Have You Got Methane? Latest Trends in Vapour Mitigation for Brownfields

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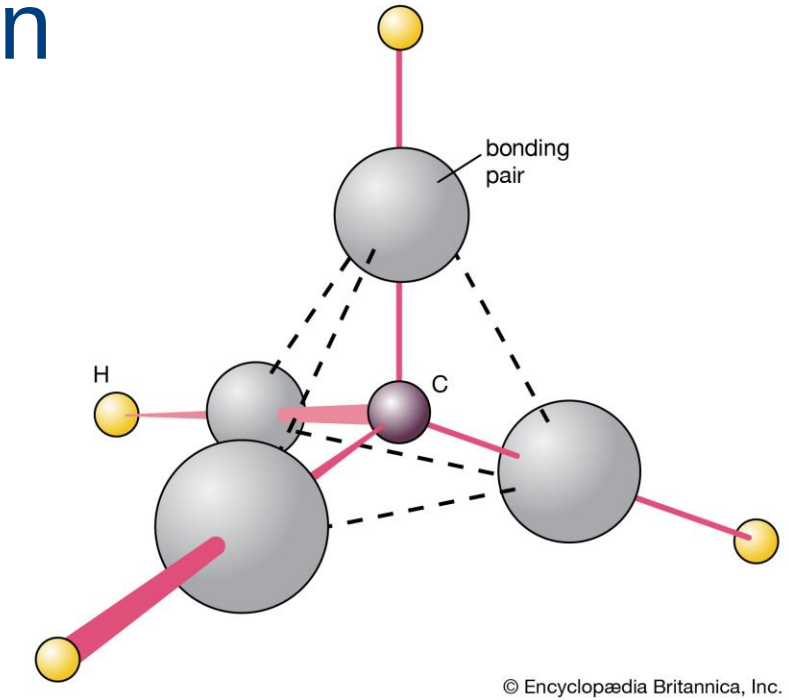
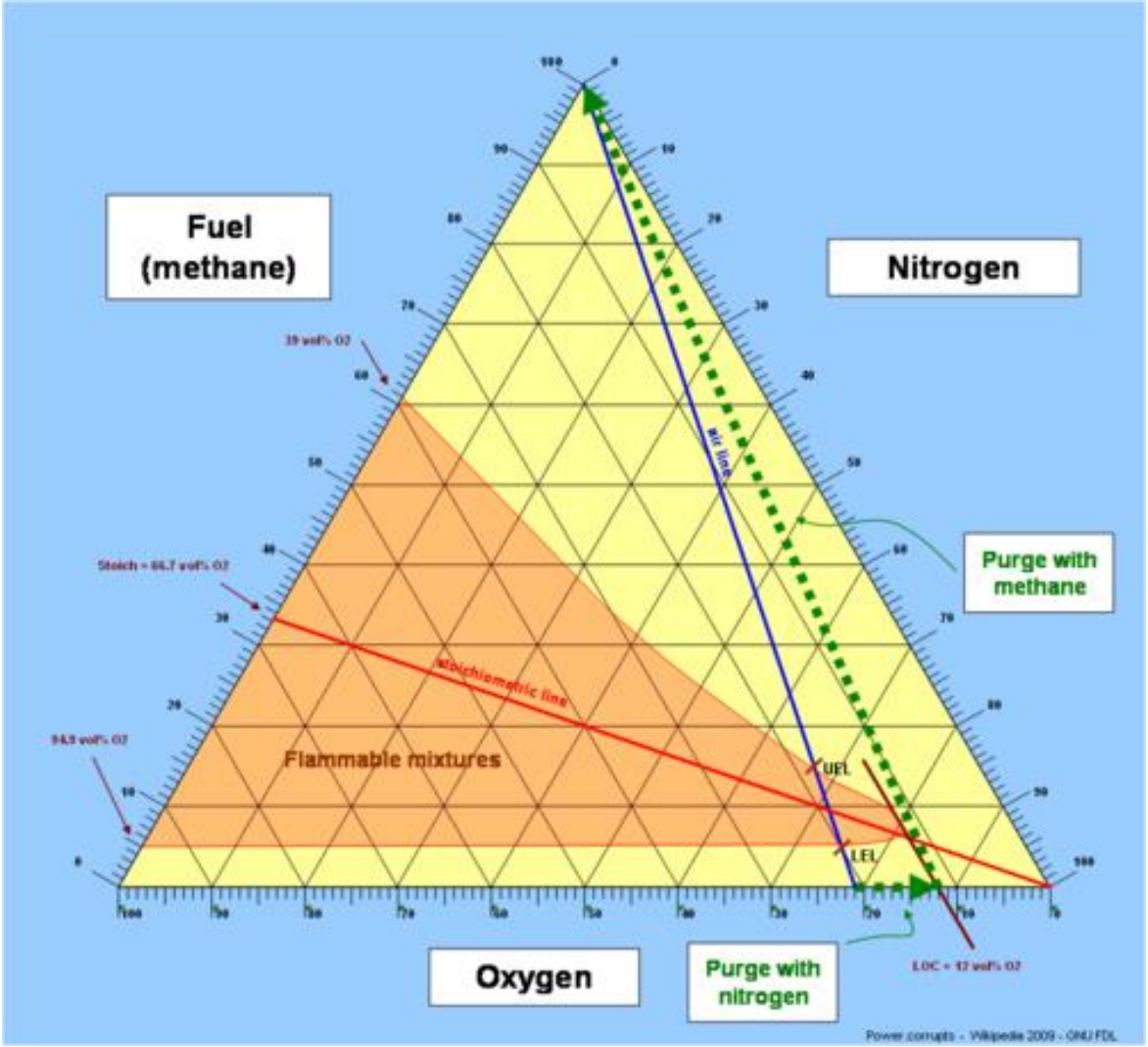
Agenda

- Why care about methane
- Investigation methods – key considerations
- Risk Perspective of Vapour Intrusion
- VI Mitigation Examples



Methane

- Explosive between 5% and 17%
- Asphyxiation hazard (+CO_2)
- Advective flow/pressure
  - Regulations vary on the evaluation and mitigation of methane



