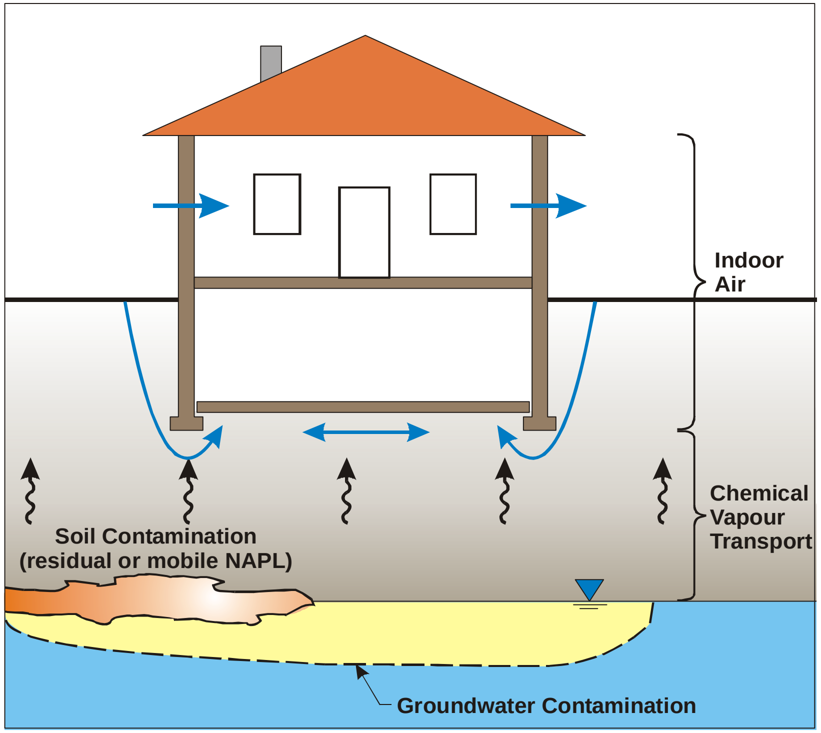
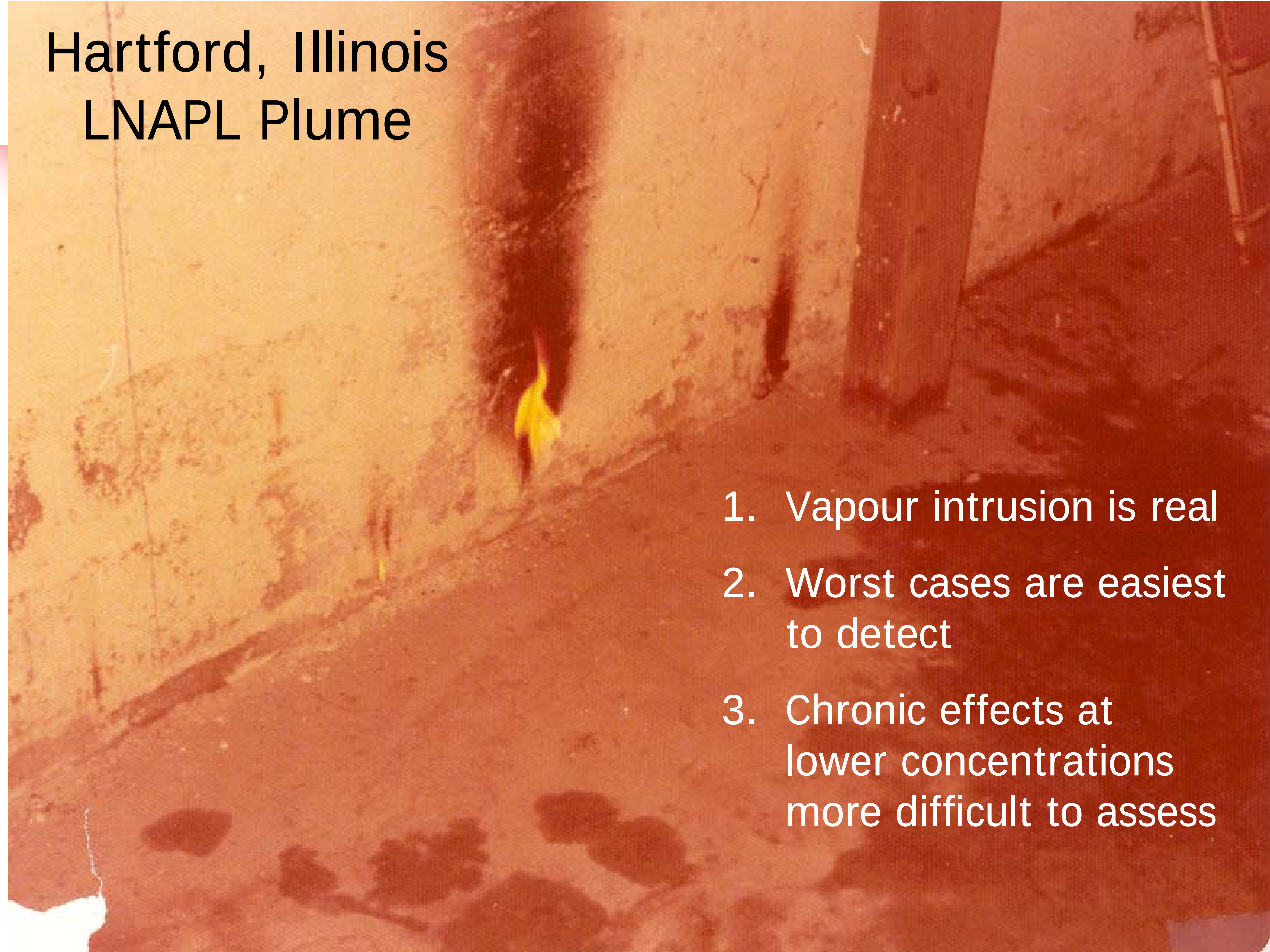
Design of Below Sub-slab Vapour Management System for a Commercial Building



