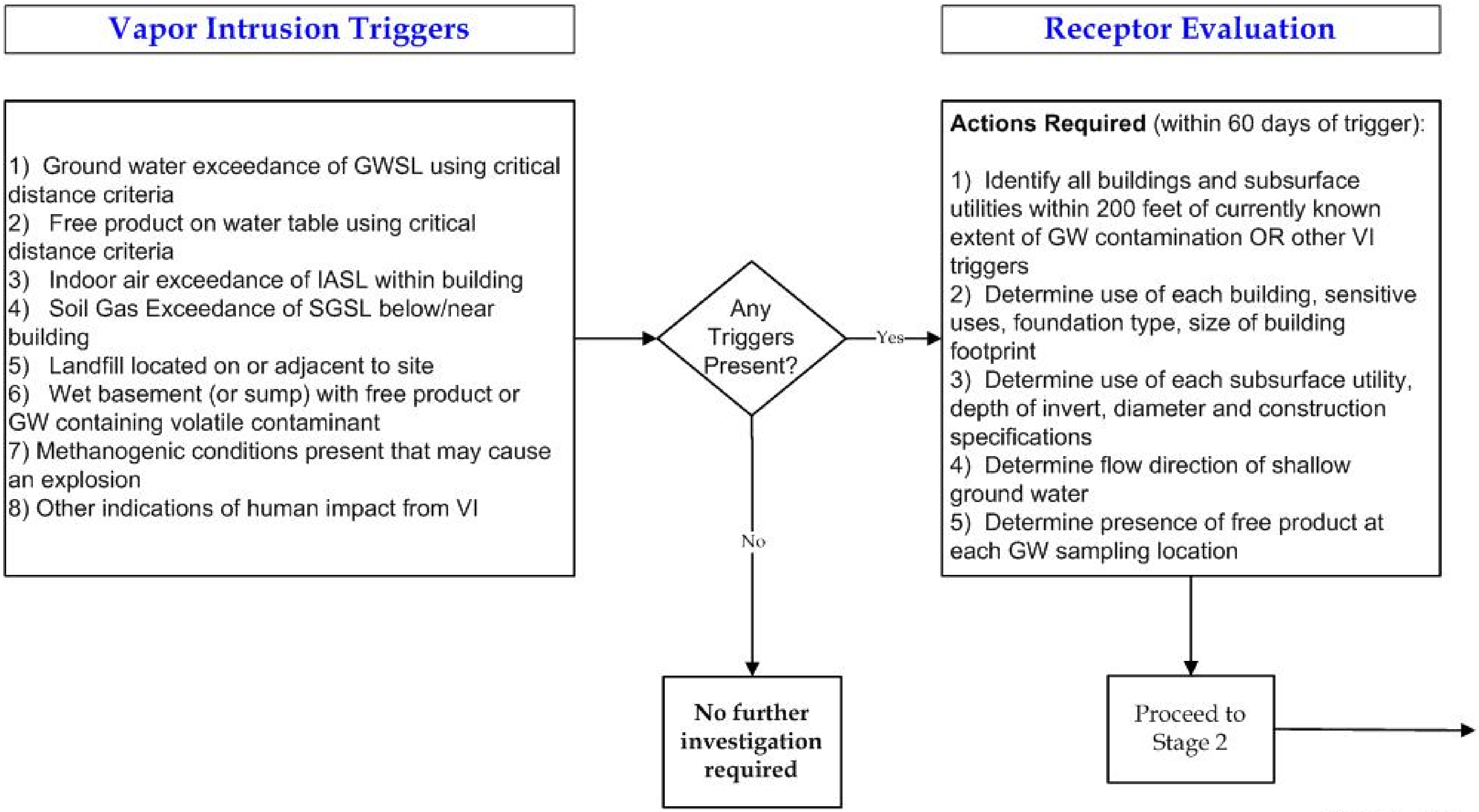
APPENDIX A

Decision Flow Chart

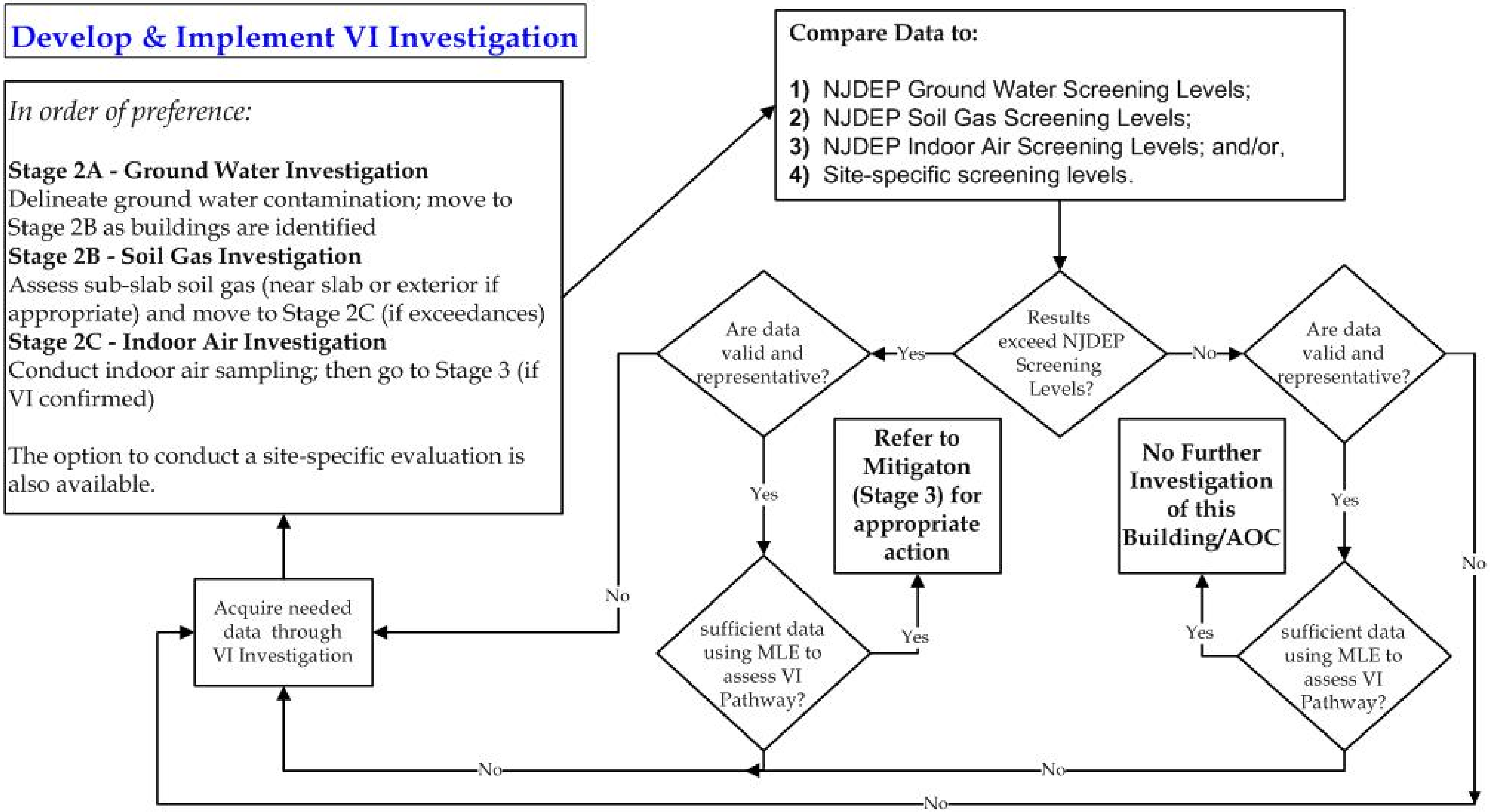
Decision Flow Chart for Vapor Intrusion Pathway

Receptor Evaluation (Stage 1)



Decision Flow Chart for Vapor Intrusion Pathway

VI Investigation (Stage 2)



Decision Flow Chart for Vapor Intrusion Pathway

Mitigation Decision Matrix - Stage 3

		Indoor Air Concentrations (for COCs)	
		< IASL	>IASL
Sub-Slab Soil Gas Concentrations (for COCs)	<SGSL	**No Action**	**No Action** * (if no other subsurface source)
	>SGSL to 10X SGSL	**Monitor**	**Mitigate**
	>10X SGSL	**Monitor / Mitigate**	**Mitigate**

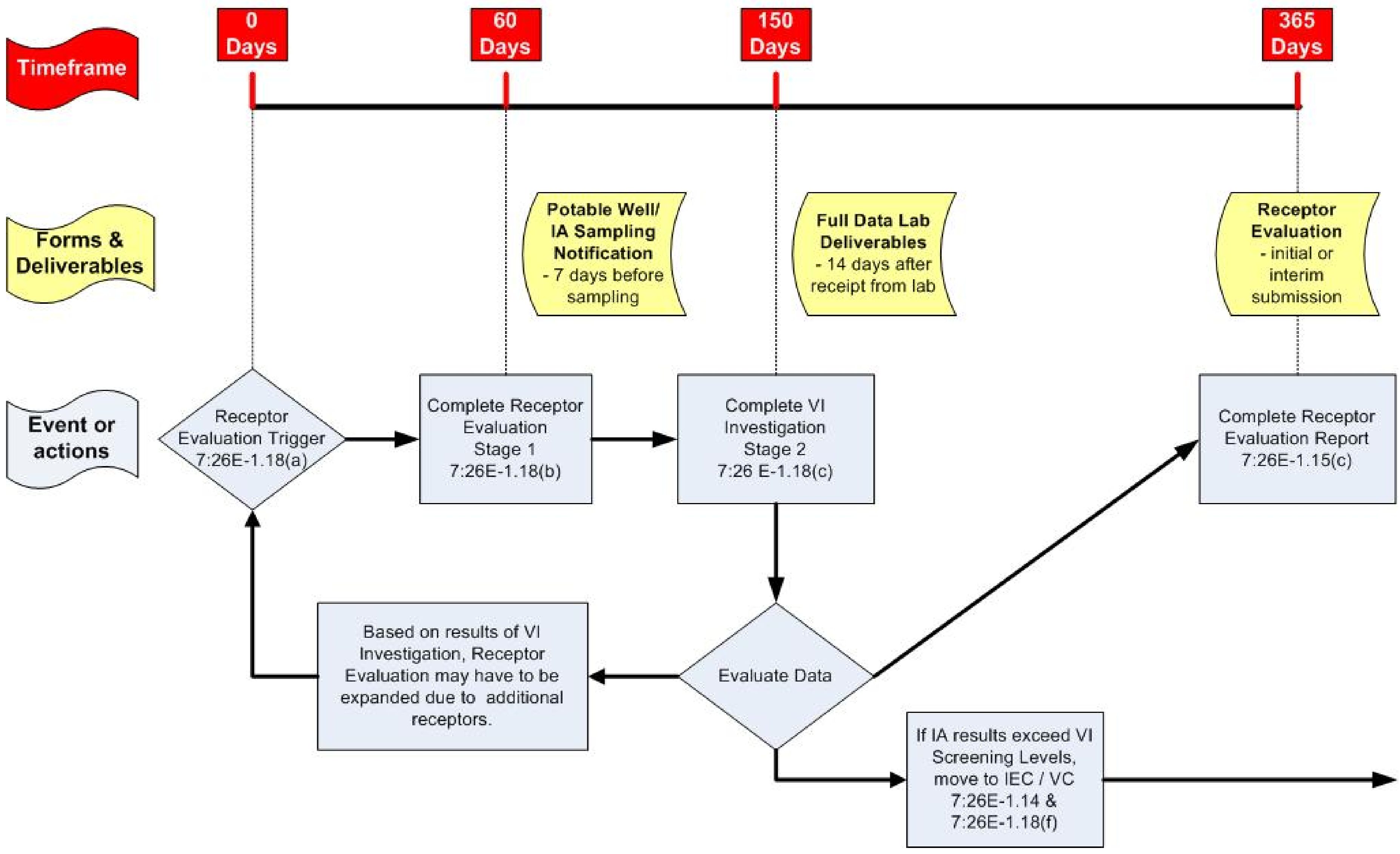
Notes:

* Investigator should consider the potential for vadose zone (soil) contamination and/or preferential pathways as part of the assessment of vapor intrusion before concluding "no further action"

