DELAWARE DEPARTMENT OF
NATURAL RESOURCES AND
ENVIRONMENTAL CONTROL

Division of Waste and Hazardous Substances
Remediation Section
https://de.gov/remediation
302-395-2600

STANDARD OPERATING PROCEDURE
SUB-SLAB AIR SAMPLING (SOIL-GAS)
April 2023

GENERAL PROVISIONS:

The Department of Natural Resources and Environmental Control – Remediation Section (DNREC-RS) has created this standard operating procedure (SOP) as a default procedure to be followed for sub-slab air sampling. Any deviation from this procedure will require prior written DNREC-RS approval.

EQUIPMENT LIST:

1) Pre-cleaned and individually certified summa canister*
2) Tape measure
3) ¼" (0.64cm) ID Teflon-lined polyethylene tubing. *Confirm appropriate size tubing for O_2 meter connection for Short-Circuiting Test.*
4) 3/8 "diameter hose barb fitting with ¼" tip or Vapor Pin™ (Procedure A)
5) 3/8" Outer Diameter (OD) Stainless Steel tubing (Procedure B)
6) Tight fitting plastic caps for hose barb or stainless-steel tubing
7) 100% Liquid silicone
8) Oxygen (0_2) meter
9) Bucket Shroud-see Attachment 1
10) Helium tank or QA/QC gas
11) Helium meter or device capable of detecting QA/QC gas
12) Concrete drill with 5/8" and 1½ " diameter bits
13) Cement grout
14) Bentonite
15) Manual vacuum pump with pressure gauge
16) Electric vacuum pump
17) Tedlar-type bag
18) Sampling form

* DNREC recommends, but does not require, that the summa canister be pre-cleaned and individually certified.

PREPARATIONS FOR SUB-SLAB AIR SAMPLING:

a) Order Summa® canisters from the laboratory for 24-hour sample time for residential and commercial exposure scenarios.
b) Personnel collecting the samples will avoid using permanent markers or wearing perfume or cologne.
c) Deactivate HVAC systems in advance of sampling to determine natural migration of sub-slab air more accurately into the building.
d) Select sampling locations.
   - Collect sub-slab samples as close to the center of the slab as possible. Recent research has demonstrated that higher concentrations of contaminants may exist closer to the center of the slab than at the edges of the slab (EPA 2015). Air samples should be collected from an adequate number of locations to assess potential exposure of building occupants to volatile chemicals from a sub-surface source. If also sampling indoor air, the indoor air sample(s) should be co-located with sub-slab samples for ease of comparison.
   - In non-residential buildings, samples should be collected during normally occupied periods to be representative of typical exposure.
   - In special circumstances it may be necessary to collect air samples at other times in order to minimize disruptions to normal building activities.
   - Sample collection intakes should be located to approximate the breathing zone for building occupants (typically three feet above the floor level where occupants are normally seated or sleep). Breathing zone level may vary depending on building use and should be modified accordingly for sampling.
   - Sampling personnel should avoid lingering in the immediate area of the sampling device while samples are being collected to avoid undue influence from sampling.
   - Longer duration sampling periods may be appropriate depending on the goals of the investigation.
   - The summa canister should be used within 24 hours of shipment to avoid cross-contamination. Canister can be stored longer with DNREC-RS' permission. Record the vacuum pressure in each summa canister. The value recorded must be within $\pm$ 2 psi of the value recorded by the lab prior to shipment in order to be used for sampling (EPA, 1992).

SAMPLING PROCEDURE

Procedure A – Preferred method for use in occupied buildings. Sample probe is installed to minimize trip hazards and aesthetic concerns.

1) Use a concrete drill to drill a 5/8" diameter hole through the slab.

2) Measure the thickness of the slab.

3) Drill halfway through the slab with the 1 ½" diameter drill bit.

4) Use drill bit to penetrate through any sub-slab material (1" or 2.5 cm) to create an open cavity in order to prevent potential obstruction of probes during sampling.

5) Clean the inside of the holes with a damp cloth thoroughly to promote a good seal during cement application.

6)

7) Install the hose barb into the lower 5/8" diameter hole. A Vapor Pin™ may also be used.

8) Seal the annular space with cement grout **unless a Vapor Pin™ is used**.

*Note - Sampling will not take place until a minimum of 24 hours after grout has been applied.