Toronto Closed Landfill Sites

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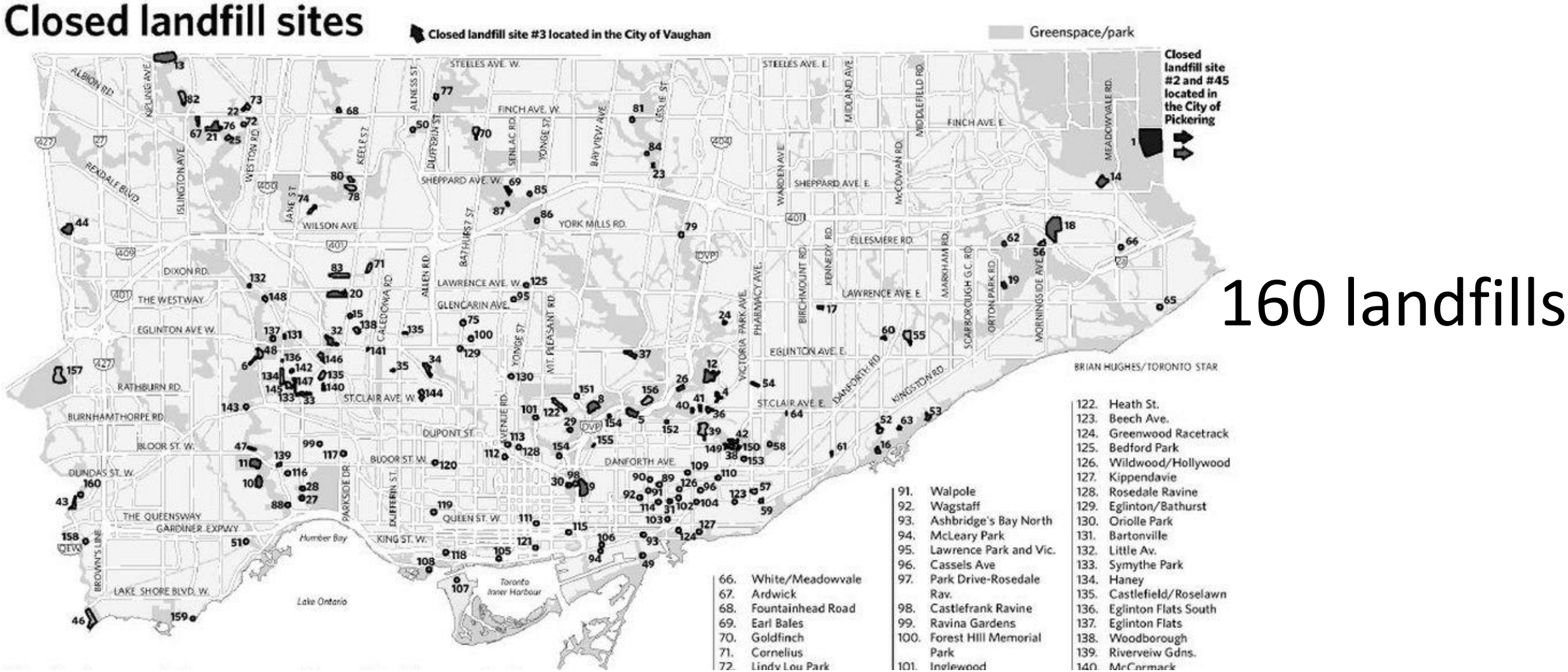

160 landfills

Montreal Former Waste Dumps

Not Just Landfills

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Table 2 Typical compositions of methane-containing gases

Source	Gas composition % by volume in air							
	CH_4	C_2H_6	C_3H_8	CO_2	CO	H_2S	N_2	O_2
Landfill gas [1]	20–65			16–57	$<1 \times 10^{-4}$	2×10^{-5}	0.5–37	<0.3
Mine gas								
seam	80–95	8	4	0.2–6			2–9	
pumped drainage[2]	22–95	3	1	0.5–6	0-10		1–61	
Wetlands/peat lands								
freshwater muds[3]	3–86			0.3–13			16–94	
saltwater muds	55–79			2–13				
marsh gas	11–88						3–69	
buried peats and organic soils	45–97						1.6–54	
Mains/natural gas[4]	94	3.2	0.6	0.5			1.2	

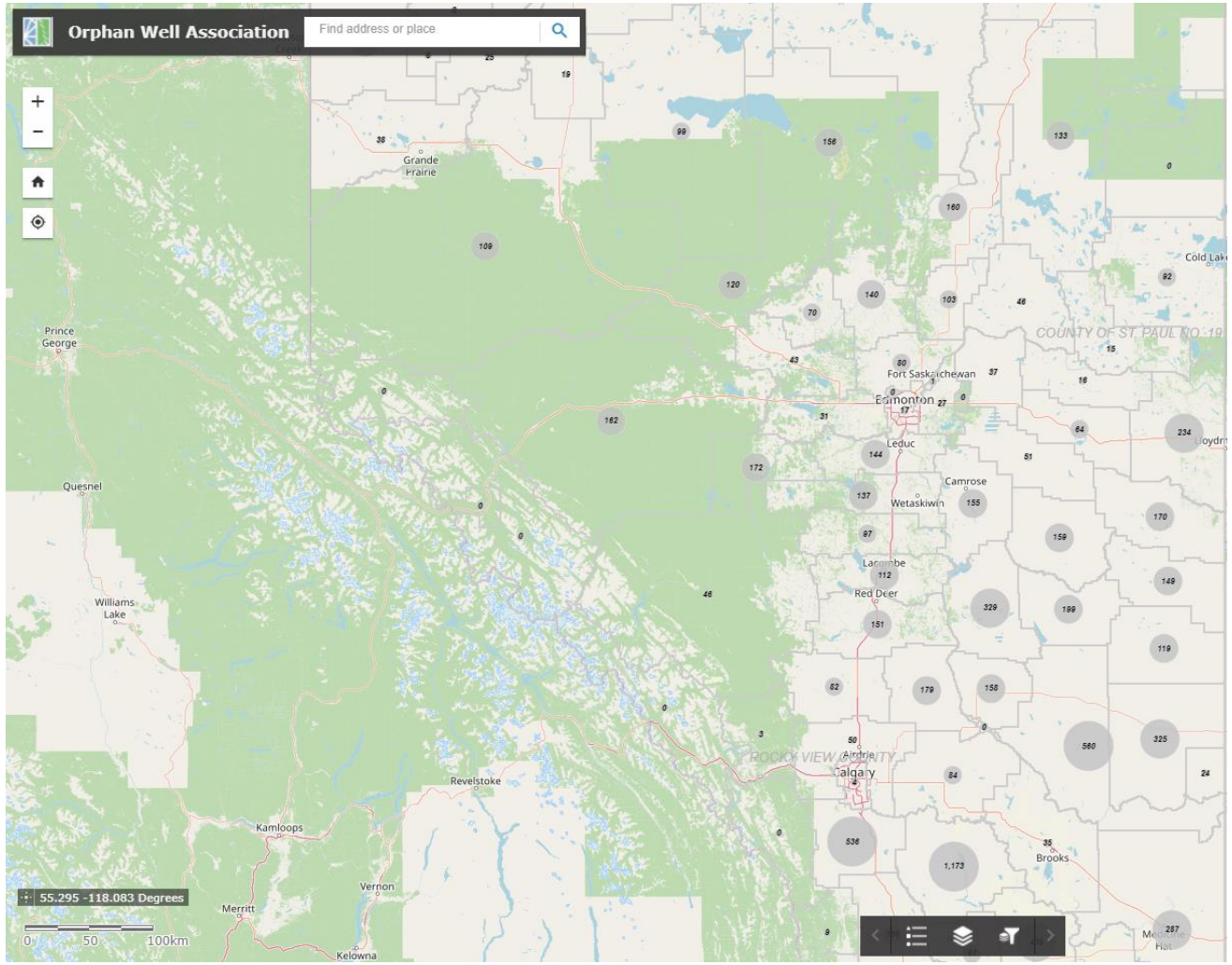
Notes:

1. See also Table 3.
2. Gas mixed with air.
3. Composition varies with depth.
4. Also 0.2% C_4H_{10} (butane).

Anthropogenic and non-anthropogenic sources

- Ratio of CO_2/CH_4 can help identify source
- H_2S
- mercaptans

Orphan Wells



- Non-production wells can still release methane

Municipal Building Codes for Methane

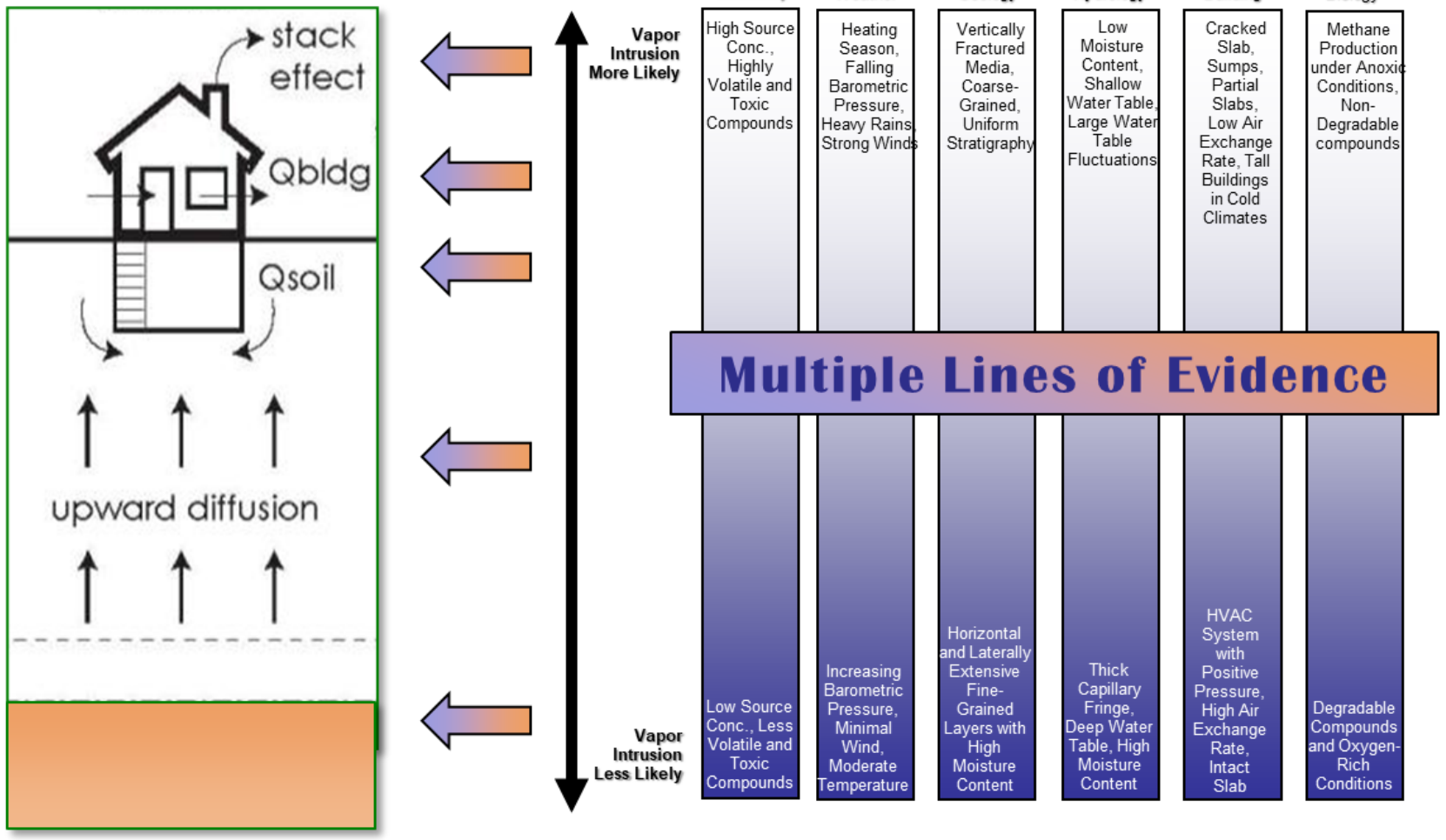
Municipalities and Cities have local building codes related to naturally occurring methane.

Jurisdictional Regulations

- City of LA have developed a buffer zone around naturally surfacing cold tar and crude oil
- Other jurisdictions have similar protocols
  - 6 cities and 2 counties have methane specific guidance for redevelopment
  - Generally, must investigate within 300 m of landfill or 100 m of oil well
  - Mitigation requirements can be linked to concentration and pressure of gas
  - Can specify various mitigation methods depending on area

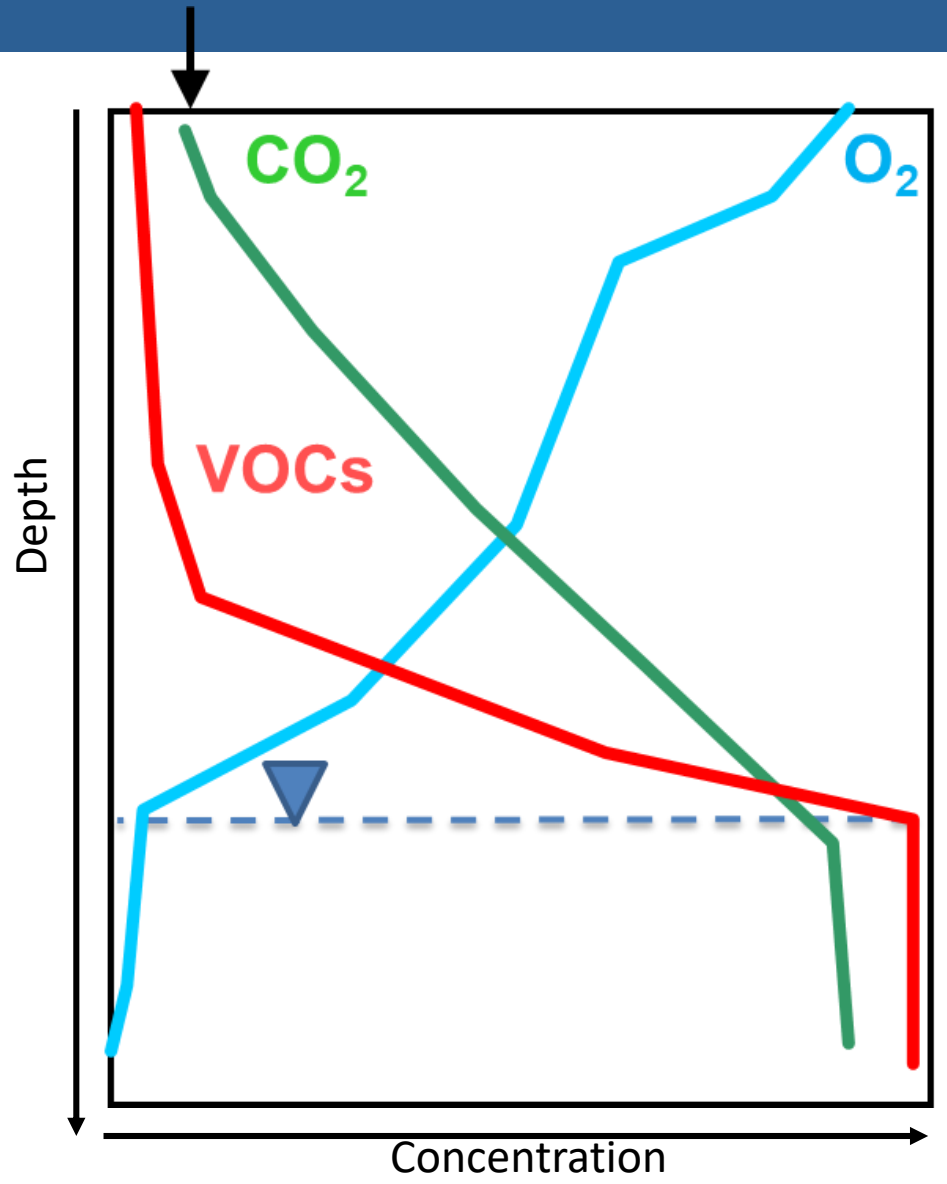
VI Investigation Methods – key considerations