RemTech 2008
October 16, 20078
Banff, Alberta

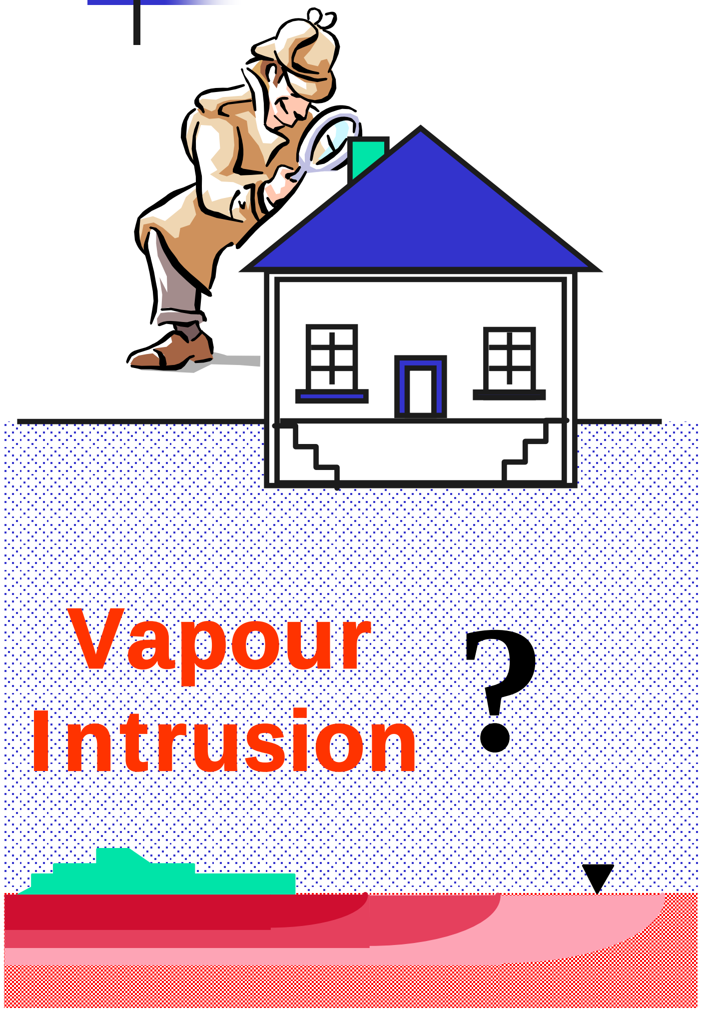
Charito Cañero

Hartford, Illinois LNAPL Plume



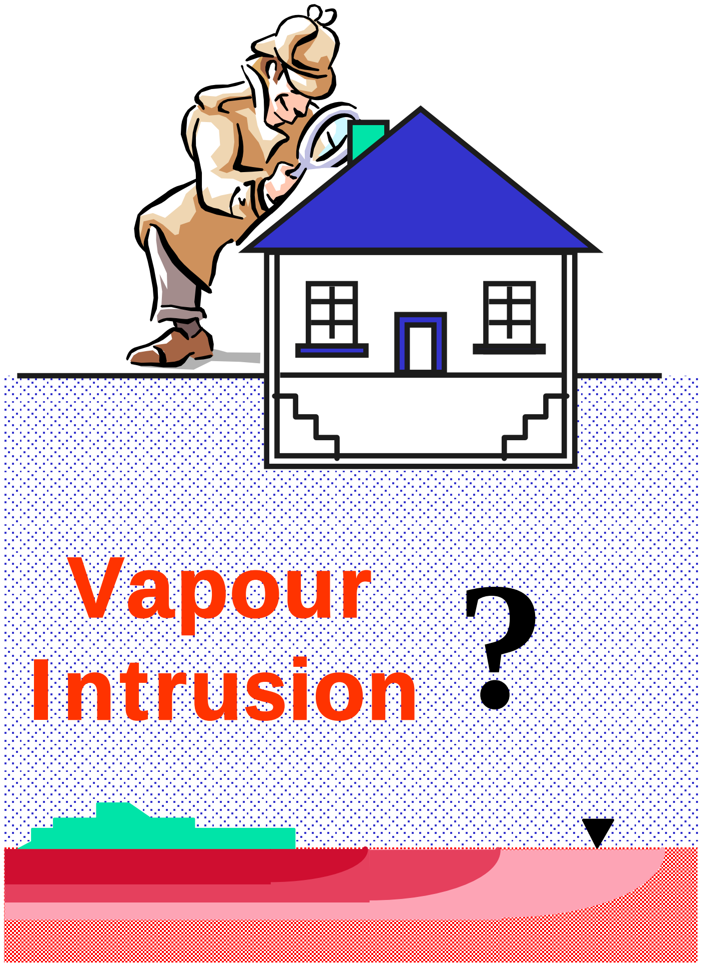
1. Vapour intrusion is real
2. Worst cases are easiest to detect
3. Chronic effects at lower concentrations more difficult to assess

Background



- Vapour intrusion ("VI") is a ***potential*** exposure pathway at many sites
- Typically concern is chronic impacts, but may also be safety concerns or odour issues for few sites
- There are an increasing number of identified sites with significant vapour intrusion impacts, but most of these are chlorinated solvent sites, with ***few*** petroleum hydrocarbon sites
- Many sites also have methane issues (woodwaste, peat, landfilled materials)

Background (cont.)



- VI is becoming of significant interest to regulators, industry & stakeholders
- Case studies and modeling indicate VI highly dependent on site specific conditions – this is challenging for generic criteria approach
- Attenuation factor "alpha"
- $\alpha = C_{air}/C_{soil\ vapour}$

Mitigation Options

- Institutional controls on land use
  - Deed restrictions or other mechanisms
- Engineering controls
  - Subslab depressurization (**“SSD”**) with active venting (interim measure for existing buildings)
  - Barrier with passive or active venting (new buildings)
  - Contaminant treatment or removal
- Intrinsically safe building design
  - Lower floors with well ventilated parking garages
  - HVAC design and operation to maintain positive pressure in buildings at all times

