2.3	7	20	27	0.5
ISO-OCTANE	139	69.5%	200	0.5	<0.25	<0.25	<0.25	0.3	0.9	2	7.5	11	0.7
ISOPRENE	111	55.5%	200	1.1	<0.25	<0.25	<0.25	0.9	2.8	4.6	13	21	2.0
ISOPROPYLBENZENE	182	91.0%	200	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	0.4	0.7	0.9	0.4
M,P-XYLENE	110	55.0%	200	0.8	<0.25	<0.25	<0.25	0.5	1.4	3.1	17	20	1.0
METHYL ETHYL KETONE	8	7.0%	114	6.2	<0.25	0.8	1.3	2.6	6.3	17	180	210	5.3
METHYL ISOBUTYL KETONE	86	75.4%	114	0.8	<0.25	<0.25	<0.25	<0.25	0.9	2.9	21	24	0.5
METHYLCYCLOHEXANE	141	70.5%	200	0.5	<0.25	<0.25	<0.25	0.3	0.8	1.6	4.7	23	0.7
METHYLENE CHLORIDE	101	50.5%	200	0.8	<0.25	<0.25	<0.25	0.7	1.6	2.9	12	23	1.6
METHYLMETHACRYLATE	110	96.5%	114	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	1.5	2.4	0.4
n-BUTYLBENZENE	53	46.5%	114	1	<0.25	<0.25	0.3	0.9	2.1	5.9	10	14	1.9
n-DECANE	174	87.0%	200	0.2	<0.25	<0.25	<0.25	<0.25	0.3	0.4	1.2	8.8	0.4
n-DODECANE	65	32.5%	200	1.3	<0.25	<0.25	0.8	2	2.6	3.6	8.5	20	4.7
n-HEPTANE	94	47.0%	200	2.2	<0.25	<0.25	0.5	1.9	4.5	7.6	27	89	4.5
n-HEXANE	57	28.5%	200	1.5	<0.25	<0.25	0.5	1	2.6	5.1	20	67	2.2
n-NONANE	79	39.5%	200	1.1	<0.25	<0.25	0.4	0.9	1.6	3.6	19	26	2.0
n-OCTANE	131	65.5%	200	0.4	<0.25	<0.25	<0.25	0.4	0.8	1.2	5.1	13	0.7
n-PROPYLBENZENE	112	56.0%	200	1	<0.25	<0.25	<0.25	0.7	1.2	2.1	8.6	90	1.5
n-UNDECANE	184	92.0%	200	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	0.5	2	8	0.4
O-XYLENE	105	52.5%	200	0.6	<0.25	<0.25	<0.25	0.7	1.7	2.3	5.8	6.8	1.5
O-XYLENE	120	60.0%	200	0.7	<0.25	<0.25	<0.25	0.6	1.7	2.5	8.9	10	1.2
sec-BUTYLBENZENE	160	80.0%	200	0.2	<0.25	<0.25	<0.25	<0.25	0.4	0.5	1.2	3.8	0.5
STYRENE	158	79.0%	200	0.2	<0.25	<0.25	<0.25	<0.25	0.4	0.6	2.3	3.6	0.5
tert-BUTYLBENZENE	177	88.5%	200	0.4	<0.25	<0.25	<0.25	<0.25	0.3	0.6	2.9	31	0.4
TETRACHLOROETHENE	143	71.5%	200	0.6	<0.25	<0.25	<0.25	0.3	0.8	1.6	12	20	0.7
TETRAHYDROFURAN	108	94.7%	114	0.3	<0.25	<0.25	<0.25	<0.25	<0.25	0.4	4	8.5	0.4
TOLUENE	12	6.0%	200	11	<0.25	0.6	1.3	2.4	5.9	21	350	640	5.1
TRANS-1,3-DICHLOROPROPENE	200	100.0%	200	0.1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	NC
TRICHLOROETHENE	177	88.5%	200	0.2	<0.25	<0.25	<0.25	<0.25	0.3	0.5	1	1.3	0.4
TRICHLOROFLUOROMETHANE	70	35.0%	200	1.7	<0.25	<0.25	0.8	2.2	3.6	6.1	17	20	5.1
VINYL CHLORIDE	197	98.5%	200	0.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.4	4.8	0.4

ND = Number of non-detects

ND (%) = Percentage of total number in sample that are non-detect

N = Total number of samples

* Non-detects were estimated at 1/2 the detection limit to calculate the mean

Min; Max = minimum and maximum value detected

Upper F = Upper Fence = The upper fence is calculated as 1.5 times the interquartile range (difference between the 25th and 75th percentile values) above the 75th percentile value.

NC = Upper Fence not calculated. Compound not detected in any sample.

Table C2. EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method

All results are micrograms per cubic meter (mcg/m^3).

Compound	INDOOR AIR											
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max
1,1,1-TRICHLOROETHANE	7	2.3%	298	16.2	<0.5	2.6	5.1	10.8	20.6	33.0	737.9	833.2
1,1,2-TRICHLOROETHANE	136	100.0%	136	0.6	<0.6	<1.0	<1.3	<1.4	<1.5	<1.6	<2.1	<2.3
1,1-DICHLOROETHANE	136	100.0%	136	0.2	<0.2	<0.4	<0.5	<0.5	<0.7	<0.8	<0.9	<0.9
1,1-DICHLOROETHENE	136	100.0%	136	0.5	<0.7	<0.9	<1.1	<1.2	<1.4	<1.6	<1.7	<1.8
1,2,4-TRICHLOROBENZENE	136	100.0%	136	1.1	<0.6	<0.9	<1.0	<1.2	<6.8	<7.2	<8.1	<8.2
1,2,4-TRIMETHYLBENZENE	52	17.7%	294	4.8	<0.4	1.7	2.8	5.1	9.5	13.7	39.0	91.0
1,2-DIBROMOETHANE	258	99.6%	259	0.6	<0.8	<1.1	<1.3	<1.4	<1.5	<1.6	<2.7	1.4
1,2-DICHLOROBENZENE	255	98.5%	259	0.6	<0.6	<0.8	<0.9	<1.0	<1.2	<1.3	10.5	11.2
1,2-DICHLOROETHANE	254	98.1%	259	0.9	<0.4	<0.5	<0.6	<0.7	<0.9	<1.0	24.8	84.9
1,2-DICHLOROPROPANE	136	100.0%	136	0.6	<0.5	<1.0	<1.4	<1.6	<1.6	<1.7	<2.3	<2.6
1,3,5-TRIMETHYLBENZENE	206	79.5%	259	1.6	<0.8	<1.3	<1.5	<4.6	3.7	4.6	9.0	16.6
1,3-BUTADIENE	39	100.0%	39	1.4	<2.1	<2.3	<2.5	<2.7	<3.0	<7.5	<7.9	<7.9
1,3-DICHLOROBENZENE	136	100.0%	136	0.6	<0.5	<0.7	<0.8	<1.1	<2.4	<2.5	<2.8	<2.9
1,4-DICHLOROBENZENE	212	71.1%	298	3.1	<0.5	<0.8	<1.2	1.4	5.5	12.5	80.5	87.1
1-BUTANOL	118	95.9%	123	42.7	<2.4	<3.6	<4.0	<4.3	<4.8	<7.9	35.3	4957.4
2-BUTANONE (MEK)	13	5.0%	259	6.2	<1.4	3.3	5.2	7.5	12.0	13.5	28.1	55.4
2-BUTOXYETHANOL	123	100.0%	123	4.0	<4.8	<7.2	<8.0	<8.6	<9.3	<10.4	<16.4	<16.8
2-ETHYL-1-HEXANOL	160	98.8%	162	3.2	<1.1	<5.0	<7.6	<8.4	<9.2	<9.7	8.2	8.4
2-METHYL-1-PROPANOL	30	76.9%	39	1.2	<0.9	<1.0	<1.1	<3.0	3.1	5.5	5.8	5.8
2-PROPANOL	8	20.5%	39	73.1	<1.3	6.6	30.0	56.0	250.0	475.0	580.0	580.0
3-METHYL PENTANE	125	48.3%	259	3.1	<0.9	<1.7	1.4	4.2	6.5	8.3	22.9	35.4
4-ETHYLTOLUENE	212	81.9%	259	1.7	<0.9	<1.5	<1.6	<3.1	3.6	5.9	9.8	16.4
4-METHYL-2-PENTANONE	153	59.1%	259	3.1	<0.7	<1.2	<1.5	3.0	6.0	8.1	58.4	72.5
ACETONE	0	0.0%	259	54.0	11.6	32.4	45.0	59.8	98.9	120.2	226.6	243.7
a-PINENE	238	79.9%	298	4.2	<0.5	<1.1	<1.2	<2.8	3.6	6.4	67.8	399.1
BENZENE	56	19.0%	294	4.5	<0.8	2.1	3.4	5.1	9.4	12.5	25.0	63.0
BENZYL CHLORIDE	136	100.0%	136	1.2	<0.8	<1.2	<1.4	<1.7	<6.8	<7.2	<8.1	<8.2
BROMOMETHANE	246	95.0%	259	0.6	<0.6	<0.8	<0.9	<1.1	<1.7	<2.1	3.6	4.6
BUTYL ACETATE	232	77.9%	298	2.9	<0.9	<1.5	<1.8	<5.2	4.5	15.8	35.3	50.6
CARBON DISULFIDE	134	51.7%	259	1.9	<0.5	<0.8	<1.3	2.1	4.2	6.4	14.8	24.5
CARBON TETRACHLORIDE	241	93.1%	259	0.5	<0.5	<0.8	<0.9	<1.1	<1.3	0.7	0.9	2.1
CHLOROBENZENE	255	98.5%	259	0.4	<0.4	<0.6	<0.7	<0.8	<0.9	<1.0	1.0	1.2
CHLOROETHANE	254	98.1%	259	1.1	<0.6	<0.8	<0.9	<1.0	<1.1	<1.3	47.9	56.7
CHLOROFORM	203	78.4%	259	0.5	<0.3	<0.4	<0.5	<1.2	1.1	1.4	4.8	12.1
CHLOROMETHANE	2	0.8%	259	2.9	<0.7	2.1	2.5	3.1	3.7	4.4	12.3	21.8
CIS-1,2-DICHLOROETHENE	136	100.0%	136	0.6	<0.6	<0.8	<1.0	<1.2	<1.9	<2.0	<2.2	<2.3

(Continued)

Table C2. EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	INDOOR AIR											
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max
CIS-1,3-DICHLOROPROPENE	136	100.0%	136	0.9	<1.2	<1.7	<1.9	<2.0	<2.3	<2.5	<2.9	<3.2
DICHLORODIFLUOROMETHANE	18	6.9%	259	13.8	<4.8	4.8	6.7	10.5	16.5	32.9	81.3	942.3
DICHLOROTETRAFLUOROETHANE	136	100.0%	136	1.6	<1.5	<2.2	<2.5	<3.0	<6.8	<7.4	<8.2	<11.3
DIMETHYL DISULFIDE	239	92.3%	259	2.0	<1.4	<2.1	<2.4	<2.7	<3.7	3.6	32.4	70.4
d-LIMONENE	74	24.8%	298	10.8	<0.7	2.5	5.3	11.3	22.5	43.7	136.7	148.0
DODECANE	107	35.9%	298	8.2	<1.7	<4.5	5.4	9.6	15.9	22.0	92.8	110.0
ETHANOL	3	7.7%	39	89.3	<1.2	26.0	79.0	140.0	210.0	290.0	300.0	300.0
ETHYL ACETATE	163	54.7%	298	3.0	<0.6	<1.0	<2.6	3.2	5.4	9.5	59.0	64.2
ETHYLBENZENE	144	49.0%	294	2.8	<0.9	<1.6	1.4	3.4	5.7	7.6	18.5	73.6
HEXACHLOROBUTADIENE	136	100.0%	136	1.5	<1.3	<1.8	<2.1	<2.5	<6.8	<7.2	<8.1	<8.2
HEXANAL	78	63.4%	123	6.8	<2.5	<3.9	<4.6	7.8	12.0	14.7	26.2	235.1
m & p-XYLENES	53	18.0%	294	10.8	<1.5	4.1	6.9	12.2	22.2	28.5	67.6	260.8
METHYL TERTIARY-BUTYL ETHER	198	76.4%	259	3.3	<1.0	<1.5	<1.7	<6.4	11.5	16.1	30.8	34.0
METHYLENE CHLORIDE	94	31.5%	298	21.2	<1.1	<1.7	2.9	5.0	10.0	16.0	1155.6	1496.9
NAPHTHALENE	254	85.8%	296	6.6	<1.4	<2.2	<2.5	<5.2	5.1	20.9	98.0	410.0
n-DECANE	58	19.5%	298	7.4	<0.7	3.0	4.6	8.4	17.5	22.4	48.6	54.8
n-HEPTANAL	36	92.3%	39	1.7	<1.2	<1.3	<1.5	<1.6	<3.6	3.1	34.9	34.9
n-HEXANE	26	16.0%	162	6.3	<.9	1.6	3.1	6.4	10.2	15.2	120.0	130.0
NONANAL	146	90.1%	162	6.8	<1.6	<5.1	<7.8	<8.6	<16.8	30.2	88.9	106.3
NONANE	101	39.0%	259	3.7	<0.5	<1.0	1.7	3.6	7.8	12.4	45.2	53.8
n-UNDECANE	25	9.7%	259	12.6	<1.1	5.1	8.9	16.4	22.6	27.4	68.7	169.6
OCTANE	155	52.0%	298	5.5	<0.4	<0.8	<2.5	2.0	4.5	8.6	47.9	921.7
o-XYLENE	81	27.6%	294	3.8	<0.7	<2.4	2.4	4.4	7.9	11.2	20.1	90.5
PENTANAL	111	90.2%	123	3.0	<2.4	<3.7	<4.1	<4.6	<7.3	7.0	20.0	57.3
STYRENE	251	85.4%	294	1.5	<0.6	<1.6	<1.8	<2.3	1.9	4.3	15.0	40.0
TETRACHLOROETHENE	103	34.6%	298	6.0	<0.9	<1.9	3.0	5.9	15.9	25.4	55.6	65.7
TOLUENE	0	0.0%	294	25.1	3.5	10.7	15.7	25.9	43.0	70.8	348.9	390.3
TRANS-1,3-DICHLOROPROPENE	136	100.0%	136	0.5	<0.5	<0.8	<1.1	<1.2	<1.3	<1.3	<1.8	<2.0
TRICHLOROETHENE	216	72.5%	298	2.6	<0.6	<1.2	<1.4	1.2	4.2	6.5	57.0	88.5
TRICHLOROFLUOROMETHANE	107	35.9%	298	19.4	<1.7	<3.7	3.9	6.7	18.1	54.0	860.6	1015.3
TRICHLOROTRIFLUOROETHANE	217	83.8%	259	2.0	<1.1	<1.7	<1.9	<3.0	3.5	9.4	19.7	30.9
VINYL CHLORIDE	257	99.2%	259	0.5	<0.6	<0.8	<0.9	<1.0	<1.9	<2.2	<2.6	7.5

(Continued)

Table C2. EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	OUTDOOR AIR											
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max
1,1,1-TRICHLOROETHANE	40	40.0%	100	1.3	<0.4	<0.6	0.8	1.7	2.6	3.8	8.4	8.7
1,1,2-TRICHLOROETHANE	46	100.0%	46	0.6	<0.6	<1.0	<1.2	<1.4	<1.6	<1.6	<1.8	<1.8
1,1-DICHLOROETHANE	46	100.0%	46	0.2	<0.4	<0.4	<0.4	<0.6	<0.6	<0.8	<0.8	<0.8
1,1-DICHLOROETHENE	46	100.0%	46	0.5	<0.8	<1.0	<1.0	<1.2	<1.4	<1.4	<1.6	<1.6
1,2,4-TRICHLOROBENZENE	46	100.0%	46	1.1	<0.6	<0.8	<1.0	<1.2	<6.4	<6.6	<7.8	<7.8
1,2,4-TRIMETHYLBENZENE	30	30.0%	100	2.6	<0.4	<1.6	1.8	3.1	5.8	7.1	19.1	24.2
1,2-DIBROMOETHANE	87	100.0%	87	0.6	<0.8	<1.2	<1.2	<1.4	<1.6	<1.6	<2.0	<2.0
1,2-DICHLOROBENZENE	86	98.9%	87	0.4	<0.6	<0.8	<1.0	<1.0	<1.2	<1.2	1.1	1.1
1,2-DICHLOROETHANE	86	98.9%	87	0.3	<0.4	<0.6	<0.6	<0.6	<0.8	<1.0	0.8	0.8
1,2-DICHLOROPROPANE	46	100.0%	46	0.6	<0.6	<1.2	<1.4	<1.6	<1.6	<1.8	<1.8	<1.8
1,3,5-TRIMETHYLBENZENE	69	79.3%	87	1.2	<0.8	<1.2	<1.4	<2.4	2.7	3.3	8.9	8.9
1,3-BUTADIENE	13	100.0%	13	1.5	<2.2	<2.4	<2.6	<2.8	<3.4	<7.6	<7.6	<7.6
1,3-DICHLOROBENZENE	46	100.0%	46	0.5	<0.6	<0.8	<0.8	<1.0	<2.2	<2.4	<2.8	<2.8
1,4-DICHLOROBENZENE	88	88.0%	100	0.7	<0.6	<0.8	<0.8	<1.4	1.2	1.7	5.4	6.1
1-BUTANOL	41	100.0%	41	2.0	<2.4	<3.4	<4.0	<4.4	<4.8	<5.2	<6.0	<6.0
2-BUTANONE (MEK)	5	5.7%	87	5.2	<1.2	2.2	3.7	5.7	11.3	14.8	43.1	43.1
2-BUTOXYETHANOL	41	100.0%	41	3.9	<4.6	<7.0	<8.0	<8.6	<9.6	<10.4	<11.8	<11.8
2-ETHYL-1-HEXANOL	53	98.1%	54	3.2	<1.2	<4.6	<7.2	<8.4	<9.6	<10.8	5.9	5.9
2-METHYL-1-PROPANOL	13	100.0%	13	0.6	<0.8	<1.0	<1.0	<1.2	<1.4	<3.0	<3.0	<3.0
2-PROPANOL	4	30.8%	13	6.4	<3.0	<4.2	4.7	6.6	16.5	23.5	23.5	23.5
3-METHYL PENTANE	55	63.2%	87	1.8	<1.0	<1.4	<1.6	2.0	4.4	6.6	10.5	10.5
4-ETHYLTOLUENE	75	86.2%	87	1.2	<1.0	<1.4	<1.6	<2.0	3.0	3.3	8.0	8.0
4-METHYL-2-PENTANONE	61	70.1%	87	1.3	<0.8	<1.0	<1.2	0.9	1.9	4.3	21.0	21.0
ACETONE	1	1.1%	87	26.5	<1.8	15.4	22.5	31.7	43.7	56.0	104.2	104.2
a-PINENE	92	92.0%	100	1.0	<0.6	<1.0	<1.2	<1.4	<6.2	3.7	6.8	8.1
BENZENE	22	22.0%	100	3.2	<1.2	1.2	2.7	3.7	6.6	9.6	12.6	13.0
BENZYL CHLORIDE	46	100.0%	46	1.2	<1.0	<1.2	<1.4	<1.6	<6.4	<6.6	<7.8	<7.8
BROMOMETHANE	82	94.3%	87	0.6	<0.6	<0.8	<1.0	<1.0	<1.6	1.0	4.5	4.5
BUTYL ACETATE	94	94.0%	100	1.4	<0.8	<1.4	<1.6	<1.8	<5.8	3.3	18.6	32.7
CARBON DISULFIDE	39	44.8%	87	2.1	<0.6	<0.8	0.9	2.2	3.7	8.3	22.0	22.0
CARBON TETRACHLORIDE	69	79.3%	87	0.5	<0.6	<0.8	<1.0	<1.0	0.7	0.7	1.5	1.5
CHLOROBENZENE	85	97.7%	87	0.4	<0.4	<0.6	<0.8	<0.8	<0.8	<1.0	1.1	1.1
CHLOROETHANE	84	96.6%	87	0.5	<0.6	<0.8	<0.9	<1.0	<1.2	<1.2	3.5	3.5
CHLOROFORM	77	88.5%	87	0.5	<0.2	<0.4	<0.4	<0.6	0.6	0.7	13.8	13.8
CHLOROMETHANE	0	0.0%	87	2.6	0.9	2.0	2.3	3.0	3.7	4.0	10.6	10.6
CIS-1,2-DICHLOROETHENE	45	97.8%	46	0.5	<0.6	<0.8	<1.0	<1.2	<1.8	<1.8	1.1	1.1

(Continued)

Table C2. EPA 2001: Building assessment and survey evaluation (BASE) database, SUMMA® canister method -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	OUTDOOR AIR											
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max
CIS-1,3-DICHLOROPROPENE	46	100.0%	46	0.9	<1.4	<1.6	<1.8	<2.0	<2.2	<2.4	<2.6	<2.6
DICHLORODIFLUOROMETHANE	7	8.0%	87	7.3	<4.4	3.8	4.4	5.8	8.1	12.2	183.7	183.7
DICHLOROTETRAFLUOROETHANE	46	100.0%	46	1.6	<1.6	<2.2	<2.4	<3.0	<6.4	<6.6	<7.8	<7.8
DIMETHYL DISULFIDE	74	85.1%	87	1.7	<1.4	<2.0	<2.4	<2.8	2.4	4.5	16.4	16.4
d-LIMONENE	73	73.0%	100	1.5	<0.8	<1.0	<1.4	2.0	3.6	4.1	9.8	12.5
DODECANE	51	51.0%	100	4.6	<2.0	<2.6	<4.0	4.2	10.4	14.1	51.0	52.3
ETHANOL	0	0.0%	13	32.0	3.8	13.0	24.5	47.0	57.0	82.5	82.5	82.5
ETHYL ACETATE	89	89.0%	100	0.7	<0.6	<0.8	<1.0	<1.2	1.5	1.9	3.7	3.9
ETHYLBENZENE	59	59.0%	100	1.4	<0.8	<1.4	<1.8	1.6	3.5	4.3	7.6	7.8
HEXACHLOROBUTADIENE	46	100.0%	46	1.4	<1.4	<1.8	<2.0	<2.6	<6.4	<6.6	<7.8	<7.8
HEXANAL	30	73.2%	41	3.1	<2.4	<3.8	<4.2	2.7	3.3	3.8	36.0	36.0
m & p-XYLENES	26	26.0%	100	5.6	<1.4	<3.6	4.4	7.3	12.8	16.1	24.8	26.8
METHYL TERTIARY-BUTYL ETHER	67	77.0%	87	2.7	<1.0	<1.4	<1.8	<5.4	6.2	13.3	36.0	36.0
METHYLENE CHLORIDE	43	43.0%	100	3.7	<1.0	<1.8	1.3	3.0	6.1	10.3	63.0	78.5
NAPHTHALENE	86	86.0%	100	10.6	<1.4	<2.0	<2.4	<4.8	4.9	15.1	379.8	670.0
n-DECANE	35	35.0%	100	3.7	<0.6	<2.0	2.4	4.2	7.6	11.4	32.4	37.3
n-HEPTANAL	10	76.9%	13	3.0	<1.2	<1.5	<1.8	<2.2	2.2	26.8	26.8	26.8
n-HEXANE	16	29.6%	54	2.5	<.8	<1.2	1.4	2.7	6.4	11.4	15.3	15.3
NONANAL	41	75.9%	54	8.6	<1.6	<6.0	<7.8	<10.8	22.7	37.6	57.0	57.0
NONANE	49	56.3%	87	1.3	<0.4	<0.8	<1.0	1.7	2.8	4.0	15.3	15.3
n-UNDECANE	13	14.9%	87	7.0	<1.0	2.6	3.9	7.8	14.8	19.7	94.8	94.8
OCTANE	73	73.0%	100	0.9	<0.4	<0.6	<0.8	1.0	1.6	1.9	11.9	17.5
o-XYLENE	36	36.0%	100	2.0	<0.6	<1.4	1.4	2.6	4.6	6.0	9.6	11.1
PENTANAL	37	90.2%	41	3.5	<2.4	<3.4	<4.0	<4.4	<6.0	7.0	52.7	52.7
STYRENE	83	83.0%	100	1.7	<0.6	<1.4	<1.6	<2.0	1.3	3.6	34.1	58.0
TETRACHLOROETHENE	51	51.0%	100	2.7	<0.8	<1.4	<2.0	3.0	6.5	10.4	24.8	27.6
TOLUENE	0	0.0%	100	15.4	2.1	5.9	9.6	16.3	33.7	49.2	86.5	93.1
TRANS-1,3-DICHLOROPROPENE	46	100.0%	46	0.5	<0.6	<0.8	<1.0	<1.2	<1.4	<1.4	<1.4	<1.4
TRICHLOROETHENE	81	81.0%	100	1.0	<0.6	<1.0	<1.5	<1.6	1.3	2.6	11.2	13.5
TRICHLOROFLUOROMETHANE	41	41.0%	100	3.6	<2.0	<2.8	1.7	2.8	4.3	5.6	71.1	132.5
TRICHLOROTRIFLUOROETHANE	75	86.2%	87	1.0	<1.2	<1.6	<1.8	<2.0	1.6	1.8	5.4	5.4
VINYL CHLORIDE	87	100.0%	87	0.5	<0.6	<0.8	<1.0	<1.0	<1.8	<2.0	<2.6	<2.6

ND = Number of non-detects
ND (%) = Percentage of total number in sample that are non-detect
N = Total number of samples
* Non-detects were estimated at 1/2 the appropriate detection limit or quantification limit to calculate the mean
Min; Max = minimum and maximum value detected

Table C3. NYSDOH 1997: Control home database

All results are micrograms per cubic meter (mcg/m^3).