- Multiple Lines of Evidence Approach
- Development a conceptual site model
- Not just multiple chemistry data points
  - Building effects
  - Permeability
  - Depth to water

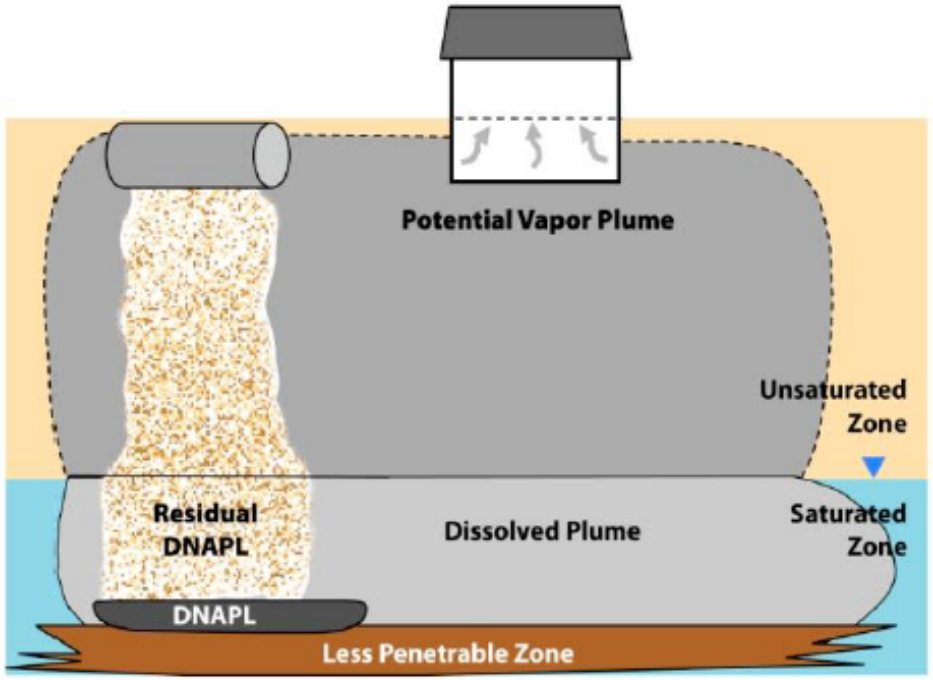


Vertical Profile

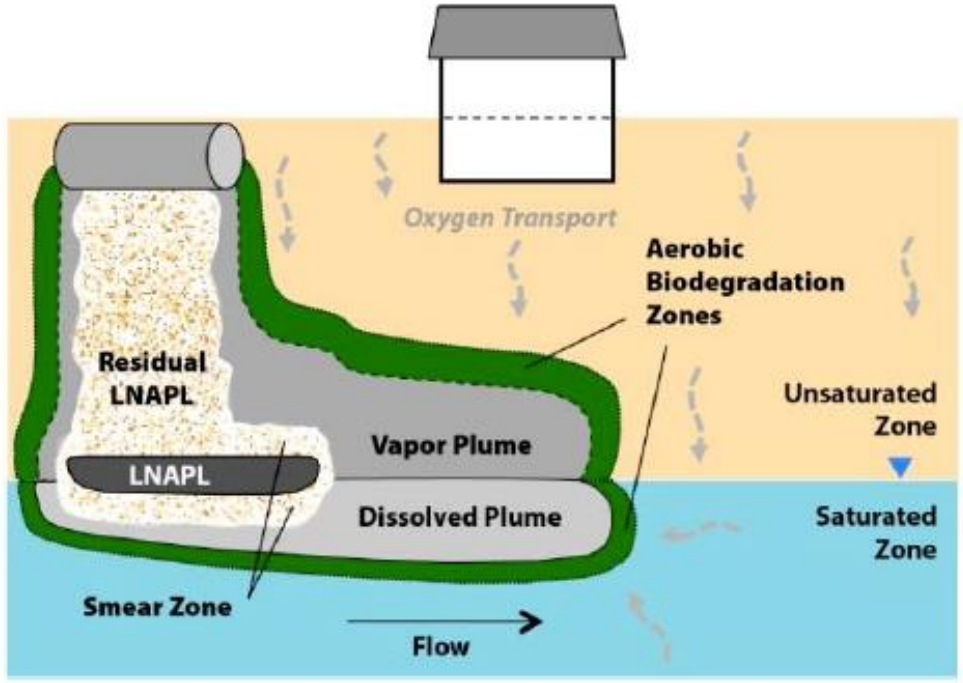
- Need to account for aerobic biodegradation of hydrocarbons
  - Screen across the vertical profile
  - Document PHCs, CH_4, O_2, CO_2
- Understand Pressure Gradients
  - Advective flow



Chlorinated VI vs. Petroleum Hydrocarbon VI



Typical chlorinated solvent transport conceptual scenario



Typical petroleum hydrocarbon transport conceptual scenario

Key Differences:

- Natural vadose-zone biodegradation mitigates vapour migration
- Common VI models do not account for bioattenuation

Safety

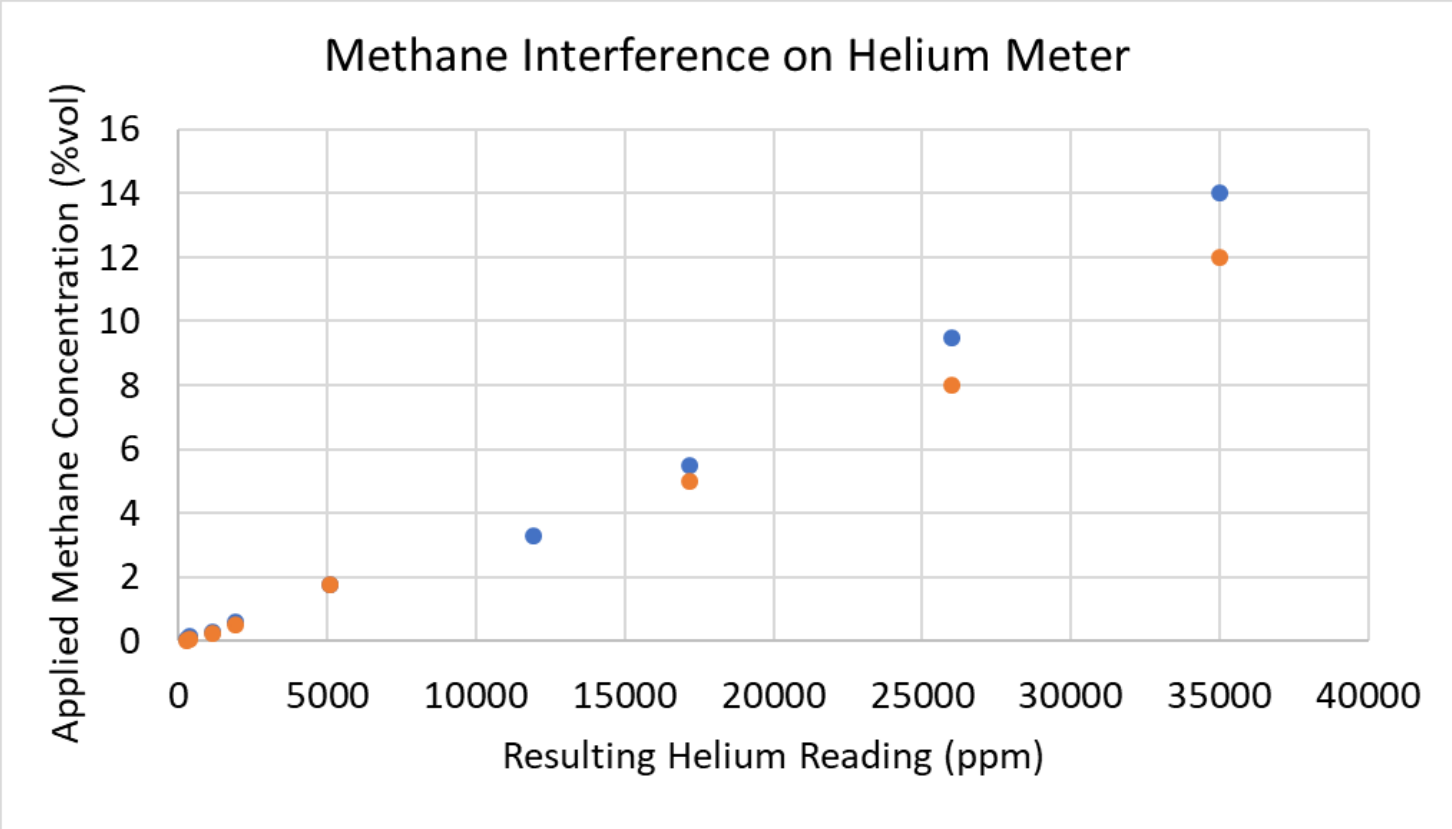
Evaluate safety when drilling into potentially high methane environments

