Infrastructure · Water · Environment · Buildings

Imagine the result

# Vapor Intrusion Mitigation Work Plan

## RACER

Former Delphi Harrison Thermal Systems Moraine Plant
Former General Motors Powertrain Group, Moraine Engine Plant
Former General Motors Truck Group, Moraine Assembly Plant

Moraine, Ohio

May 6, 2011
Revised June 3, 2011
Revised September 13, 2011

## Tables



## Figures



## Appendices

## 1. Introduction

The United States Environmental Protection Agency (U.S. EPA) requested, in a letter dated December 3, 2010 "Re: RCRA 3008(h) Unilateral Administrative Order, Docket # V-W-91 R-2 Former Delphi Harrison Thermal Systems (OHD 000 817 577) and Former Moraine Engine Plant (OHD 980 569 388) and Former Moraine Assembly Plant (OHD 041 063 074)" that Motors Liquidation Company (MLC) (as of March 31, 2011, MLC is referred to as Revitalizing Auto Communities Environmental Response Trust [RACER]) provide a draft work plan by December 13, 2010 for sub-slab and indoor air sampling in the neighborhood southwest of the Moraine Site (Site) (U.S. EPA, 2010). A Sub-Slab and Indoor Air Sampling Work Plan (Work Plan) was created to satisfy this request and was submitted to the U.S. EPA on December 13, 2010 (ARCADIS, Inc., 2010a). The Work Plan covered the scope of work for sampling sub-slab soil-gas and indoor air within residential and commercial structures located in the Riverview Plat neighborhood to the southwest of the Site. MLC received comments from the U.S. EPA on this Work Plan in a letter dated February 8, 2011 "Draft Sub-Slab and Indoor Air Sampling Work Plan – Motors Liquidation Company - Former Delphi Harrison Thermal Systems (OHD 000 817 577) and Former Moraine Engine Plant (OHD 980 569 388) and Former Moraine Assembly Plant (OHD 041 063 074)" providing conditional approval contingent upon MLC resolving U.S. EPA comments (U.S. EPA, 2011a). The Revised Sub-Slab and Indoor Air Sampling Work Plan (Revised Work Plan) addressing these comments was submitted to the U.S EPA on March 4, 2011 (ARCADIS, Inc., 2011).

The Revised Work Plan outlined the sub-slab soil-gas, ambient air, and indoor air (basement, first floor, and crawlspace) sampling program to be completed for the residential properties, church, and gas station located in the Riverview Plat neighborhood southwest of the Site. The sampling of all properties where access has been granted in the Riverview Plat neighborhood began on March 7, 2011 and is on-going as of the date of this document. Upon receipt of the final laboratory reports and completion of data validation, the data will be compared to the indoor air and sub-slab Action Levels presented on Table 1 for residential and commercial scenarios and grouped within the categories discussed in Section 2. Based on this comparison and grouping, a decision matrix will be followed to determine what action is required for each property, including "worst-case" confirmatory sampling or resident-specific mitigation based on a meeting to be held with the property owner. The results of the sub-slab soil-gas and indoor air sampling will be summarized in a property-specific letter and submitted to the property owners during the meeting. Template letters to property owners , an access agreement, and a fact sheet are included in Appendix A.

This Vapor Intrusion Mitigation Work Plan (VI Mitigation Work Plan) includes a discussion of the decision matrix (Section 2), a discussion of the VI mitigation system components and design considerations (Sections 3 and 4; Appendices C, D, and G), system sampling (Section 5 and Appendix B), the property-specific work plan template (Section 4 and Appendix E), system operation and maintenance (O&M) (Section 6 and Appendix F), system decommissioning (Section 7), and quality objectives (Section 8). This VI Mitigation Work Plan incorporates comments provided by the U.S. EPA on April 18, 21, and 22, 2011 (U.S. EPA, 2011b, c, and d) to a Draft VI Mitigation Work Plan submitted by RACER on April 8, 2011, conditional approval with comments provided by U.S. EPA in correspondence dated May 23, 2011 to the revised Draft VI Mitigation Work Plan submitted by RACER on May 6, 2011 (U.S. EPA 2011e), and final revised comments to the Vapor Intrusion Mitigation Work Plan submitted by RACER on June 3, 2011 (U.S. EPA 2011f) provided by the U.S. EPA in correspondence (July 14, 2011), conference calls (July 19, 28, and 29, 2011 and August 9, 2011), meetings (August 3, 17, 30, and 31, 2011 and September 1, 2011), and email (July 25, 28, and 29, 2011and August 5, 9, and 13, 2011).

## 2. Decision Matrix

Following receipt of the final laboratory analytical results and completion of data validation per the Revised Work Plan (ARCADIS, Inc., 2011), a decision analysis will be conducted to evaluate the vapor intrusion potential and recommend additional evaluation, sampling, or mitigation, if necessary. Each building will be evaluated on a case-by-case basis considering the indoor air (first floor, basement, and crawlspace) and sub-slab soil-gas results, applicable Action Levels (Table 1), and the results of the right-of-way groundwater and soil-gas sampling completed in the Riverview Plat. The right-of-way groundwater and soil-gas results and the applicable Action Levels are summarized on Tables 2 and 3, respectively.

Potential future actions may include “worst case” confirmation sampling or mitigation. In cases where “worst case” confirmation sampling is required, sampling will be completed during the heating season which extends from November through March (aiming at high water table conditions). If a mitigation system is required, post-installation proficiency sampling will be conducted to confirm that the mitigation system is operating properly. If post-installation proficiency sampling indicates concentrations of chemicals of concern are above the Action Levels (Table 1), mitigation system modifications may be required. Confirmatory and post-installation proficiency sampling will be completed following the standard operating procedures (SOPs 20, 21, 22) approved in the Revised Work Plan (ARCADIS, Inc., 2011), and included in Appendix B. Information regarding design, installation, sampling, and operation and maintenance of a typical mitigation system is presented in Sections 3 through 6.

The U.S. EPA has provided the following decision matrix for the Site. Categories 1 through 4 are for properties where sub-slab data was available. Categories 5 and 6 are for properties where sub-slab data was not available.

### Category 1

Sub-slab and indoor air concentrations are less than the Action Levels (see Table 1).

Category 1A: If the right-of-way sample concentration is less than the Action Levels for groundwater and/or soil-gas (see Tables 2 and 3), proceed to “worst case” confirmatory sampling (below).

Perform “worst case” confirmatory sampling biannually for two consecutive years, beginning during the up-coming heating season. Confirmatory sampling will be completed during the first quarter of the year (January through March) and the fourth quarter of the year (November through December) to coincide with the "worst case" scenario. Number of samples and sample locations will be based on building construction and previous sampling results. If confirmatory sampling results are less than the Action Levels for indoor air and sub-slab, no further action is required. If confirmatory sampling results are greater than or equal to the Action Levels for indoor air and/or sub-slab, proceed to Category 2, 3, or 4, as appropriate.

Category 1B: If the right-of-way sample concentration is greater than or equal to the Action Levels for groundwater and/or soil-gas (see Tables 2 and 3), proceed to design and install an active mitigation system.

- Design and install an active mitigation system in consultation with the property owner. The active mitigation system will be designed to depressurize the sub-slab region and prevent the entry of soil vapors into the building. Section 3.1 provides additional information for design and installation of active mitigation systems.
- Confirm mitigation system is operating properly (sub-slab region is depressurized/manometer reading).
- Perform post-installation proficiency sampling events for indoor air approximately 30 days, 180 days, and 360 days after system installation. Section 5 provides additional information for post-installation sampling.
- Complete system modifications if necessary based on proficiency sampling results.
- Perform system O&M as necessary (Appendix F).

**Category 2**

Indoor air concentrations are greater than or equal to the Action Levels and sub-slab concentrations are less than the Action Levels (see Table 1).

Perform additional review of product inventory to determine the potential for background sources to contribute to the indoor air concentrations and evaluate representativeness of sub-slab sample point. If possible, remove any identified background source.

Category 2A: If a potential background source for the detected VOC can be identified, remove the potential source and re-sample indoor air. If the results of the re-sampling indicate that indoor air concentrations are less than the Action Levels, proceed to Category 1. If the results of the re-sampling indicate that indoor air concentrations are greater than or equal to the Action Levels, proceed to Category 2B (below).

Category 2B: If a background source cannot be identified, proceed to install an active mitigation system. In this scenario, an active mitigation system should be installed regardless of the right-of-way sample results.

- Design and install an active mitigation system in consultation with the property owner. The active mitigation system will be designed to depressurize the sub-slab region and prevent the entry of soil vapors into the building. Section 3.1 provides additional information for design and installation of active mitigation systems.

- Confirm mitigation system is operating properly (sub-slab region is depressurized/manometer reading).

- Perform post-installation proficiency sampling events for indoor air approximately 30 days, 180 days, and 360 days after system installation. Section 5 provides additional information for post-installation sampling.

- Complete system modifications if necessary based on proficiency sampling results.

- Perform system O&M as necessary (Appendix F).

**Category 3**

Indoor air concentrations are less than the Action Levels and sub-slab concentrations are greater than or equal to the Action Levels (see Table 1).

Proceed to design and install of an active mitigation system.

- Design and install an active mitigation system in consultation with the property owner. The active mitigation system will be designed to depressurize the sub-slab region and prevent the entry of soil vapors into the building. Section 3.1 provides additional information for design and installation of active mitigation systems.

- Confirm mitigation system is operating properly (sub-slab region is depressurized/manometer reading).
- Perform post-installation proficiency sampling events for indoor air approximately 30 days, 180 days, and 360 days after system installation. Section 5 provides additional information for post-installation sampling.
- Complete system modifications if necessary based on proficiency sampling results.
- Perform system O&M as necessary (Appendix F).

**Category 4**

Indoor air concentrations are greater than or equal to the Action Levels and sub-slab concentrations are greater than or equal to the Action Levels (see Table 1).

Proceed to design and install of an active mitigation system.

- Design and install an active mitigation system in consultation with the property owner. The active mitigation system will be designed to depressurize the sub-slab region and prevent the entry of soil vapors into the building. Section 3.1 provides additional information for design and installation of active mitigation systems.
- Confirm mitigation system is operating properly (sub-slab region is depressurized/manometer reading).
- Perform post-installation proficiency sampling events for indoor air approximately 30 days, 180 days, and 360 days after system installation. Section 5 provides additional information for post-installation sampling.
- Complete system modifications if necessary based on proficiency sampling results.
- Perform system O&M as necessary (Appendix F).

**Category 5**

Indoor air concentrations are greater than or equal to the Action Levels (see Table 1) and sub-slab data is not available.

Proceed to design and install of an active mitigation system.

- Design and install an active mitigation system in consultation with the property owner. The active mitigation system will be designed to depressurize the sub-membrane region and prevent the entry of soil vapors into the building. Section 3.1 provides additional information for design and installation of active mitigation systems.
- Confirm mitigation system is operating properly (manometer reading).
- Perform post-installation proficiency sampling events for indoor air approximately 30 days, 180 days, and 360 days after system installation. Section 5 provides additional information for post-installation sampling.
- Complete system modifications if necessary based on proficiency sampling results.
- Perform system O&M as necessary (Appendix F).

**Category 6**

Indoor air concentrations are less than the Action Levels (see Table 1) and sub-slab data is not available.

Category 6A: If the right-of-way sample concentration is less than the Action Levels for groundwater and/or soil-gas (see Tables 2 and 3), proceed to "worst case" confirmatory sampling (below).

Perform "worst case" confirmatory sampling biannually for two consecutive years, beginning during the up-coming heating season. Confirmatory sampling will be completed during the first quarter of the year (January through March) and the fourth quarter of the year (November through December) to coincide with the "worst case" scenario. Number of samples and sample locations will be based on building construction and previous sampling results. If confirmatory sampling results are less than the Action Levels for indoor air, no further action is required. If confirmatory sampling results are greater than or equal to the Action Levels for indoor air, proceed to design and install an active mitigation system.

Category 6B: If the right-of-way sample concentration is greater than or equal to the Action Levels for groundwater and/or soil-gas (see Tables 2 and 3), proceed to design and install an active mitigation system.

- Design and install an active mitigation system in consultation with the property owner. The active mitigation system will be designed to depressurize the sub-membrane region and prevent the entry of soil vapors into the building. Section 3.1 provides additional information for design and installation of active mitigation systems.
- Confirm mitigation system is operating properly (manometer reading).
- Perform post-installation proficiency sampling events for indoor air approximately 30 days, 180 days, and 360 days after system installation. Section 5 provides additional information for post-installation sampling.
- Complete system modifications if necessary based on proficiency sampling results.
- Perform system O&M as necessary (Appendix F).

## 3. VI Mitigation Systems

For the properties that require mitigation (see Section 2), an active mitigation system should be designed to prevent vapors present below the foundation of the structure from entering the indoor air within the structure.

An active mitigation system includes a depressurization system that creates a negative pressure (vacuum) below the foundation of the structure using an electric powered fan. The proposed active mitigation includes either a sub-slab depressurization system (SSDS), a sub-membrane depressurization system (SMDS), or a crawlspace depressurization system (CSDS) as applicable based on structure. The mitigation system works by reversing the pre-existing pressure gradient across the foundation of the structure. The resulting vacuum below the foundation prevents soil vapor from entering the structure.

### 3.1 Active Mitigation Systems

Active mitigation systems are being considered for installation at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or a combination of these. The active mitigation system will be designed to depressurize the sub-slab region, sub-membrane (crawlspace sealed with reinforced, polyethylene sheeting) region, or inaccessible crawlspaces and prevent the entry of soil vapors into the building. Reinforced sheeting is the same as cross-laminated polyethylene. The active mitigation system design is based on SSDS, SMDS, and CSDS design criteria found in American Society for Testing and Materials (ASTM E2121), Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2003), U.S. EPA Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and the U.S. EPA Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

As a component of the mitigation system, the foundation will be sealed to the extent possible to minimize the existing pathways for vapors to enter the building and to minimize short-circuiting. The prevention of short-circuiting will enhance the ability of the active mitigation system to create the necessary negative pressure beneath the entire foundation of the building. Permanent sub-slab sample points will be installed in properties with basement or slab-on-grade foundation types to allow for monitoring of the pressure field extension and ensuring sub-slab depressurization that exceeds negative 0.004 inches of water column (in. w.c.). Sub-slab pressure field extension readings will be collected from the permanent sub-slab sample points during operation and maintenance inspections. If the results of post-installation proficiency sampling (see Section 5) indicate that indoor air concentrations remain above the Action Levels (see Table 1), appropriate system modifications will be included to help the pressure field extend adequately around the crawlspace or dirt floor.

### 3.1.1 Basement Foundation

Components of a typical active mitigation system installed within a basement include the following:

- Sealing (see Section 3.3) of the foundation to enable vacuum influence to extend under the entire foundation of the building.
- A suction pit installed through the basement slab. The pit will be created by removing approximately 1 cubic foot of soil from below the slab, inserting the vent piping through the slab, and sealing the slab opening with polyurethane caulk.
- Vent piping (4-inch, Schedule 40 poly-vinyl chloride [PVC]) installed from the suction pit through the sill plate of the building and up the exterior of the building to the rooftop discharge location (see photograph 1, Appendix C).
- An in-line fan installed within the vent piping on the exterior of the building. The fan will be wired through a local disconnect switch to the building's electric panel. The associated breaker on the panel will be labeled to indicate it is connected to the fan. A schematic for a typical fan to be used is included in Appendix D.
- A manometer installed on the vent piping within the basement to confirm on-going system operation within the desired range (see photograph 2, Appendix C). If approved by the homeowner, an audible alarm may also be installed to notify the property owner of system malfunction.
- Roof flashing installed as necessary to seal the penetration of the vent piping through the roof.

An example of a typical active mitigation system installed in a building with a basement foundation is depicted in Figure 1.

### 3.1.2 Slab-On-Grade Foundation

Components of a typical active mitigation system installed at a building with a slab-on-grade foundation include the following:

- Sealing (see Section 3.3) of the foundation to enable vacuum influence to extend under the entire foundation of the building.

- A suction pit installed through the slab-on-grade foundation. The pit will be created by removing approximately 1 cubic foot of soil from below the slab, inserting the vent piping through the slab, and sealing the slab opening with polyurethane caulk.

- Vent piping (4-inch, Schedule 40 PVC) installed from the suction pit, up through the attic of the building, and through the roof to the rooftop discharge location (see photograph 1, Appendix C).

- An in-line fan installed within the vent piping inside the attic of the building. The fan will be wired through a local disconnect switch to the building's electric panel. The associated breaker on the panel will be labeled to indicate it is connected to the fan. A schematic for a typical fan to be used is included in Appendix D.

- A manometer installed on the vent piping within the building to confirm system operation within the desired range (see photograph 2, Appendix C). If approved by the homeowner, an audible alarm may also be installed to notify the property owner of system malfunction.

- Roof flashing installed to seal the penetration of the vent piping through the roof, if installed through the interior of the building.

- In the event that the vent piping is not able to be installed through the interior of the building, the suction pit may be installed from the exterior of the building through the frost wall. In this case the vent piping would continue up the outside of the building to the discharge location above the roof line. The in-line fan and manometer would be installed in the piping on the exterior of the building.

An example of a typical active mitigation system installed in a building with a slab-on-grade foundation is depicted in Figure 2.

### 3.1.3 Crawlspace and Other Dirt Floor Type Foundations

Components of a typical active mitigation system installed within a crawlspace include the following:

- Sealing (see Section 3.3) of the foundation with reinforced, polyethylene sheeting to enable vacuum influence to extend under the entire foundation of the building.

- Installation of a suction point under the crawlspace sheeting. The suction point will consist of a tee connected to perforated polyethylene drain tile. The drain tile will create the necessary collection area and prevent the sheeting from being pulled into the vent pipe. These components are equivalent to a sub-membrane depressurization system.

- Vent piping (4-inch, Schedule 40 PVC) installed from the suction point through the sill plate of the building and up the exterior of the building to the rooftop discharge location (see photograph 1, Appendix C).

- An in-line fan installed within the vent piping on the exterior of the building. The fan will be wired through a local disconnect switch to the building's electric panel. The associated breaker on the panel will be labeled to indicate it is connected to the fan. A schematic for a typical fan to be used is included in Appendix D.

- A manometer installed on the vent piping at an accessible location within the crawlspace to confirm system operation within the desired range (see photograph 2, Appendix C). If approved by the homeowner, an audible alarm may also be installed to notify the property owner of system malfunction.

- Roof flashing installed as necessary to seal the penetration of the vent piping through the roof.

An example of a typical active mitigation system installed in buildings with a crawlspace foundation is depicted in Figure 3.

### 3.2 Sealing

Sealing openings in the foundation is necessary to eliminate potential pathways for soil vapors to enter the building and to enhance the performance of the mitigation system. A photo log of various sealing procedures is provided in Appendix C (see photographs 3-8).

Sealing will include sealing of all basement floor and wall cracks, basement perimeter joints, cracks in slab-on-grade foundations, crawlspaces, open block wall cores, sump lids, and any other openings leading directly to the soil. Sealing will be conducted utilizing the following methods.

- All surfaces to be sealed will be cleaned prior to applying sealant using a wet/dry vacuum. In some cases a wire brush may be necessary to loosen dirt or debris prior to vacuuming. Surfaces must be clean, dry, and free of all dirt, debris, oil, and grease prior to sealing.

- All cracks greater than 1/2 - inch wide will be filled with closed cell foam backer rod prior to applying sealant. Backer rod should be approximately 25 percent larger than the width of the crack. Backer rods should be installed using a roller or flat sided tool to prevent puncture of the rods during installation.

- Cracks will be sealed with polyurethane caulk by forcing the caulk into the crack and smoothing at or slightly below the floor/wall surface to create a complete seal to each edge of the crack.

- Open block wall cores will typically be sealed by filling the top portion of the cores with expanding foam.

- Sumps will be sealed by installing solid lids with air-tight seals around all protrusions through the lid. Lids will be sealed to the floor using a non-permanent caulking, such as silicone, or through the use of an air-tight gasket and mechanical fasteners to allow the opening of the lid for pump maintenance. A view port may also be included in the lid to enable routine inspection of pump performance without repeated removal of the lid.

- Drains installed through sump lids, through crawlspace liners, or through basement floors (not connected to sewer) will be sealed by installing a drain seal consisting of a trapped drain or a one way valve which allows water to drain, but no air to travel up through them. If a trapped drain is utilized it should be capable of holding a minimum of 6-inches of standing water to minimize the potential for drying out.

- Accessible crawlspaces will be sealed using reinforced, polyethylene sheeting. Adjacent sheets will be overlapped by 1 foot and sealed between with polyurethane caulking and tape. Sheeting will be sealed to the perimeter of the crawlspace and around any protrusions using polyurethane caulking and tape as necessary. Sheeting will be secured to the crawlspace walls using 1-inch by 2-inch wood strips (non-treated) and concrete anchors. Exterior crawlspace walls will be sealed as necessary with polyurethane caulking or by extending the sheeting up the exterior walls and securing at the top. Crawlspace access openings will be covered as necessary to prevent pets or other animals from entering and damaging the sheeting.

- Inaccessible crawlspaces will be sealed by identifying and sealing openings from the crawlspace to the first floor with appropriate materials (e.g., polyurethane caulking, expanding foam, and/or polyethylene sheeting). Cracks within the crawlspace foundation walls will be sealed with polyurethane caulking. Larger openings in the foundation will be sealed with expanding foam or covered with sheet metal, sealed with polyurethane caulk, and anchored to the foundation with screws. Concrete will be considered to seal dirt floor areas with significant foot traffic (i.e., daily). If the dirt floor is only periodically used (weekly or less) plastic sheeting protected with foam padding and plywood will be considered. Regardless, the condition of the flooring will be inspected twice during the first year after installation and annually thereafter.

- Other openings will be evaluated and sealed using polyethylene sheeting, non-shrink grout, mortar, concrete, or expanding foam.

- Based on specific construction details of each property, other sealing methods may be determined to be appropriate.

## 4. Design Process

A unique design for each mitigation system will be completed at each property. The process will begin with a visual survey of the structure. After the necessary information has been gathered the system design will be completed and submitted to the U.S. EPA for approval. After the design has been approved the system will be installed and operation verified. It should be noted that small deviations from the approved property-specific work plan may be warranted based on field conditions. These deviations will be noted in the as-built diagram provided to the resident and the U.S. EPA. An Inspection and Mitigation System Design SOP (SOP 23) is included in Appendix B.

### 4.1 Property Inspection

A visual survey and hand sketch of each building will be conducted to identify the unique characteristics of that building that will need to be considered during the design phase. The items listed below will be identified. The property owner will also be consulted for input on areas that may need sealing and on their preferences for system component location. The following information will be recorded on the Inspection Form included in the Inspection and Mitigation System Design SOP (SOP 23) in Appendix B.

- Identify each separate foundation and its type. Sketch the configuration and note the approximate size of each separate area.

- Include the size and location of crawlspace access doors and the approximate working height within each crawlspace. Note any obstacles that may present a problem for access and if any stored materials will need to be temporarily removed. Note whether padding and plywood or other materials will be needed to protect the sheeting and whether the access door will need to be protected from pets or other small animals.

- For slab-on-grade foundations sketch the floor plan of the first floor, and identify locations such as closets or utility rooms that may be candidates for system installation. If a second floor is present, identify any locations where the system piping could be installed through both floor levels within closets or other acceptable locations. Identify any cracks or other openings in the slab that are accessible for sealing.

- Sketch the basement floor plan (as applicable) including the identification of finished and unfinished areas, sumps, floor drains not connected to sewers, cracks, wall to floor joints, open block wall cores, plumbing penetrations, and any other areas that may require sealing. Note the presence of stored items that may need to be temporarily relocated to access areas for sealing and system installation. Note any significant degradation in the integrity of the floor and/or walls that would require additional sealing measures beyond the standard caulking procedures.

- If a sump is present, identify the drains that are connected to the sump and the type of sump pump that is present (pedestal or submersible).

- Identify gas fired appliances, such as furnaces and water heaters that may need to be checked for backdrafting. If a backdraft test failure is noted at any time during the mitigation design or installation process, the contractor will be assigned to diagnose the cause of the backdraft test failure. If the backdraft test failure is associated with appliance venting, the mitigation contractor will correct the problem and the appliance will be re-tested. If the backdraft test failure is associated with the appliance malfunctioning, the property owner will be asked to repair or replace the appliance prior to mitigation system operation. Mitigation systems can be installed at homes with backdraft failures; however, the mitigation system will be locked in the off position and should not be operated until the backdraft condition has been remedied.

- On the exterior of the building, identify the number of stories, the type and condition of the roof, and any receptors that may need to be avoided when determining the system discharge location.

#### 4.2 Property Specific Design Specifications

For each property that is identified for mitigation, ARCADIS will complete a design which will identify the location and components of the mitigation system. Specific design factors to be considered for each property will include the following:

- The number of suction points that will be necessary and their location. If multiple foundation types (basement, crawlspace, slab-on-grade) exist or if the building has had additions of the same foundation type, it may be necessary to install a suction point in each of these areas. This determination will be made based on the configuration of these areas.

- Pipe routing to enable installation at the required one percent slope. Where possible, multiple suction points will be plumbed together to a single fan and discharge. The discharge point will be located a minimum of 10 feet from any intakes. The fan will be located either on the exterior of the building or within the attic of the building.

- Determining the fan sizing. Fan sizing will be based on the number of suction points, the tightness of the soils present below the slab, and the background differential pressure across the slab. The fan will be sized to create 1 to 4 in. w.c. vacuum at the suction point and negative 0.004 in. w.c. under the foundation slab. It is anticipated that vacuums nearing 4 in. w.c. will need to be applied to some suction points in order to achieve the required negative 0.004 in. w.c. vacuum across the entire slab. When possible fans sized between 1 and 2.5 in. w.c. will be selected; however, fans sized up to 4 in. w.c. will be selected as necessary to achieve the sub-slab vacuum requirement. The RadonAway™ GP Series of fans represents typical in-line fan sizes that will be chosen. A schematic with fan details is attached in Appendix D.

- Areas to be sealed including crawlspaces, cracks, sumps, perimeter joints, block tops, and any other openings in the foundation.

- Sealing of mitigation system components (i.e. suction pits and sub-slab sample points) that may provide a pathway for water in the unlikely event of a flood.

The location of the components will be reviewed with the property owner.

#### 4.2.1 Property-Specific Work Plan

Property-specific work plans with the following information will be prepared for each property and submitted to the U.S. EPA for approval prior to installation. The property-specific work plans will be submitted to the U.S. EPA within five business days of the completion of the initial visit. It should be noted that small deviations from the approved property-specific work plan may be warranted based on field conditions. These deviations will be noted in the as-built diagram provided to the property owner and the U.S. EPA in the O&M Manual (see Section 4.2.2). The following information will be included in the property-specific work plans:

- A floor plan showing each foundation type, location of suction point(s) and piping, location of sub-slab sample points, and areas to be sealed;

- The fan model to be used and the manufacturers design specifications for the fan;
- The fan location;
- The discharge location; and
- Property owner preferences that are to be incorporated.

A property-specific work plan template is included in Appendix E.

#### 4.2.2 Property-Specific O&M Manual

An O&M Manual (Appendix F) will be supplied to each property owner within 10 business days of mitigation system installation. The following typical items will be included:

- Photos of the mitigation system;
- Copy of the signed access agreement;
- Copy of the sample results letter;
- Copy of confirmation sample results letter;
- Fan warranty information;
- Initial and annual O&M inspection forms; and
- Contact information.

The O&M Manual will be attached to the system piping to enable easy future access. A key will also be provided to the property owner for the padlock on the disconnect switch. The key should be kept with the O&M Manual.

#### 4.2.3 System Installation

The system installation will be completed by a State of Ohio Department of Health licensed and insured Radon Mitigation Contractor/Specialist who will perform all work in compliance with local code requirements. The installation will be conducted at no cost to the property owner. ARCADIS will be overseeing the design and installation of each system. Systems will be installed per the requirements of ASTM Standard E 2121-03 (ASTM, 2003). A System Installation SOP (SOP 24) is included in Appendix B.

#### 4.2.4 System Inspection

When active mitigation systems are installed in buildings with basement or slab-on-grade foundations, one to two permanent sub-slab sample points will be installed for collection of sub-slab pressure field extension readings as described in Section 6. A vacuum reading of negative 0.004 in. w.c. below the slab will indicate that the active system is successfully depressurizing the sub-slab area. The permanent sub-slab sample points will be located on opposite sides of the foundation from the suction point to ensure the depressurization of the entire slab (for active mitigation systems). The permanent sub-slab sample points will remain in place for future measurements to be taken during the two inspections conducted in the first year and the subsequent annual inspections. The location of the sample points and the initial sub-slab pressure field extension readings will be documented and included in the O&M Manual for future reference. A Sub-Slab Soil-Gas Point Installation and Sampling SOP (SOP 20) is included in Appendix B.

An ARCADIS team member will verify that the differential pressure measured by the manometer installed on the system piping is within the design range of 1 to 4 in. w.c. They will then mark the operating differential pressure on the manometer and will show the property owner how to read the manometer. If at any time the system is not functioning within the range marked on the monitoring device, or the property owner notices damage to the system, they will be encouraged to call the phone number listed on the system label. ARCADIS will also provide an O&M Manual (Appendix F) to each property owner with contact information for any necessary troubleshooting or repairs. All repairs will be made at no cost to the property owner. The property owner will be asked to sign a form stating that they have received the O&M Manual.

## 5. Post-Installation Proficiency Sampling

At buildings with an active mitigation system, post-installation proficiency sampling of indoor air (first floor, basement, and accessible crawlspaces) samples will be collected approximately 30 days, 180 days, and 360 days after system installation to document that the indoor air is in compliance with the U.S. EPA Regional Screening Levels at a 1 x $10^{-5}$ risk level (Action Levels) (Table 1). In addition, five years from completion of the 360 day system sampling, another round of indoor air sampling will be conducted at those properties with an active mitigation system. Property owners will be provided with a letter to notify them of the sampling results and an explanation if results are less than or greater than or equal to the Action Levels. An Indoor Air and Ambient Air Sampling SOP (SOP 22) is included in Appendix B.