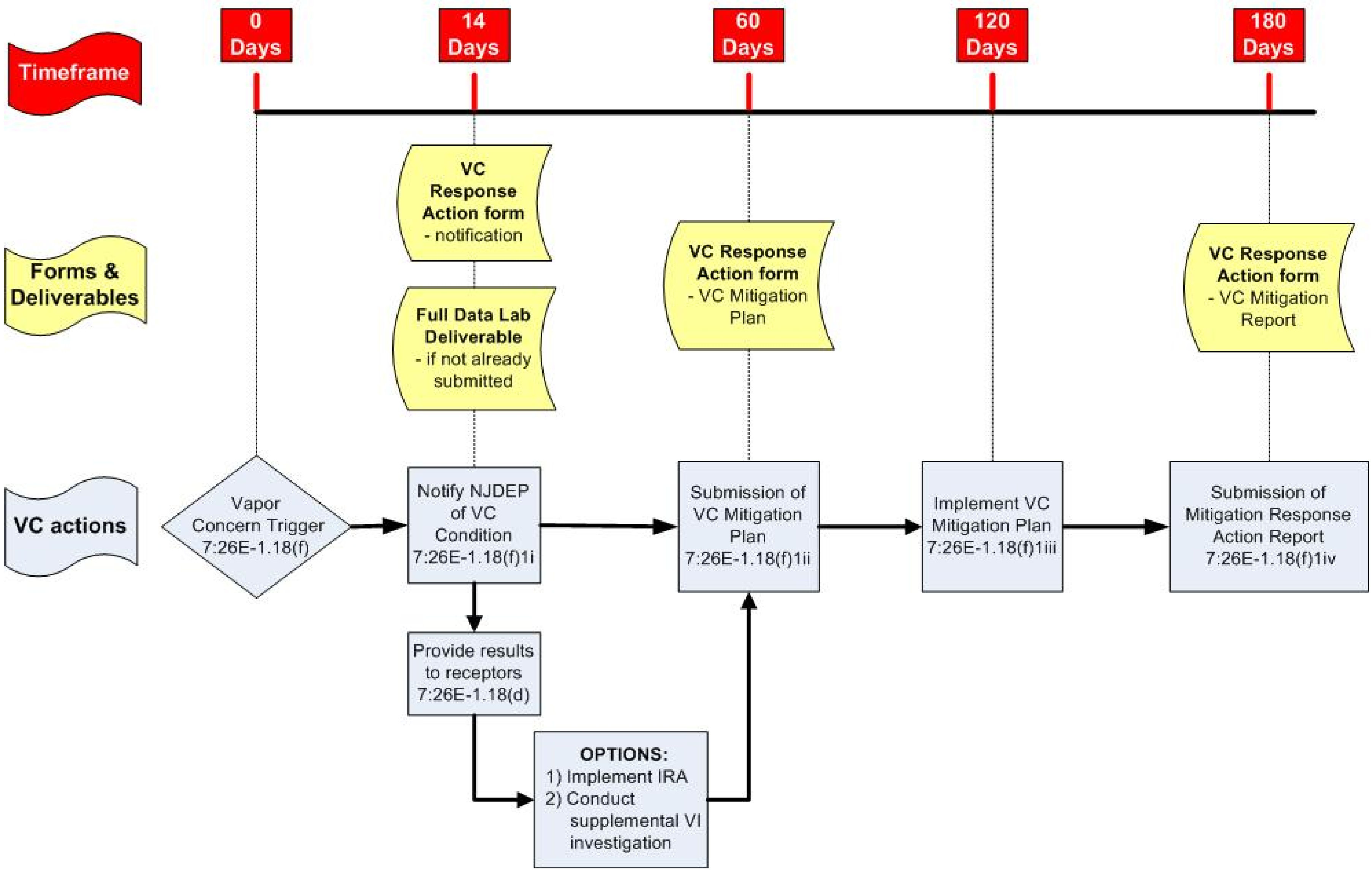
APPENDIX B

Vapor Intrusion Timeline

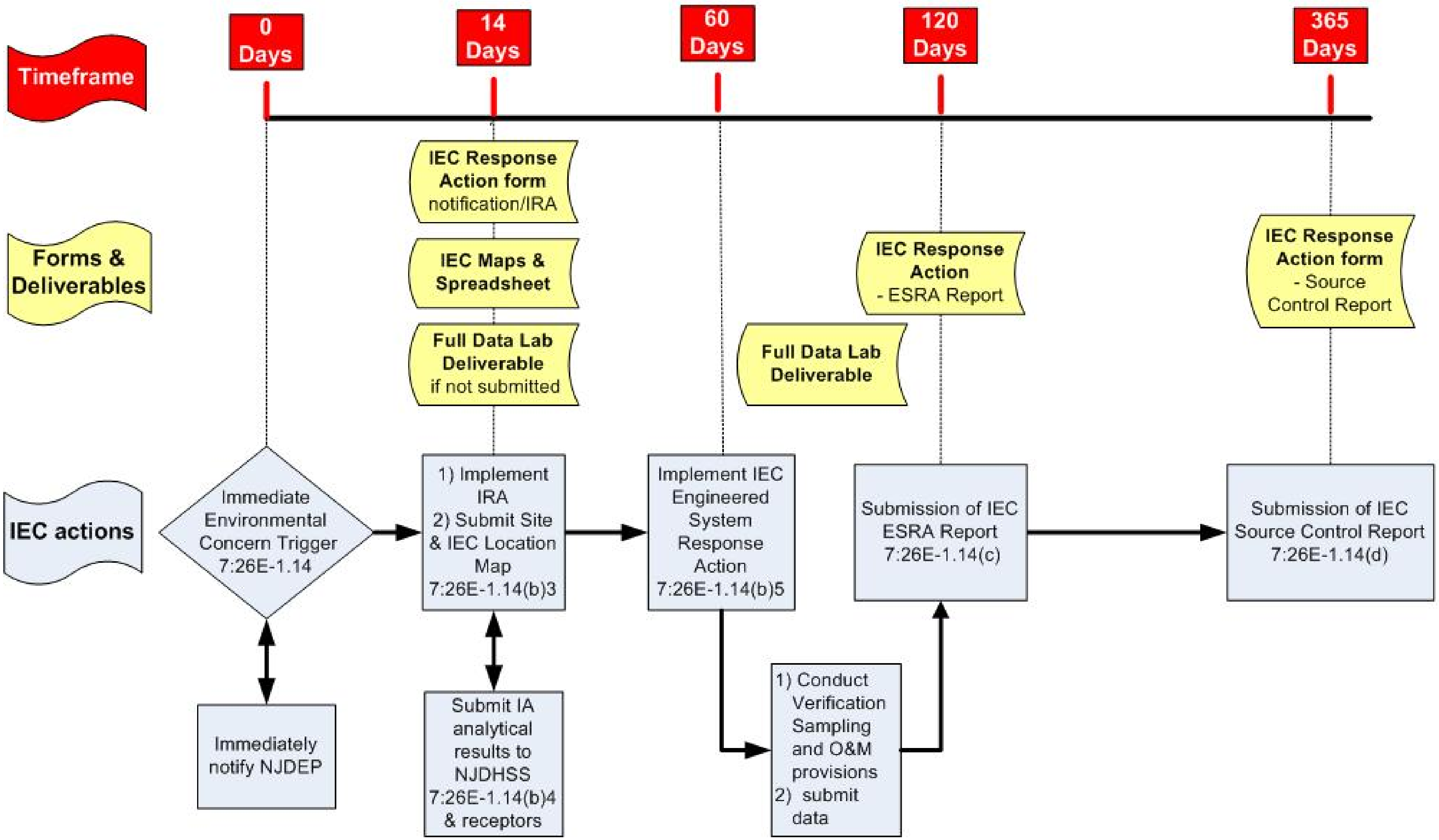
Receptor Evaluation / VI Investigation



VI Vapor Concern



VI Immediate Environmental Concern



APPENDIX C

ITRC Conceptual Site Model Checklist

CONCEPTUAL SITE MODEL (CSM) CHECKLIST

The information included in this checklist may be useful for developing the site-specific conceptual migration model and in planning the soil gas sampling. The investigator may use this checklist to compile information for each site.

Utilities and Process Piping

☐ *Locate and map out all underground utilities near the soil or groundwater impacts; pay particular attention to utilities that connect impacted areas to occupied buildings*

☐ *Locate and map out all underground process piping near the soil or groundwater impacts.*

Buildings (Receptors)

☐ *Locate and map out existing and potential future buildings*

☐ *Identify the occupancy and use of the buildings (e.g., residential, commercial) (may need to interview occupants to obtain this information.)*

☐ *Describe the construction of the building including materials (e.g., wood frame, block,), openings (e.g., windows, doors), and height (e.g., one-story, two-story, multiple-story); identify if there is an elevator shaft in the building (if applicable)*

☐ *Describe the foundation construction including:*

- *Type (e.g., basement, crawlspace, slab on grade)*
- *Floor construction (e.g., concrete, dirt)*
- *Depth below grade.*

☐ *Describe the HVAC system in the building including:*

- *Furnace/air conditioning type (e.g., forced air, radiant)*
- *Furnace/air conditioning location (e.g., basement, crawl space, utility closet, attic, roof)*
- *Source of return air (e.g., inside air, outside air, combination)*
- *System design considerations relating to indoor air pressure (e.g., positive pressure is often the case for commercial buildings).*

- ☐ *Describe sub-slab ventilation systems or moisture barriers present on existing buildings, or identify building- and fire-code requirements for sub-slab ventilation systems (e.g., for methane) or moisture barriers below foundations.*

<u>Source Area</u>

- ☐ *Locate and map out the source area for the vapor-phase contaminants related to the subsurface vapor intrusion pathway*
- ☐ *Describe the presence, distribution, and composition of any NAPL at the site*
- ☐ *Identify the vapor-phase contaminants that are to be considered for the subsurface vapor intrusion pathway*
- ☐ *Describe the status and results for the delineation of contamination in environmental media, specifically soil and groundwater, between the source area and the potential impacted buildings*
- ☐ *Describe the environmental media (e.g., soil, groundwater, both) containing contaminants*
- ☐ *Describe the depth to source area*
- ☐ *Describe the potential migration characteristics (e.g., stable, increasing, decreasing) for the distribution of contaminants.*

<u>Geology/Hydrogeology</u>

- ☐ *Review all boring logs, monitoring well construction, and soil sampling data to understand the,*
  - *Heterogeneity/homogeneity of soils and the lithologic units encountered and the expected/observed contaminant migration*
    - *Depth and lateral continuity of any confining units that may impede contaminant migration*
    - *depth and lateral continuity of any highly transmissive units that may enhance contaminant migration*
  - *Depth of Vadose (unsaturated) Zone, Capillary Fringe and the Phreatic (saturated) Zone*
    - *Note any seasonal water table fluctuations and seasonal flow direction changes (hydraulic gradient)*
    - *Note the depth interval between the vapor source and the ground surface*
    - *Note the presence of any perched aquifers*
    - *Where does the water table intersect well screen interval or note the presence of submerged screen*

- ☐ *Describe distinct strata (soil type and moisture content – e.g., "moist," "wet," "dry") and the depth intervals between the vapor source and ground surface*

- ☐ *Describe the depth to groundwater*

- ☐ *Describe groundwater characteristics (e.g., seasonal fluctuation, hydraulic gradient).*

Site Characteristics

- ☐ *Estimate the distance from edge of groundwater plume to building*

- ☐ *Nearby potential sources*

- ☐ *Estimate the distance from vapor source area to building*

- ☐ *Describe the surface cover between the vapor source area and the potentially impacted building*

APPENDIX D

Indoor Air Building Survey and Sampling Form

New Jersey Department of Environmental Protection

INDOOR AIR BUILDING SURVEY and SAMPLING FORM

Preparer's name: ______________________________________ Date: ___________________________

Preparer's affiliation: __________________________________ Phone #: ________________________

Site Name: ____ Case #: _________________________

Part I - Occupants

Building Address: ____

Building Block: _____________ Lot: ____________

Property Contact: ________________________ Owner / Renter / other: ________________________

Contact's Phone: home ( )__________ work ( )______________ cell ( )____________

# of Building occupants: Children under age 13 _____ Children age 13-18 ______ Adults _____

Part II – Building Characteristics

Building type: residential / multi-family residential / office / strip mall / commercial / industrial

Describe building: ____ Year constructed: _________

Sensitive population: day care / nursing home / hospital / school / other (specify): _______________

Number of floors below grade: ______ (full basement / crawl space / slab on grade)

Number of floors at or above grade: ______

Depth of basement below grade surface: ______ ft. Basement size: _______ ft^2

Basement floor construction: concrete / dirt / floating / stone / other (specify): ________________

Foundation walls: poured concrete / cinder blocks / stone / other (specify) ________________

Basement sump present? *Yes / No* Sump pump? *Yes / No* Water in sump? *Yes / No*

Type of heating system (circle all that apply):

hot air circulation	hot air radiation	wood	steam radiation
heat pump	hot water radiation	kerosene heater	electric baseboard

other (specify): _________________________

Type of ventilation system (circle all that apply):

central air conditioning	mechanical fans	bathroom ventilation fans
individual air conditioning units	kitchen range hood fan	outside air intake

other (specify): __________________

Type of fuel utilized (circle all that apply):

Natural gas / electric / fuel oil / wood / coal / solar / kerosene

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? *Yes / No*

Is there a whole house fan? *Yes / No*

Septic system? *Yes / Yes (but not used) / No*

Irrigation/private well? *Yes / Yes (but not used) / No*

Type of ground cover outside of building: grass / concrete / asphalt / other (specify) ______________

Existing subsurface depressurization (radon) system in place? *Yes / No* *active / passive*

Sub-slab vapor/moisture barrier in place? *Yes / No*
Type of barrier: ______________________________

Part III - Outside Contaminant Sources

NJDEP contaminated site (1000-ft. radius): ____

Other stationary sources nearby (gas stations, emission stacks, etc.): ________________________________

Heavy vehicular traffic nearby (or other mobile sources): ____

Part IV – Indoor Contaminant Sources

Identify all potential indoor sources found in the building (including attached garages), the location of the source (floor and room), and whether the item was removed from the building 48 hours prior to indoor air sampling event. Any ventilation implemented after removal of the items should be completed at least 24 hours prior to the commencement of the indoor air sampling event.

Potential Sources	Location(s)	Removed (Yes / No / NA)
Gasoline storage cans		
Gas-powered equipment		
Kerosene storage cans		
Paints / thinners / strippers		
Cleaning solvents		
Oven cleaners		
Carpet / upholstery cleaners		
Other house cleaning products		
Moth balls		
Polishes / waxes		
Insecticides		
Furniture / floor polish		
Nail polish / polish remover		
Hairspray		
Cologne / perfume		
Air fresheners		
Fuel tank (inside building)		NA
Wood stove or fireplace		NA
New furniture / upholstery		
New carpeting / flooring		NA
Hobbies - glues, paints, etc.		

Part V – Miscellaneous Items

Do any occupants of the building smoke? *Yes / No* How often? ______________

Last time someone smoked in the building? ____________ hours */ days ago*

Does the building have an attached garage directly connected to living space? *Yes / No*

If so, is a car usually parked in the garage? *Yes / No*

Are gas-powered equipment or cans of gasoline/fuels stored in the garage? *Yes / No*

Do the occupants of the building have their clothes dry cleaned? *Yes / No*

If yes, how often? weekly / monthly / 3-4 times a year

Do any of the occupants use solvents in work? *Yes / No*

If yes, what types of solvents are used? ____

If yes, are their clothes washed at work? *Yes / No*

Have any pesticides/herbicides been applied around the building or in the yard? *Yes* / No

If so, when and which chemicals? ____

Has there ever been a fire in the building? *Yes / No* If yes, when? _____________

Has painting or staining been done in the building in the last 6 months? *Yes / No*

If yes, when __________________ and where? ____________________________

Part VI – Sampling Information

Sample Technician: _____________________________ Phone number: ( ) _______ - __________

Company: ____

Sample Source: Indoor Air / Sub-Slab / Near Slab Soil Gas / Exterior Soil Gas

Were "Instructions for Occupants" followed? Y*es / No*

If not, describe modifications: ____

Sample locations (floor, room):

SAMPLING DATA

Sample #	Location	Analytical Method	Sample Volume	Sample Time	Sample Date	Sampler Type	Ambient Temp (°F)

-Drawing of Sample Location(s) in Building

Type of field instrument used (include summary of results): ______________________________

Part VII - Meteorological Conditions

Was there significant precipitation within 12 hours prior to (or during) the sampling event? *Yes / No*

Describe the general weather conditions: ____

____

Part VIII – General Observations

Provide any information that may be pertinent to the sampling event and may assist in the data interpretation process.

____

____

____

APPENDIX E

Evaluating Indoor Air near VOC Contaminated Sites Fact Sheet

Fact Sheet

Evaluating Indoor Air near VOC Contaminated Sites

What are VOCs?

Volatile organic compounds (VOCs) are a class of chemicals that readily evaporate at room temperature. Gasoline, dry cleaning fluid, degreasing agents (solvents) and paint thinners are several examples of products that contain these compounds. VOCs may be found in soil and/or ground water due to spillage onto the ground, leaks from underground storage tanks and other types of discharges.

How VOCs in soil or ground water can affect indoor air

If VOCs contaminate soil or ground water at a site, it is important to evaluate nearby buildings for possible impacts from **vapor intrusion**. Vapor intrusion occurs when gases from the contaminated soil or ground water seep through cracks and holes in foundations or slabs of buildings and accumulate in basements, crawl spaces or living areas, as shown in the diagram below.

A variety of factors can influence whether vapor intrusion will occur at a building located near soil or ground water contaminated with VOCs. These include, but are not limited to, the concentration of the contaminants, the type of soil, the depth to ground water, the construction of the building, the condition of the foundation or slab and the existence of underground utilities that can create pathways for vapors to travel.

Short term exposure to high levels of organic vapors can cause eye and respiratory irritation, headache and/ or nausea. Breathing low levels of organic vapors over a long period of time may increase an individual's risk for respiratory ailments, cancer and other health problems.

Organic vapors can be present inside a building at potentially harmful levels without being detectable by odor. **Sub-slab soil gas testing**, **near-slab soil gas testing** and/or **indoor air testing** are usually required to determine whether vapor intrusion is occurring at a property.

Testing for vapor intrusion

If your home or building is located near VOC-contaminated soil or ground water, NJDEP or an environmental contractor may ask permission to evaluate your property for vapor intrusion. This

(over)

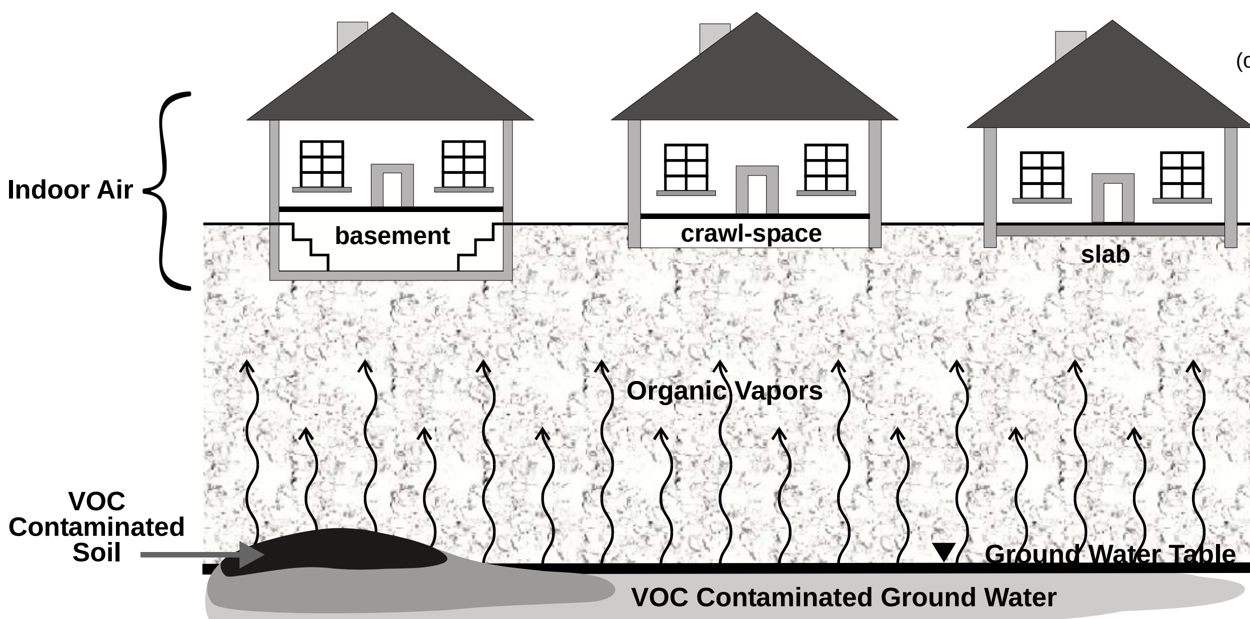


Diagram adapted from USEPA's *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Ground Water and Soils, November 2002*

New Jersey Department of Environmental Protection
Site Remediation Program

process typically involves first conducting sub-slab soil gas testing to check for vapors beneath the building, followed by indoor air testing, if necessary. During sub-slab testing, a small hole is bored through the basement floor or slab and a sample of the **soil gas** (the air trapped between the soil particles) is collected using an evacuated air testing canister (see below). If it is not possible to collect a soil gas sample from beneath the floor or slab, the sample may be collected by placing a probe in the soil directly adjacent to the building (near-slab testing). The soil gas sample is then sent to a certified laboratory to be analyzed for VOCs. If the analysis shows VOCs related to the subsurface contamination are present above NJDEP's Soil Gas Screening Levels (SGSL), then indoor air testing is necessary.