- Potential for sparks
- Dilution of CH_4 into the explosive range
- Generation of CH_4 at bioremediation sites

Field Screening Interference

Collecting a Representative Sample

- CH_4 positive bias with Helium Leak detector
- Helium tracer may have positive bias with CH_4 detector

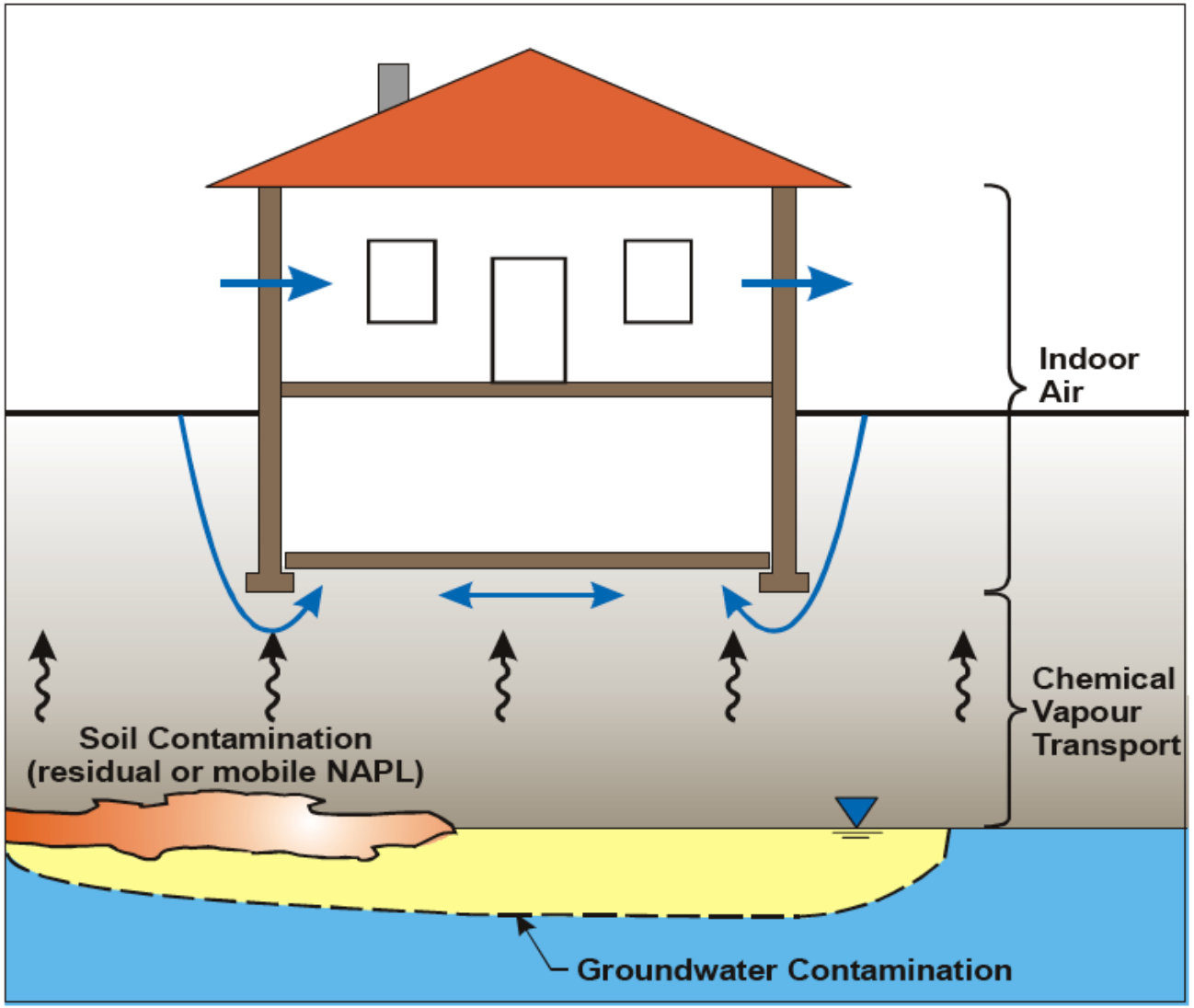


Risk Perspective of VI

- CCME – Federal Guidance
- Health Canada Guidance
- Provincial Guidance

CSR – Contaminated Site Regulation
CSAP – Contaminated Site Approved Professional

Attenuation Factors



$$AF(\alpha) = \frac{C_{IA}}{C_{Subsurface}}$$

Generic Attenuation Factors in BC and ON

BC: Protocol 22

Table 1. Vertical VAFs

Sample Location	Sample Depth[2,3,4]	Vertical VAF (α_I, α_O)[1]			
		Outdoor Exposure (α_O)	Indoor Exposure (α_I)		
			Agricultural, Urban Park, Residential Use	Commercial, Industrial Use	Parkade Use
Below unlined crawlspace, earthen basement, or wooden[5] basement	0.45 to 5 m	-	1.0×10^{-1}		-
Sub-slab[6]	-	-	2.0×10^{-2}		
In preferential flow pathway[7]	-	1.0×10^{-4}	2.0×10^{-2}		
Subsurface	< 1.0 m[8]	1.0×10^{-4}	2.0×10^{-2}		
	1.0 m	1.5×10^{-6}	2.8×10^{-3}	3.7×10^{-4}	2.8×10^{-3}
	1.5 m	1.2×10^{-6}	2.3×10^{-3}	3.4×10^{-4}	2.3×10^{-3}
	2.0 m	9.2×10^{-7}	2.0×10^{-3}	3.1×10^{-4}	2.0×10^{-3}
	3.0 m	6.1×10^{-7}	1.6×10^{-3}	2.7×10^{-4}	1.6×10^{-3}
	5.0 m	3.7×10^{-7}	1.1×10^{-3}	2.1×10^{-4}	1.1×10^{-3}
	7.0 m	2.6×10^{-7}	8.3×10^{-4}	1.7×10^{-4}	8.3×10^{-4}
	10.0 m	1.8×10^{-7}	6.2×10^{-4}	1.3×10^{-4}	6.2×10^{-4}
	15.0 m	1.2×10^{-7}	4.3×10^{-4}	9.9×10^{-5}	4.3×10^{-4}
	20.0 m	9.2×10^{-8}	3.3×10^{-4}	7.8×10^{-5}	3.3×10^{-4}
	30.0 m	6.1×10^{-8}	2.3×10^{-4}	5.5×10^{-5}	2.3×10^{-4}

[1] Use of these attenuation factors for vapour characterization is not permitted where precluding conditions apply, see Section 3.1.

