Starting Soon: Vapor Intrusion Mitigation Training – Session 1

- Vapor Intrusion Mitigation Training Online Guidance Document, https://vim-1.itrcweb.org/.
- Download PowerPoint slides
  - CLU-IN training page at https://clu-in.org/conf/itrc/VIM-1/. Under "Download Training Materials."

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Advancing Environmental Solutions

Vapor Intrusion Mitigation
VIM-1, 2021

Session 2

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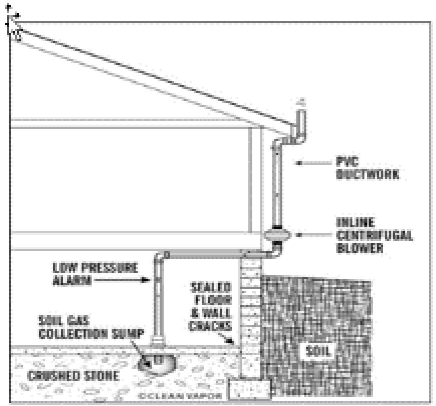
Internet Based Training (IBT)
Session 2



Source: T. Hatton, 2020. Used with permission.

Active Mitigation

Passive Mitigation

Source: Pixabay (adapted).

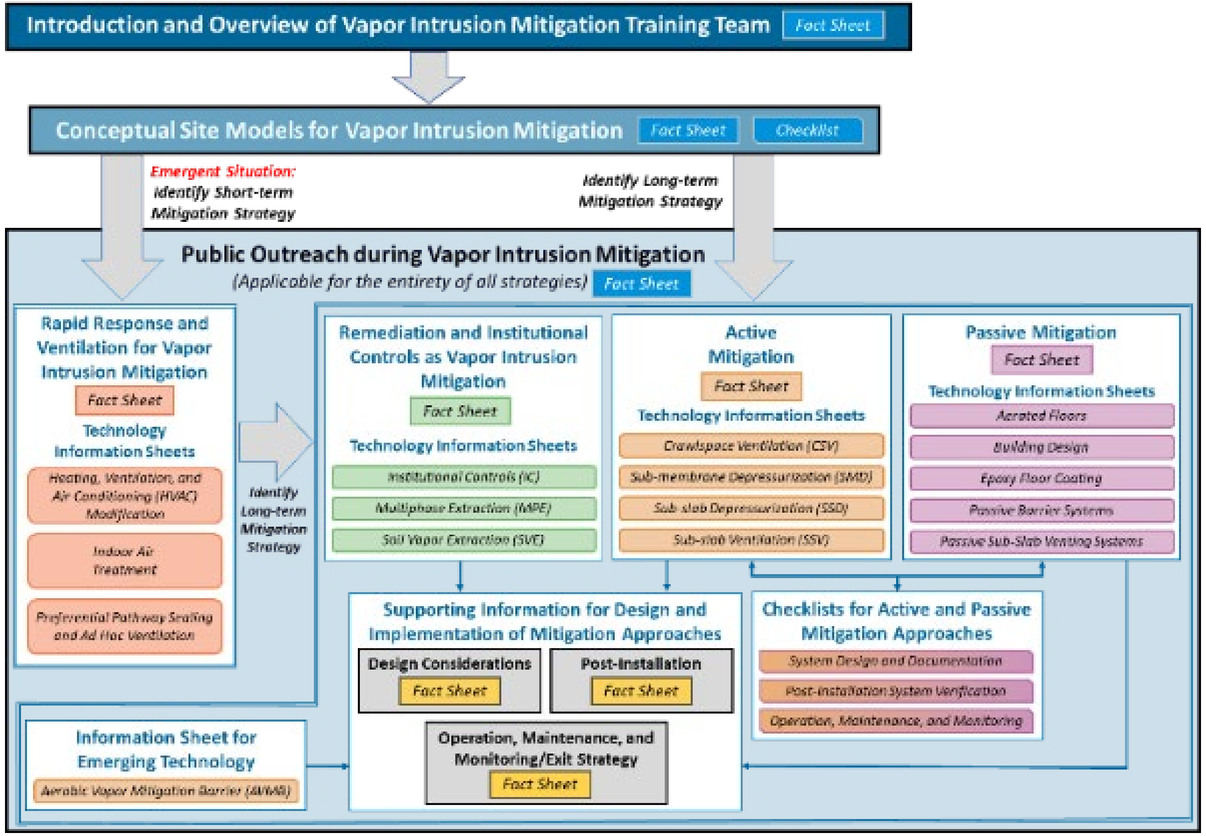
System Verification and OM&M/ Exit Strategy

What You Should Learn

- Background on the VIM Training team
- Overview of available documentation
- How access the mitigation strategies information
- Identify the sections that will be discussed in today’s session

ITRC VIM Webpage

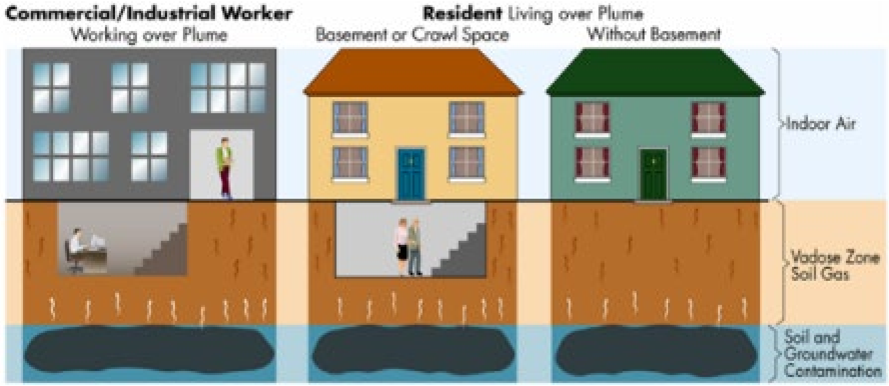
- Interactive Directory
- Fact Sheets
- Technology Information Sheets
- Flow Chart for VIM CSM Development (Figure 2-1)
- Considerations and impacts of various VIM approaches
- Checklists
- Additional information



https://vim-1.itrcweb.org/

Vapor Intrusion (VI) Reminder

- Contaminants in soil and groundwater can volatilize into soil gas.
- VI occurs when these vapors migrate upward into overlying buildings and contaminate indoor air.
- *Chlorinated Vapor Intrusion (CVI):* addresses chlorinated compounds
- *Petroleum Vapor Intrusion (PVI):* subset of VI that deals exclusively with petroleum hydrocarbon (PHC) contaminants

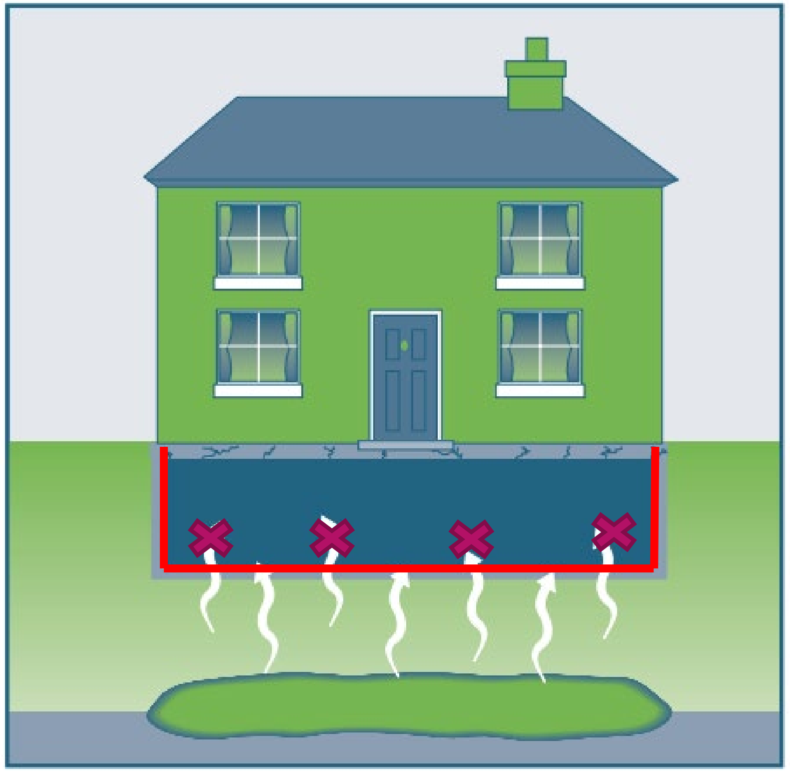


Source: ITRC Vapor Intrusion Pathway: A Practical Guideline (VI-1, 2007)

Source: ITRC Petroleum Vapor Intrusion Guidance (PVI-1, 2014)

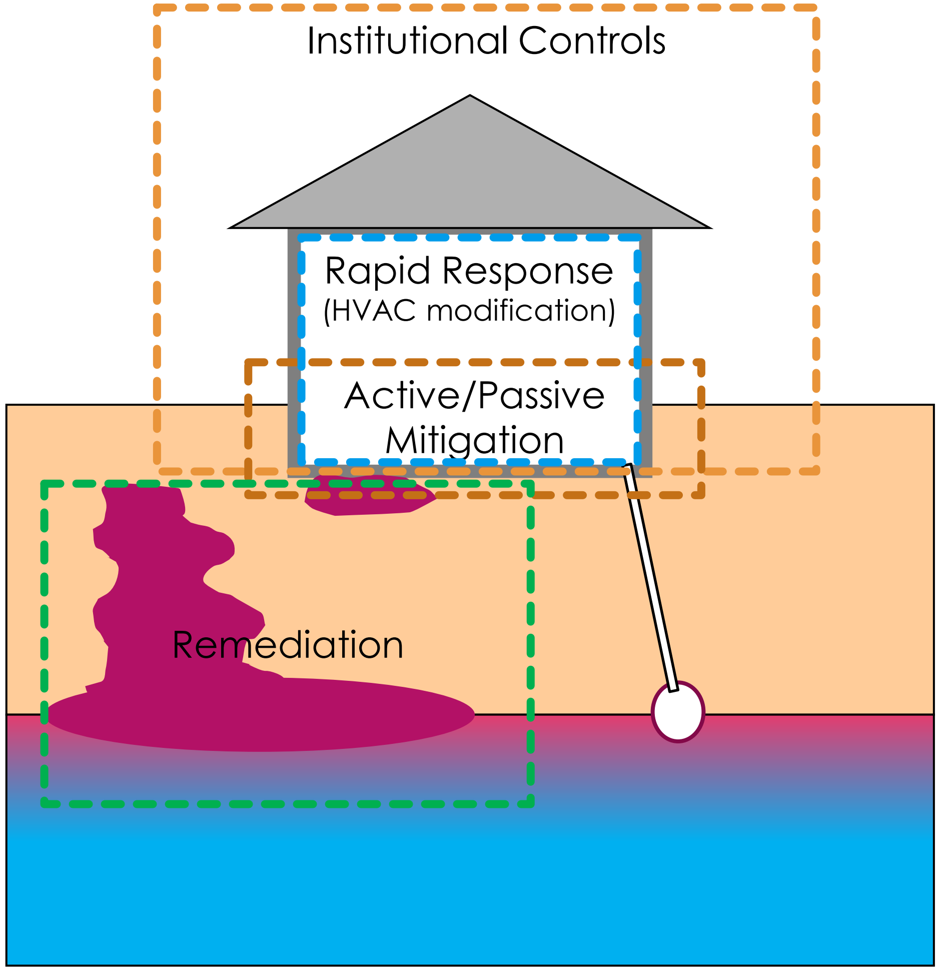
VI Mitigation (VIM)

- Implemented to reduce indoor air contaminants due to VI below applicable action or screening levels
- Accomplished by
  - Modifying the VI pathway to reduce the mass flux of contaminants entering the building
  - Reducing indoor air contaminant concentrations by removal or dilution



What is VI Mitigation (or Vapor Control)?

- VOC Vapor control can include
  - Source remediation
  - Active or passive mitigation
  - Rapid response
  - Institutional controls



Source: Geosyntec & GSI Environmental, 2020. Used with permission.

Steps in the VIM Process

Pre-System Installation

1. Assessment of Site Conditions
2. Technology Selection
3. Develop and Document System Design

System Installation

4. Pre-construction Meeting
5. Installation
6. Installation Oversight

Post-System Installation

7. System Verification
   a) Inspection
   b) Verification Sampling
   c) Confirming Performance QA/QC
8. Documentation
9. Operation, Maintenance, and Monitoring

Coming Up Next…

Introduction

Session 1

- CSM for VI Mitigation
- Public Outreach
- Rapid Response & Ventilation
- Remediation & Institutional Controls

Session 2

- Active Mitigation Approaches
- Passive Mitigation Approaches
- System Verification, OM&M, and Exit Strategy

Closing Remarks

Q&A Session to be conducted after each module

Advancing Environmental Solutions

Active Mitigation Approaches

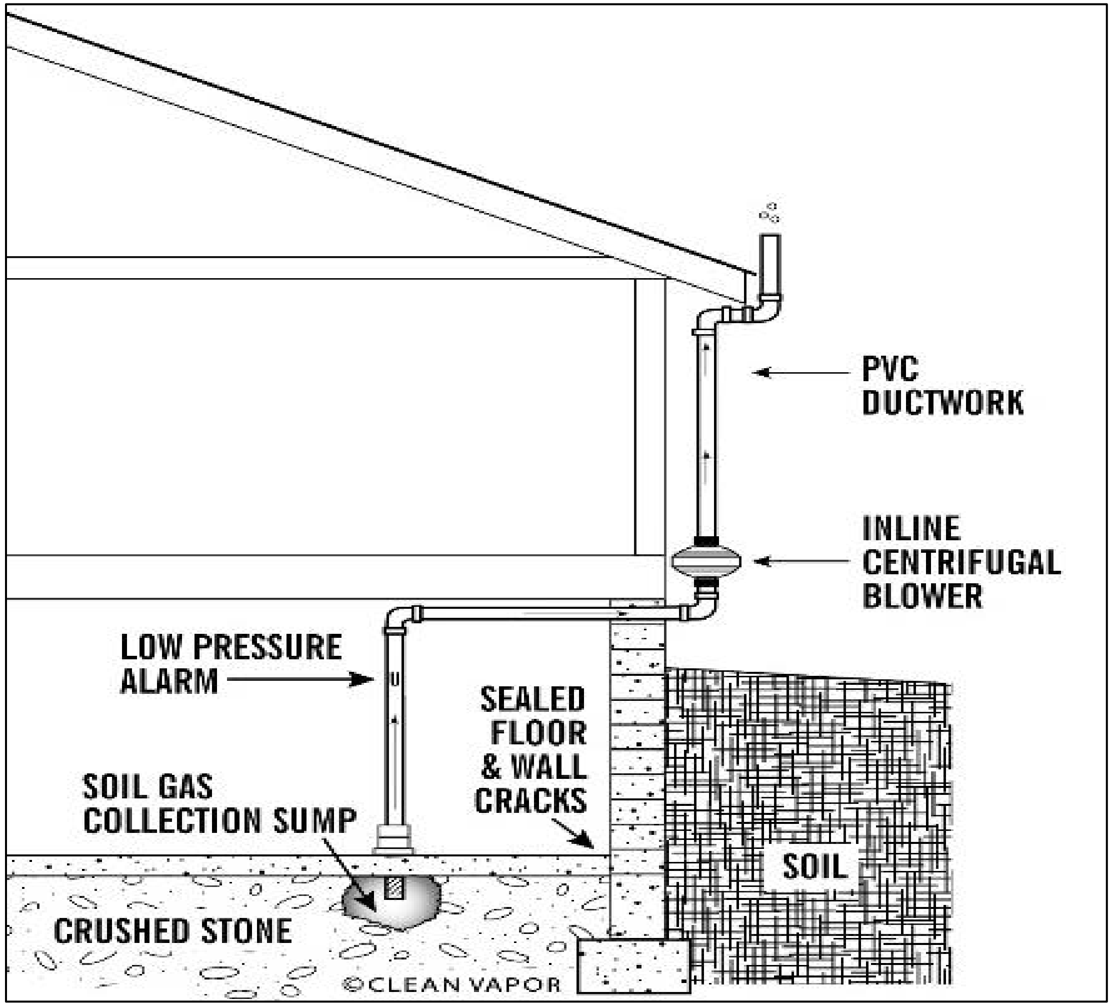


Figure 1 of the Sub-slab Depressurization (SSD) Technology Information Sheet.

Objectives of Module

- ▶ Active mitigation definition
- ▶ Technology overview
- ▶ Design considerations

What is Active Mitigation?

- Interception, dilution, diversion of soil gas
- Mechanized features (e.g., fan)
- Quantifiable by physical measurements, may include
  - Vacuum
  - Flow rate
  - Mass flux
  - Differential pressure

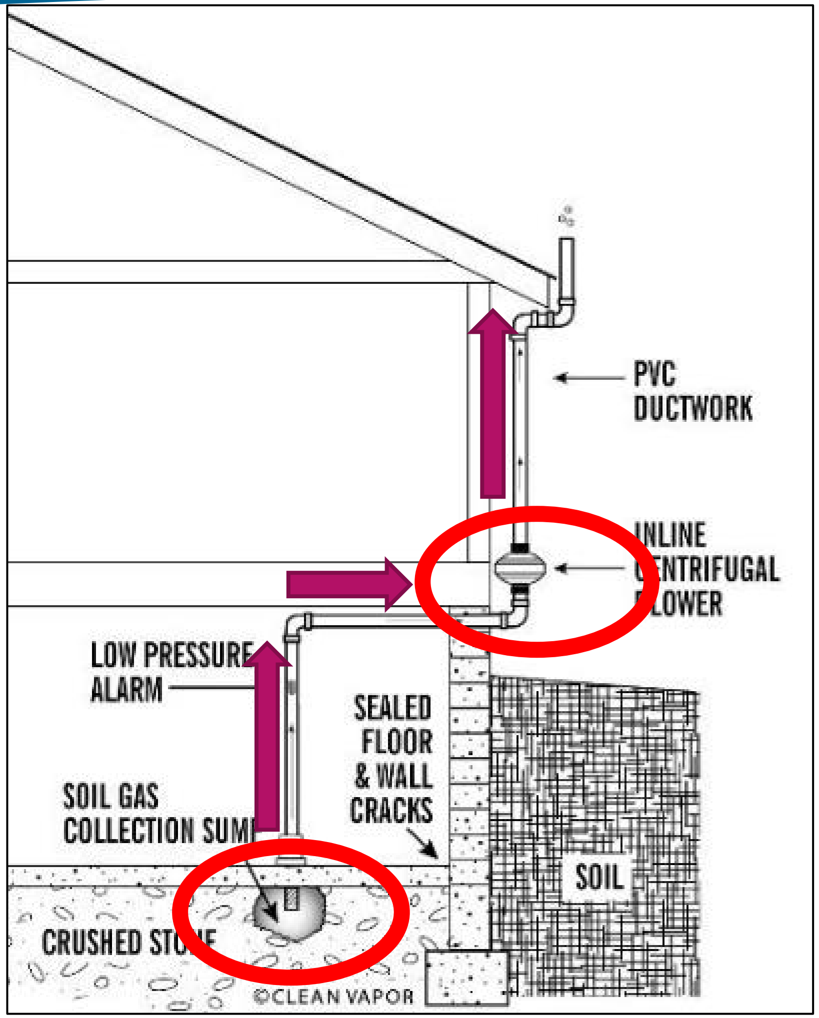


Figure 1 of the Sub-slab Depressurization (SSD) Technology Information Sheet.