9) Short-Circuiting Test- In order to confirm proper construction of the vapor point, the following procedure should be followed:

a) Connect tubing to the vapor point.

b) Connect vacuum pump with pressure gauge to the tubing and purge for 5 minutes.

c) Remove vacuum pump.

d) Connect O_2 meter and monitor the air being drawn out of the ground. The oxygen level (O_2) in the tubing must remain more than 2 percent less than atmospheric conditions (20.8%), or 18.8%. If levels do not stabilize at 18.8%, or less, then short-circuiting is occurring, and the vapor point will have to be resealed or possibly re-installed $_2$ or less, then short-circuiting is occurring, and the vapor point will have to be resealed or possibly re-installed

.

10) To conduct the QA/QC testing and sampling, first connect the hose barb to a length of Teflon-lined polyethylene tubing short enough to fit within a five- gallon bucket and connect the tubing to the hose barb on the top inside of the bucket. When not conducting QA/QC tests or sampling, ensure that the hose barb or stainless-steel tubing is capped.

11) Attachment 2 is a diagram of the QA/QC testing equipment. Complete QA/QC test as described in Attachment 3. QA/QC testing must be repeated until it passes all the tests.

12) Prior to completing the sampling, personnel will fill in the appropriate sections of the Sampling Form (Attachment 4) noting pertinent weather conditions, vacuum present in the canister when the sampling began, whether it passed QA/QC testing, etc.

13) To purge vapor point air, a vacuum pump with pressure gauge, limited to less than 0.2 liter per minute, will be connected to the tubing which is connected to the horizontal ball valve and purge for 5 minutes.

14) At the completion of the purge period, the horizontal ball valve will be turned to the off position and the pump disconnected.

15) Open the Summa® canister sample valve.

16) Shut off the canister while vacuum is still present.

* Note the remaining vacuum from the vacuum gauge on the sampling form. Summa canisters length of actual sample collection time must be within 10% of the required sampling time interval in order to be considered a valid sample and have a minimum of 1 in of vacuum remaining in the canister (Eurofins). For example, 22 hours for a 24-hour sample. Please contact DNREC as soon as possible regarding any sampling issues to discuss the data usability.

Procedure B – Alternate method of installation for use in unoccupied buildings or where trip hazards and aesthetics are not a concern.

1) Use a concrete drill to drill a 5/8" diameter hole into the slab.

2) Use drill bit to penetrate through the sub-slab material (1" or 2.5 cm) and create an open cavity in order to prevent potential obstruction of probes during sampling.

3) Clean the inside of the hole with a damp cloth thoroughly to promote a good seal during cement application.

4) Install 3/8 '' (0.64cm) outer diameter (OD) stainless steel tubing into the 5/8 " diameter hole extending 1"(2.5cm) below the concrete slab and 3-4" above the slab.

5) Seal the annular space with cement grout. *Note - Sampling will not take place until a minimum of 24 hours after grout has been applied.

6) Short-Circuiting Test- In order to confirm proper construction of the vapor point, the following procedure should be followed:

   a) Connect tubing to the vapor point.

   b) Connect vacuum pump with pressure gauge to the tubing and purge 5 minutes. Remove vacuum pump.

   c) Connect O_2 meter and monitor the air being drawn out of the ground. The oxygen level (O_2) in the tubing must remain more than 2 percent less than atmospheric conditions (20.8%), or 18.8%. If levels do not stabilize at 18.8% O_2 or less, then short-circuiting is occurring, and the vapor point will have to be resealed or possibly re-installed.

7) To conduct the QA/QC testing and sampling, first connect the stainless-steel tubing to a length of Teflon-lined polyethylene tubing short enough to fit within a five-gallon bucket and connect the tubing to the hose barb on the top inside of the bucket. When not conducting QA/QC tests or sampling, ensure that the hose barb or stainless-steel tubing is capped.

8) Attachment 2 is a diagram of the QA/QC testing equipment. Complete QA/QC test as described in Attachment 3. QA/QC testing must be repeated until it passes all the tests.

9) Prior to completing the sampling, personnel will complete a sampling form by filling in the appropriate sections (Attachment 4) noting pertinent weather conditions, vacuum present in the canister when the sampling began, whether it passed QA/QC testing, etc.

10) To purge vapor point air, a vacuum pump with pressure gauge, limited to less than 0.2 liter per minute, will be connected to the tubing which is connected to the horizontal ball valve and purged for 5 minutes.

11) At the completion of the purge period, the horizontal ball valve will be turned to the off position and the pump disconnected.

