The Vapor Intrusion Pathway

Regional DNR Staff Training
Fall 2011
By Terry Evanson

Role of Technical Guidance

- Provides direction to regulated community on what/why/how to address technical topic
- Provides assurance to regulated community that agency will accept the approach set out in guidance
- Guidance is NOT enforceable in court. If regulated community chooses not to use guidance:
  - *DNR can not insist on specifics in guidance*
  - *Regulated community must provide alternative approach and show that approach is protective of human health, welfare & environment*

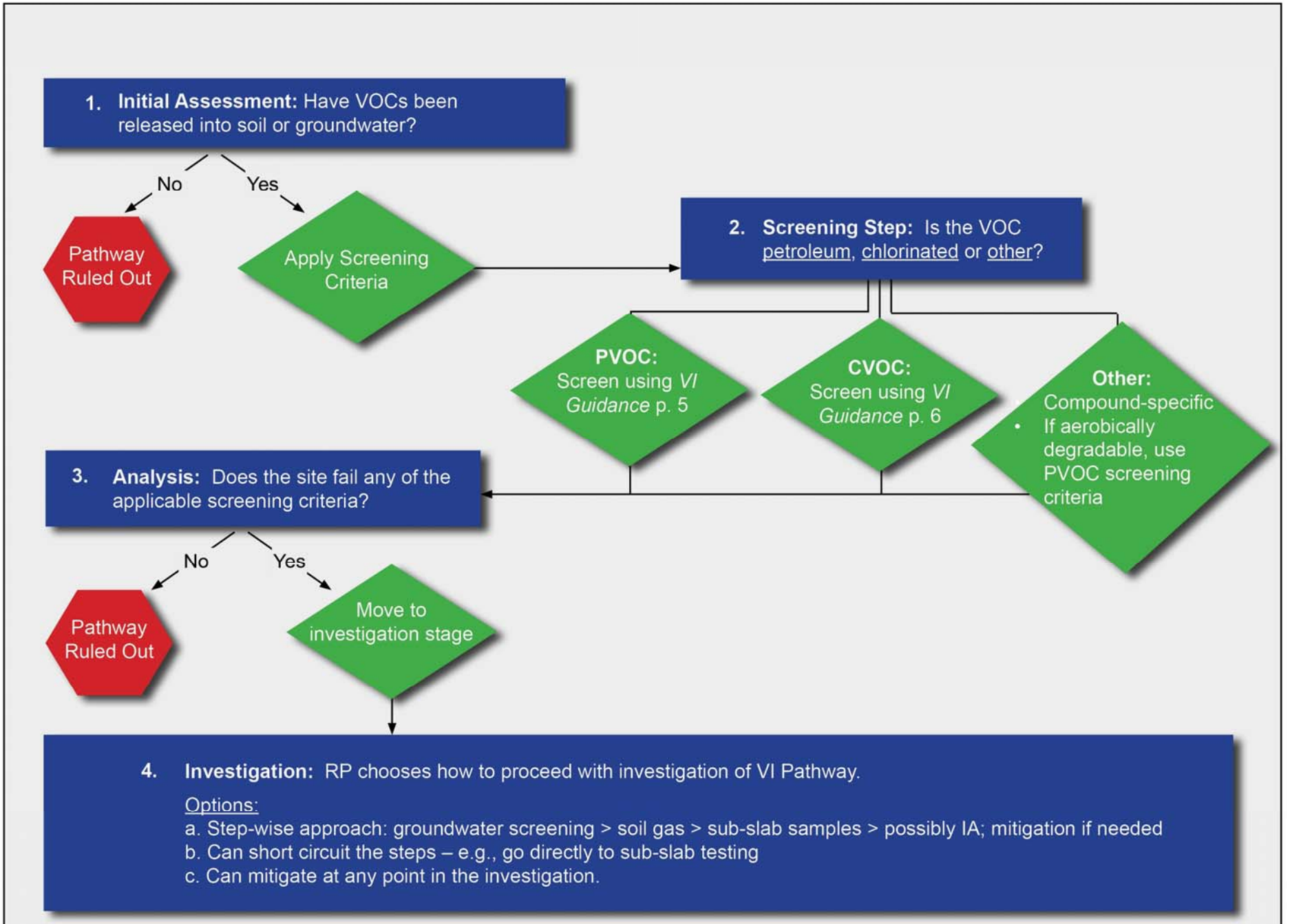
DNR Authorities & VI

- NR 716.11(3)(a) must determine the “nature, degree and extent, both areal and vertical, of the hazardous substances or environmental pollution in **all** affected media”.
- NR 716.11(5) must include an evaluation of the “pathways for migration of the contamination, including drainage improvements, utility corridors, bedrock and permeable material or soil along which **vapors**, free product or contaminated water may flow”.
- NR 726.05(8)(a)3 department can require any other condition necessary to protect public health, welfare or the environment.
- NR 726.05(4)(a) department may not close a site that poses a threat to public health, safety.

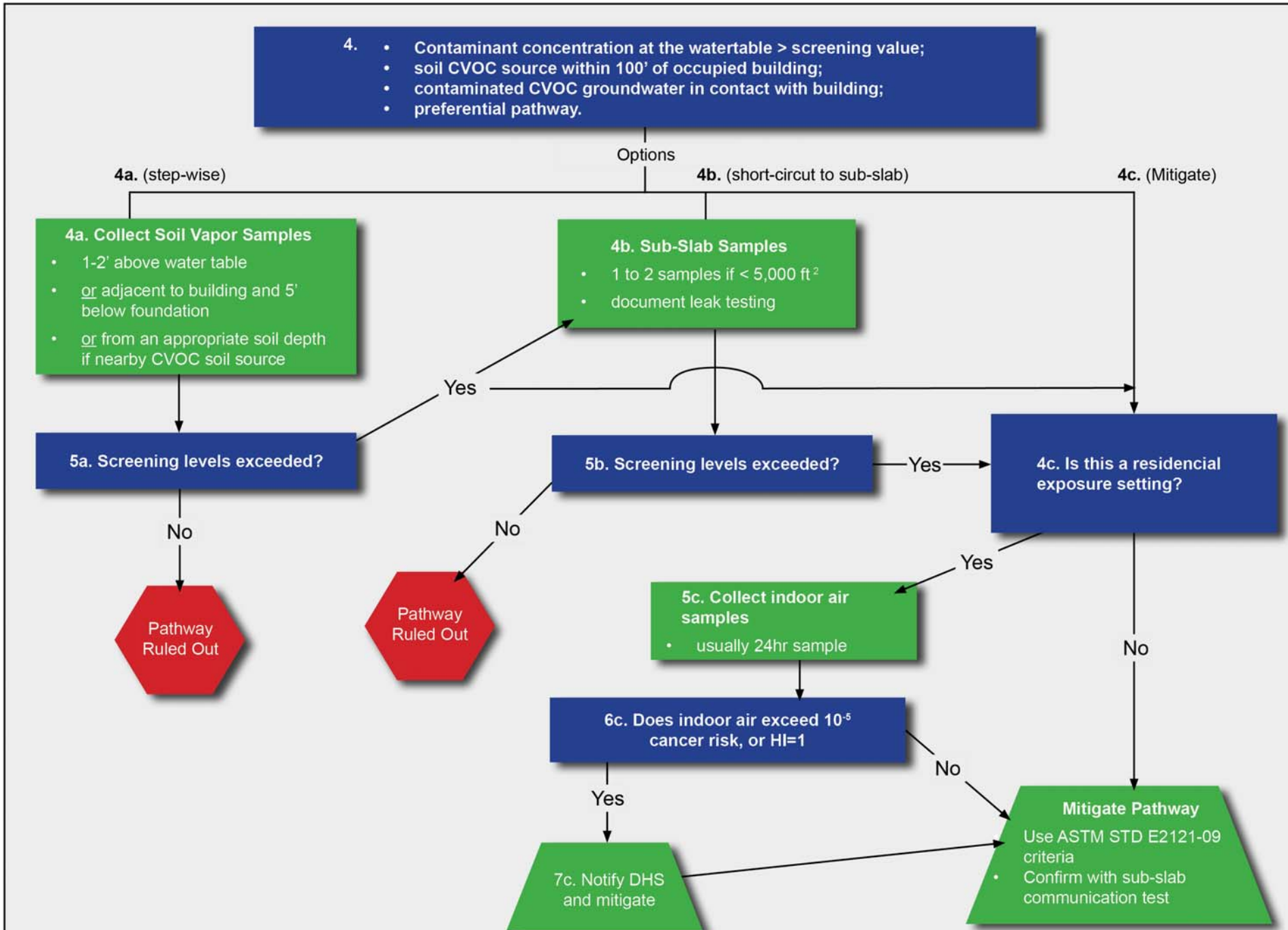
RR staff to contact when you have VI questions

- Regional Offices:
  - *NOR: Phil Richard – 715-762-1352*
  - *NER: Jennifer Borski – 920-424-7887*
  - *SER: Pam Mylotta – 414-263-8758*
  - *SCR: Jeff Ackerman – 608-275-3323*
  - *WCR: Tom Hvizdak – 715-421-7850*
- Central Office:
  - *Terry Evanson – 608-266-0941*
- DHS:
  - *Henry Nehls-Lowe – 608-266-3479*
  - *Rob Thiboldeaux – 608-267-6844*
  - *Bruce Rheineck – 608-267-3732*