If the post-installation proficiency sampling results are not below the Action Levels, ARCADIS personnel will evaluate the performance of the active mitigation system and complete any necessary system modifications and/or sealing within 30 days of receiving validated sample results. System modifications could consist of replacing the existing fan with a different size fan or the installation of additional suction point(s). For sub-membrane depressurization systems, appropriate system modifications will be included to help the pressure field extend adequately around the crawlspace or dirt floor. Following completion of the system modifications, an additional post-installation proficiency sampling event will be conducted for indoor air (first floor, basement, and accessible crawlspaces) within 30 days.

## 6. System Operation and Maintenance

An annual inspection will be conducted by ARCADIS to inspect the active mitigation systems (i.e., sub-slab, sub-membrane, and inaccessible crawlspace depressurization systems) and ensure that they are functioning properly. Two inspections will be conducted in the first year and the systems will be inspected annually thereafter. The following items will be inspected and recorded on the Inspection Form included in the O&M SOP (SOP 25) in Appendix B.

- The manometer reading will be checked to ensure the system is operating in the design range.
- Sub-slab pressure field extension readings will be measured at the permanent sub-slab sample points to ensure sub-slab depressurization of negative 0.004 in. w.c. (active systems with slab foundations only).
- The fan will be checked for unusual noise or vibration.
- The vent piping will be checked for any damage.
- The pipe supports will be checked to ensure they are secure.
- Accessible crawlspaces or other areas sealed with reinforced, polyethylene sheeting will be inspected for damage.
- For inaccessible crawlspaces, openings from the crawlspace to the first floor, cracks within the crawlspace foundation walls, and larger openings in the foundation that required sealing will be inspected for damage.
- The foundation sealing and sealing around system piping penetrations will be checked for any additional areas requiring sealing.
- The presence of the padlock on the disconnect switch will be checked.
- The presence of the O&M Manual at the residence will be checked.
- If the results of post-installation proficiency sampling (see Section 5) indicate that indoor air concentrations remain above the Action Levels (see Table 1),

appropriate system modifications will be included to help the pressure field extend adequately around the crawlspace or dirt floor.

An example of the property owner O&M Manual is included in Appendix F. Repairs to the mitigation system or additional sealing will be conducted at no cost to the property owner.

A payment will be issued annually to reimburse the property owner for the cost of operating the electric powered fan. The mitigation fans are designed to minimize energy usage, and the cost to operate the fan will be calculated by ARCADIS using local electric rates and the fan wattage.

## 7. System Decommissioning

The determining criteria for discontinuing operation of individual vapor mitigation systems will be as follows:

- Evaluation of the potential for discontinuing operation of the SSDS, SMDS, or CSDS would only be completed once the Pre-Design Investigation (PDI) (ARCADIS, Inc. 2010b) is completed and the final remedies outlined in the Corrective Measures Proposal (CMP) (ARCADIS, Inc. 2008) and CMP Addendum (ARCADIS, Inc. 2010c) are implemented.

- Based on the information collected from the PDI, an updated Conceptual Site Model (CSM) will be completed. The source of the VOC-containing soil-gas vapor will be evaluated utilizing the updated CSM. ARCADIS will use the information collected during the Revised Vapor Intrusion Verification Work Plan (ARCADIS, Inc. 2010d) to calculate site-specific attenuation factors.

- Following this evaluation, a work plan outlining sampling frequency and standards for groundwater in the upper aquifer and soil-gas within the Riverview Plat will be submitted to the U.S. EPA. Potential sampling will include the collection of groundwater from upper aquifer within the Riverview Plat neighborhood and on-site along the property boundary (southern boundary of the closed South Settling Lagoon and western boundary of Landfill L1) and Soil-Gas Sampling Points (SGP-1 through SGP-8). Additional monitor wells or grab groundwater sampling locations may be necessary to collect the data needed for future evaluation of groundwater concentrations at the water table within the Riverview Plat neighborhood.

- Based on the data collected it will be determined if concentrations are expected to be below sub-slab Action Levels (see Table 1) for selected properties.

- After concurrence with the U.S. EPA, two rounds of confirmatory sampling will be completed. Samples will be collected from the permanent sub-slab sample point or points (refer to SOP 20 and 21 in Appendix B) and the sampling will be completed during the “worst case” sampling scenario, during the heating season. To accommodate this, one sampling event will be completed in November/December and one sampling event will be completed in February/March. Prior to sampling, a request will be submitted to the property owner to shutdown the SSDS, SMDS, CSDS for 48-hours prior to sampling. As soon as the first round of data (November/December) is available the property owner will be notified of the results. If the results are above the sub-slab Action Levels, the property owner will be notified to restart the SSDS, SMDS, or CSDS. If the results are below the Action Levels, the property owner will be notified to keep the SSDS, SMDS, or CSDS off until the second round (February/March) of confirmatory sampling can be completed.

- After completion of the second round of confirmatory sampling, assuming the results are below the Action Levels, the property owner will be provided with the option of removing the system (at RACER's cost), operating the system at the owner's expense for radon mitigation, or shutting the system off and leaving the components in place.

## 8. Quality Objectives

The data quality objectives for the sub-slab soil-gas and indoor air samples collected will be performed in accordance with the Revised Work Plan (ARCADIS, Inc. 2011). A Construction Quality Assurance Plan (CQAP) has been prepared to provide a quality assurance protocol that will ensure that construction of VI mitigation systems meet or exceed a certain level of quality and workmanship as defined in the construction drawings and technical specifications. CQAP documentation (i.e., personnel involved, quality assurance methods, test results, etc.) will be included in the O&M Manual provided to each property owner. A copy of the O&M Manual will also be provided to the U.S. EPA to document that the VI mitigation systems were installed in accordance with technical specifications and drawings. The CQAP is included in Appendix G.

## 9. References

American Society for Testing and Materials (ASTM) Standard E2121. 2003. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

ARCADIS, Inc. 2008. Draft Corrective Measures Proposal, General Motors Corporation, Moraine, Ohio. August 25, 2008.

ARCADIS, Inc. 2010a. Sub-Slab and Indoor Air Sampling Work Plan, Motors Liquidation Company, Moraine, Ohio. December 2010.

ARCADIS, Inc. 2010b. Draft Pre-Design Investigation Work Plan, Motors Liquidation Company, Moraine, Ohio, November 5, 2010.

ARCADIS, Inc. 2010c. Draft Corrective Measures Proposal Addendum, General Motors Corporation, Moraine, Ohio. March 22, 2010.

ARCADIS, Inc. 2010d. Revised Vapor Intrusion Verification Work Plan, Motors Liquidation Company, Moraine, Ohio, September 16, 2010.

ARCADIS, Inc. 2011. Revised Sub-Slab and Indoor Air Sampling Work Plan, Motors Liquidation Company, Moraine, Ohio. March 4, 2011.

U.S. EPA. 1993. 625 Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA. 2008. Indoor Air Vapor Intrusion Mitigation Approaches, October 2008.

U.S. EPA. Region 5, Vapor Intrusion Guidebook. October 2010.

U.S. EPA. 2011a. Draft Sub-Slab and Indoor Air Sampling Work Plan – Motors Liquidation Company - Former Delphi Harrison Thermal Systems (OHD 000 817 577) and Former Moraine Engine Plant (OHD 980 569 388) and Former Moraine Assembly Plant (OHD 041 063 074). February 8, 2011.

U.S. EPA. 2011b. Comments on 4/7 draft Mitigation Workplan -- RACER Trust Moraine Facilities. April 18, 2011.

U.S. EPA. 2011c. Draft comments on mitigation and EPA-RACER calls -- Re: Moraine VI Mitigation. April 21, 2011.

U.S. EPA. 2011d. U.S. EPA comments on draft revisions -- Re: Moraine VI Mitigation. April 22, 2011.

U.S. EPA. 2011e. Draft Vapor Intrusion Mitigation Work Plan – RACER Trust – Former Delphi Harrison Thermal Systems (OHD 000 817 577), Former Moraine Engine Plant (OHD 980 569 388), and Former Moraine Assembly Plant (OHD 041 063 074). May 23, 2011.

U.S. EPA 2011f. U.S. EPA comments – Vapor Intrusion Mitigation Workplan – RACER Moraine, dated June 3, 2011 (FINAL REVISED). July 14, 2011.

ARCADIS

**Table 1. Residential and Commercial Action Levels for Sub-Slab Soil-Gas and Indoor Air, RACER, Moraine, Ohio.**

| Chemical Constituent* | Residential Long-Term Action Level Indoor Air[(a)] ($ug/m^3$) | Residential Long-Term Action Level Sub-Slab Soil-Gas[(b)] ($ug/m^3$) | Non-Residential Long-Term Action Level Indoor Air[(a)] ($ug/m^3$) | Non-Residential Long-Term Action Level Sub-Slab Soil-Gas[(b)] ($ug/m^3$) |
|---|---|---|---|---|
| 1,1-Dichloroethane | 15.2 | 152 | 76.7 | 767 |
| Trans-1,2-Dichloroethene | 62.6 | 626 | 263 | 2630 |
| Tetrachloroethene | 4.1 | 41.2 | 20.8 | 208 |
| 1,1,1-Trichloroethane | 5,210 | 52,100 | 21,900 | 219,000 |
| Trichloroethene | 12.2 | 122 | 61.3 | 613 |
| 1,1–Dichloroethene | 209 | 2,090 | 876 | 8,760 |
| Cis–1,2–Dichloroethene | Not available | Not available | Not available | Not available |
| Vinyl Chloride | 1.6 | 16 | 27.9 | 279 |

Action levels based on May 2010 U.S. EPA Regional Screening Levels for air.

$ug/m^3$ - Micrograms per cubic meter.

a - For Tetrachloroethene and Trichloroethene, the Indoor Air action levels were revised by employing the California EPA Inhalation Unit Risk Factors as the provisional inhalation cancer potency factors and assuming a cancer risk level of $1 \times 10^{-5}$.

For Tetrachloroethene - the California EPA IUR is 5.9E-06 $(ug/m^3)$^-1.

For Trichloroethene - the California EPA IUR is 2.0E-06 $(ug/m^3)$^-1.

b - The Sub-Slab Soil-Gas Action Levels are calculated from Indoor Air Action Levels using an attenuation factor of 0.1.

ARCADIS

**Table 2. Summary of Groundwater Sampling Results - Right-of-Way Sample Locations, RACER, Moraine, Ohio.**

| | Location Code<br>Sample Label<br>Sample Date | | SGP-1<br>SGP-1/102610/GW<br>10/26/2010 | SGP-2<br>SGP-2/102510/GW<br>10/25/2010 | SGP-3<br>SGP-3/102010/GW<br>10/20/2010 | SGP-3 (Duplicate)<br>DUP-/102010/GW<br>10/20/2010 | SGP-4<br>SGP-4/102210/GW<br>10/22/2010 | SGP-5<br>SGP-5/102910/GW<br>10/29/2010 | SGP-6<br>SGP-6/102810/GW<br>10/28/2010 | SGP-7<br>SGP-7/102110/GW<br>10/21/2010 | SGP-8<br>SGP-8/110110/GW<br>11/1/2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Units** | **MCL** | **Laboratory Analytical Results** | | | | | | | | |
| **Volatile Organic Compounds** | | | | | | | | | | | |
| 1,1,1-Trichloroethane | µg/L | 200 | < 1.4 U | 1.3 J | < 1.0 U | < 1.0 U | < 3.3 U | 1.2 J | 1.3 J | 0.73 J | 0.53 J |
| 1,1-Dichloroethane | µg/L | NA | 0.92 J | 0.96 J | < 1.0 U | < 1.0 U | 1.2 J | 2.5 J | 1.2 J | 3.4 | 2.9 |
| 1,1-Dichloroethene | µg/L | 7 | < 1.4 U | < 4.0 U | < 1.0 U | < 1.0 U | < 3.3 U | < 3.3 U | < 2.5 U | < 1.7 U | < 1.4 U |
| Benzene | µg/L | 5 | < 1.4 U | < 4.0 U | < 1.0 U | < 1.0 U | < 3.3 U | < 3.3 U | < 2.5 U | < 1.7 U | < 1.4 U |
| cis-1,2-Dichloroethene | µg/L | 70 | 2.8 | 1.9 J | 0.44 J | 0.42 J | 1.7 J | 8.2 J | 2.5 | 8.1 | 4.5 |
| Ethylbenzene | µg/L | 700 | < 1.4 U | < 4.0 U | < 1.0 U | < 1.0 U | < 3.3 U | < 3.3 U | < 2.5 U | < 1.7 U | < 1.4 U |
| Tetrachloroethene | µg/L | 5 | **39 J** | **100** | 2.1 | 2.3 | **100** | **72** | **74** | **49** | **21** |
| Toluene | µg/L | 1000 | 0.32 J | < 4.0 U | < 1.0 U | < 1.0 U | < 3.3 U | < 3.3 U | < 2.5 U | 0.32 J | < 1.4 U |
| trans-1,2-Dichloroethene | µg/L | 100 | 0.53 J | < 4.0 U | < 1.0 U | < 1.0 U | 0.91 J | < 3.3 U | 0.53 J | < 1.7 U | < 1.4 U |
| Trichloroethene | µg/L | 5 | **17** | **130** | 1.7 | 1.9 | **72** | **90** | **87** | **46** | **25** |
| Vinyl chloride | µg/L | 2 | < 1.4 U | < 4.0 U | < 1.0 U | < 1.0 U | < 3.3 U | < 3.3 U | < 2.5 U | < 1.7 U | < 1.4 U |
| Xylenes | µg/L | 10000 | < 2.9 U | < 8.0 U | < 2.0 U | < 2.0 U | < 6.7 U | < 6.7 U | < 5.0 U | < 3.3 U | < 2.9 U |

µg/L - Micrograms per Liter.
MCL - United States Environmental Protection Agency, Maximum Contaminant Level.
< - Chemical of concern not detected above laboratory reporting limit shown.
U - Chemical of concern not detected above laboratory reporting limit shown.
J - Value estimated.
NA - No action level.
**Bold** indicates sample result is above the MCL.

ARCADIS

**Table 3. Summary of Soil-Gas Sampling Results - Right-of-Way Sample Locations, RACER, Moraine, Ohio.**

| | | **Location Code** | **SGP-1** | | | **SGP-2** | | | **SGP-3** | | | **SGP-4** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Sample Date** | **11/10/2010** | | | **11/11/2010** | | | **11/9/2010** | | | **11/10/2010** | | |
| **Volatile Organic Compounds** | **Units** | **Long -Term Action Level Soil-Gas at Water Table*** | **6 feet bls** | **11 feet bls** | **16 feet bls** | **6 feet bls** | **11 feet bls** | **15.4 feet bls** | **6 feet bls** | **11 feet bls** | **16.26 feet bls** | **6 feet bls** | **11 feet bls** | **16.2 feet bls** |
| 1,1,1-Trichloroethane | µg/m³ | 220000 | 10 | 13 | 23 | 77 | 140 | 260 | 5.6 J | 20 | 32 | 11 | 18 | 40 |
| 1,1-Dichloroethane | µg/m³ | 50000 | < 4.9 U | 2.3 J | 6.8 | 6.3 J | 26 J | 82 | < 4.6 U | < 4.5 U | 3.0 J | < 4.5 U | < 6.3 U | < 10 U |
| 1,1-Dichloroethene | µg/m³ | 20000 | < 4.8 U | < 4.8 U | < 4.9 U | < 13 U | < 38 U | < 64 U | < 4.5 U | < 4.4 U | < 4.5 U | < 4.4 U | < 6.2 U | < 9.8 U |
| Benzene | µg/m³ | 310 | 2.0 J | 1.3 J | 3.0 J | 8.9 J | < 31 U | < 52 U | < 3.6 U | 0.87 J | 0.98 J | 1.0 J | < 5.0 U | 1.7 J |
| cis-1,2-Dichloroethene | µg/m³ | 3500 | < 4.8 U | < 4.8 U | 8.6 | 2.3 J | 10 J | 54 J | < 4.5 U | < 4.4 U | < 4.5 U | < 4.4 U | < 6.2 U | < 9.8 U |
| Ethylbenzene | µg/m³ | 2200 | 2.2 J | < 5.3 U | 1.9 J | < 14 U | < 42 U | < 70 U | 2.8 J | < 4.9 U | < 4.9 U | < 4.8 U | < 6.8 U | < 11 U |
| Tetrachloroethene | µg/m³ | 410 | 370 | **970** | **2400** | **5700** | **21000** | **38000** | 41 | 100 | 170 | **880** | **3200** | **5600** |
| Toluene | µg/m³ | 40000 | 8.2 | 1.8 J | 3.2 J | 21 | < 36 U | < 61 U | 2.7 J | 1.0 J | < 4.2 U | 4.8 | < 5.8 U | < 9.3 U |
| trans-1,2-Dichloroethene | µg/m³ | 7000 | < 4.8 U | 4.9 | 12 | 9.8 J | 41 | 110 | < 4.5 U | < 4.4 U | 1.8 J | < 4.4 U | < 6.2 U | 12 |
| Trichloroethene | µg/m³ | 1200 | 86 | 250 | 620 | **2000** | **6800** | **16000** | 8.8 | 70 | 120 | 180 | 600 | 1,200 |
| Vinyl chloride | µg/m³ | 280 | < 3.1 U | < 3.1 U | < 3.1 U | < 8.2 U | < 25 U | < 41 U | < 2.9 U | < 2.9 U | < 2.9 U | < 2.8 U | < 4.0 U | < 6.3 U |
| Xylenes | µg/m³ | 700000 | 10 | < 10.6 U | 3.2 JB | < 28 UB | < 84 U | < 140 U | 17.2 | < 9.8 U | < 9.8 U | < 9.6 U | < 13.6 U | < 22 U |

bls - below land surface.

µg/m³ - Micrograms per cubic meter.

< - Chemical of concern not detected above laboratory reporting limit shown.

U - Chemical of concern not detected above laboratory reporting limit shown.

B - The chemical of concern has been found in the sample as well as its associated blank.

UB - Chemical of concern considered non-detect at the listed value due to associated blank contamination.

UJ - The chemical of concern was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

* - These values are based on the "Generic Screening Levels" from Table 2b of the Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils(U.S. EPA 2002). For the constituents Tetrachloroethene and Trichloroethene, the Indoor Air action levels were revised by applying EPA's current practice of employing the California EPA Inhalation Unit Risk Factors as the provisional inhalation cancer potency factors. The attenuation factor for Indoor Air to Soil-Gas at the Water Table is 0.01.

J - Value estimated.

**Bold** indicates chemical of concern is above the Action Level.

ARCADIS

**Table 3. Summary of Soil-Gas Sampling Results - Right-of-Way Sample Locations, RACER, Moraine, Ohio.**

| | | Location Code<br>Sample Date | SGP-5<br>11/11/2010 | | | | SGP-6<br>11/11/2010 | | | SGP-7<br>11/10/2010 | | | SGP-8<br>11/11/2010 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volatile Organic Compounds | Units | Long -Term Action Level Soil-Gas at Water Table* | 6 feet bls | 11 feet bls | 14.8 feet bls | 14.8 feet bls DUPLICATE | 6 feet bls | 11 feet bls | 15 feet bls | 6 feet bls | 11 feet bls | 15.65 feet bls | 6 feet bls | 6 feet bls DUPLICATE | 11 feet bls | 14.25 feet bls |
| 1,1,1-Trichloroethane | µg/m³ | 220000 | 0.87 J | 180 | 340 | 300 | 20 | 61 | 130 | 12 | 56 | 73 | 82 | 87 | 210 | 290 |
| 1,1-Dichloroethane | µg/m³ | 50000 | < 4.5 U | 34 | 120 | 110 | < 4.7 U | < 4.8 U | 1.9 J | 2.0 J | 21 | 37 | 4.4 J | 4.0 J | 79 | 210 |
| 1,1-Dichloroethene | µg/m³ | 20000 | < 4.4 U | < 24 U | < 47 U | < 35 U | < 4.6 U | < 4.7 U | < 4.6 U | < 4.6 U | < 6.1 U | < 9.3 U | < 4.4 U | < 4.4 U | < 12 U | < 18 U |
| Benzene | µg/m³ | 310 | 1.1 J | 5.8 J | < 38 U | < 28 U | < 3.7 U | < 3.8 U | 4.2 | 6.5 | 1.8 J | 1.7 J | 1.1 J | 1.1 J | 4.9 J | 6.0 J |
| cis-1,2-Dichloroethene | µg/m³ | 3500 | < 4.4 U | 31 | 140 | 130 | < 4.6 U | < 4.7 U | < 4.6 U | < 4.6 U | 7.0 | 15 | < 4.4 U | < 4.4 U | 33 | 120 |
| Ethylbenzene | µg/m³ | 2200 | < 4.9 U | < 26 U | < 52 U | < 39 U | 2.3 J | 0.64 J | 4.2 J | 19 | < 6.7 U | < 10 U | < 4.9 U | < 4.9 U | < 13 U | < 19 U |
| Tetrachloroethene | µg/m³ | 410 | < 7.6 UB | **12000** | **22000** | **18000** | 100 | **990** | **2700** | **710** | **3400** | **4800** | **1600** | **1700** | **5800** | **11000** |
| Toluene | µg/m³ | 40000 | 5.3 | 7.3 J | < 45 U | 10 J | 16 | 1.0 J | 16 | 25 | < 5.8 U | < 8.8 U | 1.2 J | < 4.2 U | < 12 UB | < 17 UB |
| trans-1,2-Dichloroethene | µg/m³ | 7000 | < 4.4 U | < 24 U | < 47 U | < 35 U | < 4.6 U | < 4.7 U | 1.9 J | < 4.6 U | < 6.1 U | < 9.3 U | < 4.4 U | < 4.4 U | < 12 U | < 18 U |
| Trichloroethene | µg/m³ | 1200 | < 6.0 UB | **3200** | **9700** | **8400** | 29 | 270 | 1,100 | 160 | 1,000 | **1700** | 260 | 280 | **1600** | **3600** |
| Vinyl chloride | µg/m³ | 280 | < 2.9 U | < 15 U | < 30 U | < 23 U | < 3.0 U | < 3.0 U | < 3.0 U | < 3.0 U | < 3.9 U | < 6.0 U | < 2.9 U | < 2.9 U | < 7.8 U | < 11 U |
| Xylenes | µg/m³ | 700000 | < 9.8 UB | < 52 U | < 104 U | < 78 U | 9.3 J | < 10.4 UB | 6.7 J | 80 | < 13.4 U | < 20 U | < 9.8 U | < 9.8 U | < 26 U | < 38 U |

bls - below land surface.

µg/m³ - Micrograms per cubic meter.

< - Chemical of concern not detected above laboratory reporting limit shown.

U - Chemical of concern not detected above laboratory reporting limit shown.

B - The chemical of concern has been found in the sample as well as its associated blank.

UB - Chemical of concern considered non-detect at the listed value due to associated blank contamination.

UJ - The chemical of concern was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

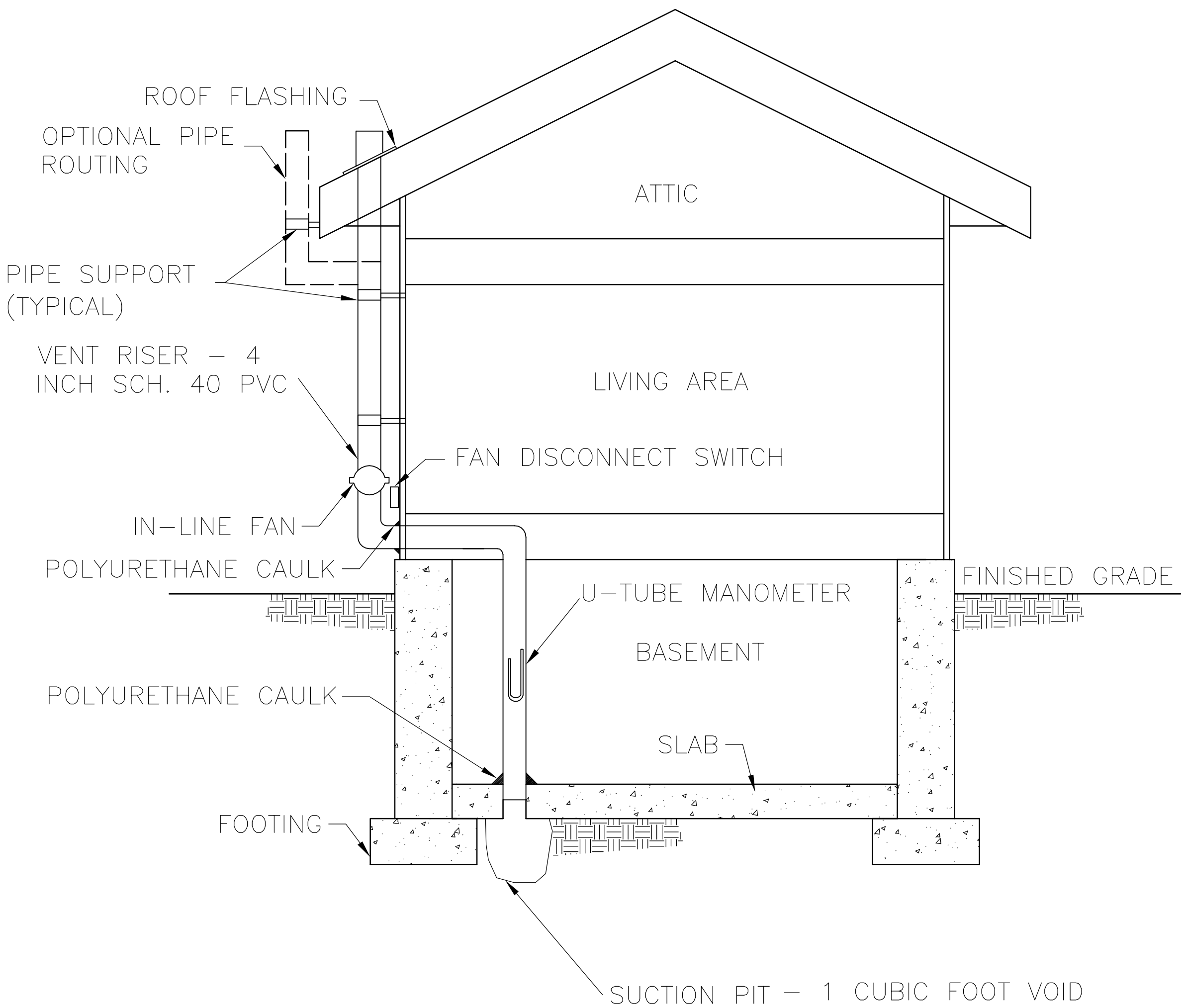
* - These values are based on the "Generic Screening Levels" from Table 2b of the Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils(U.S. EPA 2002). For the constituents Tetrachloroethene and Trichloroethene, the Indoor Air action levels were revised by applying EPA's current practice of employing the California EPA Inhalation Unit Risk Factors as the provisional inhalation cancer potency factors. The attenuation factor for Indoor Air to Soil-Gas at the Water Table is 0.01.

J - Value estimated.

**Bold** indicates chemical of concern is above the Action Level.

VENT RISER NOTES:

1. TERMINATE ABOVE ROOF LINE AND 10 FEET (MIN.) FROM ANY WINDOW, AIR INTAKE, OR OTHER OPENING LOCATED HORIZONTALLY ADJACENT TO OR ABOVE THE TERMINATION POINT.
2. HORIZONTAL PIPE RUNS SHALL BE SLOPED BACK TOWARDS THE EXTRACTION POINT AT MINIMUM 1% SLOPE.
3. INSTALL PIPE SUPPORTS NEAR DISCHARGE AND EVERY 8 FEET ON VERTICAL PIPING AND EVERY 6 FEET ON HORIZONTAL PIPING.