12) Open the Summa® canister sample valve.

13) Shut off the canister while vacuum is still present.

* Note the remaining vacuum from the vacuum gauge on the sampling form. Summa canisters length of actual sample collection time must be within 10% of the required sampling time interval in order to be considered a valid sample and have a minimum of 1 in of vacuum remaining in the canister (Eurofins). For example, 22 hours for a 24-hour sample. Please contact DNREC as soon as possible regarding any sampling issues to discuss the data usability.

APPLICABILITY:

This procedure applies to the collection of any samples on sites under the jurisdiction of the Hazardous Substance Cleanup Act (HSCA).

REFERENCES

EPA 2015. June 2015 Final OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air.

Eurofins. Guide to Air Sampling and Analysis, Section 3.2.4.

April 3, 2015. Vapor Pin Standard Operating Procedures Installation and Extraction of Vapor Pins.

Attachment 1- Bucket Shroud Construction

EQUIPMENT LIST

1 – Food-grade 5 gal plastic bucket
3 – ¼“ Male Pipe Thread (MPT) X 3/8” diameter hose barb with ¼” tip 3- ¼” MPT x ¼” MPT nipples
2 – ¼” –turn ball valves, ¼” Female pipe thread (FPT) both ends 1 – ¼” x ¼” x ¼” FPT Tee fitting
3 – 1.5” fender washers to stabilize fittings as they pass through

CONSTRUCTION

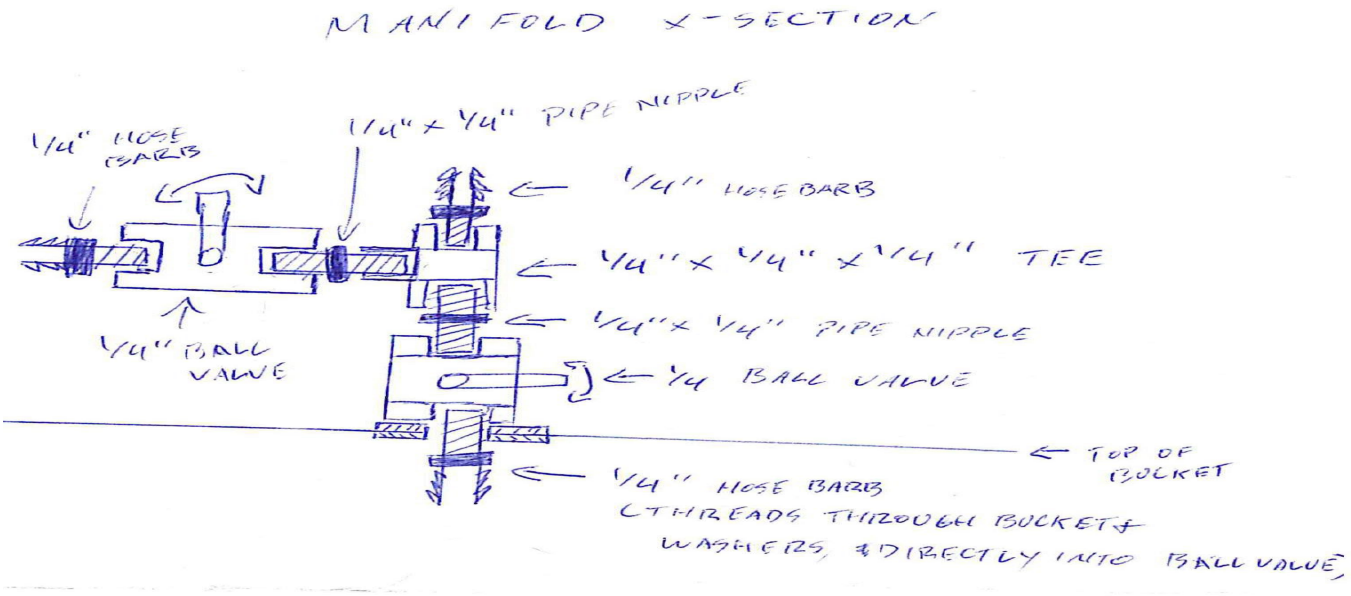
a. Drill three holes in a plastic five-gallon bucket on sides (one higher and one lower) and one on top. This is the bucket shroud. The holes need to be sufficiently large to accommodate the hose barbs in Step b.

b. Place a 3/8 “diameter male-thread Hose barb fitting with ¼” tip in each of the side holes. Place a 1.5” washer on inside and outside of the side holes. Seal with silicon caulking (100%-no VOCs). The lower port will be used for Leak-Testing and the upper port for attaching the tracer gas.

c. Place tubing onto the outside tracer gas ports.

d. Thread a ¼’ hose barb with a male thread through a 1.5” washer, the top hole in the bucket, another washer, and finally thread into the vertical ball valve. Tighten this fitting and apply silicone sealant to the washers. Assemble the remainder of the manifold as shown on the diagram below.

e. Seal all threaded connections with Teflon tape, soap all connections and pressure test. Seal any leaks.