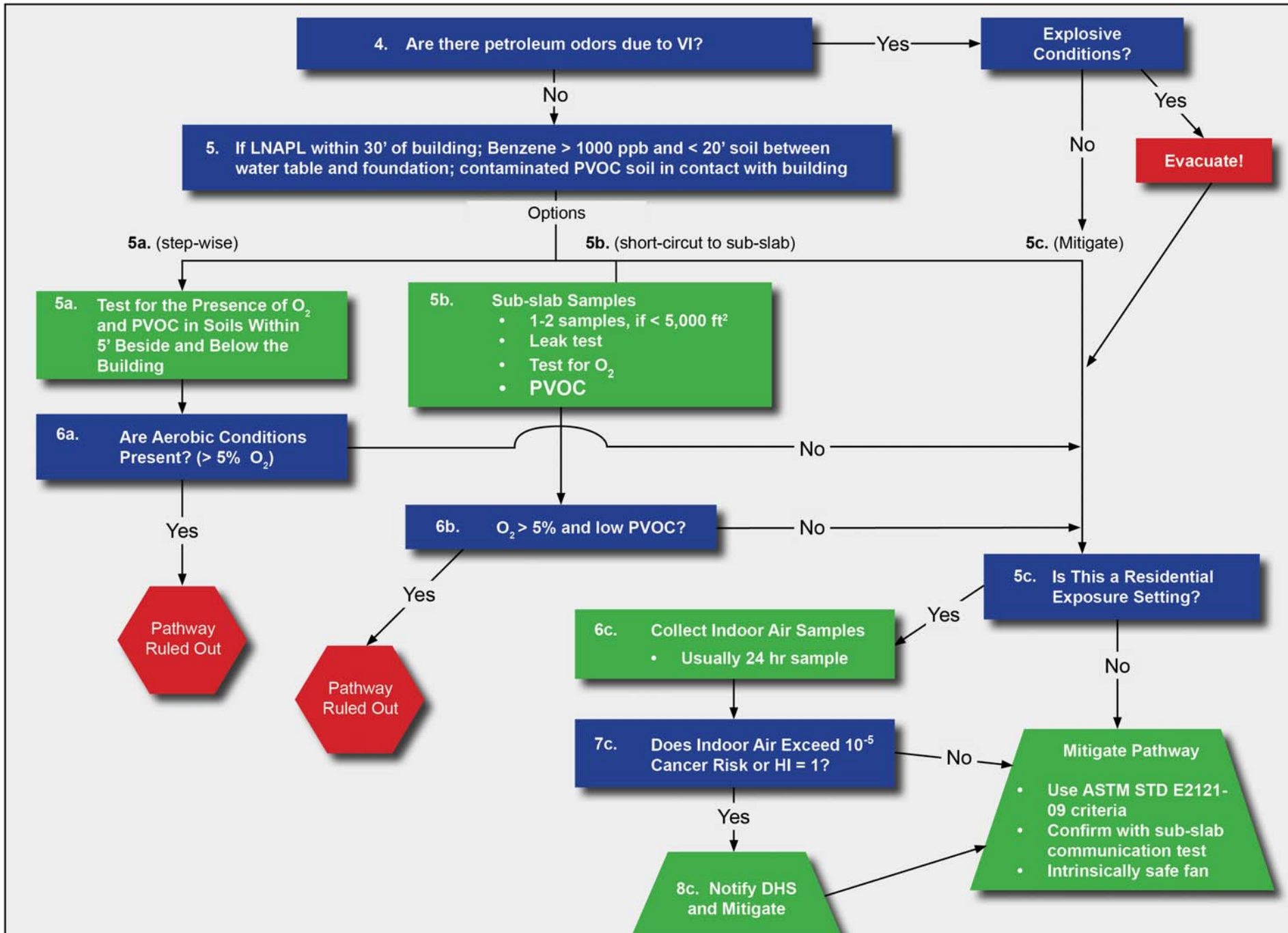
Decision-Making Process for the Vapor Intrusion Pathway



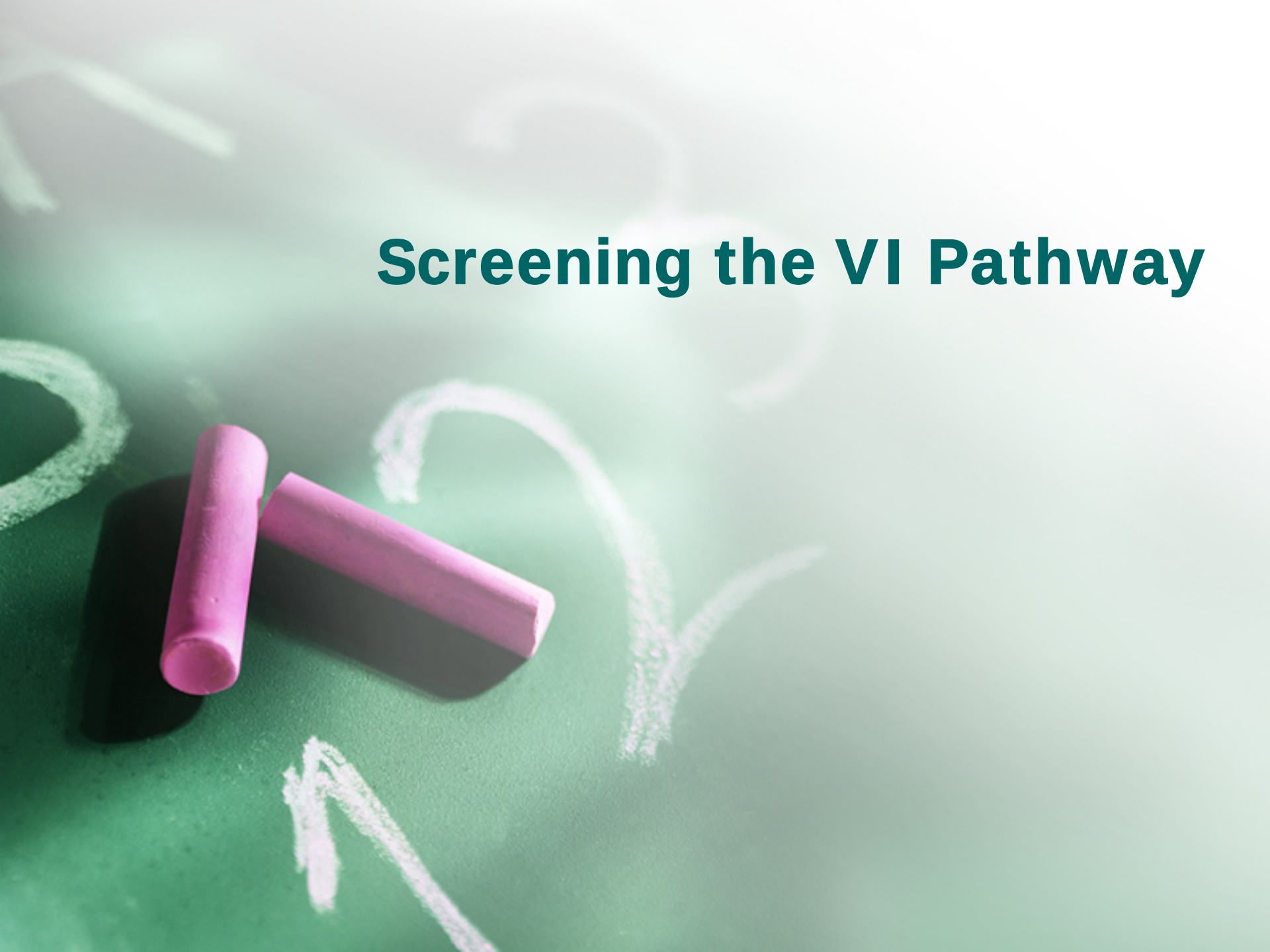
Vapor Intrusion Pathway – Investigation of CVOC



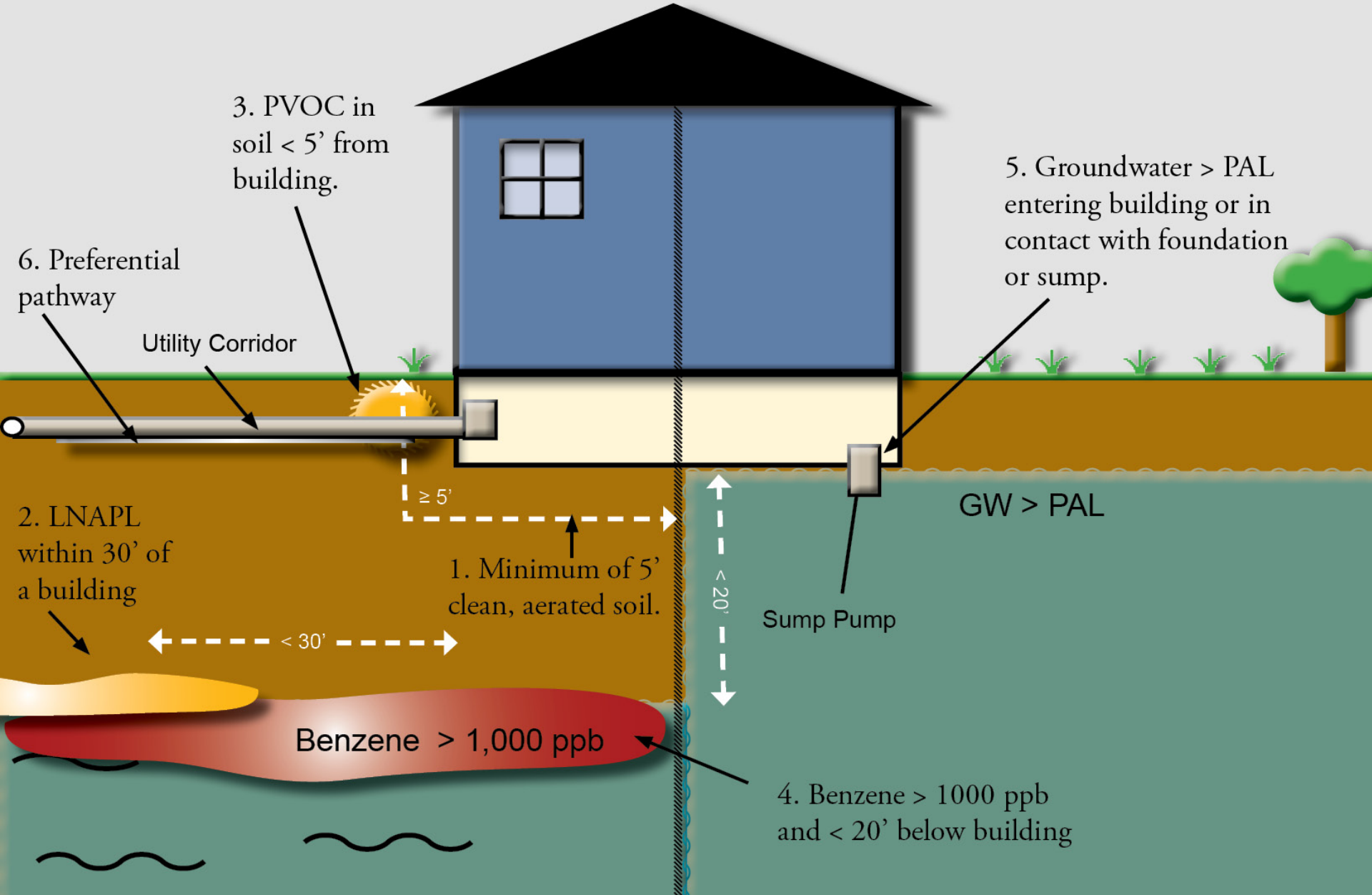
Vapor Intrusion Pathway – Investigation of PVOC



