Stoltz, Carrie R - DNR

From: Stoltz, Carrie R - DNR
Sent: Thursday, April 11, 2024 7:02 AM
To: Dave Larsen
Subject: Minocqua Cleaners PRG Decision from April 4, 2024
Attachments: Investigation of Preferential Pathways & Utility Corridors RR-649.pdf

Good morning, Dave. Last week, the Northern Region Peer Review Group (PRG) reviewed the closure for the Minocqua Cleaners (02-44-000113) site. The PRG paused the closure request until the following items are addressed. If you have any questions, please feel free to contact me.

Vapor Intrusion Investigation:

- Additional sub-slab sampling is needed, per RR-800, and should be completed in conjunction with indoor air sampling. The DNR recommends passive indoor air sampling (CVOCs only), though a summa canister with 8-hr. flow controller could also be utilized. Prior to sample collection, please remove any items that may contribute VOCs to indoor air (e.g., cleaning solutions, ski/other waxes, etc.).

- No further sampling of the sink p-trap is needed at this time.

- To evaluate potential vapor contaminant migration within utility corridors beyond the source property, vapor samples should be collected from the sanitary sewer line located directly east of the site, per the attached DNR guidance document RR-649 (*Guidance for Documenting the Investigation of Human-made Preferential Pathways Including Utility Corridors*).

Please provide vapor sampling results to the DNR within 10 business days of receiving them, per Wis. Admin. Code sec. NR 716.14. After reviewing the results, the DNR will determine if additional vapor investigation activities are warranted.

**Upon approval, please update all vapor intrusion related areas of form 4400-202.

Technical Revisions needed:

Form 4400-202

Please provide a PFAS Scoping Statement
Please revise all soil related areas in Form 4400-202 and explain the process(s) which took place historically. See Attachment B below.
Page 4 of 13:Please update 3Bi and 3Bii. These items still need further explanation. See Attachment B below.
Page 12 of 13: please update the notifications table to include the Elizabeth Goldbach Trust Property. Please see Attachment G below.

Attachment B:

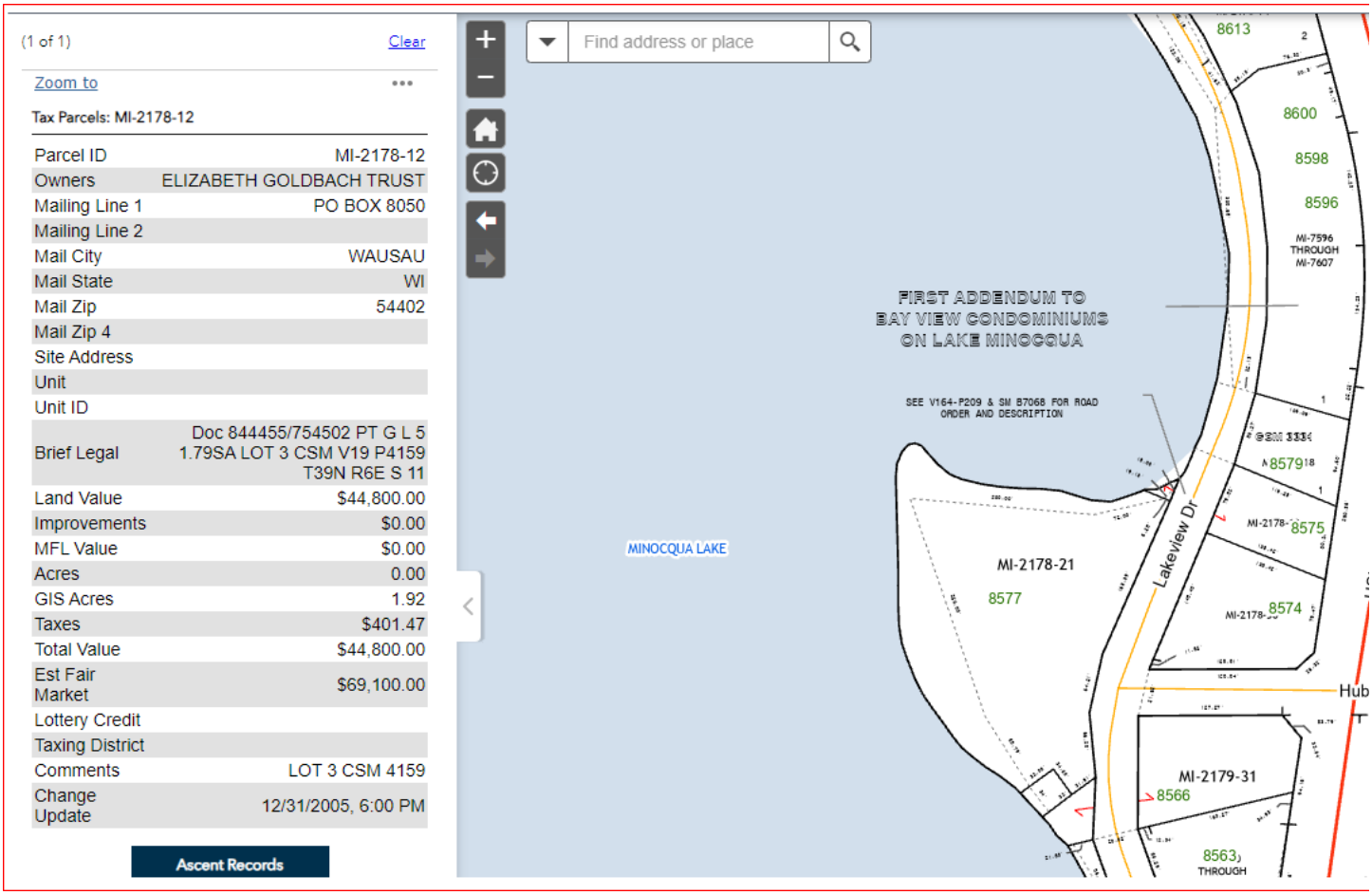
- Please prepare a soil figure(B.2.b) based on the DNR and other consultant's historic soil investigations. This figure should depict where residual soil contamination would be found You could use the PALs area as shown on Figure B.3.a.1.
- Update Attachment B Table of contents to reflect the revision above (B.2.b)

Attachment C:

- Table of Contents: C.6. Other-please label to match the corresponding figures (C.6.a thru C.6.e.)

Attachment G:

- Please notify the owner(s) of Serenity Trail (directly east of the Site) of residual groundwater contamination. GP- appears to be located on the Elizabeth Goldbach Trust Property. Please refer to Figure B.3.
- Update Table of Contents



(1 of 1) Clear

Zoom to

Tax Parcels: MI-2178-12

Parcel ID	MI-2178-12
Owners	ELIZABETH GOLDBACH TRUST
Mailing Line 1	PO BOX 8050
Mailing Line 2	
Mail City	WAUSAU
Mail State	WI
Mail Zip	54402
Mail Zip 4	
Site Address	
Unit	
Unit ID	
Brief Legal	Doc 844455/754502 PT G L 5 1.79SA LOT 3 CSM V19 P4159 T39N R6E S 11
Land Value	$44,800.00
Improvements	$0.00
MFL Value	$0.00
Acres	0.00
GIS Acres	1.92
Taxes	$401.47
Total Value	$44,800.00
Est Fair Market	$69,100.00
Lottery Credit	
Taxing District	
Comments	LOT 3 CSM 4159
Change Update	12/31/2005, 6:00 PM