Active Mitigation Fact Sheet

- Overview for work products
- Quick summaries of active mitigation approaches
- References to previous ITRC documents and ANSI/AASRT standards

Vapor Intrusion Mitigation (VIM) HOME

Active Mitigation Fact Sheet

ITRC has developed a series of fact sheets that summarizes the latest science, engineering, and technologies regarding vapor intrusion (VI) mitigation. This fact sheet describes the most common active vapor mitigation technologies and summarizes the considerations that go into design, installation, post-installation verification, and operation, maintenance, and monitoring (OM&M). More detailed information on the considerations related to each step of the mitigation implementation process can be found in ITRC's *Design Considerations Fact Sheet*, *Post-installation Verification Fact Sheet*, and *Operation, Maintenance, and Monitoring/Exit Strategy Fact Sheet*

1 Introduction

Active mitigation of the VI pathway involves interception, dilution, or diversion of soil gas entry into a building using mechanical means that are powered by electricity. The performance of active mitigation systems is quantifiable by measurement of vacuum, area of influence, flow rates, mass flux, etc. This fact sheet presents information on the design, installation, and OM&M of active mitigation technologies for both new construction and existing buildings that range from small (i.e., residential) to large (i.e., commercial/industrial) structures. Active mitigation for new construction can be significantly different than for existing buildings due to components of new buildings and control of construction of the system during construction of the building. Details and differences between active mitigation for new construction and existing buildings is listed in this fact sheet and in the *Design Considerations*, *Post-installation Verification*, and *Operation, Maintenance, & Monitoring/Exit Strategy* Fact Sheets where appropriate.

As presented in the *Conceptual Site Models (CSM) for VI Mitigation Fact Sheet*, the mitigation technologies presented in this fact sheet assume the primary means for soil gas entry is via advection, rather than diffusion. Except for situations where very high sub-slab vapor source concentrations (e.g., millions of micrograms per cubic meter [$\mu g/m^3$]) are present, diffusion through the slab is not considered a significant transport pathway. Vapor mitigation systems that are "active" are designed to

https://vim-1.itrcweb.org/active-mitigation-fact-sheet/

Tech Sheet – Sub-Slab Depressurization (SSD)

General Design

- Negative pressure in sub-slab soil relative to building envelope
- Air flow direction: sub-slab → suction point → riser pipe → vent stack → atmosphere
- Fans outside occupiable building envelope
- Seal cracks and other penetrations (utility entrances, etc.)

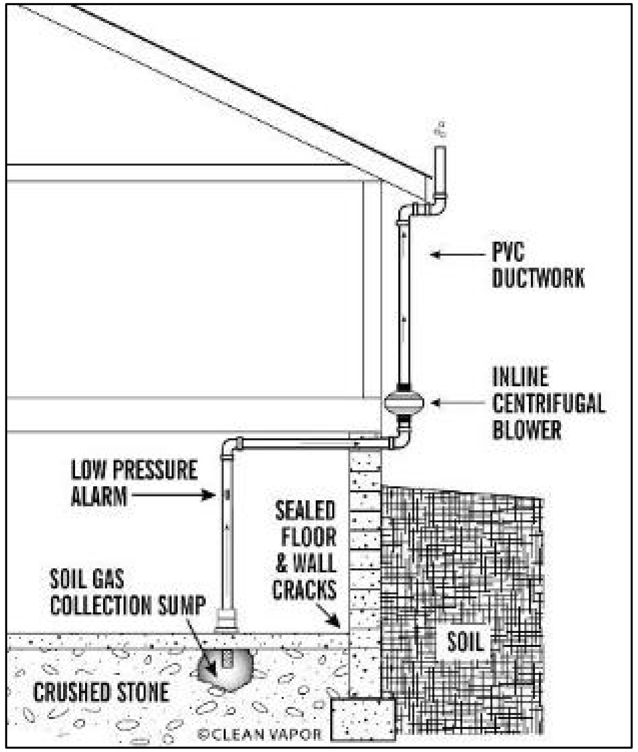


Figure 1 of SSD Technology Information Sheet

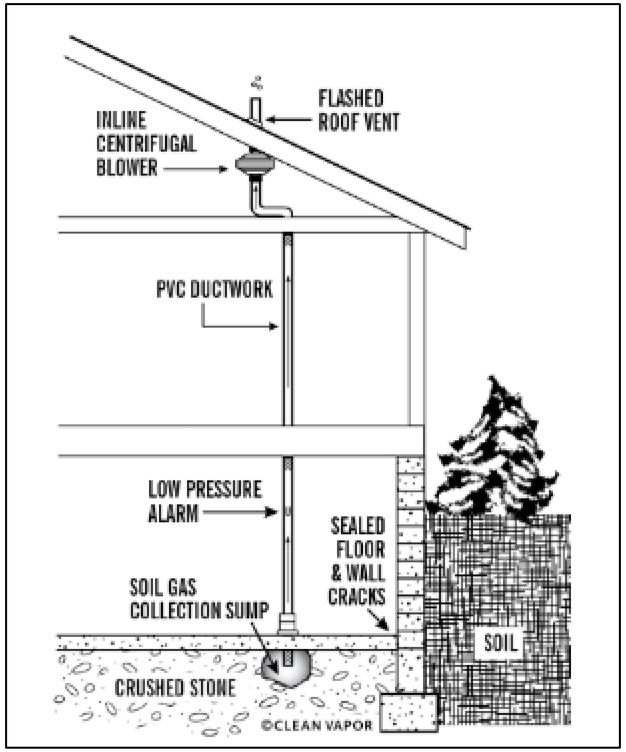


Figure 2 of SSD Technology Information Sheet

Tech Sheet - Sub-Slab Depressurization (SSD)

Components

- Electric fan/blower
- Suction points
- Vent piping & valves
- Measurement equipment (manometers, gauges, sensors, etc.)
- Optional: condensate knockout, condensate bypass, emission controls

Source: Clean Vapor , 2020. Used with permission.

Source: ERM, 2020. Used with permission.

Tech Sheet – SSD in New Construction Scenario

- ▶ Greater system influence
  - ▶ Higher subgrade material transmissivity
  - ▶ Membrane installation
- ▶ Active fan can be added after building construction
- ▶ Side benefits
  - ▶ Radon protection
  - ▶ Decrease basement moisture

Source: Clean Vapor, 2020. Used with permission.

Source: ERM, 2020. Used with permission.

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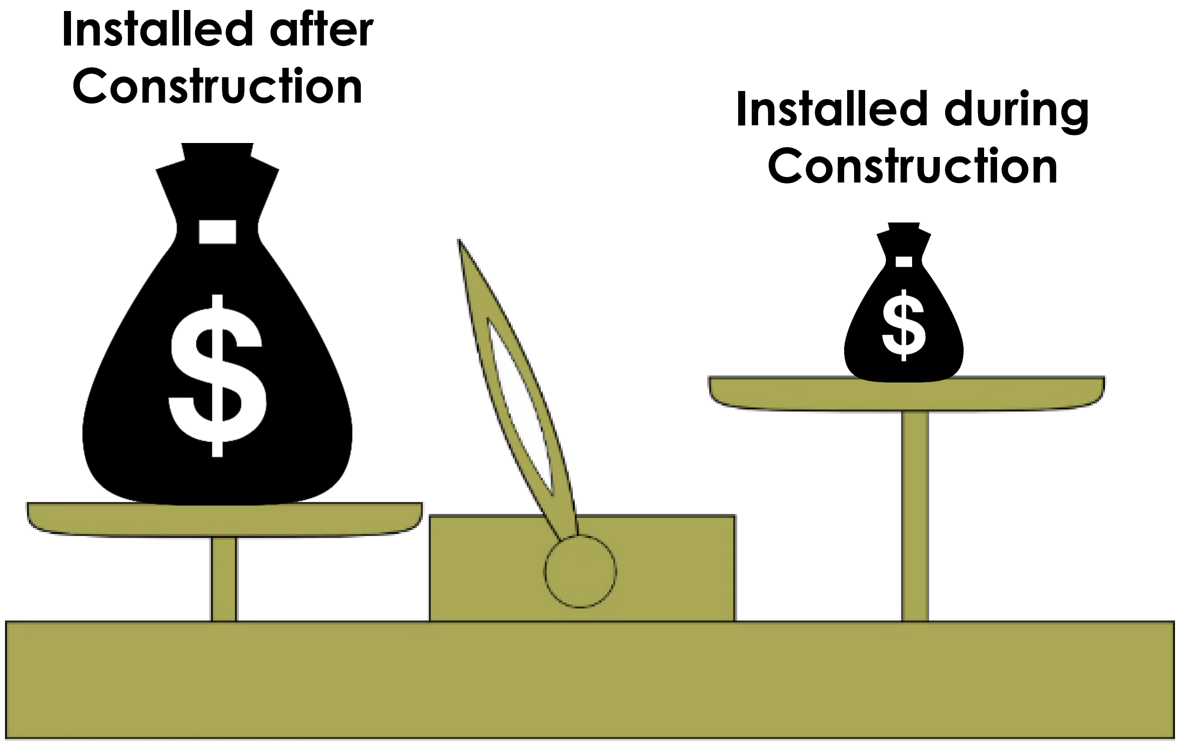
Tech Sheet – SSD in New Construction Scenario

- Positive cost impact

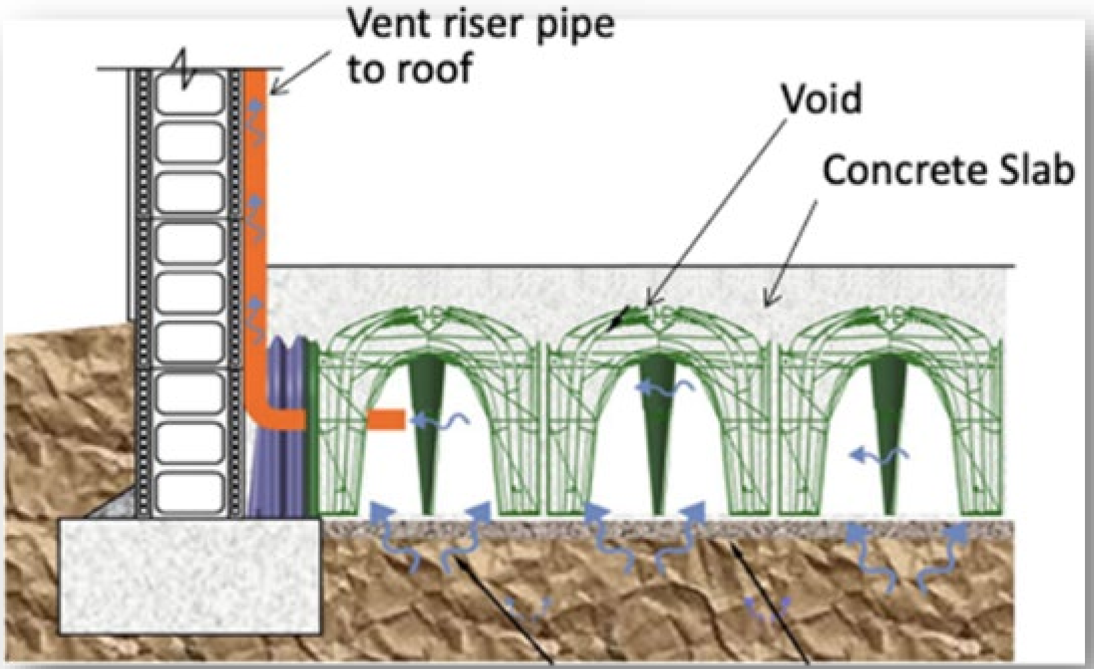


Source: Pixabay (adapted)

Tech Sheet – Sub-Slab Venting (SSV)

General Design

- Similar to SSD
- Air flow reduces sub-slab vapor concentrations
- High-permeability soils or void spaces
- Relatively low vapor concentrations
- Performance measurements include air velocity, system vacuum, vapor concentrations, mass flux



Source: Pontarolo Engineering, Inc.

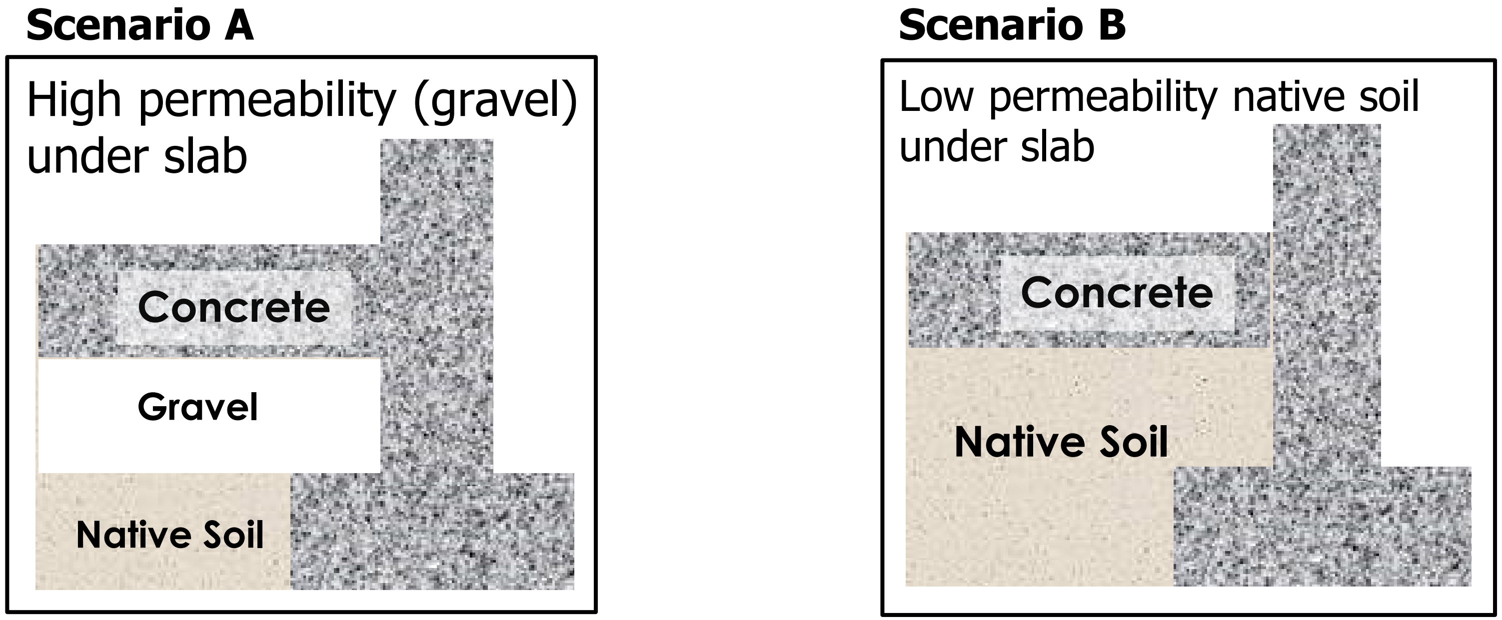
Tech Sheet – Sub-Slab Venting (SSV)

Components

- ▶ Components same as SSD
- ▶ May incorporate aerated floor system (void spaces)
- ▶ May include inlets for sub-slab dilution air

Source: Clean Vapor, 2020. Used with permission.

Knowledge Check



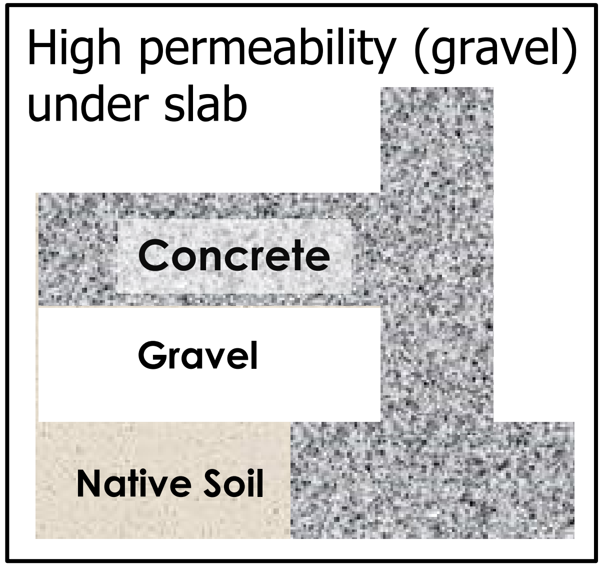
Source: ERM, 2020. Used with permission.

Which condition is more amenable to sub-slab venting?