Compound	INDOOR AIR											
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max
1,1,1,2-TETRACHLOROETHANE	22	100.0	22	4.7727	<5	<10	<10	<10	<10	<10	<10	<10
1,1,1-TRICHLOROETHANE	51	38.3	133	9.17	<1	<5	4.5	6.7	14	29	180	197
1,1,2,2-TETRACHLOROETHANE	83	98.8	84	1.86	<1	<1.3	<1.6	<8.5	<10	<10	5	5
1,1,2-TRICHLOROETHANE	83	100.0	83	1.72	<1	<1	<1	<9	<10	<10	<10	<10
1,1,2-TRICHLOROTRIFLUOROETHANE (FREON-113)	45	100.0	45	0.95	<1	<1	<1	<1	<7.8	<7.8	<7.8	<7.8
1,1-DICHLOROETHANE	65	100.0	65	2.11	<1	<1	<1	<10	<10	<10	<10	<10
1,1-DICHLOROETHENE	41	100.0	41	0.68	<1	<1	<1	<1	<1	<1	<9	<9
1,1-DICHLOROPROPENE	22	100.0	22	4.77	<5	<10	<10	<10	<10	<10	<10	<10
1,2,3-TRICHLOROBENZENE	26	100.0	26	4.60	<5	<10	<10	<10	<10	<10	<10	<10
1,2,4-TRICHLOROBENZENE	65	100.0	65	2.32	<1.6	<1.6	<1.6	<10	<10	<10	<10	<10
1,2,4-TRIMETHYLBENZENE	31	47.7	65	6.28	<1	<4.4	5	7	14	20	43	43
1,2-DIBROMOETHANE (EDB)	39	100.0	39	0.80	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6
1,2-DICHLOROBENZENE	90	100.0	90	2.02	<1.6	<1.6	<2	<6	<10	<10	<10	<10
1,2-DICHLOROETHANE	63	100.0	63	2.11	<1	<1	<1	<10	<10	<10	<10	<10
1,2-DICHLOROPROPANE	63	100.0	63	2.11	<1	<1	<1	<10	<10	<10	<10	<10
1,2-DICHLOROTETRAFLUOROETHANE	39	100.0	39	0.80	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6
1,3,5-TRIMETHYLBENZENE	45	69.2	65	2.99	<1	<1	<5	5	5	5	14	14
1,3-DICHLOROBENZENE	86	95.6	90	2.10	<1.6	<1.6	<2	<8	<10	<10	5	5
1,4-DICHLOROBENZENE	77	85.6	90	9.23	<1.6	<1.6	<2	<10	5	5.1	425	425
4-ISOPROPYLTOLUENE (p-Cymene)	22	84.6	26	6.25	<5	<10	<10	<10	12	13	27	27
BENZENE	69	47.9	144	4.64	<1	<3.2	2.5	5	11	14	37	50
BENZYL CHLORIDE	39	100.0	39	0.50	<1	<1	<1	<1	<1	<1	<1	<1
BROMOBENZENE	26	100.0	26	4.60	<5	<10	<10	<10	<10	<10	<10	<10
BROMODICHLOROMETHANE	44	97.8	45	2.67	<0.6	<0.6	<5	<10	<10	<10	5	5
BROMOFORM	43	100.0	43	2.69	<1	<1	<5	<10	<10	<10	<10	<10
BROMOMETHANE	38	97.4	39	0.64	<1	<1	<1	<1	<1	<1	6	6
CARBON TETRACHLORIDE	113	85.6	132	2.17	<0.6	<1.6	<3.2	<6.2	5	5	5	5
CHLOROBENZENE	90	100.0	90	2.00	<1	<1	<2	<10	<10	<10	<10	<10
CHLOROETHANE	51	100.0	51	0.50	<1	<1	<1	<1	<1	<1	<1	<1
CHLOROFORM	104	83.9	124	2.81	<1	<1	<4.8	<8.8	5	5	17	44
CHLOROMETHANE	63	79.7	79	1.08	<1	<1	<1	<2.6	2.5	2.7	4.5	4.5
CIS-1,2-DICHLOROETHENE	63	100.0	63	2.04	<1	<1	<1	<10	<10	<10	<10	<10
CIS-1,3-DICHLOROPROPENE	84	100.0	84	2.21	<1	<1	<5	<8.5	<10	<10	<10	<10
CYCLOPROPYLBENZENE	4	100.0	4	3.63	<5	<5.5	<7	<9	<10	<10	<10	<10

(Continued)

Table C3. NYSDOH 1997: Control home database -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	INDOOR AIR											
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max
DIBROMOCHLOROMETHANE	45	100.0	45	2.66	<0.6	<0.6	<5	<10	<10	<10	<10	<10
DICHLORODIFLUOROMETHANE (FREON-12)	45	100.0	45	0.77	<1	<1	<1	<1	<5	<5	<5	<5
ETHYLBENZENE	83	63.4	131	3.21	<1	<3.4	<4.4	4.8	5	6.5	15	23
HEXACHLOROBUTADIENE (C-46)	43	100.0	43	1.24	<2	<2	<2	<2	<2	<6	<10	<10
HEXANE	51	63.8	80	3.75	<0.8	<1	<3.6	3.6	6.6	15	50	50
ISOPROPYLBENZENE (Cumene)	26	100.0	26	4.60	<5	<10	<10	<10	<10	<10	<10	<10
M-CHLOROTOLUENE	4	100.0	4	3.63	<5	<5.5	<7	<9	<10	<10	<10	<10
M/P-XYLENE	56	43.4	129	7.43	<1	<4.4	5	9.5	16	21	64	90
METHYLENE CHLORIDE (DICHLOROMETHANE)	76	56.3	135	13.28	<1	<3	<7	5.6	23	45	240	292
N-BUTYLBENZENE	26	100.0	26	4.60	<5	<10	<10	<10	<10	<10	<10	<10
N-PROPYLBENZENE	26	100.0	26	4.60	<5	<10	<10	<10	<10	<10	<10	<10
NAPHTHALENE	45	88.2	51	4.07	<2	<2	<10	<10	5	12	18	18
O-CHLOROTOLUENE	24	100.0	24	4.75	<5	<10	<10	<10	<10	<10	<10	<10
O-XYLENE	80	55.6	144	3.71	<1	<3.8	<5.2	5	6.4	7.9	18	25
P-CHLOROTOLUENE	24	100.0	24	4.75	<5	<10	<10	<10	<10	<10	<10	<10
SEC-BUTYLBENZENE	25	96.2	26	4.94	<5	<10	<10	<10	<10	<10	14	14
STYRENE	62	95.4	65	2.21	<1	<1	<1	<10	<10	<10	5	5
TERT-BUTYLBENZENE	26	100.0	26	4.60	<5	<10	<10	<10	5	5	5	5
TETRACHLOROETHENE	103	74.6	138	4.78	<0.6	<1.6	<3.8	<10	5.5	9.7	77	103
TOLUENE	16	11.0	146	18.52	<1	6.5	13	25	39	46	95	170
TRANS-1,2-DICHLOROETHENE	26	100.0	26	4.52	<4	<10	<10	<10	<10	<10	<10	<10
TRANS-1,3-DICHLOROPROPENE	84	100.0	84	2.21	<1	<1	<5	<8.5	<10	<10	<10	<10
TRICHLOROETHENE	116	92.8	125	2.17	<0.6	<1	<2.8	<5.4	<10	5	7.5	13
TRICHLOROFLUOROMETHANE (FREON-11)	40	70.2	57	2.08	<1	<1	<1	3.8	5.6	5.9	7.5	7.5
VINYL CHLORIDE	47	100.0	47	0.70	<0.6	<1	<1	<1	<2.6	<5	<5	<5

(Continued)

Table C3. NYSDOH 1997: Control home database -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	OUTDOOR AIR											
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max
1,1,1,2-TETRACHLOROETHANE	10	100.0	10	4.75	<5	<10	<10	<10	<10	<10	<10	<10
1,1,1-TRICHLOROETHANE	45	68.2	66	2.93	<1	<2	<5.1	2.8	5	6.7	27	27
1,1,2,2-TETRACHLOROETHANE	41	100.0	41	1.75	<1	<1	<1.6	<5	<10	<10	<10	<10
1,1,2-TRICHLOROETHANE	41	100.0	41	1.61	<1	<1	<1	<5	<10	<10	<10	<10
1,1,2-TRICHLOROTRIFLUOROETHANE (FREON-113)	22	100.0	22	0.96	<1	<1	<1	<1	<7.8	<7.8	<7.8	<7.8
1,1-DICHLOROETHANE	31	100.0	31	2.02	<1	<1	<1	<10	<10	<10	<10	<10
1,1-DICHLOROETHENE	20	100.0	20	0.65	<1	<1	<1	<1	<1	<4	<7	<7
1,1-DICHLOROPROPENE	10	100.0	10	4.75	<5	<10	<10	<10	<10	<10	<10	<10
1,2,3-TRICHLOROBENZENE	13	100.0	13	4.58	<5	<10	<10	<10	<10	<10	<10	<10
1,2,4-TRICHLOROBENZENE	32	100.0	32	2.33	<1.6	<1.6	<1.6	<10	<10	<10	<10	<10
1,2,4-TRIMETHYLBENZENE	29	90.6	32	2.24	<1	<1	<1.5	<10	<10	5	5	5
1,2-DIBROMOETHANE (EDB)	19	100.0	19	0.80	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6
1,2-DICHLOROBENZENE	44	100.0	44	2.00	<1.6	<1.6	<2	<7	<10	<10	<10	<10
1,2-DICHLOROETHANE	30	100.0	30	2.02	<1	<1	<1	<10	<10	<10	<10	<10
1,2-DICHLOROPROPANE	30	100.0	30	2.02	<1	<1	<1	<10	<10	<10	<10	<10
1,2-DICHLOROTETRAFLUOROETHANE	19	100.0	19	0.80	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6
1,3,5-TRIMETHYLBENZENE	31	96.9	32	2.17	<1	<1	<1	<10	<10	<10	5	5
1,3-DICHLOROBENZENE	44	100.0	44	2.00	<1.6	<1.6	<2	<7	<10	<10	<10	<10
1,4-DICHLOROBENZENE	44	100.0	44	2.00	<1.6	<1.6	<2	<7	<10	<10	<10	<10
4-ISOPROPYLTOLUENE (p-Cymene)	13	100.0	13	4.58	<5	<10	<10	<10	<10	<10	<10	<10
BENZENE	51	71.8	71	6.97	<1	<1.6	<3.2	5	6.6	8	242	242
BENZYL CHLORIDE	19	100.0	19	0.50	<1	<1	<1	<1	<1	<1	<1	<1
BROMOBENZENE	13	100.0	13	4.58	<5	<10	<10	<10	<10	<10	<10	<10
BROMODICHLOROMETHANE	22	100.0	22	2.47	<0.6	<0.6	<2.8	<10	<10	<10	<10	<10
BROMOFORM	21	100.0	21	2.52	<1	<1	<1	<10	<10	<10	<10	<10
BROMOMETHANE	19	100.0	19	0.50	<1	<1	<1	<1	<1	<1	<1	<1
CARBON TETRACHLORIDE	55	84.6	65	2.25	<1.2	<1.6	<3.2	<6.2	5	5	5	5
CHLOROBENZENE	44	100.0	44	1.93	<1	<1	<2	<9	<10	<10	<10	<10
CHLOROETHANE	21	100.0	21	0.50	<1	<1	<1	<1	<1	<1	<1	<1
CHLOROFORM	66	100.0	66	1.90	<1	<1	<2.4	<4.8	<10	<10	<10	<10
CHLOROMETHANE	34	75.6	45	1.08	<1	<1	<2	<2.8	2.2	2.6	3.1	3.1
CIS-1,2-DICHLOROETHENE	30	100.0	30	1.97	<1	<1	<1	<10	<10	<10	<10	<10
CIS-1,3-DICHLOROPROPENE	41	100.0	41	2.15	<1	<1	<5	<5	<10	<10	<10	<10
CYCLOPROPYLBENZENE	3	100.0	3	4.00	<6	<6	<8	<10	<10	<10	<10	<10

(Continued)

Table C3. NYSDOH 1997: Control home database -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	OUTDOOR AIR											
	ND	ND(%)	N	Mean*	Min	25th	Median	75th	90th	95th	99th	Max
DIBROMOCHLOROMETHANE	22	100.0	22	2.47	<0.6	<0.6	<2.8	<10	<10	<10	<10	<10
DICHLORODIFLUOROMETHANE (FREON-12)	22	100.0	22	0.77	<1	<1	<1	<1	<5	<5	<5	<5
ETHYLBENZENE	63	91.3	69	2.16	<1	<1	<4.4	<5	<10	5	6.5	6.5
HEXACHLOROBUTADIENE (C-46)	22	100.0	22	1.41	<2	<2	<2	<2	<6	<8	<10	<10
HEXANE	38	86.4	44	1.79	<0.8	<1	<3.3	<3.6	3.7	5.8	9.2	9.2
ISOPROPYLBENZENE (Cumene)	13	100.0	13	4.58	<5	<10	<10	<10	<10	<10	<10	<10
M-CHLOROTOLUENE	3	100.0	3	4.00	<6	<6	<8	<10	<10	<10	<10	<10
M/P-XYLENE	52	76.5	68	3.63	<1	<1.4	<4.4	<10	9	13	19	19
METHYLENE CHLORIDE (DICHLOROMETHANE)	55	82.1	67	2.91	<0.8	<1	<3.4	<7.6	5	12	22	22
N-BUTYLBENZENE	13	100.0	13	4.58	<5	<10	<10	<10	<10	<10	<10	<10
N-PROPYLBENZENE	13	100.0	13	4.58	<5	<10	<10	<10	<10	<10	<10	<10
NAPHTHALENE	24	96.0	25	3.18	<2	<2	<7	<10	<10	<10	5	5
O-CHLOROTOLUENE	12	100.0	12	4.71	<5	<10	<10	<10	<10	<10	<10	<10
O-XYLENE	59	83.1	71	2.59	<1	<1	<4.4	<10	5.1	7.2	10	10
P-CHLOROTOLUENE	12	100.0	12	4.71	<5	<10	<10	<10	<10	<10	<10	<10
SEC-BUTYLBENZENE	13	100.0	13	4.58	<5	<10	<10	<10	<10	<10	<10	<10
STYRENE	32	100.0	32	2.16	<1	<1	<1	<10	<10	<10	<10	<10
TERT-BUTYLBENZENE	13	100.0	13	4.58	<5	<10	<10	<10	<10	<10	<10	<10
TETRACHLOROETHENE	60	87.0	69	2.59	<0.6	<1.6	<3.8	<6.8	5	5	16	16
TOLUENE	41	57.7	71	8.47	<1	<2	<5.6	6.1	21	58	93	93
TRANS-1,2-DICHLOROETHENE	12	100.0	12	4.42	<4	<8.5	<10	<10	<10	<10	<10	<10
TRANS-1,3-DICHLOROPROPENE	41	100.0	41	2.15	<1	<1	<5	<5	<10	<10	<10	<10
TRICHLOROETHENE	63	94.0	67	2.09	<0.6	<1	<3.4	<5.4	<10	5	11	11
TRICHLOROFLUOROMETHANE (FREON-11)	22	91.7	24	1.07	<1	<1	<1	<1	<5.6	3.9	3.9	3.9
VINYL CHLORIDE	23	100.0	23	0.70	<0.6	<1	<1	<1	<2.6	<5	<5	<5

ND = Number of non-detects

ND (%) = Percentage of total number in sample that are non-detect

N = Total number of samples

* Non-detects were estimated at 1/2 the detection limit to calculate the mean

Min; Max = minimum and maximum value detected

Table C4. EPA 1988: National ambient volatile organic compounds (VOCs) data base update

All results are micrograms per cubic meter (mcg/m^3).

Compound	Indoor Air					Outdoor Air				
	N	Mean	25th	50th	75th	N	Mean	25th	50th	75th
acetaldehyde	0					175	9.2	0	2.3	9.8
acetone	4	19	11	20	27	17	16	0	2.2	6.7
benzene	2128	16	3.3	10	21	5411	8.9	2	5.3	11
benzyl chloride	0					43	0.07	0.02	0.04	0.09
bromobenzene	0					26	1.4	0	0.15	1.1
bromodichloromethane	2120	0.05	0	0	0	495	0.01	0	0	0
bromoform	2120	0	0	0	0	496	0	0	0	0
bromomethane	0					358	12	0.18	0.7	12
butane	0					888	33	12	21	34
2-butanone (MEK)	4	27	12	21	42	280	1.9	0	0	0
n-butylbenzene	0					52	0.27	0	0	0
sec-butylbenzene	0					433	2.7	0.14	0.24	0.48
carbon disulfide	0					29	0.3	0.12	0.13	0.5
carbon tetrachloride	2120	2.5	0	0	0.83	4913	1	0.43	0.76	0.81
chlorobenzene	2126	0.19	0	0	0	1491	1.5	0	0.28	1.4
chloroethane	0					190	220	0.06	0.17	1.7
chloroform	2120	4.1	0	0.51	3.4	3658	3.1	0.05	0.28	0.88
chloromethane	0					706	1.5	1.3	1.3	1.5
o-chlorotoluene	0					309	0.59	0.05	0.21	0.67
p-chlorotoluene	0					310	1.1	0.1	0.47	1.5
dibromochloromethane	2120	0	0	0	0	510	0.27	0	0	0
1,2-dibromoethane (EDB)	585	0.008	0	0	0	1980	2.5	0	0	0.08
1,2-dichlorobenzene	2121	0.44	0	0	0	1052	7.8	0	0	0.23
1,3-dichlorobenzene	2121	24	0.32	1.7	5.6	646	5.3	0	0.18	1.2
1,4-dichlorobenzene	2121	24	0.32	1.7	5.6	947	6	0	0.25	1.2
dichlorodifluoromethane (Freon 12)	0					1080	2.2	1.6	1.7	1.7
1,1-dichloroethane	0					145	0.16	0	0.04	0.2
1,2-dichloroethane	2120	0.38	0	0	0	2044	1.6	0	0	0.22
1,1-dichloroethene	2120	79	0	0	0	1275	18	0	0	0
cis-1,2-dichloroethene	0					161	1.3	0	0.15	0.45
trans-1,2-dichloroethene	0					2	3	2.2	3	3.7
1,2-dichloropropane	0					714	0.74	0.05	0.1	0.3
cis-1,3-dichloropropene	0					148	110	34	110	160
1,2-dichlorotetrafluoroethane	2					171	0.31	0.16	0.21	0.27

(Continued)

Table C4. EPA 1988: National ambient volatile organic compounds (VOCs) data base update -- Continued

All results are micrograms per cubic meter (mcg/m^3).

Compound	Indoor Air					Outdoor Air				
	N	Mean	25th	50th	75th	N	Mean	25th	50th	75th
ethylbenzene	2278	13	2	4.8	9.6	2669	20	1	2.6	5.4
formaldehyde	315	60	23	51	88	629	10	2.3	5	12
heptane	4	5.2	4.5	5	6	1064	6.6	1.4	3.2	2.5
hexachlorobutadiene (C-46)	0					72	0.38	0.01	0.03	0.06
hexane	3	2	0	2	4	894	13	2.9	5.8	10
isopropylbenzene (cumene)	103	0.84	0	0	0.84	14	0	0	0	0
4-isopropyltoluene (p-cymene)	0					132	4	0.44	2.2	5
methane	0					244	1400	1050	1080	1410
methylene chloride (dichloromethane)	0					798	5.6	1.1	2.7	6.3
naphthalene	0					67	5.2	0.2	1.2	5.7
pentane	4	3.3	1.3	2.6	5.3	886	20	5.8	11	18
n-propylbenzene	1	0.64	0	0	0	758	1	0.39	0.79	1.3
styrene	2125	6	0	1.3	2.8	1123	1.5	0	0.51	1.4
1,1,1,2-tetrachloroethane	585	0.02	0	0	0	308	0.15	0	0	0.02
1,1,2,2-tetrachloroethane	585	0.1	0	0	0	1011	0.7	0	0	0.06
tetrachloroethene	2195	21	1.7	5	11	3226	5.8	0.82	2.4	5.9
toluene	101	0	0	32	0	4074	32	0.6	7.1	20
1,2,4-trichlorobenzene	0					18	1.3	0.74	0.74	1.5
1,1,1-trichloroethane	2120	270	3	10	30	2982	5	0.7	0.89	3.3
1,1,2-trichloroethane	0					886	6	0	0	0.14
trichloroethene	2132	7.2	0	0.67	4.5	3021	2.7	0.05	0.85	2.5
trichlorofluoromethane (Freon 11)	0					1507	1.4	1.1	1.1	1.2
1,1,2-trichlorotrifluoroethane (Freon 113)	0					184	2.7	0.46	1	2.5
1,2,4-trimethylbenzene	96	2.8	0.6	1.4	4	1018	6.7	2.8	4.6	7.4
1,3,5-trimethylbenzene	178	4.5	0	1.4	5.4	585	4	0.2	1	2.5
2,2,4-trimethylpentane	0					200	9.3	1	2	4.8
vinyl chloride	0					701	32	0	0	0.78
m-xylene	103	39	4.8	16	38	3146	50	2.5	6.1	14
o-xylene	2216	12	2	4.8	9.3	3592	33	1	3	6.5
p-xylene	2305	38	6.4	14	25	3518	46	2.3	6.8	14
m/p-xylenes (weighted)			4.3		18			2		11

N - Total number of samples

Table C5. Health Effects Institute 2005: Indoor, outdoor and personal air (RIOPA) data

All results are micrograms per cubic meter (mcg/m^3).

Compound	Indoor Air							Outdoor Air						
	N	Mean	Percentiles					N	Mean	Percentiles				
			Median (50th)	1st	5th	95th	99th			Median (50th)	1st	5th	95th	99th
Acetone	398	14	8.25	0.2	1.12	45.8	128	395	9.75	4.39	0.2	0.2	19.6	55.3
Acrolein (2-propenal)	398	1.71	0.62	0.07	0.07	5.27	14.8	395	6.28	0.47	0.06	0.07	4.6	11.9
a-Pinene	554	4.87	1.22	0.04	0.07	18.1	78.6	555	0.89	0.32	0.04	0.07	1.9	16.5
Benzene	554	3.5	2.19	0.48	0.48	10	36.4	555	2.15	1.68	0.41	0.48	5.16	11.1
b-Pinene	554	4.8	1.47	0.12	0.18	20.4	62.2	555	0.53	0.18	0.1	0.12	1.43	7.35
Carbon Tetrachloride	554	0.71	0.62	0.13	0.27	1.1	2.03	555	0.71	0.64	0.13	0.34	1.0	1.58
Chloroform	554	1.86	92	0.11	0.17	6.34	14.8	554	0.32	0.17	0.08	0.09	0.76	2.35
d-Limonene	554	31	9.67	1.1	1.27	103	273	555	2.39	1.27	0.24	0.28	6.54	37.8
Ethyl Benzene	554	2.52	1.46	0.32	0.36	7.62	26.7	555	1.29	0.93	0.15	0.3	3.04	7.05
m- & p-Xylene	554	7.33	4.07	0.25	0.7	22.2	75.2	555	3.57	2.49	0.25	0.53	10	19.1
Methylene Chloride	554	2.31	0.84	0.04	0.11	7.5	33.7	555	0.95	0.84	0.04	0.07	2.46	9.32
MTBE	553	11.8	5.98	0.44	44	36	196	555	8.1	5.32	0.43	0.44	22.1	22.1
o-Xylene	554	2.48	1.46	0.17	0.36	7.24	22.6	555	1.48	0.96	0.1	0.17	3.23	7.17
p-Dichlorobenzene	554	68.9	1.44	0.19	0.29	344	1790	555	2.25	0.72	0.09	0.19	3.66	18.3
Styrene	554	1.41	0.5	0.11	0.16	5.13	23.5	555	0.48	0.17	0.07	0.11	1.29	4.15
Tetrachloroethylene	554	1.81	0.56	0.1	0.11	6.01	20.9	555	1.0	0.56	0.09	0.11	3.17	7.75
Toluene	554	15.4	10.1	2.83	3.02	39.8	122	555	7.09	5.42	1.3	2.82	19.6	32
Trichloroethylene	554	0.46	0.12	0.04	0.05	1.36	7.84	555	0.3	0.12	0.04	0.05	0.79	1.9

Compound	Adult Personal Air							Child Personal Air						
	N	Mean	Percentiles					N	Mean	Percentiles				
			Median (50th)	1st	5th	95th	99th			Median (50th)	1st	5th	95th	99th
Acetone	409	25.9	8.36	0.2	1.74	57.7	700	169	29.1	11.5	1.41	4.25	81	759
Acrolein (2-propenal)	409	12.9	0.51	0.07	0.07	5.12	11.2	169	10.9	0.87	0.06	0.07	8.04	504
a-Pinene	544	4.21	1.21	0.05	0.07	17.6	39.4	209	3.48	1.42	0.06	0.08	15.3	25.4
Benzene	545	3.64	2.39	0.48	0.48	10.7	27.4	209	4.16	2.79	0.36	0.48	12	43.6
b-Pinene	545	5.48	1.65	0.11	0.18	22.4	72.4	209	5.32	2.85	0.18	0.18	18.2	29.8
Carbon Tetrachloride	545	0.79	0.61	0.13	0.27	1.08	2.0	209	0.56	0.56	0.13	0.21	0.83	0.97
Chloroform	542	4.2	1.04	0.14	0.17	6.34	17.4	209	2.03	1.14	0.14	0.17	7.47	7.47
d-Limonene	545	41.2	11.8	1.27	1.27	112	287	209	32.1	17.4	1.27	1.27	111	168
Ethyl Benzene	545	2.79	1.68	0.36	0.36	7.48	28.8	209	3.34	1.95	0.3	0.36	10.3	54.2
m- & p-Xylene	545	8.07	4.42	0.25	0.93	22.7	75.2	209	8.87	5.15	0.43	1.38	28.2	63.1
Methylene Chloride	545	3.04	0.84	0.04	0.13	7.39	32.9	209	1.66	0.69	0.04	0.06	5.25	16.7
MTBE	544	14.8	7.14	0.44	0.94	42.7	129	209	11.7	7.03	0.44	0.56	30.2	193
o-Xylene	545	2.89	1.73	0.17	0.47	8.14	23	209	2.91	1.96	0.11	0.52	7.97	22.2
p-Dichlorobenzene	545	56.7	1.88	0.18	0.35	314	1480	209	122	4.18	0.27	0.44	979	1460
Styrene	545	1.51	0.57	0.13	0.17	5.51	21.4	209	1.69	0.67	0.14	0.16	6.89	30.6
Tetrachloroethylene	545	7.14	0.61	0.1	0.13	7.21	57.4	209	2.81	0.56	0.09	0.12	7.34	81.8
Toluene	545	19.2	12.2	2.81	3.02	50.2	138	209	18.4	12.2	1.44	2.94	57.2	220
Trichloroethylene	545	3.64	0.13	0.04	0.05	1.88	13.3	209	0.31	0.12	0.04	0.04	0.89	7.08

N - Total number of samples

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Appendix D
NYSDOH guidelines for chemicals in air — development overview

As discussed in Section 3.2.5, the NYSDOH has developed several guidelines for chemicals in air. An overview of how the NYSDOH develops guidelines is provided in this appendix.

In general, the development of air guidelines starts with **toxicity assessment** and **exposure assessment**. In toxicity assessment, the scientific data on the toxicity and pharmacokinetics (i.e., the processes of absorption, distribution, metabolism and excretion) of a contaminant are evaluated to understand a chemical's potential for causing a health effect. In exposure assessment, scientific data are evaluated to determine the amount of air an individual breathes on a daily basis and how frequently and how long an individual may be exposed to a contaminant in air. Criteria based on cancer effects are generally expressed as the air concentration associated with a specific, excess lifetime cancer risk. Criteria based on non-cancer effects are generally expressed as a reference concentration, which is an air concentration that is expected to be without an appreciable risk of non-cancer health effects. These quantitative criteria are not, in themselves, guidelines or standards. They are based solely on data and scientific judgments on the relationship between the level of contaminant in air and health risk, and do not reflect consideration of other factors, such as whether the concentration can be measured or whether the concentration is above background.

The first two steps of the toxicity assessment are

1. Hazard Identification: What are the known or potential human health effects of an air contaminant? and
2. Dose-Response Assessment: What is the potency (strength) of the contaminant to cause each type of known or potential human health effect?

All the relevant data are evaluated and summarized and a weight-of-evidence analysis is used to make these determinations. These determinations are then used to estimate numerical criteria (cancer risks and reference concentrations).

These estimations are carried out under the premises that

a. studies on effects in animals can be used to estimate the likelihood of effects in humans and
b. studies of effects of high exposure levels in humans or animals can be used to estimate the effects of low exposure levels.

