

Thesis Title  
Brown University

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# Abstract

Abstract goes here

# Dedication

To mum and dad

# Declaration

I declare that..

# Acknowledgements

I want to thank...

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# Chapter 1

## Introduction

Determining if vapor intrusion occurs at a house or structure is often difficult. One might be tempted to believe that taking an air sample inside the house would be sufficient, i.e. that vapor contaminant concentrations is over some threshold in the house is proof of VI; absence of contaminant vapors is proof of no VI. The reality is that indoor air samples can be problematic for a few reasons. Due to their distributive nature, the residents or owners of the structure may be unwilling to let indoor samples to be taken. Indoor air samples are also susceptible to false positives and negatives.

Many common consumer products contain the same contaminants that is often of concern in VI. The presence of these contaminants in a house is thus not necessarily proof of VI but rather a line-of-evidence. Great care should be and is taken to remove any potential indoor contaminant sources before any VI investigation can begin (contributing to the distributive nature of these investigations).

There can be significant temporal variability of indoor contaminant concentrations and some sites may have "active" and "inactive" periods, thus the absence of indoor contaminant is not proof that VI is not occurring, but also a line-of-evidence. This temporal variability occurs on different time-scales as mean indoor contaminant concentrations often fluctuate across seasons, and may even significantly vary across weeks, days, or even within a day.

Another approach might be to collect groundwater and/or soil-gas samples, but this also has it's inherent issues as well. The presence of contaminant in the groundwater or surrounding soil-gas (even if found right underneath the foundation) is evidence that VI occurs. Likewise, the absence or low concentration of contaminants may only indicate that there is significant spatial variability in contaminant concentration or that the source has not been found (hidden preferential pathways may especially be issues in the latter case). The result of these samples is the same as indoor samples, they may only be used as a line-of-evidence for VI.

The combination of these line-of-evidence are usually required to prove that VI occurs; the presence of contaminant in the groundwater, in the soil-gas underneath the structure, and finally inside the structure would be good evidence that VI occurs. This multiple line-of-evidence (MLE) approach is necessary when conducting VI investigations and is recommended by the US EPA.

# Chapter 2

## Topic 1