SCALE: NOT TO SCALE



RACER TRUST
**MORAINE,OHIO**
**OH000294.2011**

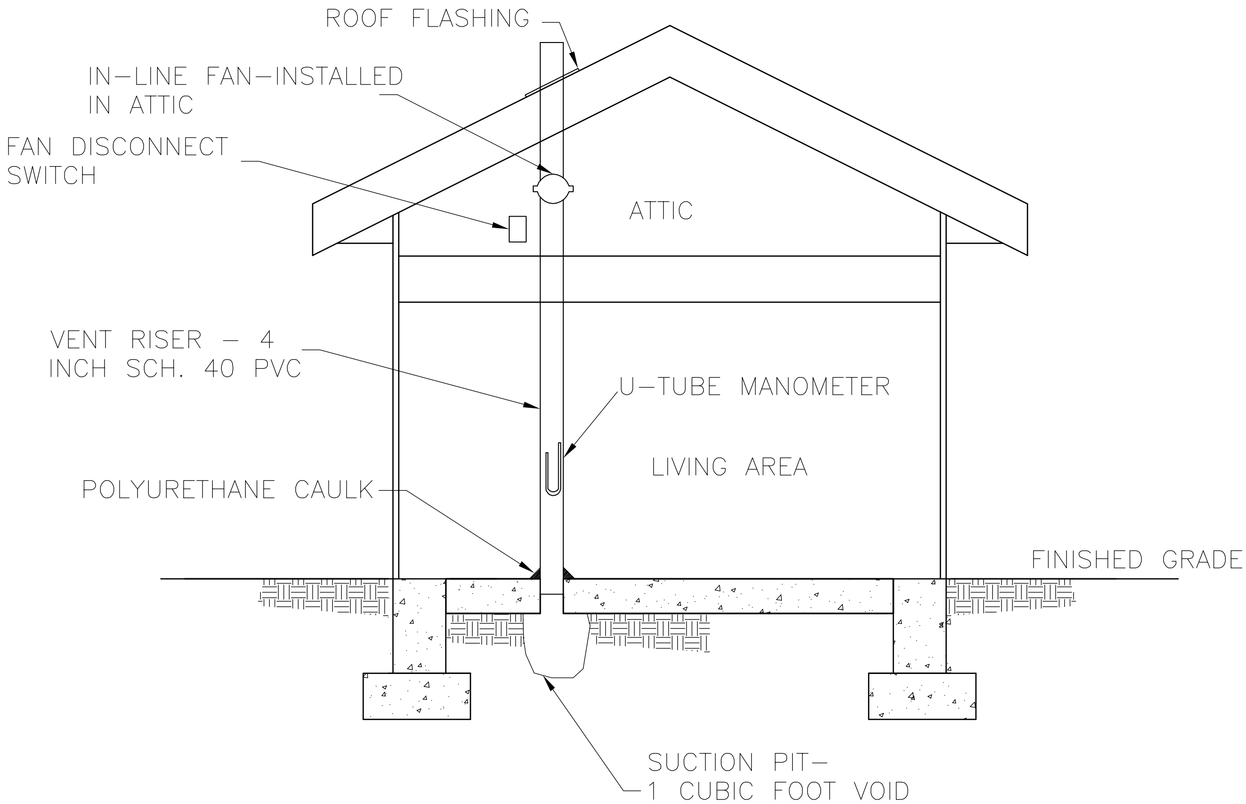
**ACTIVE MITIGATION SYSTEM INSTALLATION DETAILS - BASEMENT**

ARCADIS

FIGURE
**1**

VENT RISER NOTES:

1. TERMINATE ABOVE ROOF LINE AND 10 FEET (MIN.) FROM ANY WINDOW, AIR INTAKE, OR OTHER OPENING LOCATED HORIZONTALLY ADJACENT TO OR ABOVE THE TERMINATION POINT.
2. HORIZONTAL PIPE RUNS SHALL BE SLOPED BACK TOWARDS THE EXTRACTION POINT AT MINIMUM 1% SLOPE.
3. INSTALL PIPE SUPPORTS NEAR DISCHARGE AND EVERY 8 FEET ON VERTICAL PIPING AND EVERY 6 FEET ON HORIZONTAL PIPING.




SCALE: NOT TO SCALE

RACER TRUST
**MORAINE,OHIO**
**OH000294.2011**

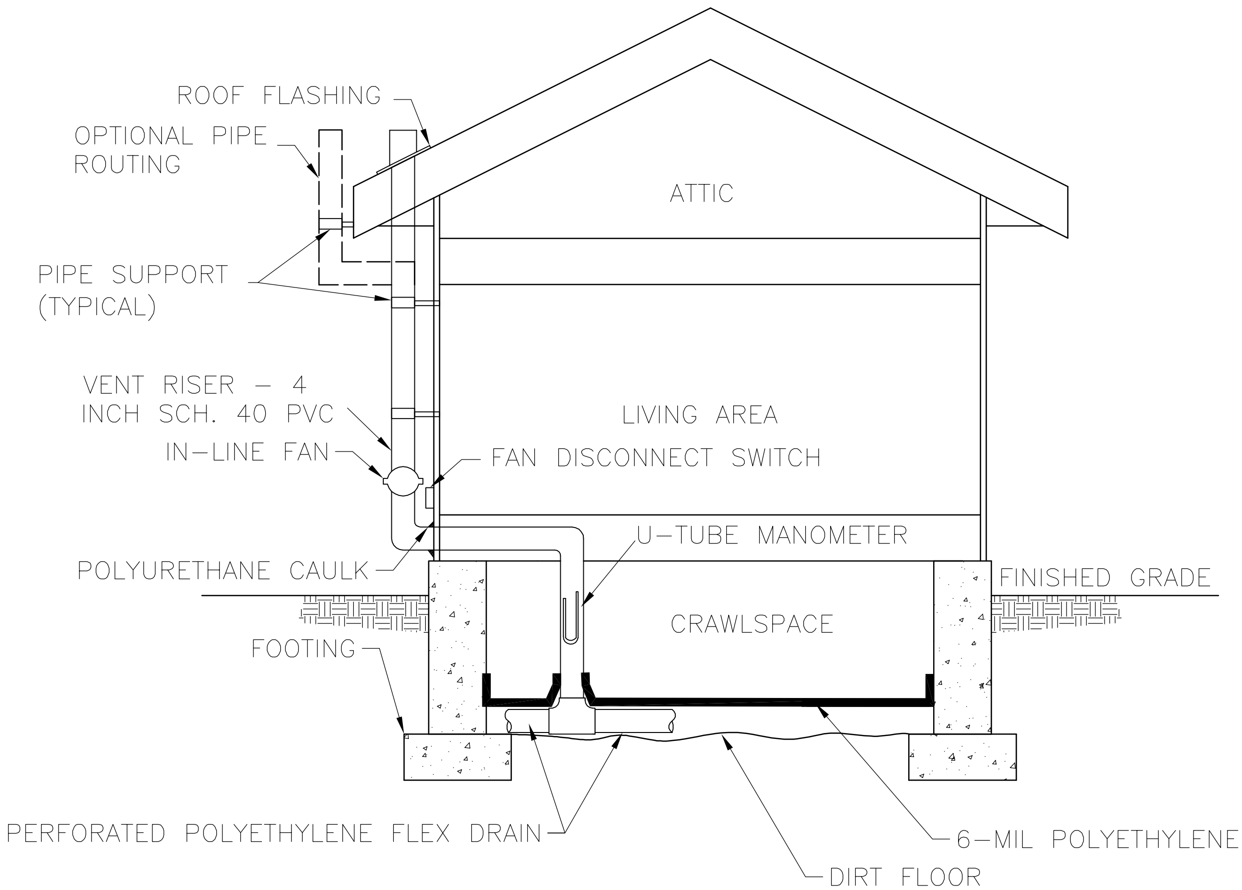
**ACTIVE MITIGATION SYSTEM INSTALLATION DETAILS - SLAB - ON - GRADE**

ARCADIS

FIGURE
**2**

VENT RISER NOTES:

1. TERMINATE ABOVE ROOF LINE AND 10 FEET (MIN.) FROM ANY WINDOW, AIR INTAKE, OR OTHER OPENING LOCATED HORIZONTALLY ADJACENT TO OR ABOVE THE TERMINATION POINT.
2. HORIZONTAL PIPE RUNS SHALL BE SLOPED BACK TOWARDS THE EXTRACTION POINT AT MINIMUM 1% SLOPE.
3. INSTALL PIPE SUPPORTS NEAR DISCHARGE AND EVERY 8 FEET ON VERTICAL PIPING AND EVERY 6 FEET ON HORIZONTAL PIPING.




SCALE: NOT TO SCALE

RACER TRUST
**MORAINE,OHIO**
**OH000294.2011**

**ACTIVE MITIGATION SYSTEM INSTALLATION DETAILS - CRAWLSPACE**

ARCADIS

FIGURE
**3**

ARCADIS

## Appendix A

Letters to Property Owners - Template

Confirmation Sampling

May XX, 2011

[RESIDENT MAILING INFORMATION]

RE: Results of Air Testing
[ADDRESS], Moraine, Ohio 45439

Dear [NAME]:

The U.S. Environmental Protection Agency appreciates your cooperation with the recent testing program in your neighborhood and allowing us to collect and analyze air samples inside your home.

As you know, on [DATE], 2011, indoor air and sub-slab vapor samples were collected to determine whether volatile organic compounds, or VOCs, are present beneath or in your home, and, if so, at what concentrations. The samples were analyzed by an independent laboratory certified by the National Environmental Laboratory Accreditation Program.

Analyses of the samples showed the presence of VOCs at concentrations below the U.S. EPA's "action levels," meaning the levels at which EPA believes action should be taken to reduce the presence of the vapors. Based on these results, EPA has determined that no further action is needed in your home at this time.

A table summarizing the analytical results and the laboratory analytical report are attached to this letter, but here is a summary. The testing was conducted to determine the presence of VOCs called tetrachloroethene (PCE) and trichloroethene (TCE). To protect confidentiality, the homes sampled in your neighborhood were given a random and unique identification number. The number for your home is **XXXX**. The following samples were collected from your location:

- XXX-SS/XXXXXXXX/ - Sub-slab sample collected on March/April XX, 2011. Sub-slab samples were collected from the permanent point(s) that was installed in the slab or basement floor of your home.
- XXX-IAB/XXXXXXX/ - Indoor air basement sample collected on March/April XX, 2011.
- XXX-IAF/XXXXXXX/ - Indoor air first floor sample collected on March/April XX, 2011.
- XXX-CS/XXXXXXX/ - Crawl space sample collected on March/April XX, 2011.

RACER's contractor, under EPA supervision, will conduct sampling at your property four more times over the next two years to confirm vapor levels are not above EPA "action levels". RACER is a not-for-profit trust that was established March 31, 2011, by a federal bankruptcy court to own, manage, remediate and revitalize the idled or unwanted properties from the 2009 General Motors bankruptcy. The Trust is not the company that released pollution at the Moraine property, but it has taken the responsibility to manage the contamination left by GM and to work with property owners, EPA and the state of Ohio. We will reach out to you again to request your permission to perform the work. There would be no cost to you for this sampling and you will receive the sampling results.

We appreciate your participation in this program. If you have questions regarding the sampling activities and results please contact me, Mirtha Cápiro, at 312-886-7567. You may also contact Mark Case or Thomas Hut at 937-225-4362 from Public Health – Dayton & Montgomery County if you have concerns about the sampling results.

Sincerely,

Mirtha Cápiro
Project Manager/Coordinator
EPA Region 5
Land and Chemicals Division

cc: P. Barnett, RACER Trust

Attachments: Sample Results Table
Laboratory Analytical Report

Active Mitigation

May XX, 2011

[RESIDENT MAILING INFORMATION]

RE: Results of Air Testing
[ADDRESS], Moraine, Ohio 45439

Dear [NAME]:

The U.S. Environmental Protection Agency appreciates your cooperation with the recent testing program in your neighborhood and allowing us to collect and analyze air samples inside your home.

As you know, on [DATE], 2011, indoor air and sub-slab vapor samples were collected to determine whether volatile organic compounds, or VOCs, are present beneath or in your home, and, if so, at what concentrations. The samples were analyzed by an independent laboratory certified by the National Environmental Laboratory Accreditation Program.

Analyses of the samples showed the presence of VOCs on your property at concentrations above EPA's "action levels," meaning the levels at which EPA believes steps should be taken to reduce the presence of the vapors. Based on these results, the installation of a venting system at no cost to you is recommended as an effective way to reduce the presence of these vapors inside your home.

A table summarizing the analytical results and the laboratory analytical report are attached to this letter, but here is a summary. The testing was conducted to determine the presence of VOCs called tetrachloroethene (PCE) and trichloroethene (TCE). To protect confidentiality, the homes sampled in your neighborhood were given a random and unique identification number. The number for your home is **XXXX**. The following samples were collected from your location:

- XXX-SS/XXXXXXXX/ - Sub-slab sample collected on March/April XX, 2011. Sub-slab samples were collected from the permanent point(s) that was installed in the slab or basement floor of your home.
- XXX-IAB/XXXXXXX/ - Indoor air basement sample collected on March/April XX, 2011.
- XXX-IAF/XXXXXXX/ - Indoor air first floor sample collected on March/April XX, 2011.
- XXX-CS/XXXXXXX/ - Crawl space sample collected on March/April XX, 2011.

If you choose to accept the vapor mitigation system – and EPA encourages you to do so – it will be installed and maintained at no cost to you by an organization called The RACER Trust. This not-for-profit trust was established March 31, 2011, by a federal bankruptcy court to own, manage, remediate and revitalize the idled or unwanted properties from the 2009 General Motors bankruptcy. The Trust is not the company that released pollution at the Moraine property, but it has taken the responsibility to manage the contamination left by GM and to work with property owners, EPA and the state of Ohio.

To move forward with the mitigation system, you will need to sign an access agreement that gives RACER permission to enter and work on your property. RACER will hire a contractor to install the system in a location that is both acceptable to you and where it will operate effectively. RACER's contractor will work with you to schedule a convenient appointment for installation.

The inconspicuous mitigation system *(see enclosed fact sheet)* will consume a modest amount of electricity. RACER will compensate you for this additional expense.

Once the mitigation system is mounted, RACER's contractor, under EPA supervision, will conduct more sampling about 30 days, 180 days, and 360 days after installation to confirm it is working effectively to reduce vapor levels. RACER's contractor will also request your permission to enter your home once a year to verify the system is still working properly.

EPA will provide information on testing results and recommended mitigation to the tenants at the residence.  EPA and RACER will continue to share any up-to-date information with current and future tenants of the same rental property.

We appreciate your participation in this program. If you have questions regarding the sampling activities and results please contact me, Mirtha Cápiro, at 312-886-7567. You may also contact Mark Case or Thomas Hut at 937-225-4362 from Public Health – Dayton & Montgomery County if you have concerns about the sampling results.

Sincerely,

Mirtha Cápiro
Project Manager/Coordinator
EPA Region 5
Land and Chemicals Division

cc: P. Barnett, RACER Trust

Attachments:
- Sample Results Table
- Laboratory Analytical Report
- Active Mitigation System Fact Sheet
- Access Agreement

Active Mitigation without Sub-Slab Data

May XX, 2011

[RESIDENT MAILING INFORMATION]

RE: Results of Air Testing
[ADDRESS], Moraine, Ohio 45439

Dear [NAME]:

The U.S. Environmental Protection Agency appreciates your cooperation with the recent testing program in your neighborhood and allowing us to collect and analyze air samples inside your home.

As you know, on [DATE], 2011, indoor air samples were collected to determine whether volatile organic compounds, or VOCs, are present beneath or in your home, and, if so, at what concentrations. The samples were analyzed by an independent laboratory certified by the National Environmental Laboratory Accreditation Program.

Analyses of the samples showed the presence of VOCs on your property at concentrations below EPA's "action levels," meaning the levels at which EPA believes steps should be taken to reduce the presence of the vapors. Based on the EPA's review of right-of-way soil-gas and/or groundwater data near your property, the installation of a venting system at no cost to you is recommended as an effective way to reduce the potential for vapors to accumulate inside your home.

A table summarizing the analytical results and the laboratory analytical report are attached to this letter, but here is a summary. The testing was conducted to determine the presence of VOCs called tetrachloroethene (PCE) and trichloroethene (TCE). To protect confidentiality, the homes sampled in your neighborhood were given a random and unique identification number. The number for your home is **XXXX**. The following samples were collected from your location:

- XXX-SS/XXXXXXXX/ - Sub-slab sample collected on March/April XX, 2011. Sub-slab samples were collected from the permanent point(s) that was installed in the slab or basement floor of your home.
- XXX-IAB/XXXXXXX/ - Indoor air basement sample collected on March/April XX, 2011.
- XXX-IAF/XXXXXXX/ - Indoor air first floor sample collected on March/April XX, 2011.
- XXX-CS/XXXXXXX/ - Crawl space sample collected on March/April XX, 2011.

If you choose to accept the vapor mitigation system – and EPA encourages you to do so – it will be installed and maintained at no cost to you by an organization called The RACER Trust. This not-for-profit trust was established March 31, 2011, by a federal bankruptcy court to own, manage, remediate and revitalize the idled or unwanted properties from the 2009 General Motors bankruptcy. The Trust is not the company that released pollution at the Moraine property, but it has taken the responsibility to manage the contamination left by GM and to work with property owners, EPA and the state of Ohio.

To move forward with the mitigation system, you will need to sign an access agreement that gives RACER permission to enter and work on your property. RACER will hire a contractor to install the system in a location that is both acceptable to you and where it will operate effectively. RACER's contractor will work with you to schedule a convenient appointment for installation.

The inconspicuous mitigation system *(see enclosed fact sheet)* will consume a modest amount of electricity. RACER will compensate you for this additional expense.

Once the mitigation system is mounted, RACER's contractor, under EPA supervision, will conduct more sampling about 30 days, 180 days, and 360 days after installation to confirm it is working effectively to reduce vapor levels. RACER's contractor will also request your permission to enter your home once a year to verify the system is still working properly.

EPA will provide information on testing results and recommended mitigation to the tenants at the residence. EPA and RACER will continue to share any up-to-date information with current and future tenants of the same rental property.

We appreciate your participation in this program. If you have questions regarding the sampling activities and results please contact me, Mirtha Cápiro, at 312-886-7567. You may also contact Mark Case or Thomas Hut at 937-225-4362 from Public Health – Dayton & Montgomery County if you have concerns about the sampling results.

Sincerely,

Mirtha Cápiro
Project Manager/Coordinator
EPA Region 5
Land and Chemicals Division

cc: P. Barnett, RACER Trust

Attachments: Sample Results Table
Laboratory Analytical Report
Active Mitigation System Fact Sheet
Access Agreement

**Table 1. Indoor Air and Sub-Slab Analytical Results for [ADDRESS]**

| | | [ADDRESS] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Location<br>Location Code<br>Sample Label<br>Sample Date | Indoor Air Basement<br>[Sample ID ]-IAB<br>[ Sample ID ]Date<br>Date | | Indoor Air First Floor<br>[ Sample ID ]-IAF<br>[ Sample ID ]Date<br>Date | | Sub Slab<br>[ Sample ID ]-SS-1<br>[ Sample ID ]Date<br>Date | | Sub Slab<br>[ Sample ID ]-SS-2<br>[ Sample ID ]Date<br>Date | |
| **Chemical of Concern** | **Units** | **Result** | **Action Level** | **Result** | **Action Level** | **Result** | **Action Level** | **Result** | **Action Level** |
| 1,1,1-Trichloroethane | μg/m$^3$ | | 5210 | | 5210 | | 52100 | | 52100 |
| 1,1-Dichloroethane | μg/m$^3$ | | 15.2 | | 15.2 | | 152 | | 152 |
| 1,1-Dichloroethene | μg/m$^3$ | | 209 | | 209 | | 2090 | | 2090 |
| cis-1,2-Dichloroethene | μg/m$^3$ | | NS | | NS | | NS | | NS |
| Tetrachloroethene | μg/m$^3$ | | 4.1 | | 4.1 | | 41 | | 41 |
| trans-1,2-Dichloroethene | μg/m$^3$ | | 62.6 | | 62.6 | | 626 | | 626 |
| Trichloroethene | μg/m$^3$ | | 12.2 | | 12.2 | | 122 | | 122 |
| Vinyl chloride | μg/m$^3$ | | 1.6 | | 1.6 | | 16 | | 16 |

Notes:

μg/m$^3$ - Micrograms per cubic meter.
< - Chemical of concern not detected above laboratory reporting limit shown.
U - Chemical of concern not detected above laboratory reporting limit shown.
Note the laboratory reporting limit is lowest concentration of a chemical that the laboratory can accurately measure.
J - Value estimated.
NS - No Standard.
**Bold indicates sample result is above the action level.**

# Community

# FACT SHEET FOR ACTIVE MITIGATION

**RACER Trust (Former General Motors) – Moraine, Ohio** **September 2011**

**Contact Information**


Pamela L. Barnett
Assembly Region Cleanup Manager
(DE, LA, MA, OH, PA, VA)
RACER Trust
pbarnett@racertrust.org
(937) 751-8635

Mirtha Cápiro
United States Environmental Protection Agency; Region 5
Environmental Scientist
Land and Chemicals Division
Remediation and Reuse Branch
(312) 886-7567


For more information on vapor intrusion and mitigation, please visit U.S. EPA's website:

http://www.epa.gov/oswer/vaporintrusion/

## A Guide to Vapor Intrusion Mitigation

*Revitalizing Auto Communities Environmental Response (RACER) Trust is working with the United States Environmental Protection Agency (U.S. EPA) to complete investigation and mitigation activities related to the former General Motors site located in Moraine, Ohio. Air samples were collected of the indoor air within your home. If your home consists of slab-on-grade construction or has a basement, the soil vapor underneath the foundation of your home was also sampled. Volatile organic compounds (VOCs) were detected in one or both of these air samples at concentrations that were above the U.S. EPA Regional Screening Levels (Action Levels) for air. Therefore, mitigation is required. This fact sheet describes the mitigation system and the steps that will be taken to design and install the mitigation system in your home.*

### What is an Active Mitigation System?

A mitigation system is designed to prevent vapors from below the foundation of your home from entering the indoor air within your home. This is done by creating a negative pressure (vacuum) below the foundation. In order to accomplish this, piping is installed through the basement floor or floor of the slab-on-grade structure (extraction point), or below a liner to be installed in a crawlspace, and connected to a fan that discharges the vapors above the roofline of the home. See the figures below.

Typically one extraction point will be sufficient to create the required negative pressure across the entire foundation of the home. In some cases, more extraction points may be necessary. Additionally, cracks or other openings in the home's foundation will be sealed. The sealing is necessary to ensure the mitigation system is able to create the necessary negative pressure beneath the entire foundation of the home. The proposed mitigation system has also been used for radon mitigation.

### Installation Process

The mitigation system will be designed by ARCADIS U.S., Inc. (ARCADIS), a RACER Trust contractor. ARCADIS will direct and oversee a subcontractor, who will conduct the installation work. By signing the access agreement provided to you for this work, you will be allowing ARCADIS to contact you to complete the following activities at times convenient to you and your household schedule:

1. An initial design visit will be completed by ARCADIS to identify the location of the mitigation system components for your home. During this visit the location of the mitigation suction point(s), to be installed through the basement or slab-on-grade floor or

### Site Background

The former General Motors Powertrain Group, Moraine Engine Plant (Moraine Engine) and the former General Motors Truck Group Moraine Assembly Plant (Moraine Assembly) are located at 4100 Springboro Road and 2601 West Stroop Road, respectively, in Moraine, Ohio. The former Delphi Harrison Thermal Systems Moraine Plant (Delphi Thermal Moraine) is located west of the former Moraine Engine and Moraine Assembly facilities, at 3600 Dryden Road. These three former facilities occupy the 363 acre site. The former Moraine Engine and Moraine Assembly facilities occupy approximately 239 acres and former Delphi Thermal Moraine occupies 124 acres.

RACER Trust is driving the cleanup efforts resulting from the historical industrial operation at the site. RACER Trust and its predecessors have completed numerous studies and cleanup activities at the site. These activities have included investigations of the sub-surface soil, soil vapor, and groundwater, the removal of contaminated soil, and on-going remediation of groundwater.

located within the crawlspace, will be identified. Information to be gathered during the initial visit will include the location of the piping to be installed. Piping may either be planned for installation up the outside of the home to the discharge point or up through the interior of the home (through a closet) and through the attic. The corresponding location of the fan will be on the piping outside of the home or within the attic. Any cracks or openings that require sealing will also be identified. This initial visit will take approximately 2 - 4 hours.

2. The installation of the mitigation system will be conducted on a day(s) that is acceptable to you. An ARCADIS team member will accompany the installation contractor and facilitate the installation of the mitigation system per the ARCADIS design. The installation is expected to take approximately 1 to 2 days in most cases.

3. An annual inspection will be conducted by ARCADIS to ensure the system is functioning properly. The foundation will also be inspected for any additional sealing that may be necessary.

4. Air sampling will be conducted approximately 30 days, 180 days, and 360 days following the system installation to verify that VOCs in indoor air are below the Action Levels.

### Health and Safety

RACER Trust is committed to the safety of our neighbors and the workers that will be performing the work inside your home. All work has and will be conducted in a safe manner that follows a Health and Safety Plan and other detailed plans prepared specifically for this project. RACER Trust will work closely with you to safely complete the work and limit disruptions.

For more information or to have questions and concerns addressed, please contact RACER Trust or the U.S. EPA as listed on the front page.

### Information for Residents

During the design visit, the ARCADIS team member will review the mitigation system design with you. Aesthetics and your preferences will be considered as much as possible in the location of the system components. Note that some preferences may affect functionality or durability and may not be able to be incorporated. ARCADIS staff will also ask for your input on any opening that you know of that may need to be sealed.

During the construction you can expect some loud noise while the concrete slab is being penetrated. The noise should not last longer than a half hour. Dust control measures will be utilized during this process to minimize the generation of dust. The sealant that will be used to seal cracks will be a low odor, paintable product. The installation contractor is a licensed and insured contractor and will perform all work in compliance with local code requirements. The installation rates will be conducted at no cost to you.

### Operation of the Mitigation System

The mitigation system utilizes an electric powered fan. The fan is designed to have a low energy usage. The energy usage will be calculated and local electric rates will be used to generate the cost that is associated with operation of the fan. You will be paid for the fan's electric usage, as calculated by ARCADIS. Usage payments will be issued annually and will continue until the system is no longer necessary.

Upon installation of the system, an ARCADIS team member will show you the device (U-tube manometer) which has been installed on the system piping to indicate whether the system is functioning properly. If at any time the system is not functioning within the range marked on the monitoring device, or you notice damage to the system, contact the phone number listed on the system label and the necessary repairs will be made at no cost to you.

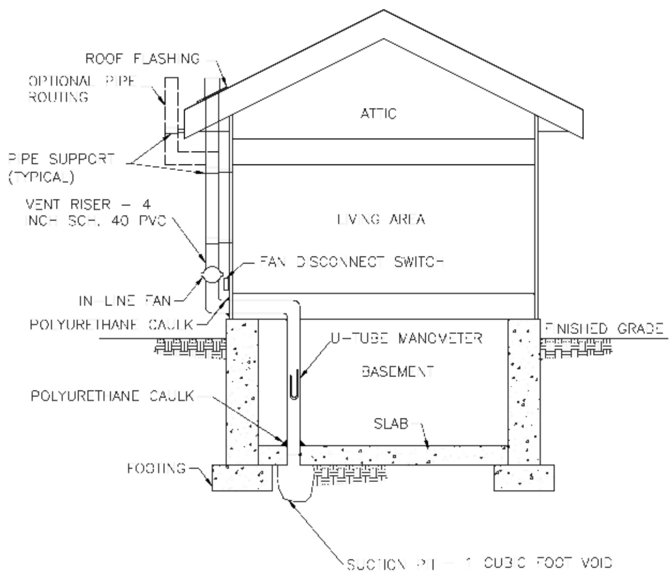
**Decommissioning of the Mitigation System**

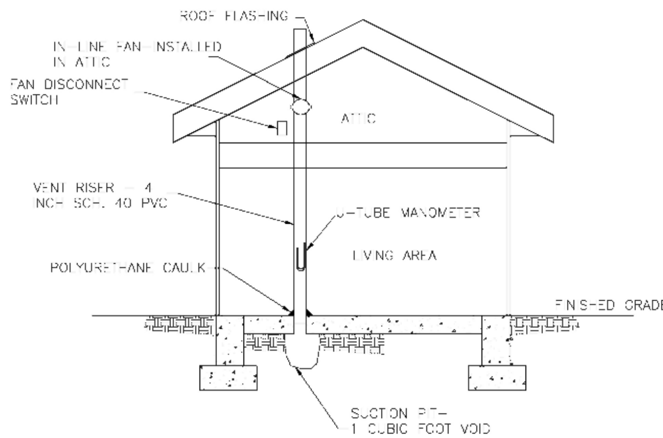
The ongoing groundwater remediation in the area is expected to reduce the VOCs in groundwater and subsequently reduce the VOCs present in the soil vapor beneath your home. When it is determined that the vapor levels of VOCs are below the U.S. EPA criteria for mitigation, the operation of the mitigation system will no longer be necessary. A confirmation sampling event will be completed to confirm VOC concentrations beneath your home are below the U.S. EPA criteria. At that time, you will be notified and will be presented with the following options:

1. The homeowner may choose to continue to operate the system; however, the electricity cost and any maintenance will be the homeowner's responsibility.

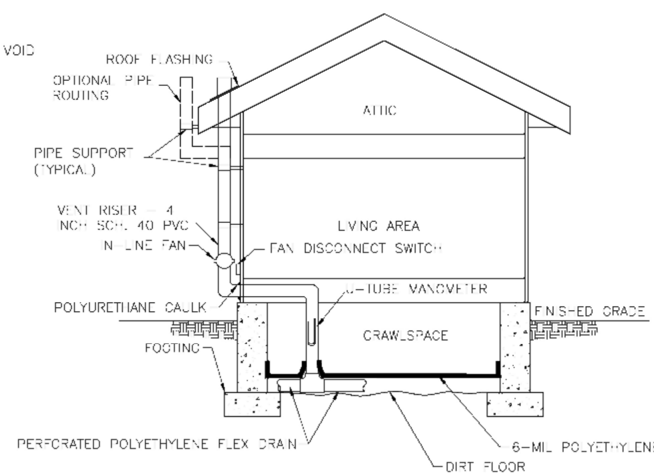
2. The homeowner may choose to turn off the system and leave it in place.

3. The homeowner can request that the system be removed, at that time the system will be removed at no cost to the homeowner.




*Examples of typical mitigation system components*



## Revitalizing Auto Communities Environmental Response Trust (RACER)

## Access Agreement

**Name (please print):** ______________________________________________

**Address of Property:** ______________________________________________

**Home Phone #** ______________________________________________

**Cell Phone #** ______________________________________________

**E-Mail Address** ______________________________________________

I consent to employees, contractors, and authorized representatives of the RACER Trust and U.S. Environmental Protection Agency (EPA) entering and having continued access to this property for the following purpose:

**Design, installation, operation, and maintenance of vapor intrusion mitigation system.**

I realize that these actions taken by RACER Trust are undertaken pursuant to their respective response and enforcement responsibilities under the Resource Conservation Recovery Act (RCRA) at Sections 3001 to 3019, and 7003, 42 U.S.C. §§ 6921 to 6939f, and under the direction of the EPA. I also realize that RACER Trust and EPA will share up-to-date information from these actions with current and future tenant(s) who reside at the above property.

My consent is given voluntarily and on behalf of myself and all other co-owners of this property, with knowledge of the right to refuse and without threats or promises of any kind.

Date __________________ Signature ______________________________________

Sample Location Questions:

1. Are you the Owner __ or the Tenant __ of the home or building? If you are the Owner, go to #3.

2. If you are the Tenant, please write the Owner's name here ____________________, and write the Owner's address and phone number under #3, below.