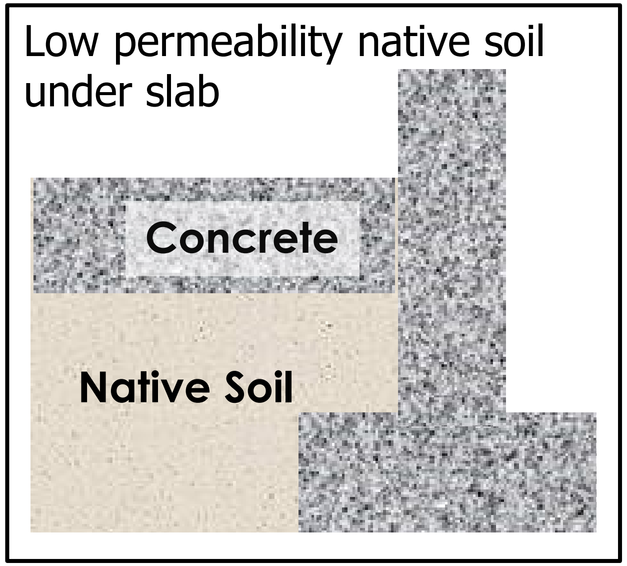
Knowledge Check

Poll Question

Scenario A



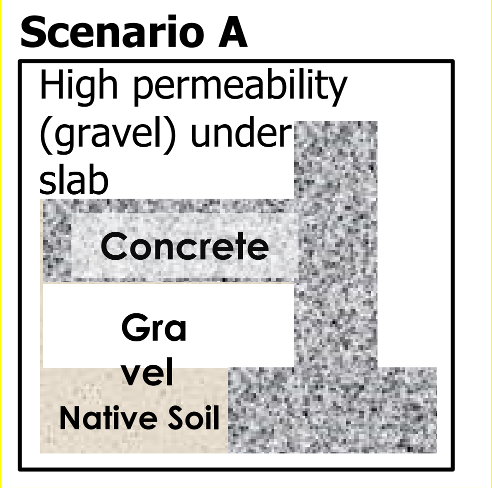
Scenario B



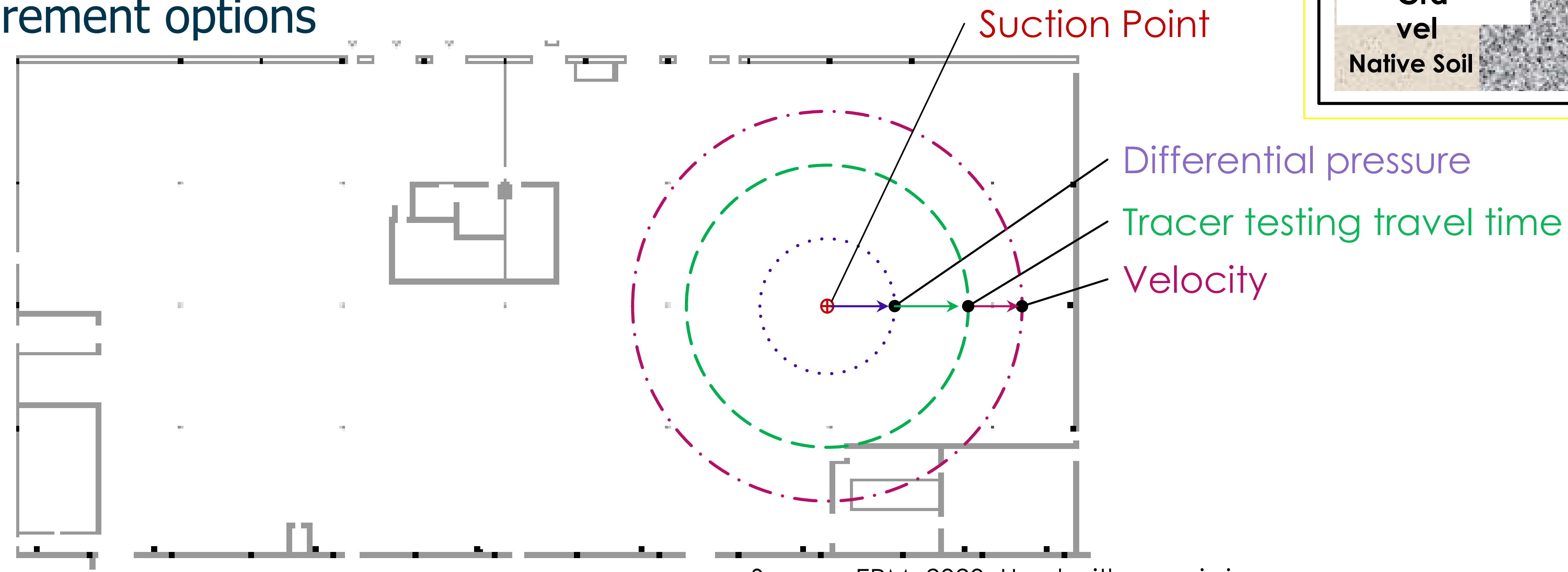
Source: ERM, 2020. Used with permission.

Which condition is more amenable to sub-slab venting?

Measurement of SSV Performance



- Measurement options



Source: ERM, 2020. Used with permission.

Differential pressure can underestimate lateral influence of SSV

Tech Sheet – Sub-Membrane Depressurization (SMD)

General Design

- Most often used for dirt floors, crawlspaces, and compromised floors
- Negative pressure below sealed membrane relative to interior space
- Membrane provides plenum for active mitigation
- More residential than industrial/commercial applications

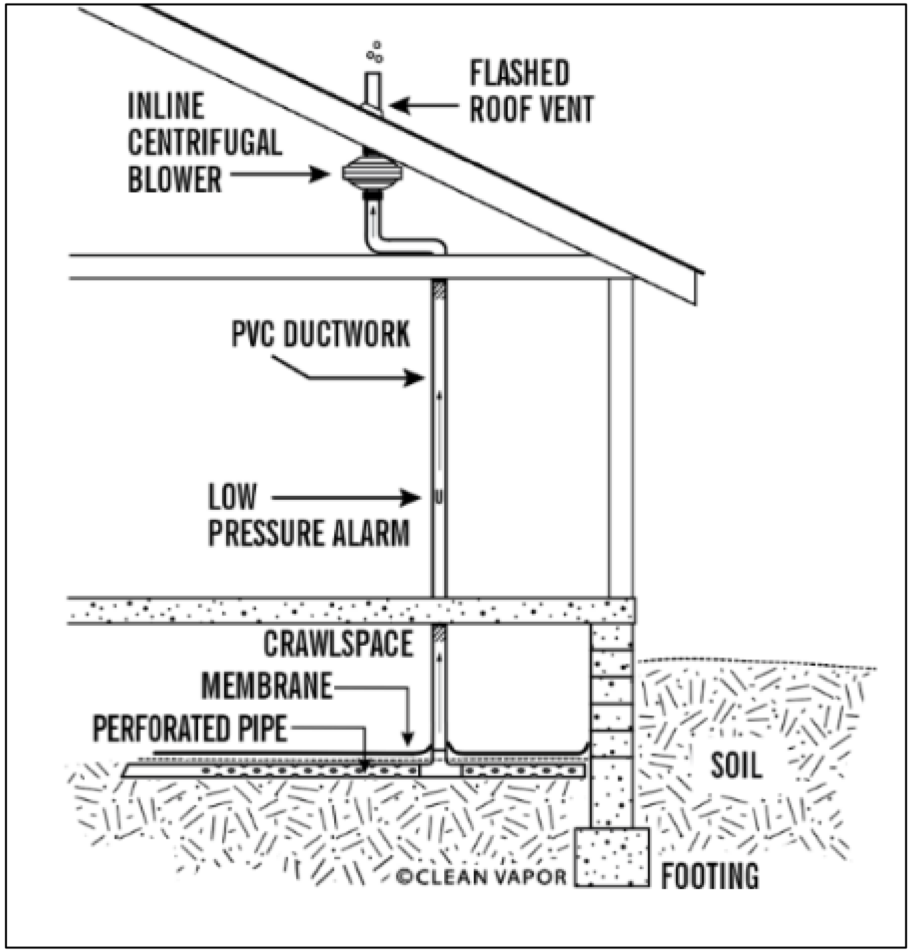


Figure 1 of the SMD Tech Sheet

Tech Sheet – Sub-Membrane Depressurization (SMD)

Components

- Electric fan/blower
- Vent piping & valves
- Membrane sealed to walls and around pipe penetrations
- Vapor collection piping/plenum under membrane
- Measurement equipment (manometers, gauges, sensors, etc.)
- Optional: condensate bypass, emission controls

Source: Arcadis, 2020. Used with permission.

Tech Sheet – Crawlspace Ventilation (CSV)

General Design

- Crawlspace air replaced with fresh air
- Vapor dilution via air exchange
- Consider significant heating or cooling impacts
- Used when other technologies are not feasible

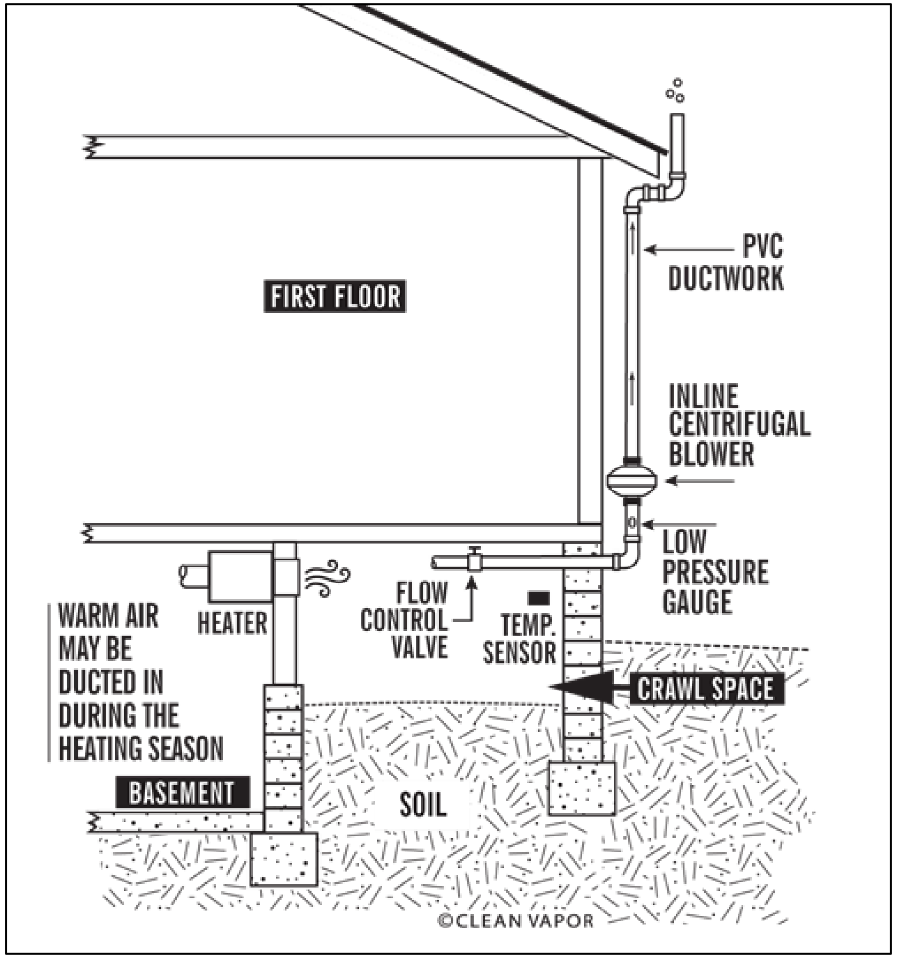


Figure 1 of the CSV Tech Sheet

https://vim-1.itrcweb.org/crawlspace-ventilation-csv-tech-sheet/

Tech Sheet – Crawlspace Ventilation (CSV)

Components

- ▶ Electric fan/blower
- ▶ Vent piping & valves
- ▶ Measurement equipment (manometers, gauges, sensors, etc.)
- ▶ Optional: temperature actuated heating, condensate bypass, emission controls

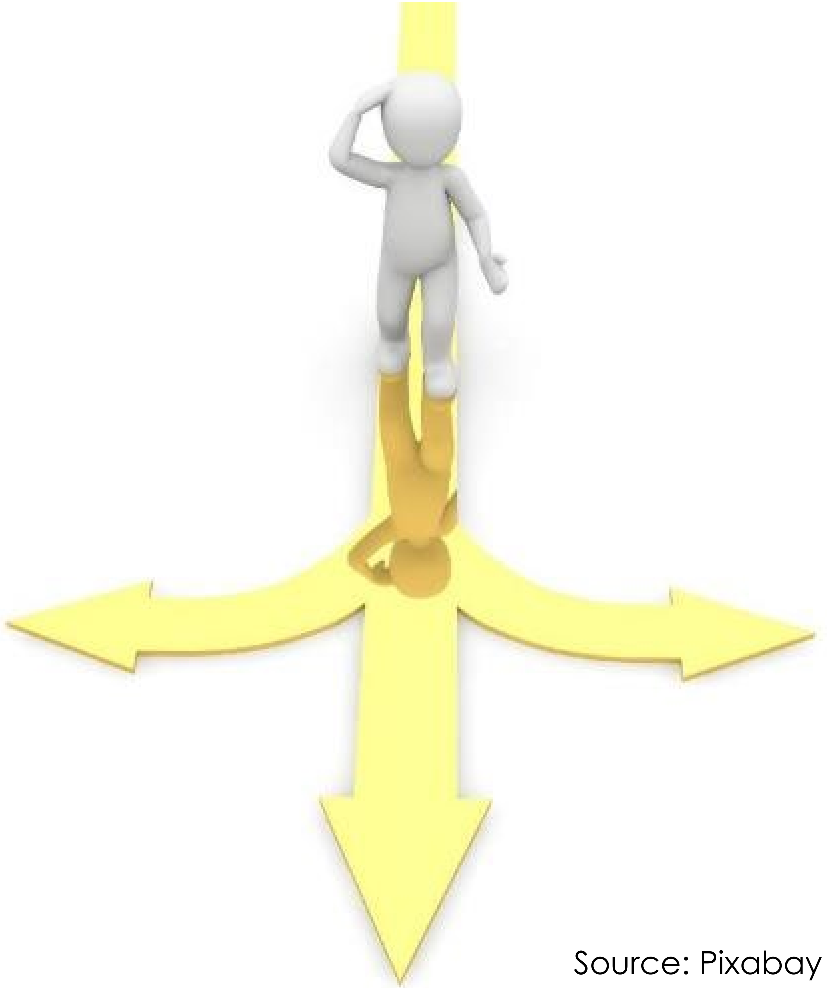
Source: ERM, 2020. Used with permission.

Starting the Design Process…

Now that you have seen what's out there, let's assume you have chosen

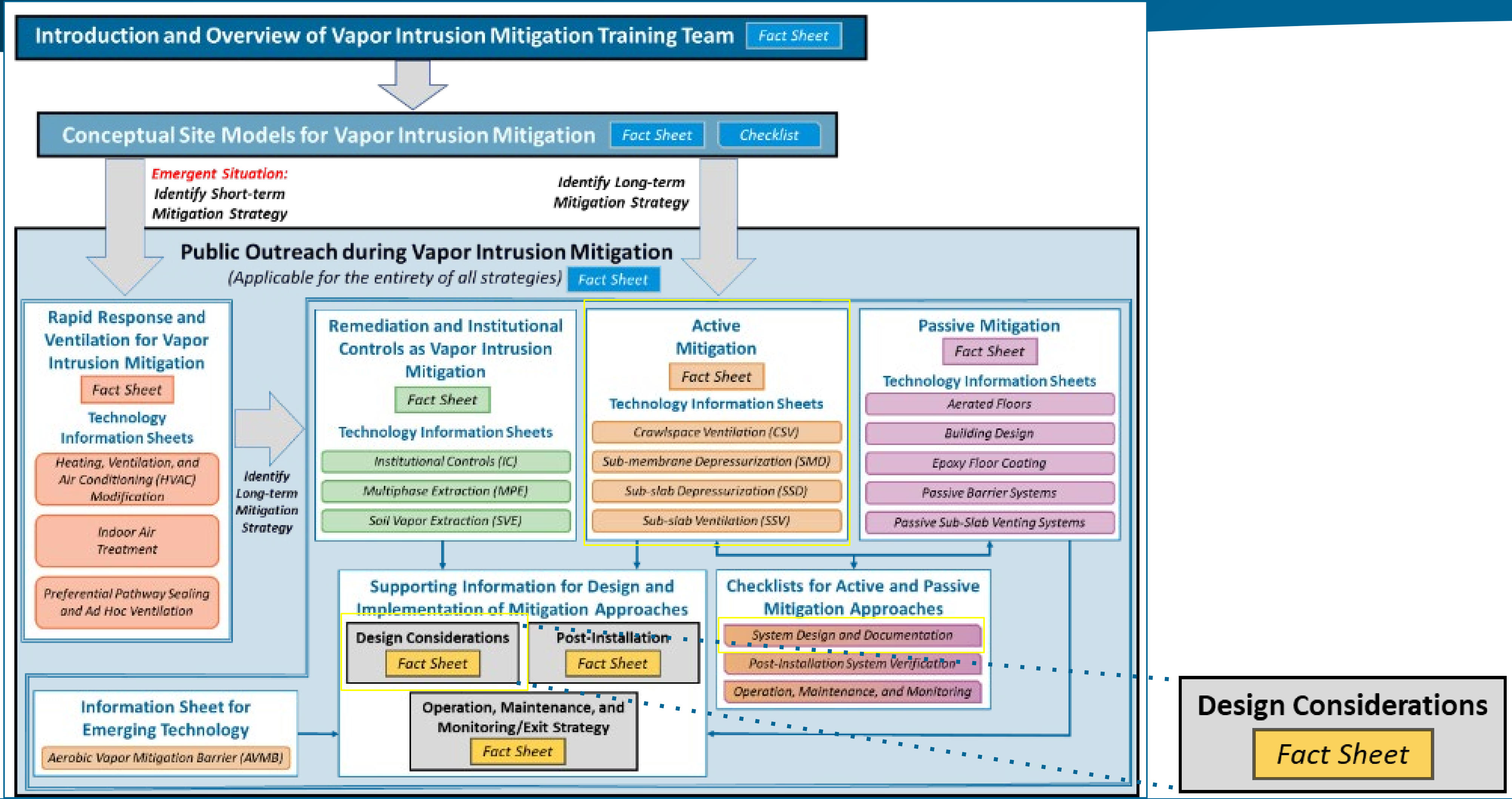
- active mitigation
- the specific approach to implement

Now what???



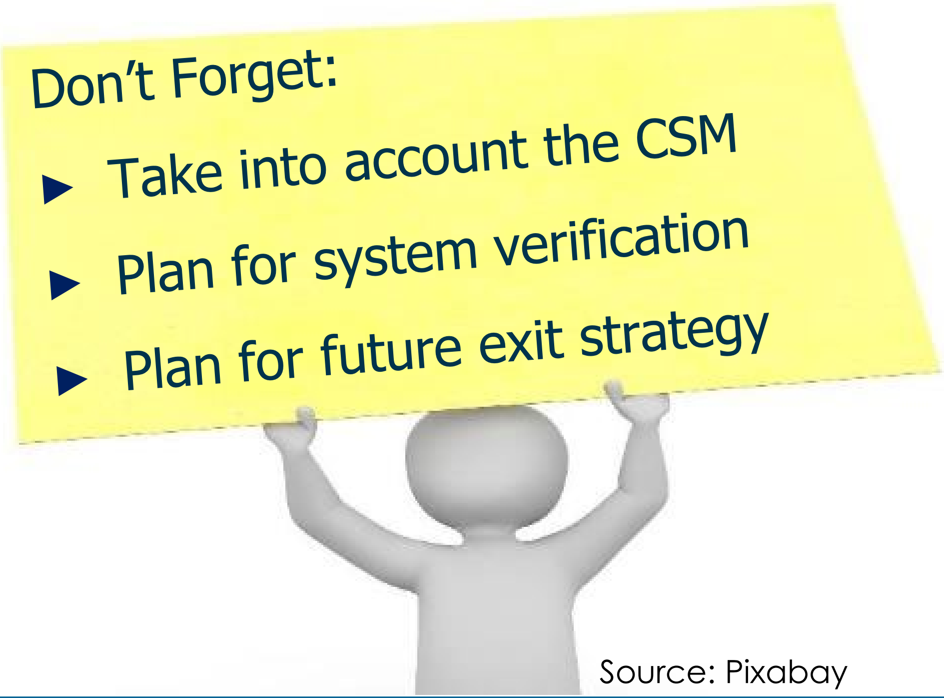
Source: Pixabay

Design Considerations Fact Sheet



Design Considerations Fact Sheet

- ▶ Guide through design considerations
- ▶ Relative importance to active mitigation



Source: Pixabay

Vapor Intrusion Mitigation (VIM)

HOME

Design Considerations Fact Sheet

ITRC has developed a series of fact sheets that summarizes the latest science, engineering, and technologies regarding the mitigation of vapors associated with vapor intrusion (VI). This fact sheet describes the most common design considerations for active mitigation systems, passive mitigation systems, and environmental remedial technologies that need to be considered as part of any design process.