During indoor air testing, a canister is placed in the basement, crawl space or other part of the building for a period of time (normally 24 hours). If the analysis of the indoor air sample shows VOCs related to the subsurface contamination are present above NJDEP's Indoor Air Screening Levels (IASL), vapor intrusion is likely occurring. Additional evaluation of the property may be needed to confirm this finding.

Background contamination

Many materials and substances commonly found in commercial and residential settings, such as paints, paint thinners, gasoline-powered machinery, certain building materials and cleaning products, dry cleaned clothing and cigarette smoke, contain VOCs that may be detected by indoor air testing. Even VOCs from motor vehicle emissions and other outdoor sources can contaminate indoor air. When VOCs from these sources are detected during indoor air testing, they are referred to as **background contamination.**

It is sometimes difficult to determine whether the VOCs detected inside a building are due to vapor intrusion, background contamination or a combination of both. Before your building is evaluated for vapor intrusion you should receive a copy of NJDEP's *Instructions for Occupants – Indoor Air Sampling Events.* Please follow these instructions to minimize background contamination and help ensure that the test results are as definitive as possible.

Addressing vapor intrusion

If testing confirms vapor intrusion is causing potentially harmful levels of VOCs to accumulate inside a building, a **subsurface depressurization system** may be installed at the property. The system prevents vapors from entering the building by continuously venting the contaminated air beneath the basement slab or crawl space to the exterior of the structure. Subsurface depressurization systems are also used throughout the country to reduce levels of naturally occurring radon gas in buildings. See NJDEP's fact sheet titled *Subsurface Depressurization Systems* for more information about how these systems work.

***Instructions for Occupants — Indoor Air Sampling Events*, the *Subsurface Depressurization Systems* fact sheet and general information about vapor intrusion can be found in NJDEP's Vapor Intrusion Guidance Technical document, or the Department's website at http://www.state.nj.us/dep/srp/guidance/vaporintrusion.**

An evacuated air testing canister. The pressure inside the canister is initially set lower than the indoor air, causing air to flow into the canister when the valve is opened.

Information for Residents and Property Owners

Contact Name ____________________

Agency/Company ____________________

Phone Number ____________________

Email Address ____________________

Sampling Date/Time ____________________

Notes/Instructions ____________________

____

____

____

____

APPENDIX F

Instructions for Occupants – Indoor Air Sampling Events (English and Spanish)

New Jersey Department of Environmental Protection
Site Remediation Program

Instructions for Occupants for Indoor Air Sampling

Representatives of ____ will be collecting one or more indoor air samples from your building in the near future. Your assistance is requested during the sampling program in order to collect an indoor air sample that is both representative of indoor conditions and avoids the common background indoor air sources associated with occupant activities and consumer products.

Please follow the instructions below starting at least 48 hours prior to and during the indoor air sampling event:

- ☑ Operate your furnace and whole house air conditioner as appropriate for the current weather conditions
- ☑ Do not use wood stoves, fireplaces or auxiliary heating equipment
- ☑ Do not open windows or keep doors open.
- ☑ Avoid using window air conditioners, fans or vents
- ☑ Do not smoke in the building
- ☑ Do not use air fresheners or odor eliminators
- ☑ Do not use paints or varnishes (up to a week in advance, if possible)
- ☑ Do not use cleaning products (e.g., bathroom cleaners, furniture polish, appliance cleaners, all-purpose cleaners, floor cleaners)
- ☑ Do not use cosmetics, including hair spray, nail polish remover, perfume, etc.
- ☑ Avoid bringing freshly dry cleaned clothes into the building
- ☑ Do not engage in hobbies indoors that use solvents
- ☑ Do not apply pesticides
- ☑ Do not store containers of gasoline, oil or petroleum based or other solvents within the building or attached garages (except for fuel oil tanks)
- ☑ Do not operate or store automobiles in an attached garage
- ☑ Do not operate gasoline powered equipment within the building, attached garage or around the immediate perimeter of the building

You will be asked a series of questions about the structure, consumer products you store in your building, and occupant activities typically occurring in the building. These questions are designed to identify "background" sources of indoor air contamination. While this investigation is looking for a select number of chemicals related to the subsurface contamination, the laboratory will be analyzing the indoor air samples for a wide variety of chemicals. As a result, chemicals such as tetrachloroethene that is commonly used in dry cleaning or acetone found in nail polish remover might be detected in your sample results.


Typical air sampling canister

Your cooperation is greatly appreciated.

If you have any questions about these instructions, please feel free to contact

____ at ______________________________________.

New Jersey Department of Environmental Protection
Site Remediation Program

Instrucciones Para Ocupantes
Eventos de Muestreo de Aire de Interiores

En un futuro cercano, representantes del Departamento de Protección Ambiental de Nueva Jersey (NJDEP) o una firma de consultoria ambiental estaran colectando una o mas muestras de aire del interior de su edificio. NJDEP requiere de su ayuda para colectar una muestra del interior en su estructura que a la vez es representativa de las condiciones del interior y el evitar las fuentes comunes de antecedentes de contaminación de aire asociado con actividades de la casa y productos de consumo.

Por favor siga las instrucciones abajo mencionadas comenzando por lo menos 48 horas antes de y durante el evento de muestreo:

- ☑ Opere su horno y el aire acondicionado de toda la casa apropiadamente a las actuales condiciones del tiempo
- ☑ No use estufas de leña, chimeneas o equipos auxiliares de calefacción.
- ☑ No abrir las ventanas o mantener las puertas abiertas.
- ☑ Evite usar aires acondicionados, abanicos o ventiladores de ventanas
- ☑ No fume dentro del edificio
- ☑ No use refrescantes de aire o eliminadores de olor
- ☑ No use pinturas o barniz (hasta una semana por adelantado, si es posible)
- ☑ No use productos de limpieza (ej. Limpiadores de baño, cera para muebles, limpiadores de aparatos electrodomésticos, limpiadores para "todo propósito", limpiadores del piso)
- ☑ No use cosméticos, incluyendo fijador del cabello, removedor de esmalte de uñas, perfume
- ☑ Evite traer ropa recientemente limpiada en seco (de la tintorería) al edificio
- ☑ No participe en pasatiempos en el interior del edificio que usen solventes
- ☑ No aplique pesticidas
- ☑ No almacene envases de gasolina, aceite o derivados de petróleo u otros solventes dentro del edificio o garajes adjuntos (con exepción de tanques de aceite de combustible -"fuel oil")
- ☑ No opere o almacene automoviles en un garaje adjunto
- ☑ No opere equipos impulsados por gasolina dentro del edificio, garaje adjunto o alrededor de los perímetros inmediatos del edificio

Se le hara una serie de preguntas acerca de la estructura, productos de consumo que usted almacena en su edificio, y actividades de la casa típicamente ocurriendo dentro del edificio. Esas preguntas son diseñadas para identificar "antecedentes" de fuentes de contaminación de aire dentro del edificio. Mientras esta investigación esta buscando por un selecto número de químicos relacionados a la contaminación de la sub superficie, el laboratorio estará analizando las muestras de aire del interior por una variedad de químicos. Así, "tetrachloroethene" usado en tintorerías o acetona encontrada en el removedor de esmalte de uñas podria ser encontrado en los resultados de su muestra.

Su cooperación es grandemente apreciada. Si usted tiene alguna pregunta acerca de estas instrucciones, por favor sienta la libertad de contactar a NJDEP al ______________________________.

APPENDIX G

Background Volatile Levels in Homes: Literature Review

BACKGROUND LEVELS OF VOLATILE ORGANIC CHEMICALS IN HOMES: A REVIEW OF RECENT LITERATURE

Introduction

For over 20 years, it has been known that many volatile organic chemicals are present in the indoor air of homes (Wallace 1986). While small contributions from outdoor air concentrations of volatiles may occur, indoor levels are typically higher (Sexton et al. 2004, Weisel et al. 2005). This is due to indoor sources of these chemicals, including the use of consumer products, the presence of home furnishings, carpeting or other building materials, the use of construction materials and fuels, and activities such as smoking and cooking. Also, vapors from gasoline, other fuels, and other chemicals may invade the indoor air space from an attached garage (Weisel et al. 2008). For this reason, when investigating the possibility of vapor intrusion occurring in homes and other buildings, it should be evaluated whether or not volatile contaminant concentrations measured in homes are present due to these sources, rather than from vapor intrusion from underlying contaminated ground water or soil.

The previous version of this guidance reviewed several past studies, dating back to the 1980s, that measured indoor background concentrations of volatile organic chemicals. It has been observed, however, that indoor contaminant concentrations from more recent studies have tended to be lower than those from earlier studies, due to a decrease of some of these contaminants in consumer products, construction materials, etc. (Hodgson and Levin 2003, Zhu et al. 2005). Therefore, this updated literature review focuses on studies that have been conducted from the late 1990s to the present. The studies are briefly summarized below.

New Jersey Department of Environmental Protection study

The NJDEP developed its own database of indoor air background concentrations in residential buildings. Since many past indoor air studies have focused on urban centers in the United States, it was desired to conduct this study on suburban and rural portions of the state, to see if indoor air concentrations were lower than in urban areas. The study was conducted by the University of Medicine and Dentistry of New Jersey. One hundred homes were sampled in this study, scattered across 13 counties in the state (Weisel et al. 2008, 2006). The homes were single family or semi attached buildings. Almost all of the sampling was conducted in 2004 and 2005, in all seasons. Candidate homes were cross-checked against geographic information system databases of known contaminated ground water and soil sites to ensure that indoor air contaminant concentrations were not influenced by local contamination. Method TO-15 was used, with a 24-hour sample collection time. Smokers were not excluded in this study, but there were only a few smokers in the homes selected. Residents were instructed that during sampling, they should keep windows closed, avoid actively ventilating the homes, not store or use gasoline or kerosene in the home (except in a garage), not use fireplaces, and avoid painting a week before sampling. Samples were collected on the ground floor.

Massachusetts study

This study was conducted by Haley and Aldrich, Inc. and Alpha Analytical Laboratories, with oversight by the Massachusetts Department of Environmental Protection and USEPA Region I (Rago et al. 2005). Samples were collected in 2004 and 2005 in 100 residences from throughout the state (urban, suburban and rural). Method TO-15 was used, and 24-hour samples were collected in early spring and late fall with the windows closed.

New York study

Between 1997 and 2003, the New York State Department of Health conducted a study of the occurrence of volatile organic chemicals in the indoor air of homes that heat with fuel oil (NYSDOH 2006). Basement and living space samples were taken from 104 single family homes during all seasons of the year. Homes were selected from across the state (except for New York City), but the majority of homes were from the Albany, New York area. Prospective residences were required to have no past oil spills, and no hobbies or home business that regularly use products containing VOCs. Two-hour samples were collected and analyzed via Method TO-15.

Denver, Colorado study

As part of an investigation and remediation of a large area of VOC-contaminated ground water underlying several hundred residences in Denver, CO, multiple indoor air background samples were collected for approximately 100 homes after vapor intrusion was mitigated with radon-type subslab ventilation systems (Folkes and Kurtz 2002a). Data were collected only from homes where the ventilation systems removed all VOC impacts from subsurface sources. The contaminants determined were several halogenated volatile organic compounds. Twenty four-hour SUMMA® canister samples were collected between 1998 and 2001, and analyzed by Method TO-15 in the selective ion monitoring mode. Detection limits were much lower for this study than for most other studies.

Minneapolis, Minnesota study

As part of a larger study on personal, indoor and outdoor exposures to hazardous air pollutants, indoor air samples were taken from 132 homes in three urban neighborhoods in Minneapolis and Saint Paul, Minnesota (Sexton et al. 2004). The study was a joint effort of the University of Minnesota, the Minnesota Pollution Control Agency, and the University of Texas. Smokers were not included in this study. Samples were taken for 48 hours and collected in the spring, summer and fall of 1999. Charcoal-based passive air samplers were used.

Ottawa, Canada study

During the winter of 2002-2003, Health Canada sampled 75 residences from urban, suburban, and the rural fringe areas of Ottawa, Canada (Zhu et al. 2005). The homes were mostly single family homes, but a few row homes and semi-detached homes were also sampled. Ten homes were occupied by smokers. Active adsorbent tubes were used, and the ground floor of each of the residences was sampled. The sampling time was 100 minutes, during which ten liters of air was sampled.

RIOPA (Relationship of Indoor, Outdoor and Personal Air) study

A study entitled Relationship of Indoor, Outdoor and Personal Air (RIOPA) was conducted between 1999-2001 that entailed sampling personal, outdoor, indoor air and air in vehicles (Weisel et al. 2005). One hundred homes each in Houston, Texas, Los Angeles County, California, and Elizabeth, New Jersey were each sampled twice using passive vapor monitors for 48 hour exposure periods. Houses with smokers were excluded. Sampling locations in Los Angeles County and Houston were biased to areas in which known outdoor sources of air toxics exist (freeways in Los Angeles, petrochemical industries in Houston). Homes were sampled in all seasons, in the main living area.

Survey of Post-1990 studies

In 2009, Dawson and McAlary published a survey of indoor air studies conducted after 1990. It is included here for completeness. It includes the studies listed above, plus additional earlier studies conducted as early as 1990.

Summary of Indoor Background Levels

With the exception of the New Jersey RIOPA data, the studies presented here represent an entirely new dataset compared to the 2005 version of the NJDEP Vapor Intrusion Guidance. They represent the most current information available, with samples being collected from 1997-2006. (The survey from Dawson and McAlary includes some studies dating back to 1990). More than 800 homes in the United States are represented, as well as 75 homes in Canada. While it is possible that some of these studies may have inadvertently included a few homes that were located above soil or ground water contaminated with volatiles, the likelihood of this is small. Use of the median and 90th percentile statistics largely avoids the effect of such outlier homes, as well as the occasional occurrence of an unusual indoor source of a particular contaminant. The median, 90th percentile, and maximum value from the reviewed studies, are reported here.

Many earlier studies were designed as personal air monitoring studies and employed compact sampling devices that could be worn by the subject. Either adsorbent cartridges or passive adsorption badges were typically used. Many of the recent studies, on the other hand, have used the current regulatory method for indoor air sampling, specifically USEPA Method TO-15, which employs the use of SUMMA® canisters. Thus, the results from these studies are directly comparable to sample analyses conducted during vapor intrusion investigations.

The volatiles subject to NJDEP guidance for the vapor intrusion pathway were surveyed for available indoor air background information. Tables G-1, G-2 and G-3 indicate median, 90th percentile, and maximum concentrations from the various studies, and a summary of these results are given in Table G-4. Compared to the 2005 version of Table G-4, it can be seen that the ranges of concentrations reported for several chemicals are somewhat lower in the more recent studies. Also apparent is that the New Jersey suburban/rural study yielded results that were not significantly different from those studies focused on urban areas, indicating that the major source of these chemicals was indoors or in an attached garage.