[2] For subsurface vapour samples taken from probes installed in boreholes (e.g., vapour or groundwater monitoring wells), the sample depth is based on the vertical distance from the bottom of

ON: Soil Vapour Intrusion Assessment

Shallow Depth to Groundwater Contamination: When the water table (highest annual) is less than 3 metres from soil surface, the groundwater to indoor air vapour attenuation factors (derived using the J&E model) used in the development of the generic MOE Tables 2 and 3 are not sufficiently conservative for a preliminary screening. For sites with water table less than 3 metres below soil surface should use the GW2 component values from the MOE SCS Tables 6 or 7 (MOE 2011a). These SCS were developed using a reasonable conservative vapour attenuation factor (0.02 for residential and 0.004 for commercial/industrial land use) based on empirical information and assuming that biodegradation between the groundwater and the basement is not occurring.

What about biodegradation?

Bioattenuation Adjustment Factors

BC: Protocol 22

In each situation you must meet certain criteria

- BAAD = 10x
- PAAD = 50x
- LAAD = 7 to 25x based on up to 30m offset

ON: Soil Vapour Intrusion Assessment

10x to 100x attenuation based on specific Criteria

- <1mg/L - >1m = 10X BAF
- <1mg/L - >3m = 100x BAF

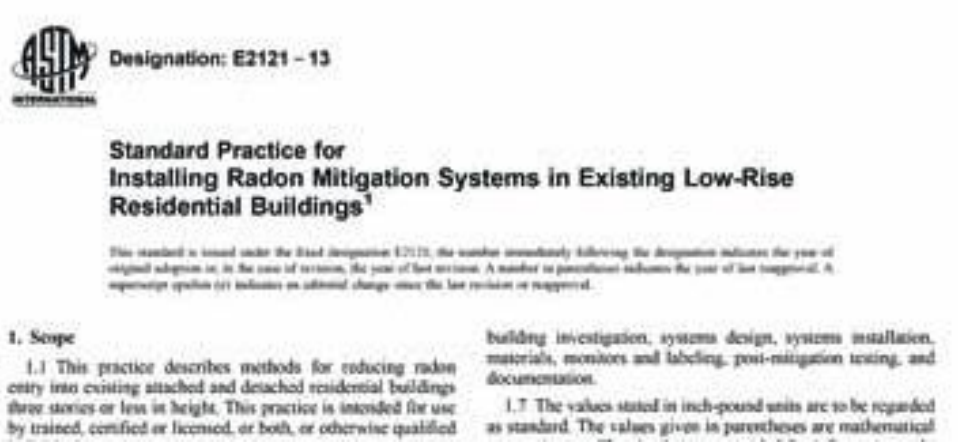
If >1 mg/L, <50mg/L separation distance must be 2m (10x) or 4m (100x)

If > 50 mg/L (NAPL) separation distance must be 3m (10x) or 5m (100x)

"AAD" – attenuation adjustment divisor

Methane Mitigation

- Typical VI mitigation designs for negative pressure below building slab (6-9 pascals)
- Standard approach to VI may not be optimal for methane
- To enhance biodegradation of methane we want to introduce O_2 into the subsurface.
- Higher flow rate = more O_2 in subsurface
- Higher flow in to subsurface = higher permeability = lower applied vacuum



Designation: E2121 – 13

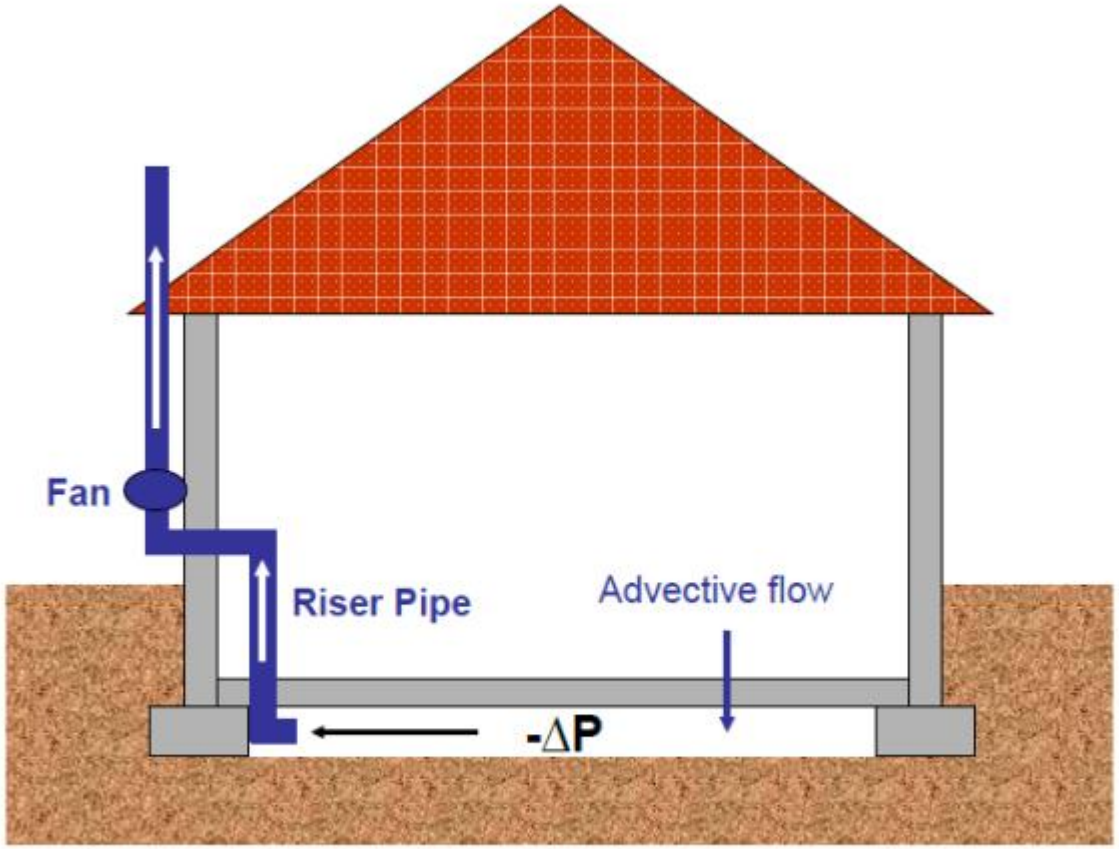
Standard Practice for
Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings[1]

1. Scope

1.1 This practice describes methods for reducing radon entry into existing attached and detached residential buildings three stories or less in height. This practice is intended for use by trained, certified or licensed, or both, or otherwise qualified building investigation, systems design, systems installation, materials, monitors and labeling, post-mitigation testing, and documentation.