1 Introduction

Multiple factors affecting the suitability and efficacy of a mitigation system should be considered during the design, review, and approval process, as discussed in this fact sheet. The selected technology should be based on a good understanding of the VI conceptual site model (VI CSM) (see ITRC *Conceptual Site Models for Vapor Intrusion Mitigation Fact Sheet*) and able to meet the remedy objectives pertaining to soil vapor conditions at the site, whether applying an active system, passive system, rapid response, and/or an environmental remediation technology.

The design process should begin with a consideration of the VI CSM elements applicable to mitigation and the remedy objectives, leading to the design basis (i.e., an explanation of how the selected approach and technologies will meet the remedy objectives at the site). In many cases, this review indicates that additional information is needed for design of a specific type of mitigation system; therefore, the need for predesign investigations and/or testing should be considered. Once sufficient information is available for design, the next consideration is the design itself—the area that requires mitigation along with the system components, installation details, and specifications. Other design considerations include installation and operating permitting requirements; stakeholder requirements and communications; and the need for construction quality control, demonstration of system effectiveness and reliability, and operation, maintenance, and monitoring (OM&M) plans, including an exit or closure strategy.

Table 1-1 identifies the design considerations that are discussed in more detail below and evaluates their typical importance and impact on the design of an active (see ITRC *Active Mitigation Fact Sheet*) system, passive (see ITRC *Passive Mitigation Fact Sheet*) system, or an environmental remediation technology (see *Remediation and Institutional Controls as Vapor Intrusion Mitigation Fact Sheet*). Note that the importance of any factor can vary depending on site- and building-specific

https://vim-1.itrcweb.org/design-considerations-fact-sheet/

Design Considerations – Building Conditions
New Construction

- Different components will be considered versus existing buildings
- Typically combined with passive mitigation technologies
- May be designed and installed but not activated

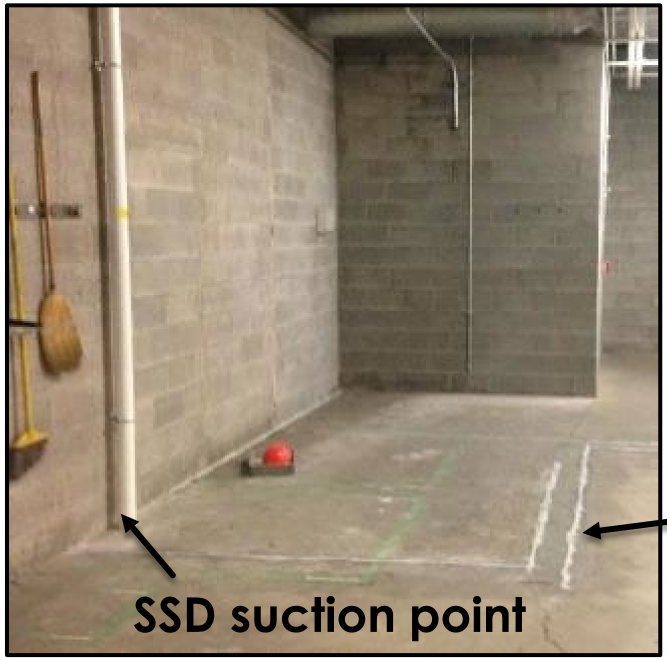
Source: Clean Vapor, 2020. Used with permission.

Design Considerations – Building Conditions

Existing Buildings

Factors included in design may be:

- ▶ Foundation type (multiple foundations)
- ▶ Slab integrity
- ▶ Preferential pathways
- ▶ HVAC
- ▶ Building dimensions
- ▶ Exterior façade requirements



Source: ERM, 2020. Used with permission.

Source: Clean Vapor, 2020. Used with permission.

Design Considerations – Sub-slab Diagnostics

- Diagnostics used to determine
  - Suction point configuration
  - Number and size of fan(s)
- Pressure field extension (PFE) testing
- Differential pressure measurements
- Other diagnostics like tracer testing may also be used

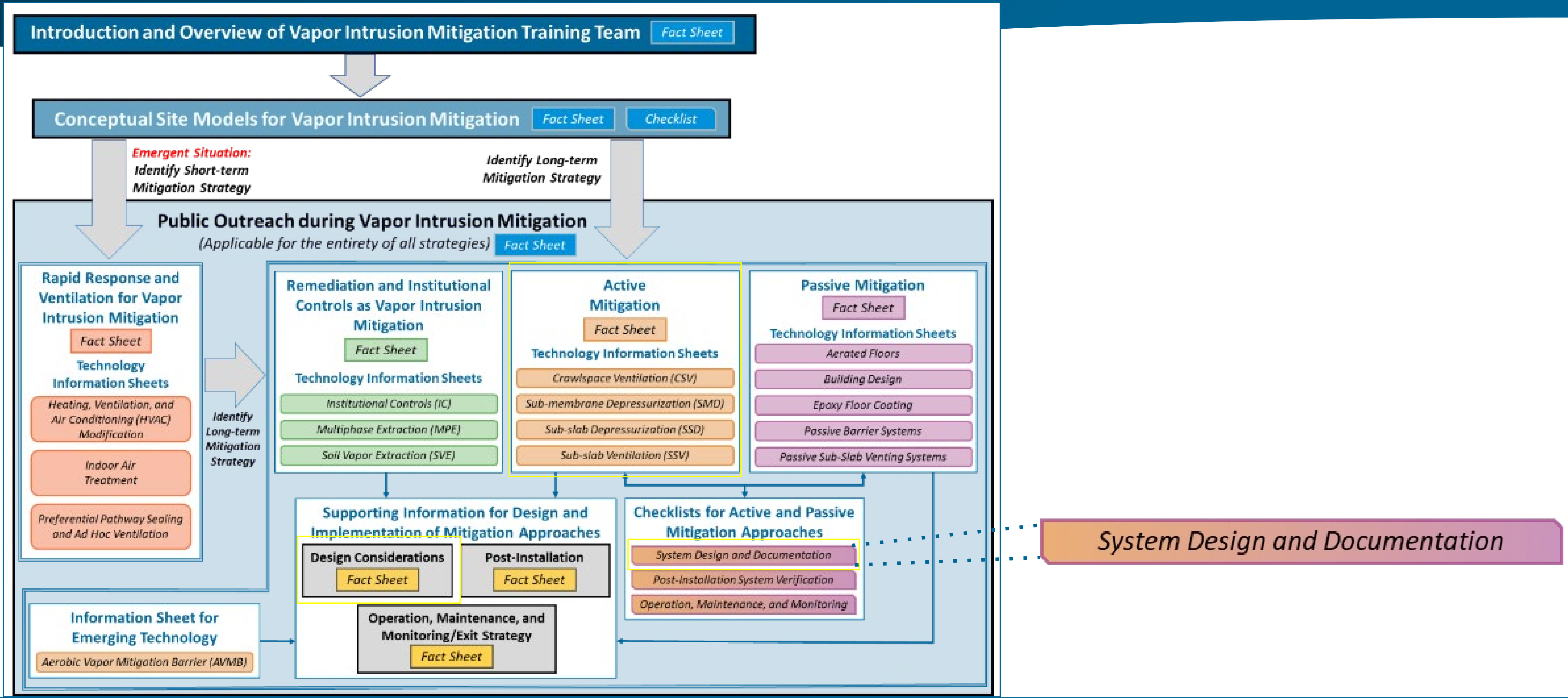
Source: ERM, 2020. Used with permission.

Design Documentation – Design Work Plan

- Design basis
- System components and system layout
- Permitting
- Installation instructions and specifications
- Construction quality assurance (CQA)
- Plan for verification and OM&M
- Plan for exit strategy

Source: Pixabay

System Design & Documentation Checklist



System Design & Documentation Checklist

- Walks through each design consideration
- Prompts user for site-specific information
- Not all items may be applicable for all sites

Active Mitigation Checklist
for
Existing Buildings and New Construction

Details and types of active mitigation can be reviewed in the ***Active Mitigation Fact Sheet***. The primary active technologies that are the focus of this design checklist are sub-slab depressurization, sub-slab venting, sub-membrane depressurization, and crawlspace venting, and these technologies are detailed in their respective technical information sheets. This section focuses on design checklist considerations for existing buildings where the design needs to accommodate an existing building slab. Some of the considerations in the checklist below may also apply to new construction if an active system such as a sub-slab depressurization (SSD) system is being installed. This is different than mitigation of new construction that consists of a passive barrier or aerated floor. For the passive mitigation systems, see the passive mitigation checklist below.

1. ACTIVE MITIGATION SYSTEM DESIGN AND DOCUMENTATION

- Have all the building slab areas been fully characterized for contaminants? ☐ Yes ☐ No ☐ NA
- Has pressure field extension (PFE) testing been completed? ☐ Yes ☐ No ☐ NA

1.1. Selection of system materials and methods

- Were total building footprint, foundation type, and under-slab compartments (created by haunches, thickened slab, or elevation changes) considered in the design process? ☐ Yes ☐ No ☐ NA

Summary

- Definition of active mitigation
- Common active mitigation approaches for new construction and existing buildings
- Considerations for designing an active mitigation technology
- Key elements in active mitigation system design
- Design documentation

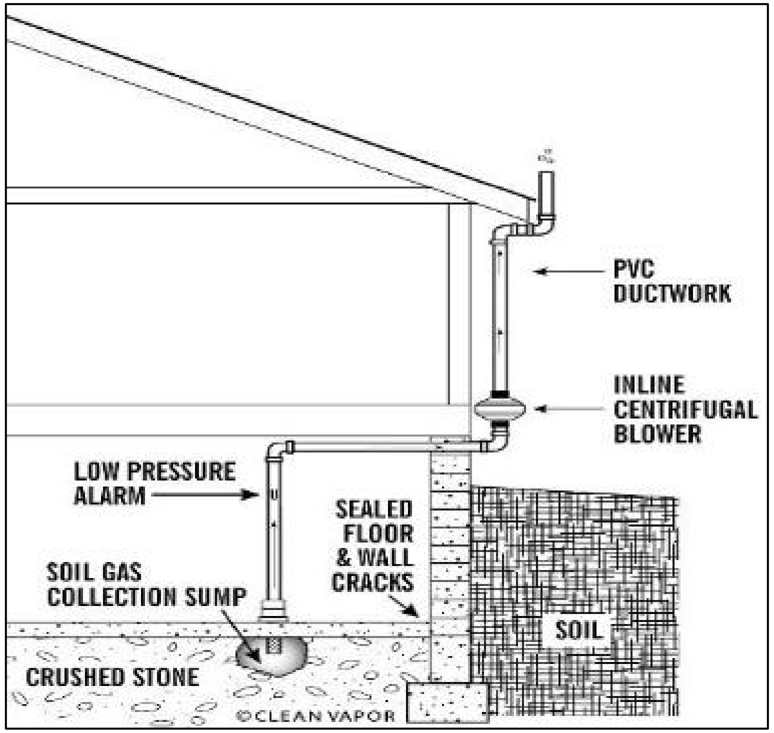


Figure 1 of the Sub-slab Depressurization (SSD) Technology Information Sheet.

Next Steps

- Install the system as designed
- Verify effective installation and operation
- Conduct routine OM&M
- Monitor and plan for an exit strategy

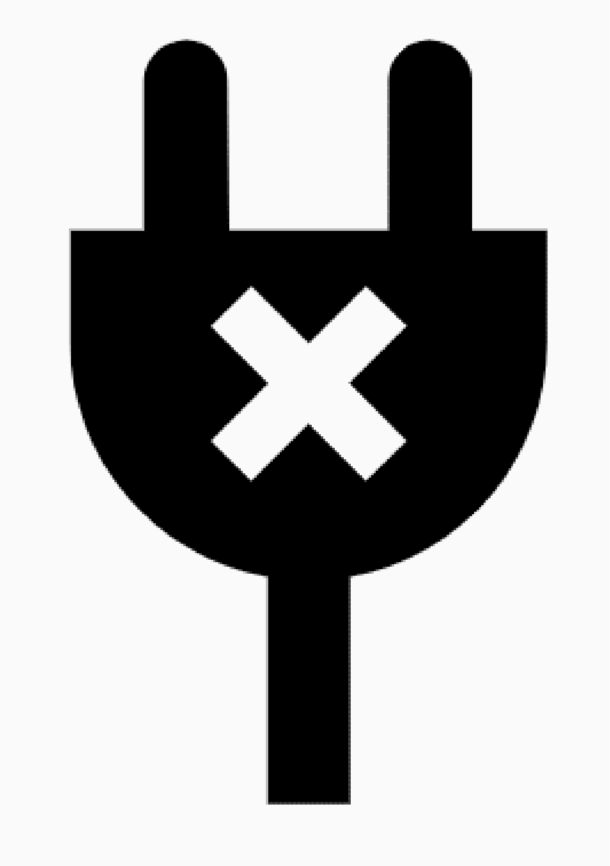
Source: Pixabay

Subsequent steps covered in other modules

Question & Answer Break

Source: Pixabay

Passive Mitigation Approaches



Source: thenounproject.com.
Used with permission.

Objectives of Module

- Passive mitigation definition
- Technology overview
- Design considerations
- Installation planning
- Construction quality assurance

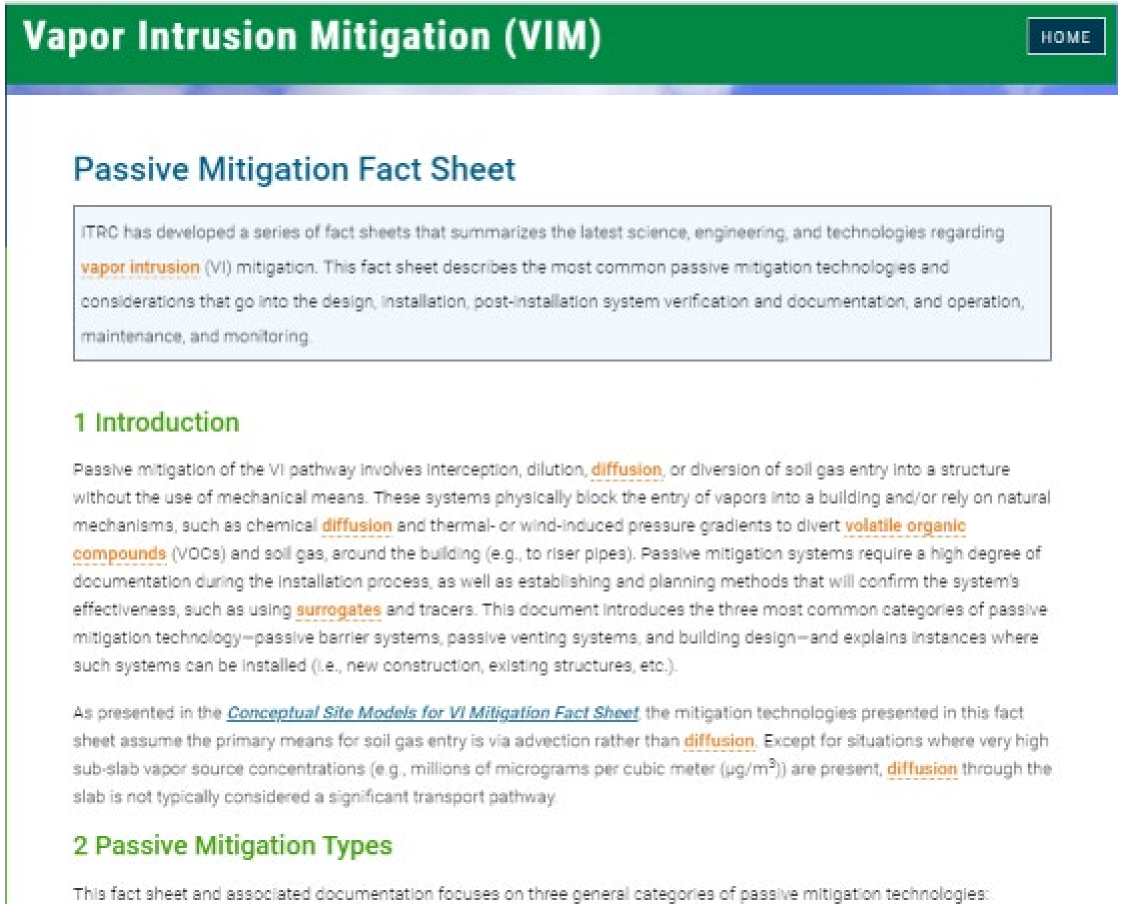
What is Passive Mitigation?

- Block or divert contaminant vapors from entering building
- Does not rely on mechanical means (e.g. blower)
- Relies on natural mechanisms

Source: Adapted from ITRC.

Passive Mitigation Fact Sheet

- Summary guide to the content in other work products
- Summaries of both common and less common passive technologies
- References to previous ITRC documents and various state vapor intrusion guidance documents



Vapor Intrusion Mitigation (VIM)

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Passive Mitigation Fact Sheet

ITRC has developed a series of fact sheets that summarizes the latest science, engineering, and technologies regarding vapor intrusion (VI) mitigation. This fact sheet describes the most common passive mitigation technologies and considerations that go into the design, installation, post-installation system verification and documentation, and operation, maintenance, and monitoring.

1 Introduction

Passive mitigation of the VI pathway involves interception, dilution, diffusion, or diversion of soil gas entry into a structure without the use of mechanical means. These systems physically block the entry of vapors into a building and/or rely on natural mechanisms, such as chemical diffusion and thermal- or wind-induced pressure gradients to divert volatile organic compounds (VOCs) and soil gas, around the building (e.g., to riser pipes). Passive mitigation systems require a high degree of documentation during the installation process, as well as establishing and planning methods that will confirm the system's effectiveness, such as using surrogates and tracers. This document introduces the three most common categories of passive mitigation technology—passive barrier systems, passive venting systems, and building design—and explains instances where such systems can be installed (i.e., new construction, existing structures, etc.).

As presented in the *Conceptual Site Models for VI Mitigation Fact Sheet*, the mitigation technologies presented in this fact sheet assume the primary means for soil gas entry is via advection rather than diffusion. Except for situations where very high sub-slab vapor source concentrations (e.g., millions of micrograms per cubic meter (µg/m^3)) are present, diffusion through the slab is not typically considered a significant transport pathway.