Uncertainties present in these estimations include the following:

a. whether or not animals are good surrogates for humans,
b. whether or not the dose-response data provide reliable data on the critical effect and its lowest dose,
c. whether or not all critical effects have been identified (no data gaps), and
d. whether or not the methods used to extrapolate from the animals to humans and from high to low doses provide plausible estimates of risk at low doses.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

In an exposure assessment for air, information is used that describes how much contaminated air a person may breathe each day. Estimations are also made about how frequently and how long people are exposed. The NYSDOH air guidelines are based on the assumption that people are continuously exposed to a contaminant in air all day, every day for as long as a lifetime.

The degree of confidence in the hazard identification and dose-response assessment is then summarized as part of the risk characterization (the last step in the risk assessment process), which describes the nature, strength of evidence, and the likelihood of adverse health effects from particular exposures.

Once criteria are derived, air guidelines are generally set using a combination of risk assessment and risk management considerations. Guidelines should be health protective; thus, the starting point in the derivation of a guideline are the criteria based on the non-cancer and cancer effects of the chemical. However, the guideline is not necessarily one of the criteria. Other factors such as uncertainties in the toxicity and exposure information, information on the nature and extent of contamination, duration of potential exposure, other sources of contaminant exposures, analytical detection limits, and background concentrations are also considered.

The following two documents are included in this appendix to illustrate the development of a guideline:

- **TCE air guideline:** NYSDOH letter from N. Kim to D. Desnoyers, Division of Environmental Remediation, NYSDEC (October 31, 2003)
- **PCE air guideline:** Tetrachloroethene Health Effects. November 6, 1991. Appendix 1 of the Tetrachloroethene Ambient Air Criteria Document. Final Report. October 1997. Albany, NY: Bureau of Toxic Substance Assessment, Center for Environmental Health, New York State Department of Health.

For additional information on NYSDOH guidelines and criteria for these and other volatile chemicals in air (Section 3), please contact the NYSDOH's Bureau of Toxic Substance Assessment by calling 1-800-458-1158, or by emailing BTSA@health.state.ny.us, or by writing to the following address:

New York State Department of Health
Bureau of Toxic Substance Assessment
Flanigan Square, 547 River Street
Troy, NY 12180-2216

STATE OF NEW YORK
DEPARTMENT OF HEALTH

Flanigan Square, 547 River Street, Troy, New York 12180-2216

Antonia C. Novello, M.D., M.P.H., Dr.P.H.
Commissioner

Dennis P. Whalen
Executive Deputy Commissioner

October 31, 2003

Dale Desnoyers, Director
Division of Environmental Remediation
NYS Department of Environmental Conservation
625 Broadway
Albany, NY 12233-1080

Dear Mr. Desnoyers:

The New York State Department of Health has derived an air guideline for trichloroethene. Trichloroethene (TCE or trichloroethylene; CAS number 79-01-6) is a chemical commonly found in the environment, including the air (outdoor and indoor) that people breathe. This letter summarizes the important toxicological and epidemiological data we used to evaluate the potential health risks associated with exposure to TCE in air. We have followed the procedures outlined by the National Academy of Sciences and federal agencies such as the United States Environmental Protection Agency (US EPA), the United States Food and Drug Administration and the Agency for Toxic Substances and Disease Registry. These procedures are most recently described in US EPA documents (1994, 2000, 2002, 2003).

Human Non-Cancer Risks Associated with Exposure to TCE in Air

For non-cancer effects, points-of-departure (no-observed-effects levels or NOELs, lowest-observed-effects levels or LOELs, benchmark doses) were identified for target organs in humans and animals. Uncertainty factors were applied to the points-of-departure to estimate criteria for long-term exposure of the general population, including subpopulations that may be more vulnerable to TCE than other groups.

Typically, several uncertainty factors (generally, each is 3 or 10) are used to derive an exposure criterion from a point-of-departure. These uncertainty factors are intended to account for:

- the variation in sensitivity among the members of the human population;
- the uncertainty in extrapolating animal data to humans;
- the uncertainty in extrapolating from data obtained in a study with less-than-lifetime exposure to lifetime exposure;
- the uncertainty in extrapolating from a LOEL rather than from a NOEL; and
- the uncertainty associated with extrapolation of results from adult humans or animals to children.

In humans, the central nervous system appears to be a sensitive indicator of TCE exposure, and there is concern that pre-natal TCE exposure may affect fetal development. In animals, TCE damages the central nervous system, liver, and kidneys of adult animals, and disrupts normal fetal development when exposure occurs during gestation. The animal data also suggest that the kidney effects generally occur at higher exposure levels than the other effects noted above.

Central Nervous System

Information on the central nervous system effects of TCE comes from studies of occupationally exposed workers and from studies of animals under controlled experimental conditions. In some occupational studies (Okawa and Bodner, 1973; Rasmussen et al., 1993; Vandervort and Polakoff, 1973), exposure to TCE is associated with effects on the central nervous system, including dizziness, headache, drowsiness, nausea and motor dyscoordination. Confidence in these studies for evaluating dose-response relationships is low because the studies did not provide adequate information on long-term TCE exposure and because the small numbers of workers who were examined were also exposed to chemicals other than TCE. Consequently, these data were not used to derive a potential criterion.

When adult male rats were exposed to TCE at 50 parts per million (ppm or 270 milligrams per cubic meter, mg/m^3) or more for eight hours per day, five days per week for six weeks, there were electroencephalographic (EEG) changes indicative of decreased wakefulness (Arito et al., 1994). The lowest exposure level in the study was an effect level. This level becomes 64 mg/m^3 after adjustment of the experimental exposure level to an equivalent level under conditions of continuous exposure (270 mg/m^3 x 8 hours/24 hours x 5 days/7 days = 64 mg/m^3). Using methods consistent with those recommended in the US EPA (1994) guidelines for deriving air criteria[1], the human adult equivalent concentration (HEC) is 64 mg/m^3. Adjusting the adult HEC to a child's HEC using a child's inhalation rate and body weight and applying an uncertainty factor of 3,000 to the child HEC suggests a potential criterion of about 9 microgram per cubic meter (9 mcg/m^3). The uncertainty factor was selected to compensate for use of a LOEL for an effect from a subchronic study in rats, human variability, and the potential increased sensitivity of children to TCE. Alternatively, applying a larger uncertainty factor to compensate for the observed effect (and an overall uncertainty factor of 10,000) suggests a potential criterion of 3 mcg/m^3.

Liver

Trichloroethene is also toxic to the liver of laboratory animals. Increases in absolute and relative liver weights were observed in male and female mice exposed continuously to 37 ppm (200 mg/m^3) or more for 30 days (Kjellstrand et al., 1983). We modeled the dose-response data for absolute liver weights and identified 13 ppm (70 mg/m^3) as the lowest air concentration corresponding to the lower bound on a 10% increase in liver effects in either male or female mice (essentially equivalent to a LOEL). Using methods consistent with those recommended in the US EPA (1994) guideline for deriving air criteria, the adult HEC is 70 mg/m^3. Adjusting the adult HEC to a child's HEC using a child's inhalation rate and body weight and applying an uncertainty factor of 3,000 to the child HEC suggests a potential criterion of about 9 mcg/m^3. The uncertainty factor was selected to compensate for use of a LOEL from a subchronic study in mice, human variability, and the potential increased sensitivity of children to TCE.

Developmental/Reproductive Effects

An epidemiological investigation (Goldberg et al., 1990) found an association between mothers living in areas where public drinking water wells were contaminated (primarily with TCE) and an increased incidence of cardiac malformations in their children. Whether or not prenatal TCE exposure played a role in producing these cardiac effects is unclear; however, this study raises concerns that developmental effects may be an important toxicological endpoint for TCE in humans.

In animals, Dawson et al. (1990, 1993) showed that exposure to TCE in drinking water during pregnancy caused a statistically significant increase in cardiac malformations in fetal rats at doses as low as 0.2 mg/kg/day. Applying an uncertainty factor of 1,000 to the animal LOEL and assuming

[1] For extrarespiratory effects of Type 3 chemicals such as TCE, the HEC equals the animal exposure concentration x an adjustment factor, which typically is a default value of 1 (US EPA, 1994).

that the inhaled and ingested doses of TCE (as mg/kg/day) are equivalent suggests a potential criterion of about 0.7 mcg/m^3. The uncertainty factor was selected to compensate for use of a LOEL in rats and human variability in the general population. Confidence in this potential criterion is lower than for those based on other animal studies.

Human Cancer Risks Associated with Exposure to TCE in Air

TCE is an animal carcinogen via the oral and inhalation routes of exposure, and evidence from occupational studies and drinking-water studies suggests that TCE is a risk factor for several types of cancer, including kidney, liver, and cancers of the lympho-hematopoietic systems (e.g., Non-Hodgkin's lymphoma (NHL) and Hodgkin's disease) (ATSDR, 1997; US EPA, 2001; Wartenberg et al., 2000). The National Toxicology Program has classified TCE as "*reasonably anticipated to be a human carcinogen*." Similarly, the International Agency for Research on Cancer classifies TCE "*as probably carcinogenic to humans.*" In both cases, the determination was based on "limited evidence" of carcinogenicity from studies in humans and "sufficient evidence" of carcinogenicity from studies in experimental animals. In short, epidemiological studies suggest, but do not conclusively prove, that TCE increases the incidence of some types of cancer in humans, animal bioassay studies show unequivocally that oral or inhaled doses of TCE cause cancer at several sites in rats and mice, and mode-of-action data suggest that the way TCE causes cancer in animals may be relevant to humans.

For cancer effects, we identified the important human and animal studies on the carcinogenicity of TCE in air, and determined the appropriateness of each study for use in estimating the human TCE air concentration associated with an excess lifetime human cancer risk of one-in-one million. In both the qualitative and quantitative evaluation, we used procedures and methods consistent with the US EPA guidelines for carcinogen risk assessment (US EPA, 2003).

We evaluated four epidemiological studies to determine their usefulness to estimate the TCE air level (mcg/m^3) associated with an excess lifetime human cancer risk of 1×10^{-6} (i.e., a TCE 1×10^{-6} air level). Three of the studies (Anttila et al., 1995; Cohn et al., 1994; Henschler et al., 1995) did not meet minimal requirements (see Hertz-Picciotto, 1995) for use in dose-response assessment, largely because each study did not characterize adequately the duration and/or magnitude of exposure to TCE. The fourth study (Hansen et al., 2001) provided estimates of TCE air levels in the workplace and of the average duration of occupational exposures and was used to derive estimates of TCE 1×10^{-6} air levels.

Using the relative risk data (from Hansen et al., 2001), exposure data from occupational studies (Hansen et al., 2001; Raaschou-Nielsen et al., 2002) and an average relative risk model recommended by the World Health Organization (WHO, 1996), our estimates of the TCE 1×10^{-6} air levels range from about 0.06 to about 1 mcg/m^3 under a standard exposure scenario (continuous exposure for 70 years, 70-kg person, and inhalation rate of 20 m^3/day), and vary with choice of cancer site, measure of relative risk, the TCE workplace air level, and years of employment. Confidence in these estimates is low because of the small number of cases, the inability to adequately control the potential influence of confounders, unavoidable uncertainties in the exposure estimates, and the lack of clear dose-response relationship. Thus, these estimates were used to check the plausibility of animal-based estimates of 1×10^{-6} TCE air level (see below).

Inhalation studies using laboratory animals provide scientifically-sound, dose-response datasets showing a statistically significant relationship between TCE exposure levels and an increased incidence of tumors (Fukuda et al., 1983; Henschler et al., 1980; Maltoni et al., 1986). These data have been used by the US EPA (1987, 2001), CA EPA (1999, 2002), WHO (1996), Health Canada (1993), and Rhomberg (2000) to derive estimates of the TCE 1×10^{-6} air level.

We evaluated published estimates and derived additional estimates based on considerations of the quality of the animal data and the use of recommended dose metrics and cross-species extrapolation factors. The estimates considered in our evaluation were based on dose-response data from rats and mice for four cancer sites (liver, lung, testes, and lymph system) using three dose metrics (lifetime average daily exposure as TCE mg/m^3; lifetime average daily metabolized TCE dose as mg TCE metabolized/kg/day; or lifetime average daily internal dose of trichloroacetic acid (TCA) in plasma or tissue as TCA-area-under-curve (mg-hr)/liter), and two cross-species scaling methods (equal risk at equal exposure or equal risk at exposure scaled by body weight$^{0.75}$). The range of estimates of the TCE 1×10^{-6} air level is about 0.2 to about 4 mcg/m^3 under a standard exposure scenario (continuous exposure for 70 years, 70-kg person, and inhalation rate of 20 m^3/day). Because there is a lack of scientific consensus on the appropriate animal surrogate and cancer sites, dose metric, and the method for scaling dose across species, no single estimate is preferred. These estimates are similar to the estimates obtained from the human data.

Summary

We have evaluated the non-cancer effects associated with TCE exposure in air, and focused our attention on those studies that identified sensitive human and animal responses to TCE exposures. Three types of effects observed in animals were used: central nervous system (Arito et al., 1994), liver (Kjellstrand et al., 1983), and developmental (Dawson et al., 1990, 1993). Using methods consistent with latest US EPA guidelines, the potential criteria range from about 1 mcg/m^3 to about 10 mcg/m^3.

In developing these potential criteria, uncertainties that limit our ability to estimate the human non-cancer effects of low-dose exposures (i.e., use of subchronic studies to evaluate chronic exposures, use of an effect level rather than a no-observed-effect level, interspecies extrapolations, and human variability) and factors necessary when considering children (respiration rate and body weight of children and the potential increased sensitivity of children to TCE exposures) were taken into account.

We have evaluated the cancer effects associated with TCE exposure in air, and focused our attention on those human and animal studies that showed significant relationships between estimated or measured TCE exposure and increased rates of cancers. We did not find any human studies strong enough to support potential criteria (i.e., TCE 1×10^{-6} air levels) based on cancer effects, although one study (Hansen et al., 2001) was used for checking the plausibility of criteria based on animal studies.

We derived estimates of the TCE air level associated with an excess lifetime human cancer risk of 1×10^{-6} using data from inhalation studies using animals (Fukuda et al., 1983; Henschler et al., 1980; Maltoni et al., 1986). Given the lack of consensus on the appropriate data, we developed estimates based on two different species, four cancer sites, three different methods of estimating dose, and two different methods for scaling dose across species. Using methods consistent with latest US EPA guidelines, the potential criteria range from about 0.2 to about 4 mcg/m^3. This range reflects the uncertainty surrounding our ability to estimate the human cancer effects of low-dose exposures. The animal-based estimates are similar to the human-based estimates.

After reviewing the data on the non-cancer and cancer effects of TCE and the potential criteria for long-term exposure of the general populations based on these effects, the New York State Department of Health has set an air guideline for TCE of 5 mcg/m^3. The margins-of-exposure between this guideline and the TCE air levels known to cause non-cancer effects in animals are consistent with recommended procedures and are adequate when

considered in conjunction with the limitations of the different studies. Similarly, the estimated increased human cancer risks associated with lifetime continuous exposure to 5 mcg/m^3 are in the risk range (1×10^{-6} to 1×10^{-4}) that is generally used by regulatory agencies when making decisions. We continue to update, review, and refine our evaluation of the potential health risks associated with TCE.

Sincerely,

Nancy K. Kim

Nancy K. Kim, Ph.D., Director
Division of Environmental Health Assessment

Enclosure
cc: R. Tramontano
C. Johnson

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FINAL REPORT

TETRACHLOROETHENE AMBIENT AIR CRITERIA DOCUMENT

OCTOBER 1997

New York State
Department of Health

CENTER FOR ENVIRONMENTAL HEALTH
BUREAU OF TOXIC SUBSTANCE ASSESSMENT

2 University Place
Albany, NY 12203-3399

APPENDIX 1

TETRACHLOROETHENE
HEALTH EFFECTS

November 6, 1991

NEW YORK STATE DEPARTMENT OF HEALTH

TETRACHLOROETHENE HEALTH EFFECTS

November 6, 1991

In evaluating the health risks from tetrachloroethene exposure, the New York State Department of Health followed the procedures outlined by the National Academy of Sciences (NAS, 1977, 1987) and federal agencies such as the U.S. Food and Drug Administration, the U.S. Environmental Protection Agency, and the Agency for Toxic Substances and Disease Registry (Dourson and Stara, 1983; US EPA 1988, 1989). We've identified either no-observed-effect levels or lowest-observed-effect levels for target organs in humans and animals. When developing exposure guidelines for long-term exposure of the general population from human data, uncertainty factors are used because effect or no-effect levels can be based on studies using healthy adults (frequently only men), short exposure times, small sample sizes and limited information on exposure levels. These same limitations may exist when using animal data, but additional uncertainty is introduced when extrapolating results from animals to humans. Uncertainty factors that are usually applied include a factor of ten for a short-term study, ten for using a lowest-observed-effect level rather than a no-observed-effect level and ten in going from a limited study in adults to the general population. Consideration may also be made for the quality and quantity of the available data.

Information on central nervous system effects comes from human controlled-chamber exposures and from epidemiological studies. The controlled studies used healthy adults and short exposure times. The epidemiological studies involved longer exposure times, but the exposure levels are less certain than for the controlled studies.

In controlled exposure studies, Stewart et al. (1970) and Hake and Stewart (1977) reported central nervous system effects when adult males and females were exposed to 100 ppm (690 milligrams per cubic meter--mg/m^3) for 7 or 7.5 hours per day for five days. Effects were not detected in adults exposed to 20 ppm (140 mg/m^3) for 7.5 hours per day for 5 days.

Workers exposed to tetrachloroethene have also been evaluated for possible central nervous system effects. A study by Lauwerys et al. (1983) did not detect adverse effects on the central nervous system of Belgian workers at dry cleaning shops who were exposed to a time weighted average (TWA) tetrachloroethene level of 21 ppm (145 mg/m^3). Seeber (1989) summarized a series of studies which evaluated such endpoints as perceptual speed, digit reproduction and sensorimotor and coordination functions in German dry cleaning workers. The performance of both the high-exposed (reported TWA 360 mg/m^3) and low-exposed (reported TWA 83 mg/m^3) groups differed significantly from the control group for some tests; however, the two exposed groups did not differ from each other.

A guideline for central nervous system effects for the general population can be derived from the no-observed-effect level in controlled chamber experiments or from the worker studies. The no-observed-effect level for central nervous system effects in the controlled chamber studies is 20 ppm (140 mg/m^3). Because this study was on healthy adults and of limited duration, an uncertainty factor of 100 is applied after averaging the concentration over 24 hours. This suggests a guideline of 0.4 mg/m^3. The lowest effect level in the worker studies was 83 mg/m^3. Because effects were observed and the study was on healthy adults, an uncertainty factor of 100 is needed after averaging the concentration over 24 hours. This suggests a guideline of 0.25 mg/m^3.

The liver is also a target organ for tetrachloroethene, particularly in mice. Case reports of liver effects have also been reported in humans who were exposed to high concentrations, sometimes under severe circumstances. The lowest-observed-effect level for mice is 60 mg/m³, when continuously exposed for 30 days (Kjellstrand et al., 1984). Liver weights were significantly elevated. Using an inhaled dose to extrapolate the results from mice to humans and applying a thousand-fold uncertainty factor would suggest a guideline of about 0.25 mg/m³ for liver effects.

The kidney is also a target organ in rats. Effects were seen in rats exposed to 200 ppm (1,400 mg/m³) for 6 hours per day, 5 days per week for 2 years (NTP, 1986). These effects included nucleus enlargement and tubular cell hyperplasia. Using an inhaled dose to extrapolate from rats to humans and applying a thousand-fold uncertainty factor would suggest a guideline of about 0.5 mg/m³ for kidney effects.

Exposure to tetrachloroethene caused liver tumors in mice and mononuclear cell leukemias and kidney tumors in rats. The exact mechanisms by which these tumors were induced are not known. Because of the uncertainty, a conservative estimate of the tetrachloroethene air concentration corresponding to the upper bound on risk and associated with a one in one million excess lifetime human oncogenic risk is 0.00005 mg/m³. This estimate is based on the assumptions that the delivered dose of the active carcinogenic agent is linearly proportional to the inhaled dose of tetrachloroethene across all doses and that surface area is the appropriate parameter for dose extrapolation. Confidence in this estimate is limited by the data which indicate that linearity across all doses does not hold for the potential oncogenic agents (tetrachloroethene or its metabolites) and by the degree to which the results of empirical observations on the toxic effects of anti-neoplastic drugs (the source of the surface area rule) are applicable to chemicals which are metabolized differently.

Correlations between the metabolic and carcinogenic data can be used to support the hypothesis that the metabolic products of the mixed function oxidase pathway for tetrachloroethene are responsible for its carcinogenicity in mice. If the available data are used with physiologically-based pharmacokinetic modeling, an estimate of the air level corresponding to the upper bound on risk and associated with a one in one million excess lifetime human carcinogenic risk is 0.0005 mg/m³ (if humans and mice are assumed to be equally sensitive to the same delivered dose). Confidence in this estimate is limited by the validity of the initial assumptions and the accuracy of the model in compensating for non-linearity when extrapolating from high to low doses and in compensating for differences in the capacity of mice and humans to metabolize tetrachloroethene by the mixed function oxidase pathway.

Correlations using urinary excretion data for tetrachloroethene metabolites can also be used to estimate an excess human cancer risk from the mouse liver tumor data. Using this method (US EPA, 1990), the tetrachloroethene air concentration corresponding to an upper bound on risk and associated with a one in one million excess lifetime human cancer risk is 0.002 mg/m³.

The New York State Department of Health recommends, based on an evaluation of the non-carcinogenic effects of tetrachloroethene, that the average ambient air level in a residential community not exceed 0.25 mg/m³ for adults, considering continuous lifetime exposure. If a child's inhalation rate and body weight are used, the guideline becomes 0.1 mg/m³. Furthermore, we recommend that the uncertainty factor not be reduced by more than an order of magnitude when considering the need to take immediate action. We also recommend that exposure to tetrachloroethene be minimized to the extent practical; e.g. regardless of the levels, solvent containers should not be left opened. The potential carcinogenic risks of tetrachloroethene will be considered further as regulations are developed for the dry cleaning industry.

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EXPOSURE ASSUMPTIONS USED TO DERIVE 1991 GUIDELINES

The exposure assumptions used to derive the non-carcinogenic guidelines are provided below.

Group	Body Weight	Daily Inhalation Rate
adult	70 kg	20 m^3/day
child	20.5 kg*	14.5 m^3/day*
mouse	0.035 kg	0.039 m^3/day
rat	0.40 kg	0.24 m^3/day

*see Table 12 of Criteria Document for age-specific data

The methods and assumptions used to derive the carcinogenic guidelines based on metabolized dose are found in Table 17 of Criteria Document.

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NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Appendix E

ASTM's *Standard Practice for Residential Radon Mitigation*

Reference:
EPA's web site at http://www.epa.gov/radon/pubs/mitstds.html
(Thursday, September 7th, 2006, posting)

EPA's Recommended Residential Radon Mitigation Standard of Practice

EPA recommends the ***Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings**** for residential radon mitigation. This voluntary, consensus-based standard was developed and issued by the American Society for Testing and Materials International, and is identified as **ASTM E-2121**.

The Agency first cited **ASTM E-2121** in 2003 as a national consensus standard appropriate for reducing radon in homes as far as practicable below the national action level of 4 picocuries per liter (pCi/L) in indoor air. As of May 2006, EPA no longer recommends, and will no longer distribute its own, superseded *Radon Mitigation Standards* (EPA 402-R-93-078, Revised April 1994).

- A single free copy of the **ASTM E-2121** standard is available from EPA's National Service Center for Environmental Publications - http://yosemite.epa.gov/ncepihom/nsCatalog.nsf/SearchPubs?OpenForm, or the Agency's IAQ-Info hotline, 1-800-438-4318.

- Copies of the standard may be purchased from ASTMI at www.astm.org/cgi-bin/SoftCart.exe/index.shtml?E+mystore, or from the American National Standards Institute (ANSI) at www.ansi.org/.

*E-2121-03 (February 10, 2003), American Society for Testing and Materials (ASTM) International; an American National Standards Institute (ANSI) approved consensus standard.

If you have questions concerning this policy, contact either Philip Jalbert jalbert.philip@epa.gov or Eugene Fisher fisher.eugene@epa.gov.

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NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Appendix F

EPA's *Model Standards and Techniques for Control of Radon in New Residential Buildings*

Reference:
United State Environmental Protection Agency. "Model Standards and Techniques for Control of Radon in New Residential Buildings" (EPA 402-R-94-009; March 1994).

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"Model Standards and Techniques for Control of Radon in New Residential Buildings"

U.S. Environmental Protection Agency, Air and Radiation (6604-J)
EPA 402-R-94-009, March 1994

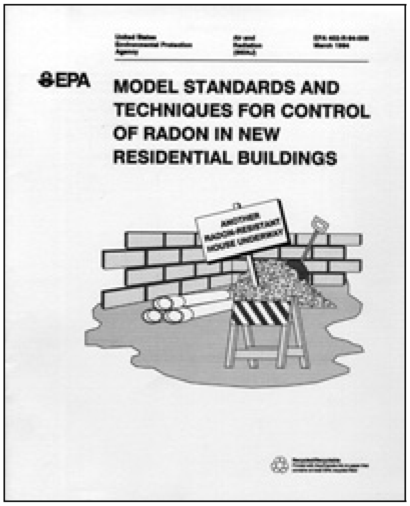

Table of Contents

DISCLAIMER

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NOTE: EPA closed its National Radon Proficiency Program on 9/30/98, see epa.gov/radon/proficiency.html for ways to find a "qualified" radon service provider.

FORWARD

This document is intended to serve as a model for use by the Model Code Organizations, States and other jurisdictions as they develop and adopt building codes, appendices to codes, or standards specifically applicable to their unique local or regional radon control requirements.

This document is responsive to the requirements set forth in Section 304 of Title III of the Toxic Substances Control Act (TSCA), 15 U.S.C. 2664, commonly referred to as the Indoor Radon Abatement Act (IRAA) of 1988. It is anticipated that future editions of this document will be prepared as additional experience is gained in constructing new radon-resistant residential buildings.

1.0 Scope

1.0.1 This document contains model building standards and techniques applicable to controlling radon levels in new construction of one- and two-family dwellings and other residential buildings three stories or less in height as defined in model codes promulgated by the respective Model Code Organizations.

1.0.2 The model building standards and techniques are also applicable when additions are made to the foundations of existing one- and two-family dwellings that result in extension of the building footprint.

1.0.3 This document is not intended to be a building code nor is it required that it be adopted verbatim as a referenced standard.

1.0.4 It is intended that the building standards and techniques contained in section 9.0 of this document, the construction method in section 7.0, and the recommended procedures for applying the standards and construction method in section 8.0, serve as a model for use by the Model Code Organizations and authorities within states or other jurisdictions that are responsible for regulating building construction as they develop and adopt building codes, appendixes to codes, or standards and implementing regulations specifically applicable to their unique local or regional radon control requirements.

1.0.5 The preferential grant assistance authorized in Section 306(d) of the Indoor Radon Abatement Act of 1988 (Title III of the Toxic Substances Control Act, TSCA, 15 U.S.C. 2666) will be applied for states where appropriate authorities who regulate building construction are taking action to adopt radon-resistant standards in their building codes.