3. If you are the Owner but live at a different address, please write your name and address below:

   Owner's Address: ____________________________________________________

   ____________________________________ Home Phone #

   ____________________________________ Cell Phone #

   ____________________________________ E-Mail Address

I DO NOT authorize access by RACER Trust to the above-referenced property.

______________________________________________________________________

Print Name Signature Date

**Appendix B**

Standard Operating Procedures

ARCADIS

Infrastructure · Water · Environment · Buildings

Imagine the result

# SOP 20

# Sub-Slab Soil-Gas Point Installation and Sampling

RACER

Moraine, Ohio

Rev. #: 1.2

Rev Date: February 10, 2011

**Approval Signatures**

Prepared by: ____________________ Date: July 7, 2010
Mitch Wacksman

Approved by: ____________________ Date: July 7, 2010
Christopher Lutes

Modified by: ____________________ Date: Revised, December 3, 2010
Joseph Rumschlag

Modified by: ____________________ Date: Revised, February 10, 2011
Mitch Wacksman

## I. Scope and Application

This document describes the procedures for installing permanent sub-slab sampling points and collecting soil-gas samples using permanent points. Samples from the points are collected in an evacuated 1-liter SUMMA®-type canister, (evacuated to approximately <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for the installation of permanent sub-slab soil-gas points and the collection of sub-slab soil-gas samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

## II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading sub-slab soil-gas sample collection activities must have previous sub-slab soil-gas sampling experience.

## III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. For sub-slab soil-gas point installation, drilling with an electric concrete impact drill should be completed only by personnel with prior experience using such a piece of equipment and with the appropriate health and safety measures in place as presented in the JLA. It is possible to encounter high concentrations of VOCs in sub-slab soil-gas, so the amount of time the borehole remains open should be minimized. For the same reason, when installing sub-slab points in spaces with minimal dilution potential, such as closets, it may be necessary to provide local ventilation. Finally, sub-slab point installation should be completed after any indoor air sampling to avoid cross contamination of the indoor air samples.

## IV. Equipment List

The equipment required to install a permanent sub-slab soil-gas point is presented below:

- Appropriate personal protective equipment (PPE; as required by the site specific HASP and the JLA);
- Electric hammer drill (e.g., Bosch®, Hilti®, etc.);
- 5/8-inch and 1 1/2-inch diameter concrete drill bits for impact drill (drill bit length contingent on slab thickness);
- Decontaminated soil-gas point (typically 3-inch stainless steel pipe 9/16-inch OD [1/4-inch NPT threads on one end], 1/4-inch NPT female coupling, stainless steel Swagelok® fitting (or similar) bored through male connector [1/4-inch tube OD x 1/4 inch male NPT]), and stainless steel Swagelok® (or similar) plug for 1/4-inch tube fitting;
- Extra 1/4-inch Swagelok® front and back compression sleeves;
- Tubing cutter with heavy-duty cutting wheel;
- Hand tools, including open-end wrench (typically 9/16-inch), pliers, Channel Lock® pliers, etc.;
- Teflon® tape;
- Quick-setting non-shrink grout powder;
- Modeling clay (VOC free and non-drying);
- Potable water for mixing grout;

- Disposable cups and spoons for mixing grout;
- Spray bottle with potable water;
- Broom and dust pan;
- Paper towels;
- Nitrile gloves;
- Work gloves;
- Knee pads;
- Bottle brush;
- Ground fault circuit interrupter (GFCI);
- Extension cords capable of amperage required for hammer drill;
- Plastic sheeting; and
- Shop vacuum with clean fine-particle filter.

The equipment required for sub-slab soil-gas sample collection is presented below:

- 1-liter stainless steel SUMMA® canisters (order at least one extra, if feasible);
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g.,30 minutes) or flow rate (e.g., 50 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible);
- 1/4-inch OD Teflon® tubing;
- 1/4-inch Swagelok® by 1/8-inch NPT male stainless steel coupling;
- Extra 1/4-inch Swagelok® front and back compression sleeves;

- Decontaminated stainless steel Swagelok® or comparable “T” fitting and needle valve for isolation of purge pump;
- Stainless steel duplicate “T” fitting provided by the laboratory (if collecting duplicate [i.e., split] samples);
- Portable vacuum pump capable of producing very low-flow rates (e.g., 50 to 200 mL/min);
- Electric flow sensor (Bios DryCal® or equivalent);
- Tracer gas testing supplies (refer to “Administering Tracer Gas” SOP #21);
- Appropriate-sized open-end wrench (typically 9/16-inch and 1/2-inch);
- Tedlar® bag to collect purge air or length of tubing sufficient to vent it outside the structure;
- Compound pressure/vacuum gauge;
- Portable weather meter, if appropriate;
- Chain-of-custody (COC) form;
- Sample collection log (attached);
- Nitrile gloves;
- Work gloves;
- Field notebook.

## V. Procedure

### Permanent Sub-Slab Soil-Gas Point Installation

Permanent sub-slab soil-gas points are installed using an electric drill and manual placement of the sub-slab point. After a dry fit, the sub-slab point is inserted into the hole and grouted with a quick-setting, non-shrink grout powder. The soil-gas point is equipped with a plug. The plug is removed and a compression fitting nut and ferrules are used to allow collection of a sub-slab soil-gas sample through Teflon® tubing. The sub-slab point and tubing will be purged with a portable sampling pump prior to collecting the sub-slab soil-gas sample. Detailed installation methods are as follows:

1. Complete utility clearance in accordance with ARCADIS Utility Locate SOP with assistance from Ohio Utility Protection Service (OUPS) prior to drilling activities.

2. Assemble the sub-slab sample point assembly. Teflon® tape should never be used with Swagelok® connections; it should be used on normal NPT threads.

3. Remove, only to the extent necessary any covering on top of the slab (e.g., carpet).

4. Lay down plastic sheeting to keep the work area clean. Check to make sure shop vacuum is working properly and fine concrete particles will not pass through filter.

5. Advance the 1 1/2-inch drill bit approximately 2 1/2 inches into the slab. This hole is drilled deep enough to permit the top of the sampling point to be set flush with the slab when the 1/4-inch tubing (9/16-inch OD) is inserted into the 5/8-inch hole drilled under Step 6, below. Clean up cuttings with shop vacuum, bottle brush, and dust pan.

6. Drill a 5/8-inch-diameter hole into the concrete slab using the electric drill. Do not fully penetrate the slab at this time. Stop drilling approximately 1 inch short of penetrating the slab. To gage this, a typical concrete slab is 4-6 inches thick. Therefore, stop drilling at 3 inches.

7. Use the shop vacuum, bottle brush and dust broom to clean up the work area and material that may have fallen into and around the drill hole.

8. Advance the 5/8-inch drill bit the remaining thickness of the slab and approximately 3 inches into the sub-slab material to create an open cavity.

   Note (if possible) from the drill cuttings any evidence for the types of materials in the immediate sub-slab – i.e. moisture barriers, sand, gravel, etc.

9. Use the bottle brush, whisk broom, and dust pan to quickly clean material around and within the hole. The hole should not be left open for any extended length of time to ensure that VOCs below the slab do not migrate into indoor air (plug with clay during clean up). Do not use the shop vacuum to clean up the drill hole after the full thickness of the slab has been penetrated.

10. Using an assembled sub-slab point, test fit the components so that the proper length of 1/4-inch tubing and depth of the 2 1/2-inch hole provides enough space for the coupling. Adjust so that the sample point plug will lie flush with the slab surface and does not create a tripping hazard.

11. If necessary, re-drill the 5/8-inch hole to ensure it remains clear. This can also be accomplished using a piece of steel rod, sample tubing, or even a piece of heavy wire (e.g., coat hanger).

12. Wrap the sample point assembly with Teflon® tape or VOC free modeling clay, to the extent necessary, for a snug fit of the assembly into the 5/8-inch diameter hole and also to prevent migration of cement to the sub-slab. Ensure that Teflon® tape or modeling clay does not interfere with the cement that will be used to permanently fix and seal the sample point.

13. Prepare a mixture of VOC-free non-shrink quick-setting cement and water according to the manufactures directions in a disposable cup using a plastic spoon for mixing.

14. Before cementing in the sub-slab point, moisten the 1 1/2-inch drill hole with the spray bottle to provide better adhesion.

15. Cement in the sub-slab point using the plastic spoon to apply the cement into the annular space between the coupling and the 1 1/2-inch drill hole.

16. Replace the surface covering (e.g., carpet) if warranted. Sample collection location should be returned to pre-sampling conditions to the extent feasible given the presence of a permanent point.

17. Proceed to sub-slab soil-gas sample collection after waiting a minimum of 24 hours for equilibration following sub-slab point installation.

**Sub-Slab Soil-Gas Sample Collection**

Once the permanent sub-slab point is installed, the following procedures should be used to collect the sample in a SUMMA® canister:

1. Record the following weather information from inside the building being sampled in the field notebook:

    a. wind speed and direction (if capable with in-field measuring device);

    b. ambient temperature;

    c. barometric pressure; and

    d. relative humidity.

2. Before sampling, remove the sample point plug and attach a compound pressure/vacuum gauge to the end of the sample point to record the pressure gradient occurring between indoors and sub-slab. Record the positive or negative pressure reading in the field notebook. Cap the sample point once the reading is collected.

3. Check all SUMMA®-type canisters for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches of mercury (in Hg) and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.

4. Remove the brass plug from the SUMMA® canister and connect the flow controller with in-line particulate filter and vacuum gauge to the SUMMA® canister. Do not open the valve on the SUMMA® canister. Record in the field

notebook and COC form the flow controller number with the appropriate SUMMA® canister number.

5. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, couple two SUMMA® canisters using stainless steel Swagelok® duplicate sample T-fitting supplied by the laboratory. Attach flow controller with in-line particulate filter and vacuum gauge to duplicate sample T-fitting provided by the laboratory.

6. Complete a "shut in" or "leak down" test prior to sampling each sub-slab soil-gas sample point to test the integrity of all above ground sampling equipment supplied by the laboratory (i.e., SUMMA® canister, flow controller, vacuum gauge, and associated fittings). All above ground sampling equipment will be assembled and the cap from the SUMMA® canister will be placed on the end of the sample train, effectively producing a closed system. The SUMMA® canister valve will then be briefly opened then closed; the vacuum applied by the canister is then effectively "shut-in" to the sample train. The vacuum gauge will be observed for at least one minute, and if there is any appreciable loss in vacuum, fittings should be adjusted to remedy the situation and create a leak-free environment. In the event a leak cannot be remedied, field staff should reject the sampling apparatus and choose another unit.

7. Connect a Swagelok® (or comparable) T-fitting to the end of the sample tubing. On one end of the T-fitting connect a short length of Teflon® tubing to the assembled sample train (flow control with in-line particulate filter and vacuum gauge and SUMMA® canister). On the other end of the T-fitting connect a Swagelok® (or similar) two-way valve using a short length of 1/4-inch OD Teflon® tubing.

8. Connect the two-way valve and the properly calibrated portable vacuum pump using a length of tubing. Affix a Tedlar® bag to the purge pump to capture all purged air. The purged air should be evacuated outside the building.

9. Purge 3 volumes of air from the sub-slab soil-gas point and sampling line using a portable pump at a rate of approximately 50 mL/min. Calculate three-times the volume of the inside of the sample tubing and sample point using the calculation:

$$V_1 + V_2 = V_t$$

where:

$V_1 = \pi r^2 h =$ open space volume of sample tubing

$V_2 = \pi r^2 h =$ open space volume of sample point
$V_t =$ total volume

$r =$ inner radius of sample point or sample tubing

$h =$ height of sample point or length of tubing

10. A tracer-gas leak test should be conducted to ensure that ambient leakage is either not occurring or is within acceptable limits. Check the seal established around all sub-slab soil-gas points and connections by using a tracer gas (e.g., helium) or other method established in the state guidance documents. [Note: Refer to SOP 21 "Administering Tracer Gas," for procedures on tracer gas use.] If unacceptable leaks are detected ($\geq$ 5% of the source concentration), take corrective action to seal all potential sources of leak in the sampling train. If the problem cannot be corrected, a replacement sub-slab point should be installed and sampled. Measure organic vapor and tracer gas levels within the Tedlar® bag, as appropriate

11. Close the two-way valve to isolate the purge pump.

12. Open the SUMMA® canister valve to initiate sample collection. Record on the sample log (attached) the time sampling began and the canister pressure.

13. On a floor plan or sketch of the area being sampled, include the following information:

    - Sample location;
    - Locations of heating, ventilation, and air conditioning equipment;
    - Chemical storage areas;
    - Any attached garages or utility areas;
    - Doorways and stairways;

- Any sumps, drains, or other utility perforations;
- Separate footings sections or buildings constructions; and
- The nearest street and the direction of north.

14. Take a photograph of the SUMMA® canister and surrounding area unless prohibited by the building owner.

15. Check the SUMMA® canister approximately half way through the sample duration and note progress on sample logs.

**Termination of Sample Collection**

1. Due to the short duration of sampling, field staff should stay with the SUMMA® canister throughout sampling.

2. Stop collecting the sample when the canister vacuum reaches approximately 5 inches of Hg (leaving some vacuum in the canister provides a way to verify if the canister leaks before it reaches the laboratory) or when the desired sample time has elapsed.

3. Record the final vacuum. Stop collecting the sample by closing the SUMMA® canister valve. Record the date, local time (24-hour time notation) of valve closing on the sample collection log, and COC form.

4. Disconnect sample tubing from the sample point and replace flush-mount cap.

5. Remove the particulate filters and flow controllers from the SUMMA® canisters, re-install the brass plugs on the canister fittings, and tighten with the appropriate wrench.

6. Package the canisters and flow controllers in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canisters should <u>not</u> be preserved with ice or refrigeration during shipment.

7. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with a string).

8. Complete the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via carrier (e.g., Federal Express) for analysis.

9. Replace the surface covering (e.g., carpet) if warranted. Sample collection location should be returned to pre-sampling conditions to the extent feasible given the presence of a permanent sample point. Document with photographs.

**Decommissioning of Permanent Sub-Slab Soil-Gas Points**

1. Remove, only to the extent necessary any covering on top of the permanent sample point (e.g., carpet).

2. Lay down plastic sheeting to keep the work area clean. Check to make sure shop vacuum is working properly and fine concrete particles will not pass through filter.

3. Using a hammer, carefully strike the sample point on the top of the plug to dislodge the permanent point from the slab. Repeat until the sample point becomes loose inside the borehole.

4. Remove the sample point from the slab.

5. Use the shop vacuum, bottle brush and dust broom to clean up the work area and material that may have fallen into and around the drill hole.

6. Prepare a mixture of VOC-free, non-shrink, quick-setting cement and water according to the manufactures directions in a disposable cup using a plastic spoon for mixing.

7. Place cement in 11/2-inch borehole using the plastic spoon until the hole is filled and wait until the cement sets.

8. Replace the surface covering (e.g., carpet) if warranted.

9. Document with photos.

## VI. Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a sub-slab soil gas sample.

- When drilling sample collection holes, utilities may be in the area. Always complete utility location, identification and marking before installing sub-slab sample points as required by the ARCADIS Utility Location Policy and Procedure. Be aware that public utility locator organizations frequently do not provide location information within buildings so alternative lines of evidence must be used.

- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens, wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.

- Care should be taken to ensure that the flow controller is pre-calibrated to the proper sample collection time (confirm with laboratory prior to sampling event, and confirm on packaging list). Sample integrity is maintained if the sampling event is shorter than the target duration, but sample integrity can be compromised if the event is extended to the point that the canister reaches atmospheric pressure. Excessive vacuum remaining in the canister can also result in elevated reporting limits.

- If low-flow conditions are encountered (when air flow rates are less-than 10 mL/min or when vacuum is greater than 10 inches of Hg) and preclude the collection of representative sub-slab soil-gas samples, due to high moisture conditions and/or tight soils, a replacement sub-slab point should be installed, for up to three attempts.

- Field personnel will properly seal the sub-slab point at the slab surface to prevent leaks of atmosphere into the sub-slab point during purging and sampling.

- Quick-setting non-shrink grout and modeling clay or other materials used to seal the hole should only be obtained from an approved ARCADIS source and should not be purchased off the shelf from an unapproved retail source. Data indicate that some modeling clays may contain VOCs that can affect sample results.

- It is important to record the canister pressure, start and stop times and sample identification on a proper field sampling form. Often SUMMA® canisters are collected over a 24 hour period. The time/pressure should be recorded at the start of sampling, and then again one or two hours later. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 inches to 27 inches of Hg). Consult your project manager (PM), risk assessor or air sampling expert by phone if the SUMMA® canister does not appear to be working properly.

- Ensure that there is still measureable vacuum in the SUMMA® after sampling. Sometimes the gauges sent from the lab have offset errors, or they stick.

- When sampling carefully consider elevation. If your site is over 2,000 feet above sea level or the difference in elevation between your site and your lab is more than 2,000 feet then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum left in the http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- Check the seal around the soil-gas sampling point by using a tracer gas (e.g., helium) or other method established in the appropriate guidance document.

- A Shipping Determination must be performed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

## VII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal.

## VIII. Data Recording and Management

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager.

## IX. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 10 air samples (10%).

Soil-gas sample analysis will generally be performed using USEPA TO-15 methodology or a project specific constituent list. Method TO-15 uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits (typically 0.5-ppbv for most VOCs prior to any dilution). Duplicate sub-slab soil-gas samples should be collected via a split sample train, allowing the primary and duplicate sample to be collected from the sub-slab soil-gas point simultaneously.

Trip blank samples will not be used during sub-slab soil-gas sampling. SUMMA® canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA® canister are metal and non-porous; therefore, there is no potential for any contamination to be absorbed. The batch certified clean SUMMA® canisters will be provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA® canister. The integrity of each SUMMA® canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.

## X. References

CEPA. 2010. Advisory – Active Soil Investigation. California Environmental Protection Agency. March.

OEPA. 2010. Sample Collection and Evaluation of Vapor Intrusion to Indoor Air. Guidance Document for Remedial Response and Voluntary Action Program. Division of Emergency and Remedial Response. May.

# Sub-slab/Soil-Gas Sample Collection Log

| | | | |
|---|---|---|---|
| ARCADIS | | Sample ID: | |
| Client: | | Boring Equipment: | |
| Project: | | Sealant: | |
| Location: | | Tubing Information: | |
| Project #: | | Miscellaneous Equipment: | |
| Samplers: | | Subcontractor: | |
| ` | | Equipment: | |
| Sampling Depth: | | Moisture Content of Sampling Zone): | |
| Time and Date of Installation: | | Approximate Purge Volume: | |

**Instrument Readings:**

| Date | Time | Canister Vacuum (a) (inches of Hg) | Temperature (°F) | Relative Humidity (%) | Air Speed (mph) | Barometric Pressure (inches of Hg) | PID (ppb) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

(a) Record canister information at a minimum at the beginning and end of sampling

**SUMMA® Canister Information:**

| | | |
|---|---|---|
| Size (circle one): | 1 L | 6 L |
| Canister ID: | | |
| Flow Controller ID: | | |
| Notes: | | |

**Tracer Test Information (if applicable):**

| | | |
|---|---|---|
| Initial Helium Shroud: | | |
| Final Helium Shroud: | | |
| Tracer Test Passed: | Yes | No |
| Notes: | | |

**General Observations/Notes:**

| |
|---|
| |
| |
| |

**Approximating One-Well Volume (for purging):**

$V_1 + V_2 = V_t$ where: $V_1 = \pi r^2 h$ = open space volume of sample tubing; $V_2 = \pi r^2 h$ = open space volume of sample point; $V_t$ = total volume; $r$ = inner radius of sample point, or sample tubing; $h$ = height of sample point or length of tubing.

ARCADIS

Infrastructure · Water · Environment · Buildings

Imagine the result

# SOP 21

# Administering Helium Tracer Gas for Leak Checks of Soil-Gas or Sub-Slab Sampling Points

RACER

Moraine, Ohio

Rev. #: 2.1

Rev Date: August 11, 2011

**Approval Signatures**

Prepared by: ____________________ Date: May 20, 2008
Mitch Wacksman

Reviewed by: ____________________ Date: May 20, 2008
Robert Uppencamp

Approved by. ____________________ Date: November 14, 2008
Christopher Lutes

Modified by: ____________________ Date: Revised, August 20, 2010
Trey Fortner

Modified by: ____________________ Date: Revised, December 3, 2010
Joseph Rumschlag

Modified by: ________________________ Date: Revised, August 11, 2011
Carolyn Grogan

## I. Scope and Application

When collecting sub-slab soil-gas samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance/quality control device to verify the integrity of the soil-gas point seal. Without the use of a tracer, verification that a sub-slab soil-gas sample has not been diluted by ambient or indoor air is difficult.

This standard operating procedure (SOP) focuses on using helium as a tracer gas. However, depending on the nature of the contaminants of concern, other compounds can be used as a tracer including sulfur hexafluoride (SF6), butane and propane (or other gases). In all cases, the protocol for using a tracer gas is consistent and includes the following basic steps: (1) enrich the atmosphere in the immediate vicinity where the sample point or sample tubing intersects the surface with the tracer gas; and (2) measure a vapor sample from the sample tubing for the presence of high concentrations (>5%) of the tracer. A pail, bucket, garbage can or even a plastic bag can serve to keep the tracer gas in contact with the sample point during the testing.

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

1. Include the tracer gas in the list of target analytes reported by the laboratory; or

2. Use a portable monitoring device to analyze a sample of soil-gas for the tracer prior to sampling for the compounds of concern. (Note that tracer gas samples can be collected via syringe, Tedlar® bag, etc. They need not be collected in SUMMA® canisters or minicans.)

This SOP focuses on monitoring helium using a portable sampling device, although helium can also be analyzed by the laboratory along with other volatile organic compounds (VOCs). Real-time tracer sampling is generally preferred as the results can be used to confirm the integrity of the sample point seals prior to formal sample collection.

During the initial stages of a sub-slab soil-gas sampling program, tracer gas samples should be collected at each of the sampling points. If the results of the initial samples indicate that the sample point seals are adequate, the Project Manager can consider reducing the number of locations at which tracer gas samples are used. At a minimum, at least 10% of the subsequent samples should be supported with tracer gas analyses. When using permanent soil-gas points as part of a long-term monitoring program, the sample point should be tested prior to the first sampling event. Tracer gas testing of subsequent sampling events is not necessary unless conditions have changed at the site.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

## II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the tracer gas testing must have previous experience conducting similar tests.

## III. Equipment List

The equipment required to conduct a helium tracer gas test are presented below:

- Appropriate PPE for site (as required by the Health and Safety Plan).
- Helium (laboratory grade).
- Regulator for helium tank.
- Shroud (plastic bucket, garbage can, etc).
    - The size of the shroud should be sufficient to fit over the sub-slab soil-gas point. It is worth noting that using a smaller shroud obviously uses less helium as well; this may be important when projects require a number of helium tracer tests.
    - The shroud will need to have three small holes in it. These holes will include one on the top (to accommodate the sample tubing), and two on the side (one for the helium detector probe, and one for the helium line).

  - o The shroud ideally encloses the entire sampling train.

- Helium detector capable of measuring from 1 - 100% (Dielectric MGD-2002, Mark Model 9522, or equivalent).

- Tedlar® bags.

- Seal material for shroud (rubber gasket, modeling clay, bentonite, etc). Although the sealing material is not in direct contact with the sample if no leak occurs, sealing materials with high levels of VOC emissions should be avoided, since they could easily contaminate a sample from a point in which a trace leak occurs.

- Field notebook.

## IV. Procedure

The procedure used to conduct the helium tracer test should be specific to the shroud being used and the methods of soil-gas point installation. The helium tracer test can be conducted when using temporary or permanent sample point installs and from inside or outside a facility. However, when using the tracer gas within an indoor area you must provide adequate ventilation because helium is an asphyxiant.

1. Attach Teflon® sample tubing to the sample point. This can be accomplished utilizing a number of different methods depending on the sample install (i.e., barbed fitting, Swagelok® fitting, ball valve, etc.).

2. Place the shroud over the sample point and tubing.

3. Pull the tubing through hole in top of shroud. Seal opening with modeling clay.

4. Place weight on top of shroud to help maintain a good seal with the ground.

5. Insert helium tubing into hole in side of shroud, seal with modeling clay to prevent leaks.

6. Fill shroud with helium. While filling shroud allow atmospheric air to escape either by leaving a crack with the surface or by providing a release value on the side of the shroud.

7. Use the helium detector to test level of helium gas from the bottom of the shroud (where the sample tubing intersects the ground). Helium should be added until the environment inside the shroud has > 60% helium.

8. Purge the sample point through the sample tubing into a Tedlar bag using a hand held sampling pump. The sample pump should be operating at a rate of 50 mL/minute (the purge rate should not exceed the sample collection rate).Use a stand-alone flow sensor to monitor purge flow-rate during purge (Bios DryCal or equivalent). Test the air in the Tedlar® bag for helium using portable helium detector. If the sample point has been installed properly there should be zero helium in purge air.

9. If > 5% helium is noted in purge air, add more clay or other material to the seal the sample point at the surface and repeat the testing procedure. If the seal cannot be fixed, re-install sample point.

10. Monitor and record helium level in shroud before, during and after tracer test.

11. Monitor and record helium level in purge exhaust at the end of purging.

12. At successful completion of tracer test and sample point purging, the soil-gas sample can be collected (if the helium shroud must be removed prior to sample collection be mindful not disturb the sample tubing and any established seals).

## V. Cautions

Helium is an asphyxiant! Be cautious with its use indoors!

Care should be taken not to pressurize shroud while introducing helium. If the shroud is completely air tight and the helium is introduced quickly, the shroud can be over-pressurized and helium can be pushed into the ground.

Because minor leakage around the sample point seal should not materially affect the usability of the soil-gas sampling results, the mere presence of the tracer gas in the sample should not be a cause for alarm. Consequently, portable field monitoring devices with detection limits in the low ppm range are more than adequate for screening samples for the tracer. If high concentrations (>5%) of tracer gas are observed in a sample, the sample point seal should be enhanced to reduce the infiltration of ambient air and the tracer test readministered. If the problem cannot be rectified, a new sample point should be installed.

## VI. Data Recording and Management

Measurements will be recorded in the field notebook at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location, and the helium concentrations in both the shroud and the purge air before, during, and after tracer testing. Any problems encountered should also be recorded in the field notes.

# APPENDIX: Compressed Gases—Use and Storage

In general, a compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders should be handled as high-energy sources and therefore as potential explosives and projectiles. Prudent safety practices should be followed when handling compressed gases since they expose workers to both chemical and physical hazards.

**Handling**

- Safety glasses with side shields (or safety goggles) and other appropriate personal protective equipment should be worn when working with compressed gases.
- Cylinders should be marked with a label that clearly identifies the contents.
- All cylinders should be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., should be taken out of use immediately and returned to the manufacturer/distributor for repair.
- All gas cylinders (full or empty) should be rigidly secured to a substantial structure at 2/3 height. Only two cylinders per restraint are allowed in the laboratory and only soldered link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Handcarts shall be used when moving gas cylinders. Cylinders must be chained to the carts.
- All cylinders must be fitted with safety valve covers before they are moved.
- Only three-wheeled or four-wheeled carts should be used to move cylinders.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off. The correct position for the main valve is all the way on or all the way off.
- Cylinder valves should never be lubricated, modified, forced, or tampered with.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Regulators and valves should be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.
- Cylinders should not be placed near heat or where they can become part of an electrical circuit.
- Cylinders should not be exposed to temperatures above 50 °C (122 °F). Some rupture devices on cylinders will release at about 65 °C (149 °F). Some small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode if exposed to high temperatures.
- Rapid release of a compressed gas should be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.

- Appropriate regulators should be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Adaptors and homemade modifications are prohibited.
- Cylinders should never be bled completely empty. Leave a slight pressure to keep contaminants out.

**Storage**

- When not in use, cylinders should be stored with their main valve closed and the valve safety cap in place.
- Cylinders must be stored upright and not on their side. All cylinders should be secured.
- Cylinders awaiting use should be stored according to their hazard classes.
- Cylinders should not be located where objects may strike or fall on them.
- Cylinders should not be stored in damp areas or near salt, corrosive chemicals, chemical vapors, heat, or direct sunlight. Cylinders stored outside should be protected from the weather.

### *Special Precautions*

Flammable Gases

- No more than two cylinders should be manifolded together; however several instruments or outlets are permitted for a single cylinder.
- Valves on flammable gas cylinders should be shut off when the laboratory is unattended and no experimental process is in progress.
- Flames involving a highly flammable gas should not be extinguished until the source of the gas has been safely shut off; otherwise it can reignite causing an explosion.

Acetylene Gas Cylinders

- Acetylene cylinders must always be stored upright. They contain acetone, which can discharge instead of or along with acetylene. Do not use an acetylene cylinder that has been stored or handled in a nonupright position until it has remained in an upright position for at least 30 minutes.
- A flame arrestor must protect the outlet line of an acetylene cylinder.
- Compatible tubing should be used to transport gaseous acetylene. Some tubing like copper forms explosive acetylides.

Lecture Bottles

- All lecture bottles should be marked with a label that clearly identifies the contents.
- Lecture bottles should be stored according to their hazard classes.
- Lecture bottles that contain toxic gases should be stored in a ventilated cabinet.
- Lecture bottles should be stored in a secure place to eliminate them from rolling or falling.

- Lecture bottles should not be stored near corrosives, heat, direct sunlight, or in damp areas.
- To avoid costly disposal fees, lecture bottles should only be purchased from suppliers that will accept returned bottles (full or empty). Contact the supplier before purchasing lecture bottles to ensure that they have a return policy.
- Lecture bottles should be dated upon initial use. It is advised that bottles be sent back to the supplier after one year to avoid accumulation of old bottles.