For several chemicals, the agreement in reported concentrations between studies is striking. For example, median benzene concentrations were tightly clustered around 2 $\mu g/m^3$ (Table G-1). Other chemicals where median values showed very similar results between studies include 2-butanone, carbon tetrachloride, chloroform, ethylbenzene, methylene chloride, styrene, toluene and xylene. For this reason, representative median concentrations can be selected and are shown in Table G-4.

Sources of these chemicals have been reported by many investigators over the years but have recently been summarized by Weisel et al. (2008). The aromatic compounds, alkanes and MTBE are frequently correlated with each other and originate from gasoline vapors, sometimes due to storage of gasoline or the presence of a vehicle in an attached garage. MTBE occurrence is expected to decline significantly with the recent phase out of MTBE in New Jersey gasoline. Aromatic compounds may also result from smoking and combustion processes. Acetone and 2-butanone are components in nail polish remover and other cosmetics. Fluorinated organics originate from leakages in air conditioning and refrigeration units. Compounds such as methylene chloride, 1,4-dichlorobenzene, 1,1,1-trichloroethane and other halogenated chemicals may result from cleaning products, paint strippers, fragrances and deodorizers. PCE is a dry cleaning compound, but may also occur in paint strippers and paint thinners. Chloroform originates from disinfected drinking water and bleach. Other sources of contaminants are carpeting, furniture, plastics, paints, rubber, adhesives, building materials and other consumer products.

Compound-specific Occurrence Data and Selection of Median Indoor Background Concentrations

Chemicals were separated into five groups, depending on their occurrence pattern in the studies surveyed. For commonly occurring chemicals with adequate data, median concentrations were determined.

Group 1 Compounds commonly detectable via Method TO-15

Several compounds were frequently detected in indoor air at $\mu g/m^3$ concentrations using Method TO-15. For these chemicals, median concentrations were reviewed in order to select representative values (Table G-4). Generally, the New Jersey suburban/rural median concentrations were used because 1) they are New Jersey specific, 2) the study is among the most recent, and 3) median concentrations from this study were often similar to those from other studies.

Acetone – Median concentrations ranged from 6-34 $\mu g/m^3$, with the New Jersey RIOPA study near the low end and the New Jersey suburban/rural study at the high end. The New Jersey suburban/rural study used the required regulatory method (Method TO-15), which is among the most recent studies, and is specific to the State. Furthermore, health-based concentrations for this chemical in air are much higher than this range. Considering all these factors, the median background concentration for acetone was set at 34 $\mu g/m^3$.

Benzene – All studies surveyed included this chemical, with all but one yielding median concentrations above the reporting limit. These median concentrations were tightly clustered between 1.8 and 3.1 $\mu g/m^3$. The Massachusetts study indicated a median concentration that was below the reporting limit of 1.6 $\mu g/m^3$, but the 75th percentile value was 1.9 $\mu g/m^3$. Both the suburban/rural and the RIOPA New Jersey studies gave nearly the same median values (1.8 and 1.65 $\mu g/m^3$, respectively), and appear to be very representative of median benzene concentrations in indoor air. The New Jersey suburban/rural study used Method TO-15, and the rounded median value from this study (2 $\mu g/m^3$) was selected as the median background concentration.

2-Butanone (MEK) – Median concentrations reported for this chemical were also tightly clustered over a narrow range (1.5-3.5 $\mu g/m^3$). Leaving out the Canadian result, the three studies remaining are all TO-15 studies and exhibit an even narrower range of median values (2.7-3.5 $\mu g/m^3$). The value from the New Jersey suburban/rural study was at the high end of the range, but is among the most recent studies and is specific to the state. This value was rounded to 4 $\mu g/m^3$ and used as the median background concentration.

Chloromethane – Median concentrations ranged from 0.5 to 1.4 $\mu g/m^3$. For reasons similar to those for 2-butanone and acetone, the rounded value from the New Jersey suburban/rural study (1 $\mu g/m^3$) was selected as the median background concentration.

Dichlorodifluoromethane – The New Jersey suburban/rural study yielded a median concentration of 3.3 $\mu g/m^3$, while the other two studies that included this compound did not detect it at reporting limits that were lower and higher than this value. In lieu of additional information, the rounded suburban/rural New Jersey median value (3 $\mu g/m^3$) was selected as the median background concentration.

Ethyl benzene – All studies surveyed included this chemical, with all but two studies yielding median values above the reporting limit. For these studies, the measured median values were tightly clustered from 1-1.7 $\mu g/m^3$. The other two studies (the New Jersey suburban/rural study and the Massachusetts study) had higher reporting limits (2.2 $\mu g/m^3$), and median values were below this level. However, the New Jersey suburban/rural study had a lowered detection limit midway through the study which resulted in greater than 50% samples with detectable levels overall, and the median concentration for the samples run using the lower reporting limit (51 samples) was 1.1 µg/m3. Since all medians in the various studies except one were less than 1.5, a round value of 1 $\mu g/m^3$ is appropriate as the median background concentration.

n-Hexane – Three studies reported median values of 2.8, less than 3.5 and 1.6 $\mu g/m^3$. The New Jersey suburban/rural study value was 2.8 $\mu g/m^3$ and the rounded value of 3 $\mu g/m^3$ appears appropriate as a median value.

MTBE – Concentrations of this chemical are expected to decrease with time due to its phase-out in gasoline. However, for the present time, the NJDEP suburban/rural rounded median value of 3 $\mu g/m^3$ is recommended. This is somewhat lower than the three RIOPA urban studies (5-7 $\mu g/m^3$), but it is more recent, and it may reflect the decreasing use of this chemical. Furthermore, it is midrange between the three RIOPA studies and the median values observed in Massachussetts and New York (less than 2 and 0.8 $\mu g/m^3$, respectively). The Ottawa, Canada value is much lower due to historical limited MTBE use in Canada.

Toluene – Toluene median values were reported in every study and have a narrow range, from about 8-13 $\mu g/m^3$. The New Jersey suburban/rural value of 13 is at the high end of this range but it was selected because it is a New Jersey-specific value and health-based permitted air concentrations are much higher.

Trichlorofluoromethane – Three TO-15 studies investigated this chemical. Two of them (including the New Jersey study) reported a median below the detection limit of 2.8 $\mu g/m^3$. The third reported a median of 2.9 $\mu g/m^3$. Similar to the situation with ethyl benzene, the New Jersey suburban/rural study had a reporting limit decrease midway through the study to 1.1 $\mu g/m^3$. This resulted in a overall detection rate of 76% of the 100 samples. After the reporting limit change, all samples except one yielded reportable levels, with a median value of 2.1 $\mu g/m^3$. The selected median value for this chemical in indoor air is 2 $\mu g/m^3$.

Xylene – This chemical was reported in all studies. Median concentrations for m & p-xylene (combined) ranged from 1.5-5.5 $\mu g/m^3$. The New Jersey suburban/rural rounded value (4 $\mu g/m^3$) is in the middle of this range and appropriate for use as a background concentration. The results for o-xylene yielded median background levels of 1.1-1.6 μ/m^3. The New Jersey study yielded less than 2.2$\mu g/m^3$ overall, but after the detection limit was lowered to 0.87 $\mu g/m^3$ midway through the study, the median concentration was 1.4 $\mu g/m^3$, in the middle of the range reported for the other studies. Therefore, a reasonable rounded median background level for o-xylene is 1 $\mu g/m^3$.

Group 2 Compounds commonly detected with methods more sensitive than Method TO-15

The following compounds were very commonly detected at sub-$\mu g/m^3$ concentrations through the use of passive vapor monitors or carbon adsorption tubes. They were also detected with Method TO-15 in the New York and Denver, Colorado studies, for which lower reporting limits were developed than those used by New Jersey and Massachusetts. As New Jersey Method TO-15 detection limits decrease, these compounds are expected to be commonly detected. When possible, representative median values were selected for these compounds and are shown in Table G-4.

Carbon tetrachloride – Several studies in Table G-1 indicate a median background concentration of about 0.6 $\mu g/m^3$.

Chloroform – Chloroform should be frequently detected as the Method TO-15 reporting limit drops below 1 $\mu g/m^3$. Other studies indicate a median indoor air concentration of about 1 $\mu g/m^3$. This would be expected in homes with chlorinated drinking water supplies.

Cyclohexane – This chemical was detected in nearly half the homes in the New Jersey suburban/rural study. Based on the last 51 samples (after the detection limit was lowered to 0.69 $\mu g/m^3$), the median concentration of this chemical indoors is about 0.7 $\mu g/m^3$. This agrees well with the New York value of 0.8 $\mu g/m^3$.

1,2-, 1,3- and 1,4-Dichlorobenzene – Data from Minneapolis and the RIOPA studies seem to suggest median indoor background concentrations are greater than 0.1 $\mu g/m^3$ for 1,4-dichlorobenzene.

The data are too scattered to suggest a representative median concentration. The other two isomers are less common but were observed greater than 10% of the time in the New York study, which had lower reporting limits.

Methylene chloride – This chemical was detected in almost half of the samples from the New Jersey suburban/rural study. Data from other studies suggest a median background concentration of 0.4-1.5 µg/m3 in the United States, with a central tendency of 1 $\mu g/m^3$. The New Jersey study detection limits were just above this range (1.7 $\mu g/m^3$).

4-Methyl-2-pentanone – Median concentrations appear to be approximately 0.2 $\mu g/m^3$ based on data from New York and Ottawa Canada, but not enough data exist to select a representative value with confidence.

Styrene – Median concentrations from studies that had lower detection limits indicate a median concentration of 0.3-0.7 $\mu g/m^3$ with 0.5 $\mu g/m^3$ as a central value.

Tetrachloroethene (PCE) – Median concentrations appear to lie between 0.3 and 1.7 $\mu g/m^3$. The center of this range is 1 $\mu g/m^3$, but data appear too scattered to select a representative median at this time.

1,1,1-Trichloroethane – Two studies report medians of 0.3 and 0.9 $\mu g/m^3$. Insufficient data are available to judge an appropriate median value.

1,1,2-Trichloro-1,2,2-trifluoromethane – The New York study indicates a possible median of about 0.5 $\mu g/m^3$, but data are insufficient to select this value.

Trichloroethene – This compound appears to occur with a median concentration of under 0.5 $\mu g/m^3$, but there are only two studies reporting median values, so no median value was selected. It is expected to commonly be found as detection limits drop below 0.5 $\mu g/m^3$.

Group 3 The following chemicals were observed in at least 10% of homes of at least one study as shown in Table G-2, but in less than 50% of homes of all studies (Table G-1). Since no median values for these chemicals are available, median background concentrations were not developed. They are not commonly detected with current New Jersey reporting limits. Only 1,3-butadiene, carbon disulfide, and 1,2-dichloroethane were detected in the New Jersey suburban/rural study.

Bromomethane – detected in greater than 10% of some New York samples
1,3-Butadiene – detected in greater than 10% of Ottawa samples
Carbon disulfide – detected in greater than 10% of Ottawa samples
1,1-Dichloroethene – detected in greater than 10% of Ottawa samples
1,2-Dichloroethane – detected in greater than 10% of Denver samples
Hexachlorobutadiene – detected in greater than 10% of New York samples.
1,2,4-Trichlorobenzene – detected in greater than 10% of New York samples

Group 4 The following chemicals were occasionally detected, but in less than 10% of homes from any study, as indicated by their listings in Tables G-2 and G-3. Only 2-chlorotoluene and *cis*-1,2-dichloroethene were detected in the New Jersey suburban/rural study.

Chlorobenzene
Chloroethane
3-Chloropropene
2-Chlorotoluene
1,2-Dibromoethane
1,1-Dichloroethane
cis-1,2-dichloroethene
1,2-Dichloropropane

1,3-Dichloropropene
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
Vinyl chloride

Group 5 The following chemicals were never detected in any of the studies surveyed (as indicated in Table G-3), based on current regulatory or research reporting limits:

Bromodichloromethane
Bromoethene
Bromoform
Chlorodibromomethane
trans-1,2-dichloroethene
Tertiary butyl alcohol

Table G-1

Median Concentrations of Volatile Contaminants in Background Indoor Air Samples (µg/m^3)

Chemical	CAS No.	New Jersey suburban/rural study, 100 homes sampled 2003-2006, Method TO-15	Massachusetts study, 100 homes sampled 2004-2005, Method TO-15	New York fuel oil homes, 104 homes sampled 1997-2003, Method TO-15	Denver, Colorado, approximately 100 remediated homes sampled 1998-2001, Method TO-15	Minneapolis, Minnesota, 132 homes sampled in 1999, passive vapor monitors	Ottawa Canada, 75 homes sampled 2002-2003, adsorbent tubes	RIOPA study, Elizabeth, New Jersey, 100 homes sampled 1999-2001, passive vapor monitors	RIOPA study, Los Angeles, California, 100 homes sampled 1999-2001, passive vapor monitors	RIOPA study, Houston, Texas, 100 homes sampled 1999-2001, passive vapor monitors	EPA 2009 survey of studies since 1990
Acetone (2-Propanone)	67-64-1	34.5	26.45	21	-	-	28.48	7.04	6.3	12.9	-
Benzene	71-43-2	1.8	<1.6	2.1	-	1.9	2.15	1.65	2.05	3.06	2.5
Bromodichloromethane (Dichlorobromomethane)	75-27-4	<1.3	<3.35	-	-	-	-	-	-	-	-
Bromoethene (Vinyl bromide)	593-60-2	<0.87	-	-	-	-	-	-	-	-	-
Bromoform	75-25-2	<2.1	<5.16	-	-	-	-	-	-	-	-
Bromomethane (Methyl bromide)	74-83-9	<0.78	<1.94	<0.25	-	-	-	-	-	-	-
1,3-Butadiene	106-99-0	<1.1	<2	-	-	-	<0.32	-	-	-	-
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	3.5	2.66	3.4	-	-	1.48	-	-	-	-
Carbon disulfide	75-15-0	<1.6	<1.56	-	-	-	0.13	-	-	-	-
Carbon tetrachloride	56-23-5	<1.3	<3.14	<0.25	-	0.5	-	0.63	0.58	0.62	0.5
Chlorobenzene	108-90-7	<0.92	<2.3	<0.25	-	-	<0.01	-	-	-	-
Chlorodibromomethane (Dibromochloromethane)	124-48-1	<1.7	<4.26	-	-	-	-	-	-	-	-
Chloroethane	75-00-3	<1.3	<1.32	<0.25	-	-	-	-	-	-	-
Chloroform	67-66-3	<2.4	<2.44	<0.25	-	0.9	1.19	0.74	0.92	1.32	1.1
Chloromethane (Methyl chloride)	74-87-3	1.4	1.22	0.5	-	-	-	-	-	-	-
3-Chloropropene (Allyl chloride)	107-05-1	<1.6	<1.56	-	-	-	-	-	-	-	-
2-Chlorotoluene (o-Chlorotoluene)	95-49-8	<1.3	-	-	-	-	-	-	-	-	-
Cyclohexane	110-82-7	0.7[a]	<1.72	0.8	-	-	4.51	-	-	-	-
1,2-Dibromoethane	106-93-4	<1.5	<3.84	<0.25	-	-	<0.02	-	-	-	-
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	<1.2	<3.00	<0.25	-	-	<0.02	-	-	-	-
1,3-Dichlorobenzene (m-Dichlorobenzene)	541-73-1	<1.2	<3.00	<0.25	-	-	0.15	-	-	-	-
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	<3	<3.00	<0.25	-	0.2	-	<1.44	0.76	2.02	-
Dichlorodifluoromethane (Freon 12)	75-71-8	3.3	<4.94	<0.25	-	-	-	-	-	-	-
1,1-Dichloroethane	75-34-3	<0.81	<2.02	<0.25	<0.08	-	-	-	-	-	<RL
1,2-Dichloroethane	107-06-2	<0.81	<2.02	<0.25	<0.04	-	<0.02	-	-	-	<RL
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	<0.79	<1.98	<0.25	<0.04	-	<0.01	-	-	-	<RL
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	156-59-2	<0.79	<1.98	<0.25	-	-	-	-	-	-	<RL
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5	<0.79	<1.98	-	-	-	-	-	-	-	<RL
1,2-Dichloroethene (total)	540-59-0	-	-	-	-	-	-	-	-	-	-
1,2-Dichloropropane	78-87-5	<0.92	<2.31	<0.25	-	-	<0.04	-	-	-	-
1,3-Dichloropropene	542-75-6	<0.91(cis);<0.91(trans)	<2.27(cis);<2.27(trans)	<0.25(cis);<0.25(trans)	-	-	-	-	-	-	-
Ethylbenzene	100-41-4	1.1[a]	<2.17	1	-	1.4	1.05	1.29	1.45	1.68	2
Hexachloro-1,3-butadiene	87-68-3	<2.1	<5.33	<0.25	-	-	-	-	-	-	-
n-Hexane	110-54-3	2.8	<3.52	1.6	-	-	-	-	-	-	-
Mercury (elemental)	7439-97-6	-	-	-	-	-	-	-	-	-	-
Methylene chloride (Dichloromethane)	75-09-2	<1.7	<3.47	1.4	0.88	1.1	1.87	<1.68	0.84	0.44	1.1
4-Methyl-2-pentanone (MIBK)	108-10-1	<2.0	<2.05	0.3	-	-	0.16	-	-	-	-
MTBE (tert-Butyl methyl ether)	1634-04-4	3.45	<2	0.8	-	-	<0.05	5.03	7.44	5.82	1.2
Styrene	100-42-5	<2.1	<2.13	0.3	-	0.5	0.46	<0.34	0.49	0.67	-
Tertiary butyl alcohol (TBA)	75-65-0	<15	-	-	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	79-34-5	<1.4	<3.43	<0.25	-	-	<0.02	-	-	-	-
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	<3.4	<3.39	0.3	1	0.6	0.47	<1.12	1.66	0.29	0.9
Toluene	108-88-3	13	7.62	9.6	-	12.3	5.53	9.74	10.6	10.3	13
1,2,4-Trichlorobenzene	120-82-1	<3.7	<3.71	<0.25	-	-	-	-	-	-	-
1,1,1-Trichloroethane	71-55-6	<2.7	<2.72	0.3	0.86	-	-	-	-	-	1.9
1,1,2-Trichloroethane	79-00-5	<2.7	<2.72	<0.25	-	-	-	-	-	-	-
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	<2.7	<2.68	<0.25	<0.26	0.2	<0.02	0.43	<0.22	<0.24	<RL
Trichlorofluoromethane (Freon 11)	75-69-4	2.1[a]	<2.81	2.9	-	-	-	-	-	-	-
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF)	76-13-1	<1.9	<2.72	0.5	-	-	-	-	-	-	0.5
Vinyl chloride	75-01-4	<0.51	<1.28	<0.25	<0.02	-	-	-	-	-	-
Xylenes (total)	1330-20-7	3.80(m,p);1.4(o)[a]	2.99(m,p);<2.17(o)	1.5(m,p);1.1(o)	-	4.8(m,p);1.6(o)	3.59(m,p);1.22(o)	3.18(m,p);1.18(o)	4.16(m,p);1.64(o)	4.55(m,p);1.53(o)	5.5(m,p);2.2(o)

