MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

Michigan's Investigative Approach for Petroleum Volatilization to the Indoor Air Pathway (VIAP)

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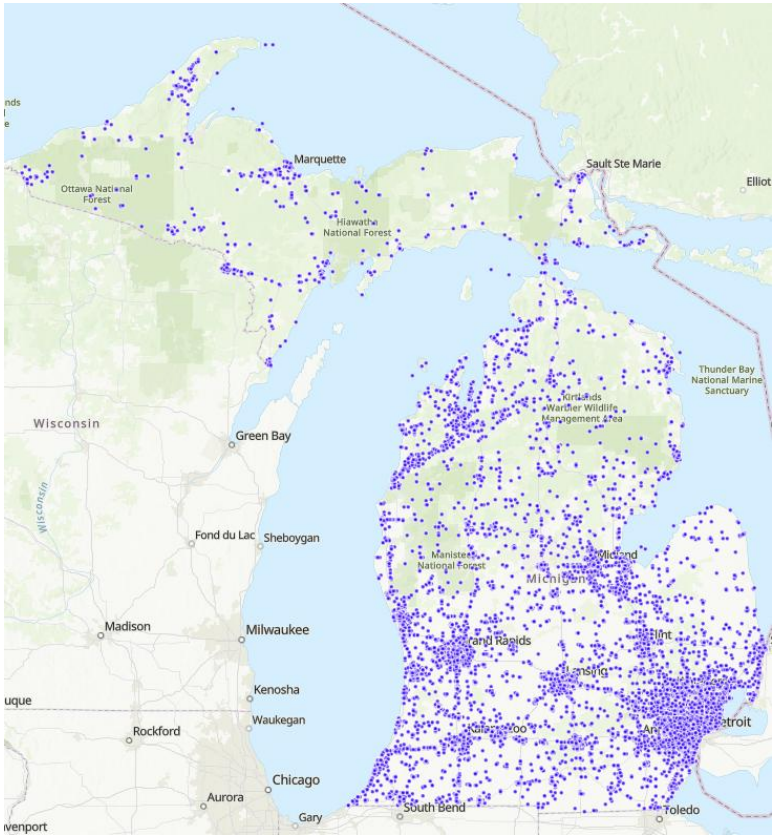
Agenda

- Foundation of Michigan's Approach
- Michigan Guidance Document for the Volatilization to the Indoor Air Pathway (VIAP)
- Step-wise approach for petroleum

Background

Part 201 and Part 213

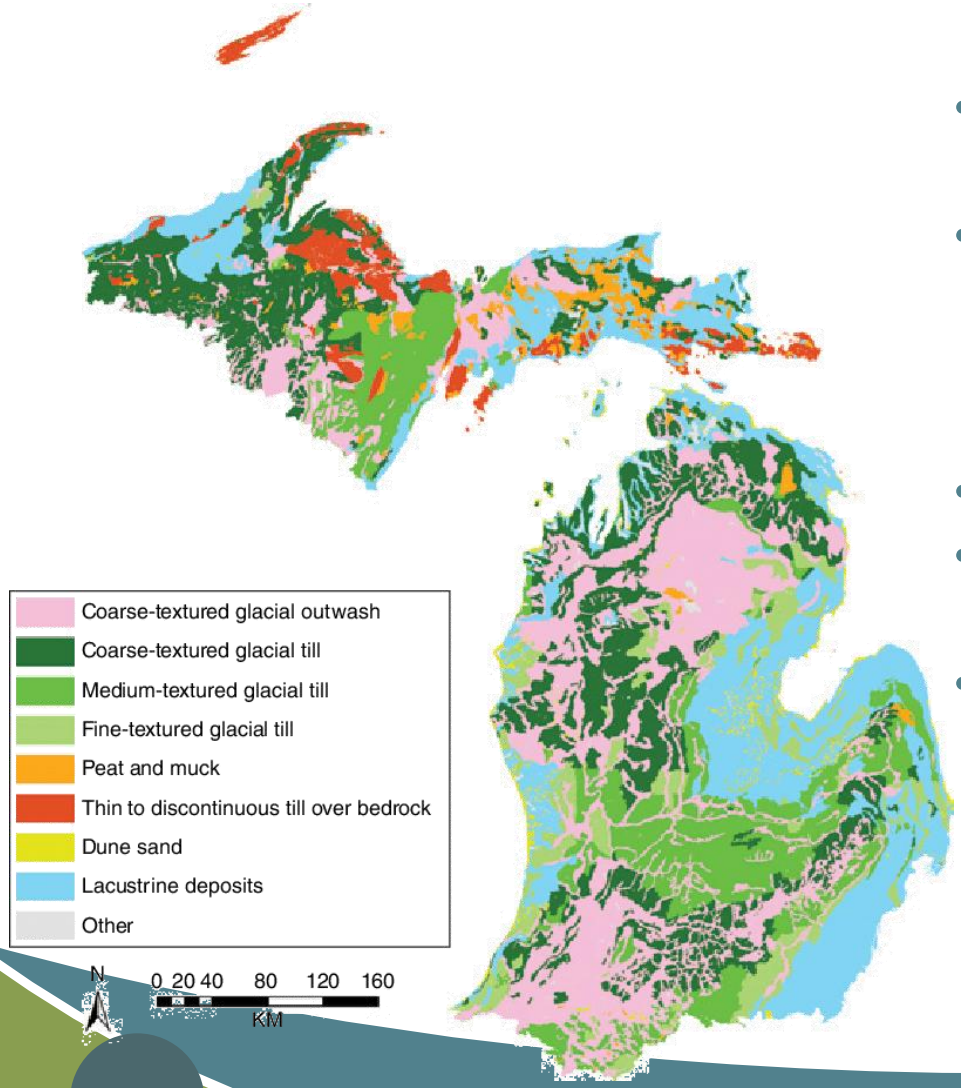


Part 201 Facilities

- Part 201 is primarily concerned with environmental remediation from a broader range of releases
- Part 213 addresses leaking underground storage tanks (6,000+ open)
- Both:
  - Parts of the Natural Resources and Environmental Protection Act (NREPA)
  - Provide a framework for managing and mitigating environmental contamination
  - ***Are not exclusive to petroleum***
  - Terminology is not the same
  - Causation liability