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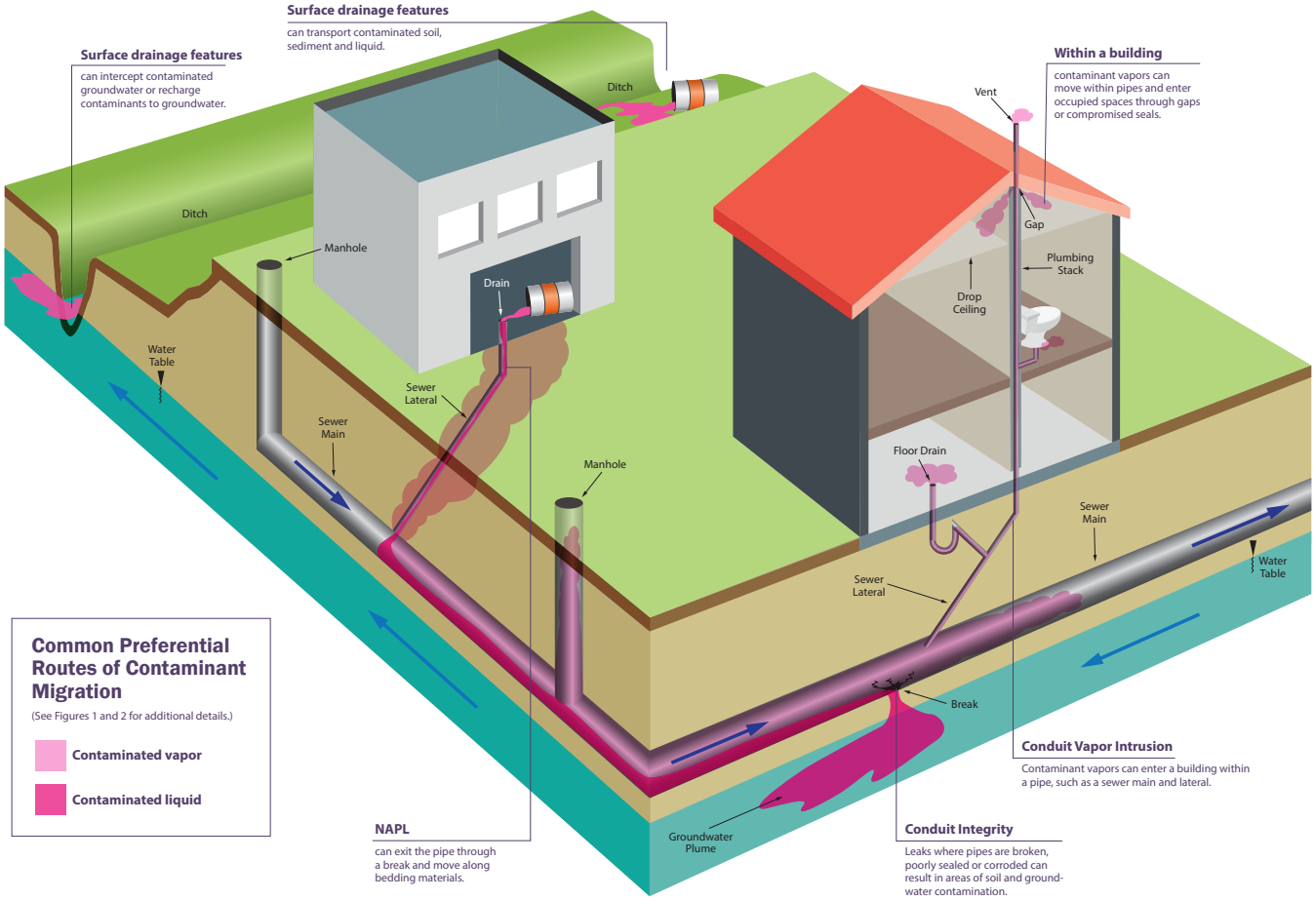
Carrie Stoltz
Hydrogeologist-Remediation and Redevelopment, EM Division
Wisconsin Department of Natural Resources
107 Sutliff Avenue, Rhinelander, WI 54501
Cell Phone: (715) 360-1966
Fax: (715)365-8932
Carrie.Stoltz@Wisconsin.gov

dnr.wi.gov

Guidance for Documenting the Investigation of Human-made Preferential Pathways Including Utility Corridors



Purpose

This guidance is for persons who perform and document investigation and remediation of sites with environmental contamination under Wisconsin Administrative Code (Wis. Admin. Code) chs. NR 700-799, including the Wisconsin Department of Natural Resources (DNR) staff who review such submittals. This guidance document presents ways that utility corridors and other human-made preferential pathways can influence contaminant migration, and methods to assess and options to sample these pathways to meet the requirements of Wis. Admin. Code § NR 716.11(5)(a).

Vapor migration through human-made preferential pathways and utility conduits is of particular importance. These preferential pathways may allow contaminant vapors to move from source areas into buildings, and to migrate beyond plume boundaries and historically recommended screening distances. **This document focuses on vapor migration in utility conduits, but also relates to the preferential migration of contaminated groundwater, soil or surface water in human-made features.**

Publication: RR-649
dnr.wi.gov Search: vapor

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Figures

Related DNR Guidance

The following documents may also be useful:

- RR-800, *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin*
- RR-598, *When Contamination Crosses a Property Line*
- RR-986, *Sub-Slab Vapor Sampling Procedures*

DNR publications and forms referenced in this document include a number beginning with "RR-" or "4400-". To locate these files, visit dnr.wi.gov and search for that number.

Abbreviations Used in This Document

CSM	conceptual site model
DNR	Wisconsin Department of Natural Resources
EPA	Environmental Protection Agency
FLIR	forward looking infrared radar
GC/MS	gas chromatography / mass spectrometer
HVAC	heating, ventilation, and air conditioning
NAPL	non-aqueous phase liquid
PID	photoionization detector
PM	project manager (DNR)
ROW	right of way
RP	responsible party
RR	Remediation and Redevelopment Program
SSGSL	sanitary sewer gas screening level
TCE	trichloroethylene
USGS	United States Geological Survey
VAL	vapor action level
VRSL	vapor risk screening level
Wis. Admin. Code	Wisconsin Administrative Code
Wis. Stat.	Wisconsin Statutes

Definitions

Attenuation factor means the ratio of the indoor air concentration arising from vapor intrusion to the subsurface vapor concentration at a point or depth of interest in the vapor intrusion pathway. (Wis. Admin. Code § NR 700.03(1s))

Conduit is a subset of preferential pathways that provide little to no resistance to fluid or vapor flow. For example, vapors easily flow through sanitary sewer pipes, or other drains or conduits.

Drainage improvements or features are elements designed to move surface water or groundwater away from an area. These can include surface features such as ditches and subsurface features such as drain tiles.

Preferential pathway is a general term used to define all high-capacity transport pathways for vapors in the vadose zone or for groundwater flow[1]. Examples of natural preferential pathways are bedrock fractures, sand lenses and rodent tunnels. Human-made preferential pathways include utility corridors as described below and features within a building such as sumps, floor drains, plumbing vent pipes and plenums. In this document, "preferential pathway" refers to utilities and other human-made preferential pathways.

Sanitary sewer gas screening level (or SSGSL) is the recommended concentration of vapors in a sanitary sewer main (typically collected from a manhole) to use in assessing whether to test nearby buildings for vapors. The concentration is determined by dividing the indoor air vapor action level (VAL) for buildings served by the sanitary sewer by 0.03.[2] This concept is similar to the sub-slab vapor risk screening level (VRSL). Unlike the sub-slab VRSL, the same 0.03 attenuation factor is used for all types of buildings because the sewer gas traps designed to prevent intrusion of sewer gases are similar for all types of buildings. However, because the VAL is different for residential versus non-residential properties, the SSGSL will also be different.

Spatial variability occurs when a quantity that is measured (such as contaminant concentration) at different spatial locations exhibits values that differ across the locations.

Temporal variability occurs when a quantity that is measured (such as contaminant concentration) at a constant location varies over time.

Utility corridor means an underground or buried utility line or pipe (conduit), including any bedding or excavated and subsequently backfilled trench, in which the utility line or pipe was constructed or placed. Utility corridors include but are not limited to sanitary and storm sewers, utility tunnels, water lines, gas lines, sewer force mains, buried electric power distribution lines and buried telephone, cable television or telecommunication lines. Utility corridors are present in public rights of way (ROWs), including streets or roads, as well as on the properties being served by the utilities.

Utility lateral refers to the piping systems that run from a property to the primary systems, normally located within the street. For wastewater systems, the "sewer lateral" is the wastewater connection between a building's wastewater drain facilities and a public sewer.

Vapor action level (or VAL) means the concentration of vapors from volatile compounds is at or above the 1−in−100,000 (1x10E-05) excess lifetime cancer risk or is at or above a hazard index of 1 for non−carcinogens. (Wis. Admin. Code § NR 700.03(66p))

Vapor risk screening level (or VRSL) means the concentration of vapors in samples collected outside a building to estimate indoor vapor concentrations. The VRSL is equal to the VAL divided by an appropriate attenuation factor. (Wis. Admin. Code § NR 700.03(66w))

Applicability

Wis. Admin. Code § NR 716.11(5)(a) requires field investigations to evaluate all potential pathways for migration of contamination, including drainage improvements and utility corridors. Contaminants migrate preferentially through zones of higher permeability, which include natural features such as fractures in bedrock and sand layers in finer-grained clay till. Human-made features may provide additional pathways of preferential flow both inside and outside buildings. For a site investigation conducted under Wis. Admin. Code ch. NR 716 to be considered complete, preferential flow paths near contaminants must be evaluated. Evaluation starts by incorporating the known and potential preferential pathways into the conceptual site model (CSM) and documentation in a site investigation work plan or report. When preferential pathways are identified as a potential route for contaminant migration at a site, sampling is required to determine if contaminants are moving through them.

Acute Risk Concerns

Wis. Admin. Code § NR 708.11 requires responsible parties to evaluate the need for an interim action if there is a threat to public health. Wis. Admin. Code § NR 708.05(2) requires responsible parties to take immediate action if there is an imminent threat (e.g., acute risk) to public health.