[a]last 51 samples only (see text)

\- = not analyzed

< RL = below reporting limit

Table G-2
90th Percentile Concentrations of Volatile Contaminants in Background Indoor Air Samples (μg/m^3)

Chemical	CAS No.	New Jersey suburban/rural study, 2003-2006, 100 homes	Massachusetts study, 100 homes sampled 2004-2005, Method TO-15	New York fuel oil homes, 104 homes sampled 1997-2003, Method TO-15	Denver, Colorado, approximately 100 remediated homes sampled 1998-2001, Method TO-15	Minneapolis, Minnesota, 132 homes sampled in 1999, passive vapor monitors	Ottawa Canada, 75 homes sampled 2002-2003, adsorbent tubes	EPA 2009 survey of studies since 1990
Acetone (2-Propanone)	67-64-1	91	61.59	110	-	-	76.4	-
Benzene	71-43-2	10	6.8	15	-	15.3	5.21	10
Bromodichloromethane (Dichlorobromomethane)	75-27-4	<3.4	<3.35	-	-	-	-	-
Bromoethene (Vinyl bromide)	593-60-2	<2.2	-	-	-	-	-	-
Bromoform	75-25-2	<5.2	<5.16	-	-	-	-	-
Bromomethane (Methyl bromide)	74-83-9	<1.9	<1.94	0.6	-	-	-	-
1,3-Butadiene	106-99-0	<1.1	<2	-	-	-	1.64	-
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	12.1	9.65	16	-	-	6.66	-
Carbon disulfide	75-15-0	<1.6	<1.56	-	-	-	0.86	-
Carbon tetrachloride	56-23-5	<3.1	<3.14	0.8	-	0.9	-	0.8
Chlorobenzene	108-90-7	<2.3	<2.3	<0.25	-	-	<0.01	-
Chlorodibromomethane (Dibromochloromethane)	124-48-1	<4.3	<4.26	-	-	-	-	-
Chloroethane	75-00-3	<1.3	<1.32	<0.25	-	-	-	-
Chloroform	67-66-3	2.62	2.46	1.4	-	3.4	4.39	3.9
Chloromethane (Methyl chloride)	74-87-3	2	1.75	3.3	-	-	-	-
3-Chloropropene (Allyl chloride)	107-05-1	<1.6	<1.56	-	-	-	-	-
2-Chlorotoluene (o-Chlorotoluene)	95-49-8	<2.6	-	-	-	-	-	-
Cyclohexane	110-82-7	4.53	2.78	8.1	-	-	15.1	-
1,2-Dibromoethane	106-93-4	<3.8	<3.84	<0.25	-	-	<0.02	-
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	<3.0	<3.00	0.7	-	-	<0.02	-
1,3-Dichlorobenzene (m-Dichlorobenzene)	541-73-1	<3.0	<3.00	0.6	-	-	1.05	-
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	3.77	<3.00	1.3	-	1.5	-	-
Dichlorodifluoromethane (Freon 12)	75-71-8	9.56	4.98	15	-	-	-	-
1,1-Dichloroethane	75-34-3	<2.0	<2.02	<0.25	-	-	43.21	<RL
1,2-Dichloroethane	107-06-2	<2.0	<2.02	<0.25	0.1	-	<0.02	0.15
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	<2.0	<1.98	<0.25	-	-	0.83	<RL
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	156-59-2	<2.0	<1.98	<0.25	-	-	-	<RL
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5	<2.0	<1.98	-	-	-	-	<RL
1,2-Dichloroethene (total)	540-59-0	-	-	-	-	-	-	-
1,2-Dichloropropane	78-87-5	<2.3	<2.31	<0.25	-	-	<0.04	-
1,3-Dichloropropene	542-75-6	<2.3(cis);<2.3(trans)	<2.27(cis);<2.27(trans)	<0.25(cis);<0.25(trans)	-	-	-	-
Ethylbenzene	100-41-4	9.64	5.25	7.3	-	8.9	4.76	8.6
Hexachloro-1,3-butadiene	87-68-3	<5.3	<5.33	4.6	-	-	-	-
n-Hexane	110-54-3	16.2	14.23	18	-	-	-	-
Mercury (elemental)	7439-97-6	-	-	-	-	-	-	-
Methylene chloride (Dichloromethane)	75-09-2	6.74	10.53	22	10	11.5	43	10
4-Methyl-2-pentanone (MIBK)	108-10-1	<2.0	<2.05	2.2	-	-	0.8	-
MTBE (tert-Butyl methyl ether)	1634-04-4	40.7	38.31	26	-	-	<0.05	26
Styrene	100-42-5	<2.1	<2.13	1.3	-	1.4	1.49	-
Tertiary butyl alcohol (TBA)	75-65-0	<15	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	79-34-5	<3.4	<3.43	<0.25	-	-	<0.02	-
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	4.39	<3.39	2.9	4.5	3.8	3.25	4
Toluene	108-88-3	60.8	42.51	58	-	53.8	25.47	51
1,2,4-Trichlorobenzene	120-82-1	<3.7	<3.71	3.4	-	-	-	-
1,1,1-Trichloroethane	71-55-6	2.81	<2.72	3.1	5.1	-	-	5.5
1,1,2-Trichloroethane	79-00-5	<2.7	<2.72	<0.25	-	-	-	-
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	<2.7	<2.68	0.5	0.3	0.8	0.19	0.9
Trichlorofluoromethane (Freon 11)	75-69-4	6.25	3.56	17	-	-	-	-
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF)	76-13-1	<3.8	3.83	1.8	-	-	-	1.8
Vinyl chloride	75-01-4	<1.3	<1.28	<0.25	-	-	-	0.03
Xylenes (total)	1330-20-7	30.2(m,p);11.1(o)	20.52(m,p);6.78(o)	12(m,p);7.6(o)	-	36.9(m,p);11.4(o)	16.35(m,p);6.48(o)	27(m,p);10(o)

- = not analyzed
<RL = below reporting limit

Table G-3
Maximum Concentrations of Volatile Contaminants in Background Indoor Air Samples (µg/m^3)

Chemical	CAS No.	New Jersey suburban/rural study, 2003-2006, 100 homes	Massachusetts study, 100 homes sampled 2004-2005, Method TO-15	New York fuel oil homes, 104 homes sampled 1997-2003, Method TO-15	Denver, Colorado, approximately 100 remediated homes sampled 1998-2001, Method TO-15	Ottawa Canada, 75 homes sampled 2002-2003, adsorbent tubes
Acetone (2-Propanone)	67-64-1	2900	257	690	-	456
Benzene	71-43-2	42	28.1	460	-	21
Bromodichloromethane (Dichlorobromomethane)	75-27-4	<3.4	<3.35	-	-	-
Bromoethene (Vinyl bromide)	593-60-2	<2.2	-	-	-	-
Bromoform	75-25-2	<5.2	<5.16	-	-	-
Bromomethane (Methyl bromide)	74-83-9	<1.9	<1.94	23	-	-
1,3-Butadiene	106-99-0	4.4	2.05	-	-	3.65
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	150	11.2	180	-	16.45
Carbon disulfide	75-15-0	4.4	<1.56	-	-	3.29
Carbon tetrachloride	56-23-5	<3.1	<3.14	4.2	-	-
Chlorobenzene	108-90-7	<2.3	<2.3	0.6	-	0.04
Chlorodibromomethane (Dibromochloromethane)	124-48-1	<4.3	<4.26	-	-	-
Chloroethane	75-00-3	1.3	5.4	4.5	-	-
Chloroform	67-66-3	5.9	8.26	25	-	8.23
Chloromethane (Methyl chloride)	74-87-3	6.2	4.21	260	-	-
3-Chloropropene (Allyl chloride)	107-05-1	1.6	<1.56	-	-	-
2-Chlorotoluene (o-Chlorotoluene)	95-49-8	6.2	-	-	-	-
Cyclohexane	110-82-7	52	9.45	510	-	54
1,2-Dibromoethane	106-93-4	<3.8	<3.84	1.1	-	<0.02
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	16	<3.00	4.9	-	0.11
1,3-Dichlorobenzene (m-Dichlorobenzene)	541-73-1	<3.0	<3.00	2.5	-	16.19
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	270	34.2	770	-	-
Dichlorodifluoromethane (Freon 12)	75-71-8	160	82.2	300	-	-
1,1-Dichloroethane	75-34-3	<2.0	<2.02	4.4	0.16	-
1,2-Dichloroethane	107-06-2	3.5	2.76	4.9	0.72	0.71
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	<2.0	<1.98	430	<0.04	4.05
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	156-59-2	2.9	<1.98	7.4	-	-
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5	<2.0	<1.98	-	-	-
1,2-Dichloroethene (total)	540-59-0	-	-	-	-	-
1,2-Dichloropropane	78-87-5	<2.3	<2.31	34	-	<0.04
1,3-Dichloropropene	542-75-6	<2.3(cis);<2.3(trans)	<2.27(cis);<2.27(trans)	3.5(cis);<0.25(trans)	-	-
Ethylbenzene	100-41-4	39	24.5	340	-	201
Hexachloro-1,3-butadiene	87-68-3	<5.3	<5.33	51	-	-
n-Hexane	110-54-3	270	38.5	950	-	-
Mercury (elemental)	7439-97-6	-	-	-	-	-
Methylene chloride (Dichloromethane)	75-09-2	94	146	2100	180	408
4-Methyl-2-pentanone (MIBK)	108-10-1	9.8	11.2	36	-	1.4
MTBE (tert-Butyl methyl ether)	1634-04-4	470	155	340	-	3.32
Styrene	100-42-5	5.1	3.24	50	-	6.53
Tertiary butyl alcohol (TBA)	75-65-0	<15	-	-	-	-
1,1,2,2-Tetrachloroethane	79-34-5	<3.4	<3.43	2.7	-	<0.02
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	540	27.6	51	440	9.23
Toluene	108-88-3	160	944	510	-	113
1,2,4-Trichlorobenzene	120-82-1	<3.7	<3.71	37	-	-
1,1,1-Trichloroethane	71-55-6	9.3	21.3	110	210	-
1,1,2-Trichloroethane	79-00-5	<2.7	<2.72	6.2	27	-
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	13	110	25	-	0.87
Trichlorofluoromethane (Freon 11)	75-69-4	62	162	190	-	-
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF)	76-13-1	2.1	4.35	7.4	-	-
Vinyl chloride	75-01-4	<1.3	<1.28	1	0.5	-
Xylenes (total)	1330-20-7	91(m,p);38(o)	81.9(m,p);27.8(o)	550(m,p);310(o)	-	139(m,p);205(o)

- = not analyzed

Table G-4
Summary of Ambient Indoor Levels and New Jersey Median Background Concentrations of Volatile Contaminants in Homes (µg/m3)[a]

Chemical	CAS No.	Range of median values	Representative median indoor air concentrations	Range of 90th percentile values
Acetone (2-Propanone)	67-64-1	6-34	34	62-110
Benzene	71-43-2	<1.6-3.1	2	5.2-15
Bromodichloromethane (Dichlorobromomethane)	75-27-4	<RL		<RL
Bromoethene (Vinyl bromide)	593-60-2	<RL		<RL
Bromoform	75-25-2	<RL		<RL
Bromomethane (Methyl bromide)	74-83-9	<RL		0.6[c]
1,3-Butadiene	106-99-0	<RL		1.6[b]
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	1.5[b];2.7-3.5[d]	4	6.7[b];9.6-16[d]
Carbon disulfide	75-15-0	0.13[b]		0.86[b]
Carbon tetrachloride	56-23-5	<0.25-0.6	0.6[f]	0.8-0.9
Chlorobenzene	108-90-7	<RL		<RL
Chlorodibromomethane (Dibromochloromethane)	124-48-1	<RL		<RL
Chloroethane	75-00-3	<RL		<RL
Chloroform	67-66-3	<0.25-2.4	1	1.4-3.4[d];4.4[b]
Chloromethane (Methyl chloride)	74-87-3	0.5-1.4	1	1.8-3.3
3-Chloropropene (Allyl chloride)	107-05-1	<RL		<RL
2-Chlorotoluene (o-Chlorotoluene)	95-49-8	<RL		<RL
Cyclohexane	110-82-7	0.7-0.8[d];4.5[b]	0.7	2.8-8.1[d];15[b]
1,2-Dibromoethane	106-93-4	<RL		<RL
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	<RL		0.7[c]
1,3-Dichlorobenzene (m-Dichlorobenzene)	541-73-1	0.15[b]		0.6-1
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	0.2-2		1.3-3.8
Dichlorodifluoromethane (Freon 12)	75-71-8	<0.25-3.3	3	5-15
1,1-Dichloroethane	75-34-3	<RL		<RL
1,2-Dichloroethane	107-06-2	<RL		0.1[e]
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	<RL		0.83[b]
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	156-59-2	<RL		<RL
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5	<RL		<RL
1,2-Dichloroethene (total)	540-59-0	-		-
1,2-Dichloropropane	78-87-5	<RL		<RL
1,3-Dichloropropene	542-75-6	<RL		<RL
Ethylbenzene	100-41-4	1.0-1.7	1	4.8[b];5.2-9.6[d]
Hexachloro-1,3-butadiene	87-68-3	<RL		4.6[c]
n-Hexane	110-54-3	1.6-2.8	3	14-18
Mercury (elemental)	7439-97-6	-		-
Methylene chloride (Dichloromethane)	75-09-2	0.44-1.9	1[f]	6.7-22[d], 43[b]
4-Methyl-2-pentanone (MIBK)	108-10-1	0.16-0.3		0.8-2.2
MTBE (tert-Butyl methyl ether)	1634-04-4	<0.05[b];0.8-7.4[d]	3	<0.05[b];26-41[d]
Styrene	100-42-5	0.3-0.7	0.5[f]	1.3-1.5
Tertiary butyl alcohol (TBA)	75-65-0	<RL		<RL
1,1,2,2-Tetrachloroethane	79-34-5	<RL		<RL
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	0.3-1.7		2.9-4.5
Toluene	108-88-3	5.5[b];7.6-13[d]	13	25[b];42-61[d]
1,2,4-Trichlorobenzene	120-82-1	<RL		3.4[c]
1,1,1-Trichloroethane	71-55-6	0.3-0.9		<2.7-5.1
1,1,2-Trichloroethane	79-00-5	<RL		<RL
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	<0.02[b];0.2-0.4[d]		0.2[b];0.3-0.8[d]
Trichlorofluoromethane (Freon 11)	75-69-4	2.1-2.9	2	3.6-17
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF)	76-13-1	0.5[c]		1.8-3.8
Vinyl chloride	75-01-4	<RL		<RL
Xylenes (total)	1330-20-7	1.5-5(m,p);1.1-1.6(o)	4(m,p);1(o)	12-37(m,p);6-11(o)