Background

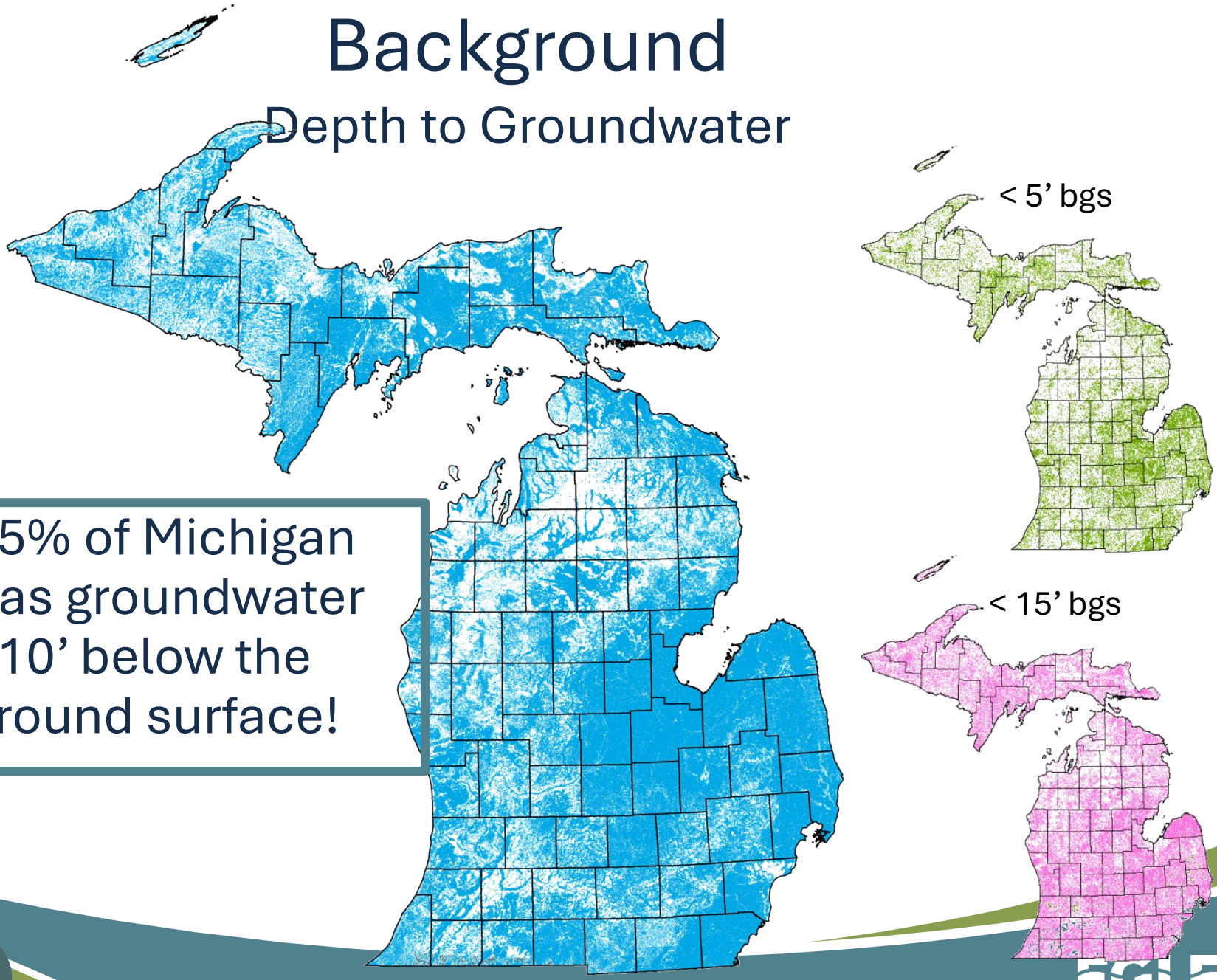
Glacial, Soil Types, and Topography



- A diverse landscape
  - Flat plains to rugged hills
- Two peninsulas
  - Elevation change of 1408 feet
    - 571 feet -shore of Lake Erie
    - 1979 feet - Mount Arvon
- Heavily influence by glaciers
- Lots of water – multiple lakes, ponds, rivers, and streams
- Significant sand dunes along the Lake Michigan shoreline, some reaching heights over 200 feet

Background

Depth to Groundwater

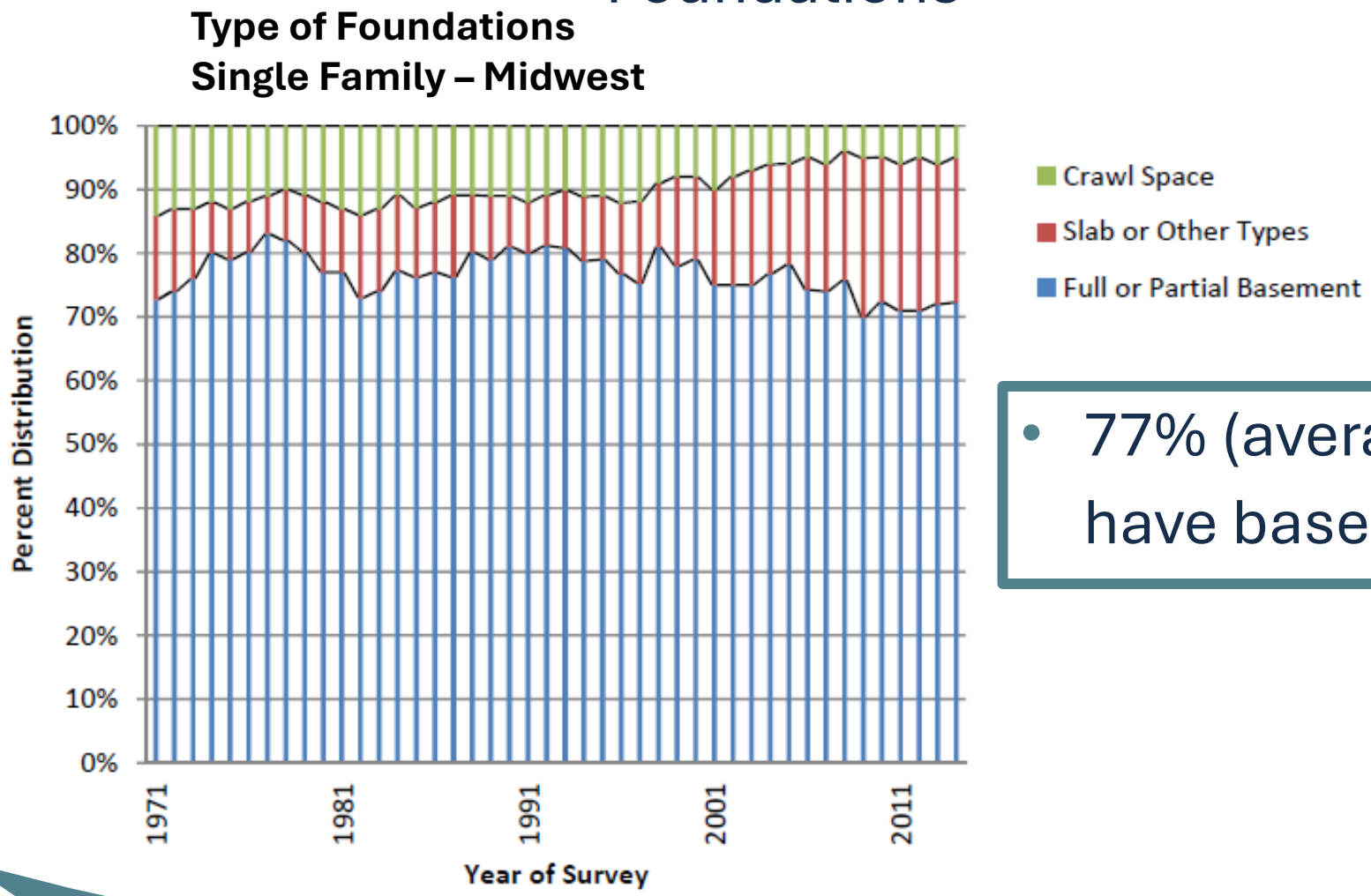


- 65% of Michigan has groundwater <10’ below the ground surface!

*Data from MSU Extension 2015

Background

Foundations

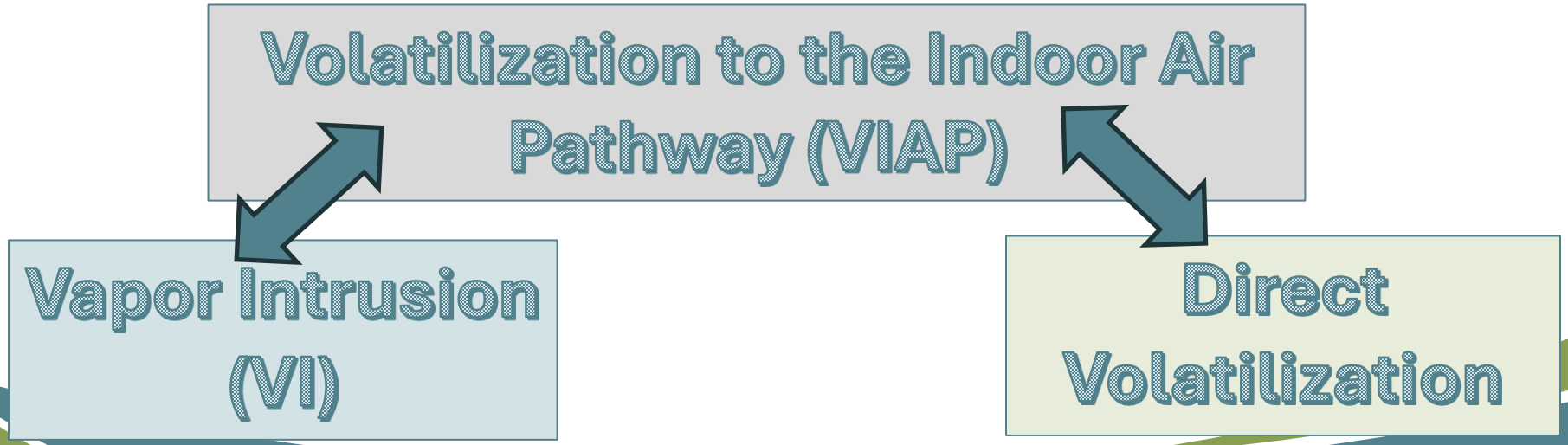


- 77% (average) have basements!