Access to Utilities

Contaminants migrating through preferential pathways commonly cross property lines. Responsible parties (RPs) are required by Wis. Admin. Code § NR 716.11(5) to investigate the extent of contamination regardless of whether it crosses a property line. However, RPs should obtain permission to enter properties from all property owners prior to conducting an investigation, including right of way (ROW) holders. See RR-589, *When Contamination Crosses a Property Line*, for more information.

Wisconsin Statute (Wis. Stat.) § 182.0175 requires excavators, except those performing utility work, to maintain minimum clearance distances from utility lines and associated facilities (both underground and above ground). Investigators should work closely with utility owners when performing work near or within underground utility pipes and lines and obtain any necessary permission. Investigators should also consult the Diggers Hotline at diggershotline.com for utility locations.

Notification of Sample Results and Activities

Utility corridor investigations may reveal the presence of contamination on off-site properties. Sample results for vapor and other media collected from the site and any off-site properties, including within ROWs, must be shared with the DNR, property owners and occupants within 10 business days of receiving the results per Wis. Admin. Code § NR 716.14, unless otherwise approved by the DNR.

Additional public participation and notification requirements are specified in Wis. Admin. Code § NR 714.07. RPs are required to evaluate the need for and level of public participation and notification appropriate for the site. Situations where contamination is migrating off-site and affecting a large area or large number of properties may warrant more involved public participation and notification activities.

Trichloroethylene (TCE) – Special Concern

TCE may pose a health risk to a developing fetus if contaminant concentrations exceed the Vapor Action Level (VAL) in air even during brief periods of time.[3,4,5,6] If TCE is present, the responsible party should quickly determine whether women of childbearing years are being exposed to TCE vapors above the VAL.

Because migration of contaminants through utility conduits can result in rapid swings in indoor air concentrations, it is particularly important to identify preferential pathways at sites with TCE contamination. Assessing temporal variability is more important if TCE is present.

TCE and other contaminants may pose an acute health risk to *all persons* if present at high enough concentrations in indoor air. Visit dnr.wi.gov, search "vapor" for additional information on the acute health risks from TCE and other contaminants. See RR-800, *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin*, for detailed information about vapor intrusion, screening, investigation, immediate and interim actions and mitigation.

DNR Assistance

It is important to work with the DNR Project Manager (PM) assigned to an individual site. Beyond general discussions, the DNR can provide detailed technical assistance for a site when a responsible party submits Form 4400-237, *Technical Assistance, Environmental Liability Clarification or Post-Closure Modification Request*, with the associated fee in accordance with Wis. Admin. Code ch. NR 749. General questions on preferential pathways not associated with a specific site can be directed to state or regional DNR vapor intrusion specialists listed on under the "contacts" tab on the Vapor Intrusion Resources for Environmental Profressionals web page.

Additional assistance for environmental professionals on communicating with affected off-site property owners and communicating information on vapor intrusion to the public is available on the Resources for Environmental Professionals web page and the Vapor Intrusion Resources for Environmental Professionals web page.

Investigation Overview

An overview of the investigation of common preferential pathways is described in this section. The route of contaminant migration can be complicated and may involve more than one preferential pathway. For example, a contaminant may have been disposed into a sewer as a liquid, migrated within the sewer in vapor form into a nearby building, and leaked out of the sewer in liquid form elsewhere, causing additional soil and groundwater contamination (see Figure 2 for an example).

Evaluating contaminant migration in utilities and other human-made preferential pathways differs from an iterative soil and groundwater investigation to define the degree and extent of contamination. See the flowchart in the Appendix, *Investigating Utility Corridors and Other Human-Made Preferential Pathways*, for a visual representation of a typical preferential pathway investigation.

Preferential Pathways – Buildings

Certain features associated with buildings can provide discrete points of entry for contaminants into the building (e.g., sumps, floor drains). Some examples are shown on Figure 1 below. A more inclusive list of examples is under "Building Features" in the box on page 8.