2 Passive Mitigation Types

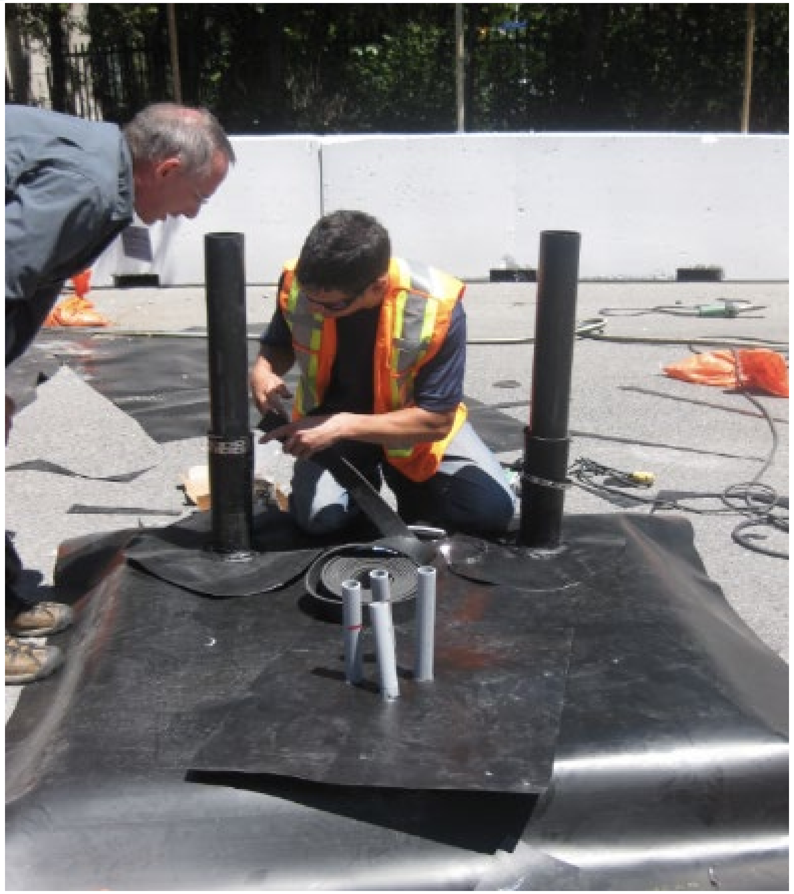
This fact sheet and associated documentation focuses on three general categories of passive mitigation technologies:

https://vim-1.itrcweb.org/passive-mitigation-fact-sheet/

Tech Sheet – Common Passive Barrier Systems

Asphalt Latex Membranes (ALM)

Source: EPRO Services, Inc, 2020. Used with permission.



Thermoplastic Membranes (TM)

Source: Steve Weiterman, 2020. Used with permission.

Composite Membranes (CM)

Source: Vadose Remediation Technologies, 2020. Used with permission.

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Tech Sheet – Passive Barrier Systems
Asphalt Latex Membranes (ALMs)

General Design

- Barrier to prevent VI in new buildings
- Typically comprised of
  - Base layer
  - Continuous spray-applied asphalt
  - Cap sheet
- Effective for a wide range of contaminants

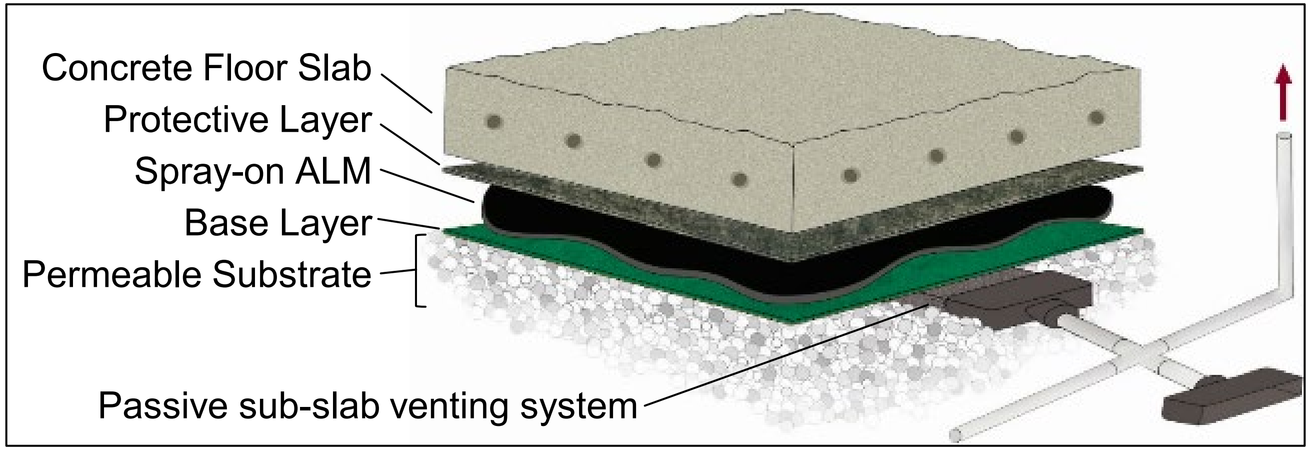


Figure 1 of Passive Barriers Technology Information Sheet.

Tech Sheet – Passive Barrier Systems
Asphalt Latex Membranes (ALMs)

Installation

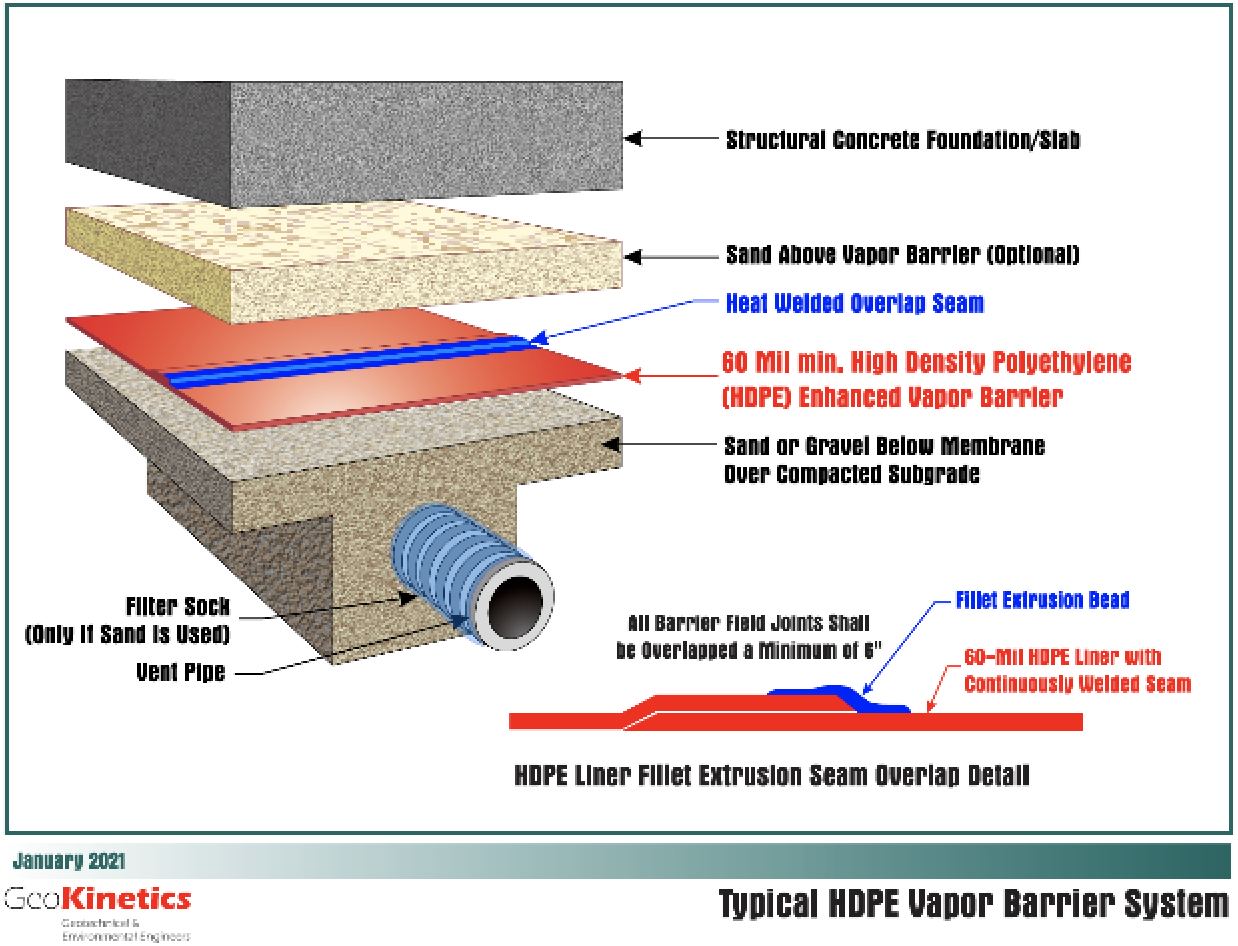
- ALM application to Thermoplastic Membrane
- Manufacturers provide specific installation instructions

Source: EPRO Services, Inc, 2020. Used with permission.

Tech Sheet – Passive Barrier Systems
Thermoplastic Membranes (TMs)

General Design

- ▶ Single layer sheet systems with heat-welded seams
- ▶ TMs are different (thicker) than "moisture vapor barriers"
- ▶ Effective for a wide range of contaminants

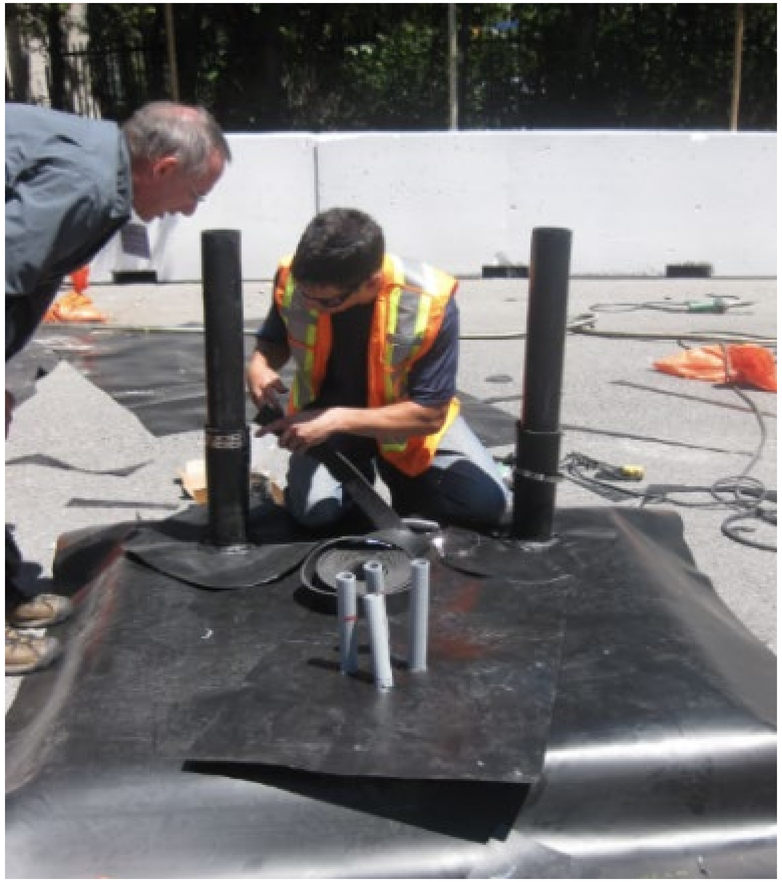


Source: Geokinetics, Inc, 2021. Used with permission.

Tech Sheet – Passive Barrier Systems
Thermoplastic Membranes (TMs)

Installation

- Heat-welded seams
- Terminations require mechanical fastening
- Pre-fabricated boots to seal penetrations
- Manufacturers provide specific installation instructions

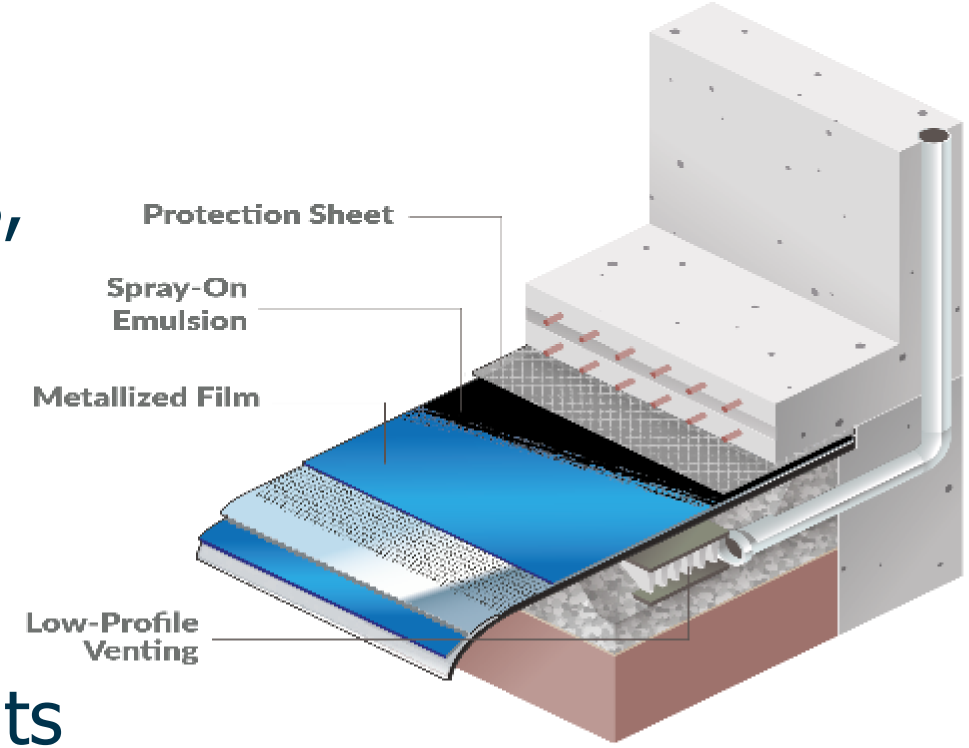


Source: Steve Weiterman, 2020. Used with permission.

Tech Sheet – Passive Barrier Systems
Composite Membranes (CMs)

General Design

- Typically comprised of multiple materials, such as
  - EVOH
  - Metallized films
  - Spray-on emulsion/ALM
- Effective for a wide range of contaminants



Source: Land Science, 2020. Used with permission.

Tech Sheet – Passive Barrier Systems
Composite Membranes (CMs)

Installation

- Seams and penetrations sealed by various methods
- Manufacturers provide specific installation instructions

Source: Vadose Remediation Technologies, 2020. Used with permission.

Tech Sheet – Other Passive Systems

Aerated Floors

Source: Vapor Mitigation Sciences, LLC, 2020. Used with permission.

Passive Sub-Slab Venting (SSV) Systems

Figures 1 and 5 of Sub-slab Venting Technology Information Sheet.

Epoxy Floor Coatings (EFCs)

Figure 1 of Epoxy Floor Coatings Technology Information Sheet.

Building Design

Figure 2 of Building Design Technology Information Sheet.

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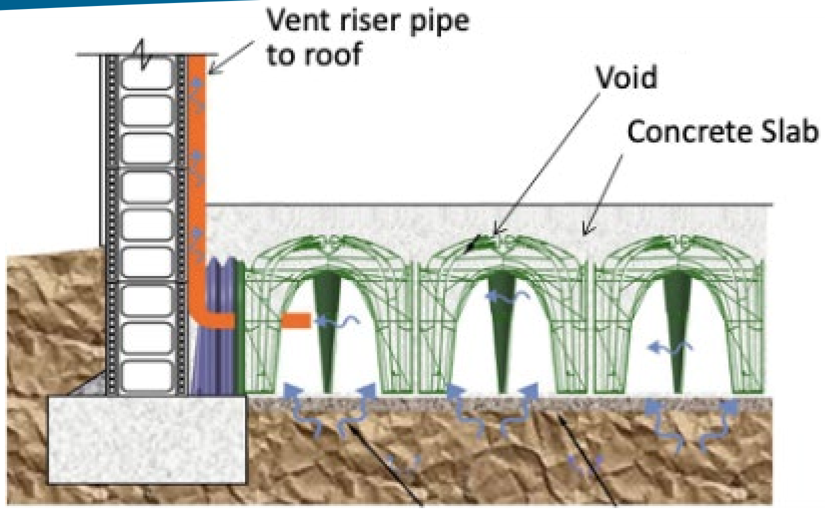
Tech Sheet – Aerated Floors

- Create continuous void space under slab
- Low resistance to air flow, air exchange rates are high
- Most applicable to new construction
- Proprietary forms designed for all building types
- Designed for SSV or SSD in either passive or active mode



Source: Pontarolo Engineering, Inc.

Source: Vapor Mitigation Sciences, LLC, 2020. Used with permission.