*US Census Data for the Midwest

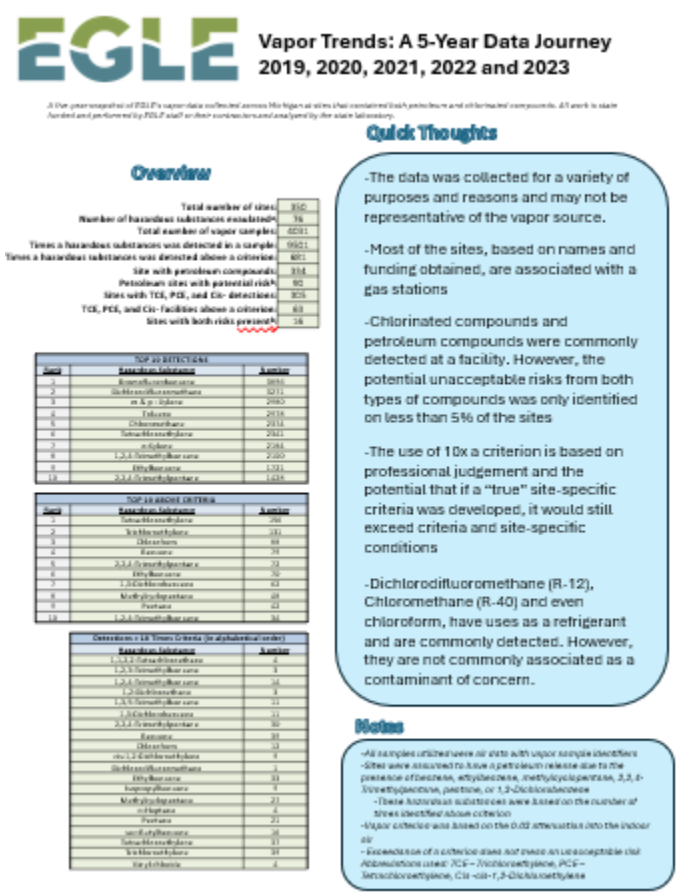
In short…

- Statue must address a wide range of sites where shallow groundwater and basements are common
  - Utilities and conduits are likely to be near groundwater
  - Deeper vapor sampling is not always possible
  - Separation Distances are not very helpful
- VIAP



Data Evaluation

- Database with data from state-funded sites



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Vapor Trends: A 5-Year Data Journey
2019, 2020, 2021, 2022 and 2023

Overview

Total number of sites:	350
Number of hazardous substances evaluated*:	76
Total number of vapor samples:	6091
Times a hazardous substances was detected in a sample:	9921
Times a hazardous substances was detected above a criterion:	601
Site with petroleum compounds:	334
Petroleum sites with potential risk*:	90
Sites with TCE, PCE, and Cis- detections:	105
TCE, PCE, and Cis- Facilities above a criterion:	63
Sites with both risks present*:	16

TOP 10 DETECTIONS

Rank	Hazardous Substance	Number
1	Dichlorodifluoromethane	1846
2	Dichlorodifluoromethane	1271
3	m & p - Xylene	2980
4	Toluene	2936
5	Chloromethane	2931
6	Tetrachloroethylene	2921
7	n-Xylene	2184
8	1,3,5-Trimethylbenzene	2180
9	Ethylbenzene	1721
10	1,2,4-Trimethylbenzene	1426

TOP 10 ABOVE CRITERIA

Rank	Hazardous Substance	Number
1	Tetrachloroethylene	266
2	Trichloroethylene	181
3	Chloroform	88
4	Benzene	78
5	1,2,4-Trimethylbenzene	73
6	Ethylbenzene	70
7	1,2-Dichloroethane	63
8	Methylcyclopentane	48
9	Pentane	43
10	1,2,4-Trimethylbenzene	34

Detections > 10 Times Criteria (in alphabetical order)

Hazardous Substance	Number
1,1,2,2-Tetrachloroethane	4
1,2,3-Trimethylbenzene	3
1,2,4-Trimethylbenzene	34
1,2-Dichloroethane	3
1,3,5-Trimethylbenzene	11
1,3-Dichlorobenzene	11
2,2,4-Trimethylpentane	30
Benzene	34
Chloroform	13
cis-1,2-Dichloroethylene	9
Dichlorodifluoromethane	1
Ethylbenzene	33
Isopropylbenzene	8
Methylcyclopentane	21
n-Heptane	4
Pentane	21
sec-Butylbenzene	16
Tetrachloroethylene	91
Trichloroethylene	39
Vinyl chloride	4

Quick Thoughts

-The data was collected for a variety of purposes and reasons and may not be representative of the vapor source.

-Most of the sites, based on names and funding obtained, are associated with a gas stations

-Chlorinated compounds and petroleum compounds were commonly detected at a facility. However, the potential unacceptable risks from both types of compounds was only identified on less than 5% of the sites

-The use of 10x a criterion is based on professional judgement and the potential that if a "true" site-specific criteria was developed, it would still exceed criteria and site-specific conditions

-Dichlorodifluoromethane (R-12), Chloromethane (R-40) and even chloroform, have uses as a refrigerant and are commonly detected. However, they are not commonly associated as a contaminant of concern.

Notes

-All samples utilized were air data with vapor sample identifiers
-Sites were assumed to have a petroleum release due to the presence of benzene, ethylbenzene, methylcyclopentane, 2,2,4-trimethylpentane, pentane, or 1,3-Dichlorobenzene
-These hazardous substances were based on the number of times identified above criterion
-Vapor criterion was based on the 0.03 attenuation into the indoor air
- Exceedance of a criterion does not mean an unacceptable risk
Abbreviations used: TCE= Trichloroethylene, PCE= Tetrachloroethylene, Cis -cis-1,2-Dichloroethylene

List of Analytes	Min	Max	Criteria	Time(s) Detected	Time(s) above Criteria	Detected > 10 Times Above Criteria
1,1,1,2-Tetrachloroethane	1.4	7.60E+02	1.30E+00	352	3	0
1,1,1-Trichloroethane	0.3	61.8	26	6	4	0
1,1,2,2-Tetrachloroethane	1.4	1.6	1	1	0	0
1,1,2-Trichloro-1,2,2-trifluoroethane	2.6	2.80E+03	63	12	10	0
1,1,2-Trichloroethane	1.1	193	5.00	22	1	0
1,1-Dichloroethane	2.2	58.8	1.30E+03	5	0	0
1,2,3-Trichlorobenzene	14	27	560	5	0	0
1,2,3-Trichloropropane	1.4	5.5	10	5	0	0
1,2,4-Trimethylbenzene	1.3	5.80E+02	2.10E+03	810	17	3
1,2,4-Trichlorobenzene	11	28	70	3	0	0
1,2,5-Trimethylbenzene	1.3	1.70E+05	2.10E+03	3130	52	12
1,2-Dibromo-3-chloropropane	7.1	17	63	3	10	0
1,2-Dibromoethane	2.6	3	63	2	10	0
1,2-Dichlorobenzene	1.4	200	1.80E+04	68	3	0
1,2-Dichloroethane	0.98	1.30E+02	33	38	6	3
1,2-Dichloropropane	1.3	14	140	28	0	0
1,3,5-Trimethylbenzene	1.3	1.30E+05	2.10E+03	1015	26	11
1,3-Butadiene	0.88	61	63	35	10	0
1,3-Dichlorobenzene	1.4	3.20E+03	300	454	32	11
1,4-Dichlorobenzene	1.4	350	200	61	1	0
2,2,4-Trimethylpentane	1.3	6.80E+04	1.30E+05	1126	72	30
2-Butanone (MEK)	15	3.60E+05	63	165	10	0
2-Methylpentane	3.0	53	350	6	0	0
3-Methyl-2-pentanone (MIBK)	5.1	510	63	113	10	0
Acetone	92	3.60E+06	1.30E+06	341	3	0
Acetonitrile	1.6	8.2	2.00	28	3	0
Acrylonitrile	1.1	4.6	13	7	0	0
Benzene	0.81	3.60E+05	320	1230	76	33
Bromobenzene	3.6	7.6	2.10E+03	5	0	0
Bromodichloromethane	1.3	550	28	17	6	0
Bromochloromethane	11.5	140	63	3478	10	0
Bromoform	3.6	3.0	730	3	0	0
Bromomethane	1.3	27	350	30	0	0
Carbon disulfide	0.76	61.8	63	274	10	0
Carbon tetrachloride	1.7	1.30E+03	63	38	10	0
Chlorobenzene	1.4	1.60E+03	1.10E+03	111	1	0
Chloroethane	3.69	84	1.30E+05	68	0	0
Chloroform	1.2	1.30E+03	63	712	88	13
Chloromethane	0.81	1.30E+03	1.10E+03	2331	3	0
cis-1,2-Dichloroethylene	1	5.20E+02	280	258	21	9
cis-1,3-Dichloropropylene	0	5	63	0	10	0
Cyclohexane	3.85	2.10E+06	2.10E+05	648	28	0
Dibromochloromethane	2.1	68	34	13	2	0
Dichlorodifluoromethane	1.3	1.20E+05	1.10E+03	3375	1	0
Diethyl ether	3.4	300	63	4	10	0
Diisopropyl Ether	1.1	8.2	63	6	10	0
Ethanol	22	6.20E+04	6.30E+05	316	3	0
Ethylbenzene	1.1	2.20E+05	360	1725	78	33
Ethylene dibromide (dibromoethane)	1.3	3.8	63	12	10	0
Hexachlorobutadiene	2.8	26	63	18	3	0
Hexane	0.3	1.20E+07	63	670	10	0
Isopropyl Alcohol	90	9.00E+04	63	276	10	0
Isopropylbenzene	1.3	1.20E+04	63	372	20	3
m & p - Xylene	1.1	5.60E+05	63	2760	80	0
Methylcyclopentane	3.83	6.60E+05	2.10E+04	719	38	21
Methylene chloride	1	1.60E+03	63	398	10	0
Methyltertbutylether	1.3	33	63	16	10	0
Naphthalene	25	260	29	11	11	0
n-Butylbenzene	0.3	1.20E+03	3.20E+03	61	0	0
n-Heptane	1	2.50E+06	1.30E+05	1198	17	4
n-Propylbenzene	1.3	5.80E+04	3.20E+03	609	3	0
n-Xylene	1.1	2.20E+05	63	2160	80	0
Pentane	2.6	1.40E+07	6.30E+04	605	59	21
sec-Butylbenzene	1.4	5.80E+03	63	96	27	16
Styrene	1.1	110	1.30E+03	231	3	0
tert-Butylbenzene	0.7	0.7	63	1	10	0
tertiary Butyl alcohol	35	3.60E+03	63	3	10	0
tertiary Amyl Methyl Ether	1.3	3.2	63	3	10	0
Tetrachloroethylene	1.7	2.20E+05	1.30E+03	2316	156	91
Tetrahydrofuran	0.72	1.30E+02	7.30E+04	870	3	0
Toluene	0.93	1.20E+06	1.30E+05	3179	6	0
trans-1,2-Dichloroethylene	0.98	1.60E+03	2.10E+03	61	0	0
trans-1,3-Dichloropropylene	1.4	1.4	63	1	10	0
Trichloroethylene	1.4	5.80E+04	63	515	132	39
Trichlorofluoromethane	1.4	7.20E+03	1.30E+04	1198	3	0
Vinyl chloride	0.69	2.20E+03	63	38	14	4
Xylene	3.5	53	63	3	10	0
Ethylene	0	3	63	0	10	0
Methane	35	3.60E+05	63	63	10	0