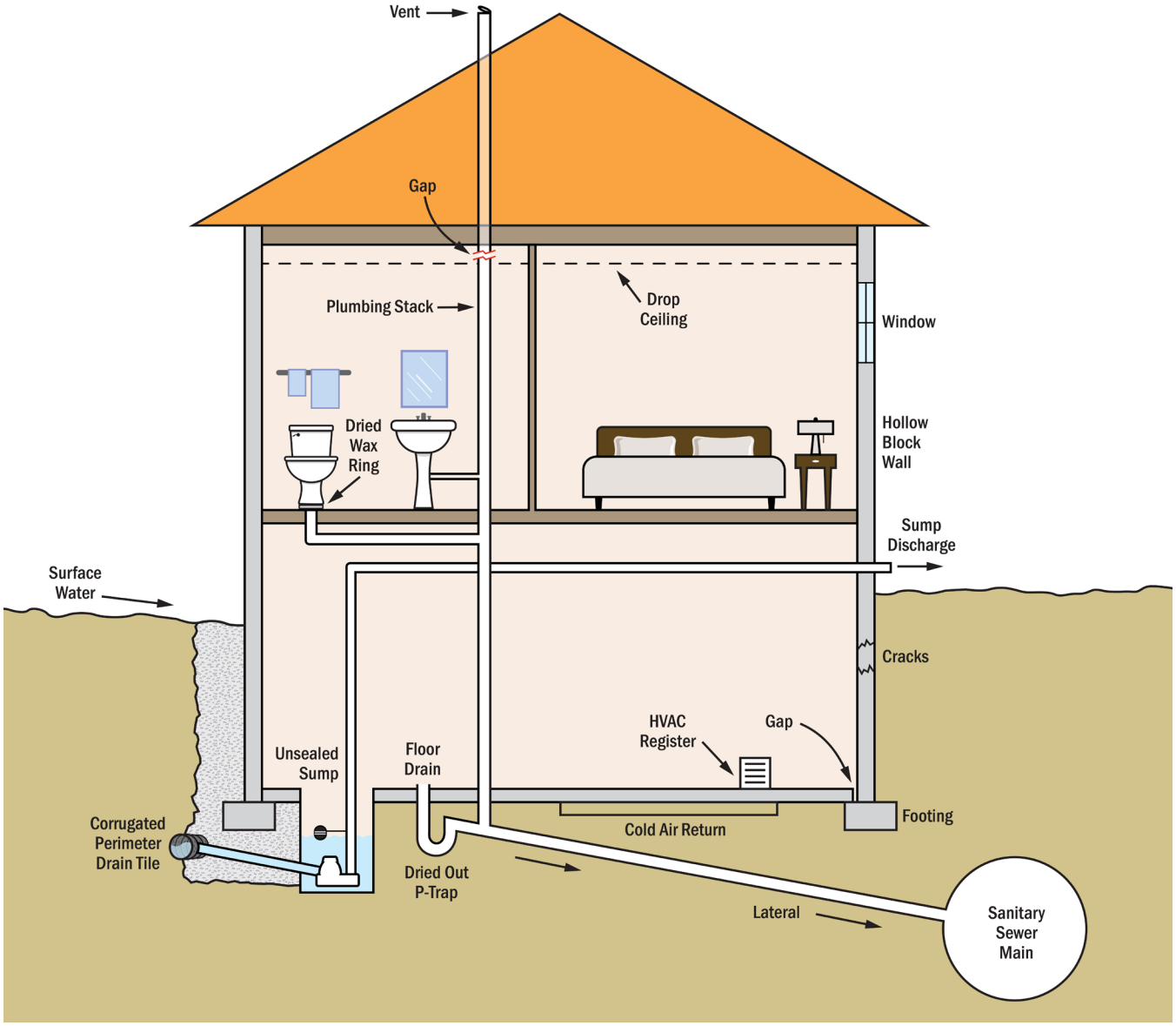


Figure 1: Examples of human-made preferential pathways — buildings

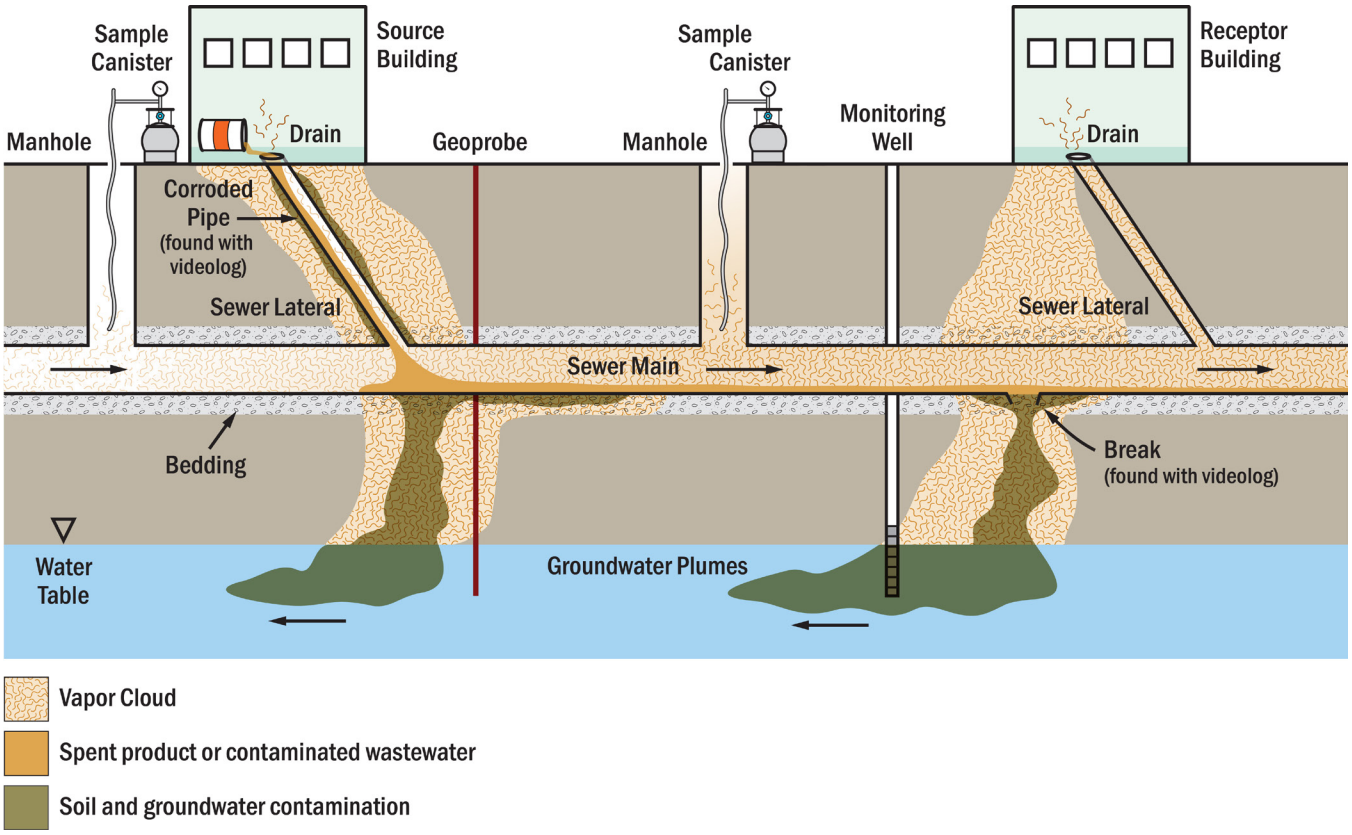


Figure 2. Examples of Preferential Pathways and Investigation - Utility Corridors

Preferential Pathways – Utility Corridors

Utility corridors can allow contaminants to migrate and impact buildings, soil, groundwater and surface water long distances from the source or at locations that differ from the direction of groundwater flow. Assessment for contaminant migration within utility conduits, through utility conduit leaks, within bedding materials and into potable water mains may be necessary. This is described further below.

CONTAMINANT MIGRATION WITHIN UTILITY CONDUITS

Contaminants may have been disposed directly into a utility conduit (e.g., sanitary or storm sewer). In other cases, the contaminant enters the utility conduit from contaminated soil or groundwater sources through compromises in the pipe that are a result of corrosion, poor fittings, breaks, etc. The risk for migration through a utility conduit depends on the concentration, volume and type of contaminants. Liquid and volatile contaminants are the most likely to migrate.

If contaminants are found within a utility conduit that is designed to convey fluids (e.g., sanitary sewer), the utility can carry the contaminant far from the source. Contaminated liquid can flow long distances by gravity and even farther if pumped within a force main; contaminated vapor from that liquid can migrate several hundred feet farther.

If the contaminated utility is connected to a building, the utility can provide a direct route of entry for contaminated liquids or vapor into a building. A common example is vapor intrusion into buildings through a sanitary sewer pipe where solvents were historically disposed.

At sites where disposal took place many years ago and contaminated liquid or sludge no longer remains within the pipe, the contaminated pipe and surrounding bedding (material placed in the bottom of the trench on which the pipe is laid) can still pose a risk. Vapors from these contaminated materials can migrate through the pipe into occupied structures.

CONTAMINANT MIGRATION THROUGH UTILITY CONDUIT LEAKS

Contaminants disposed into or entering a utility conduit such as a sanitary sewer can leak into the surrounding bedding and soils along the flow path if the sewer pipe is compromised. Leaks from a compromised sewer pipe can result in soil, groundwater and vapor contamination at a down-flow location. At some sites in Wisconsin, contamination leaked from sewer pipes and caused significant soil and groundwater contamination which resulted in a vapor intrusion risk more than a quarter mile from the source property. Many sewer pipes, particularly older ones, have insufficient integrity to prevent leaks. Leaks can occur at poorly sealed connections or cracks. Some contaminants can permeate through pipes (particularly clay tile or concrete) or corrosive contaminants can enhance pipe degradation. This may occur especially where pipes have settled.

CONTAMINANT MIGRATION WITHIN BEDDING MATERIALS

Bedding and backfill materials for utility corridors often have properties that allow migration of contaminants more readily than the native materials that surround them. Preferential movement of vapor can occur in bedding materials in some situations (e.g., short distances along sewer laterals, strong pressure gradients); however, few investigations have documented vapor movement at significant distances in unsaturated bedding materials.[2,7] Migration within the utility pipe rather than the surrounding bedding is currently recognized as being a prevalent concern for contaminant vapor migration.[2]

POTABLE WATER MAINS

It is possible for contaminants to be drawn into a pipe through faulty joint seals if contaminated soil or groundwater comes into contact with a potable water main. Although water mains are normally pressurized, pressure transients from service outages, pumping by fire departments, and pressure transients from changes in demand can induce inward flow. These are likely atypical situations. However, if high levels of contamination are found surrounding a water main or lateral, assessment of impact to potable water may be warranted.

Preferential Pathways – Surface Drainage Features

Surface water drainage features such as stormwater ditches and culverts, which intersect contaminated soil or groundwater, can carry contaminants and cause impacts great distances from the source. A detailed understanding of site hydrology (i.e., surface water drainage, groundwater-surface water interaction) may be necessary to determine where and how contamination is migrating.

Scoping and the Conceptual Site Model (CSM)

One of the first things assessed as part of every investigation should be whether preferential pathways exist; preferential pathways near contaminant sources must be evaluated under Wis. Admin. Code § NR 716.11(5). Preferential pathways, including vapor migration pathways, are present at most sites. Buildings have features that allow contaminants to move preferentially into, out of and within them.

Preliminary information on preferential pathways is used to develop a CSM, which informs where to conduct field work. This section describes the types of information used to create the CSM of preferential pathway contaminant movement.

Not all human-made preferential pathways will be routes of concern for contaminant migration at a site. If the evaluation during scoping concludes that a particular pathway is not of concern, collection of detailed information for that pathway and sampling may not be necessary. Documentation of this evaluation must be included in the site investigation work plan or report. For example, if low levels of petroleum contamination were detected in the soil of the ROW, further assessment of a nearby sanitary sewer may not be warranted without additional evidence of a concern (such as a non-aqueous phase liquid (NAPL) intersecting sewer bedding.)

The CSM should be updated and the investigation adjusted as the investigation proceeds. For example, the focus of a vapor investigation may initially be performing sub-slab, indoor air and utility conduit sampling on the source property. However, if during the initial investigation it appears that the utility conduits are contaminated, those conduits must be investigated beyond the property boundary as required by Wis. Admin. Code § NR 716.11(5)(a). The evaluation must determine whether the contaminated conduit contributed impacts to connected buildings or soil and groundwater beyond the source property.

Examples of Human-made Preferential Pathways

Exterior Features

- Ditching
- Drain tile systems
- Dry wells
- Excavations
- On-site waste (septic) system tanks, pipes, drain fields
- Permeable trenches
- Sanitary sewers
- Storm sewers
- Tunnels
- Utility corridor bedding for gas, potable water, electricity, telecommunication, etc.

Building Features

- Cisterns (beneath basements)
- Crawl spaces
- Earthen floors
- Floor drains
- Foundation seams, joint, cracks
- Elevator shafts
- Heating, ventilation and air conditioning (HVAC) ducts, plenums
- Pipes
- Sumps and drainage pits
- Utility penetrations
- Wall voids (such as hollow cinder block)
- Waste lines

Building Information

An effective sampling strategy necessitates identification of the location of all utility conduit routes within and near the building. The focus should be on sewers and drainage. This may include the location and depth (for some elements) of:

- floor drains,
- plumbing features connected to the sewer system (e.g., sinks, toilets),
- construction and functioning of plumbing traps,
- sewer vent pipes,
- clean-outs,
- sumps,
- drain tile system external to the building,
- sump discharge pathways and points,
- sewer laterals on the property leading to the municipal sanitary sewer main,
- abandoned laterals on the property,
- on-site waste disposal (septic) systems, and
- locations of penetrations of the building foundation by sanitary sewer lines and other utilities.