ITRC (2007) Guidance

Table 4.1
Comparison of Mitigation Methods

Technology	Typical Applications	Challenges	Range of Installed Costs
Passive Barriers	New construction; crawl spaces; often combined with passive or active venting, sealing openings in the slab, drains, etc.	Preventing tears, holes; may not suffice as a stand-alone technology; some states do not accept. Ensuring caulking seals cracks in floors, etc.	\$0.50-\$5/ft^2 ; thinner, less expensive barriers likely to be inadequate
Passive Venting	New construction; low vapor flux sites; should be convertible to active system if necessary	Relies on convective flow of air due to wind and heat stack effects; air flows and suction typically far less than achieved by fans	\$0.75-\$5/ft^2
Sub-Slab Depressurization (SSD)	New and existing structures; sumps, drain tiles, and block wall foundations may also be depressurized if present.	Low permeability and wet soils may limit performance; otherwise, highly effective systems	\$1-\$5/ft^2; residential systems typically in the \$1-2/ft^2 range
Sub-Membrane Depressurization (SMD)	Existing structures, crawl spaces	Sealing to foundation wall, pipe penetrations; membranes may be damaged by occupants or trades people accessing crawl space.	\$1-\$6/ft^2; residential systems typically in the \$1.50-2/ft^2 range
Sub-Slab Pressurization (SSP)	Same as SSD; most applicable to highly permeable soils	Higher energy costs and less effective than SSD; potential for short-circuiting through cracks	\$1-\$5/ft^2
Building Pressurization	Large commercial structures, new or existing; sensitive receptors	Requires regular air balancing and maintenance; may not maintain positive pressure when building is unoccupied	\$1-\$15/ft^2; heavily dependent on size and complexity of structure
Indoor Air Treatment	Specialized cases only	Typically generates a waste disposal stream; effective capture of air contaminants may be difficult; energy-intensive, with significant O&M burden	\$15,000-\$25,000 per application not atypical; actual costs heavily dependent upon type of technology employed
Sealing the Building Envelope	Cracks and holes in existing buildings	Access to perforations, permanence	Highly dependent on the extent of sealing required

New Building Mitigation

DESIGN FACTORS

VOC type (C_6H_6, CH_4, Rn)
VOC Emission/Generation Rate
Building Type
Receptor

CONTROL METHODS

Passive Venting
Active Venting
Barriers

- No standard practice for design
- Mitigation requirements are site specific (costs may not be insignificant)
- Guidance on methane mitigation includes: UK CIREA reports 149 & 665 (Assessing risks posed by hazardous gases to buildings), British Standards 8485:2007; California guidance: Los Angeles, San Diego