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Available Data

- All data collected on state-funded sites using the same lab and sampling procedures
- Identified:
  - COCs
  - COCs above criteria
  - Sites
  - more

Overview

Total number of sites:	350
Number of hazardous substances evaulated[a]:	76
Total number of vapor samples:	4031
Times a hazardous substances was detected in a sample:	9501
Times a hazardous substances was detected above a criterion:	681
Site with petroleum compounds:	334
Petroleum sites with potential risk[b]:	90
Sites with TCE, PCE, and Cis- detections:	305
TCE, PCE, and Cis- facilities above a criterion:	63
Sites with both risks present[b]:	16

Still on-going

2019	2020	2021	2022	2023	Project	DETECTI									EXCEEDE CRITERIA								
						Tetrachloroethylene	Trichloroethylene	cis-1,2-Dichloroethylene	Benzene	Ethylbenzene	Methylcyclopentane	2,2,4-Trimethylpentane	Pentane	1,3-Dichlorobenzene	Tetrachloroet	Trichloroethylene	cis-1,2-Dichloroethylene	Benzene	Ethylbenzene	Methylcyclopentane	2,2,4-Trimethylpentane	Pentane	1,3-Dichlorobenzene
				X	108 ADAMS SITE/108 ADAMS STREET,BAY CITY	1	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0
				X	1111 west nine mile road	4	0	0	4	4	4	3	4	0	1	0	0	0	0	0	0	0	0
	X				119 EAST WESLEY STREET	4	0	0	4	4	0	4	0	0	0	0	0	0	0	0	0	0	0
				X	125 EAST MAIN STREET	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X	X				1250 MADISON AVE SE	38	49	2	26	28	0	15	0	10	0	20	0	0	0	0	0	0	0

What types of sites

- Brownfield Site Assessments
- Former gas stations and drycleaners
- Brownfields
- Regulatory Interest

Quick Take on the Findings:

TOP 10 DETECTIONS		
Rank	**Hazardous Substance**	**Number**
1	Bromofluorobenzene	2793
2	Dichlorodifluoromethane	2189
3	m & p - Xylene	1934
4	Chloromethane	1918
5	Toluene	1913
6	Tetrachloroethylene	1632
7	1,2,4-Trimethylbenzene	1311
8	o-Xylene	1310
9	n-Heptane	1195
10	Ethylbenzene	1057

TOP 10 ABOVE CRITERIA		
Rank	**Hazardous Substance**	**Number**
1	Tetrachloroethylene	137
2	Trichloroethylene	89
3	Chloroform	64
4	Benzene	58
5	Methylcyclopentane	48
6	2,2,4-Trimethylpentane	47
7	Pentane	42
8	Ethylbenzene	38
9	1,3-Dichlorobenzene	36
10	cis-1,2-Dichloroethylene	19

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Quick Take on the Findings:

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10	Ethylbenzene	1057

Detections > 10 Times Criteria (in alphabetical order)		
	Hazardous Substance	**Number**
	Tetrachloroethylene	34
	Trichloroethylene	34
	Benzene	29
	Methylcyclopentane	27
	Pentane	21
	2,2,4-Trimethylpentane	20
	Ethylbenzene	17
	Chloroform	9
	1,3-Dichlorobenzene	8
	cis-1,2-Dichloroethylene	8
	1,2,4-Trimethylbenzene	6
	sec-Butylbenzene	6
	1,3,5-Trimethylbenzene	4
	n-Heptane	4
	Isopropylbenzene	3
	Vinyl chloride	3
	1,2,3-Trimethylbenzene	1

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EGLE's VIAP Guidance Document

Electronic Guidebook broken into different Volumes

Volume 1 – Volatilization to the Indoor Air Pathway (VIAP) Overview
Volume 2 – Investigation Methods for the Volatilization to the Indoor Air Pathway (VIAP)
Volume 3 – Investigation Approach for Volatilization to the Indoor Air Pathway (VIAP)
Volume 4 – Investigative Approach for Petroleum Volatilization to the Indoor Air Pathway (VIAP)
Volume 5 – Response Activity for the Volatilization to the Indoor Air Pathway (VIAP)
Volume 6 – Volatilization to the Indoor Air Criteria
Volume 7 – Updates

- Guidance document for the Volatilization to the Indoor Air Pathway (VIAP)

New Standard Operating Procedures
Volume 2 – Currently undergoing internal review

Collecting Soil Gas from Low Permeability Subsurface Material	Crawlspace Sampling via USEPA TO-15	Sampling Vapor Utilizing an Active Sorbent Analytical Method to Support Vapor Intrusion Investigations	Conduit Liquid Sampling
Conduit Vapor Sampling via TO-15	Conduit Vapor Sampling via Passive Sampling	Conduit Sediment Sampling	Pneumatic Testing of Subsurface Soil to Evaluate Permeability and Vapor Transmission
Establishing a Liner Diffusion Coefficient	Building Pressure Control/Controlled Pressure Testing	Building Pressure Testing to Prove Out an Active Vapor Mitigation System	Determination of Advective or Passive Flow of Vapors for Methane

New Vapor Insights or FAQ's

Evaluation of Conduits and Sewers from Petroleum Releases

Assessing the Potential for Unacceptable Risk Without Soil Gas Data Due to Shallow Groundwater

Is shallow soil gas (<5' below ground) representative of a soil gas sample directly beneath a slab on grade structure?

What is Soil Sampling good for when assessing the Volatilization to the Indoor Air Pathway?

How to Assess the Potential for Unacceptable Risk to Occur Without a Building

Evaluate Permeability and Vapor Transmission

Shutting Down a VMS - Speed at which vapor migrates/Time to Equilibrate

What is a Leaky Building?