Building information may be readily available from building plans or observation. Supplemental investigation using video logging, ground-penetrating radar, metal detectors or other methods may be needed to document the location of pipes and other features, particularly in older buildings where this information may not be available.

Utility Corridor Information

VAPOR WITHIN CONDUITS

The area of evaluation for preferential pathways for vapor migration within utility corridors depends on site-specific conditions. Contaminated vapors typically decrease by 80% or more at 500 feet from the source area within sewer conduits.[2] Therefore, if vapor migration along or within a utility corridor is a concern, the DNR recommends collecting the information itemized in the list under “Bedding” (pg. 9) at least 500 feet in both an up-flow and down-flow direction from where contamination intersects a utility corridor (e.g., a groundwater plume), or from where a utility corridor is joined by any utility lateral carrying contamination.

LIQUID WITHIN CONDUITS

Liquid contaminants can travel long distances within conduits. Contamination from leaking sewers has resulted in significant soil, groundwater and vapor contamination more than a quarter mile from where the contaminant entered the sewer system. The area of evaluation should be based on site-specific knowledge of disposal practices, contaminant type and utility characteristics (such as age and construction of pipe materials). For liquid contaminants that do not present a vapor risk, only information in a downflow direction is recommended.

BEDDING

If contamination in the gas or liquid phase intersects utility corridor bedding, the area of evaluation should be based on site-specific knowledge of disposal practices, contaminant type and utility characteristics (slope, characteristics of the bedding material, differential transport characteristics between the bedding and native material.)

The following information should be obtained for the area where there is a possibility of a utility migration pathway for each of the three situations described above:

- plan view with respect to source area
- depth of utilities
- date(s) of construction
- pipe materials
- bedding materials (grain size, thickness)
- flow directions
- locations of laterals
- locations of manholes
- history of cleaning, repair or video-logging since construction
- planned upgrades or maintenance
- abandoned laterals or other features
- relationship of utilities including bedding to groundwater

The local municipality (e.g., city engineer or public works) is a source for utility corridor information. Other possible sources of information include utility maps, soil maps, results from other nearby investigations and historical use maps, including fire insurance maps and United States Geological Survey (USGS) topographic maps. Field investigation may be needed to fill in data gaps when this information is not available.

Contaminant Information

It is recommended that the CSM address the following questions regarding the nature of the contaminants:

- Are vapor-forming contaminants present?
- Is TCE present?
- Is it likely that contaminants were disposed into utility conduits?
- Is free product migration likely?
- Are explosive conditions likely?
- What receptors could be impacted?
- Do the contaminants present a corrosive risk to conduit integrity?
- Are the liquid or vapor transmitting characteristics of the bedding materials substantially different from the surrounding native soils?
- Does indoor air data suggest a preferential pathway is allowing contaminants into occupied spaces? (See sidebar.)

Indoor Air Data Indicates a Preferential Pathway

Indicators that conduit vapor intrusion may be occurring include situations where indoor air concentrations in a building are higher in rooms serviced by utilities, higher in upper levels of a building, or are high compared to data from sub-slab vapor ports. In such cases, a more in-depth inventory of potential indoor air sources and the potential for conduit vapor intrusion should be further evaluated.

CSM for Vapor Intrusion

CSMs for vapor intrusion have historically focused on migration of contaminant vapors through the soil and entry into buildings through cracks in the foundation. Investigations typically assessed buildings by collecting sub-slab samples and indoor air samples in the lowest level of the structure based on this CSM. However, recent studies have shown that preferential flow of vapors into buildings within utility conduits, primarily sanitary sewer pipes, is common and should be included in the CSM for vapor intrusion.[8,9,2] Typical sub-slab to indoor air sampling strategies, although still important, may miss other routes of exposure to contamination with equal or more severe health risk that must be mitigated. For example, higher levels of contamination within indoor air than within sub-

slab vapor may be incorrectly attributed to indoor sources from general consumer products if the potential entry of contaminant vapors through utility conduits is not evaluated.

Vapor intrusion through preferential pathways can occur within buildings on the source property, as well as affecting off-site properties. The recommended strategy for assessing the role of preferential pathways is:

1. assess preferential routes into buildings close to the source (from contaminated soil or groundwater);
2. determine whether utility corridors are taking contaminants farther away from the source, particularly beyond the limits or direction of the groundwater plume; and
3. assess buildings served by those utilities.

Once a volatile contaminant enters a utility conduit, vapors can move by diffusion or differential pressure into the buildings served by those conduits. Plumbing traps are designed to prevent intrusion of sewer gases into buildings. However, dry plumbing traps at infrequently used plumbing fixtures, loose connections and cracks in vent pipes can allow contaminant vapor intrusion into indoor air. Concentrations of contaminants above VALs can be present even when a sewer gas smell is below the odor threshold.[9] Deviations from plumbing codes and other types of conduits (such as large utility vaults) can act as pathways for vapor intrusion. Cracks in sub-slab pipes can also result in vapors accumulating beneath the foundation, allowing for more typical through-the-foundation vapor intrusion.

Although all buildings have preferential pathways (e.g., some degree of foundation cracking, utility penetrations), these may not always be pathways for significant movement of vapors into occupied spaces. Vapor intrusion through these pathways is a greater concern when advective (pressure) gradients have little resistance to flow from the source, such as from a highly contaminated sewer lateral into a home through a leaky plumbing vent stack. When diffusion controls vapor movement and the contaminant source is some distance, such as a deep groundwater plume, a preferential pathway such as a sump may not provide a significant source of vapor intrusion, and typical assessment strategies (sub-slab and indoor air sampling) may be sufficient. However, as the source distance decreases and source strength increases, so does the concern for exposure to contaminant vapors through preferential pathways. Larger and more complicated building layouts are more likely to have spaces differentially affected by preferential pathways.

High concentrations of contaminants behind plumbing traps present an additional concern. There may not be a current indoor air quality problem if the plumbing traps are functioning adequately at the time of initial assessment; however, exposure to contaminant vapors without notice or detection may occur if the integrity of pipes or traps is compromised in the future.

Investigating Preferential Pathways for Contaminant Migration

General Investigation Principles

A field investigation should evaluate likely routes of migration identified during preparation of the CSM and utilize appropriate sampling methods, which may include surface water and surficial soil sampling, soil borings, groundwater monitoring wells, gas probes, geophysical assessment, sub-slab vapor, indoor air, etc., depending on site-specific conditions.

Contaminant movement via preferential pathways can occur in very discrete zones. Sampling *near* a utility line may not be sufficient to assess the pathway. For example, a soil boring or gas probe located a few feet from a utility line may not be representative of contaminant concentrations in the utility bedding. However, ensuring representative sampling will often have to be balanced against potential damage to the utility line.

Investigating Conduit Integrity

If contaminants were disposed into a utility conduit, the integrity of that conduit should be assessed, if possible, to help determine whether leaks into the subsurface through the conduit wall are likely and where this may have occurred. Without such information, sampling outside the conduit can miss significant zones of impact. Video logging of utility conduits is a commonly used method and can identify zones of breaks, sags, corrosion or other discontinuities where leaks outside the conduit were more likely to have occurred. Locations where pipes join

(e.g., lateral to sanitary sewer main or at elbows) are often where leaks occur. Other useful techniques include pressure testing, smoke testing and tracer testing. When laterals are short, the investigation often proceeds directly to sampling soils and groundwater or bedding surrounding the pipe (see "Investigating Utility Bedding," pg. 11).

How far the investigation should be taken will depend on the known or suspected discharge(s), any historical disposal and history of utility repair or replacement. If larger quantities of contaminants or longer periods of discharge or disposal are suspected, the likelihood of migration beyond the property boundary increases. In most cases, pipes beneath the source building leading from drains and the sanitary sewer lateral from the source building to the sewer main should be the initial focus. Although direct disposal of contaminants into a compromised utility conduit is a common scenario, contaminants from a groundwater or a NAPL plume may also enter a conduit, making assessment of conduit integrity and exterior sampling down-flow necessary.[2]

Investigating Utility Conduits

Situations where utility conduits may play a role in contaminant migration beyond the source property include the following:

- Disposal of contaminants directly into sewer lines is known or suspected
- Conduits intersect contaminated groundwater
- Conduits intersect contaminated soil in the vadose zone

If contamination is identified within a utility conduit on the source property, or disposal of contaminants into a conduit system is known or suspected, the conduit must be assessed beyond the property boundary in accordance with Wis. Admin. Code § NR 716.11(5)(a). Sampling within the conduit in the ROW or adjoining property is commonly needed. Sampling of liquids and solids within the conduit may be useful for certain contaminants; however, when vapors from volatile contaminants are a concern, sampling vapor directly yields the best data for assessing vapor migration. Most sanitary sewer conduit vapor investigations have not found a strong correlation between the liquid and vapor concentrations. See section on ROW Assessments under Investigating Preferential Pathways for Vapor Intrusion below for details on scoping a vapor investigation in the utility conduits.