Tech Sheet – Passive Sub-Slab Venting (SSV) Systems

- Fundamentally different from SSD
- Relies on pressure differences to induce flow
- Most applicable to new construction
- Often used in conjunction with passive barriers to improve performance
- No power source required

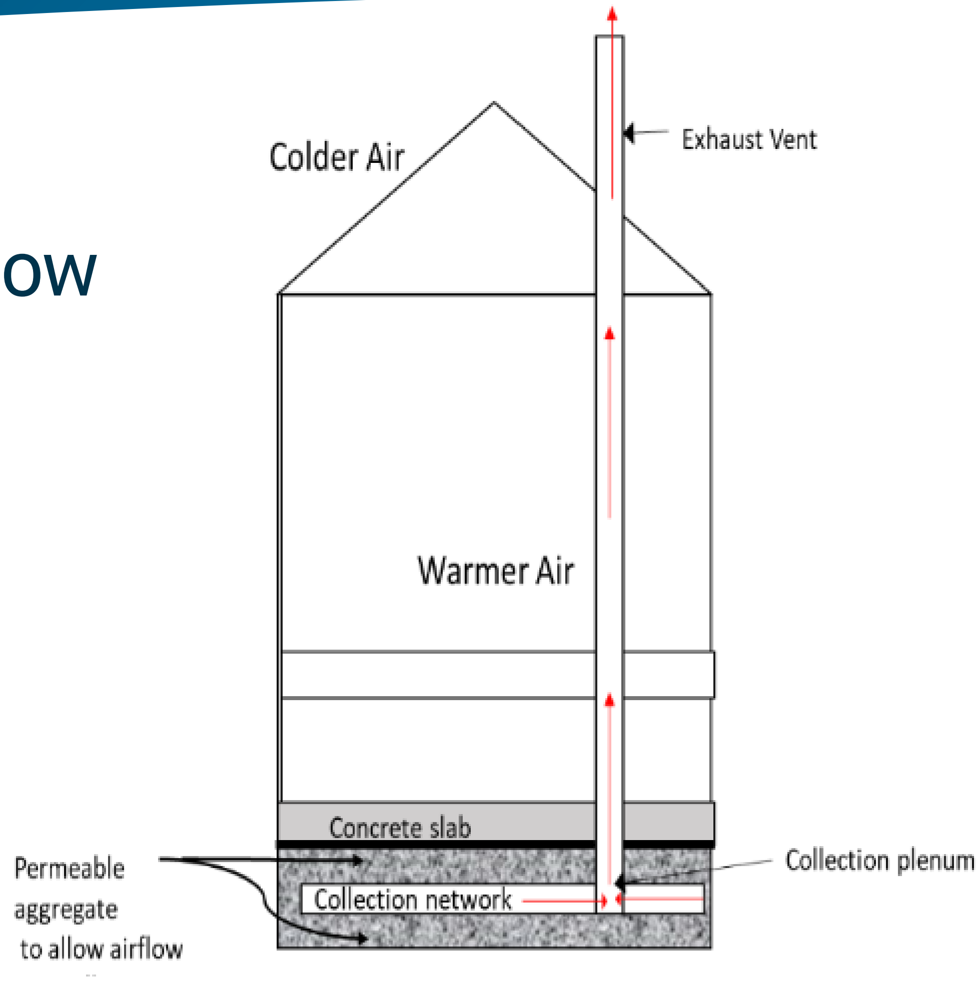
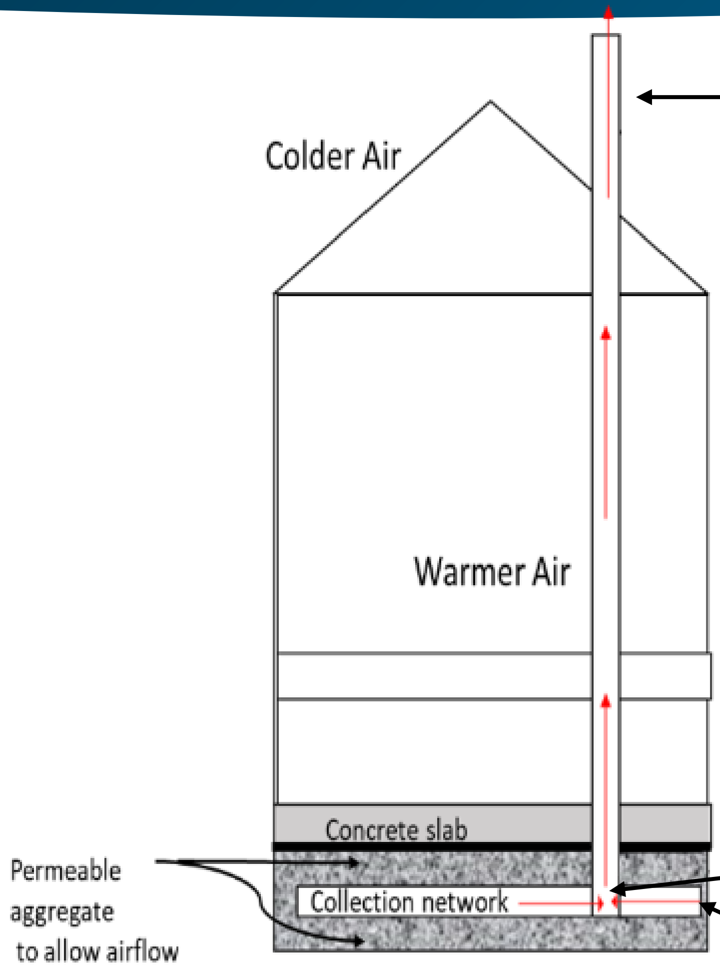


Figure 1 of Sub-slab Venting Technology Information Sheet.

Tech Sheet – Passive Sub-Slab Venting (SSV) Systems

Figures 1 and 5 of Sub-slab Venting Technology Information Sheet.



Exhaust Vent

Collection plenum

Collection network

Tech Sheet – Epoxy Floor Coatings (EFCs)

- Applicable to all building types
- Most applicable to existing building floors/walls as a passive VI barrier
- Involves concrete surface preparation prior to application
- Can protect concrete
- Requires specialty applicators

Figure 1 of Epoxy Floor Coatings Technology Information Sheet.

Tech Sheet – Building Design for Passive VIM

Vented Garages

- Mainly city setting where space is limited
- Naturally vented (passive) or mechanically vented (active)
- Design and OM&M often included in building code
- Adequate ventilation rate needed to mitigate VI

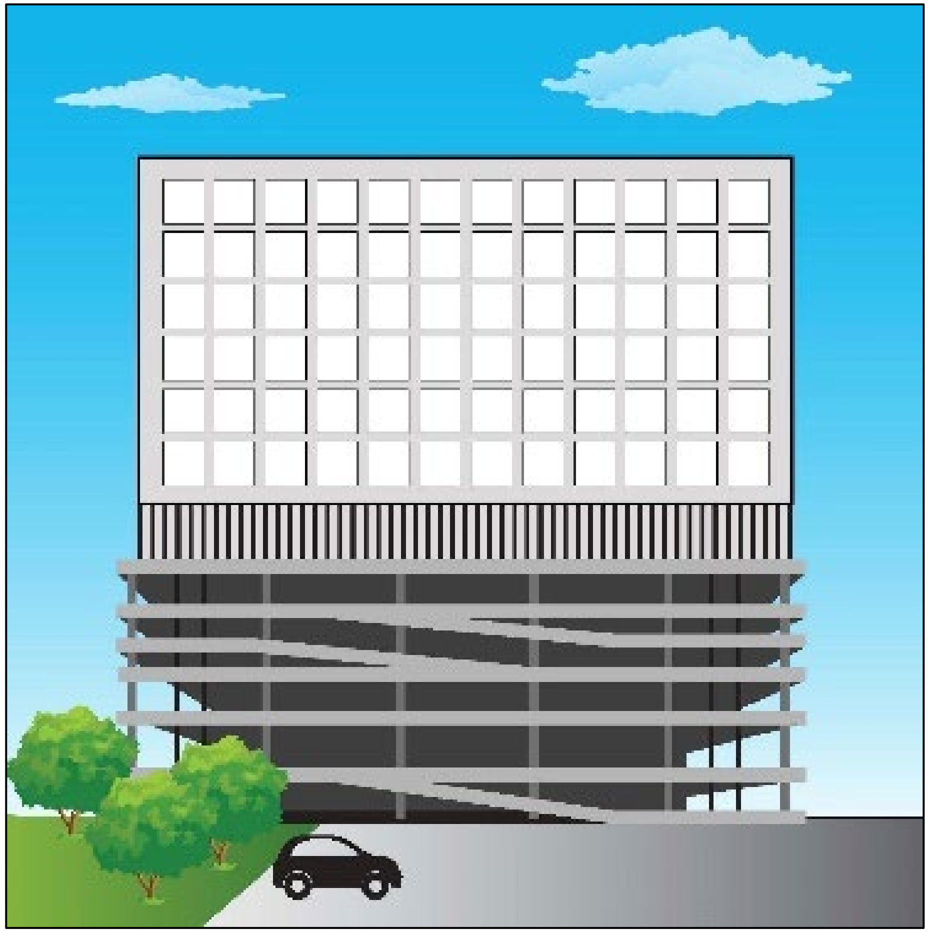


Figure 1 of Building Design Technology Information Sheet.

Tech Sheet – Building Design for Passive VIM
Raised Foundations or Crawlspace

- Temperate climates
- High water tables/flooding
- Naturally induced air exchange
- Adequate ventilation rate needed to mitigate VI

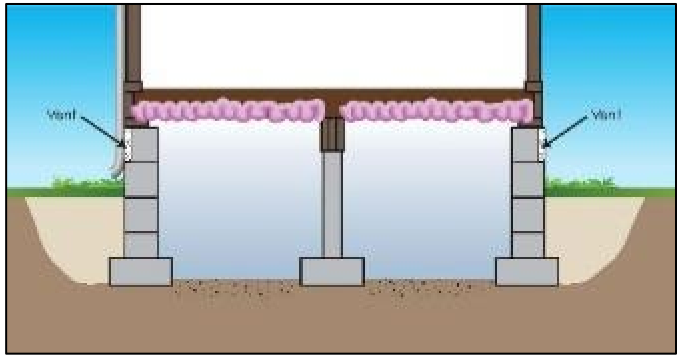


Figure 2 (top) and 3 (bottom) of Building Design Technology Information Sheet.

Knowledge Check

Poll Question

Which mitigation technology is commonly used in combination with a passive barrier system?

A. Aerated Floors
B. Epoxy Floor Coatings
C. Passive Sub-Slab Venting Systems
D. None of these

Source: Pixabay

Knowledge Check

Poll Question

Which mitigation technology is commonly used in combination with a passive barrier system?

A. Aerated Floors

B. Epoxy Floor Coatings

C. Passive sub-slab venting systems

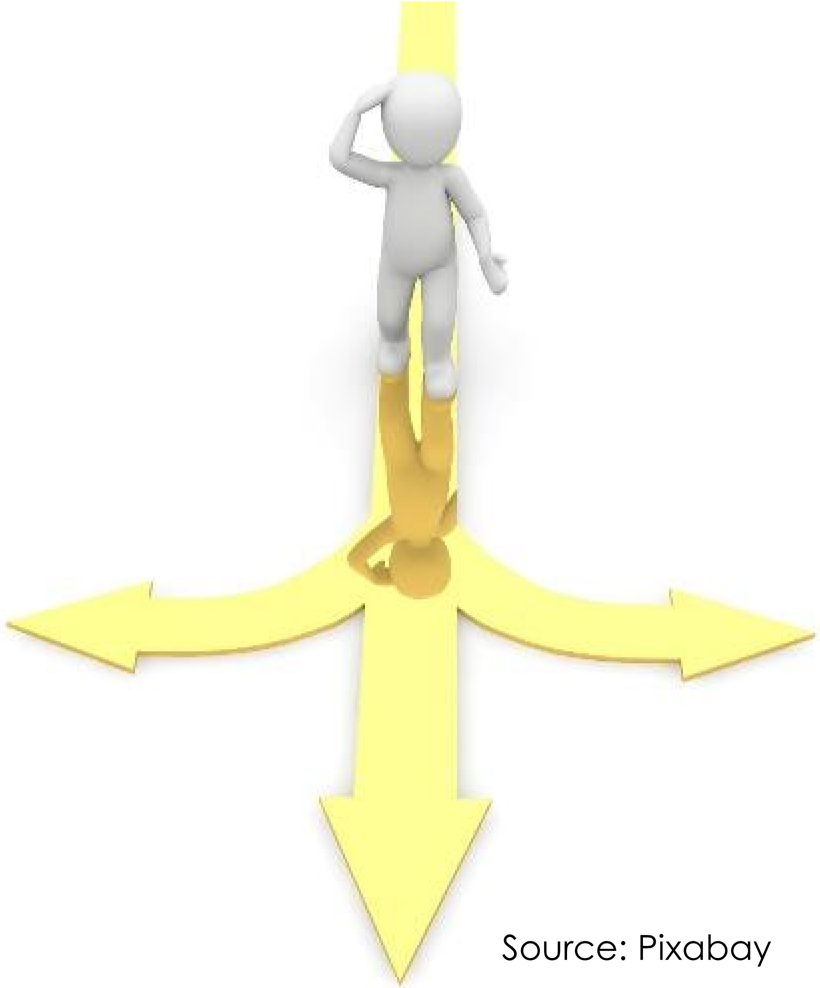
D. None of these

Starting the Design Process…

Now that you have seen what's out there, let's assume you have chosen

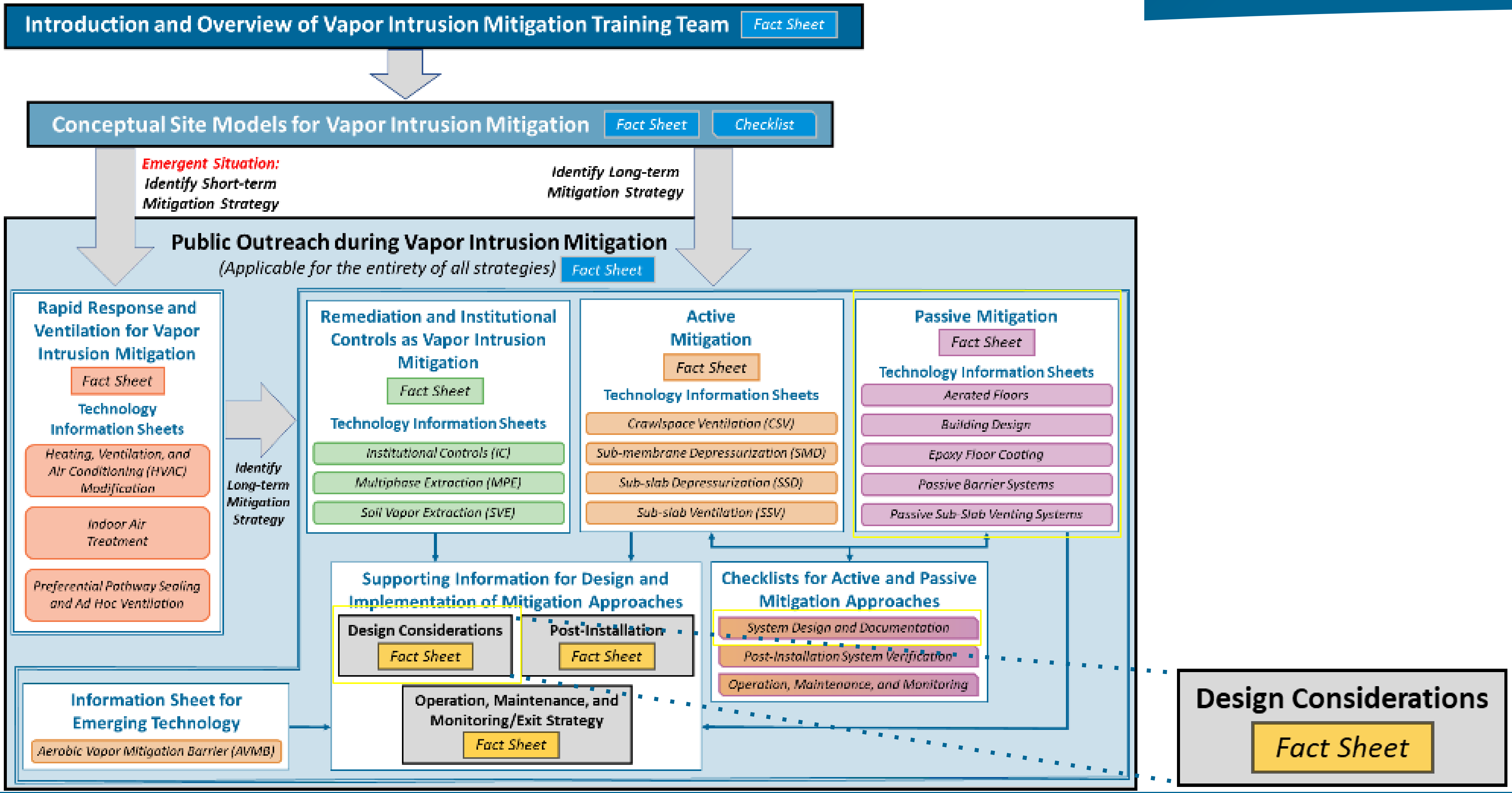
- Passive mitigation
- The specific approach to implement

Now what???



Source: Pixabay

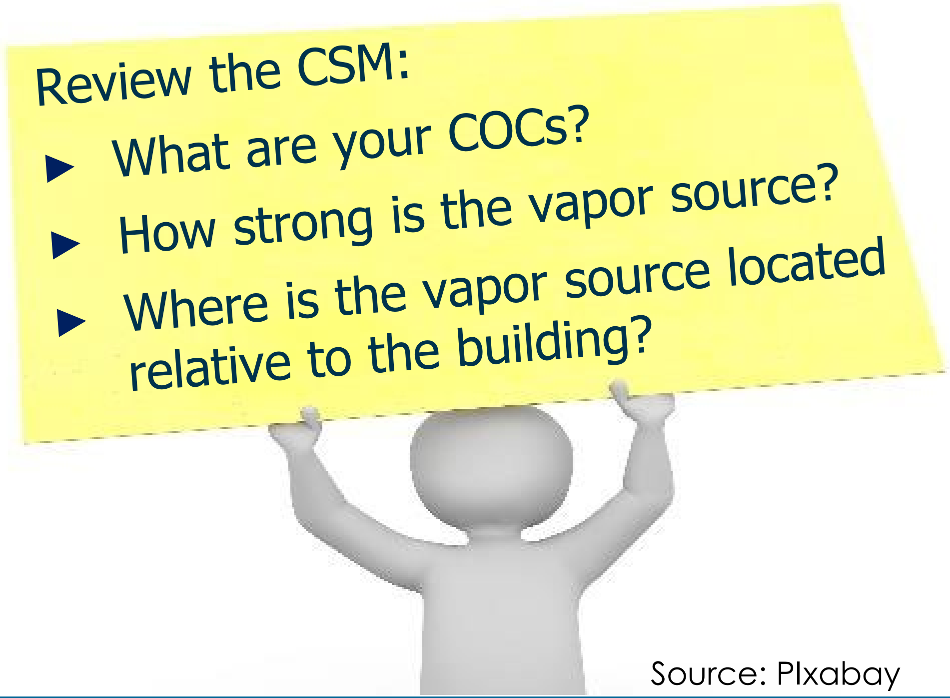
Design Considerations Fact Sheet



https://vim-1.itrcweb.org/design-considerations-fact-sheet/

Design Considerations Fact Sheet

- ▶ Guide through design considerations
- ▶ Relative importance to passive mitigation



Source: PIxabay

Vapor Intrusion Mitigation (VIM)

HOME

Design Considerations Fact Sheet

ITRC has developed a series of fact sheets that summarizes the latest science, engineering, and technologies regarding the mitigation of vapors associated with vapor intrusion (VI). This fact sheet describes the most common design considerations for active mitigation systems, passive mitigation systems, and environmental remedial technologies that need to be considered as part of any design process.