1.0.6 Model building standards and techniques contained in this document are not intended to supersede any radon-resistant construction standards, codes or regulations previously adopted by local jurisdictions and authorities. However, jurisdictions and authorities are encouraged to review their current building standards, codes, or regulations and their unique local or regional radon control requirements, and consider modifications, if necessary.

1.0.7 This document will be updated and revised as ongoing and future research programs suggest revisions of standards, identify ways to improve the model construction techniques, or when newly tested products or techniques prove to be equivalent to or more effective in radon control. Updates and revisions to the model building standards and techniques contained in section 9.0 will undergo appropriate peer review.

1.0.8 EPA is committed to continuing evaluation of the effectiveness of the standards and techniques contained in section 9.0 and to research programs that may identify other more effective and efficient methods.

2.0 Limitations

2.0.1 The Indoor Radon Abatement Act of 1988 (Title III of TSCA) establishes a long-term national goal of achieving radon levels inside buildings that are no higher than those found in ambient air outside of buildings. While technological, physical, and financial limitations currently preclude attaining this goal, the underlying objective of this document is to move toward achieving the lowest technologically achievable and most cost effective levels of indoor radon in new residential buildings.

2.0.2 Preliminary research indicates that the building standards and techniques contained in section 9.0 can be applied successfully in mitigating radon problems in some existing nonresidential buildings. However, their effectiveness when applied during construction of new nonresidential buildings has not yet been fully demonstrated. Therefore, it is recommended that, pending further research, these building standards and techniques not be used at this time as a basis for changing the specific sections of building codes that cover nonresidential construction.

2.0.3 Although radon levels below 4 pCi/L have been achieved in all types of residential buildings by using these model building standards and techniques, specific indoor radon levels for any given building cannot be predicted due to different site and environmental conditions, building design, construction practices, and variations in the operation of buildings.

2.0.4 These model building standards and techniques are not to be construed as the only acceptable methods for controlling radon levels, and are not intended to preempt, preclude, or restrict the application of alternative materials, systems, and construction practices approved by building officials under procedures prescribed in existing building codes.

2.0.5 Elevated indoor radon levels caused by emanation of radon from water is of potential concern, particularly in areas where there is a history of groundwater with high radon content. This document does not include model construction standards or techniques for reducing elevated levels of indoor radon that may be caused by the presence of high levels of radon in water supplies. EPA has developed a suggested approach (see paragraph 8.3.2) that state or local jurisdictions should consider as they develop regulations concerning private wells. EPA is continuing to evaluate the issue of radon occurrence in private wells and the economic impacts of testing and remediation of wells with elevated radon levels.

2.0.6 While it is not currently possible to make a precise prediction of indoor radon potential for a specific building site, a general assessment, on a statewide, county, or grouping of counties basis, can be made by referring to EPA's Map of Radon Zones and other locally available data. It should be noted that some radon potential exists in all areas. However, EPA recognizes that based on available data, there is a lower potential for elevated indoor radon levels in some states and portions of some states, and that adoption of building codes for the prevention of radon in new construction may not be justified in these areas at this time. There is language in paragraph 8.2.3 of this document recommending that jurisdictions in these areas review all available data on local indoor radon measurements, geology, soil parameters, and housing characteristics as they consider whether adoption of new codes is appropriate.

3.0 Reference Documents

References are made to the following publications throughout this document. Some of the references do not specifically address radon. They are listed here only as relevant sources of additional information on building design, construction techniques, and good building practices that should be considered as part of a general radon reduction strategy.

3.1 "Building Foundation Design Handbook," ORNL/SUB/86-72143/1, May 1988.

3.2 "Building Radon Resistant Foundations - A Design Handbook," NCMA, 1989.

3.3 "Council of American Building Officials (CABO) Model Energy Code, 1992.

3.4 "Design and Construction of Post-Tensioned Slabs on Ground," Post Tensioning Institute Manual.

3.5 "Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings," ASHRAE Standard 90.1-1989.

3.6 "Energy Efficient Design of New Low-Rise Residential Buildings," Draft ASHRAE Standard 90.2 (Under public review).

3.7 "Homebuyer's and Seller's Guide to Radon," EPA 402-R-93-003, March 1993.

3.8 "Guide to Residential Cast-in-Place Concrete Construction," ACI 332R.

3.9 "Indoor Radon and Radon Decay Product Measurement Device Protocols." EPA 402-R-92-004, July, 1992.

3.10 "Protocols For Radon and Radon Decay Product Measurements in Homes." EPA 402-R-92-003, June, 1993.

3.11 "Permanent Wood Foundation System - Basic Requirements, NFPA Technical Report No.7."

3.12 "Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings," ASTM Standard Guide, E1465-92.

3.13 "Radon Handbook for the Building Industry," NAHB-NRC, 1989.

3.14 "USEPA Map of Radon Zones," Dec. 1993. www.epa.gov/radon/zonemap.html

3.15 "Radon Reduction in New Construction, An Interim Guide." OPA-87-009, August 1987.

3.16 "Radon Reduction in Wood Floor and Wood Foundation Systems." NFPA, 1988.

3.17 "Radon Resistant Construction Techniques for New Residential Construction. Technical Guidance." EPA/625/2-91/032, February 1991.

3.18 "Radon-Resistant Residential New Construction." EPA/600/8-88/087, July 1988.

3.19 "Guide for Concrete Floor and Slab Construction," ACI 302.1R-89.

3.20 "Ventilation for Acceptable Indoor Air Quality," ASHRAE 62-1989.

4.0 Description of Terms

For this document, certain terms are defined in this section. Terms not defined herein should have their ordinary meaning within the context of their use. Ordinary meaning is as defined in "Webster's Ninth New Collegiate Dictionary."

ACTION LEVEL: A term used to identify the level of indoor radon at which remedial action is recommended. (EPA's current action level is 4 pCi/L.)

AIR PASSAGES: Openings through or within walls, through floors and ceilings, and around chimney flues and plumbing chases, that permit air to move out of the conditioned spaces of the building.

COMBINATION FOUNDATIONS: Buildings constructed with more than one foundation type; e.g., basement/crawlspace or basement/slab-on-grade.

DRAIN TILE LOOP: A continuous length of drain tile or perforated pipe extending around all or part of the internal or external perimeter of a basement or crawlspace footing.

GOVERNMENTAL: State or local organizations/agencies responsible for building code enforcement.

MAP OF RADON ZONES: A USEPA publication depicting areas of differing radon potential in both map form and in state specific booklets.

MECHANICALLY VENTILATED CRAWLSPACE SYSTEM: A system designed to increase ventilation within a crawlspace, achieve higher air pressure in the crawlspace relative to air pressure in the soil beneath the crawlspace, or achieve lower air pressure in the crawlspace relative to air pressure in the living spaces, by use of a fan.

MODEL BUILDING CODES: The building codes published by the 4 Model Code Organizations and commonly adopted by state or other jurisdictions to control local construction activity.

MODEL CODE ORGANIZATIONS: Includes the following agencies and the model building codes they promulgate:

- Building Officials and Code Administrators International, Inc. (BOCA National Building Code/1993 and BOCA National Mechanical Code/1993);
- International Conference of Building Officials (Uniform Building Code/1991 and Uniform Mechanical Code/1991);
- Southern Building Code Congress, International, Inc. (Standard Building Code/1991 and Standard Mechanical Code/1991);
- Council of American Building Officials (CABO One- and Two-Family Dwelling Code/1992 and CABO Model Energy Code/1993).

pCi/L: The abbreviation for "picocuries per liter" which is used as a radiation unit of measure for radon. The prefix "pico" means a multiplication factor of one trillionth. A Curie is a commonly used measurement of radioactivity.

SOIL GAS: The gas present in soil which may contain radon.

SOIL-GAS-RETARDER: A continuous membrane or other comparable material used to retard the flow of soil gases into a building.

STACK EFFECT: The overall upward movement of air inside a building that results from heated air rising and escaping through openings in the building super structure, thus causing an indoor pressure level lower than that in the soil gas beneath or surrounding the building foundation.

SUB-SLAB DEPRESSURIZATION SYSTEM (ACTIVE): A system designed to achieve lower sub-slab air pressure relative to indoor air pressure by use of a fan-powered vent drawing air from beneath the slab.

SUB-SLAB DEPRESSURIZATION SYSTEM (PASSIVE): A system designed to achieve lower sub-slab air pressure relative to indoor air pressure by use of a vent pipe routed through the conditioned space of a building and connecting the sub-slab area with outdoor air, thereby relying solely on the convective flow of air upward in the vent to draw air from beneath the slab.

SUB-MEMBRANE DEPRESSURIZATION SYSTEM: A system designed to achieve lower sub-membrane air pressure relative to crawlspace air pressure by use of a fan-powered vent drawing air from under the soil-gas-retarder membrane.

5.0 Principles for Construction of Radon-Resistant Residential Buildings

5.1 The following principles for construction of radon-resistant residential buildings underlie the specific model standards and techniques set forth in section 9.0.

5.1.1 Residential buildings should be designed and constructed to minimize the entrance of soil gas into the living space.

5.1.2 Residential buildings should be designed and constructed with features that will facilitate post-construction radon removal or further reduction of radon entry if installed prevention techniques fail to reduce radon levels below the locally prescribed action level.

5.2 As noted in the limitations section (paragraph 2.0.2), construction standards and techniques specifically applicable to new nonresidential buildings (including high-rise residential buildings), have not yet been fully demonstrated. Accordingly, the specific standards and techniques set forth in section 9.0 should not, at this time, be considered applicable to such buildings. There are, however, several general conclusions that may be drawn from the limited mitigation experience available on large nonresidential construction. These conclusions are summarized below to provide some initial factors for consideration by builders of nonresidential buildings.

5.2.1 HVAC systems should be carefully designed, installed and operated to avoid depressurization of basements and other areas in contact with the soil.

5.2.2 As a minimum, use of a coarse gravel or other permeable base material beneath slabs, and effective sealing of expansion joints and penetrations in foundations below the ground surface will facilitate post-construction installation of a sub-slab depressurization system, if necessary.

5.2.3 Limited mitigation experience has shown that some of the same radon reduction systems and techniques used in residential buildings can be scaled up in size, number, or performance to effectively reduce radon in larger buildings.

6.0 Summary of the Model Building Standards and Techniques

The model building standards and techniques listed in section 9.0 are designed primarily for control of radon in new one- and two family dwellings and other residential buildings three stories or less in height.

6.1 Basement and Slab-on-Grade Foundations.

The model building standards and techniques for radon control in new residential buildings constructed on basement and slab-ongrade foundations include a layer of permeable sub-slab material, the sealing of joints, cracks, and other penetrations of slabs, floor assemblies, and foundation walls below or in contact with the ground surface, providing a soil-gas-retarder under floors and installing either an active or passive sub-slab depressurization system (SSD). Additional radon reduction techniques are prescribed to reduce radon entry caused by the heat induced "stack effect." These include the closing of air passages (also called thermal by-passes), providing adequate makeup air for combustion and exhaust devices, and installing energy conservation features that reduce non-required airflow out of the building superstructure.

6.2 Crawlspace Foundations.

The model building standards and techniques for radon control in new residential buildings constructed on crawlspace foundations include those systems that actively or passively vent the crawlspace to outside air, that divert radon before entry into the crawlspace, and that reduce radon entry into normally occupied spaces of the building through floor openings and ductwork.

6.3 Combination Foundations.

Radon control in new residential buildings constructed on a combination of basement, slab-on-grade or crawlspace foundations is achieved by applying the appropriate construction techniques to the different foundation segments of the building. While each foundation type should be constructed using the relevant portions of these model building standards and techniques, special consideration must be given to the points at which different foundation types join, since additional soil-gas entry routes exist in such locations.

7.0 Construction Methods

The model construction standards and techniques described in section 9.0 have proved to be effective in reducing indoor radon levels when used to mitigate radon problems in existing homes and when applied in construction of new homes. In most cases, combinations of two or more of these standards and techniques have been applied to achieve desired reductions in radon levels. Because of success achieved in reducing radon levels by applying these multiple, interdependent techniques, limited data have been collected on the singular contribution to radon reduction made by any one of the construction standards or techniques. Accordingly, there has been no attempt to classify or prioritize the individual standards and techniques as to their specific contribution to radon reduction. It is believed that use of all the standards and techniques (both passive and active) will produce the lowest achievable levels of indoor radon in new homes (levels below 2 pCi/L have been achieved in over 90 percent of new homes). It is also believed that use of only selected (passive) standards and techniques will produce indoor radon levels below the current EPA action level of 4 pCi/L in most new homes, even in areas of high radon potential.

7.1 It is recommended that all the passive standards and techniques listed in section 9.0 (including a roughed-in passive radon control system) be used in areas of high radon potential, as defined by local jurisdictions or in EPA's Map of Radon Zones. Based on more detailed analysis of locally available data, jurisdictions may choose to apply more or less restrictive construction requirements within designated portions of their areas of responsibility. To ensure that new homes are below the locally prescribed action level, in those cases where only passive radon control systems have been installed, occupants should have their homes tested to determine if passive radon control systems need to be activated. In addition, it is recommended that periodic retests be conducted to confirm continued effectiveness of the radon control system.

7.2 Any radon testing referenced in this document should be conducted in accordance with EPA Radon Testing Protocols or current EPA guidance for radon testing in real estate transactions as referenced in paragraph 3.0. It is recommended that all testing be conducted by companies listed in EPA's Radon Measurement Proficiency Program (RMP) or comparable State certification programs. [Note: EPA closed its National Radon Proficiency Program on 9/30/98, see epa.gov/radon/proficiency.html for ways to find a "qualified" radon service provider.]

7.3 The design and installation of radon control systems should be performed or supervised by individuals (i.e., builders, their representatives, or registered design professionals such as architects or engineers) who have attended an EPA-approved radon training course, or by an individual listed in the EPA Radon Contractor Proficiency Program. [Note: EPA closed its National Radon Proficiency Program on 9/30/98, see epa.gov/radon/proficiency.html for ways to find a "qualified" radon service provider.]

8.0 Recommended Implementation Procedures

The following procedures are recommended as guidelines for applying the model building standards and techniques and construction methods contained in this document. These procedures are based on the rationale that a passive radon control system and features to facilitate any necessary post-construction radon reduction should be routinely built-in to new residential buildings in areas having a high radon potential.

8.1 State, county, or local jurisdictions that use these model building standards and techniques as a basis for developing building codes for radon resistant construction should classify their area by reference to the Zones in EPA's Map of Radon Zones or by considering other locally available data. While EPA believes that the Map of Radon Zones and accompanying state-specific booklets are useful in setting general boundaries of areas of concern, EPA recommends that state and local jurisdictions collect and analyze local indoor radon measurements, and assess geology, soil parameters and housing characteristics --in conjunction with referring to the EPA radon maps -- to determine the specific areas within their jurisdictions that should be classified as Zone 1.

8.2 State, county, or local jurisdictions that use these model building standards and techniques as a basis for developing building codes for radon-resistant construction should specify the construction methods applicable to their jurisdictional area.

8.2.1 In areas classified as Zone 1 in the Map of Radon Zones, or by local jurisdiction, application of the construction method in paragraph 7.1 is recommended.

8.2.2 In areas classified as Zone 2, home builders may apply any of the radon-resistant construction standards and techniques that contribute to reducing the incidence of elevated radon levels in new homes and that are appropriate to the unique radon potential that may exist in their local building area.

8.2.3 In those areas where state and local jurisdictions have analyzed local indoor radon measurements, geology, soil parameters, and housing characteristics and determined that there is a low potential for indoor radon, application of radon-resistant construction techniques may not be appropriate. In these areas, radon-resistant construction techniques may not be needed, or limited use of selected techniques may be sufficient.

8.3 It is recognized that specific rules, regulations, or ordinances covering implementation of construction standards or codes are developed and enforced by state or local jurisdictions. While developing the model construction standards and techniques contained in this document, EPA also developed several approaches to regulation that states or local jurisdictions may find useful and appropriate as they develop rules and regulations that meet their unique requirements. For example:

8.3.1 In areas where the recommended construction method or comparable prescriptive methods are mandated by state or local jurisdictions, regulations would need to include, as part of the inspection process, a review of the radon-resistant construction features by inspectors who have received additional training, to ensure that the radon-resistant construction features are properly installed during construction. It would also be necessary to establish requirements for those building officials who review and approve construction plans and specifications to become proficient in identifying and approving planned radon-resistant construction features.

8.3.2 In any area where surveys have shown the existence of high levels of radon in groundwater, or in areas where elevated levels of indoor radon have been found in homes already equipped with active radon control systems, well water may be the source. In such areas, authorities responsible for water regulation should consider establishing well water testing requirements that include tests for radon.

9.0 Model Building Standards and Techniques

9.1 Foundation and Floor Assemblies. The following construction techniques are intended to resist radon entry and prepare the building for post-construction radon mitigation, if necessary. These techniques, when combined with those listed in paragraph 9.2, meet the requirements of the construction method outlined in paragraph 7.1. (See also the construction methods listed in ASTM Standard Guide, E-1465-92.)

9.1.1 A layer of gas permeable material shall be placed under all concrete slabs and other floor systems that directly contact the ground and are within the walls of the living spaces of the building, to facilitate installation of a sub-slab depressurization system, if needed. Alternatives for creating the gas permeable layer include:

a. A uniform layer of clean aggregate, a minimum of 4 inches thick. The aggregate shall consist of material that will pass through a 2-inch sieve and be retained by a 1/4-inch sieve.

b. A uniform layer of sand, a minimum of 4 inches thick, overlain by a layer or strips of geotextile drainage matting designed to allow the lateral flow of soil gases.

c. Other materials, systems, or floor designs with demonstrated capability to permit depressurization across the entire subfloor area.

9.1.2 A minimum 6-mil (or 3-mil cross laminated) polyethylene or equivalent flexible sheeting material shall be placed on top of the gas permeable layer prior to pouring the slab or placing the floor assembly to serve as a soil-gas-retarder by bridging any cracks that develop in the slab or floor assembly and to prevent concrete from entering the void spaces in aggregate base material. The sheeting should cover the entire floor area, and separate sections of sheeting should be overlapped at least 12 inches. The sheeting shall fit closely around any pipe, wire or other penetrations of the material. All punctures or tears in the material shall be sealed or covered with additional sheeting.

9.1.3 To minimize the formation of cracks, all concrete floor slabs shall be designed, mixed, placed, reinforced, consolidated, finished, and cured in accordance with standards set forth in the Model Building Codes. The American Concrete Institute publications, "Guide for Concrete Floor and Slab Construction," ACI 302.1R, "Guide to Residential Cast-in-Place Concrete Construction," ACI 332R, or the Post Tensioning

Institute Manual, "Design and Construction of Post-Tensioned Slabs on Ground" are references that provide additional information on construction of concrete floor slabs.

9.1.4 Floor assemblies in contact with the soil and constructed of materials other than concrete shall be sealed to minimize soil gas transport into the conditioned spaces of the building. A soil-gas-retarder shall be installed beneath the entire floor assembly in accordance with paragraph 9.1.2.

9.1.5 To retard soil gas entry, large openings through concrete slabs, wood, and other floor assemblies in contact with the soil, such as spaces around bathtub, shower, or toilet drains, shall be filled or closed with materials that provide a permanent airtight seal such as non-shrink mortar, grouts, expanding foam, or similar materials designed for such application.

9.1.6 To retard soil gas entry, smaller gaps around all pipe, wire, or other objects that penetrate concrete slabs or other floor assemblies shall be made air tight with an elastomeric joint sealant, as defined in ASTM C920-87, and applied in accordance with the manufacturer's recommendations.

9.1.7 To retard soil gas entry, all control joints, isolation joints, construction joints, and any other joints in concrete slabs or between slabs and foundation walls shall be sealed. A continuous formed gap (for example, a "tooled edge") which allows the application of a sealant that will provide a continuous, airtight seal shall be created along all joints. When the slab has cured, the gap shall be cleared of loose material and filled with an elastomeric joint sealant, as defined in ASTM C920-97, and applied in accordance with the manufacturer's recommendations.

9.1.8 Channel type (French) drains are not recommended. However, if used, such drains shall be sealed with backer rods and an elastomeric joint sealant in a manner that retains the channel feature and does not interfere with the effectiveness of the drain as a water control system.

9.1.9 Floor drains and air conditioning condensate drains that discharge directly into the soil below the slab or into crawlspaces should be avoided. If installed, these drains shall be routed through solid pipe to daylight or through a trap approved for use in floor drains by local plumbing codes.

9.1.10 Sumps open to soil or serving as the termination point for sub-slab or exterior drain tile loops shall be covered with a gasketed or otherwise sealed lid to retard soil gas entry. (Note: If the sump is to be used as the suction point in an active sub-slab depressurization system, the lid should be designed to accommodate the vent pipe. If also intended as a floor drain, the lid shall also be equipped with a trapped inlet to handle any surface water on the slab.)

9.1.11 Concrete masonry foundation walls below the ground surface shall be constructed to minimize the transport of soil gas from the soil into the building. Hollow block masonry walls shall be sealed at the top to prevent passage of air from the interior of the wall into the living space. At least one continuous course of solid masonry, one course of masonry grouted solid, or a poured concrete beam at or above finished ground surface level shall be used for this purpose. Where a brick veneer or other masonry ledge is installed, the course immediately below that ledge shall also be sealed.

9.1.12 Pressure treated wood foundations shall be constructed and installed as described in the National Forest Products Association (NFPA) Manual, "Permanent Wood Foundation System - Basic Requirements, Technical Report No. 7." In addition, NFPA publication, "Radon Reduction in Wood Floor and Wood Foundation Systems" provides more detailed information on construction of radon-resistant wood floors and foundations.

9.1.13 Joints, cracks, or other openings around all penetrations of both exterior and interior surfaces of masonry block or wood foundation walls below the ground surface shall be sealed with an elastomeric sealant that provides an air-tight seal. Penetrations of poured concrete walls should also be sealed on the exterior surface. This includes sealing of wall tie penetrations.

9.1.14 To resist soil gas entry, the exterior surfaces of portions of poured concrete and masonry block walls below the ground surface shall be constructed in accordance with water proofing procedures outlined in the Model Building Codes.

9.1.15 Placing air handling ducts in or beneath a concrete slab floor or in other areas below grade and exposed to earth is not recommended unless the air handling system is designed to maintain continuous positive pressure within such ducting. If ductwork does pass through a crawlspace or beneath a slab, it should be of seamless material. Where joints in such ductwork are unavoidable, they shall be sealed with materials that prevent air leakage.

9.1.16 Placing air handling units in crawlspaces, or in other areas below grade and exposed to soil-gas, is not recommended. However, if such units are installed in crawlspaces or in other areas below grade and exposed to soil gas, they shall be designed or otherwise sealed in a durable manner that prevents air surrounding the unit from being drawn into the unit.

9.1.17 To retard soil gas entry, openings around all penetrations through floors above crawlspaces shall be sealed with materials that prevent air leakage.

9.1.18 To retard soil gas entry, access doors and other openings or penetrations between basements and adjoining crawlspaces shall be closed, gasketed or otherwise sealed with materials that prevent air leakage.

9.1.19 Crawlspaces should be ventilated in conformance with locally adopted codes. In addition, vents in passively ventilated crawlspaces shall be open to the exterior and be of noncloseable design.

9.1.20 In buildings with crawlspace foundations, the following components of a passive sub-membrane depressurization system shall be installed during construction: (Exception: Where local codes permit mechanical crawlspace ventilation or other effective ventilation systems, and such systems are operated or proven to be effective year round, the sub-membrane depressurization system components are not required.)

9.1.20.1 The soil in both vented and nonvented crawlspaces shall be covered with a continuous layer of minimum 6-mil thick polyethylene sheeting or equivalent membrane material. The sheeting shall be sealed at seams and penetrations, around the perimeter of interior piers, and to the foundation walls. Following installation of underlayment, flooring, plumbing, wiring, or other construction activity in or over the crawlspace, the membrane material shall be inspected for holes, tears, or other damage, and for continued adhesion to walls and piers. Repairs shall be made as necessary.

9.1.20.2 A length of 3- or 4-inch diameter perforated pipe or a strip of geotextile drainage matting should be inserted horizontally beneath the sheeting and connected to a 3- or 4-inch diameter "T" fitting with a vertical standpipe installed through the sheeting. The standpipe shall be extended vertically through the building floors, terminate at least 12 inches above the surface of the roof, in a location at least 10 feet away from any window or other opening into the conditioned spaces of the building that is less than 2 feet below the exhaust point, and 10 feet from any adjoining or adjacent buildings.

9.1.20.3 All exposed and visible interior radon vent pipes shall be identified with at least one label on each floor level. The label shall read: "Radon Reduction System."

9.1.20.4 To facilitate installation of an active sub-membrane depressurization system, electrical junction boxes shall be installed during construction in proximity to the anticipated locations of vent pipe fans and system failure alarms.

9.1.21 In basement or slab-on-grade buildings the following components of a passive sub-slab depressurization system shall be installed during construction.

9.1.21.1 A minimum 3-inch diameter PVC or other gas-tight pipe shall be embedded vertically into the sub-slab aggregate or other permeable material before the slab is poured. A "T" fitting or other support on the bottom of the pipe shall be used to ensure that the pipe opening remains within the sub-slab permeable material. This gas tight pipe shall be extended vertically through the building floors, terminate at least 12 inches above the surface of the roof, in a location at least 10 feet away from any window or other opening into the conditioned spaces of the building that is less than 2 feet below the exhaust point, and 10 feet from any adjoining or adjacent buildings. (Note: Because of the uniform permeability of the sub-slab layer prescribed in paragraph 9.1.1, the precise positioning of the vent pipe through the slab is not critical to system performance in most cases. However, a central location shall be used where feasible.) In buildings designed with interior footings (that is, footings located inside the overall perimeter footprint of the building) or other barriers to lateral flow of sub-slab soil gas, radon vent pipes shall be installed in each isolated, nonconnected floor area. If multiple suction points are used in nonconnected floor areas, vent pipes are permitted to be manifolded in the basement or attic into a single vent that could be activated using a single fan.

9.1.21.2 Internal sub-slab or external footing drain tile loops that terminate in a covered and sealed sump, or internal drain tile loops that are stubbed up through the slab are also permitted to provide a roughed-in passive sub- slab depressurization capability. The sump or stubbed up pipe shall be connected to a vent pipe that extends vertically through the building floors, terminates at least 12 inches above the surface of the roof, in a location at least 10 feet away from any window or other opening into the conditioned spaces of the building that is less than 2 feet below the exhaust point, and 10 feet from any adjoining or adjacent buildings.

9.1.21.3 All exposed and visible interior radon vent pipes shall be identified with at least one label on each floor level. The label shall read: "Radon Reduction System."

9.1.21.4 To facilitate installation of an active sub-slab depressurization system, electrical junction boxes shall be installed during construction in proximity to the anticipated locations of vent pipe fans and system failure alarms.

9.1.21.5 In combination basement/crawlspace or slab-on-grade/crawlspace buildings, the sub-membrane vent described in paragraph 9.1.20.2 may be tied into the sub-slab depressurization vent to permit use of a single fan for suction if activation of the system is necessary.