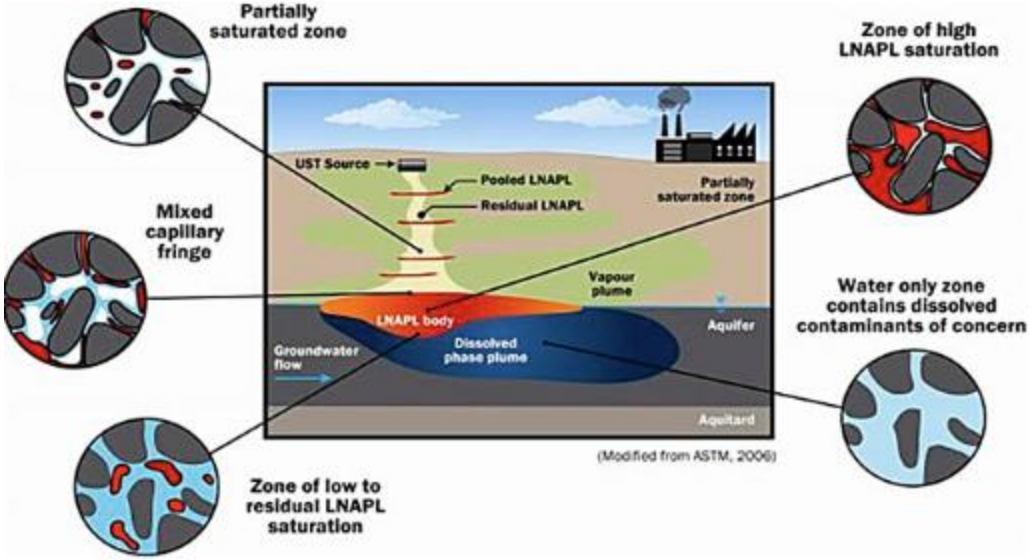

Figure 3-2. The multiphase system of a typical LNAPL body (CL:AIRE 2014 [26]).

Investigative Approach for Petroleum Volatilization to the Indoor Air Pathway (VIAP)

Volume 4

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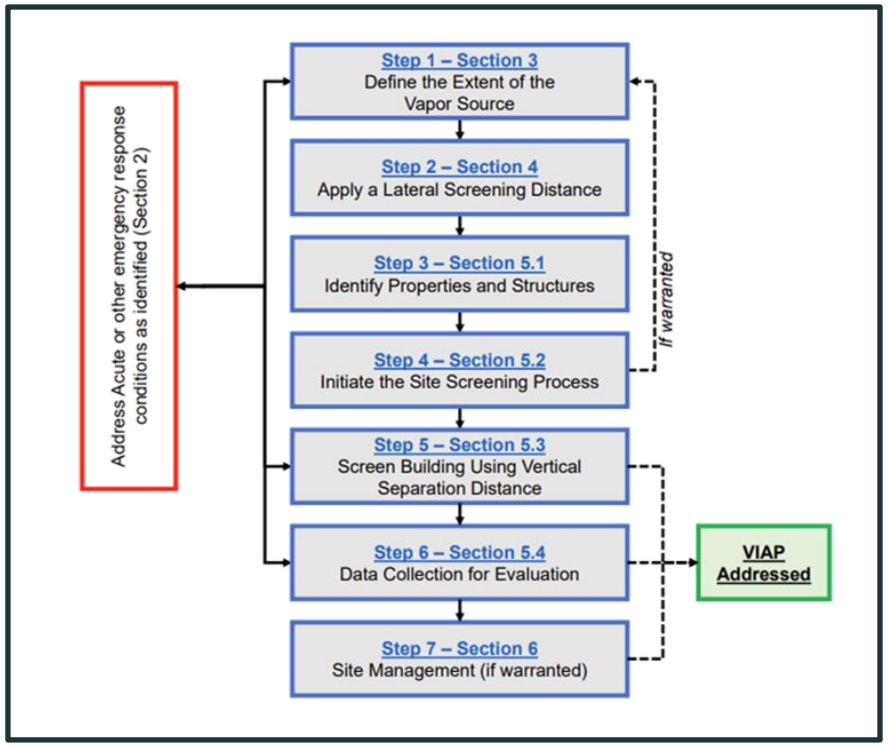
Volume 4 Overview



- Identifies a step-wise approach
- Soil concentrations along with other lines of evidence can be used to establish the extent of NAPL
- Risk evaluation is based on NAPL and GW only
- Links EGLE'S 2023 Petroleum NAPL Guidance and other key information

Volume 4

Focus for Petroleum

- Based on data unacceptable risks are associated with:
  - Non-aqueous phase liquid (NAPL) is near or entering structure
    - Enters through a sump
    - Seeps through a wall
  - Mobile NAPL has entered utility that is connected to structure; or
  - Contaminated groundwater is entering structure

NOTE: *If these don't exist, initial CSM should be VIAP not likely current risk… still need to consider* ***future risks***

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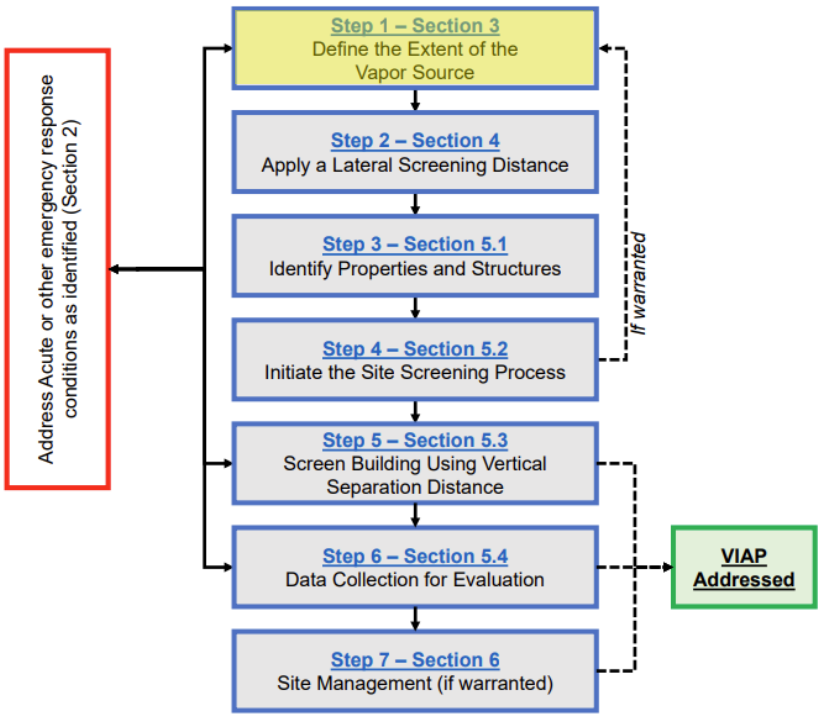
Step 1

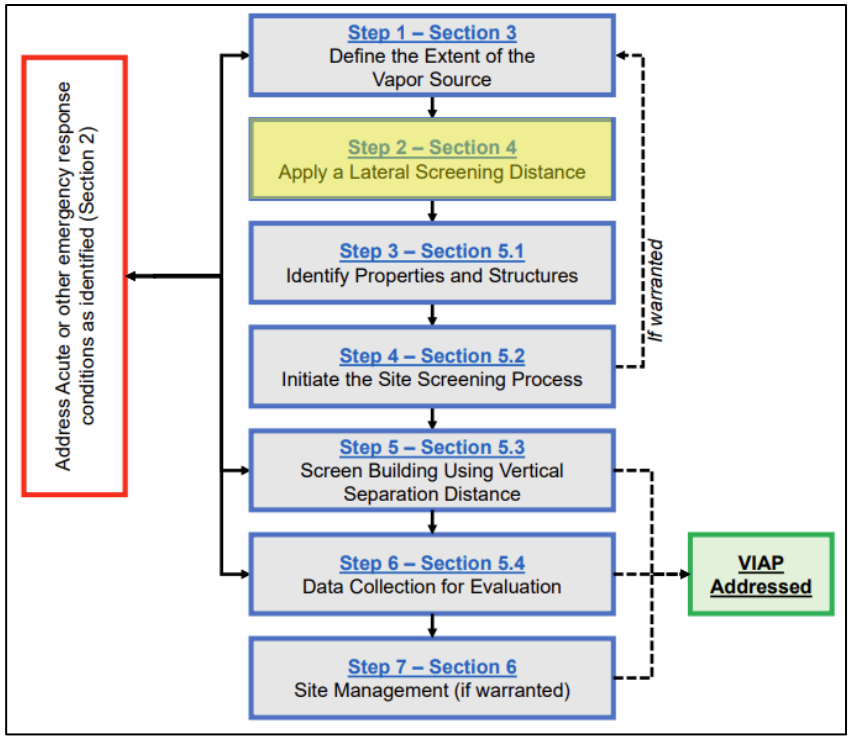
Define the Extent of the Vapor Source



- Defines extent of release and where there is reasonable potential for exposure
- NAPL
  - Includes residual, mobile, and migrating NAPL
  - Groundwater
- Based on depth of groundwater below grade
- Based on current or reasonably anticipated future land use
- Need to consider residential criteria for offsite migration