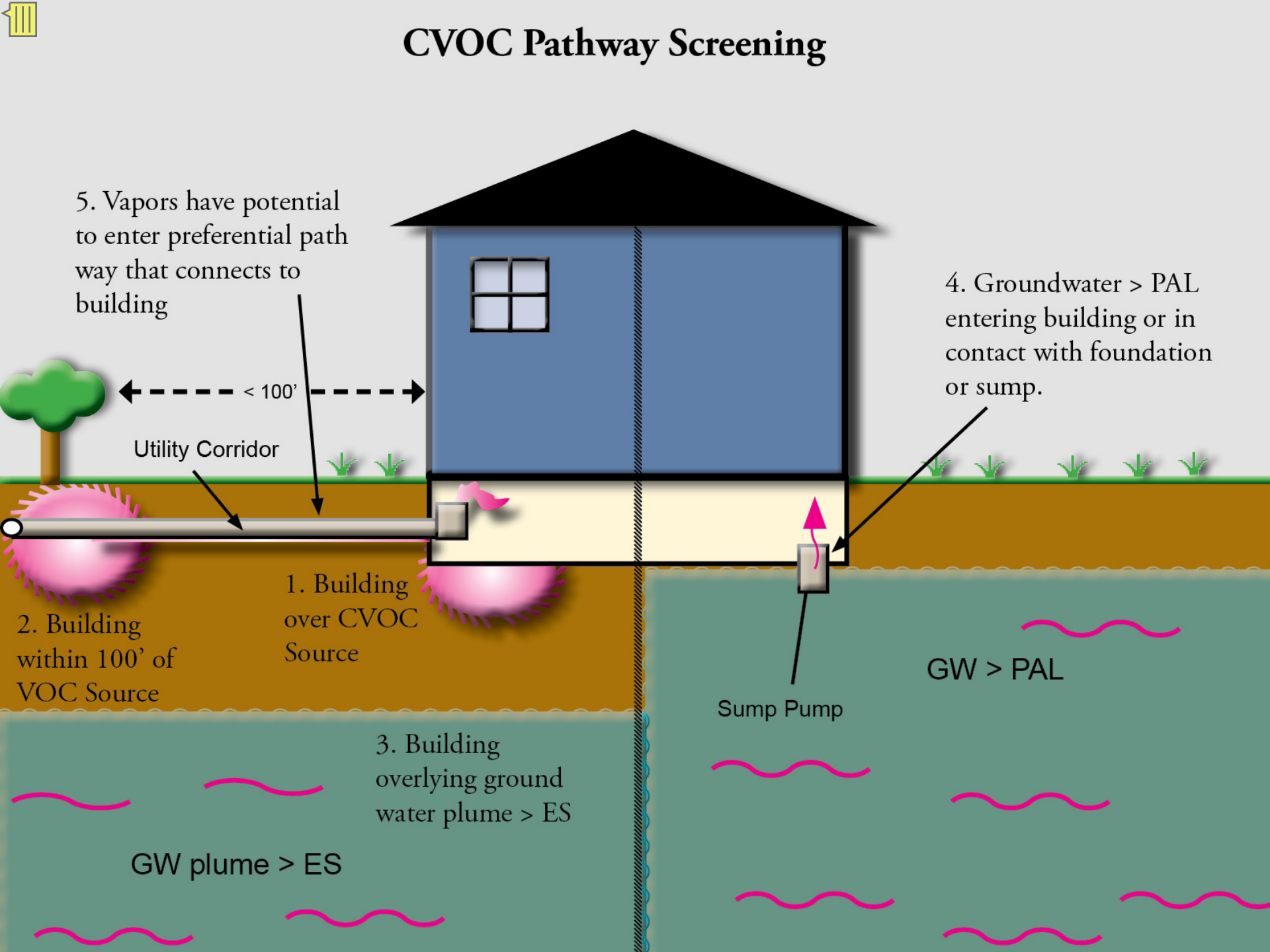
Screening the VI Pathway



PVOC Pathway Screening



CVOC Pathway Screening



VI Screening Calculator by Resty

http://intranet.dnr.state.wi.us/int/aw/rr/gen_resources/tech.htm#vapor2

Wisconsin **Vapor Intrusion Action/Screening Levels** (Commercial)

1. *Enter data in yellow cells. Only numeric values under* **Data**; *do not type "-", "NA" nor "space bar." Leave purple cells "as is."*
2. *After all entries, go to* **Row 872**. *Click* **Get Summary_Air**

Reference values (ug/m³) are from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm. Unit conversion (ug/m³ to ppb-v) uses ideal-gas molar volume at 1 atm and at the input indoor-air T. The NIOSH Pocket Guide (http://www.cdc.gov/niosh/npg/pgintrod.html) uses T of 25ºC (=77ºF). *Program by Resty M. Pelayo, WDNR, RR/5, 608/267-3539.* **8/24/2011**.

INPUT <<<--- OUTPUT --->>>

Are the data INDOOR-air concentrations? (yes / no):	yes
	no
Indoor-air Temperature (ºF):	77 ºF

Alpha α:	Target Cancer Risk
1	1.0E-05

@ 25.0 ºC:

Molar Volume for Ideal Gas

24.47 L/mole

Click here to Clear Entries below

INDOOR-AIR: TCR=1.0E-5; ncTHQ=1; Alpha=1.0

Use either of the columns

ANALYTE	CAS_NO	MW	Reference Values: EPA RSL Table Values (ug/m³) TCR_1e-6	EPA RSL Table Values (ug/m³) THQ_1	EPA RSL Table Values (ppb-v) TCR_1e-6	EPA RSL Table Values (ppb-v) THQ_1	Commercial Vapor Action Level (VAL) ug/m³	Commercial Vapor Action Level (VAL) ppb-v	VAL Basis ca: cancer nc: non-cancer (TCR=1e-5; THQ=1)	Data ug/m³	Data ppb-v	Flag E = Individual Exceedance!
Tetrachloroethylene	127-18-4	165.83	2.1E+00	1.2E+03	3.1E-01	1.8E+02	21.	3.1E+00	ca			
Trichloroethylene	79-01-6	131.39	6.1E+00	4.4E+01	1.1E+00	8.2E+00	44.	8.2E+00	nc			
Dichloroethylene, 1,2-trans-	156-60-5	96.94		2.6E+02		6.6E+01	260.	6.6E+01	nc			
Vinyl Chloride	75-01-4	62.5	2.8E+00	4.4E+02	1.1E+00	1.7E+02	28.	1.1E+01	ca			
Trichloroethane, 1,1,1-	71-55-6	133.41		2.2E+04		4.0E+03	22,000.	4.0E+03	nc			
Carbon Tetrachloride	56-23-5	153.82	2.0E+00	4.4E+02	3.2E-01	7.0E+01	20.	3.2E+00	ca			
Dichloroethylene, 1,1-	75-35-4	96.94		8.8E+02		2.2E+02	880.	2.2E+02	nc			
Dichlorodifluoromethane	75-71-8	120.91		4.4E+02		8.9E+01	440.	8.9E+01	nc			
Dichloroethane, 1,1-	75-34-3	98.96	7.7E+00		1.9E+00		77.	1.9E+01	ca			
Dichloroethane, 1,2-	107-06-2	98.96	4.7E-01	3.1E+01	1.2E-01	7.7E+00	4.7	1.2E+00	ca			
Trichlorofluoromethane	75-69-4	137.37		3.1E+03		5.5E+02	3,100.	5.5E+02	nc			

Type BRRTS No. Here (If Known)

0

(Commercial)

Exceedance Count

Type Other Pertinent info (max 256 chars)

Exposure Classification & Attenuation Factors

		Media		
	Exposure Classification	**Groundwater**	**Soil gas >5' below foundation**	**Sub-slab or soil gas < 5' below foundation**
Land Use				
Industrial/Lg Commercial	Industrial	0.0001	0.001	0.01
Commercial	Industrial	0.001	0.01	0.1
Residential & "sensitive populations"	Residential	0.001	0.01	0.1

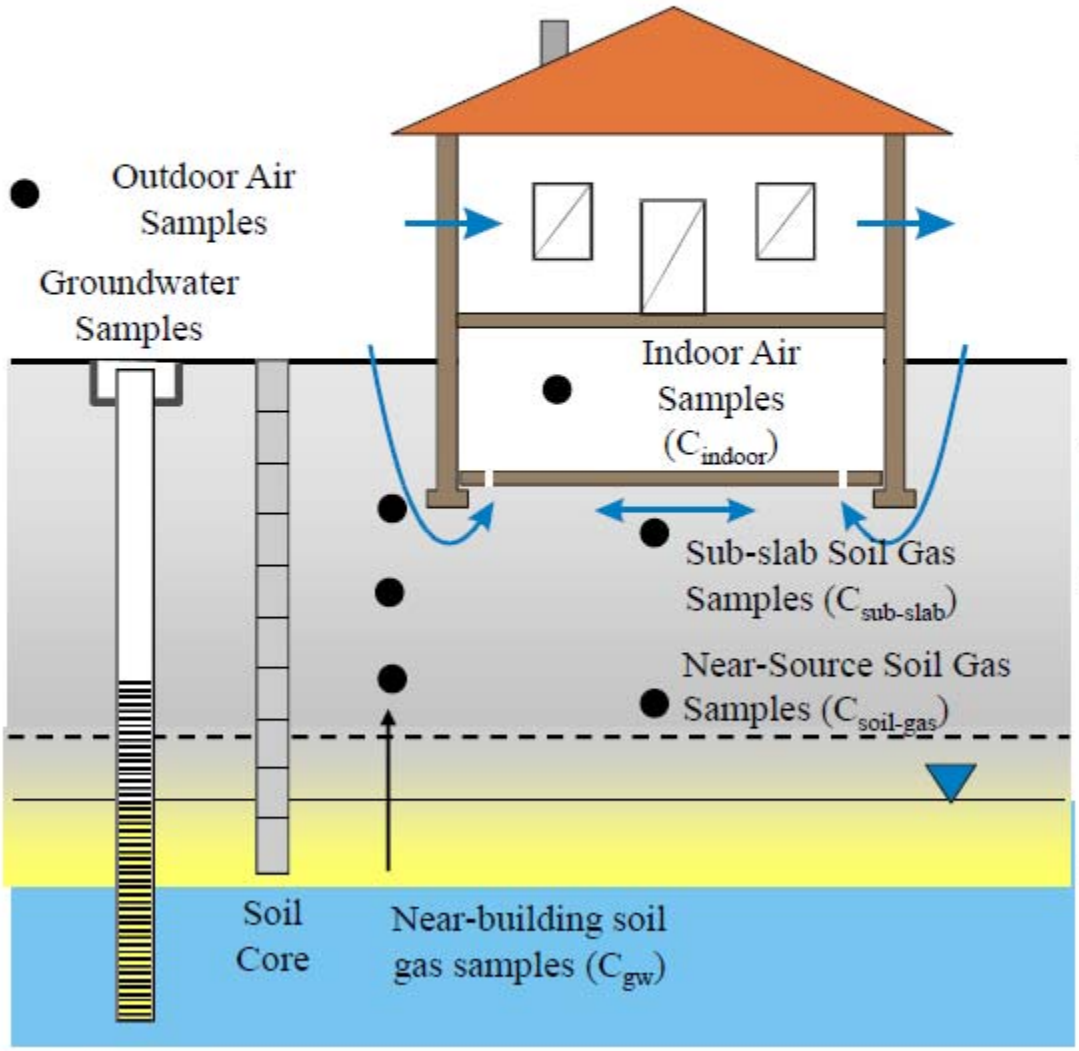
Role of DNR staff vs Consultants

- Consultants screen pathway & state in the SI report or Closure report that they have either:
  - *Ruled the VI pathway out OR*
  - *Addressed the VI pathway risk*
- DNR staff review conclusions of consultant. If staff disagree with the consultants conclusion, document additional investigation or action needed.