9.2 Stack Effect Reduction Techniques.

The following construction techniques are intended to reduce the stack effect in buildings and thus the driving force that contributes to radon entry and migration through buildings. As a basic principle, the driving force decreases as the number and size of air leaks in the upper surface of the building decrease. It should also be noted that in most cases, exhaust fans contribute to stack effect.

9.2.1 Openings around chimney flues, plumbing chases, pipes, and fixtures, ductwork, electrical wires and fixtures, elevator shafts, or other air passages that penetrate the conditioned envelope of the building shall be closed or sealed using sealant or fire resistant materials approved in local codes for such application.

9.2.2 If located in conditioned spaces, attic access stairs and other openings to the attic from the building shall be closed, gasketed, or otherwise sealed with materials that prevent air leakage.

9.2.3 Recessed ceiling lights that are designed to be sealed and that are Type IC rated shall be used when installed on top-floor ceilings or in other ceilings that connect to air passages.

9.2.4 Fireplaces, wood stoves, and other combustion or vented appliances, such as furnaces, clothes dryers, and water heaters shall be installed in compliance with locally adopted codes, or other provisions made to ensure an adequate supply of combustion and makeup air.

9.2.5 Windows and exterior doors in the building superstructure shall be weather stripped or otherwise designed in conformance with the air leakage criteria of the CABO Model Energy Code.

9.2.6 HVAC systems shall be designed and installed to avoid depressurization of the building relative to underlying and surrounding soil. Specifically, joints in air ducts and plenums passing through unconditioned spaces such as attics, crawlspaces, or garages shall be sealed.

9.3 Active Sub-Slab/Sub-Membrane Depressurization System.

When necessary, activation of the roughed-in passive sub-membrane or sub-slab depressurization systems described in paragraphs 9.1.20 and 9.1.21 shall be completed by adding an exhaust fan in the vent pipe and a prominently positioned visible or audible warning system to alert the building occupant if there is loss of pressure or air flow in the vent pipe.

9.3.1 The fan in the vent pipe and all positively pressurized portions of the vent pipe shall be located outside the habitable space of the building.

9.3.2 The fan in the vent pipe shall be installed in a vertical run of the vent pipe.

9.3.3 Radon vent pipes shall be installed in a configuration and supported in a manner that ensures that any rain water or condensation accumulating within the pipes drains downward into the ground beneath the slab or soil-gas-retarder.

9.3.4 To avoid reentry of soil gas into the building, the vent pipe shall exhaust at least 12 inches above the surface of the roof, in a location at least 10 feet away from any window or other opening into the conditioned spaces of the building that is less than 2 feet below the exhaust point, and 10 feet from any adjoining or adjacent buildings.

9.3.5 To facilitate future installation of a vent fan, if needed, the radon vent pipe shall be routed through attics in a location that will allow sufficient room to install and maintain the fan.

9.3.6 The size and air movement capacity of the vent pipe fan shall be sufficient to create and maintain a pressure field beneath the slab or crawlspace membrane that is lower than the ambient pressure above the slab or membrane.

9.3.7 Under conditions where soil is highly permeable, reversing the air flow in an active sub-slab depressurization system and forcing air beneath the slab may be effective in reducing indoor radon levels. (Note: The long-term effect of active sub-slab depressurization or pressurization on the soil beneath building foundations has not been determined. Until ongoing research produces definitive data, in areas where expansive soils or other unusual soil conditions exist, the local soils engineer shall be consulted during the design and installation of sub-slab depressurization or pressurization systems.)

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NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Appendix G
Community outreach tools — additional information

[This appendix is a modified version of Appendix A from the New York State Department of Environmental Conservation Division of Environmental Remediation's "Citizen Participation in New York's Hazardous Waste Site Remediation Program: A Guidebook" (June 1998).]

Additional information about several of the community outreach tools discussed in Section 5 of the guidance document is provided in this appendix. These tools are as follows:

Appendix G.1 Contact List
Appendix G.2 Fact Sheet
Appendix G.3 Public Meeting
Appendix G.4 Availability Session
Appendix G.5 Toll-free "800" Numbers
Appendix G.6 Door-to-door Visits
Appendix G.7 Document Repository

The additional information provided for each tool includes the following:

Description — Summarizes what the technique is and what it achieves.

Suggestions for Planning and Conducting — Offers basic ideas to develop and implement the technique successfully.

Benefits and Limitations — Describes specific benefits the technique can help achieve, and potential impediments to its effectiveness.

NOTE: Updates to this final guidance are available at http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

G.1 Contact List

G.1.1 Description

A contact list contains names, addresses and telephone numbers of individuals and organizations with interest or involvement in the site. They may be affected by or interested in the site, or have information that staff need to make effective remedial decisions. Contact lists typically include residents near the site, elected officials, appropriate federal, state, and local government contacts, local media, organized environmental groups and responsible party, as well as local business, civic and recreational groups.

The site contact list is a critical communications tool that needs to be prepared *before* other activities can be conducted. In some ways, a site-specific citizen participation program will only be as effective as its contact list, which more or less determines who gets the project information prepared, as well as invitations to participate and provide input. Development and revision of the contact list are ongoing activities throughout the site's remediation.

It is recommended that an internal distribution list be developed while preparing the external contact list. The distribution list should include all staff (NYSDEC, NYSDOH, county health department, etc.) involved in the site. This list will help ensure that all staff involved with the project will receive the same information about all phases of the site's remediation.

Note: The checklist on page G-6 will help to identify who may need to be included in a particular site's contact list.

Contact lists are used to

- send a fact sheet announcing a major project decision or proposal, project status or progress, or a public meeting or availability session;
- issue summaries of draft/final documents and announce availability of full documents;
- send a response to public questions and comments;
- transmit a request to the public for information needed by project staff;
- send summaries of information exchanged at public meetings, forums, availability sessions and other public gatherings; and
- identify individuals, groups and organizations by affiliation, interest or geographic location to help to target communication and outreach as appropriate.

G.1.2 Suggestions for Creating an Effective Contact List

Several factors help to determine the size and make up of a site's contact list, including the following:

- the nature and size of the community, whether rural, urban, densely or sparsely populated;
- the nature of hazardous waste contamination, whether confined to an area or environmental medium or more ubiquitous (and thus involving air issues, municipal well contamination, etc.);
- real or perceived impacts of site contamination on the environment, property values, and human health;
- specifics of the proposed remedial solution, especially where there are real or perceived off-site impacts (such as dust, noise, air quality);
- the stage of the remedial process and the specific issues and audiences involved;

- characteristics of the involved audience;
- the information that needs to be exchanged; and
- program resources.

The contact list will change as a remedial program progresses. These changes reflect increasing or declining interest by different individuals, groups and organizations in various aspects of the program.

G.1.2.1 <u>Some categories are a "given" for every contact list</u>

Some individuals, organizations and representatives should be included in *every* contact list:

- those who are directly affected, such as residents, property owners, and commercial establishments next to the site;
- local elected officials (mayors, supervisors, council members, clerks);
- local emergency services officials;
- local media; and
- relevant business, civic, and environmental organizations.

G.1.2.2 <u>Apply criteria to determine who else should be included</u>

Additional individuals, groups and organizations often are included in site contact lists. The following questions about the site will help determine whether the contact list is complete:

- Who has been — or currently is — affected by site contamination, or by investigation and remediation of the site?
- Who *perceives* that he/she has been — or currently is — affected by site contamination or by investigation and remediation of the site?
- Who is likely to be affected or interested as remediation progresses?
- Who has demonstrated past interest — or currently is showing interest — in the site or the remedial process?
- Who may need information about site contamination or the remedial program who is not currently on the contact list?
- Who may have information that project staff needs who is not currently on the contact list?

G.1.2.3 <u>Build upon existing information</u>

For many sites, an initial list of adjacent residents and local officials is developed when the NYSDEC sends classification or reclassification letters, etc. This list can be checked for accuracy and updated as needed. It can serve as a core group for the contact list.

G.1.2.4 <u>Include people who have shown interest</u>

Review project files to identify people who have historically demonstrated interest in the site. Review sign-in sheets from public meetings and availability sessions; include people who have written letters about the site to the state or other party, or who have called project staff or the NYSDEC or NYSDOH's toll-free information numbers.

G.1.2.5 <u>Ask other staff</u>

Ask staff from the state, county or other agencies to share contacts they have had with individuals, groups and organizations affected by or interested in the site.

G.1.2.6 Consult resource people and published lists

Ask municipal clerks and public works department staff (sewer or water system user lists); consult telephone or municipal directories, tax rolls and tax maps.

G.1.2.7 Ask the involved public

Ask the public with whom you are already communicating about the site to identify other individuals and organizations you should include.

G.1.2.8 Monitor media accounts

This includes newspaper, radio and television reports about the site, which often identify individuals and organizations interested in the site.

G.1.2.9 Make use of site visits

Use site visits as an opportunity to evaluate the community from the following points of view: Who is affected? Who is interested?

G.1.2.10 Organize the contact list into categories

This is particularly useful, especially when a list is large. You may need to target specific sub-groups for communication (for example, adjacent residents and local officials). Groups may be categorized based on geography (proximity to the site, political boundaries); by affiliation (unit of government, adjacent residents, environmental civic or business group) or by interest (e.g., remedial alternatives, future site use, off-site impacts, etc.).

G.1.2.11 Key contacts

Consider creating a short list of individuals and organizations likely to play an important participation role, or who need to be notified of project developments on short notice. *It is especially important to keep this list current and accurate.*

G.1.2.12 Update

Review and update the contact list regularly as changes, additions and deletions are obtained. Individuals and organizations may gain or lose interest or change roles in the program at different remedial stages. The need for information from certain members of the public at different stages may also change. A contact person for an organization may change if he or she is an elected official.

G.1.3 Benefits and Limitations

- A contact list helps to identify the affected and interested public, and their affiliations, locations and levels of interest.
- When categorized, a contact list helps project staff to deliver specific information to particular affected and interested individuals, groups and organizations and to plan specific communication activities.
- A contact list helps to inform public directly, without media and others filtering the information.
- A contact list helps to make written and telephone contact with the public systematic and efficient. It gives project staff confidence that affected/interested public is receiving important site information.
- A contact list, particularly a large one, requires staff time to create, update and maintain in useful form. An outdated or deficient contact list is worthless and erodes the effectiveness of the entire site-specific outreach program.

Checklist for Site Contact List

Adjacent/Nearby Affected Parties:

- ❑ Residents/property owners/commercial establishments
- ❑ Owners of rights-of-way (utilities, etc.)
- ❑ Neighborhood association
- ❑ Residents/property owners affected by remedial activity (truck routes, water line extensions)
- ❑ Municipal water suppliers

Local Officials, Committees and Boards:

- ❑ Mayor/supervisor
- ❑ City council/town board members
- ❑ Municipal clerk
- ❑ Planning board/zoning board
- ❑ School boards, officials, PTAs
- ❑ Municipal engineer/public works official
- ❑ Municipal attorney
- ❑ Police/fire/emergency services officials
- ❑ Conservation Advisory Committee

County/Regional Officials, Boards and Organizations:

- ❑ County Administrator
- ❑ County Legislator(s) for site's district
- ❑ County clerk
- ❑ County Health Department
- ❑ Environmental Management Council
- ❑ Soil and Water Conservation District
- ❑ Cooperative Extension
- ❑ Farm Bureau

State Official and Agencies:

- ❑ State senators and Assembly members
- ❑ NYSDEC
- ❑ NYSDOH
- ❑ NYS Department of Law
- ❑ NYS Department of State
- ❑ NYS Department of Transportation
- ❑ Governor's office

Federal Officials and Agencies:

- ❑ U.S. Senators, U.S. Representatives
- ❑ Environmental Protection Agency
- ❑ Occupational Safety and Health Adm.
- ❑ Office of Technology Assessment
- ❑ Department of Defense
- ❑ Department of Energy

Civic/Environmental/Recreational Groups:

- ❑ Outdoor/recreational groups (rod & gun clubs, hiking, biking, boating, birding interests)
- ❑ Local/regional citizens groups
- ❑ Rotary/VFW/American Legion/Lion's Club
- ❑ League of Women Voters
- ❑ Citizens Environmental Coalition, NYPIRG, Audubon, Trout Unlimited, etc.

Economic Interests:

- ❑ Responsible party
- ❑ Title 3 grant recipient
- ❑ Financial institutions/lenders
- ❑ Real estate developers/agencies
- ❑ Chamber of commerce
- ❑ Local economic development board

Local/Regional Media:

- ❑ Newspapers (daily, weekly)
- ❑ Radio and television stations

Geographic-specific Government Bodies and Subdivisions:

- ❑ Community boards established by New York City charter
- ❑ Adirondack Park Agency
- ❑ Tug Hill Plateau Commission
- ❑ New York City Department of Sanitation
- ❑ Adjacent state
- ❑ Canada
- ❑ Native American Nation

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

G.2 Fact Sheet

G.2.1 Description

A fact sheet is a written summary of important information about a hazardous waste site and its remedial program. It presents information in clear, concise terms for the affected and interested community. It may focus on remedial activities, legal or health issues and citizen participation opportunities.

Fact sheets ensure that site information is distributed consistently and that citizens understand the salient issues associated with the site's remedial program.

A fact sheet is a versatile tool that can be used for many purposes. It can do the following:

- announce a milestone in the site's remedial program or important site findings;
- describe major changes in the type, scope or schedule or previously announced site program activities;
- provide a "status report" during long periods of investigation or remedial construction;
- describe results or remediation efforts;
- announce availability of a document;
- publicize a public comment period or other opportunities for public input;
- announce an upcoming public meeting or availability session;
- supplement or follow up door-to-door visits; and
- complement presentations at a public meeting.

G.2.2 Suggestions for Creating a Fact Sheet

Preparation of a fact sheet can be divided into several general steps that include *planning, development and distribution*.

Note: A checklist that summarizes these major steps is on page G-12.

PLANNING THE FACT SHEET

G.2.2.1 Planning by asking questions

Before writing a fact sheet, answer the following questions to help guide your effort:

- What do readers need to know and remember? Why?
- Who is the audience for the fact sheet?
- Why should the audience read the fact sheet?
- Do you want the audience to *do* something, or *provide* something to you?
- Is the information "time-sensitive"? If so, how will this influence the way in which you distribute the fact sheet?

G.2.2.2 Identifying the message

What are the one or two *main* points that you need to communicate to the reader? These could include site findings or results, a program milestone, beginning of field work, a comment period or other opportunity for the public to provide input about the project, a public meeting, or a major change in the program. The points you identify become the focus of the fact sheet.

Besides the issues important to project staff, what issues are important to the audience? Consider acknowledging and addressing them; otherwise, the fact sheet may deter readers who will conclude that the material is irrelevant to their concerns.

In addition to the few key points you wish to emphasize, a site fact sheet always should describe

- the site's history and why it is being investigated or remediated;
- upcoming citizen participation opportunities;
- the site's document repository; and
- staff contacts and ways for readers to obtain additional information.

G.2.2.3 Defining the audience

Determine who in the affected/interested community should receive the fact sheet. Part or all of the contact list? Specific categories of people such as adjacent residents or local officials? The information contained in the fact sheet helps to identify appropriate recipients.

G.2.2.4 Distribution and logistics

Determine how to get the fact sheet into the hands of the people who need to read it. A fact sheet can be

- mailed to all or part of the site's contact list (see Appendix G.1 for a discussion about developing a site contact list);
- distributed at a public meeting or availability session;
- placed in document repositories; and
- provided to residents during door-to-door visits.

Note: The site's contact list, if you use it, should be complete and up-to-date. Be sure to include people who have attended site public meetings, or who have called or written letters about the site. Make any necessary changes based on recent local, regional or statewide elections.

During the planning stage, determine who will reproduce the fact sheet, generate labels, stuff envelopes and oversee mailing or other distribution.

G.2.2.5 Allocating responsibilities

While it is generally best to designate a point person with overall responsibility for the fact sheet, determine during planning who else needs to participate in writing, review or distribution. Be sure all necessary staff are informed and brought into the fact sheet development process in a timely way.

G.2.2.6 Timing

Does the fact sheet announce imminent remedial field work (major onsite sampling or an interim remedial action or remedial construction)? Is a major site document being made available for public review, has a public meeting been scheduled, or is a comment period about to begin?

These questions highlight cases in which timely distribution of the fact sheet is particularly important. In such situations, the fact sheet's value is twofold: a) it provides the public with information and b) invites the public's action before the important site activity begins. This means that you should build sufficient time into the fact sheet development schedule to ensure its distribution well ahead of time.

G.2.2.7 Outline

Begin writing by constructing a skeletal summary of the information, from most to least important. If it is difficult to get started, the following suggestions may help jump start the process:

- Write a summary using the *Who, What, When, Where, How, Why* method. Then add facts and details. Don't worry about writing polished text at this point;
- Try writing a headline or a simple declarative sentence proclaiming the most important fact you want to convey to the reader. For example: "State to Begin Cleanup of Hazardous Waste Contamination at Chem-Spill Site." Then begin hanging important facts on the sentence, regardless of the order in which they will ultimately appear in the text.

G.2.2.8 Selecting a format

Write clearly and concisely. Wherever possible, avoid jargon and acronyms; if they are essential to your explanation, define them clearly. This is especially important if you, for example, incorporate a test from a technical report written for specialists into a fact sheet intended for a general audience.

G.2.2.9 Capturing the reader's attention

The fact sheet must compete with all the other mail that readers have to wade through every day. Assume there are only a few seconds available to attract and hold a reader's attention to the message. Here are a few ways to do it:

- Grab the reader's attention with an informative headline.
- The lead paragraph (or at the very least the first page) of the fact sheet should contain the essence of what readers most need to know. This will help to ensure that even the most casual reader will capture the essentials of your message, even if he or she fails to turn the page or "recycles" the fact sheet after reading just the opening paragraph.
- Condense important information to essentials. If more detail is necessary, guide the reader to additional information within the fact sheet, but do not begin with background or historical information; such information, although useful, should never be the most important news for your reader. The fact sheet should lead with the most important piece of information that readers should know.
- Maps and graphics improve and increase reader understanding. The fact sheet should include a site map to help readers pinpoint the site's location, especially those who are not nearby residents. Can a simplified schematic diagram to depict the remedial technology you may be discussing be included?

G.2.2.10 Reviewing and rewriting

Make the material concise, accurate and readable, taking care to include information that should be part of every fact sheet: ways to obtain additional information, public involvement opportunities and repository information. Delete information that does not contribute to the reader's knowledge or understanding included.

Note: Staff who contributed information to the fact sheet, or who wrote portions of the fact sheet, or whose program responsibilities are described in the fact sheet, should be encouraged to review the draft before it is finalized. This includes staff from other agencies. Build enough time into the development schedule not only for reviewing and commenting, but also for incorporating important comments into the draft.

It helps to have someone not familiar with the site read the draft fact sheet for clarity and understanding. An "outsider" can provide a fresh perspective.

DISTRIBUTING THE FACT SHEET

Distribution involves the following: *who* will handle logistics, *how* distribution is conducted and *timing*.

G.2.2.11 Determining who does what

Who will handle photocopying, envelope stuffing and mailing or other distribution? Who will develop mailing labels? Don't leave these decisions until the last minute, especially if the fact sheet contains time-sensitive information. Decide during the planning stage.

G.2.2.12 Selecting method of distribution

Will all or part of the site contact list be used? If so, be sure it is up to date. Have the names from the most recent public meeting sign-in sheets been added? Did officials change after the last election?

Alternatives to mailing the fact sheet include the following: dispensing at public meetings and availability sessions, distributing during door-to-door visits, and inserting in another mailing.

G.2.2.13 Timing

The information contained in the fact sheet is time-sensitive if it announces the following:

- an upcoming public meeting (people should receive the fact sheet two weeks before the meeting so they can clear their calendars and avoid conflicts with other events);
- the start and end dates of an upcoming public comment period (the public should receive the fact sheet *before* the comment period begins; otherwise a 30-day comment period becomes, in reality, a 25-day comment period);
- imminent field investigation or construction work (e.g., workers in protective gear in the field, or a street closed or full of traffic, or the water supply to be shut off); and
- availability of an important site document for public comment, or that staff will discuss at an upcoming public meeting (people need to know in a timely way, for example, that the document is at the repository, or that it will be the focus of the public meeting).

Sufficient time should be allowed in the development and review schedule to ensure that the fact sheet is distributed, *and that it is received*, before the critical activity takes place.

G.2.3 Benefits and Limitations

- A fact sheet can effectively summarize important facts about a site's remedial program. It can also invite the public's participation in the site's decision-making process. A fact sheet often can be developed relatively quickly and distributed to a specific audience.

- Information can be provided directly to the audience without having to rely on coverage by local news media. Though local media should always be included in the intended readership, they may use some, all or none of the information contained in the fact sheet.

- A fact sheet can supplement or emphasize information provided at meetings and other forums, or can be used as a follow-up to other activities.

- When sent to the affected community throughout a site's remedial process, fact sheets can help a community stay informed and involved and demonstrate the state's commitment to public involvement.

- Sometimes a fact sheet can take significant time to plan and develop. It often requires careful coordination among staff.

- Instead of increasing public understanding, a poorly written fact sheet may mislead and confuse. Unless the fact sheet's message is clear and immediately apparent, the reader may quickly lose interest.

- If the fact sheet does not acknowledge issues that are important to the community, readers may dismiss the information as irrelevant.

- It may be difficult to determine, short of polling the audience, how many of the read the fact sheet, and how much information they retain. The fact sheet must compete with a lot of other mail for the attention of people who have limited free time to read.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Checklist to Plan, Develop and Distribute a Fact Sheet

- ❑ Determine purpose and message of fact sheet
- ❑ Identify audience and recipients
- ❑ Determine method of distribution
    - ❑ Update contact list (if mailing)
- ❑ Develop schedule for development and distribution
- ❑ Develop outline of fact sheet
    - ❑ Coordinate with project staff
    - ❑ Collect information
    - ❑ Assemble appropriate graphics
- ❑ Write draft fact sheet. Incorporate information and graphics.
- ❑ Coordinate project staff review
- ❑ Arrange reproduction of fact sheet in appropriate quantity
- ❑ Distribute fact sheet
    - ❑ Generate mailing labels, stuff envelopes and mail **and/or**
    - ❑ Insert fact sheet in separate mailing **and/or**
    - ❑ Distribute at public meeting or availability session **and/or**
    - ❑ Hand out during door-to-door visits **and**
    - ❑ Mail to document repository(ies)
- ❑ If fact sheet contains "time-sensitive" information about field work, a comment period, release of project document or other upcoming activity, ensure distribution before the start of the activity.

G.3 Public Meeting

G.3.1 Description

A public meeting brings together project staff with affected and interested citizens. Staff generally present information and answer questions, while citizens are encouraged to ask questions and provide comments.

A public meeting usually is held at a milestone in a site's remedial program, or to describe progress during a lengthy remedial stage. The meeting generally has a well-defined structure, spelled out in a formal agenda. Discrete time periods generally are defined for presentations, questions and answers, and public comment.

A public meeting helps

- ensure that important information about a site's remedial program is delivered in a consistent way to a large audience;
- identify issues and concerns important to the affected/interested community;
- ask the community for information about site history and conditions before beginning major investigation activity;
- gather public comment about a specific issue; and
- demonstrate to an emotionally-charged community that environmental officials are accessible and accountable. In such cases a public meeting should be supplemented with other outreach activities designed to help work through emotion and contribute to problem-solving. A meeting should *not* be held simply to encourage the public to vent.

G.3.2 Suggestions for Planning and Conducting a Public Meeting

Note: A checklist that summarizes major steps to plan and conduct a public meeting is on page G-19.

G.3.2.1 <u>Identifying the need for a public meeting</u>

- Define the status of the site's overall remedial and decision making process;
- Identify, in specific terms, the needs of the project staff and the community regarding information and involvement. How do those needs relate to the site's overall remedial process? Define objectives to meet those needs.
- Is a public meeting required at this point in the site's remedial process, or is it being considered as an optional activity to supplement the public outreach effort?
- Have other kinds of outreach activities been reviewed to determine whether any of them could more effectively accomplish the objectives?

If it is determined that a public meeting is required or appropriate at this time, proceed with organizing the meeting.

G.3.2.2 <u>Objectives and participants</u>

Public meetings often are conducted because of a remedial milestone or to report progress during a lengthy remedial stage. Answers to questions such as the following will help to define the goals and objectives of the meeting:

- What must be accomplished at the meeting?
- What important information must be given to or gathered from attendees? Ideally, who should these attendees be?

- What issues, questions and concerns are attendees likely to raise, whether or not related to the issues and information the project staff will discuss?

Identify program staff who have appropriate expertise and knowledge to provide the information identified and to address public comments and questions. At a minimum, staff should participate who have the program responsibilities for the remedial activities that will be the focus of the meeting.

G.3.2.3 Framework and format

Project staff should develop an agenda based on the goals of the meeting. The agenda should identify presentations to be made to the audience, the major points and the presenters. Develop handouts and other necessary supporting materials; at a minimum, these should include the agenda or a summary of the main points to be discussed, as well as a fact sheet.

Other useful supporting materials include slides and overheads (transparencies), maps and charts, cutaway sketches, blueprints, photographs, tools and instruments and even samples of liner material or other remedial equipment.

Be sure each participating staff person understands which items they are responsible for, as well as the timetable for their development.

Although slides and overheads are useful support tools, they should not overwhelm the presentation. A few suggestions:

- Use only as many slides or overheads as necessary. An AV extravaganza usually detracts from your message — the audience can be worn out, confused or overwhelmed by a myriad of charts, graphs and tables.
- Focus the message. Each slide and overhead should deal with one idea or concept. Use key words, phrases, and illustrations. Avoid undefined acronyms and technical language. Avoid the temptation to pull an entire page of text or an elaborate chart of sampling results from a technical report and throw it onto a screen. Extract the most significant statistics onto a simple overhead. Every second your audience must wade through a detailed overhead is a second spent not listening to you.
- Use large size typeface. People in the back of the room need to be able to read the material.
- Consider providing attendees with paper copies of your overheads, so they can follow along from their seats.
- After you're through with a slide or overhead, turn off the projector, or remove or cover the image. Otherwise, the audience will be distracted by the image long after you have moved on to new material.

G.3.2.4 Eliciting input

The agenda should describe the methods to be used to gather public input, whether at the meeting itself or as part of a public comment period. Furthermore, the agenda should describe the kind of input desired, from comments about a proposal, to community issues and concerns, to information about a site's history or conditions.

G.3.2.5 Planning for the number of attendees

Consider the history of public involvement related to the site. How many people are affected by or interested in the issues you will discuss at the meeting? How many people have turned out for previous sessions? If this is the site's first public meeting, you can try to gauge public interest through other means, including media coverage, letters and phone calls to project staff, and political interest at the local or state level.

NOTE: Updates to this final guidance are available at http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

G.3.2.6 Selecting a date, time and place

Choose a location, date and time conducive to public attendance. Check with the municipal clerk and school officials to be sure that your public meeting does not conflict with other meetings that could draw members of the community away.

The location should be an easily accessible building familiar to residents, such as a municipal hall, school, fire station or library. Local residents and officials can usually suggest an appropriate venue. Because locations may vary greatly in size, it is important to estimate attendance. It is better to overestimate when in doubt.