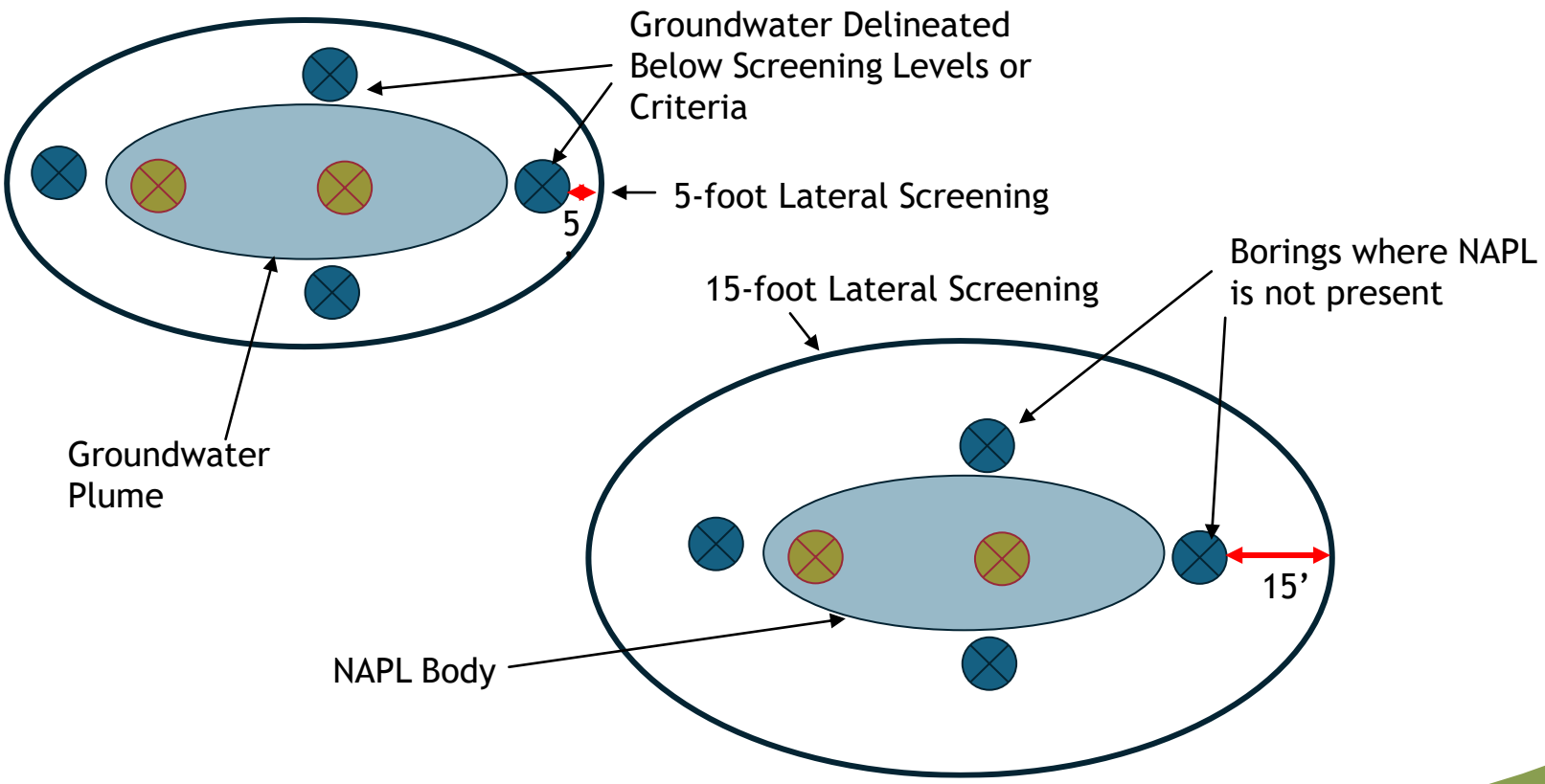
Step 2

Apply a Lateral Screening Distance



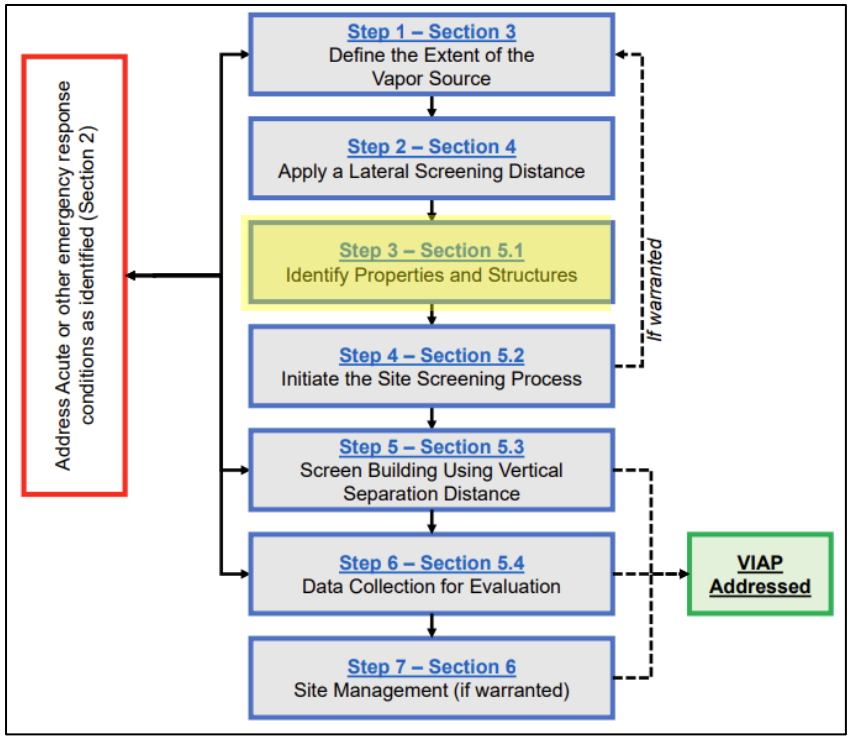
- For well characterized vapor source:
  - 15-feet from NAPL
  - 5-feet for groundwater contamination (i.e., dissolved-phase sources)
- 30-feet LIZ may be applied for facility that is not well characterized
- Physical features or obstructions (e.g., a road) that require that spacing of is long distance and extent of contamination is interpolated

What does “well characterize” mean?



Step 3

Identify Properties, Structures, and Conduits



- Identify all properties, structures, and conduits within the lateral inclusion zone

Step 3

Necessary Information

Table 5-1

Information on the Buildings, Properties, and Utilities Required

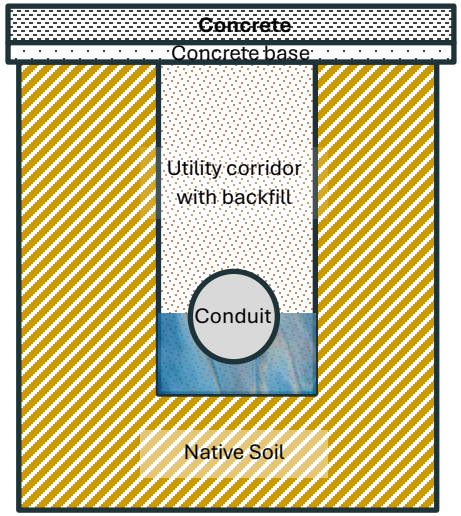
Building, Property, or Utility	Information required
Properties	• Lot lines • Current use or property restrictions
Structures	• Depth below grade of current structure • Construction materials and methods • Foundation • Presence of the sump or other features that may allow for the direct volatilization to occur
Utilities	• Location • Depth below ground • Ability to transport vapors and have a mobile NAPL vapor source enter into it
Backfill surrounding the Utilities	• Type of soil found at the property and throughout the facility

Conduits

2 situations that must be considered

Within a Conduit

- Must be in contact with mobile NAPL
- Can not be full or under pressure (need head space for vapor migration)
- Must connect to a structure
- **Can result in direct path for vapors into structures**