Investigating Utility Bedding

Once an area of possible utility conduit compromise has been identified or the utility bedding has been identified as a potential preferential migration pathway, sampling should be performed in the conduit bedding and surrounding soil and groundwater. Sampling of soil, liquid and/or vapor in bedding materials can provide useful information about the presence of contaminants in backfill materials. Passive gas samplers may be an option when other investigation techniques (e.g., borings close to a utility line) are difficult. For more references on passive vapor sampling, visit dnr.wi.gov, search "vapor."

Vapor samples collected from utility bedding can provide qualitative information; however, given the variable nature of vapor concentrations in such an environment this data should not be used to make risk decisions relating to nearby structures without additional lines of evidence.

If contamination is found surrounding utility conduits that extend to the property boundary, the extent of impact along the utility main must be determined as required by Wis. Admin. Code § NR 716.11(5)(a).

Investigating Surface Drainage Features

Investigating surface drainage features can be straightforward. Access is typically less difficult than with subsurface media and contamination may be visible. Standard soil and water sampling techniques can be used in these situations.

In some situations, investigating surface draining features may be more complex. Surface drainage features that intersect soil or groundwater contamination may transport and discharge contamination to groundwater downstream or discharge contaminants to other surface water features. In these situations, understanding surface-groundwater interactions within the drainage feature may be required. Sampling techniques such as, active and passive sampling methods for surface water, pore water (transition zone) and groundwater are available. Water quality parameters including temperature, specific conductance, dissolved oxygen, pH, turbidity and redox potential may also provide valuable information when evaluating contaminant migration pathways.

Investigating Preferential Pathways for Vapor Intrusion

SOURCE BUILDING ASSESSMENT

Buildings near the source of contamination are likely to be at highest risk of vapor intrusion through preferential pathways. Sub-surface pipes may intersect contaminated soil or groundwater and disposal of contaminants into drains may cause contamination of the pipes and/or discharge to the surrounding bedding materials. The pipe or bedding can allow vapor movement back into the source building.

Conduits within the building should be evaluated based on:

1. knowledge of operational history,
2. evidence of disposal (such as staining around drains), and
3. known distribution of contaminants (e.g., soil, groundwater or vapor contamination that appears to correlate with sewer pipes).

If chlorinated solvents were detected at the source property, evaluation of drains at sites with land uses other than dry cleaning is advisable. The field investigation at source properties can include the strategies described below.

It is highly likely that disposal to the sewer occurred for some types of operations such as dry cleaners.[10,11,12] **Utility corridors, including source property drains and laterals, must be evaluated at dry cleaner sites in accordance with Wis. Admin. Code § NR 716.11(5).**

Collect Conduit Vapor Samples (sewer/plumbing systems)

The goal of vapor sampling within utility conduits is to assess whether vapors are preferentially entering occupied spaces via conduits or have the potential to enter occupied spaces if plumbing traps or pipes become compromised. In most cases this can be accomplished by sampling air within the conduit through clean-outs. A site-specific device may need to be configured to collect a representative sample. In most cases, it is appropriate to collect conduit vapor samples as a grab sample (that is, without the use of a flow controller). A one-liter evacuated cannister will be sufficient in most circumstances.

Clean-outs: Clean-outs are normally found in the interior of the building but may also be present externally. The clean-out cover should be removed and a temporary cover installed over the opening that allows insertion of a tube for collection of the vapor sample (see Figure 3). A collar may be installed to prevent the tubing from coming in contact with the sidewalls of the pipe. It is important that the pipe is adequately sealed so that the sample is isolated from indoor air. Helium leak testing may not be feasible in many cases due to the configuration of the sampling location. After the temporary cover is installed, the conduit should be allowed to equilibrate for at least an hour. A valve should be installed above the temporary cover to allow pressure testing of fittings. At least three volumes of air should be purged from the tubing prior to sample collection.

Other collection points: If clean-outs are not accessible or if data from other areas of the building is desired, sampling other locations may be needed. Possibilities include removal of the toilet, sealing and

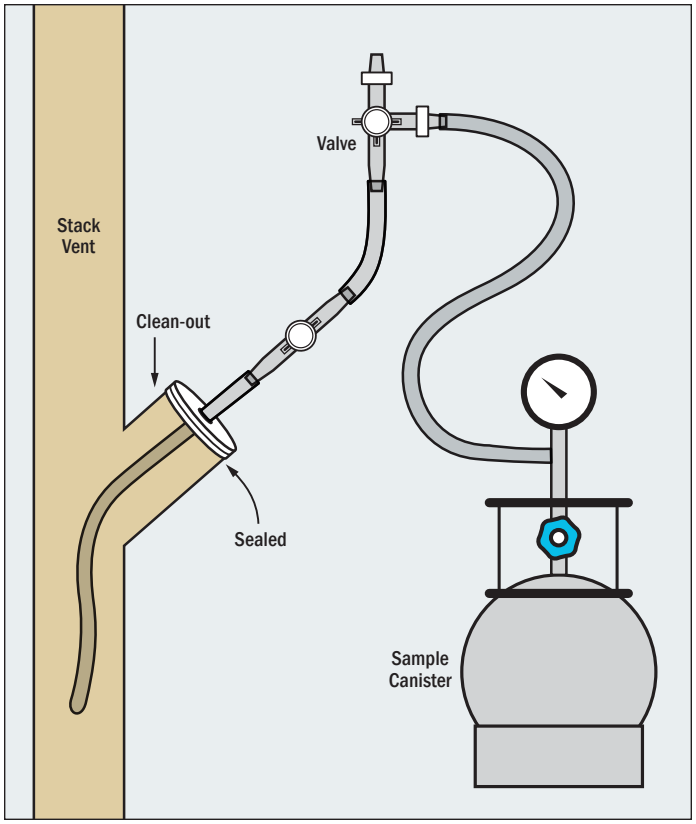


Figure 3. Sampling Plumbing Clean-outs

sampling below the wax ring; removal; running the tubing from the sampling cannister past the water in the p-trap to sample gas on the other side; or sampling down the plumbing vent pipe. Sealing and sampling floor or other drains and sumps are also options.

If a sample is collected from a drain with a functioning p-trap, the liquid in the trap should be removed prior to sampling for the sample to be representative of gas in the plumbing system. Any time a trap is removed, the sample must be obtained from a location that is sealed to prevent indoor air from diluting the sample. After the sampling location is sealed, it should equilibrate for an hour before the sample is collected. Traps should always be returned to a functioning state after sampling. It may be useful to have a licensed plumber assist with assessments of plumbing systems.

See RR-986, *Sub-Slab Vapor Sampling Procedures*, for more information on sampling sump pits. Collecting liquid samples from sumps also provides useful data and may indicate the need to investigate soil, groundwater and/or surface water farther along the piping transfer and/or at the outfall for the sump discharge. If sump water is contaminated, outfall to a storm sewer or surface discharge may also no longer be appropriate.

Other assessment methods: Utilizing passive samplers or sorbent tubes in conduits, real-time samplers, tracers, smoke testing, borescopes and manipulating building or sewer pressure to differentiate sources in assessment of preferential pathways are other assessment methods. In addition to sampling air for contaminants of concern, adding certain indicator compounds to the analyte list may help differentiate the source. For example, certain compounds such as chloroform are common in sewer gas. For references on some of these techniques, visit dnr.wi.gov, search "vapor."

Number of sampling events: Contaminant concentrations in plumbing systems can vary considerably over time. One event may be sufficient to identify the presence of a pathway that must be mitigated. However, if concentrations are low, other lines of evidence should be used to determine the number of sampling events needed to rule out the pathway. Two or more events are usually recommended.

Non-sewer System Pathways

Preferential pathways other than the sewer/plumbing system may require evaluation, including hollow foundation walls (e.g., cinder block), large gaps where foundation elements meet, elevator shafts, heating, ventilating and cooling (HVAC) ducts beneath the slab, historic chimneys, false ceilings, etc. Real-time assessment using a photoionization detector (PID) with a sufficiently low detection limit and an appropriate calibration for the contaminants of concern or techniques such as a portable gas chromatography-mass spectrometer (GC/MS), hot wire anemometers, and forward looking infrared radar (FLIR) can be useful to evaluate these potential pathways.[13]

Focused Indoor Air Sampling

Indoor air samples should be collected in rooms served by conduits, which may include rooms with plumbing features (e.g., bathrooms), floor drains, utility penetrations through the foundation, or with walls adjacent to plumbing vents. The indoor air data, when paired with conduit vapor data, can help distinguish indoor air sources from conduit sources and evaluate for acute risk to determine whether immediate action is necessary to protect public health.