[a]EPA study not included
[b]Ottawa, Canada study only
[c]New York study only
[d]United States studies only
[e]Denver study only
[f]Below New Jersey reporting limit
<RL= less than reporting limit

APPENDIX H

Common Background Indoor Air Sources

Common Background Indoor Air Sources

Acetone	rubber cement, cleaning fluids, scented candles and nail polish remover
Benzene	automobile exhaust, gasoline, cigarette smoke, scented candles, scatter rugs and carpet glue
Bromomethane	soil or space fumigant
1, 3-Butadiene	automobile exhaust and residential wood combustion
2-Butanone (MEK)	automobile exhaust, printing inks, fragrance/flavoring agent in candy and perfume, paint, glue, cleaning agents and cigarette smoke
Chlorobenzene	scented candles, plastic foam insulation and paint products
Chloroethane	refrigerant
Chloroform	generated from chlorinated water (showers)
Cyclohexane	gasoline, paint thinner, paint and varnish remover
1,4-Dichlorobenzene	moth balls, general insecticide in farming, air deodorant and toilet disinfectant
Dichlorodifluoromethane	refrigerant (CFCs) and cleaning solvent
1, 1-Dichloroethane	plastic products (food and other packaging material) and flame retardant fabrics
1,2-Dichloroethane	polyresin molded decorations (particularly from China)
1, 1-Dichloroethene	plastic products (food and other packaging material), adhesives and flame retardant fabrics
1, 3-Dichloropropene	fungicides
Ethylbenzene	paint, paint thinners, insecticides, wood office furniture, scented candles and gasoline
Formaldehyde	building materials (particle board), furniture, insulation and cigarette smoke
n-Heptane	gasoline, nail polishes, wood office furniture and petroleum products
n- Hexane	gasoline, rubber cement, typing correction fluid and aerosols in perfumes
Methylene chloride	hairspray, paint stripper, rug cleaners, insecticides and furniture polish
Methyl isobutyl ketone (MIBK)	paints, varnishes, dry cleaning preparations, naturally found in oranges, grapes and vinegar
Methyl *tert* butyl ether (MTBE)	gasoline (oxygenating agent)
Naphthalene	cigarette smoke, automobile exhaust, residential wood combustion, insecticides and moth balls
Styrene	cigarette smoke, automobile exhaust, fiberglass, rubber and epoxy adhesives, occurs naturally in various fruits, vegetables, nuts and meats
Tertiary butyl alcohol (TBA)	gasoline (oxygenating agent)
1, 1 , 2 ,2-Tetrachloroethane	solvent, paint and rust removers, varnishes and lacquers
Tetrachloroethene (PCE)	dry cleaning, metal degreasing, adhesives and glues, insecticides, scented candles and rug cleaner

Toluene	gasoline, automobile exhaust, polishes, nail polish, synthetic fragrances, paint, scented candles, paint thinner, adhesives and cigarette smoke
1, 1, 1-Trichloroethane	spot cleaner, glues, insecticides, drain cleaners, shoe polish
Trichloroethene (TCE)	glues, adhesives, paint removers, spot removers, rug cleaning fluids, paints, metal cleaners, typewriter correction fluid, and automotive cleaning and degreasing products
1, 2, 4-Trimethylbenzene	gasoline and automobile exhaust
1, 3, 5–Trimethylbenzene	gasoline and automobile exhaust
2 ,2, 4-Trimethylpentane	gasoline and automobile exhaust
Xylenes, total	water sealer, gasoline, automobile exhaust, markers, paint, floor polish and cigarette smoke

APPENDIX I

Simple Smoke Visualization Test to Assess Backdrafting

SIMPLE SMOKE VISUALIZATION TEST TO ASSESS BACKDRAFTING

(ITRC 2007)

The following procedures have been recommended by the ITRC for initial investigation and evaluation for the possibility of backdrafting;

1. Start test with the flue of all combustion appliances cool.
2. Close all exterior and interior windows and doors.
3. Open all HVAC supply and return air duct vents/registers.
4. Close fireplace and wood stove dampers.
5. Turn on all exhaust and air distribution fans and combustion appliances except the appliance being tested for Backdrafting (this does not include whole house fans).
6. Wait 5 minutes.
7. Turn on the appliance being tested. If the appliance is a forced-air furnace, ensure that the blower starts to run before proceeding.
8. Wait 5 minutes.
9. Using a smoke tube, check for flue gas entrainment near the vent hood. Smoke flow should be distinctly up into the hood and up the flue
10. If the chemical smoke is drawn up the flue, this would indicate a positive draft, qualitatively demonstrated and backdrafting would not seen to be a problem.
11. Repeat the test for each natural draft appliance being tested for Backdrafting. Extreme or unusual weather conditions need to be considered when evaluating these data.

If a backdrafting potential is identified, the sub-slab depressurization system should not be installed or operated until a qualified HVAC contractor can assess the backdrafting potential with a more comprehensive test and correct the problem.

As an added level of safety, ensure that carbon monoxide detectors are properly installed in the building.

APPENDIX J

Installation Procedures of Permanent Sub-slab Probes for Monitoring VI Mitigation Systems

INSTALLATION PROCEDURE
FOR PERMANENT SUB-SLAB PROBES

1.0 PURPOSE AND SCOPE

The purpose of this document is to detail the design and installation procedures of one example of a permanent sub-slab probe in the support of VI investigations. This type of probe can be utilized for the temporal repeatable collection of air samples from beneath the slab of buildings and for monitoring the effectiveness of a system for the mitigation of VI. Alternative design and installation procedures are acceptable.

2.0 HEALTH AND SAFETY

Prior to penetrating the subsurface, a check for the presence of utilities must be performed. Contact the local utility companies (gas, water, sewer, electric, phone) via the New Jersey One Call system (1-800-272-1000) to mark the location of utilities coming into the building from the outside. The utilities can then be traced into the building for their location. If needed, a plumber and/or electrician may be consulted to assist in identifying the location of utilities inside the building.

3.0 LOCATIONS AND QUANTITY OF SUB-SLAB PROBES

The quantity and locations of the permanent sub-slab probes will be dependent upon the objectives of the data that is required. Permanent sub-slab probes can be used for the collection of soil gas samples from the sub-slab atmosphere or for the collection of physical measurement data to monitor the effectiveness of a mitigation system.

This type of probe should be used for the collection of analytical data when several rounds of data will be required from the subsurface from a building. This will prevent variability in data from sample location and/or probe installation. The number of probes required will be dependent upon the size of the building and site specific characteristics.

The quantity of sub-slab probes to support the effectiveness of a mitigation system will be site specific based on the results of the communication test data during system installation. At a minimum, four probes are recommended on each side or corner of a building. Further information can be found in Section 6.3.2.5 of the VIT Guidance.

4.0 SUB-SLAB PROBE CONSTRUCTION

The recommended material for construction for the sub-slab probe is 316 stainless steel Swagelock® compression fittings. This material has the durability for long term use and is non-reactive to VOCs. No specialized fittings are required to connect to the probe. The ¼" NPT threads make connecting to the probe easy with common pipe fittings. This probe construction is slightly larger than other permanent probe constructions from ¼" connectors, ¼" caps and others found in the literature. Field experience has shown that those designs are not as durable due to the probe easily breaking loose in the concrete seal from over-tightening of fittings. The parts list for the sub-slab probe is as follows:

a. SS-400-7-4 - Female connector (tapered thread) ¼" tube x x1/4" NPT.

b. SS-401-PC – ¼” Tube fitting port connector.
c. *4534K12 (McMaster-Carr) Flush mount-high pressure steel thread hex socket plug, ¼” pipe, PTFE coated, ¼” Hex, 13/32 length

The construction dimensions of this probe will allow the inlet of the probe to be located within the building slab. This helps prevent the clogging of the probe with sub-slab material.

5.0 SUB-SLAB PROBE INSTALLATION

The sub-slab probe is quickly and easily installed with standard tools. The following is a list of tools and materials required for the installation:

a. rotary hammer drill with 1-1/4” diameter x 10” long spline-shank masonry bit
b. hammer drill with ¼” diameter x 12”-18” long masonry bit
c. extension cords
d. shop vacuum
e. quick drying cement or hydraulic cement with mixing cup and water
f. non VOC clay (pottery clay)
g. paper towels
h. duct tape
i. distilled water
j. carpet knife
k. sub-slab probe

5.1 Installation Procedures

5.1.1 Select the location for the permanent sub-slab probe based on the objectives of the phase of work, presence or potential presence of obstructions and input from the building owner.

5.1.2 If a floor covering is drilled through for the placement of the probe, future plans of the replacement or repair of the covering should be made in advance.

If carpeting is present, a “flap” can be cut into the carpet for access to the slab. This “flap” can then be pushed back into place when work is competed. If a sheet flooring product is present, a section can be removed to allow drilling and used for replacement after decommissioning. For tile flooring, a replacement tile or section of flooring should be obtained for installation after the probe is decommissioned.

5.1.3 Using a hammer and chisel, chip an “X” in the concrete as a starting point for drilling to prevent the bit from “wandering” off the desired target location.

5.1.4 Determine the desired depth of the probe body and mark this length on the 1-1/4” masonry bit by wrapping with duct tape with an “ear”. The “ear” will act as a depth gauge. When duct tape “ear” it hits the slab, the bit is at the appropriate depth. The desired depth of the hole will be dependent if the probe is to be flush with the floor or slightly countersunk to the floor.

5.1.5 Use the rotary hammer drill with the 1-1/4” bit to advance the outer hole to the proper depth and vacuum out the cuttings.

5.1.6 Using the hammer drill with a ¼" bit, place the bit in the center of the1-1/4" hole and drill through the slab into the subsurface material by 3-6". A significant increase in the rate of penetration by the drill will indicate the bottom of the slab has been passed through.

5.1.7 Vacuum out the drill cuttings from in and around the hole. Test fit the probe in the hole so it is at the desired location. Alter the hole depth if required.

5.1.8 Dampen a paper towel with distilled water and wipe away the dust from the 1-1/4" hole and wet the sidewalls. Do not allow excess water on the towel go into the sub-surface.

5.1.9 With a small piece of duct tape, wrap it around the plug on the probe while covering the top of the probe. This will protect the threads of the probe and plug from cement during the installation.

5.1.10 Using a small piece of clay, roll it until it is in a thin "cigar" shape. Place the clay around the port connector at the ¼" nut. Insert the probe into the hole, the clay forms a seal between the two holes in the slab, not allowing cement into the smaller hole and the subsurface.

5.1.11 Mix a small amount of cement and pour into the annular space around the probe. Allow the cement to cure for the recommended time for curing by the manufacturer of the cement. After curing remove the tape from the probe and clean the surface of unwanted cement. Figure 1 is a schematic of the cross section of the permanent sub-slab probe installation that is countersunk to the slab.

5.2 Annular Seal Leak Check

After allowing the cement to cure, a leak check should be performed to ensure a competent annular seal of the probe. A leaking annular seal will result in inaccurate readings that are biased low for physical or analytical measurements.

Perform the annular seal leak check by placing a vacuum on the probe and placing a bead of water around the probe (if installed counter sunk to the slab). Watch for changes in the water level or, use a tracer gas (helium, isopropyl alcohol, nitrogen, carbon dioxide), hook up a DRI to the probe and check for a response to the tracer gas. These same techniques can be used during sampling of the sub-slab atmosphere. If a leak is discovered, the probe must be removed, re-installed and tested again for leaks.

5.3 Flow and Vacuum Check

A flow and vacuum check should be performed on the probe if there is the potential to use the probe to collect a sample from the sub-slab atmosphere for analysis. Obtaining a sample from a sub-slab probe with excessive vacuums can change the partitioning of vapors between pore water and the soil gas potentially biasing VOC concentrations high. In addition, the high vacuum may increase the risk of leakage between the sub-slab probe and the sample container.

The flow and vacuum check is performed by connecting a pump to the probe and running at a flow rate of 200 ml/min until the vacuum stabilizes. During this test the vacuum should also be monitored. The investigator should be aware of potential portioning of VOCs from the sub-slab materials due to vacuum or flow rates.

6.0 Measurement of Sub-Slab Pressures

Measurement of sub-slab pressures (differential between the indoor air and sub-slab atmospheres) can be easily determined via the permanent sub-slab probe. A simple barb fitting connected to a digital micro-manometer capable of reading 0.001 inches of water can be used to determine the depressurization of the slab-slab atmosphere to monitor the effectiveness of a mitigation system.

7.0 Decommissioning

Once it is determined that monitoring of the sub-slab atmosphere is no longer required due to remediation of the contaminant source or other reason, the sub-slab probe can be removed. The probe can be removed by breaking the annular seal with a chisel or rotary hammer with a bull point. Once the probe is removed, seal the hole with concrete to the original level and replace the flooring that was removed during installation or glue the carpet "flap" to the floor.

The following sources were utilized in developing the installation procedures for sub-slab probes.

California Environmental Protection Agency. 2005. Guidance for the Evaluation and Migration of Subsurface Vapor Intrusion to Indoor Air. Department of Toxic Substances Control.

Hartman, B. 2004. Vapor Monitoring Wells/Implants. Standard Operating Procedures (vapor intrusion applications). H&P Mobile Geochemistry, Solana Beach, California

Hartman, B. 2004. Sub-Slab Soil Vapor. Standard Operating Procedures (vapor intrusion applications). H&P Mobile Geochemistry, Solana Beach, California.

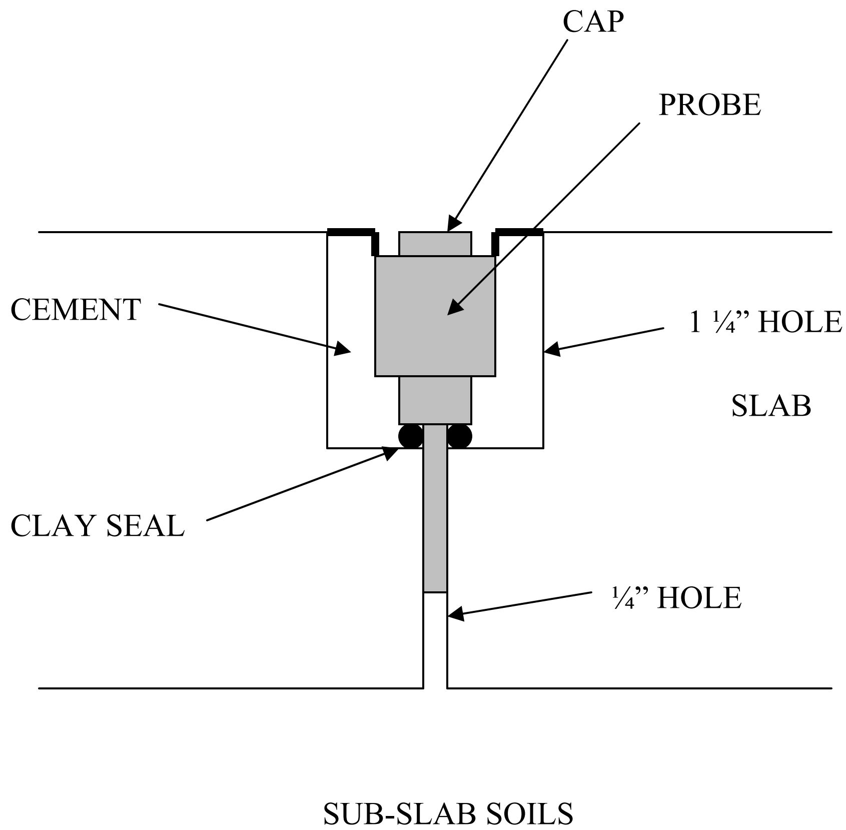
New York State Department of Health. 2006. Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York. Center for Environmental Health, Bureau of Environmental Exposure Investigation. October 2006

Reynolds, Peter A. 2007. The Use of Tracer Gas in Soil Vapor Intrusion Studies. In Proceedings of the Annual International Conference on Soils, Sediments, Water and Energy, Volume 12, Article 39. The Berkeley Electronic Press.