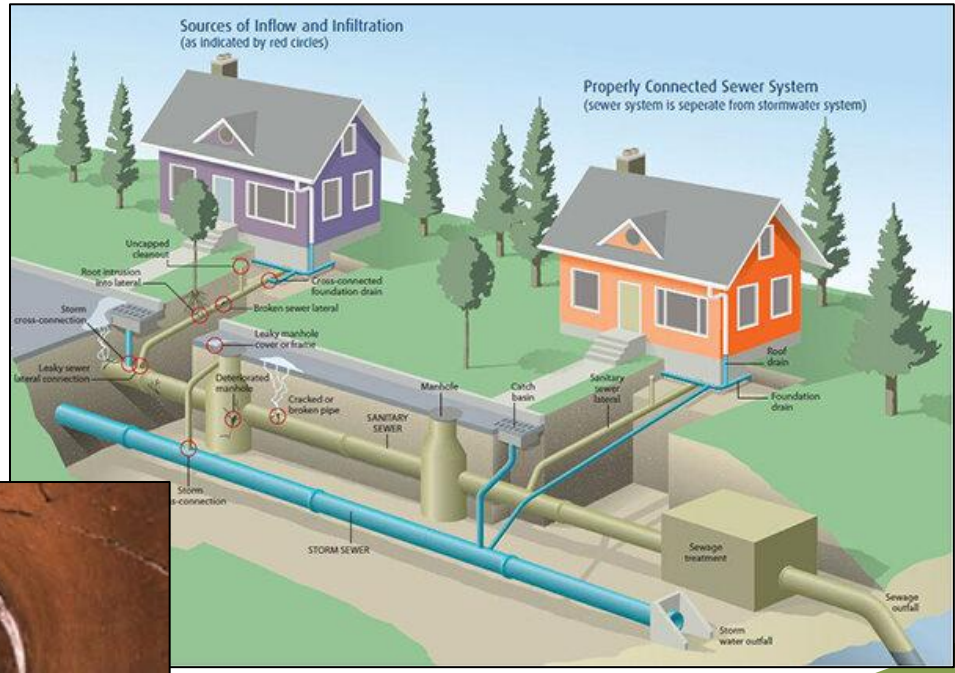
Within the Backfill

- Must be more permeable than surrounding soil
- **More of a characterization issue** as source can go where we may not expect – do not need to chase vapors any further than typical LIZ

Utilities vs Conduits

- Conduits must be:
  - Connected to a structure
  - Able to transport vapors

W	WATER LINE
S	SANITARY SEWER LINE
ST	STORM SEWER LINE
G	UNDERGROUND GAS MAIN LINE
OHE	UNDERGROUND ELECTRIC LINE
ED	EDGE DRAIN
OHE	OVERHEAD ELECTRIC LINE
OHT	OVERHEAD TELEPHONE LINE
OE/T	OVERHEAD ELECTRIC/TELEPHONE LINE



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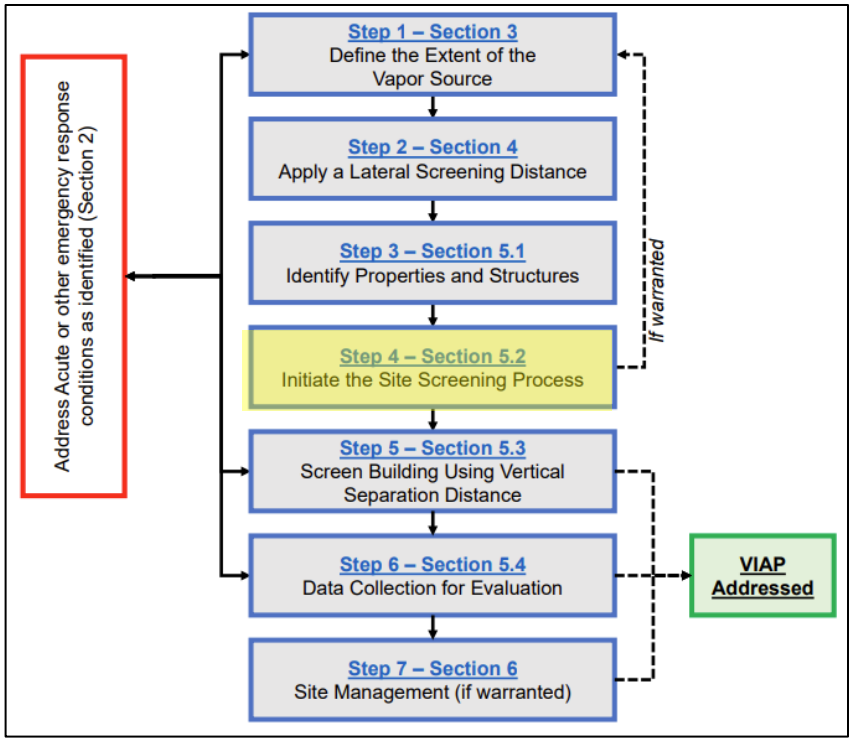
Step 4

Initiate the Site Screening Process

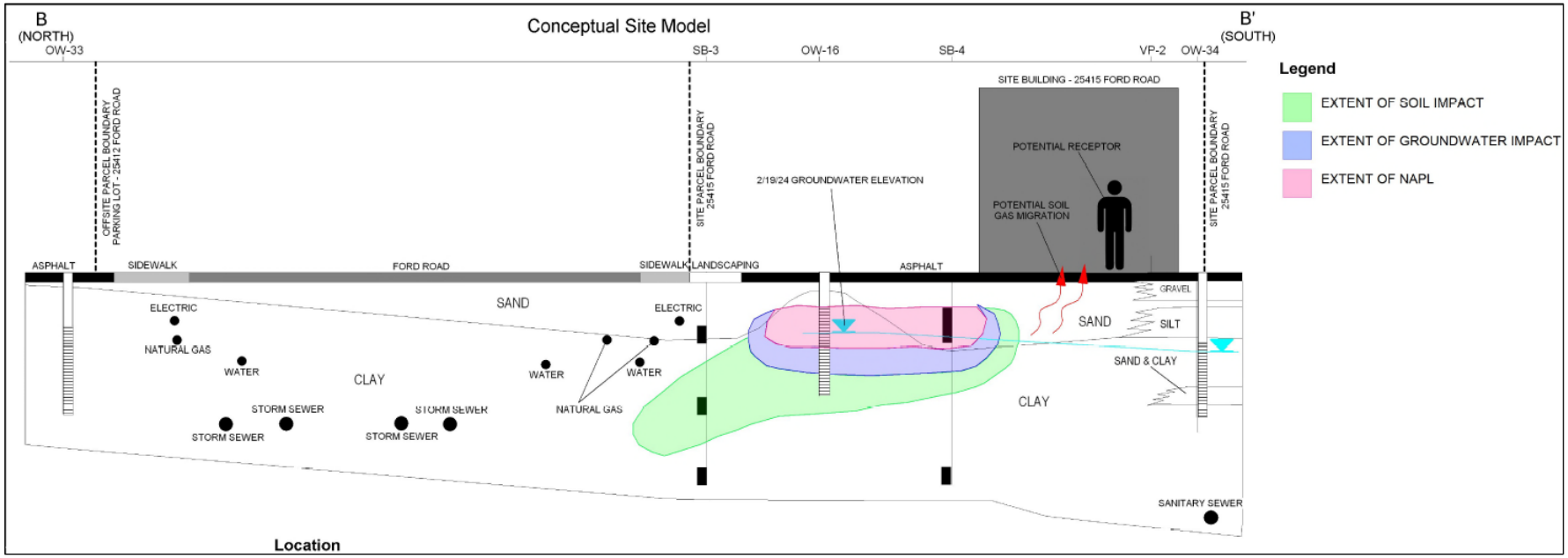


- Need to understand structures and their construction to be able to vertically screen out structure from needing further evaluation
- For conduits, need to know elevation of utilities and where mobile NAPL located

Can you answer the following?

- Is the depth of groundwater known?
- What is the depth of the building foundation (only slab or sump) below grade?
- Is the location of the vapor source known?
- Is the distance between the vapor source and the structure known?
- Where are conduits located in relation to the mobile NAPL (if present)?
- Can the mobile NAPL enter the conduit?