Investigating the VI Pathway

Changes with Time?

Buildings and their Surroundings are Dynamic Systems



Wind, temperature, barometric pressure, rainfall HVAC systems, resident behaviors (seconds-minutes-hours)

Surface drivers and proximity to foundation entry points (minutes-hours-months)

Source and some surface effects (weeks-months-years)

Source history and seasonal influences (weeks-months-years)

Purpose for Sampling Various Media during VI Investigation

- Groundwater samples
  - *Screens source of vapors (water table ONLY)*
  - *Indentifies possible extent of vapor movement*
- Soil vapor samples
  - *Screens source of vapor to building*
  - *Identify pathway of vapor movement*
  - *Identify possible extent of vapor movement*
- Sub-slab vapor samples
  - *Identifies possible vapor intrusion risk*
  - *Screens contaminant source (e.g. @drycleaner)*
- Indoor Air samples
  - *Identifies current exposure*
  - *Identifies completed vapor intrusion pathway*

Sampling Concepts for VI Pathway: Groundwater

- Only VOCs located at the water table affect VI
- Use data from water table wells or groundwater grab samples from 6 – 12” of the water table.
- Can use simple equation or Resty’s calculator to estimate concentration in groundwater that may cause vapor intrusion.

$$C_{gw} = \left(\frac{C_{IA}}{H \times AF_{gw} \times 1000\, L/m^3} \right)$$

Sampling Concepts for VI Pathway: Groundwater

- Is there a depth to groundwater where vapor migration can be ruled out?
  - *CA uses soil vapor to identify deep groundwater plumes, so soil vapor can extend significant distance above a plume.*
  - *Soil type between contaminated water table and surface is more important VI risk than depth to water table.*

Sampling Concepts for VI Pathway: Soil Vapor

- Groundwater contamination is the vapor source:
  - *1 – 2 feet above the water table*
  - *At least 5 feet below the building foundation if depth to water allows this*
  - *If depth to groundwater is > 30 feet, half the distance to the water table*
- Soil contamination is the vapor source:
  - *Collect sample in most permeable soil layer (e.g., along a sewer lateral; sand seams in clay soil)*
  - *Collect multi-depth soil vapor samples to identify zones of vapor migration.*

Sampling Concepts for VI Pathway: Soil Vapor

- Screening individual building for vapor migration:
  - *Preference is sub-slab samples, however soil vapor can be used to screen buildings for VI*
  - *Vapors can travel ~100 feet through soils in all directions from a CVOC source.*
  - *Collect a soil vapor sample as close to the building foundation as possible. Depth of the sample depends on the location of the VOC source. (see previous slide)*
  - *Sample the side of the building closest to the VOC source*

Spatial & Temporal Variability in Soil Vapor Samples

- Significant spatial variability in soil vapor concentrations
  - ➢ *Up to 10 samples needed to estimate true average VOC concentration within +/- 50%*
- Temporal variability is similar to spatial variability*
- Therefore, a small number of soil vapor concentrations likely represents an <u>order of magnitude accuracy</u>

*ESTCP Project ER-0423, Dec. 2007, Recommendations for the Investigation of Vapor Intrusion

Sampling Concepts for VI Pathway: Sub-slab vapor

- Guidance states 3 samples / average home
  - *Most sites are collecting 1- 2 samples/home or average sized building. More than 5,000 ft^2 requires additional samples.*
  - *Vapors can enter through the side-wall of a basement, especially where there is a shallow CVOC source in soils. Depending on foundation construction, vapor samples can be collected through the wall.*
  - *Sub-slab sample data are the primary information used for making mitigation decisions.*

Sampling Concepts for VI Pathway: Indoor Air

- In general, IA sampling is NOT necessary in industrial plants or commercial buildings, unless a “residential setting” exists (homes, educational, childcare & elder care facilities).
  - *If mitigation is necessary (based on sub-slab samples), effectiveness of the system will be determined through communication tests.)*
- Indoor air SHOULD be collected in homes, apartments, day care centers, clinics, etc. if sub-slab concentrations exceed screening levels in order to evaluate chemical exposure.

Sampling Concepts for VI Pathway: Indoor Air

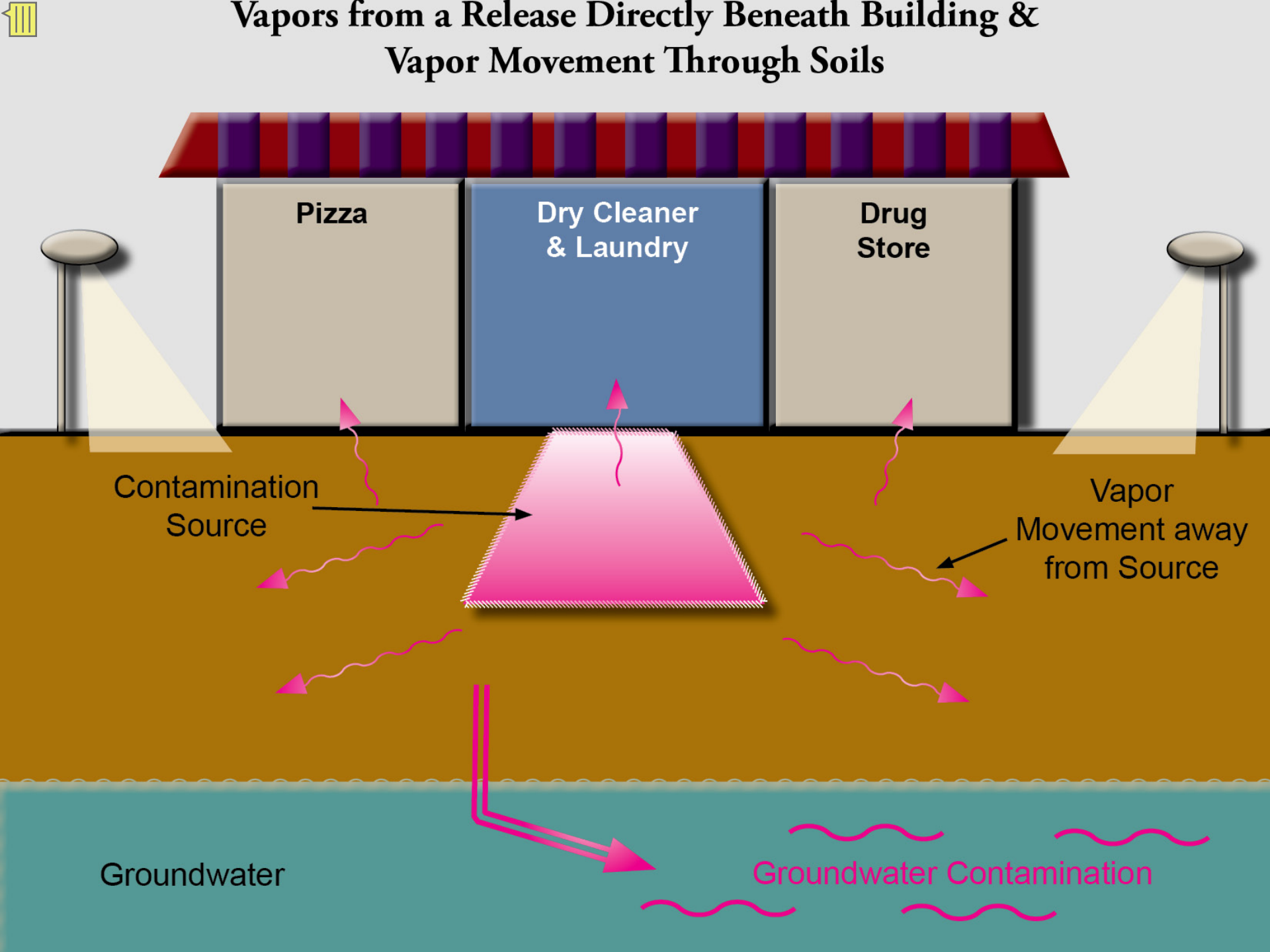
- If mitigation is necessary in a residential setting, collect a verification indoor air sample if the original IA testing exceeded screening levels.
  - *With a typical SSDS, communication testing will verify the system's effectiveness.*
  - *Where SSDS can not be used or is ineffective, follow-up IA testing will be necessary.*