New Building Mitigation

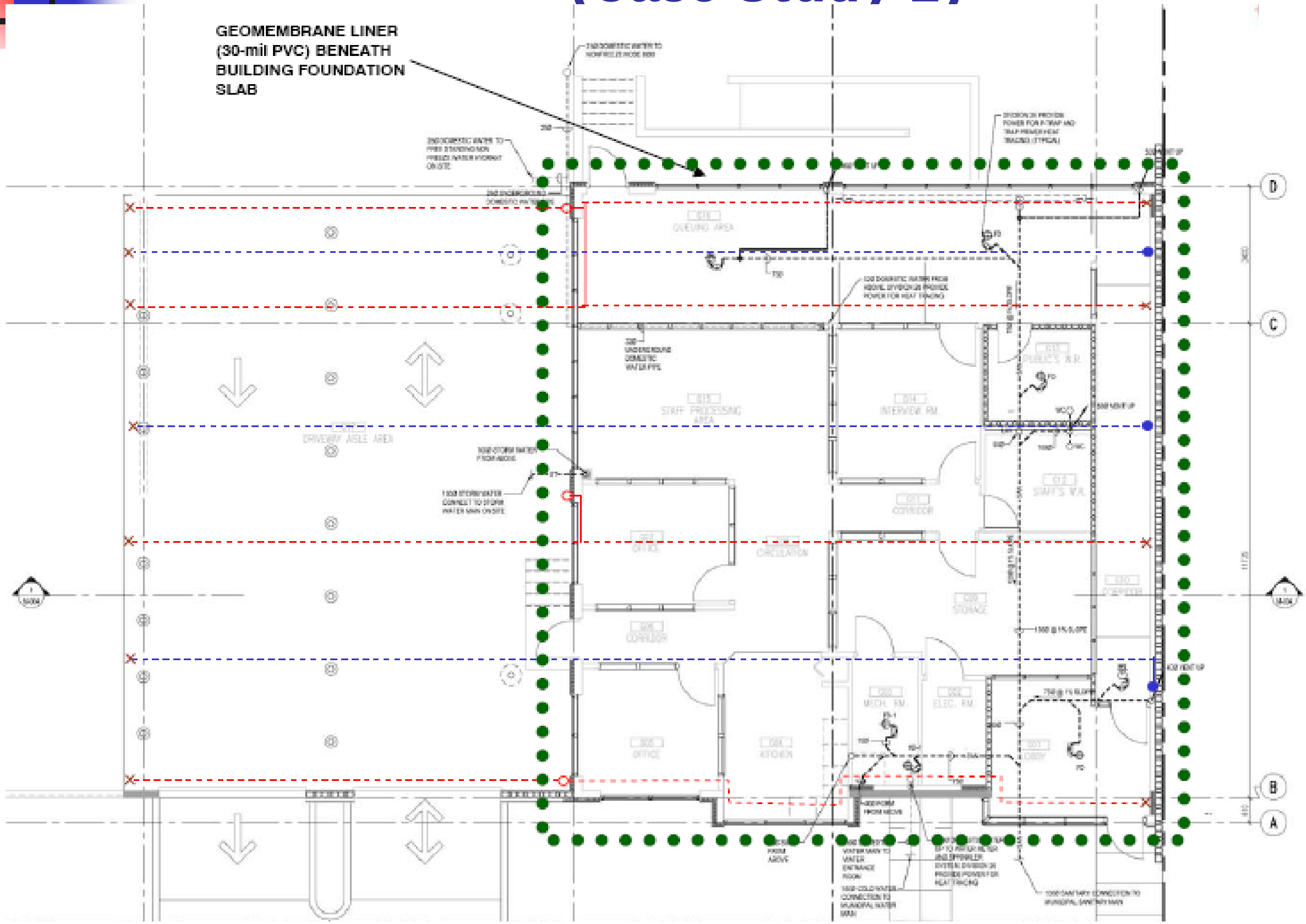
- Common approach consists of vapor barrier and passive vent pipes in coarse-grained fill layer
- Wide range barrier materials
  - **Conventional**: Polyvinyl chloride (PVC), high density polyethylene (HDPE), **Newer**: Synthetic fibre-reinforced Linear Low Density Polyethylene (LDPE) with aluminium composite, STEGO 15 mil polyolefin with taped seams, Liquid boot asphaltic emulsion
  - How do you design barrier layer?
    - Strength, elongation, permeance or vapor diffusivity, chemical compatibility, connections, penetrations
- Pipe stacks may be connected to wind turbines, or provisionally active system