U.S. Environmental Protection Agency (USEPA). 2006. Assessment of Vapor Intrusion in Homes near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples. EPA/600/R-05/147, March 2006

U.S. Environmental Protection Agency (USEPA), Region 8. Not Dated. Draft-Standard Operating Procedures for Installation of Sub-Slab Vapor Probes and Sampling Using EPA Method TO-15 to Support Vapor Intrusion Investigations. (Accessed 2009).

FIGURE I
SUB-SLAB PROBE CONSTRUCTION

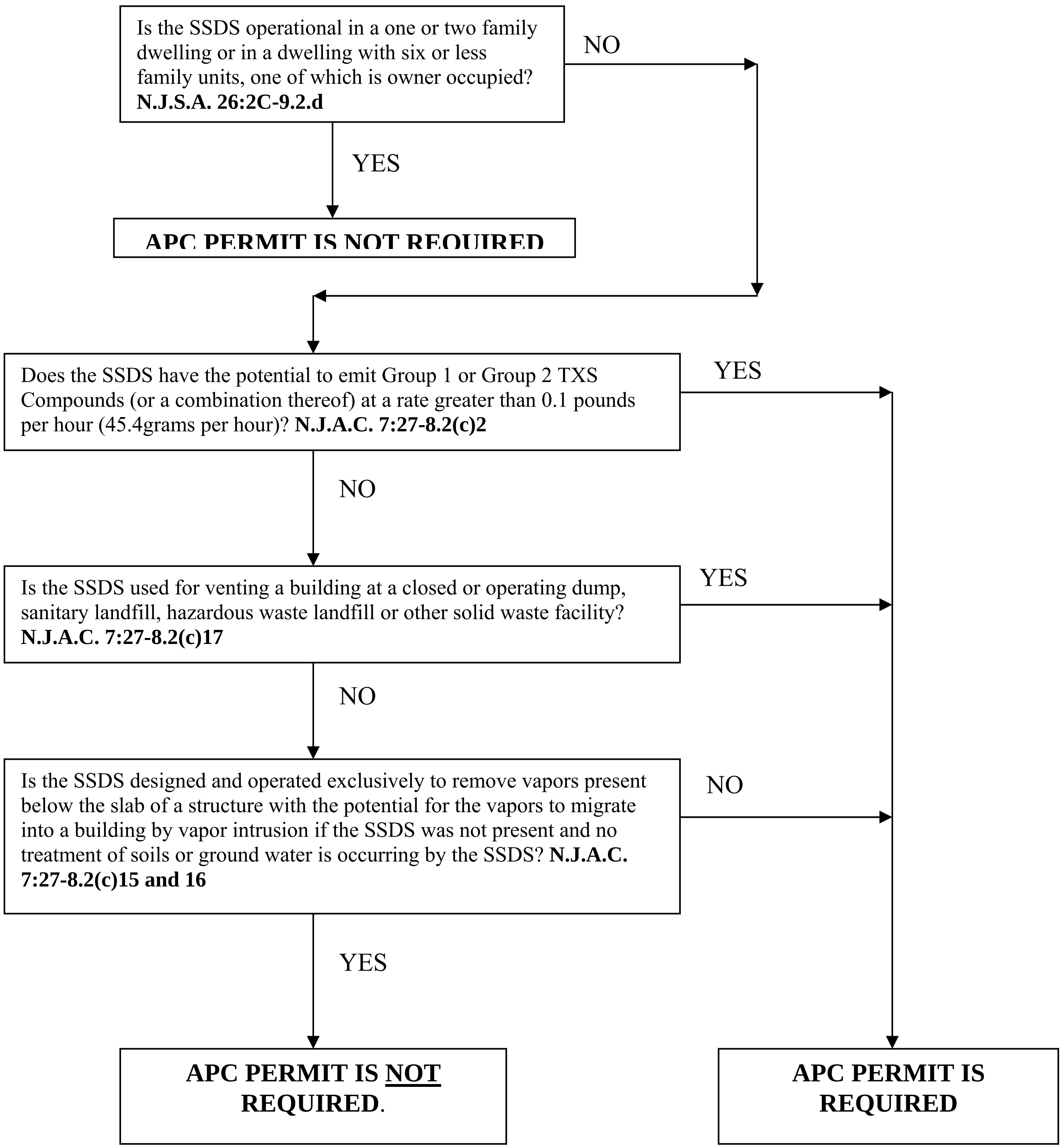


APPENDIX K

Decision Flow Chart for Air Pollution Control Permit

APPLICATION FLOW CHART FOR AN AIR POLUTION CONTROL (APC) PERMIT

APRIL 2009



LIST OF TOXIC SUBSTANCES (TXS) FROM GROUP 1 AND 2
(N.J.A.C. 7:27-17.3)

GROUP 1 TOXIC SUBSTANCES (GROUP 1 TXS)

Benzene (Benzol)
Carbon tetrachloride (Tetachloromethane)
Chloroform (Trichloromethane)
Dioxane (1,4-Diethylene dioxide; 1,4-Dioxane)
Ethylenimine (Ariridine)
Ethylene dibromide (1,2-Dibromomethane)
Ethylene dichloride (1,2-Dichloromethane)
1,1,2,2-Tetrachloroethane
Tetrachloroethylene (Perchloroethylene)
1,1,2-Trichloroethane (Vinyl trichloride)
Trichloroethylene (Trichloroethene)

GROUP 2 TOXIC SUBSTANCES (GROUP 2 TXS)

Methylene chloride (Dichloromethane)
1,1,1-Trichloroethane (Methyl chloroform)

APPENDIX L

Determining Air Pollution Control Permit Requirement

APPLICATION OF AN AIR POLLUTION CONTROL (APC) PERMIT FOR THE OPERATION OF A SUBSURFACE DEPRESSURIZATION SYSTEMS
APRIL 2009

An Air Pollution Control (APC) Permit would be required for a Sub-Slab Depressurization System (SSDS) if any of the following apply:

1. N.J.A.C. 7:27-8.(c)2 which requires an APC Permit for any source operation or equipment that has the potential to emit any Group 1 or Group 2 TXS (or a combination thereof) at a rate greater than 0.1 pounds per hour (45.4 grams per hour); or

2. N.J.A.C. 7:27-8.2(c)15 which requires an APC Permit for any equipment which is used for treating groundwater, industrial waste water, or municipal wastewater with a solids content of less than two percent by weight as it enters the equipment; or

3. N.J.A.C. 7:27-8.2(c)16 which requires an APC Permit for any equipment that is used for treating waste soils or sludges, including municipal solid wastes, industrial solid wastes, or recycled materials, if the influent to the equipment has a solids content of two percent by weight or greater; or

4. N.J.A.C. 7:27-8.2(c)17 which requires an APC Permit for any equipment used for the purpose of venting a closed or operating dump, sanitary landfill, hazardous waste landfill, or other solid waste facility, directly or indirectly into the outdoor atmosphere including, but not limited to, any transfer station, recycling facility, or municipal solid waste composting facility;

The complete text of N.J.A.C. 7:27-8.2(c) can be found at the following website: www.state.nj.us/dep/aqpp.

Consequently, if the SSDS is designed and operated exclusively to remove vapors present below the slab of the structure and no treatment of the soils or groundwater is occurring, an APC Permit would not be required pursuant to N.J.A.C. 7:27-8.2(c) 15 or 16. However, any SSDS located at a closed or operating landfill would need an APC Permit pursuant to N.J.A.C. 7:27-8.2(c)17. In addition, one or two family dwellings and a dwelling of six or less family units, one of which is owner occupied, are exempt from obtaining an Air Pollution Control Permit and Certificate pursuant to N.J.S.A. 26:2C-9.2.d.

For further details, contact the appropriate regional NJDEP Air Enforcement Regional Office (http://www.nj.gov/dep/enforcement/air.html or 609-633-7994) to determine if your system requires an APC Permit.

APPENDIX M

Vapor Intrusion Mitigation System Inspection Checklist

VAPOR INTRUSION MITIGATION SYSTEM
INSTALLATION/INSPECTION CHECKLIST

Address inspected: ____

Person(s) interviewed: ______________________________

Date of inspection: ____________________ **Time of inspection:** ____________ to ____________

Inspector(s): ____

Make and Model of Fan ____

Date System Installed____

1.0 Systems Installation and Interior Piping Recommendations	**Yes**	**No**	**Unk / NA**
1.1 Are all manifold and suction point piping solid, rigid pipe with the required diameter for the designed air flow?	____	____	____
1.2 Are all vent pipes and connections constructed of schedule 40 PVC and/or meeting all applicable codes?	____	____	____
1.3 Are all pipe interior joints and connections in mitigation systems sealed permanently? (Exceptions include installation of fans and sump covers)	____	____	____
1.4 Does the system piping avoid attachment to or support by existing pipes, ducts, conduits or any kind of equipment?	____	____	____
1.5 Does the system piping avoid blocking window and doors or access to installed equipment?	____	____	____
1.6 Are supports for system piping installed at least every four (4) feet on horizontal runs?	____	____	____
1.7 Are pipe supports present at ends of branches and at changes in elevation or direction?	____	____	____
1.8 Are vertical runs secured and within all applicable codes?	____	____	____
1.9 Are suction point pipes supported and secured in a permanent manner that prevents their downward movement to the bottom of suction pits or sump pits, or into the soil beneath a soil-gas-retarder membrane?	____	____	____
1.10 Are horizontal runs in system piping sloped to ensure that water from rain or condensation drains downward into the ground beneath the slab or soil-gas-retarder membrane?	____	____	____
1.11 Does the system piping pass the smoke stick check (no leaks)?	____	____	____
1.12 Are sample ports located on the vent pipe and at the required distances from air flow Disturbances based on distance criteria set in Air Test Method 1 (40 CFR Part 60, Appendix A – posted 8/23/2011)?	____	____	____

2.0 General Sealing Recommendations

2.1 Are openings around the suction point piping penetrations of the slab properly sealed using methods and materials that are permanent/durable and pass the smoke stick check? ____ ____ ____

2.2 Are accessible openings around utility penetrations of the foundation walls and slab, test holes, wells and other openings in slabs properly sealed using methods and materials that are permanent / durable and pass the smoke stick check? ____ ____ ____

2.3 Are openings / cracks sealed where the slab meets the foundation wall (if appropriate)? ____ ____ ____

2.4 At the point where vent pipe and electric conduit exits the building, is urethane caulk or equivalent material used, and when the joint is greater than ½ inch in width, is a foam backer rod or other comparable filler material inserted into the joint before the application of the sealant (principally from the outside)? ____ ____ ____

2.5 When installing baseboard-type suction systems, are all baseboard sealed to walls and floors with adhesives also designed and recommended for such installations? ____ ____ ____

2.6 Are all utility and other penetrations through a soil-gas-retarder membrane sealed? ____ ____ ____

2.7 Did all cracks or openings in the slab or wall pass the smoke test? If not, identify the location of failed cracks or openings in the Notes & Comments Section below. ____ ____ ____

3.0 Electrical Recommendations

3.1 Is there adequate access to service the fan and other electrical services? ____ ____ ____

3.2 Is the plugged cord used to supply power to the fan no more than six feet in length? ____ ____ ____

3.3 Is the exteriorly plugged vent fan used only in a weatherproof housing or chase? ____ ____ ____

3.4 Does the plugged cord avoid penetrating a wall or being sealed within a wall? ____ ____ ____

3.5 Is the power supply to an exterior mounted fan (not installed in a weather-proof housing) hard-wired with a non-locking electrical disconnect within line of sight and 4 feet of the fan? ____ ____ ____

3.6 Is the circuit breaker controlling the vent fan labeled "Vapor Mitigation System"? ____ ____ ____

4.0 Sub-Membrane Depressurization Recommendations

4.1 Is a sub-membrane depressurization system part of the mitigation system? ____ ____ ____

4.1.1 Is the sub-membrane material constructed of a minimum 40 mil polyethylene (PE) or a material equivalent in performance (see Section 6.3.4)? ____ ____ ____

4.1.2 In areas of high foot traffic or use, is a wearing surface installed to protect the membrane from rips and tares by materials placed on top of the membrane or from punctures by stones and rocks in the crawlspace? ____ ____ ____

4.1.3 Are seams overlapped by (12) twelve inches using a compatible adhesive? ____ ____ ____

4.1.4 Is the sub-membrane material secured to the walls with sealant and furring strips or, an equivalent method? ____ ____ ____

4.1.5 Did the sub-membrane depressurization system pass the smoke test? ____ ____ ____

4.1.6 Is a “T” installed on the end of the suction pipe to aid in depressurization? ____ ____ ____

4.1.7 Are sample ports located on the vent pipe and at the required distances from obstructions based on the sampling method? ____ ____ ____

5.0 Sump Pit Recommendations

5.1 Is there a sump pit in basement? ____ ____ ____

If yes:

5.1.1 Is there a mitigation system designed to draw soil gas from the sump pit? ____ ____ ____

5.1.2 Is the sump pit cover designed to facilitate removal for sump pit maintenance? ____ ____ ____

5.1.3 Is the sump pit installed with an impermeable cover and sealed with the recommended sealant? ____ ____ ____

5.1.4 Are the penetrations through the cover sealed? ____ ____ ____

5.1.5 Does the cover have a clear view port to permit observations of conditions in the sump pit? ____ ____ ____

5.1.6 Are sample port(s) located on the vent pipe and at the required distances from obstructions based on the sampling method (Air Test Method 1 CFR Part 60, Appendix A – posted 8/23/2011)? ____ ____ ____

6.0 Inaccessible Crawl Space Ventilation Recommendations

6.1 Is an inaccessible crawl space ventilation system part of the mitigation system? ____ ____ ____

If yes:

6.1.1 Is the inaccessible crawl space clear of combustion appliances? ____ ____ ____

6.1.2 Are all openings and cracks to the inaccessible crawl space sealed and pass the smoke test? ____ ____ ____

6.1.3 Is a valve or similar device present to control the air flow to the crawlspace? ____ ____ ____

6.1.4 Are sample port(s) located on the vent pipe and at the required distances from obstructions based on the sampling method? ____ ____ ____

6.1.4 Are the outside vents clear of debris and obstructions and in good condition? ____ ____ ____

6.1.5 Does the inaccessible crawl space ventilation system meet the ventilation requirements in the SOW? ____ ____ ____

7.0 Monitors and Labeling Recommendations

7.1 Does each suction point have a mechanism to measure vacuum? ____ ____ ____

7.2 Is the pressure reading from the latest commissioning clearly marked on the vent pipe? ____ ____ ____

7.3 Are the current diagnostic measurements within a 20% difference as compared to the system commissioning (baseline) values? ____ ____ ____

7.4 Is a system description label noting "Vapor Mitigation System" placed on the system piping or other prominent location and legible from at least three feet? ____ ____ ____

7.5 Does the label contain the name and phone number of the contact person in case of emergency? ____ ____ ____

7.6 Does the mitigation system avoid causing backdrafting of combustion products into the building? ____ ____ ____

7.7 Were indoor air measurements taken using a DRI with a CO detector? ____ ____ ____

If yes:

7.7.1 Type of instrument used:____

7.7.2 Concentration of CO in basement:_________ppm.

7.8 Were the vacuum readings in the system stable during the backdraft test? ____ ____ ____

7.9 Does the mitigation system include an operational audible alarm to inform occupants of a system malfunction? ____ ____ ____