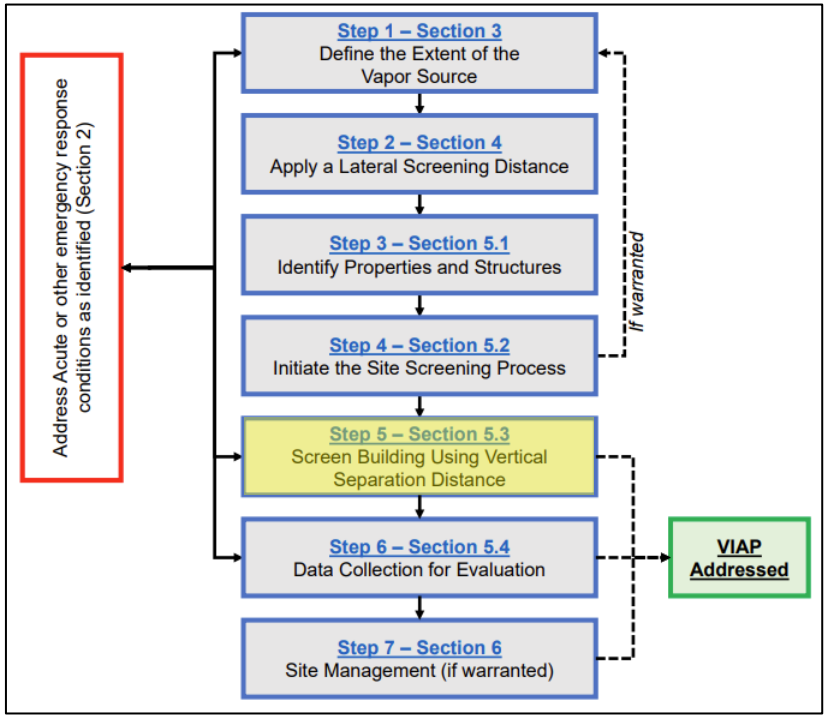
Cross Sections



NOTE: Cross sections aid in showing how utilities screen out and which buildings screen In

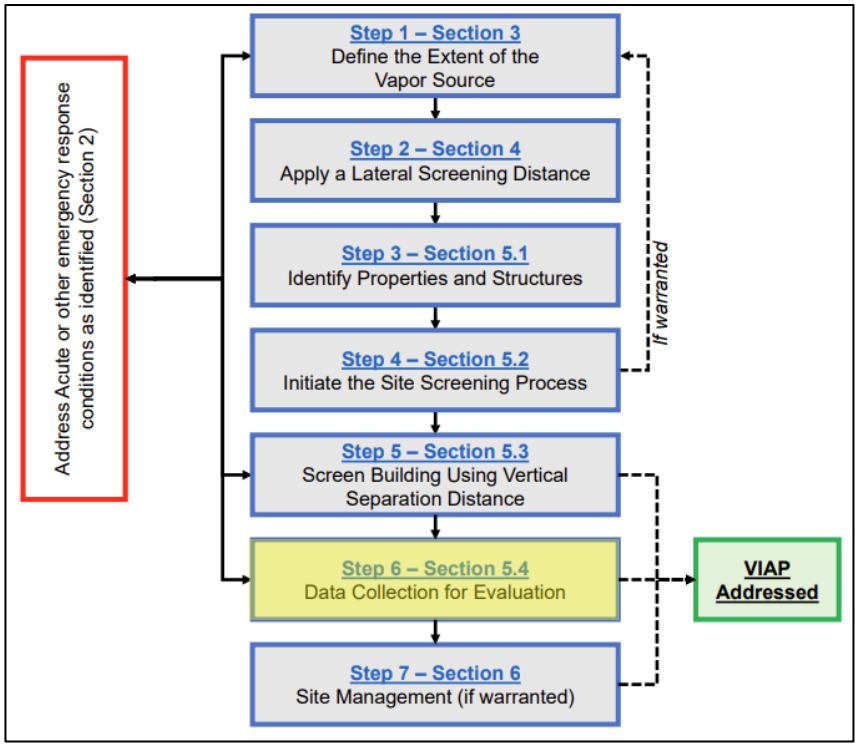
Step 5

Screen Building using the Vertical Separation Distance



- Based on measured vertical separation distance between slab or depth of any sumps that may allow for direct volatilization to occur and
  - Top of groundwater and/or
  - NAPL vapor source
- This distance is not be estimated

Step 6
Data Collection for Evaluation



- Only for:
  - Those structures that do not screen out
  - There is need to reduce lateral inclusion zone
  - Utilities in contact with mobile NAPL

Soil Gas Data

- Soil gas can:
  - Aid in vapor source and NAPL delineation
  - Be used to shrink LIZ
  - Show there is no current unacceptable risk, and
  - Can also be used to show compliance with the soil and groundwater criteria/screening levels

NOTE: Representative soil gas can show any concentration of groundwater or NAPL is in compliance, but it may not remove need for **land or use restriction** if future use cannot be evaluated.

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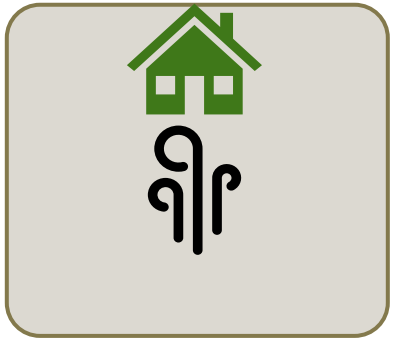
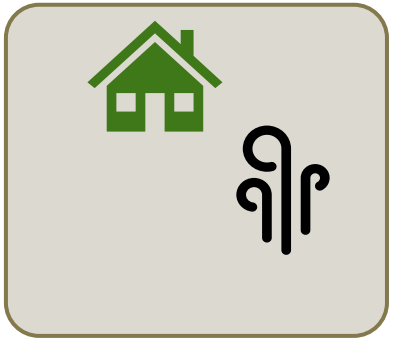
Data Collection and Evaluation

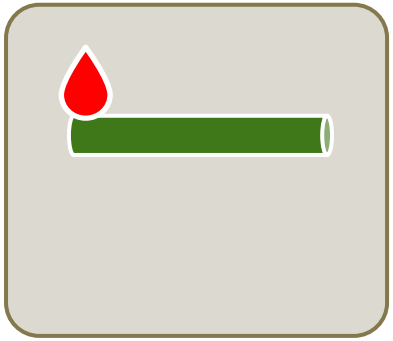
Type of Sites



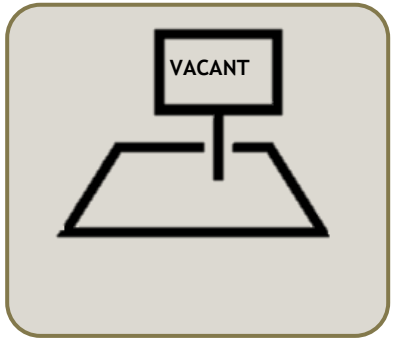
Structure over a Vapor Source, in contact and not in contact (Section C.1.0)



Structure adjacent to a Vapor Source (Section C.1.2)



Conduit in Contact with mobile NAPL (Section C.2.3)



Structures are Not Currently Present (Section C.2.4)

Data Collection and Evaluation

Sample Events and Numbers

Potential Vapor Source and Distance to Receptor	Soil Gas Sample Results	Minimum Number of Rounds
NAPL ≤ 5-feet	< VIAC	4
NAPL 5 – 10-feet	< VIAC	3
NAPL 10 – 15-feet	< VIAC	2
Dissolved Groundwater Source	< VIAC	1

Building Size	Sample Density	Minimum Number of Sampling Locations
Less than 1,000-ft^2	Not Applicable	2
1,000-feet – 10,000-ft^2	3 + one additional sample per 1,500 ft^2 of building over 1,000 ft^2	3
Greater than 10,000-ft^2	9 + one additional sample per 2,500 ft^2 of building over 10,000 ft^2	9

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Data Collection and Evaluation

NAPL entering a Conduit

Table– C-4 – Mobile NAPL Vapor Source entering an Underground Conduit

Known or Suspected	Sampling Frequency of Conduit Vapors	Response Action
Not in Contact	None	Not applicable
In contact and determined to not be entering utility	None	Response Actions may be needed to ensure vapor source will not enter in the future.
Suspected but unconfirmed	Quarterly for 1 year	Any detection in the conduit above the SSVIAC moves the utility into the known vapor source entering into an underground conduit. Response Actions may be needed to ensure vapor source will not enter in the future.
Known – Occurring	Progress sampling weekly until the vapor source is controlled. Structures connected to the utility should be evaluated for the entry of vapors and explosive conditions.	Implement immediate response activity – considered occurring until response activity is complete.
Known – post corrective or response action	Sample monthly for 3 months then quarterly for 3 additional quarters	Any detection above the SSVIAC requires sampling to return to the *Known – Occurring* sampling frequency

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Volume 4
Summary and Quick Takes

- Step-wise approach to petroleum
  - There are other approaches that may be appropriate
  - Need to understand the extent of NAPL
  - NAPL definition includes residual, mobile, and migrating
- Conduits
  - Focus on those utilities that can transport vapors to a structure and are in contact with mobile NAPL

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