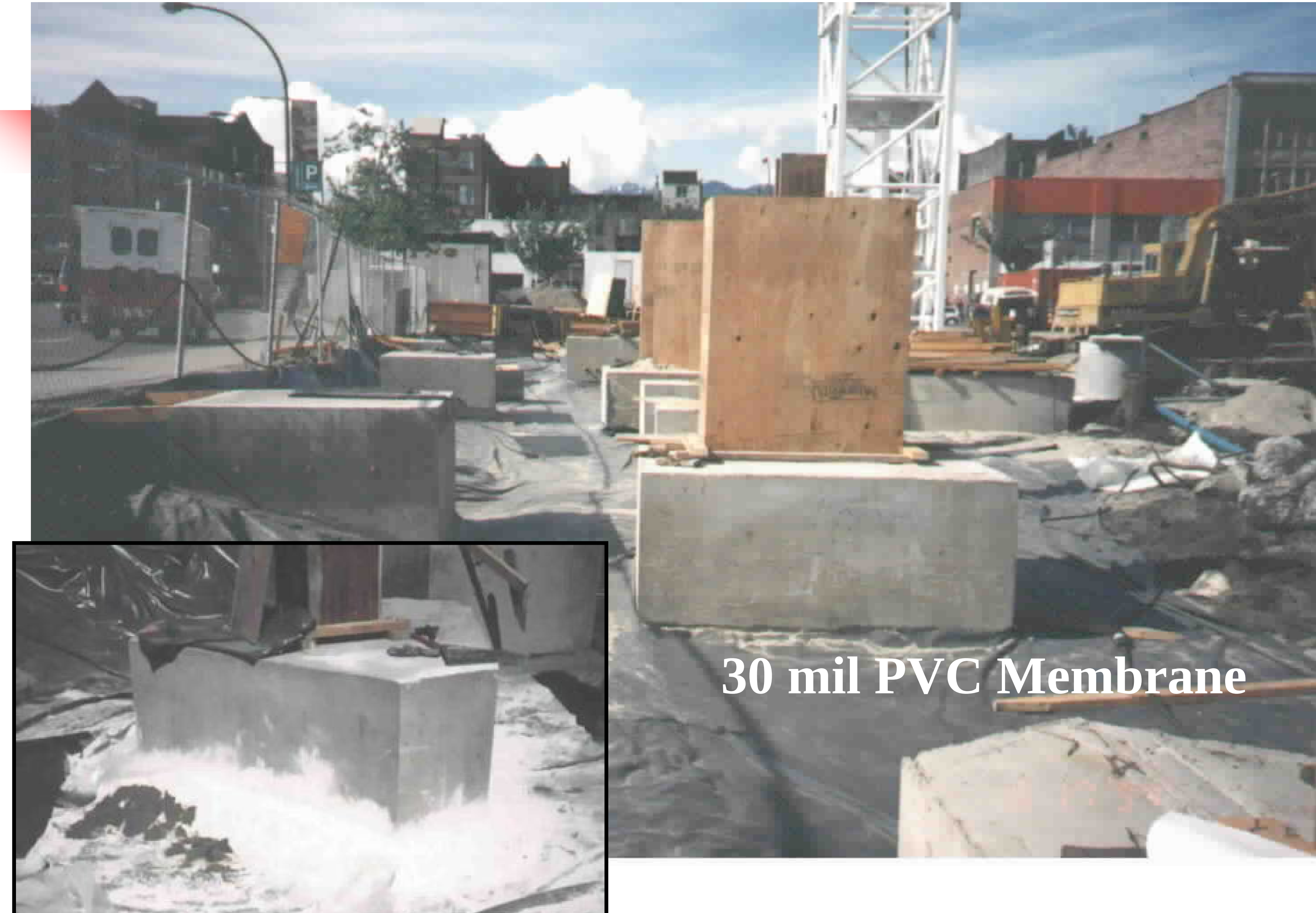
New Building Mitigation
(Case Study 1)

- Recent approximate costs for supply only (not including installation) for commercial slab-at-grade building project in Vancouver, BC (62,500 SF)
- 30 mil PVC Vapor Barrier: \$3.75 / SM
- 15 mil Layfield Vapoflex: \$1.90 / SM
- 4 oz/sq in. protective geotextile above liner: \$1.52 / SM