Sampling Concepts for VI Pathway: Indoor Air

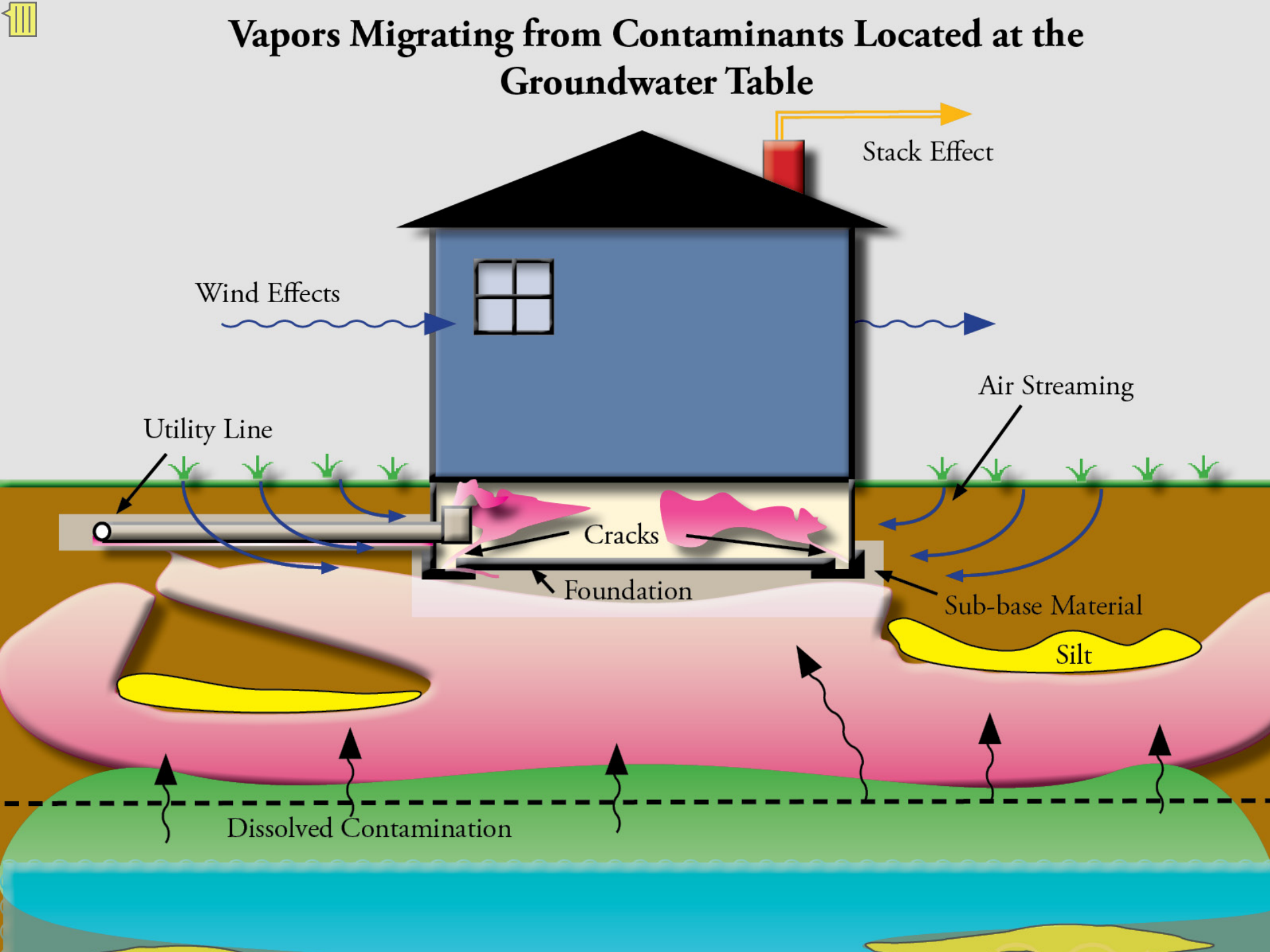
- Length of indoor air sample?
  - *24 hrs for residents*
  - *8 hr for commercial/industrial*
  - *Longer length samples are better – even 14 days*
- Methods
  - *Summa canisters analyzed using TO-15 is preferred*
  - *Tedlar bags acceptable for sub-slab & soil gas if analyzed within 48 hrs*
  - *Methanol impinger is unacceptable (detection levels are too high)*


POP QUIZ:
What & where would you collect samples to assess the VI pathway?

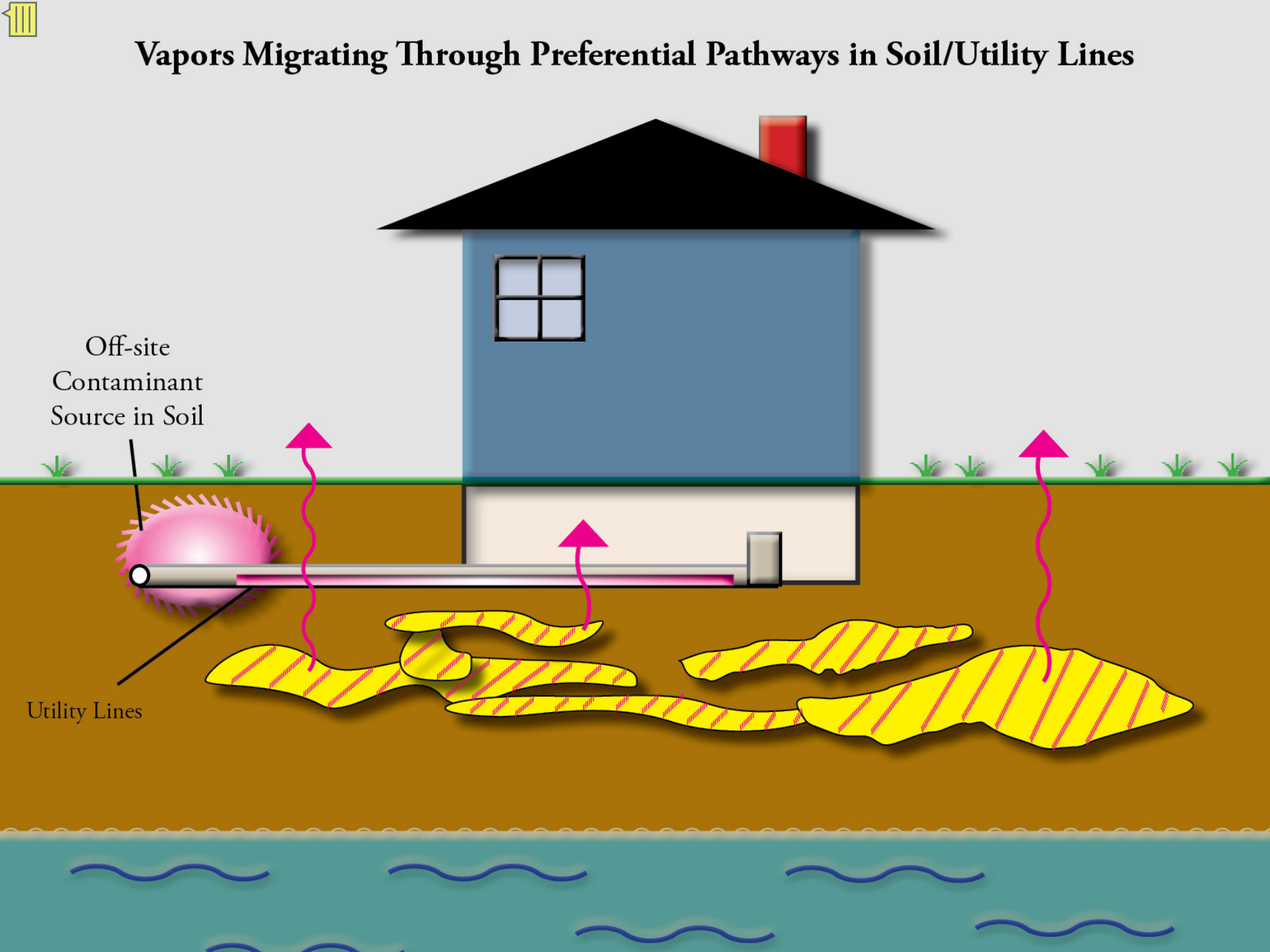
Vapors from a Release Directly Beneath Building & Vapor Movement Through Soils



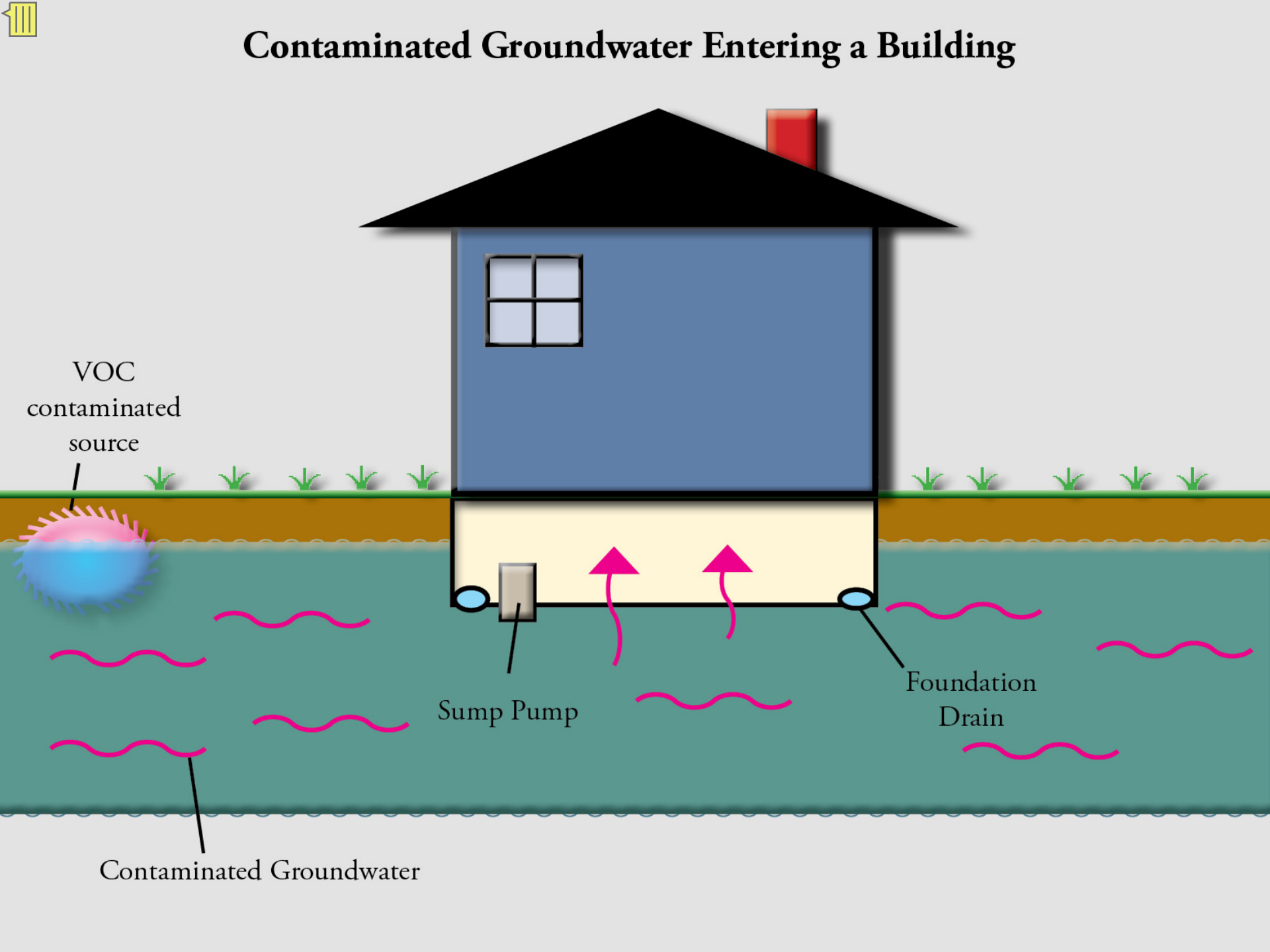
Vapors Migrating from Contaminants Located at the Groundwater Table



Vapors Migrating Through Preferential Pathways in Soil/Utility Lines



Contaminated Groundwater Entering a Building



Vapor Sampling Methodology

How to collect soil vapor / sub-slab samples

- Reference material is available on the Standards & Streamlining Team web page under Technical Resources*.
  - *Soil Vapor Sampling Video of the Geoprobe Post-run tubing method*
  - *Todd McAlary PowerPoint presentation of several soil vapor collection methods*
- QA/QC is basically the same for soil vapor and sub-slab samples