8.0 System Vent Discharge Point Recommendations

8.1 Is the vent pipe vertical and upward, outside the structure, at least 10 feet above ground level, and above the edge of the roof ? **(Req. A)** ____ ____ ____

8.2 Is the discharge of the vent pipe ten feet or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure, if the vapor discharge point is not at least 2 feet above the top of such openings? **(Req. B)** ____ ____ ____

8.3 Is the discharge of the vent pipe ten feet or more away from any opening into the conditioned or other occupiable spaces of an adjacent building? Chimney flues shall be considered openings. **(Req. C)** ____ ____ ____

8.4 For vent stack pipes that penetrate the roof, is the point of discharge at least 12 inches above the surface of the roof? **(Req. D)** ____ ____ ____

8.5 For vent stack pipes attached to or penetrating the sides of the buildings, is the point of discharge vertical and a minimum of 12 inches above the surface of the roof. ____ ____ ____

8.6 Does the horizontal run of vent stack pipe penetrate the gable end walls? **(Req. E)** ____ ____ ____

8.7 If yes, does the piping outside the structure routed to a vertical position so that the discharge point meets the requirements of (**A**), (**B**), (**C**), and (**D**)? ____ ____ ____

8.8 Do points of discharge that are not in a direct line of sight from openings into conditioned or otherwise occupiable space because of intervening objects, such as dormers, chimneys, windows around the corner, etc. meet the separation requirements of (**A**), (**B**), (**C**), (**D**) and (**E**)? ____ ____ ____

8.9 Is the outside vent piping fastened to the structure of the building with hangers, strapping or other supports that will secure it adequately (every 8 feet)? ____ ____ ____

8.10 Does the discharge piping size avoid causing back pressure to the blower? ____ ____ ____

8.11 Is the vent stack constructed of schedule 40 PVC or 3x4 inch aluminum downspout? ____ ____ ____

8.12 Is system piping and electric conduit sealed at the point of entry to the building and in compliance with fire codes? ____ ____ ____

8.13 Are all PVC pipe connections sealed permanently, with an adhesive that is compatible with the pipe material construction? ____ ____ ____

8.14 Are all aluminum downspout connections sealed permanently and secured with screws? ____ ____ ____

8.15 Is a diffuser cap or "T" installed for the vent discharge to prevent rain and debris from entering the vent? ____ ____ ____

8.16 Are sample ports present to measure air flow and vacuum and at the required distances from obstructions in air flow based on the sampling method (Air Test Method 1)? ____ ____ ____

8.17 Are all vent pipes on the discharge side of fan installed on the exterior of the building? ____ ____ ____

9.0 Fan Installation Recommendations

9.1 Is the fan installed in a configuration that avoids condensation buildup in the fan housing or is a condensate bypass system present? ____ ____ ____

9.2 Is the fan mounted on the exterior of buildings rated for outdoor use or installed in a weatherproof protective housing? ____ ____ ____

9.3 Is the fan mounted and secured in a manner that minimizes transfer of vibration to the structural framing of the building? ____ ____ ____

9.4 Does the system operate without noise or vibration above normal conditions? ____ ____ ____

9.5 If a fan is installed in the interior of a building, is the fan installed in an unoccupied attic or garage not beneath conditioned spaces? ____ ____ ____

9.6 Is the fan installed in a vertical run of pipe? ____ ____ ____

9.7 Is the fan mounted to the vent pipe with removable or flexible connections? ____ ____ ____

10.0 Passive Depressurization System Recommendations

10.1 Does the vent pipe run up through the building to the roof? ____ ____ ____

10.2 Are the horizontal runs of pipe in heated space? ____ ____ ____

10.3 Is the vent pipe insulated in the attic? ____ ____ ____

10.4 Is there a cap or screen on the vent pipe to prevent debris from entering vent? ____ ____ ____

10.5 Is an electrical box rough out installed in the attic near the vent pipe? ____ ____ ____

10.6 Was a sub-slab venting layer installed to allow the flow of soil gasses to the vent? ____ ____ ____

10.7 Was lateral venting pipe installed in the venting layer for the collection of soil gas vapors? ____ ____ ____

10.8 Was a gas vapor barrier installed and properly sealed? ____ ____ ____

10.9 What was the material and thickness of the gas vapor barrier? ____

11.0 Design Drawing and As-Built Drawing Recommendations

11.1 Was an "as built" drawing provided? ____ ____ ____

11.2 Was the system and monitoring network installed as per the design drawings? ____ ____ ____

12.0 Notes & Comments

13.0 Required Corrective Actions

APPENDIX N

Subsurface Depressurization Monitoring Form (Large Blower)

SUBSURFACE DEPRESSURIZATION SYSTEM MONITORING DATA
(LARGE BLOWER)

Site Name: ____ **Date:**______________

Company:_________________________________ **Technician:**________________________________

Blower ID#:_______________ **Make/Model/HP:** ____

Weather Conditions:____

Time of Readings		Barometric Pressure (“Hg)	
Influent Flow (CFM)		Amps	
Dilution Air Flow (CFM)		Est. % Dil. Valve Open	
Recirculation Flow (CFM)		Est. % Recirculation Valve Open	
Effluent Flow (CFM)		VOC-Total (ppmv)	
Influent Vacuum (“WC)		Methane (ppmv)	
Effluent Pressure (“WC)		Non-Methane (ppmv)	
Influent Air Temp (°F)		% Oxygen	
Effluent Air Temp (°F)		% LEL	

Vapor Extraction Point (VEP) Data

VEP ID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Time of Readings												
Flow (CFM)												
Vacuum (“WC)												
Air Temp (°F)												
Est. % Valve Open												
VOC-Total (ppmv)												
Methane (ppmv)												
Non-Methane (ppmv)												
% Oxygen												

Sub-Slab Probe Data (SSP) Data

SSP ID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Time of Readings												
Vacuum (“WC)												
% Oxygen												

System operational upon arrival? __________ System operational upon departure? __________

Bailed water traps/Empty KOP? ____________ Estimated Gallons ____________________

Comments:

APPENDIX O

Subsurface Depressurization Monitoring Form (Small Blower)

SUBSURFACE DEPRESSURIZATION SYSTEM MONITORING DATA (SMALL BLOWER)

Company:____ Date:________________________
Technician:____
Street Address: ____
Make/Model of Fan; ____ Time: ________________
Weather conditions:____

Fan Data

	FAN #1		**FAN #2**	
FAN ID:	Current	Previous	Current	Previous
Vacuum (“WC)				
Airflow (CFM)				
Pressure (“WC)				
VOC- Total (ppmv)				
VOC-methane (ppmv)				
VOC-non-methane (ppmv)				
% O_2				

Vapor Extraction Point (VEP) Data

	VEP-1		**VEP-2**		**VEP-3**	
FAN ID:	Current	Previous	Current	Previous	Current	Previous
Valve- % Open						
Vacuum (“WC)						
Airflow (CFM)						
VOC- Total (ppmv)						
VOC-methane (ppmv)						
VOC-non-methane (ppmv)						
% O_2						

Sub-Membrane Depressurization (SMD) Data

	SMD-1		**SMD-2**		**SMD-3**	
	Current	Previous	Current	Previous	Current	Previous
Valve- % Open						
Vacuum (“WC)						
Airflow (CFM)						
VOC- Total (ppmv)						
VOC-methane (ppmv)						
VOC-non-methane (ppmv)						
% O_2						

Date of “previous” results in tables above and below: ___________________

SUBSURFACE DEPRESSURIZATION SYSTEM MONITORING DATA (SMALL BLOWER)

Inaccessible Crawlspace Ventilation (ICV) Data

	ICV-1		**ICV-2**		**ICV-3**	
	Current	Previous	Current	Previous	Current	Previous
Valve- % Open						
Crawlspace Volume (ft^3)						
Airflow (ft/min)						
Airflow (CFM)						
VOC- Total (ppmv)						
VOC-methane (ppmv)						
VOC-non-methane (ppmv)						
% O_2						
Number of Air Exchanges/hr						

Sub-Slab Probe Data (SSP) Data

SSP ID	SSP-1	SSP-2	SSP-3	SSP-4	SSP-5	SSP-6
Vacuum (“WC)-Previous						
Vacuum (“WC)-Current						
% Oxygen						

COMMENTS:____
____
____
____
____
____
____
____

APPENDIX P

Electrical Cost Estimates for Subsurface Depressurization Systems

ELECTRICAL COST ESTIMATES FOR A SUBSURFACE DEPRESSURIZATION SYSTEM (SSDS)

Calculations for Determining Electric Cost

First determine the watts required by the fan. The watts required by the fan can be obtained from the information plate on the fan unit or from the fan specifications sheet provided with the fan or manufacturer.

If the wattage of the fan is unknown, locate or measure the amperage and voltage of the unit and calculate the watts:

W = V x A

W = Watts
V= Voltage
A=Amperage

Then calculate the kilo-watt hours (kWh) used by the fan per day:

kWh/day = W x 1 KW/1000 watts x hrs/day

Since the fan runs for 24 hours /day, the hrs/day will be 24.

Calculate the kWh used per year (assume 365 days per year)

kWh/month = kWh x 365 days/year

Using electric cost, determine the cost of operating the fan:

$$$/month = kWh/year x $/kWh

Example of Electric Cost Estimate of SSDS

As an example, a fan with a maximum power rating of 150 watts with an electrical service charge of $0.170156/kWh will result in a yearly electrical cost as follows:

150 watts x KW/1000watts x 24 hrs/day x 365 days/year x $0.170156/kWh =
$ 223.58/year or $ 18.63/month.

Cost to operate the fan will vary based on fan power requirements and energy cost.

APPENDIX Q

Glossary

Building— An enclosed construction over a plot of land, having a roof, door(s) and usually window(s) that is or can be occupied by people and utilized for a wide variety of activities that may include, but are not limited to, residential, commercial, retail, and/or industrial uses.

Conceptual Site Model (CSM) - A written and/or illustrative representation of the physical, chemical and biological processes that control the transport, migration and potential impacts to receptors. Development and refinement of the CSM will help identify investigative data gaps in the characterization process and can ultimately support remedial decision making.

Contaminants of Concern (COC) - Site-specific compounds associated with a discharge(s) at or from a site that are detected in environmental media (soil, ground water, surface water, sediment, air) above regulatory criteria. It also includes the degradation byproducts from the COCs.

Engineered system response - A system that is designed to mitigate risk or remediate an IEC as further described in the Department's Immediate Environmental Concern guidance.

Free product - A separate phase material, present in concentrations greater than a contaminant's residual saturation point. This definition applies to solids, liquids, and semi-solids. The presence of free product shall be determined pursuant to the methodologies described in N.J.A.C. 7:26E-2.1(a)14.

Immediate environmental concern (IEC) – As it relates to VI, a condition at a contaminated site where contamination in indoor air is at a level greater than any VI RAL included in or developed consistent with the Department's VI Guidance.

Indoor air screening level (IASL) – The concentrations of volatile contaminants in indoor air that necessitate mitigation when the contamination is related to the VI pathway. The IASLs are based on the higher of the health-based indoor air screening value and the analytical reporting limit.

Landfill - A sanitary landfill (7:26-1.4) defined as a solid waste facility, at which solid waste is deposited on or into the land as fill for the purpose of permanent disposal or storage for a period of time exceeding six months, except that it shall not include any waste facility approved for disposal of hazardous waste.

Licensed site remediation professional (LSRP) - A person defined as such pursuant to the Administrative Requirements for the Remediation of Contaminated Sites rules, N.J.A.C. 7:26C-1.3.

Light non-aqueous phase liquid (LNAPL) - Hydrocarbons that exist as a separate and immiscible phase liquid when in contact with water and/or air, can exist as a continuous phase (mobile) and/or a discontinuous mass (immobile) and is less dense than water at ambient temperature.

Mitigation - The implementation of measures designed to prevent the migration of vapors into buildings impacted or potentially impacted by the VI pathway. The measures are necessary to prevent exposure to people (e.g., building occupants) while more comprehensive measures are undertaken to remediate the source of the VI pathway.

Neutral pressure plane - A level of neutral pressure inside a building between the positive pressure that causes exfiltration and the negative pressure that causes infiltration.

Rapid action level (RAL) - Contaminant concentrations in indoor air when exceeded and determined to be related to the vapor intrusion pathway indicate an Immediate Environmental Concern (IEC) condition exists. The RAL concentrations are based on 100 times the rounded carcinogenic health-based indoor air screening value or a factor of 2 times the rounded noncarcinogenic health-based indoor air screening value, whichever is lower, and the higher of the resulting health-based indoor air screening value or the analytical reporting limit.

Sensitive uses/populations - People in buildings, including but not limited to residential homes, schools and child care centers that are considered to be high risk populations for potential health effects associated with exposure to contaminants. Consistent with the Remediation Standards (N.J.A.C. 7:26D-1.5), the Department requires use of the residential screening levels in the evaluation of the VI pathway for schools and child care centers, in addition to residential buildings.

Soil gas screening level (SGSL) – The concentrations of volatile contaminants in soil gas when exceeded and associated with a discharge indicate the potential for vapor intrusion to impact overlying buildings. The SGSLs incorporate an attenuation factor of 0.02 and are based on the higher of the health-based soil gas screening value and the analytical reporting limit.

***Structure* - A** small construction that has limited access or occupancy capability with minimal exposure potential to those individuals that may occupy the structure for a much shorter period of time.

***Vapor cloud* - C**ontamination in the soil vapor with no collated contamination in the soil or groundwater; likely caused by subsurface vapor leaks or from downward vapor migration through slabs.

***Vapor intrusion* - T**he migration of volatile chemicals from the subsurface into overlying buildings (USEPA 2002b).

Volatile Compound – A compound is considered to be volatile if its Henry's law constant is greater than 10^{-5} atm m^3 mol^{-1} and its vapor pressure is greater than 1 mm Hg at room temperature. A volatile compound can be an organic or inorganic compound.

APPENDIX R

Acronyms

AOC	area of concern
APC	Air Pollution Control
ARRCS	Administrative Requirements for Remediation of Contaminated Sites
BTEX	benzene, toluene, ethylbenzene and xylenes
BWDS	block wall depressurization system
bwt	below the water table
CEA	Classification Exception Area
COC	contaminant of concern
CSM	conceptual site model
DTDS	drain tile depressurization system
EPDM	ethylene propylene diene monomer
ESRA	Engineered System Response Action
FID	flame ionization detector
FSPM	Field Sampling Procedures Manual
GC	gas chromatography
GWQS	Ground Water Quality Standards
GWSL	Ground Water Screening Level
HDNL	Health Department Notification Level
HDPE	high-density polyethylene
HVAC	heating, ventilation and air conditioning
IA	indoor air
IASL	Indoor Air Screening Level
IEC	immediate environmental concern
IRA	interim response action
ITRC	Interstate Technology and Regulatory Council
J&E	Johnson and Ettinger model
LEL	lower explosive limit
LFG	landfill gas
LLDPE	linear low density polyethylene
LNAPL	light non-aqueous phase liquid
LSRP	licensed site remediation professional

LTM	long-term monitoring
µg/m3	microgram per cubic meter
MLE	multiple lines of evidence
MME	monitoring, maintenance and evaluation
MSDS	Material Safety and Data Sheet
MTBE	methyl tertiary-butyl ether
NAPL	non-aqueous phase liquid
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection or Department
NJDHSS	New Jersey Department of Health and Senior Services
OMM	Operation, Maintenance and Monitoring
OSHA	Occupational Safety and Health Administration
PCE	tetrachloroethene (also called perchloroethene)
PEL	permissible exposure limit
PHC	petroleum hydrocarbons
PID	photoionization detector
QA	quality assurance
RAL	Rapid Action Level
RL	reporting limits
SGSL	Soil Gas Screening Level
SMDS	sub-membrane depressurization system
SRRA	Site Remediation Reform Act
SSDS	sub-slab depressurization system
SSSG	sub-slab soil gas
SSVS	sub-slab ventilation system
SVE	soil vapor extraction
TCE	trichloroethene
TRSR	Technical Requirements for Site Remediation (N.J.A.C. 7:26E) or Technical Rules
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency

VC	vapor concern
VI	vapor intrusion
VIT	Vapor Intrusion Technical
VS	verification samples
VOC	volatile organic compound