ROW ASSESSMENT

Vapor Sampling Methods

The current recommended method to assess the potential for vapor impacts beyond the source property through a utility corridor conduit is to obtain a sample from manholes beyond the source property. Most manholes have a vent through which vapor samples can be collected or a cover that can be removed for sampling.

Both passive samplers and evacuated canisters may be used to collect samples. Sewer vapor concentrations are quite variable over time. While passive samplers can reduce some of the variability by collecting the sample over a number of days, multiple trips to the sampling location may be needed. Passive sampling also introduces concerns about the security of the sampling equipment in roadways and potential inundation during precipitation events or high use periods.

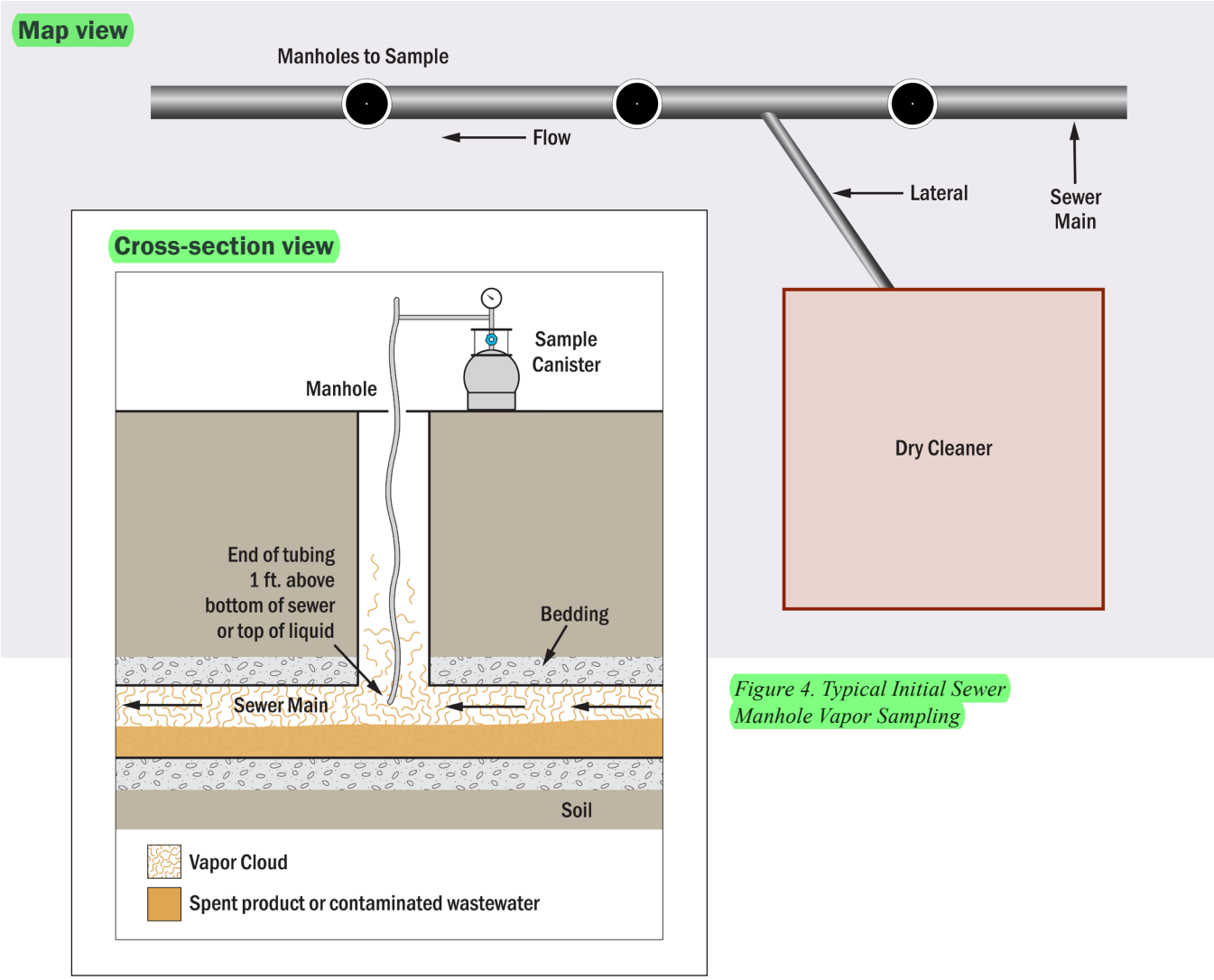


Figure 4. Typical Initial Sewer Manhole Vapor Sampling

The recommended sampling method for manholes currently consists of collection of a grab sample with an evacuated canister. As long as the opening to the manhole is small there is no need to seal the tubing in the opening. If the manhole cover must be completely removed, allow the air in the sewer to equilibrate for an hour after the cover is replaced before a sample is collected. It is appropriate to collect a grab sample (that is, without a flow controller). A one-liter evacuated cannister will be sufficient in most circumstances.[2]

Scope of Initial Sampling

Initially, samples should be collected from at least one location up-flow from where the utility corridor intersects contamination or discharge (such as the lateral from the source property) and several down-flow locations. The number of samples collected is site-specific and based on the spacing of the manholes or access points, accessibility, nature of the contamination, knowledge of the conduit system, and presence of receptors. If a contaminant plume intersects a longer stretch of the corridor, more significant volumes of contaminants were discharged, or discontinuities in the conduit within the corridor are known, additional samples may be needed. A minimum of three sampling points (one up-flow, two down-flow) within the sewer main is recommended (see Figure 4).

SSGSL:

Assessing Sample Results Using Sanitary Sewer Gas Screening Levels (SSGSLs)

In cases where sanitary sewers are a concern for allowing vapor phase contaminants into occupied structures, DNR recommends that a SSGSL be calculated for each of the contaminants of concern. The SSGSL is calculated by dividing the VAL by an attenuation factor of 0.03. The VAL appropriate for buildings served by the sanitary

sewer should be used (i.e., residential VAL or commercial/industrial VAL). If any residential use takes place within a building or the area is zoned for residential use, the lower residential VAL should be used in the calculation of the SSGSL. (Residential setting is defined in Wis. Admin. Code § NR 700.03(49g) to include any dwelling designed or used for human habitation, including educational, childcare and elder care settings.)

The SSGSL provides a concentration to use in assessing the need to collect additional samples within the sanitary sewer pipe over time or spatially, and whether the conduit vapor pathway should be further assessed in occupied structures served by those sewers. The use of SSGSLs is a screening tool that is only appropriate for samples collected from within sewer mains, not samples collected within sewer laterals. Significant attenuation of vapors are less likely to occur between a sewer lateral and indoor air. Data collected from sewer laterals should be assessed on a case by case basis.

Follow-up ROW Sampling

Temporal: Long-term (i.e., seasonal) variability of vapor concentrations in sanitary sewer systems is significantly greater than short-term (i.e., over the period of a few days). One study found that only 33% of individual samples were within two times of the long-term average concentration, but 84% were within a factor of 10 times.[2] Another study found that approximately 30 percent of sampling locations (81 of 268) varied by more than 10 times seasonally.[14] The observations reveal that vapor concentrations in sanitary sewer systems typically fall within a range of a factor of 10. Based on this, sanitary sewer data can be separated into three categories:

1. If results from the initial sampling exceed the SSGSL, collection of additional samples at the same manholes provides little added benefit; assessing adjacent structures is recommended.
2. If the results from the initial sampling are greater than 10% of the SSGSL but below the SSGSL, additional rounds of sampling at the same manholes (at least one additional round of sampling in a different season) is recommended.
3. If the results from the initial sampling are less than 0.1 times (10%) of the SSGSL, neither continued sampling at the same manholes nor assessment of impact to adjacent structures is needed at this time.

Because of the evolving science and recommendations on preferential pathways, discussing the results of the initial sampling with the DNR is recommended prior to scheduling additional sampling.