*http://intranet.dnr.state.wi.us/int/aw/rr/gen_resources/tech.htm#vapor2

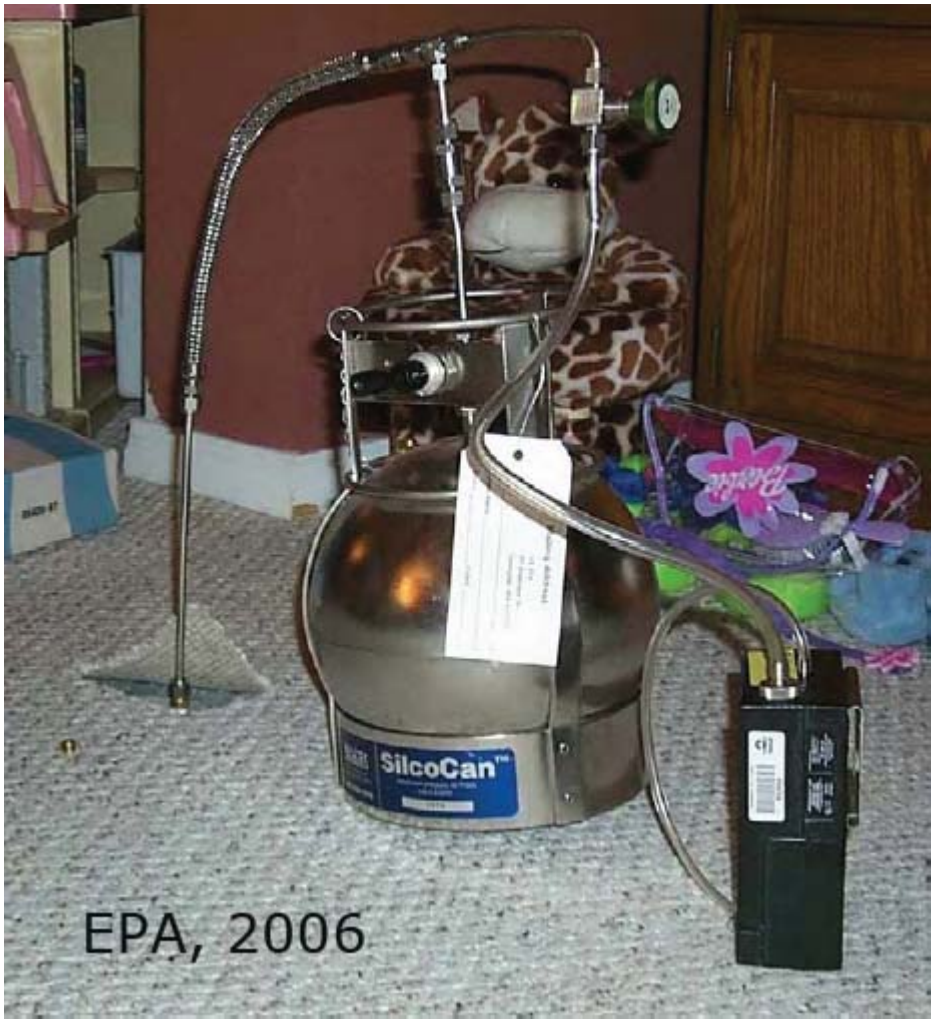
QC: Leak detection for soil vapor/sub-slab samples

- All leak detection methods involve placing a volatile chemical at the probe seal and testing for that compound in vapor extracted from the probe.
  - *Expect that leak detection method will be documented to the DNR*
  - *If the leak detection indicates the sample has been compromised (i.e., indoor air has leaked into the sample), a new sample needs to be collected and analyzed.*
    - More than 10% leakage is unacceptable
    - He method detects leaks BEFORE collecting sample

QC: Shut-in Test

- A shut-in test detects leaks in the above ground fittings in the sampling train.
- Assemble the sampling train, evacuate the lines to a vacuum of 50 – 100 inches water column and observe a vacuum gage for 1 minute. If the vacuum holds, the fittings are tight.

Shut-in Test: Summa Canister W/ vacuum gage and pump



He shroud with pump/vacuum gage

Summa canister samples

- Flow regulators
  - *Used for all but grab samples*
  - *Set by the laboratory, therefore you must tell the lab how long you need to sample for*
  - *Rate of flow depends on the sample. Generally do not recommend more than 200 ml/min. (for sub-slab sample, for instance)*
- Do you need to close the Summa canister valve after the 8 or 24 hr sample is collected?
  - *Yes. There should still be a slight vacuum AFTER sample collection. If there is no vacuum, you don't know over what period the sample was collected.*

Tubing types

- Acceptable tubing type: Stainless steel, Nylaflow, Teflon, tygon, PEEK
- Polyethylene has the poorest performance – both for off-gassing as well as reactivity.*

*(http://www.airtoxics.com/literature/papers/Media_AWMA_Sept06_Final.pdf, Impact of sampling media on soil gas measurements, A&WMA conference, 2006)

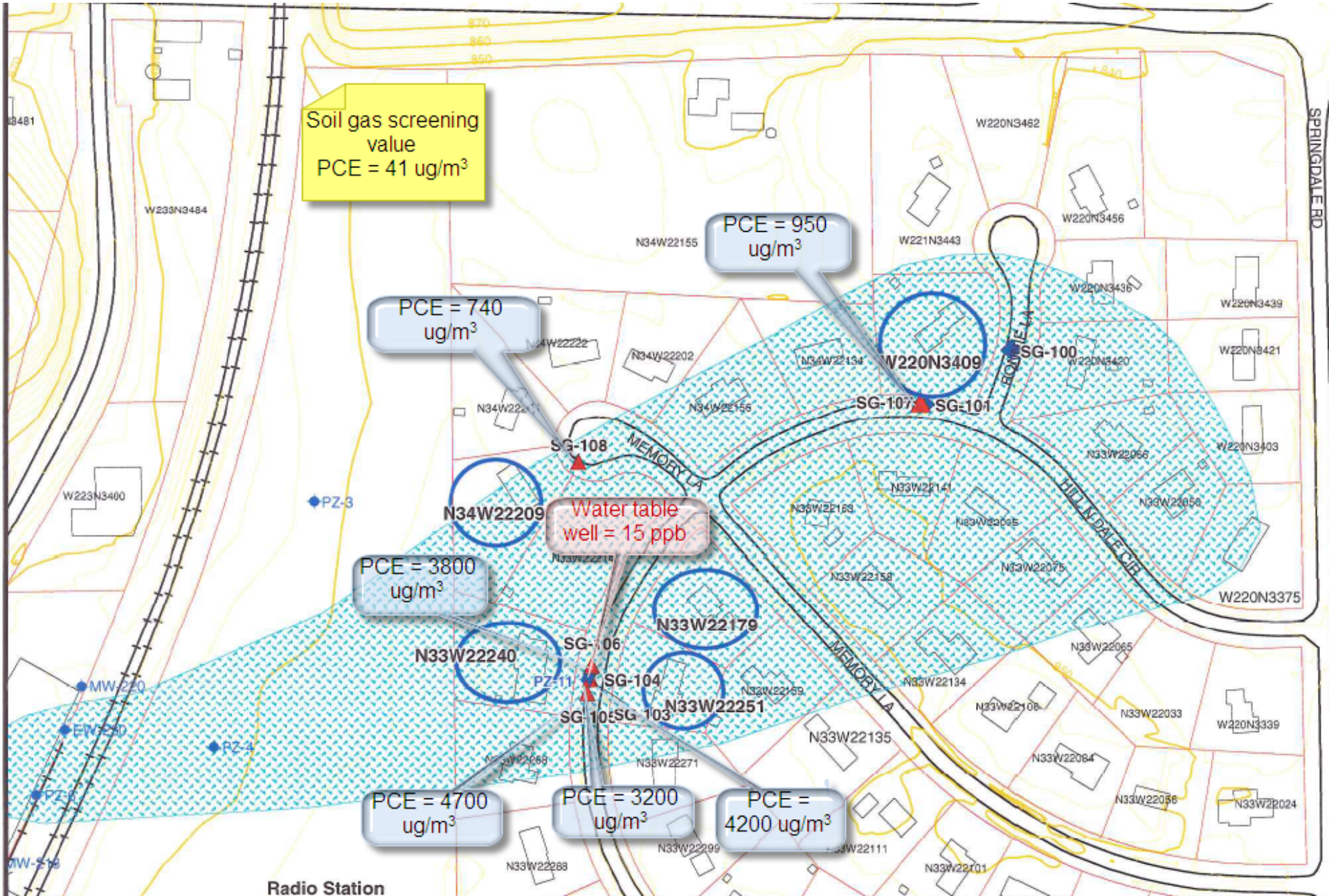
Off-Source Vapor Intrusion

How far away from the source should the investigation extend?

- *Ex – groundwater plume under 50 homes. Do you test all 50 homes?*

- Use a step-wise approach –
  - *Choose the homes closest to the source (where groundwater concentrations are highest) and test those. If sub-slab testing indicates VI may be a risk, expand the investigation downgradient.*
  - *OUTREACH is critical in these situations. Consider involve local government, hold public meetings, develop a communication plan.*