ARCADIS

Infrastructure · Water · Environment · Buildings

Imagine the result

# SOP 22

# Indoor Air and Ambient Air Sampling

RACER

Moraine, Ohio

Rev. #: 1.2

Rev Date: February 9, 2011

**Approval Signatures**

Prepared by: ____________ Date: July 7, 2010
Mitch Wacksman

Approved by: ____________ Date: July 7, 2010
Christopher Lutes

Modified by: ____________ Date: Revised, December 3, 2010
Trey Fortner

Modified by: ____________ Date: Revised, February 9, 2011
Mitch Wacksman

## I. Scope and Application

This document describes the procedures to collect indoor air and ambient air samples. Samples are collected in an evacuated 6-liter SUMMA®-type canister, (evacuated to <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for placing the sampling device and collecting indoor air or ambient air samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

## II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading indoor air or ambient air sample collection activities must have previous indoor air or ambient air sampling experience.

## III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task. The following are examples of hazards that are often encountered in conducting indoor air or ambient air sampling:

- In crawl spaces, hazards often include low head room, limited light, poisonous insects, venomous snakes, insulation, electrical and plumbing lines, and sharp debris.

- In residential buildings and neighborhoods unfamiliar pets can pose a hazard. Even though proper permission for sampling may have been secured, it is still possible to encounter persons suspicious of or hostile to the sampling team. Two sampling personnel are required at all times due to these hazards.

- In occupied industrial buildings be aware of the physical hazards of ongoing industrial processes. Examples include moving forklifts and equipment pits.

**IV. Equipment List**

The equipment required for indoor air or ambient air sample collection is presented below:

- Appropriate PPE (as required by the Health and Safety Plan);

- 6-liter, stainless steel SUMMA® canisters (order at least one extra, if feasible);

- Flow controllers with in-line particulate filters and vacuum gauges (flow controllers are pre-calibrated by the laboratory to a specified sample duration [e.g., 24-hour]). Confirm with lab that flow controller is equipped with an in-line particulate filter and pressure gauge (order an extra set for each extra SUMMA® canister, if feasible);

- Appropriate-sized open-end wrenches (typically 9/16-inch);

- Chain-of-custody (COC) form;

- Building survey and product inventory form (example attached);

- Portable photoionization detector (PID) (for use identifying potential background sources during building survey described below);

- Sample collection log (attached);

- Field notebook;

- Camera if photography is permitted at sampling locations;

- Portable weather meter capable of collecting barometric pressure, relative humidity, and temperature, if appropriate;

- Box, chair, tripod, or similar to hold canister above the ground surface; and

- Teflon sample tubing may be used to sample abnormal situations (i.e., sumps, where canisters must be hidden, etc.). In these situations ¼-inch Swagelok fittings or other methods may be appropriate to affix tubing to canister. Staff should check this before heading out into field.

## V. Procedure

### Initial Building Survey for Indoor Air Samples (if applicable to project)

1. Complete the appropriate building survey form and product inventory form (attached) as necessary in advance of sample collection. The product inventory should include ingredients of products as well as quantities. A copy of this completed form will be provided to the property owner to discuss potential background sources.

2. Confirm with building occupants that Instructions for Occupants during Indoor Air Sampling Events has been followed, and use of products that may provide interference with sample results has been discontinued and specified products removed to a non-attached structure at least 48-hours before sampling.

3. Identify on a site plan all underground utilities, piping, or conduits coming into or out of the building to be sampled.

4. Survey the area for the apparent presence of items or materials (i.e. foundation cracks) that may potentially produce or emit constituents of concern and interfere with analytical laboratory analysis of the collected sample. Record relevant information on survey form and document with photographs.

5. Record date, time, location, and other relevant notes on the sampling form.

6. Items or materials that contain constituents of concern and/or exhibit elevated PID readings shall be considered probable sources of VOCs. Request approval of the owner or occupant to have these items removed to a structure not attached to the target structure at least 48 hours prior to sampling, if possible.

7. Set a date and time with the owner or occupant to return for placement of SUMMA® canisters.

**Preparation of SUMMA®-Type Canister and Collection of Indoor Air or Ambient Air Sample**

1. Record the following information from wherever the sample is being collected (i.e. inside a building for indoor air samples or outside for ambient air samples) on the sampling form (use a hand-held weather meter, contact the local airport or other suitable information source [e.g., weather.gov] to obtain the following information):

   - ambient temperature;
   - barometric pressure;
   - wind speed; and
   - relative humidity.

2. Choose the sample location in accordance with the sampling plan. If a breathing zone sample is required, place the canister on a ladder, tripod, box, or other similar stand to locate the canister orifice 4 to 5 feet above ground or floor surface. If the canister will not be overseen for the entire sampling period, secure the canisters as appropriate (e.g., lock and chain). Canister may be affixed to wall/ceiling support with nylon rope or placed on a stable surface. In general, areas near windows, doors, air supply vents, and/or other potential sources of "drafts" shall be avoided. Ambient air samples should be placed upwind of the sampling area.

3. Record SUMMA® canister serial number and flow controller number on the sampling log and chain of custody (COC) form. Assign sample identification on canister ID tag, and record on the sample collection log (attached), and COC form.

4. Remove the cap from the SUMMA® canister. Attach the flow controller with in-line particulate filter and vacuum gauge to the SUMMA® canister with the appropriate-sized wrench. Tighten by hand first, then gently with the wrench. Use caution not to over tighten fittings.

5. Open the SUMMA® canister valve to initiate sample collection. Record the date and local time (24-hour time notation) of valve opening on the sample collection log, and COC form. Collection of duplicate samples will include collecting two samples side by side at the same time.

6. On a floor plan or sketch of the area being sampled, include the following information:

   - Sample location;
   - Locations of heating, ventilation, and air conditioning equipment;
   - Chemical storage areas;
   - Any attached garages or utility areas;
   - Doorways and stairways;
   - Any sumps, drains, or other utility perforations;
   - Separate footings sections or buildings constructions; and
   - The nearest street and the direction of north.

7. All SUMMA®-type canisters received from Air Toxics will be checked for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches (in) of Hg and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.

8. Record the initial vacuum pressure in the SUMMA® canister on the sample log and COC form.

9. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, two SUMMA® canisters will be placed side-by-side and allowed to collect a sample during the exact same period of time.

10. Take a photograph of the SUMMA® canister and surrounding area, if possible.

11. The SUMMA® canister should be checked, if possible, at least once during the 24-hour sampling process and the progress noted on the sampling log.

**Termination of Sample Collection**

1. Arrive at the SUMMA® canister location at least 1-2 hours prior to the end of the sampling interval (e.g., 24-hour), if possible.

2. Stop collecting the sample when the canister vacuum reaches approximately 5 inches of Hg (leaving some vacuum in the canister provides a way to verify if the canister leaks before it reaches the laboratory) or when the desired sample time has elapsed.

3. Record the final vacuum. Stop collecting the sample by closing the SUMMA® canister valve. Record the date, local time (24-hour time notation) of valve closing on the sample collection log, and COC form.

4. Remove the particulate filter and flow controller from the SUMMA® canister, re-install brass cap on canister fitting, and tighten with wrench.

5. Package the canister and flow controller in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canister does not require preservation with ice or refrigeration during shipment.

6. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with string).

7. Complete COC form and place requisite copies in shipping container. Close shipping container and affix custody seal to container closure. Ship to laboratory via overnight carrier (e.g., Federal Express) for analysis.

**VI. Cautions**

- Care must be taken to minimize the potential for introducing interferences during the sampling event. As such, keep canisters away from heavy pedestrian traffic areas (e.g., main entranceways, walkways) if possible. If the canisters are not to be overseen for the entire sample duration, precautions should be taken to maintain the security of the sample (e.g., do not place in areas regularly accessed by the public, fasten the sampling device to a secure object using lock and chain, label the canister to indicate it is part of a scientific project, notify local authorities, place the canister in secure housing that does not disrupt the integrity/validity of the sampling event). Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (sharpies), wear/apply fragrances, or smoke cigarettes before and/or during the sampling event.

- If a sub-slab soil-gas sample is collected from a permanent point at the same residence then wait a minimum of 24 hours after the installation of the point before sampling indoor air to minimize cross-contamination from sub-slab soil-gas that may have entered the indoor air during the installation of the point.

- Ensure that the flow controller is pre-calibrated to the proper sample collection duration (confirm with laboratory). Sample integrity can be compromised if sample collection is extended to the point that the canister reaches atmospheric pressure. Sample integrity is maintained if sample collection is terminated prior to the target duration and a measurable vacuum (e.g., 2 to 5–inches Hg) remains in the canister when sample collection is terminated.

- It is important to record the canister pressure, start and stop times and sample identification on a proper field sampling form. Often SUMMA® canisters are collected over a 24 hour period. The time/pressure should be recorded at the start of sampling, and then again one or two hours later. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 to 27 inches Hg). Consult your project manager (PM), risk assessor or air sampling expert if the SUMMA® canister does not appear to be working properly.

- When sampling carefully consider elevation. If your site is over 2,000 feet above sea level or the difference in elevation between your site and your lab is more than 2,000 feet then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum remaining http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- A Shipping Determination must be completed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

- When collecting ambient air samples it is advisable to contact the local police department to inform them of the sampling and the equipment (i.e. SUMMA®) to be used. This will inhibit any false alarms from concerned citizens.

**VII. Waste Management**

No specific waste management procedures are required.

**VIII. Data Recording and Management**

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager. A building survey form and product inventory form (Attachment A) may also be completed for each building within the facility being sampled during each sampling event as applicable.

**IX. Quality Assurance**

Duplicate samples should be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 10 air samples (10%).

Indoor air sample analysis will be according to USEPA Method TO-15. This method uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits. The GC/MS system requires a 1-liter gas sample (which can easily be recovered from a 6-liter canister) to provide a 0.5 ppbv detection limit. The 6-liter canister also provides several additional 1-liter samples in case subsequent re-analyses or dilutions are required. This system also offers the advantage of the GC/MS detector, which confirms the identity of detected compounds by evaluating their mass spectra in either the SCAN or SIM mode.

Trip blank samples will not be used during indoor air or ambient air sampling. SUMMA® canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA® canister are metal and non-porous; therefore, there is no potential for any contamination to be absorbed. The batch certified clean SUMMA® canisters will be provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA® canister. The integrity of each SUMMA® canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.

ARCADIS

**Building Survey and Product Inventory Form**

Directions: This form must be completed for each residence or area involved in indoor air testing.

Preparer's Name: ______________________________________

Date/Time Prepared: ___________________________________

Preparer's Affiliation: __________________________________

Phone No.: ___________________________________________

Purpose of Investigation: _________________________________________________________________

**1. OCCUPANT:**

**Interviewed: Y / N**

Last Name: __________________________ First Name: __________________________

Address: __________________________________________________________________

County: _____________________________________

Home Phone: ________________________ Office Phone: _________________________

Number of Occupants/Persons at this Location: __________________

Age of Occupants: _______________________

**2. OWNER OR LANDLORD: (Check if Same as Occupant ___)**

**Interviewed: Y / N**

Last Name: __________________________ First Name: __________________________

Address: __________________________________________________________________

County: ___________________________________

Home Phone: _____________________ Office Phone: _____________________

## 3. BUILDING CHARACTERISTICS:

**Type of Building:** (circle appropriate response)

| | | |
|---|---|---|
| Residential | School | Commercial/Multi-use |
| Industrial | Church | Other: _________________ |

**If the Property is Residential, Type?** (circle appropriate response)

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

**If Multiple Units, How Many?** ___________

**If the Property is Commercial, Type**?

Business Type(s) _____________________________________

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

**Other Characteristics:**

Number of Floors______ Building Age______

Is the Building Insulated? Y / N How Air-Tight? Tight / Average / Not Tight

## 4. AIRFLOW:

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

Airflow Between Floors

___

___

___

ARCADIS

Airflow Near Source

___

___

___

Outdoor Air Infiltration

___

___

___

Infiltration Into Air Ducts

___

___

___

**5. BASEMENT AND CONSTRUCTION CHARACTERISTICS:** (circle all that apply)

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

**j. Sump present?** Y / N

**k. Water in sump?** Y / N / NA

**Basement/lowest level depth below grade:** ________(feet)

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

| Potential Vapor Point Entry | Field Screening Results (ppm) | Comments |
| --- | --- | --- |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**Are the basement walls or floor sealed with waterproof paint or epoxy coatings?** Y / N

**6. HEATING, VENTILATING, AND AIR CONDITIONING:** (circle all that apply)

**Type of heating system(s) used in this building: (circle all that apply – note primary)**

Hot air circulation | Heat pump | Hot water baseboard
Space heaters | Stream radiation | Radiant floor
Electric baseboard | Wood stove | Outdoor wood boiler
Other __________

**The primary type of fuel used is:**

Natural gas | Fuel oil | Kerosene
Electric | Propane | Solar
Wood coal

**Domestic hot water tank fueled by:** ______________________________

**Boiler/furnace located in:** Basement Outdoors Main Floor Other____________

**Air conditioning:** Central Air Window Units Open Windows None

**Are there air distribution ducts present?** Y / N

ARCADIS

**Describe the supply and cold air return ductwork, and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.**

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

**7. OCCUPANCY:**

**Is basement/lowest level occupied?** Full-time Occasionally Seldom Almost Never

**General Use of Each Floor (e.g., family room, bedroom, laundry, workshop, storage):**

Basement ________________________________________________________

1st Floor ________________________________________________________

2nd Floor ________________________________________________________

3rd Floor ________________________________________________________

4th Floor ________________________________________________________

**8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY:**

**a. Is there an attached garage?** Y / N

**b. Does the garage have a separate heating unit?** Y / N / NA

**c. Are petroleum-powered machines or vehicles stored in the garage (e.g., lawnmower, ATV, car)?**

Y / N / NA Please specify: ______________________________________________

**d. Has the building ever had a fire?** Y / N When? ____________________________

**e. Is a kerosene or unvented gas space heater present?** Y / N Where? __________________

**f. Is there a workshop or hobby/craft area?** Y / N Where & Type? ________________

**g. Is there smoking in the building?** Y / N How frequently? __________________________

**h. Have cleaning products been used recently?** Y / N When & Type? _________________

**i. Have cosmetic products been used recently?** Y / N When & Type? _________________

**j. Has painting/staining been done in the last 6 months?** Y / N Where & When? ____________

**k.** **Is there new carpet, drapes or other textiles?** Y / N Where & When? ________________

**l.** **Have air fresheners been used recently?** Y / N When & Type? _______________________

**m.** **Is there a kitchen exhaust fan?** Y / N If yes, where _________________________

**n.** **Is there a bathroom exhaust fan?** Y / N If yes, where vented?________________________

**o.** **Is there a clothes dryer?** Y / N If yes, is it vented outside? Y / N

**p.** **Has there been a pesticide application?** Y / N When & Type?______________________

**q.** **Are there odors in the building?** Y / N

If yes, please describe: ______________________________________________________________

**Do any of the building occupants use solvents (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist) at work?** Y / N

If yes, what types of solvents are used? __________________________________________________

If yes, are their clothes washed at work? Y / N

**Do any of the building occupants regularly use or work at a dry-cleaning service?** (circle appropriate response)

Yes, use dry-cleaning regularly (weekly) No

Yes, use dry-cleaning infrequently (monthly or less) Unknown

Yes, work at a dry-cleaning service

**Is there a radon mitigation system for the building/structure?** Y / N

Date of Installation: ______________________

**Is active mitigation system recommended?** Y / N

**Are there any Outside Contaminant Sources?** (circle appropriate responses)

Contaminated site with 1000-foot radius? Y / N Specify ________________________________

Other stationary sources nearby (e.g., gas stations, emission stacks, etc.): ___________________

_______________________________________________________________________________

Heavy vehicle traffic nearby (or other mobile sources): __________________________________

**9. WATER AND SEWAGE:**

**Water Supply:** Public Water Drilled Well Driven Well Dug Well Other: _______

**Sewage Disposal:** Public Sewer Septic Tank Leach Field Dry Well Other: _______

**10. RELOCATION INFORMATION:** (for oil spill residential emergency)

a. **Provide reasons why relocation is recommended:** ___________________________________

_____________________________________________________________________________________

b. **Residents choose to:** remain in home relocate to friends/family relocate to hotel/motel

c. **Responsibility for costs associated with reimbursement explained?** Y / N

d. **Relocation package provided and explained to residents?** Y / N

**11. FLOOR PLANS:**

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note.

Basement:

ARCADIS

**First Floor:**

**12. OUTDOOR PLOT:**

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s), and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.

ARCADIS

## 13. PRODUCT INVENTORY FORM:

**Make and Model of field instrument used:** ____________________________________________

List specific products found in the residence or area that have the potential to affect indoor air quality (e.g., gasoline or kerosene storage cans, glues, paints, cleaning solvents/products, polishes/waxes, new furniture/ carpet, nail polish/hairspray/cologne).

| Location | Product Description | Size (units) | Condition* | Chemical Ingredients | Field Instrument Reading (units) | Photo** Y/N |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

# Indoor Air or Ambient Air Sample Collection Log

ARCADIS

| | | | |
|---|---|---|---|
| | | Sample ID: | |
| Client: | | Outdoor/Indoor: | |
| Project: | | Sample Intake Height: | |
| Location: | | Tubing Information: | |
| Project #: | | Miscellaneous Equipment: | |
| Samplers: | | Time On/Off: | |
| Sample Point Location: | | Subcontractor: | |

**Instrument Readings:**

| Date | Time | Canister Vacuum (a) (inches of Hg) | Temperature (°F) | Relative Humidity (%) | Air Speed (mph) | Barometric Pressure (inches of Hg) | PID (ppb) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

(a) Record canister information at a minimum at the beginning and end of sampling

**SUMMA Canister Information:**

| | |
|---|---|
| Size (circle one): | 1 L 6 L |
| Canister ID: | |
| Flow Controller ID: | |
| Notes: | |

**General Observations/Notes:**

| |
|---|
| |
| |
| |

ARCADIS

Infrastructure, environment, buildings

Imagine the result

# SOP 23

# Inspection and Vapor Intrusion Mitigation System Design

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: August 9, 2011

**Approval Signatures**

Prepared by: ______________________ Date: April 26, 2011
Rebecca Robbennolt

Reviewed by: ______________________ Date: May 3, 2011
Rachel Saari

Approved by: ______________________ Date: May 6, 2011
Carolyn Grogan Revised Date: August 9, 2011

## I. Scope and Application

This Standard Operating Procedure (SOP) describes the inspection and design procedures to be carried out prior to the installation of active vapor mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The inspection procedures are based on Sub-Slab Depressurization System (SSDS), Sub-Membrane Depressurization System (SMDS), and Crawlspace Depressurization System (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2003), United States Environmental Protection (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

The following sections list the necessary equipment and provide detailed instructions for completing the building inspection and design for active vapor intrusion mitigation systems.

Site-specific requirements and/or field conditions may require modifications to the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

## II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the inspection and design activities will have previous vapor intrusion mitigation experience.

## III. Health and Safety Considerations

Materials and equipment must be carefully handled to minimize the potential for injury. All inspection personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific inspection. Drilling with the concrete core drill during communication testing should be done only by personnel with prior experience using such equipment.

## IV. Equipment List

The equipment required to complete the inspection and design activities active are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Hammer drill
- Wet/Dry vacuum
- Extra vacuum hose
- Micromanometer – The Fluke 922 Airflow Meter / Micromanometer, or equivalent, will be used for this project. Please see the specification sheet attached to this SOP for details.
- Non-shrink grout
- Tubing
- Swagelok fitting
- Modeling clay
- Flashlight
- Tape measure
- Camera
- Field book or inspection form (attached to the end of this SOP)

## V. Procedure

**Vapor Mitigation System Inspection (US EPA 625 and ASTM E2121-03)**

The following definitions that are commonly used in the vapor mitigation system inspection and design process have been provided for clarification purposes:

- Suction point – The location where the proposed vapor intrusion mitigation system will extract sub-slab, sub-membrane, or crawlspace vapors. For example, a suction point could be a perforated polyethylene flex drain in a crawlspace or a polyvinyl chloride (PVC) pipe that is inserted into a vertical or horizontal suction pit. During communication testing, the vacuum should be applied to a point installed in the location of the suction point and identified as EX-1, EX-2, etc.

- Suction pit – The void installed below slab–on-grade or basement slab foundations.

- Sub-slab sample point – The sample locations used to collect sub-slab pressure field extension readings and background differential pressure readings from below the slab foundation. Permanent sub-slab sample points are installed in accordance with SOP 20, Sub-Slab Soil-Gas Point Installation and Sampling, and can also be used for collection of sub-slab samples. Temporary sub-slab sample points are installed to collect sub-slab pressure field extension readings during communication testing and are installed by drilling a small hole through the foundation. After the communication test is performed the holes are abandoned with non-shrink grout. Typically, the temporary sub-slab sample points are replaced with permanent sub-slab sample points during mitigation system installation. The sub-slab sample points should be labeled as SS-1, SS-2, etc.

Conduct a visual survey and hand sketch for the home to identify the unique characteristics of that home that will need to be considered as part of the system design and construction. Identify the following items, and document any preferences that the homeowner expresses.

a. Identify each separate foundation and its type. Sketch the configuration and note the approximate size of each separate area. Select the proposed suction point location(s) for each foundation and locate on the floor plan.

One suction point should be proposed within each foundation area unless communication between foundations can be demonstrated through completion of a communication test as described below. The following are example suction point locations that are appropriate for a variety of foundation scenarios:

- If a property has a partial basement foundation and a slab–on-grade foundation, two suction points would be proposed (one suction point in the basement foundation and one suction point in the slab-on-grade foundation).
- If a property has one crawlspace foundation that supports the entire structure, one suction point is appropriate.
- If a property has one slab–on-grade foundation and one slab–on-grade addition, two suction points should be proposed (one for each foundation) unless communication testing demonstrates pressure field extension to both areas from one suction point.

b. Include the size and location of crawlspace access doors and the approximate working height within each crawlspace. Note any obstacles that may present a problem for access and if any stored materials will need to be removed. Note whether padding and plywood or other materials will be needed to protect the sheeting and whether the access door will need to be protected from pets or other small animals.

c. For slab-on-grade foundations, sketch the floor plan of the first floor, and identify locations such as closets or utility rooms that may be candidates for system installation. If a second floor is present, identify any locations where the system piping could be installed through both floor levels within closets or other acceptable locations. Identify any cracks or other openings in the slab that are accessible for sealing.

d. Sketch the basement floor plan including the identification of finished and unfinished areas, sumps, floor drains not connected to sewers, cracks, wall to floor joint, open block wall cores, plumbing penetrations, and any other areas that may require sealing. Note the presence of stored items that may need to be relocated to access areas for sealing and system installation. Note any significant degradation in the integrity of the floor and/or walls that would require additional sealing measures beyond the standard caulking procedures.

e. If a sump is present, identify the drains that are connected to the sump and the type of sump pump that is present (pedestal or submersible).

f. Identify gas fired appliances; such has furnaces and water heaters that may need to be checked for backdrafting.

g. On the exterior of the home, identify the number of stories, the type and condition of the roof, and any receptors that may need to be avoided when determining the system discharge location.

h. Identify the location where the piping will exit the structure. Ensure that the pipe can be routed to an appropriate discharge location from this point with minimal or no jogs around windows or other obstructions. The discharge location must be located above the eve of the roof and be at least 10 feet above ground level and at least two feet above or ten feet away from any windows or other openings into the structure or into any adjacent structure. Avoid locating the piping outside of a bedroom, where fan noise could be disturbing to the homeowner.

   Fan placement will either be on the exterior piping or within the attic.

i. Use a micromanometer to measure a background differential pressure at the existing sub-slab sample point at homes with basement and/or slab-on-grade foundations, where an active mitigation system is to be installed, to determine the pre-existing sub-slab pressure that will need to be overcome.

j. Determine if a communication test is to be conducted to assist with predicting system coverage across the entire slab. Crawlspace scenarios do not require a communication test because there is no slab to test below. Communication testing should be performed if:

   1. The suction point will be located greater than 20 feet from the furthest extent of the area it is intended to provide coverage for;

   2. Tight soil conditions are suspected based on site geology or previous sample port/point installation (i.e. clay); and/or

   3. Footers or other barriers (i.e., utilities or sumps) are identified or suspected based on a visual survey that may prohibit communication across the foundation.

An Inspection and Design Flow Chart and a Communication Test Schematic have been attached to this SOP.

k. Communication testing may be conducted during a separate visit and will consist of the following.

- Drill a one-inch hole through the slab at the proposed suction point location using a hammer drill. Utilize the wet/dry vac for dust control during drilling and use hearing protection.

- Install temporary sub-slab sample point(s) on opposite side(s) of the slab by drilling small holes (same diameter as the outside diameter of the tubing to be used) through the slab, inserting tubing, and sealing around tubing with modeling clay. Permanent sub-slab sample points will be installed during system construction per the procedures in the Sub-Slab Soil-Gas Point Installation SOP (SOP 20) that is included within this appendix.

- Connect the suction hose of the wet/dry vacuum to the proposed suction point. Connect extra hose to the discharge of the vacuum and route the discharge to the outdoors.

- Connect tubing from temporary sub-slab sample point to the positive port of the micromanometer. Record the sub-slab pressure field extension reading, including the positive or negative sign.

- If a negative pressure of at least 0.004 in w.c. is not obtained at each sub-slab sample point, seal any openings in the slab and repeat the test.

- If after sealing a negative pressure is not obtained at each sub-slab sample point, identify a second suction point location closer to the area that was not being covered, and repeat the test.

- After testing is complete, remove the tubing and clay from the temporary sub-slab sample point (s) and fill the suction hole(s) and temporary sub-slab sample point (s) with non-shrink grout.

l. Test combustion appliances to document any pre-existing backdrafting conditions utilizing the following procedure:

1. Turn on the appliance being tested (If the appliance is a forced air furnace, ensure that the blower starts to run before proceeding).

2. Check for flue gas spillage near vent hood.

If backdrafting is occurring the owner will be advised of the situation. The necessary repairs must be completed by the owner prior to any vapor control work. Note that high efficiency appliances do not require backdraft testing and can be identified by the presence of PVC vent pipes.

**VII. Safety Considerations**

ARCADIS will comply with all OSHA, state, and local standards or regulations relating to worker safety during inspection of vapor intrusion mitigation system. All necessary PPE will be worn during visual inspection and communication testing.

**VIII. Waste Management**

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

**IX. Data Recording and Management**

ARCADIS will keep records of all measurements and notes taken during the inspection, and the information gathered will be used to create a property specific work plan. A detailed inspection form will be completed for each building.

**X. Quality Assurance**

ARCADIS personnel responsible for leading the inspection and design activities will have previous vapor intrusion mitigation experience.

## XI. References

ASTM Standard E2121. 2003. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches, October 2008.

FLUKE®

# Fluke 922

## Airflow Meter/ Micromanometer

## Technical Data


Today's HVAC technicians need a simple solution for diagnosing ventilation issues. The Fluke 922 makes airflow measurements easy by combining pressure, air flow, and velocity into a single, rugged meter. Compatible with most pitot tubes, the Fluke 922 allows technicians to conveniently enter their duct shape and dimensions for maximum measurement accuracy.