1 Introduction

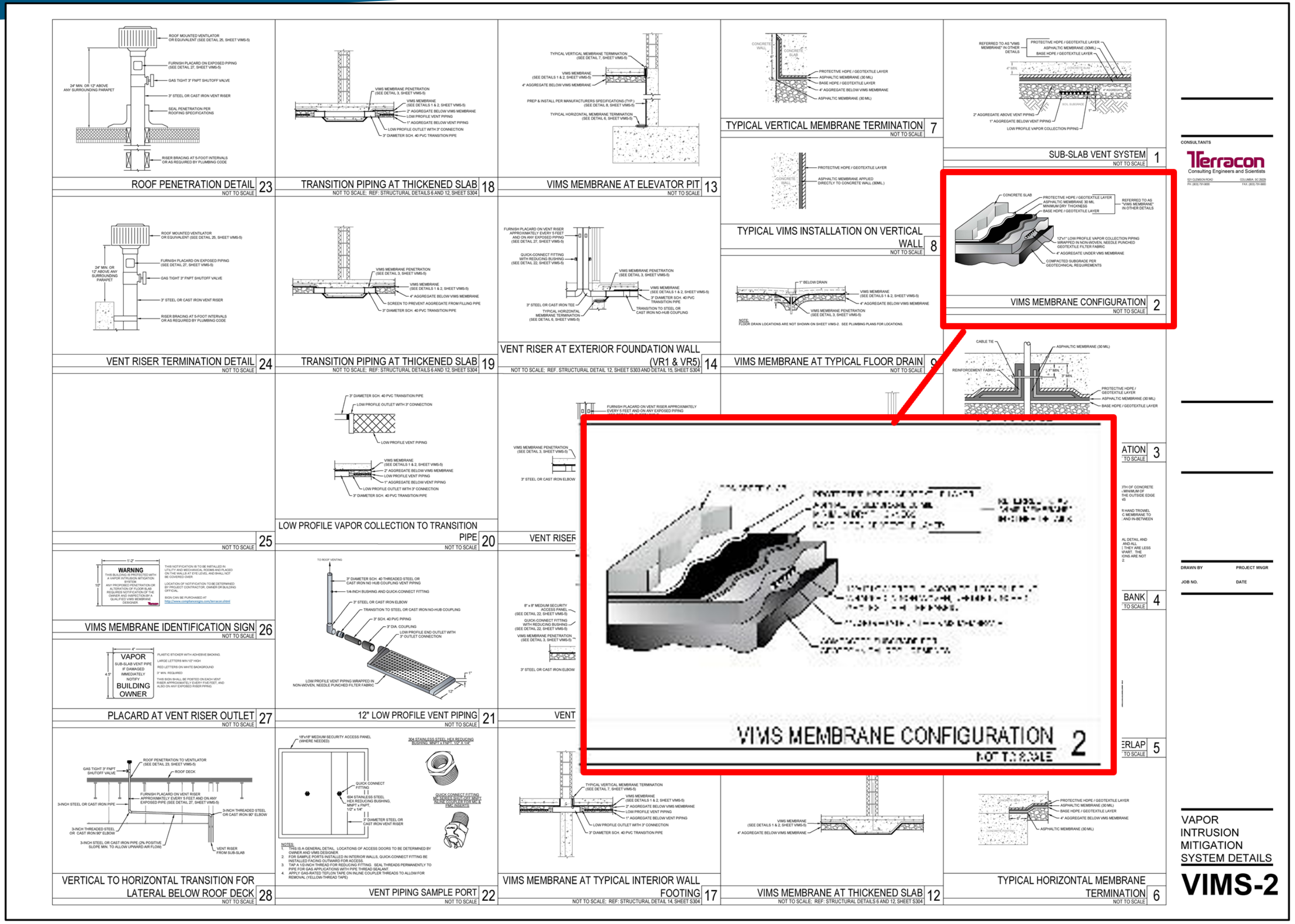
Multiple factors affecting the suitability and efficacy of a mitigation system should be considered during the design, review, and approval process, as discussed in this fact sheet. The selected technology should be based on a good understanding of the VI conceptual site model (VI CSM) (see ITRC *Conceptual Site Models for Vapor Intrusion Mitigation Fact Sheet*) and able to meet the remedy objectives pertaining to soil vapor conditions at the site, whether applying an active system, passive system, rapid response, and/or an environmental remediation technology.

The design process should begin with a consideration of the VI CSM elements applicable to mitigation and the remedy objectives, leading to the design basis (i.e., an explanation of how the selected approach and technologies will meet the remedy objectives at the site). In many cases, this review indicates that additional information is needed for design of a specific type of mitigation system; therefore, the need for predesign investigations and/or testing should be considered. Once sufficient information is available for design, the next consideration is the design itself—the area that requires mitigation along with the system components, installation details, and specifications. Other design considerations include installation and operating permitting requirements; stakeholder requirements and communications; and the need for construction quality control, demonstration of system effectiveness and reliability, and operation, maintenance, and monitoring (OM&M) plans, including an exit or closure strategy.

Table 1-1 identifies the design considerations that are discussed in more detail below and evaluates their typical importance and impact on the design of an active (see ITRC *Active Mitigation Fact Sheet*) system, passive (see ITRC *Passive Mitigation Fact Sheet*) system, or an environmental remediation technology (see *Remediation and Institutional Controls as Vapor Intrusion Mitigation Fact Sheet*). Note that the importance of any factor can vary depending on site- and building-specific

Design Considerations
Drawings

- ▶ Materials used
- ▶ Layout of system components, including vent, stack, and monitoring points
- ▶ Installation instructions and specifications
- ▶ Performance testing



Source: Terracon Consultants, Inc, 2020. Used with permission.

System Installation Planning

Pre-Construction Meeting

- Include all persons involved with the installation
- Include ancillary trades who might impact the performance of the VIMs

Source: Pixabay

Design Considerations
System Verification

- Incorporate quality assurance & quality control (QA/QC) into design
- QA/QC sources:
  - Manufacturer's specifications
  - Applicable regulations
  - Site-specific considerations
- System Verification
  - Smoke testing/Tracer gas testing
  - Coupon sampling
  - Oversight documentation

Source: EPRO Services, Inc, 2020. Used with permission.

Design Considerations
New Construction vs. Existing Buildings

Source: EPRO Services, Inc, 2020. Used with permission.

◄ High level of control in New Construction

Must work around conditions within Existing Buildings ►

Source: Contractors Waterproofing, 2021. Used with permission.

Design Considerations - New Construction

- Building-specific customization of mitigation system
- Coordination with multiple construction trades required
- VIMS design drawings aid in successful installation
- Able to combine mitigation approaches

Source: Kelly Johnson, 2020. Used with permission.

Design Considerations - Existing Buildings

- Conditions may limit the passive technologies which can be used
- Foundation can impact system effectiveness
- Building modification may be necessary to accommodate mitigation system
- Planning and construction oversight required


Source: Land Science, 2020. Used with permission.

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Knowledge Check

Poll Question

What is the most important element of good design?

A. Figuring it out as you go
B. Skipping the CSM
C. Letting the project team know you want passive mitigation
D. Proper site evaluation and planning

Image source: Pixabay

Knowledge Check

Poll Question

What is the most important element of good design?

A. Figuring it out as you go

B. Skipping the CSM

C. Letting the project team know you want passive mitigation

D. Proper site evaluation and planning

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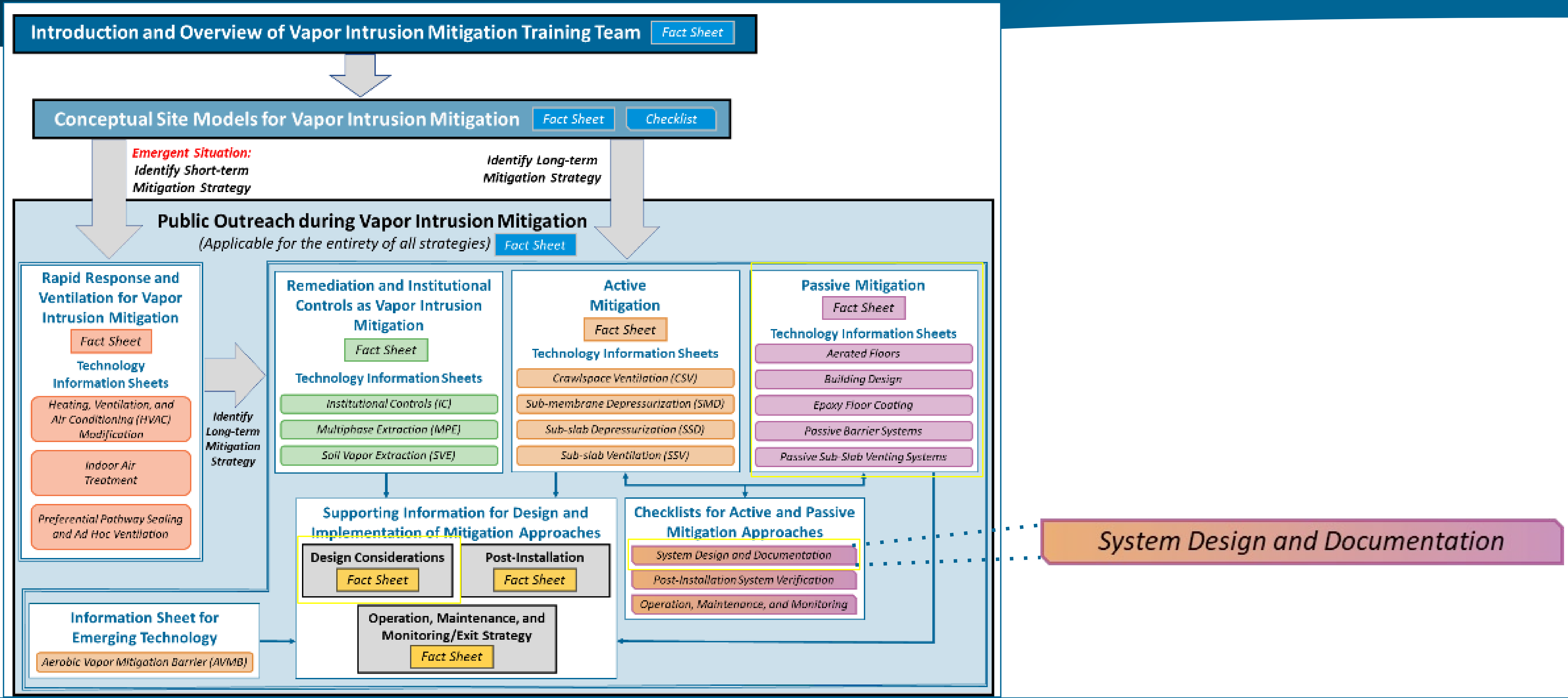
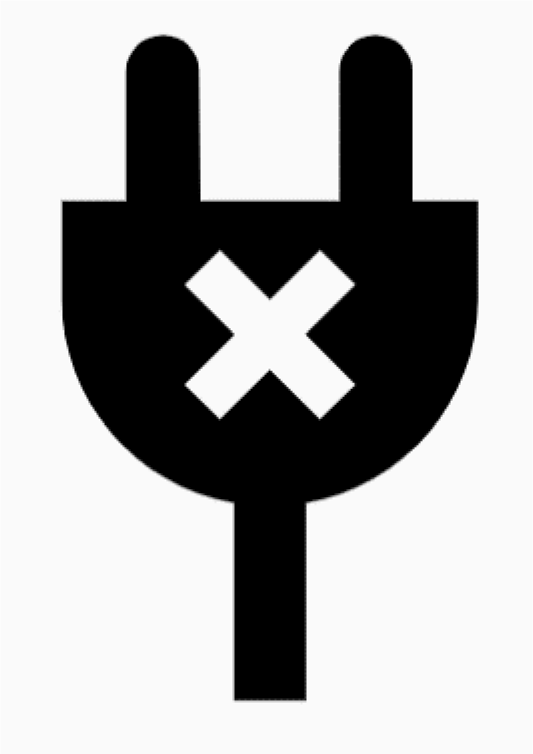
System Design & Documentation Checklist



Summary

- ▶ Define passive mitigation
- ▶ Major categories of technologies
- ▶ Key elements of system design
- ▶ Importance of Quality Assurance, oversight, and documentation



Source: thenounproject.com.
Used with permission.

Next Steps

- Passive mitigation system verification
- Conduct routine OM&M
- Assess need for continued operation of passive mitigation system
- Consideration for these steps are covered within another module.

Source: Pixabay.

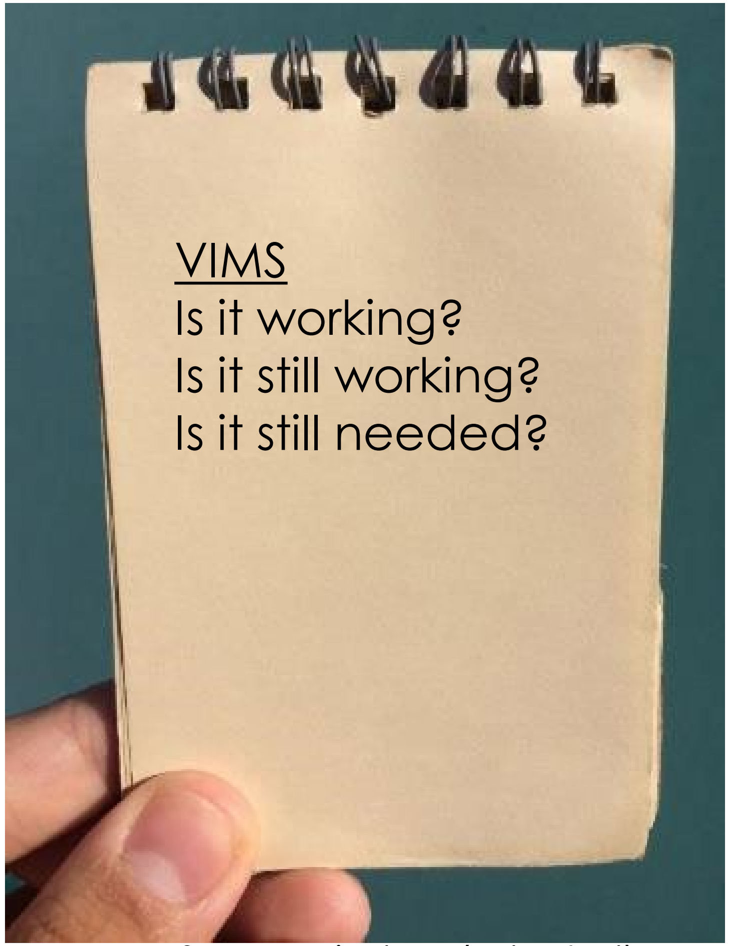
Subsequent steps covered in other modules

Question & Answer Break

Source: Pixabay

Advancing
Environmental
Solutions

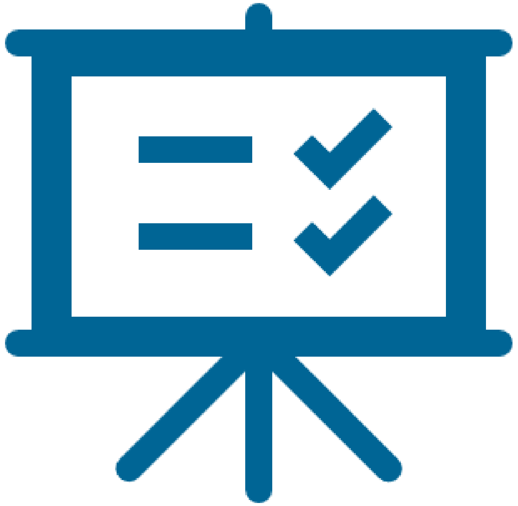
System Verification, Operation, Maintenance, and Monitoring, and Exit Strategy



Source: Pixabay (adapted)

Objectives of Module

- How to use the ITRC documents in your work
- Importance of early communication
- How to verify VIMS success
- How to address underperformance
- Planning for discontinuing a mitigation system



Communicate with your Stakeholders

Concurrence with stakeholders is critical during design:

- ▶ Keep stakeholders informed
- ▶ Confirm acceptable confirmation testing
- ▶ Select appropriate performance metrics
- ▶ Define acceptable scenarios for shutdown

Source: Pixabay

Don’t Wait Until the Last Moment

Post-Installation Fact Sheet

- Key considerations for VIMS verification
- Multiple technologies
- During-construction considerations

Vapor Intrusion Mitigation (VIM) HOME

Post Installation Fact Sheet

ITRC has developed a series of fact sheets that summarizes the latest science, engineering, and technologies regarding the mitigation of vapors associated with vapor intrusion (VI). This fact sheet describes the most common post-installation considerations for active mitigation systems, passive mitigation systems, and environmental remediation technologies that need to be considered as part of any mitigation system verification testing process.

1 Introduction

After the implementation of a mitigation strategy, post-installation verification and testing to confirm achievement of the design and operating parameters is required. It is during this time that the conceptual site model (CSM) is validated and the mitigation system is confirmed to be operating and meeting performance specifications, typically using multiple approaches or criteria.

Below are common considerations that professionals should consider or tests they may complete after implementation of a mitigation strategy for confirmation and prior to operation, maintenance, and monitoring (OM&M). Emerging technologies, such as aerobic vapor mitigation barriers (AVMB), are not addressed within this fact sheet. Please see the ***Aerobic Vapor Mitigation Barrier Technology Information Sheet*** for more information.

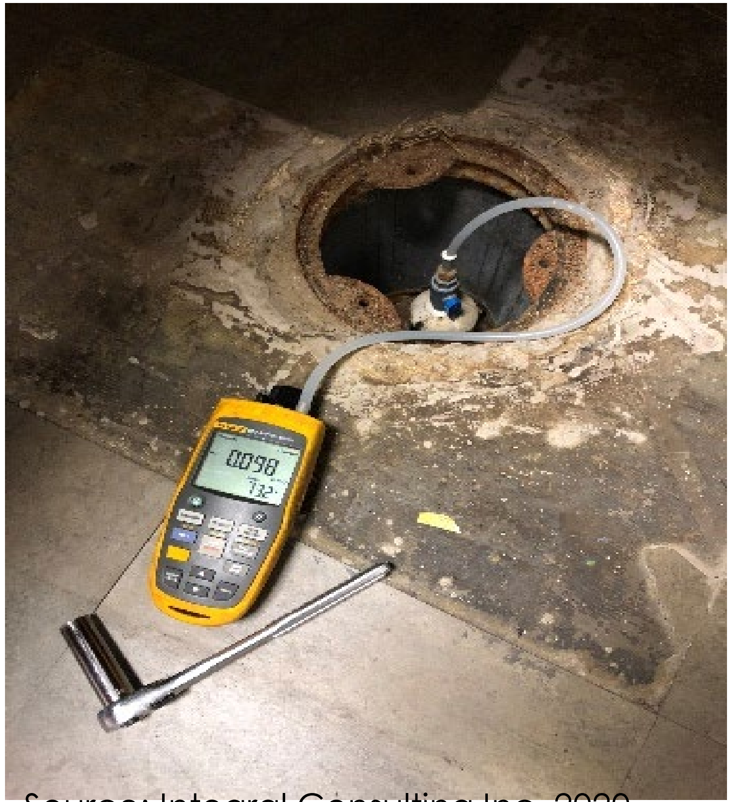
2 PreConstruction and During Construction

Planning, preparation, and oversight conducted during installation are as important as post-installation system confirmation. Attention to these items will greatly improve the post-installation evaluation and provide for a more successful implementation. The formality of planning and construction quality assurance (CQA) during installation will depend on the size and complexity of the building and the mitigation system to be constructed.