1.7 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical

Depressurization vs Venting



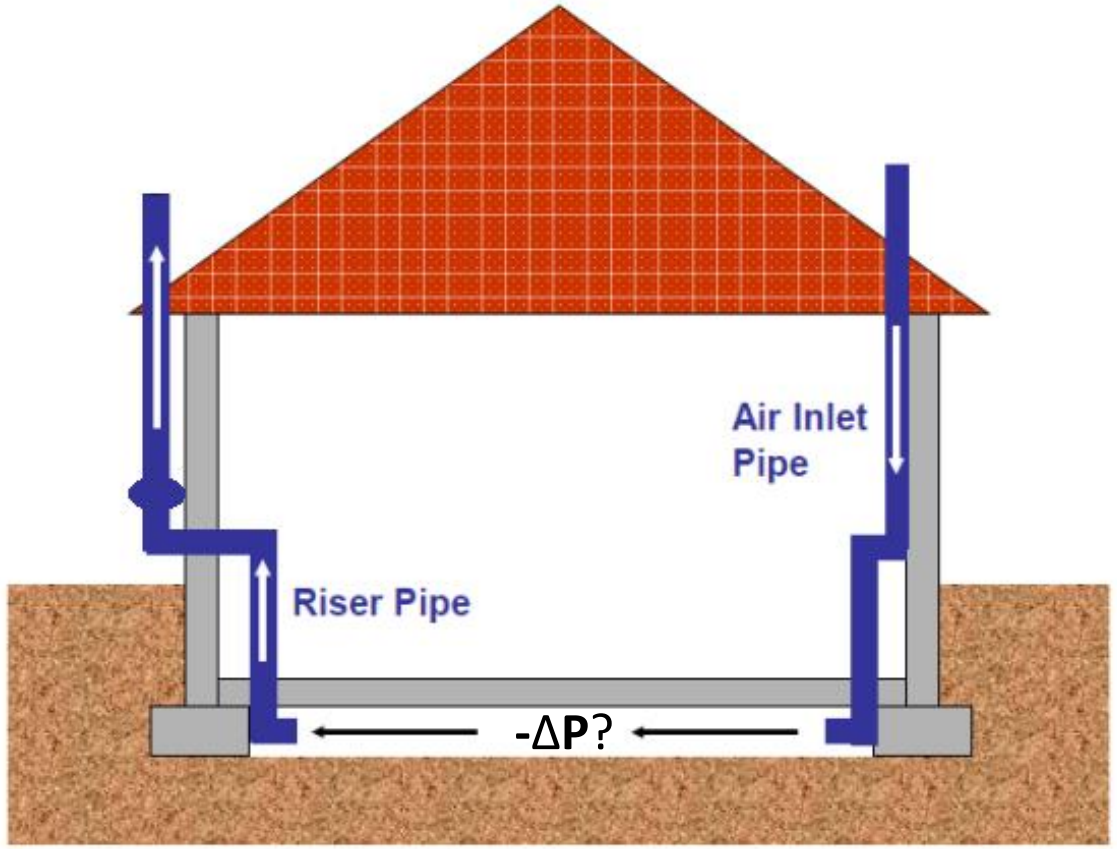


Figure 1. Conceptual diagram of an SSD system.

GTA Development

Example Mitigation Design

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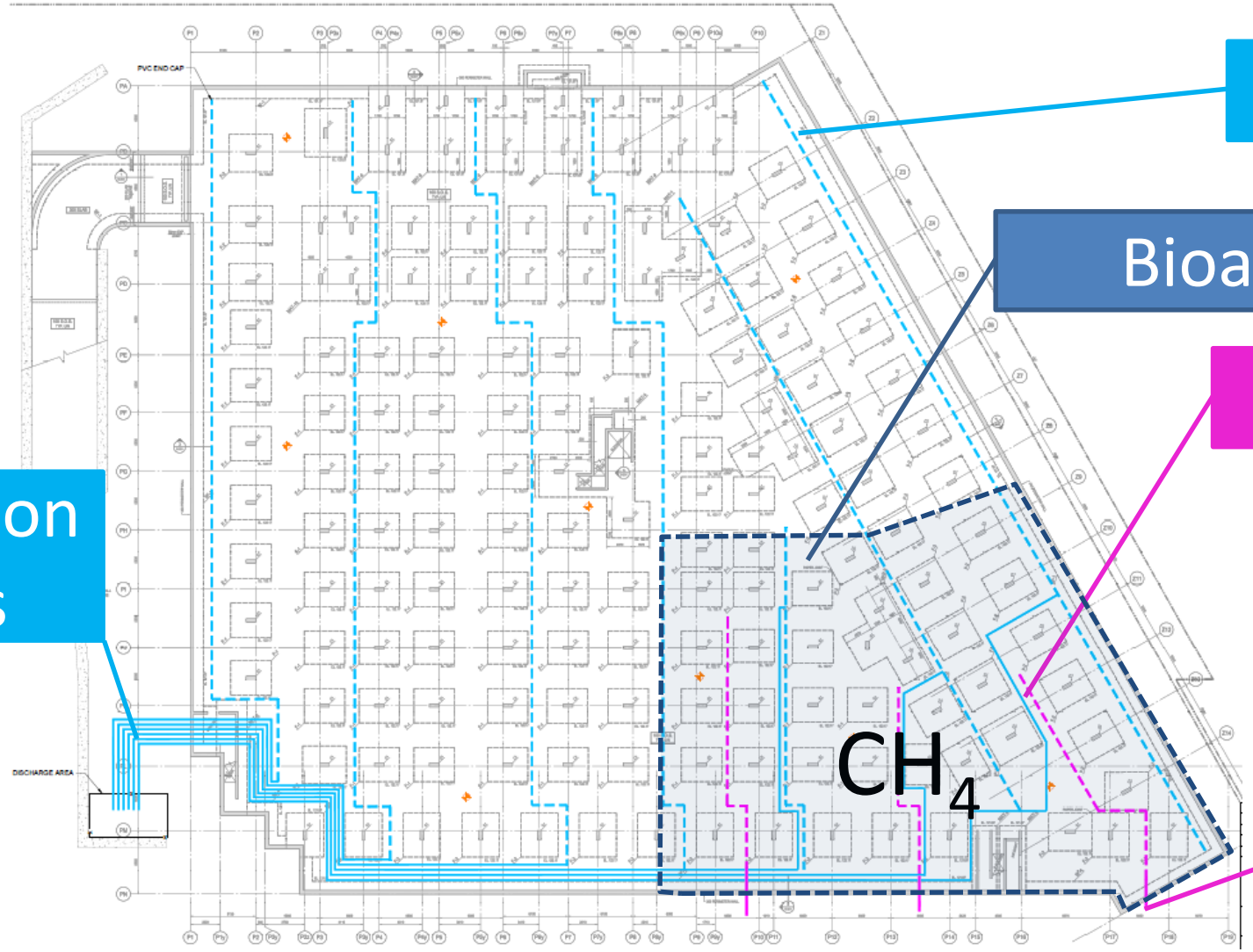