- Sch. 40 PVC perforated piping: 7.50/m
- Wind turbines: \$200/each
- Pea gravel surrounding vent pipes: \$50/m^3

New Building Mitigation

(Case Study 1)




30 mil PVC Membrane

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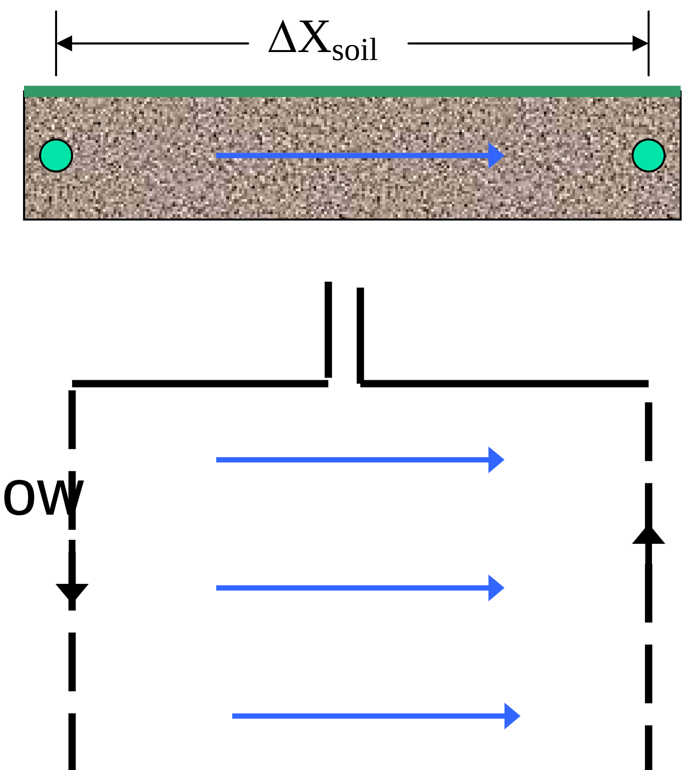
Soil Gas Ventilation System Design