Prior to construction, plan the post-installation evaluations and documentation requirements, and communicate them to the installer and CQA representative(s). Obtain necessary permits for installation and operation, and plan how to meet the permit requirements, including those for closure of the permit.

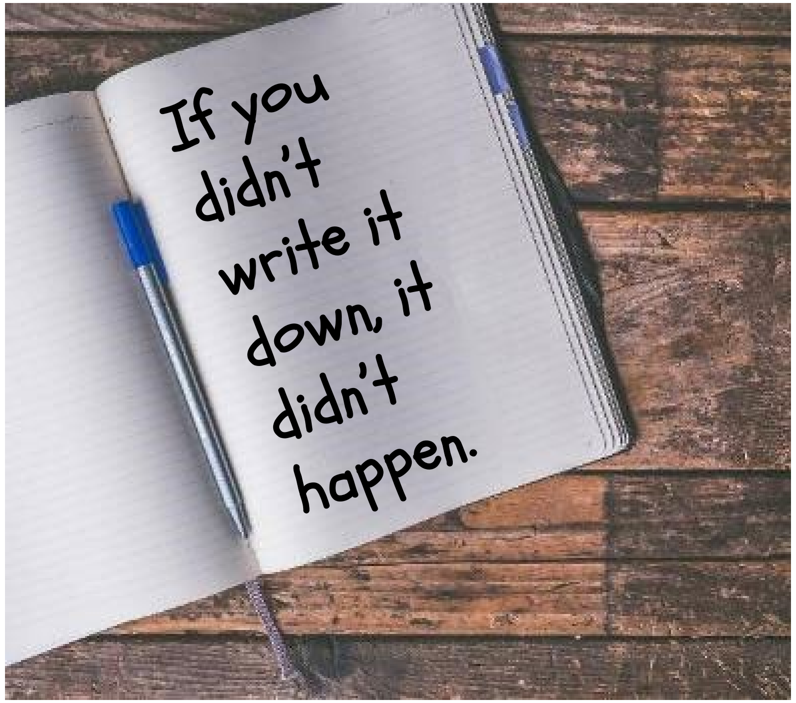
Verification – Is the VIMS Working?

- Use building condition survey
- Confirm VIMS was installed as designed:
  - Verify installed components
  - Verify proper operation
- Adjust as needed



Source: Integral Consulting Inc, 2020. Used with permission.

Documentation



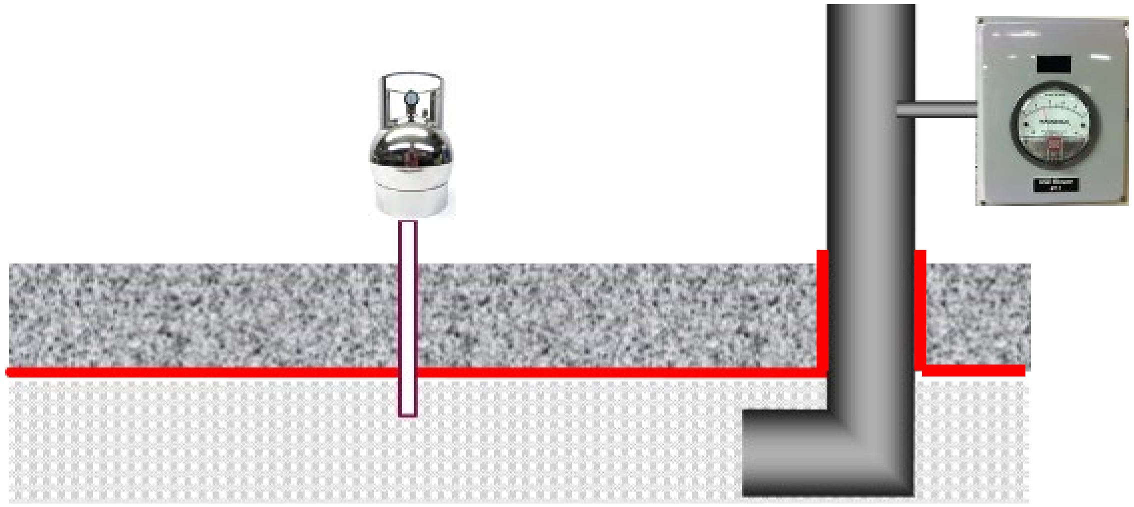
Source: Pixabay

Critical foundation for future condition evaluation

- As-built drawings
- Verification performance data

Example System Performance Metrics

- Vacuum field or pressure differential across slab
- Smoke/tracer gas testing
- IA/SG Sample results
- Long-term institutional controls
- System vacuum and airflow
- Other system/regulatory-specific metrics



Source: Geosyntec, 2020. Used with permission.

Post-Installation VIMS Verification Checklist

- Field-ready checklist
  - Active
  - Passive
- Template for state-specific or site-specific needs

Vapor Intrusion Mitigation Training (VIMT)

VAPOR INTRUSION MITIGATION SYSTEM
POST-INSTALLATION VERIFICATION CHECKLIST

The purpose of this checklist is to provide the user with a selection of tools to verify that the appropriate system components for the vapor intrusion mitigation system (VIMS) were installed and the system is operating as designed. This information applies to the four most common active mitigation systems (SSD, SSV, SMD, and CSV) and passive systems that are described in the associated Fact Sheets and Technology Information Sheets. The user of this checklist should review the VIMS design or as-built documentation prior to completing this checklist.

This document was prepared in consideration of multiple types of VIMS. Not all the information presented below is necessary to document system operation for all types of systems on all types of buildings. The user should be able to identify which criteria below best represent effective operation for their specific mitigation system and which criteria will validate the conceptual site model for the VIMS that was implemented. Timing on when to collect post-installation verification data may vary and more than one event may be reasonable. See the ***Post-Installation Verification Fact Sheet*** for additional information on timing a post-installation verification site visit.

Instructions for Use: Major system components are grouped below for this checklist, and one or more of these groups may not apply to a particular VIMS design. Those groups can be marked as Not Applicable by selecting the 'X' box to the right of the group.

Design elements within these groups that **will** apply should be selected appropriately using the dropdown boxes included for this checklist as:

Yes—the design element was considered and documented
No—this item was not considered and may be relevant to the overall system performance, applicable guidance, and/or best practices
NA—not applicable to the system design or operation

Knowledge Check

Poll Question

When is it most important to develop verification procedures and an exit strategy?

- During VI investigation
- During mitigation design and planning
- At the time of mitigation implementation
- After construction
- Never

Source: Pixabay

Knowledge Check

Poll Question

When is it most important to develop verification procedures and an exit strategy?

- ▶ During VI investigation
- ☑ During mitigation design and planning
- ▶ At the time of mitigation implementation
- ▶ After construction
- ▶ Never

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OM&M/Exit Strategy Fact Sheet

- Strategy for ongoing, acceptable performance
- Framework for exit strategy
- Early stakeholder engagement

Vapor Intrusion Mitigation (VIM) HOME

Operation, Maintenance, and Monitoring Process/Exit Strategy Fact Sheet

ITRC has developed a series of fact sheets that summarizes the latest science, engineering, and technologies regarding the mitigation of vapors associated with vapor intrusion (VI). This process fact sheet describes the most common Operation, Maintenance, and Monitoring considerations for active mitigation systems, passive mitigation systems, rapid response, and environmental remedial technologies that need to be considered as part of any design process. In addition, a termination or exit strategy is discussed in this process fact sheet.

1 Introduction

After the mitigation strategy has been selected, designed, and commissioned, the operation, maintenance, and monitoring (OM&M) plan plays a key role in demonstrating the ongoing effectiveness of the vapor intrusion mitigation system (VIMS). This fact sheet describes the key considerations of OM&M. Complex mitigation strategies will typically require more complex OM&M procedures. The key to OM&M is to gather data to support maintaining the VIMS to operate as designed, with the goal that it remains effective in the short and long term until it is appropriate to implement an exit strategy.

Emerging technologies, such as aerobic vapor mitigation barriers (AVMB), are not addressed within this OM&M Process fact sheet. Please see the *Aerobic Vapor Mitigation Barriers Technology Information Sheet* for more information.

2 Operation, Maintenance, and MONITORING Plan

An OM&M plan provides instructions for VIMS operation and upkeep and should be prepared for each installed VIMS. Details of a typical OM&M plan can be found in Section 6.3 and Section J.5 of in the *2014 ITRC Petroleum Vapor Intrusion (PVI) document* (ITRC, 2014). Information in these sections provides details for OM&M plan content that applies to the installed VIMS in general and is not specific to just PVI. The goals of OM&M are to verify performance of the VIMS during operation as compared to performance during system commissioning, and to inspect and repair any system malfunction (i.e., VIMS not operating to meet performance objectives or due to system equipment life expectancy). "In cases where testing shows the VIMS is not working and no defects in the system components have been identified, ITRC recommends re-evaluating the CSM

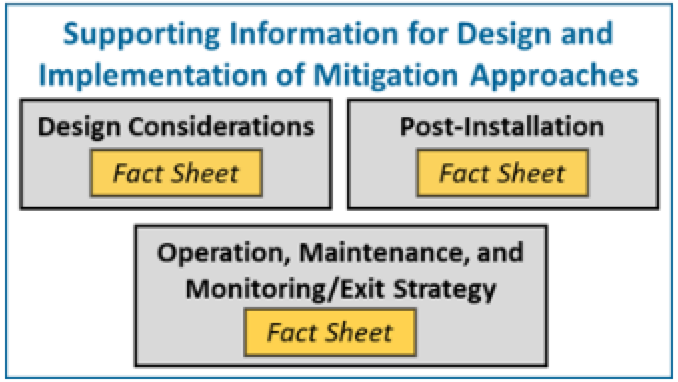
https://vim-1.itrcweb.org/operation-maintenance-and-monitoring-process-exit-strategy-fact-sheet/

OM&M – Is the VIMS Still Working?

- Determine if VIMS continues to meet performance metrics
- Analyze the cause of malfunction and implement corrective action
- Inform stakeholders if VIMS is not meeting performance metrics
- Assess results for potential to terminate VIMS

Figure 5 of the Sub-slab Depressurization Technology Information Sheet

Process Fact Sheet Rating System



Ratings provided by mitigation "type"

Category →
Principal consideration →
Subject matter →

Design consideration	Active approaches	Passive approaches	Remediation	Rapid response
VI CSM considerations				
Vapor source and concentration				
Vapor source and concentration	●	●	●	◐
Geology and hydrogeology				
Subgrade soil type	●	◒	●	◒
Depth to groundwater/high water conditions	●	●	●	◐

Key | High impact ● | Medium impact ◐ | Low impact ◒ | Not applicable —

Process Fact Sheet Narrative

Supporting Information for Design and Implementation of Mitigation Approaches

- Design Considerations *Fact Sheet*
- Post-Installation *Fact Sheet*
- Operation, Maintenance, and Monitoring/Exit Strategy *Fact Sheet*

Design consideration	Active approaches	Passive approaches	Remediation	Rapid response
VI CSM considerations				
Vapor source and concentration				
Vapor source and concentration	High impact	High impact	High impact	Medium impact
Geology and hydrogeology				
Subgrade soil type	High impact	Low impact	High impact	Low impact
Depth to groundwater/high water conditions	High impact	High impact	High impact	Medium impact

Key | High impact ● | Medium impact ◐ | Low impact ◒ | Not applicable —

Subgrade Soil Type: In most cases, the properties of soils immediately adjacent to the building (e.g., below the slab or next to foundation walls and footings) have the greatest impact on active mitigation technologies that require the movement of air and/or the propagation of vacuum below the slab. Soil type plays a major consideration for active mitigation strategies and makes some remediation technologies difficult to implement. For a more detailed description of methods to test and mathematically model the sub-slab permeability and transmissivity see (McAlary et al., 2018 ▻). See Section J.2.5 of *Appendix J in the 2014 ITRC PVI document* (ITRC, 2014 ▻) for more information on the consideration of soil type in active mitigation.

Active Mitigation	**High Impact:** Permeability of the sub-slab fill material and underlying soil controls the pressure field extension (PFE) and air flow rates and, therefore, the degree to which sub-slab depressurization (SSD) and sub-slab ventilation (SSV) contribute to indoor air quality protection. This affects the spacing of suction points and fan size required to induce and maintain the negative pressure field beneath the structure.
Passive Mitigation	**Low Impact:** Passive mitigation systems typically incorporate a permeable layer beneath barriers and around vent piping in new construction. It may not be feasible to incorporate a permeable layer beneath an existing building. Therefore, passive venting systems function best in soils that are highly permeable when retrofitting an existing building.
Environmental Remediation Technology	**High Impact:** Remediation technologies require the characterization of soils beyond the subsurface to evaluate the effectiveness of the proposed technology. MPE and SVE are generally not applicable to low-permeability soils.
Rapid Response	**Low Impact:** Rapid responses typically include ventilation changes, indoor air treatment, or other efforts that are focused inside the building, therefore sub-slab conditions are not relevant.

Checklists

Conceptual Site Models for Vapor Intrusion Mitigation | *Fact Sheet* | *Checklist*

Checklists for Active and Passive Mitigation Approaches

- *System Design and Documentation*
- *Post-Installation System Verification*
- *Operation, Maintenance, and Monitoring*

Category

Primary prompt

Prompt to record supporting information

Conditional (secondary) prompt

Clickable Check Boxes

Editable Fields

3. BUILDING CONDITIONS AND USE

3.1. Is the building's heating system or heating, ventilating, and air conditioning (HVAC) system operating? ☑ Yes ☐ No ☐ NA

If yes, provide a summary below and explain in Section 5 if the HVAC system operation could impact the effectiveness of the mitigation system.

Hours/day of HVAC operation ____12____

Climate controlled? ☐ Yes ☐ No ☐ NA

3.1.1. Is the building's heating system or HVAC system on during this OM&M event? ☐ Yes ☐ No ☐ NA

3.1.2. Is the building's heating system or HVAC system equipped with outside dampers? ☐ Yes ☐ No ☐ NA

If yes, how many? ________ *% opened* ___________

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OM&M Checklist

- Field-ready checklist for continuing verification
  - Active
  - Passive
  - Remediation
- Template for state-specific or site-specific needs

Vapor Intrusion Mitigation Training (VIMT)

VAPOR INTRUSION MITIGATION SYSTEM
OPERATION, MONITORING, AND MAINTENANCE CHECKLIST

Scope of Checklist: The purpose of this checklist is to guide the user during the inspection of a vapor intrusion mitigation system (VIMS) to (1) verify that the VIMS is operating as designed and (2) determine if certain operation, maintenance, and monitoring (OM&M) activities are necessary for continued operation and effectiveness of the system. This checklist is intended to provide factors to consider when documenting that the VIMS is operating and is effectively mitigating the vapor intrusion pathway during the lifecycle of its operation. Not all the information presented below is necessary to document system operation for all types of systems on all types of buildings, and some items may not be needed during every monitoring event. The user should be able to identify which criteria below best represent effective operation and responsible maintenance of their specific VIMS and if the conceptual site model (under which the system was designed) is still valid.

Prior to completing the inspection, it is recommended that the user review previously prepared OM&M plans. As-built drawings and performance (baseline) criteria are needed when conducting inspections of a VIMS. Monitoring scope, schedule, and methods may follow applicable agency requirements, which may be amended on a case-by-case basis through regulatory negotiation and approval. Where applicable, the monitoring and inspections must also comply with standards of practice and applicable codes (electrical code, building code).

In some situations, OM&M plans may not exist or be available or were not provided to a new operator or new building owner. Thus, the original as-built drawings and possibly the original performance criteria may not be known. In these cases, the checklist below can still be used to assist in developing the appropriate ongoing OM&M parameters for that particular site, although additional effort may be appropriate depending on the complexity of the building and site conditions.

System Shutdown – Is the VIMS Still Needed?

- Plan for the exit early in the VIMS process
- Continually evaluate VIMS for meeting exit conditions
- Specify the VIMS shut-down process

Source: Pixabay

Knowledge Check

Poll Question

Which is the most important post-installation verification measure?

- Vacuum field or pressure differential across slab
- Smoke/tracer gas testing
- IA/SG sample results
- Long-term institution controls
- System vacuum and airflow
- It depends

Source: Pixabay

Knowledge Check

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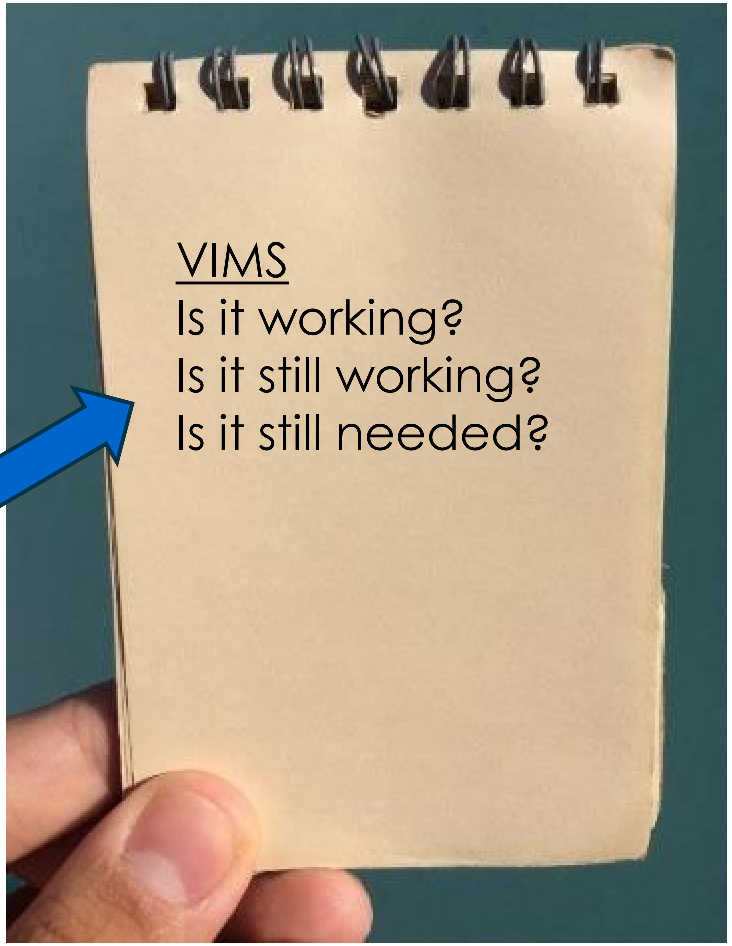
Summary

- Early planning for verification, OM&M, and exit strategy is critical
- ITRC provides comprehensive planning and delivery tools (fact sheets and field checklists) covering multiple technologies
- Keep in mind the three essential questions



Source: Pixabay (adapted)

Thank you for attending!

Questions

- Email further questions on today's session to:
  training@itrcweb.org
- Feedback Form & Certificate of Completion:
  https://clu-in.org/conf/itrc/VIM-1/feedback.cfm
- Vapor Intrusion Mitigation Training:
  https://clu-in.org/conf/itrc/vim-1

Source: Pixabay