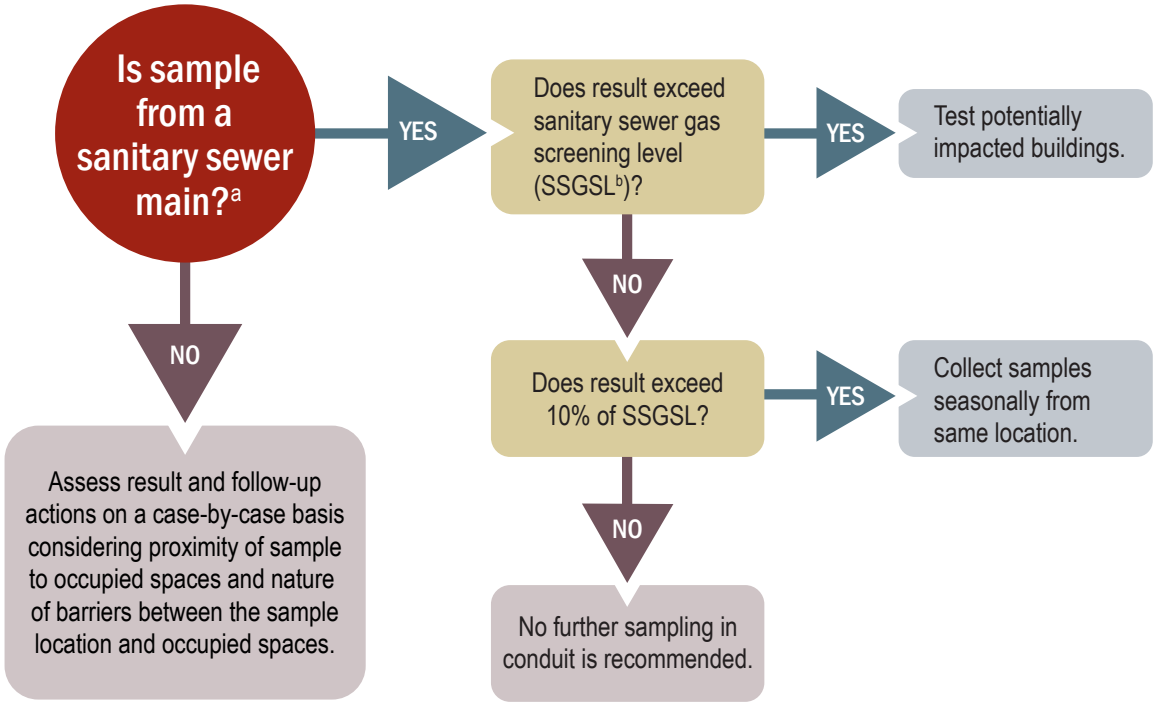
Spatial Delineation: If the SSGSL is exceeded in any of the initial samples from manholes, then sampling of additional manholes is recommended to define the extent of the risk. Sewer gas concentrations exhibit a high degree of spatial variability. Manholes or other locations along the utility corridor should be sampled laterally until there are two consecutive locations with concentrations of contaminants less than the SSGSL (see Figure 5). Where other sources of the contaminant of concern found in the sewer main are suspected, an alternative strategy to determine the spatial extent of impact may be appropriate.

OFF-SITE BUILDING ASSESSMENT

Occupied buildings connected to contaminated utility conduits and close enough to be impacted by those conduits should be evaluated for vapor intrusion. Based on previous studies[2] the DNR recommends that an attenuation factor of 0.03 be used to evaluate the utility conduit to indoor air pathway. That is, the applicable indoor air VAL (residential or commercial/industrial) divided by the attenuation factor of 0.03 equals the SSGSL. If the concentration of a vapor contaminant in the utility conduit is above this SSGSL, revision of the CSM is necessary, and assessment of adjacent buildings may be warranted; however, this attenuation factor approach is only appropriate in conduits that are protected by adequately maintained plumbing traps (such as sanitary sewer systems) and for vapor concentrations collected in the sewer main.

For data collected closer to occupied spaces such as clean-outs and plumbing vent pipes, or for situations where there are not adequate protections from conduit vapor, there is insufficient data supporting a specific amount of attenuation. Data should be assessed on a case-by-case basis.

For conduit systems that are not connected to the interior of occupied spaces such as a storm sewer manhole that is connected to an exterior drain, the vapor concentrations may be evidence of contaminant migration



Notes

a. The use of the 0.03 attenuation factor is only appropriate for samples from a sewer main manhole, generally where the sample is not close to the occupied space and the entry of vapors into buildings is inhibited by traps

b. SSGSL = VAL/0.03

Figure 5. Conduit Vapor Data Assessment and Decision Recommendations

but not necessarily vapor intrusion through the conduit and use of the SSGSL may not be appropriate. If vapor concentrations are measured in such conduits, the results should be assessed based on site-specific circumstances.

Once a decision has been made to assess a building for conduit vapor intrusion, a similar strategy as discussed in the section relating to Source Building Assessment should be followed. The main difference is that the focus should be entirely on routes into the building and not discharges from within the building.

ASSESSMENT OF DATA COLLECTED BEHIND PLUMBING TRAPS AND MITIGATION DECISIONS

No established standards or screening levels currently exist for contaminants within conduits that enter occupied structures; however, if vapor concentrations are high behind plumbing traps (e.g., p-traps, wax rings, stack vent pipes) and those safeguards are compromised, indoor air quality can quickly deteriorate, even if indoor air concentrations are currently found below VALs. This is analogous to a structure with indoor air concentrations less than the VAL, but sub-slab concentrations greater than the VRSL. The high sub-slab concentrations represent the *potential* for vapor intrusion in the future.

In addition, vapor intrusion through preferential pathways can be very episodic in response to changing pressures in indoor air that are the result of meteorological factors and changes to the building structure or use. It can be difficult to determine whether preferential pathways are compromising indoor air quality with the collection of only a few indoor air samples. For these reasons, mitigation decisions should be made on a case-by-case basis with the information available. Mitigation options specific to preferential pathways can include venting manholes, placement of activated charcoal or vapor dams in pipes, and sealing plumbing systems.

Applicable Action or Screening Levels and Suggested Sample Nomenclature

Investigating contaminant migration through preferential pathways includes collecting air/vapor samples from a variety of locations with variable applicable VALs or VRSLs. The table below is intended to summarize the more common locations and suggested nomenclature for sample locations. The DNR recommends you work with the assigned DNR PM to discuss site-specific concerns such as dried out p-traps, contaminants of concern in use within an occupied building, etc. See RR-800, *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin*, for discussion on VALs, VRSLs and default attenuation factors.

Sample Location	Action or Screening Level	Attenuation Factor	Suggested Sample Nomenclature	Additional Comments
Ambient / Indoor Air & Soil Gas Vapor				
Indoor Air (IA)	VAL	Not applicable – no attenuation	**IA** - *# or Location* (e.g., IA-1 or IA-break room)	Including basements, crawl spaces and conduits on the interior side of a p-trap (or without a p-trap)
Outdoor Air (OA)	Not applicable	Not applicable – no attenuation	**OA** - *# or Location* (e.g., OA-1 or OA-west)	Typically background outdoor air samples
Sub-Slab Vapor (SSV) (beneath the foundation)	VRSL	0.03[a] / 0.01[b]	**SSV** - *# or Location* (e.g., SSV-1 or SSV-utility room)	Includes vapor samples directly beneath a slab or membrane/vapor barrier
Sump (temporarily sealed for sample)	VAL	Not applicable – no attenuation	**Sump** - *# or Location* (e.g., Sump-1 or Sump-north)	
Conduit Vapor				
Floor Drain (FD) (behind p-trap)	Site-specific[c]	Site-specific[c]	**FD** - *# or Location* (e.g., FD-1 or FD-paint room)	
Lateral/Plumbing cleanout Gas (LPG) (behind p-trap)	Site-specific[c]	Site-specific[c]	**LPG** - *Location* (e.g., LPG-SSG lateral or LPG-vent pipe)	Includes sanitary sewer lateral, plumbing stack vent and plumbing clean-out
Sanitary Sewer Gas (SSG) (within utility main)	SSGSL	0.03	**SSG** - *Location* (e.g., SSG-MH-149 for manhole # 149)	

[a] Residential use or small commercial building

[b] Large commercial or industrial building

[c] There are currently no set action levels, screening levels or attenuation factors for these scenarios.

Remediation of Preferential Pathways

Remedial measures for preferential pathways should be made on a case-by-case basis and may include active sewer ventilation, lining of sewer pipes, relocation of sewer lines, replacement of sewer pipes, excavation of and proper disposal of contaminated bedding materials.

Wis. Admin. Code §§ NR 722.07, 722.09 and 726.05(8) require remedial actions to be evaluated and selected to reduce the mass and concentration of the source, to the extent practicable, if VRSLs are exceeded in soil gas or groundwater. Code clarifies that mitigation is not a remedy that meets this criteria since it does not reduce contaminant mass and concentration, and natural attenuation is not an acceptable remedy selection for chlorinated solvents since they persist in the environment.

See RR-800, *Addressing Vapor Intrusion at Remediation & Redevelopment Sites in Wisconsin*, for detailed information about vapor intrusion, screening, investigation, immediate and interim actions and mitigation. Additional resources on mitigation and remedial action of vapor is available (visit dnr.wi.gov, search "vapor").

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Appendix:
Investigating Utility Corridors and Other Human-made Preferential Pathways