**The Fluke 922 Airflow Meter helps you:**

- Monitor air pressure across key HVAC components
- Ensure proper air flow balance
- Promote good indoor air quality
- Maintain a comfortable environment

**Use the Fluke 922 to:**

- Measure pressure drops across filters and coils
- Match ventilation to occupant loads
- Monitor indoor vs. outdoor pressure relationships and manage the building envelope
- Perform duct traversals for accurate airflow readings

**Features:**

- Powerful meter provides differential and static pressure, air velocity and flow readings
- Rugged design built for field use
- Easy to use without sacrificing performance
- User-defined duct shape and size for maximum airflow accuracy
- Convenient colored hoses help you properly diagnose pressure readings
- Bright, backlit display for clear viewing in all environments
- Min/Max/Average/Hold functions for easy data analysis
- Auto power off saves battery life

FLUKE ®

# Fluke 922 Airflow Meter Specifications

| Feature | Range | Resolution | Accuracy |
|---|---|---|---|
| **Operating Specifications** | | | |
| **Air Pressure** | ± 4000 Pascals<br>± 16 in $H_2O$<br>± 400 mm $H_2O$<br>± 40 mbar<br>± 0.6 PSI | 1 Pascal<br>0.001 in $H_2O$<br>0.1 mm $H_2O$<br>0.01 mbar<br>0.0001 PSI | ± 1 % + 1 Pascal<br>± 1 % + 0.01 in $H_2O$<br>± 1 % + 0.1 mm $H_2O$<br>± 1 % + 0.01 mbar<br>± 1 % + 0.0001 PSI |
| **Air Velocity** | 250 to 16,000 fpm<br>1 to 80 m/s | 1 fpm<br>0.001 m/s | ± 2.5 % of reading at 2000 fpm (10.00 m/s) |
| **Air Flow (Volume)** | 0 to 99,999 cfm<br>0 to 99,999 m3/hr<br>0 to 99,999 l/s | 1 cfm<br>1 m3/hr<br>1 l/s | Accuracy is a function of velocity and duct size |
| **Temperature** | 0 °C to 50 °C<br>32 °F to 122 °F | 0.1 °C<br>0.1 °F | ± 1 % + 2 °C<br>± 1 % + 4 °F |
| **General Specifications** | | | |
| **Operating Temperature** | 0 °C to +50 °C (+32 °F to +122 °F) | | |
| **Storage Temperature** | -40 °C to +60 °C (-40 °F to +140 °F) | | |
| **Operating Relative Humidity** | 0 % to 90 %, non-condensing | | |
| **IP Rating** | IP40 | | |
| **Operating Altitude** | 2000 m | | |
| **Storage Altitude** | 12000 m | | |
| **EMI, RFI, EMC** | Meets requirements for EN61326-1 | | |
| **Vibration** | MIL-PREF-28800F, Class 3 | | |
| **Max Pressure at Each Port** | 10 PSI | | |
| **Data Storage** | 99 readings | | |
| **Warranty** | 2 years | | |
| **Power** | Four AA batteries | | |
| **Typical Battery Life** | 375 hours without backlight, 80 hours with backlight | | |

CE N10140

## Optional accessories

**PT12**
Pitot Tube, 12 in

**TPAK**
ToolPak™

**Fluke 922 comes complete with the following:**
Fluke 922 Airflow Meter, Two Rubber Hoses, Wrist Strap, Four AA Batteries 1.5 V Alkaline, Users Manual and Soft Carrying Case


**Fluke 922/Kit comes complete with the following:**
Fluke 922 Airflow Meter, 12 in. pitot tube, ToolPak™, Two Rubber Hoses, Wrist Strap, Four AA Batteries 1.5 V Alkaline, Users Manual and Hard Carrying Case

## Ordering Information

**Fluke-922** Airflow Meter
**Fluke-922/Kit** Airflow Meter with 12 in Pitot Tube
**PT12** Pitot Tube, 12 in

**Fluke.** *Keeping your world up and running.®*

**Fluke Corporation**
PO Box 9090, Everett, WA USA 98206

**Fluke Europe B.V.**
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

**For more information call:**
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.fluke.com


Printed in U.S.A. 8/2007 2791462 D-EN-N Rev C

ARCADIS

**Vapor Intrusion Mitigation System**
**Inspection and Design Form**

Property Address: ______________________ Temperature (Ambient): ____________ °F
Tenant's Name: ______________________ Temperature (House): ____________ °F
Owner's Name: ______________________ Barometric Pressure: ____________ "Hg
Owner's Address (If Different from Property Address): Weather Conditions: ____________

______________________________________________

Inspector(s) Name(s): ______________________
Date and Time: ______________________
Foundation Type(s): Slab Basement Crawlspace Crawlspace Height: ____________
Cracks or Other Areas to be Sealed: Yes No NA
List: ______________________
Open Block Cores to be Sealed: Yes No NA
List: ______________________
Sump to be Sealed: Yes No NA Sump Diameter: ____________
If Yes, Pedestal Pump, Submersible Pump, or None: ______________________
Existing Lid to be Reused: Yes No NA
Drain Seals Needed: Yes No
Diameter of Drains: ____________ How Many? ____________
Backdraft Test Completed on Furnace: Pass Fail NA - High Efficiency
Backdraft Test Completed on Water Heater: Pass Fail NA - Electric or Direct Vent
Reason Backdraft Test not Performed? ______________________
Failing Backdrafting Condition Reported to Homeowner: Yes No NA
Building Height: 1-Story 2 -Story Other ____________
Will Roof be Penetrated: Yes No
Roof Type: Metal Shingle Other ____________
Piping to be Installed through or Outside House? ______________________
Fan will be Located on Exterior or in Attic? ______________________
Verify Discharge Location will Meet Required Clearance from any Openings into Home or Adjacent Home: Yes No

**Suction Point Location and Communication Testing Determination**

Are there Multiple Foundation Types? Yes No **(Each foundation type will need to be mitigated)**
If Yes, Indicate Dimensions of Each Foundation: ______________________
Does the Structure have any Additions? Yes No **(Additions should be considered a separate foundation)**
Is the Suction Point Located Greater than 20 Feet from the Furthest Extent of the Area it is Intended to to Provide Coverage?
Yes No **(If yes, communication testing should be completed)**
Are there Footers or other Barriers that may Impede Communication across Slab? Yes No
**(If yes, communication testing should be completed)**
Communication Testing to be Completed: Yes No NA
If Communication Testing is not Completed, Reason Why: ______________________
Background Sub-Slab Pressure: Point ID: ________ Pres: ________ Point ID: ________ Pres: ________

**See Back for Communication Test Results**

ARCADIS

**Vapor Intrusion Mitigation System**

**Inspection and Design Form**

**Communication Test Results:**

**(Apply vacuum to the proposed suction point location(s) during the test.)**

| Date | Time | Location ID where Vacuum was Applied | Location ID Where Pressure Reading was Collected | Pressure (in w.c.) | Notes |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Note: Please label the location IDs on the site sketch consistent with the terminology on the table above.

Is the sub-slab pressure field extension reading more negative than -0.004 in w.c.? Yes No NA **(If No, additional suction points are necessary)**

Note if the Furnace or Air Conditioning is Operating during the Communication Test and Record Background Sub-Slab Pressure Readings. ______________________________

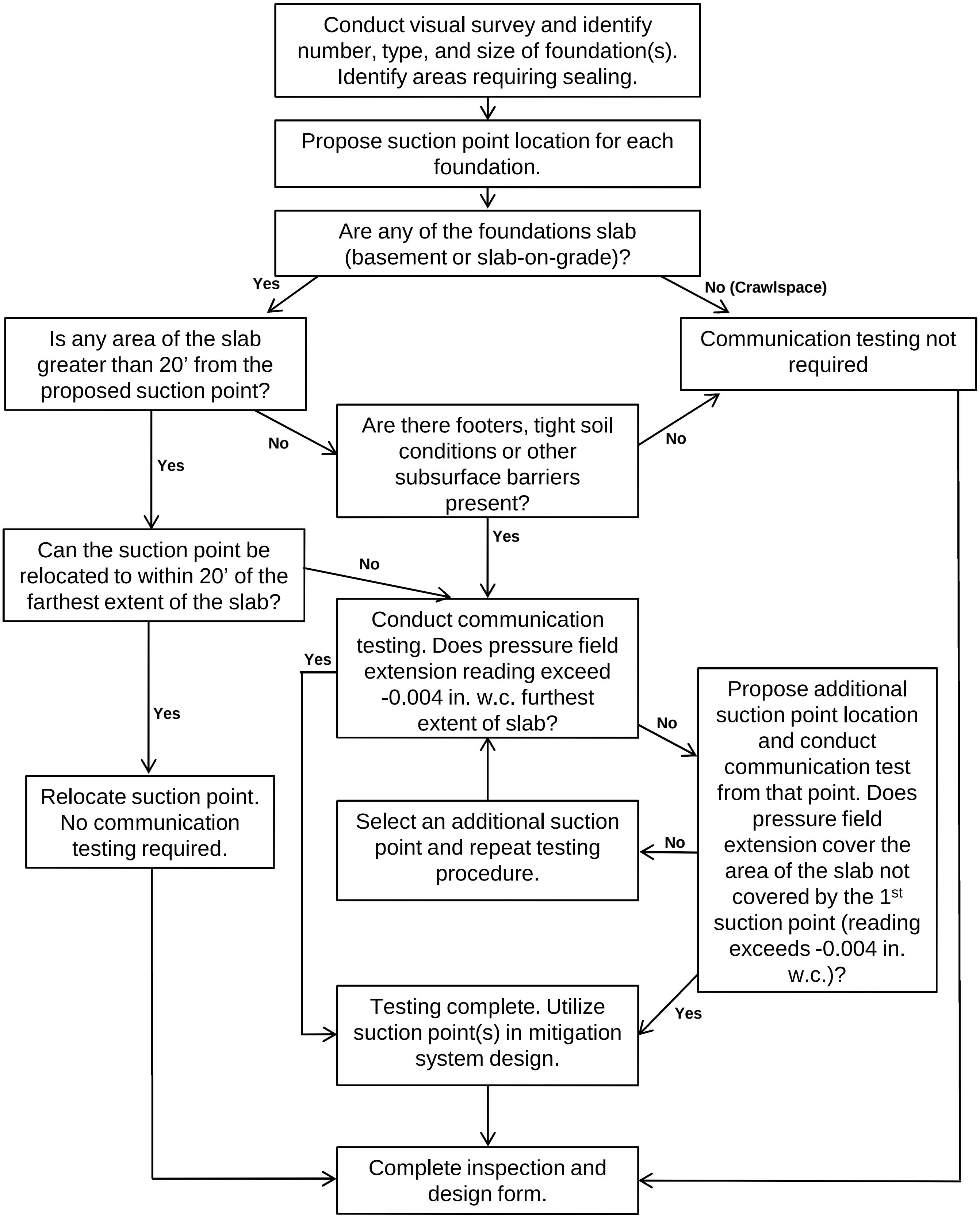
"Hg Inches of Mercury.

In w.c. Inches of Water Column.

A negative pressure reading indicates the presence of a vacuum. A positive reading indicates that there is no vacuum present.

**Attach floor plan sketch, including all requirements of the Vapor Mitigation Inspection and Design SOP. Label each foundation type on the sketch.**

**Include photos of <u>exterior of house</u>, <u>all foundation types</u>, <u>exterior discharge location (if applicable)</u>, <u>cracks and/or drains to be sealed</u>, and any other relevant photos helpful for understanding the design of the mitigation system.**

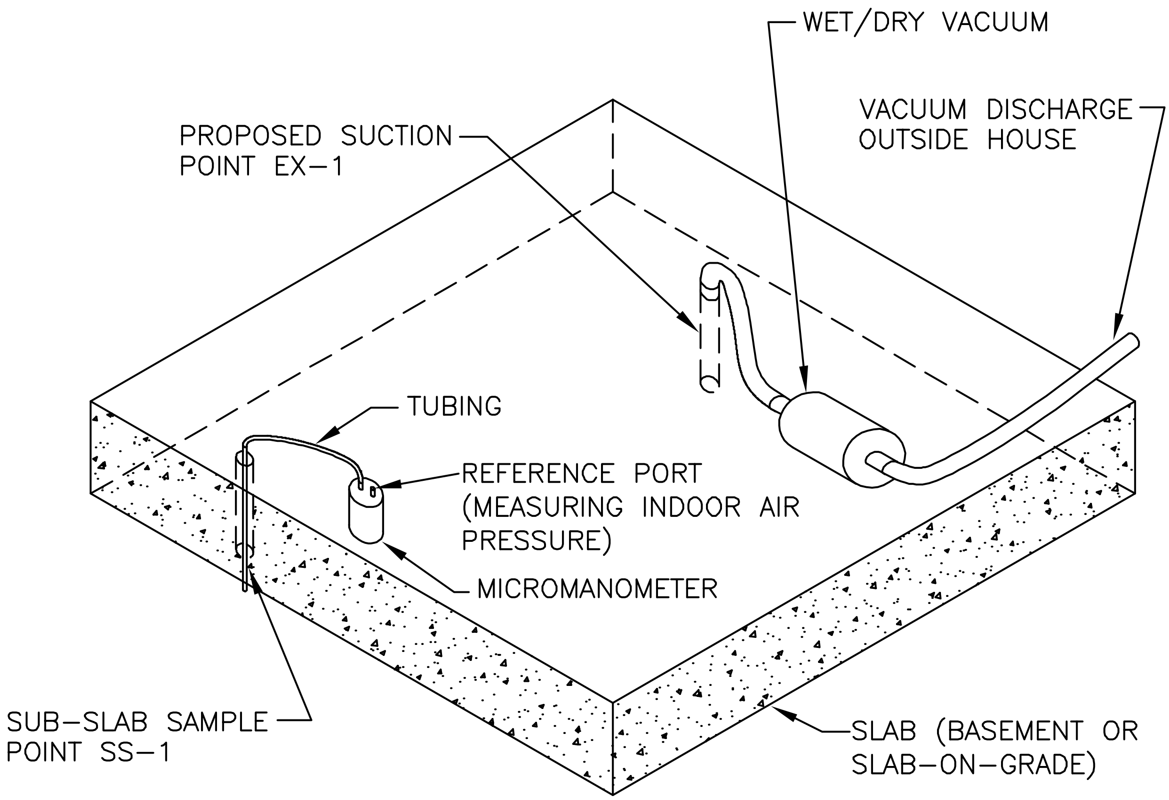



ARCADIS

SOP 23 INSPECTION AND DESIGN FLOW CHART
RACER
MORAINE, OHIO

| Date | Project Manager | Drawing Name |
|---|---|---|
| 8/10/2011 | N. GILLOTTI | SOP 23 Flow Chart |
| Drawn By S. BREWER | Lead Design Prof. R. Saari | Checked C. Grogan |
| Project Number OH000294.2011 | | Figure Number 1 |

CITY:(DUBLIN, OH) DIV/GROUP:(SER2) DB:(R. SMITH) LD:(Opt) PIC:(Opt) PM:(N. GILLOTTI) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF* LAYOUT: FIG 2SAVED: 8/1/2011 3:12 PM ACADVER: 18.0S (LMS TECH) PAGESETUP: ----PLOTSTYLETABLE: ACAD.CTBPLOTTED: 9/7/2011 1:07 PM BY: SMITH, BOB
G:\ENVCAD\Columbus-OH\ACT\OH000294-MOTORS LIQUIDATION COMPANY\racer 2011\RESIDENTIAL-HOMES\comm test sop23.dwg
XREFS: IMAGES: PROJECTNAME: ----




NOT TO SCALE

RACER
MORAINE,OHIO

OH000294.2011

**COMMUNICATION TEST SCHEMATIC SOP 23**

ARCADIS

FIGURE
**2**

ARCADIS
Infrastructure, environment, buildings

Imagine the result

# SOP 24

# Vapor Intrusion Mitigation System Installation

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: May 26, 2011

Revised: September 12, 2011

**Approval Signatures**

Prepared by: Rebecca A Robbennolt Date: May 3, 2011
Rebecca Robbennolt

Reviewed by: ______________________ Date: May 3, 2011
Rachel Saari

Approved by: ______________________ Date: May 6, 2011
Carolyn Grogan

Modified by: ______________________ Date: May 26, 2011
Rachel Saari

Modified by: ______________________________ Date: September 12, 2011

Carolyn Grogan

## I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures to install active vapor mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The active mitigation system should be designed to depressurize the sub-slab, sub-membrane (crawlspace sealed with reinforced, polyethylene sheeting), or inaccessible crawlspace and prevent the entry of soil vapors into the structure. The active mitigation system design is based on the sub-slab depressurization system (SSDS), sub-membrane depressurization system (SMDS), and crawlspace depressurization system (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008), United States Environmental Protection Agency (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), and U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

The following sections list the necessary equipment and materials and provide detailed instructions for the installation of active vapor intrusion mitigation systems for the above mentioned foundation types.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

## II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel are responsible for the coordination of the mitigation system installation with the installation contractor and the oversight of the vapor intrusion mitigation system installation activities. ARCADIS personnel leading the mitigation system installation activities will have previous vapor intrusion mitigation system installation oversight experience.

## III. Health and Safety Considerations

Installation materials and equipment must be carefully handled to minimize the potential for injury. All installation personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. Intrusive methods required for the vapor mitigation system installation (i.e., drilling with a concrete core drilling machine) should be done only by personnel with prior experience of using such equipment. Process pipe installation should be done only by personnel with prior experience and the appropriate training for working at heights. The inline fan shall be wired by a licensed electrician to an independent disconnect switch and to a breaker with sufficient capacity. Installation requirements will be outlined below.

## IV. Equipment and Materials List

The equipment and materials required to install active vapor mitigation systems for structures with each of the three different foundation types: basement, crawlspace, and slab-on-grade, or any combinations of these three are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Concrete core drilling machine
- Extension and step ladders
- Drill
- Hand tools
- Lighting
- Vent piping 3 or 4-inch schedule 40 polyvinyl chloride (PVC) pipe, PVC primer, and PVC cement
- Elbows, couplings, pipe supports, and other fittings
- Sealant (silicone and polyurethane caulk)

- 6-mil polyethylene sheeting or 3-mil cross-laminate polyethylene sheeting (crawlspace)
- Untreated 1-inch by 2-inch wood strips, airtight gaskets and mechanical fasteners
- Perforated polyethylene drain tile (crawlspace)
- Backer rod, expandable foam, non-shrink mortar, grouts, etc.
- Roof flashing
- Intumescent fire stops (fire wall penetrations)
- Drain seals and/or water traps
- In-line fan
- Manometer
- Disconnect switch
- Audible alarm

## V. Procedure

**Active Mitigation System with Basement Foundation Installation (US EPA 625 and ASTM E2121-03)**

The following steps will detail installation of an active mitigation system with a basement foundation for the given project.

1. Confirm gathered Information about the Structure: Review floor map to include rooms, crawlspaces, floor drains, cracks, pipe penetrations, plumbing rough-ins, and other openings requiring sealing. Identify any sump pits, drain tile, block walls, or baseboard drainage (see SOP 23 in this Appendix).
2. Backdrafting Check: Prior to system installation, test all combustion appliances and document pre-existing conditions (see SOP 23 in this Appendix).

3. Sealing Potential Vapor Intrusion Routes: Seal all cracks and openings in the basement walls and/or the floor slab to reduce pathways for vapors to enter the structure. Ventilate the structure during caulking activities to prevent the buildup of vapors as necessary. All surfaces to be sealed will be cleaned prior to applying sealant using a wet/dry vacuum. Wire brush may be necessary to loosen dirt or debris prior to vacuuming. Surfaces must be clean, dry, and free of all dirt debris, oil, and grease prior to sealing. Sealing will be conducted utilizing the following methods.

   a. Cracks/Openings: All cracks greater than a 1/2-inch wide will be filled with closed cell foam backer rod prior to applying sealant. Backer rod should be approximately 25 percent larger than the width of the crack. Backer rods should be installed using a roller or flat sided tool to prevent puncture of the rods during installation. Cracks will be sealed with polyurethane caulk by forcing the caulk into the crack and smoothing at or slightly below the floor/wall surface to create a complete seal to each edge of the crack.

   b. Sumps: Sumps will be sealed by installing solid lids with seals around all protrusions through the lid. Lids will be sealed to the floor using a non-permanent caulking, such as silicone, or through the use of an air-tight gasket and mechanical fasteners to allow the opening of the lid for pump maintenance. A view port may also be included in the lid to enable routing inspection of pump performance without repeated removal of the lid.

   c. Drains: Drains installed through sump lids, through crawlspace liners, or through basement floors (not connected to sewer) will be sealed by installing a drain seal consisting of a one way valve which allows water to drain out, but no air to travel up through them or a trapped drain. If a trapped drain is utilized it should be capable of holding a minimum of 6-inches of standing water to minimize the potential for drying out.

   d. Open Block Wall Cores: They will be sealed by filling the top portion of the cores with expanding foam.

   e. Other openings will be evaluated and sealed using polyethylene sheeting, non-shrink grout, mortar, concrete, or expanding foam.

f. Based on specific construction details of each property, other sealing methods may be required.

4. Confirm the Selection and Spacing of Suction Point: Confirm the selection and spacing of the suction points per the design drawing for the structure. The number and spacing of the suction point is based upon diagnostic testing reflective of the properties of soil underneath the building.

5. Confirm Pipe Routing & Fan Placement: These are determined based on design drawing for the structure. Confirm the exterior facade of the property and termination point location with the design drawing.

6. Installation of Suction Pit: Confirm all known utility lines near the proposed suction pit location. Use a portable coring tool to core through the basement slab. Remove approximately1 cubic foot of soil from below the slab. Insert the 3 or 4”-inch PVC vent piping through the slab and seal the opening with polyurethane caulk.

7. Installation of Pipe: Vent piping (3 or 4-inch, Schedule 40 PVC) will be installed from the suction point through the sill plate of the structure and up the exterior of the structure, or routed through the interior of the structure through the attic to the rooftop discharge location per the design drawings. All joints in the PVC piping will be sealed using PVC cement. All of the piping runs will slope back towards the suction point. Extraction piping designed to run along the exterior of the structure will exit the structure at the level of the floor joists. Sealing will be performed around this penetration through the structure. The exterior run of piping will be attached to the side of the structure using clamps. Penetration through the roof and installation of flashing at this penetration will be performed as necessary. For additional pipe installation requirements refer to ASTM E2121 section 7.3.2.

8. Installation of Inline Fan: The Inline fan will be installed within the vent piping on the exterior of the structure when possible. The fan will be mounted and secured in a manner that minimizes transfer of vibration to the structural framing of the building. The fan will be wired through a local disconnect switch to the structure’s electric panel. A padlock will be installed on the disconnect switch to prevent unintentional shut down of the fan. The associated breaker on the panel will be labeled to indicate it is connected to the fan. For additional fan installation requirements refer to ASTM E2121 section 7.3.3.

9. Installation of Manometer: A manometer will be installed on the vent piping within the basement to confirm on-going system operation within the desired range.

10. If an audible alarm is required, a pressure switch will be installed in the system piping. The switch will be calibrated to alarm if the vacuum within the pipe is outside of the normal operating range.

**Active Mitigation System with Slab-On-Grade Foundation Installation**

Installation procedures for active mitigation systems with slab-on-grade foundations are the same as the procedures for basement foundations with the following exceptions:

1. The suction pit will be installed through the slab and the vent piping (3 or 4-inch, Schedule 40 PVC) will be installed from the suction pit up through the interior of the structure and through the attic to the rooftop discharge location per the design drawings. The in-line fan will be installed within the vent piping inside the attic of the structure.

**Active Mitigation System with Crawlspace/Dirt Floor Foundation Installation**

Installation procedures for active mitigation systems with crawlspace foundations are the same as the procedures for basement foundations with the following exceptions:

1. Accessible crawlspaces will be sealed using reinforced, polyethylene sheeting. Adjacent sheets will be overlapped by one foot and sealed with polyurethane caulking. Sheeting will be sealed to the perimeter of the crawlspace and around any protrusions using polyurethane caulking and tape as necessary. Sheeting will be secured to the crawlspace walls using 1-inch by 2-inch (thick by wide) wood strips (non-treated) and concrete anchors. Where moisture is a concern aluminum strips can be used. Exterior crawlspace walls will be sealed as necessary with polyurethane caulking or by extending the sheeting up the exterior walls and securing at the top. Crawlspace access openings may also be covered to prevent pets or other small animals from entering and damaging the sheeting.

2. For accessible crawlspaces, concrete will also be considered to seal dirt floor areas where significant foot traffic (i.e., daily) is expected. If the dirt floor is only periodically used (weekly or less) plastic sheeting protected with foam padding and plywood will be considered.

3. For accessible crawlspaces, the suction point will be installed under the crawlspace sheeting. The suction point will consist of a tee connected to a perforated polyethylene drain tile. The drain tile will create the necessary collection area and prevent the sheeting from being pulled into the vent pipe.

4. Inaccessible crawlspaces will be sealed by identifying and sealing openings from the crawlspace to the first floor with appropriate materials (e.g., polyurethane caulking, expanding foam, and/or polyethylene sheeting). Cracks within the crawlspace foundation walls will be sealed with polyurethane caulking. Larger openings in the foundation will be sealed with expanding foam or covered with sheet metal, sealed with polyurethane caulk, and anchored to the foundation with screws.

5. For inaccessible crawlspaces, a PVC pipe will be inserted into the crawlspace wall and used as the suction point. A screen will be attached to the end of the pipe to prevent small animals from entering the system. Polyurethane caulk will be used to seal the area where the pipe enters the crawlspace.

## VII. Safety and Health Hazards (ASTM E2121-03 Section 6.0)

ARCADIS will comply with all OSHA, state and local standards or regulations relating to worker safety and occupational exposure while installing vapor intrusion mitigation systems. In addition to OSHA standards and NIOSH recommendations, the following requirements specifically applicable to the safety and protection of mitigation workers while installing vapor intrusion mitigation system will be met.

- ARCADIS or the mitigation system installation subcontractor will advise the workers of the potential hazards of the materials and supplies used, exposure to contaminants, and the importance of protective measures when working in areas of elevated contaminant concentrations.

- ARCADIS or the mitigation system installation subcontractor will ensure that appropriate safety equipment and applicable material safety data sheets are available at the job site during mitigation activities.

- Work areas shall be ventilated as necessary to reduce worker exposure to contaminants, dust, or other airborne pollutants.

- Vapor mitigation work shall not be conducted in any work area suspected of containing friable asbestos-containing material, or where work would render non-friable asbestos-containing material friable, until a determination has been made by a properly trained or certified person that such work will be undertaken in a manner which complies with applicable asbestos regulations, including those of EPA and OSHA.

- Vapor mitigation work shall not be conducted in any work areas with the potential for exposure to mold or other types of infestations or any other conditions determined to cause an unnecessary safety risk until measures have been taken to eliminate these conditions.

## VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

## X. Data Recording and Management (ASTM E2121-03 Section 7.7)

1. The Construction Quality Assurance Manager will complete an As-Built Drawing/Specifications List (attached to this SOP). The construction of the system and details pertaining to the operation of the system will be included in the As-Built Drawing/Specifications List.

2. ARCADIS will provide the property owner with an O&M manual (refer to Appendix F of the Vapor Intrusion Mitigation Work Plan) that includes the following :

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

   b. A description of the proper operating procedures of any mechanical or electrical systems (manometer, in-line fan, etc.) installed, including manufacturer's operation and maintenance instructions.

   c. Contact information to be used if the system failure warning device indicates system degradation or failure or other system maintenance is found to be needed.

d. Contact information for questions about operation of the mitigation system.

## XI. Quality Assurance (ASTM E2121-03 Section 7.6)

Upon installation of active mitigation systems in structures with basement or slab-on-grade foundations, a measurement of a negative pressure below the slab of at least 0.004 inches of water column (in. w.c.) will indicate that the active system is successfully depressurizing the sub-slab area. Measurements will be taken on opposite sides of the foundation from the suction point to ensure the depressurization of the entire slab.

Upon installation of the mitigation system, an ARCADIS team member will verify that the differential pressure measured by the manometer installed on the system piping is within the design range of 1 to 4 in. w.c. They will then mark the operating differential pressure on the manometer and will show the owner how to read the manometer installed on the system piping. If at any time the system is not functioning within the range marked on the monitoring device or the owner notices damage to the system, they will be encouraged to call the phone number listed on the system label. ARCADIS will also provide an O&M manual (refer to Appendix F of the Vapor Intrusion Mitigation Work Plan) to each owner with contact information for any necessary troubleshooting and repairs. All repairs will be made at no cost to the owner.

A post-installation proficiency sampling will be completed approximately 30 days, 180 days, and 360 days after system installation to document that the indoor air (basement, accessible crawlspace, and first floor) is in compliance with the USEPA Regional Screening Levels at a $1 \times 10^{-5}$ risk level (Action Levels). The sampling will be performed in accordance with the Indoor Air and Ambient Air Sampling SOP (SOP 22) included in this Appendix. Property owners will be provided with a letter to notified them of the sampling results and explain that the results are less than or greater than the Action Levels.

If sampling results are not in compliance with the Action Levels, ARCADIS personnel will evaluate the performance of the active mitigation system and complete any necessary system modifications and/or sealing within 30 days of receiving validated sample results. System modifications could consist of replacing the existing fan with a different size fan or the installation of additional suction point(s). Following completion of the system modifications, an additional post-installation proficiency sampling event will be completed within 30 days. Additional quality assurance measures will be outlined in the Operation and Maintenance SOP.