Extraction Pipes

Bioactive zone

Air Inlet Pipes

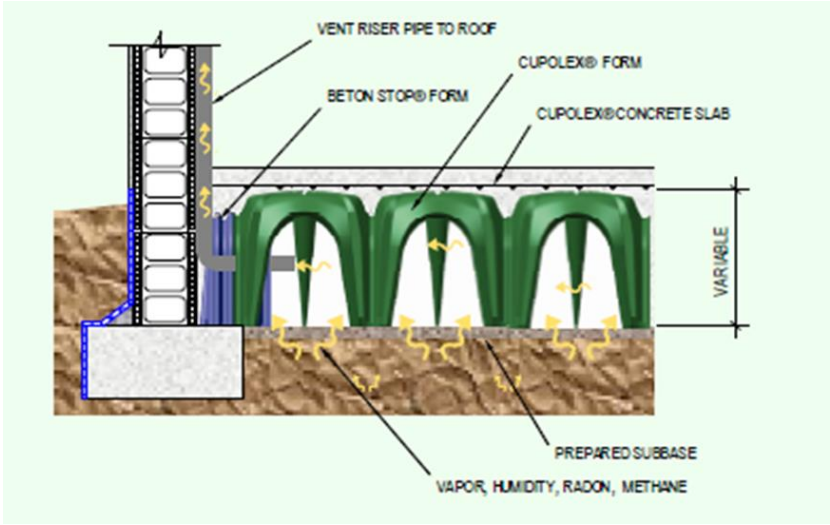
Extraction Pipes

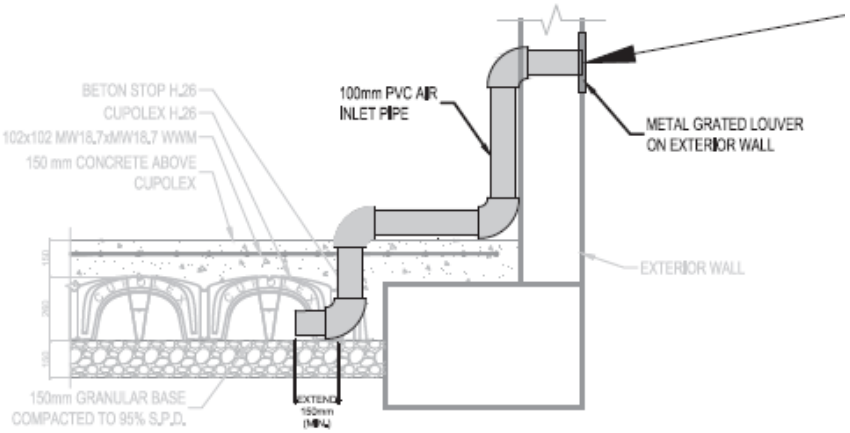
Landfill

Air Inlet Pipes

Aerated Floor Systems

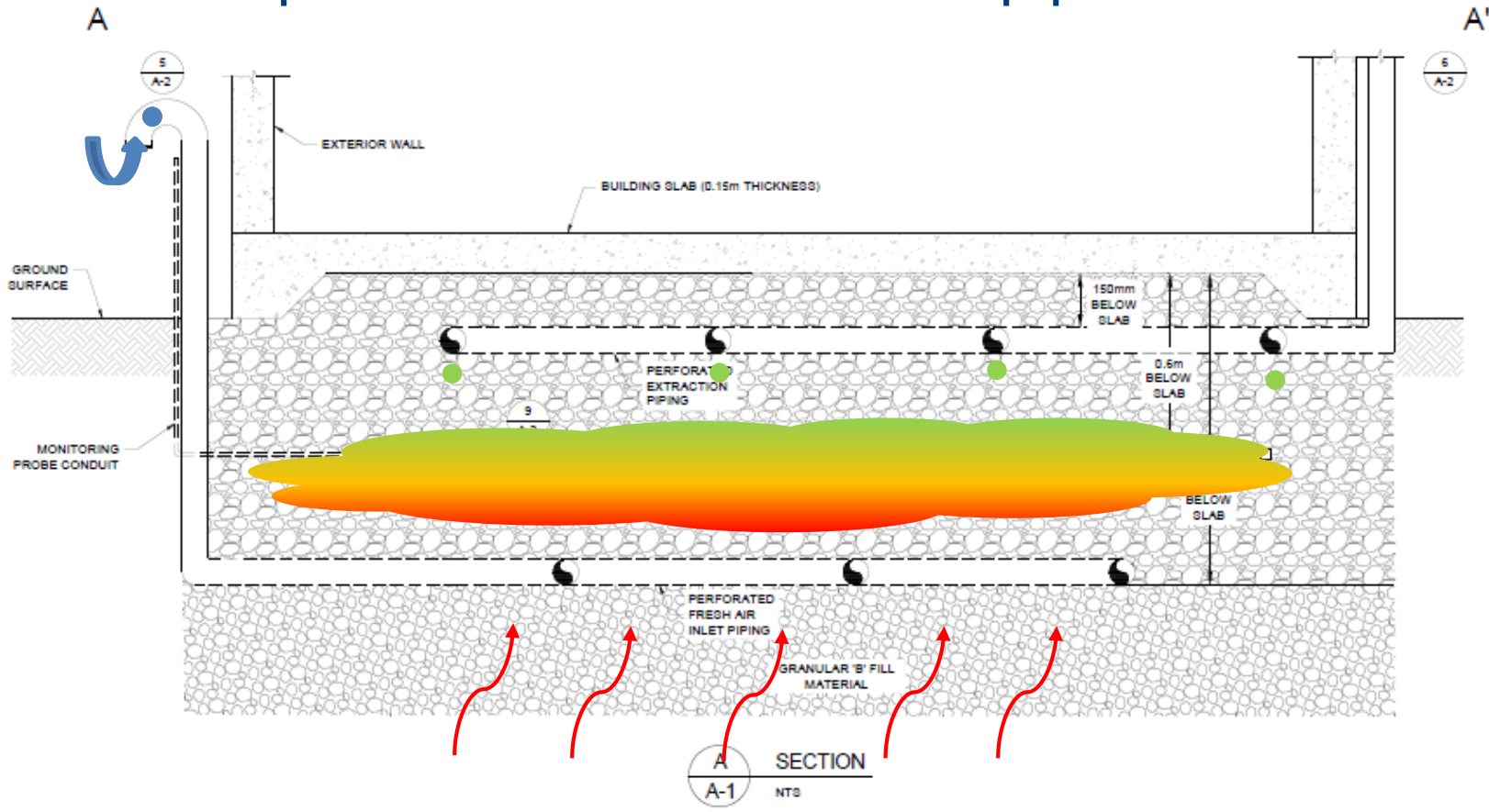
- Creates and open void space beneath the slab
- May not require a vapour barrier





Enhancing Biodegradation of methane

- Excavation of hydrocarbon UST leak prior to building construction
- Enabled the deeper installation of air inlet pipes



Permitting Mitigation Systems

Most jurisdictions do not exempt mitigation systems

- Ontario covered by ECA/EASR
- Metro Vancouver Approvals Branch

Benefits of Enhancing biodegradation

- Could use non-explosion proof fan or be passive
- Could potentially be exempt from a permit

ECA - Environmental Compliance Approval
EASR - Environmental Activity and Sector Registry

Take Home Messages

- Methane is a concern from many different sources
- Traditional mitigation system criteria doesn't account for permeable conditions
- Use biodegradation to your advantage
- Tailoring mitigation to site conditions can save money

Thank you

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