The facility should be accessible to people with disabilities. If you expect that most attendees will drive to the public meeting, there should be adequate parking. If the public meeting is being held in a large urban area, the facility should be reachable via public transportation.

Follow up on the arrangements made with a letter to the facility contact person, confirming the date and time of the meeting, and the subject of the session.

G.3.2.7 Publicity

Notify the community at least two weeks before the date of the public meeting. This allows interested people to clear their calendars and avoid conflicts with other events.

The public meeting may be publicized in many ways. Examples include the following:

- send a fact sheet or meeting announcement to part or all of the site contact list (be sure the contact list is up-to-date). Include the meeting agenda as well as highlights of the proposal or issues to be discussed. This is important because, even if people do not attend, they will receive information you want them to know.
- send a media release or a fact sheet to local newspapers and radio stations;
- telephone key individuals, organizations and officials;
- post notices at highly visible points in the community; and
- announce the upcoming public meeting at another forum, such as a town council or school board meeting.

Regardless of the methods you choose, emphasize the reasons for the meeting, the agenda, and the importance of public participation.

G.3.2.8 Coordinating with staff

Coordinate with participating staff before the public meeting to ensure that everyone understands the agenda and how the meeting will be conducted. Be sure that participating staff have developed their presentations and support materials.

Staff should try to rehearse their presentations ahead of time; they can benefit from a constructive critique about content and style. It is also useful to brainstorm questions and comments you are likely to hear at the public meeting, and to assess who is most qualified to address a particular question or issue, and whether there is sufficient information for a response. Remember to consider questions staff may want to ask the public.

G.3.2.9 Packing up and heading out

Remember the materials you will need for the meeting, such as

- fact sheets, agendas and other handouts (e.g., remedial program brochures);
- sign-in materials;
- directional signs;
- tape, pens, markers;
- support materials (slides, overheads, maps, charts, blueprints);
- equipment (slide projector, overhead projector, projection screen, tape recorder, flip chart stand and pad);
- extra projector bulbs; and
- extension cords (the nearest outlet may be 50 feet away).

G.3.2.10 Preparing the location

Arrive well ahead of time in order to get ready for the meeting:

- place directional signs as needed;
- establish a place for sign-in sheets and handout materials. Be sure that people sign in as they arrive, and use the information to update the site's contact list;
- set up equipment and support materials, such as projector or overhead, screen, flipchart, maps, tape recorder and other items; and
- set up podiums or platforms for speakers — move chairs and tables for presenters and audience as appropriate.

Try to greet people as they arrive, and introduce staff participants. A few pleasant words of greeting can help to set at ease those who may be uncomfortable in a public forum. Establish a climate that enables constructive communication.

G.3.2.11 Taking notes

A staff person who is not making a presentation should be selected ahead of time to take detailed notes of the meeting. Other staff should take notes as time and their responsibilities allow. Good notes help staff keep track of the public's questions and comments, as well as items for follow-up.

G.3.2.12 Beginning the meeting

Begin the meeting by welcoming the audience, and thanking them for taking the time to attend. Tell them about the purpose of the meeting and why it is important. Review the agenda with the audience (everyone should have a copy). State the ground rules up front and in simple terms.

G.3.2.13 Presenting information

In order to allow time for audience participation, especially questions and answers (Q & A), try to keep presentations as short as is possible. Be sure everyone can see the slides or overheads, and encourage people to move closer if they cannot.

G.3.2.14 Encouraging feedback

Adhering to the ground rules, facilitate public comments and questions during, between or after presentations. Everyone who wants to speak should have the opportunity. Be sure to ask if anyone has written comments.

Here are some tips for working effectively with the audience. Two dynamics operate at a public meeting: a) the issues and information to be exchanged; and b) the relationship between staff and audience brought to, or forged at, the meeting. The quality of the second dynamic, the relationship, usually rules the day. The importance of the information, or the craftsmanship of your presentations, will not matter if

- the prior relationship with the public has been non-productive or non-existent;
- the public distrusts the sincerity of project staff, or their motives;
- the public doubts the ability of project staff to address issues that concern them; or
- the public brings a different agenda to the meeting, or tries to obstruct the process.

It is impossible, within the confines of a single meeting, to remedy a long-standing dysfunctional relationship with the public. However, a few steps can be taken to increase trust and improve communication:

- Write the public's questions and comments on a flip-chart. This is a simple graphic demonstration that you have heard what the audience has said.
- During Q & A restate each speaker's question or comment for the entire audience. This shows the speaker that he or she has been understood, and ensures that everyone at the meeting understands what will be responded to.
- Tell the audience how their comments and input will be considered and how their overall involvement fits in the site decision-making process.
- If someone in the audience monopolizes Q & A or the comment period to the exclusion of others, gently but firmly remind the audience of the ground rules they agreed to. If the person persists, sound out the audience; sometimes an audience is its own best enforcer.
- If the meeting becomes heated or emotional, staff may feel that they are being attacked personally. Remember that people sometimes feel the need to vent and speak their piece. They may have been living with the effects of a hazardous waste site for years; or they may perceive public agencies to be slow, uncaring or mysterious, especially if the meeting is their first contact with the agencies.
- If the answer to a question is not known, say so plainly and simply. Tell the speaker an answer will be obtained and relayed as soon as possible. Be sure to follow up back at the office!
- Always tell the audience where the site remedial process is headed: what the next steps are; when they will hear from staff again and what they can expect to be told; when the public will have another opportunity to provide input.
- If the audience is not asking questions or providing comments about the information provided or the proposal outlined, staff should have several questions ready to ask the audience. The questions should be designed to break the ice and stimulate useful discussion.
- Encourage attendees to contact staff whenever they have questions, concerns or ideas outside of the meeting. Provide contact names, telephone numbers and addresses.

G.3.2.15 After the meeting

Try to allot a few minutes after the meeting to speak informally with people who need detailed answers to questions, or who prefer to ask questions privately.

G.3.2.16 Debriefing and following up

Review the substance of the meeting with all participating staff. Follow up on the public's questions and requests for information, as well as any commitments staff made. Share information with staff involved with the project that did not participate. Consider following up with another fact sheet or a responsiveness summary, but do not limit the mailing only to those who attended the meeting. Update the site's contact list with the names on the sign-in sheet.

G.3.3 Benefits and Limitations

- Public meetings help to ensure that important site information and proposals are provided to the affected and interested public.

- Public meetings encourage direct contact and communication between the public and project decision makers.

- Public meetings help reveal issues important to the public, or elicit feedback and comments staff want about the site, the surrounding community, or staff's site efforts and proposals.

- Public meetings usually require extensive preparation time, staff and resources. Presentations and supporting materials need to be prepared. Logistics for planning, conducting and following-up a large meeting can be comprehensive and time-consuming.

- Some staff are uncomfortable making presentations before large audiences. Training and rehearsal can help to increase staff confidence and effectiveness.

- Limited personal interaction can take place at a large public meeting. The setting often is formal and impersonal. Some people are not comfortable speaking out at public meetings, so it is possible that a broad spectrum of public opinion may go unheard.

- The positions which attendees take from their real or underlying interests may be difficult to distinguish. Often people feel compelled to take firm stands, or to posture for their constituents, peers or the media.

- When staff determine that they need to reach out to the community, they often decide to conduct a large public meeting. However, many public outreach and information objectives can be achieved more effectively through activities other than large group meetings. Availability sessions, meetings targeted to specific groups or interests, and fact sheets often are effective ways to provide information or encourage public input.

Checklist to Plan and Conduct a Public Meeting

- ❑ Determine purpose (s) and subject(s): ____________________
- ❑ Identify location for public meeting
  - ❑ Facility name & location: ____________________
  - ❑ Contact person/phone number at facility: ____________________
  - ❑ Accessibility
    - ❑ People with disabilities and
    - ❑ Adequate parking and/or
    - ❑ Convenient to public transportation
- ❑ Choose date and time of the public meeting: ____________________
- ❑ Confirm arrangements with follow up letter to facility contact person
- ❑ Identify staff to participate in public meeting
- ❑ Scope information to be presented (agenda, presentations, etc.)
- ❑ Identify/prepare support materials (handouts, slides/transparencies)
- ❑ Publicize the upcoming public meeting
  - ❑ Send fact sheet to all/part of site contact list and/or
  - ❑ Send fact sheet and/or media release to local media and/or
  - ❑ Telephone key individuals, organizations, officials and/or
  - ❑ Post notices in the community and/or
  - ❑ Announce the upcoming public meeting in another forum
- ❑ Hold staff pre-meeting to finalize content and coordination

- ❑ Conduct the public meeting
  - ❑ Bring and use signs, sign-in sheets and support materials
  - ❑ Collect/record comments and questions for program use or follow-up

- ❑ Follow up activities to the public meeting
  - ❑ Provide necessary follow-up to public questions/comments
  - ❑ Update contact list with sign-in sheets
  - ❑ Consider additional follow up

G.4 Availability Session

G.4.1 Description

An availability session is a scheduled gathering of project staff with the affected/interested public. The session is held in a casual setting, without a formal agenda or presentations. Staff generally conduct an availability session about a specific aspect of a site's remedial program, which it publicizes ahead of time. The format promotes detailed individual or small group discussion between staff and the public.

An availability session is an appropriate tool

- to provide information to, and address the concerns of, the affected community about specific aspects of a site's remedial program. For example, if remedial construction is about to begin, staff may wish to discuss with community members the general construction schedule, specific on-site activities, and the effects of remedial activity on the local community, such as road closures, truck traffic, dust and noise;
- to supplement a formal public meeting or other outreach activity by providing interested members of the public additional opportunity for individual, detailed discussions about the site's remediation;
- when larger crowds would discourage certain members of the public from engaging project staff or asking questions; or
- when staff do not have time or resources needed to plan and conduct a formal, large group public meeting.

G.4.2 Suggestions for Planning and Conducting an Availability Session

Note: A checklist that summarizes major steps to plan and conduct an availability session is on page G-24.

G.4.2.1 Determining the focus of the session

Define the focus of the availability session. What must be communicated? What questions and concerns are attendees likely to raise? Identify project staff who have information needed to prepare for the availability session. Determine which project staff should participate in the session. At a minimum, project staff should attend who have responsibility for the activity that will be the focus of the session.

Availability sessions generally require fewer project staff to participate than at a formal public meeting. At a minimum, however, at least two staff should participate at the availability session. To help determine the appropriate number of staff participants, consider the kind of information likely to be discussed, the estimated number of public attendees, and available staff resources.

G.4.2.2 Planning for the number of attendees

Depending on the number of people expected to attend, two sessions may be appropriate: one in the afternoon and one in the evening. If only one session is possible, extend the evening hours or bring additional staff. The availability session is designed to foster individual and small-group discussion. Try to ensure that attendees talk to staff with minimal waiting, and that staff will talk to small groups.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

G.4.2.3 Selecting a date, time and location

Choose a location, date and time that encourage attendance. An evening session will accommodate people who work during normal business hours. Check with the municipal clerk and school officials to be sure the session does not conflict with other meetings that could draw members of the community away.

The location should be in an easily accessible building familiar to residents, such as a library, municipal hall, school, fire hall or local meeting room. Local residents and officials can usually suggest an appropriate venue. Because an availability session generally involves a small number of people, there is more flexibility in choosing a location than for a large, formal public meeting.

The facility should be accessible to citizens with disabilities. If it is expected that most attendees will drive to the availability session, there should be adequate parking. If the availability session is being held in a large urban area, the facility should be reachable via public transportation.

Follow up on the arrangements with a letter to the facility contact person, confirming the date, time and subject of the session.

G.4.2.4 Supporting materials

Many materials may be suitable for an availability session: maps, schematic drawings, cutaway sketches, blueprints, photographs of the pertinent remedial technology, tools and instruments, documents, sampling results — even pieces of synthetic liner material or filter fabric. All can potentially be used to help answer the public's questions and to focus discussion.

It is generally appropriate to develop a fact sheet that covers the essential points of the discussion for distribution at the availability session.

G.4.2.5 Publicity

Notify the community at least two weeks before the date of the availability session. This allows interested people to clear their calendars and avoid conflicts with other events.

The session may be publicized in many ways. Examples include the following:

- send a fact sheet or session announcement to part or all of the site contact list (be sure the contact list is up-to-date). Include the agenda as well as highlights of the proposal or issues to be discussed. This is important because, even if people do not attend, they will receive information you want them to know.
- send a media release or a fact sheet to local newspapers and radio stations;
- telephone key individuals, organizations and officials;
- post notices at highly visible points in the community; and
- announce the upcoming session at another forum, such as a town council or school board meeting.

Regardless of the methods you choose, emphasize the reasons for the session, the agenda, and the importance of public participation.

When explaining the format of an availability session, emphasize how it differs from a public meeting:

- project staff will be available for a specific time period to answer questions, address concerns and discuss aspects of the site's remediation with individuals or small groups;
- there is no set agenda or formal presentations; and
- the public can drop by anytime during the availability session.

G.4.2.6 Coordinating with staff

Coordinate with participating staff before the availability session to ensure that everyone understands the topics for discussion and how the session will be conducted. Be sure that staff have developed and reviewed their support materials.

G.4.2.7 Conducting the availability session

Arrive well ahead of time in order to get ready for the meeting:

- place directional signs as needed;
- establish a place for sign-in sheets and handout materials. Be sure that people sign in as they arrive, and use the information to update the site's contact list; and
- set up all supporting materials.

Try to greet people as they arrive, and introduce staff participants. A few pleasant words of greeting can help to set at ease those who may be uncomfortable in a public forum. Establish a climate that enables constructive communication.

Connect people with particular questions or comments and staff with the appropriate expertise. Note comments and questions that require follow-up by project staff.

G.4.2.8 Debriefing and following up

Review the substance of the session with all participating staff. Follow up on the public's questions and requests for information, as well as any commitments staff made. Share information with staff involved with the project that did not participate. Consider following up with another fact sheet or a responsiveness summary, but do not limit the mailing only to those who attended the session. Update the site's contact list with the names on the sign-in sheet.

G.4.3 Benefits and Limitations

- A face-to-face discussion is perhaps the most efficacious form of public outreach. It encourages an exchange of information with people directly affected by site contamination, investigation activities, or remediation. The individual and small-group dialogue can help build mutual credibility between the affected community and project staff —credibility that is more difficult to achieve in other settings.

- Availability sessions stretch limited program resources. They do not require prepared presentations and are significantly faster, easier and less resource-intensive to plan and conduct than formal public meetings.

- Quicker and easier planning and implementation create flexibility to conduct an availability session in locations and for reasons that other public outreach activities could not accommodate.

- An availability session often attracts a small audience, but attendees usually bring intense rather than casual interest in a site's remediation. This heightened interest and modest attendance actually enhances direct dialogue between the public and project staff.

- When held within a day or two of a formal public meeting, an availability session can offer the public an additional forum to interact with project staff. As a result, people attending the formal public meeting may not feel pressed to compete for limited opportunities for input in a forum that must accommodate formal presentations, a large audience, and many levels of interest and understanding.

- An availability session encourages those who might be intimidated or uncomfortable in a large group setting to talk to project staff in a more intimate setting.

- After the availability session, follow-up activities may require widely varying amounts of time and resources.

- Some community members may express suspicion that availability sessions are designed to divide and conquer the affected public, and prevent the community from demonstrating unity and resolve. In such circumstances consider using the availability session to supplement other outreach activities that promote interaction with the affected community.

NOTE: Updates to this final guidance are available at http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

Checklist to Plan and Conduct an Availability Session

- ❑ Determine purpose (s) and subject(s): ____________________
- ❑ Identify location for availability session
  - ❑ Facility name & location: ____________________
  - ❑ Contact person/phone number at facility: ____________________
  - ❑ Accessibility
    - ❑ People with disabilities and
    - ❑ Adequate parking and/or
    - ❑ Convenient to public transportation
- ❑ Choose date and time of the availability session: ____________________
- ❑ Confirm arrangements with follow up letter to facility contact person
- ❑ Identify staff to participate in public meeting
- ❑ Review information to be discussed with the public
- ❑ Identify/prepare support materials (maps, blueprints, handouts, etc.)
- ❑ Publicize the upcoming public meeting
  - ❑ Send fact sheet to all/part of site contact list and/or
  - ❑ Send fact sheet and/or media release to local media and/or
  - ❑ Telephone key individuals, organizations, officials and/or
  - ❑ Post notices in the community and/or
  - ❑ Announce the upcoming public meeting in another forum
- ❑ Conduct the availability session
  - ❑ Bring and use signs, sign-in sheets and support materials
  - ❑ Record comments and questions for program use or follow-up
- ❑ Follow up activities to the availability session
  - ❑ Provide necessary follow-up to public questions/comments
  - ❑ Update contact list with sign-in sheets
  - ❑ Consider additional follow up

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

G.5 Toll-free "800" Numbers

G.5.1 Description

Toll-free information numbers are a convenient means for people with questions, comments or concerns about a hazardous waste site to obtain information, particularly those who cannot or will not participate in other outreach activities. In addition to building credibility with the public, toll-free numbers can address minor problems and concerns before they escalate into larger ones that demand greater expenditures of time and resources.

G.5.2 Suggestions for Using Toll-free "800" Numbers

G.5.2.1 Publicizing "800" numbers

Use fact sheets, media releases, public meetings, availability sessions, letters and other public contact information to announce the project's toll-free number(s). Encourage interested people to use the toll-free number(s) to contact project staff with questions or concerns at any time during the remedial process.

Publicize the NYSDEC (for central office-lead sites) and NYSDOH toll-free numbers for site-related and health-related questions, concerns and comments:

NYSDEC Division of Environmental Remediation Toll-free Information Line 1-800-342-9296	**NYSDOH** Bureau of Environmental Exposure Investigation Toll-free Information Line 1-800-458-1158, ext. 27850

NOTE: "800" numbers are typically information lines — not a "hotline" — because weeknight and weekend callers may not receive immediate responses. Avoid public misunderstanding: identify the number as an "information-only" line when it is publicized.

G.5.2.2 Managing toll-free number(s)

Whenever the "800" numbers are publicized in a fact sheet, meeting announcement or newsletter, be sure that a copy of the material has been provided to staff managing to "800" numbers. This helps to prevent staff from being blindsided: with the publicity material site in hand, they can often answer calls directly, or immediately know to which staff members to forward calls.

G.5.2.3 Following up

It may be appropriate to follow up a toll-free call by sending a letter or other written material to satisfy a caller's more detailed questions.

G.5.2.4 Involving project staff

To provide a complete answer to a caller's questions or information requests, all appropriate staff should be involved in reviewing the response.

G.5.2.5 Sharing information

As appropriate, be sure to share with other staff involved with the site the questions and concerns being received from the toll-free number(s). This information may assist other staff as they communicate with the public about the site.

G.5.3 Benefits and Limitations

- Can be an effective way to interact with many people to gather comments and answer questions.

- Helps to build and maintain credibility by improving public access to project staff and information.

- Timely response to calls is important. Delayed or inadequate response can damage credibility and increase public frustration or cynicism.

- Despite all the best efforts, some people may believe the toll-free information number is a "hotline" and may expect immediate response.

- The NYSDEC toll-free number can only be called from within New York State, so care should be used when publicizing it at a site that may border an adjacent state or Canada.

G.6 Door-to-door Visits

G.6.1 Description

Door-to-door visits involve gathering or distributing site information by meeting individuals at their residences or businesses. Project staff visit residents near a site to provide information, answer questions or obtain permissions for activities on private properties.

Door-to-door visits may be appropriate when

- on-site investigation or remediation activity is imminent, and there is not enough time for mailings or public meetings (for example, an impending emergency removal action or a time-sensitive interim remedial measure);
- there is a need to reach a particular group of people for a particular purpose, such as obtaining signatures to allow access to properties near the site;
- public concern about site contamination or other site-related issues is extremely high; and
- personal contact could effectively supplement other outreach efforts.

G.6.2 Suggestions for Conducting Door-to-door Visits

Door-to-door visits require specialized techniques applied within well-defined circumstances, such as those listed above. When planned and conducted properly, visits can be extremely effective in reaching their designated audience.

G.6.2.1 Preparation

Identify as specifically as possible the information that needs to be provided or gathered. What site issues or activities are driving these needs? Establish the time-frame for the visits, especially when there is a deadline. Be sure that door-to-door visits are the appropriate method of outreach.

G.6.2.2 Identifying the area and audience

Determine the residences and businesses that need to be visited (this is influenced largely by the site issues or activities and whom they affect). Be sure that there are sufficient staff and resources to cover the designated area.

G.6.2.3 Planning with project staff

Defining the information that needs to be provided or gathered will indicate which remedial, health or consultant staff should participate in the door-to-door visits. If these staff are unavailable, they should still help plan the visits and brief other staff with answers to anticipated questions.

Be sure all participating staff clearly understand the information to be discussed with the public, so that they provide consistent, accurate information throughout the area to be visited.

G.6.2.4 Reviewing the message

The information provided or gathered during door-to-door visits should be

- specific — pertinent to a particular issue or activity of the site;
- timely —involving a situation or activity soon to occur or which has already begun; and
- clear — staff should know what is needed from the residents, while residents should understand what staff need to tell them.

G.6.2.5 Written summaries

Develop a written summary (essentially a short fact sheet) that encapsulates the information to be provided or requested during the door-to-door visits. Distribute this summary to the occupants, even when no one is present.

Be sure the written material meets the standards of specificity, timeliness, and clarity, and lists ways for residents to contact staff with questions or comments.

G.6.2.6 Conducting the visits

Allow sufficient time to cover the designated area and to account for lengthy discussions that may occur. Staff should always

- wear or carry identification;
- tell residents why they are conducting the visits;
- present and request information consistently at all addresses called upon;
- distribute the written summary at all addresses visited;
- note all information provided by residents;
- note areas covered; and
- note names and addresses of people who have requested additional information.

Based on the particulars of the site and the area being visited, it may be advisable for staff to pair up when conducting visits. This will help to ensure that staff with varied expertise are available to answer a range of questions.

G.6.2.7 Following up

Staff participants should meet after the visits to discuss their experiences and compare notes. Be sure to respond promptly to requests for information that was not provided during the visits. Consider sending a follow-up letter or fact sheet to all residents in the designated area.

G.6.3 Benefits and Limitations

- Project staff can meet directly with the people that they need to communicate with about specific issues or activities.

- Door-to-door visits help to distribute information quickly, when time is of the essence and when other activities such as mailing cannot accomplish the task during the identified time frame.

- Door-to-door visits demonstrate a commitment to the community when other, less direct outreach seems insufficient to deal with community concerns effectively.

- Despite best intentions, door-to-door visits can foster unfavorable cliches (e.g., "We're from the government and we're here to help.")

- Door-to-door visits can be time-consuming. In addition, some project staff may not be comfortable with the technique or have appropriate training to conduct the activity effectively. As a result, the technique should be used only if other outreach cannot be used or will likely be ineffectual.

- If there are concerns for the safety and security of staff, even more resources may be required to conduct visits than usual.

G.7 Document Repository

G.7.1 Description

A document repository is a collection of documents and other information developed during the investigation and remediation of a waste site. It is located in a convenient public facility, such as a library, so that interested members of the public can easily access and review important information about the site and the site's remedial program. A repository is maintained through the site's operation and maintenance phase, or until its release from the applicable remedial program.

A site document repository is helps the public review

- documents about which the state is seeking public comment;
- studies, reports and other information;
- complete versions of documents summarized in fact sheets, meeting presentations or media releases (summaries should note the location(s) of a local repository where the complete documents are available).

G.7.2 Suggestions for Establishing a Document Repository

The appropriate regional NYSDEC office often generates or receives documents developed during a site's investigation and remediation. However, most people don't live near a regional office. The selection of a local repository becomes very important.

G.7.2.1 Determining the location

The repository should be located near the site and the affected and interested community. Residents, municipal clerks, local officials and school officials can to help identify a suitable location.

If possible, a location should be selected to can accommodate people who work during normal business hours. In addition, the availability of public transportation in locations where parking or automobile travel is inconvenient should be considered. Access for disabled people and the availability of photocopying should be determined.

A local public library usually is a suitable location. Alternatives include municipal offices, public health offices and schools.

G.7.2.2 Contact the potential repository

Be sure to contact the potential repository *before* sending documents. Most librarians and municipal clerks are more than willing to help make documents available to the public. They don't appreciate receiving a box full of reports with an explanatory letter out of the blue.

When calling a library, the reference librarian is a good first contact. Explain that you would like to have site program documents maintained in an accessible spot for public review and copying. Because space may be limited, the librarian may ask for an estimate of the total volume of documents you will be sending over a given time.

Follow up the conversation with a courtesy letter confirming the agreed-upon terms and conditions for the repository. Be sure to restate your understanding of who the repository contact person will be and where the documents will be maintained.

G.7.2.3 Depositing documents and other information

Send studies, reports, information sheets and other suitable materials to the repository. Consider providing several copies of documents that are likely to be of great interest to the public.

G.7.2.4 Accommodating the repository host

When sending a document to the repository, transmit it with a cover letter that describes what the document is, why it was produced and which briefly summarizes its contents. This will help the host maintain an ordered file and will help the public locate documents of interest. For documents about which the state is seeking public comment, provide information about how the public is to comment, such as the length of the comment period, and where to send comments.

G.7.2.5 Publicizing the repository and its contents

It is important to remind the public about the repository as often as possible. Take advantage of the public contact tools you use during the public outreach program. Use fact sheets, media releases, public meetings, availability sessions, door-to-door visits, letters and telephone calls to tell people about the repository, its contents, and why public review is important. Provide the repository's location, days and hours of operation and the repository contact person.

G.7.2.6 Special consideration for time-sensitive documents

Some documents are placed in a repository for public review during a prescribed comment period. Be sure that documents for public comment are in the repository when the comment period starts. This affords the public maximum opportunity for review and comment.

G.7.2.7 Updating the repository

Send materials as soon as possible after they are developed. Remove/replace outdated materials. Provide finalized and revised versions of documents.

G.7.2.8 Consider providing additional copies of documents

As mentioned earlier, consider sending additional copies of documents to a repository when sustained public interest is anticipated. In addition, consider providing copies of appropriate documents to local officials, involved organizations and others who have demonstrated a keen interest in the site and its remedial program.

G.7.3 Benefits and Limitations

- A repository makes detailed, timely information available to residents, officials and others in the community affected by or interested in the site and the remedial program. In particular, the repository serves community members interested in additional details beyond summaries provided in fact sheets and public meeting presentations.
- A repository should be maintained to ensure timely availability of current information. It should be checked occasionally to ensure that materials are available.
- Even when a local repository is established to improve access to project information, most people do not read complete documents.
- A repository supports — but cannot substitute for — two-way communication between project staff and the community.

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

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Appendix H

NYSDOH fact sheets related to soil vapor intrusion

As introduced in Section 5, fact sheets are often used to share information with the public in a variety of ways: mailed to all or part of the site's contact list, distributed at a public meeting or availability session, placed in document repositories, provided to residents during door-to-door visits, and/or included in letters transmitting sampling results.