## XII. References

American Society for Testing and Materials (ASTM) Standard E2121. 2003. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

United States Environmental Protection Agency (U.S. EPA), Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches. October 2008.

| ARCADIS | As-Built Documentation | |
|---|---|---|
| | Site Identifier | |

| | | | |
|---|---|---|---|
| **Client** | RACER | **Installation Location** | |
| **Field Personnel** | | **Photo Number(s)** | |
| **Site Location** | Moraine, Ohio | **Date/Time** | |
| **Project Number** | OH000294.2011.00007A | **Contractor** | |

**Vapor Intrusion Mitigation System Inspection and Design Form Date:**

**Vapor Intrusion Mitigation System Inspection and Design Form Attached:** Yes or No

**Design Drawings Attached:** Yes or No

**Design Drawing Deviations**

**Additional Notes/Observations**

**Vapor Intrusion Mitigation System**
**Installation Checklist**

Address Inspected: ______________________ Property ID #: ______________________
Tenant's Name: ______________________ Owner's Name: ______________________
Owner's Address (If Different from Property): ______________________ Make and Model of Fan: ______________________
Inspector's Name: ______________________ Date Installed: ______________________
Date: ______________________
Time: ______________________

| System Pressures | SS- | SS- | SS- | FAN |
|---|---|---|---|---|
| Observed Pressure Field Extension Reading (in w.c.) | | | | |
| Required Pressure Field Extension Reading (in w.c.) | -0.004 | -0.004 | -0.004 | Between 1 and 4 |
| Difference (in w.c.) | | | | |

**1.0 Systems Installation and Interior Piping Requirements**

| | Yes | No | NA |
|---|---|---|---|
| 1.1 Is all system piping Schedule 40 PVC of not less than 3-inch diameter? | ______ | ______ | ______ |
| 1.2 Are all system piping connections permanently sealed? (Exceptions include installation of fan and sump cover) | ______ | ______ | ______ |
| 1.3 Does the system piping avoid attachment to or support from existing pipes, ducts, conduits, or any other kind of equipment? | ______ | ______ | ______ |
| 1.4 Does the system piping avoid blocking windows and doors or access to installed equipment? | ______ | ______ | ______ |
| 1.5 Are supports for system piping installed at least every 6 feet on horizontal runs? | ______ | ______ | ______ |
| 1.6 Are vertical runs secured above or below the points of penetration through floors, ceilings, and roof, and at least every 8 feet? | ______ | ______ | ______ |
| 1.7 Are suction point pipes supported and secured in a permanent manner that prevents their downward movement to the bottom of suction pits? | ______ | ______ | ______ |

## 2.0 General Sealing Requirements

| | Yes | No | NA |
|---|---|---|---|
| 2.1 Is the suction point piping penetration through the slab and/or polyethylene sheeting properly sealed using polyurethane caulk or equivalent? | ______ | ______ | ______ |
| 2.2 Are accessible openings around utility penetrations through the foundation walls and slab, test holes, sub-slab sample points, and any other openings in slabs properly sealed using polyurethane caulk or equivalent? | ______ | ______ | ______ |
| 2.3 Are openings/cracks sealed where the slab meets the foundation wall using polyurethane caulk or equivalent? | ______ | ______ | ______ |
| 2.4 Was backer rod used when sealing cracks greater than ½ inch wide? | ______ | ______ | ______ |
| 2.5 Are drain seals properly installed? | ______ | ______ | ______ |
| 2.6 Is the sump pit installed with an impermeable cover and sealed with O-ring or silicone caulking? | ______ | ______ | ______ |
| 2.7 Are open block cores sealed? | ______ | ______ | ______ |
| 2.8 Is crawlspace sheeting sealed to foundation walls, at overlapping pieces, and at penetrations? | ______ | ______ | ______ |
| 2.9 Is crawlspace sheeting protected from damage? | ______ | ______ | ______ |
| 2.10 Is piping penetration through the siding sealed? | ______ | ______ | ______ |
| 2.11 Is piping centered within roof flashing? | ______ | ______ | ______ |

## 3.0 Electrical Requirements

| | Yes | No | NA |
|---|---|---|---|
| 3.1 Is the power supply to the fan hard-wired with an electrical disconnect within line of sight and within 4 feet of the fan? | ______ | ______ | ______ |
| 3.2 Is the padlock in place on the disconnect switch? | ______ | ______ | ______ |
| 3.3 Is the electrical service panel labeled to indicate the circuit breaker powering the fan? | ______ | ______ | ______ |

## 4.0 Monitors and Labeling Requirements

| | Yes | No | NA |
|---|---|---|---|
| 4.1 Does the suction point have a manometer to measure vacuum? | ______ | ______ | ______ |
| 4.2 Is the manometer clearly marked to indicate the initial pressure reading? | ______ | ______ | ______ |
| 4.3 Is a system description label placed on the mitigation system or other prominent location? | ______ | ______ | ______ |
| 4.4 Is the label legible from a distance of at least 3 feet and does it display the following information: Purpose of the system ("Vapor Intrusion Mitigation"), name, address, and phone number of the contact person? | ______ | ______ | ______ |
| 4.5 Was backdraft testing successfully completed after system installation? | ______ | ______ | ______ |
| 4.6 Is the audible alarm operational? | ______ | ______ | ______ |

## 5.0 System Vent Discharge Point Requirements

| | Yes | No | NA |
|---|---|---|---|
| 5.1 Is the vent pipe discharge vertical and upward, outside the structure, at least 10 feet above ground level, and at least 12 inches above the surface of the roof? | ______ | ______ | ______ |
| 5.2 Is the discharge of the vent pipe 10 feet or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure or any adjacent structure, if the vapor discharge point is not at least 2 feet above the top of such openings? | ______ | ______ | ______ |
| 5.3 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 and within 2 feet of the discharge)? | ______ | ______ | ______ |
| 5.4 Is vent stack piping ID at least as large as the largest used in the manifold piping? Manifold piping to which two or more suction points are connected shall be at least 4 inch ID. (3x4 inch aluminum downspout is an acceptable deviation) | ______ | ______ | ______ |
| 5.5 If metal roof, is piping protected from snow damage? | ______ | ______ | ______ |
| 5.6 Is exterior piping painted to protect from UV damage? | ______ | ______ | ______ |

## 6.0 Fan Installation Requirements

| | Yes | No | NA |
|---|---|---|---|
| 6.1 Is the fan installed in a configuration that avoids condensation buildup in the fan housing? | ______ | ______ | ______ |
| 6.2 If the fan is mounted on the exterior of buildings, is it rated for outdoor use or installed in a weather proof protective housing? | ______ | ______ | ______ |
| 6.3 Does the system operate without unacceptable noise or vibration? | ______ | ______ | ______ |

## 7.0 Design Drawing and As-Built Drawing Requirements

| | Yes | No | NA |
|---|---|---|---|
| 7.1 Was the system installed per all requirements of the property-specific work plan? | ______ | ______ | ______ |
| 7.2 Were deviations from the property-specific work plan documented and approved by the U.S. EPA? | ______ | ______ | ______ |

## 8.0 Notes & Comments (List any deviations from the property-specific work plan.)

## 9.0 Required Corrective Actions

ARCADIS
Infrastructure, environment, buildings

Imagine the result

# SOP 25

# Vapor Intrusion Mitigation System Operation and Maintenance

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: May 27, 2011

Revised: September 12, 2011

**Approval Signatures**

Prepared by: Rebecca A Robbennolt Date: April 26, 2011
Rebecca Robbennolt

Reviewed by: Rachel R. Saari Date: May 3, 2011
Rachel Saari

Approved by: Carolyn Grogan Date: May 6, 2011
Carolyn Grogan

Modified by: Rachel R. Saari Date: May 27, 2011
Rachel Saari

Modified by: Carolyn Grogan Date: September 12, 2011
Carolyn Grogan

## I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures for operation and maintenance (O&M) of active vapor intrusion mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The O&M procedures are based on Sub-Slab Depressurization System (SSDS), Sub-Membrane Depressurization System (SMDS), and Crawlspace Depressurization System (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008); United States Environmental Protection Agency (U.S. EPA) 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993); and U.S. EPA Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010).

The following sections list the necessary equipment and materials and provide O&M instructions for the active vapor intrusion mitigation systems for the above mentioned foundation types.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

## II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel are responsible for the coordination and oversight of the vapor intrusion mitigation system O&M activities. ARCADIS personnel leading the O&M activities will have previous vapor intrusion mitigation system O&M oversight experience.

## III. Health and Safety Considerations

Materials and equipment must be carefully handled to minimize the potential for injury. All O&M personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of potential hazards associated with the job site and the specific O&M.

## IV. Equipment and Materials List

The equipment required for O&M of active vapor intrusion mitigation systems is presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Micromanometer
- Flashlight
- Inspection form (included at the end of this SOP)
- Camera

## V. Procedure

**Annual Operation and Maintenance (US EPA Region 5 Vapor Intrusion Handbook, U.S. EPA 625, and ASTM E2121-03)**

Inspections will be conducted by ARCADIS to ensure that it is functioning properly. The inspections will cover the following items:

1. The manometer reading will be recorded and checked against the operating value recorded at the completion of the system installation to ensure the system is operating in the design range.

2. The sub-slab pressure field extension readings will be recorded at the sub-slab points that were installed during system construction. The recorded values will be compared to the values recorded at the completion of the system installation.

3. The condition of the fan and disconnect switch lock will be recorded.

4. The condition of the system piping, fittings, and pipe supports will be recorded.

5. The condition of the foundation sealing including crawlspace sheeting will be recorded.

6. Confirmation that the system O&M manual is present will be recorded.

7. Any changes to the building structure or areas in need of additional sealing will be recorded.

If any deficiencies are found, corrective actions will be undertaken as soon as possible and at a minimum within 30 days of discovery.

## VII. Safety Considerations

ARCADIS will comply with all OSHA, state, and local standards or regulations relating to worker safety during the O&M of vapor intrusion mitigation systems. All necessary PPE will be worn during annual inspection.

## VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e. tubing) should be collected by field personnel for proper disposal.

## IX. Data Recording and Management (ASTM E2121-03 Section 7.7)

1. ARCADIS will keep records of all mitigation work performed and maintain those records for three years.

2. Health and safety records shall be maintained for a minimum of 20 years.

3. ARCADIS will provide clients with information that includes the following:

    a. Inspection forms

    b. Documentation of corrective actions completed

## X. Quality Assurance

After corrective actions have been implemented, manometer readings and sub-slab pressure field extension readings will be recorded as necessary to document the corrective actions have been successfully implemented.

## XI. References

ASTM Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

**Sub-Slab, Sub-Membrane, and Crawlspace Depressurization Systems - Annual O&M Inspection Form**

Property Identification Number: ____________________

Tenant's Name: ____________________

Owner's Name: ____________________

Owners Address (If Different from Property): ____________________

Temperature (Ambient): ____________________ $^{o}F$

Temperature (House): ____________________ $^{o}F$

Barometric Pressure: ____________________ "Hg

Weather Conditions: ____________________

Inspector Name: ____________________

Date: ____________________

Time: ____________________

**System Inspection**

Is Fan Operating? Yes No NA

Any Unusual Fan Noises? Yes No

Are Vent Piping and Piping Joints Intact? Yes No

Any Caulking Required Around Piping Penetrations? Yes No

Is System Padlock Intact (System ON/OFF Switch)? Yes No NA

Is O&M Manual Present? Yes No

Any Areas In Need of Additional Sealing? Yes No

List Areas to be Sealed: ____________________

List Any Necessary System Repairs: ____________________

**Tenant Observations**

Any Change in Fan Noise or Vibration? Yes No

Have you Turned the Fan OFF for Any Period of Time? Yes No NA

Reason? ____________________

Is Differential Pressure in the Manometer Outside of Normal Operating Range? Yes No NA

Is the System Manometer Steady? Yes No NA

Have You or the Owner Made any Changes to the Basement or Other Foundation? Yes No

Is So, What Were the Changes: ____________________

**Measurements**

| Sample Point ID | Post Install Pressure (in w.c.) | | Inspection | | | | Post Repair (If Necessary) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Date | Time | Pressure (in w.c.) | | Date | Time | Pressure (in w.c.) |
| Manometer | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

Comments (Any Repairs Made While Visiting, etc.): ______________________________

______________________________________________________________________

______________________________________________________________________

**Repairs**

Additional Sealing Completed: ______________________________ Date: __________

System Repairs Completed: ______________________________ Date: __________

Note: The active mitigation system design is based on the sub-slab depressurization system (SSDS), sub-membrane depressurization system (SMDS), and crawlspace depressurization system (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008), United States Environmental Protection Agency (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), and U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

ARCADIS

## Appendix C

Photographs of Mitigation System Components

PHOTOGRAPH 1: Mitigation system fan and discharge. The fan creates a vacuum under the concrete floor slab or crawlspace. The vacuum draws vapors from under your home into a PVC pipe system that is vented above the structure. The fan must be “on” and running 24 hours a day to ensure the system is operating effectively. The vent pipe must be clear of obstructions at all times. This includes caps and covers.


PHOTOGRAPH 2: Manometer (vacuum pressure gauge) to monitor system performance; the “u-tube” will display a reading greater than zero (the system is designed to operate between 1-4 inches of water column) on the side where the small poly tubing is located when the system is operating effectively.

PHOTOGRAPH 3: Extraction point. PVC piping extends through the concrete slab floor or crawl-space liner. PVC pipe extends upward to an overhead piping system routed to an “in-line” fan or turbine used to vent the sub-slab space.

PHOTOGRAPH 4: Overhead extraction piping to exterior fan or turbine. Horizontal piping is installed at a 1% slope back the extraction point. Pipe is supported every 8 feet on vertical piping, every 6 feet on horizontal piping, and near the discharge.

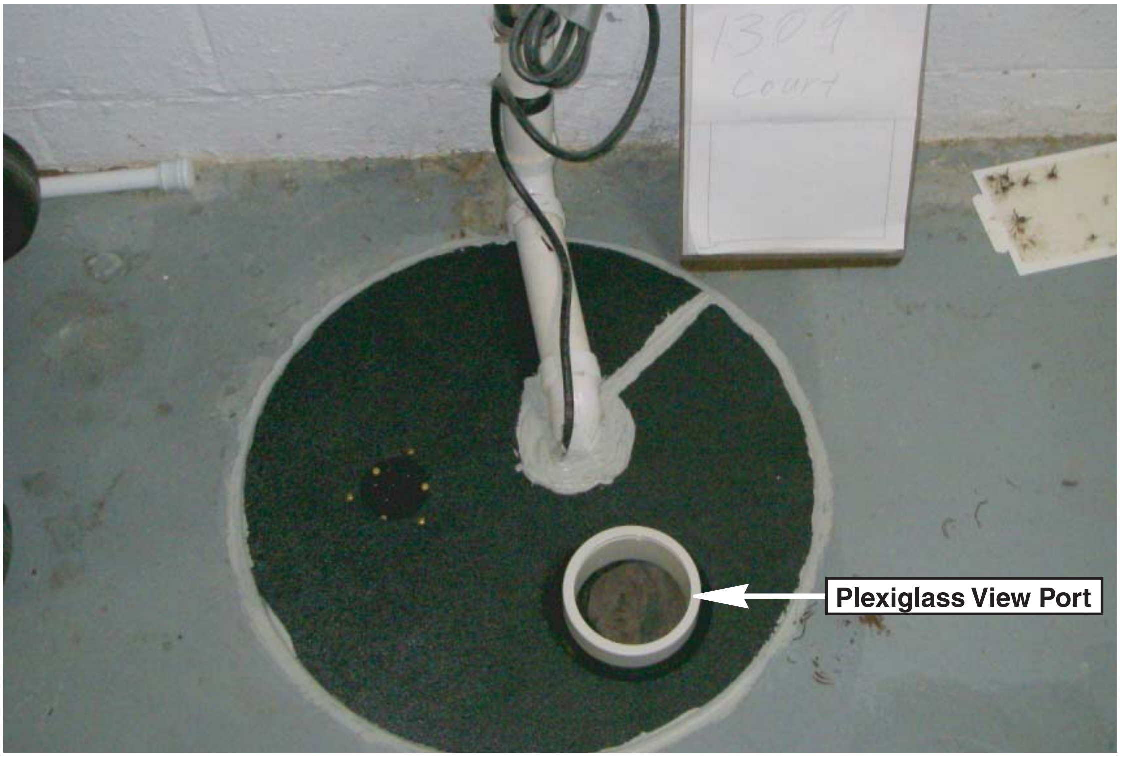
ARCADIS

PHOTOGRAPH 5: Cracks sealed using polyurethane caulk. Any new cracks should be confirmed and sealed during annual inspection or sooner as necessary.

PHOTOGRAPH 6: Liner used to seal damaged wall. Liner should be maintained to ensure vapors are captured by the mitigation system.

ARCADIS

04MAY11\ENVIRONMENT\SS\LMB
COMMON\REBECCA\MORAINE\REV SOPS APRIL 2011\O&M MANUAL\PHOTO PAGE 3.AI




PHOTOGRAPH 7: Sump cover installed and sealed. Lid view port can be used for pump performance inspection without lid removal.

PHOTOGRAPH 8: Crawlspace sealed using polyethylene sheeting. Sheeting is sealed at the perimeter of the crawlspace and around any protrusions. Polyethylene sheeting installed in areas accessible to foot traffic or used for storage are protected using foam padding and untreated plywood.

ARCADIS


PHOTOGRAPH 9: Padlock located on the "on/off" switch located on the exterior of your structure. This system is designed to run in the "on" position at all times to ensure it is effective.

ARCADIS

**Appendix D**

Schematic of Mitigation System Components

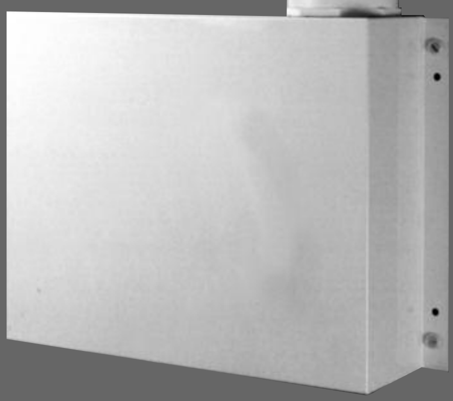
# GP500

## Radon Mitigation Fans

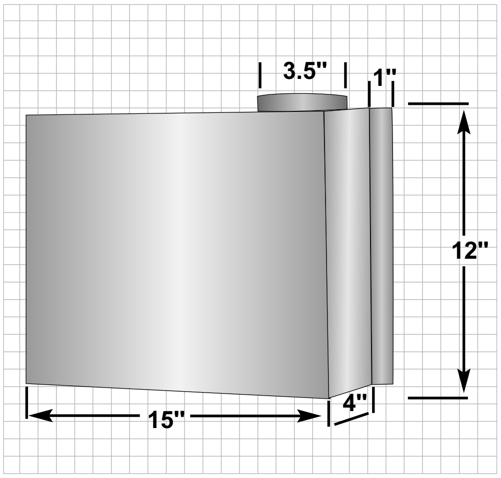
All RadonAway fans are specifically designed for radon mitigation. The GP500 is an attractive alternative to the inline tube fan. The flush mounting of the GP500 protrudes only 4" giving a neat, unobtrusive appearance. The electrical connection is inside the house.

## Features:

- Attractive alternative to inline tube fans
- Very quiet and attractive
- Two-year warranty
- Thermally protected
- High performance
- Non-yellowing finish



| Model | Watts | Max. Pressure "WC | 1.0" | 1.5" | 2.0" | 2.5" | 3.0" | 3.5" | 4.0" |
|---|---|---|---|---|---|---|---|---|---|
| | | | Typical CFM vs. Static Pressure WC | | | | | | |
| GP500 | 70-130 | 4.3 | 88 | 80 | 74 | 65 | 54 | 28 | 14 |




**For Further Information Contact:**

3/08
P/N 02001

# RadonAway

*The World's Leading Radon Fan Manufacturer*

# GP Series

## Radon Mitigation Fans

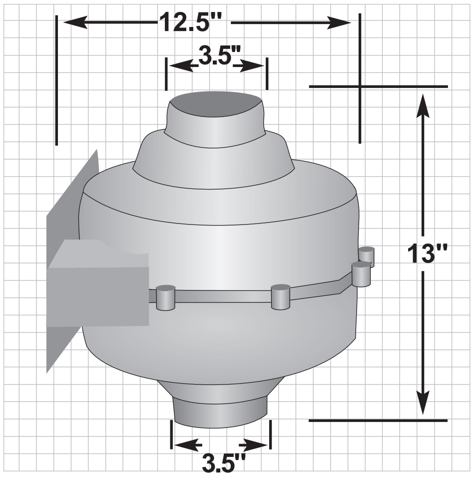
All RadonAway fans are specifically designed for radon mitigation. GP Series Fans provide a wide range of performance that makes them ideal for most sub-slab radon mitigation systems.

## Features:

- Five-year hassle-free warranty
- Mounts on duct pipe or with integral flange
- 3.5" diameter ducts for use with 3" or 4" pipe
- Electrical box for hard wire or plug in
- ETL Listed - for indoor or outdoor use
- Meets all electrical code requirements
- Thermally protected
- Rated for commercial and residential use.

| Model | Watts | Max. Pressure "WC | Typical CFM vs. Static Pressure WC 1.0" | 1.5" | 2.0" | 2.5" | 3.0" | 3.5" | 4.0" |
|---|---|---|---|---|---|---|---|---|---|
| GP201 | 40-60 | 2.0 | 82 | 58 | 5 | - | - | - | - |
| GP301 | 55-90 | 2.6 | 92 | 77 | 45 | 10 | - | - | - |
| GP401 | 60-110 | 3.4 | 93 | 82 | 60 | 40 | 15 | - | - |
| GP501 | 70-140 | 4.2 | 95 | 87 | 80 | 70 | 57 | 30 | 10 |

Choice of model is dependent on building characteristics including sub-slab materials and should be made by a radon professional.




**For Further Information Contact:**

10/08
P/N 02002

ARCADIS

## Appendix E

Property-Specific Work Plan Template

**<u>Property-Specific Work Plan for [insert address or ID number]</u>**

### Introduction

ARCADIS on behalf of Revitalizing Auto Communities Environmental Response Trust (RACER) is proposing to install a mitigation system at [insert address or ID number] based on the results from testing at the subject property on [insert date]. The installation will be conducted per the approved Vapor Intrusion Mitigation Work Plan dated June 3, 2011 and revised on [insert date] and the property-specific design information provided below. This Property-Specific Work Plan (PSWP) has been submitted to the U.S. EPA and was approved on [insert date]. The inspection of the home was completed by ARCADIS and Environmental Doctor (State of Ohio Department of Health licensed Radon Mitigation Contractor/Specialist) personnel per the Inspection and Vapor Intrusion Mitigation Design Standard Operating Procedure (SOP 23) on [insert date]. The design and inspection form is presented in Attachment 1.

### Mitigation System Design

The building is a [insert building-specific information]. The active mitigation system for this property will consist of the following [example information provided below]:

- The mitigation system for this property will include a combination sub-slab depressurization system (SSDS) for the basement and a sub-membrane depressurization system (SMDS) for the crawlspace or dirt floor.
- Two suction points will be installed, one under each of the two foundations. A sub-slab suction pit will be installed through the basement slab. A suction point consisting of perforated polyethylene flex drain will be installed in the crawlspace or dirt floor below the membrane consisting of 6-mil reinforced polyethylene sheeting (see Figures 1 and 2).
- Four-inch Schedule 40 polyvinyl chloride (PVC) vent piping will be installed from the sub-slab suction point and crawlspace or dirt floor suction point and piped to a single discharge point located approximately 12 inches above the roof line of the home. The piping leg leading to the crawlspace or dirt floor suction point will contain a valve or damper to balance the air flow. The vent piping will be routed through the interior of the house to the attic, where the fan and disconnect switch will be installed. The piping will penetrate the roof and terminate approximately 12-inches above the roofline (see Figures 1 and 2).
- A U-tube manometer will be installed in the system piping extending up from the basement sub-slab suction point (see Figure 2).
- A label with contact information will be placed on the vent piping near the manometer.
- An audible alarm will be installed on the system piping adjacent to the U-tube manometer (see Figure 2).
- The Operation and Maintenance (O&M) Manual will be attached to the system piping and will include a key for the disconnect switch, which will be locked in the on position.
- The appropriate breaker in the home's electric panel will be labeled as powering the mitigation system fan.
- Permanent sub-slab sample points will be installed during mitigation system installation for future monitoring of sub-slab depressurization.
- The exterior system piping will be sprayed with white Krylon Fusion for aesthetics and UV protection and may be painted to match the exterior of the home based on the preference of the property owner.

See Figures 1 and 2 for drawings of the system configuration.  Minor modifications to this property-specific work plan may be necessary during system installation and all modifications will be discussed with the property owner, RACER, radon contractor, and ARCADIS National Environmental Health Association National Radon Proficiency Program (NEHA NRPP) certified radon mitigator before completion. Modifications made to the PSWP will be noted in the as-built diagram provided in the Operation & Maintenance (O&M) Manual that will be provided to the property owner and the U.S. EPA within 10 business days of mitigation system installation.

**Sealing**

Cracks in the basement foundation will be sealed with polyurethane caulk.  Sheeting will be sealed to the crawlspace walls with polyurethane caulking, 1-inch by 2-inch wood strips, and concrete anchors.  A sump lid will be installed and sealed.  A drain seal will be installed in the basement floor drain, which leads to the sump.  Cracks in the basement floor slab and basement ledge will be sealed with polyurethane caulking.  The basement sub-slab suction point and vent piping will be sealed with polyurethane caulk where exiting the suction pit and where piped through the wall of the home.  See Figure 1 for the location of areas to be sealed.

**Backdraft Testing**

A backdraft test was completed during the initial design visit on the furnace and water heater and the property passed. The results were reported to the property owner.  The windows in the home were closed during testing.  Chemical smoke was applied at the flue of the furnace and water heater.  The smoke traveled up the flue of each appliance, indicating a passing test. Upon system completion, both appliances will be tested again to verify that they are continuing to draft properly.

If a backdraft test failure is noted at any time during the mitigation design or installation process, the contractor will be assigned to diagnose the cause of the backdraft test failure. If the backdraft test failure is associated with appliance venting, the mitigation contractor will correct the problem and the appliance will be re-tested.  If the backdraft test failure is associated with the appliance malfunctioning, the property owner will be asked to repair or replace the appliance prior to mitigation system operation.  Mitigation systems can be installed at homes with backdraft failures; however, the mitigation system will be locked in the off position and should not be operated until the backdraft condition has been remedied.

**Communication Test/Fan Selection**

Communication testing was completed using the permanent sub-slab sample point and temporary sub-slab sample points at the locations indicated on Figure 1 and following procedures outlined in SOP 23. Vacuum readings exceeding negative 0.004 inches water column were recorded at the permanent sub-slab sample points during both communication tests indicating the communication test was successful, as required in the Vapor Intrusion Mitigation Work Plan.  Based on the results of the communication testing, the RadonAway GP-501 fan, or equivalent, was selected for installation of this system.  Fan information is included in Attachment 3.

**Property Owner Requests**

The owner signed the mitigation access agreement for the system installation on [insert date] (Attachment 4). The homeowner preferred that the vent piping exit the east side of the house. This request was incorporated into the system design.

**Post-Installation Proficiency Sampling**

Post-installation proficiency sampling of indoor air (first floor, basement, and accessible crawlspace) samples will be collected approximately 30 days, 180 days, and 360 days after system installation to document that the indoor air is in compliance with the Action Levels. The property owner will be provided with a letter to notify them of the sampling results and an explanation if results are less than or greater than or equal to the Action Levels.

If the post-installation proficiency sampling results are not below the Action Levels, ARCADIS personnel will evaluate the performance of the mitigation system and complete any necessary system modifications and/or sealing within 30 days of receiving validated sample results. System modifications could consist of replacing the existing fan with a different size fan or the installation of additional suction point(s). For the sub-membrane depressurization system, potential system modifications may include installing sub-slab sample points for implementing pressure field extension readings. Following completion of the system modifications, an additional post-installation proficiency sampling event will be conducted for indoor air (first floor, basement, and accessible crawlspaces) within 30 days.

**Operation and Maintenance (O&M)**

An annual inspection will be conducted by ARCADIS to inspect the mitigation system and ensure that it is functioning properly. Two inspections will be conducted in the first year and the systems will be inspected annually thereafter. The following items will be inspected and recorded on an Inspection Form.

- The manometer reading will be checked to ensure the system is operating in the design range.
- Sub-slab pressure field extension readings will be measured at the permanent sub-slab sample points to ensure sub-slab depressurization of negative 0.004 in. w.c.
- The fan will be checked for unusual noise or vibration.
- The vent piping will be checked for any damage.
- The pipe supports will be checked to ensure they are secure.
- The accessible crawlspaces or other areas sealed with reinforced, polyethylene sheeting will be inspected for damage.
- The foundation sealing and sealing around system piping penetrations will be checked for any additional areas requiring sealing.
- The presence of the padlock on the disconnect switch will be checked.
- The presence of the O&M Manual at the residence will be checked.

Repairs to the mitigation system or additional sealing will be conducted at no cost to the property owner.

A payment will be issued annually to reimburse the property owner for the cost of operating the electric powered fan. The mitigation fans are designed to minimize energy usage, and the cost to operate the fan will be calculated by ARCADIS using local electric rates and the fan wattage.

**Schedule**

The property owner will be contacted to schedule the installation upon receipt of U.S. EPA approval of this work plan.

**Work Plan Attachments:**

Figure 1. Basement/Crawlspace Layout

Figure 2. Active Mitigation System Installation Details – Basement/Crawlspace

Attachment 1. Vapor Intrusion Mitigation System Inspection and Design Form [Note: Not included in this template]

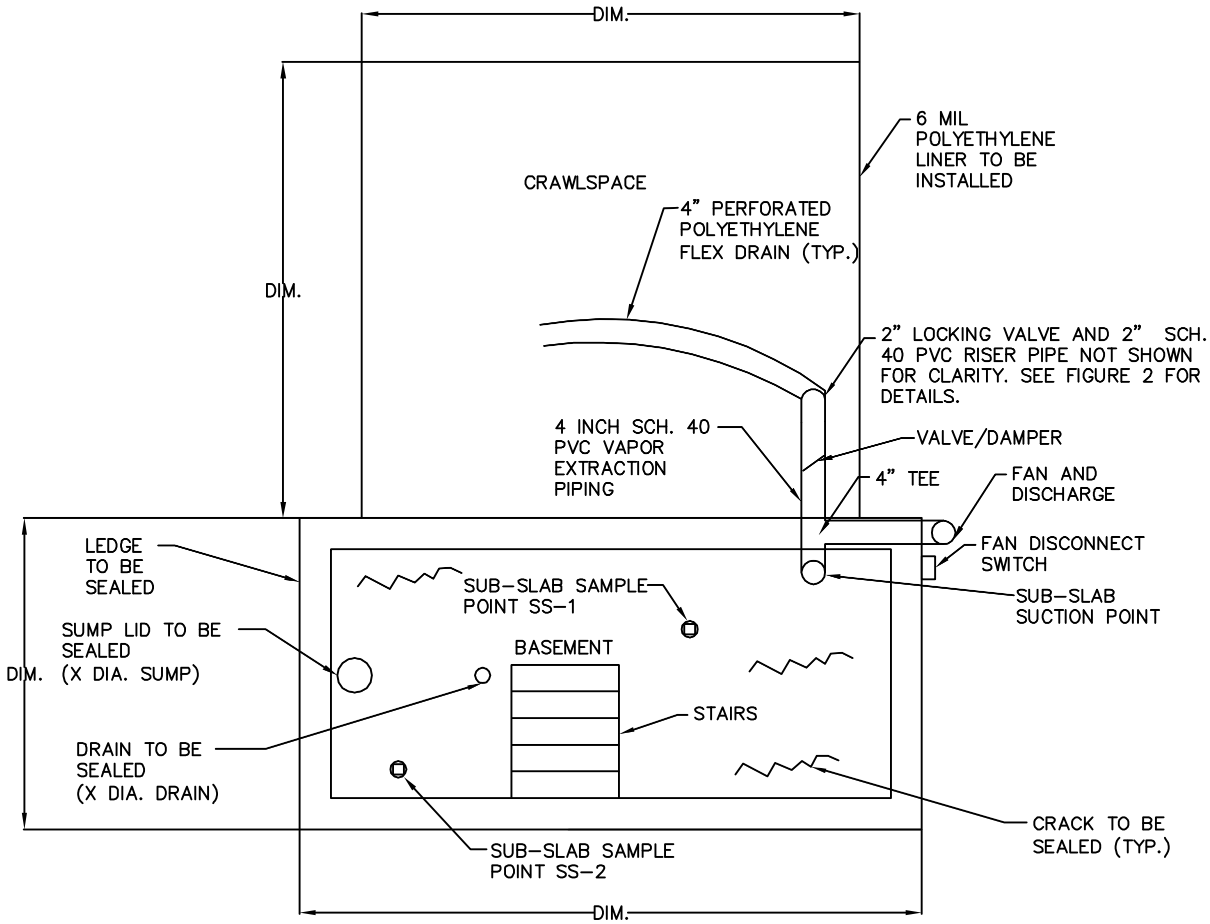
Attachment 2. Material Safety Data Sheets [Note: Not included in this template]

Attachment 3. Mitigation System Components [Note: Not included in this template]

Attachment 4. Access Agreement for Design, Installation, Operation and Maintenance of the Vapor Intrusion Mitigation System [Note: Not included in this template]

NOTES:

1. CRACKS IN BASEMENT/FOUNDATION TO BE SEALED.
2. CRAWLSPACE WILL BE SEALED WITH POLYETHYLENE SHEETING.
3. DIMENSIONS ARE APPROXIMATE.