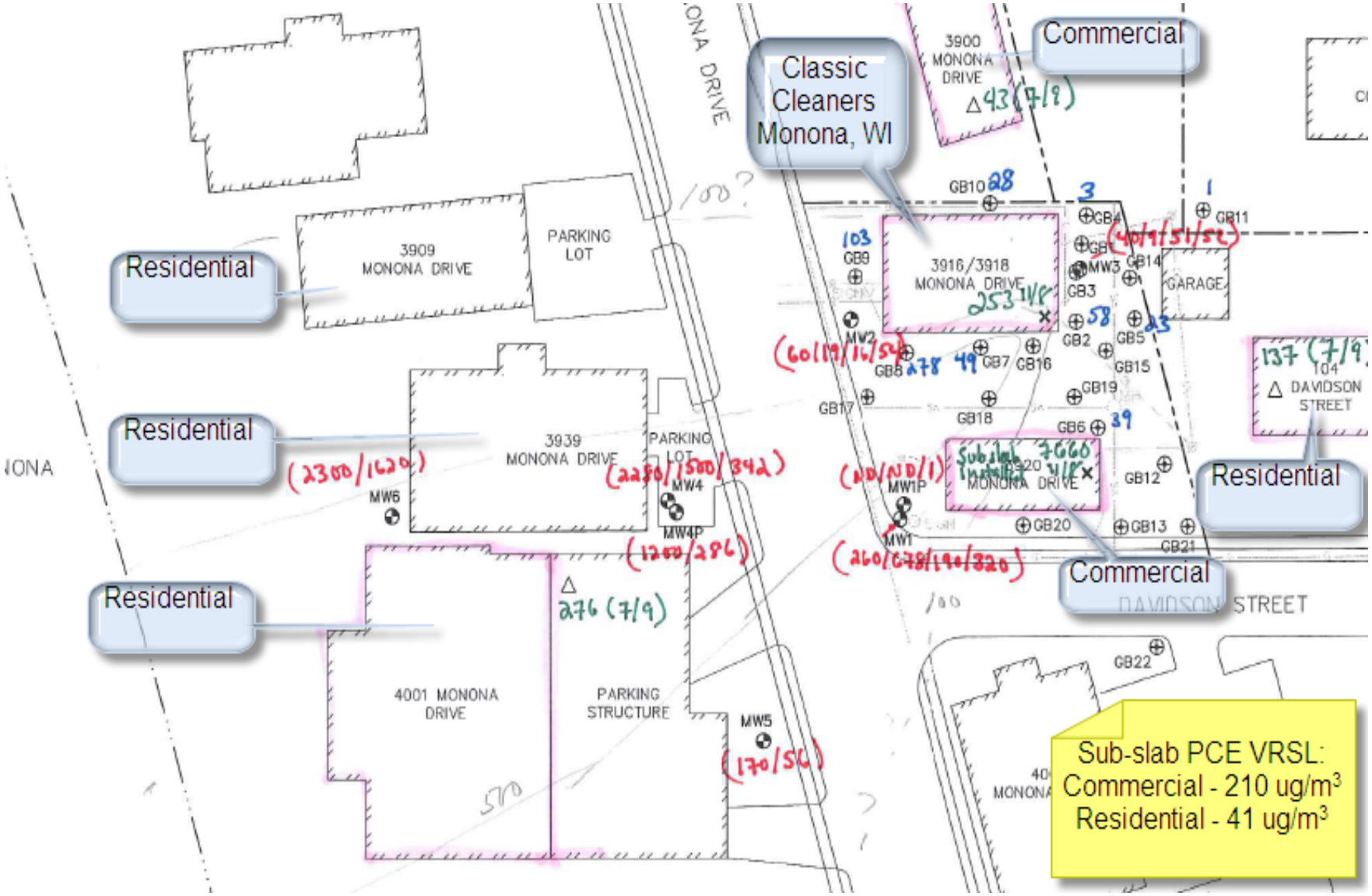
Quad-Graphics, PCE soil gas (ug/m³)



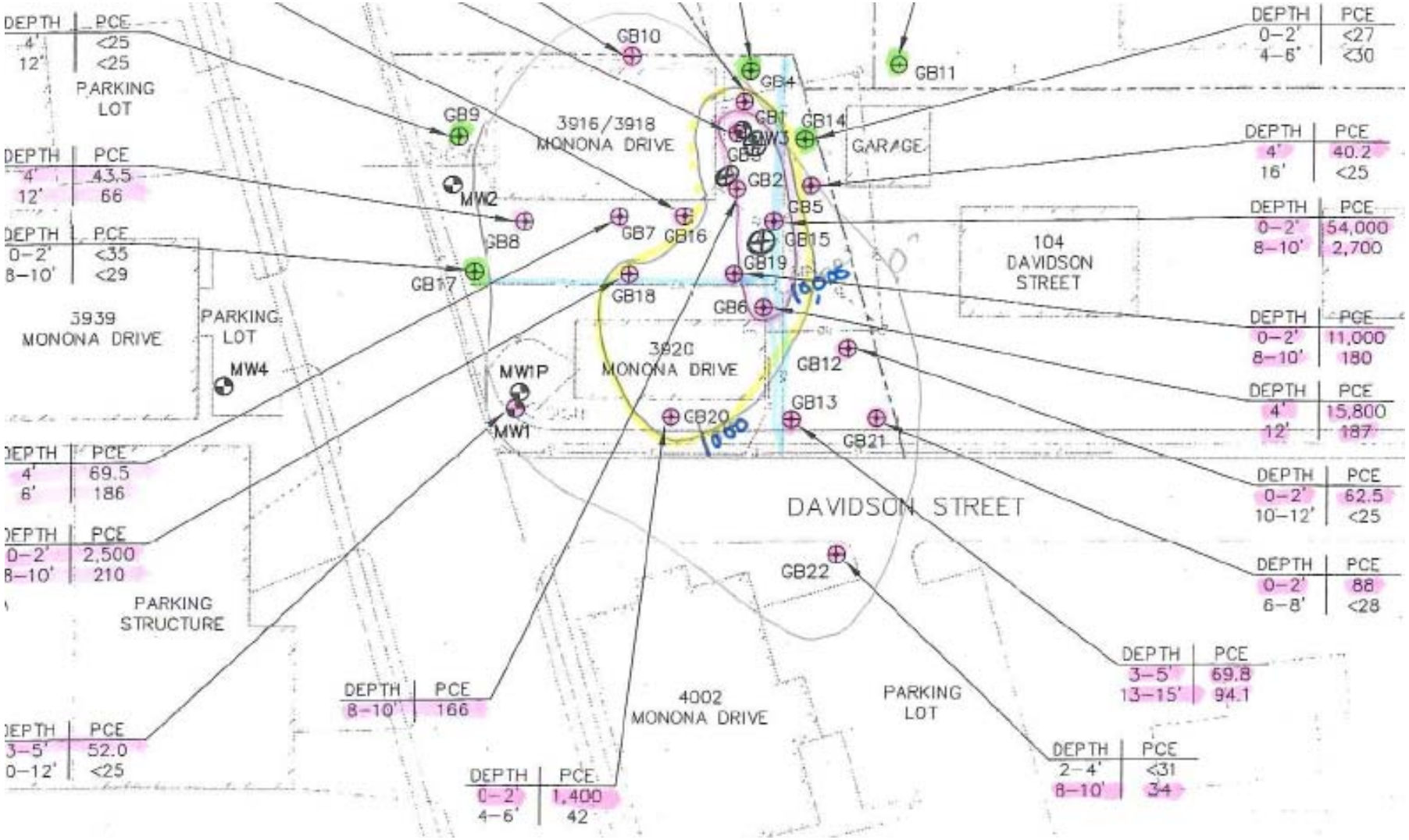
If vapors are not found at the source building, is off-source investigation needed?

- Site-specific decision. Soil vapor movement is very difficult to predict
  - *Use multiple lines of evidence – extent of soil & groundwater contamination; soil type; preferential pathways, etc.*
- You MUST understand where the release occurred.
  - *Example: Classic Cleaners, Monona, WI*
  - *Example: Gardner Mfg, Horicon, WI*

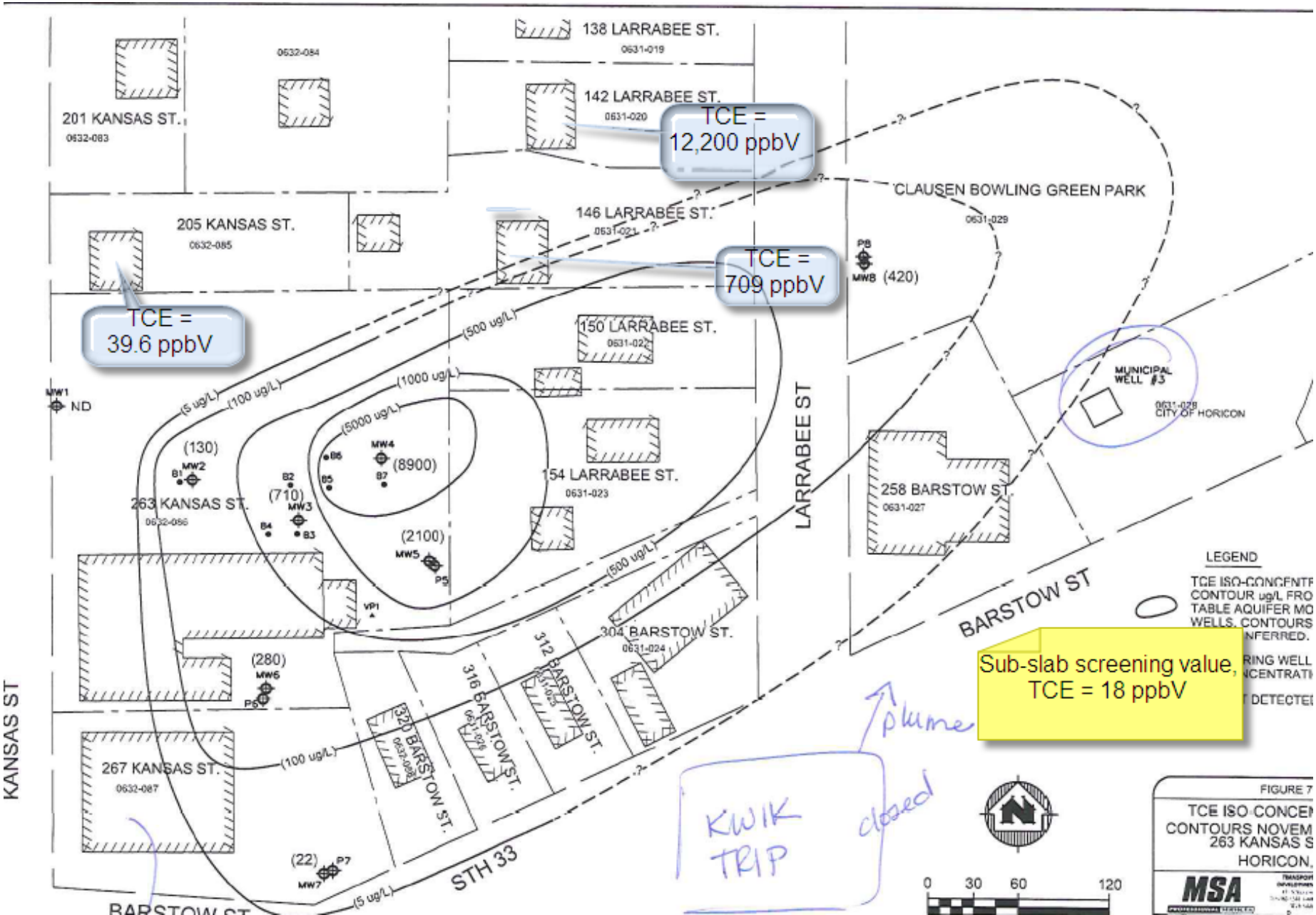
Classic Cleaners – Monona, WI



Classic Cleaners – Soil PCE (ug/kg)



Gardner Mfg – Horicon, WI



Factors to consider when evaluating off-site VI impacts

- Distance from the contaminant source
- Likelihood that sewers were involved in release
- Extent of water table contamination
- Soil type – clay less transmissive of vapor than sand.
  - *This is applicable where significant clay layer exists between contaminated groundwater & building*
- Aerobic degradability of contaminant
- Thoroughness of site investigation