Copies of the following fact sheets, which are commonly used to supplement discussions related to soil vapor intrusion, are provided in this appendix:

What is exposure? Information Sheet

- describes how a person may come into contact with chemicals in the environment

Soil Vapor Intrusion: Frequently Asked Questions Sheet

- describes the process referred to as "soil vapor intrusion"

PCE Fact Sheet

- provides information on tetrachloroethene (PCE) and the NYSDOH guideline for PCE in air

TCE Fact Sheet

- provides information on trichloroethene (TCE) and the NYSDOH guideline for TCE in air

Radon: Frequently Asked Questions Sheet

- provides information on this gas, commonly found in many areas of New York State, that may also migrate into buildings from the subsurface

NOTE: Updates to this final guidance are available at
http://health.ny.gov/environmental/indoors/vapor_intrusion/update.htm

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New York State Department of Health

What is Exposure?

Exposure is contact. No matter how dangerous a substance or activity, without exposure, it cannot harm you.

Information Sheet

Amount of exposure:

Over 400 years ago, a scientist said "...nothing [is] without poisonous qualities. It is only the dose that makes a thing poison." The **dose** is the amount of a substance that enters or contacts a person. An important factor to consider in evaluating a dose is body weight. If a child is exposed to the same amount of chemical as an adult, the child (who weighs less) can be affected more than the adult. For example, children are given smaller amounts of aspirin than adults because an adult dose is too large for a child's body weight.

The greater the amount of a substance a person is exposed to, the more likely that health effects will occur. Large amounts of a relatively harmless substance can be toxic. For example, two aspirin tablets can help to relieve a headache, but taking an entire bottle of aspirin can cause stomach pain, nausea, vomiting, headache, convulsions or death.

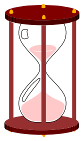
Routes of exposure:

There are three major means by which a toxic substance can come into contact with or enter the body. These are called routes of exposure.

Inhalation (breathing) of gases, vapors, dusts or mists is a common route of exposure. Chemicals can enter and irritate the nose, air passages and lungs. They can become deposited in the airways or be absorbed through the lungs into the bloodstream. The blood can then carry these substances to the rest of the body.

Direct contact (touching) with the skin or eyes is also a route of exposure. Some substances are absorbed through the skin and enter the bloodstream. Broken, cut or cracked skin will allow substances to enter the body more easily.

Ingestion (swallowing) of food, drink, or other substances is another route of exposure. Chemicals that get in or on food, cigarettes, utensils or hands can be swallowed. Children are at greater risk of ingesting substances found in dust or soil because they often put their fingers or other objects in their mouths. Lead in paint chips is a good example. Substances can be absorbed into the blood and then transported to the rest of the body.
The route of exposure can determine whether or not the toxic substance has an effect. For example, breathing or swallowing lead can result in health effects, but touching lead is not usually harmful because lead is not absorbed particularly well through the skin.



Length of exposure:

Short-term exposure is called **acute exposure**. Long-term exposure is called **chronic exposure**. Either may cause health effects that are immediate or health effects that occur days or years later.

Acute exposure is a short contact with a chemical. It may last a few seconds or a few hours. For example, it might take a few minutes to clean windows with ammonia, use nail polish remover or spray a can of paint. The fumes someone might inhale during these activities are examples of acute exposures.

Chronic exposure is continuous or repeated contact with a toxic substance over a long period of time (months or years). If a chemical is used every day on the job, the exposure would be chronic. Over time, some chemicals, such as PCBs and lead, can build up in the body and cause long-term health effects.

Chronic exposures can also occur at home. Some chemicals in household furniture, carpeting or cleaners can be sources of chronic exposure.

Sensitivity:

All people are not equally **sensitive** to chemicals, and are not affected by them in the same way. There are many reasons for this.

- People's bodies vary in their ability to absorb and break down or eliminate certain chemicals due to **genetic differences.**

- People may become **allergic** to a chemical after being exposed. Then they may react to very low levels of the chemical and have different or more serious health effects than nonallergic people exposed to the same amount. People who are allergic to bee venom, for example, have a more serious reaction to a bee sting than people who are not.

- Factors such as **age, illness, diet, alcohol use, pregnancy and medical or nonmedical drug use** can also affect a person's sensitivity to a chemical. Young children are often more sensitive to chemicals for a number of reasons. Their bodies are still developing and they cannot get rid of some chemicals as well as adults. Also, children absorb greater amounts of some chemicals (such as lead) into their blood than adults.

For more information:

New York State Department of Health
Center for Environmental Health
Flanigan Square
547 River Street, Room 316
Troy, NY 12180-2218
1-800-458-1158 (ext. 2-7530)

March 2001

NEW YORK STATE
DEPARTMENT OF HEALTH

SOIL VAPOR INTRUSION

Frequently Asked Questions

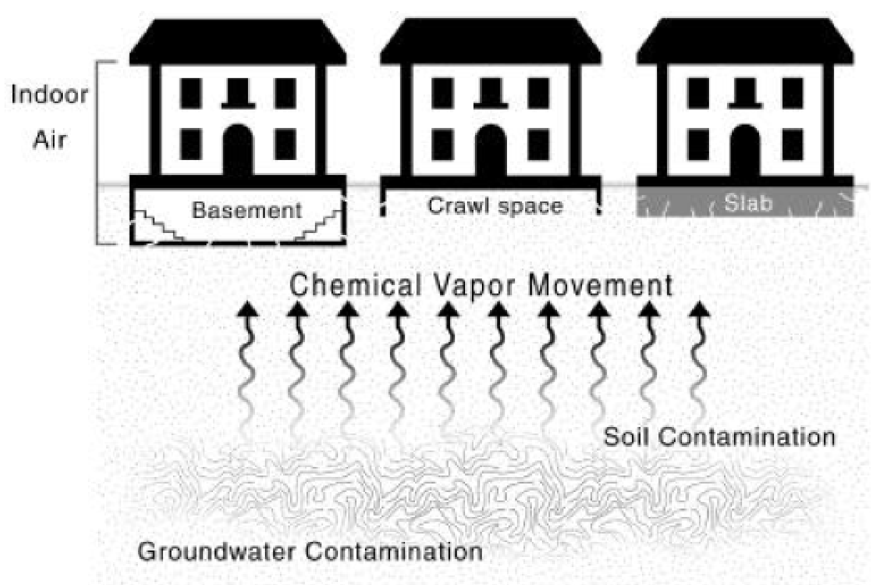
What is soil vapor intrusion?

The phrase "soil vapor intrusion" refers to the process by which volatile chemicals move from a subsurface source into the indoor air of overlying buildings.

Soil vapor, or soil gas, is the air found in the pore spaces between soil particles. Because of a difference in pressure, soil vapor enters buildings through cracks in slabs or basement floors and walls, and through openings around sump pumps or where pipes and electrical wires go through the foundation. Heating, ventilation or air-conditioning systems may create a negative pressure that can draw soil vapor into the building. This intrusion is similar to how radon gas seeps into buildings.

Soil vapor can become contaminated when chemicals evaporate from subsurface sources and enter the soil vapor. Chemicals that readily evaporate are called "volatile chemicals." Volatile chemicals include volatile organic compounds (VOCs). Subsurface sources of volatile chemicals may include contaminated soil and groundwater, or buried wastes. If soil vapor is contaminated, and enters a building as described above, indoor air quality may be affected.

When contaminated vapors are present in the zone directly next to or under the foundation of the building, vapor intrusion is possible. Soil vapor can enter a building whether it is old or new, or whether it has a basement, a crawl space, or is on a slab (as illustrated in the figure).



[Source: United States Environmental Protection Agency, Region 3]

How am I exposed to chemicals through soil vapor intrusion?

Humans can be exposed to soil vapor contaminated with volatile chemicals when vapors from beneath a building are drawn through cracks and openings in the foundation and mix with the indoor air. Inhalation is the route of exposure, or the manner in which the volatile chemicals actually enter the body, once in the indoor air.

Current exposures are when vapor intrusion is documented in an occupied building. *Potential* exposures are when volatile chemicals are present, or are accumulating, in the vapor phase beneath a building, but have not affected indoor air quality. Potential exposures also exist when there is a chance that contaminated soil vapors may move to existing buildings not currently affected or when there is a chance that new buildings can be built over existing subsurface vapor contamination. Both current and potential exposures are considered when evaluating soil vapor intrusion at a site that has documented subsurface sources of volatile chemicals.

In general, exposure to a volatile chemical does not necessarily mean that health effects will occur. Whether or not a person experiences health effects depends on several factors, including inhalation exposure, the length of exposure (short-term or acute versus long-term or chronic), the frequency of exposure, the toxicity of the volatile chemical, and the individual's sensitivity to the chemical.

What types of chemicals associated with environmental contamination may be entering my home via soil vapor intrusion?

Volatile organic compounds, or VOCs, are the most likely group of chemicals found in soil vapor, and which can move through the soil and enter buildings. Solvents used for dry cleaning, degreasing and other industrial purposes (e.g., tetrachloroethene, trichloroethene, 1,1,1-trichloroethane and Freon 113) are examples of VOCs. Examples of petroleum-related VOCs from petroleum spills are benzene, toluene, ethyl benzene, xylenes, styrene, hexane and trimethylbenzenes.

Is contaminated soil vapor the only source of volatile chemicals in my indoor air?

No. Volatile chemicals are also found in many household products. Paints, paint strippers and thinners, mineral spirits, glues, solvents, cigarette smoke, aerosol sprays, mothballs, air fresheners, new carpeting or furniture, hobby supplies, lubricants, stored fuels, refrigerants and recently dry-cleaned clothing all contain VOCs. Household products are often more of a source of VOCs in indoor air in homes than contaminated soil vapor.

Indoor air may also become affected when outdoor air containing volatile chemicals enters your home. Volatile chemicals are present in outdoor air due to their widespread use. Gasoline stations, dry cleaners, and other commercial/industrial facilities are important sources of VOCs to outdoor air.

What should I expect if soil vapor intrusion is a concern near my home?

If you live near a site that has documented soil, groundwater and/or soil vapor contaminated with volatile chemicals, you should expect that the potential for vapor intrusion is being, or has been, investigated. You may be contacted by the site owner or others working on the cleanup with information about the project. Your cooperation and consent would be requested before any testing/sampling would be done on your property. You may ask the person contacting you any questions about the work being done. You can also contact the NYSDOH's project manager for the site at 1-800-458-1158 (extension 2-7850) for additional information.

How is soil vapor intrusion investigated at sites contaminated with volatile chemicals?

The process of investigating soil vapor intrusion typically requires more than one set of samples to determine the extent of vapor contamination. Furthermore, four types of environmental samples are collected: soil vapor samples, sub-slab vapor samples, indoor air samples and outdoor air (sometimes referred to as "ambient air") samples.

<u>Soil vapor samples</u> are collected to characterize the nature and extent of vapor contamination in the soil in a given area. They are often collected before sub-slab vapor and/or indoor air samples to help identify buildings or groups of buildings that need to be sampled. Soil vapor samples are used to determine the *potential* for human exposures. *Soil vapor* samples are not the same as *soil* samples.

<u>Sub-slab vapor samples</u> are collected to characterize the nature and extent of vapor contamination in the soil immediately beneath a building with basement foundations or a slab. Sub-slab vapor results are used to determine the potential for *current* and *future* human exposures. For example, an exposure could occur in the future if cracks develop in the building's foundation or changes in the operation of the building's heating, ventilation or air-conditioning system are made that make the movement of contaminated soil vapor into the building possible.

<u>Indoor air samples</u> are collected to characterize the nature and extent of air contamination within a building. Indoor air sample results help to evaluate whether there are *current* human exposures. They are also compared to sub-slab vapor and outdoor air results to help determine where volatile chemicals may be coming from (indoor sources, outdoor sources, and/or beneath the building).

<u>Outdoor air samples</u> are collected to characterize site-specific background air conditions. Outdoor air results are used to evaluate the extent to which outdoor sources, such as automobiles, lawn mowers, oil storage tanks, gasoline stations, commercial/industrial facilities, and so forth, may be affecting indoor air quality.

What should I expect if indoor air samples are collected in my home?

You should expect the following:

- Indoor air samples are generally collected from the lowest-level space in a building, typically a basement, during the heating season. Indoor air samples may also be collected from the first floor of living space. Indoor air is believed to represent the greatest exposure potential with respect to soil vapor intrusion.
- Sub-slab vapor and outdoor air samples are usually collected at the same time as indoor air samples to help determine where volatile chemicals may be coming from (indoor sources, outdoor sources, and/or beneath the building).
- More limited sampling may be performed outside of the heating season. For example, sub-slab vapor samples without indoor air or outdoor air samples may be collected to identify buildings and areas where comprehensive sampling is needed during the heating season.
- An indoor air quality questionnaire and building inventory will be completed. The questionnaire includes a summary of the building's construction characteristics; the building's heating, ventilation and air-conditioning system operations; and potential indoor and outdoor sources of volatile chemicals. The building inventory describes products present in the building that might contain volatile chemicals. In addition, we take monitoring readings from a real-time organic vapor meter (also known as a photoionization detector or PID). The PID is an instrument that detects many VOCs in the air. When indoor air samples are collected, the PID is used to help determine whether

products containing VOCs might be contributing to levels that are detected in the indoor air.

What happens if soil vapor contamination or soil vapor intrusion is identified during investigation of a site?

Depending on the investigation results, additional sampling, monitoring or mitigation actions may be recommended. Additional sampling may be performed to determine the extent of soil vapor contamination and to verify questionable results. Monitoring (sampling on a recurring basis) is typically conducted if there is a significant potential for vapor intrusion to occur should building conditions change. Mitigation steps are taken to minimize exposures associated with soil vapor intrusion. Mitigation may include sealing cracks in the building's foundation, adjusting the building's heating, ventilation and air-conditioning system to maintain a positive pressure to prevent infiltration of subsurface vapors, or installing a sub-slab depressurization system beneath the building.

What is a sub-slab depressurization system?

A sub-slab depressurization system, much like a radon mitigation system, essentially prevents vapors beneath a slab from entering a building. A low amount of suction is applied below the foundation of the building and the vapors are vented to the outside (see illustration). The system uses minimal electricity and should not noticeably affect heating and cooling efficiency. This mitigation system also essentially prevents radon from entering a building, an added health benefit. The party responsible for cleaning up the source of the soil vapor contamination is usually responsible for paying for the installation of this system. If no responsible party is available, New York State will install the system. Once the contamination is cleaned up, the system should no longer be needed. In areas where radon is a problem, the NYSDOH recommends that these systems remain in place permanently.

What else can I do to improve my indoor air quality?

Household products and other factors, such as mold growth, carbon monoxide, and radon, can degrade the quality of air in your home. Consider the following tips to improve indoor air quality:

- Be aware of household products that contain VOCs. Do not buy more chemicals than you need at a time.
- Store unused chemicals in tightly-sealed containers in a well-ventilated location, preferably away from the living space in your home.
- Keep your home properly ventilated. Keeping it too air-tight may promote build up of chemicals in the air, as well as mold growth due to the build up of moisture.
- Fix all leaks promptly, as well as other moisture problems that encourage mold growth.
- Make sure your heating system, hot water, dryer and fireplaces are properly vented and in good condition. Have your furnace or boiler checked annually by a professional.
- Test your home for radon; take actions to reduce radon levels if needed.
- Install carbon monoxide detectors in your home; take immediate actions to reduce carbon monoxide levels if needed.

Where can I get more information?

For additional information about soil vapor intrusion, contact the NYSDOH's Bureau of Environmental Exposure Investigation at 1-800-458-1158 (extension 2-7850).

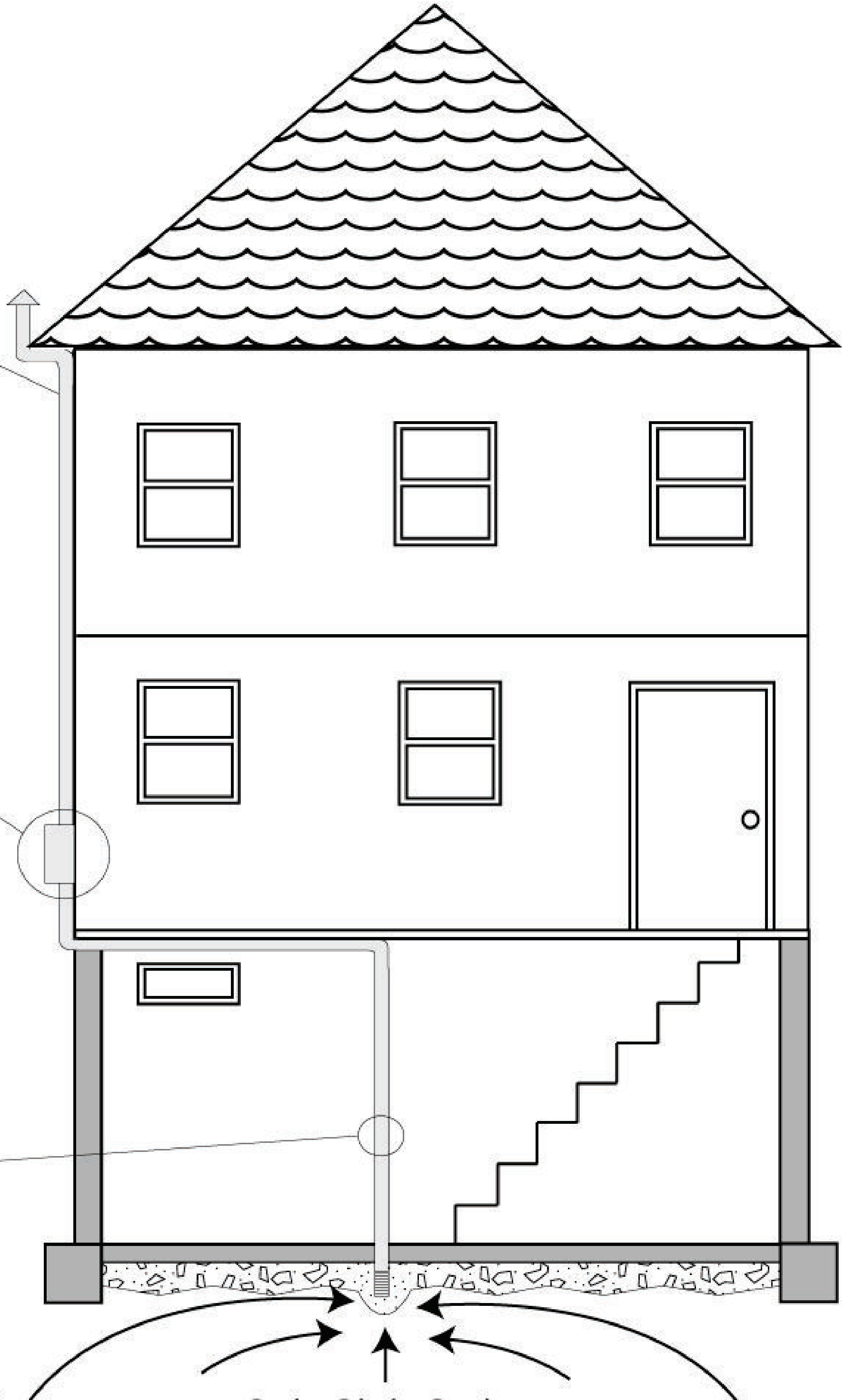
Sub-Slab Depressurization System

(commonly called a radon mitigation system)

The vent pipe is routed up the side of the structure to a location above the roof line.

A fan is used to draw soil vapor from beneath the slab.

A liquid gauge, or manometer is used to verify that the system is operating properly



A sub-slab depressurization system vents contaminated soil vapor before it enters a structure. The fan draws vapor from beneath the building outside to the roof line where it is released to the outside air.

FACT SHEET

TETRACHLOROETHENE (PERC) IN INDOOR AND OUTDOOR AIR

MAY, 2003

This fact sheet answers a few questions about a chemical called tetrachloroethene (PERC), which is widely used to dry-clean clothes. It provides information on health effects seen in humans and animals exposed to PERC in air. It also provides information about the New York State Department of Health (NYSDOH) guideline of 100 micrograms of PERC per cubic meter of air (100 mcg/m^3) or 0.1 milligrams of PERC per cubic meter of air (0.1 mg/m^3). The fact sheet focuses on the health risks from air exposures because most of the PERC released into the environment goes into air.

Prepared by

New York State Department of Health

1. WHAT IS TETRACHLOROETHENE (PERC)?

Tetrachloroethene is a manufactured chemical that is widely used in the dry-cleaning of fabrics, including clothes. It is also used for degreasing metal parts and in manufacturing other chemicals. Tetrachloroethene is found in consumer products, including some paint and spot removers, water repellents, brake and wood cleaners, glues, and suede protectors. Other names for tetrachloroethene include PERC, tetrachloroethylene, perchloroethylene, and PCE. PERC is a commonly used name and will be used in the rest of the fact sheet.

PERC is a nonflammable, colorless liquid at room temperature. It readily evaporates into air and has an ether-like odor. Because most people stop noticing the odor of PERC in air after a short time, odor is not a reliable warning signal of PERC exposure.

2. HOW CAN I BE EXPOSED TO PERC?

People are exposed to PERC in air, water, and food. Exposure can also occur when PERC or material containing PERC (for example, soil) gets on the skin. For most people, almost all exposure is from PERC in air.

PERC gets into outdoor and indoor air by evaporation from industrial or dry-cleaning operations and from areas where chemical wastes are stored or disposed. Groundwater near these areas may become contaminated if PERC is improperly dumped or leaks into the ground. People may be exposed if they drink the contaminated water. They may also be exposed if PERC evaporates from contaminated drinking water into indoor air during cooking and washing. PERC may evaporate from contaminated groundwater and soil and into the indoor air of buildings above the contaminated area. PERC also may evaporate from dry-cleaned clothes and into indoor air or may get into indoor air after PERC-products, such as spot removers, are used. Indoor air PERC levels may get high if PERC-products are used in poorly ventilated areas.

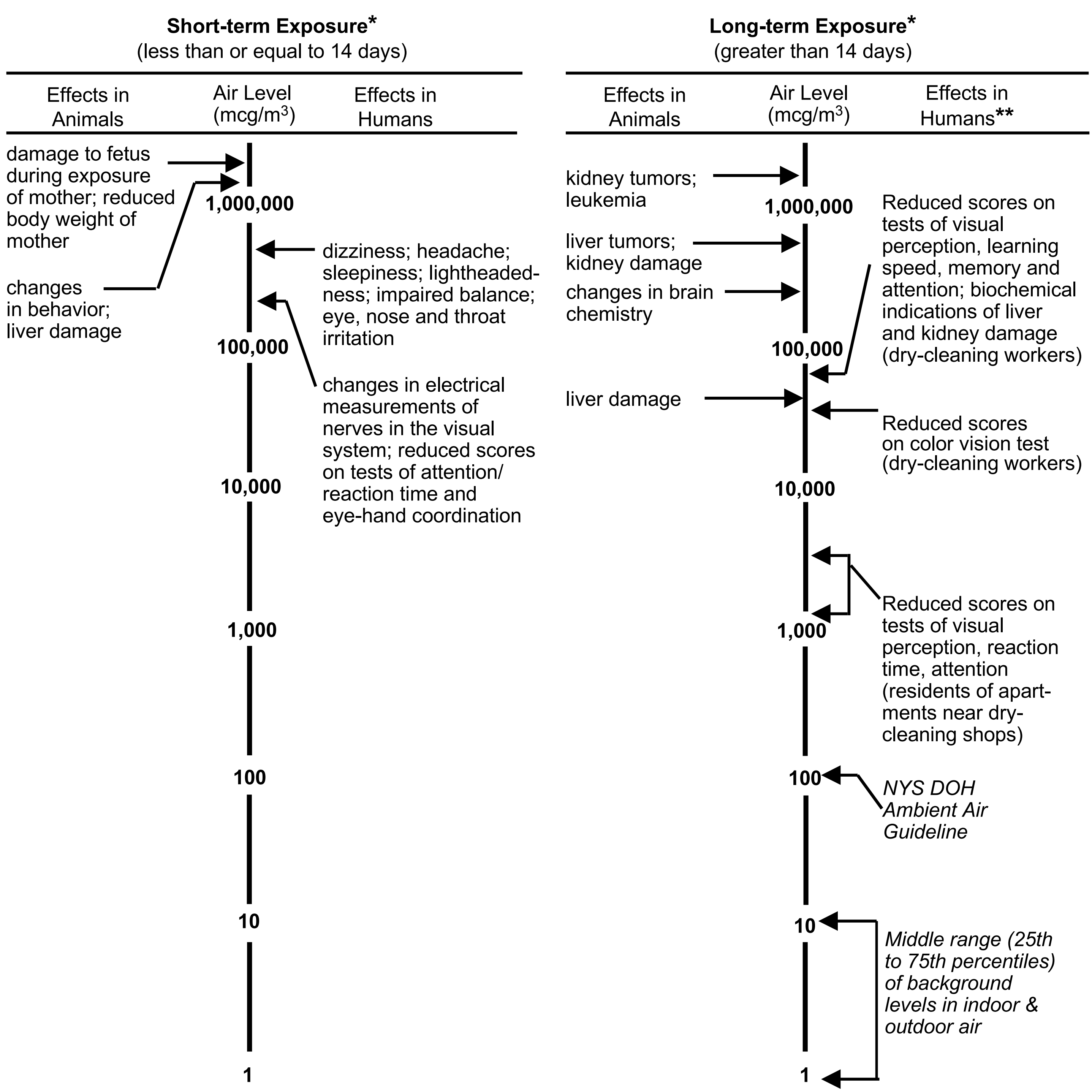
3. HOW DOES PERC ENTER AND LEAVE MY BODY?

When people breathe air containing PERC, the PERC is taken into the body through the lungs and passed into the blood, which carries it to all parts of the body. A large fraction of this PERC is breathed out, unchanged, through the lungs into the air. Some of this PERC is stored in the body (for example, in fat, liver, and brain) and some is broken down in the liver to other compounds and eliminated in urine. PERC can also be found in breastmilk. Once exposure stops, most of the PERC and its breakdown products leave the body in several days. However, it may take several weeks for all of the PERC and its breakdown products to leave the body.

4. WHAT KINDS OF HEALTH EFFECTS CAN BE CAUSED BY EXPOSURE TO PERC IN AIR?

In humans and animals, the major effects of PERC exposure are on the central nervous system, kidney, liver, and possibly the reproductive system. These effects vary with the level and length of exposure. Figure 1 shows the types of health effects seen in humans and animals and the lowest levels of PERC in air at which the effects were seen. The diagram on the right side of the figure shows the effects of long-term exposures in humans and animals whereas the diagram on the left side shows the same information for short-term exposures. Because there is a

Figure 1. Health Effects from Breathing Tetrachloroethene (PERC). The diagram shows the effects observed in humans and animals exposed to measured levels of PERC in air. The diagram contains information on the effects observed after short-term and long-term exposure. Also shown are background levels in indoor and outdoor air.



*Effects are listed at the lowest level (micrograms per cubic meter of air, mcg/m^3) at which they were first observed. They and other effects may also be seen at higher levels. 100 mcg/m^3 = 0.1 mg/m^3 (milligrams per cubic meter of air) = 15 ppb (parts per billion) = 0.015 ppm (parts per million).

**Studies have shown that workplace exposure to PERC is associated with an increased risk of cancer and spontaneous abortion, but studies did not provide good quantitative data on exposure levels.

large amount of information on the human effects of PERC, the rest of the fact sheet will discuss only the human data.