<u>LEGEND</u>

| | |
|---|---|
| SCH. | SCHEDULE |
| DIA. | DIAMETER |
| DIM. | DIMENSION |

NORTH
NOT TO SCALE

RACER
MORAINE,OHIO

OH000294.2011

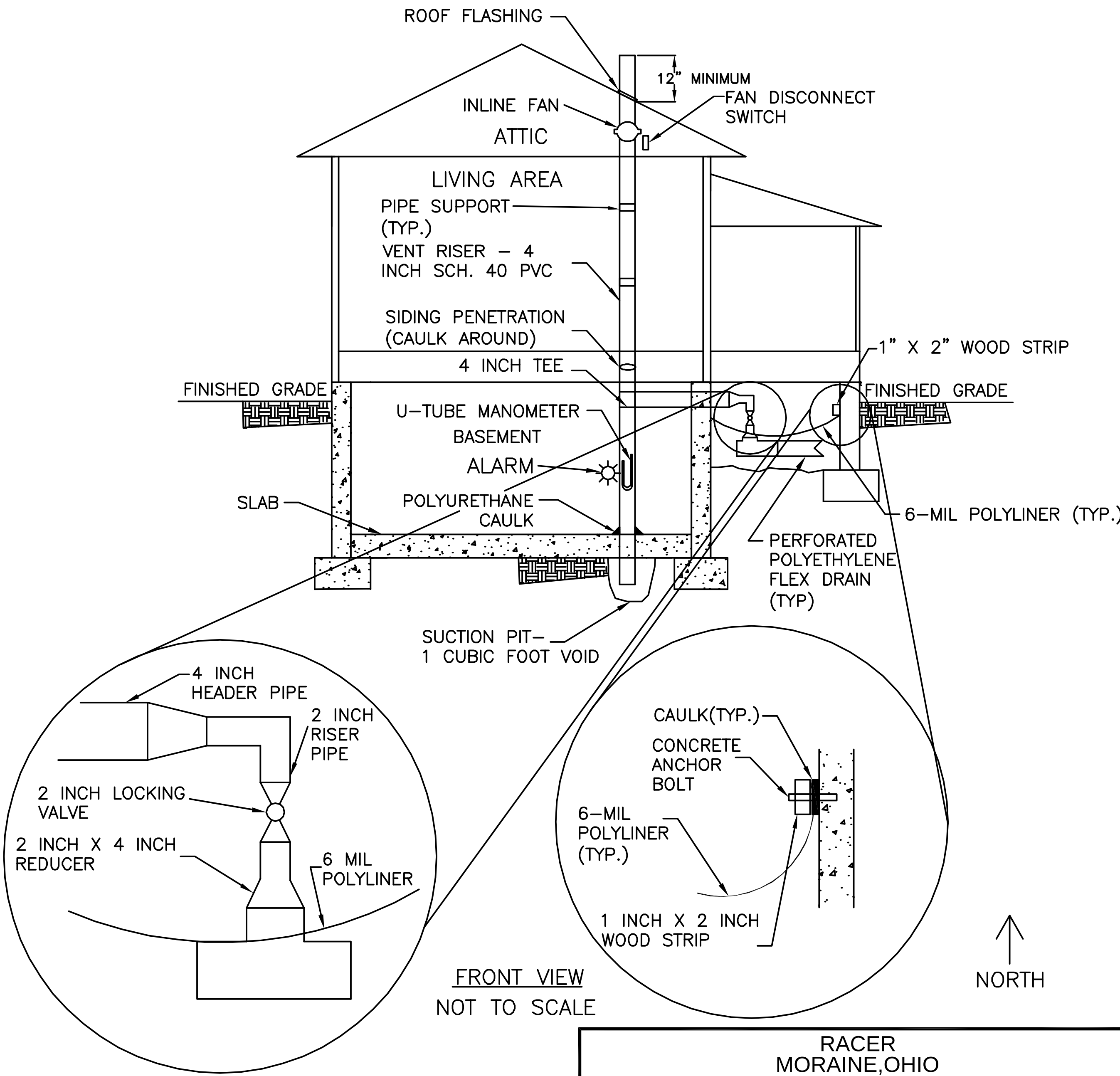
**BASEMENT/ CRAWLSPACE LAYOUT**
**PROPERTY ADDRESS**

ARCADIS

FIGURE
**1**

NOTES:

1. VENT RISER WILL TERMINATE A MINIMUM OF 12 INCHES ABOVE ROOF ELEVATION AND A MINIMUM OF 10 FEET FROM ANY AIR INTAKE LOCATED HORIZONTALLY ADJACENT TO OR ABOVE THE TERMINATION POINT.
2. HORIZONTAL PIPE RUNS SHALL BE SLOPED BACK TOWARDS THE SUCTION POINT AT MINIMUM 1% SLOPE.
3. INSTALL PIPE SUPPORTS NEAR DISCHARGE, EVERY 8 FEET ON VERTICAL PIPING, AND EVERY 6 FEET ON HORIZONTAL PIPING AT A MINIMUM.
4. CRACKS IN BASEMENT/FOUNDATION TO BE SEALED.
5. DIMENSIONS ARE APPROXIMATE.




FRONT VIEW

NOT TO SCALE

RACER
MORAINE,OHIO

OH000294.2011

**ACTIVE MITIGATION SYSTEM INSTALLATION DETAILS - BASEMENT/CRAWLSPACE PROPERTY ADDRESS**

ARCADIS

FIGURE
**2**

ARCADIS

## Appendix F

Operation and Maintenance (O&M) Manual

XXX XX, 2011

[RESIDENT MAILING INFORMATION]

RE: Operation and Maintenance (O&M) Manual
[ADDRESS], Moraine, Ohio 45439

Dear [NAME]:

The Revitalizing Auto Communities Environmental Response Trust (RACER) appreciates your cooperation with the installation of an active vapor mitigation system at your home. On [DATE], 2011, [NAME OF CONTRACTOR], an approved contractor under the supervision of ARCADIS personnel, on behalf of RACER, completed the installation of an active vapor mitigation system at your home, located at [ADDRESS] in Moraine, Ohio. RACER completed this work in cooperation with the United States Environmental Protection Agency (U.S. EPA) and in association with the on-going environmental cleanup activities at the former General Motors facilities in Moraine, Ohio.

The following attachments make up the O&M Manual specific to your property: a copy of the signed access agreement, a copy of the sample results letter, a copy of confirmation sample results letter, photos of each component of your mitigation system, mitigation system as-built drawings, Material Safety Data Sheets (MSDSs) for the products used during system installation, the fan warranty information, the manufacturer's instructions, a copy of the initial O&M inspection form, a copy of the annual O&M inspection form, contact information for any questions you may have regarding the vapor mitigation system, and a form that should be signed to acknowledge your receipt of the O&M Manual. In addition, enclosed with this manual is a key for the padlock on the fan disconnect switch. To confirm vapor mitigation system performance, two inspections will be conducted in the first year and the system will be inspected annually thereafter.

We greatly appreciate your participation in this program. If you have any questions concerning this matter, please do not hesitate to contact me at XXX-XXXX-XXXX. You may also contact Mark Case or Thomas Hut of Public Health – Dayton & Montgomery County at 937-225-4362 if you have concerns about the sampling results.

Sincerely,

ARCADIS

cc: L. Marshall, Ohio EPA
P. Barnett, RACER
M. Cápiro, U.S. EPA

Attachments:
Copy of Signed Access Agreement
Copy of Sample Results Letter
Copy of Confirmation Sample Results Letter
Photos of the Active Mitigation System
Mitigation System As-Built Drawings (Layout and Installation Details)
MSDSs
Fan Warranty Information
Manufacturer's Instructions
Initial O&M Inspection Form
Annual O&M Inspection Form
Contact Information
O&M Manual Receipt Form

**Appendix G**

Construction Quality Assurance Plan (CQAP)

ARCADIS

Infrastructure · Water · Environment · Buildings

Imagine the result

# Construction Quality Assurance Plan

## RACER

Former Delphi Harrison Thermal Systems Moraine Plant
Former General Motors Powertrain Group, Moraine Engine Plant
Former General Motors Truck Group, Moraine Assembly Plant

Moraine, Ohio

**May 6, 2011**
**Revised June 3, 2011**
**Revised September 7, 2011**

ARCADIS

## Table of Contents

## Figures

# 1. Introduction

## 1.1 Background

In coordination with the United States Environmental Protection Agency (U.S. EPA), Revitalizing Auto Communities Environmental Response Trust (RACER), formerly Motors Liquidation Company (MLC) is completing sub-slab and indoor air sampling in the Riverview Plat neighborhood located southwest of the Moraine Site (Site). The sub-slab soil-gas, ambient air, and indoor air (first floor, basement, and crawlspace) sampling program was outlined in the Revised Sub-Slab and Indoor Air Sampling Work Plan submitted to the U.S. EPA on March 4, 2011. The sampling of all properties where access has been granted in the Riverview Plat neighborhood began on March 7, 2011 and is on-going as of the date of this document. Upon receipt of the final laboratory reports and completion of data validation, the data will be compared to the indoor air and sub-slab action levels for residential and commercial scenarios. Based on the data, it will be determined if a vapor intrusion mitigation system is necessary for each property. This Construction Quality Assurance Plan (CQAP) has been prepared as an appendix to the Vapor Intrusion (VI) Mitigation Work Plan for the properties that require mitigation. VI mitigation will include active sub-slab depressurization systems (SSDS), sub-membrane depressurization systems (SMDS), and crawlspace depressurization systems (CSDS).

## 1.2 Quality Control and Quality Assurance & CQAP Definitions

Quality Assurance (QA) and Quality Control (QC) are defined as follows:

- QA – A planned and systematic pattern of means and actions designed to provide confidence that materials or services meet contractual and regulatory requirements. QA is typically performed to assure RACER and/or the Regulatory Oversight Agency that delivered materials or services are of desired quality.

- QC – Those actions that provide a means to measure and regulate the characteristics of a material or service to meet contractual and regulatory requirements. QC is typically performed by or for the provider of materials or services as a control mechanism on the quality of the provider's efforts.

In the context of this CQAP, the terms are further defined as:

- Construction quality assurance (CQA) refers to the means and actions employed by the Project Manager to confirm conformity of the systems' installation with this CQAP, drawings, and specifications. This activity begins prior to construction, continues throughout construction, and ends with acceptance of the installation. CQA is provided under the oversight of the Project Manager.

- Construction quality control (CQC) refers to those actions taken by the manufacturer, fabricator, or Contractor to provide materials and workmanship that meet the requirements of this CQAP, drawings, and specifications. CQC may include inspections, verifications, audits, and evaluation of materials and workmanship necessary to determine and document quality of the construction. CQA is performed independently of CQC.

### 1.3 Purpose

This CQAP intends to provide a quality assurance protocol to be implemented that will ensure that construction of VI mitigation systems meet or exceed a certain level of quality and workmanship as defined in the construction drawings and technical specifications detailed in the VI Mitigation Work Plan. This CQAP will address quality during the following phases of construction:

- Pre-construction Activities,

- VI Mitigation System Installation, and

- Post-construction Activities.

The construction guidelines of the CQAP shall be followed to monitor and document the quality of materials used and the conditions and manner of their placement. The CQAP will also serve to detect deviations from the construction drawings or technical specifications caused by error or negligence on the part of the Contractor, and allow for suitable corrective measures to be taken. Finally, by adhering to the plan, the Contractor and the Engineer can address and resolve design problems during the construction phase of the project.

## 2. Roles and Responsibilities

The successful completion of the installation of VI mitigation systems depends upon the interaction of many qualified parties. An organizational flow chart of the parties involved in the CQA/CQC of the VI mitigation systems may be found on Figure 1, attached to this document. Definitions and responsibilities of the parties involved are provided below.

### 2.1 Oversight Personnel

#### 2.1.1 Regulatory Oversight Agency

The Regulatory Oversight Agency may provide on-site monitoring and observation of construction activities and CQA measures. Representatives from the Regulatory Oversight Agency may participate in project meetings and be provided with the results and data of CQA. The Regulatory Oversight Agency will be informed of field decisions that were made based on the necessity to deviate from the approved design. The Regulatory Oversight Agency has the responsibility to review, and either approve or reject design revisions or variance requests during the VI mitigation system construction.

For the purposes of this document, the Regulatory Oversight Agency is the U.S. EPA and/or the Ohio EPA.

#### 2.1.2 RACER

RACER is funding the activities pertaining to the installation of VI mitigation systems by ARCADIS. RACER will be responsible for communication with the property owners and the U.S. EPA.

#### 2.1.3 ARCADIS

ARCADIS is the environmental engineering consultant responsible for the CQA and CQC of the construction process for the installation of VI mitigation systems. ARCADIS is the official on-site representative of the RACER and will supervise field activities, review Contractor submittals, recommend and approve design or field modifications should they be necessary, and document the various phases of construction. In this capacity, ARCADIS will be knowledgeable of the construction drawings and technical specifications governing the remediation of the Site.

ARCADIS is responsible for organization and ensuring implementation of this CQAP. ARCADIS will inform RACER and the Regulatory Oversight Agency of deviations from the construction drawings and technical specifications and will provide the certifications required during the various phases of the project. Responsibility for construction deficiencies shall lie with the Contractor, not ARCADIS. ARCADIS will be familiar with general construction techniques, regulatory requirements, and the CQAP.

#### *2.1.3.1 Project Manager*

The ARCADIS Project Manager (Nancy Gillotti) maintains overall responsibility for carrying out the provisions of this CQAP. The Project Manager is responsible for verifying that VI mitigation system construction activities are completed in accordance with this CQAP, and all components of the construction are consistent with the approved property-specific work plan. The Project Manager may perform periodic inspections to confirm the CQA program's compliance with this CQAP. The Project Manager will rely on the Construction Manager and field personnel to confirm that this CQAP is implemented correctly and that the Contractor has provided the required submittals; the Contractor is in compliance with this CQAP, drawings, and specifications; and that CQA field tasks are performed, such as material inspection. The Project Manager will be informed of items that do not conform to the drawings, specifications, and this CQAP and will be directly involved in resolving these issues.

The Project Manager will be supported by the Construction Manager. The Project Manager may delegate work to the Construction Manager, but will be responsible for any delegated work. The Project Manager is the prime contact with RACER and the U.S. EPA for the Contractor, Construction Management Staff, and CQA Staff.

#### *2.1.3.2 Construction Manager*

The ARCADIS Construction Manager (personnel to be determined) has overall responsibility for all aspects of the project, including the implementation of CQA activities. The Construction Manager shall provide the design review and final approval for all property-specific work plans. The Construction Manager will be a National Environmental Health Association National Radon Proficiency Program (NEHA NRPP) certified radon mitigator. The Construction Manager shall also provide support to the field personnel should any discrepancies arise during CQA.

As such, the Construction Manager will:

- Confirm that CQA procedures are completed in accordance with this CQAP; and
- Verify Contractor qualifications and assist the CQA Manager in coordinating Contractor activities.

The Construction Manager will be supported by the Construction Field Coordinator. The Construction Manager may delegate work to the Construction Field Coordinator, but will be responsible for any delegated work.

##### *2.1.3.3 Project Health and Safety Manager*

The ARCADIS Project Health and Safety Manager (personnel to be determined) has overall responsibility for the health and safety aspects of the VI mitigation system installation, including review and approval of the Health and Safety Plan (HASP). Modifications to CQA procedures should be reviewed with the Project Health and Safety Manager prior to implementation to confirm that adequate health and safety measures are employed. Inquiries regarding health and safety procedures for construction activities or CQA activities should be addressed to the Project Health and Safety Manager. The Project Health and Safety Manager must approve changes or addenda to the HASP. The Project Health and Safety Manager is not expected to be on site daily but will be supported by a CQA Manager and Field Technicians. The Project Health and Safety Manager may delegate work to the CQA Manager, but will be responsible for any delegated work.

##### *2.1.3.4 Construction Field Coordinator*

The ARCADIS Construction Field Coordinator (personnel to be determined) shall provide the field construction itinerary to all Field Site Personnel including the CQA Manager, Field Technicians, and Contractors. The Construction Field Coordinator will also provide office activity support to the Field Site Personnel. The Construction Field Coordinator may delegate work to the CQA Manager, but will be responsible for any delegated work.

## 2.2 ARCADIS Field Site Personnel

### 2.2.1 CQA Manager

The ARCADIS CQA Manager (personnel to be determined) has overall responsibility for construction aspects of the installation of VI mitigation systems, including the facilitation of CQA activities. The CQA Manager reports to the Construction Manager and Construction Field Coordinator. The CQA Manager will:

- Manage daily construction activities;
- Prepare the daily construction report;
- Maintain contact with the Project Health and Safety Manager;
- Coordinate Contractor activities and verify Contractor qualifications; and
- Coordinate and schedule support personnel for construction oversight tasks at the Site.

The CQA Manager will be supported by a Field Technician. The CQA Manager may delegate work to the Field Technician but is responsible for any delegated work.

#### 2.2.2 Field Technicians

Field Technicians are the adjunct persons to the CQA Manager. Field Technicians are responsible for seeing that the CQC and CQA procedures are adhered to during all field activities.

### 2.3 Contractors

Contractors will complete construction activities at the Site, including mobilizations, site preparation, and installation of VI mitigation systems all of which are in accordance with the property-specific work plan, as directed by ARCADIS. Contractors must perform the VI installation in accordance with the property-specific work plan, complete timely submittal of all documentation, facilitate the completion of CQA activities, notify the construction manager of issues related to CQA, participate in project meetings and planning, and comply with this CQAP. The Contractor will have a site specific HASP and/or will acknowledge that they will follow the HASP prepared for the Site by ARCADIS.

### 2.4 Property Owner

The Property Owner (or Home Owner) may or may not occupy the home in which the VI mitigation system is being installed. The Property Owner may, if they choose, provide preferences in the location of the VI mitigation system, which will be incorporated to the extent possible into the property-specific work plan. The Property Owner's signed acknowledgement of the property-specific work plan and signed access agreement will be required prior to system installation.

## 3. Quality Assurance/Quality Control Meetings and Documentation

Routine meetings will be conducted between the Contractor, ARCADIS CQA Manager, ARCADIS Construction Manager, and Regulatory Oversight Agency (if available) to discuss and review the construction activities, work schedule, and potential changes in construction activities or construction products. The results of these discussions and follow-up actions will be included in meeting minutes and/or outlined in daily construction reports.

### 3.1 Project Meetings

To maintain clear and open channels of communication through construction, specific project meetings will be held regularly. These meetings are detailed below.

#### 3.1.1 Pre-Construction Construction Quality Assurance Meeting

A pre-construction CQA meeting will be held prior to commencing construction activities to confirm that concerns can be adequately addressed prior to construction. This meeting will include the Contractors, Construction Manager, CQA Manager, Construction Field Coordinator, and the Project Health and Safety Manager.

The purpose of the pre-construction CQA meeting is to coordinate the completion of CQA activities, discuss potential problems that might cause quality issues and delays in construction, and discuss the roles and responsibilities for CQA activities. It is important that the rules regarding testing and repair be known and accepted by each party.

Specific topics considered for the pre-construction CQA meeting may include the following:

- Review the responsibilities of each party;
- Review lines of authority and communication;
- Review critical design details for the installation of VI mitigation systems, including the property-specific work plan;
- Review project schedule;

- Review CQA activities;
- Review methods for documenting and reporting, and for distribution of documentation and reports;
- Review any modifications to this CQAP that may be necessary;
- Review and develop appropriate Job Loss Analyses (JLAs) relating to the construction process; and
- Review work area security.

Meeting minutes will be recorded and transmitted to the parties in attendance.

#### 3.1.2 Weekly Progress Meeting

A weekly progress meeting will be held at the Site. The purpose of the weekly progress meeting is to discuss construction activities and CQA activities. At a minimum, the weekly progress meeting will be attended by the Contractors, CQA Manager, and Field Technicians. Attendance of the weekly progress meeting by telephone is acceptable. Topics to be discussed at the weekly progress meeting may include:

- Review the previous week's construction activities;
- Review the work activity and locations for the coming week;
- Review the work schedule;
- Discuss weekly assignments for the construction personnel and equipment;
- Discuss status of CQA activities;
- Discuss potential problems;
- Review construction documentation requirements; and
- Discuss health and safety, and recognize potential hazards in upcoming work.

The CQA Manager will coordinate the weekly progress meeting; develop and circulate a weekly meeting agenda; prepare weekly meeting minutes and distribute to RACER, the Regulatory Oversight Agency, Project Manager, Project Health and Safety Manager, Construction Field Coordinator, and Construction Manager.

#### 3.1.3 Daily Work Meeting/Tailgate Meeting

Daily work meetings/Tailgate meetings will be held at the beginning of each work day at the Site. If VI mitigation system installation activities at multiple homes in one day are anticipated, the variances between homes and construction activities proposed for those homes will be considered during the daily meetings. The purpose of the daily work meeting is to discuss construction activities and CQA activities. At a minimum, the daily work meetings will be attended by the Field Technicians and Contractors. Topics to be discussed at the daily work meetings may include:

- Discuss the previous day's construction activities;
- Review the construction activities for the current day;
- Review CQA activities for the current day; and
- Review health and safety-related requirements/issues per the HASP.

The Field Technician will coordinate the daily work meetings.

#### 3.1.4 Request for Information

In the case of any discrepancies discovered in the proposed VI mitigation system or during inspection of the VI mitigation system by the CQA Manager and/or Field Technician, the Contractor may issue, in writing, a request for information (RFI). Any request by the Contractor for substitution/change from the approved VI mitigation system design shall be accompanied by appropriate literature and justification for said substitution/change. The CQA Manager is responsible for reviewing, filing, and responding to any RFI initiated by the Contractor. The CQA Manager may request input from the Certified Mitigator/Construction Manager in responding to any RFI initiated by the Contractor.

## 4. Quality Control Plan

The Construction Manager will implement a CQA/CQC procedure which will include pre-installation, installation, and post-installation phases. The usage of the three phase system is necessary to ensure that system designs supplied by ARCADIS are being adhered to by the Contractors and their activities during installation. This will ensure proper system construction and performance for the best possible functionality of the VI mitigation system.

### 4.1 Contractor Selection

Several Contractors will be considered for installation of VI mitigation systems. It is the responsibility of ARCADIS and RACER to select the Contractor. The following considerations will be evaluated when selecting a Contractor:

1) Safety Record - Contractors will be required to submit a safety record prior to being considered for use on the project. The record must contain information for the past 3 years of operation. Contractors will be required to submit a summary of their training, policies, and reporting of safety.

2) Experience - Contractors will be required to provide photos of systems their company has installed, worker resumes, a summary of applicable experience, and types/number of systems installed in the past 3 years. Contractors must also have sufficient manpower to complete the installation process in a safe and efficient time frame.

3) Price - Contractors must submit a proposal that is competitive for labor and materials for installation of VI mitigation systems.

### 4.2 Pre-Installation Phase

The property-specific work plan for each property shall be finalized and approved by the U.S. EPA and the Property Owner.

#### 4.2.1 Pre-Construction CQA Meeting

Prior to commencing field activities, ARCADIS will meet with the selected Contractor to review this plan and the design information for clarity. The review will address design criteria, and the property-specific work plan. If any information is deemed unclear, the appropriate documentation will be returned to ARCADIS for clarification or modification. A recommended agenda with specific topics for the pre-construction meeting includes the following:

1. Introductions
2. Tour Home or Building to be Mitigated
3. Review Documents and Procedures
    A. Property-Specific Work Plan
    B. CQA Requirements
    C. Health and Safety Plan
4. Define Lines of Communication
    A. Lines of Communication
    B. Progress Meetings
    C. Procedures for Approving Design Clarifications and Changes During Installation
5. Review Site Requirements
    A. Safety Rules
    B. Site Rules
    C. Work Schedule
    D. Storage of Materials
    E. Available Facilities
    F. Contractor Submittals

6. Discuss Construction Issues

   A. Property-Specific Work Plan

   B. Construction Procedures

      1) Proposed Construction Sequencing

      2) Equipment

      3) Construction Waste Management

   C. Construction Schedule

#### 4.3 Installation Phase

The Installation Phase of the Quality Control Plan ensures that oversight of the construction activities is being done by either the CQA Manager or Field Technician, which are reported back to the appropriate ARCADIS personnel. The Installation Phase of the Quality Control Plan will be repeated for each VI mitigation system installation. As part of the Installation Phase of the Quality Control Plan, there are certain construction aspects which must be addressed:

- Review of safety procedures and JLAs to ensure compliance with the HASP;
- Inspection of the area where the VI mitigation system is to be installed;
- A materials check to ensure all materials to be used, including tools and hardware to be used, meet the requirements of the property-specific work plan;
- Oversight of the Contractor to ensure the level of workmanship meets acceptable standards and the systems are being installed to the property-specific work plan. The oversight may include adherence to the work plan of the following system installation components (if applicable):
  - Suction points
  - Vent piping and securing of piping
  - In-line fan

- Manometer audible alarm, unless the property owner objects to installation of the alarm
- Disconnect switch and wiring
- Sealing
- Roof flashing

- Communication with the Contractors as needed related to safety talking-points that may arise during installation; and

- Improvements or deviations to the finalized property-specific work plan shall be communicated during this phase to all ARCADIS personnel, RACER and the U.S. EPA before implementation/communications with the Contractor.

Since each residence or structure is unique in its construction, configuration, and age; it is necessary to consider each residence separately with respect to the design of VI mitigation system design. Therefore, as stated in the VI Mitigation Work Plan, a property-specific work plan will be created and implemented at each property. However if the need for any deviations arises during construction, the VI Mitigation Work Plan will be adhered to.

#### 4.4 Post-Installation Phase

Following the successful installation of the VI mitigation system, ARCADIS will inspect the construction of the system and operation thereof. If there is a need for corrective actions, it will be done as soon as possible by the Contractor. If necessary, the following corrective actions may be taken:

- As-Is – Observed nonconformance does not adversely affect construction or operation;

- Fix – Observed nonconformance requires minor repairs or modifications to enable proper system operation;

- Modify – Disassembly or additional actions are required; and

- Refuse – The system or work is unacceptable. Additional actions must be taken by the Contractor to remove/revamp the system or work to meet specifications.

All nonconformance issues shall be documented and communicated to the Construction Manager and Construction Field Coordinator.

#### 4.5 Proficiency Sampling

Proficiency sampling will be done within approximately 30, 180, and 360 days after installation of VI mitigation systems and again five years after the 360 day sampling. If post-installation proficiency sampling indicates concentrations of chemicals of concern are above the action levels, mitigation system modifications may be required. Procedures for proficiency sampling of indoor air will be completed in accordance with the VI Mitigation Work Plan. Indoor air (first floor, basement, and accessible crawlspace) samples will be collected for confirmation that the VI mitigation system is functioning as intended.

When active mitigation systems are installed in homes with basement or slab-on-grade foundations, one to two sub-slab sample points will be installed for collection of sub-slab pressure field extension measurements.  A measurement of a negative pressure below the slab of 0.004 inches of water column will indicate that the active system is successfully depressurizing the sub-slab area.  Sample points will be located on opposite sides of the foundation from the suction point to ensure the depressurization of the entire slab.  Sample points will remain in place for measurements to be taken within 30 days of system installation and during annual inspections.

Documentation of the proficiency sampling will be in accordance with the VI Mitigation Work Plan.

#### 4.6 System Operation and Maintenance (O&M)

An annual inspection will be conducted by ARCADIS to inspect the active mitigation systems and ensure that they are functioning properly. Two inspections will be conducted in the first year and the systems will be inspected annually thereafter. The following items will be inspected and recorded on the Inspection Form included in the O&M SOP (SOP 25) in Appendix B of the VI Mitigation Work Plan.

- The manometer reading will be checked to ensure the system is operating in the design range.

- Sub-slab pressure field extension readings will be measured at the sub-slab pressure points to ensure sub-slab depressurization of negative 0.004 in w.c.

- The fan will be checked for unusual noise or vibration.
- The vent piping will be checked for any damage.
- The pipe supports will be checked to ensure they are secure.
- Crawlspaces or other areas sealed with reinforced, polyethylene sheeting will be inspected for damage.
- The foundation sealing and sealing around system piping penetrations will be checked for any additional areas requiring sealing.
- The presence of the padlock on the disconnect switch will be checked.
- The presence of the O&M Manual at the residence will be checked.

# 5. Documentation

## 5.1 Field Documentation

All activities in the field pertaining to construction, installation, and O&M of VI mitigation systems shall be recorded and documented.

## 5.2 Construction Quality Assurance Documentation

Upon completion of the work, CQA documentation will be included in the Operation and Maintenance (O&M) Manual. The property owner and the U.S. EPA will receive an O&M Manual for each system installed. The documentation shall summarize the activities of the project, and document aspects of construction and installation of VI mitigation systems.

The CQA documentation shall include the following information:

- Parties and personnel involved with the project;
- Scope of work;
- Outline of project;
- Quality assurance methods;
- Test results (conformance, destructive and non-destructive, including laboratory data); and
- Design drawings.

The Contractor shall document in a report that the installation activities proceeded in accordance with the CQA Plan except as noted in that report.

## 6. References

ARCADIS, Inc., 2011. Revised Sub-Slab and Indoor Air Sampling Work Plan, Motors Liquidation Company, Moraine, Ohio. March 4, 2011.

ARCADIS

Figure 1: Organizational Flow Chart, RACER, Moraine, Ohio.