Attachment 2

Attachment 3- QA/QC Steps

1) Conduct a Quality Assurance/Quality Control (QA/QC) test of the equipment. The vapor point must pass the QA/QC test in order to collect the samples in the canisters. Please review the *October 2006 New York State Department of Health, "Guidance for Evaluating Soil Vapor Intrusion", pages 26-28* for additional guidance on conducting QA/QC procedures. See Attachment 1 for an illustration of the QA/QC Procedures.

2) Helium or propylene may be used as a tracer gas.

3) The QA/QC set-up is as follows:

   a. Hook up the tubing from the PVC cap on the top of the vapor point to the brass hose barb tubing at the top of the inside of the bucket.

   b. Connect Teflon-lined tubing between the top of the stainless-steel manifold and the summa canister. This is known as the "sample train."

   c. Seal the bucket to the ground with bentonite.

   d. Connect the tracer gas meter to the tracer gas relief port on the side of the bucket shroud using Teflon-lined tubing.

   e. Connect tracer gas tank to a tracer gas fill port on the side of the bucket shroud using Teflon-lined tubing and then fill the bucket with tracer gas.

   f. Measure the tracer gas concentration with a meter capable of detecting the tracer gas. Note the concentration. This represents the concentration in the bucket.

   g. Remove the tracer gas meter and crimp or place a plastic cap on the end of the tubing.

   h. The concentration measured from the ball valve should be less than 10% of concentration measured from the tracer gas relief port. This indicates a good seal.

   i. If it is greater than 10%, recheck all fittings and seal fitting on the vapor point until it meets this 10% rule.

   j. Shut-in Test: Close the ball valve (located directly above the bucket) while attaching a vacuum pump with a pressure gauge to the horizontal ball valve with Teflon- lined tubing. Open the horizontal ball valve and using the vacuum pump lower the pressure within the sample train to -7" Hg (NJDEP, 2013). If after 5 minutes there is less than +2 psig change in the vacuum, then proceed with the sampling otherwise tighten fittings until this is achieved.

Attachment 4~ DNREC~RS Sampling Form

DNREC RS Vapor Intrusion Policy
Field Sampling Form

(Attach Sample Map)

Project #: _____ Sample
Project Name: _____
Sampled By: _____
Date Sampled: _____ Time: _____

General Site Conditions:

Atmospheric Data:

_____ Source of Data
_____ Precipitation during sampling
_____ Amount of Precipitation
_____ Barometric Press.(Outside/Inside))
_____ Temp(Outside/Inside)
_____ Wind Speed
_____ Wind Direction

Sampling System (check one)

( ) Whole-Air active approach (summa)
( ) Whole-Air passive approach
( ) Sorbed contaminants-active approach
( ) Sorbed contaminants-passive approach
( ) Headspace or extraction approach
( ) soil pore liquid headspace approach ( ) Sample Replicate

_____ _____

System Purge Volume (0.086 L/ft) * Depth (ft): _____ Volumes Purged (3): ( ) Sample Volume

Sorbent Device: Installed: _ Date/time
Recovered _ Date/time

Sample Container Type: _____ Sample Container #: _____

Analytical Method: _____(Chain of Custody Attached)

Analyzer Result:

Surface cover: _____ Concrete Thickness: _____

Condition Of Concrete Floor near Sample: _____

Sample Depth: Sampling rate: _____

Soil Composition:
- Clay _____%
- Soil Organic matter _____%
- Fine Granular Material _____%
- Coarse Granular Material _____%

Moisture Content: _____

Other characteristics:
- _____ free water present
- _____ Free product
- _____ contaminant odors
- _____ indurated
- _____ soil discoloration
- _____ probable connection to surface macropores

QA/QC Testing Results

Note- Each vapor point must pass all the QA\QC Tests below before sampling. Reseal and Retest until the vapor point passes the test.