VI and Vacant Land

- Recommend that closure letter include a condition requiring vapor resistant construction on any future buildings.
- Basis of this condition will be the presence of VOC residual soil or groundwater contamination remaining on-site at the time of closure. VI investigation is usually NOT done on vacant property.
  - *However, passive vapor sampling can help identify VOC sources.*
  - *Assumes vapor not migrating to off-site buildings.*

How to Assess VI Data from the Laboratory

Laboratory Methods & Parameters to report

- Most common vapor method is TO-15; TO-14a is acceptable; on-site GC/MS; others may be acceptable
- Parameter reporting:
  - *Sub-surface samples – usually report all parameters; however the target is the compound(s) released to the environment*
  - *Indoor air – report only the compound(s) associated with the release*

Sub-slab data – Gardner Mfg (TCE site)

Table 1
Sub-Slab Vapor Analytical Results Summary
Former Gardner Manufacturing / BT Squared Project #4281
(Results are in ppbv)

Sample	Date	Lab Notes	Acetone	Acrolein	Benzene	Carbon Disulfide	Carbon Tetrachloride	PCE	TCE	m-Xylene & p-Xylene
rstow #1	4/28/2011	--	13.6	<0.085	0.628	0.486	<0.085	<0.085	<0.085	1.41
rstow #2	4/28/2011	(1)	4.64	0.289	0.511	<0.085	0.211	<0.085 *IS	<0.085	1.18 *
rstow	4/27/2011	--	9.66 *QU	<0.2 *D	0.886	0.59	<0.2 *D	0.660	6.76	3.05
rstow	4/27/2011	--	19.4	<2.5 *D	<2.5 *D	3.74	<2.5 *D	<2.5 *D	9.38	18.4
rstow	4/27/2011	--	56	NA	<20	<20	<20	<20	<20	<40
rabee	4/27/2011	--	<100 *D	NA	<100 *D	<100 *D	<100 *D	<100 *D	709	<200 *
rabee	4/28/2011	(2)	3.95	0.180	0.331	0.527	<0.085	<0.085	1.40	0.693
rabee	4/28/2011	(3)	2.51	<0.085	1.62	0.649	<0.085	0.314 *IS	0.434	2.17 *
Indoor Air Concentration (risk – 10^{-5})(ug/m^3)					3.1		4.1	4.1	12	
Indoor Air Concentration (HI=1)(ug/m^3)			32,000	0.021	31	730	100	280		730
Indoor Air Conc. (risk – 10^{-5}, HI=1) ppbv			13,471	0.00916	0.97	234	0.65	0.6	2.2	168
Sub-Slab Vapor Concentration (0.1 AF)			134,710	0.092	9.7	2,340	6.5	6	22	1,680

Indoor Air – Gardner Mfg (146 Larabee)

146 Larabee	TCE (ppbV)	Attenuation
Sub-slab	709	
Basement	0.49	0.0007
1st Floor	0.303	
2nd Floor	ND	
Outdoors	ND	

What does exceedance of RSL table numbers mean?

- Screening values are used to:
  - *Determine when potentially significant contamination requires a SI*
  - *Develop remediation goals that are modified according to site-specific conditions*
- To modify, must address fundamental risk questions, such as exposure and land use assumptions.
  - *Investigators may modify the screening values for site-specific application, but they need to set out the basis for doing so, just as with soil contaminant values.*

Addressing Exceedance of RSL Table Value

- Options to address contaminants in the environment include:
  - *Cleanup of contaminant*
  - *Create a barrier (can be institutional and/or physical) to protect the public from residual contaminant*
- Vapor pathway options
  - *Cleanup source of contaminant*
  - *Physical barrier usually a radon mitigation system*
    - Can include barrier between source & receptor

When to involve DHS staff

- Contact DHS when:
  - *Indoor air concentrations exceed risk screening values (10-5 cancer risk or HI = 1)*
  - *Risk communication help is needed (e.g., consultant is reluctant to collect sub-slab samples in private homes)*
- Contact DNR staff for:
  - *Investigation approaches & techniques*
  - *Data evaluation & decisions on next steps*
  - *Funding requests if RPs can't/won't undertake action*

Involving Local Health Departments

- DHS staff in Madison involve local health departments when necessary
  - *DNR staff should work through DHS if it is necessary to involve a local health department*
- Local health departments (not DNR) make decisions regarding habitability.
  - *Local health departments can order buildings vacated or restrict certain uses*
  - *Local health staff rely on State DHS staff opinions*

Mitigating the VI Pathway

When to Mitigate the VI Pathway?

- When VI presents a risk to receptors.
  - *If indoor air in a residential setting >10^{-5} risk due to VI, mitigation is always required.*
  - *Sub-slab vapor concentrations used to make a decision on whether a risk to receptors exists.*
  - *Usually installed as an interim measure while remedy proceeds.*
  - *Guidance allows on-going monitoring of indoor air*
- If possible, remediate first to avoid mitigating.
  - *If only commercial properties involved or indoor air <10^{-5} in residential setting, may be able to delay mitigation until remedy complete & then assess need for mitigation.*

Other Vapor Mitigation Options

- High water table
  - *Even a small amount of air space (1/2”) between the water table & foundation will allow installation of SSDS.*
  - *Sealing and venting sump basin; sealing any cracks in foundation*
  - *Vent basement air*
- Building pressurization (commercial facilities)

Sub-Slab Depressurization Systems

- **Standards**: (1st 2 on DNR intranet)
  - *ASTM Standard Practice for Installing Mitigation Systems in Existing Low-Rise Residential Buildings (E2121-09)*
  - *AARST* Active Soil Depressurization Radon Mitigation Standards for Low-Rise Residential Buildings (2006, draft)*
  - *EPA's Radon Mitigation Standards (1994) has been superseded by the ASTM Standard E2121.*

** American Association of Radon Scientists and Technologists*

Sub-Slab Depressurization Systems

- Design & proper installation are the responsibility of radon contractors
- "Radon Mitigation System Inspection Checklist" on DNR intranet.
  - *Use this if you inspect a sub-slab depressurization system or need information on basic construction & operation criteria.*
  - *http://intranet.dnr.state.wi.us/int/aw/rr/gen_resources/radon_Mtg_checklist.pdf*

Communication Testing

Drill small hole(s) in slab and insert a micromanometer. Pressure difference between indoor and sub-slab pressure should be 6 – 9 Pa or 0.025 to 0.035 inches water column. (ASTM standard)

Verification testing of SSDS

- Communication tests:
  - *If sub-slab soils are permeable, communication tests can be run after system installation*
  - *Wet or tight sub-slab soils – may need to wait a number of weeks to months to test communication*
- Indoor air testing (where needed)
  - *Wait 3 months after system installation*
  - *1 test adequate if system operating effectively*

What if SSDS “doesn’t work”

- 1st - Communication test to establish that a pressure differential exists beneath slab
  - *Additional SSDS may be necessary*
- 2nd - ID other possible sources of vapor
  - *Sidewall of basement?*
  - *Entraining vapors from adjacent facility or outdoor air?*
  - *Indoor sources?*

Operational Responsibilities of SSDS

- The property owner is responsible for operating the SSDS after installation.
  - *WI State Stats, chap 292.11 and 292.12*
  - *The property owner can enter into a legally enforceable agreement with the RP for maintenance of the SSDS*
- If DNR installs an SSDS, the property owner is expected to continue operations.
- Systems are considered permanent part of building. We do not anticipate shutting SSDS off.

Operational Responsibilities of SSDS

- Closure letter template refers to “property owner” for maintenance of cap, VMS. However statute allows closure conditions to be placed on building “occupants”.

  292.12(5), Stats. - Compliance with requirements and limitations.

  (a) - property owner (maintenance of an engineering control, si/ra if structural impediment removed, unless contract with another person (RP))

  (b) - property owner or occupant (limitations or conditions imposed in accordance with rules)

Vapor Intrusion & Closure

Closure issues

- Is there a fee if there are no soil or groundwater issues & vapor is the only continuing obligation?
  - *No.*
- Can sites be listed on the GIS registry for vapor alone?
  - *Yes – but the DNR must put the GIS packet together and no fee can be charged.*
  - *If a VMS is in place, the site will go on the GIS for a continuing obligation, but no fee will be charged or a GIS package submitted. (i.e., DNR will prepare the GIS package.)*
  - *Processing GIS package: must ID either soil or groundwater contamination. Ask GIS Team member which route to include.*

Closure issues

- Can industrial zoning be required where vapors are above residential standards on an industrial property?
  - *Yes. Authority: s. NR 726.05(8) (a) 3. allows site-specific conditions at closure.*

Closure issues

- How is a continuing obligation for an off-site property owner (OSPO) documented in the closure letter, BRRTS & the GIS?
  - *Closure letter must specify the name & address where the system is located and that the property owner is responsible for O&M.*
  - *Property owner receives a specific letter (currently no template for this) as well as a copy of the closure letter*
  - *OSPO only shows up on GIS (not BRRTS) with a red dot & address only available on GIS*
  - *Address information is collected on Form 4400-246, Off-Source Property Owner (GIS pkg)*

Closure issues

- Examples of sites closed with VI continuing obligations
  - *Do a BRRTS search for code 11 (closure) and 226 (VI conditions)*
  - *Silver Spring Terrace (closed DC with VMS): \\central\efiles\SER\Milwaukee\02 ERP\0241191377\0241191377.pdf*
  - *Jomblee (active DC with VMS):*

    \\central\efiles\SER\Milwaukee\02 ERP\0241543523\0241543523.pdf
  - *Pioneer Mini-mart (off-site VMS recommended):*

    \\central\efiles\NER\Fond du Lac\02 ERP\0220550928\0220550928.pdf

Miscellaneous

What vapor concentration indicates the possible presence of NAPL?

- Saturated vapor concentration is the maximum amount of contaminant that can exist in vapor.
- Pure product is indicated by a few % of saturated vapor concentration

Compound	Saturated Vapor Conc. ($\mu g/m^3$)	Indicator of NAPL (5%) ($\mu g/m^3$)
PCE	1.3×10^8 $\mu g/m^3$ (19,000 ppmV)	6,500,000 $\mu g/m^3$ (2,000,000 ppbV)
TCE	4.2×10^8 $\mu g/m^3$ (77,000 ppmV)	21,000,000 $\mu g/m^3$ (3,850,000 ppbV)

Vapors from water supply system vs. vapor intrusion

- Risk from dermal/inhalation = oral risk from water supply
  - *At 10^{-4} risk in water supply, DHS issues a flush only advisory due to risk from vapor exposure*
- Risk from vapor intrusion pathway evaluated using very similar equations, slope factors, etc. as used to evaluate risk from drinking & groundwater. (See link below)

  http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/equations.htm

Helpful References

- DNR intranet: http://intranet.dnr.state.wi.us/int/aw/rr/gen_resources/tech.htm#vapor2
- Clu-In Vapor Page: http://clu-in.org/issues/default.focus/sec/Vapor_Intrusion/cat/Overview/