The human effects shown in Figure 1 represent the average response of a group of individuals at an estimated level of exposure (typically, the average of the measured air levels). Because data for individual people are not usually reported, some people (those sensitive to the effects of PERC) may have experienced effects at air levels below the average air level, whereas other people (those resistant to the effects of PERC) may not have experienced effects at air levels above the average air level. The difference in how people respond to the same or similar exposure levels is due, in part, to the individual differences among people. People, for example, differ in age, sex, diet, family traits, lifestyle, genetic background, the presence of other chemicals in their body (e.g., alcohol, prescription drugs), and state of health. These differences can affect how people will respond to a given exposure. One person may feel fine during and after an exposure while another person may become sick. This is known as sensitivity. Differences in sensitivity should be kept in mind when reading the following information on the human health effects of PERC.

Short-Term Exposure - Studies with volunteers show that exposures of 8-hours or less to 700,000 micrograms per cubic meter of air (mcg/m^3) cause central nervous system symptoms such as dizziness, headache, sleepiness, lightheadedness, and poor balance (Figure 1). Exposures to 350,000 mcg/m^3 for 4 hours affected the nerves of the visual system and reduced scores on certain behavioral tests (which, for example, measure the speed and accuracy of a person's response to something they see on a computer screen). These effects were mild and disappeared soon after exposure ended.

Long-Term Exposure – Numerous studies of dry-cleaning workers indicate that long-term exposure (9 to 20 years, for example) to workplace air levels averaging about 50,000 mcg/m^3 to 80,000 mcg/m^3 reduces scores on behavioral tests and causes biochemical changes in blood and urine (Figure 1). The effects were mild and hard to detect. How long these effects would last if exposure ended is not known.

One study reported reduced scores on behavioral tests in 14 healthy adults living (for 10.6 years, on average) in apartments near dry-cleaning shops. The effects were small; the average test scores of the residents were slightly lower than the average score of unexposed people. The range of measured air levels in 13 apartments was 7.6 mcg/m^3 to 23,000 mcg/m^3; one air level was below 100 mcg/m^3, five values were between 100 and 1,000 mcg/m^3, and seven values were above 1,000 mcg/m^3. The average air level in all apartments was 5,000 mcg/m^3 and the median value was about 1,400 mcg/m^3 (that is, half the measured air levels were above 1,400 mcg/m^3 and half were below it). As with the long-term occupational studies, how long these effects would last if exposure ended is not known. Confidence in the understanding of exposure in this study is less than that in the occupational studies.

Some studies show a slightly increased risk of some types of cancer and reproductive effects among workers, including dry-cleaning workers, exposed to PERC and other chemicals. Cancers associated with exposures include cancers of the esophagus, bladder, and non-Hodgkin's lymphoma. Cancers less clearly associated with exposures include cancers of the cervix, tongue, and lung. The reproductive effects associated with exposure included increased risks of spontaneous abortion, menstrual and sperm disorders, and reduced fertility. The data suggest, but do not prove, that the effects were caused by PERC and not by some other factor or factors.

Data on the workplace air levels in these studies ranged from none (reproductive studies) to some (cancer studies); however, workplace air levels during the times these studies were conducted were considerably higher than those found in indoor or outdoor air (see next question).

5. WHAT ARE BACKGROUND LEVELS FOR PERC IN INDOOR AND OUTDOOR AIR IN AREAS THAT ARE NOT NEAR A KNOWN SOURCE OF PERC?

The United States Environmental Protection Agency (US EPA) has collected and analyzed information on PERC levels in indoor and outdoor air. Table 1 contains the results from air samples collected inside and outside of buildings that were not near known sources of PERC and other chemicals (for example, a home not known to be near a chemical spill, a hazardous waste site, a dry-cleaner, or a factory). The middle half (25^{th} to 75^{th} percentile) of PERC levels in indoor and outdoor air samples is about 1 to 10 mcg/m^3. A similar result was found for NYS homes not near known PERC sources. NYSDOH sampled 138 homes between 1989 and 1996 and the level of PERC in the indoor air was below 10 mcg/m^3 in 95% of the homes. Collectively, these data show that background levels of PERC in air are seldom above 10 mcg/m^3.

Table 1.

<table>
<tr><th rowspan="2">Sample</th><th colspan="3">PERC Air Levels (mcg/m^3)[A]</th><th rowspan="2">Sample Size</th></tr>
<tr><th>25^{th} Percentile</th><th>50^{th} Percentile (Median)</th><th>75^{th} Percentile</th></tr>
<tr><td colspan="5">Homes & Offices: Nationwide 1970 – 1988[B]</td></tr>
<tr><td>Indoor</td><td>1.7</td><td>5.0</td><td>11</td><td>2,195</td></tr>
<tr><td>Outdoor</td><td>0.82</td><td>2.4</td><td>5.9</td><td>3,226</td></tr>
<tr><td colspan="5">Offices: Nationwide 1994 – 1996[C]</td></tr>
<tr><td>Indoor</td><td rowspan="2">not detected*</td><td>3.0</td><td>5.9</td><td>298</td></tr>
<tr><td>Outdoor</td><td>not detected*</td><td>3.0</td><td>100</td></tr>
</table>

[A] These databases contain air-testing results from studies where there were no known sources of chemicals or chemical spills. Outdoor samples were taken at the same time as indoor samples and at a location close to the building sampled.

[B] The US EPA Volatile Organic Compounds Database was published in March 1988.

[C] From 1994 through 1996, US EPA measured volatile organic compounds in indoor and outdoor air at 100 randomly selected public and private office buildings across the US.

* Not detected means that the amount of PERC in the air sample was less than the smallest amount of PERC that could be accurately measured (that is, the level was less than the detection limit); in these studies, the detection limit ranged from 1.4 to 2.0 mcg/m^3.

6. WHAT IS THE NEW YORK STATE DEPARTMENT OF HEALTH'S (NYSDOH) GUIDELINE FOR PERC IN AIR?

NYSDOH recommends that the average air level in a residential community not exceed 100 micrograms of PERC per cubic meter of air (100 mcg/m^3), considering continuous lifetime exposure and sensitive people. Three other ways of expressing the guideline are 0.1 milligrams per cubic meter of air (0.1 mg/m^3), 15 parts per billion (ppb) or 0.015 parts per million (ppm).

The purpose of the guideline is to help guide decisions about the nature of efforts to reduce PERC exposure. Reasonable and practical actions should be taken to reduce PERC exposure when indoor air levels are above background, even when they are below the guideline of 100 mcg/m^3. The urgency to take actions increases as indoor air levels increase, especially when air levels are above the guideline. Finally, NYSDOH recommends taking immediate action to reduce exposure when an air level is ten-times or more higher than the guideline (that is, when the air level is 1,000 mcg/m^3 or higher). In all cases, the specific corrective actions to be taken depend on a case-by-case evaluation of the situation. The goal of the recommended actions is to reduce PERC levels in indoor air to as close to background as practical.

7. SHOULD I BE CONCERNED ABOUT HEALTH EFFECTS IF I AM EXPOSED TO AN AIR LEVEL SLIGHTLY ABOVE THE GUIDELINE?

The guideline is lower than the air levels that caused either non-cancer or cancer effects (Figure 1); thus, the possibility of health effects is low even at air levels slightly above the guideline. In addition, the guideline is based on the assumption that people are continuously exposed to PERC in air all day, every day for as long as a lifetime. This is rarely true for most people, who are more likely to be exposed for a part of the day and part of their lifetime.

8. WHEN SHOULD MY CHILDREN OR I SEE A PHYSICIAN?

If you believe you or your children have symptoms that you think are caused by PERC exposure, you and your children should see a physician. You should tell the physician about the symptoms and about when, how, and for how long you think you and/or your children were exposed to PERC.

9. WHERE CAN I GET MORE INFORMATION?

If you have any questions about the information in this fact sheet or would like to know more about PERC, please call the New York State Department of Health at 1-518-402-7800 or 1-800-458-1158 (extension 2-7800) or write to the following address.

New York State Department of Health
Bureau of Toxic Substance Assessment
Flanigan Square, 547 River Street
Troy, NY 12180-2216

Trichloroethene (TCE) in Indoor and Outdoor Air

NEW YORK STATE
DEPARTMENT OF HEALTH

FACT SHEET

February 2005

What is trichloroethene?

Trichloroethene is a manufactured, volatile organic chemical. It has been used as a solvent to remove grease from metal. Trichloroethene has also been used as a paint stripper, adhesive solvent, as an ingredient in paints and varnishes, and in the manufacture of other organic chemicals. Other names for trichloroethene include TCE and trichloroethylene. TCE is a common name for trichloroethene and will be used for the rest of this fact sheet.

TCE is a clear, colorless liquid, and has a somewhat sweet odor. It is non-flammable at room temperature and will evaporate into the air.

How can I be exposed to TCE?

People can be exposed to TCE in air, water and food. Exposure can also occur when TCE, or material containing TCE, gets on the skin.

TCE gets into the air by evaporation when it is used. TCE can also enter air and groundwater if it is improperly disposed or leaks into the ground. People can be exposed to TCE if they drink groundwater contaminated with TCE, and if the TCE evaporates from the contaminated drinking water into indoor air during cooking and washing. They may also be exposed if TCE evaporates from the groundwater, enters soil vapor (air spaces between soil particles), and migrates through building foundations into the building's indoor air. This process is called "soil vapor intrusion."

How can TCE enter and leave my body?

If people breathe air containing TCE, some of the TCE is exhaled unchanged from the lungs and back into the air. Much of the TCE gets taken into the body through the lungs and is passed into the blood, which carries it to other parts of the body. The liver changes most of the TCE taken into the blood into other compounds, called breakdown products, which are excreted in the urine in a day or so. However, some of the TCE and its breakdown products can be stored in the fat or the liver, and it may take a few weeks for them to leave the body after exposure stops.

What kinds of health effects are caused by exposure to TCE in air?

In humans, long term exposure to workplace air containing high levels of TCE (generally greater than about 40,000 micrograms of TCE per cubic meter of air (mcg TCE/m^3)) is linked to effects on the central nervous system (reduced scores on tests evaluating motor coordination, nausea, headaches, dizziness) and irritation of the mucous membranes. Exposure to higher levels (generally greater than 300,000 mcg TCE/m^3) for short periods of time can irritate the eyes and respiratory tract, and can cause effects on the central nervous system, including dizziness, headache, sleepiness, nausea, confusion, blurred vision and fatigue. In laboratory animals, exposure to high levels of TCE has damaged the central nervous system, liver and kidneys, and adversely affected reproduction and development of offspring. Lifetime exposure to high levels of TCE has caused cancer in laboratory animals.

Some studies of people exposed for long periods of time to high levels of TCE in workplace air, or elevated levels of TCE in drinking water, show an association between exposure to TCE and increased risks for certain types of cancer, including cancers of the kidney, liver and esophagus, and non-Hodgkin s lymphoma. One study showed an association between elevated levels of TCE in drinking water and effects on fetal development. Other studies suggest an association between workplace TCE exposure and reproductive effects (alterations in sperm counts) in men. We do not know if the effects observed in these studies are due to TCE or some other possible factor (for example, exposure to other chemicals, smoking, alcohol consumption, socioeconomic status, lifestyle choices). Because all of these studies have limitations, they only suggest, but do not prove, that exposure to TCE can cause cancer in humans and can cause developmental and reproductive effects as well.

What are background levels of TCE for indoor and outdoor air?

The exact meaning of background depends on how a study selected sampling locations and conditions. Generally, sampling locations are selected to be not near known sources of volatile chemicals (for example, a home not near a chemical spill, a hazardous waste site, a dry cleaner, or a factory). In some studies, the criteria for sampling indoor air may require checking containers of volatile chemicals to make sure they are tightly closed or removing those products before samples are taken. The New York State Department of Health (NYSDOH) has used several sources of information on background levels of TCE in indoor and outdoor air. One NYSDOH study of residences heated by fuel oil found that background concentrations of TCE in indoor and outdoor air are less than 1 mcg/m^3 in most cases. In this study, most homes did not have obvious sources of volatile organic compounds (VOCs). In those homes with VOC sources, samples were taken and the data are included in the study.

What are sources of TCE in air in homes?

TCE is found in some household products, such as glues, adhesives, paint removers, spot removers, rug cleaning fluids, paints, metal cleaners and typewriter correction fluid. These and other products could be potential sources for TCE in indoor air.

Another source of TCE in indoor air is contaminated groundwater that is used for household purposes. Common use of water, such as washing dishes or clothing, showering, or bathing, can introduce TCE into indoor air through volatilization from the water.

TCE may also enter homes through vapor intrusion as described on page 1 in the question "How can I be exposed to TCE?".

What is the level of TCE that people can smell in the air?

The reported odor threshold (the air concentration at which a chemical can be smelled) for TCE in air is about 540,000 mcg TCE/m^3. At this level, most people would likely be able to start smelling TCE in air. However, odor thresholds vary from person to person. Some people may be able to detect TCE at levels lower than the reported odor threshold and some people may only detect it at concentrations higher than the reported odor threshold.

If I can't smell TCE in the air, am I being exposed?

Just because you can t smell TCE doesn t mean there is no exposure. Sampling and testing is the best way to know if TCE is present.

What is the NYSDOH's guideline for TCE in air?

After a review of the toxicological literature on TCE, the NYSDOH set a guideline of 5 mcg/m^3 for TCE in air. This level is lower than the levels that have caused health effects in animals and humans. In setting this level, the NYSDOH also considered the possibility that certain members of the population (infants, children, the elderly, and those with pre-existing health conditions) may be especially sensitive to the effects of TCE.

The guideline is not a bright line between air levels that cause health effects and those that do not. The purpose of the guideline is to help guide decisions about the nature of the efforts to reduce TCE exposure. Reasonable and practical actions should be taken to reduce TCE exposure when indoor air levels are above background, even when they are below the guideline of 5 mcg/m^3. The urgency to take actions increases as indoor air levels increase, especially when air levels are above the guideline. In all cases, the specific corrective actions to be taken depend on a case-by-case evaluation of the situation. The goal of the recommended actions is to reduce TCE levels in indoor air to as close to background as practical.

Should I be concerned about health effects if I am exposed to air levels slightly above the guideline? Below the guideline?

The possibility of health effects occurring is low even at air levels slightly above the guideline. In addition, the guideline is based on the assumption that people are continuously exposed to TCE in air all day, every day for as long as a lifetime. This is rarely true for most people who are likely to be exposed for only part of the day and part of their lifetime.

How can I limit my exposure to TCE?

TCE can get into indoor air through household sources (for example, commercial products that contain TCE), from contaminated drinking water, or by vapor intrusion. As with any indoor air contaminant, removing household sources of TCE will help reduce indoor air levels of the chemical. Maintaining adequate ventilation will also help reduce the indoor air levels of TCE. If TCE is in the indoor air as a result of vapor intrusion, a sub-slab depressurization system, much like a radon mitigation system, will reduce exposures by minimizing the movement of vapors that are beneath a slab into a building. If TCE is in the water supply of a house, a carbon filter on the water supply to remove the TCE will minimize ingestion and inhalation exposures.

Is there a medical test that can tell me whether I have been exposed to TCE?

TCE can be measured in people s breath soon after they are exposed. TCE and some of its breakdown products can be measured in the urine and blood. These tests are not routinely available at a doctor s office. Urine and blood tests can indicate that you may have recently (within the last few days) been exposed to a large amount of the chemical. However, they cannot tell you the source of the exposure. Some of the breakdown products of TCE can also be formed from other chemicals.

When should my children or I see a physician?

If you believe you or your children have symptoms that you think are caused by TCE exposure, you or your children should see a physician. You should tell the physician about the symptoms and about when, how and for how long you think you and/or your children were exposed to TCE.

What is the NYSDOH doing to educate physicians about TCE?

The NYSDOH maintains an Infoline (1-800-458-1158) that physicians or the public can call when they have questions related to various types of chemical exposures. A certified occupational and environmental health nurse is available to triage physicians' questions and to direct their inquiries to the appropriate staff member.

The NYSDOH also works closely with the federal Agency for Toxic Substances and Disease Registry (ATSDR), making their educational materials available to physicians upon request. One of these items is an environmental medicine case study entitled "Trichloroethylene (TCE) Toxicity," which provides the opportunity for physicians to earn continuing medical education credits from the Centers for Disease Control and Prevention. Physicians who would like to complete this training are encouraged to contact the NYSDOH for more information. A printed copy can be mailed to the physician or it can be accessed on-line at the following web site http://www.atsdr.cdc.gov/HEC/CSEM/tce/index.html.

Where can I get more information?

If you have any questions about the information in this fact sheet or would like to know more about TCE, please call the NYSDOH at 1-800-458-1158 or write to the following address:

New York State Department of Health
Bureau of Toxic Substance Assessment
Flanigan Square, 547 River Street
Troy, NY 12180-2216

NEW YORK STATE
DEPARTMENT OF HEALTH

RADON

Frequently Asked Questions

What is radon and where does it come from?

Radon is a gas that comes from the radioactive decay of radium in the soil. Radon is a colorless, tasteless and odorless gas that can only be measured through the use of proper test procedures.

Radon is constantly being generated by the decay of radium. Radium is the decay product of uranium, which is commonly found in rocks and soils present in the earth's crust. The concentration of radon gas in the soil will be related to the amount of uranium present. However, this is not a good indicator of the level of radon that may be in an individual home. The radon concentration in a home is dependent on many factors, including the types and properties of the soil that the home is built on and the individual features of the building.

Radon can also be dissolved in ground water and can be introduced into the indoor air through the aeration of well water during its use in washing machines, showers, and so forth. However, in New York State, with a few exceptions, this component is usually relatively small compared to the amount of radon entering the home from the soil.

What are the health effects of radon?

Based on data provided by the United States Environmental Protection Agency (EPA), the Surgeon General has warned that radon is the second leading cause of lung cancer in the United States, resulting in an estimated 22,000 lung cancer deaths annually. Many homes contain radon concentrations that are high enough to give their occupants lifetime exposures that could increase their risk of developing lung cancer. As one inhales, radon decay products in the inhaled air are deposited in the lungs. Radon and its decay products emit alpha and beta particles and gamma photons. The alpha particles are very damaging if emitted from radioactive material within the body. The alpha particles can strike sensitive lung tissue causing damage to the cells in the lungs and increase the risk of lung cancer. The risk associated with exposure to radon is thought to increase along with increasing radon concentration, so the higher the average radon level is in a house, and the longer the exposure period, the greater the risk to the occupants.

In addition, if you are a smoker, radon greatly increases your risk of lung cancer.

RADON RISK

Radon Level	If 1,000 people who smoked were exposed to this level over a lifetime	If 1,000 people who never smoked were exposed to this level over a lifetime
20 pCi/L	About 135 people could get lung cancer	About 8 people could get lung cancer
4 pCi/L	About 29 people could get lung cancer	About 2 people could get lung cancer
0.4 pCi/L	About 3 people could get lung cancer	Less than 1 person could get lung cancer

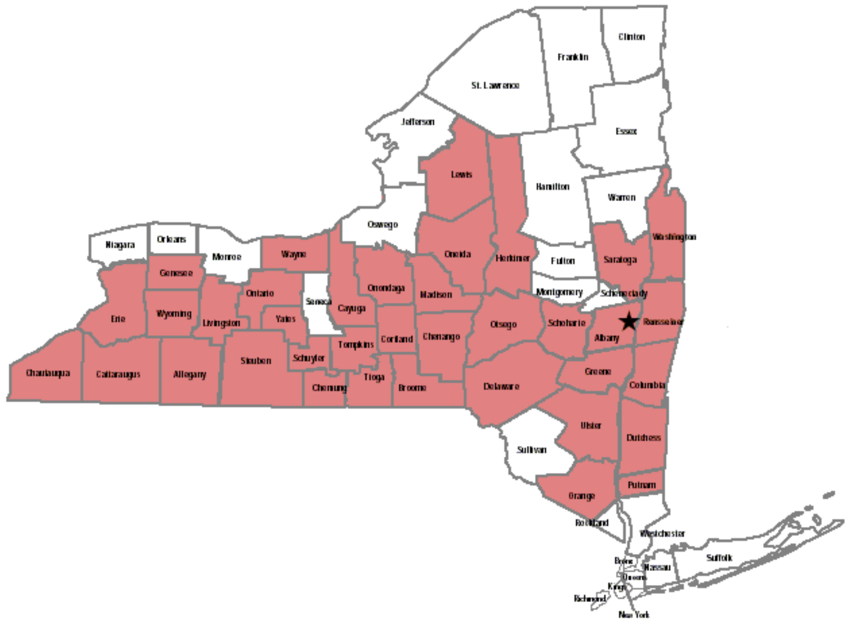
* The risk of exposure to radon in addition to other causes.

** Radon concentration in air is measured in units of "picoCuries per Liter (pCi/L)." The picoCurie (pCi) is a unit of radioactivity which represents one trillionth of a Curie or 2.22 nuclear-transformations per minute.

Do I live in an area designated as a "high radon risk area" by the United States Environmental Protection Agency and New York State?

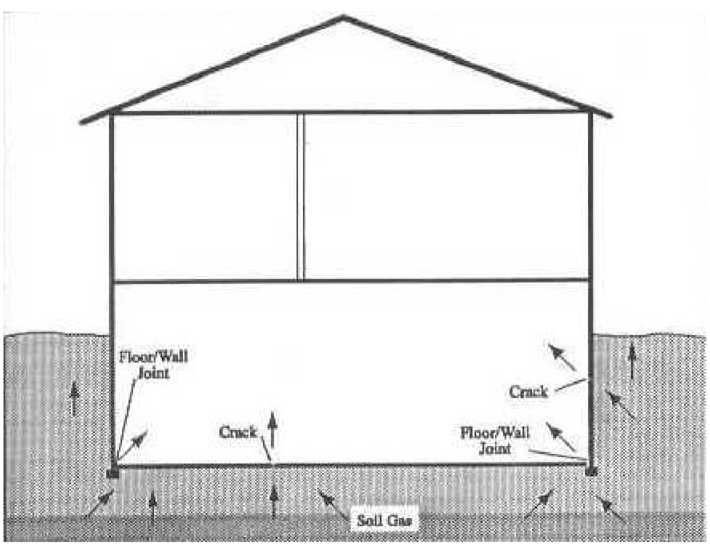
Thirty-seven (37) counties in the state have been designated as "high radon risk areas" by the EPA and New York State. They are as follows (shaded on the map):

Albany
Allegany
Broome
Cattaraugus
Cayuga
Chautauqua
Chemung
Chenango
Columbia
Cortland
Delaware
Dutchess
Erie
Genesee
Greene
Herkimer
Lewis
Livingston
Madison
Oneida
Onondaga
Ontario
Orange
Otsego
Putnam
Rensselaer
Saratoga
Schoharie
Schuyler
Steuben
Tioga
Tompkins
Ulster
Washington
Wayne
Wyoming
Yates



How can radon enter my home?

Radon can enter a home whether it is old or new, or whether it has a basement or is on a slab. Radon enters homes through cracks in slabs or basement floors and walls, and through openings around sump pumps because of a difference in pressure. Heating, ventilation or air-conditioning systems may create a negative pressure that can draw radon into the building. The major routes of entry into a home in New York State are illustrated in the figure.



How can I test the radon levels in my home?

Testing for radon is simple and inexpensive. You can test your home any time, although it's better to do so during the heating season when the home is less ventilated. Remember that the longer you wait, the longer you and your family may be exposed to radon.

Test kits can be purchased in many hardware stores, the hardware sections of discount outlets, from local health departments, or from the New York State Department of Health (NYSDOH). The kits should display the phrase "Meets EPA or National Radon Proficiency Requirements."

There are two categories of detectors: long-term (90 days to one year) and short-term (less than 90 days, typically 2 to 7 days). The length of testing varies depending on the type of radon information you are interested in. Short-term tests are useful for screening and for situations where results are needed quickly. A long-term test will usually be a better indicator of the radon level in your home. Since the long-term test occurs over a longer period of time, the influence of daily and seasonal fluctuations in your home s radon level will be reduced. A long-term test will provide a true annual average. "Alpha track" and "electret" detectors are commonly used for this type of testing. Long-term test kits cost about 30, and are accurate to within plus or minus 25 .

The most commonly used device for making short-term radon measurements in homes is the charcoal canister. These devices are fairly quick, inexpensive, and easy to use. Their accuracy is about plus or minus 20 . Since short term tests can be affected by daily and seasonal fluctuations in your home s radon level, the NYSDOH recommends that the average of two charcoal canister measurements be used before making a decision to take appropriate corrective action. Short-term charcoal canisters are available from the NYSDOH at a cost of 6.75 per detector ordered (New York State Residents ONLY). To obtain an order form, please visit the NYSDOH website at http://www.health.state.ny.us/nysdoh/radon/detector.pdf or call 1-800-458-1158, ext. 2-7556.

Continuous electronic radon monitors may also be used for short-term measurements (often for real estate transactions). They should only be used by certified professional radon testing firms. Tests using these monitors are more expensive (about 100). To obtain the names of certified professional radon testing firms, contact the NYSDOH's Radon Program, the National Radon Safety Board's web site (NRSB; www.nrsb.org), the National Environmental Health Association's web site (NEHA; www.neha.org), or the NYSDOH's Environmental Laboratory Approval Program web site (www.wadsworth.org/labcert/elap/radon.html).

What is the recommended action level for radon?

The NYSDOH and the EPA use 4 pCi/L as a recommended action level. When testing indicates that the radon level in the lowest primary living area of the home is above this action level, the NYSDOH recommends that the homeowner take appropriate corrective action.

How can I reduce the radon levels in an existing house?

Radon levels in a house can be reduced. This can be done by several methods, including sealing cracks in floors and walls. One of the most widely used methods is the active sub-slab depressurization system. This technique will reroute the radon gas from the soil away from the house, by using a fan to create a pressure that will move the soil gas from beneath the basement to a point above the roof. This technique is very effective and will typically cost between 1,000 and 1,500 to install. There are contractors in most areas of the state who have met certain requirements and are trained to identify and fix radon problems in your home. To obtain the names of local contractors, contact the NYSDOH's Radon Program at 1-800-458-1158, extension 2-7556, or visit the NRSB's web site or NEHA's web site.

What types of radon reduction techniques are available for new construction?

If you are building in an area known to have a high probability of elevated radon levels, there are certain steps that can be taken during construction that will reduce the radon levels. EPA's *Model Standards and Techniques for Control of Radon in New Residential Buildings* and *Building Radon Out: A Step-by-step Guide on How to Build Radon Resistant Homes* (both available on EPA's web site) contains information on how to incorporate these techniques and materials in residential construction. Essentially this will consist of a layer of semi-permeable material, such as sand or gravel, under the foundation, a 6 mil or thicker layer of plastic between the gravel under the foundation and the concrete, a 4" PVC pipe through the foundation floor and extending through the roof, a roughed in electrical box in the attic or loft near the PVC pipe, and sealing and caulking of all openings in the concrete floor.

Where can I get more information?

For more information about radon or radon testing, or to obtain the names of local contractors, contact the NYSDOH's Radon Program at 1-800-458-1158, extension 2-7556.

Email:
radon   health.state.ny.us

Web sites:
http://www.health.state.ny.us/nysdoh/radon/radonhom.htm
http://www.wadsworth.org/labcert/elap/radon.html
http://www.epa.gov/iaq/radon
http://www.nrsb.org
http://www.neha.org