Test #1A- Short Circuit Test
Oxygen reading in % O_2 : _____ Did the vapor points pass the test (<=18.8%): Y/N (circle one)

Notes: _____
Test #1B- Short Circuit Test
Oxygen reading in % O_2 : _____ Did the vapor points pass the test (<=18.8%): Y/N (circle one)

Notes: _____

Test #2- Helium Test (Please see Attachment 3- Active Soil Gas or Sub-Slab Air Sampling SOP for details)
Test #2A- Helium Concentration within the Shroud: _____
Helium Concentration within tubing: _____
Did the vapor points pass the test (tubing<10% of the shroud): Y/N (circle one)

Test #2B- Helium Concentration within the Shroud: _____ Helium Concentration within tubing: _____

Did the vapor points pass the test (tubing<10% of the shroud): Y/N (circle one)

Notes: _____

Test #3- Shut-in Test (Please see Attachment 3- Active Soil Gas or Sub-Slab Air Sampling SOP for details)

Test 3A# Pass Shut in test by maintaining -7 in. Hg in tubing from the shroud to the summa canister for 5 minutes: Y/N (circle one)

Notes: _____

Test 3B# Pass Shut in test by maintaining -7 in. Hg in tubing from the shroud to the summa canister for 5 minutes: Y/N (circle one)

Notes: _____

Test 3C# Pass Shut in test by maintaining -7 in. Hg in tubing from the shroud to the summa canister for 5 minutes: Y/N (circle one)

Notes: _____

Sampling Information

Laboratory: _____

Sample #	**Floor**	**Room**	**Canister / Tube #**	**Pump ID #** (if applicable)	**Sample Start** Date / Time	**Sample End** Date / Time

Sample location(s):

Provide Drawing of Sample Location(s) in Building

Sample #_____- _____

Did the occupants not follow any of the "Instructions for Residents" directions? *Yes / No*

If so, describe modifications: _____

General Observations

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

INDOOR AIR
BUILDING SURVEY

Survey Completed By: _____ Date: _____

Site Name: _____ DE#: _____

Part 1 Occupants

Building Address: _____

Property Contact: _____

Owner/Renter/Other: _____

Contact Phone: Home: _____ Cell: _____

Contact Email: _____

Building Occupants:

Children under age 13: _____ Children 13-18: _____

Adults: _____

Special Health Concerns:

_____ Respiratory _____ Cardiovascular _____ Partially Able

_____ Home Bound _____ Other (please specify)

Allergies: ____ Yes ____ No Other (Describe):_____

Part II Building Characteristics

Building Type:

____ Single Family Residential ____ Trailer or mobile _____ Office

____ Multi-family residential ____ Duplex _____ Row Home

____ Apartment ____ Strip Mall _____ Commercial

____ Industrial ____ Other (specify)

Describe Building:

Age: _____

Construction: _____Frame _____Masonry _____Steel

_____Other (Specify) _____

Type of Insulation: _____

Type of Roof: _____

General Condition and Air Tightness: _____

Fireplace or Chimney: _____ Last Service Date: _____

Number of Floors-below grade: _____

_____ Full Basement _____ Crawl Space _____ Slab

Number of Floors-at- or above ground? _____

Number of Rooms: _____ Do the Windows Open? _____

Basement Size: _____ft²

Basement Floor: _____Concrete _____Dirt _____Floating _____Other (Specify)

Foundation Type: _____Poured Concrete _____Cinder blocks (Hollow?) _____Stone

_____Other (Specify) _____

Type of ground cover around outside of building:

_____grass _____concrete _____asphalt _____other(specify):

Is there vegetation? _____ Does it appear stressed? _____

French Drain? _____ Flooding experienced? _____

Floor Drains present? _____ If yes, is a trap present? _____

Is there water in the trap? _____

Connected to a: _____ Sanitary Sewer _____Storm Sewer

_____Septic System _____Surface Discharge _____unknown

Basement Sump Present? _____ Sump Pump? _____

Type of heating system (Check all that apply)

_____hot air circulation _____hot air radiation _____Wood

____Steam Radiation _____Hot water radiation _____Kerosene

____Electric Baseboard _____Heat Pump _____Solar/Air

____Solar/Glycol or other heat transfer fluid _____Solar/Water

_____Other (Specify) _____

If air, when were filters last changed? _____

Type of ventilation system: (Check all that apply)

_____Central Air Conditioning _____Mechanical Fans _____Kitchen Range Hood Fans

_____Bathroom Vent Fans _____Individual Air Conditioning Units

_____Other (Specify) _____

Type of Fuel Utilized (check all that apply)

_____Natural Gas _____Electric _____Fuel Oil ____Coal

_____Wood Pellets _____Solar _____Kerosene _____Waste Oil

_____Outside Fresh Air intake

Septic System: _____Yes ____Yes, but not used _____No-irrigation.