Gas Flow in Soil

- $q = k\ \Delta P_{soil} / \mu \Delta X_{soil}$
- k = soil air permeability
- μ = viscosity of gas
- ΔP_{soil} = pressure drop in soil; easy to solve analytical for 1-D flow

Gas Flow Into & Through Pipe

- $P_{LO} = C\ (V_1/4005)2$
- $P_{LP} = f\ LV_2^2/D2g$
- Total Loss = $\Delta P_{pipe} = P_{LO} + P_{LP}$
- $\Delta P_{pipe} < 0.1^*\ \Delta P_{soil}$



Golder has developed spreadsheet model for design

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When Is A **GAS VAPOR BARRIER** Required Or Necessary?

Former Manufacturing Facilities, MGP, Gas Station, Dry Cleaner, Tank Farm, and Landfill Sites

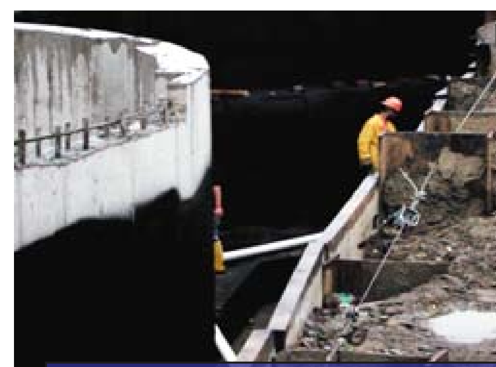
Former Manufacturing Facility

Former Gas Station

Former Landfill

Former Dry Cleaner

Former MGP Site



Former Tank Farm

LIQUID BOOT® Spray-Applied **GAS VAPOR MEMBRANE**

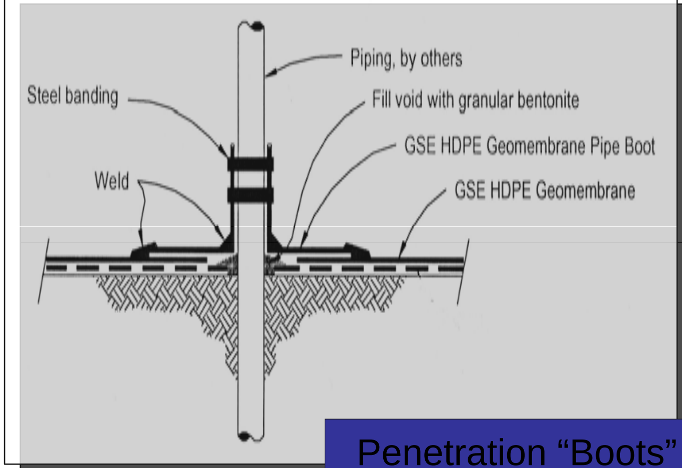
Single course, high build, polymer modified asphaltic emulsion

Costco-Ocean Township, New Jersey

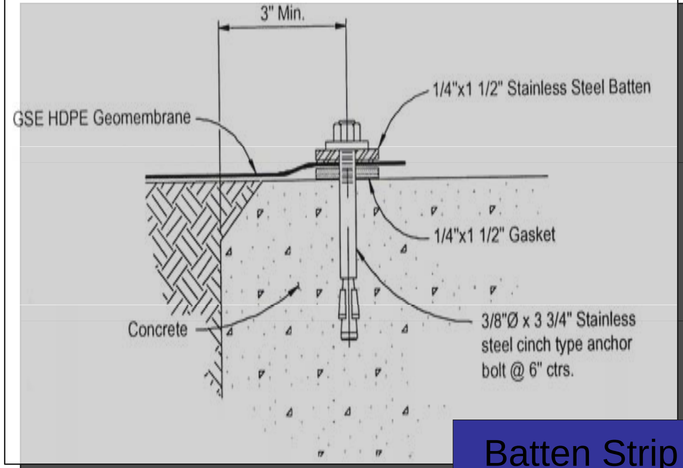
Constructability Of **HDPE / PVC** Under Buildings

Seaming

Batten Strip



Penetration “Boots”



Batten Strip