Private Well: _____Yes _____Yes, but not used _____No

Public or Private Well: _____ If Public, name of company:_____

Existing Subsurface depressurization (radon) system in place? _____Yes/No Running: _____Y/N

Part III Outside Contaminant Sources

1000ft. Radius nearby contaminant source:

_____DNREC/DEN _____Marplot _____Brownfield Lists

Previous Land Use in Area: _____

Other Stationary Sources nearby: (Check all that apply)

_____Gas Stations _____Emission Stacks _____Refineries/Chemical Plants

_____Waste Disposal Facilities (LFS & WWTPs) _____Drycleaners

_____Beauty _____Hot Mix Plants _____Auto Repair Body Shop

_____Fuel Oil Tanks _____Road Repair with Hot Water

Wetlands Nearby? (Distance and Direction)

Heavy Vehicular Traffic nearby? Or other mobile sources?

Known groundwater or soil contamination within 1000 feet?

Physical Parameters of unsaturated zone (Summarize or attach)

Sinkholes or Debris Pits? _____Y/N

Part IV Indoor Contaminant Sources

Identify all potential indoor sources found in the building (including attached garages), the location of the source (floor & room), and whether the item was removed from the building 48-hours prior to indoor air sampling event.

Potential Sources	Location(s)	Removed Prior to Sampling? (Yes/No/NA)
Gasoline storage cans		
Gas-powered equipment		
Kerosene storage cans		
Paints *I* thinners *I* strippers *I* glues *I* caulks		
Cleaning solvents		
Oven cleaners		
Carpet *I* upholstery cleaners		
Other house cleaning products/laundry products		
Moth balls		
Polishes *I* waxes		

Insecticides		
Furniture *I* floor polish		
Nail polish *I* polish remover		
Hairspray		
Cologne *I* perfume *I* after-shave, etc.		
Air fresheners		
Fuel tank (inside building) (outside)		NA
Wood stove or fireplace		NA
New furniture *I* upholstery		
New carpeting *I* flooring /paneling		NA
Recent painting in building?		
Roof repair?		
Hobbies - glues, paints, etc.		
Toilet or septic additives		
Dry drain traps, plugged drains, toilets won't		
Garbage/spoiled food		
Standing water/tire piles/recent flooding		
Sewage/septic		
Dead animals (including unusual numbers of		
Mold/mildew		
Wet sheetrock/paneling/flooring		
Neighbors making drugs/explosives?		
Mercury-containing switches or instruments		
Alcohol/bleach/ disinfectants		
Recent concrete/masonry work?		
Flowers		
Pets (Specify), scented kitty litter?		
Compost/Manu		

Part V – Miscellaneous Items

Do any occupants of the building smoke? ____Yes/No How often? _____

Do any of the occupants have any chronic health issues? _____ Yes/No

Has anyone smoked inside of the building within the last 48 hours? _____Yes/No

Does the building have an attached garage? _____Yes/No

If yes, does the garage have heat/ventilation? _____Yes/No Windows? _____Yes/No

Is the garage connected to the house? _____Yes/No

Is a car usually parked in the garage? _____Yes/No

Do the occupants of the building dry clean their clothing? _____ Yes/No

If yes, name of dry cleaner: _____

When were the dry-cleaned clothes last brought into the building? _____

Have the occupants ever noticed any unusual odors in the building? _____ Yes/No

Describe (with location) _____ Date: _____

Amount: _____

Any known spills of chemicals, fuels, or sewage immediately outside, or inside, the building? _____Y/N

Fires? _____ Yes/No If yes, describe with location: _____

Have any pesticides/herbicides been applied around the building foundation or in the yard/garden? Y/N

Have any pesticides been applied regionally, e.g., by Mosquito Control or DSWC? _____Y/N

If so, when and which chemicals? _____

Are odors more noticeable in certain weather conditions? _____ Y/N

If yes, describe (wind direction, speed, precipitation, temperature, humidity): _____

_____